SECTION XIV.

WATER CONSERVATION AND IRRIGATION.

§ 1. Water Supply Works.

1. **General.**—In every country in which droughts are recurrent, there are few problems of greater importance to be solved than that of an adequate system of water conservation. Much has been done so far as the supply of water to centres of population is concerned, and a description of several of the metropolitan water works will be found herein, viz., in the section dealing with "Local Government."

2. **The Goldfields Water Supply of Western Australia.**—The scheme by which the Government of Western Australia undertook to provide a permanent supply of water for the population on the eastern goldfields of that State comes properly under the heading of "Water Supply Works," but owing to its magnitude and special character it could not be included in the section "Local Government."

The Act under which the works were constructed was introduced in Parliament by Sir John Forrest, G.C.M.G., then Premier of Western Australia, in September, 1896, and provided for an expenditure of £2,500,000 and a daily supply of 5,000,000 gallons. The works, designed by the late Mr. C. Y. O'Connor, Engineer-in-Chief of the State, were originally known as the "Coolgardie Water Scheme," but are now officially called the "Goldfields Water Supply." So soon as the Act was passed through Parliament the works were energetically undertaken, so that, apart from reticulation works, the whole scheme was completed early in 1903, viz., in about six years. The scheme is unique in more than one way. The weir across the Helena River, near Mundaring, at a point where the width between the banks is 760 feet, is the highest overflow weir in existence. The surplus water flows directly over the weir crest and down the solid concrete face of the wall to the river 100 feet below. The capacity of the Mundaring reservoir is 4,600,000,000 gallons, and its daily output capacity 5,000,000 gallons. The main service reservoir from which the goldfields towns are supplied, is situated at Bulla Bulling, 351 miles from Mundaring, and at an altitude 1200 feet above that of the last-named locality. It becomes, therefore, necessary to pump a daily quantity of 5,000,000 gallons of water, weighing approximately 22,300 tons, over a distance of 351 miles, and to raise it 1200 feet. This is done by means of eight pumping stations along the principal main, the diameter of which is 2 feet 6 inches. The area to which the trading operations of the scheme are confined extends from Guildford, in the west, to Kanowna, in the east, and there are twelve smaller reservoirs and tanks, with a total capacity of 31,500,000 gallons, in the neighbourhood of the towns which are supplied with water from the scheme. The total cost was £3,078,500, and the price of water ranges from two shillings and sixpence in the western area to eight shillings and fourpence at Kanowna, with an average of about five shillings and sixpence. During the financial year 1907-8 the total consumption amounted to 837,296,000 gallons, while the number of services was 12,400. The gross revenue was £172,550, and the working expenses £74,883, leaving a gross profit of

£97,667. Of this amount interest at 3½ per cent. and payment of 2 per cent. to sinking of the supplementary debenture capital of £353,000 absorbed £16,885, thus leaving £80,802 available for payment into the general revenue of the State. As interest on the main capital amounts to £91,700, and payments to the sinking fund to £80,000, or a total of £171,700, there was therefore a deficiency of £90,898 on the year's transactions to be made good from general revenue.

3. **The Mines Water Supply Branch.**—Prior to the commencement of the Goldfields Water Supply Scheme works of different kinds were carried out by Government in order to afford temporary relief to the population on the goldfields. These works comprised shallow and artesian boring, conservation and protection of water in natural and artificial reservoirs, sinking of wells, erection of condensers, etc. Administratively the goldfields area is divided into three water supply districts—Coolgardie, Murchison, and Pilbara. It has been the policy of the department charged with the supervision of water supply works, viz., the Mines Department, to lease watering stations wherever that could be done to advantage, and from twenty to thirty leases are generally executed in the course of a year. The tanks which have been constructed by the department vary in size from 200,000 gallons to 37,500,000 gallons (at Niagara).

