

1902.



INTERSTATE ROYAL COMMISSION

ON THE

RIVER MURRAY,

REPRESENTING THE

STATES OF NEW SOUTH WALES, VICTORIA, AND
SOUTH AUSTRALIA.

REPORT

OF THE

COMMISSIONERS.

Melbourne :

SANDS & McDOUGALL LIMITED, PRINTERS.

1902.

VICTORIA



(TO WIT).

EDWARD, by the Grace of God, of the United Kingdom of Great Britain and Ireland, and of the British Dominions beyond the Seas, King, Defender of the Faith, Emperor of India—

To our Trusty and Well-beloved—

JOSEPH DAVIS, Esquire, of the State of New South Wales;

STUART MURRAY, Esquire, of the State of Victoria;

FREDERICK NEWMAN BURCHELL, Esquire, of the State of South Australia.

Greeting :

KNOW you, That We, reposing great trust and confidence in your ability, zeal, industry, discretion, and integrity, do, by these presents, authorise and appoint you to make a diligent and full inquiry concerning the Conservation and Distribution of the waters of the river Murray and its Tributaries for the purposes of Irrigation, Navigation, and Water Supply, and to report as to the just allotment of the Waters of the Murray Basin to the use of each of the States of New South Wales, Victoria, and South Australia, and upon the best methods, joint or otherwise, for their conservation and distribution for the purposes aforesaid, and as to the practicability and cost of the necessary works for such objects: We also authorise you to make the fullest investigation in regard to any other matter concerning the utilisation of the waters of the said River and its Tributaries which may be brought before you during the course of your inquiry: And We do give you power, at your discretion, to procure such assistance as you may deem necessary for enabling you duly to execute this Our Commission: And Our further will and pleasure is that you do, within four months after the date of this Our Commission, certify to Us, in the Office of Our Chief Secretary, under your hand and seal, what you shall find touching the premises: And We hereby command all Government Officers, and other persons whomsoever within Our said State, that they be assistant to you in the execution of these presents: And We appoint you, the said JOSEPH DAVIS, President of this Our Commission: And We do hereby declare this Our Commission to be a Commission for all purposes of the Act 54 Victoria, No. 1,088, intituled *Evidence Act 1890*.

In testimony whereof, We have caused these Our Letters to be made Patent, and the Seal of Our said State of Victoria to be hereunto affixed.

Witness Our Trusty and Well-beloved Sir GEORGE SYDENHAM CLARKE, Knight Commander of the Most Distinguished Order of St. Michael and Saint George, Fellow of the Royal Society, Governor of the State of Victoria and its Dependencies, in the Commonwealth of Australia, &c., &c., &c., at Melbourne, this thirteenth day of May, one thousand nine hundred and two, and in the second year of Our Reign.

(L.S.) GEORGE SYDENHAM CLARKE.

By His Excellency's Command,

W. A. TRENWITH.

Entered on Record by me, in the REGISTER OF PATENTS, Book 24, page 258, this thirteenth day of May, one thousand nine hundred and two.

G. C. MORRISON

1902.

VICTORIA.



ROYAL COMMISSION—CONSERVATION AND DISTRIBUTION
OF THE WATERS OF THE MURRAY RIVER BASIN.

REPORT OF THE COMMISSIONERS.

To His Excellency Sir George Sydenham Clarke, Knight Commander of the Most Distinguished Order of Saint Michael and Saint George, Fellow of the Royal Society, Governor of the State of Victoria and its Dependencies, in the Commonwealth of Australia, etc., etc., etc.

MAY IT PLEASE YOUR EXCELLENCY :

We, your Commissioners, appointed on the thirteenth day of May, 1902, "to make a diligent and full enquiry concerning the Conservation and Distribution of the Waters of the River Murray and its Tributaries for the purposes of Irrigation, Navigation, and Water Supply, and to report as to the just allotment of the waters of the Murray basin to the use of each of the States of New South Wales, Victoria, and South Australia, and upon the best methods, joint or otherwise, for their conservation and distribution for the purposes aforesaid, and as to the practicability and cost of the necessary works for such objects," and other matters, have the honour to submit this our report :

Sixty-three meetings for taking evidence have been held at various places in the three States concerned in this enquiry, and two hundred and ninety-four witnesses have been examined ; eighty meetings have also been held in Committee.

CAP. 1.—HISTORY OF THE RIVER QUESTION AND ENQUIRIES
BY FORMER COMMISSIONS.

THE River Murray, judged by its length of channel and area of catchment, should be one of the great streams of the world ; and, although its volume of water is small, relatively to its immense gathering ground, it is yet the greatest waterway in Australia, and its utilisation is of the first importance to the inhabitants of the States through which it flows. It is, therefore, matter for surprise that the problems which it is the function of this Commission to investigate still remain unsettled.

Importance of
the Murray
River to
Australia.

The history of the rivers question for the past eighteen years is briefly as follows :—

New South
Wales
Commission,
1884.

In 1884 a Royal Commission was appointed in New South Wales, under the Presidency of the Honourable W. J. (now Sir W. J.) Lyne, M.P., "to make a diligent and full enquiry into the best method of conserving the rainfall, and of searching for and developing the underground reservoirs supposed to exist in the interior of this colony, and also into the practicability, by a general system of water conservation and distribution, of averting the disastrous consequences of the periodical droughts to which the colony is from time to time subject."

Victorian
Commission,
1885.

This Commission presented three reports, a prominent feature of which was the utilisation of the waters of the River Murray. Two conferences were also held, in 1886, with a Royal Commission on Water Supply appointed by the Governor of Victoria. The result was the adoption of the following resolutions:—

Conference
between the
N. S. Wales
& Victorian
Commissions
and resolu-
tions agreed
on.

1. That a joint Trust shall be constituted, equally representative of the colonies of New South Wales and Victoria, in which shall be vested the control of the whole of the Murray River and its tributaries, from its source to Howlong, to be known as the Upper Murray; and of the whole of the Murray River, from Howlong to the Eastern boundary of the Colony of South Australia, to be known as the Lower Murray; and such Trust shall have power to regulate all diversions of water from the river and tributaries within its jurisdiction.

2. That the waters of the tributaries of the Lower Murray, except such proportions thereof as shall, under the direction of the Trust, be required as compensation water for the main "river," may be diverted and used by the respective colonies through which they flow.

3. That the whole of the waters of the "Upper Murray" and its tributaries, and the whole of the waters of the "Lower Murray," shall be deemed to be the common property of New South Wales and Victoria. And, subject to the reservation of such compensation water as the Trust may from time to time determine, each of the said colonies shall have the right to take and divert one-half of such water at such point or points as may, at the sanction of the Trust, be fixed on as most suitable for the requirements of such colony. Provided always that the totals of the quantities so diverted by the two colonies, when the whole surplus (after providing compensation water as above) is utilised, shall be equal.

4. That all natural diversions of water from the Murray shall be gauged under the direction of the Trust, and the portion of such diversions not returned to the channel of the main river shall be debited to the colony into which such water is diverted, in the same manner as if such diversion had been made under the last preceding section.

5. That the Trust may fix and determine levels, to be known as the high flood levels of the Murray, and may make such regulations for the disposal of water flowing above such levels as to it shall seem expedient.

6. That works for the storage and regulation of the waters of the Murray may, under the supervision of the Trust, be constructed at the joint cost of the colonies of New South Wales and Victoria, such cost to be borne by each colony in proportion to the benefits derived by it from such works.

7. That so far as possible the two colonies shall take united action in respect of all works intended to provide for the utilisation of the Murray Waters.

8. That the Trust shall consist of not more than six members, three of whom may be appointed by the Government of New South Wales and three by the Government of Victoria, such members to hold office for terms of not more than five years. The expenses of the Trust and its officers to be defrayed by the two colonies in equal proportions.

9. That a bill embodying the above resolutions shall be prepared under the supervision of the Water Supply Commissions for submission to the Parliaments of New South Wales and Victoria. The Government of each colony, having approved of the measure, shall be requested to secure for it the earliest possible consideration by its Legislature.

10. That the Governments of the respective colonies of New South Wales and Victoria shall be requested to hold themselves bound *ad interim* by the provisions of the above resolutions until they shall be dealt with by the Legislatures of both colonies.

These resolutions were accordingly submitted to the Governments of the two colonies, but no Bill was prepared by either for the constitution of the proposed Trust.

South Australia, being greatly interested in the navigation of the river, also appointed a Commission, and asked to be joined in conference with the Commissions of New South Wales and Victoria. Circumstances, which it would serve no good purpose to recapitulate here, prevented any conference taking place. Since that time the establishment of the Renmark Irrigation Trust, and of a number of smaller Irrigation Settlements, has given South Australia an added interest in the maintenance of the volume of water in the river. Considerable areas of land bordering the river in that State are regarded as suitable for irrigation; and, apart from the Settlements referred to, private irrigation is already carried on, on a moderate scale, with varying success.

South
Australian
Commission.

South Austral-
ia's interest
in the river
question.

One tangible result of the New South Wales Royal Commission of 1884 was the organisation of a Water Conservation Service, under the charge of Mr. H. G. McKinney, who had acted as engineer to the Commission. Mr. McKinney proposed the construction of a series of canals for irrigation, principally from the Murray and Murrumbidgee. In 1896 the New South Wales Government invited Col. Home, an Indian officer of large experience in irrigation works, to visit the colony, and report upon these various schemes, and generally upon the prospects of water conservation and irrigation. Col. Home, reporting in 1897, selected two projects as those most likely to prove successful. These were:—A canal leaving the left bank of the Murrumbidgee, below the off-take of the Yanko Creek; and:—A canal from the right bank of the Murray River, at Bungowannah, seven miles below Albury. He recommended an alteration of site of the off-take of the Murrumbidgee Canal; and in both projects the provision of storage to ensure the maintenance of a permanent supply.

Organisation
of water
supply
service in
N. S. Wales.

In Victoria, a Water Supply Department had been in existence for many years. Under its direction, various works had been carried out for the supply of country towns; but the report of the Victorian Royal Commission of 1886 created a new interest in irrigation, and led to greatly increased activity. The Department was re-organised; Mr. Stuart Murray, who had been associated with the Commission as Professional Assistant, was appointed Chief Engineer; and, under the Ministerial guidance of Mr. Alfred Deakin, who had been its President, attention was devoted to providing facilities for irrigation. A large number of the schemes then initiated have since been carried into effect.

Re-organisa-
tion of the
Victorian
Water
Supply
Department.

The birth of the Commonwealth has brought into existence a new authority vested with powers which, within certain limits, are supreme. The introduction of this new, and, to some extent, controlling factor, made it more than ever necessary that the States interested in the disposal of the waters of the Murray Basin should come to some conclusion as to their respective rights and interests in the river and in works for the utilisation of its waters. Several successive years of drought, too, had made the residents in the Riverina district of New South Wales keenly anxious for the realisation of some of the projects for the irrigation of their lands, already so long under discussion. This anxiety found public expression in March of this year, when an organisation, called the Murray River Main Canal League, invited the Federal Premier, the Premiers of New South Wales, Victoria, and South Australia, and other representative men, to a conference at Corowa. At the conference, several resolutions were passed, the principal of which are the following:—

Authority of
the Common-
wealth.

The Corowa
Conference
of March,
1902.

1. That the Governments of the Commonwealth and the States concerned be urged to co-operate in preparing and carrying out a comprehensive scheme for the utilisation of the waters of the River Murray, which, while improving the

navigability of that river, will also provide for the imperative needs of the residents on both banks in the conservation and distribution of its waters.

2. That, owing to the urgent necessity for a scheme of water conservation for the Riverina, Northern Victoria, and South Australia, and as an instalment of a comprehensive scheme, the States of New South Wales, Victoria, and South Australia be asked to empower the Federal Government to provide storage reservoirs on the Upper Murray and a weir at Bungowannah, as proposed by Mr. McKinney and endorsed by Col. Home and Mr. McGregor; such head works to be National.

3. That, contingent upon the above resolution being adopted by the Governments concerned, this Conference recommends the public bodies interested to approach their respective Governments, and request that the distributing works, for utilising the Upper Murray storages and Bungowannah weir, be commenced at such time as will enable them to be completed concurrently with the head works named.

4. That, in the opinion of this Conference, the circumstances of Australia demand that all natural waters not already appropriated under legal sanction shall be declared public water, and made subject to a suitable system of law applicable to the whole of the Continent, and that the Commonwealth and State Governments be respectfully asked to consider such legislation as will provide for its regulation and disposal, in such manner as shall secure its fullest possible use in the interests of the whole of the people.

Appointment
of this
Commission.

These resolutions were considered by the Premiers present; and, before the delegates to the Conference separated, it was announced that a Royal Commission would be appointed by the three States concerned to investigate and report. This Commission is the result. The utilisation of the waters of the Murray Basin, and their appropriation to the service of the several States, being the chief subject for investigation, it will be convenient here to give a brief outline of the geography and physical conditions of the Basin.

CAP. 2.—GEOGRAPHY AND PHYSICAL CHARACTERISTICS OF THE MURRAY RIVER BASIN—ITS EXTENT AND IMPORTANCE.

Necessity for
a clear idea
of the
geography of
the basin.

Description of
the river
basin and its
boundaries.

BEFORE devising schemes for the utilisation of the waters of a river, it is necessary to know their volume, the sources whence they are derived, and the losses to which they are subject in their progress to the sea. It is also very advisable to have a clear idea of the geography, and of the varying physical conditions, of the country forming the river basin, both from the point of view of its water-yielding capacity, as a source of supply, and from that of its agricultural value as a field for the utilisation of that supply in irrigation, or for other industrial purposes. The Murray is the great natural main drainage line of the South-eastern part of Australia, the basin of the river and its tributaries comprising 414,253 square miles—an area equal to double that of France—out of a total of 2,950,000 square miles in the whole Australian Continent. That is to say, this river basin includes within its limits nearly one-seventh of the entire mainland subject to the jurisdiction of the Commonwealth, being five-sixths of New South Wales, considerably more than half of Victoria, over one hundred thousand square miles of Queensland, and twenty-four thousand square miles of South Australia. Its boundaries are:—On the East, the coast Range, roughly parallel to, and at a distance of 30 to 130 miles from, the Eastern coast line of Queensland and New South Wales; on the South the Great Dividing Range following a Westerly direction, from sixty to a hundred miles distant from the coast, through the State of Victoria, and by an almost direct line, through South Australia,

to the River mouth; on the West the Mount Lofty and the Barrier Ranges, and badly defined low hills, through South Australia, New South Wales, and Queensland; and on the North, through the latter State, the Warrego and Carnarvon Ranges. The greatest height reached at any point on the boundary is in the South-east, where Kosciusko, the highest land in Australia, attains an altitude of 7,256 feet. It may be further worthy of note that, if to this vast catchment there be added the strip of coast land lying between it and the sea, from the Condamine River in the North-east to Lake Alexandrina in the South-west, the total would become one-fifth of the Australian Continent, containing at least three-fourths of its entire present population and much more than half of its agricultural and pastoral possibilities for the sustenance of human life. Of the whole 414,253 square miles within the Basin only 158,499 square miles make any effective contribution to the volume of the river. The remaining 255,754 square miles consist chiefly of delta lands, or other flat alluvial areas, that quickly absorb the rainfall on their surface; or that afford a scanty run off only during exceptional floods, when their contribution can serve no apparent useful purpose. The following tabular statement gives the details of the drainage areas, showing their extent within the several States, and the names of the tributaries through which their waters are discharged:—

Relation of
basin to the
whole of
Australia.

STATE OF QUEENSLAND.

WATERSHED OF THE	EFFECTIVE CATCHMENT IN SQUARE MILES.
MacIntyre and Dumaresq	3,062
Weir	2,693
Moonie	2,348
Condamine	16,274
Maranoa	7,126
Warrego	17,167
Paroo	13,567
Mungalalla, &c.	5,453
	<hr/>
Delta lands, &c.	67,690
	36,835
	<hr/>
	104,525

Details of
areas of
catchment.

STATE OF NEW SOUTH WALES.

WATERSHED OF THE	EFFECTIVE CATCHMENT IN SQUARE MILES.
MacIntyre and Dumaresq	5,188
Gwydir	4,796
Namoi	9,462
Castlereagh	3,069
Macquarie	10,359
Bogan	4,930
Lachlan	20,159
Murrumbidgee	13,384
Billabong	1,779
Murray	2,373
	<hr/>
Delta lands, &c., East of the Darling	75,499
" " West of the "	109,023
	49,840
	<hr/>
	234,362

STATE OF VICTORIA.

WATERSHED OF THE	EFFECTIVE CATCHMENT IN SQUARE MILES.
Upper Murray	1,500
Mitta	2,400
Kiewa	700
Ovens	2,700
Goulburn	5,240
Campaspe	970
Loddon	1,800
	<hr/>
	15,310
Delta lands, &c.	35,669
	<hr/>
	50,979
	<hr/>

STATE OF SOUTH AUSTRALIA.

	SQUARE MILES.
Non-contributing area	24,387

TOTAL CONTRIBUTING AREAS IN THE SEVERAL STATES.

	SQUARE MILES.
Queensland	67,690
New South Wales	75,499
Victoria	15,310
	<hr/>
Total	158,499
	<hr/>

TOTAL NON-CONTRIBUTING AREAS.

	SQUARE MILES.
Queensland	36,835
New South Wales	158,863
Victoria	35,669
South Australia	24,387
	<hr/>
Total	255,754
	<hr/>
Grand Total	414,253
	<hr/>

Low discharge
from the
catchment;
reasons
thereof.

High dis-
charge from
the mountain
areas.

When the rainfall over the whole area, low as it is, averaging only about 13 inches per annum, is compared with the flow of the river, a great disparity is seen to exist. Evidently the two chief reasons are:—The level character of most of the country; and the distribution of the rainfall, which, while of small amount, is so distributed in point of time that little water flows off from the surface. To these causes is to be attributed the fact that more than 255,000 square miles within the Murray Basin are to be regarded as non-contributing; while of the 159,000 square miles set down as contributing, a considerable portion is so in a small degree only. Part of the catchment, however, has a heavy rainfall; while some of the more rugged and mountainous portions, for example, the Jagungal, Bogong, and Dargal Ranges are covered with snow for several months in each year.

On the Victorian side the contributing area above Albury is double that in New South Wales, but the volumes discharged are more nearly equal, the New South Wales tributaries being more largely fed by the heavy deposits of snow that melt in spring and early summer. The drainage area of the Upper Murray, with a mean

rainfall of more than 40 inches, constitutes the most reliable and effective part of the whole catchment. There is no other part of Australia, with the exception of portions of the catchments of the Murrumbidgee and Goulburn, where snow falls in sufficient quantities to have any marked influence upon the flow of the streams.

Above Albury the hills enclosing the river valley are generally about half-a-mile apart. Below that point they recede, and seven miles below Albury, the last spur of primary rock is seen at Bungowannah. Thence, throughout the whole of its course to the sea, the river flows through what may be termed level country, the fall being 9 inches per mile from Albury to Tocumwal, $7\frac{1}{4}$ inches from Tocumwal to Echuca, $4\frac{1}{2}$ inches thence to Euston, $3\frac{3}{4}$ inches to Wentworth, where it is joined by the Darling, and from Wentworth to Lake Alexandrina under 3 inches per mile. Fall of the river.

In regularity of flow and volume of discharge, the Murrumbidgee ranks next in importance to the Murray. Like it, its head waters are in high mountainous country, its sources being near Kiandra, whence it receives seasonable accessions of volume from the melting snows. The Lachlan, a tributary of the Murrumbidgee, rises on the Cullarin Range, a short distance from the town of Gunning, on the main railway line between Melbourne and Sydney. After a course of about eighty miles, it is joined by the Abercrombie, which comes from the Blue Mountains. It then flows North-westerly, through hill country, to Forbes. Below Forbes the country is flat, the run off contributing nothing to the volume of the river, except in times of extreme rainfall. Lower down the river becomes deltaic, till, finally, below the town of Oxley, it has no clearly defined channel, and loses itself in reed beds. It is only in times of high flood that the waters of the Lachlan actually reach the Murrumbidgee. The Murrumbidgee.
The Lachlan.

Of the Darling, the portion within the boundaries of New South Wales—that is, from Mungundi to its junction with the Murray at Wentworth—has a length of about 1,350 miles. It is the longest affluent of the Murray, and has its source in the Great Dividing Range in Queensland, where it is known as the MacIntyre. About 120 miles from its source the MacIntyre is joined by the Dumaresq, which forms portion of the northern boundary of New South Wales, and a little lower down, by a New South Wales stream which also bears the name MacIntyre. From the latter junction the river is known as the Barwon, and flows south-westerly to Walgett and thence westerly to Bourke, receiving by the way a number of tributaries from each side. From Bourke downwards it is known as the Darling; its course being south-westerly to Menindie, thence south to its junction with the Murray at Wentworth. The general fall of the Darling is about three inches per mile; the velocity, even in flood time, being only about three miles per hour. The Darling.

The most important of the Victorian tributaries of the Murray is the Goulburn, to which the description of the Upper Murray is in many respects applicable. It rises in the Dividing Range, near Wood's Point, where the summits reach an elevation of about 5,000 feet, about 1,500 square miles of the catchment being in mountainous country of considerable elevation. About 5,240 square miles of the total drainage area are effective, the balance being non-contributing. Many of the sub-tributaries of the Goulburn are, in themselves, so large as to deserve to be ranked as important rivers. The Goulburn.

The other important tributaries of the Murray, on the Victorian side, are:—The Mitta, Kiewa, Ovens, Campaspe, and Loddon. The Avoca rarely, and the Wimmera never, though both within the Murray Basin, make any contribution to the main stream. Other Victorian tributaries.

In the beds of the rivers of the Murray Basin, many of which are wide, and often carry a small depth of water, the losses from evaporation are high. A further loss, the amount of which cannot be even approximately estimated, is due to their being dry during lengthened periods of drought, and to large quantities of water being absorbed on the occurrence of rain before a flow is again set up. Recorded observations appear to indicate that the maximum loss from evaporation may be taken as about 60 inches per annum. Large as this appears, it is not, after all, a Losses by evaporation.

very considerable item when compared with the average annual flow of the rivers in fairly good years. Its effect is, however, felt severely in dry years, the rate of evaporation no doubt increasing as the depth of water decreases.

Volumes of
the River and
tributaries.

The following tabular statement shows the total natural discharges for a typical high year, for a typical low year, and for a mean year, of the River and its contributing streams, as well as the losses from overflow, soakage, evaporation, and other causes between the points of affluence. It gives, in fact, the natural volumes at leading points for each species of typical year, with the sources whence these volumes are derived :—

TOTAL NATURAL DISCHARGES OF THE RIVER MURRAY AND ITS
CONTRIBUTING STREAMS.

All figures represent millions of cubic feet.

FOR A TYPICAL HIGH YEAR (1894).

ALBURY	}	NEW SOUTH WALES—Upper Murray	...	...	...	...	119,000
		VICTORIA	}	Upper Murray	...	...	34,000
				Mitta	...	...	88,000
				Kiewa	...	...	29,000
								<u>151,000</u>
		Discharge at Albury	...	...	...	...	264,000
						Total	270,000	
						Losses, Overflow, etc.	<u>6,000</u>	
ECHUCA	}	NEW SOUTH WALES	}	Upper Murray	...	...	119,000
		Major's Creek (estimated)		...	...	5,000	
								<u>124,000</u>
		VICTORIA	}	As before	151,000
				Ovens	...	...	83,000
GOULBURN	...			...	178,000		
						<u>412,000</u>		
		Discharge at Echuca	...	...	...	...	403,000
						Total	536,000	
						Losses, Overflow, etc.	<u>133,000</u>	
		Losses, Overflow, etc., between Albury and Echuca	...	...	...	...	127,000
TOOLEYBUC	}	NEW SOUTH WALES—As before	...	...	...	...	124,000
		VICTORIA	}	As before	...	...	412,000
				Campaspe	...	...	15,000
				Loddon	...	...	19,000
								<u>446,000</u>
		Discharge at Tooleybuc	...	...	...	...	295,000
						Total	570,000	
						Losses, Overflow, etc.	<u>275,000</u>	
		Losses, Overflow, etc. between Echuca and Tooleybuc	...	...	...	...	142,000
MILDURA	}	NEW SOUTH WALES	}	As before	...	...	124,000
		Murrumbidgee, Wakool, etc., estimated		...	...	528,000	
								<u>652,000</u>
		VICTORIA	}	As before	446,000
		Discharge at Mildura	...	...	...	...	763,000
						Total	1,098,000	
						Losses, Overflow, etc.	<u>335,000</u>	
		Losses, Overflow, etc., between Tooleybuc and Mildura	...	...	...	...	60,000

MORGAN	NEW SOUTH WALES	{ As before	...	...	...	652,000	
		{ Darling...	...	...	...	358,000	
							1,010,000
	VICTORIA	...	...	...	...	...	446,000
					Total	...	1,456,000
					Discharge at Morgan	...	971,000
					Losses, Overflow, etc.	...	485,000
					Losses, Overflow, etc., between Mildura and Morgan		150,000

FOR A TYPICAL LOW YEAR (1896).

ALBURY	NEW SOUTH WALES	{ Upper Murray	...	...	...	40,000	
		{ Victoria	...	...	...	12,000	
			{ Mitta	32,000	
			{ Kiewa	13,000	
								57,000
					Total	...	97,000	
					Discharge at Albury	...	91,000	
					Losses, Overflow, etc.	...	6,000	

ECHUCA	NEW SOUTH WALES	{ Upper Murray	...	...	...	40,000	
		{ Major's Creek (estimated)	...	...	...	1,000	
							41,000
	VICTORIA	...	...	...	...	57,000	
							29,000
						59,000	
							145,000
					Total	...	186,000
					Discharge at Echuca	...	157,000
					Losses, Overflow, etc.	...	29,000
					Losses, Overflow, etc., between Albury & Echuca	...	23,000

TOOLEYBUC	NEW SOUTH WALES	{ As before	...	...	...	41,000	
		{ Victoria	...	...	...	145,000	
			{ Campaspe	4,000	
			{ Loddon	4,000	
								153,000
					Total	...	194,000	
					Discharge at Tooleybuc	...	140,000	
					Losses, Overflow, etc.	...	54,000	
					Losses, Overflow, etc., between Echuca and Tooleybuc	...	25,000	

MILDURA	NEW SOUTH WALES	{ As before	...	...	...	41,000	
		{ Murrumbidgee, Wakool, etc. (estimated)	...	...	...	108,000	
							149,000
	VICTORIA	...	...	...	...	...	153,000
					Total	...	302,000
					Discharge at Mildura	...	218,000
					Losses, Overflow, etc.	...	84,000
					Losses, Overflow, etc., between Tooleybuc and Mildura	...	30,000

MORGAN	NEW SOUTH WALES	{ As before	...	...	...	149,000	
		{ Darling	...	...	...	144,000	
							293,000
	VICTORIA, as before	...	...	...	...	...	153,000
					Total	...	446,000
					Discharge at Morgan	...	318,000
					Losses, Overflow, etc.	...	128,000
					Losses, Overflow, etc. between Mildura and Morgan	...	44,000

FOR A MEAN YEAR (1900).

									70,000		
ALBURY	..	}	NEW SOUTH WALES—	Upper Murray	...	...	...	20,000	
			VICTORIA	Upper Murray	...	...	...	51,000	
				Mitta	...	...	...	21,000	
				Kiewa	...	...	...	
										<u>92,000</u>	
			Total	...	...	...	...	162,000	
			Discharge at Albury	...	...	...	...	144,000	
			Losses, Overflow, etc.	...	...	...	...	<u>18,000</u>	
ECHUCA	...	}	NEW SOUTH WALES	Upper Murray	...	...	...	70,000	
				Major's Creek (estimated)	...	...	...	3,000	
			VICTORIA	As before	...	...	...	92,000	
				Ovens	...	...	...	48,000	
				Goulburn	...	...	...	100,000	
			Total	...	...	...	...	240,000	
			Discharge at Echuca	...	...	...	...	313,000	
			Losses, Overflow, etc.	...	...	...	...	254,000	
			Losses, Overflow, etc., between Albury and Echuca	...	...	...	...	<u>59,000</u>	
			Losses, Overflow, etc., between Albury and Echuca	...	...	...	...	41,000	
TOOLEYBUC	...	}	NEW SOUTH WALES—	As before	...	...	...	...	73,000
			VICTORIA	As before	...	...	...	240,000	
				Campaspe	...	...	...	7,000	
				Loddon	...	...	...	8,000	
						Total	255,000
			Discharge at Tooleybuc	...	...	...	...	328,000	
			Losses, Overflow, etc.	...	...	...	...	208,000	
			Losses, Overflow, etc., between Echuca and Tooleybuc	...	...	...	...	<u>120,000</u>	
			Losses, Overflow, etc., between Echuca and Tooleybuc	...	...	...	...	61,000	
MILDURA	...	}	NEW SOUTH WALES	As before	...	...	...	73,000	
				Murrumbidgee, Wakool, etc. (estimated)	...	...	...	203,000	
			VICTORIA	As before	...	...	...	...	...
						Total	276,000
						Discharge at Mildura	255,000
			Losses, Overflow, etc.	...	...	...	...	531,000	
			Losses, Overflow, etc., between Tooleybuc and Mildura	...	...	...	...	<u>371,000</u>	
			Losses, Overflow, etc., between Tooleybuc and Mildura	...	...	...	...	160,000	
			Losses, Overflow, etc., between Tooleybuc and Mildura	...	...	...	...	<u>40,000</u>	
MORGAN	...	}	NEW SOUTH WALES	As before	...	...	...	276,000	
				Darling	...	...	...	148,000	
			VICTORIA	As before	...	...	...	...	...
						Total	424,000
						Discharge at Morgan	255,000
			Losses, Overflow, etc.	...	...	...	...	679,000	
			Losses, Overflow, etc., between Mildura and Morgan	...	...	...	...	<u>455,000</u>	
			Losses, Overflow, etc., between Mildura and Morgan	...	...	...	...	224,000	
			Losses, Overflow, etc., between Mildura and Morgan	...	...	...	...	<u>64,000</u>	

From the above figures it will be seen that the overflows between Albury and Tooleybuc are considerable, reaching to 200,000 millions of cubic feet in a high, and 40,000 millions in a mean year. A considerable proportion of the spill over is, however, returned by way of the Wakool.

CAP. 3.—GAUGINGS OF THE RIVER AND TRIBUTARIES, AND
NECESSITY FOR CONTINUOUS RECORDS OF GAUGINGS.

THE following extract is from a recent publication by the Victorian Water Supply Department. It shows very clearly the need that exists for accurate observation and complete records of the discharge of rivers, especially in a country like Australia, where the available supply of water is small compared with the demand. It indicates briefly also the method of gauging now generally recognised as applicable to Australian rivers.

“A knowledge of the quantity of water that may be relied on, to be obtained from any proposed source of supply, is an essential preliminary to the discussion of any scheme of works for its diversion and utilisation. . . . The quantity of water needed for irrigation is very great, compared with that demanded for most other industrial purposes. Indeed, it may be said that the fundamental question here is, not—how much water is required for the treatment of a given area of land? but how much water is available? and to how much of the land commanded can it be profitably applied? The area of irrigable land will always be in excess of the capabilities of the volume of available water. Hence it is most important to ascertain with precision what that volume really is, so that works of diversion and distribution may not be constructed in excess of the water that can be supplied by their means. . . . To know what quantity of water a river or stream will discharge, it is only necessary to know what it has discharged. By this it is not meant to be asserted that the average discharge of a river is the same for every year, that the maximum and minimum for one year are the same as the maximum and minimum for every other year, or that the mean discharge for any season may be relied on as the volume always discharged at that season. But it is tolerably certain that the discharge from day to day and from month to month, recorded over a long period of time, will fairly represent the daily and monthly discharges over any similar period of time. The difficulty is to say what, in the case of any particular river, is the duration of the period or cycle.

General
necessity for
proper gaug-
ings and
records
thereof.

“Of the rainfall precipitated on the drainage area, or basin, of a river, a portion is re-absorbed by evaporation into the atmosphere; a portion descends through the permeable upper strata, to reappear in the form of springs, perhaps in the basin of some other river; or finds its way to the sea through beds of deep-seated drift, or fissures and channels in the rock; the balance is discharged through the river channel. The proportion of the total rainfall on any drainage area that passes down its natural drainage line is extremely variable. It is greatest from those areas whose inclinations are steep, and in which the surface rocks are of compact and hard texture, and but thinly covered with soil. And it is greatest in those seasons when the rains are heavy and the temperature low; and least when the temperature is mild, and the rain discharge distributed over comparatively long periods of time. Of the rain water that does find its way to the river channels, a portion only is carried by them to the sea; much of it . . . passes through drifts, and possibly rock fissures, in the river beds, to travel to its ultimate destination by underground channels. In the rivers of the Murray system a considerable proportion is dissipated by flowing off into ana-branches, effluent creeks, lakes, and lagoons, and being there evaporated. To determine fully the hydrographic conditions of a river it is necessary, therefore, that gaugings be made at more than one point of its course; and it is very desirable—where gaugings are made with a view to specific diversion and utilisation—that they be as near to the intended point of off-take as possible.

