SECTION XIV.

WATER CONSERVATION AND IRRIGATION.

§ 1. Artesian Water.

1. **General.**—In every country in which droughts are recurrent, there are few problems the solution of which is of greater importance than that of an adequate system of water conservation. Much has been done in the Commonwealth so far as the supply of water to centres of population is concerned, and a description of several of the metropolitan water works will be found herein, viz., in the section dealing with "Local Government." In May 1912 an Interstate Conference on artesian water was held in Sydney, at which it was agreed that combined Governmental action should be taken with reference to delimitation of the artesian basin, hydrographic survey, analyses and utilisation of artesian water, etc. (See map on page 551.)

(i.) *The Great Australian Artesian Basin.* In speaking of the "Great Australian Artesian Basin," the area is understood which includes (*a*) considerably more than one-half of Queensland, taking in practically all that State lying west of the Great Dividing Range, with the exception of an area in the north-west contiguous to the Northern Territory; (*b*) a considerable strip of New South Wales along its northern boundary and west of the Great Dividing Range; and (*c*) the north-eastern part of South Australia proper, together with the extreme south-eastern corner of the Northern Territory. This basin (shewn approximately by the map on page 551) is said to be the largest yet discovered, and measures about 569,000 square miles, of which 376,000 square miles are in Queensland, 90,000 square miles in South Australia, 83,000 square miles in New South Wales, and 20,000 square miles in the Northern Territory. The area of the intake beds is estimated at 60,010 square miles, viz., 50,000 square miles in Queensland and 10,010 square miles in New South Wales. A description of the basin and its geological formation will be found in previous issues of the Year Book (see No. 6, p. 569).

(ii.) *The Western Australian Basins.* The Western Australian Basins fall naturally within five distinct groups, viz., the Eucla Basin, in the extreme south-east of the State, extending well into South Australia along the shores of the Great Australian Bight; the Coastal Plain Basin, west of the Darling Range; the North-West Basin, between the Murchison and Ashburton Rivers; the Gulf Basin, between Cambridge Gulf and Queen's Channel; and the Desert Basin, between the De Grey and Fitzroy Rivers. The boring operations in these basins are referred to hereinafter (see page 538).

The Recent and Tertiary strata which enter Western Australia at its eastern border, and which have a prevailing dip towards the Great Australian Bight, form the Eucla artesian water area. But where boring operations have been undertaken, the water has been found to be salt or brackish, and there are other conditions affecting the supply, such as local variations in the thickness of the beds, their relative porosity, and the unevenness of the floor upon which they rest, which, so far, have not been examined with sufficient thoroughness to enable many particulars to be given in regard to this basin.

In the Coastal Plain Basin to the west of the Darling Ranges artesian boring has, on the other hand, been carried on successfully for many years.

(iii.) *The Murray River Basin.* The Murray River basin extends over south-western New South Wales, north-western Victoria, and south-eastern South Australia. It is bounded on the west by the azoic and palæozoic rocks of the Mount Lofty and other ranges, extending northwards from near the mouth of the Murray to the Barrier Ranges, and on the east and north-east by the ranges of Victoria and New South Wales. This tertiary water-basin is occupied by a succession of sedimentary formations, both porous and impervious. It is of interest to note that the waters of the Murray River are partly supplied by influx from the water-bearing beds of this basin; this is proved by the fact that, at low water, springs are observed at certain places flowing into it from beneath the limestone cliffs from Pyap Bend downwards. Similar springs exist along the courses of other branches of the River Murray system, where they cut through the tertiary formation. On the Victorian side several bores have been put down, and water has been struck at various levels.

(iv.) *Plutonic or Meteoric Waters.* In previous Year Books will be found the theory of Professor Gregory[1] as to the origin of the water in the Australian artesian basin, together with the objections held thereto by a former Government Geologist of New South Wales.[2] (See Year Book No. 6, p. 570.)

(v.) *Particulars of Artesian and Sub-artesian Bores.* The following table gives particulars of artesian and sub-artesian bores in each State and in the Northern Territory up to the latest available date:—

COMMONWEALTH AND STATES.*—PARTICULARS OF ARTESIAN AND SUB-ARTESIAN BORES.

Particulars.	N.S.W. 1916-17.	Vict. 1916-17.	Q'land.‡ 1915-16.	S. Aust.‖ 1916-17.	W. Aust. 1916-17.	N. Ter.‡ 1914.	Total.‡
Bores existing ... No.	491	285	2,816	141	115	128	3,976
Total depth bored ... feet	815,088	81,000	2,791,471	107,216	121,036	52,294	3,968,105
Daily flow ... ,000 gals.	§95,899	†	433,871	¶2,746	32,071	†	†
Depth at which artesian water was struck—							
Maximum ... feet	4,086	1,400	5,045	5,458	4,106	502	5,458
Minimum ... feet	89	150	10	65	175	110	10
Temperature of flow—							
Maximum ... °Fahr.	148	†	210	208	140	†	†
Minimum ... °Fahr.	70	†	81	82	60	†	†

* There are no artesian bores in Tasmania. † Not available. ‡ Latest figures available. § Incomplete. ‖ Government bores only. ¶ Exclusive of flow from pumping bores.

2. **New South Wales.**—(i.) *Artesian Water Supply.* The New South Wales portion of the great Australian basin, comprising approximately 70,000 square miles, is situated in the north-western portion of the State. Artesian boring in New South Wales dates from 1879, when a private bore was put down on the Kallara pastoral holding, between Bourke and Wilcannia. The first Government bore was that at Goonery, on the Bourke-Wanaaring road, completed in 1884.

1. See *J. W. Gregory, F.R.S., D.Sc.:* "The Dead Heart of Australia," London, John Murray, 1906: "The Flowing Wells of Central Australia," Geogr. Journ., July and August, 1911.

2. *E. F. Pittman, A.R.S.M., formerly Government Geologist of New South Wales:* "Problems of the Artesian Water Supply of Australia, with special reference to Professor Gregory's Theory." (Clarke Memorial Lecture, delivered before the Royal Society of New South Wales, 31st October, 1907); "The Great Australian Artesian Basin," Sydney, 1914; "The Composition and Porosity of the Intake Beds of the Great Australian Artesian Basin," Sydney, 1915.

The following statement shews the extent of the work which has been successfully effected by the Government and by private owners up to 30th June, 1917 :—

NEW SOUTH WALES ARTESIAN BORES, 1917.

Bores.	Flowing.	Pumping.	Total.	Total Depth.
For Public Watering-places, Artesian Wells, etc.	124	31	155	320,970
For Country Towns Water Supply ...	2	1	3	4,354
For Improvement Leases	39	3	42	66,287
Total Government Bores	165	35	200	391,611
Private Bores	222	69	291	423,837

The average depth is 1,958 feet in the case of Government bores, and of private bores 1456 feet, and it ranges from 89 to 4338 feet. The two deepest wells in New South Wales are those at Boronga, in the County of Stapylton, with a depth of 4338 feet and a present outflow of 958,784 gallons; and at Dolgelly, in the Parish of Carcenga, in County Stapylton, with a depth of 4086 feet, and a present discharge of 577,930 gallons per day. The largest flow at the present time is that at the Wirrah bore, in the County of Benarba, which yields 1,205,190 gallons a day, and has a depth of 3578 feet.

Of the 541 bores which have been sunk, 387 are flowing, and give an aggregate discharge of 95,427,215 gallons per day; 104 bores give a pumping supply, the balance of 50 being failures; the total depth bored represents 877,242 feet.

The flow from seventy-three bores is utilised for supplying water for stock on holdings served in connection with Bore Water Trusts or Artesian Districts under the Water Act of 1912. The total flow from these bores amounts to 38,125,605 gallons per day, watering an area of 4,421,461 acres by means of 2702 miles of distributing channels. The average rating by the Bore Trusts to repay the capital cost, with four per cent. interest, in twenty-eight years, is 1.627d. per acre, including the cost of maintenance and administration.

In the majority of cases the remaining bores are used by pastoralists for stock watering purposes only, but in a few instances the supply is utilised in connection with country towns.

The watering of the north-western country by means of bore water has largely increased the carrying capacity of the land; and, what is of perhaps greater importance, it has made comparatively small pastoral settlement practicable in country previously confined almost entirely to the operations of companies holding immense areas.

It having been determined that multiplicity of bores is the chief factor governing the annual decrease in bore flows, and also that limiting the discharge from a bore will prolong its flowing life, action has been taken to prevent any waste by controlling the bore flow to actual requirements. It is confidently anticipated that this action will materially reduce the rate of decrease in the future.

(ii.) *Shallow Boring.* The scheme described in Official Year Book No. 9 (p. 520) for assisting settlers by sinking shallow bores has met with considerable success.

Operations commenced with one plant only, but the number has been increased gradually until twelve plants are at work.

A large number of applications from settlers wishing to take advantage of the liberal conditions offered under the regulations has been received, and further applications are coming to hand daily, so that even when the whole of the plants referred to are at work, they will probably be insufficient to cope with the demand. Out of 108 bores put in hand up to 30th June, 1917, eleven have proved failures.

There can be no question that the added value of the holdings represented by the bores already put down is considerably in excess of their cost, and as fairly conclusive evidence of this, it might be stated that in several instances the Government Savings Bank has, on completion of a bore, made the settler a sufficient advance to enable him to pay the total cost in cash.

In addition to the work carried out under the Shallow Boring Regulations outlined above, three plants are at present engaged in sinking bores on Crown lands in the Pilliga scrub for the Lands and Forestry Departments.

The fact that of the bores put down in the Pilliga scrub, twenty-five are giving a flowing supply, adds much to their value, and is of special interest as indicating the possibility of tapping a small and hitherto unknown artesian basin.

(iii.) *Private Artesian Bores.* Much has been done in the way of artesian boring by private enterprise. As far as can be ascertained, 318 private bores have been undertaken in New South Wales, of which twenty-seven were failures. The yield of the flowing bores is estimated at over 40 million gallons per day. No data are available regarding the pumping bores.

