CHAPTER VII.

ELECTRIC POWER GENERATION AND DISTRIBUTION.

This chapter is divided into three major parts. A.—Introduction, which deals briefly with the resources, generation and distribution, and future development of electric power in Australia; B.—The Snowy Mountains Hydro-electric Scheme; and C.—The origins, development, present situation and new projects of electrical systems in each Australian State and Territory. A Statistical Summary is appended.

It should be noted that the information contained in the chapter relates to situations existing and projects contemplated in 1959 and that it may be considerably affected by changes in policy or plans, or by developments in the projects themselves.

A. INTRODUCTION.

1. **Distribution of Population and Location of Power Resources.**—The geographical pattern of electric power generation and distribution in Australia has been affected by two main influences—the distribution of population, with a resulting distribution of industry, and the location of fuel and water resources.

The Australian population increased between 1939 and 1959 from approximately 6,968,000 to 10,061,000. The two principal centres of population and industry, the metropolitan areas of Sydney and Melbourne, make the greatest demands for electric power and their growth has been associated with the development of large deposits of coal located relatively close to the source of demand. This, together with the fact that the major water resources are also located in the south-eastern portion of the Commonwealth materially influences the distribution of industrial population and the location of major electric power stations.

By far the most important source of energy used in the production of electric power in Australia is coal. At 30th June, 1958, thermal power equipment represented 76 per cent., hydro plant 19 per cent. and internal combustion equipment 5 per cent. of the total installed generating capacity.

Most of Australia is poorly supplied with water, only about 15 per cent. receiving an annual rainfall of 30 inches or over. This is confined largely to Tasmania and to the narrow coastal strip along the east coast. The possibility of establishing large hydro or steam stations in inland areas is, therefore, strictly limited by the lack of sufficient water.

The only region on the mainland of Australia high enough to receive reliable winter snowfall, and from which, therefore, reasonably constant water supplies throughout the year can be expected, is the mountain chain which stretches from the high plateaux of south-eastern New South Wales through to the north-eastern highlands of Victoria. The hydro-electric potential of this area is considerable, and plans have been formulated to develop more than 3,000,000 kW within the next 25 years. The two major construction projects in this area are the Snowy Mountains and Kiewa schemes. Other hydro-electric potential does exist on the mainland on the rivers of the coastal areas of New South Wales and Queensland, but the amount there available is only small compared with the potential of the Alpine region. In Tasmania, hydro-electric resources have been estimated at about 50 per cent. of the total Australian hydro-electric potential. Whereas on the mainland the chief source of energy is coal, water occupies this position in Tasmania.

2. **Electric Power Generation and Distribution.**—(i) *Ownership of Undertakings.* At the beginning of this century, Australia's electrical undertakings were carried on mainly by private enterprise, but some measure of governmental control was exercised through various electric light and power Acts. This legislation was designed to provide standards of safety, and to define the scope and obligations of the private organizations engaged in producing electric power for sale. A trend towards public ownership commenced during the 1914–18 War and became more pronounced after the 1939–45 War. By 1959, all major

generating stations supplying the public were, in varying degrees, under the control of State statutory organizations constituted with the object of unifying and co-ordinating the generation and distribution of electricity supplies within the various States. There are, however, still a large number of small private and municipal enterprises generating power for supply to country towns, although central authorities are extending supply to these places wherever practicable. In many areas, however, it has been and remains the practice for central authorities to sell power in bulk to local distributing organizations which undertake reticulation.

In addition to the private, local government and statutory organizations which generate and/or distribute electricity for sale, there are numerous firms generating power for use in their own establishments, particularly those engaged in mining pursuits remote from the main centres of population. This chapter, however, is concerned mainly with the activities of central electric stations, and the power regularly produced for such internal consumption is, in any case, a relatively small proportion of the total power produced.

(ii) *Power Production and Generating Capacity.* In the period between 1938–39 and 1958–59, production of electric power in Australia increased by over 350 per cent. from 4,688 to 21,135 million kilowatt hours.

Since the 1939–45 War, industry and commerce have expanded rapidly, many new houses have been built and the population has increased by approximately 36 per cent. These factors, together with the extension of electricity supplies to rural areas and the increased use of domestic electric appliances, have all contributed to bring about a position where the greatly increased demand for power cannot be satisfied by the existing installed capacity of central generating stations.

At 30th June, 1958, installed generating capacity in Australia totalled approximately 4.88 million kW compared with 1.62 million kW in 1939, an increase of 200 per cent. In 1957–58, each kW of installed capacity produced an average of 4,057 kWh compared with an average of 3,000 kWh in 1938–39. These figures are based on Commonwealth totals; figures for the States vary, depending on such factors as the distribution of demand, number of consumers, and type of equipment employed.

B. SNOWY MOUNTAINS HYDRO-ELECTRIC SCHEME.*

1. **Snowy Mountains Hydro-electric Power Act, 1949.**—In July, 1949, the Commonwealth Government passed the Snowy Mountains Hydro-electric Power Act establishing the Snowy Mountains Authority.

The functions and powers of the Authority as defined in the Act are:—

(*a*) to generate electricity by means of hydro-electric works in the Snowy Mountains Area;

(*b*) to supply electricity generated to the Commonwealth:—

(i) for defence purposes;
(ii) for consumption in the Australian Capital Territory.

The Authority also is empowered to supply to a State, or to a State Authority, electricity not immediately required for defence purposes or for consumption in the Australian Capital Territory.

To enable it to perform its functions, the Authority is given power to construct, maintain, operate, protect, manage and control works:—

(*a*) for the collection, diversion and storage of water in the Snowy Mountains Area;
(*b*) for the generation of electricity in that area;
(*c*) for the transmission of electricity generated by the Authority;
(*d*) incidental or related to the construction, maintenance, operation, protection, management or control of any works otherwise specified in the Act.

The Authority is constituted by a Commissioner appointed by the Governor-General. He is assisted by two Associate Commissioners also appointed by the Governor-General.

* *See also* Chapter VIII.—Water Conservation and Irrigation, page 248 of this issue and special detailed article in Official Year Book No. 42, pp. 1103–1130.

The Snowy Mountains Act is supported by a detailed Agreement between the States of New South Wales and Victoria and the Commonwealth in regard to the construction and operation of the Scheme, the distribution of power and water, charges to be made for electricity, and other such matters. The Snowy Mountains Council established under the terms of the Agreement and consisting of representatives of the Commonwealth, the Authority and the two States, directs and controls the operation and maintenance of the permanent works of the Authority and the allocation of loads to generating stations.

2. **Geography of the Area.**—The Snowy Mountains Area in south-eastern New South Wales is the only part of the continent in which altitudes exceed 7,000 feet and in which there is a substantial area over the altitude of 6,000 feet. The precipitation which results from the presence of this barrier on the line of the prevailing winter depressions of Antarctic origin amounts to as much as 120 inches a year in the vicinity of Mt. Kosciusko, the highest point in Australia. The drainage from the snowfields is practically all to three systems—those of the Murray and Murrumbidgee Rivers, which flow inland, and that of the Snowy River, which flows southwards to Bass Strait.

3. **Description of the Scheme.**—(i) *General.* 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. These two diversions divide the Scheme geographically into two sections, the Snowy-Tumut Development and the Snowy-Murray Development. The features referred to may be identified by reference to the map on page 223. For purposes of both power production and irrigation, it is necessary to provide a considerable degree of regulation of run-off and this will be achieved by the use of Lake Eucumbene formed by the construction of Eucumbene Dam to control the waters of the Eucumbene, Murrumbidgee and Tumut Rivers for the Snowy-Tumut Development and of the Snowy River for the Snowy-Murray Development.

(ii) *Snowy-Tumut Development.* This development comprises works for the diversion and regulation of the waters of the Eucumbene, Upper Tooma, Upper Murrumbidgee and Upper Tumut Rivers and their combined development through a series of power stations down the length of the Tumut itself. A major dam has been constructed on the Eucumbene River to create Lake Eucumbene with an ultimate usable storage of 3.5 million acre feet. The waters of the Upper Murrumbidgee River will be diverted into Lake Eucumbene by construction of a dam at Tantangara and a 10½ mile tunnel from Tantangara reservoir. From Lake Eucumbene, the water will flow through a 14 mile tunnel to Tumut Pond Reservoir on the upper reaches of the Tumut River where it will join the waters of the Tumut River itself and the waters of the Tooma River diverted to Tumut Pond Reservoir by a diversion dam and a 9 mile tunnel. A feature of this 14 mile Eucumbene-Tumut Tunnel will be its use during periods of high flow to divert waters of the Tumut River from Happy Jacks Shaft or from Tumut Pond back to Lake Eucumbene for storage.

From Tumut Pond, water will be conveyed by pressure tunnel to Tumut 1 underground Power Station (capacity 320,000 kW), returned to the Tumut River and then conveyed by another pressure tunnel to Tumut 2 underground Power Station (capacity 280,000 kW), thence discharging into Tumut 3 Reservoir at Lobs Hole also on the Tumut River.

Tumut 3 and Tumut 4 Power Stations will be constructed between Tumut 3 and Blowering Reservoirs. Blowering Dam is to be constructed by the State of New South Wales and will provide for the regulation of power station discharges for use for irrigation in the Murrumbidgee valley. The Authority will, however, construct another power station at the foot of this dam to make use of irrigation releases for power purposes.

(iii) *Snowy-Murray Development.* The principal features of the Snowy-Murray Development are the diversion of the main stream of the Snowy River by tunnel westwards through the Great Dividing Range into the Swampy Plain River in the catchment of the Upper Murray and the development of power on the western slopes of the Alps. The main works of the development will be:—

(*a*) The construction of a tunnel from the Snowy River near Island Bend through the Great Dividing Range to Geehi Reservoir on the Geehi River and two power projects between Geehi Reservoir and the Swampy Plain River near Khancoban. The power stations associated with these two power projects, Murray 1 and Murray 2, will be the Scheme's largest stations and will have a combined capacity of 1,200,000 kW.

(*b*) Construction of a tunnel from a small dam on the Snowy River near Island Bend to Eucumbene Dam to carry Snowy water to Lake Eucumbene for storage at times of high river flows. When river flows are lower than average, this stored water will be returned towards Island Bend and thence through the Snowy-Geehi Tunnel to Geehi Reservoir and Murray 1 and Murray 2 Power Stations.

(*c*) The construction of a dam on the Snowy River near Jindabyne to store the residual flow of the Snowy and Eucumbene Rivers downstream from Island Bend and Eucumbene Dams, including the flows of major tributaries, the Crackenback and Mowamba Rivers, and the construction of a pumping plant, pipeline and tunnel to lift this water from Jindabyne Reservoir to the Snowy-Geehi Tunnel near Island Bend where it will join the flow to the Geehi Reservoir for use through Murray 1 and Murray 2 Power Stations.

Associated with the main Snowy-Murray diversion are power developments of the Upper Snowy and Upper Geehi Rivers. The Upper Snowy proposals provide for a series of three power projects utilizing the fall in the waters of the Snowy River from Kosciusko Reservoir at elevation 5,800 feet to Island Bend at elevation 3,900 feet. One of these, the Guthega Project, came into operation in February, 1955.

On the western side of the Divide, the waters of the Upper Geehi River and its tributary, Windy Creek, falling from an altitude of 5,200 feet to Geehi Reservoir at elevation 3,600 feet, will provide power in Windy Creek Power Station.

4. ***Utilization of Power.***—*The future electric power plants on the mainland of Australia* will be predominantly thermal or thermo-nuclear installations and in an electrical system in which the greater part of the energy is generated in thermal plants it is usually found that the hydro installations operate to the best advantage on peak load. However, the existing New South Wales and Victorian systems include a proportion of relatively old and less efficient installations which, for reasons of fuel economy, are also best used for the production of peak load power. Therefore, in order to utilize the potential of the Snowy Mountains Scheme most effectively, it is proposed to arrange the order of development so that the early stations will operate, initially, somewhat below the peak of the system load, with a progressive change to predominantly peak load operation as construction proceeds and as the load increases in magnitude.

The Snowy Mountains Scheme is situated geographically about midway between the principal load centres of Sydney and Melbourne and will be connected to these centres by 330,000 volt transmission lines. It will, consequently, be in a strategic position to take advantage of the diversity in the power requirements of these two load systems, a most important factor in so far as it affects the economy of operation of the supply systems of the two States.

Although most of the output from the Scheme will go to the States of New South Wales and Victoria, the Commonwealth Government also has the right to draw from the Scheme its requirements of power and energy for the Australian Capital Territory and for defence purposes. For convenience, the Commonwealth's share of power and energy will be drawn from the New South Wales transmission network by an exchange arrangement between the Commonwealth and the Electricity Commission of New South Wales. After fulfilling the Commonwealth's requirements, the remaining power and energy from the Scheme will be divided between the States of New South Wales and Victoria in the ratio of 2 : 1.

5. **Progress and Future Programme.**—The first power station in the Scheme, Guthega, of 60,000 kW initial capacity, came into operation in February, 1955. This was followed by Tumut 1 Power Station, total capacity 320,000 kW, which came into operation progressively during 1959. Eucumbene Dam, which provides the major regulating storage for the Scheme, was completed in May, 1958, and water now being stored in Lake Eucumbene will be used later for power generation through the Tumut Power Stations. Completion of the Eucumbene-Tumut Tunnel in June, 1959, made possible the first major trans-mountain diversion of water. Construction is at present in progress on works to divert the Murrumbidgee River to Lake Eucumbene and the Tooma River to Tumut Pond Reservoir and on the second of the Tumut River Power Stations, Tumut 2, which, with a capacity of 280,000 kW, is planned to come into operation in 1962.

The next works to be constructed will be parts of the main Snowy-Murray Development and it is anticipated that the first production of power from the Murray 1 Power Station and the first trans-mountain diversion of the water from the Snowy River to the Murray will occur during 1966.

C. STATES AND TERRITORIES.

§ 1. New South Wales.

1. **General.**—In Official Year Book No. 39, an account was given, in some detail, of the origin and development of electricity generation and distribution in New South Wales, describing in particular the growth of the systems of the Sydney County Council, the Department of Railways, the Electric Light and Power Supply Corporation Ltd., the Southern Electricity Supply and the Clarence River County Council (now the Northern Rivers County Council). A description was also given of the legislation which constituted The Electricity Authority of New South Wales and the Electricity Commission of New South Wales as well as legislation existing prior to their constitution. At present, the three main Acts governing electricity supply in New South Wales are:—

(i) The Local Government Act 1919 which lays down the various rights and responsibilities of local government bodies in the establishment and operation of electricity trading undertakings.

(ii) The Electricity Development Act 1945–1957 which established the Electricity Authority of New South Wales as the body responsible for the co-ordination of electricity supply throughout the State.

(iii) The Electricity Commission Act 1950–1954 which constituted The Electricity Commission of New South Wales as the major generating authority and not subject to the provisions of the Electricity Development Act.

2. **Organization.**—(i) *The Electricity Commission of New South Wales.*—The Commission, which was constituted under the Electricity Commission Act 1950–1954 consists of five members of whom one is a full-time Chairman. In its administration, the Commission is directly responsible to the Minister for Local Government.

When the Commission was established, 93 per cent. of the State's power requirements were generated by four bodies—the Sydney County Council, the Department of Railways, the Southern Electricity Supply (a division of the Department of Public Works) and the privately-owned Electric Light and Power Supply Corporation Ltd. The Electricity Commission Act 1950–1957 and the Electricity Commission (Balmain Electric Light Company Purchase) Act 1950 provided for the acquisition of the power stations and main transmission lines of those bodies. The transfer of the power stations and transmission lines of all these undertakings has now been effected. On 1st July, 1956, the Commission acquired the power station and bulk supply system of the Tamworth City Council, which supplied in bulk to a number of distributing bodies in the north of the State.

The main function of the Commission is the generation and transmission of electricity which it sells in bulk to distributing authorities (mainly local government bodies) throughout a large part of the State, to the government railways and tramways, and to certain large industrial consumers. As the major generating authority, it is also responsible for the development of new power sources. An important exception is the hydro-electric potential of the Snowy Mountains region which is being developed by the Snowy Mountains Hydro-electric Authority, a Commonwealth Government body.

(ii) *Other Electricity Supply Authorities.* The retail sale of electricity to the public is, in general, carried out by separate electricity supply authorities—municipal and shire councils, electricity county councils (consisting of groups of shire and/or municipal councils) or private franchise holders. At 1st September, 1959, there were 68 of these supply authorities throughout the State of which 24 also generated part or all of their power requirements. The majority of country power stations are small oil engine plants which are becoming increasingly costly to operate. Consequently, they are gradually being closed down as the main transmission network is extended further afield.

Over the past few years, there has been a distinct trend towards the consolidation of supply areas, many of which have been regarded as being too weak individually to form satisfactory areas for distribution. Generally these consolidations have taken the form of a county district consisting of a number of neighbouring shire and municipal areas grouped for electricity supply purposes only and administered by a county council of representatives elected by the constituent shire and municipal councils.

It is interesting to note that, of the 227 shires and municipalities in New South Wales, 203 are included in one or other of the 37 electricity county districts. Thirty-three of these county districts have been constituted since 1945. The largest of the county councils is the Sydney County Council which at 30th June, 1959, was supplying 460,663 consumers in the Sydney Metropolitan Area. Unlike the other county councils, which are constituted under the provisions of the Local Government Act 1919, the Sydney County Council was specially constituted under the Gas and Electricity Act 1935.

(iii) *The Electricity Authority of New South Wales.*—The Electricity Authority was constituted under the Electricity Development Act 1945–1957, for the stated purpose of promoting and regulating the co-ordination, development, expansion, extension and improvement of electricity supply throughout the State. The Authority, which is a regulatory body only, consists of seven members of whom one is a full time Chairman. Like the Commission, it is responsible to the Minister for Local Government.

The main functions of the Authority are as follows:—

(*a*) *Distribution.* Under the Act the approval of the Authority is required, *inter alia*, for the establishment or acquisition of an electricity trading undertaking by a local government council, for the granting or renewing by such a council of electricity franchise agreements or corresponding agreements with other councils, and for the giving or taking of bulk supplies of electricity. It also has power to formulate proposals for the establishment of county councils.

In exercising these powers, the Authority is mainly concerned with seeing that distributing authorities are sufficiently strong to provide an economical, efficient and satisfactory service. Its most important activities in this regard are in investigating supply areas and in making recommendations to the Minister for the consolidation of such areas into county districts. Many of the new county districts referred to earlier have been formed largely as a result of the Authority's advice.

(*b*) *Rural Electrification.* The Authority administers the rural electricity subsidy scheme under which rural electrification throughout the State is progressing very rapidly (*see* para. 4, page 222).

(*c*) *Safety.* The Electricity Development Act 1945–1957 contains provisions for the making of regulations relating to most aspects of safety and these powers are being used more and more extensively. Safety regulations now in force cover such matters as inspection of consumer's installations, licensing of electricians and electrical contractors, approval of electrical appliances, safety of linesmen and overhead line construction.

(*d*) *Generation and Transmission.* The approval of the Authority is required for the establishment or extension of power stations and main transmission lines (with the exception of those of the Electricity Commission).

3. **Generation and Transmission.**—(i) *General.* Except in the Snowy Mountains district and in one or two other areas, New South Wales is lacking in major water power potential and for the generation of electricity the State is, therefore, dependent mainly on steam power stations. During the year ended 30th June, 1959, coal-fired stations generated 93.0 per cent. of the State's energy requirements, hydro-electric stations 6.4 per cent. and internal combustion plants 0.6 per cent.

The proportion of power generated in the hydro-electric stations will increase considerably with the future plant development of the Snowy Mountains Scheme by the Commonwealth Government but at no stage of its development will the Scheme supply more than 15 per cent of the State's energy requirements. Coal-fired steam power stations, therefore, will continue to supply the greater part of requirements for the foreseeable future.

(ii) *Major Generating Stations.* In New South Wales, the generation of electricity has followed the general world trend towards large centralized power stations supplying large areas through inter-connected transmission networks. The greater part of the coal-fired generating plant is now concentrated within the bounds of the industrial centres of Sydney, Newcastle and Wollongong, where most of the population is also located.

As at 30th June, 1959, the major power stations of the State system of the Electricity Commission of New South Wales and their installed capacities were as follows:—*Steam*—Bunnerong "A" and "B" (Sydney), 375,000 kW; Pyrmont "A" and "B" (Sydney), 220,000 kW; White Bay (Sydney), 172,000 kW; Ultimo (Sydney), 80,000 kW; Balmain (Sydney), 107,000 kW; Port Kembla, 60,500 kW; Zarra Street (Newcastle), 50,000 kW

Tallawarra (Lake Illawarra), 120,000 kW; Wangi (Lake Macquarie), 210,000 kW; Wallerawang (near Lithgow), 90,000 kW; Lithgow, 27,000 kW; Maitland, 20,000 kW; Penrith, 20,000 kW; Liverpool, 20,000 kW; Tamworth, 27,000 kW; *Hydro*—Hume (near Albury), 50,000 kW; Burrinjuck (near Yass), 20,000 kW. There were also various other steam, hydro and internal combustion stations aggregating 52,550 kW. The total installed capacity of the Electricity Commission's system was 1,721,050 kW.

It will be seen, therefore, that the greater part of the Commission's generating plant is concentrated within a hundred mile radius of Sydney—the largest stations outside this area being located at Hume, capacity 50,000 kW and at Tamworth, capacity 27,000 kW.

(iii) *Interconnected Network.* Some 97 per cent. of the population of New South Wales is supplied by distributing authorities who obtain power in bulk from the Electricity Commission's network. This system of 330 kV, 132 kV, 66 kV, 33 kV and 22 kV transmission lines covers must of the eastern portions of the State, extending geographically as far as 300 miles inland from the coast and linking the power stations with the load centres in this area.

In May, 1959, Australia's first 330 kV transmission line and 330 kV substation were put into service. The line is 85 miles long and connects the Snowy Mountains Hydro-electric Authority's Upper Tumut switching station with the new 330/132 kV substation located at Yass for the distribution of power through the Commission's interconnected system in the South-west portions of the State. The transformer capacity of 162,000 kVA at this new substation will be doubled before the end of 1959 and later will be raised to a designed capacity of 486,000 kVA.

