CHAPTER VIII.

WATER CONSERVATION AND IRRIGATION.

A. RESOURCES, UTILIZATION AND NATIONAL AND INTERSTATE ASPECTS.

§ 1. Introduction.

Official Year Book No. 37, pages 1096–1141, contained a special article "The Conservation and Use of Water in Australia" prepared by Mr. U. R. Ellis. In subsequent issues, much of Mr. Ellis's article of a statistical nature has been advanced, as has the general information on the more important developments in this field, but for details of general, descriptive and historical matter reference should be made to the original article. Appended to the special article, pages 1140–41, was a bibliography of selected books, reports, papers, etc., dealing with the development of the water resources of Australia and their conservation.

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 XIX.—Local Government; and on the generation of hydro-electric power to Chapter VII.—Electric Power Generation and Distribution, of this issue.

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

§ 2. Water Resources and their Utilization.

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

2. **Major Dams and Reservoirs.**—The table below lists existing major dams and reservoirs, together with those under construction and those projected as at June, 1961. The list is confined to dams and reservoirs with a capacity of 100,000 acre feet or more. There are, in addition, many others of smaller capacity in Australia.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA.

Name.	Location.	Capacity (Acre feet).	Height of Wall (Feet).	Remarks.
EXISTING DAMS AND RESERVOIRS.				
Eucumbene ..	Eucumbene River, New South Wales	a3,500,000	381	Part of Snowy Mountains Hydro-electric Scheme.
Eildon	Upper Goulburn River, Victoria	2,750,000	260	Storage for irrigation and for the generation of electricity.
Hume	Murray River near Albury	2,500,000	142	Part of Murray River Scheme—storage for domestic, stock and irrigation purposes. Hydro-electric power also developed.
Menindee Lakes Storage .	Darling River, near Menindee, New South Wales	2,000,000	..	Part of Darling River Water Conservation Scheme for irrigation and possible hydro-electric power generation.
Warragamba ..	Warragamba River, New South Wales	1,670,000	379	For Sydney water supply. Also provides for generation of hydro-electricity and flood mitigation

(a) Useful storage only.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA—*continued.*

Name.	Location.	Capacity (Acre feet).	Height of Wall (Feet).	Remarks.
EXISTING DAMS AND RESERVOIRS—*continued.*				
Miena	Great Lake, Tasmania	(*a*)984,500	40	Regulates water to Waddamana hydro-electric power station.
Burrinjuck ..	Murrumbidgee River, New South Wales	837,000	264	Storage for irrigation and production of hydro-electric power.
Somerset	Stanley River, Queensland	735,000	173	Brisbane-Ipswich water supply, flood mitigation and small hydro-electric power station.
Lake Victoria ..	Murray River near South Australian border, in New South Wales	551,700	..	Natural storage for irrigation in South Australia. Storage improved by construction of embankments and control regulators.
Lake Echo ..	Lake Echo, Tasmania	(*a*)412,200	60	Storage for Lake Echo and Tungatinah hydro-electric power stations.
Keepit	Namoi River, near Gunnedah, New South Wales	345,000	177	For rural water supplies and hydro-electricity generation.
Waranga	Goulburn River, Victoria	333,400	..	Irrigation storage.
Tinaroo Falls ..	Barron River, North Queensland	330,000	133	For irrigation purposes in the Mareeba-Dimbulah area.
Glenbawn ..	Hunter River, near Scone, New South Wales	293,000	251	Part of Hunter Valley conservation work, for irrigation and flood mitigation.
Rocklands ..	Glenelg River, Victoria	272,000	..	Part of Wimmera-Mallee domestic and stock water supply system.
Clark	Derwent River, Tasmania	(*a*)253,400	200	Serves Tarraleah hydro-electric power station.
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.
G'enmaggie ..	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.
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	240	For rural water supplies, flood mitigation and possible hydro-electric power generation.
Wyangala ..	Lachlan River, New South Wales	1,000,000	280	Strengthening and enlarging of existing dam for increased water supply and hydro-electric power generation. (*See also* under Existing Dams and Reservoirs.)
Eppalock ..	Campaspe River, near Heathcote, Victoria	250,000	150	To supplement supply to Bendigo and for irrigation.
Koombooloomba ..	Tully River, North Queensland	146,000	123	For hydro-electric and possibly irrigation purposes.
Serpentine ..	Serpentine River, Western Australia	143,500	171	For Perth water supply.

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

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA—*continued.*

Name	Location.	Capacity. (Acre feet).	Height of Wall (Feet).	Remarks.
DAMS AND RESERVOIRS PROJECTED.				
Burdekin Falls ..	Burdekin River, North Queensland	6,584,000	150	For generation of hydro-electric power, irrigation and flood mitigation.
Chowilla	Murray River, in South Australia near Victorian border	4,650,000	63	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	846,000	280	For regulation of discharges from stations of Snowy Mountains Hydro-electric Scheme, primarily for irrigation but also for power generation.
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.
Arthur Lakes ..	Source of Lake River near Great Lake, Tasmania	(*a*)339,000	50	Part of Great Lake hydro-electric power development.
Tumut 4	Tumut River, New South Wales	138,000	300	Part of Snowy Mountains Hydro-electric Scheme.
Tumut 3	Tumut River, New South Wales	120,000	240	Part of Snowy Mountains Hydro-electric Scheme.

(*a*) Useful storage only.

3. Irrigation.—(i) *History.* For some brief remarks on the history of irrigation in Australia referring to the efforts of the Chaffey brothers and to the Victorian Irrigation Act in 1886 *see* issues of the Official Year Book prior to No. 39. Trends in irrigation practice in more recent years were described in Official Year Book No. 37, page 1099.

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

The following table shows the area of land irrigated in each State during the years 1956–57 to 1960–61.

AREA OF LAND IRRIGATED.

(Acres.)

Season.	N.S.W. (*a*)	Vic. (*b*)	Q'land.	S. Aust.	W. Aust.	Tas.	N.T.	A.C.T.	Aust.
1956–57 ..	525,236	855,182	121,672	66,118	38,567	12,110	168	885	1,619,938
1957–58 ..	695,365	1,001,800	160,345	80,853	41,319	15,321	(*c*) 127	1,396	1,996,526
1958–59 ..	641,361	965,766	154,633	85,081	44,102	13,431	(*c*) 274	1,224	1,905,872
1959–60 ..	722,668	1,052,782	152,136	100,899	45,889	18,108	(*c*) 365	869	2,093,716
1960–61 ..	658,671	1,007,180	184,974	102,023	48,551	18,934	(*c*) 602	1,432	2,022,367

(*a*) Source: Water Conservation and Irrigation Commission. (*b*) Source: State Rivers and Water Supply Commission. (*c*) Incomplete; excludes area of rice irrigated.

The next table shows the area of land irrigated in each State during 1960–61 according to the nature of irrigated culture.

AREA OF LAND IRRIGATED, 1960-61.

(Acres.)

Crop.	N.S.W. (a)	Vic. (b)	Q'land.	S. Aust.	W. Aust.	Tas.	N.T.	A.C.T.	Aust.
Rice	46,116	..	..	..	..	..	(c)	..	46,116
Vegetables ..	3,362	21,735	29,698	10,643	9,076	2,103	103	114	76,834
Fruit	17,962	40,274	5,758	22,706	8,335	3,311	80	8	98,434
Vineyards ..	12,388	44,817	(d)	26,071	897	..	..	..	84,173
Sugar-cane ..	(e)	..	68,987	..	..	..	..	..	68,987
Hops	..	(e)	..	..	(e)	1,364	..	..	1,364
Cotton	..	..	2,675	..	(e)	..	..	..	2,675
Other Crops (including Fodder and Fallow land)	115,071	79,017	(f)62,205	23,555	5,591	1,787	295	867	288,388
Total, Crops	*194,899*	*185,843*	*169,323*	*82,975*	*23,899*	*8,565*	*478*	*989*	*666,971*
Pastures ..	463,772	821,337	15,651	19,048	24,652	10,369	124	443	1,355,396
**Total	658,671	1,007,180	184,974	102,023	48,551	18,934	(g) 602	1,432	2,022,367

(a) Source: Water Conservation and Irrigation Commission. (b) Source: State Rivers and Water Supply Commission. (c) Not available for publication. (d) Included with Fruit. (e) Included in Other Crops. (f) Includes Tobacco, 12,066 acres. (g) Incomplete; excludes area of rice irrigated.

(iii) *Research.* Comprehensive programmes of research and investigation are being pursued by State water and agricultural authorities and the Commonwealth Scientific and Industrial Research Organization, often in collaboration. Special attention is being given to the following:—high water tables due to the application of water; surface accumulation of salt and other soil changes associated with irrigation; methods of applying water efficiently; soil treatments to improve the physical condition of irrigated heavy clay soils; the utilization of irrigated pastures by stock; growth problems affecting plants and trees; the prevention of evaporation from water storages; and the potability of saline waters for stock.

The Commonwealth Scientific and Industrial Research Organization maintains the following research stations:—Merbein (Victoria)—irrigation problems with particular reference to ground-water, hydrology and viticulture; Griffith (New South Wales)—irrigation problems with particular reference to citrus and stone fruits and to vegetables; Deniliquin (New South Wales)—irrigated pastures; and the Kimberley Research Station (Western Australia)—tropical crops and pastures. In the maintenance of Merbein and Griffith stations, the Commonwealth is assisted, financially and otherwise, by the New South Wales Water Conservation and Irrigation Commission, by the Dried Fruits Export Control Board and by private organizations.

The Soils Division of the Organization has made detailed surveys of more than a million acres since 1927, with less detailed reconnaissance surveys over many millions of acres. The Division works closely with State authorities. The keynote of soil investigations is the relationship between soil and land use, and there is an increasing tendency to seek such surveys before irrigation districts are established. Research is also conducted in the field of water percolation in relation to soil structure.

The Physical Chemistry Division of the Commonwealth Scientific and Industrial Research Organization is currently investigating methods of minimizing evaporation losses from both large and small reservoirs.