3. **Victoria.**—Victoria lies altogether outside the Great Australian Artesian Basin, and as water is generally available from surface or shallow underground supplies, there has not been much occasion for artesian boring. As early as 1880, however, an artesian well was bored at Sale, which gave a large supply of water of fair quality before it failed through corrosion of the casing. In 1905 a new bore was put down, which at a depth of 277 feet yielded sufficient water to fill Lake Guthridge, a local depression. But as the water was impure, and contained too much sulphuretted hydrogen, boring operations were continued to 520 feet, when the lowering of the casing shut off the supply of water. A further bore was then put down at some distance from the first, and this, at a depth of 238 feet, yielded a fresh and clear water supply of about 145,000 gallons per day. Corrosion troubles occurred here also, and at the end of 1912 a third bore was put down to a depth of 235 feet, artesian flows being struck at 187 feet and 235 feet. Towards the end of 1915 a flow of 200,000 gallons per day was struck at a depth of 125 feet on the Powerscourt Estate, near Maffra. Other bores are being put down in the locality.

Largely due to the failure of surface supplies in the drought of 1878 to 1886, no less than 499 bores were, before the end of 1888, put down by shire councils aided by the Government. The total depth bored was 40,000 feet; fresh water was struck in 78 instances; 47 yielded brackish but usable water; 229 were salt, while the balance were dry. The bores covered practically the whole of the settled portions of Northern and North-western Victoria and parts of Gippsland.

In the late eighties a number of bores were put down in the north-western part of the State, varying from 200 to over 2000 feet in depth, but without any notable success. In 1897 a Board reported on boring for artesian water supply in the Mallee country, but this report was adverse, except as regards the extreme northern portion thereof. In 1906 eight bores were put down on the Overnewton Estate, Maribyrnong, to depths varying from 147 to 272 feet; small supplies of good and medium water for stock purposes were obtained, but only one of the wells yielded water fit for domestic purposes. In 1908 boring was commenced in the Mallee country near the Border east of Pinnaroo in South Australia, and a line of bores from the Border to Kow Plains has proved the existence of a large sheet of underground water. Altogether, 87 bores have been successful in striking fresh water, and their depths vary from 155 to 752 feet, the water rising to within from 207 to 6 feet of the surface. In three instances the bores flow, the water

rising from four to seventeen feet above the surface. The fresh water extends nearly as far east as the 142nd meridian, and its northern limit is approximately the 35th parallel.

At the end of 1916 the number of existing Government bores in use in Victoria was 83, from which supplies are obtained by pumping. The total depth bored amounted to 39,783 feet, while the maximum and minimum depths at which water was struck were 1400 and 150 feet respectively. There are also about 140 existing private bores, with a total depth of about 30,000 feet.

4. **Queensland.**—A return relating to the 30th June, 1917, classifies the Queensland artesian bores under the following headings:—

QUEENSLAND ARTESIAN BORES, 30th JUNE, 1917.

Sunk by—	Artesian Flows.	Sub-Artesian or Pumped Supplies.	In Progress, Abandoned, or Uncertain.	Total.
Government	60	81	99	240
Local governing authorities	14	17	14	45
Private owners	1,072	987	717	2,776
Total ...	1,146	1,085	830	3,061

Of the 1146 flowing bores, 121 were of less than 10,000 gallons per day; 253 from 10,001 to 100,000 gallons; 476 from 100,001 to 500,000 gallons; 273 from 500,001 to 1,500,000 gallons; 18 from 1,500,001 to 2,000,000 gallons; and 5 from 2,000,001 gallons upwards. The deepest well was about forty miles west of Blackall, lying east of the Barcoo River; this had a depth of 5610 feet, and was stated to yield 80,000 gallons daily. Further sinking is in progress. The flow is, of course, a comparatively small one, many wells yielding, when uncontrolled, from one to three million gallons a day. The waters of many of the wells have been analysed, and some found suitable for wool-scouring only, others are suitable for watering stock but not for irrigation, owing to the presence of alkali; others again serve for both stock and irrigation, while some, such as those containing sulphuretted hydrogen, are not of any use. Water fit for stock may generally be said to be "safe" for domestic purposes in spite of its slightly mineral taste. The wells yielding the mineral waters known as "Helidon Spa," "Boonah Spa," and "Junot Spa," which are much in use in Queensland and New South Wales, are shallow wells from 60 to 200 feet in depth.

The following table shews particulars as to Queensland bores at the end of June, 1917:—

QUEENSLAND ARTESIAN AND SUB-ARTESIAN BORES, 30th JUNE, 1917.

Particulars.		State and Local Authorities.	Private.	Total.
Bores existing	No.	285	2,776	3,061
Total depth bored	feet	241,175	2,735,300	2,976,475
Daily flow	gallons	33,061,540	397,280,450	430,341,990
Depth at which artesian water was struck—				
Maximum	feet	4,256	5,450	...
Minimum	,,	354	10	...
Temperature of flow—				
Maximum	°Fahr.	198	210	...
Minimum	°Fahr.	85	81	...

5. **South Australia.**—There were in South Australia 141 bores existing at 31st December, 1917, of which 34 were artesian and 107 sub-artesian. There are 107 under 1000 feet in depth, 20 from 1000 to 2000 feet; six from 2000 to 3000 feet; five from 3000 to 4000 feet, and three over 4000 feet. The deepest flowing bore was at Patchawarra, on the Farina to Haddon, via Innamincka, route, measuring 5458 feet, but yielding only 200 gallons per day. The maximum flow, viz., 1,250,000 gallons, is obtained at Coonie Creek, east of Lake Frome.

The following table shews particulars as to South Australian bores at the end of December 1917:—

SOUTH AUSTRALIAN BORES, 1917.

Particulars.		Artesian and Sub-artesian.
Bores existing		141
Total depth bored	feet	107,216
Daily flow	gals.	*
Depth at which water was struck—		
Maximum	feet	5,458
Minimum	feet	65
Temperature of flow—		
Maximum	°Fahr.	208
Minimum	°Fahr.	82
Total cost of construction of bores up to end of year ...		£283,927
Expenditure during year on boring operations ...		£33,862

* Not available.

(i.) *Bores between the Murray and the Eastern Boundary of the State.* The sinking of bores across the Ninety-mile Desert between the Murray and the Victorian boundary was commenced in 1886 at Coonalpyn; with the exception, however, of salt water at 55 ft., no success was met with. Ki Ki bore was sunk in 1887, and at 361 ft. a good supply of water fit for stock was struck. Tintinarra bore was sunk in 1887; it was artesian when first tapped. The water was found to be fit for locomotive engines and is still used for that purpose. The bore at Emu Flat was also sunk in 1887. In 1904 a bore was sunk at Cotton, and numerous successful bores have since been put down by the Public Works Department, and subsequently by residents of the district. The water rises to a distance from the surface of from 15 to 320 feet, and the maximum quantity obtained per diem is 48,000 gallons at the Gosden bore. Several wells, ranging in depth from 55 to 221 feet, have also been sunk in this district. The latest Government bores are Kumara in the Hundred of Kingsford, and Perponda in the Hundred of Vincent. The former has a depth of 240 feet, and the water, which is in large supply, rises to within about 96 feet of the surface. The latter is 300 feet in depth, and the water rises to within 56 feet of the surface. The water is fresh, containing about $\frac{3}{8}$ oz. salts and other solid matter per gallon.

(ii.) *Bores West of Oodnadatta.* A series of bores has been sunk, beginning with Breaden bore, 20 miles west of Oodnadatta, which was put down in 1911. The others since put down in this district are at Gypsum, Imbitcha, Mirackina, Raspberry Creek, Appreetinna, Wintinna and Marla. Of these, the only artesian supply is at Raspberry Creek, where 1,000,000 gallons per day of good water is obtained. The depths of these bores range from 280 feet at Mirackina to 1122 feet at Breaden, and the water from all of them is good.

(iii.) *Other New Bores.* New bores have been sunk at Peachawarrina, about 45 miles north-east of Marree, to a depth of 2484 feet, a large supply of good water being obtained, flowing over the surface at the rate of 500,000 gallons per diem; Possum bore, on

Opossum Creek, 1334 feet; and Allinga bore on Allinga Creek, 2½ miles north-west of Mount Ludgate, 1160 feet, where a good supply of water was obtained, flowing over the surface at the rate of 412,800 gallons per diem.

(iv.) *Eyre Peninsula.* From time to time bores have been sunk on Eyre Peninsula, but with little success. In some instances, stock water (1½ ozs. salts to the gallon) was obtained, but this only occurred on the Nullarbor plains. In all other cases the water struck was far too salt to be used. Consequently the supply of water is now principally from catchments. A number of reservoirs have been constructed to hold from 1,000,000 to 9,000,000 gallons each. Many underground tanks have been built to contain from 40,000 up to 500,000 gallons each.

6. **Western Australia.**—The work by which the Government of Western Australia provides a permanent supply of water to Kalgoorlie, Boulder and adjacent districts on the eastern goldfields comes properly under the heading of "Water Supply Works." A description of this undertaking is fully given in previous issues of the Year Book. (See No. 6, p. 576.)

In August 1912 the administration of the Goldfields Water Supply and of the Mines Water Supply was transferred to a newly established Water Supply, Sewerage and Drainage Department. The statistics in connection with this department will be found in the section of this book dealing with *Local Government.*

The following table shews particulars as to Western Australian artesian bores at 30th June, 1917 :—

WESTERN AUSTRALIAN ARTESIAN BORES, 30th JUNE, 1917.