§ 2. Artesian Wells

1. **General.** (i.) *The Great Australian Artesian Basin.* Although there are some artesian wells outside this area, yet, in speaking of the "Great Australian Artesian Basin," the area is understood which includes (*a*) considerably more than one-half of Queensland, taking in practically all that State lying west of the Great Dividing Range, with the exception of an area in the north-west contiguous to the Northern Territory; (*b*) a considerable strip of New South Wales along its northern boundary and west of the Great Dividing Range; and (*c*) the north-eastern part of South Australia proper, together with the extreme south-eastern corner of the Northern Territory. This basin (shewn approximately by map in Section XXVI., Local Government), is said to be the largest yet discovered, and is about 569,000 square miles, of which 376,000 square miles are in Queensland, 110,000 square miles in South Australia, and 83,000 square miles in New South Wales. The area of the intake beds is estimated at 68,000 square miles, viz., 50,000 square miles in Queensland and 18,000 square miles in New South Wales. The basin is what is technically known as a one-sided or half-basin, the intake beds outcropping along its eastern and north-eastern sides only, while the remainder of the water-bearing formation is hidden under the superficial deposits forming the plains of the interior of the States. Although it has not been definitely decided whether the basin has outlets towards the Gulf of Carpentaria in the north, and towards the Great Australian Bight or towards Lake Eyre in the south, there is a preponderance of opinion and strong evidence in favour of the existence of such outlets, an opinion which receives strong support from the maps published by the Geological Department of Queensland, which shew an apparent dip in the water-bearing strata towards the Gulf of Carpentaria in the north and towards Lake Eyre and the Great Australian Bight in the south. It is estimated that at present there are about 1650 bores tapping the basin in the three States.

(ii.) *The Western Australian Basin.* 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 an artesian water area. But where boring operations have been undertaken the water has been found to be salt or brackish, and there are other conditions affecting the supply, such as local variations in the thickness of the beds, their relative porosity, and the unevenness of the floor upon which they rest, which so far have not been examined with sufficient thoroughness to enable many particulars to be given in regard to this basin.

In the coastal area to the west of the Darling Range artesian boring has, on the other hand, been carried on successfully for many years.

(iii.) *Plutonic or Meteoric Water.* While it has long been held that the Australian artesian basin is a typically-formed one, and that its intake beds are as described above, a theory has been recently advanced (viz., by Professor Gregory,[1] formerly of Melbourne, but now of Glasgow University), that the water, although called artesian, is not impounded rain-water, or *meteoric* water at all, but is derived from the older rocks, *i.e.*, that it is *plutonic* in character. If this were so, and if the water contained in the basin were merely such as occurs in the molten lava from volcanoes or imprisoned in the solidified quartz of granites, we should, of course, be rapidly exhausting our supply. He founds his main arguments on (*a*) the amount of friction caused by the flow of water through the minute interstices between the sand grains, *i.e.*, on the loss of its hydrostatic head before the bores are reached; (*b*) on anomalies in temperature and pressure; (*c*) on the chemical analysis of some of the waters; and (*d*) on evaporation measurements in Central Australia. He suggests the pressure of overlying rock, and gas pressure caused by the internal heat of the earth, as causes of the flow from the bores.

This new theory has recently been replied to at length by the Government Geologist of New South Wales.[2] While this Year Book is hardly the place to enter at length upon arguments of a purely scientific nature, it may be said that Mr. Pittman avers that "many of Professor Gregory's statements appear to be in opposition to observed facts." In regard to the loss of hydrostatic head, he quotes the opinion of the United States Geological Survey in regard to bores in Kentucky, and the experience in connection with the Grenelle bore in Paris. So far as temperature is concerned, he shews that it would be illogical to contend that, because some Australian bores give higher rates of increase than the average results of a number of ascertained bores and tunnels in other parts of the world, the water must be plutonic and not meteoric. In regard to pressure, stress is laid on the more accurate results obtained with the dumpy level than with the aneroid, and it is shewn how accurately the height to which the water would rise has been predicted in many localities. It is also pointed out that the isopotential lines as laid down are tentative, as information in regard to many private wells is unreliable. The question of the chemical constituents of artesian water is dealt with at length, and it appears that instead of decreasing from east to west, as stated by Professor Gregory, the salinity of the water actually increases, and that some of the wells in the eastern district mentioned by the latter as being particularly rich in saline matter are actually outside the artesian basin altogether.

In regard to evaporation measurements in Central Australia, Mr. Pittman shews also that these do not affect the question at issue at all, as the water does not enter the porous beds in Central Australia, but on the flanks of the Dividing Range, where the rainfall is copious. The theories of the pressure of overlying rock and of gas pressure are also utterly repudiated.

