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THE RURAL RECONSTRUCTION
COMMISSION.

IRRIGATION, WATER CONSERVATION
AND LAND DRAINAGE.

The Commission's EIGHTH REPORT
to the Honorable J. J. Dedman, M.P.,
Minister for Post-war Reconstruction.

Dated 11th day of December, 1945.

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This present Report is the eighth produced by the Rural Reconstruction Commission. Earlier Reports were—

- 1. A General Rural Survey. (Dated 17/1/44.)**
- 2. Settlement and Employment of Returned Men on the Land. (Dated 18/1/44.)**
- 3. Land Utilization and Farm Settlement. (Dated 30/6/44.)**
- 4. Financial and Economic Reconstruction of Farms. (Dated 28/8/44.)**
- 5. Rural Credit. (Dated 28/2/45.)**
- 6. Farming Efficiency and Costs, and Factors relating thereto. (Dated 11/4/45.)**
- 7. Rural Amenities. (Dated 18/5/45.)**

CHAPTER I.—INTRODUCTION.

1680. During the course of its investigations the Commission has given consideration to the potentialities for further development of farming industries in Australia. As the population of the Commonwealth increases, the demand for farm produce will also increase, and ultimately a point will be reached at which food and other supplies will be required in excess of the quantities produced at the present time. In the long run, therefore, increase of food supplies for the local population would become an urgent matter. The Commission has not given much attention to the numerous calculations which have been made as to the numbers which Australia could clothe and feed from her own resources. It has, however, given considerable thought to the directions in which the future expansion of farm production may be expected to occur.

1681. In the first place, some increase may be expected from an improvement in farming efficiency. Secondly, in the areas of high rainfall near the coast large tracts of country occur in which the soils are too poor for effective use under present systems of agriculture, while sometimes the native vegetation is too dense to make the economic establishment of farming easy. Doubtless progress will be made in the better utilization of some of these lands, but in general it seems likely that many of them will remain expensive farming regions. They have a good deal in common with much of the land originally heavily wooded in the coastal regions of eastern United States of America where experience has shown that farming is frequently an uneconomic proposition. The third direction from which more farm products will come is from the judicious development of irrigation in regions where the chief obstacle to better farming to-day is the low and uncertain nature of the rainfall. In such regions cropping is uncertain, while even the livestock industries cannot be intensified because of the great losses which occur from time to time owing to droughts. The artificial supply of irrigation water to selected areas can add a stability to farming which it will otherwise never possess.

1682. In the event of a real population pressure developing in Australia, circumstances could easily arise under which the development of the continent would ultimately depend upon the wisdom of the national policy in respect to water. In this, the driest of the continents, the conservation and development of water resources should be an important item in national policy at all stages.

1683. Irrigation is not only of importance in expanding and stabilizing general forms of farm production, but certain specific industries which can only flourish in a hot climate are entirely dependent upon it. Many thousands of Australians already earn their living from the production of dried fruits, canned fruits and rice, which would not be produced on their present scale if irrigation schemes had not been developed in the past.

1684. *Brief Historical Survey.*—Irrigation was practised in dry countries long before written historical records. It was natural, therefore, that as soon as the first surge of settlement had spread over the Australian continent and men began to find the extent to which their pastoral and agricultural occupations were handicapped by uncertain rainfall and recurrent droughts, they should also begin

to think of reinforcing the natural rainfall by supplies of water obtained by other means. The Commission does not propose to make any detailed survey of the history of irrigation in the various parts of the Commonwealth but is content with emphasizing those particular points which seem to be of significance in future development.

1685. The first irrigation schemes were private affairs developed on individual holdings. Some of these were remarkably successful. Later larger scale district schemes were developed in various regions, notably along the middle reaches of the Murray. Many of the early district schemes failed, partly because the land irrigated was often not particularly suitable, partly because the methods employed were extremely crude and partly because many farmers did not recognize that a district irrigation scheme involves its members in a liability to pay their share of the charges in seasons when they do not want the water, as well as in the drier years. In Victoria the unsatisfactory financial position of these schemes led to the Government taking them over and setting up a State body to deal with irrigation matters in 1905. Towards the end of the last century the late Hon. Alfred Deakin, then Premier of Victoria, was greatly impressed by the important part which irrigation might play in Australian development. He visited irrigation areas in India and America and induced the brothers Chaffey to come to Australia in 1886 with the idea of establishing irrigation settlements. After many delays and much opposition in political circles and in the press, these brothers established settlements at Renmark and Mildura in 1887. These settlements differed from earlier ones in that they involved raising the level of the water to a considerable height by pumping, thus incurring costs which could only be met by a high value of production per acre. From time to time other irrigation schemes have been developed in various States. In practically all cases these have been set up as a result of the action of one or more governments. The most significant development of all was the creation of the River Murray Commission in 1917 under which the governments of the Commonwealth, of New South Wales, Victoria and South Australia agreed to a comprehensive scheme for controlling the waters of the Murray and some of its tributaries and for regularizing the flow of the river. This scheme, which has gradually come into operation, has, in the view of this Commission, received scant publicity, and if it had taken place in some other countries would have been held up to the world as a magnificent achievement. The scheme on the Murrumbidgee which began with the construction of the Burrinjuck Dam in 1907 and led to much development at Leeton and Griffith after the end of the last war is the largest single scheme apart from those of the Murray itself. Others of special interest are at Ayr in Queensland and Carnarvon in Western Australia, where water is pumped by individual landholders from subterranean supplies in river gravels.