The Irrigation Research and Extension Committee plays an important part in the agricultural activity of the Murrumbidgee Irrigation Areas. It is representative of the State Department of Agriculture, the Commonwealth Scientific and Industrial Research Organization, the Rural Bank of New South Wales, the Soil Conservation Service of New South Wales and certain farmers' organizations (including Extension Groups). Finance is provided by these authorities on an agreed basis. The objectives are:—to enable the

agricultural extension services to the farmers in the defined sub-region to be continued and developed; to provide a system for advising on local agricultural policy and organization; to provide means for farmer opinion to have due weight in the consideration of regional agricultural administration and policy; to achieve a unified approach to sub-regional extension in all branches of agriculture; to advise on the research needs of the sub-region and the co-ordination of the agricultural research of the various rural institutions working therein; to achieve close liaison between research and extension; and to conduct research in extension methods.

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

5. **Sub-surface Supplies.**—(i) *General.* Much of Australia's 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 supplies.

The Underground Water Conference of Australia was established on a Commonwealth basis in May, 1961. This body is made up of representatives from Commonwealth and State departments interested in underground water, and was established as a consequence of recommendations made by the Australian Academy of Science to the Commonwealth Government in 1958.

The various States and Territories maintain Geological Surveys and Water Commissions which are continually extending the knowledge of their own States. For example, in New South Wales, the Hunter Valley Research Foundation is carrying out scientific investigations in the catchment area of the Hunter River, and this includes an integrated study of water, soils and climate.

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

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

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

(ii) *Artesian and Sub-artesian Supplies.* Pressure water (either artesian or sub-artesian) variable in quantity and quality is obtainable in many parts of Australia, the various artesian basins extending over about half the continent. A map of Australia showing the extent of the known artesian basins appears on page 273 of this Year Book.

The Great Artesian Basin, the most extensive in the world, underlies an area of approximately 670,000 square miles, comprising about 430,000 in Queensland, 120,000 in South Australia, 80,000 in New South Wales and 40,000 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	670,000	Up to 7,000
Canning and Fitzroy	Western Australia	Mesozoic-Palaeozoic	160,000	100 to 1,500
Murray ..	Victoria, New South Wales and South Australia	Miocene-Eocene ..	107,000	100 to 1,300
Eucla	Western Australia, South Australia	Pliocene-Miocene ..	68,000	300 to 2,000
Barkly-Georgina	Northern Territory, Queensland	Cretaceous, Ordovician, Cambrian and Upper Proterozoic(?)	57,000	150 to 1,000
Carnarvon ..	Western Australia	Cretaceous, Permian..	40,000	230 to 4,000
Perth	Western Australia	Tertiary, Quaternary, Mesozoic	10,000	200 to 2,500
Western District	Victoria ..	Miocene-Eocene ..	6,500	100 to 4,500
Pirie-Torrens ..	South Australia..	Recent, Pleistocene ..	4,000	Up to 600
East Gippsland ..	Victoria ..	Pleistocene-Eocene ..	2,500	200 to 3,500
Adelaide ..	South Australia..	Recent, Oligocene ..	1,100	10 to 850
Basins of Ord-Victoria Region	Northern Territory, Western Australia	Mainly Cambrian and Permian	Unknown	Unknown

More than 3,000 artesian bores have been constructed within the Great Artesian Basin, while the daily free discharge from all bores continuing to flow in Australia has been stated to exceed 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* Official Year Book No. 37, pp. 1103–4.)

(iii) *Shallow Groundwater.* Shallow groundwater supplies are used in various parts of Australia for industry, irrigation, stock and domestic purposes. Two of the most important of these supplies are in New South Wales. The Hunter District Water Board pumps 15 million gallons a day for general use from the Tomago coastal sands near Newcastle and at Botany, Sydney, private industry pumps 8–10 million gallons a day for its own use from similar sands. Exploration of the coastal sands north of the Tomago Sands has revealed a further potential production of 25 million gallons a day.

In the sugar-cane growing areas of Queensland, particularly the Burdekin Delta, groundwater is used extensively for irrigation. Having a greater opportunity for replenishment of their water supplies, many of the smaller groundwater occurrences are more important than is suggested by comparison of their extent with that of larger basins. Some of these occurrences have, as yet, not been significantly developed.

§ 3. National and Interstate Aspects.

1. General.—As the Commonwealth Constitution makes special reference to water rights, both the Commonwealth and the State Governments have an interest in the control and conservation of water. The main responsibility for control of water resources rests with the individual State governments, but as political boundaries sometimes intersect river valleys and catchments, co-operation between governments has been necessary to develop resources in certain cases. Specific examples of Commonwealth-State and interstate co-operation and approach are given in the following sections.

On page 257 of Official Year Book No. 47, information is given on the Rural Reconstruction Commission's Report of 1945, which emphasized national aspects of water conservation and use, and the Irrigation Production Advisory Committee, whose functions are to prepare for consideration conclusions from investigations as to possible agricultural industries on irrigated lands, and to undertake long-term co-ordination of land utilization in irrigable areas served by the Murray River and its tributaries.

2. 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 River Murray Basin is mainly grapes for wine, dried fruits, fresh fruits, rice, vegetables, dairy produce, wool, fat lambs, poultry, eggs and pigs.

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. The Agreement provided for the construction of works, the allocation of the water between the three States, and the appointment of a Commission to implement the Agreement. The Commission comprises four Commissioners, representing the Commonwealth and the three States respectively. The Commonwealth representative presides.

(ii) *River Murray Waters Agreement.* Under the Agreement, construction works are carried out by the States (who are also responsible for maintenance) subject to the approval and direction of the Commission. The Agreement provides that the minimum quantity of water to be allowed to pass for supply to South Australia in each year shall be sufficient to fill Lake Victoria storage once, and with the aid of water returned from Lake Victoria, 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. These flows are to meet domestic and stock requirements in South Australia, losses of water in lockages and evaporation losses other than in the lakes at the Murray mouth, together with 603,000 acre feet per annum for diversion from the Murray in South Australia. 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* Official Year Book No. 40, page 1065, and earlier issues.

At a conference of Ministers held in July, 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. 4, Snowy Mountains Hydro-electric Scheme, p. 257) and that a storage of not less than 1,500,000 acre feet 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 found that an increase in capacity of 500,000 acre feet in storage on the Upper Murray River above Albury was the maximum that was economically justifiable for the regulation for irrigation purposes of the waters of the Upper Murray River and of waters added from the Snowy River. The Commission agreed that this increase could best be provided by increasing the size of the Hume Reservoir from its previously designed capacity of 2,000,000 acre feet to 2,500,000 acre feet, but if additional storages for hydro-electric purposes become justified in the future, better provision could be made at some other site. It subsequently recommended to the contracting Governments that the River Murray Waters Agreement be amended to provide for this enlargement of the Hume Reservoir to 2,500,000 acre feet. A conference of Ministers considered the recommendation in July, 1954, and agreed to the enlargement. In addition, it was 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.

The estimated quantity (in acre feet) of water diverted during 1960–61 from the Murray and its tributaries for irrigation and other purposes under the River Murray Agreement was as follows:—New South Wales, 2,324,000; Victoria, 2,296,000; South Australia, 230,000; a total of 4,850,000 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 1,000 feet and an earthen embankment 110 feet high extending for 4,000 feet across the river flats, the length of the total structure being approximately one mile. Work on the enlargement of the reservoir to its approved capacity was completed in August, 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 capacity of 551,700 acre feet and 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 total capacities of such main storages are: New South Wales—Menindee Lakes Storage (Darling), 2,000,000 acre feet; Burrinjuck (Murrumbidgee), 837,000 acre feet; Keepit (Namoi), 345,000 acre feet; Wyangala (Lachlan), 245,000 acre feet; Victoria—Eildon (Goulburn), 2,750,000 acre feet; Waranga (Goulburn), 333,400 acre feet. More 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, but a proposal has been made recently by the South Australian Government for a 4¼ million acre feet storage at Chowilla on the river about 37 miles above Renmark.

3. 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 costs of these works and of administration are to be borne by the States in equal shares. The agreement further provides that the water discharged 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. The construction of Bonshaw and Cunningham Weirs on the Dumaresq River was completed in January, 1953 and June, 1954, respectively.

A weir and regulator has 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 it is necessary to supplement rainfall from April to October 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.

4. 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 in July, 1949, passed the Snowy Mountains Hydro-electric Power Act setting up an Authority to implement the proposals agreed upon.

* *See also* Chapter VII.—Electric Power Generation and Distribution, p. 224. 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 Official Year Book No. 42.

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.

The Scheme involves two main diversions, the diversion of the Eucumbene, a tributary of the Snowy, to the Upper Tumut River and the diversion 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* p. 225).

Additional water is now available for irrigation in the Murrumbidgee Valley and it is expected that this will amount to 500,000 acre feet per annum by 1963. 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 should result in a substantial increase in annual primary production.

B. 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 national and interstate projects. The following survey indicates 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 Official 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. 45, 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, 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 257 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 has been commenced on the Macquarie River. 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 451,189 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 (74,133 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).
Hunter:—Glenbawn Dam (185,000 acre feet irrigation storage; 108,000 acre feet flood mitigation storage).

Water from the Hume Reservoir is used for domestic and stock purposes, to provide bulk supplies for country towns, for the irrigation of vines, fruits and fodder in the Curlwaa and Coomealla Areas, for fruit, vegetables and dairy products in the Buronga Irrigation Area, for horticulture and mixed farming in the Mallee Cliffs Irrigation Area, for rice and other cereals and for pastures in the Tullakool Irrigation Area, for domestic and stock supply and irrigation in the Berriquin, Wakool, Deniboota and Denimein Districts, and for water trusts for domestic and stock purposes and/or irrigation.

The Wyangala Dam is 30 miles upstream from Cowra in the Central West. It has a catchment of 3,200 square miles. Water from the dam, supplemented by the unregulated flow of the Belubula River, provides for domestic and stock purposes along the full length of the downstream river (approximately 800 miles) and also for irrigation by land holders operating licensed pumps. The towns of Cowra, Forbes, Condobolin, Hillston and Booligal are supplied. Balance storages at Lake Cargelligo and at Lake Brewster conserve water during periods of high flow for release as required. Water from the Lachlan, diverted at Jemalong Weir, supplies the districts of Jemalong and Wylde's Plains, serving an area of approximately 225,000 acres.

The approximate total length of supply channels (including main canals) constructed by the Water Conservation and Irrigation Commission in New South Wales is 3,316 miles. The approximate length of drains and escape channels is 1,202 miles, and the total length of pipe lines is approximately 69 miles, making a grand total of 4,587 miles of channels and pipe lines, etc.