At 30th June, 1959, there were also in service 1,340 miles of 132 kV lines (including 250 miles designed and built for 330 kV operation at a later date), and over 2,500 miles of 66 kV and lower voltage lines (including 314 miles built for eventual operation at 132 kV). The total capacity of transformers installed in the Commission's system exceeds 3,000,000 kVA.

(iv) *Separate Systems and Total State Installed Capacity.* There are a number of separate systems and isolated plants which have not yet been interconnected with the main network and which at 30th June, 1959, had an aggregate installed capacity of 27,923 kW. Some councils along the Victorian border receive bulk supplies from Victorian authorities.

A number of local government bodies have undertaken the development of independent power stations. Of these the more important are:—The Northern Rivers County Council which has constructed a steam power station at Koolkhan (near Grafton) with an installed capacity of 25,750 kW and the North-West County Council which has established a 12,500 kW steam power station on the Ashford coalfield.

The Tamworth system which formerly supplied power to an extensive district in the north of the State from Tamworth power station through 66 kV and 33 kV transmission lines was interconnected with the main system in June, 1958, by a newly constructed 330 kV transmission line from Muswellbrook to Tamworth (79 miles). This line is now being operated at 66 kV but will be raised to higher voltages later.

The aggregate installed capacity for the whole of the New South Wales systems and isolated plants was 1,827,741 kW as at 30th June, 1959.

(v) *Future Development.* The major new thermal stations now being developed on the coalfields will become the main base load centres for the northern, southern and western regions respectively. At Vales Point on Lake Macquarie, near Newcastle, work has commenced on a large thermal station with a planned capacity of about 1,000,000 kW. The initial installation will comprise two 200,000 kW generating units. At Wangi, also on Lake Macquarie, four units with a combined capacity of 210,000 kW are operating and work is proceeding to install two further units which will bring the capacity of this station to 330,000kW.

At Tallawarra on Lake Illawarra, near Wollongong, work on extensions involving the installation of two 100,000 kW generating units is progressing. When completed, the capacity of this station will be 320,000 kW. At Wallerawang, three 30,000 kW units are operating and work is proceeding on the installation of a further three units which will increase the capacity of the station to 240,000 kW.

Hydro-electric stations are being installed at the Warragamba Dam (50,000 kW) in conjunction with the major new source of Sydney's metropolitan water supply and at Keepit Dam (6,000 kW) near Gunnedah.

Development of the 330 kV network to extend from the Snowy Mountains hydro-electric power stations in the south, through the load centres of Wollongong, Sydney and Newcastle, to Armidale in the north is expected to be rapid in the next few years. In addition to the eighty-five miles of 330 kV line between the Snowy Mountains Hydro-electric Authority's Upper Tumut switching station and the Commission's 330 kV substation at Yass, other elements of the 330 kV system totalling 250 miles have already been built and have been placed in service at lower voltages for the present. A further section of this system is to be built between a new 330/132 kV substation immediately south of Sydney and a new 330 kV switching station at Dapto for the connexion of the extensions at Tullawarra Power Station. This work will permit full 330 kV operation of the whole of the link between the Upper Tumut switching station and the new 330 kV substation immediately south of Sydney when the next large Snowy Mountains hydro-electric power station is completed in 1961.

New construction of 132 kV and 66 kV transmission lines will extend the system geographically within the next next two years to South Grafton in the north, Burren Junction in the north-west and Hay and Cobar in the west. The mileage of these and other lines of this voltage to be built within this period exceeds 400 miles.

(vi) *Hydro-electricity.* The greater part of the hydro-electric potential of New South Wales is concentrated in the Snowy Mountains Area (*see* Snowy Mountains Hydro-electric Scheme, p. 216). Apart from this area, there are in operation the new hydro-electric station at the Hume Dam (50,000 kW), the 20,000 kW station at the Burrinjuck Dam, and the 7,500 kW station at the Wyangala Dam. The output of all these stations is dependent on the release of water for irrigation.

Of the remaining hydro installations, the largest is that of the New England County Council on the Oakey River, a tributary of the Macleay River, which has a capacity of 5,250 kW.

The Northern Rivers County Council operates a hydro-electric power station on the Nymboida River, a tributary of the Clarence River. This station has a capacity of 4,650 kW.

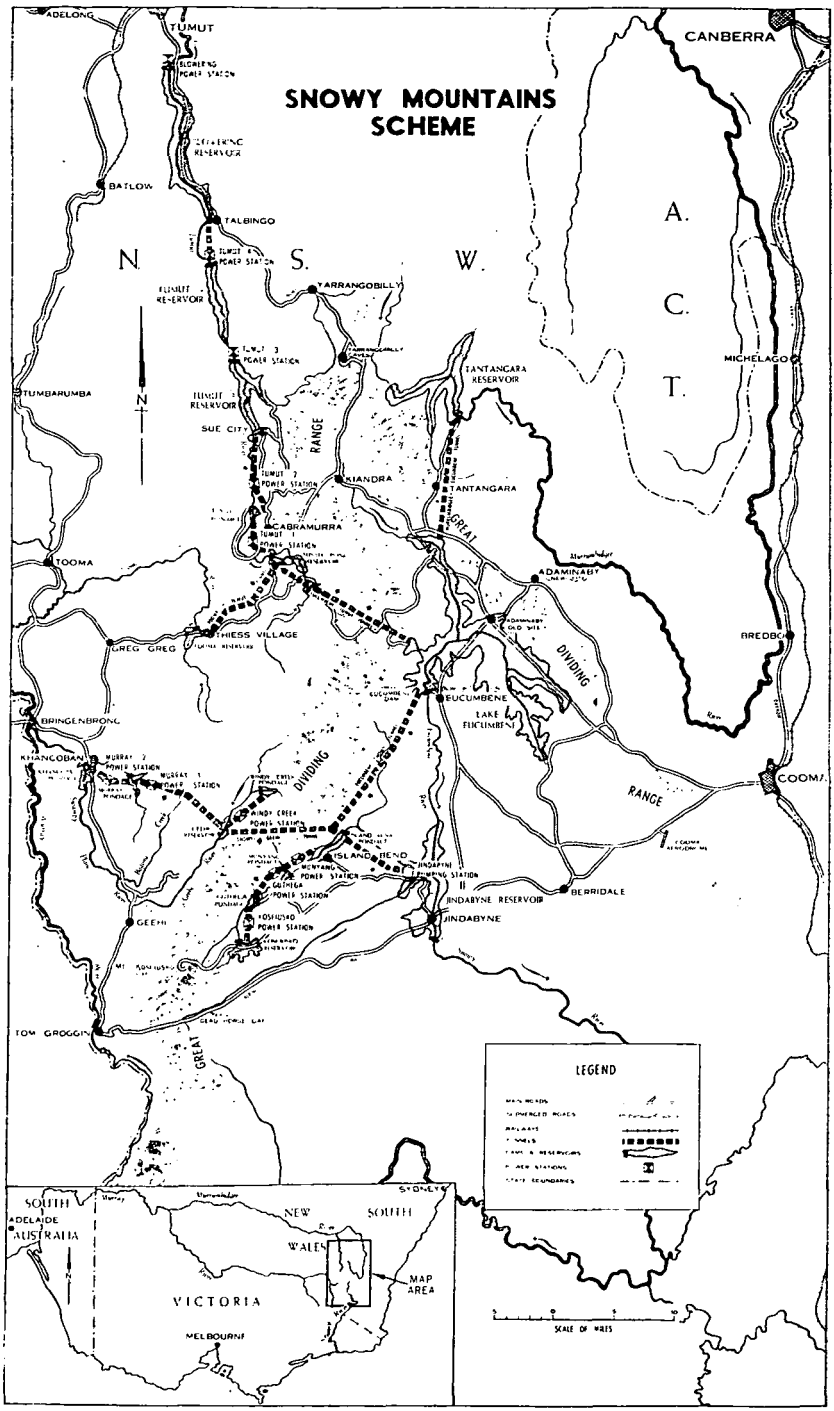
The Bega Valley County Council has constructed a hydro-electric scheme at Brown Mountain utilizing the headwaters of the Bemboka River. This installation has a capacity of 3,950 kW.

The Mullumbimby Municipal Council has in operation two 150 kW hydro units on Wilson's Creek, a tributary of the Richmond River.

4. **Rural Electrification.**—When The Electricity Authority of New South Wales was constituted in 1946, one of its first tasks was the devising of a scheme for subsidizing the cost of rural electrification. At that time, only 16,000 New South Wales farms were being served with electricity—less than one-quarter of those within reasonable reach of public electricity supply systems. In August, 1946, a subsidy scheme was approved by the Government and put into immediate operation. Under this scheme, local electricity suppliers receive subsidies from the Electricity Authority towards the cost of new rural lines. The amount of subsidy is based on the estimated cost of the proposed extension and the number of consumers able to be served by the new lines. In order that the funds available for subsidy purposes might be used to the best possible advantage, the scheme was designed to encourage local electricity supply authorities to construct the more economic extensions first. This was achieved by fixing a limit to the cost eligible for subsidy. Originally this limit was £250 per consumer when averaged over the cost of the whole extension but the limit was raised to £400 in December, 1953. Some subsidy was paid on higher cost extensions but the excess over an average of £400 was not subsidized.

To assist supply authorities in extending supply to less populated, and thus high-cost, areas of the State, the subsidy scheme has been extended (from May, 1959) to provide for payment of increased subsidy in respect of extensions where the average capital cost per consumer lies within the range of £600–£800.

Between August, 1946, and October, 1959, about 33,500 miles of new distribution lines in rural areas were erected at a cost of over £22,500,000. These lines served 43,000 farms and 27,300 other rural consumers. During the same period, the percentage of farms connected had been raised from 22 per cent. to 82 per cent. At 31st October, 1959, the Electricity Authority was committed to the payment of £10,059,464 in subsidies, of which £4,302,907 had actually been paid.


SNOWY MOUNTAINS SCHEME
CANBERRA
A. C. T.
N. S. W.
ADELONG
TUMUT
BATLOW
TALBINGO
YARRANGOBILLY
TUMUT 3 POWER STATION
TUMUT 2 POWER STATION
TUMUT 1 POWER STATION
TUMUT 4 POWER STATION
TUMBARUMBA
SUE CITY
KIANDRA
TANTANGARA
TANTANGARA RESERVOIR
MICHELAGO
COOMA
ADAMINABY
BREDBO
TOOMA
CABRAMURRA
THREDBO VILLAGE
GREG GREG
BRINGENBRONG
KIANGOBAR
MURRAY 2 POWER STATION
MURRAY 1 POWER STATION
LAKE EUCUMBENE
EUCUMBENE
GEEHI
JINDABYNE
JINDABYNE RESERVOIR
BERRIDALE
TOM GROGGIN
RANGE
DIVIDING
GREAT
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SOUTH AUSTRALIA
ADELAIDE
NEW SOUTH WALES
VICTORIA
MELBOURNE
SYDNEY
MAP AREA

§ 2. Victoria.

1. General.—In Official Year Book No. 39, a detailed description is given of the development of electricity generation in the cities of Melbourne, Geelong, Bendigo and Ballarat up to the time of transfer of control of electricity undertakings in those cities to the State Electricity Commission of Victoria. An account is also given of the events culminating in the establishment of the Commission in 1919, and of the early developments in the Commission's undertakings.

2. State Electricity Commission of Victoria.—(i) *Power and Fuel Authority.* Since it began operating in 1919, the State Electricity Commission has expanded and co-ordinated the production and supply of electricity on a State-wide basis to the point where its system now generates almost all the electricity produced in Victoria and serves about 97 per cent. of the population through a supply net-work covering more than two-thirds of the populated area of the State.

Development of Victoria's State electricity system is based on the utilization for both power and fuel of Victoria's extensive brown coal resources in the Latrobe Valley in eastern Gippsland, with supplementary development of the hydro-electric potential of north-eastern Victoria. Victoria shares with New South Wales in the electricity generated at Hume hydro station on the River Murray. Victoria is also entitled to one-third of the electricity from the Snowy Mountains Hydro-electric Scheme, after the Commonwealth has taken the power it needs for the Australian Capital Territory and within the Snowy Mountains area. Output from the Snowy scheme was made available to Victoria in the latter half of 1959. Two-thirds of the State's electricity is generated from brown coal, either used in its raw state or manufactured into higher quality fuel in the form of brown coal briquettes. Ninety-eight per cent. of the brown coal and all the briquette fuel are supplied by undertakings which the Commission itself owns and operates. Output of brown coal in 1958–59 from the three open cuts at Yallourn, Yallourn North and Morwell totalled 11,500,864 tons, of which 8,302,571 tons were used in the Commission's own power stations, and 2,458,048 tons were manufactured into 642,590 tons of brown coal briquettes, 17 per cent. of the briquette output then being used for electricity production in metropolitan and provincial steam power stations.

The two functions, generation of electricity and production of fuel, are closely integrated. Apart from the large proportion of brown coal and briquette fuel directly consumed in the power stations, the actual process of briquette manufacture results also in large-scale generation of electricity, since the steam needed for processing the raw coal in the briquette factory is first used to operate turbo-generators in associated power plant which functions as part of the briquette works.

(ii) *Status and Powers.* Constituted by Act of the Victorian Parliament, the State Electricity Commission is a semi-governmental authority administered since 1921 by a full-time Chairman and three part-time Commissioners. The principal duty of the Commission is to co-ordinate and extend on an economic basis the supply of electricity throughout Victoria. For this purpose, it is vested with power to erect, own and operate power stations and other electrical plant and installations, supply electricity retail to individual consumers or in bulk to any corporation or public institution, acquire and operate electricity undertakings, develop, own and operate brown coal open cuts and briquetting works, and develop the State's hydro-electric resources. From its own revenues, which it controls, the Commission must meet all expenditure in the operation of its power, fuel and subsidiary undertakings, and all interest and other charges incurred in the service of its loans and other capital commitments.

The Commission is the controlling authority for all electrical undertakings in Victoria. It is responsible for the registration of electrical contractors, the licensing of electrical mechanics, the control of installation methods and material and the testing and approval of electrical equipment and appliances. Incidental to its main operations, the Commission owns and operates the tramway systems in Ballarat and Bendigo. For the accommodation of its employees at Yallourn, the Commission owns and administers the town of Yallourn and owns large housing estates in the surrounding area. In the Kiewa hydro-electric works area, it has built the two townships of Mount Beauty and Bogong, municipal administration of the former now being vested in the Shire of Bright.

(iii) *Electricity Supply.* At 30th June, 1959, consumers in Victoria served by the State system totalled 831,068. Outside the State system, there were 21,220 other consumers served by local country undertakings. The system supplies all the Melbourne metropolitan area and nearly 1,500 other centres of population.

The Commission sells electricity retail in all areas except part of the metropolitan area, where it sells in bulk to eleven municipal undertakings which operate as local retail supply authorities under franchises granted before the Commission was established. Bulk supply is also being provided at present to several New South Wales municipalities and irrigation settlements bordering the River Murray. Rural electrification is now about 86 per cent. completed, the over-all plan to extend the State system to all populated regions of Victoria having made rapid progress during recent years. Consumers served by the State system outside Melbourne metropolitan area (347,191) have more than doubled, and the number of farms connected to supply (41,748) has almost trebled in the past 10 years. Of the new consumers connected to supply each year, over three-quarters are outside the metropolitan area. New farm connexions average about 3,000 a year.

The Commission's retail consumers totalled 649,704 at 30th June, 1959. Retail supply is administered through the metropolitan branch, seven extra-metropolitan branches (namely Ballarat, Eastern Metropolitan, Geelong, Gippsland, Midland, North Eastern and South Western) and the North Western Region, which comprises Bendigo branch and the two sub-branches based on Mildura and Horsham (Wimmera). At 30th June, 1959, there were branch and district supply offices in 79 towns in Victoria.

(iv) *Electricity Production.* Electricity generated in the State system totalled 5,534 million kWh in 1958–59 or 99 per cent. of all the electricity generated in Victoria. The system comprises 21 steam, hydro and internal combustion power stations within Victoria. Inclusive of generator capacity available to the Victorian system from outside the State, the total installed generator capacity at 30th June, 1959, was 1,319,000 kW. Nineteen of these power stations, totalling 1,294,000 kW are interconnected, and feed electricity into a common pool for general supply. The major power station in this interconnected system is the brown coal burning power station at Yallourn, which alone generates nearly half of Victoria's electricity. Other power stations in the interconnected system comprise the new brown coal burning power station at Morwell, steam stations in Melbourne (Newport, Richmond and Spencer-street), Geelong (two stations) and Ballarat (two stations); hydro-electric stations at Kiewa (two stations) and Eildon, and on the Rubicon and Royston Rivers (four stations), near Eildon; and three internal combustion stations at Shepparton, Warrnambool and Hamilton (Hamilton power station was closed down on 31st July, 1959). All are Commission owned, except Spencer-street power station, which remains the property of the Melbourne City Council, although operated as a unit in the interconnected system. Also linked with the Victorian interconnected system is the hydro station at Hume dam on the River Murray. This power station is operated by the Electricity Commission of New South Wales. Output and operating costs are shared by Victoria and New South Wales.

In meeting the total demand on the system, which fluctuates throughout the day and from month to month, each group of stations in the interconnected system, whether steam, hydro or internal combustion, is assigned a predetermined function dependent upon the availability of power from each group and the over-all economics of generation. The various stations are utilized in the combination that will meet the system load most economically at a given time. This procedure results in an arrangement of the system on the following general lines:—

(*a*) Yallourn power station, owing to the low cost of extraction and ample supply of raw brown coal, is a base load station, and is operated continuously at its maximum economic capacity. The new Morwell power station, which like Yallourn, burns raw brown coal, is also a base-load power station.

(*b*) Metropolitan and provincial steam stations and provincial internal combustion stations situated close to load centres are designed to operate as peak load stations to assist in meeting the heavy, short period load. Pending the completion of extensions to Yallourn power station, a substantial proportion of the base load on the system is carried by Newport power station.

(*c*) Hydro stations are operated in accordance with the availability of water. Their primary function is to provide peak load power. As the basic purpose of Eildon reservoir is to provide water for irrigation, generation of electricity is mainly governed by irrigation requirements, but provision has been made for limited operation of the power station in winter when electricity requirements are at their heaviest and there is no irrigation demand for

water. Hume hydro station also operates on water released for irrigation and no regular output of electricity can be expected during the non-irrigation months in the winter.

Commission power stations not yet connected with the rest of the State system comprise the two steam stations (Redcliffs and Mildura) serving the Mildura region.

(v) *Transmission and Distribution.* The electrical transmission and distribution system in the State supply network at 30th June, 1959, comprised 29,803 miles of power lines, 14 terminal receiving stations and almost 21,000 distribution sub-stations. Main transmission is by 220 kV, 132 kV and 66kV power lines which supply the principal distribution centres and also provide interconnexion between the power stations. The 330 kV line connecting the Victorian system with the Snowy Mountains Scheme via Dederang, near Kiewa, was still under construction at 30th June, 1959—for completion later in 1959. The 220 kV system now extends from Yallourn to Melbourne, Melbourne to Kiewa and Kiewa to Shepparton. Two further sections of the 220 kV system—Melbourne to Colac and Shepparton to Bendigo —are operating temporarily at 66 kV. From Yallourn there are also 132 kV transmission lines to Melbourne. The 66 kV lines radiate from Melbourne to Geelong and main centres in the South West, Ballarat and Horsham, and Bendigo and Charlton, and also to Benalla and other main centres in the North East. Further 66 kV lines radiate from Yallourn to main centres in Gippsland.

(vi) *Future Development.* In conformity with its dual responsibility for producing and supplying Victoria's electricity and producing a large proportion of the State's solid fuel, the Commission's developmental programme is in two parts, which are, however, closely dependent one upon the other. The major part of this programme is for the development of the brown coal undertakings at Yallourn and Morwell in the Latrobe Valley and the erection of a large new brown coal burning power station (Hazelwood) near Morwell; and the second and lesser part for the development of the hydro undertaking at Kiewa. At the same time, the Commission will continue its programme of rural electrification, extension of the State system (particularly in western and north western Victoria) and reinforcement of supply by extending the 220 kV system from Bendigo north-westwards to Kerang and Redcliffs, near Mildura, and also to Ballarat and Geelong where connexion will be made with the existing Melbourne-Colac line, thus completing a 220 kV circle around Central Victoria.

Yallourn power station is being greatly enlarged. Four 50,000 kW generators in two extensions have been added recently. A third extension of 240,000 kW capacity is due for completion in 1962. Enlargement of the power station will require a corresponding expansion in production of brown coal at Yallourn. New dredger plant will increase annual output at the Yallourn open cut to over 12 million tons in 1962. This will complete the Yallourn power generation development, except for the eventual replacement of 175,000 kW of old plant probably with one generating unit of about 200,000 kW capacity.

At Morwell, six miles from Yallourn, the Commission is developing a second brown coal power and fuel project. The new project comprises a large brown coal open cut and a major new power station operating in association with a large new briquetting plant. Some of the electricity generated at Morwell is needed to operate the briquette works, but most of the output of the power station is transmitted through Yallourn to metropolitan terminal stations for general supply through the State network. The power station began operation at the end of 1958. Output for general supply will increase progressively to 151,000 kW in 1963. Briquette production is scheduled to start in the latter part of 1959. It will increase to 1,500,000 tons a year in 1961. Annual output of brown coal at the Morwell open cut will increase progressively to over six million tons over the same period, and will be further expanded in subsequent years to an ultimate annual output of about 19 million tons to meet the fuel requirements of the new Hazelwood power station, proposals for which were submitted to the Victorian Parliament in the latter months of 1959. Hazelwood power station is designed for an ultimate capacity (in about 1970) of 1,200,000 kilowatts in units of 200,000 kW each, the first to be in service not later than 1964. The power station will be located south of Morwell, and brown coal fuel will be supplied by belt conveyor direct from the Morwell open cut.

(vii) *Hydro electricity.* At the Kiewa hydro-electric undertaking, where two stations, totalling 87,600 kW capacity, are now in service, work is in progress on a third power station of 96,000 kW capacity, which is due to have the first two of its six generators operating

before the middle of 1960, and alternators in service in 1961. Work was completed in 1959 on the construction of Rocky Valley Reservoir, which is designed to provide the main high level storage for the operation of the Kiewa power stations.

