CHAPTER XXIII.

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 Australia 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 in the chapter dealing with Local Government. Interstate Conferences on artesian water were held in 1912, 1914, 1921, and 1924, when combined Governmental action was agreed upon with reference to delimitation of the artesian basins, hydrographic surveys, analyses and utilization of artesian water, etc. (See map on page 859).

2. **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 (shown approximately by the map on page 859) is said to be the largest yet discovered, and measures about 600,000 square miles, of which 376,000 square miles are in Queensland, 118,000 square miles in South Australia, 80,000 square miles in New South Wales, and 25,000 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).

3. **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 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. 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.

4. **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 palaeozoic rocks of the Mount Lofty and other ranges extending northwards from near the mouth of the Murray to the Barrier Range, 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 bores have been put down, and water has been struck at various levels.

5. **Plutonic or Meteoric Waters.**—In previous Year Books will be found a statement of the theory of Professor Gregory* as to the origin of the water in the Australian artesian basins together with the objections held thereto by a former Government Geologist of New South Wales † (See Official Year Book No. 6, p. 570).

6. **Artesian and Sub-Artesian Bores.**—(i) *General.* The following table gives particulars of artesian and sub-artesian bores in each State and in the Northern Territory :—

ARTESIAN AND SUB-ARTESIAN BORES, 1927–28.

Particulars.	N.S.W.	Vic.	Q'land.	S. Aust. (c)	W. Aust.	N. Ter.	Total.
Bores existing .. No.	532	374	3,260	145	234	187	4,732
Total depth of existing bores feet	896,788	99,700	d3,979,003	113,058	219,149	60,796	5,368,494
Daily flow 1,000 gals.	a78,959	(b)	a309,499	a12,972	68,945	7,640	e478,015
Depth at which artesian water was struck—							
Maximum .. feet	4,338	800	7,009	4,850	3,325	1,760	7,009
Minimum .. feet	89	150	10	55	39	42	10
Temperature of flow—							
Maximum .. °Fahr.	139	(b)	212	208	140	(b)	212
Minimum .. °Fahr.	68	(b)	78	82	75	(b)	68

(a) Flowing bores only. (b) Not available. (c) Government bores only. (d) Total depth of all bores. (e) Incomplete.

(ii) *New South Wales.*—(a) *Artesian Water Supply.* The New South Wales portion of the great Australian basin, comprising approximately 80,000 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.

The following statement shows the extent of the work successfully carried out by the Government and by private owners up to 30th June, 1928 :—

EXISTING ARTESIAN BORES.—NEW SOUTH WALES, 1928.

Bores.	Flowing.	Pumping.	Total.	Total Depth.
For Public Watering-places, Artesian Wells, etc.	134	39	173	362,720
For Country Towns Water Supply ..	3	1	4	6,533
For Improvement Leases	19	7	26	38,621
Total Government Bores ..	156	47	203	407,874
Private Bores	232	97	329	488,914

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

† *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 ; and "The Composition and Porosity of the Intake Beds of the Great Australian Artesian Basin," Sydney, 1915.

The average depth is 2,009 feet in the case of Government bores, and of private bores 1,486 feet, and it ranges from 89 to 4,338 feet. The two deepest wells in New South Wales are those at Boronga, in the County of Stapylton, with a depth of 4,338 feet and a present daily outflow of 809,251 gallons; and at Dolgelly, also in County Stapylton, with a depth of 4,086 feet, and a present discharge of 450,854 gallons per day. The largest flow at the present time is that at the Gareunga No. 2 Bore, in the County of Stapylton, which yields 1,278,340 gallons a day, and has a depth of 4,014 feet.

Of the 581 bores which have been sunk, 388 are flowing, and give an aggregate discharge of 78,959,271 gallons per day; 144 bores give a pumping supply, the balance of 49 being failures; the total depth bored represents 959,136 feet.

The flow from 92 bores is utilized for supplying water for stock on holdings served in connexion with Bore Water Trusts or Artesian Districts under the Water Act of 1912. The total flow from these bores amounts to 33,752,684 gallons per day, watering an area of 4,874,774 acres by means of 3,082 miles of distributing channels. The average rating by the Bore Trusts to repay the capital cost with interest is 2.12d. 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 utilized in connexion 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 holdings 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 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.

(*b*) *Private Artesian Bores.* Much has been done in the way of artesian boring by private enterprise. As far as can be ascertained, 354 private bores have been undertaken in New South Wales, of which 25 were failures. The yield of the flowing bores is estimated at 37¼ million gallons per day. No data are available regarding the pumping bores.

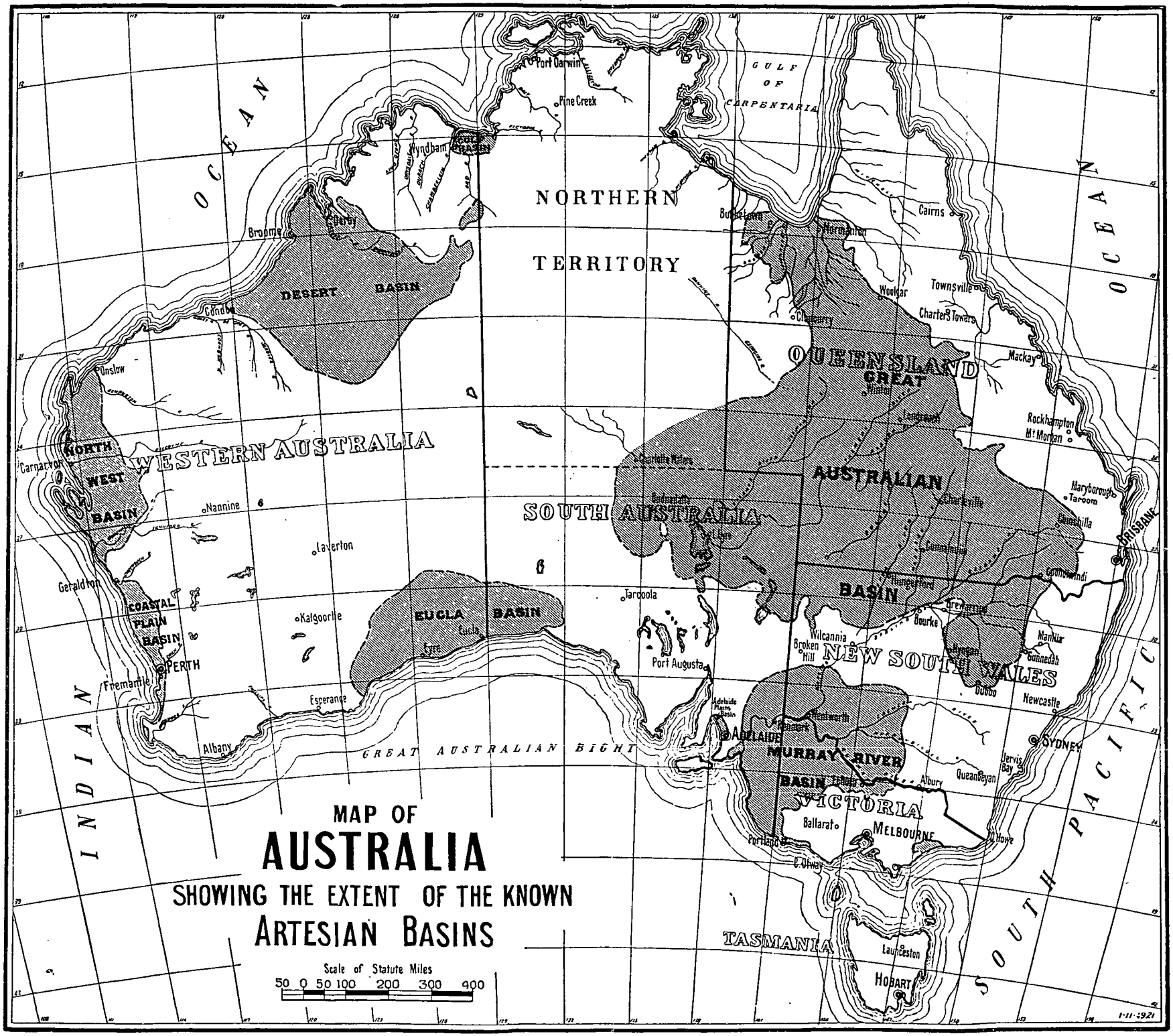
(*c*) *Shallow Boring.* The scheme described in Official Year Book No. 9 (p. 520) for assisting settlers by sinking shallow bores has met with considerable success.

Operations commenced with one plant only, but the number has been increased gradually until 36 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, consequently the plants now in use will probably be insufficient to cope with the demand. Out of 2,408 bores put in hand up to 30th June, 1928, 423 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, shallow boring plants have sunk 22 bores in the Pilliga scrub and on Crown lands for the Lands and Forestry Departments.



This map was included in the Report of the Third Interstate Conference on Artesian Water held in Adelaide during September, 1921. It contains the latest available information regarding the extent of the artesian basins. See also letterpress on page 856.

The fact that of the bores put down in the Pilliga scrub, 63 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.

(*d*) *Shallow Boring by Privately-owned Plants.* In addition to the above-mentioned scheme, regulations have been made under the *Irrigation Act* 1912–1928 providing for the sinking of shallow bores for settlers by privately-owned plants. Under these regulations, upon a settler submitting an application accompanied by a tender from a contractor for the sinking of a bore, agreements are entered into—

(*a*) with the contractor under a standard specification in which the proper construction of the bore is provided for;

(*b*) with the settler that he shall pay the ascertained cost as set out in certificate under extended terms of repayment, with interest.

Under this scheme up to June, 1928, 24 bores, to a depth of 11,185 feet, had been completed.

(iii) *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. As the water was, however, impure, and contained an excess of 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 another 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 was put down in the north-western part of the State, varying from 200 to over 2,000 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, 98 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 4 to 17 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 30th June, 1928, the number of existing bores in use in the north-western portion of Victoria (Mallee) was 374, from which supplies are obtained by pumping. The total depth bored amounted to 99,700 feet, while the maximum and minimum depths at which water was struck were 800 and 150 feet respectively. The figures include about 275 existing private bores, with a total depth of about 53,600 feet.

(iv) *Queensland.* A return relating to the 30th June, 1928, classifies the Queensland artesian bores under the following headings :—

ARTESIAN BORES.—QUEENSLAND, 30th JUNE, 1928.

Sunk by—	Artesian Flows.	Sub-Artesian or Pumped Supplies.	In Progress, Abandoned, or Uncertain.	Total.
Government	71	236	200	507
Local governing authorities	48	27	29	104
Private owners	1,253	1,625	1,009	3,887
Total	1,372	1,888	1,238	4,498

The estimated yield of water from 1,372 flowing bores on 30th June, 1928, was 309,498,703 gallons per diem. The deepest well was about 40 miles west of Blackall, lying east of the Barcoo River; this had a depth of 7,009 feet, and was stated to yield 42,740 gallons daily. 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 both for 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.