“The volume of water passing any point on the course of a stream, at a particular date, is obviously equal to its sectional area multiplied by its mean velocity. The cross sectional area in feet, multiplied by the mean velocity throughout the section, in feet per minute, is equal to the discharge in cubic feet per minute. Thus, if the breadth be 20 feet, the average depth 3 feet, and the

Methods of
gauging.

mean velocity 70 feet per minute, the discharge will be 4,200 cubic feet per minute. To ascertain the sectional area is usually a comparatively simple matter; to obtain the mean velocity, with any degree of certainty, is very much more difficult. The determination of the mean velocity of water flowing in open channels has been the subject of much careful investigation, and has been treated by numerous writers of repute in the field of hydraulic science. . . . It is needless to say, however, that their formulæ are purely empirical—dependent on experiment alone. . . . None of them are based on a sufficiently wide range of observations, or on experiments of a sufficiently conclusive character, to entirely satisfy the mind of their applicability to all classes of conditions. Even if we had a formula, conclusive and reliable as applied to channels of definite and uniform cross section and grade, it by no means follows that it would be applicable to the channels of rivers. Rivers are not canals; and in general it may be said . . . that it would be impossible to include the whole of the conditions of a sufficient length . . . in a clear and intelligible statement, far less to embody them as terms in a solvable equation. It becomes necessary, therefore, to determine the velocities by actual measurement; no other course seems possible in the circumstances. Even this is more difficult than might be expected. A great deal has been written on the subject of the ratio subsisting between the maximum velocity of current in any cross section of a channel, and the mean velocity throughout that section. But the results of experiments, made with a view to its determination, are even less conclusive and reliable than those bearing on the subject of the relation of velocity to hydraulic radius and hydraulic grade. The older writers generally affirm the proposition that the maximum velocity is at the surface, and in the centre of the stream. More recent authorities place it in that position for shallow water, but beneath the surface for deep water. No definition of the very vague terms 'shallow' and 'deep' seems to have been attempted. . . . In these circumstances, it is necessary that the velocity measurements . . . be made throughout the section. Nothing less could furnish results on which reliance could be placed."

Recommendations of
N. S. Wales
Commission
of 1884.

The importance of the question of river-gauging was recognised by the New South Wales Royal Commission on the Conservation of Water (1884), as will be seen by the following, which was one of the Commission's recommendations:—

"The gauging of the rivers initiated by us should be continued in a systematic manner, so that the discharge of all rivers likely to be tapped for Water Supply purposes may be known for all readings of the gauges. This information is particularly necessary in the cases of the Murrumbidgee, the Darling, and the Murray."

Victorian
gaugings.

The most complete records of river-gaugings in Australia are those of the Water Supply Department of Victoria. They embrace the continuous gauging of thirty-one rivers and streams at 60 points, and the intermittent gauging of others, where partial information was required for certain special purposes. The Murray has been gauged at Mildura and Echuca since 1865, at Albury since 1877, and at Jingellic since 1890. Gaugings of the Mitta and Kiewa have been continuous since 1885, of the Ovens, King, and Broken Rivers since 1886, of the Goulburn and Loddon since 1881, the Campaspe since 1885, the Avoca since 1889, and the Wimmera since 1884. The Murray in South Australia has been gauged at Morgan since 1884, by the Government officers of that State, at depths varying from summer level up to 25 feet. Gaugings of the Murray, Murrumbidgee, and Darling have also been made by the New South Wales officers, but these records are not sufficiently complete for publication. Some of the evidence tendered by the officers of the latter State is, however, of a character to emphasise the need for reliable and complete records. Mr. McKinney, in his evidence, stated that during periods of low river the greater part of the discharge of the Murray at Jingellic comes from New South Wales, whilst at Albury, after it has received the waters of the Victorian tributaries Mitta and Kiewa, the proportions are nearly equal. Mr. Smail, who has investigated the discharges of the Upper Murray, supports this evidence, accounting for the fact by the circumstance that by far the greater area of snow land is within the State of New South Wales. Within the past few days, there has been a consultation and

N. S. Wales
evidence on
the subject.

examination of records by the officers charged with the work of river gauging, in New South Wales and Victoria respectively; with the object of reaching definite conclusions as to the relative volumes supplied to the Upper Murray from each of these States. This was called for by the considerable discrepancies between the evidence tendered by the two sets of officers. The result of the consultation is a common understanding and agreement as to the figures to be adopted. They are embodied in the tabular statement of discharges given in Cap 2—*ante*.

In some river channels the total volume that flows down in certain winters is many times greater than in other winters. The discharge of the Wimmera at Glenorchy, for example, is found to have been in one year nearly twelve times what it was in another year. The Goulburn also has discharged in one year nearly four times as much as in another year, while the Murrumbidgee in one year discharged seven times as much as it did in another, and the Darling ten times as much in one year as in another. All this points to the necessity for storing largely of the winter flow to provide for dry years, and also to the need of accurate and complete records. To this end, the officers entrusted with the measurements and observations should be expert surveyors and trained to the work.

Variable
volume of
rivers.

Necessity for
storage of
river waters.

The method of gauging generally adopted by the New South Wales engineers has been that known as the "rod and float system." In Victoria and South Australia the more elaborate plan of combining cross sections with velocities obtained by current meter has been resorted to.

Appliances
used in the
different
States.

The value of stream gauging increases with the length of time over which it is extended; and it is important that, here in Australia, there should be some uniformity of system both of observing and recording. This can only be attained by entrusting the work to one authority, or by proper concert among the States. A complete compilation of results of the gaugings of all the important streams that contribute to the flow of the Murray should be published periodically, and made readily available to the section of the public specially interested.

Need for
uniformity
of methods
and of
recording.

CAP. 4.—WATER SUPPLY FOR ORDINARY STOCK AND DOMESTIC USE, &c., IN RURAL DISTRICTS; AND FOR IRRIGATION —EXPERIENCE IN THE THREE STATES.

IN Victoria much has been done, both by the Government and by local bodies, either created for the express purpose or invested with special powers, in the way of carrying out works for the supply of rural districts, apart altogether from those on a scale necessary to provide the large volumes of water essential for irrigation. One of the most extensive of these schemes has, for its primary purpose, the promotion and support of the gold mining industry. Others provide water for drinking, and for domestic and sanitary use, for the rural population, as well as water for the cattle of the farmer and the grazier, during the dry season of the year and throughout years of drought. A very large proportion of the Northern districts of Victoria are served by such schemes. Others are in process of being carried out, or are under consideration by the Government with a view to being carried out. Several, both of those already in existence and of those in contemplation, among the latter the proposed service for the Mallee, involve the expenditure of very large sums of public money. From the essential point of view of service, though by no means uniformly successful, they have in general conferred immense benefits on the settlers. From the financial point of view they have been less so; chiefly, however, because Governments and Parliament have been forbearing and generous, rather than because those benefited have been unable to pay the rates demanded of them.

Rural water
supply in
Victoria.

Rural supply
in New South
Wales and
S. Australia.

In New South Wales, and to a less extent in South Australia, similar systems of works have been carried out in the Murray basin, with similar objects. In both of these States, however, the construction and administration of rural water supplies have been solely in the hands of the Government. The experience, from the point of view of service, has been similar to that of Victoria. Of the financial experience nothing can be said, because, for the most part, no direct financial return has been looked for, the schemes being carried into effect on the grounds of public advantage merely. But, even in New South Wales, there are no such extensive reticulations of channels, and no such provision of local storages, as are to be found in many parts of Victoria, though there is much agitation on the part of the settlers, and much pressure exerted on the State Government to have them carried out.

Irrigation in
Victoria.

As there is more irrigation carried on in Victoria than in any other of the Australian States, it is to her likewise that those who wish to study irrigation here will naturally turn. There they will find much to interest, and something to criticise. The part played by the engineer is of course highly important; but even with the most skilful location, grading, and construction of works, nothing is more certain than that every individual cultivator, who uses water, has to learn the art; either through intelligent study of the experience of others, and careful observations and experiments of his own; or by the more painful, and in some cases ruinous, teaching of failure arising from his want of skill. The records of irrigation works in many countries seem strangely alike in one particular. Nearly all cultivators, to whom the practice is new, fall into the mistake of thinking that, because water is a good thing for the land, they can never do wrong in applying it. But the cultivator needs to be educated in the use of water:—Because he cannot otherwise obtain the best results, and may find failure where a very high degree of success is attainable; and, because, in a country like this, where the extent of irrigable land is far in excess of the possible supply of water, it is necessary in the interests of the community that the highest possible duty should be obtained from that used. This can never be the case while there is ignorance as to the best times of using and of the volumes to be applied.

Waste of
water by
irrigators.

In order to the most economical and effective use of water, it is obviously necessary that the users should know how much they are using; otherwise they cannot make intelligent deductions from their own experiences. In this respect Victorian practice is singularly deficient. Speaking generally, the Trust officials, and the individual users of water, have the vaguest notions of the quantities used. In some Trusts there are no steps whatever taken to measure the water received either by the Trust as a whole or by the individual farmers. The consequence is great waste, and an unobservant habit of cultivation. The successful cultivation of land is a business demanding both brains and energy. Irrigation is an added art which the cultivator must master before he can reckon on success; the experience of Victoria is on the whole, however, encouraging.

Financial
results of the
Trust
System.

Certain main works, such as large dams and main supply channels, are constructed by the Water Supply Department, and are called "national works." Local government being much more highly developed than in New South Wales, the construction and management of minor works of distribution are placed in the hands of "trusts." Doubtless this system has many advantages, and is not likely to be changed. It has, however, certain disadvantages, and does not always lead to the greatest efficiency, nor perhaps to economy and consistency of policy. It has indeed the same advantages and the same defects that attend municipal government generally. Some are "irrigation trusts," and some, generally where the supply of water is insufficient for irrigation, are "waterworks trusts;" that is, they supply water only for domestic and stock use. The financial operations of the irrigation Trusts have not, so far, been attended by a very high degree of success. In no case have they fully met their engagements to the Government, so that in 1899 an Act was passed, under which large sums of principal and interest were written off. Out of a total indebtedness of about £1,300,000 about £1,000,000 was cancelled. The sums charged against the Trusts did not include the cost of the Goulburn and Laanecoorie weirs and Kow Swamp works, and it is the opinion of some experienced

officials that it is not at all likely the Trusts can ever carry more than the cost of the distributing channels, and that, if they pay interest and sinking fund upon these, no more can reasonably be expected of them.

Apart from Mildura, which will be separately referred to, the most important irrigation works in Victoria are in the wide and fertile Goulburn Valley. A considerable part of this district is irrigated from a system of channels connected with the weir near Murchison; the Rodney Trust, comprising 277,545 acres, being one of the most prosperous agricultural areas within the Murray Basin. Evidence shows that the supply of water has practically doubled the price of land in the district. Within the Trust territory there is one large estate, containing about 24,000 acres. The remainder is occupied in comparatively small holdings; and there are instances where, by intense culture, a good living is obtained from areas as small as 25 acres. Such areas are generally devoted to fruit growing; peaches, pears, apples, Zante currants, and other fruits, being successfully grown. Wine grapes thrive in some parts of the Valley, table grapes in others. Wheat, oats, and lucerne are also profitably grown, while the irrigation of paddocks for fattening, enables some of the landowners to keep up an almost continuous output of fat stock. One witness, himself one of the most experienced irrigators in the Goulburn Valley, a fattener of stock, and who for that purpose irrigates chiefly lucerne, but has also successfully grown mangolds, amber cane, &c., says that, "upon the whole, the yield is just about doubled by irrigating." "Last year," he says, "I paid £14 for rates and £22 water charges, or about 1s. 6d. per acre for irrigation." But, though Rodney is cited as, on the whole, the most successful irrigation Trust in Victoria, there are others that afford ample proof of the benefits of irrigation. Wherever water has been made available it has improved land values, promoted denser settlement, and given a degree of certainty in the production of crops not previously possible.

Irrigation in
the Goulburn
Valley.

Experience in other countries has everywhere in modern times led irrigators to economy in the use of water, so that the supply has year by year become effective for a larger area than at first served. Even on land that, to the eye, appears almost perfectly adapted for the application of water there is often a good deal of grading and other preparation necessary to secure a beneficial result. The rougher land must be divided into small lots, by temporary banks thrown up with the plough. When water is turned upon uneven land, the lower portions receive too much before the higher are even covered; a matter about which some agriculturists are very careless, with the result that, not only is water wasted, but sometimes the land is injured instead of being benefited. Mr. Hector, engineer to the Rodney Trust, said as to the grading of the land in his Trust district:—"The Trust "try to encourage it, but it is difficult to get owners to do it; during the last few years, however, there has been a great improvement in this respect, people are beginning to see the necessity for grading. . . Those who have tried grading have found it of great benefit." Not only is less water used when land is properly graded, but Mr. Hector points out another great advantage, namely, the irrigation is carried through in less time. Some farmers, too, turn the water first on to the lowest parts of their land instead of the highest; with such carelessness as to suggest that something in the way of direct instruction might with profit be given systematically by the State Department of Agriculture. The total area at present under irrigated culture in Victoria is, as nearly as can be ascertained, 276,000 acres.

Economy in
the use of
water.

So far there has been little development of irrigation in New South Wales; although, at Hay and at Wentworth, irrigation schemes were started some years ago, under the authority of Acts of Parliament. Some of the land at Hay is not considered suitable for irrigation, the site, as a whole, not being so good as that at Mildura. But perhaps the chief reason the settlement has not been quite successful is that those who first took up the land lacked experience. Regarding this, one witness said:—"I consider the soil is adapted for irrigation, and I have confidence in the scheme if we only had practical men on the area, men who understood fruit culture and the growing of crops by applying water to the land. . . We have found that land and water in themselves are not sufficient, that there is a proper method of putting water on, and that method has to be learned by experience. A good

Irrigation in
New South
Wales.

Hay
Irrigation
Trust.

Wentworth
Irrigation
Trust.

many people who put in crops regardless of method found that they got no result simply from inexperience." The Wentworth Irrigation Trust is also largely a failure, only 130 acres being under cultivation. The land comprised in this Trust area is excessively saline and otherwise unsuitable. One witness, however, says:—"I think, not that the land would not pay well, but a prejudice has stopped settlement. There is a class of land at Mildura comparatively shallow, and the settlers only get water there at very long intervals; consequently, that class of ground dries up and the crops suffer. People think the land here is of the same class, but they forget that they can have water here every fortnight; that is, the land here is classed as the Mildura shallow land, and people do not take other circumstances into consideration."

Private irriga-
tion schemes.
Hon. S.
McCaughey's
irrigation.

The most successful irrigation in New South Wales has been carried on by individual landowners, prominent among whom is the Hon. S. McCaughey, M.L.C. Mr. McCaughey has about 60 miles of channels on his North Yanko property, chiefly supplied by pumping. Last year he irrigated about 400 acres of crop; and, if gravitation water were available, he would irrigate 800 or 900 acres for sorghum and lucerne. "Sorghum is the best for summer fodder. In a year like this you get quicker results from Sorghum than anything else. . . . Lucerne would be the best to grow on a large scale; it does not require the annual expense of cultivation." Mr. McCaughey read a statement descriptive of his own experiences, from which the following is an extract:—

"The proposed Murrumbidgee weir below the Yanko junction would be of immense value to the inhabitants of the towns, and the owners of lands on the Yanko, Colombo, Billabong, and Forest Creeks. The estimated storage capacity of the proposed reservoir at Yass is about 18,000,000,000 cubic feet. This quantity of water would irrigate 275,482 acres to a depth of 18 inches, which would be sufficient to grow two crops of sorghum or four of lucerne. The former would carry fifty sheep to the acre for four months; the latter fifteen to the acre for six months; or a total of 13,774,100 sheep if fed on sorghum, and of 4,132,230 sheep if grazed on lucerne. . . . I estimate that it costs the owners of stock 6d. per head per month for renting grass, including other expenses, to save their sheep; this would be equal to 2s. per head on sheep fed on sorghum for four months, or £1,377,410, which is more than double the estimated cost of the proposed Murrumbidgee canal and Yass storage reservoir, and if the same acreage were in lucerne (275,482 acres), estimated to carry fifteen sheep to the acre for six months at 3s. per head, it would amount to the sum of £619,834—about the estimated cost of the proposed Murrumbidgee weir, canal, and Yass reservoir. These figures do not represent one-half the benefit annually that would be derived from saving the stock in such disastrous droughts as those experienced of late years; as, under present conditions, it will take several years to breed up to the full carrying capacity of the country; whereas, with the water supply mentioned, sufficient stock could always be available to take advantage of good seasons when they come. There is a deterioration in stock during seasons of drought that could be avoided if the higher method of stock farming were adopted by growing food as proposed. . . .

"Two-sevenths of the waste flow"—of the Murrumbidgee—"would irrigate 2,203,856 acres of wheat, oats, or barley to a depth of $4\frac{1}{2}$ inches; which would, judging from my experience, give a return of 40 bushels of wheat or 60 bushels of oats to the acre, worth, say, 2s. for the former, and 1s. 4d. for the latter, or a gross return of £8,815,424 in either instance. The water would make a certainty of this return, whereas for the last five years the crops from Narrandera to Balranald have been almost total failures.

"The estimate of 50 sheep to the acre, fed on sorghum for the four Summer months, is only half the stock carried per acre on a small paddock on North Yanko last year. The average cost of growing sorghum would be about £1 per acre per annum, and of lucerne considerably less, as the sowing of the latter would only be required once in five years, whilst sorghum would require to be sown annually. The amount of labour required to cultivate and water the areas referred to would bring unprecedented prosperity to the towns in the districts benefited by this scheme, as well as the whole community. I know of no soil better suited for the

growth of sorghum than the immense polygonum areas below Hay. If supplied by gravitation with, say, 18 inches of water annually, it would increase its value tenfold. The estimate of 40 bushels of wheat and 60 bushels of oats to the acre is considerably less than some of the New Zealand yields; for there we often hear of 60 bushels of wheat and up to 100 bushels of oats to the acre, and, I believe, with irrigation equally good yields would be obtained here."

Mr. R. O. Blackwood, of Hartwood Station, another leading pastoralist, thus emphasises some of the losses from drought that might be minimised by the provision of water for irrigation and for stock:—

Mr. R. O.
Blackwood's
evidence.

"One feature connected with these losses must not, however, be overlooked, as I imagine the vast importance of it to the entire Commonwealth has not yet been fully realised. I refer to the loss, either by deaths or owing to lack of increase, there has been amongst the old-established stud flocks in the Deniliquin district, also to the loss there has been amongst what are known as the flock-breeding ewes in the same district. For the last fifty years or more these sheep have been most carefully handled, and . . . a higher class of sheep is now to be found in the district named than in any other part of the continent. This particular area is called upon to supply rams and high-class flock ewes to almost every part of the country. It stands to reason, therefore, that any serious diminution in the numbers of these sheep must not only be a very serious loss to the owners of them, but to all those also who depend upon them for the improvement of their own flocks; which, in the absence of the importation of high-class blood, must either advance but slowly by the process of selection, or else possibly go backwards. Such a state of things must be very prejudicial to the prosperity of a great number of those engaged in sheep raising, and the loss to the States owing to the non-improvement of the flocks . . . can only be looked upon as a national disaster."

"The fodder bill paid by Riverina to Victoria is a very material loss to New South Wales. Up to July last the Victorian Railways had carried fodder for Riverina to the value of about half a million pounds, and thousands of pounds' worth also must have entered this State without passing over the Victorian Railways. With irrigation facilities all this might readily have been produced on the North side of the Murray."

"A comprehensive scheme would enable a supply of water to be placed in every paddock, and so prevent losses of stock during droughts of moderate severity. . . To illustrate the vast saving there would be by growing our own fodder under a scheme of irrigation instead of purchasing it, I have prepared a short statement, by which it will be seen that, whereas it would cost at any place (say) 35 miles distant from Deniliquin, with fodder purchased at current rates, £717 10s. (or 7½d. per head of stock) per week to feed 22,400 sheep on only one pound of hay per day per head, it would only cost £73 10s. (or considerably under 1d. per head of stock) per week to feed the same number of sheep on two pounds of hay per day per head, if produced at home by irrigation."

Apart from the Renmark Irrigation Colony and the Village Settlements along the banks of the Murray in South Australia, irrigation has not been practised to any great extent in that State. A few small pumping plants exist on the banks of the Torrens and the Murray. Mr. H. W. Morphett, of Wood's Point, stated that, in one year, he obtained 150 tons of onions from five acres of irrigated land on the Murray River, the net profit from the crop being no less than £600. The aridity of the soil and the low rainfall being such as to render the artificial application of water a matter of prime importance in South Australia, it is a little remarkable that irrigation has not been more generally practised. The one great illustration, in this State, of its advantages is to be seen at Renmark; where, in the midst of a typically dry Australian country, practically rainless in its natural condition, there exists a thriving settlement, carrying a population of about 1,000. The experience of the Village Settlements has, on the whole, been unfortunate; but this is explained by Mr. McIntosh, Inspector of Settlements in South Australia, as being due to the fact that the settlers were almost without practical experience.

Irrigation in
S. Australia.

S.A. Village
Settlements.

Irrigable land
in South Aus-
tralia.

Mr. Jones, Secretary of the Public Works Department, states that there are 450 square miles of river flats suitable for the growth, under irrigation, of grass, cereals, onions, potatoes, etc., though not as a rule suitable for fruit culture, as the soil is chiefly composed of river mud. The remainder of the irrigable land along the banks of the Murray, in South Australia, he gives as 1,000,000 acres, 250,000 acres of which he considers could be utilised under existing conditions. The ground is well adapted for the cultivation of fruit, being good sandy soil of great depth, with a varying subsoil, clayey in some places, calcareous in others. The whole of this land is at such a level as to involve the use of pumping machinery, but the experience of Mildura and Renmark shows that this condition is not necessarily prohibitive.

Financial
prospects of
irrigation.

The development of a young country, by settling suitable people on the soil, and by aiding those who have undertaken the work of pioneering, is of prime importance to its Government. It is clear that, where the State has the predominant financial interest in irrigation works, the conditions are entirely different from those in countries where concessions are granted for the exploiting of water rights. Except in some rare instances, it is manifest that, in the latter, returns must be direct. State Governments, however, can afford to take a broader view, and to weigh the indirect as well as the direct benefits. Colonel Home, whose large experience in India entitles his opinion to respect, says:—"In connection with the financial prospects of irrigation projects, it may be mentioned that the development of irrigation is comparatively a slow process, and that it is not reasonable to expect that a canal should pay as soon as it is completed. This is fully recognised in India, where a canal is classed as remunerative, and carried out with borrowed money, if the forecast statements show that it will pay maintenance and interest charges within ten years after completion, and at the end of twenty years will pay the prescribed rate of interest on the sum at charge of the project, which is the capital cost, plus the balance, if any, of maintenance and interest charges over receipts from revenue."

Policy in
regard to
Trusts in Vic-
toria.

In Victoria, the policy of the earlier legislation was to charge Trusts not only the cost of distributaries but also of the diversion and head works. But, if the experience of that State during the last ten years can be accepted as a guide, it would seem that in general such bodies are not likely, except under compulsion, to defray the maintenance and interest of the whole cost. The utmost that can be expected from their voluntary efforts is payment of interest and sinking fund on the cost of distributing channels and minor works. The financial relief recently given to Irrigation and Waterworks Trusts in Victoria, by Parliament, indicates that no more than this is to be looked for.

Trust finance.

It is questionable whether the method of trust finance is the best or only practicable one. It is usual to charge a rate on the annual value of land within the irrigated area of from 9d. to 2s. 6d. in the £. The remainder of the revenue is from sales of water, the system universally followed being that of supplying on orders received from day to day. Anything like a reliable estimate of revenue is thus impossible, while actual receipts are subject to the greatest fluctuations. So long as water is believed to be available at twenty-four hours' notice, farmers will naturally delay their orders until the very last moment, in the hope that rain may fall. If charges were based on the system prevailing in cities, where every property owner within a fixed distance of the supply pays a rate charged on the assessment, it would be possible to ascertain with a fair degree of exactness the revenue from any proposed work, whilst the use of water would also be greatly stimulated. Mr. George Gordon, President of the Eastern Goulburn Irrigation League, says, in advocacy of the extension of a canal for irrigation on the Eastern side of the Goulburn:—"My reasons for advocating irrigation are:—I came here some eleven years ago, and, after I had been out here for two or three years, I found that the people in Rodney" (probably the most successful Irrigation Trust in Victoria) "seemed to be making more money and doing better off the land than we were doing. To see what was the cause of this, I went over to Rodney, to get acquainted with the irrigated areas, and to see how it was they were turning off more fat stock and doing so much better than we were doing on this side. After spending a good deal

Trust
management.

of time amongst the people of that part, I found that their better circumstances were due to the benefit they were deriving from the water. On this side of the river the land is practically lying idle from the middle of October until well on in April, generally up to the end of April. It is consequently lying idle six months in the year, and therefore giving us no return. In Rodney, where they put down the lucerne and irrigate it, they can make more money off 300 acres than we can here off 1,000 acres during those six months; so, that we are considerably handicapped in the way of production by not having irrigation." Questioned as to how it is the Rodney people do not appear to fully appreciate the advantages of irrigation, as is evidenced by the fact that only about 37,000 acres, or about 13 per cent. of the Trust area, is irrigated, Mr. Gordon replied, "I cannot understand how that is so, but I base my opinion on the 'figures' that a number of the men who are using the water are making. As to the people who are not using the water, their land is lying idle like ours."

The Tragowel Plains Trust, which derives its supply from the Loddon, is in times of drought without sufficient water to provide more than stock and domestic wants, so that irrigation cannot then be practised; while the Macorna North Trust, fed from the Murray, has generally sufficient water to provide for irrigation. As instancing the resulting gain to the latter Trust, Mr. Donald McIvor says:—"It has been impossible to carry on dairying profitably on the Tragowel Plains Trust since 1894, and cropping has been a comparative failure also; but in the Macorna North Trust you can nearly always depend on getting some returns, say, $2\frac{1}{2}$ to 3 bags of wheat and from 7 to 8 bags of oats per acre. Then, in regard to dairying, I may say that the yield from my sixty cows in the Tragowel Plains dropped to 50 gallons per day; but when I shifted them to the Macorna North Trust, it rose in three days to 130 gallons, and in a fortnight to 160 gallons." Important evidence in this respect was also given by Mr. R. Richardson, of Kerang, who says:—"Before the water was brought along the Macorna Channel, I was obliged to mortgage my property. As soon as water was available, I applied it to the land, and gradually removed the mortgage, and have made a comfortable living since. Failing the water, I could not have remained in the district. I might state that I am a director of the Pyramid Butter Factory, and about two months ago the united cheque of twenty suppliers of cream from the south side of the Macorna Channel, where they have a very indifferent supply, only amounted to £18; whereas four suppliers from the North side, where they have an ample supply, drew from that factory £32. Owing to the want of water, my own revenue has gone down from £9 or £10 per week to about £2 10s."

Tragowel
Plains Irriga-
tion Trust.

The Victorian experience is sufficient to show that irrigation works should not be commenced without due consideration of the financial prospects. The indirect benefit to those districts favourably situated for irrigation, by settling a large population on the land, may perhaps be considered to go far towards reimbursing the State, even where, as in Victoria, a large proportion had been written off the cost. At the same time, what has happened there may be taken as showing that other methods of finance, at least, demand a trial, not merely for ensuring a certainty of return, but also as an indirect means of inducing a more extensive and more profitable use of water when provided.

Lessons of
Victorian
experience.

The extent of irrigable land in the Murray Basin, that is land commandable by water, and of character and quality suitable for wet culture, within the States of New South Wales, Victoria, and South Australia, is shown in the following tabular statement. It is not to be understood that the whole of this can be irrigated in any one year. It cannot be so; the available volume of water is wholly insufficient, even in years of high river discharge. It is the land that might be profitably irrigated, if water were available:—

IRRIGABLE AREAS.

NEW SOUTH WALES—

		Acres.
Darling and tributaries	...	Gravitation 22,387,200
Lachlan	... ..	" 9,539,200
Murrumbidgee	... ..	" 6,995,840
Murray	" 4,620,160

VICTORIA—

Murray and tributaries	...	Gravitation 4,000,000	43,542,400
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SOUTH AUSTRALIA—

Murray	Pumping to 110 feet level	1,000,000
"	Pumping to 160 feet level	1,500,000
			2,500,000

Total Area in the three States 50,042,400

CAP. 5.—SPECIAL IRRIGATION SETTLEMENTS IN VICTORIA AND SOUTH AUSTRALIA.

Mildura.

The Chaffey Concessions.

THE Mildura Irrigation Colony is on the left bank of the Murray, about sixteen miles by direct route above the junction of the Darling. It was founded in 1887 under an agreement between the Government of Victoria and the Messrs. Chaffey Brothers, conveying certain rights of land purchase, with authority to divert water from the river. The agreement was subsequently embodied in a special Act of Parliament, and ratified by the Legislature. Messrs. Chaffey Brothers were authorised to divert from the Murray volumes varying with the season of the year, and limited in respect of the number of acres under irrigated culture. In the month of March, for instance, when the river is generally at its lowest, one cubic foot per minute was allowed for each twelve acres under cultivation; while, during September, October, and November, when the volume is usually greatest, it was increased to one cubic foot per minute for every four acres. The total area of the concession is 250,000 acres, the land in its virgin state being, practically, valueless red sandy loam, covered with mallee and blue bush, with an average rainfall of less than eleven inches. It has been subdivided into agricultural blocks of ten acres, suburban lots of two and a half, and township lots of one-eighth acre.

Failure of the Messrs. Chaffey.

Constitution of Trust.

Difficulty from loss of water.

Present prosperity of settlement.

In the early history of the settlement, considerable dissatisfaction arose from the inability of the Messrs. Chaffey to fulfil the covenants into which they had entered; till at length, in consequence of their financial difficulties, the Government took over the works, and constituted a trust, with jurisdiction over 45,070 acres of the original concession, whereof 15,127 were sold land. The settlers, profiting by the mistakes of the past, are now utilising the soil to advantage and obtaining excellent results. Water is pumped from the Murray into channels at various levels, commanding an irrigable area of about 35,000 acres, whereof between 9,000 and 10,000 are under intense culture. The crops raised include raisins, sultanas, currants, apricots, peaches, and citrus fruits, representing an annual value of about £114,000. A considerable loss of water, from soakage, occurred from the 169 miles of channels when first constructed. This has now been in great part remedied by lining at an expenditure of £29,000. The Engineer of the Trust says that a further expenditure will be needed to place the whole in good condition. Mildura at present contains a population of about 4,000, and is in a fairly prosperous condition. The railway from Melbourne will be completed to the town by the end of March, 1903, and will give command of the markets, not only of the metropolis, but of several large provincial towns. The capital value of the improved lands is given as £500,000; which fact, seeing that they were practically valueless without irrigation, affords an excellent object lesson of what can be accomplished by skilful cultivation and judicious application of water. Mildura and Renmark are notable as the only settlements in Australia which, as a consequence of the concentration rendered practicable by irrigation, can afford the advantages of town life.

Apart from these settlements, which depend wholly upon intense culture, there are some among the irrigated districts of the Goulburn Valley, such, for instance, as Ardmona, where pleasant homes set in attractive gardens afford proof of the prosperity that attends skilful cultivation, where water within reach renders the cultivators independent of the uncertain rainfall. The possibilities of extension of such settlements in Australia are not so great as in the United States. The conditions of water supply on the one hand, and of available markets on the other, are handicaps against us. Yet even these—the latter, at all events—are not as great as might be supposed. For, if we are not quite so well placed as to the European market, our situation with regard to the East is favourable, and the possibilities of development of trade in that direction are great. And, again, distance from a market, where there is ocean carriage, constitutes no serious disadvantage, except in the case of perishable products.

Other irrigation settlements on like lines.

Possibilities of extension.

Much that has been said about Mildura applies equally to Renmark. Both colonies are on the red soil country of the Lower Murray, the conditions being similar in the two cases. The area of the Renmark concession is 250,000 acres; extending from the common boundary of New South Wales and South Australia, down the Murray, to the north bank of which it has a frontage of about 40 miles. In 1887 a beginning was made of the irrigation works, and the town of Renmark laid out, about 70 miles from Morgan, which is connected with Adelaide by rail. The license granted to the Messrs. Chaffey by the South Australian Government is identical with that granted by the Victorian Government in the case of Mildura. Here, also, owing to the failure of the promoters, the works were taken over, and a Trust formed, with an area of about 12,000 acres. The works are similar in character to those at Mildura.

Renmark.

The value of the citrus and dried fruits, and olive oil, shows a steady yearly increase. The export in 1901 was £29,474, being an increase of £8,542 over the previous year. As an evidence of the value of irrigation it may be pointed out that Chowilla Station, adjoining Renmark, and containing 250,000 acres, is, owing to the drought, carrying only 5,000 sheep, whereas Renmark, with 3,000 acres under irrigated culture, maintains a prosperous population of 1,000 persons, living under agreeable social conditions. "Chowilla" is by no means destitute of country which under irrigation might be as productive as Renmark. The contrast simply emphasises the revolution wrought by irrigation.

Produce of Renmark.

Neither at Mildura nor at Renmark does the Trust limit its constituents to the volumes of water conceded to the original licensees. The depth actually applied to the orchard lands of both settlements is 28 inches per annum, representing a volume so great as to inspire apprehensions of serious waste. If this volume really is required for fruit culture, in the climate and soil of the Murray Valley, no time should be lost in amending the grants to the Trusts; while the fact should be borne in mind in any future concessions proposed under like circumstances.

Water used at Mildura and Renmark.

Notwithstanding the criticisms to which untoward circumstances have exposed them, the Mildura and Renmark settlements show the possibilities of the lands in the River Valley, under a proper system of culture, in the production of nutritious, palatable, and wholesome food, in the support of a large industrial population, and in contributing to the trade and commerce of the States. Their experiences, however, have already begun to prove that the area of land suitable for the higher class of intense culture is limited by conditions not at first apparent. It is also showing that continuously cropping even the most suitable lands with any succession of the same kinds of crop—fruit, for example—must lead to the impoverishment of the soil, and to its reduction to an unfavourable condition of tilth. It is as necessary in fruit growing as in any other kind of agriculture that there should be a rotation of crops. This is pointed out by Dr. Jules Guyot in his well-known work on the cultivation of the vine, and is very apparent in the experiences of the Mildura and Renmark settlers.