Particulars.	State.	Private.	Total.
Bores existing	66	49	115
Total depth ... ... feet	81,092	39,944	121,036
Daily flow ... ... gals.	23,864,700	8,206,700	32,071,400
Depth at which artesian water was struck—			
Maximum ... ... feet	4,016	*	...
Minimum ... ... feet	175	*	...
Temperature of flow—			
Maximum ... ... °Fahr.	140	*	...
Minimum ... ... °Fahr.	60	*	...

* Not available.

To 30th June, 1917, the total number of Government bores was 66, and there were approximately 49 private bores recorded in addition. The total cost of construction of State bores to 30th June, 1917, was about £137,874, of which amount £96 was expended during the twelve months ended 30th June, 1916. The maximum outflow, 4,000,000 gallons per day, was obtained at Leederville in connection with the Metropolitan Water Supply at 2097 feet.

The boring operations which have been carried out in the artesian basins along the West Australian Coast are as follows :—

(i.) *The Coastal Plain Basin or Perth Area,* which, generally speaking, extends from Cape Leeuwin to Dongarra, and from which the Metropolitan Water Supply is largely drawn, yields a supply of water mostly fresh and suitable for domestic purposes, though towards the north it becomes brackish and is only suitable for stock purposes.

There are fifty-seven bores in the Metropolitan District, several of which have been put down to augment the hills supply and the domestic supply of the suburbs, and Fremantle is largely dependent upon this source.

(ii.) *The North-west Basin or Carnarvon Area* may be said to extend from Gantheaume Bay in the south to Onslow in the north, and embraces a very large tract of ideal sheep country.

Many private bores have been put down on sites which permit of the gravitation of the water for miles, and, by this means, a very considerable area has been put under stock. Some remarkable flows have been obtained and, in one case, at a depth of 300 feet a flow reputed to be 3,000,000 gallons per day was struck, the water being suitable for stock.

In all, about 27 bores have been put down.

(iii.) *The Gulf Basin or Broome Area.* So far very little development work has been done. Artesian bores have been put down in the town site, and the domestic requirements of the town are entirely supplied from this source.

The area extends from Condon in the south-west to the Meda River beyond Derby in the north, and for a considerable distance inland.

So far only five bores have been sunk, two being at Broome and two at Derby, and one on the telegraph line on the road between Derby and Hall's Creek, about 67 miles inland.

(iv.) *Eucla Area.* This area extends from Eucla on the South Australian border, to west of Israelite Bay. So far, beyond the bores put down on the route of the Trans-Australian Railway, very little has been done in proving the resources of this area.

In 1902 the first bore was sunk, about 35 miles north of Madura, and sub-artesian water struck at 430 feet, at an elevation of 400 feet above sea level.

Following upon this, a deep bore was put down at Madura, below the cliff and nearer the coast, when an artesian supply of stock water was obtained at a depth of 2101 feet, yielding 31,000 gallons per day.

This was followed later with about 20 bores along the survey line of the proposed railway, which runs east and west about 90 miles inland. These bores were put in at intervals between the 205 mile peg and the South Australian border, and ranged in depth between 323 and 1344 feet. In most instances only stock water was struck at depths varying between 300 and 1300 feet, and the largest estimated supply was about 10,000 gallons per day.

7. **Northern Territory.**—In the Northern Territory, bores to the number of 128 were put down up to 31st December, 1914, 25 belonging to the Commonwealth Government. The cost of construction of the Government bores to that date was £6254. The total depth bored in State bores was 17,600 feet; in private bores 34,694 feet. Maximum depths were 213 feet in State, and 502 feet in private bores, and minimum depths were 110 feet and 128 feet respectively.

§ 2. Irrigation Plants.

1. **General.**—Australia's first experiments in irrigation were made with the object of bringing under cultivation areas in which an inadequate rainfall rendered agricultural and even pastoral occupations precarious and intermittent, and, although these original settlements have for the most part proved fairly successful, most of the States, instead of promoting new settlements in unoccupied regions, are adopting the policy of making existing settlement closer, by repurchasing big estates and large farms, subdividing them into holdings of suitable sizes for cultivation, and selling the land upon easy terms of payment. It is in connection with this Closer Settlement policy that the special value of irrigation is recognised.

2. **New South Wales.**—(i.) *Water Conservation and Irrigation Commission.* The provision of an adequate water supply for other than domestic purposes is essential to the well-being of all primary industries, and particularly in a country liable to dry

seasons which affect extensive areas. A large portion of the State receives an adequate and regular rainfall, but there is a considerable extent of country where all the factors exist which are requisite to success in agricultural pursuits excepting only a constant water supply. The recognition of the fact that the area suitable for cultivation might be extended largely by a comprehensive system of water conservation and irrigation has induced the Government to undertake various detached works and schemes, which will constitute portion of the ultimate irrigation system necessary to serve the whole State.

Water conservation and irrigation works within the State of New South Wales are under the control of the Water Conservation and Irrigation Commission, which consists of the Minister for Agriculture for the time being as Chairman, and two other Commissioners. The works controlled by the Commission include the great Murrumbidgee Irrigation Scheme, the small irrigation settlements at Hay and Wentworth, natural works of water conservation, shallow boring for settlers, and water trusts and artesian bore trusts operating under the Water Act. The Commission has control also of storages and diversions of water by private persons for purposes of water conservation and irrigation.

(ii.) *Murrumbidgee Irrigation Scheme.* The main features of the scheme include the storage dam across the Murrumbidgee to retain the floodwaters, which will be released for use lower down the river during the dry summer months ; a movable diversion weir, about 240 miles below the dam, to turn the required amount of water from the river into the main canal ; a main canal, leaving the river near the weir ; four main branch canals ; and a series of subsidiary canals and distributing channels through the area to be irrigated ; bridges, checks, regulators and other structures throughout the entire system, and meters for measuring the volume allowed to each farm ; towns and villages, also roadways to serve each farm, and a general surface drainage system, are also included in this scheme.

The site of the storage dam is at Burrinjuck, three miles below the confluence of the Murrumbidgee and Goodradigbee Rivers. The dam wall is being constructed of cyclopean masonry and concrete, and when completed will have a maximum height of 240 feet, and will impound the waters in a lake covering 12,740 acres. Ample water is being stored to meet the requirements of the farms already occupied, and to allow of water being drawn off during the summer months to augment the natural flow of the river for the benefit of riparian holders down stream. The reservoir will have a capacity of 33,612 million cubic feet, or 771,641 acre feet, the catchment area being about 5000 square miles, drained by three principal streams—the Murrumbidgee, Goodradigbee, and Yass Rivers—up which the water will be backed, when the dam is full, to distances of 41 miles, 15 miles, and 22 miles respectively. Direct communication between Burrinjuck and the Main Southern railway has been provided by the construction of a 2-foot gauge line from Goondah, a distance of 26 miles.

The diversion weir is situated at Berembed, about 40 miles by river and 19 miles in a direct line above the town of Narrandera. It is founded on a solid granite bar extending across the river, and has a length over all of 270 feet between abutments, divided into a sluiceway 40 feet wide in the clear ; a lock chamber, 40 feet wide, capable of taking barges up to 100 feet in length ; and 55 channoine wickets, manipulated from a punt moored up-stream. During the winter freshets the wickets are lowered, thus affording a clear water-way in the river channel.

The main canal branches from the river just above the weir, and, after passing through Narrandera, continues in a north-westerly direction, skirting the hills abutting on the plains. A scheme for enlarging the main canal to double its present capacity (1000 cubic feet per second) has been recommended by the Public Works Committee. The principal canals are the Gogeldrie canal, which off-takes at 47 miles from Berembed, and runs approximately parallel to the Narrandera-Hay railway through the Yanco area, and the Mirrool branch canal, which off-takes at 78 miles from Berembed and supplies portion of the Mirrool area.

The scheme, as described above, applies only to the land on the northern side of the Murrumbidgee River. It was originally intended to provide a canal to supply the land on the southern side, but subsequently it was decided to apply all the water available from the Burrinjuck Dam to the northern areas, sufficient land suitable for irrigation being there available, which, it is anticipated, will be worked profitably in small blocks devoted to mixed farming, dairying, and stock raising, or fruit and vegetable growing, etc. When the areas are fully settled it is estimated that there will probably be nearly 6000 farms and 100,000 people. With the aid of irrigation the soil and climate of these areas are suitable for the production of apricots, peaches, nectarines, prunes, pears, plums, almonds, melons, cantaloups, and citrus fruits, also wine and table grapes, raisins, sultanas, figs, olives, and most varieties of vegetables and fodder crops. Dairying, and pig-raising are already being successfully undertaken by settlers in the areas.

The first area made available for settlement was in the vicinity of Yanco Siding on the Hay railway line. The second, which is situated on the northern side of the Mirrool Creek, is served by an extension of the railway from Barellan to Griffith.

Further areas are being thrown open for settlement as the construction works are completed. Farms varying in size from 2 acres to over 200 acres have been made available. The "water right" or number of "acre feet" of water allotted to each holding is specified when the holding is notified as available for application. An "acre foot" of water means such a quantity, 12 inches deep, as would cover an area of one acre. The cost of water is five shillings per acre foot. The charge for water is reduced during the early years. For the first year the charge is 2s. 6d. per acre foot, thereafter increased annually by sixpence per acre foot until in the sixth and following years the full rate of five shillings becomes payable. The average "all-irrigable" farm is about 50 acres, but to suit the requirements of dairymen and other stock farmers, blocks of larger areas have been made available. These comprise non-irrigable or "dry" areas, in addition to the irrigable portion. Some of these mixed farms are 200 acres or upwards in extent, but the maximum water right allowed in respect of any of these larger farms is 100 acre feet. Additional water may be obtained, if available, by arrangement.

The conditions for the disposal of irrigation blocks are contained in the Crown Lands Consolidation Act of 1913, and Amending Acts. Any person of or over the age of 16 years, if a male, or 18 years if a female (other than a married woman not living apart from her husband under decree of judicial separation), or two or more such persons jointly, may apply for a farm or block. A married woman, not judicially separated from her husband, may, however, if she be not subject to any other statutory disqualification: (*a*) acquire by way of transfer, with the consent of the Minister, out of her own moneys, a lease within an irrigation area; (*b*) continue to hold a lease which she held before her marriage; (*c*) hold a lease which may devolve on her by will or intestacy of a deceased person. The tenure is perpetual leasehold.