(iii) *Extent of Systems and Nature of Irrigated Culture.* The following table shows the areas of the various irrigation systems and particulars of the areas under irrigated culture in New South Wales during 1960–61.

AREAS OF SYSTEMS AND OF LAND IRRIGATED: NEW SOUTH WALES, 1960-61.

(Acres.)

System, etc.	Total Area.	Area Irrigated.										
		Rice.	Other Cereals Grown for Grain.	Lucerne.	Other Fodder Crops.	Pastures.		Vineyards.	Orchards. (a)	Vegetables.	Fallow Land and Miscellaneous.	Total.
						Sown.	Natural.					
Irrigation Areas—												
Murrumbidgee (within the Areas) ..	451,189	26,993	14,257	4,496	2,599	76,511	1,740	5,362	15,346	3,091	22,023	172,418
Lands adjacent supplied under agreement	(b)	..	299	..	6	49	1,560	2	83	10	..	2,009
Coomealla	34,672	..	..	6	..	..	..	4,323	1,093	..	..	5,422
Curlwaa	10,393	..	..	..	35	..	..	427	1,149	..	..	1,611
Hay	6,850	..	..	119	402	2,152	68	..	..	..	12	2,753
Tullakool	18,006	982	150	30	135	6,093	..	..	..	..	203	7,593
Buronga	8,693	..	..	..	..	..	..	..	..	..	..	..
Mallee Cliffs ..	1,900	..	..	..	..	..	..	..	..	..	..	..
Coleambally ..	74,153	1,559	388	50	64	310	139	..	..	..	3,995	6,505
*Total	c 605,856*	*29,534*	*15,094*	*4,701*	*3,241*	*85,115*	*3,507*	*10,114*	*17,671*	*3,101*	*26,233*	*198,311*
Irrigation Districts—												
Benerembah ..	112,818	5,547	5,225	1,475	1,723	34,514	20	..	..	20	3,633	52,157
Tabbita	32,330	353	670	240	255	3,405	300	..	..	..	257	5,480
Wah Wah	575,716	..	2,950	1,240	1,445	5,200	200	..	..	..	3,070	14,105
Berriquin	784,537	..	5,323	15,268	1,241	224,829	915	..	..	123	2,190	249,889
Wakool	503,322	4,582	1,483	1,224	1,676	59,050	470	..	..	14	422	68,921
Denimein	147,005	2,545	366	1,182	597	11,373	..	..	12	10	70	16,155
Jemalong and Wylde's Plains	224,556	..	1,974	7,805	..	12,339	..	..	..	..	..	22,118
Gumly	353	..	31	70	2	30	..	..	19	50	..	202
Deniboota	337,252	3,555	320	1,745	310	22,505	..	..	..	..	310	28,745
*Total	2,717,889*	*16,582*	*18,342*	*30,249*	*7,249*	*373,245*	*1,905*	..	*31*	*217*	*9,952*	*457,772*
Flood Control Districts—												
Lowbidgee	375,000	..	..	..	..	..	(b)	..	..	..	..	(b)
Medgun	272,800	..	..	..	..	..	(b)	..	..	..	..	(b)
*Total	647,800*	..	..	..	..	..	(b)	..	..	..	..	(b)
Irrigation Trusts—												
Pomona	1,580	..	..	..	..	..	..	770	130	..	..	900
Bringan	4,933	..	..	..	..	..	..	..	..	..	..	(b)
Bungunyah-Koraleigh	1,810	..	..	..	..	..	..	980	88	40	..	1,108
Glenview	661	..	..	..	..	..	..	..	..	..	..	(b)
Goodnight	1 104	..	..	..	..	..	..	524	42	4	10	580
Bama	3,446	..	..	..	..	..	..	..	..	..	..	(b)
*Total	13,534*	..	..	..	..	..	..	*2,274*	*260*	*44*	*10*	(c) *2,588*
*Water Trusts—Domestic and Stock Supplies ..	2,916,026*	..	..	..	..	..	..	..	..	..	..	..
Grand Total(c) ..	6,901,105	46,116	33,436	34,950	10,490	458,360	5,412	12,388	17,962	3,362	3[illegible],195	d658,671

(a) Citrus and deciduous. Deciduous amounted to 8,500 acres, of which 8,288 acres were in the Murrumbidgee Irrigation Area. (b) Not available. (c) Incomplete. (d) Excludes some Irrigation Trusts and Licensed Diversions for which information is not available.

3. Murrumbidgee Irrigation Areas.—(i) *Description.* These areas, together with adjacent lands supplied under agreement, received 340,324 acre feet, or about a quarter, of the total water (1,316,949 acre feet) allocated within the State for stock, domestic supply and irrigation. They are served by the Burrinjuck Dam (capacity 837,000 acre feet), 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, 96½ miles from the off-take. Reticulation channels aggregate approximately 879 miles and drainage channels 822 miles. In addition, approximately 448 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 are situated originally comprised large sheep stations and was sparsely populated, but at 30th June, 1961, its population was approximately 26,000, that of Leeton Shire being 10,351, and that of Wade Shire 15,883.

(ii) *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 under freehold or perpetual lease tenure or leased for short terms for grazing or cultivation. The area under occupation at 30th June, 1961, was 381,538 acres, including 36,775 held for short lease grazing, agriculture, etc.

(iii) *Production.* Since the inauguration of the scheme in 1912, the volume of production from the area has greatly increased. Numbers of new crops are grown, while the volume of the major products of the area prior to the scheme, such as wool and livestock for slaughtering, has expanded considerably. The principal products to-day are: wool, livestock for slaughtering, rice, citrus fruits, peaches and nectarines, grapes, tomatoes, peas, beans and root vegetables.

Rice growing was initiated on the Murrumbidgee Irrigation Areas in 1924 and has since become the most important crop grown in the area. In 1960–61, the total area sown was 26,993 acres, and the total quantity of water delivered for the rice crops was 149,011 acre feet. In a normal season, the water supplied for rice represents about one-half of the total delivered to the Murrumbidgee Irrigation Areas.

The co-operative system is a prominent feature in the Murrumbidgee Areas. Co-operative organizations in the Mirool section handle about 200,000 bushels of fruit a year (compared with 54,600 in 1927–28). The annual sales turnover of the Leeton cannery in recent years has approximated £2,000,000. Settlers and government agencies co-operate extensively in all matters relating to irrigation practice.

4. 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.

Coomealla Area, 9 miles upstream from Curlwaa, comprises 34,672 acres of which 31,664 acres were occupied at 30th June, 1961. Production consists primarily of vine and citrus fruits. An extension of the Coomealla Irrigation Area was completed in recent years to provide irrigation farms for ex-servicemen.

Tullakool Area, formerly part of the Wakool Irrigation District, comprises 18,006 acres of which 14,394 acres are occupied. Main products are fat lambs, wheat and rice.

Buronga Area, on the Murray River, upstream from Wentworth, consists of 8,693 acres, of which 2,495 acres are occupied. Production is mainly fruit, vegetables and dairy products. Mallee Cliffs is also upstream from Wentworth, its area being 1,900 acres, of which 1,863 acres are occupied.

Hay Area, on the lower Murrumbidgee, consists of 6,850 acres, of which 6,401 acres are occupied. Production comprises dairy products, fat lambs, sheep, wool and fodders.

Curlwaa Area, on the Murray near Wentworth, consists of 10,393 acres of which 7,820 acres were occupied at 30th June, 1961. Production consists of dried vine fruits, deciduous fruits and fodder crops.

Coleambally area, a new area served by the Coleambally Canal off-taking from the Murrumbidgee River upstream from Gogeldrie Weir, has an area of 74,153 acres, of which 65,923 acres are occupied. Production is expected to be mainly fat lambs, wool, beef, citrus fruit and peaches, with rice growing being allowed in the initial stages.

5. **Irrigation Districts.**—These Districts are set up under the Water Act 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. The following are the districts or provisional districts constituted and the areas of land benefited:—*Murray River*—Wakool District 503,322 acres, Berriquin Provisional District 784,537 acres, Deniboota Provisional District 337,252 acres, Denimein Provisional District 147,005 acres, Jernargo Provisional District (certain portions of which have been included in Berriquin District) 4,325 acres, Barramein Provisional District (domestic and stock supply only—works not yet commenced) 89,080 acres; *Murrumbidgee River*—Wah Wah District 575,716 acres, Benerembah District 112,818 acres, Tabbita District 32,330 acres, Gumly Provisional District 353 acres; *Lachlan River* (completed)—Jemalong and Wylde's Plains Districts 224,556 acres.

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 will be 100 miles long when completed. 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, 1961, the total length of completed canals and channels in Berriquin District was 981 miles, comprising Mulwala canal 75 miles, Berrigan channel 22 miles, subsidiary channels 778 miles, escape channels 96 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 306 holdings and the area developed by irrigation includes about one acre in eight of the total area. The total area irrigated in 1960–61 was 68,921 acres and water supplied was 187,657 acre feet. Crops comprised fodders, pastures, rice, cereals and vegetables, but 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. Total irrigated acreage was 249,889 at 30th June, 1961. Sheep and wheat growing are the main industries. The fat lamb industry is well developed and expanding. A dairying industry with an associated butter factory at Finley has been established.

In the Benerembah, Tabbita and Wah Wah Districts, supplied from the channels of the Murrumbidgee Irrigation Areas, the quantity of water supplied during the 1960–61 season for irrigation, etc., was 121,962 acre feet, and the area irrigated was 71,742 acres, including rice and other cereals, pastures, and fodder crops.

For the same season, 21,405 acre feet of water were supplied from the Lachlan River to irrigate a total area of 22,118 acres within the Jemalong and Wylde's Plains Districts.