Lessons of Mildura and Renmark.

In 1894 the Government of South Australia set apart several areas on the banks of the Murray for the establishment of Village Settlements. Several methods

South Australian Village Settlements.

of providing for the unemployed had been tried, with little result. The establishment of these settlements was regarded as an experiment; in the first place, to supply healthy employment, in the second to utilise, by irrigation, the waste lands on the river banks. They were started on communistic principles; but, owing to the lack of practical knowledge, and disagreements among the settlers, they have been by no means successful. Some have been entirely abandoned, while, in others, the original plan has been departed from. One was worked on the lines of the "New Australia" movement; this also proved a failure, and was closed in 1899. It is evident that here human nature is among the elements to be reckoned with, no less than quality of soil, suitable climate, and available water supply; and human nature as stubbornly resists amelioration as does the flintiest soil or the most arid climate.

Murtho.

The Murtho Settlement is three miles above the Renmark pumping station, on the opposite bank of the river. It was originally formed by the settlers contributing £60 each, and being assisted by the South Australian Government with a loan of 50 per cent. on the value of all improvements. It was closed in 1894, and is now let on lease. The area is 2,998 acres, 250 of which are under cultivation.

Lyrup.

Lyrup, about 24 miles lower down on the same side of the river, originally embraced 14,049 acres, 7,000 of which have been resumed. Of the remaining area, 500 acres are under cultivation, supporting a population of 105. This is the most successful of the river Village Settlements, a fact largely attributable to its proximity to Renmark, of whose experience the settlers took advantage.

Pyap.

About 40 miles further down, is Pyap, with an area of 9,132 acres and a population of 69. Two hundred and ten acres are under cultivation, served by a pumping plant delivering 32,000 gallons per hour.

New residence.

About four miles below Pyap, is the settlement of "New Residence." Meeting with little success, it has been abandoned, and is now the subject of a lease.

Moorook,
Kingston,
and Holder.

Moorook, about eight miles below New Residence, embraces 3,200 acres, 160 of which are under cultivation; the population is 52. Kingston contains 3,901 acres, of which 180 are irrigated; the population is 56. The area of the Holder Settlement is 7,560 acres, 220 of which are irrigated; the population is 74.

Waikerie.

Waikerie was originally established on communistic principles. There are 3,300 acres of land in the settlement, 290 being under irrigation. It contains a population of 64.

Ramco.

The area of the Ramco settlement is 3,680 acres, about 150 of which are under irrigation and watered by a pumping plant capable of lifting 36,000 gallons per hour. The population numbers 38.

Gillen and
New Era.

Gillen and New Era are the last two village settlements on the river; Gillen being twelve miles below Ramco, and New Era eighteen miles further, or five miles above Morgan. Both, after an unsuccessful struggle of two years, were abandoned. They are now let on lease.

CAP. 6.—IRRIGATION IN OTHER COUNTRIES. ITS LESSONS FOR AUSTRALIA.

Diversity of
conditions.

A BRIEF glance at what has been done in other countries, in the application of water to the soil to produce food for the people, will be useful; even where the conditions differ widely from ours, there may still be much to learn. In Egypt, the oldest field of irrigation in the world, and where without its aid life would be impossible, the circumstances of the cultivator are as diverse from those aspired to on the part of our settlers as it is possible to conceive. In Egypt, the entire

agriculture of the country—practically the entire productive labor of the country—is performed by some two and a half millions of felahen. This handful of people, in fact, sunk in a condition bordering on slavery, carries on its shoulders the seven or eight millions that constitute the population of the country. In the United States of America, on the other hand, in the arid western regions especially, irrigation has brought profitable employment, provided abundance of nutritious food, comfort, and luxury for the masses; while it has also found a profitable field for the investment of capital and for the operations of the merchant and financier. There is much to be learned from each of these cases, as well as from others where the circumstances do not reach either of the extremes; perhaps no less from the country whose conditions differ widely from our own than from that in which they are more nearly identical.

Few areas on the world's surface support so dense a population as the narrow strip of land lying along the banks of the Nile. On both sides of that river, for hundreds of miles above Cairo, the fringe of fertility is hemmed in by the desert, which in many places extends down to the river itself. For many centuries it has supported a total population of nearly five persons to each acre of cultivation; a density which, if it could be extended to countries like Australia, where there are millions of acres of irrigable land, would bring about a social revolution of unimaginable magnitude. It is obvious that the conditions of perennial productiveness must exist in Egypt in phenomenal perfection. What, then, are these conditions? Virtually it is a rainless region; it is one which, with almost, though not absolutely quite, unbroken regularity, is inundated year after year by the waters of the Nile; finally, the river brings down at each annual flood a rich charge of fertilising silt, which, by the basin system adopted by the cultivators retaining the water upon each field for some weeks, ensures the deposit of a thin layer of soil. Are these, then, the ideal conditions of productiveness—absence of rain, and the annual flooding of the fields with water charged with rich soil or other manurial substance? Wonderful effects are ascribed to the fertilising properties of the silt, which is chiefly brought into the Nile by the Atbara or Black River. Prof. Hilgard, Director of the Agricultural Department of the University of California, shows that the layer of new soil so deposited is only of the thickness of common cardboard, about one twenty-fifth of an inch, equal to two good waggon loads per acre; observing that farmers would gladly haul and spread such fertilisers upon their land, if assured that they could thereby produce the like results. He also shows "that the neighbouring province of Fayoum, in Libya, shares the perpetual fertility of the Nile Valley, though irrigated only with the clear water of Lake Mœoris; that the regur lands of the Deccan, in South Central India, have been phenomenally productive for thousands of years; and that the region of China drained by the head waters of the Yellow River has been the granary of China for ages." From such facts Prof. Hilgard concludes that the extraordinary fertility of the valley of the Nile and other perennially fertile though arid lands is due to a quality inherent in aridity itself.

Prof. Hilgard found, as the result of more than one thousand analyses of the soils of the arid Western regions of the United States, and of the well-watered Eastern regions, that the soils of the arid West contain, on an average, three times as much potash, six times as much magnesia, and fourteen times as much lime as the others. This high percentage of fertilising elements explains its superior productiveness. The Professor has even ventured on the following generalisation—"Arid countries are always rich countries when irrigated." This is the reasoning by which he supports his maxim:—"Soils are formed from rocks by the physical and chemical agencies commonly comprehended in the term weathering, which includes both their pulverisation and chemical decomposition by atmospheric action. Both actions, but more especially the chemical one, continue in the soil itself, the last named in an accelerated measure, so as to give rise to the farmer's practice of fallowing, that is leaving the land exposed to the action of the air, in a well-tilled but unplanted condition, with the view of increasing the succeeding year's crops by the additional amount of plant food rendered available, during the fallow, from the soil itself. This weathering process is accompanied by the formation of new compounds out of

Irrigation in Egypt.

Professor Hilgard on the effects of aridity.

the minerals originally composing the rock. Some of these, such as zeolites, and clay, are insoluble in water, and therefore remain in the soil, forming a reserve of plant food that may be drawn upon gradually by plants; while another portion, containing especially the compounds of alkaline potash and soda, are easily soluble in water. Where the rainfall is abundant, these soluble substances are currently carried into the country drainage, and through the rivers into the ocean. Among these are potash, lime, magnesia, sulphuric and a trifle of phosphoric acids. Where, on the contrary, the rainfall is insufficient to carry the soluble compound formed in the weathering of the soil mass into the country drainage, these compounds must of necessity remain and accumulate in the soil." But the great advantage of aridity cannot be fully availed of without an adequate supply of water for irrigation. There is no doubt about the high quality of much of the plain country on both sides of the Murray; the character of the land in the Goulburn Valley in Victoria is almost identical with a good deal of the Riverina Country in New South Wales; and, in both, not only is much of the soil rich, but there are immense areas where the levels are entirely suitable for irrigation, and where the cost of preparing the land would approach a minimum. It is in these districts, if anywhere in the Murray basin, that the financial and social advantages that may result from irrigation will be possible.

Willcocks on
Egyptian
irrigation.

The political events of 1882, which led to the British occupation of Egypt, had as one result the transferring from India to Egypt of a number of highly-trained irrigation engineers. Sir Colin Scott Moncrieff, regarded as one of the ablest, was placed in charge of the Egyptian Public Works, and assigned the services of several Anglo-Indian engineers to assist him. One of these, Mr. W. Willcocks, has published a work called "Egyptian Irrigation," in which very interesting information is given as to the results obtained. For the system of "basin" irrigation, which has been developed and perfected in Egypt during the past five thousand years, Mr. Willcocks has nothing but admiration. The valley of the Nile, from Assouan to the Mediterranean, having been formed by the gradual deposit of alluvial matter from the river when in a state of flood, the high land is always next the bank and the low land near the desert. This conformation, which is similar to that of our Riverina country, explains the ease with which the lands between the river and the desert can be irrigated when the Nile rises. The following extract from Mr. Willcocks' book will explain the "basin" system:—

"Upper Egypt, with the exception of the Ibrahimia Canal system and the Fayoum, is divided into basins by earthen dykes running transversely to the direction of the river, starting from its bank, and reaching the desert. A dyke running parallel with the river, along its bank, encloses the basins on the river side, while the desert generally forms the fourth side. Some basins are still further divided, by one or more dykes parallel to the direction of the river, in order to divide the low lands near the desert from the higher lands near the river's edge. Large communities have made further sub-divisions, surrounded their properties by dykes, and made private basins, which they can irrigate at will, and of which they control the water supply independently of the main basins. Almost all these basins have special canals to lead directly into them the flood waters charged with alluvium. The beds of the canals are almost midway between the low Nile and ground-level; *i.e.*, about three or four metres below the level of country, or the same depth below ordinary flood; the canals are consequently dry during winter and summer. Many of the feeder canals have no regulating heads, but only a mass of loose stone at the take-off from the river. The heads of the canals taking off from the Nile are annually closed with earthen banks, which are cut about the 10th or 12th of August, when the millet crops in the basins have been removed; and the Assouan gauge being ordinarily at $14\frac{1}{2}$ pics, the muddy flood water can flow freely into the canals. Each system of basins depends on one or more canals for its irrigation; some of the canals are insignificant, and feed only a few basins; while some, like the Sohagia, discharging 30,000,000 cubic metres per twenty-four hours (735,000 cubic feet per minute), are veritable rivers, and irrigate a very extended system. As the feeder canal passes each transverse dyke, it is provided ordinarily with a masonry regulator, to control the amount of water entering the basins. Each system of

basins possesses an escape, which allows the water, after it has deposited the alluvium, and stood some forty days on the land, to flow back into the river. Wherever the desert impinges on the river bank, there is a break in the system of basins. This happens very frequently on the right bank, but seldom on the left, where nearly all the cultivated land lies. The filling of the basins begins ordinarily about the 12th of August, and in the southernmost basins is completed by the 1st October, when the escapes are opened and the water discharged back into the Nile, ordinarily by the 15th October."

The works by which the English engineers have specially placed their mark upon Egypt are the restoration, and practical rebuilding, of the great barrages or dams below Cairo, which regulate the flow at the point where the Nile bifurcates and the delta of Lower Egypt begins; and the great regulating dam at Assouan, which was opened this year. They have also done much to improve the condition of the canals, particularly by works for reducing the excessive deposit of silt.

In those regions of the United States that approach most nearly in physical conditions to the Riverina and Goulburn Valley country, irrigation, as described by Smythe in "The Conquest of Arid America," elsewhere quoted from in this report, has had a most marvellous social influence, and made it possible for cultivators of the soil to live together in large villages, where they can enjoy many of the advantages of town life. The writer insists on the fact that irrigation not only makes possible, but to a great extent compels, the adoption of small farm units. His description of Riverside, an orange-growing colony in Southern California, discloses astonishing results. This settlement, originally consisting of 2,000 acres of pastoral land, bought at 10s. per acre, has been gradually extended until it now embraces 10,000 acres. The "farms" are from 5 to 10 acres in extent. When irrigation facilities were supplied, the land sold readily at £5 an acre. A few years later the unimproved lands sold for prices ranging from £60 to £100 an acre. The improved irrigated orchards, evolved from the sheep pasture, were valued, and actually sold at, from £200 to £400 per acre. There have been years when the best of them earned a profit of 50 per cent. on the higher figure. Perhaps there are few places where the financial results are so striking; but, judged by this test alone, irrigation in the United States seems everywhere to have been a success, so far at least as the cultivators of the soil are concerned. Although the net gains from irrigation in the United States have been enormous, there have been many difficulties and some heavy losses. It would be easy to select examples from the records of American irrigation to show that under the operation of unrestricted private competition, litigation has been frequent. In some cases works have been constructed with a haste that did not permit of stability; rates for water have been unduly high; and there has often been comparative scarcity where, with more careful preliminary investigation, there might have been abundance. Some companies holding valuable concessions have, after spending all their capital, been obliged to leave their schemes unfinished. Very serious difficulties also have arisen from the unsuitability of the English Common law to the conditions of the Western States. Some reference to the dealing with these difficulties, by the State legislatures and the State courts, will be found in that part of this report dealing with the legal aspects of the Murray River question.

Irrigation in
the United
States.

Mr. J. D. Schuyler, in a work on American irrigation published in 1901, says:—"Capital has been slow to undertake the largest and most important works because of the difficulty of realising immediate returns from the investment. The development of a new section upon which water is but recently introduced, the construction of distributing canals, ditches, and pipes, the cultivation of the land and the planting of orchards, in fact, the conversion of the desert to a condition of profitable productiveness, is a work of time, which cannot be begun until the irrigation works are actually completed, and when begun is slow to fully develop. Meantime, however, the interest account accumulates, and often is so far in excess of possible revenues as to bring discouragement, and sometimes actual bankruptcy,

Necessity for
storage.

before a paying basis is reached. That storage reservoirs are a necessity, and indispensable adjunct to irrigation development, no less than to the utilisation of power, requires no argument to prove. That they will become more and more necessary to our western civilisation is equally sure, and certain signs of the times seem to point to the inevitable necessity of Governmental control in their construction, ownership, and administration."

Storage of
water pro-
perly a
function of
Government.

This is not merely the isolated opinion of an individual. The responsible leaders of the United States Government recognise that, in the arid regions, without irrigation, homes can neither be created nor maintained. The Secretary of the Interior, in his report to the President, of November, 1901, said:—"In my report for 1900, attention was drawn to the importance of providing, through wise administration, for the creation of homes for millions of people upon the arid but fertile public lands. . . . There is no function within the power of the Government higher than that of making possible the creation of prosperous homes." In his speech at Minneapolis, Mr. Roosevelt said:—"Throughout our country the success of the home-maker has been but another name for the upbuilding of the nation." President Roosevelt, in his message to Congress, delivered 3rd December, 1901, made some statements that well deserve quoting. He said:—"In the arid region it is water and not land which measures production. The western half of the United States would sustain a population greater than that of our whole country to-day if the waters that now run to waste were saved and used for irrigation. . . . Great storage works are necessary to equalise the flow of streams and to save the flood waters. Their construction has been shown to be an undertaking too vast for private effort. Nor can it be best accomplished by the individual States acting alone. Far-reaching interstate problems are involved, and the resources of single States would often be inadequate. It is properly a national function, at least in some of its features. It is as right for the national Government to make the streams and rivers of the arid region useful by engineering works of water storage as to make useful the rivers and harbours of the humid region by engineering of another kind. The reclamation and settlement of the arid lands will enrich every portion of our country. . . . It would be unwise to begin by doing too much, for a great deal will doubtless be learned, both as to what can and what cannot be safely attempted, by the early efforts, which must of necessity be partly experimental in character. No reservoir or canal should ever be built to satisfy selfish personal or local interests, but only in accordance with the advice of trained experts, after long investigation has shown the locality where all the conditions combine to make the work most needed and fraught with the greatest usefulness to the community as a whole. There should be no extravagance, and the believers in the need of irrigation will most benefit their cause by seeing to it that it is free from the least taint of excessive or reckless expenditure of the public moneys."

Irrigation in
the countries
bordering
the Mediter-
ranean.

France.

Irrigation has probably been practised, in parts of the European countries adjoining the Mediterranean littoral, from times as remote as in the lands of the East. The principal irrigation countries in Europe to-day are France, Spain, and Italy. Almost throughout France, irrigation is practised to some extent for the production of hay; but it is in the South, where the mean temperature is highest, and the rainfall most scanty, that the system is fully developed. All through the South, lucerne, beans, and lentils, vegetables of all kinds, and occasionally wheat and vines, are grown by the aid of irrigation. Lucerne does extremely well when irrigated, yielding five or six crops a year. The ground is first liberally manured, about five cubic yards of stable dung being allowed per acre. It is then sown with wheat, and, when this has braided, lucerne seed is sown over it. In April of the year following the lucerne begins to yield its first crop. An acre of lucerne, on highly manured land, and irrigated, often produces as much in value as £18 10s per annum. One of the most valuable products of Southern France was the madder, which is specially adapted for irrigated lands; but its cultivation has been almost entirely extinguished by the substitution of aniline dyes for the rich purple formerly produced from the roots of the plant. Some costly irrigation works, notably in the Department of the *Bouches du Rhone*, were rendered valueless by this change in the process of dyeing. But the inventive powers and scientific skill of the

French people were equal to the emergency. The water formerly used for the irrigation of madder was applied to other plants, chiefly certain varieties of wine grapes, theretofore believed to be unadapted for wet cultivation, with the result that the total value of the products of the country, as well as that of the irrigation works, remained undiminished. Irrigation canals in the South of France are the property of voluntary associations or Trusts. Designs for the works must be submitted to the Government engineers, whose approval is necessary, and who sometimes superintend the construction of new works or of extensive repairs. France is pre-eminently the land of small holdings; it is the small proprietor, whose little property can be tilled by his own hands, that fully appreciates the value of irrigation. Without men of this class, perhaps few, if any, of the irrigation canals would be constructed; at the same time their lack of capital often prevents the formation of associations capable of undertaking the work.

Spain, with a high mean temperature, has in most parts a moderate or even scanty rainfall. At Madrid, for instance, where the mean temperature is 60 degrees Fahr., the annual rainfall is only 14.4 inches, of which 8 inches fall during the seven hottest months. Some of the rivers, capable of irrigating considerable tracts of country, and which have irrigable lands on their banks, are almost unused; but, in Southern Spain, especially in the province of Valencia, irrigation is very highly developed. Subdivision of land and peasant proprietorship have, in Spain, been carried far beyond the limits within which they might produce results socially beneficial. From this cause it is often difficult or impossible to obtain capital for useful works. It is estimated that there are, in Valencia, considerably over 100,000 acres of irrigated land; the necessity of irrigation in this region being apparent from the fact that, during the six hottest months, the average rainfall is only 4.6 inches. Fortunately, however, the hills to the north of the Huerta are of sufficient magnitude to constitute the sources of three considerable rivers, and of many smaller streams, which have been utilised with such skill and economy that the plains, even while scorching under the heat of the summer sun, are unsurpassed in beauty and in productiveness. The waste of water, throughout Spain, is nevertheless enormous, while the methods of measurement, if they can properly be at all so designated, are worthy of the Dark Ages. This country possesses one of the most perfect codes of law, on the subject of water and water rights, but it is one of the worst administered. The result is that half of its natural resources are absolutely wasted.

Irrigation in Spain.

In Northern Italy, Piedmont and Lombardy are amongst the most highly irrigated tracts. Lombardy seems to combine, within itself, all the circumstances that favour irrigation. The soil is of exceptional fertility, the regular slope of the land makes the application of water particularly easy, abundant supplies from streams that have their rise in the Alps prevent any anxiety as to shortage, in even the driest summers, while the peasantry is industrious and highly skilled in the arts of agriculture. Although the density of population is not so great here as in some other places that have been mentioned, the conditions in general are of the most favourable character. About one-third of the whole productive area is irrigated, but it has to be noted that the rainfall is, for certain crops, generally sufficient.

Irrigation in Italy.

Probably the largest, and in some respects the finest, irrigation work in Europe is the Cavour Canal, in Piedmont, which was originally designed to draw its supply from the Po. Like many other large works, this one was started on an unsound financial basis, besides which an extraordinary error was made as to the minimum discharge to be relied on from the river. This, it was stated, had never been known to carry less than 4,677 cubic feet per second; but after the canal had been built, it was found that during the months of July and August the supply fell to no more than 1,600 or 1,800 feet per second. Fortunately, other sources proved available and at moderate cost. But for this circumstance the Cavour Canal project would have resulted largely in failure.

In Lombardy, it would appear, the administration of the canals has no monetary interest in the question whether the cultivator does or does not make an

economic use of the water supplied to him. The Piedmont cultivator, on the other hand, generally pays according to the area he waters; so that the question of use or waste is of prime interest to the owners of the works. The staple products of the irrigated lands of Northern Italy are butter and cheese, the water being employed chiefly for raising fodder for dairy cattle.

In Southern Italy there is a total irrigated area of about 600,000 acres, chiefly for the growth of oranges and other citrus fruits, which are largely exported. None of the works in the south are on a scale of great magnitude; they consist chiefly of diversions from the streams that flow from the Appenines to the sea on either coast.

Irrigation in
India.

The experience of India is specially interesting to us, because it was there that English engineers first came into contact with a system of irrigation—a system that had, for uncounted centuries, been an important factor in enabling a dense population to maintain the struggle for existence, in face of conditions often extremely adverse. In many respects the physical conditions are not dissimilar from those with which we are familiar in Australia. One immense advantage for the Indian engineers is, that the most important of the rivers have their sources in the greatest mountains of the world, and are fed by their heavy rains and melting snows. Some, however, like our own, pass through hundreds of miles of plain country, and become sluggish streams. The like great differences of level and volume that we find here, are characteristic, though on a much more gigantic scale, of these Indian rivers. Indian irrigation covers districts of high temperature and low rainfall, so low indeed in parts of Northern India that even the scanty figures of the Western country of New South Wales seem large by comparison. There are in India districts where the rainfall does not exceed three to four inches per annum. On the other hand, it also extends to tracts in which the rainfall is excessive at certain seasons, while at others the prevailing condition is arid heat.

Up to 1891 a little over £33,000,000 (taking the rupee at its face value) had been spent on irrigation works generally in India, yielding a net return of 4.2 per cent. Of this sum nearly £30,000,000 had been expended in what are known as productive works, that is works intended to be directly remunerative. Before being sanctioned, seeing that they are to be constructed with borrowed money, and it being held as essential that borrowed money should only be expended on works likely to be remunerative, the projects are severely criticised, not only from the engineering but also from the commercial point of view; yet some have not fulfilled expectations; though, taken collectively, they have covered the interest charges, with a gross surplus to the credit of the Government of nearly £4,000,000, and the profit is increasing year by year. Among the most satisfactory returns are those from the Eastern Jumna, Western Jumna, Godaveri and Cauvery Canals. All of these schemes were initiated by the native governments that preceded British rule, but since being taken over they have been extended, improved, and developed. Considerable sums have also been spent in protective works, that is works not expected to pay directly, but to operate as an insurance against famine; these date only from 1884. The gross area irrigated in India in 1891 was 13,405,195 acres. As illustrative of the vast scale of the profits derived from the irrigated lands of India, it was stated, in the report of the Indian Famine Commission in 1880, that:—"The ordinary rental of land is doubled by irrigation, while in eleven districts in Madras the average rental rises from 1.4 to 5.4 rupees per acre when supplied with water. In Tinnevely the increase is nearly tenfold. In the 8 years preceding 1875-76, the average selling price of irrigated lands in the Cauvery Valley of Mysore was £35 an acre; while the best 'dry' land, at the same time, did not fetch more than £2 or £2 10s."

These are typical examples, covering a very wide range of conditions, of what irrigation has done and of what it may do for the tillers of the soil, dwelling in the more arid regions of the earth. Not one of the cases quoted is so exactly parallel to ours as to be capable, without modification, of being used as a model here. Yet, from one and all of them there is much to be learned that would prove of use to the settlers in the basin of the Murray, if only properly applied.

CAP. 7.— NAVIGATION — ITS EXTENT AND THE VESTED INTERESTS IN AND ASSOCIATED WITH IT. COMPARISON OF ITS CLAIMS WITH THOSE OF GENERAL SUPPLY AND IRRIGATION.

THE navigation of the Murray is, and always has been, largely in the hands of South Australia. The evidence shows that in most years the river is navigable to Wentworth for about seven months. For the last three, however, it has been navigable only about six months in each year. These years have also been unfavourable to navigation of the Darling; which, with the exception of a short distance near the Murray junction, has been practically non-navigable for the whole of that time. The Murrumbidgee may be regarded as navigable to Hay during certain months. A report of the New South Wales Public Works Committee, of 31st July, 1896, states with regard to the Darling that, for the fourteen years preceding, that river had been navigable for, on an average, half the year. Captain King, who has been engaged in the river trade for forty years, said that the Murray is navigable "generally, from May to December, from Blanchetown through to Albury, sometimes from end of July to December." The average is about six months navigation per year." At the time this Commission took evidence in South Australia (May, 1902), there was no navigation above Morgan. Its discontinuance is doubtless a grave inconvenience and often serious loss to the settlers along the river, who are dependent on water carriage for their supplies and for transit of their products. To many the river is practically the sole highway of trade, the cost of land carriage being prohibitive.

Extent and annual duration of navigation.

There are about 90 registered steamers plying on the river, and about the same number of barges; the largest barges having a capacity of about 300 tons. The capital value of this fleet cannot be stated with exactness; but, upon the basis of the evidence of Mr. Tetlow, Manager for Messrs. Permewan, Wright and Co., at Echuca, it may perhaps be taken as about £250,000.

Capital invested in the river trade.

It seems unlikely that the navigability of the river has been appreciably affected by anything done in the way of irrigation, either in New South Wales or Victoria. The volume diverted from the Murray in New South Wales, for this purpose, is at present practically nil; and although some is diverted from the tributaries, as well as from the main stream, in Victoria, the total would have no sensible influence on the level of the river, or the duration of the period of navigation. An important factor affecting the duration of navigation has been the natural storage in certain lakes; a great part of which flowed out as the river sank, so maintaining its volume, sometimes for one to two months beyond that at which navigation would otherwise have ceased. Some of these natural storages are capable of improvement and regulation, their beneficial effect upon the navigability of the river being thereby extended.

Effect of diversions on the navigable volume of the river.

Although the witnesses generally are agreed that it would be a convenience to have the river open for navigation all the year round, there is evidence to show that the periods of actual navigability are sufficient, both for the volume of trade and for the needs of the settlers. One exception, however, should be mentioned. At the Renmark Irrigation Settlement the fruitgrowers suffer considerable annual loss owing to the river being closed at the time their perishable fruits are ripe. A grower, who was offered £150 for his pears when on the point of ripening, had absolutely to lose the whole because he could not get them to market. The like has happened two or three times with regard to this particular crop. One of the principal settlers at Renmark said that, if the river had been navigable in June, which it was not, about 500 cases of oranges per week would have been sent away. It was also stated that at the same time there were from 250 to 300 tons of fruit river-bound at Renmark. Although it was admitted that

Extent of the inconvenience and loss caused by closure of river.

railway carriage is less damaging to fruit, and that the element of time is often a consideration, the Renmark witnesses expressed a desire for the locking of the river rather than the extension of the railway from Morgan. The inconvenience and loss arising from non-navigability of the river has perhaps been felt more acutely at Mildura than even at Renmark, navigation being maintained for some weeks longer at the latter than the former place. To Mildura, however, a railway is now in course of construction, and will probably be completed in March, 1903. This will give direct communication with Melbourne, and incidentally will command several of the large inland towns of Victoria. Opinion at Mildura therefore differs from that at Renmark. The local Shire secretary in his evidence stated that, the railway being assured, the people of Mildura feel little interest in the navigation of the river; their chief interest is now in the conservation of the water for irrigation. It appears, too, that the Mildura Railway Act embodies a Shire guarantee of a rate of 1s. in the £ on the value of property; it is, therefore, the interest of the settlers to send their produce by rail rather than by river, in order to minimise liability under the guarantee. Spite of this, however, there was one of the witnesses at Mildura, Mr. W. B. Chaffey, who expressed the opinion that, as the quantity of fruit produced increases, the river will be valuable as a means of carriage for export.

Value of the
river trade.

It is not easy to arrive at the value of the trade maintained by navigation. How it is regarded by a representative of South Australian interests may be gathered from the evidence of the Honorable Alfred Catt, Chairman of Committees in the House of Assembly. When asked his opinion as to whether the volume of river-borne trade would be sufficient to warrant an expenditure of £350,000 in the construction of locks between Mannum and Wentworth, this gentleman said he was very doubtful whether it is so at present, but the question is whether the locking of the river would not cause an increase in the river traffic. Another view of the value once placed upon the river trade by South Australia appears from the fact that, for several years from 1878, the South Australian Government paid to that of New South Wales £40,000 per annum for the privilege of free trade with the latter colony. This may also be compared with the evidence of the Secretary to the Commissioner for Public Works, who, after stating that in his opinion the Murray should be locked as far as Echuca, the Darling to Wilcannia, and the Murrumbidgee probably to Balranald, said:—"I would like to add that if locking is carried out I maintain strongly that it must be on a basis which would not require the steamers or trade saddled with the expense of interest and maintenance. I do not say there should be no charge, but that it should be a comparatively small one. The effect of saddling the trade with interest and working expenses would be to largely prevent trade going on the river at all." Owners of river boats are of course concerned in the maintenance of navigation, and if it were permanent instead of intermittent, it would no doubt be greatly to their advantage. As it is, the boats are laid up for some months every year, and capital is consequently idle. The Darling is affected in this way to a much greater extent than the Murray.

South
Australia the
outlet for
river traffic.
River trade
decreasing.

South Australia is the natural outlet for a large proportion of the river-borne traffic, and, as before pointed out, it is largely in the hands of South Australians. The volume of this trade, however, far from increasing, has been seriously decreasing of late years. During the last two or three the condition of drought, prevailing throughout a large part of the country that furnishes the trade, may have had an important effect upon its reaching South Australia. A witness at Bourke stated that, in one year, the wool forwarded by his firm amounted to 67,558 bales, whereas during last year it was only 5,500 bales. The Bourke preferential railway rates have, no doubt, had a good deal to do with diminishing the river traffic at that port, but the drought is the chief cause. The extension of Victorian railways and differential rates to various points on the Murray has had still more to do with the decrease in the quantity of wool and other produce carried to Morgan, Murray Bridge, and Victor Harbour, and to a certain extent also the extension of the New South Wales railways to Hay, Bourke, and Brewarrina. It has been urged, in evidence, that it is not the mere construction of railways, but the preferences accorded by them, that have largely affected the direction of trade. A South Australian witness, master of a river

Influence of
railway rates.

boat, said:—"One time we were sole possessors of the Darling, but of late years Victoria wanted to have a slice in it, and imposed preferential rates, and gave us masters a bonus of 6d. per bale for bringing the Darling wool on to Echuca." It was also stated that the rate for wool from Echuca to Melbourne (156 miles) is fixed to compete with the South Australian rate from Murray Bridge to Port Adelaide (69 miles).

Some figures supplied by the Collector of Customs at Port Adelaide, giving the value of imports and exports *via* the Murray, show conclusively how the trade has decreased of late years. For instance, the imports for the ten years 1882-1891 were of the average value of £544,259, while for the succeeding ten years the average was £298,875; the average for each of the last five years being £199,516. The exports *via* the river for the same periods show a similar decrease; the figures being for the years 1882-1891, £185,584; and for the ten years ending 1901, average £77,016 per annum. A portion of the river trade diverted from South Australia has gone to Swan Hill and Echuca, both of which ports have experienced considerable improvement. The inward shipping to the former has increased from 25,784 tons 1896, to 42,447 tons in 1901; while the outward shipping during the same period increased from 26,367 to 43,171 tons. At Echuca, in 1890, the inward shipping was 25,428 tons, while in 1901 it was 28,801 tons, an increase of 3,373 tons during the period. The total of vessels outward at that port in 1890 was 23,865 tons; while in 1901 it was 28,769, or an increase of 4,904 tons.

So far as the lower Murray ports are concerned, as well as Goolwa and Victor Harbour, the railway policy of South Australia itself bids fair to complete what New South Wales and Victorian railway competition had begun. At Victor Harbour, for instance, figures supplied show that for the four years up to 1901 the average number of bales of wool annually exported was 3,473; whereas the average for the preceding ten years was 10,499. Most of it came from the Darling, and a witness expressed the opinion that, although the drought has a great deal to do with the falling off, the diversion of trade by means of the railways to Murray Bridge and Morgan had also contributed. Murray Bridge is 61 miles from Adelaide and Morgan 105, but the rates for river-borne goods are the same from both.