The improvement conditions attached to the farm holdings include fencing, planting of trees for windbreaks, construction of dwellings, destruction of noxious plants, and the cultivation of a specified area in each year.

The special reservation of a number of farms for application by returned soldiers is in contemplation. As a preliminary measure a camp has been established on the Mirrool Subdivision, at which it is proposed to employ returned soldiers in the first instance, and thus afford the men an opportunity of gaining an insight into the climatic and other conditions connected with irrigation farming. It is proposed that accepted applicants for this camp shall receive a weekly payment exclusive of their keep, and while in camp they will clear, fence and grade the land, which will ultimately be made available to them for application as irrigation farms. Barracks have been provided, and a camp manager will have direct control thereof.

Subject to such conditions as to security and terms of repayment as the Commission may think fit to impose, settlers may obtain an advance, or have payment of rent or water rate suspended. Such advances are limited to the total amount of funds made available by Parliament for this purpose.

The Government Savings Bank Commissioners have statutory power to make loans upon mortgage of irrigation farm leases, and many settlers have already obtained help from the Bank. Concessions in railway fares and freights are made on New South Wales railways to *bona fide* applicants for land.

Towns and villages have been established at centres of the Yanco and Mirrool irrigation areas; the Commission is empowered to construct streets, and to provide water supply, sanitary and other services.

An up-to-date butter factory is in operation at Leeton. The output at the end of 1917 reached 5 tons per week, from an average of 120 to 130 suppliers. The factory also supplies ice to town residents and settlers. A fruit and vegetable canning factory with a rapidly increasing output has also been provided, which purchases vegetables and fruits grown by the settlers. A bacon factory and abattoirs have been erected at Yanco, where about 300 pigs, including a considerable number from other districts in the Riverina outside the irrigation areas are treated weekly, and where stock for butchers is slaughtered for local consumption.

To assist settlers on the Mirrool area, which is situated over 30 miles from Leeton, a small cheese factory has been opened at Griffith. A good marketable cheese is being produced. As an adjunct to the canning factory, a pulping plant has also been installed at Griffith.

One of the most important departmental undertakings on the irrigation areas is undoubtedly the State Nursery. For some years past the Leeton Nursery has been supplying trees to settlers, and in 1916 a second nursery was established at Griffith. Every effort is made to supply only the very best trees, free from disease, and to ensure this, as much use as possible is being made of budding wood from proven trees in the Leeton Nursery, and at the Yanco Experiment Farm.

The Department of Agriculture, which controls the Yanco Experiment Farm, has also established at Griffith (Mirrool irrigation area), a Viticultural Nursery for the propagation of vines on phylloxera resistant stocks. These stocks are intended not only for the supply of settlers on the areas, but for vignerons in all parts of the State.

An electric power station has been erected near Yanco Siding; electric light and power are supplied to the various factories, business people, and residents of Leeton and Yanco, and the supply is also available for settlers when the number of applicants in any centre warrants the connections being made.

On the 31st December, 1917, 831 farms were held, representing a total area of 36,433 acres. In addition, 135 town land blocks were held under lease.

In the matter of cultivation, the following particulars indicate the extent of the work performed by the settlers:—3112 acres under stone fruit, 346 under pome fruit, 1656 under citrus fruits, 1171 under vines, and 327 acres under mixed fruits. Particulars as to the area under fodder crops in 1917 are not available. However, in 1916, the area under cultivation in this regard amounted to 16,347 acres. The estimated population of the irrigation areas is about 5000.

(iii.) *Other Irrigation Settlements.* Irrigation settlements have been established at Curlwaa near Wentworth, and at Hay. These were in 1913 placed under the control of the Water Conservation and Irrigation Commission.

(*a*) *Curlwaa Irrigation Area.* The Curlwaa irrigation area embraces 10,600 acres, of which 1363 acres have been subdivided into 94 irrigable blocks. On 31st December, 1917, 85 blocks, comprising 1296 acres, had been taken up, in areas of 1½ to 37 acres. There are also 90 non-irrigated holdings of from ¾ to 336 acres, comprising 7104 acres, of which 82 blocks, representing an area of 6953 acres, were in occupation on the above date. An area of 1290 acres has been reserved as a common. The balance of the area is made up of road and channel and other reserves. During 1916-17 approximately 1100 acres were under cultivation, the greater part being devoted to fruit, including oranges, peaches, apricots, nectarines, pears, grapes, sultanas and currants. The area planted to fruit was 776 acres, of which about 600 acres were in bearing. It has been

proved beyond doubt that the Curlwaa soil is eminently suited to the growth of citrus and other kinds of fruit, and some of the finest oranges grown in New South Wales are produced on this area.

The estimated weight of dried fruits produced on the Curlwaa area in the year 1916-17 was 7022 cwt., the principal yields being sultanas, 2581 cwt.; peaches, 1423 cwt.; currants, 1404 cwt. In the previous year the product was 5955 cwt.; in 1914-15 it was 3178 cwt.; in 1913-14, 5118 cwt.; and in 1912-13, 4247 cwt. The heaviest crops have been sultanas and currants. The value of the dried fruit production for the twelve months ending 30th June, 1917, is estimated at not less than £20,000; in addition to which the area produced fresh fruit, crops and other produce of the value of some thousands of pounds.

The pumping machinery consists of a suction-gas plant, supplying two engines of about 55 brake horse-power each, working two centrifugal pumps, with an average combined capacity of about 4600 gallons per minute. With eight pumpings during the 1916-17 season, 89,243,000 cubic feet of water were supplied. The length of the main channels is about 8 miles 55 chains. The land may be leased for periods not exceeding thirty years, the annual rent at present varying from 1s. to 10s. per acre. The rate for water is fixed from time to time by the Commission, and is at present, except in a few special cases, 20s. per acre per annum. Each lessee is entitled to receive a quantity of water equivalent to a depth of 30 inches per annum, limited to 4 inches in any one month.

(*b*) *Hay Irrigation Area.* The Hay irrigation area consists of about 4160 acres, and previous to 1913 was controlled by a Trust appointed in 1897. On 31st December, 1917, the area held and used for irrigation purposes was 1002 acres, in 105 blocks of from 3 to 34 acres. The term of lease is generally 30 years, and the annual rental from 5s. to 12s. per acre. In addition, there was at that date an area of 2040 acres of non-irrigated land taken up in 43 blocks as permissive occupancies. The water rate is fixed from time to time, and during 1917 was £1 per acre per annum. The pumping machinery is of similar type to that at Curlwaa, the capacity of the pumps being 4000 gallons per minute. During 1916-17 season 90,182,240 cubic feet of water were pumped. Dairying is the principal industry; the cultivation of fruit is very limited.

(iv.) *Projected Irrigation Schemes.* The Water Conservation and Irrigation Commission are investigating schemes for storing water for the purpose of irrigation on the Darling, Lachlan, Macquarie, Hunter, Namoi, Peel and Warragamba Rivers.

(*a*) *Murray River.* An investigation is being made into the manner in which the New South Wales proportion of the Murray waters can be most profitably applied, but as yet no conclusion has been reached.

(*b*) *Darling River.* A preliminary investigation has been made of the Darling River, which shews that the most suitable site for the storage of large volumes of water is in the lake system to the east of the river, comprising Lakes Boolaboolka, Ratcatcher, and Victoria, and a number of other lakes (seventeen in all) fed from the river in high floods from the Talyawalka Creek, which takes off from the river about 260 miles above Menindie. Further investigation is required to determine the area which can be commanded from this storage. The question of establishing a small irrigation area, by direct pumping from the river, in the vicinity of Menindie, has also received attention.

(*c*) *Lachlan River.* The construction of a storage reservoir at Wyangala, below the confluence of the Abercrombie River, has been investigated with the intention of affording water in the river channel for pastoral purposes and for the irrigation of small areas along the river banks by pumping. A proposal is also being investigated for the increase of the storage in Lake Cudgellico, which is fed from the Lachlan River, and for the pumping thence of the water for the irrigation of an area of about 5000 acres adjacent to the lake. The possibility of regulating the amount of water lost in numerous effluent creeks is being considered, so that the best use may be made of the Lachlan River water.

(d) Macquarie River. The construction of a storage reservoir has been proposed on the river at Burrendong, below the confluence of the Cudgegong River, for the purpose of affording water by gravitation for the irrigation of certain lands to the west of Narromine. Smaller schemes for the construction of storage dams at White Rock, and on Campbell's River, at Bathurst, have also received consideration. The run-off from this catchment is somewhat uncertain, and before giving consideration to the construction of any State irrigation scheme, further investigation is necessary.

(e) Hunter, Namoi and Peel Rivers. Pumping by private irrigators under the Water Act is increasing at such a rapid rate that in the case of some of the rivers, such as the Peel and the Hunter, it will not be possible to supply the pumps in dry seasons until head storage works have been constructed. Surveys have been completed for storage dams on the Hunter and Peel Rivers and for a dam on the Namoi River above Manilla.

(f) Warragamba River. The Warragamba project will serve the dual purpose of amplifying the Sydney Water Supply and irrigating the best lands in the Nepean Valley. The rate of increase in the population of the metropolitan area during recent years, if maintained, will in a short space of time cause the consumption of water to overtake the capacity of the present catchment area of the Sydney water supply, and the next available source of supply will then be the Warragamba River, a scheme for the storage of water from which has been prepared. It is proposed to construct a large storage dam capable of supplying about 200,000,000 gallons daily for water supply, irrigation and trade purposes, and for compensation water. Surveys have been made and details are being prepared of this scheme, which has been submitted to the Public Works Committee.