1686. Although the progressive development of irrigation areas has been very gratifying yet the history of the individual districts concerned has been less satisfactory. In the early days it became clear that successful irrigation required more than the mere application of water to the land. In the first place, unless the land itself was suitably graded the amount which reached parts of a paddock varied considerably, so that when some of the plants were effectively supplied

others had received too little, or alternatively if the latter were properly watered the former were drowned. Secondly, it became clear that as far as pastures were concerned the native grassland species were attuned to periodic desiccation and when this no longer occurred they were quite unable to take advantage of the new supplies of water.* Later it also became evident that some low-lying areas in each district were being adversely affected by water seeping through the soil from adjacent properties. Usually this water was accompanied by the appearance of salt and alkali on the surface, to the inevitable destruction of vegetation. New varieties of cultivated plants had therefore to be produced or introduced if irrigators were to receive benefits from their work, while intensive research into the actual methods for applying the water was needed so as to avoid soil deterioration on the one hand and to achieve reclamation of damaged areas on the other. In addition, knowledge was required as to how much water to apply at each watering and the frequency of watering necessary for the satisfactory development of each crop in each district. Last, but by no means least, it gradually became obvious that it was most unwise to inaugurate large irrigation schemes unless some thought had been given to the use to which the land would be put: while the actual cost of setting up irrigation and equipping the farms had to be considered in relation to the value of the commodities produced.

1687. It has been gradually appreciated that there is no point in developing large areas for irrigation unless there is a reasonable prospect that those who settle on them will in the course of their agriculture perform a new and useful function in connexion with the national economy as a whole or can improve the economy of industries already existing in the district. The development of large-scale irrigation schemes is expensive and although they may be almost essential in the satisfactory development of agriculture in some regions it is also highly desirable that they should be as nearly as possible self-supporting. In the past there have been too many cases of unwise development of unsatisfactory irrigation. These are a warning that in the future no scheme should be undertaken without the most careful investigation and planning.

1688. Expansion of Irrigation in the Future.—If the Commission's views expressed in paragraphs 1680 to 1683 are correct then it is important that irrigation should be planned on a national scale. On this assumption the Commission has collected from various sources data concerning the catchment areas of the various States, which areas will be the chief sources of supplies of surface irrigation water in the future. It has also endeavoured to collect information about sub-surface waters, which can be derived from superficial strata by pumping. Recent developments in other countries using new techniques suggest that there may be considerable possibilities in this method in some special localities in the Commonwealth. These matters are set out in Chapter II. of this report. Brief reference is made in Chapter III. to certain points in connexion with the efficient conservation of water at all stages. In Chapter IV. various financial and political aspects of irrigation are discussed; among these some are local, some State-wide, while others are of national significance.

* In economic terms if the annual productive value of an acre of native grazing was 5s. and irrigation only raised it to 7s. 6d. there was no profit from the irrigation, the minimum cost of which was about 5s. per acre; the need was to develop a new pasturage which could grow in the district with irrigation and the production from which would have a value of 20s. per acre or more.

1689. In Chapter V. of the present report the subject of land drainage is approached. Drainage schemes are essential for improving dry land farming while in many irrigation areas drainage has been found to be highly desirable. Certain swamp areas, most of which are coastal in their location, have been turned from useless thickets of reeds and scrub into highly productive land. In the high rainfall areas of the continent, wherever the terrain is flat, drainage becomes an important factor at some season or other of the year. There is every reason why the approach to land drainage should be much the same in these regions as the approach to irrigation in areas where rainfall is low. In Chapter VI. certain large-scale irrigation projects are given special consideration, and the use and conservation of artesian water are discussed in the light of the latest information.

1690. All these matters have been gathered together in the present report because they are of great significance to Australia's future development. The Commission is well aware that for the most part individual irrigation projects are matters concerning individual States although some affect more than one State. Nevertheless the sums involved are large and if the capital investment is to be made wisely it follows that some nation-wide policy should be adopted to ensure that progress is orderly and takes place in those regions where it is most necessary. In the extent to which it succeeds in restraining local desires and interests in irrigation matters and in subordinating them to the broader needs of a national policy, Australian statesmanship has a great opportunity to indicate its capacity.

1691. In a final conclusion on this subject the Commission draws together the main results of its survey and emphasizes again the need for irrigation to be developed on a national basis rather than from the point of view of individual States or localities.