3. **Local Country Electricity Undertakings.**—At 30th June, 1959, there were 34 independent electricity undertakings in country centres in Victoria generating and distributing their own local supply. Most of these undertakings were in the far south west, west and north west of the State. Under the State Electricity Commission's rural electrification programme, almost all the independent local country undertakings will ultimately be acquired and absorbed into the State system. For the year 1958–59, the total production of the independent undertakings was 44 million kWh. The number of consumers at 30th June, 1959, was 21,220. The operation of the independent undertakings is governed by the Electric Light and Power Act, 1958, which the State Electricity Commission administers.

§ 3. Queensland.

1. **General.** In Official Year Book No. 39, an account is given of the growth of electricity generation in Queensland, with particular reference to the City Electric Light Co. Ltd. of Brisbane (now the Southern Electric Authority of Queensland), the Brisbane City Council and the Toowoomba Electric Light and Power Co. Ltd.

The first of these organizations supplies a large part of Brisbane's electric power requirements, and those of a considerable rural area in the south-eastern corner of the State, from a modern power station at Bulimba, a suburb of Brisbane. Capacity is 95,000 kW at Bulimba "A", plus 10,000 kW, " packaged plant " at Abermain (near Ipswich), 120,000 kW at Bulimba " B " and 120,000 kW at Tennyson. The output from a 3,200 kW hydro-electric unit installed at Somerset Dam near Brisbane is fed into the Southern Electric Authority system. With these plants, 723 million kWh were generated in 1957–58 while the total number of the Authority's consumers at 30th June, 1958, was 113,483.

The Brisbane City Council's electrical undertaking and power production in 1957–58 had an installed capacity of 160,000 kW plus a 10,000 kW " packaged plant " erected at Tennyson, units purchased and generated amounted to 608 million kWh, and there were 128,846 consumers connected.

The Toowoomba Electric Light and Power Co. Ltd., which commenced operations in 1905, has now been absorbed by the Southern Electric Authority of Queensland.

The generation and distribution of electric power in Queensland had, until the last decade, tended to lag behind developments in this field in other States of Australia. The comparatively slow growth in the production and consumption of electricity can be attributed to some extent to the absence, prior to 1938, of a central statutory authority constituted to undertake the functions of co-ordinating, unifying and controlling the production and transmission of electric power. In addition, Queensland's vast area, coupled with a low population density, made large-scale rural electrification, elsewhere than in the south-eastern portion of the State, which surrounds the major centres of industry and population, an uneconomic proposition.

Before establishment of the Regional Electricity Boards in 1945, no attempts had been made to unify or co-ordinate electricity supplies outside of south-eastern Queensland, and rural electrification, apart from reticulation within certain townships, was practically unknown.

2. **Royal Commission on Generation and Distribution of Electric Power in Queensland, 1936.**—On 5th December, 1935, the Queensland Government appointed a Royal Commission to inquire into and make recommendations on matters relating to the generation and distribution of electric power in Queensland. An account of the results of its investigations and of the alternative proposals put before it will be found on page 1182 of Official Year Book No. 39.

3. The State Electricity Commission of Queensland:—The State Electricity Commission of Queensland commenced to function during January, 1938. Its main powers were to secure a proper and efficient supply of electric power, review tariffs, grant licences to supply electricity, secure the safety of the public, and control and advise electrical undertakings generally. It was thus a controlling authority as distinct from an operating authority. Details of its growth and development may be found in earlier issues of the Official Year Book (*see* No. 44, p. 284). Since its inception, the Commission has made considerable progress in its task of developing the State's power resources and promoting a more widespread use of electric power. The degree of utilization of electrical energy in Queensland now compares favourably with other States in the Commonwealth.

4. **Regional Electricity Boards.**—With a view to facilitating the control and development of electricity supply in areas of low population density and those having a predominantly primary producing economy, the Government, in 1945, passed the Regional Electric Authorities Act providing for the creation of regions of electricity supply and the constitution of Regional Electricity Boards.

Soon after passage of the Act, four Regional Boards were constituted, namely, Wide Bay, Capricornia, Townsville and Cairns. A fifth Board, entitled South Burnett, became an operating authority in October, 1947, but on 1st July, 1951, was absorbed in the Wide Bay Regional Board and this organization is now known as the Wide Bay-Burnett Regional Electricity Board.

As from 1st March, 1957, a further Regional Board became operative, covering the areas of Mackay, Sarina, Proserpine and adjacent rural areas under the name of Mackay Regional Electricity Board.

Supply throughout this Region is provided from the central generating station at Mackay and accelerated electrical development of this area is being undertaken. The Townsville Regional Electricity Board's area was extended in July, 1957, to include that of the Bowen electricity undertaking. The local authority areas of Thursday Island and Cook were included in the Cairns Regional Electricity Board's area from 1st July, 1956, and 1st July, 1957, respectively. As from 1st January, 1958, the Capricornia Region was extended to include the Shires of Bauhinia, Belyando, Emerald and Peak Downs in Central-West Queensland.

Activities of the original four Regional Boards in 1957–58 and 1958–59 compared with operations of the stations located in regions in 1945–46, and totals for Queensland as a whole are shown in the following table:—

QUEENSLAND: REGIONAL OPERATIONS.

Region.	1945–46.		1957–58.		1958–59.	
	Units Generated.	No. of Consumers.	Units Generated.	No. of Consumers.	Units Generated.	No. of Consumers.
	Million kWh		Million kWh		Million kWh	
Wide Bay-Burnett ..	13.7	11,467	79.0	28,003	81.2	29,513
Capricornia	19.5	11,196	128.8	21,743	146.9	22,417
Townsville	25.8	11,612	(*a*) 97.1	25,812	(*a*) 99.7	26,929
Cairns	22.7	9,722	150.5	19,930	174.8	21,088
Total	*81.7*	*43,997*	*455.4*	*95,488*	*502.6*	*99,947*
Total Queensland	**487.0**	**194,429**	**1,852.4**	**365,048**	*b* **2,019.1**	*b* **380,500**

(*a*) Excludes 28 m.kWh purchased from Tully Falls power station in 1957–58 and 49 m.kWh in 1958–59. (*b*) Estimated.

Generator capacity of the five existing Regional Boards installed at 30th June, 1959, was:—Wide Bay-Burnett, 37,500 kW; Capricornia, 54,743 kW; Townsville, 40,646 kW; Mackay, 12,500 kW; Cairns, 91,080 kW; total 236,469 kW.

5. Creation of Southern Electric Authority of Queensland.—A further major step in electrical progress, comparable with that taken when the agreements with the City Electric Light Co. Ltd. and Toowoomba Electric Light and Power Co. Ltd. were first entered into, was taken by the passing of the Southern Electric Authority of Queensland Act of 1952. This Act constituted the City Electric Light Co. Ltd. as a public authority to be known as the Southern Electric Authority of Queensland.

Two Government representatives are included on the Board of the new Authority, whose establishment prepares the way for the complete amalgamation, in due course, of the electrical undertakings serving the south-eastern Queensland area of supply.

As from 1st July, 1954, the Southern Electric Authority acquired the Toowoomba Electric Light and Power Co. Ltd., thus bringing this company's area of supply under its control. The Southern Electric Authority is now responsible for the electrical supply and development of a consolidated area of 19,386 square miles.

6. **Hydro-electricity.**—Behind the costal plain of the Cairns-Ingham area is an extensive plateau, the elevation ranging from 2,000 to 3,000 feet, although isolated peaks exceed 4,000 feet. The short coastal streams which rise on the plateau descend rapidly into deep gorges, which they have cut through the divide. With heavy monsoonal rainfall on their catchments and concentrated fall, these streams represent a considerable potential source of power, but storage, which can be provided in most cases, is essential to control the very variable flow.

There is a pronounced wet season from December to March, with a dry season from July to November. Average annual rainfall varies greatly with geographic location, being 178 inches at Deeral (midway between Cairns and Innisfail) but only 34 inches at Cashmere (120 miles south-west of Innisfail).

In 1935, a small hydro-electric power station was placed in service at Barron Falls, ten miles north-west of Cairns. The station comprises three 2,000 h.p. turbines, each driving a 1,320 kW generator, and with a hydraulic head of 410 feet. An output of 25 million kWh was attained during 1958–59, the station operating essentially as a run-of-river station without any significant water storage capacity being available. Power is fed at 22 kV into the main network at Mareeba and Cairns.

The hydro-electric power scheme at Tully Falls was commissioned in September, 1957, with an initial plant installation of 36,000 kW. Work has now been completed on the installation of a further two 18,000 kW sets, making a total installation of 72,000 kW. An output of 135 million kWh was obtained from this station during 1958–59. Water controlled by Koombooloomba Dam at present under construction on the upper Tully River is diverted, a short distance above Tully Falls, through a tunnel and steel penstocks to an underground power station in the gorge at the foot of the falls operating with Pelton driven generators under a head of 1,485 feet. Power is transmitted to the load centres at Cairns and Innisfail by means of 132 kV transmission lines. Future automatic power plants upstream and downstream from Tully Falls consisting of two 7,500 kW sets under 405 feet head and one 5,400 kW set under 230 feet head are under consideration. The combined peak load for the three plants would then be 69,000 kW. Interconnexion of the Tully scheme with the Townsville area, which is also being served by a thermal station, was completed in February, 1958, by the provision of a 160 mile double circuit 132 kV transmission line. On present estimates, power from the completed Tully scheme will be sufficient to supply the interconnected area until 1963 when additional power will be required.

The construction of a new peak load power station at Barron Falls to provide a firm (dry year) output of 60,000 kW at 25 per cent. load factor (i.e. firm output of 131 million kWh per annum) has been authorized by the Queensland Government. Orders have been placed for the major items of plant and construction of the scheme has commenced. This scheme will ensure an adequate supply of power to the Cairns and Townsville areas until 1967.

The completed scheme will provide for an underground power station below the Barron Falls containing two 30,000 kW Francis turbines, operating under a head of 920 feet. Water will be carried from a pond above the Falls by horizontal tunnel and pressure tunnel to the power house. The existing weir will be raised by 8 to 16 feet for this purpose. An earth and rock fill dam will be built on Flaggy Creek, a tributary of the Barron, to provide storage capacity for the scheme, although initially spare storage capacity at the Tinaroo Falls Dam will be used.

Other major schemes which are currently being investigated include North Johnstone-Russell Rivers (32,000 kW); Beatrice-North Johnstone Rivers (9,000 kW); South Johnstone River (25,000 kW); Herbert River (90,000 kW).

In the Townsville Region, the Commission, acting on behalf of the Burdekin River Authority, investigated the proposed hydro-electric development of the Burdekin. The Scheme envisaged a power plant immediately below the Burdekin Falls Dam to operate under an average head of 225 feet.

In relation to other projects, the Scheme is not as favourable economically as a power production project alone but, as a joint power production, irrigation and flood mitigation scheme, it has considerable potentialities. An estimated output of 80,000 kW at 50 per cent. load factor would be available.

The State Electricity Commission, in conjunction with other Government Departments is carrying out an extensive investigation into the development of hydro-electric resources. It is estimated that full development of the hydro-electric potential of North Queensland would provide the equivalent of over 300,000 kW of power at 50 per cent. load factor or approximately 1,300 million kWh a year.

A number of small hydro-electric projects are being investigated in other parts of the State. On the Broken River near Eungella (50 miles west of Mackay), a site exists for the establishment of a peak load hydro-electric power station, and this is being examined. The construction, in the future, of a major dam on the Dawson River at Nathan Gorge (near Cracow) in the Capricornia Region for irrigation purposes, would permit the installation of a small hydro-electric power station at this site if the power produced could be economically absorbed. A plant of 3,200 kW capacity has been installed to utilize the outflow from Somerset dam on the Stanley River a few miles above its confluence with the Brisbane River.

7. **New Capacity.**—(i) *Regions.* To provide for development of the electric power resources in the regions, the State Electricity Commission formulated a ten-year programme divided into two five-year periods. In the first, it was planned to erect main transmission systems to connect existing power stations located within the regions and supplement generating capacity by the construction of new stations. Work on this section of the plan in the original Regional Board areas is now virtually complete. In the second, the transmission system will be extended to more sparsely settled areas, the ultimate purpose being the provision of "ring" transmission lines throughout each region and inter-connexion between the regions.

A number of new generating stations have been commissioned as follows:—Wide Bay (Burnett Region), of which 15,000 kW was placed in service during September, 1951, and 7,500 kW in 1954, while a further set of 15,000 kW was installed in 1957. Rockhampton (Capricornia Region) of which 22,500 kW was placed in service during September, 1952, and a further 15,000 kW in May, 1956, and a further 15,000 kW in December, 1958; and Townsville (Townsville Region) of which 22,500 kW was commissioned in July, 1953, and a further 15,000 kW in January, 1956. Each of these stations will have an ultimate installed capacity of 52,500 kW and be steam-operated. In the Cairns Region, the Tully Falls hydro-electric power station has been completed with 72,000 kW installed capacity.

The Tully Falls scheme (*see* para 6, p. 230) was planned to link with the Townsville Regional Electricity Board's system for the purpose of marginal supply, and construction of this interconnexion was completed by the close of 1957. Preliminary work has commenced on the construction of a further hydro-electric scheme on the Barron River which should be completed by June, 1963, and will add 60,000 kW to the available hydro-electric generation capacity in the area. The first stage of the scheme's development is estimated to cost £5,850,000, and initially full use will be made of available storage capacity at Tinaroo Falls Dam, thus enabling construction of a £5,000,000 storage dam on Flaggy Creek to be postponed for a number of years.

At Mackay, where supply was first given in 1924, a Regional Electricity Board has now been constituted and a 66 kV transmission line to Proserpine has been erected. The generating capacity of the station under the control of this Regional Board is 12,500 kW, and a further 3,000 kW of diesel plant is being installed. At Bowen, the Town Council, which established the service in 1952, has now transferred control of its area to the Townsville Regional Electricity Board, and transmitted supply is provided by a 66 kV transmission line. During 1935, a small (3,800 kW) power house—Australia's first underground hydro station—was placed in service at Barron Falls near Cairns. When the Cairns Regional Board was established during 1946, operation of the station passed to the Board's control and now comprises part of its generating plant.

(ii) *Western Queensland.* In western Queensland, where a number of small isolated generating stations supply power to some of the larger towns, the Commission has evolved a plan to increase and modernize existing capacity. It involves installation of small internal combustion units ranging in size from 100 kW to 600 kW according to the load likely to be experienced, and conversion from direct to alternating current supply. The Government has assisted the scheme by subsidy—a feature of electrical development in Queensland. Assistance provided for regional electrical development comprises subsidies of up to one-third of capital cost on annual loan charges, with special subsidies of up to 50 per cent. for authorities in the larger towns outside the Regions.

In addition to improving supplies to the larger western towns, a scheme has been devised for electricity supplies for smaller towns in the western districts, where consumers range from 50 to 200. Subsidies of 65 and 60 per cent. will apply in those cases where the number of consumers supplied is less than 100 and 200, respectively. This plan has now been virtually implemented and at 30th June, 1958, 28 townships in western Queensland had been provided with electricity. The power is being supplied by small oil driven generating sets with automatic controls which can be run with a minimum of operating attendance. In addition, investigations of the possibility of supply have been carried out at a number of other small centres.

Coal-burning gas producers have been succesfully commissioned for public electricity supply purposes at Longreach, Clermont, Dalby, Blackall and Barcaldine and further extension of their use in western Queensland is predicted, as lower tariffs and more efficient production of electricity should follow their use.

(iii) *South-eastern Queensland.* To increase the availability of electric power in the south-eastern area of the State, the two major generating authorities, in conjunction with the Commission, have power station projects under construction which are designed to place in service, by 1968, new generating units totalling 400,000 kW. The Southern Electricity Authority is continuing the development of the station known as Bulimba "B", on a site adjacent to Bulimba "A". 120,000 kW had been installed to 30th June, 1959, and the ultimate capacity may reach 180,000 kW. At Tennyson in the Brisbane area, the Brisbane City Council has constructed a new power station with an initial capacity of 60,000 kW which ultimately may be increased to 180,000 kW. At 30th June, 1959, generating plant of 120,000 kW was in service at this new station. To supplement capacity pending operation of these projects, "packaged" generating units totalling 20,000 kW were obtained from overseas and commissioned early in 1953, one 10,000 kW set having been installed at Tennyson and another 10,000 kW set at Abermain near Ipswich.

The power stations of the two major generating authorities at New Farm and Bulimba are interconnected at 33 kV.

§ 4. South Australia.

1. **General.**—An account referring to the companies generating electric power in South Australia prior to the establishment of the Adelaide Electric Supply Co. Ltd., and describing the development of that company's activities, was given in Official Year Book No. 39. Also included in the account was some reference to the early measures of public control over electricity supply in South Australia and the extent to which they were applied, and also to the inquiries into the activities of the Adelaide Electric Supply Co. Ltd. in 1932 and 1935.

Following upon an inquiry instituted by the Government in 1943, relative to measures for increasing electricity supply to the metropolitan area and country districts, the Electricity Act 1943 was passed which, *inter alia*, established the South Australian Electricity Commission. However, until the State assumed full responsibility for the supply of electric power, this body was not able to do much more than exercise the formal functions conferred on it by the Act.

2. **The Electricity Trust of South Australia.**—Early in 1946, legislation was passed transferring the assets of the Adelaide Electric Supply Co. Ltd. to the newly formed public authority, the Electricity Trust of South Australia, which became responsible for unification and co-ordination of the major portion of the State's electricity supplies. This legislation

provided that the Trust should take over the powers vested in the South Australian Electricity Commission under the 1943 Act, which, after establishment of the Trust, would cease to exist. In addition to the powers specified in the Adelaide Electric Supply Company's Acts 1897–1931, the Trust may, *inter alia*, supply electricity direct to consumers within a district or municipality with the approval of the local authority, and by agreement with other persons who generate or supply electricity, arrange to inter-connect the mains of the Trust with those of other persons, and give or receive supplies of electricity in bulk.

3. **Capacity and Production.**—There are three main categories of organizations generating electric power in South Australia, namely:—(*a*) Governmental, which include the Electricity Trust; (*b*) Local Authorities, e.g., municipal and district councils, and Renmark Irrigation Trust; and (*c*) Other, including individuals and firms primarily engaged in generating power for sale, firms generating power primarily for their own use but supplying outside consumers, and firms generating power solely for their own use.

In 1957–58, total installed capacity in South Australia was 402,386 kW, an increase of 48,556 kW on the year before. The units generated totalled 1,580 million kWh compared with 1,315 million kWh in the previous year.

Of the total installed capacity, the Electricity Trust of South Australia operated plant with a capacity of 365,600 kW. It is thus the most important authority supplying electricity in the State. There were approximately 264,000 ultimate consumers of electricity, of whom 238,362 were supplied directly by the Trust and approximately 11,000 supplied indirectly by the Trust (i.e. through bulk supply). Its major steam stations were Osborne " A " (70,000 kW), Osborne " B " (180,000 kW) and Port Augusta " A " (90,000 kW) while the balance of the capacity controlled consists of house sets and regional stations at Port Lincoln and Mount Gambier.

No hydro-electric potential exists in South Australia. Steam generating units comprise 95 per cent. of installed capacity and the balance is internal combustion equipment. Until recently, all fuel consumed in the thermal stations was obtained from sources outside the State, and at times power restrictions were necessary owing to the inadequacy of supplies.

4. **Leigh Creek and other New Capacity.**—With a view to reducing the dependence on external sources of fuel, steps have been taken to produce local coal and to install plant to use it. Fairly extensive deposits of low-grade sub-bituminous coal are obtainable at Leigh Creek, about 360 miles north of Adelaide. Under the Electricity Trust of South Australia Act Amendment Act 1946, the Trust was given authority to develop Leigh Creek coal for use in its own undertakings and also for sale to other consumers. Production from the Leigh Creek field commenced in 1944, and in the year ended 30th June, 1958, 687,114 tons of coal were sold. Of this amount, the electricity undertaking used 668,128 tons.

In order to cope with the rapidly increasing demand for power, the Electricity Trust is constructing a second power station at Port Augusta, to be known as Port Augusta " B ". This station will have a capacity of 240,000 kW making the combined capacity at Port Augusta 330,000 kW. The first 60,000 kW turbo-alternator is expected to be commissioned about March, 1960, and the station is scheduled for completion about 1964. Leigh Creek coal will be used exclusively. The power station will be interconnected with the metropolitan area by two 275 kV transmission lines. Consideration is now being given to the establishment thereafter of some pumped-storage hydro plant, as being possibly the most economic way of handling the peak loads of the system.

It is possible that an installation of this type of plant would serve the increasing needs of the system until the late 1960's. In addition, at Port Lincoln and Mount Gambier, the Trust operates steam power stations of 5,000 kW and 16,800 kW capacity, respectively, the former burning fuel oil and the latter either wood waste or fuel oil.

§ 5. Western Australia.

1. **General.**—Electrical undertakings in Perth and Fremantle formerly owned by the Perth City Council, the Western Australian Government Electricity Supply, the Fremantle Municipal Tramways and Electric Lighting Board and other metropolitan, municipal and road board supply authorities have been taken over by the State Electricity Commission of Western Australia. For information on the early history of electricity supply in the metropolitan area, *see* Official Year Book No. 39, page 1189.

2. **Metropolitan Undertaking.**—Statistics relating to activities of the Metropolitan undertaking are shown in the following comparative table.

WESTERN AUSTRALIA: METROPOLITAN UNDERTAKING.
(*Including Bunbury Power Station*).

Particulars.	1938–39.	1957–58.	1958–59.
Plant capacity .. .. kW	57,000	{*a* 25,000 / *b* 160,000}	.. / (*b*)215,000
Maximum load .. .. kW	33,000	124,000	133,000
Units generated .. .. Million kWh	137	571	605
Fuel used per unit (kWh) generated .. lb.	2.77	1.55	1.56
Coal used .. .. tons	168,722	389,423	414,919

(*a*) 40 cycles. (*b*) 50 cycles.

As a result of a separate inquiry conducted at the same time as the early investigations into the proposed new station at South Fremantle, a recommendation was made favouring conversion of the East Perth 40 cycle system to the British and Australian Standard Frequency of 50 cycles per second. The recommendation was adopted and implemented by making the frequency of generation at South Fremantle 50 cycles and installing at East Perth a frequency changer able to convert 25,000 kW of energy from one frequency to the other.