The strength of the argument seems to be unquestionably in favour of the older theory of meteoric water, as upheld by Mr. Pittman, and in his reply he appears to have disposed of every feature in Professor Gregory's argument to which weight might have been attached.

2. **Queensland.**—The publication of the valuable reports issued annually by the Hydraulic Engineer of Queensland has been suspended during the last six years, and complete statistics are only available to 30th June, 1902. At that date the following bores were in existence :—

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1. See *J. W. Gregory, F.R.S., D.Sc.*: "The Dead Heart of Australia"; London, John Murray, 1906.

2. *E. F. Pittman, A.R.S.M., 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).

QUEENSLAND ARTESIAN BORES ON 30th JUNE, 1902.

Sunk by—	Artesian Flows.	Sub-Artesian Flows.	Pumped Supplies.	In Progress; Abandoned; Uncertain.	Total.
Water Supply Department (trial borings)	22	...	3	24	49
Railway Department	2	...	2	13	17
Local governing authorities	10	...	15	5	30
Private owners	530	9	131	168	838
Total ...	564	9	151	210	934

The depth of 850 of these wells is given, and it appears that there were 229 less than 500 feet deep, 200 from 500 to 1000 feet, 231 from 1000 to 2000 feet, 124 from 2000 to 3000 feet, and 66 over 3000 feet. The deepest well was one known as Bimerah Run No. 3, Whitewood, lying between the Barcoo and Thomson Rivers; this had a depth of 5045 feet, and was stated to yield 70,000 gallons daily. This flow is, of course, a comparatively small one, many wells yielding, when uncontrolled, from one to three million gallons a day. A well at Cunnamulla is stated to have a daily flow, when uncontrolled, of no less than 4,500,000 gallons. The waters of many of the wells have been analysed, and some found suitable for wool-scouring only, others are suitable for watering stock but not for irrigation, owing to the presence of alkali; others again serve for both stock and irrigation, while some, such as those containing sulphuretted hydrogen, are not of any use. Water fit for stock may generally be said to be "safe" for domestic purposes in spite of its slightly mineral taste. The wells yielding the mineral water known as "Helidon Spa," which is much in use in Queensland and New South Wales, are shallow wells from 60 to 200 feet in depth.

It is stated that the total number of artesian wells in Queensland at the end of 1907 was 1081, of which 174 were Government wells. The maximum depth for Government wells is given as 4010 feet, and of private wells as 5045 feet, while the minimum depths were 250 feet and 60 feet respectively. The maximum and minimum temperatures of Government wells were 174° and 70° Fahrenheit, and of private wells 202° and 60° Fahrenheit.

3. **New South Wales.**[1]—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. At the middle of 1908, out of 449 known wells in New South Wales, nearly 200 were Government wells, a very much larger proportion than in Queensland.

The distribution of these wells was as follows:—

NEW SOUTH WALES ARTESIAN BORES ON 30th JUNE, 1908.

Purpose of Bore.	Flowing.	Pumping.	Failure.	Total.
Private	198	34	21	253
Artesian wells district	25	...	1	26
Water and Drainage Trust district	11	...	...	11
Country towns water supply	2	...	...	2
Public watering place	58	28	17	103
Improvement lease	48	2	4	54
Total	342	64	43	449

1. See *Percy Allan, M. Inst. C.E., M. Am. Soc. C.E., Principal Assistant Engineer for Water Conservation in New South Wales*, in "The Drought Antidote for the North-West." (Lecture delivered before the Sydney University Engineering Society, October 10th, 1906.)

The total depth of these 449 wells is given as 675,495 feet.