CHAPTER II.—THE ALLOCATION OF AUSTRALIAN WATERS.

Rainfall Availability.

1692. The Commission accepts the view that water will ultimately be one of the most important of all commodities in the Australian economy. It is therefore worth while constructing a yearly water balance-sheet for Australia. The total amount of precipitation as rain or snow would appear on one side of the account and the various ways in which that water disappears would appear on the other. A tentative estimate of this kind has been prepared for Victoria by Mr. J. A. Aird.* Unfortunately no similar estimate has been prepared for the whole of Australia, and this Commission has neither the time nor the staff to do it. However, the relevant principles to enable the construction of a national water balance-sheet are set out in this chapter and should be of assistance in its ultimate production. The Commission feels that such a statement would be of considerable value to those concerned in the formulation of water conservation policy.

1693. Rain which falls on the land is disposed of in some or all of four ways—some evaporates directly, some is held in the surface soil and subsequently evaporated by plants, some filters through the superficial layers and passes downward into the rocky strata beneath, and some runs off giving rise to streams and rivers. The movement of water after it reaches the soil depends among other things on the average amount of rain in any one fall, on its intensity and on the nature of the surface on which it falls.

1694. When the rainfall is made up of a large number of small falls then a high proportion may be evaporated after each wet day; the remainder passes into the soil, the nature of which in its several horizons will determine the extent of penetration; in dry areas both penetration and run-off can be small. Where the rainfall usually comes in a small number of heavy bursts, the tendency is for run-off to be rapid; consequently in such districts soil does not accumulate on slopes and the hills usually consist of craggy slopes on which vegetation tends to be sparse.

1695. Run-off and Catchment Efficiency.—The water which runs off is the source of supply for most irrigation schemes and its volume determines how much irrigation can be undertaken. The actual percentages of rainfall falling on various catchments and becomes available in the reservoirs which they feed, show marked differences. It would be unreasonable to expect uniformity since many variables influence these percentages; e.g. the rainfall rate, its duration and frequency, and the shape and kind of surface of the catchment. The following table which sets out percentages of rainfall that run into catchments in various parts of Australia shows the variability. Some of the authorities who have provided

the figures on which the table is based have emphasized that the data are only approximate, but the divergence between catchments is so great that there is no doubt that the underlying reasons are worthy of further investigation.

TABLE 1.—RAINFALL AVAILABILITY FROM VARIOUS AUSTRALIAN CATCHMENT AREAS.

Catchment Basin.	Gauging Station.	Area.	Mean Annual Rainfall.	Mean Annual Discharge.	Percentage of Rainfall Discharged. (Approx.)
		Sq. miles.	Inches.	Inches.	Per cent.
Barron River ..	Picnic Crossing	88	61	25	41
Tully River ..	Tully Falls ..	105	94	58	62
Stanley River ..	Somerset ..	515	49	13	27
Murrumbidgee River ..	Burrinjuck ..	5,000	32	4	13
Murray River ..	Jingellic ..	2,520	38	14	38
Goulburn River ..	Eildon Weir ..	1,500	41	19	46
Snowy River ..	Orbost ..	5,210	28	7	23
Macalister River ..	Glenmaggie Weir	813	44	11	26
Mount Emu Creek ..	Skipton ..	492	24	3	11
Hopkins River ..	Wickliffe ..	509	23	1	6
Canning Reservoir ..	.. ..	269	54	..	6
Mundaring Reservoir ..	.. ..	569	42	..	4
Wellington Reservoir ..	.. ..	1,000	39	..	5
Harvey Reservoir ..	.. ..	140	40	..	24

1696. In part the divergencies shown in the above table are due to the nature and density of the vegetation on the catchment areas. Some are covered with dense forest and scrub, others with lighter forest and some grass and/or bracken, others have a very light cover. At first it might be assumed that the dense forest would use most water because of the immense amount used by the plants comprising it; however, some of the areas with the densest vegetational cover have the highest percentage of run-off. It seems likely that in some of the cases of low run-off, the poor collection is to be associated with the amount of rain which percolates through permeable soil into the sub-soil layers. Most of this is lost to the catchment although some of it may appear lower down in springs, the remainder going through underground channels to the sea floor.

1697. From the point of view of high efficiency in run-off, bare rock is the ideal catchment area. The small water schemes based on the rocky bosses in parts of the Western Australian wheat belt are instances of this fact. Such reservoirs receive all of their supply in the course of a few hours or days after each fall of rain. On the other hand, from the point of view of storing the water, the greater the amount of vegetation on a catchment the deeper becomes its covering of soil and humus, the slower the rate of run-off and the longer its period of flow, consequently a reservoir collecting from a catchment of this type will continue to receive water for months after precipitation has ceased. The dam constructed to hold the water from the latter catchment need not be nearly as large or as expensive per acre foot delivered as would be that required in the former case.