3. **Kalgoorlie.**—In Kalgoorlie, the Municipal Council supplies approximately 3,800 consumers with either direct or alternating current. A diesel station of 1,825 kW generating capacity provides direct current to the limit of its capacity. Alternating current is purchased from Kalgoorlie Power Corporation and retailed by the Council to some consumers, while portion is passed through a rectifier to convert it to direct current. Primarily established to supply power to the gold mines, the Kalgoorlie Electric Power and Lighting Corporation operates a steam station of 11,000 kW and maintains a 22 kV line of 21 miles to the Celebration mine. Alternating current is also supplied to about 1,400 consumers. The Corporation's undertaking generates approximately 35 million kWh per annum and boilers are fired by Collie coal.

4. **General Pattern of Electricity Supply.**—The pattern of the generation and distribution of electric power in Western Australia consists of a number of isolated systems each supplying a particular area. Except in the metropolitan area and in the area embraced by the South-West Power Scheme (*see* para. 6 below), where in both cases electricity supply is in the hands of the State Electricity Commission of Western Australia, local authorities are generally responsible for the supply of electricity for domestic and industrial purposes. In the area between the Great Southern Railway from Northam to Albany and the west coast, however, the State Electricity Commission has now constructed transmission lines to give central station supply to the towns and their surrounding rural areas. In addition, there are several mining companies which generate electricity for use in their mines. In order to cater for the expected growth in demand, the capacity of the State's major generating stations is being increased.

The system in the Metropolitan area has been interconnected with the Bunbury area by means of two 132 kV transmission lines.

The main load centre of the State is, of course, the Perth-Fremantle area into which is concentrated the major portion of the State's population and industry. The interconnexion between the Metropolitan and Country systems is, however, expected to lead to a gradual decentralization of load.

5. **The State Electricity Commission of Western Australia.**—(i) *Origin and Aims.* In order to ensure an organized and co-ordinated future growth of electricity generation and distribution throughout the State, the Government introduced a Bill in 1945 to establish the State Electricity Commission, which, together with an Electricity Bill, became law early in 1946. Under these Acts, the Commission was given power, *inter alia*, to secure the ultimate co-ordination of all State or other electrical undertakings in the State, to construct and operate power stations and transmission lines and purchase as a going concern and carry on the undertaking of any supply authority. Under the Electricity Act, which should be read in conjunction with, and is subject to, the State Electricity Commission Act, no person or organization is permitted to construct or extend an electricity supply undertaking without

consent from the Commission. Local authorities are empowered to operate and construct power stations and other works associated with the supply of electricity, provided that authority is first obtained from the Commission and any proposals are not inconsistent with the Commission's plans.

(ii) *New Projects.* Since its inception in 1946, the Commission has proceeded with the task of increasing generating capacity in an endeavour to cater for a greatly increased demand for power. Long-range plans were formulated to interconnect the south-western portion of the State with the Perth-Fremantle system. One of its most important and immediate problems was to increase the capacity of the generating equipment serving Perth and Fremantle. During the 1939–45 War years, it became evident that the growth of demand for electric power would necessitate provision of additional generating equipment in the metropolitan area as soon as possible. Accordingly, the Government Electricity Supply authority commenced design work for a new station of 50,000 kW capacity. Contracts were let in 1945 and construction commenced on a site selected at South Fremantle. Responsibility for completion of this project was given to the Commission under the Act of 1946. As it was considered that an even larger station would be required, provision was made for the installation of two additional units giving an ultimate capacity of 100,000 kW. Steam is furnished by eight boilers designed to use pulverized coal from Collie, which is located about 120 miles from the station. At the end of 1954, four units had been placed in service and the output was being fed into the metropolitan system.

At the East Perth power station, a new 30,000 kW unit has been commissioned and an additional boiler installed. A 25,000 kW unit, commissioned in 1938 (generating 40 cycles) is also available at this station.

6. **South-west Development.**—At the request of the Government, the Electricity Advisory Committee, in 1945, submitted a report recommending, amongst other things, that a national power scheme for the south-west be proceeded with. The plan provided for acquisition of the existing Collie power station and installation of additional generating capacity, construction of a power station at Bunbury and interconnexion of the south-west scheme with the metropolitan system. On 12th October, 1946, the State Electricity Commission acquired the Collie power station, which prior to 1946 was owned and operated by the Collie Power Company Limited. At the date of acquisition, the station's installed capacity was 5,000 kW, comprising two steam units. The capacity of the station was increased to 12,500 kW in 1952.

Since 1950, the Commission has acquired a number of electrical undertakings from municipal bodies and private organizations in the south-west area and is proceeding with arrangements for the purchase of others. In August, 1951, the first portion of the South-West Power Scheme was officially opened at Collie and many of the south-west towns have now been connected by transmission line to the Collie Power Station. When completed, a system of power lines will reticulate electricity over an area of approximately 25,000 square miles. The first two 30,000 kW units and associated boilers at Bunbury Power Station have been placed in service. Work is proceeding as programmed on two similar units to give the Station an ultimate capacity of 120,000 kW. The first section was officially declared open on 23rd August, 1957.

Diesel stations of 5,400 kW capacity at Albany serve the towns of Albany, Denmark, and Mount Barker in the extreme south of the State.

§ 6. Tasmania.

1. **General.**—A considerable part of the water catchment in Tasmania is at high level, with a substantial natural storage available, and this has made it possible to produce energy at lower cost than elsewhere in Australia, or in most other countries. Other factors contributing to the low costs are that rainfall is distributed fairly evenly throughout the year, with comparatively small yearly variations. The cheap power has led to the establishment in Tasmania of several large electro-chemical works with high load factor, and as a consequence the system load factor is also very high (at present 67.3 per cent.).

For information on hydro-electric development in Tasmania prior to the establishment of the Hydro-Electric Commission in 1930, *see* Official Year Book No. 39, pages 1192–3.

2. **The Hydro-Electric Commission.**—(i) *Present System.* In 1929, the Government passed the Hydro-Electric Commission Act, under which was established the Hydro-Electric Commission and which vests in the Commission, with some minor exceptions, the right to use the waters of the State of Tasmania and authorizes it to develop and reticulate electric power for all purposes. In 1930, this corporate body took over the State hydro-electric undertaking and the business of the Hydro-Electric Department.

The first project undertaken by the Commission was the Shannon Power Development which utilizes 258 feet of the difference in level between the Great Lake (Miena Dam) and Waddamana forebay. A small earthen dam diverts the outflow from the Great Lake through 2½ miles of canal and then by two pipelines to the Shannon power station, where 10,500 kW was added to the system in 1934. After passing through Shannon power station, the water discharges into the Waddamana canals to be used again at the Waddamana power stations.

In 1933, it was decided to proceed with the Tarraleah Power Development. In this scheme, the waters of the River Derwent are picked up near Butler's Gorge by a canal and conveyed 14 miles to the pipeline forebay 982 feet above the power station on the Nive River where three 15,000 kW generators were placed in service in 1938. Shortly afterwards two more 15,000 kW units were added and a sixth machine installed in 1951 brought the total installed capacity at Tarraleah power station to 90,000 kW. Storage is provided at Lake St. Clair and at Lake King William, an artificial lake created by the 200-ft. high Clark Dam across the Derwent at Butler's Gorge. In the Butler's Gorge power station at the foot of the dam, a single 12,200 kW generator was installed in 1951. To increase the security of the system and to permit variable seasonal loading of Tarraleah station, a second canal from Clark Dam to Tarraleah was completed in 1955.

Early in 1939, it was decided to make full use of the Great Lake storage by increasing the peak capacity at Waddamana. War conditions impeded progress, but by 1945 two 12,000 kW generators had been installed in a new power station, Waddamana "B", adjacent to the original station Waddamana "A". A third unit installed in 1946 and a fourth in 1949 brought the total to 48,000 kW. To enable a full peak capacity to be maintained at both Waddamana stations a duplicate of the original Waddamana canal was constructed during 1947–48.

Between 1930 and 1948, the generating capacity of the system was increased by 121,500 kW but the demand for power continued to increase rapidly and it was obvious that a greatly accelerated construction programme would have to be undertaken. Construction of the Tungatinah Power Development was started in 1948 and the Trevallyn Power Development in 1949.

The Tungatinah scheme draws water from three separate catchment areas located on the Central Plateau between the Great Lake (Shannon-Waddamana) and Lake St. Clair (Butler's Gorge-Tarraleah) catchments and control of practically the whole run-off from the Central Plateau has now been effected.

The principal catchment utilized by the Tungatinah scheme is drained by the Nive River. A 120-ft. high dam at Pine Tier diverts the waters of the Nive through 6½ miles of canal system to the first of a chain of four artificial lakes, created by dams constructed across the outlets from natural marshes and linked by large open cuts. From the southernmost lake, a tunnel and then five steel pipelines lead to the five 25,000 kW generators in Tungatinah power station, 1,005 feet below on the Nive River just upstream from Tarraleah station on the opposite bank of the river. Power was first generated at Tungatinah in mid-1953 with a capacity of 125,000 kW. Water from the smaller Clarence River catchment is brought into one of the lakes in the Tungatinah system by means of a woodstave pipeline 5½ miles in length and the third catchment area utilized is the Lake Echo-Dee River catchment. Regulation of this catchment has been achieved by construction of a dam at Lake Echo to provide the main storage reservoir for the Tungatinah scheme, construction of the Lake Echo power station (one 32,400 kW generator) to utilize 568 feet of the difference in level between Lake Echo and Dee Lagoon, and the diversion of water from Dee Lagoon through 2 miles of tunnel to the main Tungatinah system.

The Trevallyn Power Development, the first constructed by the Commission outside the Central Plateau region, was undertaken primarily to meet the requirements of the aluminium industry. The waters of the South Esk River are diverted through 2 miles of

tunnel and pipeline to a power station on the Tamar River near Launceston. Three 20,000 kW generators were installed in mid-1955 and a fourth unit has since brought the total capacity of Trevallyn Power Station to 80,000 kW.

(ii) *New Capacity.* The Hydro-Electric Commission is engaged in a progressive construction programme comprising the completion of the Wayatinah " A " project and the construction of the Catagunya and the Great Lake Power Developments. Since 1948, the generating capacity of the system has been increased by 312,850 kW to a total of 485,350 kW and present construction is planned to bring this total to 917,000 kW by 1966. There will still remain very considerable resources for future development, as it is considered that at least 2,400,000 kW can be economically developed.

The Wayatinah Power Development, now nearing completion, will comprise two power stations and headworks to utilize water which is, in the main, already regulated and which has been used several times. The volume of water available is much larger and the head smaller than in the case of other major stations. All the water which has passed through Tarraleah or Tungatinah stations will be diverted, by a weir across the Nive River below Tarraleah, through 4 miles of tunnel and then steel pipes to Wayatinah " A " power station lower down on the Nive River where 83,700 kW will be installed by 1960.

A dam across the River Derwent, just below its junction with the Nive, has created a small lake into which will flow all the water from Wayatinah " A " plus water collected by the Derwent below Clark Dam. One mile of tunnel and one mile of pipeline will lead the water to Wayatinah " B " power station on the Derwent three-quarters of a mile below its junction with the Florentine River. The lower station, Wayatinah " B ", was constructed first and was completed in 1957. Installed capacity is 32,250 kW.

In the Catagunya Power Development, now under construction, a pre-stressed concrete dam on the River Derwent, four miles below Wayatinah " B ", will divert the water through a flume and then steel pipes to the Catagunya power station on the left bank of the river about one-third of a mile downstream where 48,000 kW will be installed by 1962.

The Great Lake Power Development, now in the preliminary stages of construction, is the most recent project to be undertaken by the Commission. In this scheme, the water of the Great Lake, by its diversion in the direction of the most precipitous fall, will be used to much greater advantage than at present. Eventually reaching the South Esk River it will be used again through the generators of the Trevallyn Power Station.

The works will consist of an intake at the Great Lake, a four mile headrace tunnel through the Western Tiers, one mile of surface pipeline on the face of the Tiers, a vertical shaft leading to the power station some 500 feet underground, a two and a half mile tailrace tunnel discharging into a canal, thence through a regulating pond into a channel flowing into the Lake River, a tributary of the South Esk River.

In this development, the power will be generated by the fall of water through a vertical distance of 2,750 feet to an underground power station where generators of 300,000 kW capacity will be installed. The station will be known as Poatina Power Station. A further section of the scheme includes the provision of a dam at Arthur Lakes to increase greatly the storage of the system and a pumping station and a conduit discharging into the Great Lake so that water from this catchment will be utilized through the Poatina Power Station.

There is every indication that the demand for power in Tasmania will continue to increase. The Commission is conducting extensive surveys and investigation of other schemes with a view to further construction after the completion of the present programme.

3. **Power Usage by Secondary Industry.**—The abundant and comparatively cheap supplies of electricity and other natural resources attracted to Tasmania a number of important secondary industries for which energy costs constitute a significant proportion of the total cost of production. Some of the more important organizations and their continuous power demands when plant is operating are as follows:—Electrolytic Zinc Company of Australasia Ltd., 72,735 kW at Risdon and 4,100 kW at Rosebery; Australian Aluminium Production Commission, 34,000 kW; Australian Newsprint Mills Ltd., 20,700 kW; Associated Pulp and Paper Mills Ltd., 14,900 kW; Australian Commonwealth Carbide Company Ltd., 7,800 kW.; and Goliath Portland Cement Company Ltd., 3,350 kW.

§ 7. Commonwealth Territories.

1. **Internal Territories.**—(i) *General.* The electricity supply undertakings at Canberra in the Australian Capital Territory and at Darwin, Katherine, Tennant Creek and Alice Springs in the Northern Territory are operated by the Commonwealth Government.

(ii) *Australian Capital Territory.* The supply authority is the Canberra Electric Supply. Supply was first established at Canberra during 1915 and was met from local steam plant. Connexion to the New South Wales interconnected system was effected in 1929, and all requirements are now taken from this system. Total population served with electricity at 30th June, 1959, was 46,000 and the total number of ultimate consumers was 13,753. Average annual rate of increase of demand since 1947–48 has been 14.13 per cent. and the figure for energy was increased by 13.65 per cent.

During the year 1958–59, the bulk electricity purchase was 103,442,000 kWh and the maximum demand incurred was 26,400 kVA.

(iii) *Northern Territory.* At Darwin, supply was established by the Town Council in October, 1934, but later, during April, 1937, responsibility for generation and supply was transferred to the Northern Territory Administration. The power station is equipped with diesel generating plant of 6,770 kW capacity, two new 970 kW diesel sets being installed in 1955–56 and an additional 1,380 kW diesel set during 1957. At Alice Springs, the Power Station is equipped with diesel generating plant of 1,982 kW capacity, two 230 kW diesel sets being installed in 1956–57 and an additional 520 kW diesel set during 1957–58.

At Katherine, the power station is equipped with a small diesel generating plant of 450 kW capacity. The diesel station at Tennant Creek was closed down in 1957, supply for the township being purchased in bulk from Peko Mines No Liability.

The total number of ultimate consumers served in the Territory was 4,238 in 1958–59.

In 1956–57, the Department of Works selected a site on the water front of Darwin for a 15,000 kW steam driven generating set. This steam station is being designed to supply Darwin and suburbs when the present diesel station has reached its maximum economical capacity. Construction work has been undertaken on preparation of the site and is planned to be completed during 1959–60.

2. **External Territories—Papua and New Guinea.**—Responsibility for the operation and establishment of the electrical undertakings in Papua and New Guinea is vested in the Administration of the Territory of Papua and New Guinea, whose headquarters are located at Port Moresby. The total generating capacity of the diesel engine driven generating sets amounts to 6,389 kW and of the hydro operated sets 3,230 kW. The generating capacity of the power plants at the main centres is—Port Moresby, diesel 2,303 kW, hydro, 3,000 kW; Rabaul, 1,300 kW; Lae, 1,286 kW; Madang, 410 kW; Samarai, 300 kW; Kavieng, 114 kW; Wewak, 150 kW; Lorengau, 76 kW; Goroka, hydro, 200 kW; Aiyura, hydro, 30 kW; and 450 kW distributed among outstations where generating capacity is between 5 kW and 60 kW. The townships of Wau and Bulolo are still supplied by the Bulolo Gold Dredging Co., which operates a hydro-electric plant of 5,500 kW. This power is produced mainly to supply alluvial dredges and, in addition, now supplies power to the plywood mill at Bulolo.

The number of ultimate consumers served was 3,584 in 1955–56, 4,258 in 1956–57, 4,755 in 1957–58 and 5,329 in 1958–59.

Vast hydro-electric potential exists in New Guinea and it has been estimated at 15,000,000 kW, but because of the island's location, absence of large load centres and lack of industrialization, only a small proportion could, at present, be economically developed.

In 1950, the Commonwealth Government joined with the British Aluminium Co. Ltd. of London to locate and develop large capacity hydro-electric schemes in New Guinea. A new company was formed, known as New Guinea Resources Prospecting Co. Ltd., with a capital of £100,000. The Commonwealth Government held 51 per cent. of the shares and had a controlling interest on the board of five members. It was recently announced that the Commonwealth Government had sold its interest to a company which has been formed by Consolidated Zinc Pty. Ltd., and the British Aluminium Co. Ltd. both of London. This company is continuing investigations into the hydro-electric potential with the object of treating bauxite, which is to be mined in the Gulf of Carpentaria.

The following hydro-electric schemes are now in operation: Port Moresby—at Rouna on the Laloki River, generating sets have been established with an initial capacity of 3,000 kW, with provision for expansion to 5,500 kW as stage 2, and to 17,500 kW as stage 3. The power station came into operation in January, 1957. The present project utilizes only portion of the power available from the Laloki River and the economic ultimate development will be of the order of 40,000 kW. At Aiyura, a 30 kW hydro-electric station for the Agricultural Experimental Station, was brought into operation in August, 1956.

At Goroka, two 100 kW hydro-sets are now in operation and a 200 kW set is on order. Investigations are now being carried out to ascertain the possibility of installing an additional 500 kW hydro-set.

Stream gauging and other preliminary investigations for hydro-electric schemes have been carried out at Lae, Rabaul, Madang, Wewak and Highland stations.

There are possibilities for major hydro-electric development in the following localities:—Rouna Falls (near Port Moresby), Upper Snake and Busu-Erap-Leron (near Lae), Upper Ramu (near Markham-Ramu divide—80 miles from Lae) and Hathor Gorge (on Purari River) with an estimated average power of 100,000 kW, 150,000 kW, 2 million kW, 250,000 kW, and 3 million kW respectively. These have estimated run-offs of 1,400; 6,000; 12,000; 1,000; and 75,000 cusecs respectively.

In an area of 150,000 square miles of the Eastern New Guinea mainland, the power potential has been estimated at 150 kW per square mile which compares favourably with potentials of 170 kW per square mile for Switzerland and 95 kW per square mile for Norway.

D. STATISTICAL SUMMARY, 1952-53 AND 1957-58.

The following table shows statistics for each State separately and for the six States combined for 1952–53 and 1957–58 and relates to:—(i) the numbers and installed capacity of central electric generating stations, (ii) the values of production and output and the average numbers of persons employed in the generating side of the electricity supply industry and (iii) the amount of electricity generated and the number of ultimate consumers of electricity.

For further statistics of the electricity supply industry (years 1938–39 and 1953–54 to 1957–58), *see* Chapter VI.—Manufacturing Industry.

CENTRAL ELECTRIC STATIONS.

Particulars.	N.S.W.	Vic.	Q'land.	S. Aust.	W. Aust.	Tas.	Total.
1952–53.							
Generating Stations—							
Government .. No.	18	11	..	7	8	5	49
Local Authority ,,	36	33	43	14	37	..	163
Companies .. ,,	32	24	9	21	50	1	137
Total	*86*	*68*	*52*	*42*	*95*	*6*	*349*
Installed Capacity of Generators—							
Steam .. '000 kW	1,133	608	304	(*a*)	136	(*a*)	2,435
Hydro .. ,,	35	52	4	(*a*)	..	(*a*)	313
Internal combustion ,,	91	35	41	(*a*)	45	(*a*)	224
Total	*1,259*	*695*	*349*	(*a*)	*181*	(*a*)	*2,972*
Persons employed(*b*) No.	4,851	2,608	1,176	(*a*)	1,003	(*a*)	10,891
Value of output(*c*) £'000	26,762	14,095	7,599	(*a*)	5,110	(*a*)	60,083
Value of production(*d*) ,,	10,606	6,352	2,566	(*a*)	2,200	(*a*)	24,582
Electricity generated(*e*) million kWh	4,868	3,193	1,349	822	569	1,244	12,045
Ultimate consumers(*f*) No.	897,286	655,055	290,179	199,149	110,521	93,100	2,245,290

CENTRAL ELECTRIC STATIONS—*continued.*

Year.	N.S.W.	Vic.	Q'land.	S. Aust.	W. Aust.	Tas.	Australia.
			1957–58.				
Generating Stations—							
Government .. No.	28	17	1	7	11	8	72
Local Authority ,,	25	17	57	11	36	..	146
Companies .. ,,	19	17	2	20	40	3	101
Total	*72*	*51*	*60*	*38*	*87*	*11*	*319*
Installed Capacity of Generators—							
Steam .. '000 kW	1,681	877	518	(*a*)	240	(*a*)	3,705
Hydro .. ,,	155	237	43	(*a*)	2	(*a*)	933
Internal combustion ,,	92	47	36	(*a*)	57	(*a*)	243
Total	*1,928*	*1,161*	*597*	(*a*)	*299*	(*a*)	*4,881*
Persons employed(*b*) No.	5,558	3,247	1,605	(*a*)	1,070	(*a*)	12,833
Value of output(*c*) £'000	44,312	25,536	12,055	(*a*)	7,038	(*a*)	100,515
Value of production(*d*) ,,	26,283	13,706	5,260	(*a*)	3,318	(*a*)	55,514
Electricity generated(*e*) million kWh	7,595	5,321	2,133	1,580	829	2,338	19,796
Ultimate consumers(*f*) No.	1,067,205	816,411	367,600	264,000	144,864	111,650	2,771,730

(*a*) Not available for publication; included in the total for Australia. (*b*) Average employment in generating station, over whole year, including working proprietors. (*c*) Value, at generating station, of electricity produced plus certain earnings. (*d*) Value added in the process of generation. (*e*) Total generated including that generated by factories for their own use. (*f*) Approximate figures supplied by the electricity authority in each State. An "ultimate consumer" is a person, business, undertaking, etc., that has contracted to receive electric power from a public or private organization supplying this service. The number of ultimate consumers is not identical with the number of persons served with electricity because one ultimate consumer may represent three or four persons, e.g. in a household.