Those interested in the trade of the lower river are much concerned to see a scheme carried out that will have the effect of restoring the trade to what they regard as its natural outlet; a scheme by which the river boats will be able to tranship cargo to ocean-going steamers. Two have been proposed; one to render the Murray mouth navigable for ocean-going vessels, the other to cut a canal for river boats from Goolwa to Victor Harbour. The Murray mouth greatly resembles the entrances of the bar-bound coastal rivers of New South Wales, but its similarity to the Gippsland Lakes entrance, in Victoria, is still more striking. Many proposals have been made for rendering it navigable. Mr. Hickson, in 1876, recommended a piled work at the sea entrance, sheltered by a breakwater 8,260 feet long, without deepening, and the establishment of a transshipping place inside the bar, at an estimated cost of one and a half millions sterling. Sir John Coode, in 1879, questioned whether the result would warrant such an expenditure, and was of opinion that the action of the east winds would shoal up the channel. He considered that the only reasonable prospect of success lay in the construction of two breakwaters running out from the shore, one on either side of the entrance so as to cover it, and terminating in not less than six fathoms at low-water spring tides. The cost of these works, including the breakwaters each over a mile long, he thought would not be less than two millions, and reluctantly concluded that the Murray mouth works involved too large an expenditure, with very doubtful prospects of success. In heavy gales, the waves break through the entrance from 15 to 20 feet high, and the sand bar is constantly shifting its position. One effect of a deep entrance channel would be to increase the saltness of the lakes, which, after a strong north-west or westerly gale, are brackish; the salt water being forced up the channels as far as Wellington. When the wind shifts to the south-east it is again blown out of the lake, a greater quantity running out under

Effect of river trade on sea traffic with South Australia.

South Australian railway policy adverse to river trade.

Schemes to provide a sea port for the Murray trade.

The direct outlet channel.

Saltness of the Murray Lakes and its causes.

these circumstances than during any river flood. The following, according to the report of Lieutenant Goalen, is the discharge at low water on the bar:—

Goolwa Channel	...	...	3,767,000	cubic feet per minute
Coorong	„	...	980,000	„ „
Mundoo	„	...	255,000	„ „

Canal to
Victor
Harbour.

The second project, that of constructing a canal from Goolwa, either to the sea direct or to Victor Harbour, is not new; as far back as 1874 a sum of £150,000 was actually set down on the estimates by Mr. Boucaut for a canal to Victor Harbour. Mr. Lindon Bates, who reported on it in 1901, advocates the construction of this canal in preference to a short cut from Goolwa to the sea. He estimates the cost at £571,000. Upon a former project, to bring the sea-going ships to Goolwa, there have been several reports since the year 1874; but Mr. Bates prefers the smaller canal, to bring the river craft to the ocean-going ships. Mr. Moncrieff, the Engineer-in-Chief for South Australia, although he estimates that the canal could probably be carried out for £473,000, or £100,000 less than Mr. Bates' estimate, does not think that, under present circumstances, it would be a justifiable work. If carried out, this scheme would entail a cost of over £20,000 per annum for interest and working expenses. And, assuming the export of wool as 40,000 bales, an increase of over 20 per cent. on the highest record, the cost per bale would be not less than 10s. for these charges alone.

Several very positive statements were made in evidence by residents in the neighborhood of Lake Alexandrina of the increasing saltness of the lakes at the Murray mouth; the witnesses generally attributing it to the depletion of the river by diversions higher up, especially in Victoria. One gentleman, a station manager, however, attributed the increased saltness observable of late years to the continued drought. Another, master of a trading-boat, also attributed it to the low river. This gentleman said he had known the water of the lakes as salt in past years. Apart from verbal statements, the evidence of facts is against the hypothesis that there has been any increase of saltness in the Murray Lakes by reason of diversions of water from the river channel. We are of opinion that the proper course to maintain a supply of fresh water is the construction of a work at the outlet to exclude the sea, so designed as to discharge river floods over its crest. An estimate of the cost of such a weir was, some years ago, given by the Engineer-in-Chief of South Australia as £51,600. In the apportionment of water recommended in this report, provision has been made of a sufficient volume to make good the losses by evaporation in the Lakes.

Agricultural
and pastoral
landsdemand
water supply.

The occupation, except for pastoral purposes, of vast areas in the three States is only possible with a water supply. These arid portions must remain practically desert, unless the available water is economically distributed. It has been conclusively shown that it is only possible to supply a small proportion of the irrigable land, owing to the limited volume of the river. The employment of its water for navigation, great as may be the advantage in reducing cost of carriage, will therefore have to be a minimum. The irrigable area of 50,042,000 acres, already shown to exist in the three States, consists chiefly of fertile alluvial plains, timbered with myall, wilga, needle bush, and clumps of box and pine. The river frontages and country subject to periodical inundation are timbered with red gum and box. A portion of the land near the junction of the Murray and Murrumbidgee, and a considerable area in Victoria and South Australia, consists of reddish sandy soil, underlain in many places by nodular limestone and covered with mallee. The whole of these are, with a sufficient water supply, capable of profitable agricultural and pastoral settlement. Without it they must remain uninhabited wastes.

The Darling
and Lachlan
country.

The Murray
and Murrum-
bidgee
country.

The levels of the country near the Darling and the Lachlan do not admit of irrigation by gravitation. And, although the cost of pumping, as is proved at Mildura and Renmark, is not an absolute bar to its success, there appear to be few places on these rivers where conditions of soil, proximity to market, &c., make the establishment of irrigation settlements probable. The plain country adjacent to the Murray and Murrumbidgee, on the other hand, is, for the most part, readily commandable by gravitation.

It is estimated by Mr. Allen, fruit expert to the New South Wales Government, that, between Corowa and Finley, there is an area of 600,000 acres of splendid irrigable land adapted to growing fruit, cereals, and lucerne. There are also 10,000 acres of suitable land near Deniliquin, 100,000 acres near the junction of the Murray and Murrumbidgee, 20,000 acres near Euston, and 20,000 acres near Gol Gol. The latter he considered equal to the best Mildura land, and suitable for olives, raisins, sultanas, etc. Much of the country west of Moulamein is of a heavy clayey nature, and not suitable for irrigation; and there is also a large belt of polygonum country, entirely unsuitable for cropping. Mr. Cobcroft, District Surveyor, estimates that the area within the Wagga Wagga district that will be affected by the proposed Murray and Murrumbidgee canals is 3,401,380 acres. A very large extent of this is agricultural land, mostly a strong reddish loam. Of the remainder the soil is of a clayey nature, with belts and patches of loam suitable for cultivation. Under existing conditions, on the timbered agricultural lands, an average area of 700 or 800 acres would be necessary for the maintenance of a settler; but, given a permanent water supply and opportunity for irrigating, half this area would suffice. Of the clayey plains, about 2,000 acres would be necessary to maintain a settler, but, with a permanent water supply, this might be reduced to 1,200 acres. Mr. Cobcroft is of opinion that the present water supply is quite inadequate for the requirements of settlement, as the principal watercourse, the Billabong Creek, is generally a chain of waterholes. Mr. Broughton, District Surveyor of Hay, states that 9,100,000 acres within his district will be affected by the proposed Murray and Murrumbidgee schemes; the whole of which is suitable for grazing. The best agricultural land is situated south of a line running westerly from Coree to Morago, and comprises an area of 300,000 acres.

Irrigable land
in Riverina.

Lands in the
Wagga
district.

Existing water
supply
insufficient.

Lands in the
Hay district
suitable for
settlement.

As to Victoria, Mr. Kenyon, of the Water Supply Department, classifies the irrigable areas thus:—Irrigable river flats in the mountain districts, 24,500 acres; river flats liable to submergence and therefore to a certain extent naturally irrigated, 224,000 acres; land eminently suitable for irrigation, forming the "plains" of the various river valleys, 3,700,000 acres. The total of nearly four million acres is, however, in Mr. Kenyon's opinion, beyond the practicable limit of irrigation works; their cost would be prohibitive. But there would be no difficulty in providing, at reasonable cost, for 2,000,000 acres; and this, he thinks, is the limit of area in Victoria that can be profitably irrigated.

Irrigable
lands in
Victoria.

The irrigable area in South Australia is stated at 2,500,000 acres. Little or none of it is commanded by gravitation; while of that within a lift of 110 feet at low water of the river the evidence shows that, under present conditions, not more than 250,000 acres can be expected to be occupied for intense culture.

Irrigable
lands in
South
Australia.

On the whole, the weight of evidence is in favour of considering irrigation as superior in importance to navigation. The views of some of the witnesses are, however, evidently tinged by the interests of the districts in which they live, or by their trade or business connections. As to the Darling, one witness expressed the opinion that, if there were no navigation of that river, settlement would die out. No proposal, however, has yet been made that would have the effect of rendering the Darling non-navigable, or even sensibly less navigable than it is now in ordinary seasons.

Effect of the
weight of
evidence.

Col. Home, R.E., who reported to the New South Wales Government on the prospects of irrigation in that colony in 1897, speaking of this river, says:—"The Darling has throughout a deep well-defined channel which only overflows during high floods, when a great deal of flat country is under water. Beyond this flat area the ground rises on either side, in some places rapidly. The channel is very tortuous, the distance by river from Walgett to the confluence of the Murray at Wentworth being nearly 1,200 miles, and the fall in flood surface averaging little over 3 inches per mile; at Bourke the floods rise over 40 feet. The supply in the river is not to be depended upon, there being no regular rainy season in the catchment area, and the flow in it has even been known to cease altogether. In these circumstances it is impossible to look for irrigation on the Darling by gravitation or from reservoirs filled by the river when it is in flood. The former

Col. Home's
report on the
Darling.

plan might be resorted to in places where a good water-hole exists, and where suitable land can be found on the margin of the river; but most of the flooded land is not suited to irrigation, and this class of irrigation could hardly be practised on a large scale. The latter plan would have greater advantages, but the difficulty in this case is to store a sufficient depth of water to cover the loss by evaporation, etc., during the period between floods."

Navigation must be held subservient to water supply and irrigation.

The conclusion is unavoidable that, although existing vested interests demand certain substantial concessions in favour of maintaining the navigable condition of the rivers, the extension of navigation, except by the construction of locks, is not to be looked for. It is further evident that, in the event of circumstances at any time causing a conflict of interests, the demands of navigation must yield to those of general supply to settlers and for the irrigation of land.

CAP. 8.—EXISTING AND PROPOSED WORKS IN THE STATES OF NEW SOUTH WALES, VICTORIA, AND SOUTH AUSTRALIA, AND DIVERSIONS OF WATER FROM THE MURRAY AND TRIBUTARIES.

THE following is a brief summary of the principal works in New South Wales:—

- Tuppal Creek Cutting.** Tuppal Creek Cutting takes off from the Murray $1\frac{1}{2}$ miles below Tocumwal; it has a length of $4\frac{1}{2}$ miles. The diverted water is used for stock and domestic purposes; the surplus returning to the Murray through the Edwards River.
- Eagle Creek Cutting.** Eagle Creek Cutting takes off immediately above the village of Barmah. The water is used for stock and domestic supply. The cutting is about 3 miles in length, and cost, including head regulator, about £6,000.
- Wakool Cutting.** The Wakool Cutting leaves the Edwards 5 miles below Deniliquin. It was completed in 1902 at a cost of £3,000.
- Yanko Creek.** The only work carried out in the Murrumbidgee district is the improvement of the Yanko Creek; paid for in part by private subscription, in part by the Government.
- Lake Cudgellico.** The Lake Cudgellico works are about 9 miles in a direct line south-westerly from Euabalong. A cutting of $2\frac{3}{4}$ miles leads from the Lachlan towards the lake. There is a regulator at its head, so that the water diverted is under control. It is intended to conserve flood waters and draw off when the river is low. The volume that can be stored is about 1,185,000,000 cubic feet. The cost of these works has been £22,000.
- Booberoi Creek.** The Booberoi Creek works are about 11 miles north-easterly from Euabalong. They consist of a concrete weir on the Lachlan, and cutting to Booberoi Creek, about a mile in length. There is a controlling regulator at the head. Water is backed by the weir for a distance of about 20 miles, with a maximum depth of about 17 feet. The cost has been about £7,500.
- Willandra Billabong.** The Willandra Billabong Creek head works are about 23 miles north-easterly from Hillston. They comprise a timber crib weir, a dam in the river, and a cutting to the creek. Water is backed in the river about $12\frac{1}{2}$ miles, with a depth of 14 feet. Willandra Creek itself has been improved for a distance of about 10 miles. There is at present a drop board regulator at the head of the creek, but it is proposed to build a permanent structure to command the flow down the cutting. The cost so far has been about £10,000.

The head of the Middle Billabong Creek is about 15 miles north-easterly from Hillston. There is a timber weir in the river, and cutting leading to the creek. Water is backed for a distance of 15 miles, with a depth of 15 feet. There is a low regulator at the head of the cutting; but, as in the case of the Willandra Creek, it is proposed to eventually provide a work that will properly command the diversions. The cost to date has been £8,200.

Middle Billabong Creek.

The Gin Gin Weir, on the Macquarie River, is 25 miles in a direct line upstream from Warren. It is of solid concrete, and diverts water down Ewenmar Creek, *via* Crooked Creek. The weir, which is about 28 feet high, backs water for a distance of about $21\frac{1}{2}$ miles. The Crooked Creek Cutting has a length of about 1 mile. The cost of the works was £26,000.

Gin Gin Weir.

The Belaringar Cutting is 7 miles, in a direct line, upstream from Warren, and has a length of about $1\frac{1}{4}$ miles to Belaringar Creek. The cost has been £4,100.

Belaringar Cutting.

Warren Weir, 3 miles upstream from Warren, is a timber crib work, and raises water to Gunningbar Cutting. It holds back a supply for a distance of about 15 miles. By its means water is diverted to Cookamurra Creek and Crooked Creek, and from the last named, by a cutting, to Duck Creek. Total cost about £10,000.

Warren Weir.

There are three cuttings in connection with schemes for diverting water in the Gwydir River District. No. 1, $1\frac{1}{2}$ miles in length, takes off from the great ana-branch of the Gwydir about $2\frac{1}{2}$ miles in a direct line north-westerly from the town of Moree; No. 2, from the Meehi River, about $1\frac{3}{4}$ miles below the junction of Wee Waa Creek, is about $2\frac{1}{4}$ miles. No. 3, from the Moomin Creek, in the Parish of Millibee, is about 5 miles. There is a weir at the head of each of these cuttings. The total cost has been £22,500.

Works in the Gwydir River District.

The whole of the foregoing works are for stock and ordinary supply only.

The Hay and the Wentworth Irrigation Trusts have been already referred to. Their works call for no special reference or further description here.

Hay and Wentworth Irrigation Trusts.

No works carried out in New South Wales materially affect either the Murray or its tributaries. Diversions are merely along the course of natural channels, which have been improved, and which eventually return the balance of diverted water, after a portion has been used for stock and general purposes, to the main stream. The Lachlan contributes so little that it may almost be classed as non-effective. The enlarged supply obtained from some of its effluents, by improving their beds, etc., amounts to no more than the utilisation of that which would otherwise be lost by soakage and evaporation in swamps.

Works do not materially affect river.

With a view of providing permanent navigation on the Darling, several investigations were made. At length it was decided to construct an experimental lock and weir two miles below the town of Bourke. The site does not appear to have been judiciously selected, as a large sandbank has formed and blocks the approach. The type of weir adopted is the Chanoine, which has been successfully tried, both in France, where it was invented, and in America. On the Seine, several of this type have been in use for a number of years. The lock is of concrete, on the right bank of the river, and is 200 feet long by 37 feet wide. The weir consists of a series of timber shutters, which, in time of flood, lie flat on the river bed; but, when the river falls below navigation level, are lifted in succession. At the back of each shutter there is a vertical trestle with a sloping strut. The total cost of the work, the first of its kind constructed in Australia, has been £23,000. Neither the lock nor the weir can be said to have been a success, though doubtless something may be learned from their failure.

Bourke Lock and Weir.

From Narrandera downwards on the Murrumbidgee, and from Bungowannah on the Murray, the natural conditions are very favourable for irrigation. The levels are exactly suited to the construction of canals, and a large percentage of the soil is admirably fitted for irrigation. The rainfall decreases rapidly towards the western end of the tract of country between the Murray and Billabong. West of Deniliquin

Irrigation for the Riverina country.

Tocumwal
Canal.

the average is about 15 inches, while to the east it is nearly 20. This consideration led Colonel Home to suggest investigating a scheme for a canal from the Murray at Tocumwal that would serve to irrigate the drier country to a point beyond Maude on the Murrumbidgee. Mr. Wade, Principal Engineer for Water Supply and Sewerage, has shown in his evidence that a canal from Tocumwal could be carried across the Murrumbidgee at Pevensey, below Hay, terminating at about 140 miles further on, at a cost less than that of the Bungowannah scheme.

Bungowannah
Canal.

The proposed canal from Bungowannah, of which surveys have been made, would provide for the irrigation of the tract between the off-take and the Edwards River, north of Deniliquin. Branches would be taken to Jerilderie, Conargo, Mulwala, and Deniliquin. The main canal, as originally proposed, would have a capacity of 78,000 cubic feet per minute. It would be 129 miles in length, with branches totalling 175 miles. The estimated cost, including one-half of the weir and head works, would be £732,000. In the apportionment of the waters of the Upper Murray, however, it has been found that only 60,000 cubic feet per minute will be available for New South Wales from that source, and, as a portion of this volume will be required for the country west of Tocumwal, it would not be prudent to make provision for more than 50,000 cubic feet per minute to be diverted at Bungowannah. The estimated cost of the weir and canals for the smaller supply will be £550,000. It is concluded that about 300,000 acres could be irrigated each year from this work. Assuming that one-seventh of each holding would be irrigated annually, the canals might be said to command 2,000,000 acres for irrigation. The evidence is emphatic that the Bungowannah canal would traverse some of the best irrigable land in New South Wales, and, although the rainfall is greater than in the country west of Tocumwal, it would be better to take off at Bungowannah. Another argument in favour of the Bungowannah scheme is that it would serve an area on which there is already settled a population of practical farmers prepared to utilise the water, while the Tocumwal scheme would benefit only a few large landholders.

Victorian
Works.

In the State of Victoria, works for the conservation, diversion, and distribution of the waters of the Murray basin are much more extensive than in New South Wales.

The Goulburn
National
Works.

The Goulburn National Works comprise a weir on the Goulburn River, eight miles above Murchison, and nineteen and three-quarter miles of Main Channel, with regulators, off-takes, etc. The weir raises the summer level of the river about 45 feet, and provides an available storage of 670,000,000 cubic feet for the channel. Its length, over abutments, is 695 feet, exclusive of the head-gates, a further 230 feet. The waterway of the weir is occupied by 21 flood-gates, each 20 feet horizontally by 10 feet vertically in the clear. Each gate weighs 7 tons, and is worked by screw gearing, the motive power being obtained from the river itself. An electric lighting plant is provided for convenience of night work during floods. The Western Channel has a bed-width of 110 feet, normal side-slopes $1\frac{1}{2}$ to 1, full supply-carrying depth 7 feet, and capacity, according to Kutter's formula, 103,000 cubic feet per minute. The proposed Eastern Channel has not yet been constructed. The Rodney Irrigation, and the Echuca and Waranga Waterworks, Trusts are supplied from the Western Channel. The total cost of the works, so far, has been £465,000, of which £144,000 was paid for land compensation.

Broken River
National
Works.

The Broken River National Works comprise two weirs of cement-concrete masonry on the Broken River, one about six miles below Benalla, known as Casey's Weir, the other at Gowangardie, about fifteen miles lower down. They were constructed by the Tungamah, Numurkah, and Shepparton Shire Waterworks, Trusts, and made National Works by Act of Parliament in 1900.

Loddon
National
Works.

The Loddon National Works comprise a regulating reservoir on that river, about half a mile above Laanecoorie, and two weirs for diversion, at Bridgewater and at the effluence of the Kinypanial Creek. The Laanecoorie Storage is a compound structure, the portion in the river bed being an overshot weir of concrete masonry, with a row of wrought iron automatic gates (of the type invented by Chaubart) along the crest. The remainder is in the form of an earthen embankment. The length of

the masonry weir is 320 feet, and of the earthen extension 700 feet. There are four thirty-six inch outlets, controlled by valves. The impounded water extends some five and a half miles up the river valley, the depth to the inverts being thirty-two feet, and the available contents, 610,000,000 cubic feet. The total cost of the work has been £133,000, of which £47,000 was for land compensation.

The Bridgewater Weir is of concrete masonry, and forms a kind of cap to a natural barrier of basalt rock crossing the river at this point. Its function is to divert water into the Bridgewater Channel, which supplies the Bullock Creek.

The Kinypanial Weir is of timber. Its purpose is to regulate and control the diversions into a cutting to the Kinypanial Creek, and for the North and East Boort Irrigation, and the Loddon United Waterworks, Trusts.

The Kerang Lakes National Works consist of a weir on the Loddon River, just below the town of Kerang, constructed by the Swan Hill Shire Waterworks Trust, and taken over by the Board of Land and Works; regulating weirs on the Sheepwash and Washpen Creeks, which are supplied from the Kerang Weir; channels thence to Reedy, Middle, and Third Lakes, Lake Charm, Racecourse, Cullen's, and Kangaroo Lakes, and Lake Tutchewop; and an overflow channel from Lake Tutchewop to the Little Murray at Fish Point. The supply is obtained from the River Loddon in times of flood; or, failing this, from the River Murray, *via* the Kow Swamp National Works and the Pyramid Creek, which enters the Loddon just above the Kerang Weir. The cost to date is about £9,000.

Kerang Lakes
National
Works.

The Wimmera River National Works consist of a storage reservoir at Lake Lonsdale, distributing channels to the Mallee country, and storage weirs on the Lower Wimmera.

Wimmera
River
National
Works.

The Lake Lonsdale Storage Dam is of earth, with an inner core wall of clay, extending northward 7,695 feet, from the high ground on the northern slopes of Mount Dryden to the Little Wimmera River. The channel is crossed by a masonry weir, 310 feet long, with bywash excavated out of the rock on the right bank. The reservoir has a maximum depth of 16 feet, and an available storage capacity of 1,981,000,000 cubic feet. This work is in course of construction, and will be completed early in next year. The cost, including land purchase and all charges, will not exceed £50,000.

Lake
Lonsdale.

The distributory works comprise a channel from the Donald weir, on the Richardson River, of a length of 22 miles; with branches to Birchip West, Sea Lake, Tyrrell West, Boigbeat and Nine-mile, and Kaneira, totalling about 200 miles. The cost will be £38,000.

Distributory
Works.

There are also four weirs to be constructed on the Wimmera; near Dooen, at Dimboola, at Antwerp, and at Jeparit. With the exception of the last, which will be a compound structure, they will be timber weirs, with movable crests to provide for the passage of floods. The depths impounded vary from 8 to 10 feet, and the length backed up from 2 to 8 miles. The total cost of the four is estimated at £7,500.

Lower Wim-
mera Weirs.

The Kow Swamp National Works are for the supply of water for irrigation to the Lower Loddon District. They comprise an in-take and regulator, at the effluence of Gunbower Creek from the Murray River, for diversion into a natural lagoon, known as Kow Swamp. The Gunbower itself and Taylor's Creek are utilised, as far as possible, as part of the channel of conveyance. The Kow Swamp reservoir is capable of storing 1,780 millions of cubic feet, available for summer use. A channel is also carried round the Swamp, from Taylor's Creek, to join the Macorna Channel, which issues from the storage at its north-western point; supply being thus available both from the Murray direct and from the storage. The Macorna Channel reaches the Loddon at a point about 12 miles south of the town of Kerang, crosses the river by a wrought-iron siphon, and terminates at a total distance from the Gunbower in-take of $44\frac{1}{2}$ miles. It has a carrying capacity of 10,000 cubic feet per minute. The inlet sill to the Gunbower Creek is at such a level that diversions take place only when the river is above full navigation level. The total cost of the works, including land compensation, has been £179,000.

Kow Swamp
National
Works.

Coliban
Scheme.

The Coliban works supply water for domestic, manufacturing, and mining purposes to the City of Bendigo, the boroughs of Chewton, Castlemaine, Eaglehawk, and Raywood, and the townships of Taradale, Fryers, Maldon, Huntly, and Sebastian, and water for mining, irrigation, and general purposes to the interjacent districts. The scheme includes two principal storage reservoirs on the Coliban River, one at Malmsbury, the other about 10 miles higher up, with capacities of 3,337 millions and 4,093 millions of gallons respectively; a total of 7,430 million gallons, or nearly 1,190 millions of cubic feet. There are also 284 miles of main and branch channels, 25 subsidiary reservoirs and tanks with an aggregate storage capacity of 1,407 millions of gallons, 265 miles of main and reticulation pipes, together with flumes, bridges, and other works. Both reservoirs are of earth, the lower 1,727 feet in length by 60 in maximum height, the upper 883 feet long and impounding a depth of 63 feet. The total debit to capital account of the Coliban Scheme is, at present, £1,132,000.

Long Lake
Pumping
Scheme.

Long Lake Scheme includes a pumping plant of 3,000,000 gallons per twenty-four hours, seven miles of eighteen inch diameter wrought-iron pipe, and about eighty miles of main distributary channels, of four feet bed width, with ruling grade of one foot per mile. The supply is from Long Lake, about ten miles south-east of Swan Hill, fed by overflow from the Little Murray in times of high river. It will be for the supply of part of the Eastern Mallee, the construction being just entered on.

Trust Works
in Victoria.

Besides the Mildura Trust, already referred to, there are in existence, within the Murray Basin, in Victoria, twenty Irrigation Trusts and seven Waterworks Trusts. The districts under their jurisdiction are shown on one of the plans accompanying this report. The works carried out by them comprise weirs, dams, storages, and off-takes, regulators, channels, etc., and supply for stock and ordinary use, and for irrigating a large area of country. These do not include the supplies to towns, of which there are a great number within the area, but whose demands are relatively so small as to be a negligible quantity in the present enquiry.

Proposed
Works in
Victoria.

There are certain works now proposed in Victoria, in fact decided on, though not in detail, and already in their initial stages. The principal of these are:—The Waranga Basin, to store 7,500 millions of cubic feet of the waters of the Goulburn; a Main Channel westward from this storage, to serve the country as far as the Yarriambiack Creek, in the Mallee, and to supplement the supply to the Mallee; the Eastern Goulburn Main Channel, to provide an irrigation supply to the country included in the Shepparton and Numurkah Trusts; and a Storage Basin on the Wimmera River, to supplement the supply from Lake Lonsdale.

Other proposals have been examined and entertained, but none of them are sufficiently definite to warrant their inclusion in the list of settled projects.

Proposed
Works in
South
Australia.

Certain proposals for construction of works have been made in South Australia. The chief of these are the Lake Bonney, Morgan, and Burra Creek irrigation schemes. In 1894, the South Australian Parliament passed an Act providing for the establishment of an Irrigation Colony near Lake Bonney, between Morgan and Renmark. Preliminary surveys have been made in anticipation of a commencement of the work. The area of the proposed settlement is 100,000 acres, the land being similar to the Renmark Irrigation Colony.

Schemes are also under consideration at Morgan and Burra Creek, and detail surveys have been made of the sites. The area set apart at Morgan is about 2,000 acres, at Burra Creek about 2,500 acres, with provision for extension in both cases. Although the lift will be greater than at Renmark, it is anticipated that these projects will pay; as, owing to their proximity to the railway, they will command a ready market for perishable fruits.

The annual diversions authorised and unauthorised, in the three States are, as nearly as can be ascertained, as follows:—

IN VICTORIA.

						Mean annual diversion in cubic feet.
Murray ...	...	...	1898-1901	...	...	6,986,000,000
Goulburn ...	...	...	1898-1901	...	...	4,135,000,000
Broken River ...	...	...	1898-1901	...	...	955,000,000
Campaspe ...	...	...	1898-1901	...	...	1,033,000,000
Loddon ...	...	...	1899-1901	...	...	4,885,000,000
						17,994,000,000
Unauthorised "pumping"	200,000,000
Total ...						18,194,000,000

IN NEW SOUTH WALES.

Murray, etc.	510,000,000
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IN SOUTH AUSTRALIA.

Murray	541,000,000
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The Government of Victoria has entered into certain quasi obligations by giving authority to Trusts and persons to divert from the Murray and tributaries within her territory. So far as the tributaries are concerned, these are not of sufficient moment to affect navigation; there can be little doubt, therefore, that in these she is within her rights. So far as regards the Murray itself, there may be grave doubts as to the legality of these authorities; but, as they relate to a total volume—a mere fraction of that proposed to be conceded to Victoria by the recommendations of this Commission—it is unnecessary to further refer to them.

CAP. 9.—WORKS PROPOSED BY THE COMMISSION.

INVESTIGATIONS have been instituted, on behalf of Victoria and New South Wales, by the officers of the latter State, and by Mr. Thos. Murray, an Engineer of the Victorian Water Supply Department, with a view of ascertaining the most suitable site for a reservoir on the Upper Murray. Surveys and borings have been made at Talmalmo, Thologolong, and, on the advice of Mr. T. Murray, at Cumberoona, respectively 55, 40, and 20 miles above Albury. Mr. Wade, the Engineer-in-Charge, states that he considers the Cumberoona site the most suitable, on the ground both of capacity and cost. A dam 70 feet high would impound 25,367,000,000 of cubic feet, and would be 8,000 feet long from the New South Wales to the Victorian side of the Valley. Its cost is estimated at £670,000, and the land resumptions at £117,500, or a total of £787,500. The total area submerged would be about 23 square miles.

Proposed
Upper
Murray
Reservoir.

Calculations, based on the gaugings of the past eleven years, show that a volume could have been drawn off sufficient to make, with the added discharges of the Mitta and Kiewa, a nearly continuous flow of 180,000 cubic feet per minute throughout the year. This it is proposed should be divided equally among the three States, in consideration of their bearing equal shares of the cost. In most years the basin would have been overflowing for several consecutive months; while in 1894 it would have been so for nine months. Although the total volume passing Bungowannah in the year 1901 was greater than in many previous years, yet, owing to the low winter discharge of the Mitta and Kiewa and the reduced flow of the Upper Murray, the volume of 180,000 cubic feet per minute could not have been maintained, during three months of that year. The mean discharge at Bungowannah for these three months would have been as follows:—

May ...	...	...	102,880 cubic feet per minute
June ...	...	...	150,700 " "
July ...	...	...	101,450 " "

Thus the deficiency, a comparatively small one, occurred during the months when a full supply would not have been required in the irrigation channels, whilst the reservoir, though empty at the end of July, would have been refilled and overflowing in the early part of September. A diagram attached to the report shows how the reservoir would have behaved during the eleven years 1891 to 1901.

Lake Victoria
Reservoir.

Lake Victoria is near the Murray, below the town of Wentworth, and about 50 miles above the South Australian border. It covers an area of about 30,000 acres, and is connected with the main stream by the Rufus River, through which it is fed when the Murray is high. The level of water permanently impounded by the bar is R.L. 73.00, whereas flood marks show that the Lake has been filled to R.L. 90.00, the storage between the two levels being 17,000 millions of cubic feet. Mr. Sharman, the manager of Lake Victoria Station, states that he has seen the outflow from the Lake keep the river navigable to South Australia for four weeks after it had been closed above the Rufus. In order that full advantage might be taken of such floods, the Lake could be filled by raising the river level below Frenchman's Creek, and diverting through it to Lake Victoria. It is estimated that a weir on the river would cost £80,000, and the improvement of Frenchman's Creek and the erection of embankments and regulators £4,800, or a total of £84,800. These works would make possible the storage of 22,399 millions of cubic feet, a volume which, while allowing for evaporation at the rate of 60 inches per annum, would provide, in times of low river, 100,000 cubic feet per minute for a period of nearly four months. The cost of the Lake Victoria Storage, it is also proposed, should be borne in equal shares by the three riparian States.

Besides the works described in the foregoing, there are many other possible storages that cannot be particularised. On the Darling, Lachlan, Murray, and Murrumbidgee there are numerous lakes or natural reservoirs that receive large volumes of water in floods. When the river falls, the impounded water is released and flows back into the stream, contributing largely to its volume. On the Darling alone there are 70 lakes, the largest being Lake Cawndilla, which has a storage capacity of 7,196,000,000 cubic feet. Lake Menindie, it is estimated, will impound 16,700,000,000 cubic feet. The outflow from Lake Menindie alone, after having been filled by flood waters, has been observed to maintain navigation in the Lower Darling for many months after it had ceased higher up.

The importance of some of the lakes on the Darling may be understood from evidence given by Mr. A. F. Cudmore, of Avoca Station. This gentleman stated that the lessees of the station obtained an Act of Parliament authorising them to make a cutting from the Darling for 10 or 12 miles in order to take flood water from that river at a lower level. By means of this cutting, and by erecting dams across the ana-branch, the flood waters were backed up into lakes covering approximately 180 square miles. The depths vary from 6 to 14 feet, the average being about 10 feet. These lakes were filled to the brim in the 1890 flood, and even then an immense amount of water got away. The stored water remained in the best holding ground for about five years.

Locks and
Weirs.

Some reference has already been made in this report to the subject of locks as means of promoting navigation. Estimates have been placed before the Commission of the cost of locks and weirs in the Murray, Murrumbidgee, and Darling. As to the South Australian portion of the Murray, Mr. Moncrieff, Engineer-in-Chief for that State, submitted plans for a typical lock and weir, which he estimates can be constructed for about £100,000; and he thinks that the cost of locking the river between Blanchetown and the New South Wales border will be, approximately, £600,000. The raising of the water level by these weirs would have the effect of submerging an area of over 85,000 acres of river flats.

From the South Australian boundary to Echuca, a distance of 666 miles, Mr. Wade estimates that twenty locks would be required at an estimated total cost of £730,000. The locks would be 200 feet long by 37 feet wide, and the lifts from 5 to 15 feet; the average length of each reach would be 31 miles. The surface area

of water in the length of river channel referred to would be 26,222 acres, and the water impounded 16,278,000,000 cubic feet. Assuming that there would be 400 lockings per annum, the quantity required, for this purpose, would be 38,640,000 cubic feet.