6. **Water Trust Districts, Irrigation Trusts and Flood Control and Irrigation Districts.**—The Water Act provides for the constitution of Trust Districts for domestic and stock water and irrigation and empowers the Commission to construct, acquire or utilize necessary works. When the works are completed, they are handed over to trustees to administer. The trustees are elected by the occupiers of the land and act with a representative of the Commission. They are empowered to levy and collect rates covering the cost of the works

repayable to the Crown by instalments and also the cost of operation and maintenance of the works. The rates are struck according to the area of land which benefits. The following water trusts—other than irrigation—have been constituted (the area in acres of each district is shown in parentheses)—*Murray River*—Little Merran Creek (157,440). Tuppal Creek (78,080), Bullatale Creek (68,320), Poon Boon (34,300), Minnie Bend Flood Prevention (2,190); *Murrumbidgee River*—Yanco, Colombo and Billabong Creeks (1,007,780); *Lachlan River*—Marrowie Creek (292,640), Torriganny, Muggabah and Merrimajeel Creeks (170,240), Ulonga (64,960), Micabil Weir (11,500), Condobolin West Weir (4,480); *Miscellaneous*—Great Anabranch of Darling River (967,339), Nidgery Weir (46,880), Algudgerie Creek (9,760), Collarenebri town water supply (117)—making in all a total area of 2,916,026 acres. Thirteen of these trusts have been formed for the provision of water for domestic and stock purposes, one for a town supply and one for flood prevention.

Irrigation Trusts are established under the same Act and are administered by trustees in a similar way. The following are the Trust Districts (area in acres is shown in parentheses):—*Murray River*—Bringan (4,933), Bama (3,446), Goodnight (1,104), Bungunyah-Koraleigh (1,810), Glenview (661); *Darling River*—Pomona (1,580)—making in all a total area of 13,534 acres.

The Lowbidgee Provisional Flood Control and Irrigation District (375,000 acres), 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 (272,800 acres) near Moree in the north-west is also in operation. In this area, about 58,000 acres benefit from controlled floodings.

7. **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.

The Farm Water Supplies Act was passed in 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.

8. **Underground Water.**—Extensive use is made of artesian, sub-artesian, and shallow underground water. Nearly eighty thousand square miles in the northern and western portions are covered by the Great Artesian Basin. Eighty-nine Bore Water Trusts and 12 Artesian Wells Districts have been constituted. The Bore Trusts are administered in the same way as Water Trusts, but in Artesian Wells Districts settlers maintain the drains. Bore Trusts and Artesian Districts cover over 5 million acres and water is distributed through approximately 8,000 miles of open earth drains. The number of artesian bores giving a flowing or pumping supply at 30th June, 1961, was 1,081 and the estimated total daily flow from approximately 600 flowing bores was 65 million gallons. The estimated flow in 1914–15 was 99 million gallons a day from 372 bores. The deepest bore is Boronga No. 2 (4,570 feet), which also has the greatest flow, about 1 million gallons a day.

Of other structural basins of sedimentary rocks, e.g. Murray, Cumberland (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 of the south-western lobe of the Cumberland Basin 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.

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 50,000 gallons an hour are obtained from wells and screened bores in these areas and are used for irrigation purposes. The Government is carrying out investigations to determine the groundwater 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 1955 amendments to the Water Act that all wells and bores be licensed and details of over 14,000 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.

Since 1912, the Government has assisted settlers in shallow boring operations for which repayments are required over a period. To 30th June, 1961, the number sunk by the Commission's plants was 5,236 and their average depth was 306 feet.

9. **Future Programme.**—The programme of post-war development already 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 in progress. Legislation has been passed authorizing the construction of a flood control and irrigation dam at Warkworth in the Hunter Valley and a storage dam at Blowering on the Tumut River. The Hunter River development, of which Glenbawn Dam is an integral part, concerns an exceptionally fertile coastal valley, forming the hinterland to Newcastle, where the annual rainfall is not heavy and variations from month to month are considerable, This is the first coastal scheme initiated in New South Wales. At 30th June, 1961, a diversion weir at Gogeldrie on the Murrumbidgee River was supplying water to a number of farms in a new irrigation area (Coleambally) on the south side of the river to comprise not less than 1,000 new irrigation farms. Later development will extend to a new area on the north side of the river. 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. A proposed new earth and rock fill dam will be built behind the present dam to give a storage of 1,000,000 acre feet.

10. **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. 230).

§ 3. Victoria.

1. **General.**—(i) *Rainfall.* Particulars of the rainfall pattern of Victoria were given on page 1117 of Official Year Book No. 37. (*See also* Chapter II.—Physiography, p. 45, of this Year Book.)

(ii) *Administration.* The passing of the Irrigation Act of 1886 put the control of surface waters under the Crown, provided for the establishment of Irrigation Trusts and marked the beginning of irrigation development. In 1905, the Water Act 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 to 4,263,618 acre feet at 30th June, 1961. 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 5,625,038 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 1,007,180 acres in 1960–61 to which 1,373,717 acre feet of water were delivered. The Commission estimated the value of irrigated production in 1959–60 at £57,800,000 representing about one-sixth of the value of Victoria's total rural production.

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

A notable development in the post-war years has been Soldiers' Settlement Schemes based on irrigation. Altogether, more than one thousand holdings have been prepared for settlers, including 550 in the Murray Valley District, 250 at Robinvale and 125 in Gippsland.

Town water supply, sewerage works and land drainage, flood protection and river improvement works serve many thousands of people. A domestic and stock water supply is given to various rural areas throughout the State, but principally to the Wimmera and Mallee about which a detailed description is provided later in this chapter.

3. **Storages.**—The capacities of the main storages in the various systems (in acre feet) at 30th June, 1961, 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; *Wimmera-Mallee*:—Rocklands, 272,000; Total, 563,800; *Gippsland*:—Glenmaggie, 154,300; Total, 154,340; *Coliban*:—62,730; *Werribee-Bacchus Marsh*:—34,900; *Mornington Peninsula*:—5,800; *Otway*:—1,080; *Miscellaneous*:—8,058; *Grand Total*:—5,625,038.

4. **Extent of Systems and Nature of Irrigated Culture.**—The following table shows the areas of the various irrigation systems and the areas under irrigated culture during 1960–61.

AREAS OF SYSTEMS AND OF LAND IRRIGATED: VICTORIA, 1960-61.
(Acres.)

System.	Total Area.	Area Irrigated.									
		Cereals.	Lucerne.	Other Fodder Crops.	Pastures.		Vineyards.	Orchards.	Market Gardens.	Fallow and Miscellaneous.	Total.
					Sown.	Natural.					
Goulburn-Loddon ..	*1,288,880*	*2,551*	*16,461*	*4,487*	*358,661*	*18,934*	*218*	*21,662*	*3,923*	*5,310*	*432,207*
Murray—											
Torrumbarry ..	377,384	3,669	4,590	3,090	180,715	33,435	5,192	983	951	5,723	238,348
Murray Valley Irrigation Area ..	274,123	100	7,965	391	91,722	1,412	29	5,465	535	211	107,830
Pumping(*a*) ..	80,754	..	471	206	571	207	36,243	2,578	398	916	41,590
Total	*732,261*	*3,769*	*13,026*	*3,687*	*273,008*	*35,054*	*41,464*	*9,026*	*1,884*	*6,850*	*387,768*
Other Northern Systems(b)	*19,735*	*95*	*1,400*	*33*	*8,860*	*835*	..	*3,710*	*746*	*12*	*15,691*
Southern Systems ..	*147,260*	*57*	*1,403*	*601*	*51,548*	*3,123*	..	*587*	*5,584*	*390*	*63,293*
Private Diversions(c) ..	(*d*)	*1,468*	*7,582*	*1,431*	*62,246*	*9,068*	*3,135*	*5,289*	*9,598*	*8,404*	*108,221*
Grand Total ..	e2,188,136	7,940	39,872	10,239	754,323	67,014	44,817	40,274	21,735	20,966	1007180

(*a*) Includes First Mildura Irrigation Trust. (*b*) Area of Campaspe District only. (*c*) Excludes private diverters in the Toorumbarry System, but includes all other private diverters along the Murray River. (*d*) Not available. (*e*) Incomplete; excludes Private Diversions and part of other Northern Systems.

5. Irrigation Systems.—(i) *Goulburn.* The storage capacity for this system is provided principally by Eildon Reservoir. The enlargement of the storage capacity of this reservoir was completed in 1956, enabling 600,000 acres to be irrigated when the necessary distributary works are completed. Water from Eildon Reservoir flows down the Goulburn River to the Goulburn Weir, located near Nagambie. This raises the summer level of the river about 45 feet for the purpose of diversion. From this Weir, water is diverted via the East Goulburn Main Channel direct to the irrigation areas around Shepparton. The western main channels from the Weir convey water to the Waranga Reservoir near Murchison in addition to supplying part of the large Rodney Area directly.

Two main outlet channels issue from Waranga Reservoir. One serves the western section of Rodney Area while the other serves Irrigation Areas as far west as Boort, and continues into the Wimmera-Mallee Domestic and Stock System to provide a supplementary supply as far as Beulah East (*see* (iv), below).

Water is also supplied to part of the Goulburn System from Cairn Curran Reservoir on the Loddon River, and from Tullaroop Reservoir on one of its tributaries. 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 an area of approximately 750,000 acres 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 Murray Valley Irrigation Area, which is served from Yarrawonga Weir, comprises 274,000 acres west of Yarrawonga between the Murray River and Broken Creek. Dairy products, fat lambs and canning fruit are the main items produced.

The gravitation system based on Torrumbarry Weir (52 miles downstream from Echuca) serves an area of about 378,000 acres 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 fruits and vegetables are grown around Swan Hill and tobacco growing is increasing in importance.

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 an area of 130,000 acres around Maffra and Sale, mainly devoted to dairying. This is supplied from Glenmaggie Reservoir on the Macalister River and from the natural flow of the Thomson River when the flow is adequate. Other important irrigation districts are located quite close to Melbourne around Werribee and Bacchus Marsh. These districts are intensively developed for dairying and vegetable growing.

(iv) *Wimmera-Mallee Domestic and Stock Supply System.* This system serves an area of 11,000 square miles or nearly one-eighth of the State. Without the artificial supply of water, development in this area would be meagre and hazardous owing to the constant threat of drought. The main supply is drawn from the Grampians storages and can be supplemented by water drawn from the Goulburn and Loddon Rivers, via the Waranga Western Channel referred to previously. Works in progress will make the Wimmera and Mallee independent of supplies from the Goulburn and Loddon Rivers in the near future. In addition, certain areas in the north of the system are supplied 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.

6. **Town Water Supplies and Sewerage.**—Details of the operations of the State Rivers and Water Supply Commission which supervises water supplies and sewerage for country towns and local government authorities are given in § 5 of Chapter XIX., Local Government, of this Year Book.

7. **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 over £3 million a year.

By the River Improvement Act of 1948, the formation of local river improvement and drainage trusts under the supervision of the Commission has been greatly facilitated and since 1950, 20 such trusts have been formed. The importance of river improvement work is expected to continue to grow.