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. Ulrich Ellis of Canberra. 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 259–265 of this Year Book and a map showing the extent of known artesian basins throughout Australia is shown on page 257.

§ 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, 1959:—The list is confined to dams and reservoirs with a capacity of 100,000 acre feet or more. There are, in addition, many other dams and reservoirs 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	(a)3,500,000	381	Part of Snowy Mountains Hydro-electric Scheme.
Eildon	Upper Goulburn River, Victoria	2,750,000	250	Storage for irrigation and for the generation of electricity.
Hume	Murray River near Albury	1,800,000	176	Part of Murray River Scheme—storage for domestic, stock and irrigation purposes. Being increased to 2,500,000 acre feet. Hydro-electric power also developed.
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.

(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.*				
Lake Echo ..	Lake Echo, Tasmania	(*a*)412,200	60	Storage for Lake Echo and Tungatinah hydro-electric power stations.
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.
Wyangala ..	Lachlan River, New South Wales	303,900	190	Storage for domestic, stock and irrigation purposes and for generation of hydro-electric power.
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.
Avon	Avon River, New South Wales	173,800	232	Part of Sydney water supply.
Glenmaggie ..	Gippsland, Victoria	154,300	100	Storage for irrigation.
Lake St. Clair ..	Central Highlands, Tasmania	(*a*)154,200	..	Improved natural storage for Tarraleah hydro-electric power station.
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.				
Menindee Lakes Project	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	1,694,900	379	For Sydney water supply. Also provides for generation of hydro-electricity and flood mitigation.
Burrendong ..	Macquarie River, near Wellington, New South Wales	1,361,000	240	For rural water supplies, flood mitigation and possible hydro-electric power generation.
Keepit	Namoi River, near Gunnedah, New South Wales	345,000	177	For rural water supplies and hydro-electricity generation.
Tantangara ..	Murrumbidgee River, New South Wales	(*a*)193,000	148	Part of Snowy Mountains Hydro-electric Scheme.
Wellington ..	Collie River, Western Australia	150,000	112	Existing dam is being enlarged for supply of water to irrigation districts and to agricultural areas and towns.
Koombooloomba ..	Tully River, North Queensland	146,000	123	For hydro-electric and possibly irrigation purposes.
DAMS AND RESERVOIRS PROJECTED.				
Burdekin Falls ..	Burdekin River, North Queensland	6,584,000	150	For generation of hydro-electric power, irrigation and flood mitigation.
Blowering ..	Tumut River, New South Wales	800,000	250	Part of Snowy diversion scheme, for irrigation and hydro-electric 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	400,000	100	Flood mitigation 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 1009.

(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, fodders, 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, fodders, and pastures are served. Large scale irrigation schemes have not been developed in Tasmania or the Northern Territory although reference is made on page 282 to investigations 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 1954–55 to 1958–59:—

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.
1954–55 ..	616,264	863,563	139,414	69,452	36,130	13,761	151	791	1,739,526
1955–56 ..	379,611	634,334	136,019	70,987	37,164	11,499	225	774	1,270,613
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

(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 1958–59 according to the nature of irrigated culture:—

AREA OF LAND IRRIGATED, 1958-59.

(Acres.)

Crop.	N.S.W. (a)	Vic. (b)	Q'land.	S. Aust.	W. Aust.	Tas.	N.T.	A.C.T.	Aust.
Rice	47,054	..	..	..	..	..	(c)	..	47,054
Vegetables ..	15,828	18,595	26,597	10,675	8,211	1,386	95	176	81,563
Fruit	22,134	35,349	4,876	20,795	6,850	1,737	50	13	175,129
Vineyards ..	13,039	44,267		25,389	630	..	..	..	
Sugar-cane ..	(d)	..	65,613	..	..	..	..	..	65,613
Hops	..	(d)	..	..	..	1,292	..	..	1,292
Cotton	..	..	1,520	..	..	..	..	..	1,520
Other Crops (including Fodder and Fallow land)	116,531	39,050	(e)45,625	6,975	3,429	1,514	114	664	213,902
Total, Crops	*214,586*	*137,261*	*144,231*	*63,834*	*19,120*	*5,929*	*259*	*853*	*586,073*
Pastures ..	426,775	(f)828,505	10,402	(g)21,247	24,982	7,502	15	371	1,319,799
Total ..	641,361	965,766	154,633	85,081	44,102	13,431	(h) 274	1,224	1,905,872

(a) Source: Water Conservation and Irrigation Commission. (b) Source: State Rivers and Water Supply Commission. (c) Not available for publication. (d) Included in Other Crops. (e) Includes Tobacco, 7,490 acres. (f) Includes lucerne for both hay and pasture. (g) Includes lucerne for pasture. (h) 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)—horticultural problems, particularly of the dried vine fruits industry; Griffith (New South Wales)—the influence of irrigation on plant life (using horticultural trees as test plants), irrigation methods, land drainage and soil structure; 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 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 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.* There is no national body in Australia concerned with Commonwealth-wide research into and delineation of underground water resources. However, the Australian Academy of Science, in 1956, instituted a Standing Committee on Hydrology; as a result of discussions by this committee, the Academy, in 1958, recommended the need for such a body. The Commonwealth Government subsequently convened, in 1959, a meeting of interested Government agencies from all States to discuss the need for a permanent Commonwealth and States Conference on Underground Water and the need for the appointment of more Government hydro-geologists. The meeting acknowledged both these needs; its decisions are being considered by the respective Governments.

Although there is no national co-ordinating body, the various States and Territories do maintain Geological Surveys and Water Commissions which are continually extending the knowledge of their own States.

As a result a more or less complete general picture of the available and potential surface water resources exists, but much remains to be done with regard to the location and development of sub-surface supplies (artesian, sub-artesian and ground water), in view of their importance as the basis of settlement over large areas of Australia.

The extent of the artesian basins—particularly the Great Artesian Basin—has been determined fairly accurately while the use of sub-artesian supplies is extensive and more development is possible. The shallower ground-water supplies, however, particularly along alluvial valleys and coastal sandbed areas, have not been investigated or developed to any degree, except in a few localities.

(ii) *Artesian and Sub-artesian Supplies.* Pressure water, variable in quantity and quality, either artesian or sub-artesian, is obtainable in many parts of Australia, the various artesian basins extending over approximately one-third of the continent. A map of Australia showing the extent of the known artesian basins appears on page 257 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, 80,000 in New South Wales, 120,000 in South Australia and 40,000 in the Northern Territory. Of the numerous defined major and minor water-bearing basins in Australia, the following are the principal:—

PRINCIPAL WATER-BEARING BASINS: 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
Desert and Fitzroy	Western Australia	Mesozoic-Palaeozoic	160,000	100 to 1,500
Murray ..	Victoria, New South Wales and South Australia	Miocene-Oligocene ..	107,000	100 to 900
Eucla	Western Australia, South Australia	Pliocene-Miocene ..	68,000	300 to 2,000
Barkly ..	Northern Territory, Queensland	Cretaceous, Cambrian and Upper Precambrian	57,000	150 to 1,000
North-west ..	Western Australia	Cretaceous, Permian..	40,000	230 to 4,000
South-west ..	Western Australia	Recent, Jurassic ..	10,000	200 to 2,500
Pirie-Torrens ..	South Australia..	Recent, Pleistocene ..	4,000	Up to 600
East Gippsland ..	Victoria ..	Pleistocene-Oligocene	2,500	200 to 1,800
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 it is unsuitable for plant life, while in certain areas sub-artesian waters are suitable for all uses including irrigation. In some districts, a considerable amount of irrigation is carried out from shallow ground-water supplies.

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, many will not cease, but will assume a perpetually steady rate of flow, corresponding with the average intake of water from rainfall absorbed by sandstone outcrops. 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) *Ground Water.* Ground water 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 5 million gallons a day for its own use from similar sands.

Recent exploration of the coastal sands north of the Tomago Sands has revealed a further potential production of 25 million gallons a day.

§ 3. National and Interstate Aspects.

1. **General.**—As the Commonwealth Constitution makes special reference to water problems, 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 resides in 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.

In the Report on Irrigation, Water Conservation and Land Drainage presented to the Commonwealth Government by the Rural Reconstruction Commission in 1945, national aspects of water conservation and use were emphasized. The report recommended that, to obviate lack of co-ordination, an all-Australian plan having the assent of the various governments be adopted, and that the Commonwealth should endeavour to promote interstate co-operation and co-ordinated development generally.

In 1946, a conference between the Commonwealth and States agreed to revive the Irrigation Production Advisory Committee first established under the authority of the Australian Agricultural Council in 1938. Its functions are:—(*a*) to prepare for the consideration of the Australian Agricultural Council or any Committee of Ministers appointed by the Council, conclusions formed from investigations to be carried out by Commonwealth and State Officers into the various agricultural industries which it is possible to develop on irrigated lands; (*b*) to undertake long-term co-ordination of land utilization in irrigable areas served by the River Murray and its tributaries, involving co-ordination of all available lands and the carrying out of such supplementary investigations as may prove necessary.

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 Murrumbidgee (980 miles), the Darling (1,700 miles), and the Goulburn (280 miles). The average annual flow of each of the chief contributory streams is as follows:—Upper Murray, including the Mitta Mitta and Kiewa Rivers, 3,506,000 acre feet; Murrumbidgee River, 2,280,000 acre feet; Goulburn River (including Broken River), 2,502,000 acre feet; Darling River, 2,224,000 acre feet; and Ovens River, 1,169,000 acre feet. Irrigated production in the River Murray basin is mainly in the form of 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 for irrigation 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. 248) 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 further increases would best be provided 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 River Murray 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 River Murray, 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 1958–59 from the Murray and its tributaries for irrigation and other purposes under the River Murray Agreement was as follows:—New South Wales, 2,155,000; Victoria, 2,576,000; South Australia, 260,000; a total of 4,991,000 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 33,000 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 is approximately one mile. Work is nearly completed on the enlargement of the reservoir to its approved capacity of 2,500,000 acre feet. The fixed spillway was completed to its final level in May, 1957, and installation of flood gates to raise the level a further 24 feet was completed in September, 1958. The anchoring of the concrete section of the dam to the underlying rock by prestressed cables was still in progress in September, 1959. On completion of this work, the storage may be raised to its approved capacity. In the meantime, the storage can be progressively increased as work proceeds.

The Yarrawonga Diversion Weir was completed in 1939 to raise 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, and will 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, and is designed 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. Work has recently been completed on the enlargement of the inlet channel to Lake Victoria 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—Burrinjuck (Murrumbidgee), 837,000 acre feet; Wyangala (Lachlan), 303,900 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.

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 in the Macintyre River at Goondiwindi and the existing weir in 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. Exploratory drilling of the tributary sites is now in progress.

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 is at present under construction on the Barwon River at the offtake of the Boomi River. The construction of a low level weir to establish a pumping pool at Glenarbon on the Dumaresq River was complete at 30th June, 1959, except for the installation of a fish ladder. 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

* *See also* Chapter VII.—Electric Power Generation and Distribution, p. 216. 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.

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.

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 transmountain diversions and the associated power works together with details of progress and construction are given in Chapter VII.—Electric Power Generation and Distribution.

Commencing in the 1960–61 irrigation season, the Scheme will make available an additional 170,000 acre feet of water each year for irrigation in the Murrumbidgee Valley. During 1963, this will increase to 500,000 acre feet per annum. 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 additional annual primary production to the value of some £30 million per annum.

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 appertains 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.* In issue No. 37 of the Year Book (p. 1110), 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, 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 248 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 and Lake Brewster on the Lachlan, a tributary of the Murrumbidgee, and by Glenbawn Dam on the Hunter 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 head storages have been commenced on the Macquarie and Namoi Rivers whilst Menindee Lakes storage, to conserve the waters of the Darling River, is being constructed. 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 seven irrigation areas:—The Murrumbidgee Irrigation Areas consisting of 451,251 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 10,549 acres, supplied from the Murray by pumping; the Hay Irrigation Area of 6,806 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; and the recently established Buronga (8,693 acres) and Mallee Cliffs (1,900 acres) Irrigation Areas served by pumping from the Murray. 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:—

Murray:—Half share of Hume Reservoir, weirs and locks to Wentworth (1,011,420); Stevens Weir, Edward River (7,165).

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

Lachlan:—Wyangala Dam (303,900); 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 rice and other cereals and for pastures in the Tullakool Irrigation Area, for domestic and stock supply and irrigation in the Berriquin, Wakool 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 river (over 700 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 224,556 acres. Proposals for future development include provision of a head storage on the Belubula River.

The approximate total length of channels (including main canals) constructed by the Water Conservation and Irrigation Commission in New South Wales is 3,247 miles. The approximate length of drains and escape channels is 1,000 miles, and the total length of pipe lines is approximately 68 miles, making a grand total of 4,315 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 1958–59:—

AREAS OF SYSTEMS AND OF LAND IRRIGATED: NEW SOUTH WALES, 1958-59.

(Acres.)

System, etc.	Total Area.	Area Irrigated.										
		Rice.	Other Cereals Grown for Grain.	Lucerne. (a)	Other Fodder Crops.	Pastures.		Vineyards.	Orchards. (c)	Vegetables.	Fallow Land and Miscellaneous.	Total.
						Sown. (b)	Natural.					
Irrigation Areas—												
Murrumbidgee (within the Areas) ..	451,251	28,021	8,309	3,008	2,733	66,649	2,407	5,191	14,624	3,842	18,610	153,394
Lands adjacent supplied under agreement	(d)	..	..	89	7	186	1,560	2	73	4	..	1,921
Coomealla	34,672	..	..	6	..	..	..	4,292	944	..	..	5,242
Curlwaa	10,549	..	..	..	40	..	..	479	1,055	..	..	1,574
Hay	6,806	..	..	58	186	1,591	77	..	..	..	..	1,912
Tullakool	18,006	1,021	130	60	10	6,580	..	..	..	..	335	8,136
Total	*e 521,284*	*29,042*	*8,439*	*3,221*	*2,976*	*75,006*	*4,044*	*9,954*	*16,696*	*3,846*	*18,945*	*172,179*
Irrigation Districts—												
Benerembah ..	112,818	5,345	5,012	1,107	705	16,580	..	..	..	..	3,940	32,689
Tabbita	10,745	297	..	50	267	1,610	400	..	..	..	20	2,644
Wah Wah	575,224	..	1,360	1,440	1,390	8,250	..	..	..	..	1,750	14,190
Berriquin	781,152	..	6,400	13,768	1,750	201,792	2,250	..	..	10	2,270	228,240
Wakool	494,708	6,364	1,750	1,519	1,242	55,596	630	..	..	20	810	67,931
Denimein	147,005	2,486	1,185	1,380	90	10,650	200	..	12	..	760	16,763
Jemalong and Wylde's Plains	224,556	..	90	6,832	..	3,025	..	..	..	..	393	10,340
Gumly	353	..	39	76	8	37	..	..	19	45	..	224
Deniboota	307,212	3,520	630	1,139	505	16,392	160	..	..	..	1,195	23,541
Total	*2,653,773*	*18,012*	*16,466*	*27,311*	*5,957*	*313,932*	*3,640*	..	*31*	*75*	*11,138*	*396,562*
Flood Control Districts—												
Lowbidgee	375,000	..	..	..	..	..	(f)94,118	..	..	..	..	(f)94,118
Medgun	272,800	..	..	..	..	..	(f)61,760	..	..	..	..	(f)61,760
Total	*647,800*	..	..	..	..	..	*f 155,878*	..	..	..	..	*f 155,878*
Irrigation Trusts—												
Pomona	1,580	..	..	..	..	..	..	770	130	..	..	900
Bringan	4,933	..	..	..	..	..	..	..	..	..	..	(d)
Bungunyah-Koraleigh	1,810	..	..	..	..	..	..	990	72	80	..	1,142
Glenview	661	..	..	..	..	..	..	..	..	..	..	(d)
Goodnight	1,167	..	..	..	..	..	..	548	41	2	10	601
Bama	3,446	..	..	..	..	..	..	..	..	..	..	(d)
Blairmore ..	315	..	..	..	..	..	..	..	..	..	..	(d)
Total(e) ..	*13,912*	..	..	..	..	..	..	*2,308*	*243*	*82*	*10*	*2,643*
Water Trusts—Domestic and stock supplies .. Licensed Diversions(g)—	*2,909,456*	..	..	..	..	..	..	..	..	..	..	..
To irrigate	(d)	..	..	*16,145*	*5,338*	*25,668*	*4,485*	*767*	*5,164*	*11,285*	*(h) 585*	*69,977*
Grand Total(e) ..	(d)	47,054	24,905	46,677	14,271	414,606	168,047	13,039	22,134	15,828	30,678	*i* 797,239

(a) Includes grazing and cutting. (b) Perennial and annual self-seeding. Perennial amounted to 53,042 acres. (c) Citrus and deciduous. Deciduous amounted to 9,277 acres of which 7,795 acres were in the Murrumbidgee Irrigation Area. (d) Not available. (e) Incomplete. (f) Area irrigable; details of area actually irrigated are not available. (g) Excludes domestic and stock supplies for which particulars are not available. (h) Tobacco. (i) Includes Flood Control Districts; but excludes some Irrigation Trusts for which information is not available.

3. **Murrumbidgee Irrigation Areas.**—(i) *Description.* These areas together with adjacent lands supplied under agreement, received 288,412 acre-feet, or about a quarter, of the total water (1,183,989 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 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 and spring freshets, fed by melting snows, 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 802 miles. In addition, approximately 446 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, but land transactions are not under its control.

The land on which the Murrumbidgee Irrigation Areas are situated originally comprised large sheep stations and was sparsely populated. Population was 12,000 in 1923, 15,000 in 1929, 20,000 at the 1947 Census and 24,000 at the 1954 Census. At the 1954 Census, the population of the Yanco District (with Leeton as the centre) was 10,000 and the population of the Mirrool Area (with Griffith as the centre) was 14,000. At 30th June, 1958, the population of Leeton Shire was estimated at 10,400, and that of Wade Shire at 15,450.

(ii) *Administration.* The Water Conservation and Irrigation Commission control land transactions and water supplies for the Murrumbidgee Irrigation 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, 1959, was 382,970 acres, including 39,171 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 1958–59, the total area sown was 28,021 acres and the total quantity of water delivered for the rice crops was 146,697 acre feet. In a normal season, the water supplied for rice represents about one-half of the total delivered to the Murrumbidgee Irrigation Areas.

Co-operation is a prominent feature in the Murrumbidgee Areas. Co-operative organizations in the Mirrool section handle about 300,000 bushels of fruit a year (compared with 54,600 in 1927–28). The annual sales turnover of the Leeton cannery in recent years has exceeded £2,000,000. Settlers and government agencies co-operate extensively in all matters relating to irrigation practice.

4. **Other Irrigation Areas.**—The Curlwaa, Coomealla, Hay, Buronga, Mallee Cliffs and Tullakool 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 also is responsible for the operation and maintenance of works to supply water.

Curlwaa Area, on the Murray near Wentworth, consists of 10,549 acres of which 7,815 acres were occupied at 30th June, 1959. Production consists of dried vine fruits, deciduous fruits and fodder crops.

Coomealla Area, 9 miles upstream from Curlwaa, comprises 34,672 acres of which 31,013 acres were occupied at 30th June, 1959. Production consists of vine and citrus fruits. An extension of the Coomealla Irrigation Area was completed in recent years to provide irrigation farms for ex-servicemen and 100 ex-servicemen were placed on the new farms.

Tullakool Area, formerly part of the Wakool Irrigation District, comprises 18,006 acres of which 14,311 acres are occupied. Main products are fat lambs, wheat and rice.

Hay Area, on the lower Murrumbidgee, consists of 6,806 acres, of which 6,241 acres are occupied. Production comprises dairy products, fat lambs, sheep, wool and fodders.

Buronga Area, a new area on the Murray River, upstream from Wentworth, consists of 8,693 acres, of which 1,151 acres are occupied. Production will be mainly fruit, vegetables and dairy products. Mallee Cliffs is also a new area upstream from Wentworth, its area being 1,900 acres, of which 1,332 acres are occupied.

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 (completed) 494,708 acres, Berriquin Provisional District 781,152 acres, Deniboota Provisional District 307,212 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* (completed)—Benerembah District 112,818 acres, Tabbita District 10,745 acres, Wah Wah District 575,224 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, 1959, the total length of completed canals and channels in Berriquin District was 970 miles, including Mulwala canal 75 miles, Berrigan channel 22 miles, subsidiary channels 767 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 384 miles of channel, contains 308 holdings and the area developed by irrigation comprises about one acre in eight of the total area. The total area irrigated in 1958–59 was 67,931 acres and water supplied was 110,314 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 228,240 at 30th June, 1959. Sheep and wheat growing are the main industries. The fat lamb industry is well developed and expanding. Dairying is making headway, and a butter factory has been established at Finley.

In the Benerembah, Tabbita and Wah Wah Districts, supplied from the channels of the Murrumbidgee Irrigation Areas, the quantity of water supplied during the 1958–59 season for irrigation, etc., was 95,864 acre feet, and the area irrigated was 49,523 acres, including rice and other cereals, pastures, and fodder crops.

For the same season, 8,468 acre feet of water were supplied from the Lachlan River to irrigate a total area of 10,340 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*—Tuppal Creek (78,080), Bullatale Creek (68,320), Little Merran Creek (157,440), Poon Boon (34,300), Minnie Bend Flood Prevention (2,190); *Murrumbidgee River*—Yanco, Colombo and Billabong Creeks (1,001,210); *Lachlan River*—Torriganny, Muggabah and Merrimajeel Creeks (170,240) Condobolin West Weir (4,480), Marrowie Creek (292,640), Ulonga (64,960), Micabil Weir (11,500); *Miscellaneous*—Algudgerie Creek (9,760), Nidgery Weir (46,880), Great Ana Branch of Darling River (967,339), Collarenebri town water supply (117)—making in all a total area of 2,909,456 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*—Bama (3,446), Goodnight (1,167), Bungunyah–Koraleigh (1,810), Glenview (661), Bringan (4,933); *Darling River*—Pomona (1,580); *Hunter River*—Blairmore (315)—making in all a total area of 13,912 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. There are 50 holdings. Another district, Medgun (272,800 acres) near Moree in the North-West is also in operation. There are 20 holdings in the district and the area benefited by controlled floodings is 61,760 acres.