For locking the Murrumbidgee from its junction with the Murray to Hay, a distance of 240 miles, Mr. Wade estimates that nine locks would be required; the average distance between locks being $26\frac{1}{2}$ miles, and the average lift 11 feet 3 inches. The volume impounded in the river would be 3,443,000,000 cubic feet. On the assumption of 400 lockings per annum, the quantity lost in this way would be 67,620,000 cubic feet. The estimated cost of the scheme is £321,750.

For the Darling, a scheme was prepared in 1890 by Mr. C. W. Darley, then Engineer-in-Chief for Public Works, New South Wales. He proposed the construction of forty locks and weirs between Wentworth and Walgett, at an estimated cost of £1,420,000. Mr. Darley proposed fixed weirs. Mr. Wade has substituted movable weirs, increasing the average lift from about 8 feet to about 13 feet; reducing the number of locks to twenty-four, and the cost to £920,000.

For providing locks and weirs for the navigation of the Murray, Murrumbidgee, and Darling, the total estimated cost is as follows:—

MURRAY—	No. of Locks.	Estimated Cost.
Blanchetown to State boundary of South Australia	6	£600,000
South Australian boundary to Echuca	20	730,000
		£1,330,000
DARLING—		
Wentworth to Walgett	24	920,000
MURRUMBIDGEE—		
Junction of Murray to Hay	9	321,750
Total		£2,571,750

CAP. 10.—LEGAL ASPECT OF STATE RIGHTS AND PRINCIPLES TO BE ADOPTED IN APPORTIONMENT OF WATERS.

IN considering the just allotment of the waters of the Murray Basin to the use of each of the States of New South Wales, Victoria, and South Australia, the legal grounds of their several claims cannot be entirely ignored. But the uncertainty of the effect of decisions—Common law alone being applicable—on the various questions involved, renders it impossible, even were it advisable, to deal with them on this sole basis. Considerations of policy, of vested interests, and of the general welfare of the people must be accorded due weight in the settlement. It would be a public calamity that State rights should be left to be fought out in the courts; it would be hardly less calamitous to attempt to deal with them on what might be deemed strictly legal grounds, untempered by other considerations. Of the possible diversity of opinion as to these rights arising among trained lawyers, an idea may be gathered from a perusal of the evidence tendered in the course of the enquiry. What may, not improperly, be termed legal opinions were given by seven witnesses, of whom three are practising lawyers, as well as members of either the Federal or State legislatures; two are professors of law in Australian universities, and two are State officials.

Legal witnesses, diversity of opinion,

To fully appreciate the effect of their evidence, it is necessary to go back a little, and to look at the Imperial Act 18 and 19 *Vict.*, *Cap.* 54. Section 5 of this Statute contains the following:—“Whereas by an Act of the fourteenth year of

Section 5 of
Imperial Act
18 and 19
Vict.,
Cap. 54.

Her Majesty chapter fifty-nine it is amongst other things enacted that the territories therein described should be erected into a separate colony to be known and designated as the Colony of Victoria. And whereas doubts have been entertained as to the true meaning of the said description of the boundary of the said Colony it is hereby declared and enacted that the whole watercourse of the River Murray from its source therein described to the Eastern boundary of the Colony of South Australia is and shall be within the territory of New South Wales." The section goes on to provide that it shall, nevertheless, be lawful for the two colonies separated by the river to make regulations for the levying of customs duties on goods imported by way thereof, and for the regulation of navigation by their vessels trading thereon. It also makes it competent for them, by agreement, to define in any different manner the boundary line along the course of the river.

Effect of the
Section as to
jurisdiction
over and
rights in the
Murray.

It does not appear that the legal effect of these words has ever been pronounced upon judicially. There has been one case, however, in which the Judicial Committee of the Privy Council gave an award in a matter in which the words of the section were necessarily involved. This was the case of the disputed ownership of Pental Island, near Swan Hill, which is bounded on the north by the Murray, and on the south by the Murrabit, an ana-branch of the Murray, but also contributed to by the Loddon, a purely Victorian river. In 1859, the island being at that time in occupation of a tenant, holding a lease from the Victorian Government, New South Wales raised the question whether it was not part of the territory comprised within the boundary declared by Section 5 of the Statute above quoted from. After protracted negotiation, it was resolved, in 1870, that the two colonies should each prepare its case, and that the question should then be remitted to the Judicial Committee of the Privy Council, the colonies undertaking to abide by the decision, as the Committee had no jurisdiction as a legal tribunal to entertain the matter. The proceedings assumed the form of an arbitration, and the award gave Pental Island to Victoria. Referring to this, one legal witness says:—"If that had been argued in the ordinary way, so as to be capable of being quoted in courts, that would be a very strong case, because it shows that, at all events, the Judicial Committee considered that Victoria had a riparian frontier." Another legal witness expressly concurs in this view, and refers to the Pental Island award as a very strong decision indeed. But the opposite view finds a supporter in a witness who holds that, since the waters of the Murray, from their source to the boundary of South Australia, pass wholly over New South Wales territory, they are the property of New South Wales. The contention is based on the well-known legal maxim that "*whosoever owns the land owns all that is thereon.*" This gentleman held that the grant to New South Wales was absolute and unqualified; besides which, there was no court having powers to restrain that colony in the use of the waters, and no executive with powers to enforce restraint. A less absolute view of the rights of New South Wales, conferred by Section 5 of *Act 18 and 19 Vic., Cap 54*, is that this colony is invested with exclusive rights of legislation in regard to the Murray; the term "watercourse" in the Statute being held to include the water in the channel as well as the bed and banks thereof. This view would, of course, imply that any Victorian legislation purporting to authorise or control diversion of the Murray waters would be in excess of her authority. It was further held that the conferring of exclusive powers of legislation over the Murray upon New South Wales did not destroy the riparian rights of Victoria as an adjacent owner, the right to the water being pertinent to the ownership of the banks, not the bed, and limited to such a use as does not diminish the customary flow. Again, it was asserted that the Imperial Parliament never intended to grant the whole of the waters of the Murray to New South Wales; the object of Section 5, already cited, was to confer criminal jurisdiction, which might otherwise be of doubtful residence in either colony. A practically identical view is that both the State of Victoria and its citizens, riparian owners within the State, are entitled to an easement, almost tantamount to a right of property, in the water of the river. It has to be borne in mind that, legally, there is a wide distinction between rights of property and rights of government. The majority of the witnesses admitted the

rights of Victoria as a riparian State to a certain easement in the river waters, a right that was absolutely denied by only one of them. A majority also held, subject to certain minor differences, that the sole jurisdiction over the river, and the exclusive right to legislate in regard to it, are vested in New South Wales.

As to the tributaries of the Murray, the witnesses agreed that the rights of the States within their own boundaries have not been affected by federation; except that they have been restricted in respect of diversion, when this would impede the navigation of the main river. This restriction is, by some, held to be subject to the State rights of reasonable use, reserved by Section 100 of the *Commonwealth Constitution*. By others it is held that Section 100 does not abridge the right of the Commonwealth to see that the navigable depth is maintained. The balance of opinion was also that, before federation, each colony had full control over and power to use all the waters within its own territory, irrespective of the effect such use might have on the waters of the Murray itself. It was even held by some that the only limit to the right of New South Wales to the absolute use of the waters within her territory, including the Murray to the South Australian boundary, arose out of the obligations of comity towards the neighbouring States. Following this doctrine, Victoria would be within her powers in granting rights of diversion from the tributaries; she would exceed them in granting rights in the main stream. The opposite view was put forward in the form of a claim on behalf of South Australia, that she is entitled to a share in the waters of the Murray and of all the tributaries of that river. This appears equivalent to a declaration that riparian rights of States, within the Murray Basin, are subject to the ordinary rules of Common law affecting private proprietors. Riparian Common law, it was stated in this connexion, is applicable between the States as between individuals. Another view was that riparian law, as between the States, would be the same as between individuals, with the qualification that the State rights are territorial, the private rights pertinent to property. A third, the direct converse of the first, was that the Common law of riparian right, as between private proprietors, does not hold as between States.

Rights in and jurisdiction over the tributaries.

The precedence to be accorded to the respective claims of navigation and of irrigation hinges mainly on the interpretation of the trade and commerce sections of the *Commonwealth Constitution*. The opinions on the point given in evidence may be summarised thus:—Any interference with the natural flow of the Murray, that would render the river less navigable, would be unconstitutional. In this sense the tributaries are part of the main stream:—Legislation in regard to diversions must have respect to the maintenance of navigation. And on the other hand:—Any scheme interfering with the natural flow of the river, and constituting a complete or even serious obstruction to its navigability for the purposes of interstate trade, would be an infringement of Section 98 of the Constitution; subject, however, to the restrictions imposed by Section 100:—The establishment of federation does not affect the constitutionality of any State bringing about a diminution of the navigability of the Murray, save to the extent to which such enactment conflicts with some enactment of the Federal Legislature on the subject of navigation:—Water for irrigation may be held to be a natural right where cultivation is impossible without it. This application of Common law principles has grown up in America. It leads to the conclusion that the use of water for navigation must be subservient to irrigation. If the English Common law were admitted here, without modification, five-sixths of the Australian Continent would remain uninhabitable for all time. Neither in America nor Australia has irrigation yet become a factor in the life struggle of humanity; but, with the increase of population, it must so become in time. Natural rights of navigation extend only to tidal rivers. In non-tidal rivers they may be acquired by lengthened use, but extend only so far as that use. America has amended the Common Law to meet local conditions. In that country the Common law doctrine as to navigability of rivers has been set aside, and it has been held that a river navigable in fact is navigable in law. But, though navigability in fact gives rise to a legal right, that right is not paramount, and does not give navigation precedence over irrigation:—If a great and important industry demanded the diversion of the river water to an extent injurious to

Relative precedence of navigation and irrigation.

navigation, the question of paramount right would be one for the High Court. Under the Federal Constitution, the test of navigability of a river would consist in its capacity for being used as a channel of trade and commerce.

Meaning of
reasonable
use in Sec.
100 of the
Constitution.

As pertinent to the question of the precedence to be accorded to the respective claims of navigation and of irrigation, comes next to be considered that of reasonableness in the use of the river waters; in other words, the meaning to be attached to the expression "reasonable use," in Section 100 of the Constitution. On this three opinions were expressed:—The Federal Interstate Commission will probably be invested with powers to decide as to what is reasonable use. In that event no appeal would lie to the High Court on the question:—The interpretation of the words "reasonable use," under Section 100 of the Commonwealth Constitution, would be a matter for evidence, and is necessarily subject to doubt. This is a strong reason for its being made the subject of agreement. And finally:—Reasonable use (Section 100 of the Constitution) means such use as would not interfere with the rights of others.

Powers of the
States to
make an
effective
agreement,
and mode of
legalising the
same.

As to the best method of making effective any agreement entered into among the States represented on the Commission for the utilisation of the water of the Murray and its tributaries, for conservation and irrigation, and as to the respective legislative powers of the Federal and State Parliaments in regard thereto, the balance of legal opinion was that advantage should be taken of the provisions of Subsection xxxvii of Section 51 of the Constitution, which confers upon the Federal Legislature power to deal with matters referred to it by the Parliaments of the States. The only way in which the Parliament of a State can speak to the Federal Parliament is by an enactment. There is no provision for exchange of messages. The necessary preliminary, therefore, would be the passing of a Statute by each of the three States concerned. Even with regard to this, one witness remarked that the Federal Parliament would not be bound to pass the measure in the identical form in which it was presented, nor afterwards to abstain from altering or repealing it without the consent of the States concerned. It seems clear, on the whole, that the legislative powers of the Commonwealth do not extend to conservation and irrigation. The Federal Parliament may legislate on these matters only on the motion of the States, and it further appears that such legislation can only be made applicable to the States at whose instance the law is passed. Another way of stating the position is:—The right to legislate in regard to conservation and irrigation pertains to the States. The riparian States may agree to legislate thereon. The Federal Parliament cannot do so, except on the motion, and with the concurrence and sanction, of the States:—Any agreement between the States as to rights in the river waters ought to be ratified by Federal legislation, under Section 51, Subsection xxxvii, of the Constitution, subject, however, to rights of reasonable use, as provided by Section 100, and also to rights of navigation.

Jurisdiction
and powers
of the High
Court.

On the question of jurisdiction it is clear from the evidence that, prior to Federation, the enforcement of riparian rights as between colonies, or between the citizens of different colonies, was practically impossible, by reason of the absence of any common interstate law of riparian rights, and of any tribunal with powers to declare and enforce them. The establishment of the High Court, under the Commonwealth, will fill up this hiatus in our old constitutions. Jurisdiction, in matters arising under the constitution or laws of the Commonwealth, have passed to the Commonwealth. The judicial powers of the High Court, also, are held to extend to the enforcement of rights of conservation and irrigation, as well as of navigation; though the Federal Parliament is not entitled of itself to interfere in the first two of these matters:—One witness held, and he has not been contradicted, that rights accorded by a State, in excess of its powers, are valid only as between its own citizens. When they affect others they are, by that very fact, invalid. Again:—Prior to Federation, questions of riparian right, between citizens of different States, were within the jurisdiction of the courts of the State where an alleged wrong was done. They have now passed to the Federal High Court:—The Federal High Court, when created, may declare the law as

between States; it cannot make or amend the law. It may also declare the law as between citizens of different States, questions between citizens of one State are referable to the courts of that State:—If any State were injured by the act of another in respect of the river or its tributaries, an appeal for redress would lie to the Federal High Court.

There was a consensus of opinion as to the need for amendment of the Common law in regard to riparian rights, or, perhaps, more correctly for its supersession by Statute; but there was some divergence of opinion in detail. The following is a brief summary of the several views:—Under the Roman Civil law the water of streams is of public right, and its appropriation by a first comer gives him a right as against lower riparian owners. The Civil law is more conducive to the use of water in agriculture than the Common law, and would be more beneficially applicable in Australia. In arid America the Common law has been in some States abolished, in some ignored, in all modified, to meet the actual facts. Legislation in Australia, to modify the Common law herein, should be by the Federal Legislature, but undertaken only under the advice, on the motion, and with the concurrence of the States concerned:—Unless the principle of the Civil law is applied to the Western Division of New South Wales, and the country served by the tributaries of the Darling, the central and western districts of that State must remain undeveloped:—It is a matter for legislation, which is the quickest mode of dealing with it, to declare a code of law with regard to the use of waters:—The Common law might, with advantage, be abrogated in respect of riparian rights, in so far that these should be vested in the Crown instead of in private owners. To this end the individual States must concur. The Crown could not alter the law here without this sanction:—In Australia, the Common law must be modified in its application to questions of riparian right. The Privy Council itself would, in such cases, modify the rigour of the Common law.

Necessity for amendment of the Common law of riparian rights, or its supersession by Statute.

Closely touching the proposed amendment of the Common law is the question of extending the principle laid down by the New South Wales Water Rights Act to the Commonwealth generally; on this witnesses were asked to express an opinion. The Act referred to vests in the Crown the right to the use, flow, and control of the water in all rivers and lakes that flow through or past, or are situated within, the land of two or more occupiers; reserving to the occupiers of land on the bank of the river or lake the right to use the water then being in the river or lake for domestic purposes, and for watering cattle or other stock, and for gardens not exceeding five acres in extent, used in connexion with dwellings. Speaking generally, witnesses approved of the principle of the Act, but did not commit themselves to an unreserved opinion that it should be extended to the whole Commonwealth. For instance:—“In some features, I think the New South Wales Water Rights Act worthy of being copied, inasmuch as it enables, though it does not compel, the Government to have works executed for the general benefit, which would otherwise be neglected; but I question whether it was necessary or desirable to vest the whole right to the flow of water in the Crown; at least without a much clearer definition of its rights and duties, as well as of the rights of individuals. It seems to me that the experience of the American States which have dealt with such questions ought to be closely studied before such an Act is extended”:—The Water Rights Act of New South Wales should be extended to the other States, with some modifications and amendments, and with certain reservations of the rights of riparian owners:—The riparian Common law is probably unsuited to the physical conditions of Australia, and might advisably be modified, as for example it has been by the New South Wales Water Rights Act.

The New South Wales Water Rights Act.

As to the administration of any Statute embodying an agreement among the riparian States, concerning their respective rights in the waters of the Murray basin, and as to the supervision and control of works their joint property and held for their joint benefit, the opinion seemed to be that these functions could not be effectively performed by a department of the Federal Government. The creation of a special Commission was suggested. And again:—The control of conservation, irrigation, and navigation might, by agreement, be in a central authority. But if such

Future administration and control of joint works.

authority should infringe the right reserved by Section 100 of the *Constitution*, its action might be upset by the Federal High Court.

Recognition
of vested
interests.

Navigation.

Construction
of weirs and
locks.

The proposition has been already enunciated in the opening paragraph of this chapter, that considerations of policy, of vested interests, and of the general welfare of the people must be accorded due weight in the allotment of the waters of the Murray basin to the use of the several States. The conservation of existing interests, especially of such as have grown out of the natural conditions of the country of their birth, and have remained for a lengthened time unchallenged, is a fundamental principle of law, no less than of the public sense of justice and right, among all civilised communities. In the navigation and trade of the Murray and its larger tributaries a considerable capital has been already embarked; suitable vessels have been built and equipped, wharves constructed and warehouse accommodation provided; facts that cannot be ignored in any attempted settlement of rights. Provision will therefore be proposed for the continuance of a supply of water in those portions of the channels heretofore commonly navigated, sufficient to carry vessels of the like class and of the same draught as those hitherto employed in the river trade; such supply to be continued during the same period of each year as navigation has, in the past, been usually carried on. The volume required for this purpose would be greatly reduced by the construction of weirs and locks in the channels, and a much larger volume thus released for employment in other ways. It will be recommended that these works be taken in hand as early as possible, their construction being a condition precedent to the proper utilisation of the resources available from the rivers. Judging by much that has from time to time appeared in the public press, there seems to be a good deal of popular misapprehension on the subject of weiring and locking the Murray, and of the benefits that might accrue therefrom. Locks have been spoken of as if they would be available for storage of the river water, and also as if the water stored would be available for diversion at higher levels, and at points more favourable than in the natural course. Let it be understood, once for all, that the weirs and locks proposed in this report will have as their essential, and, indeed, sole purpose, the maintenance of navigation for a maximum period in each year, if possible, for the whole year, with a minimum supply of water passing down the channel. It is possible that, in selecting sites for these works, some may be taken advantage of so conditioned as to be capable of rendering essential service in connexion with diversions. But to attempt to select sites, with an express view to diversion, would be to court failure for both it and navigation. The suggestion, that the works for facilitating navigation might also serve the purposes of storage, is impracticable—is, in fact, a chimera. Almost equally so is the suggestion that they will facilitate diversions by pumping. They will raise the level of the low-water surface of the river, certainly, and to this extent may facilitate pumping. They will provide no drop of water; that must be the function of independent storage.

Apportion-
ment of
available
surplus.

After provision for navigation on the scale proposed, there will be a considerable, but variable, surplus available for irrigation and other industrial uses; variable, not only at the various seasons of the year, but also from year to year, as the year happens to be one of low, of mean, or of high discharge. The equitable apportionment of rights in this available, but variable, surplus is the most difficult part of the duty assigned to this Commission. If a solution of this difficulty can be arrived at, such as can be generally accepted and concurred in by the States, and by the citizens of the States, concerned, the most formidable obstacle to a general settlement of the whole Murray River question will have been removed. To this end, the country commanded by the river water—that is, the country that can be served by gravitation, either from the main river or from the tributaries—must be considered as a whole. The question to be solved is:—How, and on what principle, are rights to be assigned, so as to ensure the widest extent of permanent settlement, the maximum of productiveness, the most active internal trade, and the most profitable foreign commerce? The largest rights should, from this point of view, be assigned to the States that have the largest areas of irrigable land; whose land, commanded by the available water supply, is of the character and quality most likely to profit by being brought under irrigation; and whose land, of suitable

quality, can most readily and most cheaply be provided with the necessary works of conveyance and distribution. Some regard must also be had to vested interests that have already grown up, as at Mildura and Renmark, and in respect of rights conceded to certain of the Victorian Irrigation Trusts. Further, there must be recognition of, and concession to, what would be the riparian rights of the States, if they were private proprietors, or if the Common law of riparian rights could be held applicable to their case.

There are numerous towns and villages, some of the former of considerable magnitude, scattered throughout the Murray basin. Bendigo, Castlemaine, Maryborough, Beechworth, Kyneton, Kerang, may be cited as typical samples of those in Victoria. Albury, Orange, Bourke, Balranald, Deniliquin, Wentworth, may be taken as representative cases in New South Wales. Also, there are numerous herds of cattle and flocks of sheep depasturing on the lands drained by the River and its tributaries, as well as settlers, both agricultural and pastoral, dwelling on these lands. The natural wants of the whole of these must be granted on a liberal scale, and must be made a first charge on the available water supply. But, in recognition of this concession, there must be an end of river pollution, whether by the insanitary condition of towns or the dwellings of settlers, or by the continued appropriation of the watercourses of the country as common drains for the disposal of mine débris or of the waste products of factories.

Precedence to supplies for domestic use and for stock.

Cessation of pollution.

Finally, in the consideration of claims and apportionment of rights, the River and its tributaries must be looked on as one. The Murray has, in fact, scarcely any existence apart from its tributaries. The only portion of the River proper having an independent source of supply is the Indi, from its point of origin at Forest Hill to its junction with the Swampy Plain River, the first important New South Wales affluent. From this point of junction the stream receives continual accessions, now from one side, again from the other. Any attempt to deal with each of these separately would be lost labour; they are essentially parts of a single system and must be so dealt with.

River and tributaries must be dealt with as a whole.

CAP. 11.—DIVISION OF AVAILABLE WATER AMONG THE STATES.

FEW useful suggestions have been offered in evidence as to the basis of allotment of the available waters, while, as to the volume necessary for navigation, there has been some conflict as to the facts. The Principal Engineer for Water Supply, New South Wales, proposes that certain laterals should be set apart for the sole use of the States through which they pass, and that certain other tributaries should be reserved for the sole use of the River channel itself. He assumed that, if no territorial boundaries existed, each mile of river frontage would have equal rights to the flow of the stream. On this basis the division of the water reserved for the main River is a simple matter. Taking the relative lengths in the several States, they would each be entitled to a third portion, to be delivered exclusive of losses by evaporation, at the points of diversion. He goes on to suggest "that the whole of the flow of the Murray above Albury, the whole of the flow of the Mitta, Kiewa, and Ovens be reserved for the supply of the Murray channel; and that each State have the sole use of the lateral streams, other than those mentioned, within its boundaries." The effect of this would be, in a year like 1896, which may be regarded as a typical low year, that, when the losses below the affluence of the Ovens were deducted, South Australia would get about 33,000 million cubic feet at her border line.

Proposals by Witnesses.

Mr. McKinney, on the assumption that New South Wales and Victoria are on perfectly equal terms with regard to the Murray, suggests certain volumes as the maximum which Victoria and New South Wales might equitably be allowed to divert from the Murray, Murrumbidgee, and Goulburn, without injury to the interests of South Australia.

Mr. J. W. Jones claimed, on behalf of South Australia, that all diversions from any part of the Murray or its tributaries (except, apparently, within South Australia itself) should cease when the flow of the river at the South Australian border falls to 600,000 cubic feet per minute. On this basis, in the year 1899, supposing South Australia had taken this quantity when it was to be had, and the reduced flow at other times, the amount left for division between New South Wales and Victoria would have been 47,000 millions of cubic feet, or about 16 per cent. of the total volume. He further thinks that, if the salt water were excluded from the lakes, the river locked in South Australia, and to a reasonable extent in the other States, and at least one reservoir constructed in South Australia, the works being at the expense of the Federal Government, the volume of flow at the South Australian border, below which all diversions by gravitation should cease, might be fixed at 300,000 cubic feet per minute.

Resolutions with regard to the Murray, agreed to at a Conference between Commissions representing New South Wales and Victoria, in 1886, have been given in the early part of this report.

All Available
Watershould
be Reserved
for Irriga-
tion.

The proved value of water for irrigation, in the drier parts of the Murray Basin, where the land is fertile, makes it imperative that as much as possible should be devoted to this purpose. In New South Wales, though nothing on a great scale has yet been attempted, preparations have been made for initiating large schemes. In Victoria, while much has already been accomplished, further works, based upon accurate information, are likely to be proceeded with. It is absolutely necessary therefore that the volumes to be depended on from the rivers should be determined. The construction of storage reservoirs will not only have the effect of conserving the Winter supplies for use in the Summer, but the flow in the rivers will be equalised. If therefore, with storage, the total supply for a typical low year be taken, the volume available under normal conditions can be ascertained. The records point to 1896 as the year to be adopted; it is, however, anticipated there will be years of lower discharge than 1896, and provision is made for such a contingency, although the discharge of most years will be greatly in excess of it.

Provision for
Navigation.

It has already been shown that no apportionment of water can be made between the States for irrigation and water conservation, without regard to the requirements of navigation. Sufficient water must be allowed to pass down the rivers to maintain navigability as heretofore, and, as time must elapse before the construction of locks and weirs, it is important to decide what are the conditions that will secure this meanwhile.

In his evidence before the Royal Commission on the utilisation of the Murray River waters, Mr. J. W. Jones, then Conservator of Water, stated that:—"For the present steamers a minimum depth of 4 feet would suffice to ensure uninterrupted navigation." He further stated that, except for small steamers, the river is not navigable when down to zero on the Overland Corner gauge.

Captain Barber, superintendent of deepening operations, who had been acquainted with the river for thirty-two years, stated that the Murray steamers draw from 3 to 5 feet. He fixed the Overland Corner gauge; the zero was 18 inches above the lowest known low water, and when the gauge is at zero there is 3 feet 3 inches over the shallows. As to the period of navigability, Captain Barber remarked that steamers stop running for four months, but it is sometimes longer and sometimes shorter. With the exception of 1864, 1870, and 1871, navigation was stopped for some portion of each year up to 1887.

Mr. Graham Stewart said that the works carried out by South Australia, on the lower river, secure from two to three feet depth in the shallow parts at summer level.

Mr. Kenyon, an engineer of the Victorian Water Supply Department, in his evidence before this Commission, stated that the river might be considered open with a flow of 250,000 cubic feet per minute at Mildura, and that the smallest steamer could get through with a volume of 150,000 cubic feet per minute; that, on the South Australian river, steamers like the "Ellen" could get through, towing a

barge drawing 5 feet of water, with 250,000 cubic feet per minute; that, at Swan Hill, the river is open with a flow of 270,000 cubic feet; and that small steamers could get through at 150,000 cubic feet; that at Echuca the river is open at about 5 feet on the guage, or 250,000 cubic feet, and that small steamers can get through at 3ft. 6in., or 170,000 cubic feet per minute. This witness, we understand, has arrived at the conclusions regarding navigable volumes, stated in his evidence, by direct gaugings, made at times when steamers were just able to navigate. He travelled in the "Ellen" from Wentworth to Morgan, when she was towing a barge drawing 5 feet. The river he gauged at this time, and found the discharge to be 250,000 cubic feet per minute.

Mr. Alfred Battye, of Victor Harbour, asked by Mr. Burchell:—"Do you think 4 feet deep enough for river boats?" Replied:—"Well, 4 feet would take most of them; there may be some which would take 5 feet." And again:—"But even 5 feet would not admit the largest boats, would it?" "I think the largest boat draws 6 feet, but, loaded light, could go in 5 feet."

Mr. J. D. Ritchie, in answer to question:—"How long during the year is the river navigable?" said:—"As far as Wentworth I should say it is navigable, on an average, for somewhere about 9 out of the 12 months;" and, further:—"I think that is a very fair average, taking it right through."

Captain Oliver, on the other hand, who has been a master of river steamers for 25 years, said, in reply to question:—"How many months in the year is the Murray River navigable?" "As far as Wentworth, this last 3 years, it has only been navigable about 6 months." (Question):—"Formerly how long?" (Answer):—"Some time ago we would run for about 4 years in succession."

Mr. J. M. Smith, Chairman of the Renmark Irrigation Trust, in answer to question, "We understand that the river is navigable for about seven or eight months in the year?" replied, "About that."

Mr. Robert McMonnies, Storekeeper, at Euston, in answer to question, "How many months of the year, as a rule, can you get goods by boat?" stated, "Six or seven."

Mr. H. L. Harben, Storekeeper, Balranald, in a statement handed in, says, "Taking the average for past years, the navigability of the Murray and Murrumbidgee can only be relied on for about six months in each year, and as Balranald is the centre of a large district extending a distance of 150 miles back, the majority of the people have to depend for their supplies on the local storekeepers."

Mr. P. McW. Glynn, M.H.R., in his evidence before this Commission, said, "At Morgan, the navigable discharge, I am told, is 340,000 cubic feet per minute." Being asked on whose authority that statement rested, Mr. Glynn said, "I think on the authority of the Conservator of Water (Mr. James W. Jones), given in his evidence before the Royal Commission on the Murray Waters in 1890, and it will be seen in the gaugings, in appendices to that report."

The Hon. Alfred Catt was asked by Mr. Burchell, "At present four feet of water is required at Morgan for navigation purposes;—do you know that is equal to 340,000 cubic feet per minute;—with locks you would not require anything near as much as that?" His reply was, "I do not think so."

Much consideration was given to the question of navigation in the debates of the Federal Convention, held in Sydney, Melbourne, and Adelaide, during 1897-8. At Adelaide, on 17th April, 1897, Mr. Glynn used the following words, page 810:—"The Murray at navigation level was 356,000 feet per minute. . . . The depth required to be kept in the river for the purpose of navigation is 4 feet. I am speaking from the evidence of experts before the South Australian Commission." Page 812:—"The constant depth ought to be about 4 feet. There are some boats, no doubt, with a capacity of 2 feet 3 inches; but for the purpose of trade they should rely on steamers that have a draught of between 3 and 4 feet. That is, at any rate, the effect of the evidence given by Mr. Landseer, who is a practical man, and

knows more about it than any hon. member of this Convention. I am taking an average, and I say, if you do not allow for a depth of about 4 feet, the use of navigation for the trade between these colonies will be gone." In his remarks at Melbourne, in January, 1898 (Vol. 1, p. 143), Mr. Glynn said:—"The discharge at Overland Corner goes down to 120,000 cubic feet per minute. Now, under locking, we would always keep a minimum of 350,000 cubic feet per minute, and that is the navigable discharge . . . but the moment you keep the river near the navigable discharge—at, for instance, 200,000 feet per minute—then a compensation of 50,000 feet per minute would bring it up to navigable point." In Melbourne, in the course of his remarks, on the 1st February, 1898, Mr. Glynn referred to a map, put in at the Sydney Convention in 1897, prepared and signed by Mr. F. N. Burchell. A portion of this map (*see Appendix B*) shows the navigable depth of the Murray; the volume there given as necessary to secure navigation is 337,000 cubic feet per minute.

Conclusions
from the
Evidence.

The only conclusions that can be drawn from the evidence are:—(a) That, whilst the zero of the Overland Corner gauge is fixed at an assumed Summer level, it is at least 18 inches above the low level of the river, and 3 feet 3 inches above the shallows. (b) That when the river is from 4 to 5 feet deep, which corresponds with 1 to 2 feet on the Overland Corner gauge, the condition of navigability has been secured. (c) That the steamers trading on the Murray draw from 3 feet to 5 feet. (d) That the zero of Overland Corner gauge corresponds with the zero of the gauge at Morgan. (e) That the volume of water passing Morgan, at Summer level, is 119,000 cubic feet per minute; at 1 foot above Summer level 164,000 cubic feet per minute; at 2 feet, 215,000; at 3 feet, 273,000; and at 4 feet, 337,000 cubic feet per minute. (f) That, in the opinion of some witnesses, if 5 feet deep pass down the river, ample provision will be made for navigation; whilst, in the opinion of others, it will be provided for by 6 feet depth of water, or 337,000 cubic feet per minute measured at Morgan.

The only witness who differed from these conclusions is Mr. Jones, Secretary to the Commissioner of Public Works, South Australia, who stated that a volume of 450,000 cubic feet per minute would be required for the larger vessels, and adds that "a good river year would be about 800,000 million cubic feet." By reference, however, to Mr. Moncrieff's evidence, it will be seen that from 1884 to 1901, inclusive, there had been only three years—viz., 1890, 1891, and 1894—when the discharge, as gauged by the South Australian Officers has exceeded this volume.

In addition to the requirements of navigation, and apart from the use of the water by the upper States, South Australia requires 12,500 millions of cubic feet per annum for irrigation, 42,000 millions of cubic feet to compensate for evaporation in the Lakes at the Murray mouth, and the volume required to make good the losses on the River in South Australia. Although we are of opinion that 42,000 millions of cubic feet, or about 14 per cent. of the total available quantity in 1896, to be devoted to the Lakes, is prodigal, in view of the comparatively small service it renders; we have, nevertheless, until locks and weirs are constructed, provided for this as well as the other South Australian requirements.

The following are the divisions proposed; and as they were arrived at in the shape of resolutions they are here stated in that form:—

RESOLUTION I.

Resolutions.

(a) The navigation of the lower part of the main river, and of certain portions of the larger tributaries, will eventually be provided for by the construction of locks and weirs. Until the initiation of such a system of works, the upper riparian States shall restrict their total diversions to about 440,000 cubic feet per minute for seven months, from July to January, inclusive, and during the months from February to June, inclusive, shall restrict their total diversions to about 370,000 cubic feet per minute.

(b) As, however, the Campaspe and Loddon rivers, and the Broken River, with its effluent the Broken Creek, and the Avoca and Wimmera Rivers, in Victoria,

and the Wakool, Lachlan, Bogan, Macquarie, Castlereagh, Namoi, and Gwydir rivers in New South Wales, make no effective contributions to the Murray River except during floods, rights of diversion from these rivers shall be accorded to the respective States in addition to those stipulated above.