1698. It may well be that in the future something may have to be done in the way of improving the run-off from catchments in districts where water is particularly necessary and difficult to obtain. On the other hand, improvements in the retention of water in catchments, and the retardation of its rate of run-off, where desirable, by the encouragement of suitable types of vegetational cover, can be commenced forthwith. This procedure is particularly economical, and where forest growths are concerned they can often be used as sources of timber supply.

Australian River Catchments and their Present Utilization.

1699. The Commission took the view that it was important for it to try to assemble the available data as to the amount of surface water available in each of the mainland States. Some States, by virtue of large areas of country with high rainfall and suitable catchments, have more water available than others; some, for various reasons which need not be discussed here, have already gone much further than others in the development of their water resources. Each mainland State was therefore approached and asked to afford information first as to the boundaries of the major catchments within its territory, and secondly as to the available information on the average amount of river flow. No State irrigation authority is satisfied with the data which it has so far accumulated. In many cases the river gaugings are not as accurate as is desirable, in others the period over which they have been recorded is too short. However, the Commission considered that such information as was available should be published, for although there are doubtless inaccuracies in particular cases yet the general picture of Australia's somewhat limited potentialities in respect to surface irrigation water should be realized. Unfortunately the public is far too easily led to assume that Australia has an almost unlimited future in the development of irrigation schemes.

1700. The method adopted for the presentation of the data has been to prepare for each State a rough map showing the approximate boundaries of each catchment and also a table in which is set out the extent to which the water is at present impounded and the extent of schemes which are proposed but not yet constructed. Irrigation water used by private pumping plants is not generally included in the water used; in most cases the amount is relatively small. It must be emphasized that the river flows given are average flows and that the quantity of water passing down most of the rivers shows marked variations from year to year. It would therefore be too optimistic to plan any irrigation scheme on the expectation of being able to use an amount of water equal to the average flow of the river concerned, unless the reservoir is made large enough to carry forward a considerable volume from a wet series of years to a dry series. Each river has its own characteristics in this matter.

1701. New South Wales.—Figure 1 shows the map for this State and Table 2 gives the data.

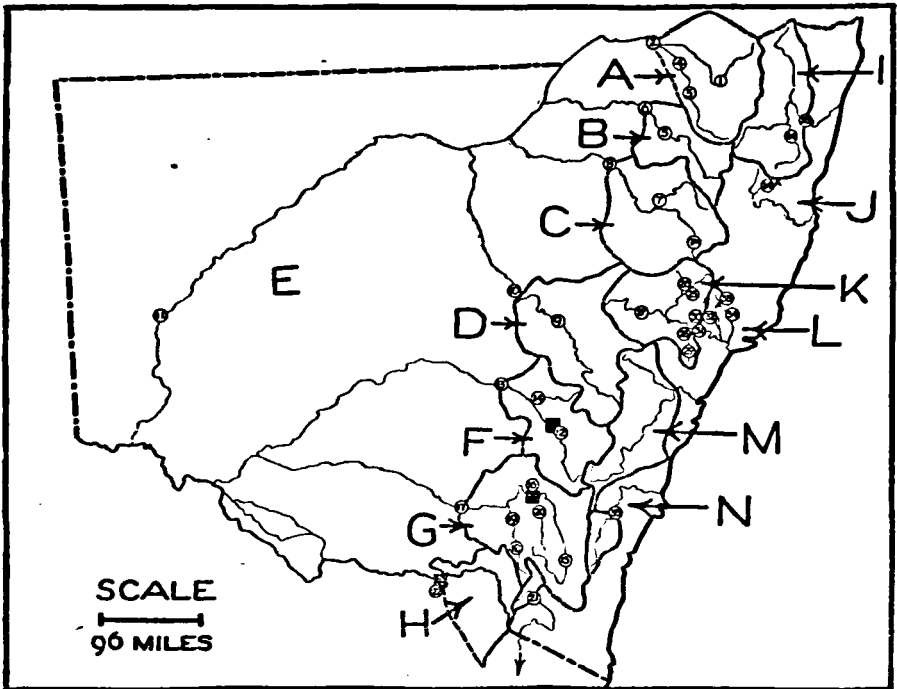


Figure 1.—New South Wales—Approximate boundaries of main river catchments, location of gauging stations (numbers in circles) and principal existing dams (black squares). The letters and numbers refer to the catchments and gauging stations as listed in Table 2.

TABLE 2.—NEW SOUTH WALES.