(v.) *Water Rights.* The Water Act 1912 consolidates the Acts relating to Water Rights, Water and Drainage, Drainage Promotion and Artesian Wells. Part II. of the Act vests in the Crown the right to the use, flow and control of the water in all rivers and lakes which flow through or past, or are situate within the land of two or more occupiers. It abolishes "riparian rights," and establishes a system of licenses for works of water conservation, irrigation, and drainage. Prior to the passing of the Act relating to water rights, such works on creeks and rivers, constructed by private individuals, were liable to destruction by any person who considered their existence opposed to his interests. Now, under the Water Act, a severe sentence of imprisonment may be imposed in respect of interference with any work for which a license has been granted. The security thus provided has stimulated the construction of a better class of works for irrigation and the other purposes mentioned. Notwithstanding the generally favourable season experienced throughout the State, which lessened the necessity for irrigation during the year ended 31st December, 1917, 95 applications were made for new licenses, and 62 for the renewal of existing licenses, and at the end of the year 1206 licenses were in force.

(vi.) *Water Trusts and Bore Trusts.* Part III. of the Water Act 1912 provides for the supply of water either for irrigation, stock, or domestic purposes, and for drainage, the liabilities on which are repaid to the Crown, with interest spread over a period of years, and the works are administered by trustees appointed from among the beneficiaries under the Act; except in the case of trusts in the Western Division, where the Western Land Board is appointed as trustee. For the supply of water, trusts have been constituted in connection with (*a*) seventy-six artesian wells; (*b*) eight schemes for the improvement of natural off-takes of effluent channels, for the purpose of diverting supplies from the main rivers; (*c*) in four instances for the construction of weirs across stream channels (one has since been dissolved); and (*d*) two pumping schemes, one from natural watercourses, and one from a well. The total area included within these trusts amounts to 6,809,537 acres.

3. **Victoria.**—(i.) *Classification of Works.* The Water Conservation Works in Victoria divide themselves into irrigation works proper, and those providing mainly a domestic supply, such as the works for the supply of Melbourne, controlled by the Melbourne and Metropolitan Board of Works; the Coliban, Wonthaggi, Broken River, Kerang Lakes, Naval Base and Mornington Peninsula, and Mallee Supply Works, administered by the State Rivers and Water Supply Commission, and other works for domestic supply controlled by Water Works Trusts or Municipal Corporations. With the exception of the works administered by the Commission, particulars as to these works will be found in the section on "Local Government" in this volume.

(ii.) *Works Controlled by the Commission.* All the irrigation schemes (with the exception of that of the First Mildura Irrigation and Water Supply Trust), and the more important domestic and stock water-supply works in rural districts, are vested in and controlled by the State Rivers and Water Supply Commission, a body composed of three members, which was created by the Water Act 1905, now incorporated in the Water Act 1915.

(*a*) *Irrigation Schemes.* This division comprises the schemes constructed and under construction for the supply of water to some seventeen irrigation districts. Up to 1906 these schemes were controlled by local Trusts, which had obtained the moneys for their construction on loans from the State. By the Water Act 1905 all local control was abolished except in the case of Mildura, and the districts were transferred to the State Rivers and Water Supply Commission. Since that date the Government has adopted a vigorous irrigation policy, and the capital expenditure at 30th June, 1917, on water supply in the irrigation and water supply districts under the control of the Commission, and at Mildura, was £3,980,000. The irrigation works draw their supplies mainly from headworks constructed on the Murray, Goulburn, and Loddon Rivers. The cost of these headworks, which now stands at £1,123,000, is not debited to any particular districts, but is borne by the State. The extent of land under irrigated culture, for all kinds of crop, is 258,000 acres, which, notwithstanding the abnormally wet season, was within 3000 acres of the average area irrigated in the previous six years.

The following particulars of the principal schemes will be of interest, and will convey some idea of the extent to which the one-time arid northern portion of this State is now insured against droughts like that of 1902, when the combined capacities of its storages for irrigation by gravitation were only 75,000 acre feet, and of its pumping plants, 400 acre feet per day.

Goulburn Scheme. The Goulburn River Gravitation Scheme (see map on page 553) is the largest of Victoria's irrigation enterprises. It serves, either for irrigation or domestic and stock purposes, 850,000 acres of land in the valleys of the Goulburn, Campaspe and Loddon Rivers. The present headwork of the system is a diversion weir on the Goulburn River, near Nagambie. It is constructed of concrete masonry, with 21 flood gates, which raise the up-stream water level 10 feet above the concrete crest. These gates are lowered, during high stages of river flow, to provide a clear waterway for the discharge of floods. The weir has a total length, including channel regulators, of 925 feet, and a height of 50 feet. The water is diverted by two main channels, the eastern carrying 330 cubic feet per second (660 acre feet per day) a distance of 33 miles to the country north of the Broken River, while the western, which has a capacity of 1700 cusecs,* and a length of 23 miles, is used to feed distributaries of the Rodney District and to fill Waranga Reservoir, the present principal storage basin of the scheme. This reservoir, formed by an earthen embankment 4½ miles long across a natural depression, covers an area of 19 square miles to an average depth of 16 feet, and stores 197,000 acre feet. Works now in progress will raise the full supply level of this reservoir by ten feet, and increase the storage capacity to 330,000 acre feet. Two main channels issue from this reservoir, the Waranga-Rodney, of 250 cusecs* capacity, which feeds Rodney distri-

* Cusecs=Cubic feet per second.

butary channels, and the Waranga-Campaspe-Serpentine, which leaves the reservoir with a capacity of 1000 cusecs, and ends at the Serpentine Creek, 92 miles westward, with a capacity of 200 cusecs. The total length of distributary channels is 1600 miles.

The portion of the State served by this system comprises 19,000 acres east of the Goulburn, 564,000 acres between the Goulburn and the Campaspe, and 267,000 acres between the Campaspe and the Loddon. These areas include the irrigated Closer Settlements at Shepparton, Tongala, Rochester and Dingee (see "Closer Settlement in Irrigation Districts," page 276) in which annual water rights are allotted of not less than one acre foot of water to each acre of irrigable land. They include also the districts formerly controlled by the Rodney and Tragowel Plains Irrigation Trusts, in which districts, generally, the holdings are larger than in Closer Settlement areas. The water rights in these districts are, for lands under intense culture, one acre foot of water to each irrigable acre, and for other irrigable lands, one acre foot to four irrigable acres in the former district, and one to five in the latter. The balance of the area, including Deakin district, while not subject to a compulsory irrigation charge, is provided with a domestic and stock supply, and water is sold for occasional irrigation on application. The amount of the compulsory charge for irrigation water allotted as a "right" is at present 6s. per acre foot in the two districts—Tragowel Plains and Dingee—farthest removed from the sources of supply, and 5s. per acre foot elsewhere. With a view of meeting the increasing demand for water in dry seasons, and providing an irrigation supply for other suitable lands, the Commission is constructing a storage reservoir on the Upper Goulburn, just below its junction with the Delatite River, at what is known as the Sugarloaf site. The dam, which is 2550 feet in length, consists of a diaphragm wall of reinforced concrete, built from bed rock (in some places 75 feet below natural surface) to crest level 135 feet above the river bed; a wall of clayey material on the upstream side of the diaphragm; and supporting masses of rock. This reservoir will submerge an area of 7600 acres, and store about 300,000 acre feet of water, bringing the total capacity of the Goulburn storages to 630,000 acre feet. The foundations of the Sugarloaf structure will permit of the dam being raised, if necessary, to a height of 190 feet above the river bed. This would add 8600 acres to the area submerged, and would increase the storage capacity from 300,000 to 900,000 acre feet.

Loddon River Scheme. This also is wholly a gravitation system. The headwork is a regulating weir on the Loddon at Laanecoorie, about 22 miles westerly from Bendigo. This weir is constructed of concrete masonry with "Chaubart" automatic floodgates five feet high for a length of 320 feet, combined with an earthen embankment, the length over all being 940 feet. Its storage capacity is 14,000 acre feet. Other works of the scheme are timber diversion weirs at Serpentine and Kinypanial, 80 and 120 miles downstream respectively, also 160 miles of channels (taken over from several irrigation Trusts in the Boort district) which supply an area of 74,000 acres for domestic and stock purposes and partial irrigation.

Murray River Schemes. These comprise both gravitation and pumping schemes. The only wholly gravitation system is that known as the Kow Swamp scheme, which supplies the Kerang irrigation district of some 85,000 acres. The off-take is at Torrumbarry headworks, from which the Gunbower channel diverts water, when the Murray river is five feet above summer level, to the Kow Swamp storage, a natural depression improved so as to hold a volume of 41,000 acre feet. From this reservoir the water is distributed by the Macorna channel (40 miles in length) and about 200 miles of distributaries.

The Cohuna, Gannawarra, Koondrook and Swan Hill Schemes are combined gravitation and pumping schemes. The Cohuna-Gannawarra plant consists of two 36 inch and four 39 inch centrifugal pumps—total capacity 280 cusecs; those at Koondrook and Swan Hill, each of 100 cusecs capacity, consist each of two 39 inch centrifugal pumps. The pumped supplies are supplemented at varying stages of river level by the gravitation water.

Note.—Cusecs=Cubic feet per second.

The Cohuna, Koondrook and Swan Hill Districts, comprising 106,000 acres, embrace the irrigated Closer Settlements of the same names. In these districts and that of Gannawarra (comprising 44,000 acres) the quantity of water allotted as a "right" is one acre foot per irrigable acre. The compulsory charge is at present 5s. per acre foot of such water right. In Kerang district—not under a compulsory irrigation charge—water is sold to irrigators on application at a charge not exceeding 3s. per acre foot of water supplied.