Of the 4,498 bores in Queensland, 611 have been put down by the State Government or Local Authorities, while 3,887 have been sunk by private enterprise; 1,372 bores are flowing, and 1,888 give a pumping supply; the balance of 1,238 are either in progress of construction, abandoned, or uncertain. The total depth bored is 3,979,003 feet. The minimum and maximum depths at which artesian water was struck are 10 feet and 7,009 feet respectively, while the temperature of the flow ranged from 78 to 212 degrees Fahr.

Fifty-four Bore Water Supply Areas were completed on 30th June, 1928, two of which had not been gazetted as completed, comprising a total of 4,979,900 acres within the gazetted areas, over which water was distributed in 2,104 miles of drains. Five additional Bore Water Supply Areas were in hand on 30th June, 1928, comprising an area of 670,228 acres, and 401½ miles of drains.

(v) *South Australia.*—(a) *General.* There were in South Australia 145 Government bores existing at 30th June, 1928, of which 36 were artesian and 109 sub-artesian. Of these, 107 were under 1,000 feet in depth; 23 from 1,000 to 2,000 feet; 7 from 2,000 to 3,000 feet; 5 from 3,000 to 4,000 feet; and 3 over 4,000 feet. The deepest flowing bore was at Patchawarra, on the Farina to Haddon via Innamincka route, measuring 5,458 feet, but now yielding only 50 gallons per day. The maximum flow, viz., 1,250,000 gallons, is obtained at Coonie Creek, east of Lake Frome.

The following table gives particulars as to South Australian bores at 30th June, 1928 :—

ARTESIAN BORES.(*a*)—SOUTH AUSTRALIA, 1928.

Particulars.		Artesian and Sub-artesian.
Bores sunk during 1927–28	No.	1
Bores existing	No.	145
Total depth of existing bores	feet	113,058
Daily flow	.000 gallons	(*b*)12,972
Depth at which water was struck—		
Maximum	feet	4,850
Minimum	feet	55
Temperature of flow—		
Maximum	°Fahr.	208
Minimum	°Fahr.	82
Total cost of construction of existing bores up to 30th June, 1927	£	325,016
Expenditure during year on boring operations	£	1,281

(*a*) Government bores only. (*b*) Flowing bores only.

Of the above-mentioned bores, 46 are situated within the Great Artesian Basin, and the remainder are in the Lower Murray and other local basins.

(*b*) *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 feet, no success was met with. Ki Ki bore was sunk in 1887, and at 361 feet 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 144,000 gallons at the Pinnaroo No. 2 bore. Several wells, ranging in depth from 55 to 221 feet, have also been sunk in this district. The latest Government bores are Pata bore in the Hundred of Pyap, and Beulah bore in the Hundred of Wilson, at both of which large supplies of water containing $\frac{3}{4}$ oz. of solids per gallon were obtained.

(*c*) *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 are obtained. The depths of these bores range from 280 feet at Mirackina to 1,122 feet at Breaden, and the water from all of them is good. Warranarrea bore, situated 72 miles west of Oodnadatta on Pastoral Lease No. 1297 has been completed to a depth of 466 feet, a large supply of good water being obtained.

(*d*) *Eyre Peninsula.* From time to time bores have been sunk on Eyre Peninsula, but with little success. In some instances, stock water ($1\frac{1}{2}$ oz. salt to the gallon) was obtained, but this occurred only on the Nullarbor plains. In all other cases the water struck was too salt to be used. Consequently the supply of water is now principally from catchments, and a number of reservoirs has been constructed to hold from 1,000,000 to 18,500,000 gallons each, while many underground tanks have been built to contain from 40,000 up to 500,000 gallons each.

(*e*) *Bores sunk during the Year.* A bore has been put down in Hundred McGorrery, Merribah No. 2, and has been completed to a depth of 246 feet: a large supply of good water ($\frac{1}{2}$-oz. solids to the gallon) was obtained.

Boring operations are being carried out on Eyre Peninsula between Buckleboo and Pildappa for the purpose of ascertaining whether useful supplies of underground water are available in that part of the State.

(vi) *Western Australia.*—(*a*) *General.* 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 Official Year Book. (See Official Year Book No. 6, p. 576.)

Statistics in connexion with the Goldfields Water Supply undertaking and the Mines Water Supplies will be found in the chapter of this book dealing with *Local Government.*

The following table gives particulars regarding Western Australian artesian bores at 30th June, 1928:—

EXISTING ARTESIAN BORES.—WESTERN AUSTRALIA, 30th JUNE, 1928.

Particulars.		State.	Private.	Total.
Bores sunk during year	No.	..	3	3
Bores existing	No.	112	122	234
Total depth of existing bores	feet	95,834	123,315	219,149
Daily flow	gallons	27,458,700	41,486,180	68,944,880
Depth at which artesian water was struck—				
Maximum	feet	2,527	3,325	3,325
Minimum	feet	39	70	39
Temperature of flow—				
Maximum	°Fahr.	140	128	140
Minimum	°Fahr.	76	75	75

To 30th June, 1928, the total number of Government bores was 112, while there were, in addition, approximately 122 private bores recorded, making a total of 234 bores, distributed as follows:—Kimberley Division 12, North-West Division 104, Metropolitan Division 48, South-West Division 45, and Eucla Division 25.

(*b*) *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 only suitable for stock.

There are 48 bores in the Metropolitan area, 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.

(*c*) *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 made available for stock-raising. In all, about 104 bores have been put down.

(*d*) *The Desert 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 about 12 bores have been sunk, 3 being at Broome, 2 at Derby, and 3 on the telegraph line on the road between Derby and Hall's Creek, about 12, 67, and 80 miles inland, and 1 on Meda station.

(*e*) *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 was 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 2,041 feet, yielding 5,700 gallons per day. Later, about 23 bores were sunk along the survey line of the 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 1,344 feet. In most instances only stock water was struck at depths varying between 300 and 1,300 feet, and the largest supply was estimated at about 10,000 gallons per day.

(vii) *North Australia.* In North Australia, bores to the number of 187 were put down up to 30th April, 1929, which number does not include bores put down by hand-boring plants for test purposes. One bore is artesian, and the others give a pumping supply, the daily flow being 7,640,000 gallons. The total depth bored in State and private bores was 60,796 feet, and the maximum and minimum depths were 1,760 and 42 feet respectively.

§ 2. Irrigation.

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 generally proved fairly successful, most of the States, instead of promoting new settlement in unoccupied regions, are adopting the policy of making existing settlements closer, by repurchasing large estates, subdividing them into holdings of suitable sizes for cultivation, and selling the land upon easy terms of payment. It is in connexion with this Closer Settlement policy that the special value of irrigation is recognized.

2. **New South Wales.**—(i) *General.* The recognition of the fact that the area suitable for cultivation might be extended largely by a system of water conservation and irrigation has induced the Government to undertake various detached works and schemes, which will constitute portion of the system necessary to serve the whole State.

The system, and the works necessary to its maintenance and development 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 smaller irrigation settlements at Hay, Curlwaa (Wentworth) and Coomealla; national works of water conservation; shallow boring for settlers; and water trusts and artesian bore trusts operating under the Water Act of 1912. The Commission has control also of storage and diversions of water by private persons for purposes of conservation and irrigation.

(ii) *Murrumbidgee Irrigation Scheme.* The main features of the scheme include a storage dam across the Murrumbidgee at Burrinjuck to retain the river flow, which is released for use lower down the river particularly during the dry summer months; a movable diversion weir at Berembed, 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, roadways to serve each farm, and a general surface drainage system, are also included in this scheme.

Further details in respect of the storage dam, diversion weir and canals, together with the areas thrown open for settlement are contained in previous issues of the Official Year Book. (See Official Year Book No. 15, page 442).

Particulars in respect of tenure are set out in Chapter V., Land Tenure and Settlement.

The irrigation area is situated on the northern side of the Murrumbidgee River, where it is anticipated that there will ultimately be upwards of 200,000 acres under irrigation in blocks devoted to fruit, vegetable and rice growing, dairying, stock raising, etc. 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 vegetable and fodder crops. Dairying and pig-raising are being undertaken by a large number of settlers in the areas, and the canning and drying of fruit and the production of wine are industries of considerable dimensions. The district is one of the greatest fresh fruit producing centres in the State. The growing of rice on this area is developing into an important industry. Rice from an area of about 12,000 acres was harvested in 1928, the resultant crop being approximately 19,000 tons. As the total requirements for the Commonwealth are about 24,000 tons, it may be assumed that the Murrumbidgee Irrigation areas can produce the whole of Australia's requirements in this cereal as there is ample land in the district suitable for rice-growing. Approximately 14,000 acres will be sown to rice for the 1928–29 season giving an estimated yield of 25,000 tons of paddy rice.

On the 30th June, 1928, 1,854 farms were held, representing a total area of 115,755 acres. The number of town blocks held was 894.

In the matter of cultivation, the following particulars indicate the extent of the work performed by the settlers :—There are approximately 7,677 acres under deciduous fruits, 5,341 under citrus fruits, 5,260 under vines, and for the 1929 harvest about 14,000 acres under rice. The estimated population of the area is about 15,000.

The total production of the Murrumbidgee Irrigation areas for the year ended 30th June, 1928, is valued at £841,000.

(iii) *Curlwaa Irrigation Area.* The Curlwaa irrigation area is situated on the Murray River near its junction with the Darling River, and comprises 10,550 acres, of which on 30th June, 1928, irrigable holdings consisting of 2,017 acres had been taken up in areas of 1½ to 40 acres, with a leasehold tenure of 30 years, at rentals of from 3s. to 10s. per acre per annum for the most part, and up to 35s. per acre in some blocks set apart during recent years. Of the balance, 6,842 acres were leased as non-irrigable holdings for short terms, in the majority of cases up to five years, with rentals of from 5d. to 5s. per acre, while the remainder of the area, with the exception of a few vacant holdings, is made up of roads, channels, and other reserves. Of the irrigable area, 1,293 acres are planted as orchards and vineyards, of which 1,119 acres are in full bearing. There is also a small area under lucerne. It has been proved 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 1927–28 was 413 tons, while the production of citrus fruit was 37,503 cases. The total value of production for the year is estimated approximately as follows :—Dried fruits, £35,163, citrus fruits, £27,608 ; other fresh fruit, £614 ; other produce and live stock, etc., £4,450 ; a total of £67,835. A considerable quantity of fresh fruit, comprising apples, pears, peaches, grapes, nectarines, and apricots was transported by motor for sale in Broken Hill.

Water is pumped from the Murray River by a suction gas plant in 3 units, with a total capacity of 11,000 gallons per minute and a lift of about 36 feet, and is supplied to the lessees at a flat rate of 20s. per acre per annum. There is also a general rate of 14s. per acre per annum upon the portion of the irrigated area in productive bearing. During the season 1927–28 the quantity of water supplied was 214,207,320 cubic feet, or 4,917 acre-feet, the average area watered during six irrigations being 1,416 acres. Each lessee is entitled to receive a quantity of water equivalent to a depth of 30 inches per annum.