Catchment.	River.	Gauging Stations.		Names and Capacity of Dams.		Remarks.
		No. on Map.	Annual Run-off.	Present.	Proposed.	
			'000 acre feet.	'000 acre feet.	'000 acre feet.	
A	Dumaresq ..	1	89	..	Mingoola .. 300	*Includes run-off from Dumaresq. S. & D. supply.
	Macintyre ..	2	522*	..	Macintyre .. 257	
	Macintyre ..	3	39	..	..
	Macintyre ..	4	296	..	..
B	Gwydir ..	5	175	..	Bingara .. 643	S. & D. supply.
	Gwydir ..	6	300	..	..
C	Peel ..	7A	55	..	Bowling Alley Point 45	*Run-off includes Peel River.
	Namoi ..	7	270*	..	Keepit .. 345 (under construction)	
	Namoi ..	8	504*	..	..
D	Macquarie ..	9	465	..	Burrendong .. 520	
	Macquarie ..	10	603	..	..
E	Darling ..	11	2,170	..	..	Total flow of Darling and tributaries.
F	Lachlan ..	12	393	Wyangala .. 303	..	Lake Cargelligo (29,000 acre feet) already used as storage. Ballyrogan storage proposed (122,000 acre feet).
	Lachlan ..	13	547	..	..
	Belubula ..	14	102	..	Cranky Rock .. 200	
G	Murrumbidgee ..	15	331	..	..	See Snowy River scheme (para. 1833). *Includes 18 and 19.
	Murrumbidgee ..	16	1,136*	Burrinjuck .. 771	..	
	Murrumbidgee ..	17	2,819	..	..
	Tumut ..	18	573	..	Talbingo .. 448	
	Tumut ..	19	993	..	..
	Goodradigbee ..	20	290	..	Brindabella .. 308	
	Snowy ..	21	937	..	..	See Snowy River scheme (para. 1832).
H	Murray ..	22	3,710	Hume .. 1,250	.. 750	Proposed addition to Hume Weir.
I	Clarence ..	23	2,020	..	The Gorge .. 2,139	Hydro-electric scheme.
	Nymboida ..	24	568	..	Nymboida .. 150	160,000 acre feet already used for hydro-electric purposes under Nymboida scheme.
J	Styx ..	24A	100	..	..	Recommended scheme for hydro-electric.

TABLE 2.—NEW SOUTH WALES—*continued.*

Catchment.	River.	Gauging Stations.		Names and Capacity of Dams.		Remarks.
		No. on Map.	Annual Run-off.	Present.	Proposed.	
			'000 acre feet.	'000 acre feet.	'000 acre feet.	
K	Hunter	25	137	..	Glenbawn .. 119	} Information as to flows not yet adequate, but a series of small storages with piped distribution of water is under consideration. *Includes total flow of Hunter and tributaries excluding 32, 33, 34.
	Pages	26	31	..	Brushy .. 94	
	Goulburn	27	?	..	Kerrabee .. 80	
	Wollombi Brook	28	126	..	Wollombi .. 70	
	Wollombi Brook	29	?	..	.. ..
	Falbrook	30	?	..	Fal .. 50	
	Hunter	31	590*	..	.. ..
L	Paterson	32	?	}	Hunter District Water Supply Scheme.
	Allyn	33	?		.. ..
	Williams	34	60		.. ..
M	Nepean, Hawkesbury and tributaries	..	1,220	Sydney Water Supply Catchment. Various storages in existence, others proposed.
N	Shoalhaven	35	297	Various schemes have been proposed.

1702. The above schedules show in outline the official proposals for the future control and storage of water for irrigation in New South Wales. In addition certain other plans have been put forward by other organizations* but these are mostly in the nature of amplifications or modifications and, although of great significance to the districts concerned, do not markedly alter the total amount of water which can be made available. The figures must be used with caution because some of the gaugings are not entirely satisfactory, and it would be quite incorrect to assume that all the water passing through a gauging station can be used for new irrigation: some must be directed towards maintaining a minimum stream flow, some is used for private irrigation schemes and some for town water supplies. Despite these modifying factors the data as shown indicate clearly that both the Murray and Murrumbidgee schemes already in operation impound a greater amount of water than any proposed scheme except the Snowy and the Clarence. If all the proposed reservoirs were constructed the new water available for irrigation would not do much more than double the amount at present available for that purpose. The Snowy River project will be referred to in some detail in Chapter VI.