The Nyah Irrigation Area was occupied in 1894 under village settlement conditions, settlers being allowed up to 50 acres each. Individual attempts at irrigation having proved unsuccessful, a Government scheme was prepared for the whole settlement. A number of settlers surrendered portions of their holdings, which were too large for effective working, and these portions, with adjacent Crown lands, were re-subdivided and made available, under the Murray Settlements Act 1907, on easy terms. Water is diverted from the Murray by a high lift pumping plant—capacity 25 cusecs— consisting of two coupled 24 inch turbine centrifugal pumps. The settlement now contains 141 holdings, of an average area of 20 acres, of which 128 are settled. Water rights are apportioned to these holdings on the basis of 2½ acre feet of water for each irrigable acre, and the compulsory charge is at present 14s. per acre foot of such water rights. The land is devoted mainly to vineyards and orchards, and the settlers, taken as a whole, are making good progress.

The Merbein Irrigation Area (formerly known as White Cliffs) comprises 6200 acres of what, eight years ago, were Crown lands. This settlement now contains 239 holdings, averaging 26 acres each, so highly improved as to sell, as orchard properties, at prices up to £200 per acre. The water is pumped from the Murray by a plant of four turbine centrifugal pumps—lift 96 feet, capacity 50 cusecs—and one 36 inch high lift centrifugal pump, capacity 50 cusecs. The land settlement conditions and water rights apportioned are the same as at Nyah, but the compulsory charge is at present 15s. per acre foot. Last year's production at Merbein comprised some 2600 tons of dried fruits, 4000 tons of distillery grapes, and 6600 cases of fresh fruits, of a total value of £185,000, an average of about £30 per acre occupied.

Werribee River Schemes.—Bacchus Marsh. The headwork of this gravitation scheme is a reservoir of 15,000 acre feet capacity on Pyke's Creek, a tributary of the Werribee, the in-take from the creek catchment being supplemented by a tunnel through a dividing spur, which taps the Werribee River near Ballan. The dam, 1000 feet in length and 100 feet in height, is built of earth, with dwarf concrete core. The area of the district is 6600 acres—half of which is irrigable—and includes some of the richest lucerne land in the State. The annual water right is one acre foot per irrigable acre, and the present compulsory charge is £1 per acre foot of such right. The higher portion of the district receives a supply for domestic and stock purposes.

Werribee. This is another gravitation scheme on the same river. The headwork is a reservoir at Melton, immediately below the Bacchus Marsh district. The dam is of earth, with dwarf concrete core. Its length is 600 feet, height 100 feet, and the storage capacity of the reservoir 17,000 acre feet. A diversion weir at Werribee, 71 miles downstream from the reservoir, a main channel therefrom, and the usual distributaries and appurtenant works, complete the scheme. The irrigation district comprises some 7000 acres of first-class land, being the irrigable portion of the Werribee Closer Settlement Estate, which is within 20 miles southwesterly of Melbourne. Most of this land is settled, and the balance is held for discharged soldiers. The water right allotment is one acre foot per irrigable acre, and the charge at present is 10s. per acre foot. The non-irrigable portion of the estate, containing about 13,000 acres, is supplied with water for domestic and stock purposes.

(*b*) *Domestic and Stock Schemes.* The second division takes into account the schemes constructed and under construction for the supply of water for domestic and stock purposes, the capital expenditure on which at 30th June, 1917, was £4,951,000.

The area of country lands artificially supplied with water for these purposes is nearly 21,000 square miles. The number of towns supplied, exclusive of the City of Melbourne and its suburbs, is 154, serving an estimated population of 293,000. In addition to the Commission's districts, some large areas are still administered by local authorities.

The principal scheme in this division is that known as the *Wimmera-Mallee Gravitation Channel System.* This comprehensive scheme of works will compare favourably, it is believed, with any similar individual scheme, for domestic and stock service, in any part of the world. The main supply is drawn from three reservoirs in the catchment area of the Wimmera River, at the foot of the Grampians Ranges, viz.:—Lake Lonsdale, Wartook, and Fyans Lake. A fourth—Taylor's Lake—now under construction, is nearing completion. The reservoirs in use have a combined storage capacity of 86,000 acre feet. The completion of the works in progress, and other minor works, will bring this total to 122,000 acre feet. The water is conveyed, partly by natural watercourses, but chiefly by artificial channels, aggregating over 3600 miles in length, over farming districts comprising about 8500 square miles, approximately one-tenth of the whole State (see map on page 554).

Another scheme in this division which calls for mention here is the *Naval Base and Mornington Peninsula Scheme.* This comprehensive scheme—prepared at the request of the Naval Authorities—is for the supply of water to the Flinders Naval Base, and for the service of fifteen townships en route, including Berwick, Beaconsfield, Pakenham, Aspendale, Chelsea, Carrum, Frankston, Mornington, and Hastings. An ample supply of water is obtainable from the headwaters of the Bunyip River, which drains some 30 square miles of forest country above the point of off-take. The works are already well advanced, those portions which more directly affect the Naval Base being expedited so as to give water to that important area before the end of the present year.

(iii). *Mildura.* The creation of an irrigation colony at Mildura was the outcome of a visit by Mr. Deakin to California in 1885, when Messrs. Chaffey Bros. were invited to visit Victoria, with the object of founding a similar settlement to those which they had been largely instrumental in establishing in California.

Active operations were commenced in 1887, since which date marvellous progress has been made, instanced in the fact that, originally used as a sheep run and carrying one sheep to every thirty acres, the dried fruit harvested from 12,000 acres in 1916 was valued at £683,000 gross.

Water is pumped and supplied under Act of Parliament by the first Mildura Irrigation Trust from the river Murray by two pumping stations, viz.:—(1) into a billabong, and thence to pumps lifting to various levels, and (2) to a comparatively small area adjacent to the town.

The length of the Trust's main and subsidiary channels is 280 miles. For the year ending 30th June, 1917, the Trust's receipts aggregated £29,167, and its expenditure £22,654. For the same period the number of water acres supplied was 29,966.

Loans (balance) advanced to the Trust by the Government for the purpose of improving the plants and channels, etc., amounted at 30th June, 1917, to £82,595, exclusive of the sum of £10,797 (balance) arrears of interest.

The area of the settlement is 45,000 acres, of which 12,000 acres are under intense culture, vines predominating.

4. **Queensland.**—The main irrigation works in Queensland are as follows:—(*a*) those at Ayr, which utilise the waters of the Burdekin River, and shallow wells on its banks; (*b*) those at Bingera, near Bundaberg, which utilise water pumped from the Burnett River just above the point of meeting of the salt and fresh waters, and (*c*) those at Fairymead, which utilise water pumped from a number of shallow spear wells sunk on the alluvial flats on the north side of the Burnett River and about six miles from Bundaberg. There were 741 irrigators in the State in 1916, chiefly farmers and graziers, and the area irrigated was 10,886 acres.

5. **South Australia.**—(i.) *The Renmark Irrigation Trust.* The Renmark Irrigation Trust was established in 1893 on similar lines to Mildura, but on a smaller scale. The area of settlement is 21,000 acres, the area under irrigation being 5270 acres. There are also 1000 acres under crop for hay. The dried fruit pack for 1917 was 2350 tons, green fruit 2300 tons, and the gross value of the production for that year was £126,000. The population of the town and settlement is 3000. The chief products are sultanas, currants, raisins, oranges, apricots, peaches, pears, olive oil, and grape spirit. There are two distilleries for the manufacture of grape spirit.

(ii.) *Other Waterworks.* A number of country water works are under the control of the Public Works Department. As, however, they are not irrigation works properly so called, but are used for supplying water for domestic purposes, etc., to several towns, no further reference will be made to them in this chapter. (See Section XXVI., *Local Government.*)

(iii.) *Area under Irrigation.* Until 1910, irrigation in South Australia, with the exception of the schemes already mentioned, made little, if any, progress; but in that year an Irrigation and Reclamation Works Department was created, and the preparation of land for irrigation settlements has since been vigorously pursued.

The functions of the Department cover (*a*) the reclamation of the swamp lands along the lower reaches of the Murray, which are watered by gravitation, and (*b*) the preparation of the sandy loam highlands for intense culture, the water, after being pumped from the river, being distributed by concrete channels. A number of the small settlements along the river, originally established as village settlements, were taken over by the Department, and the areas available for reticulation extended and offered for occupation. These include Waikerie, with an irrigable area of 2515 acres, in addition to 4372 acres of "dry" land; Kingston with 415 acres of irrigable and 3096 of "dry" land; and Moorook with 2950 acres, of which 1200 acres can be irrigated. The new areas commenced by the Department were Berri, where 3043 acres of irrigable land and 2364 acres of "dry" land have been allotted to 160 settlers. Further pumping plants have been installed, which will enable this settlement to be extended to 9000 acres of irrigable land and 11,000 acres of "dry" land. The adjoining area of Cobdogla, the preparatory survey of which has been completed, contains approximately 30,000 acres of first-class land suitable for intense culture, in addition to 111,000 acres of "dry" land. The first section of this area, comprising about 2000 acres, which can be watered from a lift of about 20 feet, is now available for allotment. When completed, this settlement will be supplied from four distinct pumping plants, two on the River Murray at different points, and two on Lake Bonney at the north and south ends respectively. This lake is fed from the river by means of Chambers' Creek, and comprises an area of 4000 acres. At Cadell an area of 2700 acres has been acquired, 1200 acres of which are first-class irrigable land; this is now being prepared by the Department for settlement. The reclaimed swamps, which have already been completed and allotted, comprise 3600 acres, while other swamp lands of about 3200 acres are in course of reclamation.