(iv) *Hay Irrigation Area.* The Hay irrigation area consists of about 4,500 acres, of which on 30th June, 1928, the area held and used for irrigation purposes was 1,027 acres, in 107 blocks of from 3 to 30 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 2,884 acres of non-irrigated land taken up in 52 blocks for short terms up to five years,

with rentals of from 1s. to 10s. per acre. Water is lifted from the Murrumbidgee River by suction gas-driven pumping machinery in 2 units, with a total capacity of 4,000 gallons per minute, and a maximum lift of 30 feet. The rate charged to settlers is £1 10s. per acre per annum, but no general rate is levied as at Curlwaa. During the 1927–28 season 152,982,720 cubic feet of water were pumped with eight pumpings. The average area watered was 1,072 acres. This includes lands outside the area which are watered by a special agreement. The principal industry is dairying, milk being supplied to the town of Hay, and cream to the local butter factory.

(v) *Coomealla Irrigation Area.* The Coomealla Irrigation Area is situated on the Murray River about 9 miles by road from Wentworth. The land is rich chocolate loam, timbered with pine, belah, and sandalwood, and has a limestone subsoil varying from 2 feet to 10 feet below the surface. The soil is admirably suited to horticultural farming, especially viticulture. The first section at present being developed embraces 3,090 acres, of which 2,314 acres have been subdivided into 42 residential holdings and 124 horticultural farms, the average area of the latter being 17.7 acres, of which 15.9 acres are irrigable. The tenure is either perpetual leasehold or farm purchase, at the option of the settler, with a payment period of 36½ years. Water is pumped from the Murray River by steam-driven engines, operating two-stage centrifugal pumps, in duplicate, with a total capacity of 38 cubic feet per second. The rising main is of steel, 2,150 feet long, 5 ft. 6 in. diameter, and is of sufficient capacity to permit of an extension of the area later. The supply channels have been lined throughout with concrete and mortar, and the scheme also includes the construction of drainage channels, bridges, and other structures.

At 30th June, 1928, 102 holdings were held as leases or purchases, 92 being horticultural and 9 residential holdings. The total area of these is 1,728½ acres, of which 940 acres had been planted, principally to sultanas and citrus fruits.

During the year 1927–28 the quantity of water supplied was 182,800,000 cubic feet or 4,197 acre-feet, the average area watered during four irrigations being 1,046 acres.

(vi) *Projected Irrigation Schemes.* (*a*) *General.* The Water Conservation and Irrigation Commission is investigating schemes for utilizing the New South Wales share of the Murray waters, and for storing water for the purpose of irrigation and stock and domestic supply on the Lachlan, Macquarie, Hunter, Namoi and Peel Rivers. The necessary survey information is being obtained.

(*b*) *Murray River.* The effect of constructing the Upper Murray storage will be to ensure at all times sufficient flow below Albury to permit of diversions for irrigation and stock and domestic supplies, and 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 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 132,500 acre-feet per month at Albury during the irrigating season, and this will permit of a considerable amount of irrigation development along the 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 no conclusion has yet been reached. Construction has advanced to such a stage that probably 100,000 acre-feet will be stored behind the Hume Reservoir wall by the end of June next.

(*c*) *Lachlan River.* In December, 1926, the Parliamentary Standing Committee on Public Works completed its inquiry into alternative schemes for water conservation on the Lachlan River. These comprised: (1) construction of a large storage dam at Wyangala, (2) the raising of Lake Cudgellico, and (3) a number of low weirs between Goolagong and Booligal. The Committee recommended the construction of the Wyangala Dam, subject to some 850,000 acres of mallee country along the Condobolin-Broken Hill railway line between Euabalong and Roto being thrown open for settlement. It is proposed to serve this area with stock and domestic water, which will be diverted from the Lachlan River at the Booberoi Weir and conveyed in channels to the area. The Wyangala Dam will have a capacity of 273,694 acre-feet, and is estimated to cost £1,352,000. (Construction has since commenced at the Wyangala Dam.)

(*d*) *Macquarie River.* The question of construction of a storage dam at Burrendong, together with a diversion weir in the vicinity of Narromine, and a canal therefrom to serve an irrigation area between Narromine and Trangie was also inquired into by the Parliamentary Standing Committee on Public Works, but the inquiry was not completed at the expiration of Parliament, and is remaining in abeyance for the present.

(*e*) *Hunter, Namoi, and Peel Rivers.* Pumping by licensed private irrigators under the Water Act of 1912 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 adequately to supply the pumps in dry seasons until head storage works have been constructed. Investigations are in progress for storage dams on the Hunter and Peel Rivers, for dams at alternative sites on the Namoi River at Keepit and above Manilla.

(vii) *Water Rights.* By Part II. of the Water Act 1912, the right to the use and flow and to the 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 is vested in the Crown. Private rights are almost wholly abolished, riparian law is simplified, and a system of licences is established for the protection of private works of water conservation, irrigation, water supply, drainage, and the prevention of inundation of land. The enactment prevents litigation and determines the rights of riparian owners.

During the year ending 30th June, 1928, applications were received under the Water Act 1912 for 250 new licences and 171 for renewals of existing licences for pumps, dams, and other works. The new licences issued were 180 in number, while 39 were not renewed, so that on the 30th June, 1928, there were 2,201 in force. In most instances the period for which these licences are issued is five years. A fee covering the whole of the period of each licence is charged to cover the cost of administration.

(viii) *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 of land. The liabilities thereon are repaid to the Crown, with interest spread over a period of usually from 10 to 28 years inclusive. Under the law the administration, except for the Western Division, is vested in trustees—either three or five to each trust, of whom, in the former case, one is the official trustee representing the Government, and in the latter two are official trustees acting in a similar capacity. In the Western Division the Western Land Board is appointed trustee. For the supply of water, trusts have been constituted in connexion with (*a*) 76 Bore Water Trusts; (*b*) seven schemes for the improvement of natural off-takes of effluent channels, for the purpose of diverting supplies from the main rivers; (*c*) in five instances for the construction of weirs across stream channels; (*d*) five pumping schemes; and (*e*) one for impounding by means of regulators water which flows into natural lakes. The area included within these trusts amounts to :—Bore Water Trusts 4,549,827 acres, and Water Trusts and Irrigation Trusts 3,470,851 acres.

In addition to the Trust Districts, there are 12 Artesian Wells Districts totalling 324,947 acres supplied with water under the provisions of Part V. of the Water Act 1912.

Included in the above total are four Trusts constituted under the Water (Amendment) Act 1924, which enables the Water Conservation and Irrigation Commission to exercise control over the subdivision of holdings by private persons who desire to provide works for the supply of water, and then subdivide and dispose of such in small areas as irrigated blocks.

3. **Victoria.**—(i) *General.* The Water Conservation Works in Victoria consist of 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 of domestic supply controlled by Water Works Trusts or Municipal Corporations. Particulars of the works not controlled by the Commission will be found in the chapter on Local Government in this volume. With the exception of that of the First Mildura Irrigation Trust, all the irrigation schemes, 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.

While not covering the whole of the activities of the State Rivers and Water Supply Commission, the particulars in the following statement will furnish a general idea of the development of water conservation and distribution in Victoria under its administration; also of the value of an efficient water supply to country lands, whether for domestic and stock purposes only, or for the addition of irrigation to lands already so supplied :—

Irrigation Districts—	At 30.6.07—	At 30.6.28—
Number of Districts administered	10	30
Number of Districts having Water Rights	Nil	23
Total of such Water Rights	Nil	379,200 acre-feet
Area under Irrigated Culture	108,000 acres	477,500 acres
Valuation for Rating purposes	£196,000	£705,000
Rural Waterworks Districts—		
Number of Districts administered (excluding Coliban)	3	25
Valuation for Rating purposes	£125,000	£1,670,000
Urban Districts—		
Number of Districts administered	1	62
Valuation for Rating purposes	£5,600	£472,000

The storages for irrigation and domestic and stock supply purposes had, at 30th June, 1928, a total capacity of 1,215,880 acre-feet. The completion of works now under construction will bring the total to 1,297,530 acre-feet, as against a total of 172,000 acre-feet in 1902. The capacity of the Hume Reservoir, which is being constructed on the Upper Murray, is not included in these figures. This reservoir, when completed, will contain 2,000,000 acre-feet, half of which, under the provisions of the River Murray Agreement, can be credited to the State of Victoria.

(ii) *Irrigation Schemes.* (*a*) *General.* This division comprises the schemes constructed and under construction for the supply of water to some thirty irrigation districts. Up to 1906, irrigation schemes were controlled by local Trusts, which had obtained the moneys for their construction on loan 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, 1928, on water supply for the irrigation and water supply districts under the control of the Commission and at Mildura, exclusive of the amount of £1,703,000 expended by it on River Murray Agreement Works, was £10,393,000. The irrigation works draw their supplies mainly from headworks constructed on the Goulburn, Murray, and Loddon Rivers. The cost of these headworks, which now stands at £1,127,000, is not debited to any particular districts, but is borne by the State. The extent of land under irrigated culture during the year 1927–28 for all kinds of crop was 477,500 acres, the largest yet recorded, being an increase of 70,968 acres over the area irrigated in the previous year and 117,300 acres over the average area irrigated during the previous five years.

(*b*) *Goulburn Irrigation System.* The Goulburn Irrigation System (see Official Year Book No. 13, map on page 561) is the largest project of the kind in Victoria. The need for irrigation in the Goulburn Valley is indicated by its low annual rainfall, 18 inches, while the great variation in the rainfall over the catchment area, 20 inches to 52 inches; in the rate of flow, 180 cusecs* to 80,000 cusecs; and in the volume of the annual river discharge, 620,000 acre-feet to 6,200,000 acre-feet, reveal clearly the necessity for regulating the river flow by storage. The progress made in this direction is shown by the fact that the existing storages of this system will hold some 660,000 acre-feet, which, added to 300,000 acre-feet divertible direct from the river, brings the total artificial supply to 960,000 acre-feet.

* Cusecs — Cubic feet per second.

The Goulburn Scheme comprises a diversion weir on the Goulburn River, near Nagambie, which raises the summer level of the river about 45 feet to 408 feet above sea level, the height necessary to command the lands to be irrigated; two main channels, the eastern diverting water to the Shepparton Irrigation District, and the western supplying the eastern half of the Rodney main channels and filling Waranga Basin, the principal storage reservoir of the scheme. Two further main channels issue from this reservoir, one feeding the western half of the Rodney main channels, and the other serving settlements due west as far as the Loddon River. Further details in respect of this scheme are contained in previous issues of the Year Book (see Official Year Book, No. 19, page 834).

In view of the continually increasing demand for water in dry seasons, and the repeated requests for extensions of the system, the Commission had investigations made to determine the most suitable site for an additional storage reservoir. After a number of sites had been examined as to foundations, probable storage capacity, and estimated cost, the Commission adopted what is known as the Sugarloaf site, just below the junction of the Goulburn and Delatite Rivers, as the most economical. A dam has been constructed to a height of 140 feet above the river bed, its foundation being in places 75 feet below the natural surface. It has an over-all length of 3,000 feet, of which 2,300 feet consist of "rock fill" bank with a reinforced concrete-core wall, the remaining 700 feet being of mass concrete, and forming a flood spillway. The dam submerges an area of 8,000 acres and permits the storage of 306,000 acre-feet of water. The catchment area above this reservoir is 1,500 square miles.