8. **Finance.**—The capital liability of the Commission at 30th June, 1961, was £98,500,000. Of this amount, £69,000,000 was expended on irrigation and £7,000,000 on domestic and stock supply systems. Both these amounts were financed entirely by the State. The total liability for urban supply was £14,000,000 of which 51 per cent. was borne by the State and the remainder by the districts concerned.

9. **Underground Resources.**—The active investigation of a survey of these resources is being carried out by the Victorian Department of Mines. Their deep drilling plant has located suitable water for town supplies at Portland, Heywood, Port Fairy, Timboon and Petersborough in aquifers ranging to 4,500 feet in the Western Districts Basin. Other drilling plants are engaged in other parts of the State and up to date over 100 wells have been successfully completed.

The Murray Artesian Basin underlies an area of 107,000 square miles, of which 27,000 square miles are in Victoria, 28,000 square miles in South Australia and 52,000 square miles in New South Wales. The quality of the water varies, and is suitable for domestic purposes in much of the south-western part of the basin in Victoria, but elsewhere is suitable only for limited stock use. There are innumerable bores in Victoria ranging to 6,000 feet in depth. Some individual bores can yield up to 2,000,000 gallons a day. In the last few years, the Department of Mines has expanded considerably the work of exploration for underground water.

10. **Future Programme.**—The main work under construction is the enlargement of the channels of the Goulburn System to distribute the extra water now available from Eildon, Cairn Curran and Tullaroop Reservoirs. A considerable amount of this work has already been carried out. Other large projects under construction are the enlargement of Eppalock Reservoir on the Campaspe River to a capacity of 250,000 acre feet and important new works in the area known as Carrum Drainage District.

11. **Hydro-electricity.**—Details of hydro-electricity potential and utilization in Victoria may be found in the previous chapter (*see* p. 232–4).

§ 4. Queensland.

1. **General.**—(i) *Rainfall.* Particulars of the rainfall pattern of Queensland are given in Official Year Book No. 37, page 1122. (*See also* Chapter II.—Physiography, page 45, of this Year Book.)

(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* Official 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 constructed 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 approximately 46 per cent. of total agricultural production. Approximately 15 per cent. of the sugar cane acreage was irrigated in 1960–61, which represented some 40 per cent. of the total irrigated area in Queensland. Queensland is also Australia's major tobacco-producing State, and plans are in hand to increase greatly the annual production of this crop by means of development under irrigation. The area of tobacco irrigated during 1960–61 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. There has been considerable development during recent years of individual water conservation projects (water harvesting) to provide storage for irrigation of pastures, fodder crops and small crops, and orchards. Where available, electricity is the most popular source of power for pumping and the principal areas supplied with electricity are the Burdekin Delta, the Lockyer Valley, and the Darling Downs.

It has been estimated that about two-thirds of the total area irrigated in Queensland is supplied from underground water. The main areas where these supplies have been developed extensively are the Burdekin Delta (Ayr-Home Hill Area), the Pioneer Valley, Callide Valley, Lower Burnett (Bundaberg Area), Lockyer Valley and Redland Bay. Similar development is taking place in other areas such as parts of the Darling Downs.

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

The following table shows for each division of the State the number of irrigators and the areas irrigated for the year ended 31st March, 1961.

AREA OF LAND IRRIGATED: QUEENSLAND, 1960-61.

Division.	No. of Irrigators.	Area Irrigated (Acres).							
		Vegetables.	Fruit.	Sugar-cane.	Tobacco.	Cotton.	Other Crops.	Pastures.	Total.
Southern Queensland ..	5,518	24,313	4,686	17,309	3,218	721	42,367	11,876	104,490
Central Queensland ..	609	1,089	256	..	7	1,819	6,257	1,679	11,107
Northern Queensland ..	1,712	4,296	816	51,678	8,841	135	1,515	2,096	69,377
Total	7,839	29,698	5,758	68,987	12,066	2,675	50,139	15,651	184,974

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

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

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

and sands carrying water suitable for irrigation. Despite a mean annual rainfall of 30 inches, the variation is great, and irrigation is necessary for continuous agricultural production. Surveys suggest that of some 60,000 acres of land highly suitable for irrigation only about 30 per cent. 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 1,370 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 Agriculture and Stock.

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

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

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

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

(ii) *Government Projects.* The Irrigation and Water Supply Commission has constructed and operates two dams and forty-one weirs with a storage capacity of 452,776 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 existence of large areas of sandy soils suitable for tobacco production in the valleys of the Walsh and Barron Rivers in the neighbourhood of Mareeba and Dimbulah led to large-scale investigations into the possibility of irrigation development in the area.

During 1952, a report on the utilization of waters of the Walsh and Barron Rivers was prepared, and the establishment of an irrigation undertaking approved by the Queensland Government. The projected undertaking provided for construction of a major storage at Tinaroo Falls on the Barron River to store 330,000 acre feet, and construction of irrigation works to serve 78,000 acres commanded by this storage, of which 49,000 acres on 910 tobacco farms and 180 mixed farms will be irrigated annually. Construction of Tinaroo Falls Dam has been completed, and work is progressing on the construction of irrigation works. Tobacco will be the basic crop, while peanuts, vegetables, maize, cotton and stock fattening also appear suitable. One hundred and four miles of channels have been constructed, and irrigation water from Tinaroo Falls Dam is available to 335 farms.

In 1960–61, the value of tobacco leaf sold was £4.8 million from 425 farms.

(*b*) *Burdekin River Irrigation Area.* A major multi-purpose scheme, involving irrigation, flood control and hydro-electric power generation, has been investigated by the various interested government departments under the general supervision of the Burdekin River Authority. The development envisaged includes a dam storing 6,584,000 acre feet, which would make water available for the irrigation of at least 250,000 acres. The principal industries anticipated are tobacco growing, dairying, and cattle-fattening, with sorghum, sunflowers, peanuts, cotton and sugar-cane as other possible forms of production.

The Clare Irrigation Area, constituted in 1949, the Millaroo Irrigation Area, constituted in 1952, and the Dalbeg Irrigation Area, constituted in 1953, representing the first stage of the major Burdekin River Irrigation, Hydro-electric and Flood Mitigation Project, are at present predominantly used for tobacco production. Located from 25 to 65 miles upstream from the mouth of the Burdekin, these areas comprise 18,862 acres, and obtain irrigation waters from central pumping stations drawing on the flow of the Burdekin. A temporary storage of 7,670 acre feet capacity has been constructed about 79 miles upstream from the mouth of the Burdekin to augment supplies. At 30th June, 1961, 149 farms were occupied, and total production for 1960–61 was valued at £883,331. Construction of further stages of the scheme has been deferred indefinitely.

(*c*) *Dawson Valley Irrigation Area.* The Dawson River, a 392-mile long tributary of the Fitzroy River, rises in the Carnarvon Range and joins the Mackenzie River to form the Fitzroy River, 50 miles west of Rockhampton. Lands bordering the river in its northerly course of about 170 miles before its confluence with the Mackenzie River are commonly termed the Dawson Valley. A scheme for the development of the Dawson Valley providing for the irrigation of 70,000 acres was inaugurated in 1923. Storage for the scheme was to be provided by a dam of 2,500,000 acre feet capacity at Nathan Gorge. Much investigational and survey work on the scheme was carried out, but the general financial depression and limited loan funds brought about the cessation of this work. However, the initial step in construction has been 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 £350,000. Pasture, vegetables, cotton, fruit and dairy products are the principal produce. Recently, further attention has been given to the former plans for the valley, and earlier work has been under close scrutiny as a prelude to future development. Construction of works to serve some 2,400 acres at Gibber Gunyah, adjacent to the existing Theodore Area, has been completed, and 17 farms have been occupied.

(*d*) *St. George Irrigation Area.* The St. George Irrigation Area comprises 18 farms engaged mainly on raising fat lambs in conjunction with irrigated pastures. Water supply for the area is obtained by pumping from the combined weir and road bridge on the Balonne River at St. George.

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

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

(*g*) *Upper Condamine Project.* Work has commenced on the establishment of township accommodation and facilities at Leslie Dam Site. 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 257.

3. **Great Artesian Basin.**—(i) *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 430,000 square miles or about two-thirds of the total State area of 667,000 square miles.

(ii) *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. This decline gave rise to the fear that supplies from the basin would eventually cease. As a result, in 1939, the Queensland Government appointed a committee to ascertain the nature and structure of the Great Artesian Basin, with particular reference to the problem of diminishing supply. The final report, which was presented in 1954, indicated that the majority of the Committee expected the output to 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, 1961, 2,709 artesian bores had been drilled of which 1,816 were still flowing. The total depth drilled amounted to 3,816,910 feet and the estimated daily flow was 208 million gallons. Although very few bores exceed 2,000 feet in depth (the average depth is 1,408 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 is steadily diminishing, the rate of decrease varying widely throughout the basin. Present average rates of diminution are:—pressure 1–2 feet/head; total flow 2–3 per cent. per annum.

The greater part of the artesian discharge is distributed by open earth channels which total some 15,500 miles in length. A large proportion of the water flowing along these channels is lost by soakage and evaporation, less than 10 per cent. being actually used by stock. The amount of loss through soakage depends on several factors, including the permeability of the earth, the rate of evaporation (which varies from season to season), and the shape and maintenance of the drains. More effective utilization of this water could be obtained by the use of piping to overcome the loss by soakage and evaporation in the open earth channels.

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 stockwatering. Practically the whole of the final steady-rate discharge from flowing bores will be needed for the watering of stock.

A programme of strict conservation, involving the restriction of bore flows and the improvement of bore drains, would result in smaller shrinkage of the area served by flowing bores. Such a scheme would actually cost less than the installation and maintenance of pumps or other watering facilities which would be required to provide alternative water supply as additional bores ceased to flow because of a policy of non-restriction. On the other hand, strict conservation would not increase the amount of water ultimately available as perennial flowing supply, and would in fact decrease the amount of water passed from intake beds to aquifers within the basin by flattening the hydraulic gradient. It is considered that the benefit from strict conservation was not sufficiently great, nor sufficiently concrete, to warrant implementation.

Shallow sub-artesian 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 9,740 sub-artesian bores, within the Great Artesian Basin, have been registered in Queensland. An essential practical consideration is that the main artesian beds are continuous and the sub-artesian beds are not continuous.