A recent innovation has been the preparation of joint schemes of reclaimed and irrigable land, the swamps being reclaimed and the adjoining sandy loam highlands channelled, thus enabling the adoption of dairying, fodder growing, and stock raising in conjunction with horticulture. The areas comprise, Mypolonga, 1700 acres of reclaimed land, 1254 acres of irrigable, and 1481 acres of "dry" land; Wall, 619 acres of reclaimed land, 160 acres of irrigable and 208 acres of "dry" land; Pompoota, 560 acres of reclaimed land, 250 acres of irrigable land, and 3277 acres of "dry" land; Jervois, 990 acres of reclaimed land, 290 acres of irrigable land, and 260 acres of "dry" land; Swanport, 116 acres of reclaimed and a similar area of irrigable land; Neeta, 560 acres of reclaimed, 1820 acres of irrigable, and 2348 acres of "dry" land. Mypolonga and Wall have been allotted, the latter to returned soldiers, and Pompoota is being utilised as a training farm for returned soldiers. The other areas have yet to be allotted for settlement. The reclaimed lands consist of peaty soils composed of rich river silt, and are eminently

suited for the growth of lucerne and other fodders, onions, potatoes, etc. The soils of the irrigable lands have already proved their suitability for the production of peaches, apricots, nectarines, oranges, lemons, figs, and grapes.

All lands are allotted under perpetual lease, and blocks are surveyed into areas varying up to 50 acres of irrigable or reclaimed land. No lessee is permitted to hold more than 50 acres of irrigable or reclaimed land or of both irrigable and reclaimed, except that in the case of a partnership 50 acres may be allotted for each member of the partnership up to a maximum of 150 acres. In addition, areas of non-irrigable land are allotted to lessees of irrigation and reclaimed blocks for dry farming. The rentals of the blocks are fixed by the Land Board immediately prior to the land being offered for application. For the reclaimed land an amount is charged sufficient to cover interest on cost of land and reclamation, while for the irrigable land the rent is based on the unimproved value of Crown lands, or to cover interest on cost of repurchased lands.

On the irrigable land, the water rate has been fixed at 30s. per acre per annum for the first four years, after which an amount will be charged sufficient to cover actual cost of supplying water, and interest on pumping plant, channels, etc. On the reclaimed lands an amount is charged to meet annual management, drainage, and maintenance expenses. A sliding scale covers the rent on all land, and water rates on the irrigable land for the first four years, *i.e.*—first year, one-quarter of the rent and water rate; second year, one-half; third, three-quarters; fourth and afterwards, full amount per acre. On the irrigable lands, each lessee is entitled for the water rate to 24 acre inches per annum, supplied in six irrigations; special irrigations and domestic supplies are supplied at times other than during the general irrigations, at a nominal cost. On the reclaimed lands, water is supplied regularly by reticulation from the river.

The Department assists settlers by fencing, clearing, grading and constructing irrigation channels and tanks. Such improvements are undertaken up to a value not exceeding £15 per acre of the irrigable area in each lessee's block, but before the work is commenced a deposit must be paid equal to 15% of the Department's estimated value of such improvements. The total cost of the work, less deposit, is treated as a loan to the lessee, and is repayable in twenty equal annual instalments after the expiration of five years, or at any shorter period if desired by the lessee; current rate of interest being charged. Any lessee is permitted to accept the contract for carrying out his own improvements according to the specifications and estimates of the Department, up to the maximum amount per acre, as mentioned above. Advances can be obtained from the Advances to Settlers Board for the purchase of stock, discharging mortgages, erecting permanent buildings, and other improvements, the first £400 being advanced on the fair estimated aggregate value of the settler's lease, and any improvements already made on the holding, and those in course of being made thereon. Any loan beyond £400 would not exceed 15s. in the £ of the fair estimated value of the improvements already made.

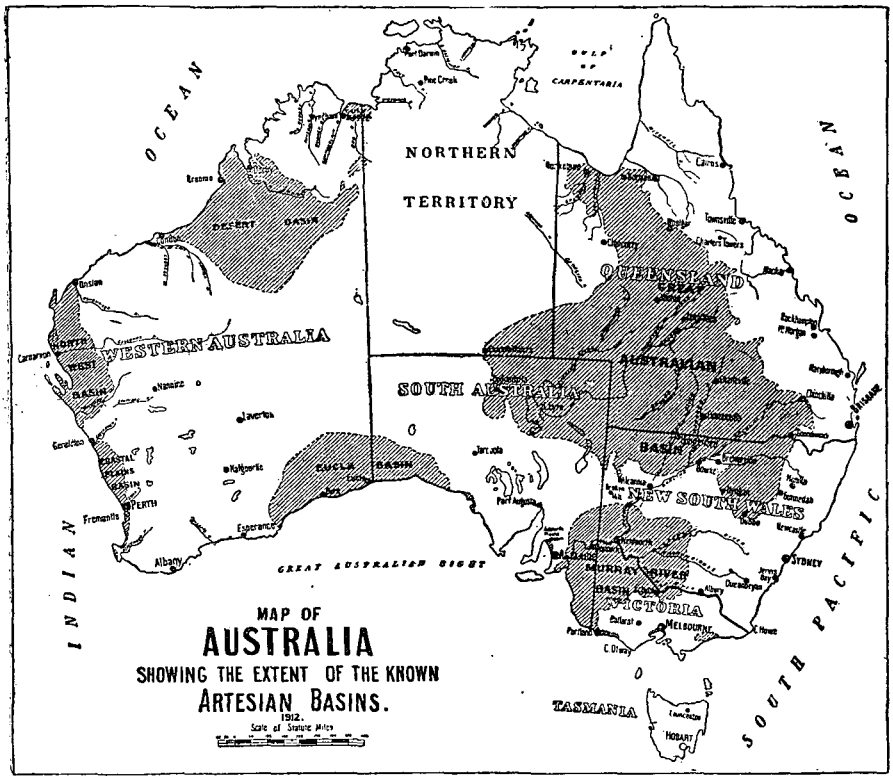
In the section dealing with Closer Settlement (page 271) the subject of irrigation areas in South Australia has already been referred to.

6. **Western Australia.**—An Irrigation Act has been brought into force providing for the constitution of irrigation districts. At Harvey the works for irrigating about 4000 acres devoted to fruit growing, principally oranges, were completed, and formally opened on the 21st June, 1916. A scheme is now in preparation for irrigating a further area of about 4600 acres in the same district.

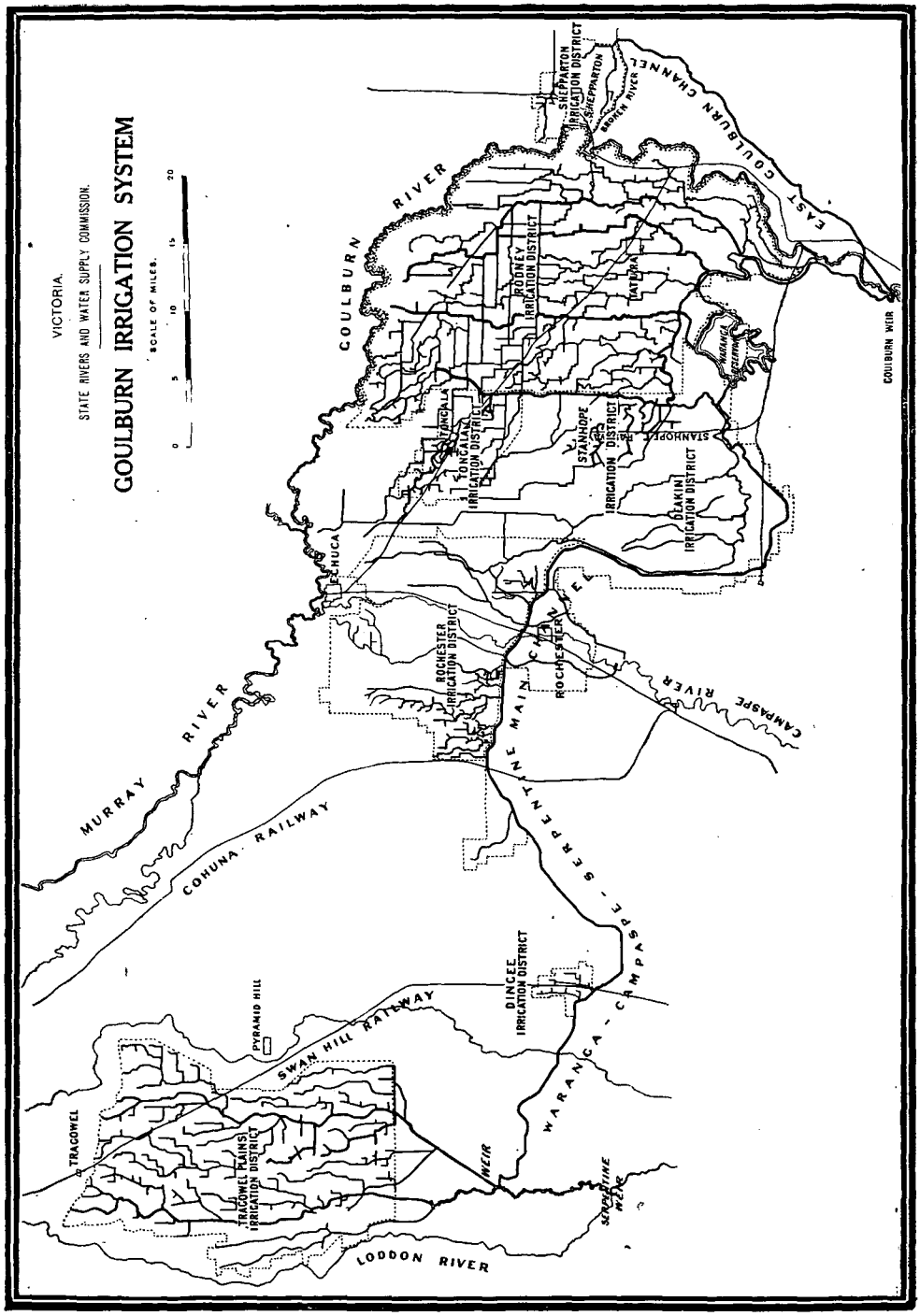
Numerous small private irrigation schemes are in full operation on many of the south-west rivers in connection with fruit, fodder, and potato growing.