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.

8. **Underground Water.**—Extensive use is made of artesian, sub-artesian, and shallow underground water. Eighty thousand square miles in the northern and western portions are covered by the Great Artesian Basin. Eighty-one 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 about 5 million acres and water is distributed through approximately 7,400 miles of open earth drains. The number of artesian bores giving a flowing or pumping supply at 30th June, 1959, was 1,071 and the estimated total daily flow from 600 flowing bores was 61 million gallons. The estimated flow in 1914–15 was 99 million gallons a day for 372 bores. The deepest bore is Boronga No. 2 (4,570 feet), which also has the greatest flow, namely, 1,010,200 gallons a day. Of the total number of bores sunk, 246 have been installed by the Government in connexion with public watering places, Bore Water Trusts or Artesian Wells Districts.

Of other structural basins of sedimentary rocks, e.g. Murray, Cumberland, 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 sandstones 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 water supply, the Botany sands are now utilized mainly by industry. The Tomago sands provide a considerable proportion of 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 13,000 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, 1959, the number sunk by the Commission's plants was 4,961 and their average depth was 308 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 and Keepit Dam on the Namoi River is nearing completion. Legislation has been passed authorizing the construction of a flood control and irrigation dam at Warkworth in the Hunter Valley and a storage dam at Blowering on the Tumut River. The Menindee Lakes storage project, part of the scheme for conserving the waters of the Darling River, is in course of construction. 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, 1959, work was completed on construction of a diversion weir at Gogeldrie on the Murrumbidgee River from which water will be supplied to a new irrigation area (Coleambally) on the south side of the river comprising not less than 1,000 new irrigation farms. At Wyangala Dam, on the Lachlan River, work has commenced on the temporary lowering of the fixed crest of the dam spillway to enlarge the spillway for passage of greater floods. Investigations are being made concurrently to determine whether the dam can be increased in height to provide a greater storage. Later development will extend to a new area on the north side of the river.

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. 222).

§ 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.**—Since 1902, when a great drought emphasized the need for a concerted attack on water problems, the total capacity of water storages including Victoria's half share of River Murray storages has increased from 172,000 to 5,246,850 acre feet at 30th June, 1959. Most of the water from these storages is used for irrigation.

The area actually irrigated has risen from 105,000 acres in 1906 to 965,766 acres in 1958–59 to which 1,220,971 acre feet of water were delivered. The Commission estimated the value of irrigated production in 1957–58 at £53,000,000 representing about one-sixth of the value of Victoria's total rural production.

Town water supply and sewerage works have expanded to the stage where two-thirds of the population outside the metropolitan area is served by a reticulated water supply and one-third is served by a sewerage system. Land drainage, flood protection and river improvement have also been advanced.

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.

Besides supplying water to its own irrigation districts, the Commission also supervises the diversion of water by private persons by means of licences and permits. In the last ten years, the area so licensed has increased by 50 per cent. and private diverters now provide an eighth of the irrigation production.

Another notable development in the post-war years has been Soldiers' Settlement Schemes based on irrigation. Altogether, nearly one thousand holdings have been prepared for settlers, including more than 500 in the Murray Valley District, 250 at Robinvale and 125 in Gippsland.

3. **Storages.**—The capacities of the main storages in the various systems (in acre feet) at 30th June, 1959, were as follows:—

Goulburn System:—Eildon Reservoir, 2,750,000; Waranga Reservoir, 333,400; Total, 3,104,100; *Murray–Loddon System*:—Half share of River Murray storages, 1,011,420; Cairn Curran, 120,600; Tullaroop, 60,000; Total, 1,340,230; *Wimmera-Mallee*:—Rocklands, 272,000; Total, 538,900; *Gippsland*:—Glenmaggie, 154,300; Total, 154,340; *Coliban*:—62,730; *Werribee-Bacchus Marsh*:—34,900; *Mornington Peninsula*:—5,800; *Otway*:—1,080; *Miscellaneous*:—4,770; *Grand Total*:—5,246,850.

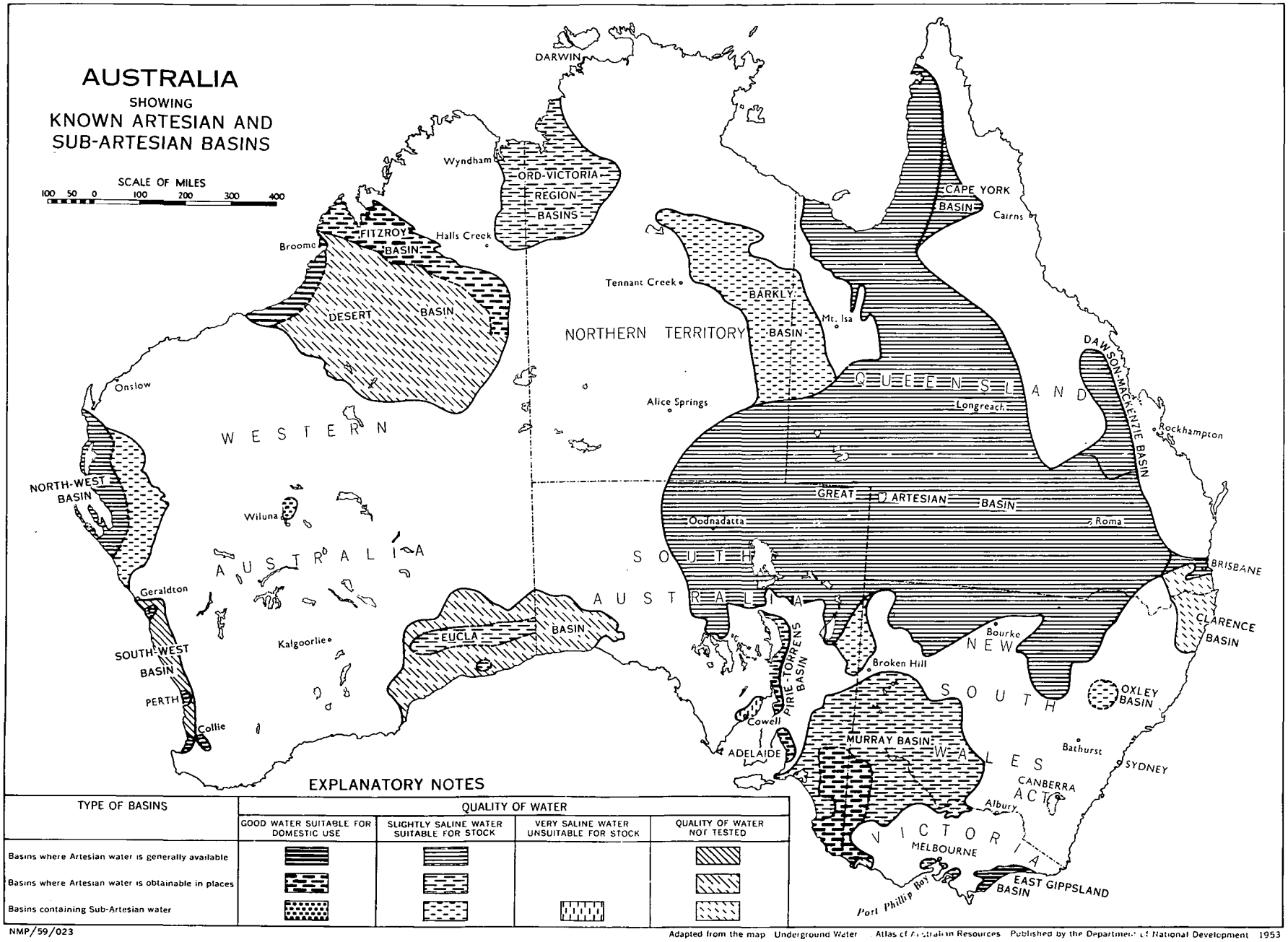
4. **Extent of Systems and Nature of Irrigated Culture.** The following table shows the areas of the various irrigation systems and the areas under irrigated culture during 1958–59.

AREAS OF SYSTEMS AND OF LAND IRRIGATED: VICTORIA, 1958-59.

(Acres.)

System.	Total Area.	Area Irrigated.									
		Cereals.	Lucerne. (a)	Other Fodder Crops.	Pastures.		Vineyards.	Orchards.	Market Gardens.	Fallow and Miscellaneous.	Total.
					Sown.	Natural.					
Goulburn	*1,256,955*	*4,508*	*12,330*	*4,801*	*336,819*	*21,547*	*197*	*18,356*	*2,118*	*6,081*	*406,757*
Murray—											
Torrumbarry Weir ..	377,544	2,651	3,811	3,346	156,272	30,437	4,860	1,086	1,400	2,936	206,799
Yarrawonga Weir ..	267,812	68	10,307	648	81,080	4,455	32	4,375	374	20	101,359
By Pumping ..	35,727	50	277	14	569	527	23,997	1,682	262	371	27,749
Total	*681,083*	*2,769*	*14,395*	*4,008*	*237,921*	*35,419*	*28,889*	*7,143*	*2,036*	*3,327*	*335,907*
Loddon and other Northern Systems ..	*(b) 19,735*	*936*	*2,342*	*983*	*24,500*	*3,341*	..	*3,585*	*361*	*1,929*	*37,977*
Southern Systems ..	*146,693*	*412*	*1,797*	*912*	*54,878*	*2,812*	..	*578*	*6,313*	*2,135*	*69,837*
Mildura and Private Diversions	*(c) 45,000*	*811*	*7,888*	*4,524*	*62,833*	*9,683*	*15,181*	*5,687*	*7,767*	*914*	*115,288*
Grand Total ..	**2,149,466**	**9,436**	**38,752**	**15,228**	**716,951**	**72,802**	**44,267**	**35,349**	**18,595**	**14,386**	**965,766**

(a) Includes lucerne for both hay and pasture. (b) Area of Campaspe District only. (c) Area of First Mildura Irrigation Trust only.

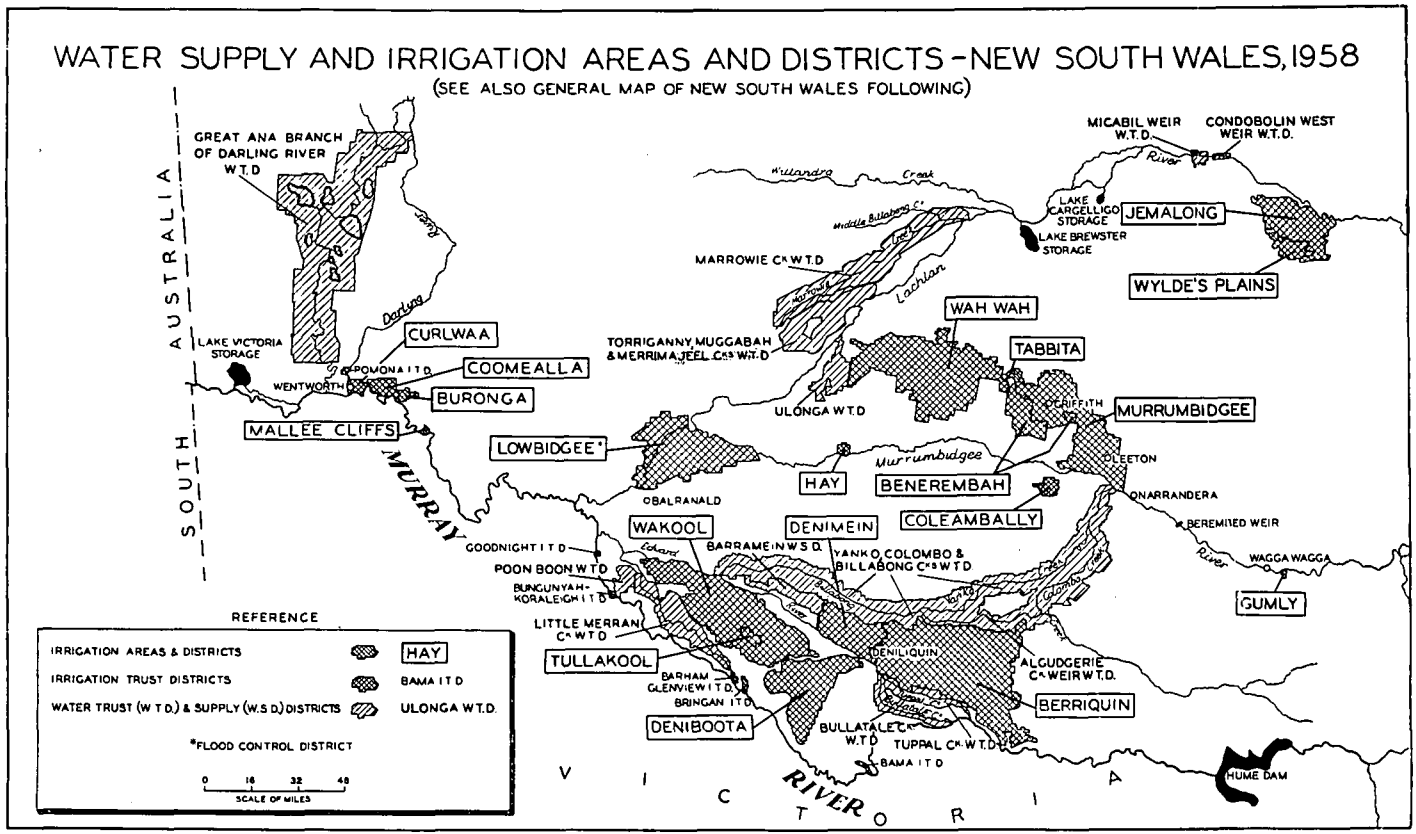


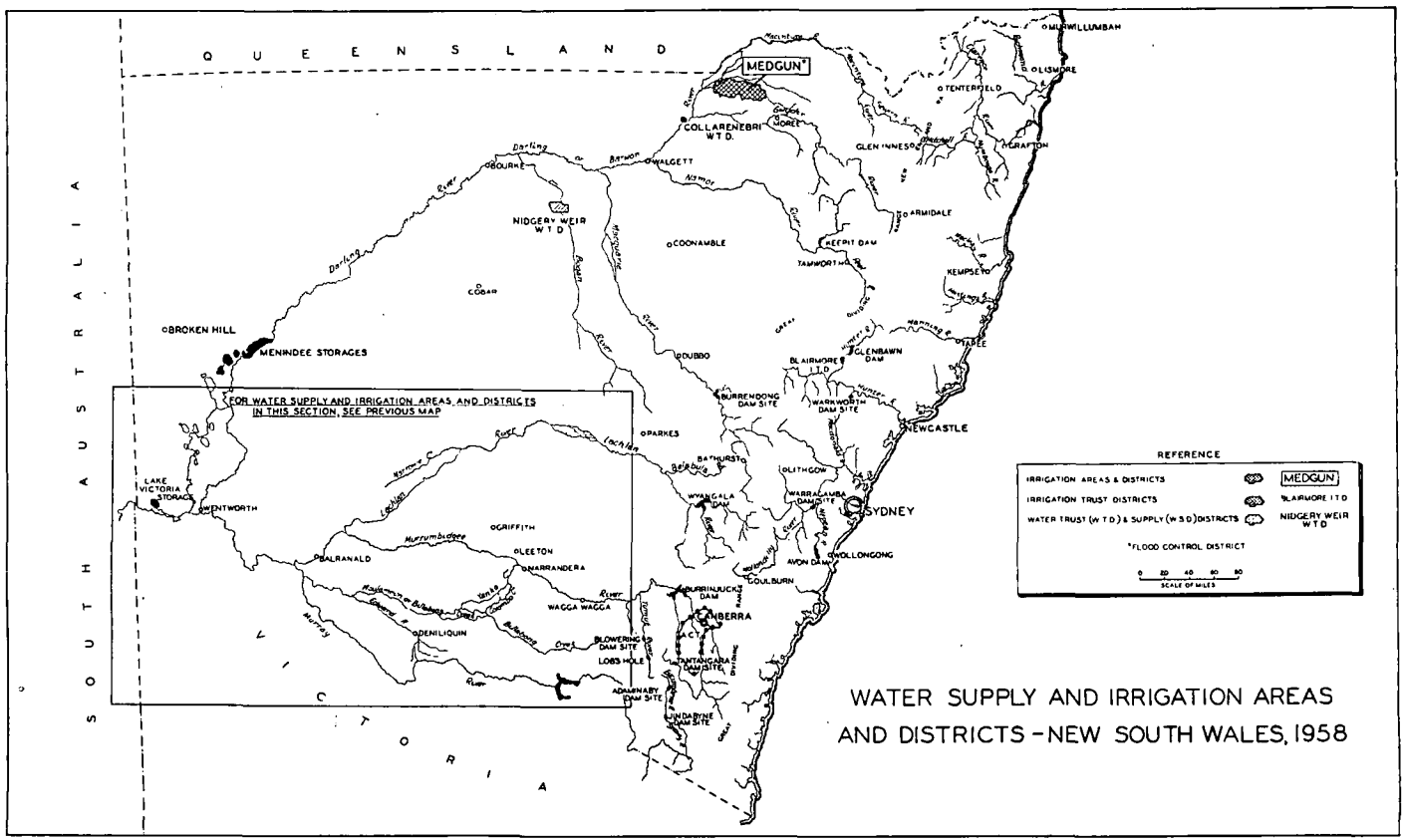
EXPLANATORY NOTES

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				

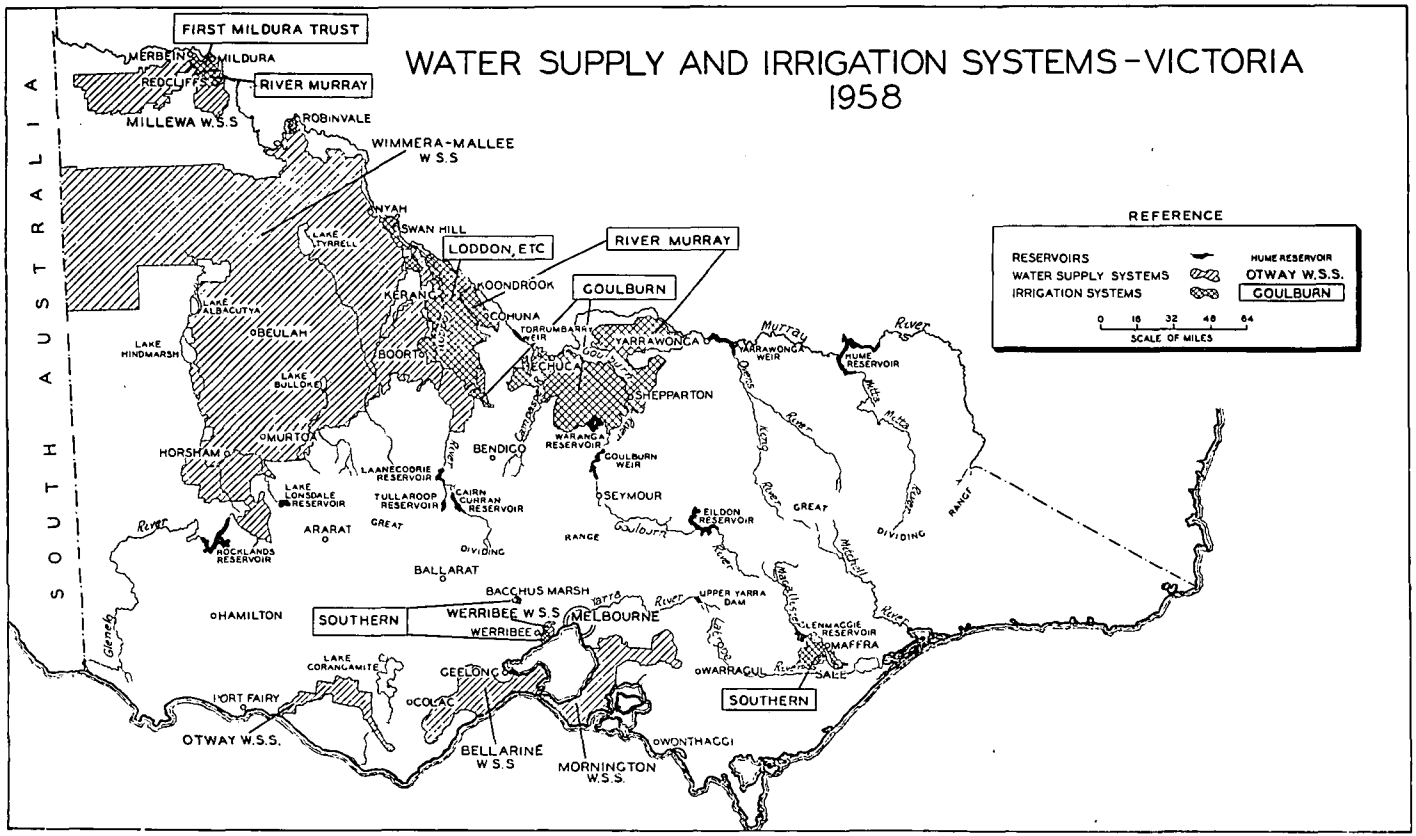
NMP/59/023

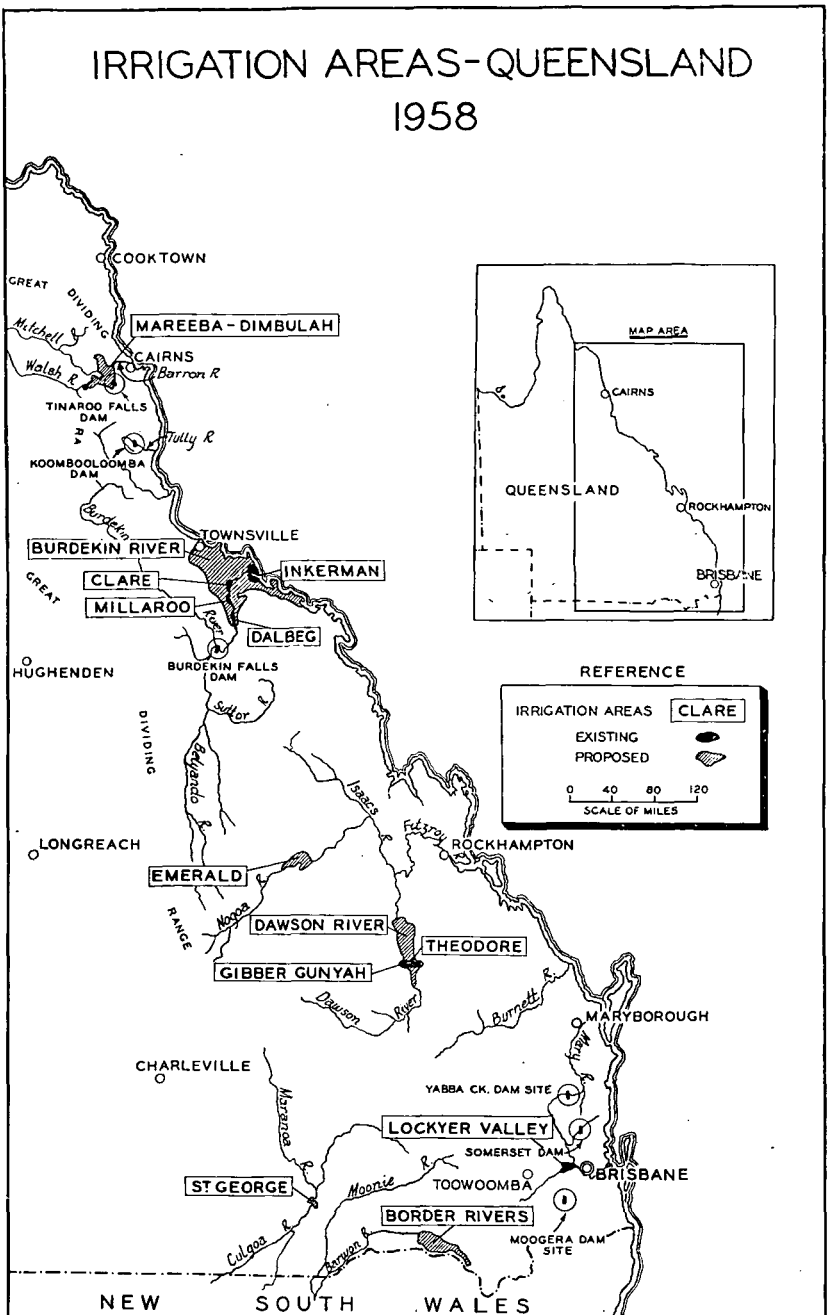
Adapted from the map Underground Water Atlas of Australian Resources Published by the Department of National Development 1953