Of the wells at the end of 1906, the depth is stated in 390 cases, and it appears that only 18 wells were less than 500 feet deep; while 76 ranged from 500 to 1000 feet; 215 from 1000 to 2000 feet; 64 from 2000 to 3000 feet; and 17 over 3000 feet. As in Queensland, there is a preponderance of wells from 1000 to 2000 feet in depth, but neither the shallow wells under 500 feet, nor the very deep wells over 3000 feet are so numerous in proportion as in the northern State. The two deepest wells in New South Wales are those at Boomi, in County Benarba, with a depth of 4008 feet and a daily outflow of 1,428,640 gallons; and at Dolgelly, in the Parish of Careunga, in County Stapylton, with a depth of 4086 feet, and an outflow of 682,200 gallons per day. The largest outflow is stated to be that at the Munna Munna well, in County Leichhardt, which yields 1,657,230 gallons a day, and has a depth of 2197 feet. The total flow of the bores cannot be given, as many of the private bores have not been gauged, and in other cases the gaugings are not regarded as reliable. Accurate meter-gaugings are, however, being extended throughout the State, and the Department of Water Conservation hopes, therefore, soon to be in a position to give fairly reliable information on this point.

The water of a large number of wells has been analysed by Mr. J. C. H. Mingaye, F.C.S., etc., of the New South Wales Mines Department, and it may be of interest to give a list of those containing, among all the wells examined, the maximum quantities of particular salts in solution:—

NEW SOUTH WALES ARTESIAN BORES—CHEMICAL ANALYSIS.

Name of Bore.	County.	Salt found in greater quantity than in any other bore.[1]	Grains per Imperial Gallon.
Tunderbrine No. 1 ...	Gowen	Sodium carbonate ($Na_2 CO_3$)	124.7
Fort Bourke	Gunderbooka ...	Potassium carbonate ($K_2 CO_3$)	12.3
Gaffney's	Barrona ...	Calcium carbonate ($Ca CO_3$)	10.5
Bancanya	Mootwingee ...	Magnesium carbonate ($Mg CO_3$)	10.7
Cuttaburra	Irrara & Barrona	Sodium chloride (Na Cl)	349.0
Warratta	Evelyn	Potassium chloride (K Cl)	22.1
Momba	Fitzgerald and Yungnulgra...	Magnesium chloride ($Mg Cl_2$)	28.0
Sandy Creek	Mootwingee ...	Sodium sulphate ($Na_2 SO_4$)	28.1
Gilgandra...	Ewenmar ...	Potassium sulphate ($K_2 SO_4$)	19.3
Wingadee No. 1	Leichhardt ...	Iron oxide ($Fe_2 O_3$) and alumina ($Al_2 O_3$)	1.4
Coonamoona	,, ...	Silica ($Si O_2$)	4.5
Momba	Fitzgerald and Yungnulgra...	Calcium chloride ($Ca Cl_2$) and calcium sulphate ($Ca SO_4$)	22.2 & 12.0
Burrawang No. 2, I.L. 1211	Cunningham ...	Total solid matter —	1802.0

1. This is, of course, not necessarily the salt found in greatest quantity.

The Zetz Spa, much used as a mineral water in New South Wales, comes from Ballimore, near Dubbo.

It may be said that the cost of artesian wells works out at an average of about 17s. 6d. per lineal foot; it depends, of course, upon the depth to which boring operations have to be extended, and on the accessibility of the bore to a railway station. Contracts have recently been let for boring and the use of six-inch casing at the following rates:—To 1000 feet, 11s. per foot; 1000 to 1500 feet, 12s. 6d.; 1500 to 2000 feet, 13s.; 2000 to 2500 feet, 14s.; 2500 to 3000 feet, 16s.; 3000 to 3500 feet, 19s.; 3500 to 4000 feet, 24s. To these prices must be added the cost of cartage and of finishing off the work.

4. **South Australia.**—The information about artesian wells is very defective. Early in 1908 a list of twenty-five of the principal Government bores was published, of which four were under 1000 feet in depth, twelve from 1000 to 2000 feet, two from 2000 to 3000 feet, and seven over 3000 feet. The deepest flowing well was at Goyder's Lagoon, measuring 4580 feet, and yielding 600,000 gallons per day. The maximum flows, viz., 1,250,000 gallons and 1,000,000 gallons daily, occurred at Coward Springs and Dulkaninna respectively.

Artesian water has also been found outside the basin at Tintinara, on the Adelaide to Melbourne railway, where a well, 253 feet deep, yields 4300 gallons daily, and at Boolcunda, where a well, 687 feet in depth, gives 19,200 gallons daily.