Detailed surveys of numerous other sources of underground water in the State, such as the smaller sedimentary basins, the Cainozoic alluvial deposits, recent coastal sands and fractured older rocks, still largely remain to be carried out.

(iii) *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 1960–61 are: Areas constituted, 72; administered by Commissioner, 54; administered by local boards, 6; number abolished, 12; area benefited, 3,842,297 acres; average rate per acre, 1.01d.; number of flowing bores, 58; total flow, 24,868,000 gallons a day; drains served, 2,627 miles.

4. **Other Basins.**—Two major areas bordering the Great Artesian Basin in Queensland carry artesian water. One is located on the western slopes of Cape York Peninsula and the other in the Dawson-Mackenzie River (Bowen) Basin. A small area in which flowing wells occur (the Gatton Basin) extends from Gatton to the coast.

Sub-artesian water supply from the Barkly Basin which extends into western Queensland from the Northern Territory, is referred to in the section dealing with the Northern Territory.

5. **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 40 per cent. 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.

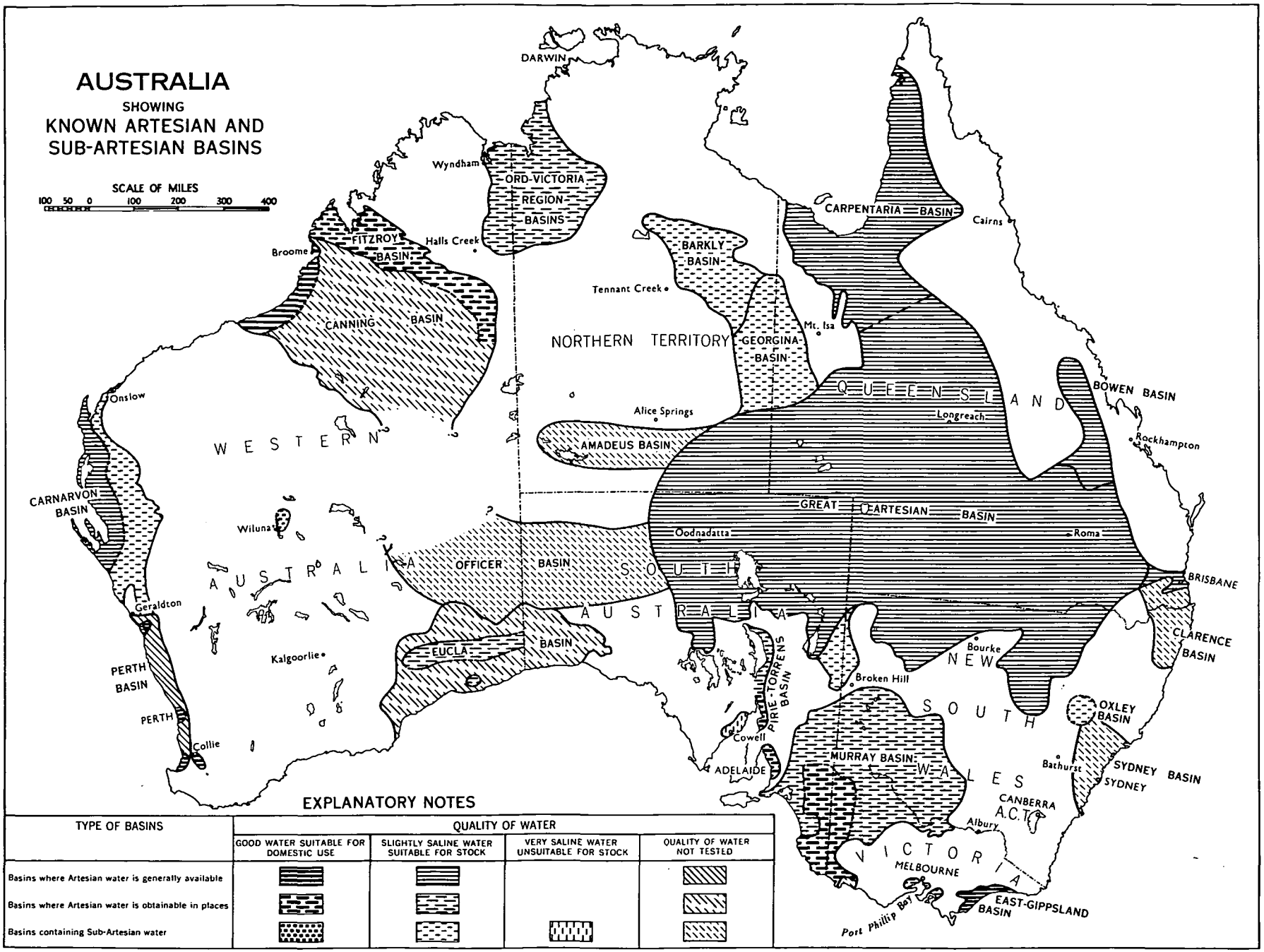
(ii) *Main Stock Routes.* During 1935, a scheme was inaugurated to water adequately stock routes in the western portion of the State including main trunk routes connecting Eromanga to Burketown, Charleville to Normanton, and Clermont to Einasleigh, with branches to railheads, a total distance of 3,117 miles. Watering facilities were also provided on subsidiary routes. Under the Stock Routes and Rural Lands Protection Act of 1944, a co-ordinating board was constituted, representative of Government departments and pastoral interests, under the direction of the Minister for Lands and with an officer of the Department as superintendent. His duty was, *inter alia*, to investigate and implement a long-range, co-ordinated plan for adequate watering of all stock routes throughout the State. Natural waters are being supplemented by artificial facilities at intervals of about 9 miles. Construction is supervised by the Irrigation and Water Supply Commission and by local authorities. On completion, facilities are vested in local authorities for control and maintenance. From 1935 to 30th June, 1961, 536 facilities had been completed, and at 30th June, 1961, 40 facilities were under construction or investigation.

(iii) *Channel Country Stock Routes.* Extensive investigations have been made of the Channel Country fed by inland rivers in the south-western corner of the State. This country is intersected by shallow and irregular flood channels through which huge volumes of flood waters pass in favourable seasons. Consequent on the flooding, a heavy growth of natural pastures is produced on the flooded lands, providing feed in quantities far in excess of that required for the normal stock population of the area. If flooding could be made more reliable by means of storages to create artificial floods, the pastoral resources of the area would be enormous. However, inquiries directed on these lines have revealed that little can be done to increase or stabilize the turn-off of fat cattle by artificial storage.

At 30th June, 1952, 41 watering facilities at an estimated cost of £300,000 had been proposed under a Commonwealth-State agreement for stock routes through, and in the approaches to, the Channel Country. By 30th June, 1961, 35 had been completed, while one sub-artesian bore and one excavated tank were under construction.

6. **Technical and Financial Assistance to Farmers.**—The year 1960–61 was the third year of operations under The Farm Water Supplies Assistance Act of 1958. The purpose of the Act is to:—

(i) Improve the standard of stock and domestic water supply installations on individual holdings;
(ii) Encourage greater development of individual irrigation schemes by—
  (*a*) Modern methods of water conservation and water harvesting,
  (*b*) Development and utilization of sub-surface supplies,
  (*c*) Ensuring that such development is soundly planned, technically and economically;
(iii) Provide greater stability of production and avoid losses in time of drought together with generally increasing production.



EXPLANATORY NOTES

TYPE OF BASINS	QUALITY OF WATER			
	GOOD WATER SUITABLE FOR DOMESTIC USE	SLIGHTLY SALINE WATER SUITABLE FOR STOCK	VERY SALINE WATER UNSUITABLE FOR STOCK	QUALITY OF WATER NOT TESTED
Basins where Artesian water is generally available	▬	▬		▨
Basins where Artesian water is obtainable in places	▬	▬		▨
Basins containing Sub-Artesian water	▬	▬	▬	▨

Compiled from map "Underground Water" (1953) of the Atlas of Australian Resources and later information.

Department of National Development, Canberra, A.C.T. 1960

To achieve this purpose the Act authorizes the provision of technical and financial assistance to landowners for the investigation, design and installation of approved works of farm water supply. All projects for which finance is provided under the Act are carried out under Commission supervision, and for the payment of a small charge the Commission will supervise the construction of works designed by its staff, but for which the landowners do not require financial assistance under the Act.

During 1960–61, 721 requests (463 for technical assistance only, and 258 for technical and financial assistance) were dealt with in addition to advice on a further 641 requests on groundwater supplies. An amount of £290,340 was approved for advances under the Act in 1960–61.

7. **Hydro-electricity.**—An outline of Hydro-electricity Schemes operating in Queensland is given in the previous chapter (*see* p. 236).

§ 5. South Australia.

1. **General.**—(i) *Rainfall.* Brief particulars of the climatic conditions in South Australia are given on page 1129 of Official Year Book No. 37. (*See also* Chapter II.—Physiography, page 45 of this Year Book.)

(ii) *Administration.* Water supplies, other than irrigation works, are under the control of the Engineering and Water Supply Department, which administers the Waterworks Act governing the supply of water through mains in water districts for townships and farm lands. The Water Conservation Act 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, 1961, more than 550 dams, tanks and " rainsheds " had been built or acquired by the State, in addition to 460 wells and 340 bores, at a total cost of £1,774,888. The " rainsheds " are timber frameworks roofed with galvanized iron to catch precipitation 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, discharging into tanks ranging from 2,000 to 500,000 gallons. 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.**—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 upper Murray of South Australia and the Mildura area of Victoria formed the cradle of Australian irrigation. 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. Including land allotted for War Service Land Settlement purposes, the Department of Lands administers in the Murray Valley an area of 32,933 acres of irrigable high land, together with 9,532 acres of reclaimed swamp and 166,870 acres of non-irrigable land in the irrigation areas, and 29,794 acres of land temporarily leased and reserved for commonage or other purposes amounting in all to 239,129 acres. In addition, the Renmark Irrigation Trust controls 20,557 acres, of which 9,300 are irrigated. Water used for irrigation purposes in 1960–61 in the high land irrigation areas controlled by the Department of Lands was approximately 100,000 acre feet and, in addition, approximately 41,000 acre feet were applied to the reclaimed areas. In the Renmark area, approximately 35,000 acre feet of water were used for irrigation in 1960–61. The production of the upper Murray areas is almost exclusively fruit and vines. Principal crops are sultanas, currants, lexias, apricots, peaches, nectarines, pears and figs (mainly for dried fruit), wine grapes, and citrus fruits. Before irrigation, these semi-arid lands were of little productive value.