(c) The requirements of South Australia, in respect of water to be sent down the river channel by the upper riparian States for supply, and to make good losses by percolation and evaporation in the river, and in the Lakes at its mouth, shall be for the seven months, July to January, inclusive, 170,000 cubic feet per minute, and for the five months, February to June, inclusive, 70,000 cubic feet per minute.

(d) Whenever the volumes of water available are insufficient to provide the foregoing—440,000 or 370,000, and 170,000 or 70,000 cubic feet per minute respectively, a proportionate reduction shall be made in each, so as to bring their sum within the total available. All of these concessions will be subject to the provision of storage as shall be hereafter decided. (Agreed to unanimously.)

RESOLUTION II.

(a) During the seven months, July to January, inclusive, the diversions on the part of New South Wales and Victoria shall be respectively 292,000 cubic feet per minute, and 146,000 cubic feet per minute, unless the volume of the river at Morgan exceeds 337,000 cubic feet per minute, in which case the diversions may be proportionately greater.

(b) During the five months, February to June, inclusive, the diversions on the part of New South Wales and Victoria shall be respectively 240,000 cubic feet per minute, and 127,000 cubic feet per minute, unless the volume of the Murray at the South Australian border exceeds 70,000 cubic feet per minute, in which case the diversions shall be proportionately greater.

(c) The foregoing quantities to be computed as follows:—

NEW SOUTH WALES.

SOURCE.	CUBIC FEET PER MINUTE.				POINTS OF DIVERSION.		
	For seven months, July to January, inclusive.		For five months, February to June, inclusive.				
Upper Murray catchment (to below junction of Kiewa) ... }	...	60,000	...	...	60,000	..	{ From any point or points on the Murray River.
Murrumbidgee and Dar- ling catchments ... }	...	232,000	...	...	180,000	...	{ From any point or points on the Murrumbidgee or Darling.

VICTORIA.

Upper Murray catchment (to below junction of Kiewa) ... }	...	60,000	...	...	60,000	...	{ From any point or points on the Murray River.
From Goulburn catch- ment ... }	...	86,000	...	...	67,000	...	{ From any point or points of the Goulburn River, or an equivalent thereof, from any point or points of the Ovens River.

Carried—Mr. Burchell disagreeing.

RESOLUTION III.

That the rights of diversion accorded by Resolutions Nos. I. and II. are intended to secure the navigability of the Rivers, equivalent to that of their natural condition in typical years of low discharge, in so far as relates to the passage of boats of the class heretofore trading thereon, and shall be so accepted in the further discussion. Carried—Mr. Burchell disagreeing.

RESOLUTION IV.

That as the proposed Cumberoona Reservoir, on the Upper Murray, if constructed of a capacity of 25,367,000,000 cubic feet, will be capable, in conjunction with the natural discharge of the tributaries between the site of the dam and the gauging station at Albury, of so regulating the river as to ensure a practically uniform discharge of 180,000 cubic feet per minute below the affluence of the Kiewa; the volumes so regulated shall belong in equal shares to New South Wales, Victoria, and South Australia, conditionally upon these States bearing equal shares of the cost of the reservoir. Carried—Mr. Burchell disagreeing.

RESOLUTION V.

That, when the navigability of the lower part of the main river, and of certain portions of the larger tributaries, is permanently secured by the construction of locks and weirs, the restriction of diversions by the upper riparian States shall be amended, so that, in addition to the 60,000 cubic feet per minute (South Australia's allotment from the Upper Murray) an average of 55,000 cubic feet, equal to 28,908 millions of cubic feet per annum, shall pass down the main stream at the South Australian boundary. The total quantity, 115,000 cubic feet per minute, equal to 60,444 millions of cubic feet per annum, shall be held to make good the loss by evaporation in the Lakes at the river mouth, the loss occurring in the river between the South Australian boundary and those Lakes, and to satisfy the irrigation rights of that State. The increased loss from the Darling and the Murrumbidgee, due to the weirs thereon, and the volume necessary for working the locks on these rivers, being supplied from their own catchments, it is agreed by New South Wales and Victoria that a volume sufficient to make good the losses in the River between Albury and the South Australian border, with 55,000 cubic feet per minute as provided above, shall be supplied in the main river as follows:—

At the affluence of the Kiewa, being the excess available after providing the regulation volume	...	...	...	1.2	per cent. of the total required.
At the affluence of the Ovens	...	...	...	8.8	" " " "
At the affluence of the Goulburn	...	...	...	16.5	" " " "
At the affluence of the Murrumbidgee	...	...	...	28.7	" " " "
At the affluence of the Darling	...	...	...	44.8	" " " "
				<u>100</u>	per cent.

It is, however, stipulated that the obligations of either State shall be held to be fulfilled by the required volume being supplied from one or other or more of the tributaries named within its own boundaries. It is further stipulated that, should it at any time appear that the volume passing the South Australian boundary, together with those diverted by the States of New South Wales and Victoria, are such that the total stipulated would not be available for the year then current—that is to say, that they would be less for the year than 321,000 millions of cubic feet—then, and in such case, there shall be a *pro rata* reduction of the supplies to each of the three States, so as to maintain the same proportions as those agreed upon. Carried unanimously.

CAP. 12.—SPECIAL QUESTIONS REFERRED TO THE COMMISSION.

SEVERAL special questions have been referred to the Commission for report. These, which do not come strictly within the scope of the inquiry, as set forth in the original appointment, are as follows:—

Statement of
the questions
referred.

I. Pollution of the River waters, by the sewage and other refuse of towns, hamlets, and the dwellings of settlers; by boats plying on the River; by the waste products of factories; and by the sludge and débris of mines.

II. Proposed diversion from the Acheron River, a tributary of the Goulburn, by the Melbourne and Metropolitan Board of Works.

III. Proposed establishment of an irrigation settlement on a site about three miles north from Bourke.

I. As to sewage pollution, it has been already stated in this report that precedence is, in all cases, to be given to demands for water for domestic, sanitary, and ordinary use. And it is just and reasonable that, in requital for this concession, every proper precaution should be taken to exclude sewage matter from the river channels. The sewage question.

The Mayor of Balranald complained to the Commission that the Murrumbidgee is at present (June, 1902) very seriously polluted. He said that the volume was then insignificant and the current sluggish, and the discharge of sewage from the towns above, such as Gundagai, Wagga, Narrandera, and Hay, had a very serious effect on the water, and Balranald was then threatened with an epidemic of typhoid, for which the river waters were held to be responsible. The Mayor admitted that the discharge from Balranald itself was as objectionable as that from towns higher up, although its injurious effect could not be felt to the same extent, inasmuch as Balranald is the lowest town on the Murrumbidgee. He said also that the Council had applied for a grant to carry out a sewerage system. At Hay a sewerage system is being carried out, which, when completed, will have the effect of remedying the nuisance now arising from the discharge of foul liquids into the river. At Narrandera a partial system, capable of being extended, is in operation.

The pollution of rivers by sewage is easily remediable in every case, and the residents in riverside towns should be impressed with the necessity of dealing with this question. The development and proved success of what is known as the septic system of sewage treatment has simplified the work and diminished its cost. So that, in towns where there is an adequate water supply, there is no reason that pollution of rivers by town sewage should be allowed to continue. The question is one that must be faced sooner or later; and important and wealthy urban communities cannot begin too soon to give it their serious consideration. The like remarks apply, with little less force, to the dwellings of settlers in the river basin, whose surroundings are, sometimes, of a most insanitary character; and to boats plying on the rivers, in which, as a rule, there are no proper sanitary provisions whatever. Either the provisions of the law relating to public health, in the several States, should be put in motion to induce efficient sanitation, or if the law, as it stands, is insufficient, it should be amended to give the necessary powers.

The pollution of rivers by mine débris, and by the sludge from batteries and puddling mills, and, following the example of the miners, by the waste products of factories, is of very old date. It is, in fact, as old as gold mining in the Australian States; that is to say its origin, is contemporaneous with the great access of population that ushered in the *modern era* in Australia. The miners, or, at all events, the mining industry, may be said to have established some kind of prescriptive right to use the watercourses of the country as its common drains. But here we may appeal to the well-known maxim, both of law and policy, that *the public welfare is the supreme law*. It cannot reasonably be contended that any body of men can acquire a prescriptive right to carry on their industry, however profitable, at the expense of the health and well-being of the entire community. In the issue of any future leases of land for mining, there ought to be a condition that no water used for washing auriferous earth, or for treating any auriferous matrix, shall be liberated after use, containing in suspension solid matters of more than a certain fixed percentage, to be determined by competent expert authority. A provision should also be inserted in an amendment of the *Mining Statute*, imposing the like restriction on the holders of claims under the Mining Bye-laws. Mine pollution.

II. The officers of the Metropolitan Board of Works were heard in evidence, before the Commission, on the question of diversion from the Acheron. The case, as put on behalf of the Board, with the reply of the Victorian Water Supply Department, is embodied in a memorandum by the Chief Engineer of Water The Acheron question.

Supply, who is a member of this Commission. The Commission concurs in and adopts the view of the Chief Engineer, as set forth in the memorandum, which is here given as a reply to the request of the Board :—

“(1) The Chairman and Officers of the Board having, at the request of Mr. Fitz Gibbon, been heard by the members of the Murray River Interstate Commission, have now placed on record, in a form more definite than, and slightly different from, any in which it has previously appeared, the request of the Board in respect of a right of diversion. Briefly stated, the right now asked for is as follows:—To divert from the Acheron River 10 millions of gallons per day throughout the year, except during the months of November, December, January, February, and March; during which five months all diversions shall be subject to the direction of the Chief Engineer of Victorian Water Supply. But no diversions to be made at any time when the natural volume of the Acheron is less than 10 millions of gallons per day; and all diversions to be subject to a condition that 10 millions of gallons per day, at least, shall be allowed to pass down the river at the off-take.

“(2) Having looked into the question with care, I am of opinion that we ought not to consent to a grant of right of diversion, in the Acheron, in the terms proposed by the Board; but I think that a right, that should prove of even greater service to the Board, may be accorded without tangible injury to the interests of settlers in the Goulburn Valley. The right I propose is as follows:—The Board to be entitled to divert from the Acheron River, at all times, except during the months of January, February, March, and April, during which four months there shall be no diversion, a volume not exceeding 20 millions of gallons per day; provided that there shall be no diversion when the natural volume of the Acheron is less than 10 millions of gallons per day; and provided also that during diversion a volume of 10 millions of gallons per day, at least, be allowed to pass down the river at the off-take.

“(3) From an analysis of the available gaugings of the Acheron River, which, however, extend over one year only, it would appear that the total volume of possible diversion for a year under the above proposed right would be about 3,863 millions of gallons. This volume would be the equivalent of about $15\frac{3}{4}$ millions of gallons per day for eight months, or $10\frac{1}{2}$ millions of gallons per day for the whole twelve months. I think, therefore, it may be taken to be more than a fair equivalent for the right asked for; besides which, it is, in my opinion, the only form of right of diversion from the Acheron that can be granted without tangible injury to the interests of settlement in the Goulburn Valley.”

Proposed
irrigation
settlement,
North
Bourke.

III. The question of establishing an irrigation settlement at North Bourke appears resolvable into a proposal to provide an object lesson in irrigation, at the charge of the New South Wales Government. If this is so, clearly, the conditions ought to be, if not the most favourable possible, at least reasonably favourable. The conditions at North Bourke are not so. The soil is far from being of the best obtainable for the purpose, the water supply is deficient and uncertain, and there is no large market for the produce of irrigated land available in the immediate vicinity. It would be better if the Government were to depute a competent expert to select a site where the conditions are favourable. It is not likely that a settlement will be even self-supporting for some time after establishment. Seeing that it will demand a considerable outlay of public money, there should be an assurance that the result will be commensurate with the outlay.

CAP. 13.—CONTROL OF THE RIVER AND TRIBUTARIES.

River control
before
Federation.

BEFORE Federation the South Australian portion of the main stream was controlled by the Government of that province. The upper portion, though forming part of the territory of New South Wales, was, as to control of Victorian vessels trading on the River and the collection of Customs duties on the goods landed on the Victorian bank, subject to the concurrent control of Victoria. Customs and Navigation are now under the jurisdiction of the Federal Government.

The control of Navigation being in the Commonwealth, and of Irrigation and Conservation in the States, it is necessary that their administration should be kept apart. Whilst, however, Commonwealth authority and control of State rights should be distinct, it is important that there should be proper concert between them.

This object would be secured by the appointment of a Permanent Commission, representative of New South Wales, Victoria, and South Australia, to administer and control diversions, and to construct and control those works of irrigation and conservation in which more States than one are concerned, with powers to consult with the Federal Government, and to conclude agreements with it, on all such matters affecting the rivers as are subject to Commonwealth jurisdiction. The realisation of this proposal would demand concurrent legislation on the part of the States, with confirmatory action by the Parliament of the Commonwealth.

Proposed
Commission.

The powers and duties of the Permanent Commission should be wide enough to enable it to deal, from time to time, with such questions as those remitted to this Commission. Its functions should be defined in regard to the broad lines to be followed, but not as to details of methods of procedure.

Its powers and
duties.

Matters specifically remitted to it, in addition to those mentioned, should be:—The direction and control of gauging of all streams within the Murray Basin, and keeping the records thereof:—The investigation of all proposals, for the construction of storage and other works, intended to serve the interests of more than one State, and the apportionment of the cost thereof:—The variation, where necessary to meet altered conditions, such, for instance, as the construction of navigation works, or to conform with the fuller information, from time to time available, of the volumes to be provided for navigation, or for the respective service of the several States:—The settlement of disputes arising, between the States, out of matters connected with the administration of the agreement, or modifications thereof, relating to the control and diversion of water from the Murray or its tributaries:—The making of regulations, either temporary or permanent, limiting the volumes to be diverted from time to time, or at any specified season, or diminishing or suspending diversions; providing against the pollution of rivers and streams; and for all other purposes necessary to the proper exercise of its functions.

The expenses of the Commission should be borne by the several States in the proportion of their respective populations.

To give effect to the conclusions arrived at in the course of our enquiry, we desire to make the following recommendations:—

Recommendations.

1. That the division of the waters of the Murray Basin among the three States shall be, before and after the construction of locks and weirs on the river, as set forth in the Resolutions in Cap. 11.

2. That the storage reservoirs at Cumberoona and Lake Victoria, and the weirs at the Murray mouth, shall be constructed at the cost of the three States in equal shares, and that the weir and head-works at Bungowannah shall be at the cost of New South Wales and Victoria in equal shares.

3. That a Permanent Commission be appointed to control and modify diversions of natural waters within the Murray Basin, and charged with the administration of all matters appertaining thereto, including the questions dealt with in Cap. 12 of this report.

4. That, inasmuch as the conditions in Australia are such that the Common law doctrine of riparian right is unsuitable, steps be taken to legislate on the lines of the *Water Rights Act* of New South Wales, and to vest the ownership and control of all natural waters in the Crown.

5. That, concurrently with the construction of the proposed Cumberoona Reservoir on the Upper Murray, we advise that the scheme for diverting water from Bungowannah be carried out by the Government of New South Wales, the estimated cost being £550,000; such scheme to provide for the conveyance and distribution of 50,000 cubic feet per minute from the Murray into New South Wales.

6. While admitting the benefit of a permanently navigable river, we are of opinion that the present traffic is not sufficient to warrant a complete system of locking. We think, however, that a beginning might be made with the Murray, from Blanchetown to the junction of the Darling at Wentworth, at an early date. For this, eight locks would be required, viz.:—Six between the South Australian border and Blanchetown, and two between the South Australian border and Wentworth. The estimate, according to the evidence of Mr. Moncrieff of South Australia, and of Mr. Wade of New South Wales, is £760,000. We recommend that the Federal Government be invited to consider the desirability of carrying out this first instalment of locking the River.

General map.

The large map of the Murray River basin, which shows by colour the main and contributing portions of the catchment area, also existing and proposed works of water conservation within the area, has been prepared by Mr. A. W. Roberts of the Victorian Water Supply Department.

Accompanying the report and evidence are the following appendices and plans.

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|-------------|---|--|
| Appendices. | { | <ul style="list-style-type: none"> A. Diagram showing behaviour of proposed Cumberoona Reservoir. B. Diagram (portion) showing volume of water required for navigation on the Murray. (Printed with proceedings of the Australian Convention 1897). 1. Tabulated Statement showing estimated monthly discharge of the Murrumbidgee River at Hay. 2. Tabulated Statement showing estimated monthly discharge of Darling River at Wilcannia. 3. Tabulated Statement showing estimated monthly discharge of Murray River at Albury. 4. Section showing Tuppal Cutting, New South Wales. 5. Section showing Eagle Creek Cutting, New South Wales. 6. Section showing Yanko Creek Cutting, New South Wales. 7. Section showing Willandra Weir Cutting, New South Wales. 8. Section showing Middle Billabong Cutting, New South Wales. 9. Section showing Crooked Creek Cutting, New South Wales. 10. Section showing Murray's Break Cutting, New South Wales. 11. Section showing Gunningbar Creek Cutting, New South Wales. 12. Section showing Greenbah Creek Cutting, New South Wales. 13. Section showing Moomin Creek Cutting, New South Wales. 14. Section showing Thalaba Creek Cutting, New South Wales. 15. Section showing Meehi Creek Cutting, New South Wales. 16. Section showing Carore Creek Cutting, New South Wales. 17. Statement of diversions from the Murray and tributaries within the State of Victoria. 17a. Statement of diversions from non-contributing streams within the watershed of the Murray River in the State of Victoria. 18. Schedule showing existing and proposed works on Murray River in South Australia. 19. Schedule showing details of Irrigation Trusts in Victoria. |
| Plans. | { | <ul style="list-style-type: none"> 1. Sketch Plan showing suggested Storage Sites on the Upper Murray. 2. Plan of the Murray River Basin, showing main and contributing streams with their catchment areas, also existing and proposed works of water conservation. 3. Plan showing existing and proposed works of water conservation in the Murray River Basin in Victoria. 4. Plan showing existing and proposed works of water conservation in the Murray River Basin in South Australia. 5. Plan showing Murray and Murrumbidgee Rivers Districts, New South Wales. 6. Plan showing Darling River District, New South Wales; also longitudinal section of the River. 7. Plan showing Lachlan River District, New South Wales; also longitudinal section of the River. 8. Plan showing Bogan, Macquarie, and Castlereagh Rivers District, New South Wales. 9. Plan showing Namoi River District, New South Wales. 10. Plan showing Dumaresq, MacIntyre, and Gwydir Rivers Districts, New South Wales. 11. Longitudinal Sections of Murray and Murrumbidgee Rivers, New South Wales, showing system of locks. 12. Plan showing proposed improvements to Lake Victoria, New South Wales. |

In concluding this report we desire to leave on record our appreciation of the valuable services rendered by our Secretary, Mr. R. T. McKay. He has, by his zealous attention to his duties, and his unceasing efforts to bring to a successful issue the Commission with which we have been entrusted, secured our satisfaction and won our respect. We are also indebted to the Shorthand writers, Messrs. Frankham and Daunt, who have rendered valuable assistance during the course of our inquiry. To these we desire to express our thanks.

We have the honor to be,

Your Excellency's most obedient Servants,

J. DAVIS, M. Inst. C.E., *President.*

STUART MURRAY.

F. N. BURCHELL, SUBJECT TO DISSENT.

MELBOURNE, 9th December, 1902.

DISSENT.

I most respectfully dissent from the foregoing report on the following grounds:—

1. Its terms are, in my opinion, calculated to confuse the real question at issue, *i.e.* particularly in regard to Resolutions II. and III., or any reference thereto.

2. The first and paramount duty of the Commission is, in my opinion, to determine the minimum flow necessary to be maintained for the purpose of navigation. The question of the just allotment of the waters between the States for Conservation and irrigation being subsidiary to the main necessity of keeping the rivers navigable.

3. The evidence shows that the minimum depth of water necessary for navigation of the River Murray is four feet above zero on the Overland Corner gauge (see exhibit 43), therefore, no diversion by or in any State should be permitted while this requirement is unsatisfied, except as mentioned in the next paragraph.

4. I admit that to impose the absolute condition that no water should be taken from the River while the flow is less than 4 feet above zero at Overland Corner, would injuriously affect the irrigation pumping schemes now in operation, and which, being already established, require special consideration. I think therefore, that this condition should, as a matter of Inter-state concession, be qualified to the extent of allowing a sufficient quantity of water to continue to be pumped at all times, for the supply of existing pumping schemes. But that this concession should extend only to the absolute necessities of the said schemes, and that, in all such cases, the abstraction of water should be controlled by the Inter-state Commission.

5. Subject to the maintenance of the River Murray as a navigable water-way, as stated in paragraph 3 of this dissent, the question of the just allotment of the waters to the use of the States of New South Wales, Victoria, and South Australia for irrigation is one concerning which I am prepared to recommend the utmost liberality to the States of New South Wales and Victoria. In my opinion, the surplus waters of the River Murray and its tributaries should be distributed as follows:—

New South Wales and Victoria in such proportions as they may agree upon between themselves $\frac{7}{8}$, and South Australia $\frac{1}{8}$.

6. I have dealt, so far, with the question upon the assumption that the rivers remain in their present natural condition, but should a system of weirs and locks be established, which in my opinion is desirable, then, contingent upon the exclusion of the sea water from Lakes Alexandrina and Albert by the erection of a barrage at near the mouth of the river Murray, a sufficient quantity of water should be allowed to flow into South Australia to:—

(a) Provide for navigation.

(b) Maintain the lakes at a proper level at all seasons of the year.

(c) Give sufficient water for a reasonable development of irrigation works in South Australia.

(d) Ensure the thorough effectiveness of a system of locks and weirs. The weiring and locking of the rivers would not only allow of these requirements being amply provided for, but will give more water to the riparian States for conservation and irrigation.

7. In reference to resolution 4, and as to the cost of the Storage Reservoir at Cumberoona, it is my opinion that if the upper riparian States desire to take so much water from the River that it would be rendered unnavigable, unless storage is arranged for to maintain navigability, then the States desiring to do this should pay for such storage.

8. In reference to Chapter XI., paragraph 21, I wish to point out that according to the diagram of gaugings of the River Murray, submitted by the Engineer-in-Chief of South Australia (Mr. A. B. Moncrieff), the average navigability per annum of the river—for all steamers—for the ten years, August, 1886, to December, 1896, was eleven months, and that during that period the river was continuously navigable for two years and four months, two years and nine months, and three years and seven months respectively for all steamers.

9. In reference to the following excerpt from Chapter XI., paragraph 19—"In 1897, Mr. Glynn referred to a map put in at the Sydney Convention, prepared and signed by F. N. Burchell. A portion of the map (see Appendix B) shows the navigable depth of the Murray; the volume there given as necessary to secure navigation is 337,000 cubic feet per minute."—I wish to state that this is an entire misconception of the purport of the said diagram:—

1. The zero on the gauges at Morgan and Overland Corner are not set at corresponding levels; *i.e.*, when the river is stationary, the zero on the gauge at Morgan is 18 inches lower than the zero on the gauge at Overland Corner.

2. The table of discharges on the margin of the diagram refers to the Morgan gauge, as is shown by the note.

3. The information giving the navigable depth at Overland Corner is on the portion of the plan which, for some reason, was not printed.

In my opinion the most reliable and complete evidence given to the Commission on the above subject is to be found on the official record of River Gaugings, taken at Morgan, Overland Corner, and Wentworth, which extended over a period of 18 years. This diagram (Exhibit 43) was put in by Mr. A. B. Moncrieff, Engineer-in-Chief of South Australia, and definitely states the depth required for the safe navigation of all steamers at the respective places named. It is a matter for regret that this diagram, which should have been accorded great weight as being official and impartial, has been entirely ignored in the preparation of the report.

9A. In this report no particular reference has been made to the gravitation diversion channel at Deep Creek, in connection with Cohuna Irrigation Trust, Victoria. It consists of a cutting on the Victorian side of the river Murray; the level of the bottom corresponds with summer level of the river, *i.e.*, 4 or 5 feet below navigation level (see question 3,604). I consider the above-mentioned work forms

a most serious precedent, and regard with great suspicion the effect it will have on the navigability of the river. I suggest that the off take of any gravitation channel should not be below navigation level of the river.

10. I also dissent from recommendation 4, that the Common Law Doctrine of riparian rights is unsuitable in Australia, particularly in regard to the waters of the Murray Basin. I believe the riparian rights existing as between individuals, is the only equitable basis upon which to arrive at any decision in regard to the apportionment and distribution of the waters of the Murray River to the riparian States.

11. I further dissent from recommendation 5, as I consider that no obstruction should be placed across the River Murray for any such diversion as would be likely to impair the navigability of the river until such time as weiring and locking is undertaken for permanently ensuring navigation.

F. N. BURCHELL.

9.12.1902.

NOTE.

It is matter for regret that the representatives of the three States have been unable to reach unanimity on some of the issues dealt with in the report. We feel compelled to say, however, that the position assumed by the representative of South Australia seems somewhat inconsistent. Mr. Burchell, in his "Dissent," holds that the first and paramount duty of the Commission is to determine the minimum flow necessary for navigation; and insists that this minimum is four feet above zero on the Overland Corner gauge. He does not say that his colleagues have proposed to allow a less depth; but he leaves it to be inferred that they have, by going to much trouble to show that they have misconceived the meaning of a diagram signed by himself, on which the navigable depth and corresponding volume are figured.

At a meeting of the Commission on 12th November, and again on the 13th November, a resolution was submitted, beginning in the following terms:—"The navigation of the lower part of the main river, and of certain portions of the larger tributaries, will eventually be provided for by the construction of locks and weirs. Until the initiation of such a system of works, the upper riparian States shall restrict their total diversions, so that, for the seven months, July to January inclusive, the lower river shall be maintained in a condition of navigability equivalent to that of its natural conditions, in so far as relates to the passage of boats of the class heretofore trading thereon. This condition will be held to be fulfilled, when the level of water is not less than 4 feet on the gauge at Morgan. It will also be held to be met by restricting the diversions by New South Wales and Victoria, during these months, to about 440,000 cubic feet per minute." This resolution, concurred in by his colleagues, failed to secure the assent of Mr. Burchell; who, on the 14th November, proposed Resolution I., as it now stands on pages 52 and 53 of this report, and which was unanimously agreed to. In view of these, it is difficult to understand Mr. Burchell's position, or the grounds on which he refuses to concur in the finding of his colleagues.

Mr. Burchell says that—"The zero on the gauges at Morgan and Overland Corner are not set at corresponding levels." Assuming that what is meant is that the zeros do not apply to equal volumes, all that can be said is, that nothing of the kind can be inferred from the diagram put in in evidence, nor from that published with this report, and signed by Mr. Burchell himself. On the contrary, the diagram put in by Mr. Moncrieff states specifically that the zeros at Morgan and Overland Corner do correspond. What the navigable volume is Mr. Glynn evidently had no doubt when, at the Melbourne Convention, in 1898, he referred to Mr. Burchell's diagram, and to the navigable volume thereon shown as 337,000 cubic feet per minute. That Mr. Burchell himself adopted the same view at Adelaide, on the 24th May, 1902, may be inferred from his question, No. 135, to Mr. Catt: (See reference to this in page 51 of the Report).

In paragraphs 5 and 6 of the "Dissent," Mr. Burchell does not make himself quite clear. Evidently, however, the intention is to traverse Resolutions I. and V. in the report. Seeing that Resolution I. was proposed by himself, and that he agreed to both it and Resolution V., it is useless to subject these paragraphs to further criticism.

In paragraph 9, subclause 3, the following appears:—"The information giving the navigable depth at Overland Corner is on the portion of the plan which, for some reason, was not printed." In the reference column of the plan referred to, printed as Appendix B of the Report, is this note:—"Faint blue line F shows limit of depth of water required in river at Overland Corner to admit of safe navigation of steamers." The line F is shown on the printed plan, as well as the explanatory note above quoted. In Mr. Burchell's original plan, which is some 14 feet long, the note is repeated in identical words in another place. Surely it is too absurd for Mr. Burchell to complain that the Commission has not printed the whole of this plan.

9TH DECEMBER, 1902.

J. DAVIS.
STUART MURRAY.

PROPOSED STORAGE RESERVOIR

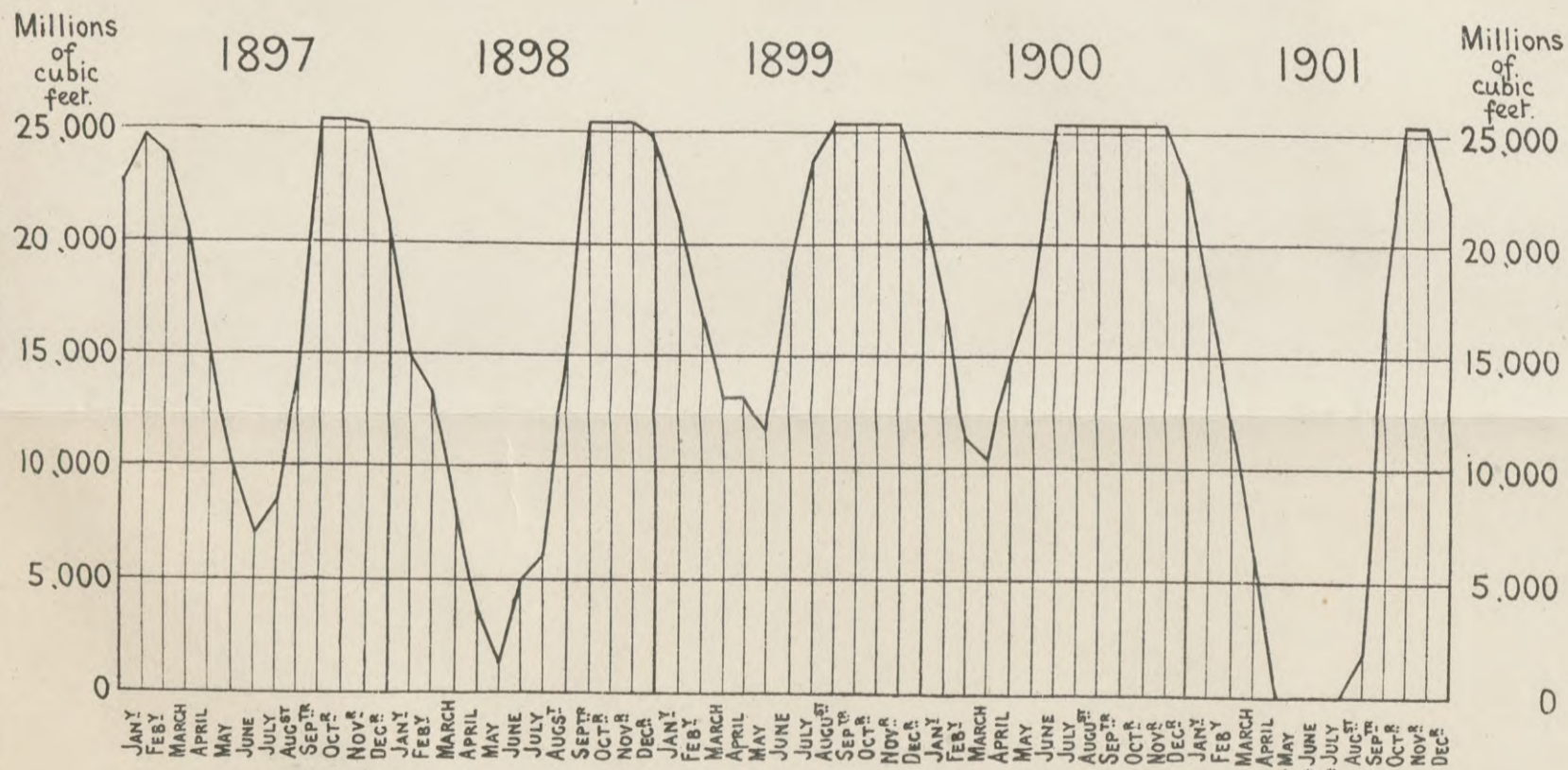
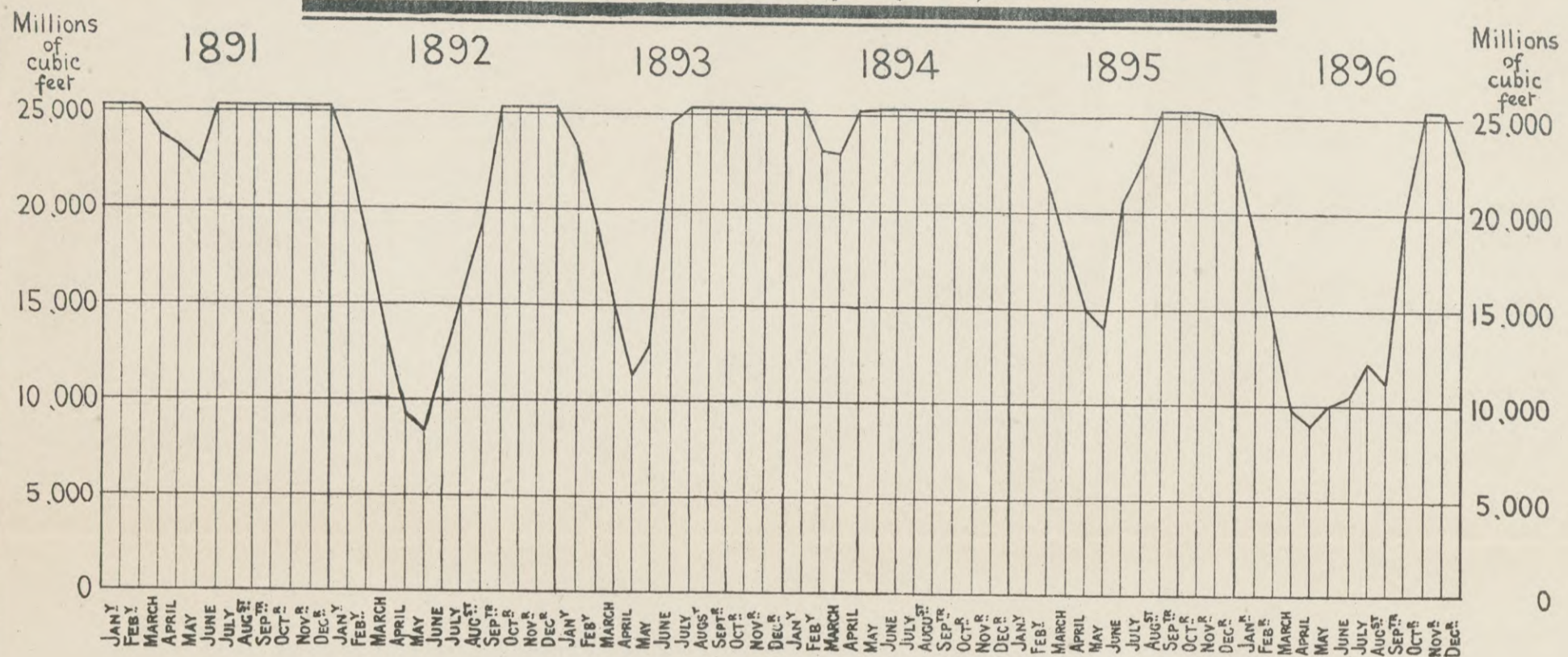
Appendix "A"