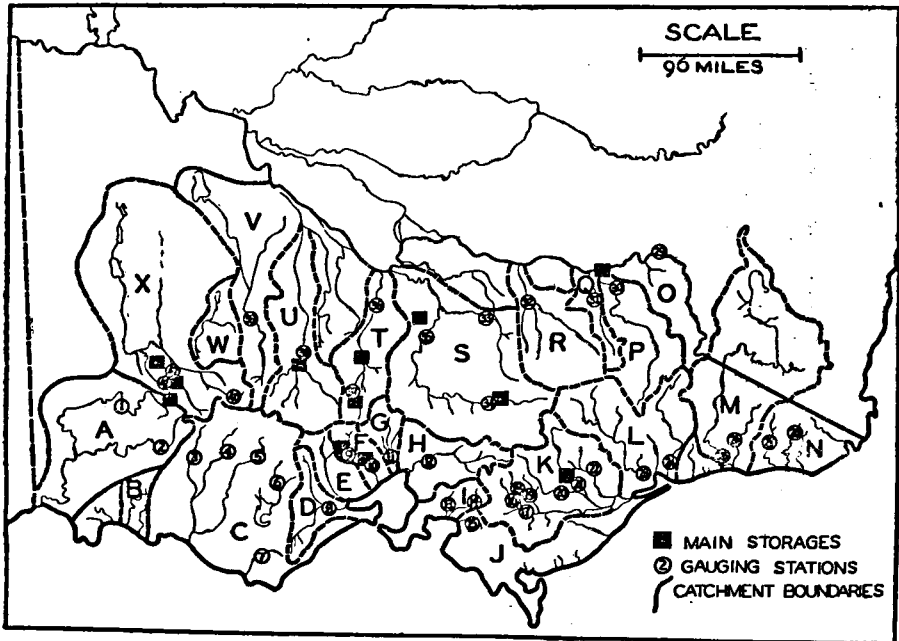


Figure 2.—Victoria—Approximate boundaries of main river catchments, location of gauging stations and principal existing dams. The letters and numbers refer to the catchments and gauging stations as listed in Table 3.

1703. *Victoria*.—This State was the first to adopt irrigation on a large scale. Development has been fairly continuous; Figure 2 and Table 3 show the position as it is at the moment. Again it is necessary to emphasize that the irrigation authority is not fully satisfied with the accuracy or completeness of the gauging data. Again the main conclusion to be gleaned from this information is that the major sources of water supply (except the Snowy River and the further impounding of Murray water) have been utilized; new storages will therefore be relatively small.

* E.g., the Clarence River Gorge Scheme by Sir Earle Page.

TABLE 3.—VICTORIA.

Catchment.	River.	No. of Gauging Station on Map.	Average Annual Run-off.	Names and Capacity of Dams.	Remarks.
			'000 acre feet.	'000 acre feet.	
A	Glenelg	1	116.5	{ Rocklands .. 264 Barton's Swamp 68	Part of head waters diverted to Wimmera storage. Under construction.
B	Wannon	2	23	.. ..
C	Eumeralla .. ..	..	..	.. ..	} These rivers run through a plain which has been created by lava flows filling up old land surfaces. This plain has for the most part a natural internal drainage system linked up to evaporating lakes, many of which are saline. Partly used for town water supply in Western District Scheme.
	Hopkins	3	39	.. ..
	Fiery Creek	4	28	.. ..
	Mount Emu Creek	5	68	.. ..
	Woody Yallock	6	22	.. ..
	Carlisle	7	48	.. ..
D	Barwon	8	145	.. ..	Water supply scheme for Bellarine Peninsula and Geelong Geelong and Ballarat water supply.
E	Moorabool .. ..	..	93	.. ..
F	Pyke's Creek	9	15	Pyke's Creek .. 21	
	Werribee	10	55	Melton 19	
G	Maribyrnong	11	88	.. ..	Remarks under storages 3 to 6 apply.
H	Yarra	12	721	.. ..	Melbourne water supply.
I	Cardinia Creek	13	9	.. ..	} Mornington Peninsula water supply (stock and domestic).
	Bunyip	14	125	.. ..
J	Lang Lang	15	38	.. ..
K	Latrobe	16	211	.. ..	} Also measured in 17.
	Tanjil	18	147	.. ..
	Latrobe	17	489	.. ..
	Tyer's	19	106	.. ..	} Partly used in connexion with steam raising at the electricity plant at Yallourn and by paper mills at Morwell.
	Thompson	20	327.5	.. ..
	Macallister	21	434	Glenmaggie .. 1,045	
	Avon	22	90	.. ..
	Mitchell	23	685	.. ..
L	Tambo	24	191	.. ..
M	Snowy	25	1,699	.. ..	See parae. 1829-1844.
	Brodribb	26	60	.. ..
N	Bemm	27	94	.. ..
	Cunn	28	38	.. ..
O	Murray	29	1,864	} Hume 1,250	} Victoria shares water above Albury with New South Wales subject to South Australian rights.
P	Mitta Mitta	30	1,121		

TABLE 3.—VICTORIA—continued.

Catchment.	River.	No. of Gauging Station on Map.	Average Annual Run-off.	Names and Capacity of Dams.	Remarks.
			'00 acre feet.		
Q	Kiewa	31	523		Hydro-electric scheme under construction. The waters of 31 and 32 at present supplement the volume available for irrigation areas below Yarrawonga.
R	Ovens	32	1,178		
S	Broken	33	212		
	Goulburn	34	1,424*	{ Eildon 306 Goulburn Weir 21 Waranga 333	*Included in 35.
		35	2,306		
T	Campaspe	36	186			Eppalock .. .. 1.2
	Coliban	37	53	Coliban Storages 59	Bendigo water supply.
U	Loddon	38	175	Laanecoorie 6.6	
V	Avoca	39	59		
W	Avon .. ..	..	..
X	Wimmera	40	33.5	} Wimmera Storages 196.8	Used for stock and domestic supply in Wimmera-Mallee system.
	Mackenzie	41	21		
	Little Wimmera	42	74		

NOTE.—The use of streams as a source of supply for towns and townships has not been noted.