The State Electricity Commission has proceeded with its scheme of hydro-electric works at the Sugarloaf Reservoir, in connexion with which the Water Commission provided a separate outlet for emergency or power purposes. Generally, the regulated flow from the reservoir required for water supply purposes can be discharged through this pipe, thus enabling it, in the whole or part, to be passed through the turbines on its way to the river.

The portion of the State at present served by the Goulburn system comprises 106,000 acres east of the river, 573,000 acres between the Goulburn and the Campaspe, and 387,000 acres between the Campaspe and the Loddon. These areas include the irrigated closer settlements at Shepparton, Stanhope, Tongala, Rochester, Echuca North, and Dingee, as well as the districts formerly controlled by the Rodney and Tragowel Plains Trusts, where the holdings are larger than in closer settlement areas. The main channels of the system have an aggregate length of 200 miles, in addition to which there are 2,250 miles of distributaries, a total for the whole system of 2,450 miles.

The balance of the area, including Deakin District, 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" in the older districts is at present 7s. per acre-foot in the two districts—Tragowel Plains and Dingee—farthest removed from the sources of supply, 7s. 6d. in special circumstances at Echuca North, and 6s. per acre-foot elsewhere.

The East Goulburn main channel, with a capacity of 666 acre-feet per day and a length of 32 miles to the Broken River, has supplied the Shepparton Irrigation District of about 25,000 acres—mainly Closer Settlement areas—since its inception in 1912, and is now being enlarged to 1,100 acre-feet per day, and extended to a total length of 51 miles to supply also the recently constituted Irrigation Districts of South Shepparton (34,000 acres), North Shepparton (38,000 acres), and Katandra (10,000 acres). These districts will be gradually extended as required to include additional areas served by further distributary channels completed from time to time, until the whole of the suitable area, bounded by the East Goulburn main channel on the east, the Goulburn River on the west, and the Nine-Mile Creek on the north, has been supplied. In the South Shepparton district water rights of 1 acre-foot of water to each 4 acres of irrigable land have been allotted, the compulsory charge owing to the greater cost of construction being, for the present, 8s. per acre-foot. The Waranga Western main channel has been enlarged from 520 to over 800 acre-feet per day from the Piccaninny Creek to a point about 1¼ miles westward. From this point a new channel—the Tandarra–Calivil main—has been

constructed through Dingee District and an adjoining area known as Calivil to the No. 1 main of Tragowel Plains District. This new channel came into use in September, 1926, and has since relieved the pressure on the Tragowel Plains system, which supplies an area of 189,000 acres, and released most of the capacity of the Waranga Western main channel for the delivery of supplies to the recently constituted Calivil District, and to supplement the supply to Boort District, previously dependent mainly on the Loddon River. This channel is being extended westward of the Loddon, with a view to improving the water supply conditions of the Wimmera–Mallee districts as mentioned on page 874.

The development of the fruit-canning industry emphasizes the success of irrigation in the Goulburn Valley. The canneries at Shepparton and Kyabram, together with the recently established one at Mooroopna, processed during the 1928 season the largest pack of canned fruit yet produced in Victoria, the aggregate of the three canneries being 20,000,000 tins.

(*c*) *River Murray Irrigation Schemes.* The group of irrigation schemes for the service of the districts along the frontage of the River Murray, and drawing supplies direct from that river, ranks next in importance in point of development to the Goulburn Irrigation System. These schemes already supply an area of 404,000 acres, served by 1,700 miles of channels, and are capable of considerable expansion when the Hume Storage Reservoir, now under construction, becomes operative.

The districts supplied are all situated in the portion of the Murray Valley below the town of Echuca, and in an area of comparatively low rainfall. Those between Echuca and Swan Hill, excepting Tresco, are supplied by gravitation, while the Tresco district, and those lower down the river—Nyah, Merbein, Mildura and Red Cliffs—are supplied by pumping.

The present headwork of the gravitation schemes is a weir and lock at Torrumbarry —some 20 miles (by road) down-stream from Echuca—constructed under the powers conferred by the River Murray Waters Acts, the constructing authority being the State Rivers and Water Supply Commission.

This weir was commenced early in 1919 and completed in the latter part of 1923. It raises the summer level of the river by some 16 feet, and thus substitutes continuous diversion for the intermittent diversion hitherto dependent on the varying level in the river, and at the same time provides for the passing of river craft but without offering serious obstruction to the passage of floods.

These objects have been achieved by the construction of a concrete foundation, combined with movable steel trestles, which support stop bars to the height necessary to keep the river at diverting level. In times of flood the bars, and if necessary the trestles themselves, are removed to the river bank.

The effect of this work, as regards irrigation, is the ensuring of a regular supply by gravitation throughout the year to the districts between Torrumbarry and Swan Hill. The districts first benefited by this supply are those known as Cohuna, Gannawarra, Koondrook and Swan Hill, comprising in all 194,000 acres on the river frontage (hitherto dependent on pumping plants during low stages of river flow), and the Kerang and Mystic Park districts and adjacent areas, containing about 112,000 acres, more distant from the river, and receiving a more or less irregular supply, by gravitation, from the Kow Swamp Free Headworks. These headworks comprise a gravitation offtake at the effluence from the Murray of the Gunbower Creek; a main channel thence (the Gunbower Creek improved) to Kow Swamp Reservoir, a natural depression improved so as to hold 40,860 acre-feet; and a main supply channel therefrom (the Macorna channel) westward to the Loddon River.

The quantity of water allotted as a "right" in these districts is 1 acre-foot per irrigable acre. The compulsory charge is at present 6s. per acre-foot of such water rights. In Kerang district—not yet under a compulsory irrigation charge—water is sold to irrigators on application at a charge not exceeding 4s. per acre-foot of water supplied. The districts supplied include the Cohuna, Koondrook, and Swan Hill Closer Settlement Estates, comprising in all 34,000 acres. Of this area, 8,000 acres were specially purchased for soldier settlement, the channel systems being correspondingly extended.

In addition to improving the supplies to existing irrigation districts, the Torrumbarry weir will enable large areas adjacent to these districts to be commanded by extensions of existing gravitation channel systems. The most important works so far constructed for this purpose are (*a*) the Gunbower–Cohuna Main Channel, which with the necessary distributaries provides water for irrigation for the new Leitchville Irrigation District of 10,000 acres situate between Kow Swamp State Works and the Cohuna Irrigation District, and (*b*) the Third Lake Main Channel and distributaries, which convey supplies for the irrigation of some 13,000 acres of land (constituted the Third Lake Irrigation District) and 5,800 acres (constituted the Fish Point Irrigation District) lying between that Lake and the Little Murray River. The compulsory charge is at present 7s. per acre-foot in Leitchville and Third Lake Districts, and 8s. per acre-foot at Fish Point.

Extensions of irrigation schemes dependent on the River Murray, hitherto impracticable owing to lack of storage on that river, will be rendered possible on the completion of the Hume Reservoir. This storage work, now in course of construction jointly by the States of New South Wales and Victoria, is one of the works authorized by the River Murray Waters Acts. (Detailed reference to this undertaking will be found at the end of this section.) The site of the dam is a little below the junction of the Murray and Mitta Rivers. The catchment area is about 6,000 square miles of mountainous country. A reservoir of a capacity of 2,000,000 acre-feet would submerge some 69 square miles—about four times the area of Sydney Harbour.

The irrigation areas supplied by means of pumping, and not commandable by gravitation from the Torrumbarry offtake, stated in geographical order, are the Tresco Irrigation District, the Nyah and Merbein Murray Frontage Settlements, the First Mildura Irrigation Trust District, and the Red Cliffs Soldier Settlement.

The Tresco District of 4,000 acres, created by private enterprise, and recently taken over by the State Rivers and Water Supply Commission, is supplied by water lifted from Lake Boga by pumps throwing 80 acre-feet per day. Its channel mileage is 50. The water supplied is 2½ acre-feet to each irrigable acre, and the compulsory charge at present £2 per acre.

The Nyah Irrigation Area is supplied with water diverted from the Murray by a high-lift pumping plant—capacity, 94 acre-feet per day. The total length of the channels is 53 miles, of which 33 miles are lined with concrete. The settlement contains 3,800 acres, subdivided into 237 holdings of an average area of 15 acres—practically all settled. The settlers include 66 discharged soldiers. 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 20s. 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 value of irrigation to the district is reflected in the selling price of the land, fully planted blocks bringing remarkably high prices.

The Merbein Irrigation Area comprises 8,300 acres, originally Crown lands. This settlement now contains 421 holdings, averaging 20 acres each, practically all settled, the settlers including 161 discharged soldiers. The water is obtained from the Murray by pumps, which deliver 225 acre-feet per day. The main and distributary channels have a combined length of 60 miles. The land settlement conditions and the water rights apportioned are the same as at Nyah, but the compulsory charge is 24s. per acre-foot. The Merbein Works supply also the adjacent Yelta Waterworks District of 48,000 acres.

The Red Cliffs Irrigation Settlement comprises an area of 18,000 acres including the township and 15,000 acres of first class irrigable land adjoining the Mildura Settlement. It is the irrigable portion of the large Red Cliffs estate of 33,000 acres, known as the Debenture Holders' Land, acquired by the State for soldier settlement. The scheme of works for this district ranks first in importance among Victoria's pumping systems. It includes a pumping plant capable of delivering 500 acre-feet of water

per day, lifted 105 feet, a reinforced concrete rising main 6 feet 6 inches in diameter, 34 chains long, two electric generators each of about 350 k.v.a. capacity, to provide for relifts, and a system of main and distributary channels to command every holding in the district. The three pumping units have already been installed and are in operation. The total length of channels constructed to date is 124 miles, the excavation involved totalling 665,000 cubic yards. Channels having a length of 114 miles have been lined with concrete with the result that 699 blocks, 99 per cent. of the total in the settlement, are protected from seepage from the channels. Some 700 discharged soldiers have been allotted blocks on this settlement. The Red Cliffs township, which is growing rapidly, has been proclaimed an urban division of the Irrigation District, and is supplied with the necessary reticulation from a concrete stand pipe 70 feet high and 26 feet in diameter. The Red Cliffs works supply also the adjacent Carwarp and Carwarp Central Waterworks Districts having a total area of 206,000 acres.

The area planted to date consists of 9,400 acres of vines and 600 acres of citrus trees. The first harvest (1924) returned 570 tons of dried fruit, in addition to which large quantities of table grapes were sold for consumption. The 1927 harvest produced 11,000 tons of raisins, currants, and sultanas, in addition to large quantities of grapes sold for dessert and distillation. The 1928 harvest, which was severely affected by frost, yielded 8,500 tons of dried fruits.