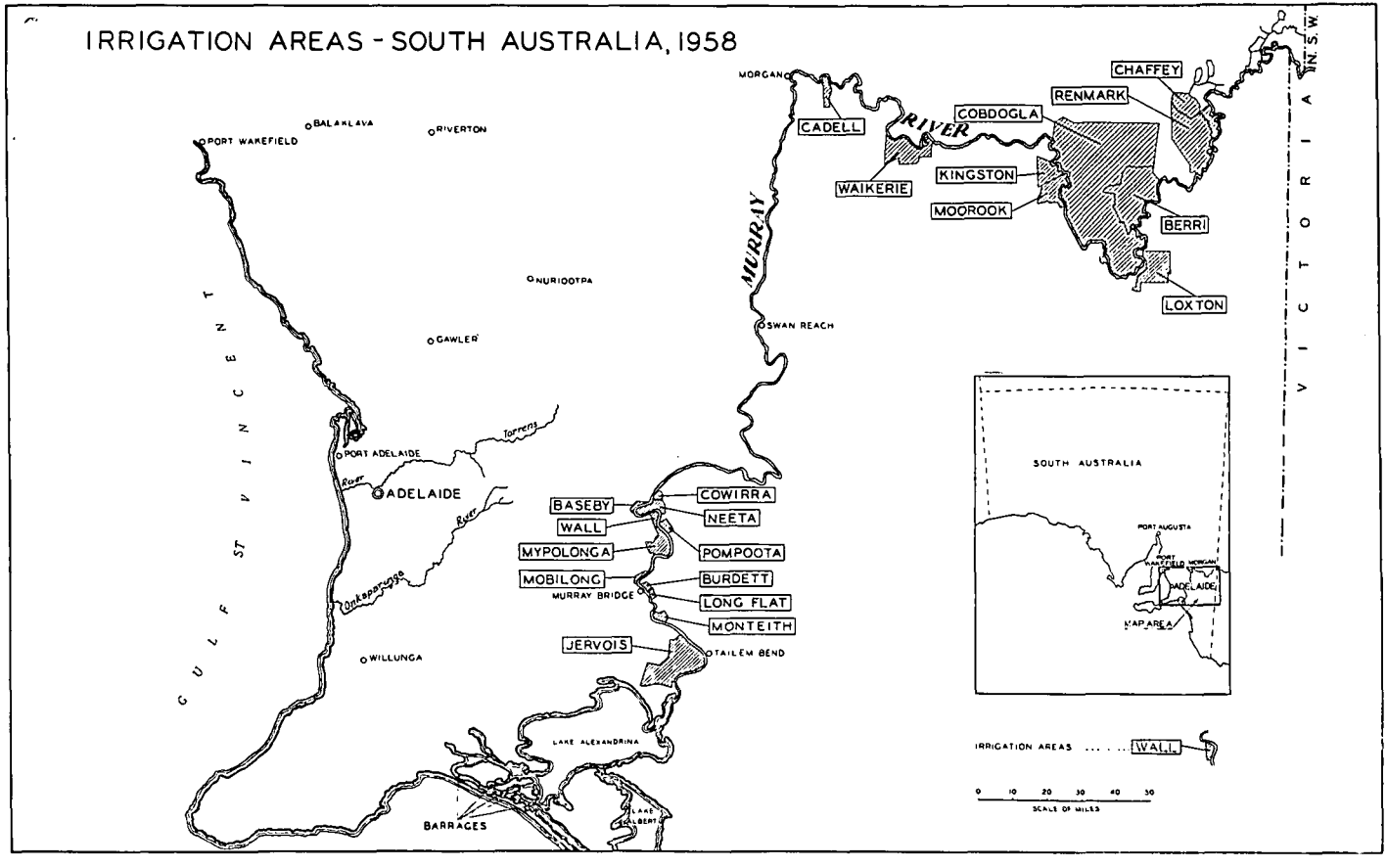

WATER SUPPLY AND IRRIGATION AREAS AND DISTRICTS - NEW SOUTH WALES, 1958
(SEE ALSO GENERAL MAP OF NEW SOUTH WALES FOLLOWING)
SOUTH AUSTRALIA
GREAT ANA BRANCH OF DARLING RIVER W.T.D
Darling
LAKE VICTORIA STORAGE
CURLWAA
COOMEALLA
BURONGA
MALLEE CLIFFS
POMONA I.T.D
WENTWORTH
MURRAY
LOWBIDGEE*
OBALRANALD
MICABIL WEIR W.T.D.
CONDOBOLIN WEST WEIR W.T.D.
Lachlan River
LAKE CARGELLIGO STORAGE
LAKE BREWSTER STORAGE
JEMALONG
WYLDE'S PLAINS
MARROWIE Ck W.T.D
TORRIGANNY, MUGGABAH & MERRIMAJEEL Cks W.T.D
ULONGA W.T.D
WAH WAH
TABBITA
GRIFFITH
MURRUMBIDGEE
Murrumbidgee River
HAY
BENEREMBAH
COLEAMBALLY
LEETON
NARRANDERA
BEREMITED WEIR
WAGGA WAGGA
GUMLY
WAKOOL
DENIMEIN
GOODNIGHT I.T.D
POON BOON W.T.D
BUNGUNYAH-KORALEIGH I.T.D
BARRAMEIN W.S.D.
YANKO, COLOMBO & BILLABONG Cks W.T.D
Edward River
Billabong Creek
Colombo Creek
Yanko Creek
LITTLE MERRAN Ck W.T.D
TULLAKOOL
DENILIQUIN
ALGUDGERIE Ck WEIR W.T.D.
BERRIQUIN
BARHAM
GLENVIEW I.T.D
BRINGAN I.T.D
DENIBOOTA
BULLATALE Ck W.T.D
TUPPAL Ck W.T.D
BAMA I.T.D
HUME DAM
VICTORIA
REFERENCE
IRRIGATION AREAS & DISTRICTS
HAY
IRRIGATION TRUST DISTRICTS
BAMA I.T.D
WATER TRUST (W.T.D.) & SUPPLY (W.S.D.) DISTRICTS
ULONGA W.T.D.
*FLOOD CONTROL DISTRICT
0 16 32 48
SCALE OF MILES

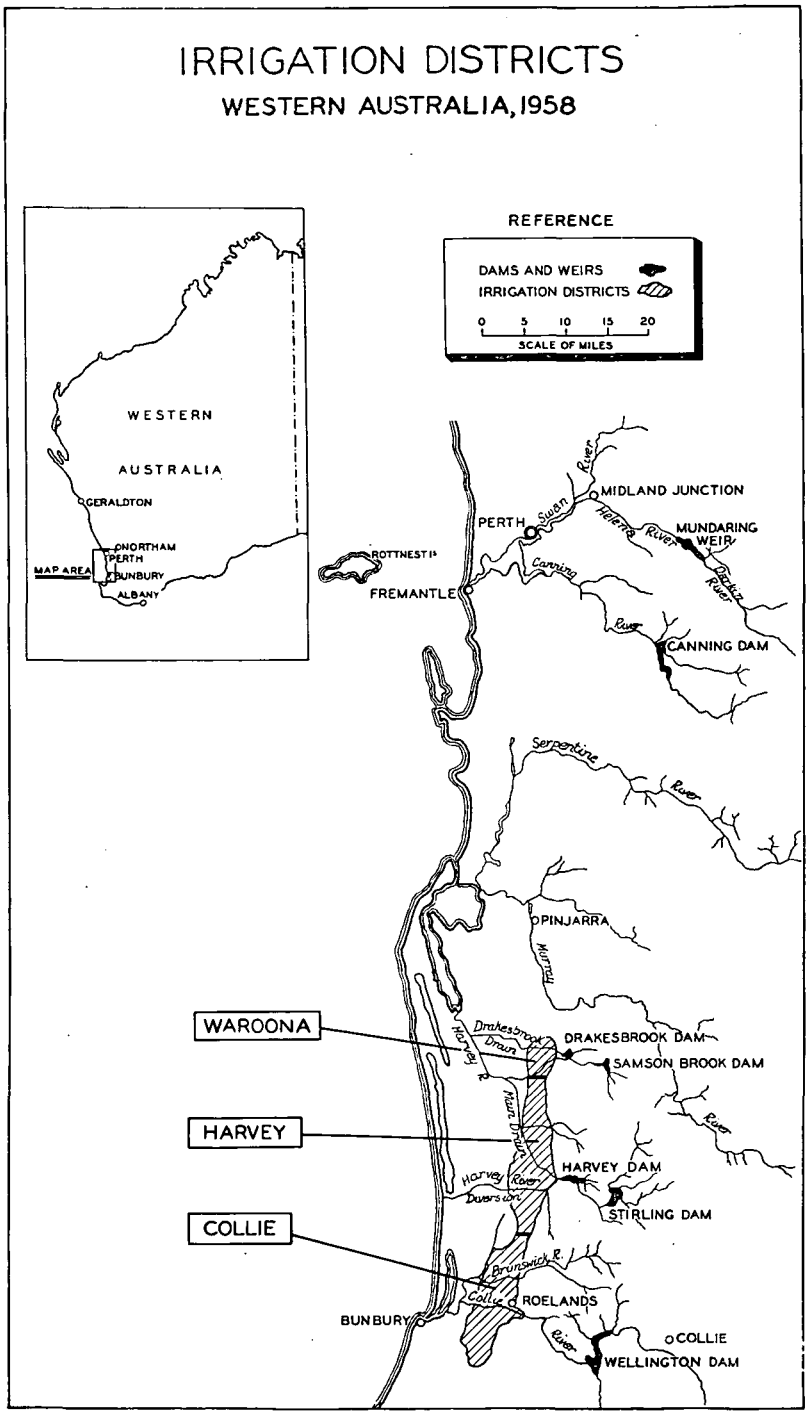


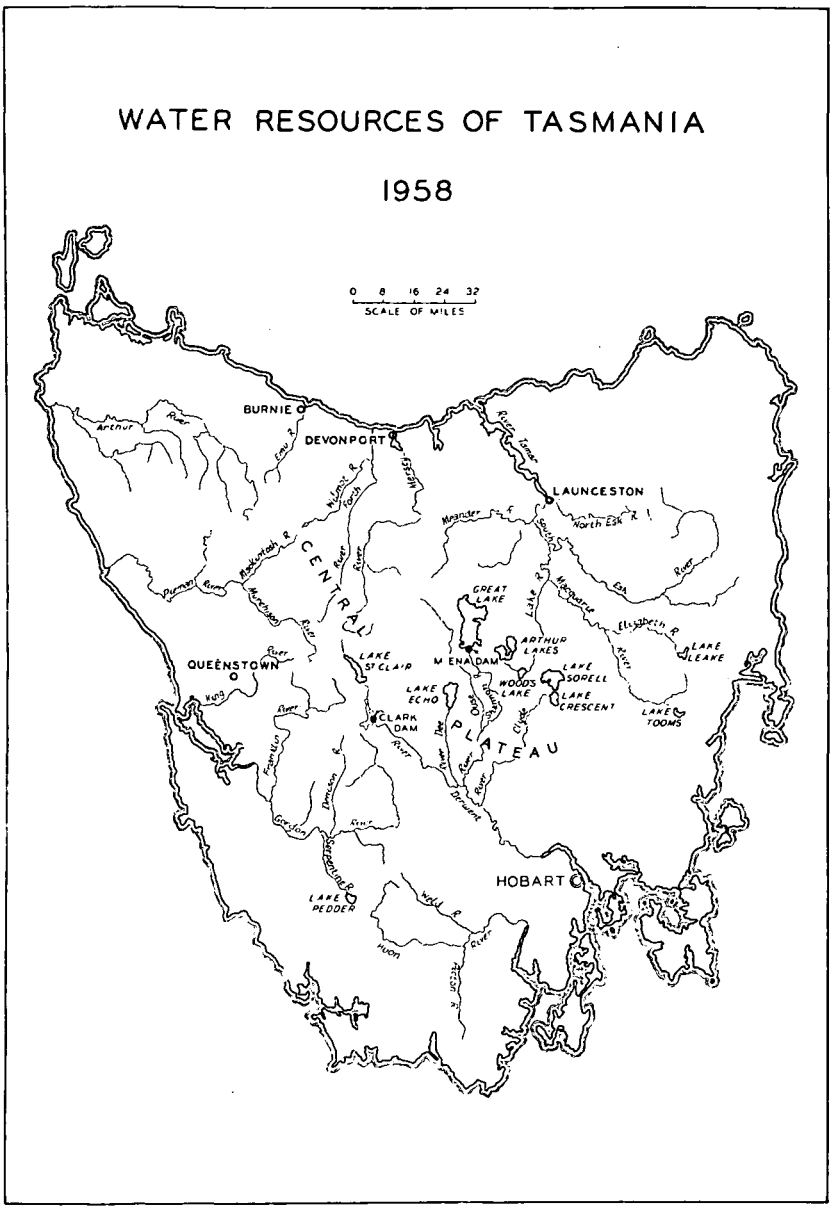
WATER SUPPLY AND IRRIGATION AREAS AND DISTRICTS - NEW SOUTH WALES, 1958


WATER SUPPLY AND IRRIGATION SYSTEMS - VICTORIA
1958
FIRST MILDURA TRUST
MERBEIN
MILDURA
REDCLIFFS
RIVER MURRAY
MILLEWA W.S.S
ROBINVALE
WIMMERA-MALLEE W.S.S
NYAH
SWAN HILL
LAKE TYRRELL
LODDON, ETC
RIVER MURRAY
GOULBURN
KOONDROOK
KERANG
COHUNA
TORRUMBARRY WEIR
YARRAWONGA
LAKE ALBACUTYA
BEULAH
LAKE MINDMARSH
BOORT
MECHUCA
SHEPPARTON
LAKE BULLOKE
MURTOA
HORSHAM
BENDIGO
WARANGA RESERVOIR
GOULBURN WEIR
LAANECOORIE RESERVOIR
LAKE LONSDALE RESERVOIR
TULLAROOP RESERVOIR
CAIRN CURRAN RESERVOIR
SEYMOUR
EILDON RESERVOIR
ARARAT
ROCKLANDS RESERVOIR
BALLARAT
BACCHUS MARSH
HAMILTON
SOUTHERN
WERRIBEE W.S.S
WERRIBEE
MELBOURNE
UPPER YARRA DAM
ENNAGGIE RESERVOIR
MAFFRA
LAKE CORANGAMITE
GEELONG
WARRAGUL
SALE
SOUTHERN
PORT FAIRY
COLAC
OTWAY W.S.S.
BELLARINE W.S.S
MORNINGTON W.S.S.
WONTHAGGI
SOUTH AUSTRALIA
REFERENCE
RESERVOIRS
HUME RESERVOIR
WATER SUPPLY SYSTEMS
OTWAY W.S.S.
IRRIGATION SYSTEMS
GOULBURN
0 16 32 48 64
SCALE OF MILES


IRRIGATION AREAS-QUEENSLAND
1958
COOKTOWN
GREAT DIVIDING
Mitchell R.
MAREEBA-DIMBULAH
CAIRNS
Barron R.
Walsh R.
TINAROO FALLS DAM
Tully R.
KOOMBOOLOOMBA DAM
Burdekin R.
TOWNSVILLE
BURDEKIN RIVER
INKERMAN
CLARE
MILLAROO
DALBEG
Burdekin River
BURDEKIN FALLS DAM
HUGHENDEN
Suttor R.
DIVIDING
Belyando R.
LONGREACH
Isaacs R.
Fitzroy R.
ROCKHAMPTON
EMERALD
RANGE
Nogoa R.
DAWSON RIVER
THEODORE
GIBBER GUNYAH
Dawson River
Burnett R.
MARYBOROUGH
Mary R.
CHARLEVILLE
YABBA CK. DAM SITE
Maranoa R.
LOCKYER VALLEY
SOMERSET DAM
BRISBANE
TOOWOOMBA
ST GEORGE
Moonie R.
BORDER RIVERS
MOOGERA DAM SITE
Culgoa R.
Barwon R.
NEW SOUTH WALES
MAP AREA
CAIRNS
QUEENSLAND
ROCKHAMPTON
BRISBANE
REFERENCE
IRRIGATION AREAS
CLARE
EXISTING
PROPOSED
0 40 80 120
SCALE OF MILES


IRRIGATION AREAS - SOUTH AUSTRALIA, 1958
MORGAN
CADELL
RIVER MURRAY
CHAFFEY
RENMARK
COBDOGLA
KINGSTON
WAIKERIE
MOOROOK
BERRI
LOXTON
VICTORIA (N.S.W.)
BALAKLAVA
PORT WAKEFIELD
RIVERTON
NURIOOTPA
GAWLER
SWAN REACH
GULF ST VINCENT
PORT ADELAIDE
ADELAIDE
Torrens River
Onkaparinga River
WILLUNGA
BASEBY
WALL
MYPOLONGA
MOBILONG
MURRAY BRIDGE
COWIRRA
NEETA
POMPOOTA
BURDETT
LONG FLAT
MONTEITH
JERVOIS
OTAILEM BEND
LAKE ALEXANDRINA
LAKE ALBERT
BARRAGES
SOUTH AUSTRALIA
PORT AUGUSTA
PORT WAKEFIELD
MORGAN
ADELAIDE
MAPAREA
IRRIGATION AREAS ..... WALL
0 10 20 30 40 50
SCALE OF MILES


IRRIGATION DISTRICTS
WESTERN AUSTRALIA, 1958
REFERENCE
DAMS AND WEIRS
IRRIGATION DISTRICTS
0 5 10 15 20
SCALE OF MILES
WESTERN
AUSTRALIA
GERALDTON
NORTHAM
PERTH
BUNBURY
ALBANY
MAP AREA
ROTTNEST I.
FREMANTLE
PERTH
Swan River
MIDLAND JUNCTION
Helena River
MUNDARING WEIR
Darling Range
Canning River
CANNING DAM
Serpentine River
PINJARRA
Murray
WAROONA
Drakesbrook Drain
Harvey R.
DRAKESBROOK DAM
SAMSON BROOK DAM
HARVEY
Main Drain
HARVEY DAM
Harvey River
Diversion
STIRLING DAM
COLLIE
Brunswick R.
Collie R.
ROELANDS
BUNBURY
COLLIE
WELLINGTON DAM


WATER RESOURCES OF TASMANIA
1958
0 8 16 24 32
SCALE OF MILES
BURNIE
DEVONPORT
LAUNCESTON
QUEENSTOWN
HOBART
LAKE PEDDER
CENTRAL
PLATEAU
GREAT LAKE
ARTHUR LAKES
MEN-A-DAM
LAKE ST CLAIR
LAKE ECHO
CLARK DAM
WOODS LAKE
LAKE SORELL
LAKE CRESCENT
LAKE TOOMS
LAKE LEAKE
Arthur River
Forth River
Mersey River
Leven R.
Meander R.
South Esk R.
North Esk R.
Macquarie River
Elizabeth R.
Gordon River
Franklin River
Derwent River
Huon River
Weld R.
Picton R.

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, and will enable 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, which 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 two western main channels from the weir (one of which was recently duplicated) convey water to the Waranga Reservoir near Murchison in addition to supplying part of the large Rodney District directly.

Two main outlet channels issue from Waranga Reservoir. One serves the western section of Rodney District while the other serves irrigation districts 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.

Water is also supplied to part of the Goulburn System from Cairn Curran Reservoir on the Loddon River, and Eildon itself may be used to supplement supply to the districts along the Murray River.

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

(ii) *Murray River System.* The waters of the River Murray are used to supply an area of more than 700,000 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 are supplied by pumping.

The Murray Valley Irrigation District, which is served from Yarrawonga Weir, comprises 268,000 acres west of Yarrawonga between the River Murray 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 again 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 a total of 1,500 holdings devoted largely 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.

(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 is supplemented by water drawn from the Goulburn and Loddon Rivers, via the Waranga Western Channel referred to previously, although works in progress will make the Wimmera and Mallee independent of supplies from the Goulburn and Loddon River in the near future. In addition, certain areas in the north of the system are supplied direct from pumps on or near the River Murray.