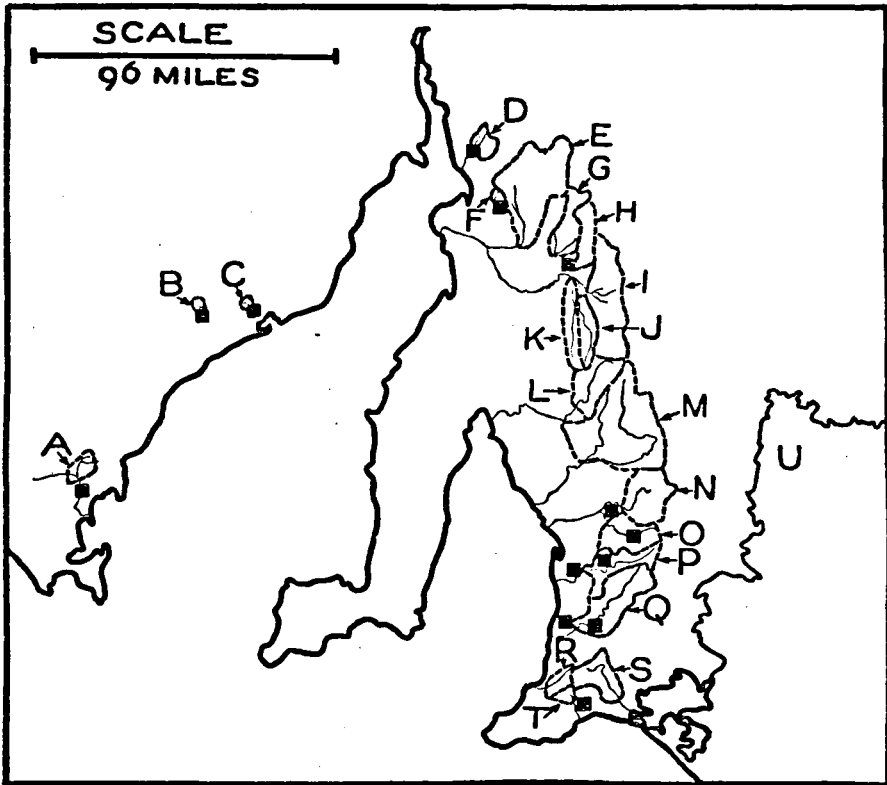


Figure 3.—South Australia—Approximate boundaries of main river catchments and principal existing dams (black squares). Letters refer to catchments as listed in Table 4.

1704. South Australia, apart from the outfall of the Murray, has very few rivers of any size and most of these are intermittent in flow; the State has therefore used practically all the available waters for township or stock and domestic supply schemes. In some cases gauging stations are not maintained although the water is already impounded and used. Figure 3 and Table 4 set out the position as far as this State is concerned. Surface water is so limited in amount that additional irrigation cannot be developed except by the further control of Murray waters. The possibility of additional water being obtained from underground sources is under examination and may prove valuable. In the south eastern part of the State large quantities of water occur near the surface in the underlying rocks but being heavily charged with carbonate, are not useful for irrigation. During wet winters they lead to much flooding in the low-lying regions near the coast.

TABLE 4.—SOUTH AUSTRALIA.

Catchment.	River.	Run-off.	Remarks.
A	Tod	'000 acre feet. Ungauged ..	Water utilized to capacity of present diversion works
B	Yeldulknie Creek ..	" ..	Fully utilized
C	Ullabidinie ..	" ..	Fully utilized
D	Baroota Creek ..	" ..	Fully utilized
E	Rocky	" ..	Use not anticipated
F	Beetaloo Creek ..	" ..	Fully utilized
G	Bundaleer and Baderloo Creeks	" ..	Used to capacity of diversion works
H	Freshwater Creek..	" ..	Used to capacity of diversion works
I	Broughton	" ..	Used to capacity of diversion works
J	Hill	" ..	Eventual use anticipated
K	Hutt	" ..	Eventual use anticipated
L	Wakefield	" ..	Eventual use anticipated
M	Light and Gilbert ..	" ..	Eventual use anticipated
N	North Para	11	Eventual use anticipated
O	South Para	20	Used to capacity of diversion works
P	Torrens	40	Used to capacity of diversion works
Q	Onkaparinga	65	Used to capacity of diversion works
R	Myponga Creek ..	10	Eventual use anticipated
S	Finniss	Ungauged ..	Eventual use anticipated
T	Hindmarsh	" ..	Used to capacity of impounding reservoir
U	Murray	" ..	Under Murray River Agreement a sufficient volume of water is conserved in other States to keep the river running in summer. This water is used for irrigation by pumping. The connexion between Lake Alexandrina and the sea has now been closed and the waters of this lake are becoming less salt. They will in time be available for irrigation by pumping