(*d*) *Loddon River Scheme.* This also is wholly a gravitation system, with a regulating weir on the Loddon at Laanecoorie as its headwork. Its storage capacity is 14,000 acre-feet, and other works include timber diversion weirs at Serpentine and Kinypanial, and 260 miles of channels which supply an area of 79,000 acres in the Boort district for domestic and stock purposes and partial irrigation, and a considerable portion of the adjoining Loddon United Waterworks Trust District with water for domestic and stock use.

(*e*) *Werribee River Schemes.* (1) *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 intake from the creek catchment being supplemented by a tunnel through a dividing spur, which taps the Werribee River near Ballan. The area of the district is 6,700 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 22s. 6d. per acre-foot of such right. The higher portion of the district receives a supply for domestic and stock purposes.

(2) *Werribee.* This is another gravitation scheme on the same river, with a reservoir of 17,000 acre-feet capacity at Melton as its headwork. The irrigation district comprises 10,000 acres of first-class land, being the irrigable portion of the Werribee Closer Settlement Estate, which is within 20 miles south-westerly of Melbourne. The water-right allotment is one acre-foot per irrigable acre, and the charge at present is 12s. per acre-foot. The non-irrigable portion of the estate, containing about 13,000 acres, is supplied with water for domestic and stock purposes.

(*f*) *Macallister River (Maffra) Scheme.* The works of this scheme, the first irrigation scheme in the south-eastern portion of the State, now in course of construction, comprise a storage reservoir on the Macallister River, at Glenmaggie near Heyfield, and a system of main and distributary channels capable of commanding by gravitation some 80,000 acres of the rich river flats along the Macallister, Avon, and Thomson Rivers, near Maffra, Stratford, and Sale. The conditions in these areas as to quality of lands and annual rainfall are similar to those at Bacchus Marsh and Werribee before irrigation. The design of the dam—a large cyclopean concrete structure 1,000 feet in length—provides for the raising of water to a maximum height of 100 feet above the foundations. The catchment area above the dam is 813 square miles and the area submerged at full supply level will be 4,500 acres, while the capacity of the storage will be 150,000 acre-feet, and the unregulated flow of the river will yield an additional 100,000 acre-feet. The construction of the works is practically complete. Approximately 105,000 acre-feet of water can now be stored, and arrangements can be made to store the whole volume of 150,000 acre-feet when required. The commanded lands are specially suitable for beet

culture and dairying, and include some 11,000 acres acquired by the State Rivers and Water Supply Commission for soldier settlement. The area first supplied was 8,000 acres of the Avon River flats, including the Boisdale Closer Settlement Estate, and was constituted the Maffra Irrigation District in 1927. This district was subsequently extended to include a total supplied area of 20,000 acres. Further extensions of the channels enabled supplies to be given to settlers on some 6,000 acres of closer settlement estates, and 9,000 acres of private holdings in the vicinity of Sale, and the Sale Irrigation District of 15,000 acres has been constituted accordingly, making the total area now served by the Maffra–Sale system 35,000 acres. Outlets for the produce of irrigated farms are already provided by the sugar, butter, and condensed milk factories, which are within easy reach, while the proximity to railway stations ensures to settlers the necessary transport facilities.

(iii) *Domestic and Stock Schemes.* (*a*) *General.* 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, 1928, was £8,413,000. The area of country lands artificially supplied with water for these purposes is 23,523 square miles. The number of towns supplied, exclusive of the City of Melbourne and its suburbs, is 214, serving an estimated population of 377,660. In addition to the Commission's districts, some large areas are still administered by local authorities.

(*b*) *Wimmera-Mallee System.* 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 five reservoirs in the catchment area of the Wimmera River, at the foot of the Grampians Ranges, viz.:—Lake Lonsdale, Wartook, Fyans Lake, Taylor's Lake, and Pine Lake. The reservoirs in use, including some minor works, have a combined storage capacity of 183,050 acre-feet. The completion of the works in progress will bring this total to 213,050 acre-feet. The water is conveyed partly by natural watercourses but chiefly by artificial channels aggregating 5,450 miles in length over farming districts comprising about 11,000 square miles, approximately one-eighth of the whole State (see Official Year Book No. 13, map on page 562). This system also furnishes supplies for 32 townships controlled by the Commission, and 6 towns controlled by local Waterworks Trusts or Shires. The construction of the new main channel from the Wimmera River at Glenorchy to the important town of Charlton on the Avoca River provided not only a full gravitation supply of good quality to that town, in lieu of the poor unsatisfactory supply previously pumped from the Avoca River, but, in addition, greatly improved supplies for domestic and stock purposes to about 236,000 acres in the districts of four local Waterworks Trusts, and the area so served has, with the concurrence of those bodies, been added to Waterworks Districts under the jurisdiction and control of the Commission. As this area included the entire districts of the West Charlton and Shire of Donald Waterworks Trusts, these trusts were abolished under the provisions of the Water Acts.

The rainfall on the Wimmera Catchment during the last three years has been so light that the 1927–28 watering had to be commenced with partially depleted storages. There has been a considerable increase in the quantity of water used in both urban and rural districts, as the average capacity of farmers' storages has doubled during the last fifteen years, and the consumption in urban districts has risen to 80 gallons per head per day, as compared with a consumption of 56 gallons per head for Melbourne.

The Commission, after serious consideration of these important facts, commenced construction of a further section of the Waranga Extension Channel north-westerly beyond the Avoca River, in order to supplement the Wimmera–Mallee supplies from the more permanent streams to the eastward during winter periods when water could be made available without affecting irrigation supplies. This extension, the first portion of which is ready for the 1928–29 season, will eventually command practically the whole of the area served by the Wimmera–Mallee system north of the 36th parallel, thus leaving the Wimmera catchment available for the southern portion of the area dependent on the system.

(c) *Northern Mallee Water Supply Scheme.* In what is known as the northern Mallee, an area of about 1,250,000 acres, adjoining the Wimmera-Mallee Gravitation Channel System, but above its channel level, the Commission has provided a water supply for the large wheat holdings in the Walpeup and adjoining districts, by means of bores and large public tanks. The number of successful Government bores in use in this area is 99, their average depth being 460 feet. There are also 260 tanks, having a total capacity of 1,209,600 cubic yards, or 204 million gallons.

(d) *Carwarp Scheme.* The works of this scheme—a system of distributary channels—were constructed to provide domestic and stock supplies for an area of 215,300 acres of Mallee lands situated immediately south of the Red Cliffs Irrigation District and traversed by the Mildura Railway, the supply being drawn from the Red Cliffs pumping station. The whole of this area was at first embraced within the Carwarp Waterworks District, but, subsequently, an improved supply was given to some 15,000 acres around the railway station, and above the general level of the surrounding country, by means of a pump and rising main, with 12 miles of channels. The high lands so supplied have been constituted the Carwarp Central Waterworks District, and some 14,000 acres were transferred to the Millewa District.

(e) *Millewa Scheme.* This recent and important addition to Victoria's water supply schemes for domestic and stock purposes is designed to serve 1,000,000 acres of the extreme northern Mallee between the Mildura railway and the South Australian border, which is being opened up for settlement by this water supply scheme, and the construction of 55 miles of railway from Red Cliffs westward toward South Australia. The water for this extensive area will be drawn from the River Murray. The scheme comprises two main lifts, of about 113 and 145 feet respectively, the first lift being from Lake Cullulleraine on the flats 5 miles from the Murray. This lake, the main storage of the scheme, which holds 2,000 acre-feet, will be filled from No. 9 Lock now in course of construction. Holdings aggregating 600,000 acres have already been allotted to 421 settlers, and, for the service of this area, 664 miles of channels have been excavated, and 37 earthen storages, with a combined capacity of 361,000 cubic yards, have been constructed at convenient distances from railway stations. The first unit of the pumping scheme and the rising main having been completed, water was turned into the channels and storages early in 1924, and in May and June of that year the whole occupied area received a supply of water by channel. The extension of the pumping stations to their final capacity is being proceeded with. The Millewa Waterworks District constituted in 1924 with an area of 250,000 acres has been extended, as the works progressed, till some 585,000 acres are being served. This area includes 209,000 acres above the general level of the district which is being supplied by a relief pumping plant, and which in view of the higher cost of supply has been constituted a separate district known as Millewa Central Waterworks District. The construction of the remaining works of the scheme will precede the throwing open of additional lands for settlement. In this area and the adjacent Sunset country, 80 tanks have been constructed with a total storage capacity of 110,700 cubic yards. Works for the pipe reticulation of the township of Werrimull having been completed, this township has been proclaimed an Urban District. The population supplied is 160.

(f) *Coreena Waterworks District.* A scheme to supply an area of 212 square miles between Tyntynder Waterworks District and the River Murray, but too high to be commanded by the Wimmera-Mallee Irrigation System, has been prepared at the request of the landholders, mostly returned soldiers. The works comprise a pumping plant on the River Murray, 20 miles below Euston, to deliver 15 cusecs through a 27-in. diameter steel rising main, 60 chains in length, to a high ridge from which 130 miles of main and distributary channels will distribute supplies for domestic and stock purposes. The maximum lift will be 91 feet. The area to be served has been constituted the Coreena Waterworks District, and good progress has been made with the works.

(g) *The Coliban System* comprises two main storage reservoirs on the Coliban River on the northern slope of the Dividing Range, the "Upper Coliban" with a capacity of 25,700 acre-feet, and "Malmsbury" with a capacity of 12,300 acre-feet, together with main and distributary channels aggregating 340 miles in length, 28 subsidiary reservoirs with a total capacity of 6,910 acre-feet, and 300 miles of urban pipe reticulation. This scheme supplies water for domestic and stock purposes to the city of Bendigo, also to Castlemaine, Maldon, and eighteen other townships, and the interjacent rural districts,

containing in all some 235,000 acres. The population served is 61,000. This system also supplies the demands of the quartz and sluice mining industries throughout this area, and provides water for irrigation for orchards, market gardens and similar purposes, the area irrigated annually being about 7,000 acres.

(*h*) *Naval Base and Mornington Peninsula Scheme.* 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, at Crib Point, and for the service of nineteen other townships, including the bayside resorts at Aspendale, Edithvale, Chelsea, Carrum, Seaford, Frankston, South Frankston, Mornington, and Mount Martha, and the inland townships of Beaconsfield, Berwick, Dandenong, Noble Park, Spring Vale, Pakenham, Cranbourne, Somerville, Hastings, and Bittern. An ample supply of water is obtainable both for ordinary domestic and stock use and for market gardening, in the vicinity of Dandenong, from the headwaters of the Bunyip River, which drains some 30 square miles of forest country above the point of off-take.

The scheme was extended to supplement the supply to the township of Dandenong previously controlled by a local Trust, the works of which were then transferred to the Commission, which administers them as part of the general scheme. The expansion of the reticulation systems in this district having necessitated the provision of additional supplies to meet the demand during dry periods, the Commission has constructed a new Main Supply Line from Toomuc Creek to the headwaters of the Bunyip River. This extension, which includes 25 miles of open race and 8 miles of 2-ft. pipes, has proved most conclusively the value of that river as a source of supply for the Mornington Peninsula areas.