ON THE

MURRAY RIVER AT CUMBEROONA

Diagram showing behaviour of reservoir in providing
180,000 cubic feet per minute at Bungowannah
Capacity of reservoir 25,367,000,000 cubic feet

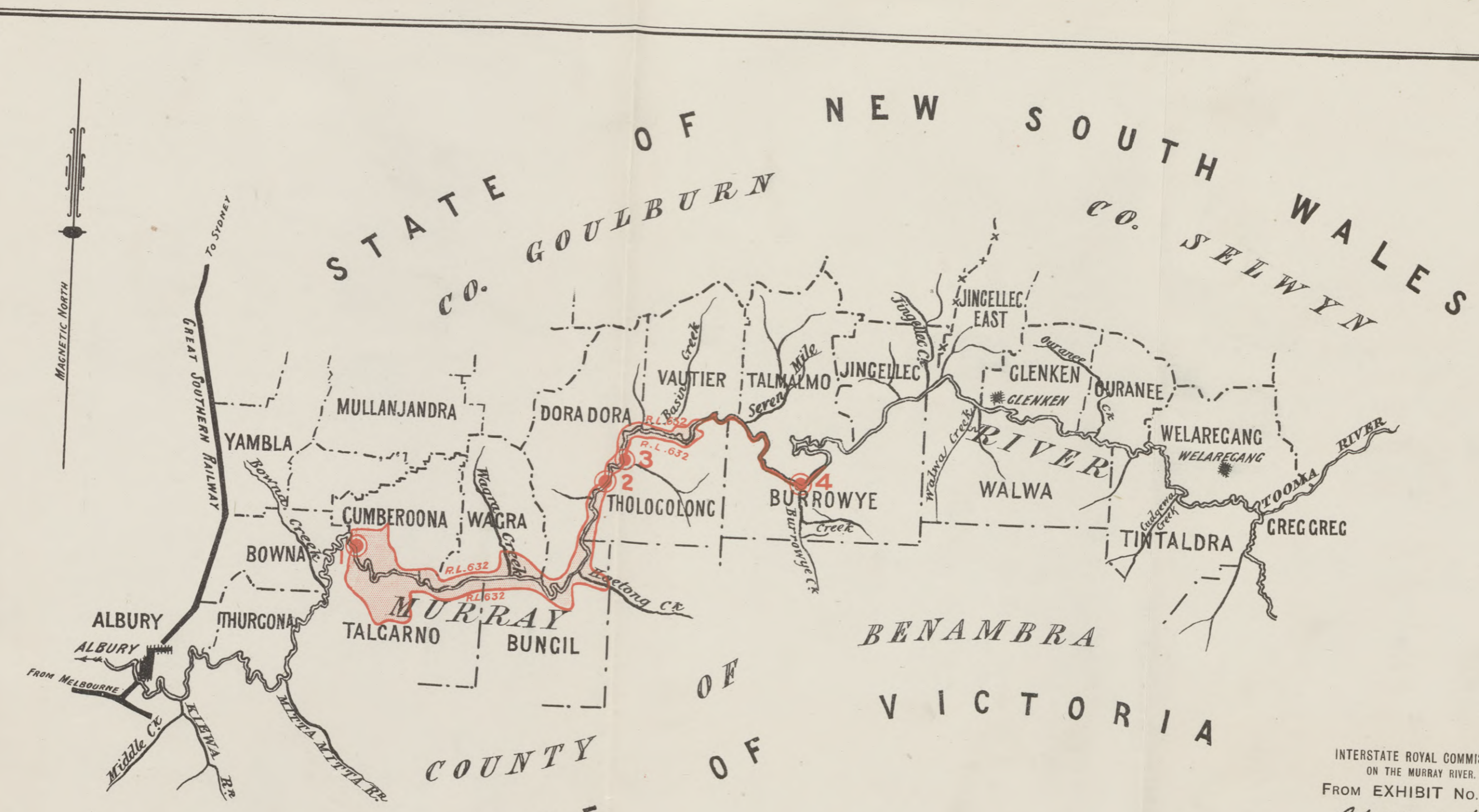
*L. Davis M.A. 1892
President
2nd Dec 1902*



* Reservoir empty on 3rd May. Discharge at Bungowannah (natural flow) 102,880 c.ft. p.min. in May; 150,700 in June; & 101,450 in July

*R. L. ...
Secretary
Interstate Royal Commission
on the Murray River.
7/12/02*

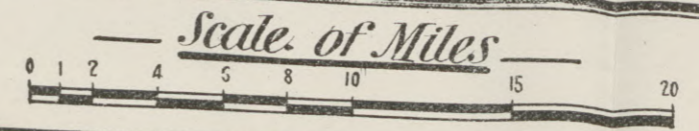
1-12-02



Note:- SUGGESTED DAM SITES SHOWN THUS:-
 N^o1 Cumberoona Site.
 N^o2 Thologolong Lower Site.
 N^o3 Thologolong Upper Site.
 N^o4 Talmalmo Site.

*J. Davis M. Arch. C.E.
 President 1/12/02*

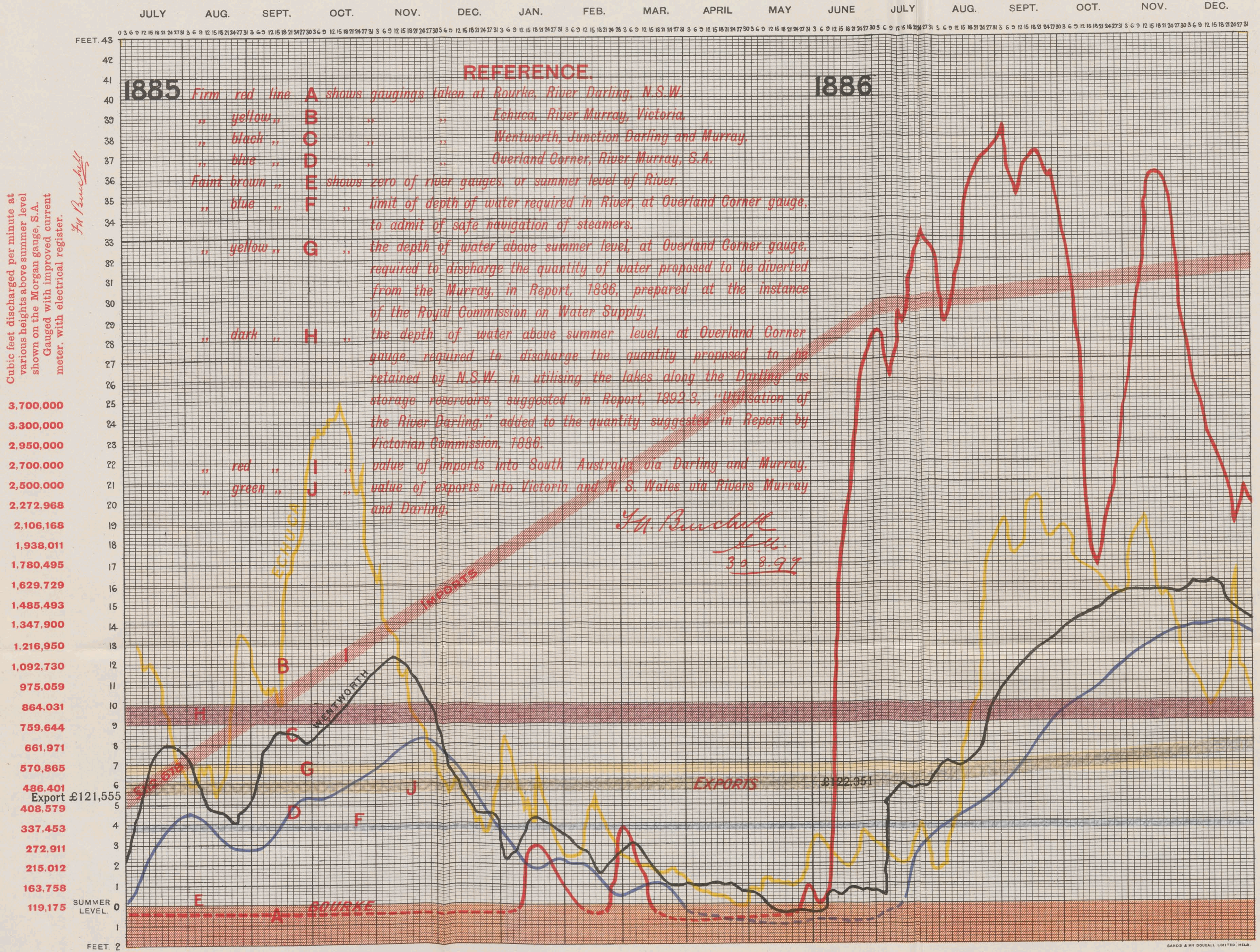
SKETCH PLAN
Shewing Suggested Dam Sites



INTERSTATE ROYAL COMMISSION
 ON THE MURRAY RIVER.
 FROM EXHIBIT No. 138.
Robert E. Mackay
 Secretary.

DIAGRAM OF GAUGINGS OF THE RIVER MURRAY.

Appendix "B."



AUSTRALASIAN FEDERAL CONVENTION, SYDNEY, 1897.

PLAN showing, at various points in their course during each month of several years, the levels of the Murray and Darling, the effect on trade of the rise and fall of the rivers; and to what extent, and within what time, a flood near the source affects the levels lower down.

Laid on the Table by the Honorable Mr. Barton, and ordered to be lithographed, September 22nd, 1897 (Sydney).

INTERSTATE ROYAL COMMISSION
ON THE
MURRAY RIVER

MURRAY RIVER BASIN

SHOWING
MAIN AND CONTRIBUTING STREAMS
WITH THEIR
CATCHMENT AREAS
ALSO
EXISTING AND PROPOSED WORKS
OF
WATER CONSERVATION

REFERENCE

BOUNDARY OF MURRAY BASIN SHOWN THIS
CONTRIBUTING PORTION
NON-CONTRIBUTING PORTION
EXISTING WORKS
WORKS PROPOSED BY STATE GOVERNMENTS
PROPOSED SITES FOR LOCKS

SCALE OF STATUTE MILES
0 10 20 30 40 50 60 70 80 90 100

J. Davis, M. Inst. C.E.
President,
1/12/02.



DRAINAGE AREA OF THE MURRAY RIVER

WATERCOURSE	CONTRIBUTING AREA (SQ. MILES)	NON-CONTRIBUTING AREA (SQ. MILES)	TOTAL (SQ. MILES)
QUEENSLAND			
Macintyre and Dumaresq Rivers	3 022		
Moonie River	2 023		
Condamine	2 348		
Mungallala and other creeks	16 214		
Warrego River	7 126		36 835
Paroo	5 453		
	17 167		
	13 567		
Totals	67 600	36 835	104 535
NEW SOUTH WALES			
Dumaresq River	2 027		
Macintyre	3 161		
Cwydir	4 726		
Maranoa	8 462		
Castlereagh	3 082		
Macquarie	10 359		
Bogan	4 510		
Lachlan	20 120		
Murrumbidgee	13 384		
Bilbarong Creek	1 778		
Murray River	2 313		
East of the Darling	29 341		
West of the Darling	54 291		
South	26 202		
	109 023		
	49 840		
Totals	75 495	158 863	234 358
VICTORIA			
Murray River	1 500		
Mitta	2 400		
Kiewa	700		
Ovens	2 700		
Coulburn	5 240		
Campaspe	310		
Loddon	1 800		
Araucan, Avon, and Wimmera Rivers, and Mallee country	27 120		
	15 310		
	35 665		
	50 978		
Totals	24 387	24 387	24 387
Grand Totals	158 495	158 754	416 253

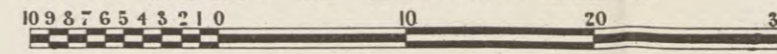
INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER
Robert Lowry
Secretary,
1/12/02.



INTERSTATE ROYAL COMMISSION
ON THE
MURRAY RIVER

PLAN SHOWING
EXISTING AND PROPOSED WORKS
OF
WATER CONSERVATION
IN THE
MURRAY RIVER BASIN
IN
VICTORIA

Scale of Statute Miles



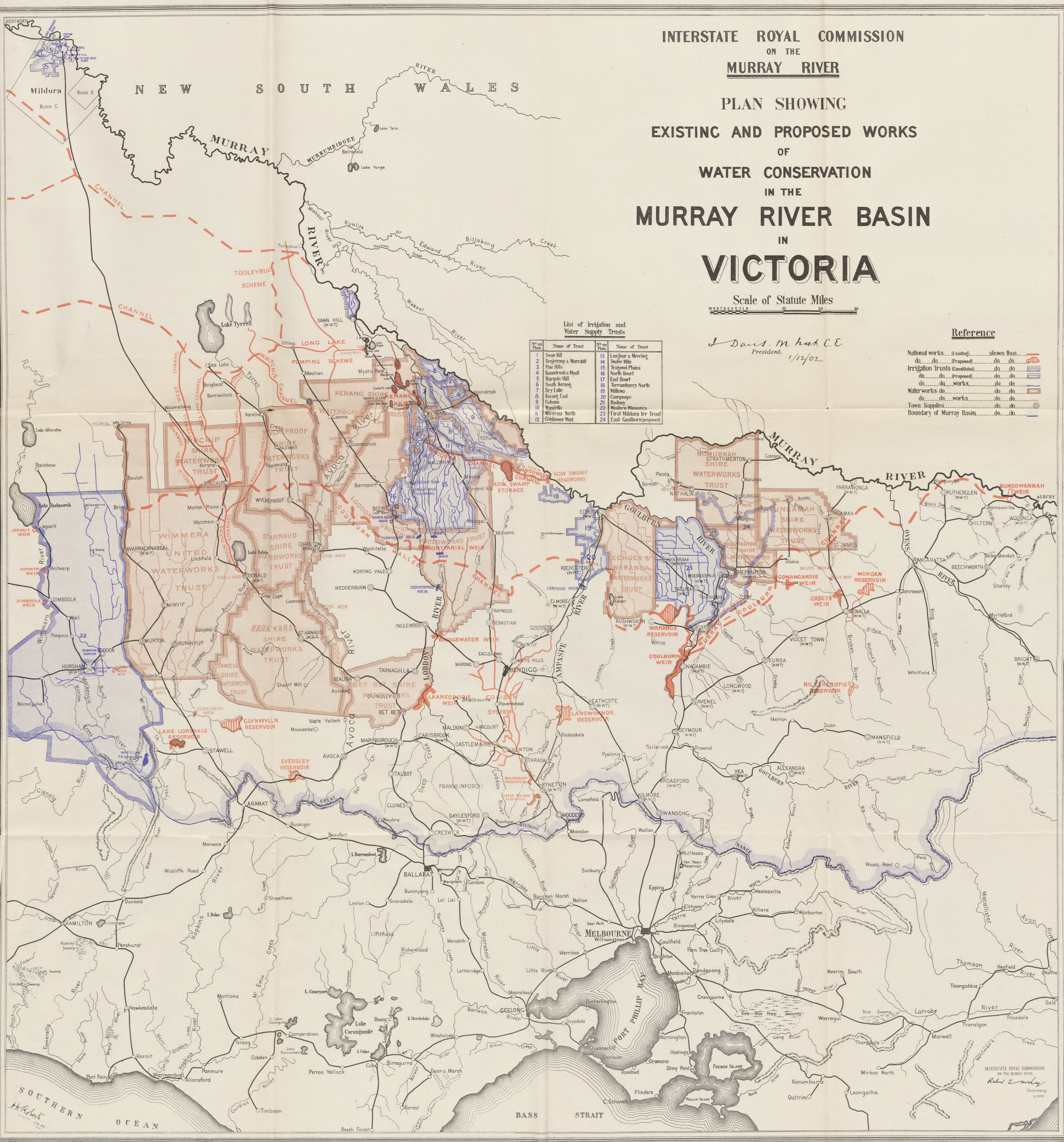
J. Davis, M. Inst. C.E.
President, 1/12/02

Reference

- National works... (Existing) shown thus
- do do (Proposed) do do
- Irrigation Trusts Constituted do do
- do do Proposed do do
- do do works do do
- Waterworks do do do do
- do do works do do
- Town Supplies do do
- Boundary of Murray Basin do do

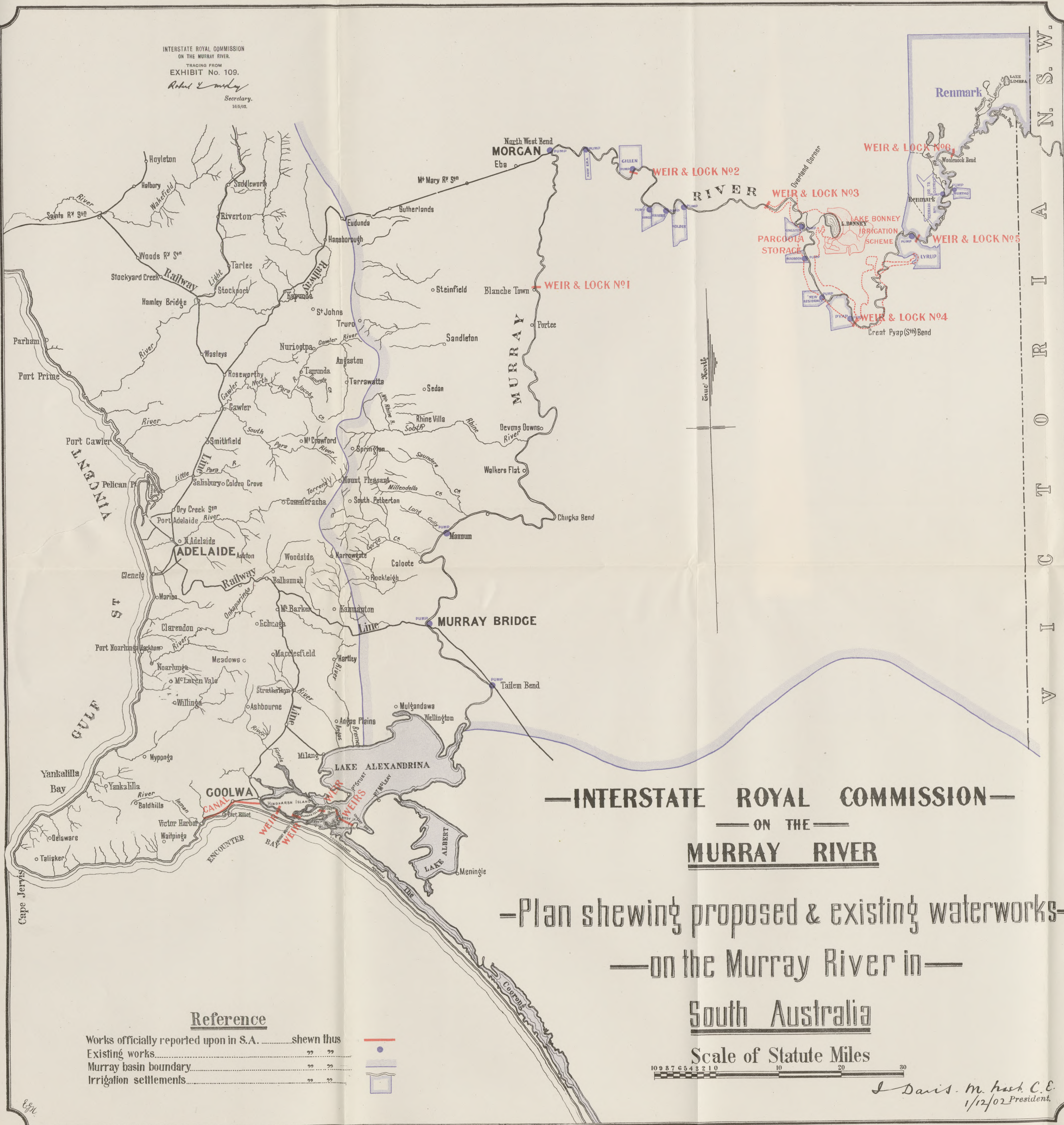
List of Irrigation and Water Supply Trusts

No on Plan	Name of Trust	No on Plan	Name of Trust
1	Swan Hill	13	Leighur & Mering
2	Benjeroop & Murrabit	14	Twelve Mile
3	Pine Hills	15	Traralgon Plains
4	Koonrook & Myall	16	North Boroit
5	Marpis Hill	17	End Boroit
6	South Kerang	18	Torrumberry North
7	Dry Lake	19	Milwaka
8	Kerang East	20	Campaspe
9	Culnha	21	Rodney
10	Wandella	22	Western Wimmera
11	Wimmera North	23	First Mildura Irr. Trust
12	Gundowree West	24	East Goulburn (proposed)



INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER
Robert C. Smith
Secretary
1.12.02

INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER.
TRACING FROM
EXHIBIT No. 109.
Robert L. Mackay
Secretary.
16/5/02.



V I C T O R I A N S W.

— INTERSTATE ROYAL COMMISSION —
— ON THE —
MURRAY RIVER

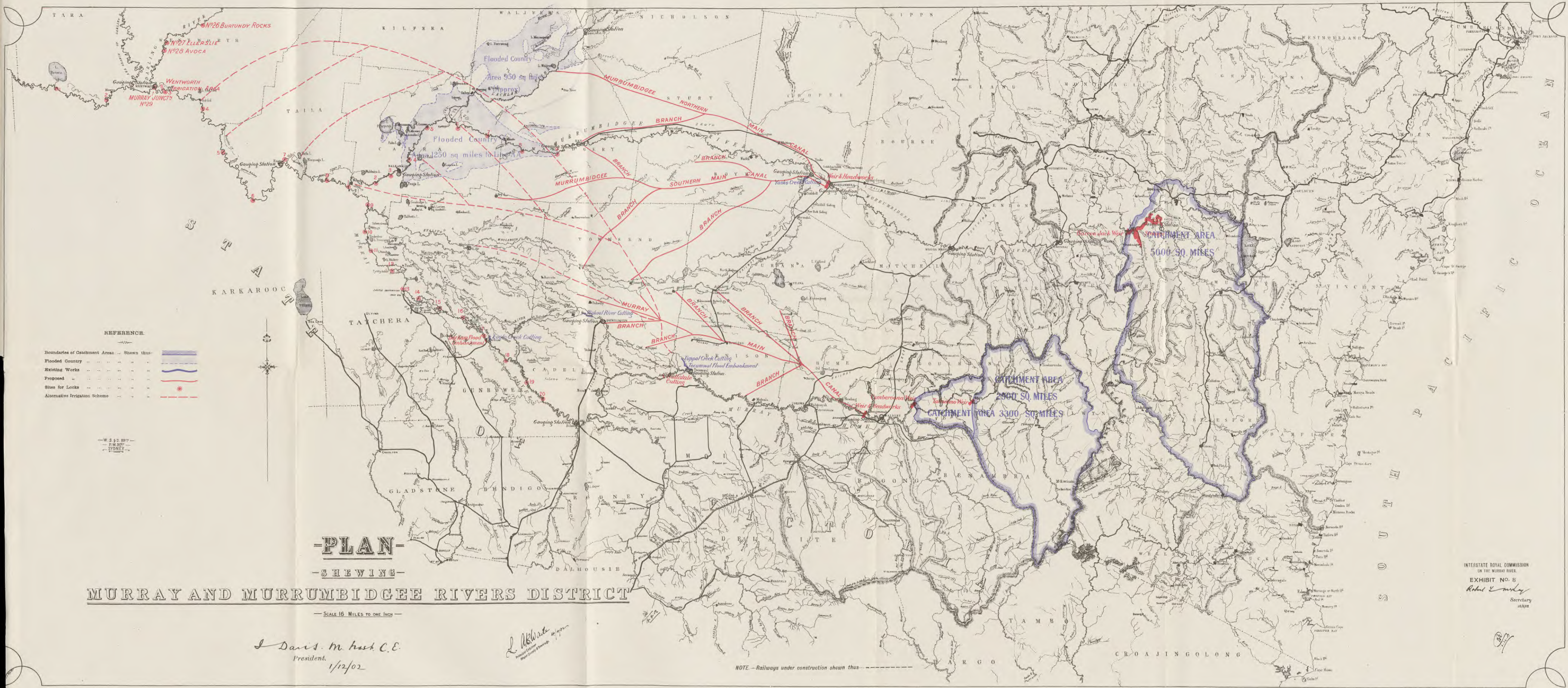
— Plan shewing proposed & existing waterworks —
— on the Murray River in —
South Australia

Reference

- Works officially reported upon in S.A. shewn thus
- Existing works " "
- Murray basin boundary " "
- Irrigation settlements " "



J. Davis. M. Mack. C.E.
1/12/02 President.



REFERENCE.

Boundaries of Catchment Areas	Shows thus	
Flooded Country	Shows thus	
Existing Works	Shows thus	
Proposed "	Shows thus	
Sites for Locks	Shows thus	
Alternative Irrigation Scheme	Shows thus	

-PLAN-
-SHOWING-
MURRAY AND MURRUMBIDGEE RIVERS DISTRICT

SCALE 16 MILES TO ONE INCH

J. Davis, M. Esq. C.E.
 President.
 1/12/02

L. Akwate
 Engineer

NOTE.—Railways under construction shown thus

INTERSTATE ROYAL COMMISSION
 ON THE MURRAY RIVER.
 EXHIBIT NO. 8
Robert E. Smith
 Secretary
 1902

W.S.A.S. BRO.
P.W. DEP.
SYDNEY.

PLAN — SHEWING — — DARLING RIVER DISTRICT —

— WALGETT TO WILCANNIA —

— SCALE 1/6 MILES TO ONE INCH —

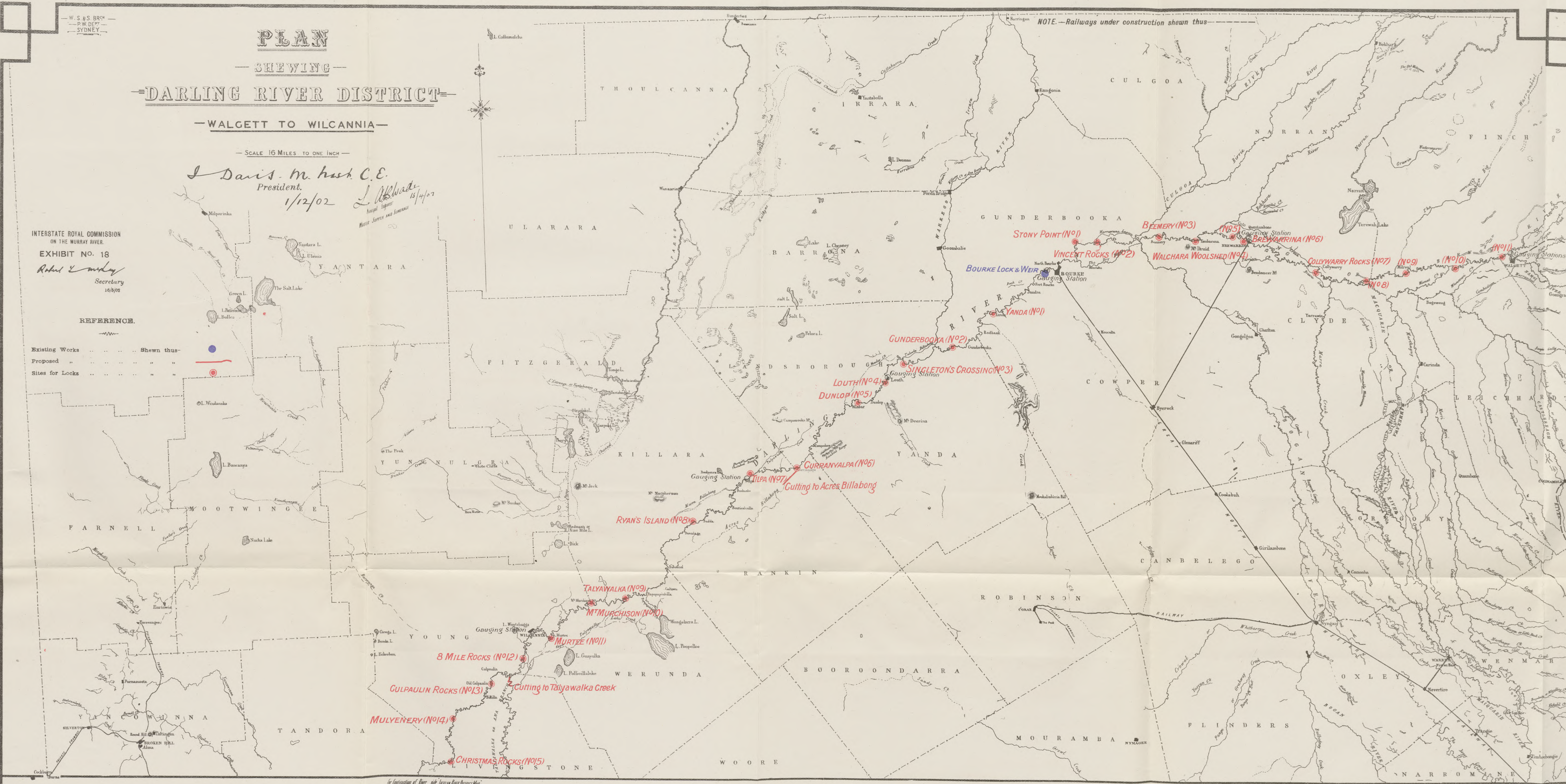
I. Davis, M. Esq. C.E.
President.
1/12/02
L. Wade
15/11/02
Major Survey and Liaison

INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER.
EXHIBIT No. 18
Robert C. Smiley
Secretary
16/6/02

REFERENCE.