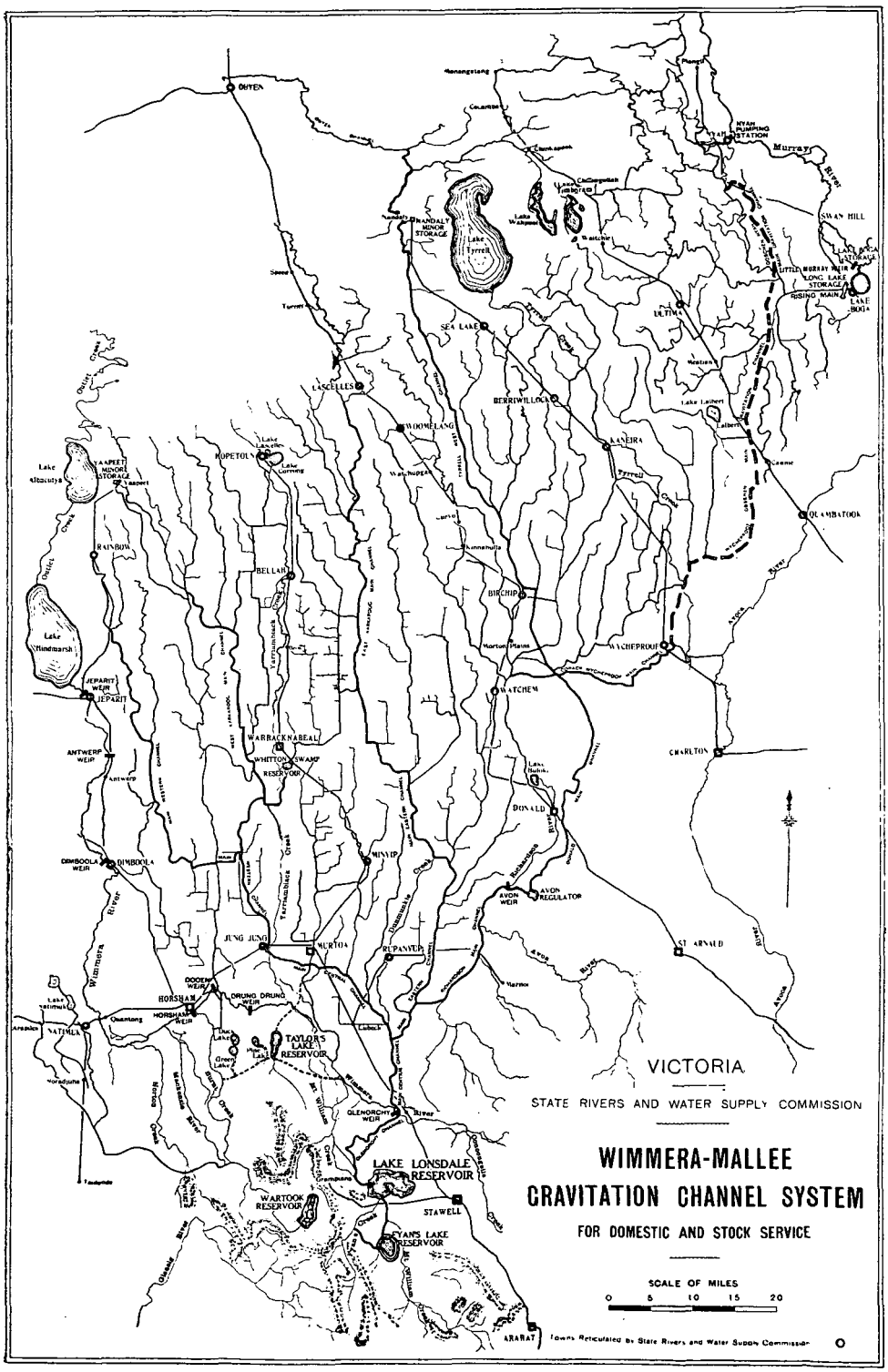
7. **Murray Waters.**—The negotiations which took place prior to the passing of the River Murray Waters Act as to the relative State rights of New South Wales, Victoria and South Australia to the waters, are given in detail in previous issues of this book. (Year Book No. 9, page 537.)

MAP SHEWING THE POSITION AND EXTENT OF THE "AUSTRALIAN ARTESIAN BASINS."



This map was prepared by the Interstate Conference on Artesian Water, held in Sydney during May, 1912. It contains the latest facts relative to the various artesian basins of the Australian continent. Of these basins the most important is the Great Australian Basin, which is about 569,000 square miles in extent, viz.:—About 376,000 square miles in Queensland, 90,000 square miles in South Australia, 83,000 square miles in New South Wales, and 20,000 square miles in the Northern Territory. The Murray River Basin extends over South-Western New South Wales, North-Western Victoria, and South-Eastern South Australia. The Western Australian Basins fall naturally within five groups, viz.:—The Eucla Basin, the Coastal Plains Basin, the North-West Basin, the Desert Basin, and the Gulf Basin. (See also pages 532 to 539.)


VICTORIA.
STATE RIVERS AND WATER SUPPLY COMMISSION.
GOULBURN IRRIGATION SYSTEM
SCALE OF MILES.
0
5
10
15
20
MURRAY RIVER
COHUNA RAILWAY
TRAGOWEL
TRAGOWEL PLAINS IRRIGATION DISTRICT
PYRAMID HILL
SWAN HILL RAILWAY
LODDON RIVER
WEIR
SERPENTINE WEIR
DINGEE IRRIGATION DISTRICT
WARANGA - CAMPASPE - SERPENTINE MAIN CHANNEL
ROCHESTER IRRIGATION DISTRICT
ROCHESTER
CAMPASPE RIVER
ECHUCA
TONGALA IRRIGATION DISTRICT
TONGALA
STANHOPE IRRIGATION DISTRICT
STANHOPE
DEAKIN IRRIGATION DISTRICT
RODNEY IRRIGATION DISTRICT
TATURA
COULBURN RIVER
SHEPPARTON IRRIGATION DISTRICT
SHEPPARTON
BROKEN RIVER
EAST GOULBURN CHANNEL
COULBURN WEIR


VICTORIA
STATE RIVERS AND WATER SUPPLY COMMISSION
WIMMERA-MALLEE
GRAVITATION CHANNEL SYSTEM
FOR DOMESTIC AND STOCK SERVICE
SCALE OF MILES
0 5 10 15 20
Towns Reticulated by State Rivers and Water Supply Commission
OUYEN
Murray
River
NYAH PUMPING STATION
SWAN HILL
LAKE BOGA STORAGE
LITTLE MURRAY WEIR
LONG LAKE STORAGE
RISING MAIN
LAKE BOGA
RANDALL'S MINOR STORAGE
Lake Tyrrell
Lake Wahpool
Watchem
SEA LAKE
ULTIMA
Nestleton
Lake Albert
Albert
Lake Lascelles
LASCELLES
WOOMELANG
BERRIWILLOCK
LAMEIRA
Lake Albacutya
LAMPEET MINOR STORAGE
HOPETOUN
Lake Lake Lake Lake
RAINBOW
BELLAR
BIRCHIP
Lake Hindmarsh
Morton Plains
WYCHEPROOF
JEPARIT WEIR
JEPARIT
WATCHEM
ANTWERP WEIR
WARRACKNABEAL
WHITTON SWAMP RESERVOIR
CHARLTON
DONALD
DIMBOOLA WEIR
DIMBOOLA
WINYIP
AVON WEIR
AVON REGULATOR
JUNG JUNG
MURTOA
RUPANYUP
ST ARNAUD
DODEMA WEIR
HORSHAM
DRUNG DRUNG WEIR
HORSHAM WEIR
NATIMUK
TAYLOR'S LAKE RESERVOIR
GLENORCHY WEIR
LAKE LONSDALE RESERVOIR
WARTOOK RESERVOIR
STAWELL
EVANS LAKE RESERVOIR
ARARAT
Wimmera
River
Avon
River

On the 31st January, 1917, the River Murray Waters Act was brought into operation. The principal provisions of this Act are that a storage of one million acre feet is to be created by the construction of a dam on the Upper Murray above Albury. This work is to be constructed by New South Wales and Victoria conjointly. A joint investigation has been in progress by the two States interested for some years past, with a view to determining the most suitable site for the construction of this large work, but although a number of sites have been tested, no determination has yet been arrived at.

From the storage dam to Echuca, the river will not be locked, but from Echuca to Blanchetown in South Australia, 26 weirs and locks will be constructed, affording a navigable depth at all times for vessels drawing 5 feet of water. The weirs and locks above Wentworth will be constructed by Victoria and New South Wales jointly, and below Wentworth by South Australia. The Act also provides for the construction of locks and weirs in the Murrumbidgee River from its junction with the Murray River to Hay, or alternatively, for an equivalent expenditure of £540,000 upon locking the Darling River from its junction with the Murray upwards.

A system of storage is to be provided in Lake Victoria, to be controlled by South Australia.

The total expenditure involved by the construction of the works covered by the Act is estimated at £4,663,000, of which the Commonwealth Government will contribute £1,000,000, and the three States interested, the balance in equal shares.

The effect of constructing the River Murray storage would be to insure at all times sufficient flow below Albury to permit of diversions for irrigation, and stock and domestic supplies, and also to make good the losses in the river due to seepage, evaporation, and lockages. The Act provides that, subject to certain conditions, New South Wales and Victoria shall share the regulated flow of the river at Albury, and shall each have the full use of all the tributaries of the River Murray within its territory below Albury, with the right to divert, store and use the flows thereof. It is estimated that the New South Wales regulated river flow after the construction of the Upper Murray storage will amount to at least 120,000 acre feet per month at Albury during the irrigation season, except in a period of phenomenal drought, such as 1902 and 1903. The River Murray Commission has been constituted, and is making investigations regarding works to be carried out.