An important development of this scheme was the purchase by the Commission of 3,300 acres of land in the vicinity of Narre Warren, on the main Gippsland railway, for closer settlement under irrigation. This land, which is within about 25 miles of the metropolis, is being subdivided into blocks of 10 to 15 acres, suitable for market gardening and other forms of intensive culture. Drainage works are being provided where necessary, and every block will receive a satisfactory supply of water under pressure from a pipe system connected with the main race. Electricity for all purposes will be available from the works of the Electricity Commission. The land is being settled under the ordinary closer settlement conditions, and there is a good demand for the blocks.

(*i*) *The Bellarine Peninsula Works.* The long-felt need of an efficient water supply for this peninsula, including the towns of Portarlington and Queenscliff on Port Phillip Bay and the seaside resorts along the south-western coastline of that area, led to investigation of proposals for a similar scheme to serve these areas by supplies drawn from the headworks of the Barwon River. A comprehensive scheme was prepared, which comprises a large storage reservoir at Wurdee Boluc, filled by an inlet channel which taps various tributaries of the Upper Barwon, beginning with Retreat Creek and the eastern branch of Pennyroyal Creek, and gradually extending to pick up the flows of the larger and more permanent tributaries as the demand for water grows. This scheme, which will serve the above-named towns, also Drysdale and other inland townships, and the coastal townships from Point Lonsdale to Anglesea, will, in addition, furnish a much needed supplementary supply to the city of Geelong, thus allowing the development of that important centre to be unchecked. The scheme has been endorsed by the Municipal Authorities concerned, and the Commission is now proceeding with the work of construction. The first stage of the Wurdee Boluc storage (capacity 9,500 acre-feet) is practically complete, and the construction of inlet and outlet works is being expedited.

(*j*) *The Kerang North-West Lakes Works* consist of a chain of lakes, situate a few miles to the north-west of Kerang, connected by channels to each other and to the Loddon River, and improved so as to be capable of storing 88,500 acre-feet of water. This system serves, for domestic and stock purposes, an area of 42,900 acres, constituted the "Kerang North-West Lakes Waterworks District." When the supply from the Loddon River is insufficient, the lakes are filled by gravitation from the Torrumbarry Weir, on the River Murray, via the Kow Swamp Irrigation Works. The water is diverted

along Sheepwash Creek—an improved natural effluent from the Loddon—the river level having been raised by a concrete weir at Kerang. As in the Coliban District, limited quantities of water are sold on application for irrigation purposes, about 5,500 acres having been irrigated annually from this source for some years. These irrigation facilities have been so appreciated that, in response to a strong demand, an irrigation District of 18,000 acres (" Mystic Park ") was constituted on the west of the Lakes, and further works were constructed to provide an irrigation supply to some 12,000 acres lying to the north of " Third Lake." This area has been constituted the Third Lake Irrigation District, in which water rights have been allotted on the basis of 2 acre-feet of water to each 3 acres of irrigable land. To provide complete circulation throughout the chain of lakes a large channel with a capacity of 400 acre-feet per day has been constructed from Lake Tutchewop to Lake Boga.

(*k*) *The Broken River Works* comprise two weirs—" Casey's " and " Gowangardie "—above Shepparton, and offtake works therefrom, for the diversion of water into the channels of the Tungamah, Shepparton, and Numurkah Waterworks Trusts.

(*l*) *The Wonthaggi Works* comprise a storage reservoir on Lance Creek, capacity 421,000,000 gallons, a main pipe line therefrom 9 miles in length to the coal-mining towns of Wonthaggi and North Wonthaggi, a service reservoir—capacity 1,400,000 gallons, and 24 miles of pipe reticulation for the service of those towns. The population supplied is 10,000, and there is a service to the State Coal Mine and Railways Department.

(iv) *Flood Protection.* The Water Acts of Victoria provide for the constitution of Flood Protection Districts, in which the residents are rated for schemes carried out for their benefit. The works are constructed, and districts administered by the State Rivers and Water Supply Commission, and the Commission has carried out extensive schemes at Koo-wee-rup and Cardinia, in the south-eastern portion of the State, at Loch Garry and Kanyapella on the Goulburn River between Shepparton and Echuca, and works on a smaller scale at the town of Echuca.

The Koo-wee-rup and Cardinia Flood Protection Districts together embrace the whole of a large continuous depression south of the main Gippsland railway and along the sea-board of Westernport, containing in all about 100,000 acres of very fertile country, the proper development of which was seriously retarded by periodical inundations. A large portion of the land was reclaimed, subdivided, and settled by the State, but it became evident, during periods of heavy rainfall, that only a comprehensive drainage scheme for the whole area affected would afford the needed protection from flooding.

At the request of the settlers, the Commission prepared schemes for this purpose, and, after the concurrence of the settlers had been obtained, practically carried the schemes into effect; and the two large districts above-mentioned were constituted, and are now being rated on an acreage basis in respect of benefits derived from the works. The Commission's works are now well advanced, and provide flood protection from all but abnormal floods, and the duration of even these is considerably shortened and their effect correspondingly lessened as the result of the works, which consist of the substantial enlargement and remodelling of most of the existing principal drains, the construction of new internal drains, and the cutting of several distinct outlets, thus avoiding concentration of flood waters in the main drains.

The Loch Garry Flood Protection Works comprise about 5½ miles of earthen levee banks around Loch Garry, and a concrete regulator and spillway 400 feet in length, to control overflows from the loch. The purpose of the scheme is to protect some 40,000 acres of lands previously flooded by overflows of the Goulburn River by way of Loch Garry and Bunbartha Creek. The Kanyapella Scheme provides for the conservation of a domestic and stock supply in Warrigal Creek, and the exclusion therefrom of certain flood waters. The area benefited is 13,500 acres. Both schemes have been approved by a majority of the landholders concerned and are now in operation.

(v) *Mildura.* Particulars regarding this area will be found in the appendix.

4. **Queensland.**—The main irrigation works in Queensland are as follows :—

(i) *Dawson Valley Scheme.* The Dawson Valley Irrigation Scheme, now in its initial stage, comprises :—(*a*) A concrete dam at Nathan's Gorge, some 30 miles below the town of Taroom, to impound 2,500,000 acre-feet of water : (*b*) an offtake weir 80 miles down stream for the diversion of water for the irrigation of 70,000 acres in the Dawson Valley ; and (*c*) Theodore Zone (see below).

The Dawson River rises in the Great Dividing Range. The catchment above the proposed Nathan Dam is 9,000 square miles, over which the average annual rainfall is 27 inches. An arched dam is involved, with termini on lines tangential to the curve. The rock forming the foundations is a hard sandstone, the crushing strength of which ranges from 3,000 to 5,000 lb. per square inch. It is designed to fix the water level 130 feet above summer level at the site, and the crest height at 145 feet, with a spillway on the left bank. The crest length of the dam will be 860 feet, 500 feet on the curved portion. The reservoir will be the largest artificial storage in the world.

An approach road from Wandoan Railway Station to the dam site has been under construction during the year. This is 54 miles in length and now available for traffic, so that the carting of plant and materials for the construction of the Nathan Dam can be commenced at an early date.

The irrigable lands are of a good agricultural type with fair capillarity, ample humus, and containing liberal amounts of all mineral plant foods in readily available form. About 120,000 acres are commanded on the eastern side of the river, and 80,000 on the western side. A hydro-electric station at the Nathan Dam may utilize the water power to irrigate high level lands not commanded by gravitation, provide stock and domestic supplies to dry areas, power for factories, and light throughout the settlement.

The Dawson Valley is situated in the Central Division of the State, which comprises 209,340 square miles, or nearly one-third of the total area of Queensland. The population is less than one person to two square miles, and subtracting those resident in the principal towns, the ratio is one inhabitant to four square miles, although there is only a comparatively small proportion of inferior land in the whole area. This irrigation scheme not only provides an opportunity for increasing population and extending agriculture, but will also form a fodder reserve area for pastoral lands where rainfall is insufficient for agriculture, and water conservation impracticable. A fodder conservation proposal is being considered for the early stages of settlement with this end in view, and to give settlers an opportunity readily to dispose of some of their produce.

A railway line is constructed through the irrigation areas from the terminus of the Dawson Valley line at Baralaba to Theodore, the first zone to be settled.

In order to minimize heavy interest charges accruing during the process of construction, the project has been designed on the zone system, by which one area is prepared for settlement and completed before the next zone is proceeded with. Five zones have been designed, each comprising a certain area of irrigated land attached to a considerable acreage of dry lands. The dry lands will be allotted in proportion to irrigated land held. Though forming an integral part of the gravitation system, each zone will be a separate entity, served by its own central township, and in close connexion with the Dawson Valley railway system.

Theodore Zone. On the completion of all necessary works for irrigation purposes the Theodore zone of 30,000 acres was thrown open for selection on 1st November, 1926, and by the 30th June, 1928, 258 farms were occupied. This area is divided into 373 farms, of which 264 are irrigated and 109 are attached dry farms. A considerable proportion of the latter consists of good vine scrub land, and all is classed as soil suitable for agriculture, on which dry areas products such as wool, butter, cotton, etc., can be raised in conjunction with an irrigation farm, as an insurance over dry periods. The rich country back from the river flats is expected to form a great attraction to settlement. The pumping station established on the river operated satisfactorily during the past year. The river bank at this point is higher than the surrounding 5,000 acres, so that when the water is pumped up, the channels radiating from the Power Station carry it by gravitation. Local storage of over 5,000 acre-feet has been obtained by the erection of a timber and earth weir below the pumping station, the crest of which is 13 feet above ordinary summer level of the river.

(ii) *Inkerman Irrigation Area.* This area is situated at Home Hill, Ayr district, using the waters of the Burkedin River, with electrically operated shallow well pumps. The number of wells and pumps is 230, and the acreage under irrigation during 1927–28 exceeded 5,000 acres. Provision is being made to increase this area to 10,000 acres.

(iii) *Other Schemes.* Smaller schemes include Townsville (wells, creek, and river); Rockhampton (wells, river, creek, etc.); those at Bingera, near Bundaberg, which utilize water pumped from the Burnett River just above the point of meeting of the salt and fresh waters; and those at Fairymead, which utilize water pumped from a number of shallow spear wells sunk on the alluvial flats on the north side of the Burnett River and about 6 miles from Bundaberg.