5. **Victoria.**—Victoria lies altogether outside the artesian basin, and as water is obtainable in most parts of the State at shallow depths, there has not been much occasion for artesian boring. As early as 1884, however, an artesian well was bored at Sale, which for a number of years gave a supply of about 100,000 gallons per day until, either through corrosion of the casing or by choking up with sand from below, the flow ceased. In 1905 a new bore was, therefore, put down, which at a depth of 277 feet yielded sufficient water to fill Lake Guthridge, a local depression. But as the water was impure and contained too much sulphuretted hydrogen boring operations were continued to 520 feet, when the lowering of the casing shut off the supply of water. A second bore was then put down at some distance from the first, and this, at a depth of 238 feet, yielded fresh and clear water. The supply at present is stated to be about 145,000 gallons per day.

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 drinking purposes.

6. **Western Australia.**—Out of twenty-four artesian bores put down by the Mines Department Water Supply Branch to the end of 1906 in the artesian basin east of the Darling Range, fifteen were less than 500 feet in depth; five between 500 and 1000 feet; three between 1000 and 2000 feet; and one only, at Davyhurst, over 2000 feet, viz., 3624 feet.

The number of wells between the Darling Range and the coast in 1906 was stated at forty-two, of which fourteen were less than 500 feet; nine from 500 to 1000 feet; sixteen from 1000 to 2000 feet; two from 2000 to 3000 feet; and one over 3000 feet. The last-named bore, situated at Carnarvon, is 3011 feet in depth, and yields a daily supply of 515,000 gallons. The maximum outflow, 1,167,000 gallons per day, is said to be obtained from a well at Guildford.

At the end of 1907 the total number of bores was 71, of which 40 were Government bores. The total depth bored is given as 44,625 feet in Government and 26,315 feet in private bores. The total cost of State bores was about £52,000, of which amount £7000 was spent in 1907. The total daily flow is stated as 20,929,000 gallons. The maximum and minimum depths of State bores were 3011 feet and 56 feet respectively, and the maximum and minimum temperatures 140° and 60° Fahrenheit.

§ 3. Irrigation Plants.

1. **General.**—Various causes have combined to keep proposals for irrigation works on a large scale before the Parliaments of several of the States for a number of years without any very tangible results, except in the case of Victoria and South Australia. The absence of the example of any country which has constructed such works under similar climatic and labour conditions, the very partial success of some of the smaller works undertaken in Australia, and the abundant supply of artesian water obtained during the last twenty years in parts of the continent most liable to droughts, have all tended to delay the undertaking of any large works.

2. **Victoria.**—(i.) *Classification of Works.* The Water Conservation Works in Victoria naturally divide themselves into those providing mainly a domestic supply, such as the Yan Yean works, controlled by the Melbourne and Metropolitan Board of Works; the Coliban, Broken River, Kerang Lakes, and Mallee Supply works, which, although now administered by the State Rivers and Water Supply Commission, are properly local government works; other works for domestic supply controlled by Water Works Trusts or Municipal Corporations, and irrigation works proper. With the exception of the last named class particulars as to these works will be found in the section "Local Government" of this book.

(ii.) *Works Controlled by the Commission.* With the exception of the First Mildura Irrigation and Water Supply Trust, these works are now all under the control of the

State Rivers and Water Supply Commission, which was created by the Water Act 1905, in force since 1st May, 1906. The works comprise the following:—

(*a*) The Goulburn River works (including the Waranga Basin, with a storage capacity of 9500 million cubic feet, and constructed at a cost of £716,003;
(*b*) The Loddon River works, with a storage capacity of 610 million cubic feet, constructed at a cost of £156,408;
(*c*) The Kow Swamp works, with a storage capacity of 1780 million cubic feet, constructed at a cost of £187,779; and
(*d*) Nineteen other irrigation and water supply districts, the capital expenditure on which has been £806,932.