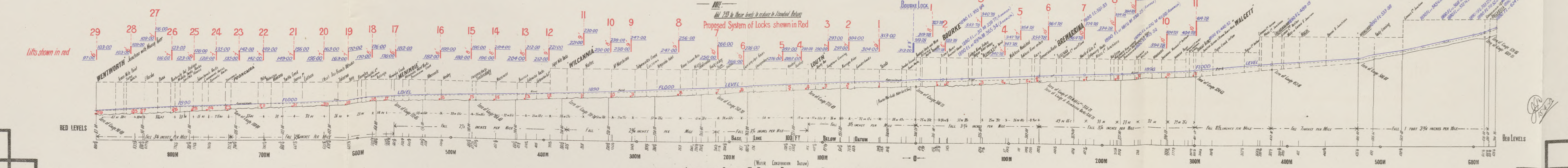
Existing Works Shewn thus
Proposed
Sites for Locks

NOTE.—Railways under construction shewn thus



In continuation of Plan, No. 14, Murray River Survey Map

Proposed System of Locks shewn in Red



LONGITUDINAL SECTION OF THE DARLING RIVER
— WILCANNIA TO WALGETT —
SCALE: Horizontal 50 Miles to One Inch, Vertical 400 Feet to One Inch

SANDS & McDOUGALL LIMITED

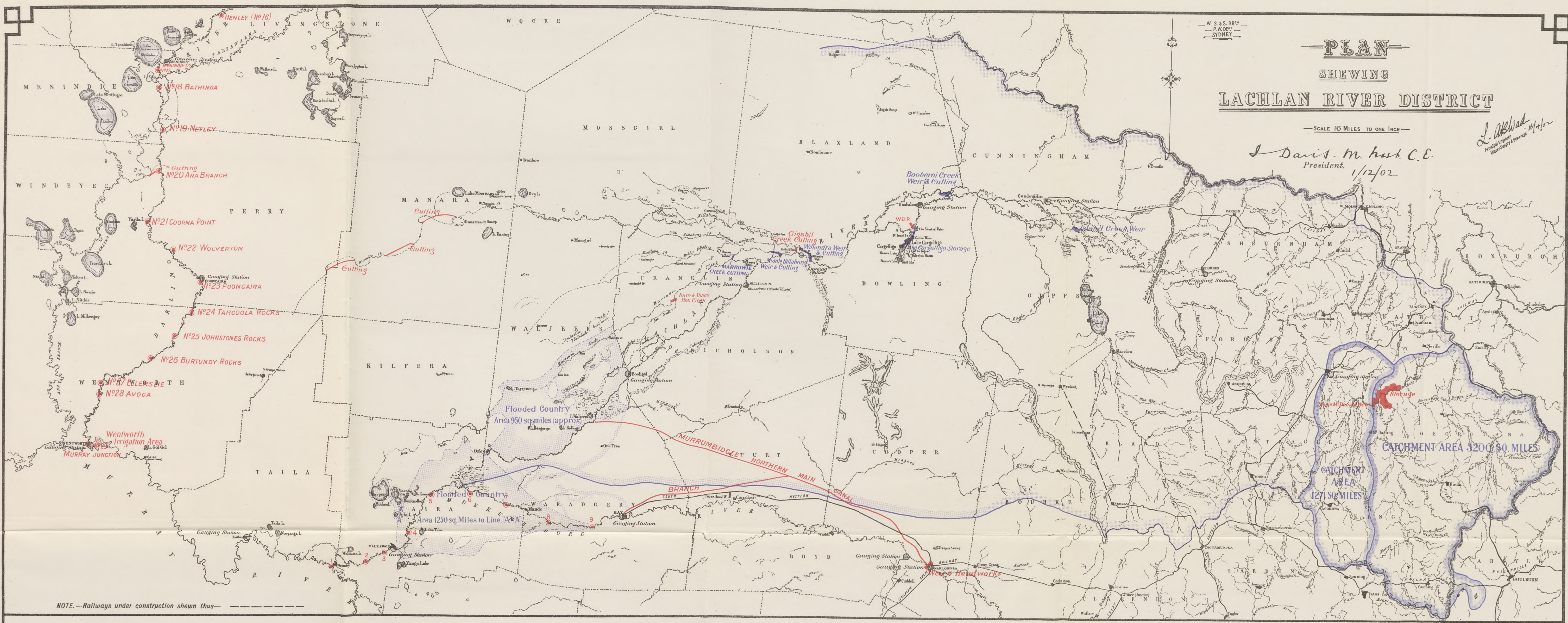
W. S. S. 88°
P. W. DEPT.
SYDNEY

PLAN SHEWING LACHLAN RIVER DISTRICT

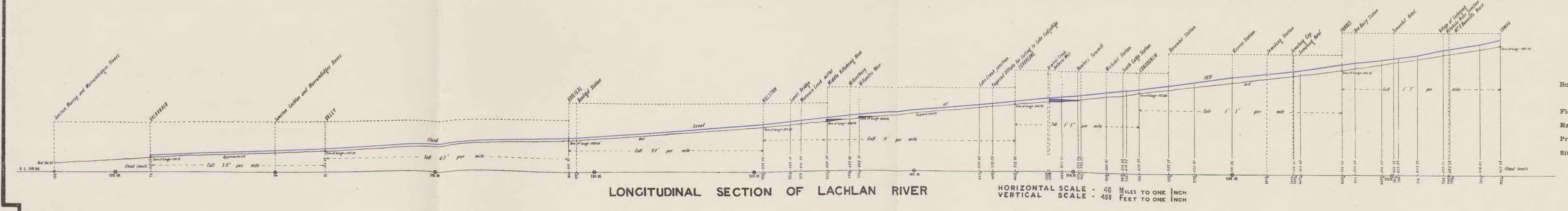
SCALE 16 MILES TO ONE INCH

J. Davis M. Inst. C.E.
President.
1/12/02

L. A. Wade
Principal Engineer
Water Supply & Sewerage



NOTE.—Railways under construction shewn thus



REFERENCE.

Boundary of River Basin	Shewn thus	
" " Catchment Areas	" "	
Flooded Country	" "	
Existing Works	" "	
Proposed "	" "	
Sites for Locks	" "	

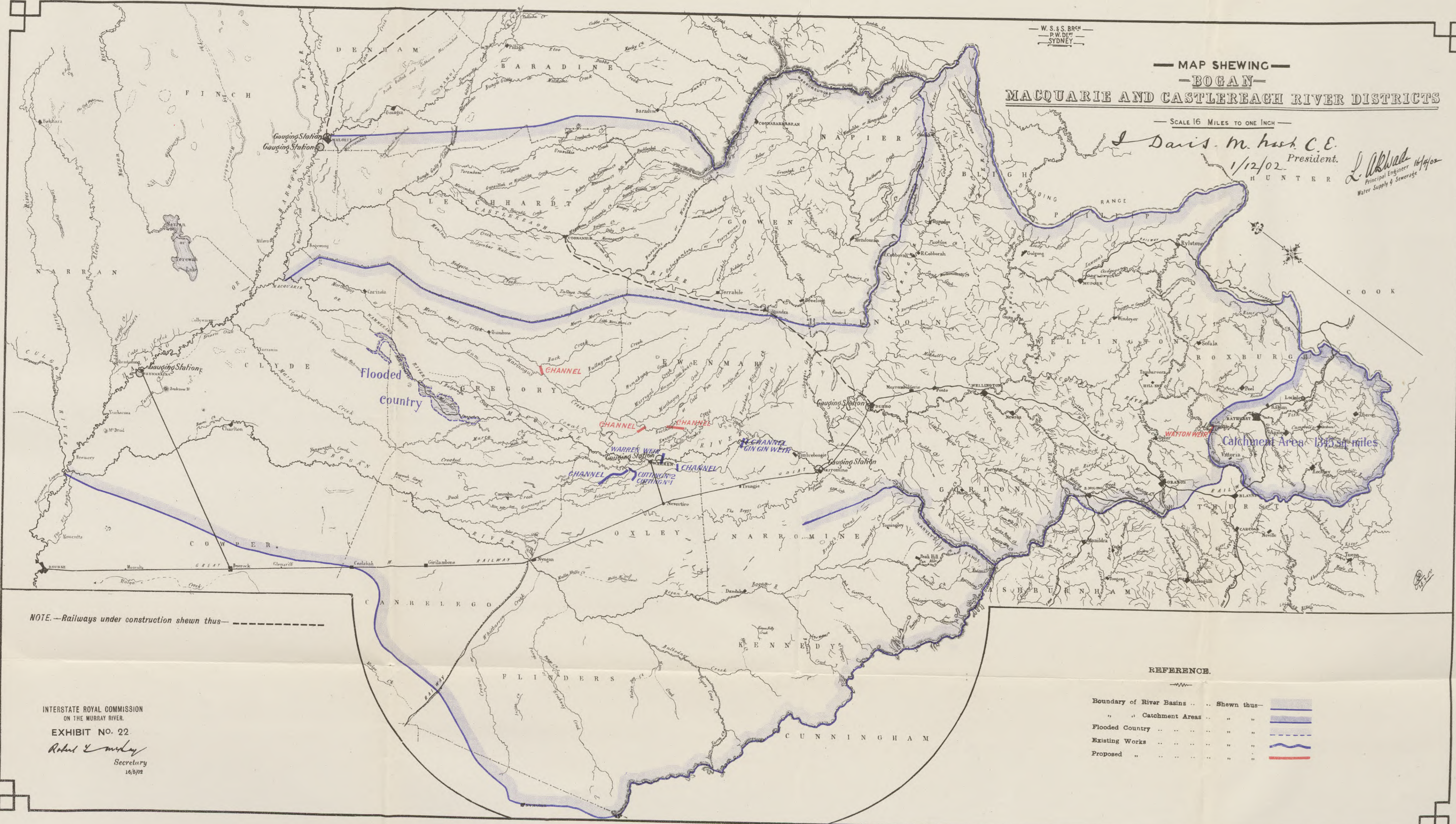
INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER.
EXHIBIT No. 15.
Robert E. Milroy
Secretary.
16/8/02

W.S. & S. BRCH
P.W. DEPT
SYDNEY

MAP SHEWING
BOGAN
MACQUARIE AND CASTLEREACH RIVER DISTRICTS

SCALE 16 MILES TO ONE INCH

J. Davis M. Inst. C.E.
1/12/02 President.
HUNTER
L. Alward
Principal Engineer 16/1/02
Water Supply & Sewerage



NOTE.—Railways under construction shewn thus—

INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER.
EXHIBIT NO. 22.
Robert L. Munday
Secretary
16/5/02

REFERENCE.

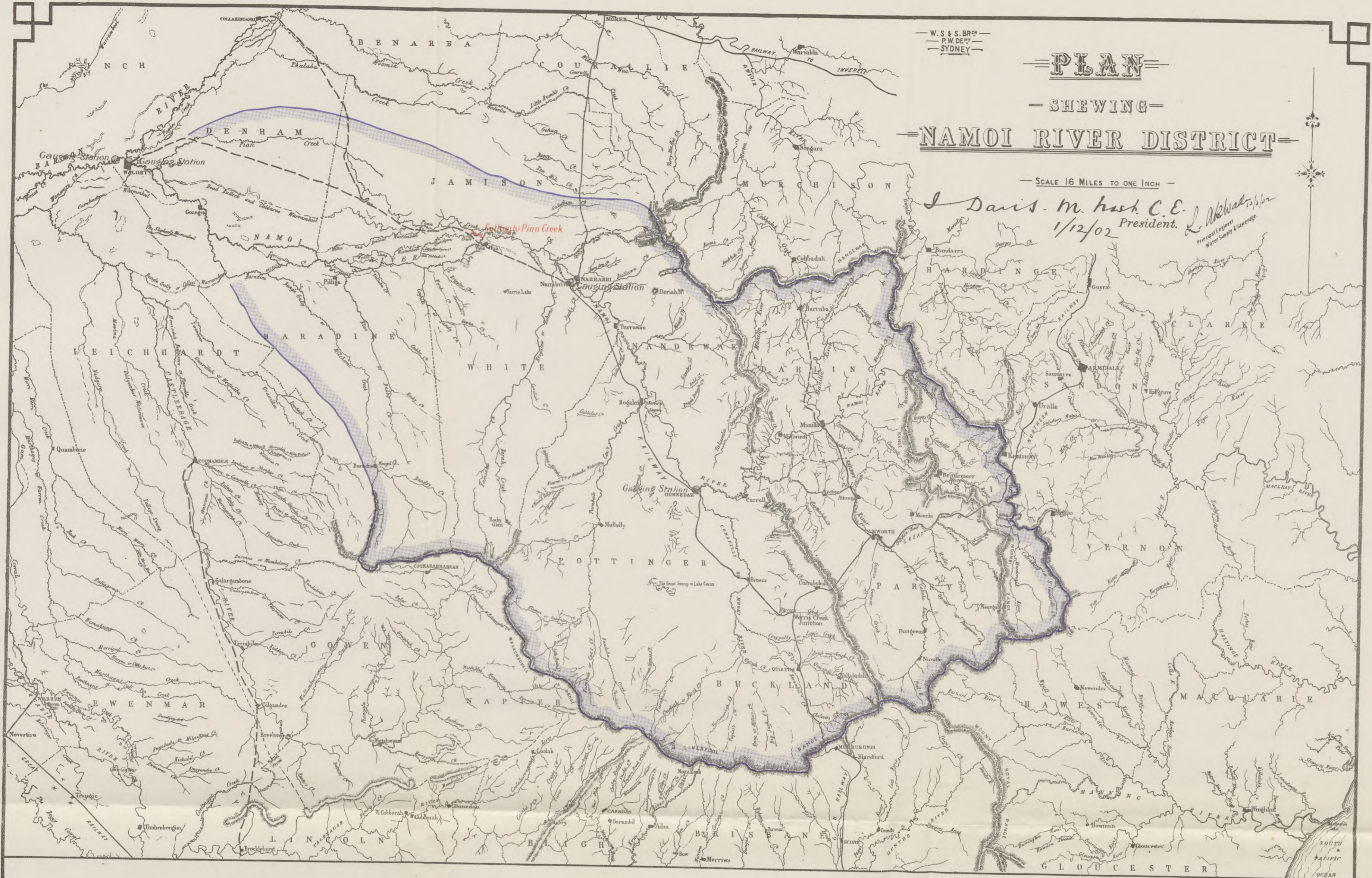
Boundary of River Basins ..	Shewn thus—	
" " Catchment Areas ..	" " "	
Flooded Country ..	" " "	
Existing Works ..	" " "	
Proposed ..	" " "	

W. S. & S. BROS.
P. M. DE'77
SYDNEY

PLAN
— SHEWING —
NAMOI RIVER DISTRICT

— SCALE 16 MILES TO ONE INCH —

J. Davis, M. Inst. C.E.
1/12/02
President. *J. M. Watson*
Principal Engineer
Water Supply & Sewerage



REFERENCE.

- Boundary of River Basin Shown thus—
- Proposed Works

NOTE.—Railways under construction shewn thus—

INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER.

EXHIBIT NO. 23

Robert C. Mackay
Secretary
16/5/02

W.S. & S. BRCH
P.W. DEPT
SYDNEY

REFERENCE

- Boundary of River Basins Shewn thus—
- Flooded Country " " "
- Existing Works " " "
- Proposed " " "

INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER.

EXHIBIT NO. 24

Robert L. Mackay
Secretary
16/6/02

NOTE.—Railways under construction shewn thus—

PLAN

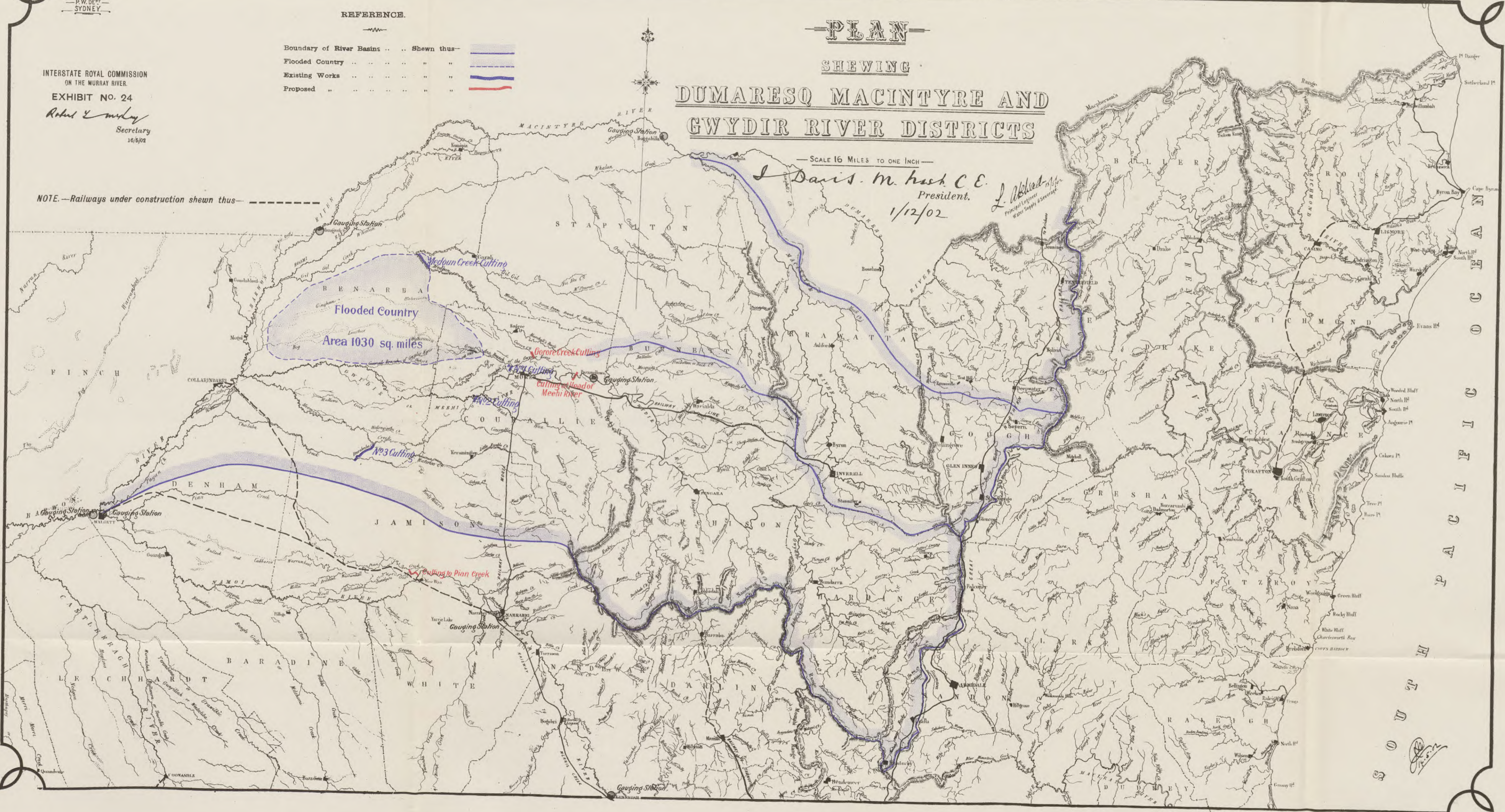
SHEWING

DUMARESQ MACINTYRE AND
GWYDIR RIVER DISTRICTS

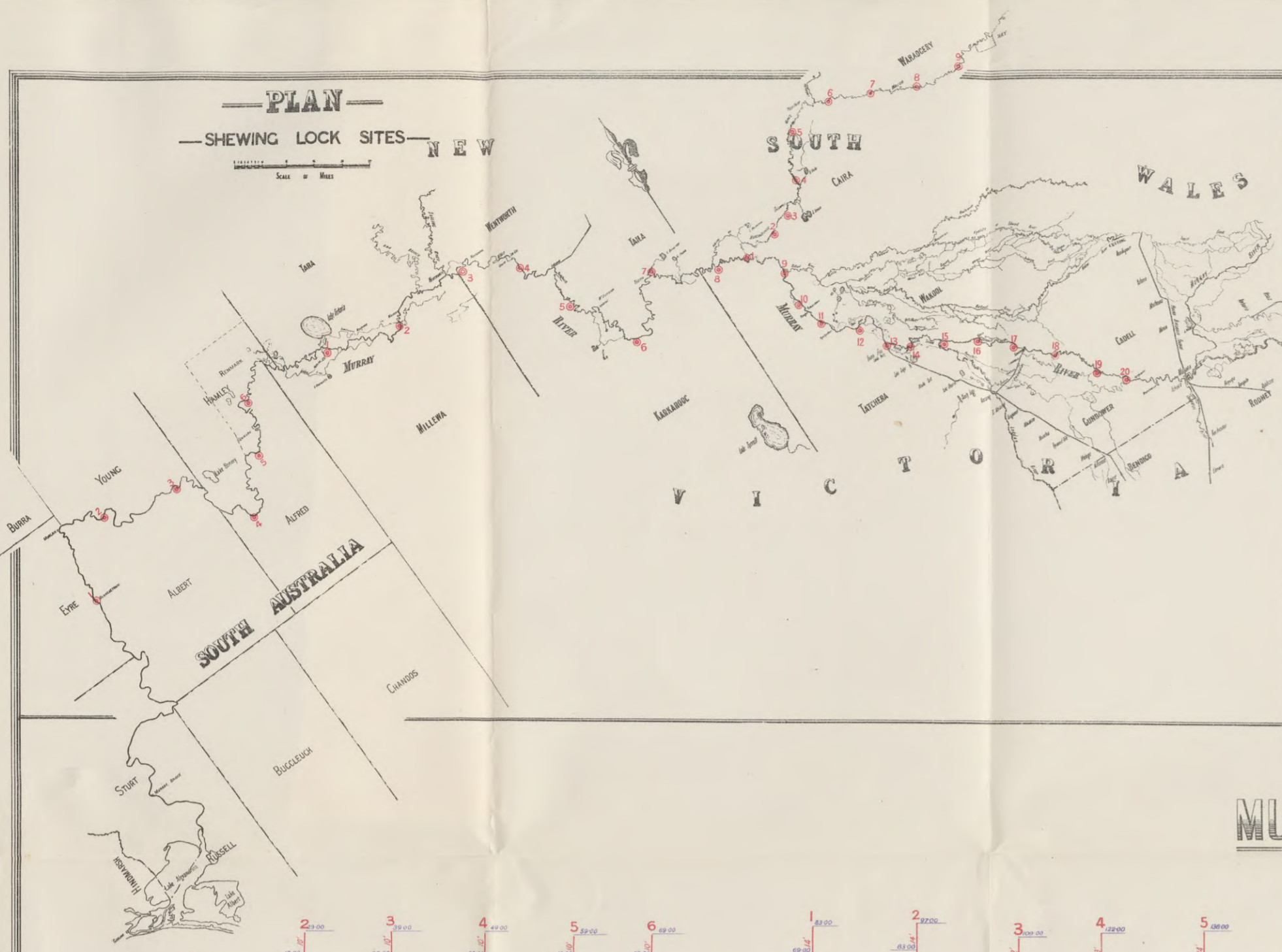
SCALE 16 MILES TO ONE INCH

J. Davis M. Esq. C.E.
President.
1/12/02

L. Ashford Esq.
Principal Engineer
Water Supply & Sewerage



PLAN
— SHEWING LOCK SITES —



MURRAY AND MURRUMBIDGEE RIVERS

— LONGITUDINAL SECTIONS ALONG BEDS —

Showing:

SYSTEM OF LOCKS

SCALE (Horizontal — 30 Miles) TO ONE INCH
(Vertical — 150 FEET)

WATER CONSERVATION DATUM.
ADD 2.93 TO
THESE LEVELS TO REDUCE TO
STANDARD DATUM

Navigation Levels are for Vessels of 4 feet draught

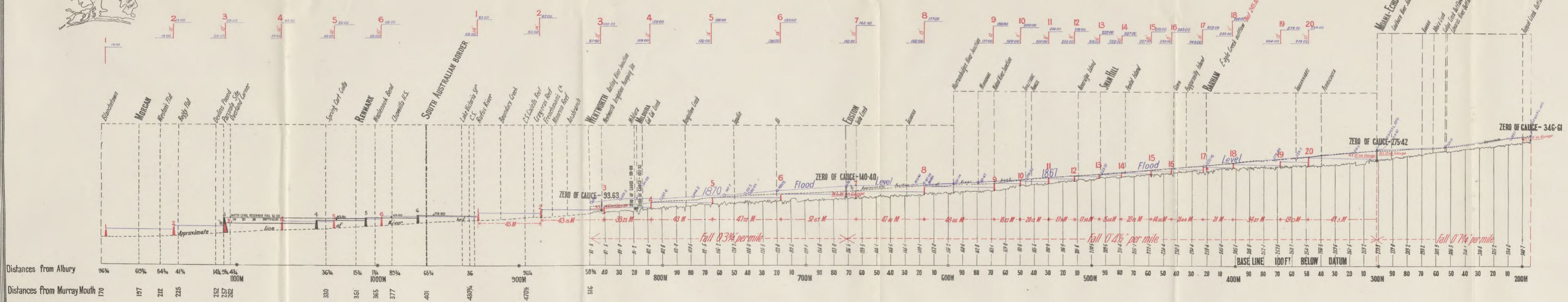
Davis Mackay C.E.
President,
1/12/02

INTERSTATE ROYAL COMMISSION
ON THE MURRAY RIVER.
DRAWN FROM
EXHIBITS NOS. 6 & 133.
Robert Smith
Secretary,
1/12/02.

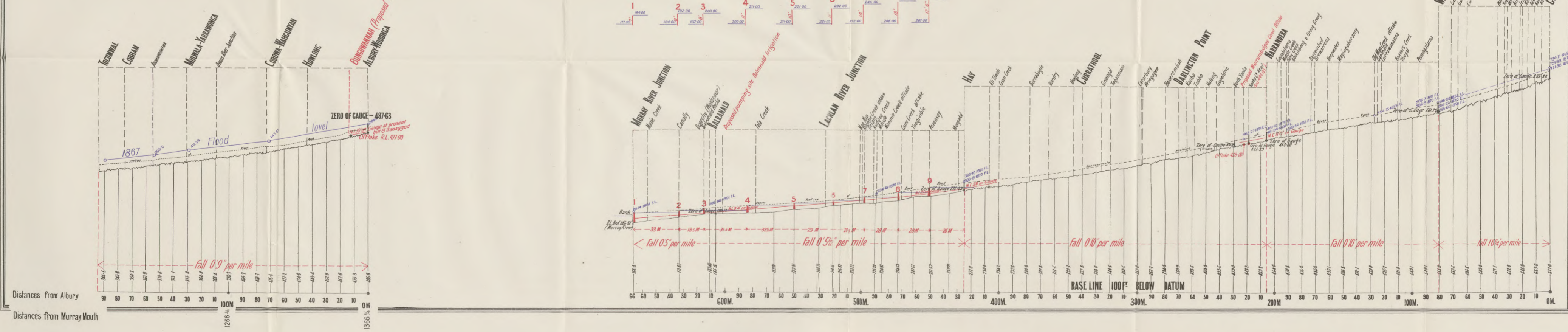
L. Nelson
Mining Engineer
for M.A.S. Supply and Storage

MURRAY RIVER

Note: 1867 flood levels only available 0 to 616 miles
1870 - - - - - 616 to 880 -



MURRUMBIDGEE RIVER



P. W. D.
W. S. & S. Branch
Sydney

PROPOSED IMPROVEMENTS LAKE VICTORIA CONTOUR PLAN OF LAKE AND Sections of Rufus River & Frenchmans Creek

Survey & Level Books 877 & 878 Turner

J. Davis, M. Inst. C.E.
President.
1/12/02

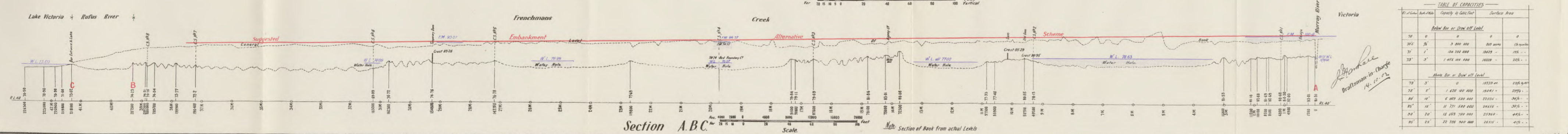
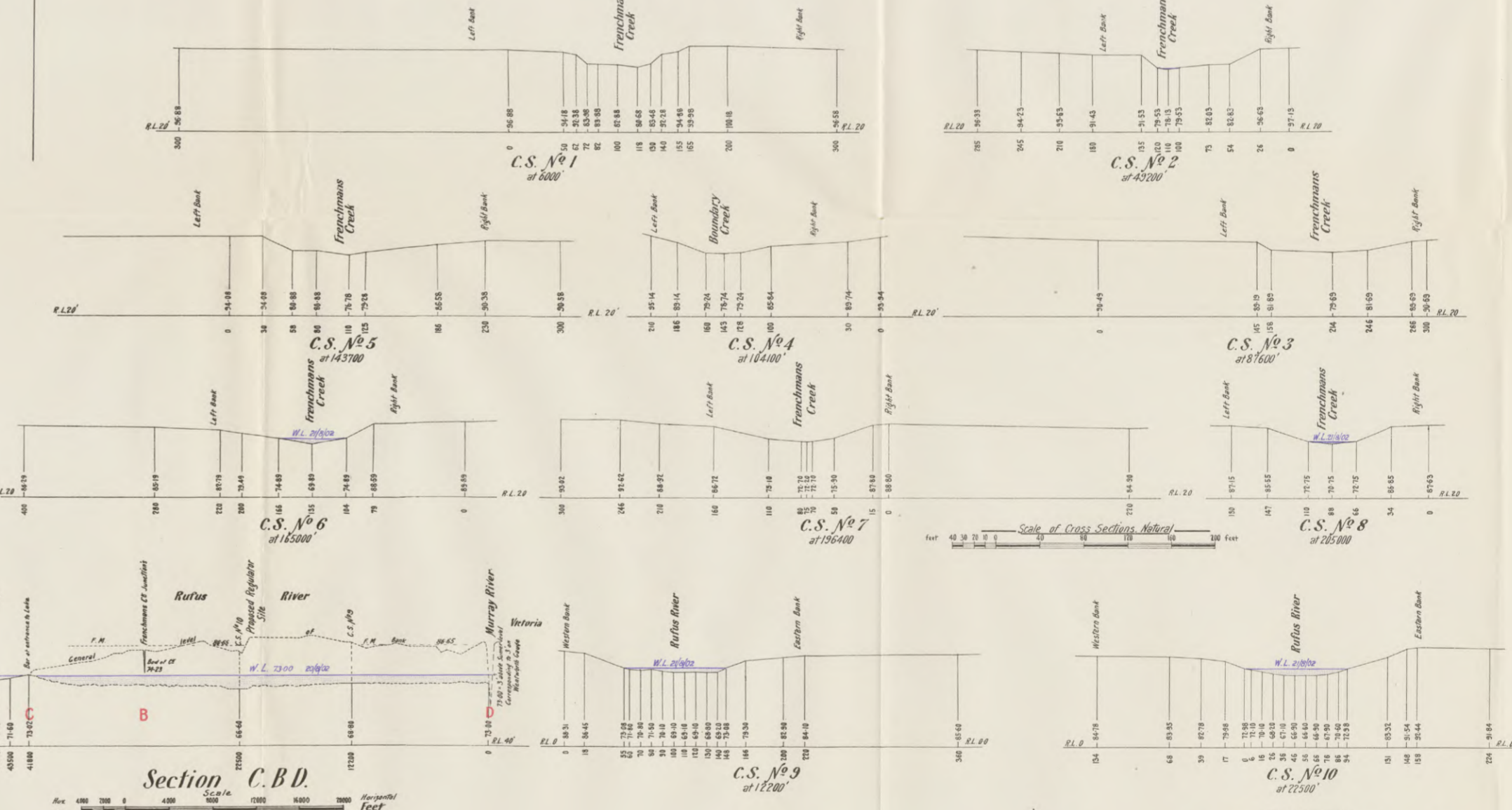
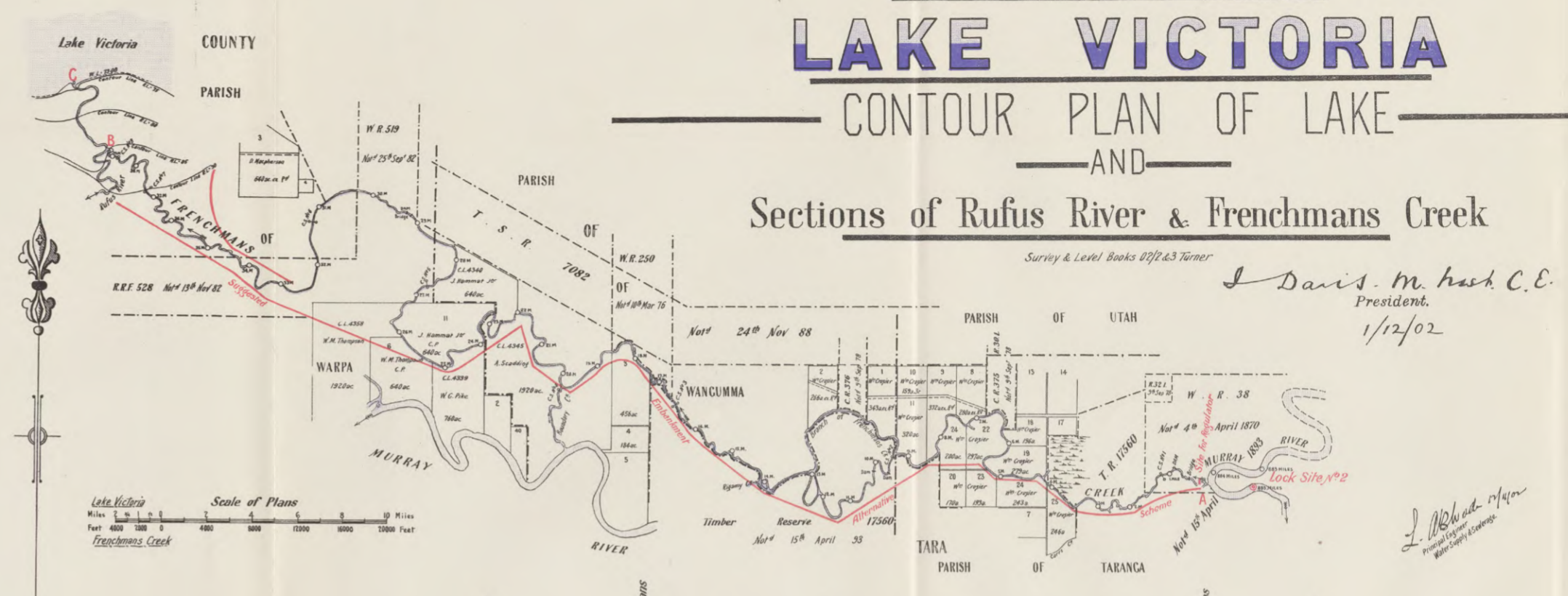


TABLE OF CAPACITIES

Water Level	Capacity in Gallons	Surface Area
70' 0"	0	0
70' 5"	3,000,000	100 acres
71' 0"	6,000,000	200 "
71' 5"	9,000,000	300 "
72' 0"	12,000,000	400 "
72' 5"	15,000,000	500 "
73' 0"	18,000,000	600 "
73' 5"	21,000,000	700 "
74' 0"	24,000,000	800 "
74' 5"	27,000,000	900 "
75' 0"	30,000,000	1,000 "
75' 5"	33,000,000	1,100 "
76' 0"	36,000,000	1,200 "
76' 5"	39,000,000	1,300 "
77' 0"	42,000,000	1,400 "
77' 5"	45,000,000	1,500 "
78' 0"	48,000,000	1,600 "
78' 5"	51,000,000	1,700 "
79' 0"	54,000,000	1,800 "
79' 5"	57,000,000	1,900 "
80' 0"	60,000,000	2,000 "

J. Davis
Draftsman-in-Charge
No. 10/02



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