Renmark Irrigation Trust is administered 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 channel for reticulation to 9,300 acres.

The following table shows the acreage devoted to various crops in the government-controlled and Renmark Irrigation Trust areas on the upper Murray, and in the government-controlled reclaimed swamp districts near the mouth of the Murray, which are devoted to dairying. It should be noted that these acreages are exclusive of areas of land irrigated privately by landowners. In 1960–61, a total of 102,023 acres under irrigation was reported in the annual Agricultural and Pastoral Census, a figure which includes areas administered by the Department of Lands and the Renmark Irrigation Trust.

LAND IRRIGATED IN AREAS ADMINISTERED BY THE DEPARTMENT OF LANDS AND THE RENMARK IRRIGATION TRUST, 1960-61.

(Acres.)

Area.	Vine Fruits.	Tree Fruits.	Citrus Fruits.	Sown Pastures.	Total
DEPARTMENT OF LANDS.					
Orchard Land—					
Berri	4,938	1,159	1,343	..	7,440
Cadell	566	191	130	..	887
Waikerie	1,829	624	1,399	..	3,852
Cobdogla	4,022	220	290	..	4,532
Moorook	320	165	259	..	744
Kingston	204	77	256	..	537
Mypolonga	..	274	494	..	768
Chaffey—Ral Ral Division ..	782	206	14	..	1,002
Total	*12,661*	*2,916*	*4,185*	..	*19,762*
War Service Land Settlement—					
Cooltong Division	380	247	490	..	1,117
Loxton area	3,059	1,108	2,205	113	6,485
Loveday Division	224	36	21	..	281
Total	*3,663*	*1,391*	*2,716*	*113*	*7,883*
Reclaimed Swamp Land—					
Monteith	..	..	..	992	992
Mypolonga	..	..	..	1,314	1,314
Wall	..	..	..	487	487
Burdett	..	..	..	109	109
Mobilong	..	..	..	429	429
Long Flat	..	..	..	338	338
Neeta	..	..	..	561	561
Pompoota	..	..	..	426	426
Cowirra	..	..	..	571	571
Jervois	..	..	..	3,636	3,636
Total	..	..	..	*8,863*	*8,863*

IRRIGATION AREAS ADMINISTERED BY THE DEPARTMENT OF LANDS AND THE RENMARK IRRIGATION TRUST—*continued.*

(Acres.)

RENMARK IRRIGATION TRUST.

Area.	Vine Fruits.	Tree Fruits.	Citrus Fruits.	Fodder and Vegetables.	Total.
Renmark Irrigation Trust ..	*5,366*	*2,477*	*1,000*	*457*	*9,300*

3. **Water Supply Schemes.**—(i) *Adelaide Metropolitan Water Supply.* Adelaide derives its water from five 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 51,497 acre feet. At present Mount Bold Dam is being raised to store an additional 18,365 acre feet. Additional pumps have been installed to give the pipeline a capacity of 65,000 acre feet a year.

A concrete arch dam is nearing completion at Myponga, and this will impound 22,000 acre feet of water. This storage will supply development projects south of Adelaide. 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 1960–61 was 80,735 acre feet, equivalent to a consumption of 96 imperial gallons per head per day. The capital cost to 30th June, 1960 was £36,573,780.

(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 remove 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 the capacity. A large part of Eyre Peninsula is supplied from the 240-mile Tod River Main. The 104-mile East Coast main will obtain water from the Tod River reservoir (9,160 acre feet), the sand beds of the Uley-Wanilla Basin and the newly developed Lincoln 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 have cost £36,675,924 (exclusive of river control and irrigation works on the Murray River) and contain 6,889 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, notably in the south-east of the State, in which ground water occurs. 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. However, deep boreholes have been drilled by the Government to provide watering places along stock routes, and pastoralists rely largely on supplies from non-pressure aquifers at shallower depths. Marree township is supplied from this source, its deepest bore being 575 feet.

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 are used to supply Naracoorte, Bordertown, Pinnaroo, Penola, Lameroo, Coonalpyn, Nangwarry, Mount Burr, Kingston (S.E.), Parilla and Karoonda. The deepest bore in this Basin is 1,805 feet. Other towns which are supplied from bores include Mount Barker, Peterborough (supplemental to supplies from the Morgan–Whyalla pipeline), Warooka, Willunga and Port Lincoln as part of the Eyre Peninsula supply system.

Pastoralists, farmers, market gardeners and others have been assisted with expert advice on drilling, and the Government maintains and operates 30 drilling plants which to date have developed an underground water supply potential in excess of 140 million gallons of water per diem throughout the State. The whole of the Murray River Basin has been examined critically to ascertain the extent of land which could be used for lucerne, and considerable tracts of previously undeveloped country in the upper south-east, Kangaroo Island and Yorke Peninsula have been found to have usable water and are now being opened up.

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

5. **Farm Water Schemes.**—While the Department of Mines and the Engineering and Water Supply Department give assistance to individual farmers in the provision of supplies from underground sources, 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.**—Nature has played an ironic prank in the south-east of South Australia where it has been necessary to construct costly drainage schemes to dispose of surplus water. The area comprises a series of valleys or flats separated by low ranges parallel to the coastline which prevent natural drainage. The highest " range " is approximately 50 feet above the adjacent flat and the most easterly flat, some 50 miles from the coast, is 200 feet above sea level. The ranges are generally of poor soil or stony but the flats are fertile.

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, involving an excavation of 8,100,000 cubic yards, has been completed. Work is in progress on the Northern Section of 140,000 acres where 23 miles of the main outlet drain, involving the excavation of nearly 2 million cubic yards of material, have been completed. In addition, work has commenced on the construction of the main outlet drain for the Eastern Division where an area of 727,000 acres of land will benefit by drainage.

The capital cost of drainage in the South-Eastern Drainage Area System to 30th June, 1961 was £5,728,886, and the length of drains constructed was 715 miles.

§ 6. Western Australia.

1. **General.**—(i) *Rainfall.* Brief particulars of the climatic conditions in Western Australia are given on page 1133 of Official Year Book No. 37. (*See also* Chapter II.—Physiography, page 45 of this Year Book.)

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

2. Irrigation.—(i) *South-West.* The main irrigation areas are situated along the South-Western Railway between the towns of Waroona (70 miles from Perth) and Dardanup (116 miles from Perth).

The Water Supply, Sewerage and Drainage Department controls three irrigation districts—Waroona, Harvey and Collie River—the total area irrigated in these districts during 1960–61 being 22,603 acres and the total water used 88,600 acre feet. The total of acre waterings (that is, the number of acres watered multiplied by the average number of waterings) was 141,379. 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 (3,417 rated acres) is supplied from Samson Brook Dam (7,437 acre feet capacity) and Drakes Brook Dam (1,855 acre feet), the Harvey Irrigation District (14,369 rated acres) from Stirling Dam (46,191 acre feet) and the Harvey Weir (8,372 acre feet), and the Collie River Irrigation District (9,269 rated acres) from the Wellington Dam (150,107 acre feet). The Logue Brook Dam (19,246 acre feet) within the Harvey Irrigation District is currently under construction.

The following table shows acre waterings supplied to crops in the irrigation districts of Harvey, Waroona and Collie River during the seasons 1956–57 to 1960–61.

IRRIGATION, WESTERN AUSTRALIA: ACRE WATERINGS(*a*).

Year.	Pasture.	Fodder.	Potatoes.	Other vegetables.	Orchards and Vineyards.	Flax, Broom Millet, and Miscellaneous.	All Crops.
1956–57	129,502	3,757	3,995	3,317	1,024	119	141,714
1957–58	133,634	5,384	3,299	2,947	972	..	146,236
1958–59	136,940	6,324	1,858	2,495	1,014	1	148,632
1959–60	112,193	4,774	1,351	1,978	729	844	121,869
1960–61	133,185	3,886	1,780	1,964	507	57	141,379

(*a*) Number of acres watered multiplied by average number of waterings.

(ii) *General.* In 1960–61, the total area irrigated in Western Australia was 48,551 acres made up of pastures (24,652 acres), vegetables (9,076 acres), fruit (8,335 acres), vineyards (897 acres) and other crops (5,591 acres).

An area of approximately 650 acres of Gascoyne River flats adjacent to Carnarvon is under irrigated cultivation. The principal crops are bananas and beans, but others such as tomatoes are also grown. For this agriculture, some 130 acre feet of water a week are drawn from river underflow.

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

The Ord River in the Kimberley Division of Western Australia traverses a tropical area served with monsoonal rains of irregular incidence and quantity, varying from 20 inches in the south to 30 inches in the north. The hottest months (December to March) are also the months of highest rainfall. Communications and population are sparse. The Western Australian Government is considering a proposal to build a dam to conserve 3,500,000 acre feet of water, equipped with a hydro-electric plant, which might supply water for an area of some 200,000 acres agriculturally and topographically suitable for irrigation. Investigations show that the climate and soil conditions are suitable for the cultivation of sugar cane, rice, cotton, safflower and various oil seeds. The economic production of these and other crops, as well as the possible use of such irrigation areas for fattening cattle, is being examined at the Kimberley Research Station on the Ord River. Construction of a diversion dam at Bandicoot Bar, now in progress some 30 miles downstream from the main dam site, will enable a number of pilot irrigation farms to be established.

3. Water Supply Schemes.—(i) *Metropolitan.* Particulars relating to the Metropolitan Water Supply are given in § 5 of Chapter XIX., 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 Official 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 13.3 million gallons a day with provision to increase this to 18.5 million gallons a day. The total capacity of all receiving, regulating, standby and service tanks along the main pipeline is 154 million gallons, which includes three standby reservoirs at Kalgoorlie having a combined capacity of 60 million gallons.

Hundreds of miles of branch pipelines have been laid to mining areas, agricultural areas and country towns, a notable one being the Norseman extension of 101 miles. The system serves some 83 towns and water is reticulated to 3,800,000 acres of mixed farming lands. The total length of pipelines is 3,528 miles and the number of services is 23,728. The total quantity of water pumped from Mundaring Reservoir in 1960–61 was 3,168 million gallons. The total cost of the scheme to the end of 1960–61 was £17,290,300, of which the Commonwealth Government contributed £3,318,400 under the terms of the Comprehensive Water Supply Scheme.