Many of the original irrigation trusts had been badly managed and were in financial difficulties when they were taken over by the Commission, and it became necessary for Government to write off considerable amounts both of capital debt and of arrears of interest, so that the capital cost of the works taken over by the Commission, including works for domestic supply, on 30th June, 1907, stood as follows:—

(*a*) Free head works, in respect of which no charge for interest is to be made against any district served by these works... ...		£1,172,027
(*b*) Other State works		1,749,892
(*c*) Branch distributory channels connected with Long Lake free head works		10,370
(*d*) Irrigation and water supply works—		
Total advances...	£791,528	
Less repaid, £5591; and written-off, £540,404 ...	545,995	
		245,533
Total		£3,177,822

In the above statement the amount shewn under (*b*) is exclusive of £456,700, the cost of the Geelong Water Supply works, which have been placed under the control of the Geelong Municipal Waterworks Trust.

The Commission is charged with the duty of assessing the values of properties served by the various water supply works, and of imposing thereon certain rates. In 1906-7 the gross revenue amounted to £88,847, and the expenditure to £62,329. Deducting from the latter amount £8869 expenditure charged to capital account, the working expenses may be stated as £53,460, and the net revenue as £35,387.

(iii.) *Mildura.* The first settlement of Mildura dates from 1884. After being managed until 1887 by Chaffey Bros., and then until 1895 by Chaffey Bros. Company Limited, it was in that year taken over by the First Mildura Irrigation Trust, and has since then made great progress. Its population, which at the Census of 1891 was 2321, had by September, 1907, increased to 4355. The exports of dried and canned fruit from Victoria, nearly all of which came from Mildura, amounted in 1907 to £190,654, viz.:—Canned fruits, £48,718; dried fruits—raisins, £123,679; other, £18,257. Of these exports £128,762 worth were sent to the other States of the Commonwealth, chiefly New South Wales, Queensland, and Western Australia, while the balance of £61,892, of which raisins accounted for £47,513, was exported oversea.

No precise figures are available as to the capital cost of the works at Mildura, probably the sum was not less than £180,000. The amount due to Government is £58,700, exclusive of £17,729 for accumulations of interest.

(iv.) *Area Irrigated.* The total area of districts served by irrigation plants in 1906-7 is given as 2,702,180 acres, of which 103,070 acres were irrigated. Of the area watered, viz., 160,574 acres, 12,069 acres were under cereals, 41,373 acres under lucerne and other permanent fodder crops, 10,183 acres under sorghum and other annual fodder crops, 59,008 acres under pasture, 35,941 acres (of which 28,640 acres at Mildura) were vineyards, orchards, and gardens, while the balance of 2000 acres was in fallow, etc. The total

waterings at Mildura were 31,970 acres over an actual area of 7,189 acres, giving an average of 4.4 waterings per annum.

(v.) *The Trawool Scheme.* A project has been mentioned of constructing a weir across the Upper Goulburn river at the Trawool Gorge, in the neighbourhood of Seymour. If this scheme should ever be carried out, the weir would have to be about 1700 feet long, and at the deepest part of the river 140 feet high. It is expected that the weir would impound water for about twenty miles upstream, and that it would provide a reservoir of a capacity of 60,000 million cubic feet. About 28,000 acres of gullies and river flats would be permanently submerged. The estimated cost is about £1,500,000. This would make it by far the largest reservoir in existence, the Assouan dam only holding 35,840 million cubic feet, while the capacity of the Waranga basin amounts to 8811 million cubic feet. The Barren Jack reservoir, now in course of construction, in New South Wales, will, with water of a maximum depth of 224 feet, hold 33,613 million cubic feet, but as it is now being built, providing for a depth of 120 feet only, is limited to 7000 million cubic feet.

3. **South Australia.**—(i.) *The Renmark Irrigation Trust.* The Renmark Irrigation Trust was established on similar lines to Mildura, but on a considerably smaller scale. At present the land assessed for the purposes of the trust measures about 3600 acres, and maintains a population of about 1000. The export of Renmark products averages about £35,000 per annum. It is claimed that without irrigation the land would barely feed 500 sheep.

(ii.) *Other Waterworks.* The Bundaleer reservoir consists in a large earth and clay embankment which impounds water in a natural basin away from the main water-courses. Its capacity is stated as 1,319,000 gallons.

The Barossa waterworks have a reservoir wall of concrete seventy-five feet in height. The reservoir has a holding capacity of 993,340,000 gallons.