5. **South Australia.**—(i) *The Renmark Irrigation Trust.* The Renmark Irrigation Trust was established on similar lines to Mildura, but on a smaller scale. The area of settlement is 23,000 acres, and the irrigated area 7,700 acres, while the population of the town and settlement is 4,800. Water is obtained from the Murray by pumping. The main pump situated on the river bank lifts the water into a large lagoon, from which three further pumps of 17 feet, 26 feet, and 27 feet-lift raise the water and irrigate 950, 4,200, and 1,800 acres respectively. A fifth pumping plant again lifts the water 26 feet and irrigates 750 acres. The total length of the channels is 78 miles, and of roads 98 miles, while the annual water rate is £2 5s. per acre. It is anticipated that when Murray locks 4 and 5 are completed, it will be possible to gravitate the water into the lagoon, and plans are on foot for the establishment of a central power station and the gradual electrification of all the pumping plants. Cultivation on the settlement is as follows: Sultanas, 2,441 acres; currants, 1,335 acres; gordos, 922 acres; doradillos and wine grapes, 404 acres; pears, 155 acres; apples, 8 acres; apricots, 292 acres; peaches and nectarines, 109 acres; citrus fruits, 438 acres; figs, 11 acres; prunes, 7 acres; olives, 39 acres; miscellaneous fruits, 16 acres; and the balance in fodder crops. The most up-to-date and largest fruit-packing shed in the State is situated at Renmark, and is co-operatively owned, as is also a large distillery for the manufacture of grape spirit. There are several private packing sheds and a private distillery.

(ii) *Other Waterworks.* A number of country waterworks is 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 chapter on Local Government.)

(iii) *Areas under Irrigation.* The Irrigation Areas on the River Murray above Morgan under Government control up to the end of December, 1928, contained 27,986 acres of irrigable land, allotted to 1,173 settlers, including 495 returned soldiers. The pumping plants at present installed or being installed on these areas aggregate 7,653 brake horse-power, with a pumping capacity of over 12 million gallons per hour. These lands are devoted almost entirely to fruit growing, including citrus, deciduous and vine fruits.

The *Cadell Irrigation Area* is 7 miles by river above Morgan, and comprises 2,727 acres, of which 1,136 are irrigable. Blocks have been allotted to 55 soldier settlers and 8 civilian settlers. The area is suitable for fruit growing. The pumping plant is a 190 b.h.p. steam plant, with a capacity of 4,200 gallons per minute against a head of 75 feet. Two semi-Diesel crude oil pumping plants of 25 and 35 h.p., and having capacities of 417 and 700 gallons per minute respectively, have been installed to deal with seepage water. This area was first allotted on 30th September, 1919.

The Waikerie Irrigation Area is situated 39 miles above Morgan by river. It is settled by 250 settlers (10 of whom are soldier settlers) occupying 8,203 acres, of which 5,111 acres are irrigable.

The Area is divided into three divisions, viz., the Waikerie, Ramco, and Holder Divisions. The Waikerie and Ramco Divisions comprise 9,290 acres, of which 3,358 acres are irrigable and the Holder Division contains 2,486 acres, of which 459 acres are irrigable.

The irrigable land is used for the cultivation of fruit trees and vines.

These were originally village settlements established in 1894 for the relief of the unemployed. The communistic form of control was not successful and the schemes reverted to the Crown.

The irrigable areas were subsequently increased by pumping to higher levels, land in the extension areas being first allotted in 1910.

Pumping Plants. Three Diesel units totalling 1,170 b.h.p. have replaced the four suction gas and one steam units. Their combined capacity is 16,667 gallons per minute against a total head of 140 feet.

Two of the old suction gas units of a total b.h.p. of 560 and a capacity of 5,833 gallons per minute have been retained as stand-by plants.

Holder Division consists of two steam units, with a total of 238 b.h.p. and a capacity of 3,750 gallons per minute against a total head of 115 feet. An adjoining irrigable area of 110 acres held by Holder Limited is also irrigated by this plant.

The *Kingston Irrigation Area* is situated 75 miles above Morgan by river, and comprises the old village settlement of that name. It has a total area of 3,747 acres, of which 470 acres are irrigable, and has been allotted to 34 settlers. The water is pumped by a 130 b.h.p. steam plant with a capacity of 2,000 gallons per minute against a total head of 114 feet.

The *Moorook Irrigation Area*, adjoining the Kingston Area, contains 5,971 acres of land, of which 645 acres are irrigable. All of the irrigable land has been allotted to 41 settlers, of whom 10 are soldier settlers. The control of the original scheme was taken over by the Government in February, 1915, and the area to be irrigated was extended. The first allotment of the extension area took place in March, 1916. This area is irrigated by a 430 b.h.p. steam plant of two units, with a capacity of 7,160 gallons per minute against a total head of 120 feet.

The *Cobdogla Irrigation Area* is on the opposite side of the river to Kingston and Moorook Areas. It was formerly a sheep station held under pastoral lease, and was resumed by the Government for irrigation purposes. The total area of the station was 160,000 acres, of which 23,400 acres has been set apart as the Berri Area, and the remaining 136,600 acres as the Cobdogla Area. The latter area includes Lake Bonney, 4,000 acres in extent. This lake is situated 3 miles inland from the Murray from which, now that No. 3 Lock is in operation, it is kept partially filled by Chambers Creek.

The Cobdogla Area contains about 34,500 acres of land capable of being irrigated. It is divided into 5 sections, viz., the Cobdogla, Nookamka, Loveday, McIntosh, and Weigall divisions. The 68 civilian and 147 soldier settlers on the area occupy 5,102 acres of irrigable land and 20,107 acres of dry land. The first allotment took place in 1918.

The Cobdogla division has been developed as a low-lift area, the pumping head being about 34 feet, to irrigate 1,460 acres of land. About one-half of this is devoted to lucerne and other fodders for sheep raising.

The Nookamka division, south of Lake Bonney, has an irrigable area of 2,507 acres.

The Loveday division has an irrigable area of 8,627 acres. The reticulation on this division is by means of concrete pipe lines, for both mains and branches, instead of open channels.

The *Weigall Division* contains approximately 9,000 acres that could be irrigated, but with the falling off in the demand for land for fruit growing, no development work has been undertaken. A number of small blocks have been allotted for dry farming to settlers who hold irrigable land in adjoining areas, and the remainder of the division has been divided into 9 blocks of about 3,000 acres in area for grazing and cultivation and let under Miscellaneous Lease.

Pumping plants have been installed to supply water to the Cobdogla, Nookamka and Loveday divisions. On the Cobdogla division a 240 b.h.p. steam plant with a capacity of 16,700 gallons per minute has been installed and is now used as a subsidiary plant. The main water supply is obtained from the two "Humphrey" gas plants installed with a combined capacity of 47,600 gallons per minute. The Nookamka division has two steam units, totalling 640 b.h.p., installed with a combined capacity of 12,500 gallons per minute, which have recently been superseded by a pipe line connecting with the Loveday

water mains, which now supply the Nookamka requirements. The Loveday division has a 300 b.h.p. suction gas unit, with a capacity of 6,000 gallons per minute, and two steam units installed, with combined power and output of 1,315 b.h.p., and 33,300 gallons per minute respectively, pumped against a total head of 93 feet.

The *Berri Irrigation Area* is 120 miles above Morgan by river, and contains a total area of 23,400 acres, of which 7,665 acres are suitable for fruit and vine culture. A total of 7,617 acres of irrigable land has been allotted to 436 settlers, of whom 231 are soldier settlers. An area of 80 acres of the irrigable land is used as an experimental farm. The first allotment of the older portion of this area took place in January, 1911. The pumping plant consists of five units, three suction gas and two steam units, with a total of 2,250 b.h.p., and a capacity of 42,500 gallons per minute against total heads varying from 50 feet to 120 feet.

The *Chaffey Irrigation Area* comprises a large area of country adjacent to Renmark. Preliminary survey work has been carried out over 14,000 acres of prospective irrigable land. A portion of this area, known as the Ral Ral Division, containing 2,023 acres, of which 1,643 are irrigable land, has been surveyed into blocks. A total of 1,163 acres, including 1,022 acres of irrigable land, has been allotted to 46 settlers, 39 of whom are soldiers. A pumping plant of 220 b.h.p., with a capacity of 12,500 gallons per minute against a total head of 30 feet has been installed.

The *Irrigation and Reclaimed Swamp Areas* under Government control on the River Murray below Morgan contain 10,234 acres of rateable land, i.e., 941 acres of high irrigable and 9,293 acres of reclaimed swamp land, allotted to 217 settlers, of whom 36 are soldier settlers. The former land is irrigable by pumping, and is devoted to the production of citrus, deciduous and vine fruits; the latter is watered by gravitation and its production is confined to fodder for dairying and sheep raising.

Pumping plants installed total 1,241 b.h.p., with a capacity of 5½ million gallons per hour.

Mobilong and Burdett Divisions of the Murray Bridge Irrigation Area, adjoining Murray Bridge, contain 577 acres of irrigable reclaimed fodder land with 45 settlers, of whom one is a soldier.

Long Flat and Monteith Flat below Murray Bridge have between them a reclaimed irrigable area of 1,344 acres, all of which has been allotted to 48 settlers, of whom three are soldiers.

Swanport Area below Murray Bridge has 192 acres of fruit and fodder land, and is allotted to one civilian settler.

The *Jervois Irrigation Area* is situated from 15 miles to 18 miles by river below Murray Bridge and contains 17,413 acres, 3,438 acres being reclaimed swamp. There are 68 settlers on the area, 6 of whom are soldiers. The allotted land comprises 2,439 acres of reclaimed swamp and 11,903 acres of dry land.

The area is divided into four divisions, viz., Woods Point, Jervois, Wellington, and Highland Divisions. The first three consist mostly of reclaimed swamp, and the Highland Division contains dry or " high " land which is allotted to the settlers on the three swamp divisions.

The *Mypolonga Area* is 9 miles above Murray Bridge, and has a river frontage of 7 miles. The total area of this settlement is 5,792 acres, of which 853 are irrigable high land and 1,355 acres irrigable reclaimed land. A rateable area of 2,062 acres has been allotted to 88 settlers, of whom 3 are soldiers.

The *Pompoota Area,* situated 13 miles above Murray Bridge, was previously used as a Training Farm for prospective soldier settlers. The area contains 2,470 acres, of which 388 acres are irrigable reclaimed land. The whole of the rateable area has been allotted to 8 soldier settlers and 5 civilian settlers.

The *Wall Area,* 16 miles above Murray Bridge, has an area of 999 acres, of which 464 acres are rateable reclaimed swamp land. Ten soldiers and a civilain are settled on the area.

The *Neeta Irrigation Area* is 20 miles above Murray Bridge, and contains a total of 2,760 acres, of which 525 acres are rateable reclaimed swamp land. The rateable area of 525 acres has been allotted to 7 civilian and 8 soldier settlers.

The *Cowirra Irrigation Area* is 20 miles above Murray Bridge, and contains a total of 2,368 acres, of which 574 acres are rateable reclaimed swamp land. A rateable area of 402 acres has been allotted to 14 civilian settlers and one soldier settler.

The *Baseby Area* is about 21 miles above Murray Bridge, and has an area of 1,350 acres. This area has been leased to a civilian settler. 528 acres are reclaimed swamp.

The reclaimed lands on the River Murray consist mainly of peaty soils composed of rich river silt, and are eminently suitable 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, etc.