District water supply schemes established for the purpose of supplying certain country towns and mixed farming lands have been absorbed into the Goldfields and Agricultural Water Supply. For further particulars *see* Official Year Book No. 37, page 1135.

(iii) *Comprehensive Water Supply Scheme.* A comprehensive water supply scheme to supplement water supplies to the goldfields, agricultural areas, and country towns, authorized in 1947 as a joint work between the Commonwealth and State Governments and estimated to cost £10,200,000 is under construction in two main parts. The northern section is an enlargement and extension of the Goldfields and Agricultural Water Supply. The southern section is the Great Southern Towns Water Supply. Linked with Wellington Dam (initially an irrigation work on the Collie River) by 80 miles of 30-inch diameter pipe through three pumping stations to Narrogin, it now supplements the existing water supplies to country towns along the Great Southern Railway, north to Brookton and south to Katanning. The raising of the impounding wall of Wellington Dam to increase its storage to about 150,100 acre feet was completed in 1960. Expenditure on the Scheme to 30th June, 1961, amounted to £9,915,300.

(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. Seventy-six separate reticulated water supplies serve country towns and districts. Of these, seventy-two are controlled by the Water Supply, Sewerage and Drainage Department and the remainder by local authorities.

(v) *Commonwealth and State Government Railways.* Railways of the Commonwealth and State Governments make independent provision for supplies of water for their own purposes, although considerable additional quantities are consumed by the Railways from other sources, e.g., Public Works and Metropolitan Water Supply Departments.

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

A total of 72 rated stream gauging stations is operating in the South-west, North-west and Kimberley Divisions. Three types of catchment peculiar to this State developed in connexion with local water supplies and deserving special mention are:—rock catchments, which consist mainly of clear granite out-cropping rock, from which the overall run-off from rain amounts to approximately 40 per cent.; bituminous catchments, which are areas which have been sealed with emulsified bitumen—some hundreds of acres have been so treated and yield a run-off of approximately 80 per cent. of the rainfall; and roaded catchments, where selected areas of a catchment are cleared, graded and formed into roads to assist in obtaining additional rainfall run-off.

4. Underground Water.—Individual farmers, orchardists, market gardeners and others pump groundwater from wells and bores, using windmills, engines or electric power. Water is also obtained from artesian and sub-artesian bores. Local artesian aquifers are utilized for town supplies at Bunbury and Busselton, while underground water is piped from the Wicherina Basin (in the Perth Basin) for the town supply at Geraldton. The Public Works Department hires out to local authorities boring plants which are then hired out to farmers to assist their boring operations. In addition, the department operates its own boring plants and contracts with private firms in connexion with water supply works.

Considerable advances in the knowledge of aquifers and quality of water in the main sedimentary basins have been made as a result of the extensive geological surveys in connexion with oil exploration during the past ten years and most of these results are now in the course of publication. The Geological Survey of Western Australia has established a Hydrological Division to investigate and advise on the underground water resources of the State. A detailed survey of the Perth Basin, extending from Northampton to Augusta, is in progress. The Mines Department Drilling Section, with its own plant and by separate contracts, drills the exploratory holes recommended by the Geological Survey.

§ 7. Tasmania.

1. General.—(i) *Rainfall.* Brief particulars of the rainfall pattern in Tasmania are given on page 1136 of Official Year Book No. 37. (*See also* Chapter II.—Physiography, page 45 of this Year Book.)

(ii) *Main Purposes of Conservation and Utilization.* Owing to the generally more adequate rainfall in Tasmania, scarcity of water is not such a problem as it is in most mainland areas, though not all streams are by any means permanently flowing. The only large scale conservation by reservoirs is for hydro-electric power generation, but there are some moderately sized dams built by mining interests, and by municipal authorities for town water supplies.

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

Underground water is generally of poor quality through mineralization, but a small quantity, exploited to a minor degree by bores and pumps, exists over an area in the midlands, and on King Island.

(iii) *Administration.* Municipal water supply is primarily the responsibility of local Councils, subject to approval of plans and finance by the Rivers and Water Supply Commission. This body came into existence in September, 1958, taking over all functions of the old Water, Sewerage and Drainage Board as well as other duties and powers.

With regard to water, the Commission does not own the waters of streams and lakes, but 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 at 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.

* *See also* Chapter VII.—Electric Power Generation and Distribution, p. 243.

Most of the water potential is located on the Central Plateau, with an area of about 1,500 square miles at an altitude of from 2,000 to 4,000 feet, and subject to rainfall of from 30 inches a year in the east to 80 inches on the western perimeter. On the plateau are a large number of lakes which provide the means for storage at low cost. These include Great Lake with an area of 58 square miles, Lake St. Clair and Lake Echo each more than 12 square miles, and others of smaller area.

The Derwent River and its tributaries, which flow south-easterly, carry off by far the greatest part of the water which falls on the plateau, and these rivers are therefore the most abundant source of power. They have been the cheapest to develop to date and most of the existing generating stations are located on them.

The three main rivers running westerly from the plateau—the Arthur, Pieman and Gordon—have only a small portion of their catchment areas at high level, but they run through regions of high rainfall and their power potentials are considerable. However, because of inaccessibility and climate, development of these rivers may be rather expensive and has been deferred so far in favour of more convenient schemes.

Rivers draining from the plateau towards the north and north-west coast, including the Emu, Forth and Mersey, have small catchments at high levels and no natural storages.

Two other important water power sources, independent of the Central Plateau, are the South Esk River in the north and the Huon River in the south. A power station at Trevallyn, near Launceston, utilizes water from the South Esk. The Huon has a large low-level catchment in the high-rainfall area near the west coast. Storage could be provided on this river at a reasonable cost and, because of its proximity to Hobart, a future power station would have considerable value for peak load development.

3. **Industrial.**—Three principal industrial schemes have been installed privately. Australian Newsprint Mills Ltd. pump approximately 10 million gallons a day from the Derwent River at Lawitta for the Boyer Mills. Associated Pulp and Paper Mills Ltd. pump several million gallons a day from the Emu River at Burnie, and Titan Products Pty. Ltd. reticulate water from Chasm Creek to their factory at Heybridge. 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.

A second regional water scheme draws water from the River Derwent at Lawitta to provide domestic and industrial supplies in five southern municipalities. 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 side of the watersheds is not regarded as practicable.

4. **Irrigation.**—There are no State irrigation projects at present, but the Rivers and Water Supply Commission is investigating the possibility of establishing a storage for the Coal Valley. Preliminary investigations have also been made in the Jordan Valley. The Water Act 1957 provides for irrigation works to be undertaken by municipalities and by Trusts constituted for the purpose, but no such works have been undertaken to date. All systems operating are privately owned, and with one exception (at Bushy Park) are single-farm units. At Bushy Park, a small system serves a group of properties. The larger proportion of the area under irrigation is watered by gravitational systems and the remainder comprises areas devoted to vegetables and served by municipal water supplies or private spray systems. Irrigation in Tasmania was applied in 1960–61 to 18,934 acres devoted to: pastures (10,369 acres); fruit (3,311 acres); hops (1,364 acres); vegetables (2,103 acres); and other crops (1,787 acres).

§ 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 Official 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 1938-1959 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 in the Northern Territory Administration under the control of a Director. The functions of the Branch include systematic stream gauging, collection of data on surface and underground water supplies, planning of water use for irrigation and town water supplies, and flood prevention and control.

Another function of the Branch, which is increasing in importance as it builds up a body of technical data and information about the Territory's water resources, is the dissemination of this knowledge by the provision of advice and assistance to the public and professional drillers.

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 the bulk 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 population is dependent on underground supplies for three to five months each year.

Rainfall is one of the factors controlling cattle population, but geological features, controlling both soils and the storage of underground water, are equally important. In the northern-most portion of the Territory, which receives from 25 to 60 inches of seasonal rainfall a year, surface water supplies are, in general, adequate for the pastoral industry. Despite this, however, this area has a comparatively low carrying capacity for cattle, and the pastoral industry is concentrated more in inland areas where feed retains more nutritive value in the 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. Ground water is obtained in shallow bores averaging 70 to 80 feet in depth and producing small supplies which range up to 1,500 gallons an hour. For the most part, water is stored in joints, faults or cracks in the rocks, although in places sub-artesian conditions pertain, and, on the whole, selection of bore sites is difficult. There are also small sedimentary basins 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. Boring in the metamorphic rocks and granite of the basement has, on the whole, met with little success. In many areas, the underground water is of poor quality.

Considerable research has been undertaken in recent years into increasing the Alice Springs water supply from alluvial basins and provision of a water supply for the mining town of Tennant Creek from the Cabbage Gum Basin, a small basin in deeply weathered Precambrian rocks, 15 miles south of the town.

Up to 30th June, 1961, 2,510 bores and wells had been registered in the Territory. Of these, 1,655 were on pastoral properties, 71 on agricultural properties, 122 served town and domestic water supplies, 20 were located on mining fields, 35 were being used as test-bores and 369 were used by Defence Departments during World War II. The number of registered stock route bores established by the Government is 238.

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 are expected in the near future. Hydrological investigations are being carried out by the Administration to determine the supply of water and the best methods of control and use in the potential rice-growing areas of the Territory. One hundred and twenty gauging stations were in operation in the Territory at 30th June, 1961, under the control of the Administration's Water Resources Board. Of these, 68 are equipped with automatic water level recorders. The remaining 52 are staff gauges. Sixteen gauging stations are for recording changes in water level only, one of these being the Darwin Harbour Tide gauge, which is operated on behalf of the Harbour and Marine Branch. The other 15 gauges of this kind are scattered over the north sub-coastal plains and measure the depth of flooding over the plains. The information is required for future agricultural production in these areas, notably rice culture. 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.

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.

§ 9. Papua and New Guinea.

1. **Rainfall.**—Rainfall in Papua and New Guinea varies considerably from approximately 250 inches near Lindenhafen (New Britain) and 231 inches at Kikori (Papua) to about 70 inches near Marienburg (New Guinea) and 40 inches at Port Moresby (Papua).

2. **General.**—For a general description of these territories *see* Chapter V.—The Territories of Australia, page 129, 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 (a description of which is given in Chapter XXVI. of Year Book No. 40), 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.