The largest of the South Australian undertakings is the Beetaloo waterworks, which command the towns of Port Pirie, Moonta, Wallaroo, Kadina, and fifteen others, besides one million acres of country lands. The cast-iron reticulation pipes in connection with Beetaloo are 637 miles in length, and the capital cost of the works was £989,950.

None of the South Australian works, Renmark excepted, are, however, irrigation works properly so called, although they are to some extent used for irrigation purposes.

4. **New South Wales.**—(i.) *Irrigation Trusts.* The first attempts at irrigation, apart from artesian wells, were made by the establishment of the three Irrigation Trusts of Wentworth in 1890, Hay in 1892, and Balranald in 1893. The Wentworth Trust controlled an area of 10,600 acres, but has been dissolved and its powers assumed by Government. The original area under the Hay Trust was 12,847 acres, but in 1896 this was reduced to 3000 acres. The trust was at the same time remodelled through having three Government officials appointed as members. The Balranald Trust controls 1000 acres; it has petitioned Government for dissolution and for the administration of its works to be handed over to the Western Land Board.

(ii.) *Private Irrigation Works.* The most extensive private irrigation works in the State are those at North Yanko, which take their water from Cudgell Creek, a tributary of the Murrumbidgee.

(iii.) *The Barren Jack Scheme.* The weir which will impound the waters at Barren Jack is situated about three miles below the confluence of the Murrumbidgee and Goodradigbee Rivers. The catchment area will be fully 5000 square miles, and it is estimated that if the dam is constructed to a sufficient height to allow of a maximum depth of 120 feet of water the capacity of the basin will be about 7000 million cubic feet. If, however, a larger supply be required it will be possible to raise the weir, so as to allow of a depth of 224 feet of water. The length along the crest of the weir in its ultimate shape will be 784 feet, the thickness at the crest 18 feet, and the maximum thickness at

the base 169¾ feet, with a maximum height from the foundation of 240 feet. This would give a depth of water at the face of the dam of 224 feet, equivalent to a holding capacity of the reservoir of 33,613 million gallons, or only 10.8 per cent. less than that of the Assouan dam. The dam itself will contain about 581,000 tons of materials. The distributing channels in connection with this work, as it is at present being carried out, will command an area of about 358,000 acres, of which 196,000 acres is first-class land, but eventually 1,500,000 acres could be irrigated. The dam has been in course of construction for less than two years, but the progress made has been so satisfactory that it is expected that the land will be ready for settlement in 1910. It should be possible, when the complete scheme has been carried out, to settle from 50,000 to 100,000 people on the land to be made available. As the scheme is purely a gravitation scheme, the working expenses are expected to be small, and the water should therefore cost the settlers much less than in places where expensive pumping operations have to be resorted to.

(iv.) *Other Schemes.* Of other projects, the execution of which is probably only a matter of time, may be mentioned :—

(*a*) The Wyangala scheme, which would tap the Lachlan below its junction with the Abercrombie River ;

(*b*) The Terramungamine scheme, which would draw its water from the Macquarie River, in the neighbourhood of Narromine ; and

(*c*) The Bungowannah scheme, which would be connected with the Murray not far from Albury.

5. **Conflicting Interests.**—The relative rights of the States of New South Wales, Victoria, and South Australia to the waters of the Murray River appeared to be indeterminate. Territorially the south bank of the Murray was the boundary between the two former States, *i.e.*, the region of the river itself, up to the point where it enters South Australia, was wholly within New South Wales.

At the Federal conventions which preceded the establishment of the Commonwealth the South Australian representatives expressed their fear lest too much irrigation on the Murray and Darling might impair the navigability of the latter river, and the result was the insertion of a provision in the Commonwealth Constitution which reads as follows:—

" *Section 100.*—The Commonwealth shall not, by any law or regulation of trade or commerce, abridge the right of a State or the residents therein to the reasonable use of the waters of rivers for conservation and irrigation."

Under this section negotiations have for several years been in progress between the three interested States, and an arrangement was some time ago come to under which, subject to Parliamentary sanction being given to the arrangement in the three States concerned, the navigability of the Darling will be maintained, while at the same time New South Wales and Victoria will be able to construct large irrigation works. This sanction has, however, not been obtained in any of the three States, and there does not appear to be any immediate prospect of a satisfactory settlement.