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 10,000 farmers served to provide sufficient storage capacity on their farms to meet their domestic and stock needs for the year. In addition to meeting this demand, the Grampians storages provide a water supply for 40,000 people in 47 towns and are used to irrigate a small area near Horsham.

6. **Town Water Supplies and Sewerage.**—Details of water supplies and sewerage to towns and local authorities by the Commission 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 £3 million a year.

Another large-scale work, which was completed during 1958–59, is the drainage of 12,500 acres of privately owned land flooded by a recent rise in the level of Lake Corangamite in the Western District. This will free a large area of the lake for grazing in normal years.

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, 16 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, 1959, was £93,500,000. Of this amount, £64,000,000 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 £12,000,000 of which 60 per cent. was borne by the State and the remainder by the districts concerned.

9. **Underground Resources.**—Due to inadequate information as to their extent, the underground waters of Victoria have not as yet been greatly utilized. The first stage of a comprehensive survey of these resources by the Victorian State Rivers and Water Supply Commission, which is partly responsible for the location, investigation and development of subterranean waters, has been completed. It provides records of bores in the Mallee, Wimmera and Glenelg regions, and a description of the Murray Artesian Basin. Investigations have also been made into the underground water resources of local areas such as Orbost Flats, Llowalong Estate on the Avon River and elsewhere.

The Murray Artesian Basin underlies an area of 107,250 square miles, of which 26,808 square miles are in Victoria, 28,269 square miles in South Australia and 52,173 square miles in New South Wales. The quality of the water varies from suitable for domestic purposes in much of the South-western part of the basin to saline and suitable for stock in the rest of the basin. Over 300 bores exist in Victoria, ranging in depth from 50 to 3,000 feet and with an average daily flow of 3,000,000 gallons. In the last few years, the Victorian Department of Mines has expanded considerably the work of exploration for underground water.

10. **Future Programme.**—The main irrigation work under construction is the enlargement of the channels of the Goulburn System to distribute the extra water now available from the Eildon Reservoir and the Cairn Curran Reservoir. A considerable amount of this work has already been carried out. Other large projects include the construction of Castlemaine Reservoir 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* page 227).

§ 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.* The administration of irrigation and water supply in Queensland is under the control of 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.* Queensland's predominant interest in the field of water conservation is the provision of stock and domestic water supplies in its great pastoral areas which contain nearly half of the Commonwealth's cattle and a seventh of the sheep. In addition to the stabilization of water supplies in the pastoral areas and the provision of water along stock routes for travelling stock, the development of irrigated pastures on the eastern seaboard for fattening stock adjacent to meat works and markets has received much attention in later years. The development of projects of water conservation and irrigation on individual farms for irrigation of pastures and fodder crops for dairy herds and for growing small crops and orchard fruits has also received attention.

The State's crops differ from those of other States in that a large proportion is tropical. Sugar-cane is the greatest individual crop, representing in value approximately 45 per cent. of total agricultural production. Approximately 18 per cent. of the sugar-cane acreage was irrigated in 1958–59 and this represented some 42 per cent. of the total irrigated area in Queensland. Queensland is Australia's major tobacco-producing State, and plans are in hand to increase annual production of this crop greatly by means of development under irrigation. The area of tobacco irrigated during 1958–59 represented 94 per cent. of the total plantings of this crop in the State.

2. **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. Statistics of bores and flow as at 30th June, 1959, are:—Artesian bores drilled, 2,620; artesian bores still flowing, 1,725; total depth drilled, 3,704,363 feet; deepest bore, 7,009 feet; total estimated flow, 208 million gallons a day. Certain bores previously classified as "ceased" have been inspected and found to be still flowing. Some ceased bores, after deepening, are again flowing. The average depth of artesian bores is 1,408 feet. Some 9,400 sub-artesian bores, within the Great Artesian Basin, have been registered in Queensland. Artesian pressure and flow are both steadily diminishing. The rate of diminution varies widely throughout the basin. Present general 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 totalling some 15,500 miles in length. Most of the water flowing along these channels is lost by soakage and evaporation and less than 10 per cent. is actually used by stock. The amount of soakage depends largely on the permeability of the earth and the rate of evaporation varies from season to season, but the shape and maintenance of the drains constitute further factors. The effective utilization of this water could be increased by the use of piping to overcome the loss by soakage and evaporation occurring in the open earth channels.

Although artesian beds underlie such 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 are not economical watering facilities, because of depth, limited area to be watered, and difficult terrain for distribution of water by drains. Very few new bores exceed 2,000 feet in depth, and a new bore greater than 3,000 feet in depth is exceptional.

Shallow sub-artesian supplies, of variable quality and volume, are available at depths of less than 1,000 feet over a large area of the basin. These beds are not connected with the artesian beds. An essential practical consideration is that the main artesian beds are continuous and the sub-artesian beds are not continuous.

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 was recorded in 1914. By 1938, the flow was only 230 million gallons a day. The decline gave rise to the fear that supplies were giving out and that the basin was seriously threatened. 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. In its final report, presented in 1954, the majority of the Committee found that the output will continue to decline during the next sixty years when the flow from the remaining flowing bores will be of the order of 110 million gallons per day. At this stage, the discharge from windmills, springs and other leakages and the underflow past the Queensland borders will be of the order of 20 million gallons a day. The total discharge of the order of 130 million gallons a day will be in equilibrium with the recharge of the basin. Numbers of bores on higher ground will cease to flow during the next sixty years and the area served by flowing bores will contract by perhaps 20 per cent.

A programme of strict conservation, involving the restriction of bore flows and improved bore drains, would result in smaller shrinkage of the area served by flowing bores and 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 on 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. The benefit from strict conservation was not considered sufficiently great, nor sufficiently concrete, to warrant implementation.

The quality of artesian water from the greater part of the basin is such that it is not suited for prolonged use for irrigation on most soils. Moreover, artesian supplies are not sufficient for both large scale irrigation and stock-watering. Practically the whole of the final steady-rate discharge from flowing bores will be needed for the watering of stock. 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.

(ii) *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 the 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 1958–59 are:—Areas constituted, 72; administered by Commissioner, 56; administered by local boards, 6; number abolished, 10; area benefited, 4,425,382 acres; average rate per acre, 1.8d.; number of flowing bores, 56; total flow, 24,092,000 gallons a day; drains served, 2,754 miles.

3. **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 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.

4. **Stock Route Watering.**—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 that Department as superintendent whose 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. Completed facilities are vested in local authorities for control and maintenance. From 1935 to 30th June, 1959, 471 facilities had been completed and at 30th June, 1959, 66 facilities were under construction or investigation.

5. **Irrigation.**—(i) *General.* Irrigation as a means of stabilizing and increasing agricultural production is continuing to receive attention in Queensland. In addition to the Theodore Irrigation Area on the Dawson River, orthodox projects served by a channel system have been developed at Clare, Millaroo and Dalbeg, all on the Burdekin River, and Gibber Gunyah on the Dawson River. St. George on the Balonne River is also being developed. Construction in the St. George Area is approaching completion and 20 farms have been opened, of which 18 are in production. Construction of the main channel system within the Mareeba-Dimbulah Irrigation Area has continued and 25 existing farms are being supplied with water by gravity. Because of the large variations in both monthly and annual river flows, major developments cannot be undertaken until large storage works are provided. Most irrigation in Queensland is undertaken by private farmers operating under licence and obtaining 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 extensively developed 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 adopted to a considerable extent for fruit, vegetables, fodder crops and a small part of the tobacco. Spraying is well suited to 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 its use 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, 1959.

AREA OF LAND IRRIGATED: QUEENSLAND, 1958-59.

Division.	No. of Irrigators.	Area Irrigated (Acres).							
		Vegetables.	Fruit.	Sugar-cane.	Tobacco.	Cotton.	Other Crops.	Pastures.	Total.
Southern Queensland ..	5,040	21,523	3,943	16,322	2,024	339	31,461	7,326	82,938
Central Queensland ..	535	901	217	18	9	978	5,124	1,493	8,740
Northern Queensland ..	1,574	4,173	716	49,273	5,457	203	1,550	1,583	62,955
Total	7,149	26,597	4,876	65,613	7,490	1,520	38,135	10,402	154,633

The pattern of irrigation in Queensland is unlike that in southern States; the more important developments in tropical and sub-tropical areas are therefore discussed briefly in the sub-sections following. It should be noted that the spring to autumn " irrigation season " of the temperate southern irrigated lands is not applicable, and that 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.

(ii) *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 some 60,000 acres of land highly suitable for irrigation are available. Of this area, only about 30 per cent. is under irrigation, the number of pumps operating from wells and open water exceeding 550 and 600 respectively. Over 60 per cent. 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.

(iii) *Burdekin River.* 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. Present development is confined to the delta area. 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 irrigated crop, 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.

A major multi-purpose scheme, involving irrigation, flood control and hydro-electric power generation, is being 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 projected scheme will change the Burdekin from a mixed blessing to one of the Commonwealth's greatest resources for agricultural and industrial production.

The Clare Irrigation Area, constituted in 1949, the Millaroo Irrigation Area, constituted in 1952, and the Dalbeg Irrigation Area, constituted in 1953, are at present predominantly used for tobacco production. Located from 25 to 65 miles upstream from the mouth of the Burdekin, these areas comprise 12,000 acres and obtain irrigation waters from central pumping stations drawing initially on the unregulated flow of the Burdekin. A temporary storage of 6,700 acre feet capacity has been constructed about 79 miles upstream from the mouth of the Burdekin. At 30th June, 1959, 146 farms were occupied and total production for 1958–59 was valued at £795,000.

(iv) *Dawson Valley.* 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 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 had 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. Pasture, vegetables, cotton, fruit and dairy products are the principal produce. Attention has recently been given to the former plans for the valley and earlier work is now 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 19 farms have been occupied.

(v) *Mareeba-Dimbulah 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 has led to large-scale investigations into possible irrigation development in the area. Surveys indicate that 40,000 acres of land suitable for irrigated culture, including 32,000 acres suitable for tobacco, are available. In 1958–59, some 4,116 acres of high-grade tobacco were grown. Seven weirs with a combined capacity of 2,650 acre feet have been completed on a number of streams to store water for irrigation.

During 1952, a report on the utilization of waters of the Barron and Walsh Rivers was prepared and the establishment of an irrigation undertaking approved by the Queensland Government. The projected undertaking provides for construction of a major storage at Tinaroo Falls on the Barron River to store 320,000 acre feet, and construction of irrigation works to serve 78,000 acres commanded by this storage. In each case, construction has commenced. Further development by construction of a second storage at Nullinga on the Walsh River has been deferred for the present. Tobacco will be the basic crop while peanuts, vegetables, maize, cotton and stock fattening also appear suitable.

(vi) *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 248.

(vii) *Balonne River.* The St. George Irrigation Area has been constituted and construction of works to serve some 11,000 acres is in progress. Water supply for the area will be obtained by pumping from the combined weir and road bridge on the Balonne River at St. George.

6. **Channel Country.**—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 the occurrence of 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 £277,000, had been proposed under a Commonwealth-State agreement for stock routes through, and in the approaches to, the Channel Country. By 30th June, 1959, 31 had been completed, while four sub-artesian bores and one excavated tank were under construction.

7. **Hydro-electricity.**—An outline of Hydro-electricity Schemes operating in Queensland is given in the previous chapter (*see* page 230).

§ 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 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, 1959, 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 £1,759,395. The " rainsheds " comprise 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. Pipelines in preference to open channels and covered storages are used to reduce evaporation. 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 on to 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 32,758 acres of irrigable high land together with 9,449 acres of reclaimed swamp and 167,175 acres of non-irrigable land in the irrigation areas and 29,747 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 9,550 are irrigated. Water used for irrigation purposes in 1958–59 in the high land irrigation areas controlled by the Department of Lands, excluding War Service Land Settlement areas in course of development, was approximately 100,000 acre feet and, in addition, approximately 63,000 acre feet were applied to the reclaimed areas. In the Renmark area, approximately 29,000 acre feet of water were used for irrigation in 1958–59. 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, 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 9,550 acres.

The following tables show 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.

AREA OF LAND UNDER IRRIGATED CULTURE, 1958-59.

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

(Acres.)

Area.	Vine Fruits.	Tree Fruits.	Citrus Fruits.	Sown Pastures.	Total.
Areas Administered by the Department of Lands.					
Orchard Land—					
Berri	5,104	1,104	1,320	..	7,528
Cadell	564	154	112	..	830
Waikerie	1,826	624	1,288	..	3,738
Cobdogla	3,754	172	194	..	4,120
Moorook	323	129	186	..	638
Kingston	222	87	247	..	556
Mypolonga	..	337	527	..	864
Chaffey—Ral Ral Division ..	795	103	8	..	906
Total	*12,588*	*2,710*	*3,882*	..	*19,180*
War Service Land Settlement—					
Cooltong Division	375	255	482	..	1,112
Loxton area	3,067	1,100	2,185	..	6,352
Loveday Division	235	47	22	..	304
Total	*3,677*	*1,402*	*2,689*	..	*7,768*
Reclaimed Swamp Land—					
Monteith	..	..	..	960	960
Mypolonga	..	..	..	1,314	1,314
Wall	..	..	..	490	490
Burdett	..	..	..	109	109
Mobilong	..	..	..	429	429
Long Flat	..	..	..	339	339
Neeta	..	..	..	561	561
Pompoota	..	..	..	422	422
Cowirra	..	..	..	567	567
Jervois	..	..	..	3,602	3,602
Total	..	..	..	*8,793*	*8,793*
Renmark Irrigation Trust.					
Renmark Irrigation Trust ..	*7.330*	*950*	*1,270*	..	*9,550*

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 River Murray at Mannum. The reservoirs have a storage capacity of 51,497 acre feet and the pipeline a capacity of 53,627 acre feet a year. The consumption for the year 1958–59 was 80,476 acre feet, equivalent to a consumption of 108 imperial gallons per head per day. The capital cost to 30th June, 1959, was £29,936,090.

(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 (36,290 acre feet) in the Barossa Ranges. To supplement these storages, a branch main from the Mannum-Adelaide Pipeline feeds into Warren Reservoir.

Agricultural towns and areas further north are supplied from Beetaloo, Bundaleer and Baroota Reservoirs, with connexions to the Warren system and the Morgan-Whyalla Pipeline. The 223-mile pipeline from Morgan on the River Murray to Whyalla was designed to deliver annually 4,400 acre feet to Whyalla and 3,300 acre feet to the northern districts. Branch pipelines have been constructed to Jamestown, Caltowie, Peterborough, Clare and Woomera. Yorke Peninsula is now being reticulated. A pipeline has been laid from the Bundaleer Reservoir, and the reticulation system will be extended south to Edithburgh. Work is in progress on the construction of the Myponga Reservoir. A concrete arch dam is being built on the Myponga River, impounding 22,000 acre feet of water. This storage will be used to supply towns and country lands south to Normanville and as an additional source of supply for the Adelaide Metropolitan area.

Water conservation and distribution works in country districts have cost £31,203,396 (exclusive of river control and irrigation works on the River Murray) and contain 6,349 miles of water mains. The capacity of country storages is 71,569 acre feet, serving a population of approximately 306,500.

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 to Mount Gambier, 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. Towns elsewhere which are supplied from bores include Mount Barker, Port Lincoln, Peterborough, Warooka and Willunga.

Pastoralists, farmers, market gardeners and others have been assisted with expert advice on drilling, for which the Government maintains about 30 drills. 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 obtains water supply 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 was completed in 1885, when 100,000 acres were reclaimed by 225 miles of drains at a cost of £150,000, which was included in the land allotment prices.

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 20 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, and a start has been made on the northern section of 140,000 acres.

The capital cost of drainage in the South-Eastern Drainage Area System at 30th June, 1959, was £4,564,951, and the length of drains constructed was 666 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 1914–1951, 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 1947–1957 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 1958–59 being 25,252 acres and the total water used approximately 90,000 acre feet. The total of acre waterings (that is, the number of acres watered multiplied by the average number of waterings) was 148,632. 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 (10,397 acres) is supplied from Drakes Brook Dam (1,854 acre feet capacity) and Samson Brook Dam (6,624 acre feet), the Harvey Irrigation District (37,269 acres) from the Harvey Weir (8,370 acre feet) and Stirling Dam (46,368 acre feet), and the Collie River Irrigation District (36,020 acres) from the Wellington Dam (29,440 acre feet).

The following table, which shows acre waterings supplied to crops in the irrigation districts of Harvey, Waroona and Collie River during the seasons 1954–55 to 1958–59 illustrates the general growth of these irrigation schemes.

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

Year.	Pasture.	Fodder.	Potatoes.	Vege-tables.	Orchard.	Flax, Broom Millet, and Preparation of Ground.	All Crops.
1954–55	112,659	3,268	2,363	3,294	845	121	122,550
1955–56	108,468	3,599	1,834	3,452	946	127	118,426
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

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

(ii) *General.* In 1958–59, the total area irrigated in Western Australia was 44,102 acres made up of vegetables (8,211 acres), fruit (6,850 acres), vineyards (630 acres), pastures (24,982 acres) and other crops (3,429 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.

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 3,000,000 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 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 of cattle, is being examined at the Kimberley Research Station on the Ord River.

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 62,560 acre feet and a catchment of 569 square miles. The water passes through 346 miles of main, mostly steel and 30 inches in diameter, equipped with eight pumping stations.

Maximum pumping capacity from No. 1 Pumping Station at Mundaring Reservoir is nominally 15.9 million gallons a day. The total capacity of all receiving, regulating, standby and service tanks along the main pipe line is 154 million gallons which includes three standby reservoirs at Kalgoorlie having a combined capacity of 60 million gallons.

Hundreds of miles of branch pipe lines 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 74 towns and water is reticulated to over 2,000,000 acres of mixed farming lands. The total length of pipe lines is 2,756 miles and the number of services is 21,799. The total quantity of water pumped from Mundaring in 1958–59 was 3,002 million gallons. The total cost of the scheme to the State Government to the end of 1958–59 was £11,856,953. Under the terms of the Comprehensive Water Supply Scheme the Commonwealth Government has contributed a further £2,196,486 making a total cost of £14,053,439.

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 Scheme. 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 and estimated to cost £10,000,000 is at present (1959) 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 150,000 acre feet is in progress. Expenditure on the Scheme to 30th June, 1958, amounted to £6,618,037.

(iv) *Local Water Supplies.* Local schemes other than above comprise those in the remaining agricultural and mining areas, including the North-West and Kimberley Divisions. Sixty-two separate reticulated water supplies serve country towns and districts. Of these, 55 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 66 rated stream gauging stations is operating in the South-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 of mostly 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 ground water from wells and bores, using windmills, engines or electric power. Water is also obtained from artesian and sub-artesian bores. 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. In view of the importance of finding water for towns and farms in low rainfall areas outside the sedimentary basins, the Geological Survey of Western Australia and the Commonwealth Bureau of Mineral Resources recently combined to apply geophysical prospecting to the search for water in weathered granites in the south-western part of the State. The results of this work so far have been promising.

§ 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 Tasmania's fortunate rainfall position, scarcity of water is not a serious problem in normal seasons. Conservation of water for hydro-electric generation is the predominant interest, and conservation for domestic and industrial purposes is more important than irrigation. Conservation of water on farms is not practised to the same extent as on the mainland, probably because running streams and good rainfall are on a more generous scale. Provision of artificial storages (apart from house tanks) is rare, but progressive landowners are beginning to take advantage of modern plant, such as bulldozers, to provide small excavated storages on their properties. Underground water is of poor quality but a small quantity, which has been exploited to a limited extent by bores and windmills, exists over an area in the Midlands. Geological conditions do not appear to favour the utilization of underground water except on a minor scale.

(iii) *Administration.* On 1st September, 1958, a Rivers and Water Supply Commission was brought into operation with control over all natural waters. The Commission does not own the waters but may take them subject to existing rights, of which the most important are riparian rights. In addition to licensing the use of water, the Commission supervises

the construction of municipal water supply schemes which was previously a function of the Water, Sewerage and Drainage Board. It has similar functions in relation to river improvement and irrigation.

2. **Hydro-electricity.***—Tasmania depends entirely on water for power development. 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.

Much 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 greater 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 six 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 has constructed a regional water scheme to serve the Australian Aluminium Production Commission's plant 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 scheme in 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. Irrigation in Tasmania was applied in 1958–59 to 13,431 acres devoted to: hops (1,292 acres); fruit (1,737 acres); pastures (7,502 acres); green fodder, etc. (782 acres); and other crops (2,118 acres).

* *See also* Chapter VII.—Electric Power Generation and Distribution, p. 235.

§ 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 Use 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, flood prevention and control.

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 underlines 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 even more 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 annual average rainfall of only five inches at the margins of the Simpson Desert in the south-east corner. In the lighter rainfall areas, the search for potable underground water becomes exacting but, in general, the regions providing the best pastures—the Ord-Victoria Region, the Barkly Tablelands and smaller areas in the Alice Springs district—provide also sub-surface conditions suitable for the storage of water. This comes about largely because, in these areas, both pasture and water are related to flat lying or gently folded limestones or volcanics of Upper Proterozoic or Cambrian age, overlying the basement of older, more tightly folded, metamorphic rocks and granites which crop out over wide areas within the Territory.

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.

Considerable research has been undertaken in the last three 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.

Similar basins to the Cabbage Gum probably occur in the Territory, south of Alice Springs. If present tests of the Cabbage Gum Basin are successful, it is possible that greater supplies of water than previously expected may be discovered in this area.

A review is being made of the information available concerning the number of bores and wells sunk in the Territory. Up to September, 1959, 1,871 bores and wells had been registered. Of these, 883 were on pastoral properties, 47 on native reserves, 13 for town water supplies and six on mining fields. The number of registered stock route bores established by the Government is 176.

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 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 and a public company to determine the supply of water and the best methods of control and use in the potential rice-growing areas of the Territory. A total of 86 gauging stations has been established in the Territory. They are of various types, namely long-term automatic, short-term automatic, staff gauge-daily readings, and staff gauge-intermittent readings, of which 24 are associated with proposed rice growing areas. The remaining gauging stations have been located to assess the river water potential of the Territory. A further 70 stations are planned for installation over the next two years. 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. The Administration is preparing a programme of extension work into saline water conversion under Territory conditions. For further particulars, *see* page 1138 of Official Year Book No. 37.

§ 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.