(iv) *Allotment of Irrigated Land.* All lands are allotted under perpetual lease, and blocks are surveyed into areas varying up to 50 acres of high irrigable or reclaimed swamp land. It is not the practice to allot more than 50 acres of irrigable or reclaimed land, or of both irrigable and reclaimed, to any one settler, 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 Irrigation Commission immediately prior to the land being offered for application. For the reclaimed land an amount is charged sufficient to cover interest on cost of the land, the survey thereof, and interest on cost of the levee; 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 present rate is 60s. per acre per annum. On the reclaimed lands an amount is charged to meet the annual management, drainage, maintenance expenses, and certain interest charges, the present rate being 30s. per acre. A sliding scale applies to 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 full rent and water rates; 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 rates to 24 acre-inches per annum, supplied mostly in four irrigations; special irrigations and domestic supplies are available at a nominal cost at times other than during the general irrigations. On the reclaimed lands, water is supplied as required.

Liberal assistance is provided by the Government to lessees of irrigation blocks. Apart from the erection of pumping plants, construction of main channels and other work necessary to render the land ready for occupation, the Irrigation Commission has power to carry out improvements in the nature of clearing, channelling, fencing, etc. The lessee on allotment is required to take over any expenditure so incurred, and to pay an amount of not less than 15 per cent. of the cost of the work. Subsequent to allotment the Commission has power to expend a sum not exceeding £30 per acre of the irrigable land in any lessee's block in making the following improvements, or any of them:— Fencing, clearing, grading, constructing irrigation channels, drains and tanks thereon, and connecting such channels or drains with the nearest main channel or drain. The lessee is required to pay a deposit before the work is commenced equal to not less than 15 per cent. of the Commission's estimate of the cost of carrying out such improvements. The Commission may also make cash advances to any lessee for all or any of the following purposes:—

(*a*) For carrying out improvements and the erection of buildings to the extent of the estimated value of the lease and improvements already made or in course of being made thereon, but not exceeding £650.

(*b*) For the purchase of implements, stock, seeds, plants, trees, etc., to any amount not exceeding £200.

(*c*) For any other purpose that may be approved by the Commission, but not exceeding three-fourths of the estimated value of the lease and any improvements already made thereon.

The total amount that may be expended or advanced, however, for all or any of the above purposes, including improvements carried out by the Commission, shall not exceed in aggregate the sum of £600, or £30 per acre of the irrigable portion of the land, whichever sum is the greater.

All expenditure incurred by the Commission in improving the land either before or after allotment, or advanced to the lessee to carry out further improvements, must be repaid under the following conditions:—For the period of 5 years following the date on which the land was allotted or advances made, the lessee shall pay interest on the amount at current rates. After the expiration of 5 years, the lessee is required to repay the amount expended or advanced by 70 equal half-yearly instalments, together with interest at current rates on the balance remaining unpaid.

6. **Western Australia.**—In this State an Irrigation Act provides for the constitution of irrigation districts. At Harvey, works for irrigating about 4,000 acres devoted to fruit growing, principally oranges, were opened on the 21st June, 1916.

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

7. **Murray Waters.**—(i) *River Murray Agreement.* The River Murray Agreement, with subsequent amendments, entered into by the Governments of the Commonwealth and the States of New South Wales, Victoria, and South Australia, provides for the construction of the following works:—(*a*) The Hume reservoir, (*b*) The Lake Victoria storage, (*c*) Twenty-six weirs and locks in the River Murray, and (*d*) Nine weirs and locks in the River Murrumbidgee. In the agreement provision is made for these works to be undertaken by the Governments of the three States—the Hume Reservoir and 17 weirs and locks between Echuca and Wentworth, including that at Wentworth, to be constructed by the Governments of New South Wales and Victoria severally or jointly, as may be mutually agreed upon by them; the 9 weirs and locks in the River Murrumbidgee to be constructed by the Government of New South Wales; and the Lake Victoria Storage and 9 weirs and locks in the River Murray below Wentworth by the Government of South Australia

The River Murray Commission, appointed in pursuance of the Agreement referred to, and comprising a representative of each of the four contracting Governments, is charged with the duty of giving effect to the Agreement and the River Murray Waters Acts.

(ii) *Works.* (*a*) *General.* The works which have been put in hand to date, with the exception of the weir and lock at Blanchetown, which was commenced before the Agreement came into operation, have been or are being constructed in accordance with designs approved by the River Murray Commission.

The following are the works which have been put in hand:—

The Hume Reservoir, Weir and Lock No. 26 (Torrumbarry, near Echuca), Weir and Lock No. 11 (Mildura), Weir and Lock No. 10 (Wentworth), a little below the junction of the Rivers Murray and Darling, *Weir and Lock, No. 15, near Euston,	By the Governments of New South Wales and Victoria.
The Lake Victoria Storage, Weirs and Locks Nos. 1, 2, 3, 4, 5, 6, 7, and 9.	By the Government of South Australia.

* Operations at Weir and Lock No. 15 have been suspended in order that available funds may be utilized for more urgent works.

(*b*) *The Hume Reservoir.* The site of the Hume Dam, which is being constructed jointly by the Constructing Authorities for New South Wales and Victoria, is located a little below the junction of the Rivers Murray and Mitta Mitta, where the reservoir will receive the run-off from a catchment of 6,000 square miles of mountainous country. The original designs prepared in connexion with this work provided for a reservoir with a capacity of 1,100,000 acre-feet, and the work was put in hand on both sides of the river in accordance with such designs, but with a view to making provision for the greatest possible storage, and in order to enable the Reservoir to be utilized for the purpose of hydro-electric generation the four Contracting Governments, acting on expert advice, later agreed to the construction of the dam of dimensions and height sufficient for a capacity of 2,000,000 acre-feet. The cost of the enlarged reservoir has been estimated at £5,872,637.

The dam, which is in course of construction, will consist of two main sections—(1) the outlets and flood spillway, and (2) the earthen embankment containing a concrete core wall sunk into the solid granite, and provided with a tunnel for drainage and inspection purposes. The first section, which will extend from the New South Wales bank of the river to the Victorian bank, and which will be practically all of concrete, is being constructed by the New South Wales Constructing Authority. The remaining section of the dam, which extends from the Victorian bank of the river to the high ground bordering the river flats, is in course of construction by the Victorian Constructing Authority. The total length of the dam, including both sections above referred to, will be 4,200 feet.

During the course of the year, the gap in the dam on the New South Wales portion of the work was closed, and the outlet and spillway sections raised to a height sufficient to impound 100,000 acre-feet of water. The stored water is at present being discharged through four outlets. On the Victorian side of the river the construction of the earthen embankment and the concrete core wall is considerably advanced. The piers for the bridge over the Hume Reservoir in the vicinity of the dam have been erected, and the first span of the superstructure is in position. The total expenditure incurred to 30th June, 1929, on the whole of the works at the Hume Reservoir amounts to £3,438,000.

(*c*) *Lake Victoria Storage.* The Lake Victoria Storage is situated in the south-west corner of the State of New South Wales. The scheme approved consists of the construction of extensive embankments and channels, the construction of three regulators (the inlet regulator in the Frenchman's Creek, the controlling regulator in the main inlet channel, and the outlet regulator in the Rufus River), and improvements to Frenchman's Creek and Rufus River.

These works, which are now practically completed, will provide for the storage in the lake of 514,000 acre-feet of water for use by the State of South Australia. The expenditure on this work to 30th June, 1929, amounts to £462,000.

(*d*) *Weirs and Locks.* Nine weirs and locks, viz., No. 10 (Wentworth)—New South Wales—Nos. 11 (Mildura) and 26 (Torrumbarry)—Victoria—and Nos. 1, 2, 3, 4, 5, and 9—South Australia—have been completed, and are now in operation. Of the remaining weirs and locks at present in hand, No. 6 (South Australia) is in an advanced stage of construction.

(iii) *Finance.* (*a*) *General.* In the River Murray Agreement of 1914, the estimated total cost of the whole of the works was set down at £4,663,000. Although definite estimates of the cost of those works not yet authorized have not been prepared, it is anticipated that the total ultimate cost of the whole of the works covered by the River Murray Agreement will be in the vicinity of £15,000,000. The total expenditure incurred up to 30th June, 1929, on that portion of the scheme completed and in course of construction amounted to £7,118,000, towards which expenditure the four Contracting Governments in conformity with the amending Agreement previously referred to, have contributed in equal shares.

(*b*) *Programme of Works to be constructed during the period ending 30th June,* 1932. At a conference of representatives of the four Contracting Governments, it was decided definitely to limit the programme of works to be constructed during the period ending 1932 to the following works, viz. :—The construction of the Hume Reservoir to provide for a capacity of 2,000,000 acre-feet; the completion of the Lake Victoria Storage; and the completion of all Weirs and Locks from No. 1 (Blanchetown) to No. 11 (Mildura) and Weir and Lock No. 15 (Euston).

The amount of £800,000 made available by the Loan Council for expenditure on works and land resumptions during the financial year 1929-30 has been allocated by the River Murray Commission as follows :—

New South Wales	£293,000
Victoria	368,000
South Australia	139,000
	£800,000

The four Contracting Governments will furnish their respective contributions towards this proposed expenditure as required during the year.

(iv) *Gaugings.* The River Murray Agreement places upon the Commission the duty of carrying on an effective and uniform system of making and recording continuous gaugings of the main stream of the River Murray and its tributaries within the boundaries of each of the States of New South Wales, Victoria, and South Australia, and of all diversions, whether natural or artificial or partly natural and partly artificial, from the main stream and its tributaries. It is further provided that, in lieu of making any such gaugings, the Commission may accept any gaugings made and recorded by any of the Contracting State Governments.

Arrangements have been made with the three Contracting State Governments for the adoption of uniform methods in connexion with all gaugings on the River Murray and its tributaries, and for the submission periodically to the Commission, for purposes of the River Murray Agreement, of the results of such gaugings.

The gaugings made at the Renmark Gauging Station during the year 1927–28 indicated that the total flow of the river at that point was 5,674,653 acre-feet for the year. The total flow at the same station for the preceding year was 10,417,208 acre-feet.

The approximate quantity of water diverted from the river by the three States by artificial or partly artificial means for the same year was 1,966,101 acre-feet.

(v) *River Murray Commission.* The River Murray Commission, as at present constituted, is as follows :—

Commonwealth	.. Senator the Hon. John Barnes (President).
	Deputy Commissioner—Mr. T. Hill, M.V.I.E., A.M.I.E.Aust.
New South Wales	.. Mr. H. H. Dare, M.E., M. Inst. C.E., M.I.E., Aust.
Victoria ..	.. Mr. R. H. Horsfield, M. Inst. C.E., M.I.E., Aust.
South Australia	.. Mr. J. H. O. Eaton, M. Inst. C.E., M.I.E., Aust.
	Secretary—Mr. D. P. Israel, L.I.C.A., A.A.I.S.
	Accountant—Mr. F. A. Piggin.

More detailed references to the River Murray Agreement and the operations of the Commission will be found in previous issues of the Year Book (see Official Year Book, No. 19, pages 845–850).