1705. Western Australia, despite its great size, is relatively poorly supplied with rivers. In recent years a great deal of investigation has been carried out and the possibilities of irrigation have been clarified. Broadly speaking, the State is divisible into three zones—

- (a) The Northern area of summer rainfall, monsoonal in character, which gives rise to great downpours over short periods; these conditions add to the difficulty of conservation but they have been overcome in other countries, notably Southern India, and presumably they could be overcome here.
- (b) The Central area of low and unreliable rainfall with no marked periodicity; at times this district experiences violent hurricanes and the rivers only run during limited periods.
- (c) The South-western area of winter rainfall where studies have been made of most of the streams and where the existing irrigation and water supply storages are located.

1706. Figure 4 shows the approximate location of the main river basins in the State and Table 5 sets out the approximate effective areas of the respective catchments in zones (a) and (b).

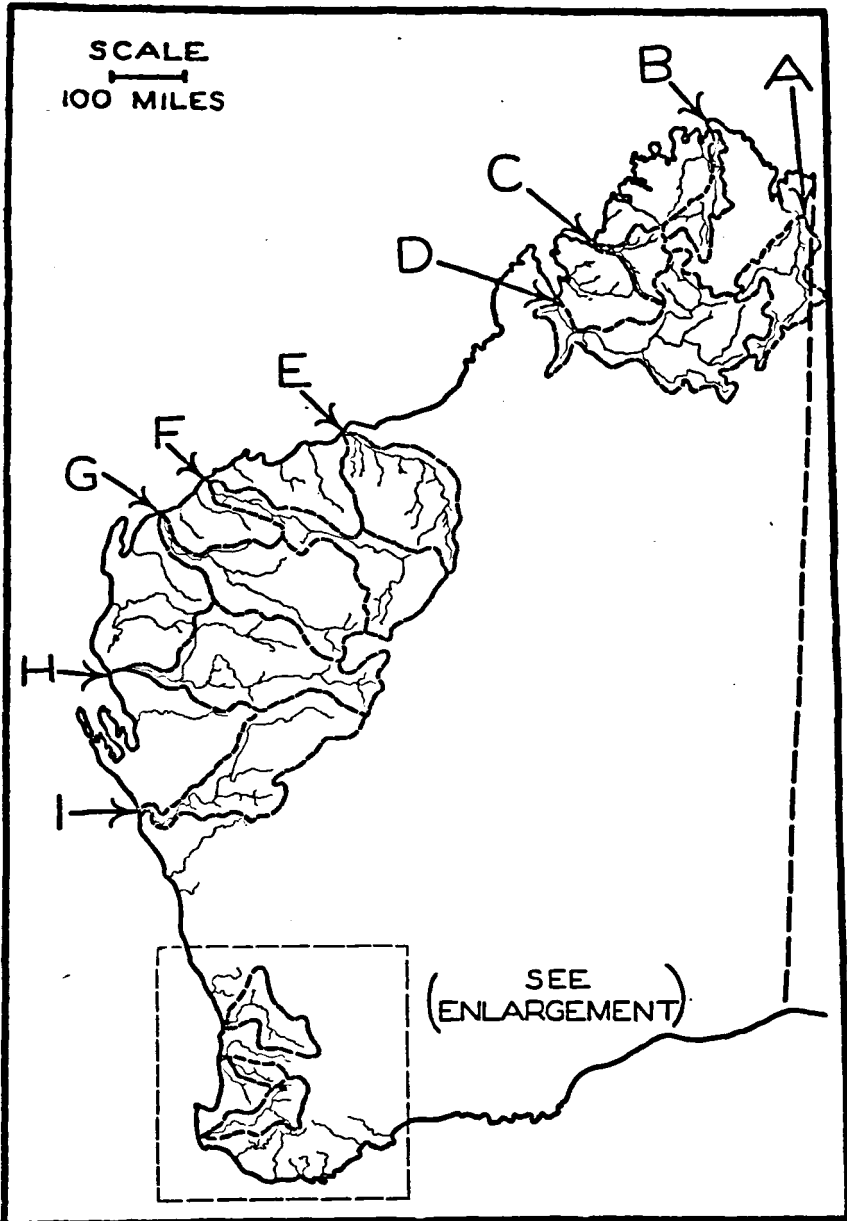


Figure 4.—Western Australia—Approximate boundaries of main river catchments in the major part of the State and location of the south-west region enlarged in Figure 5. Letters refer to the catchments as listed in Table 5.

1707. Of the northern rivers the Ord (A) is the most promising and a detailed scheme is being worked out for a storage of 2,000,000 acre feet. The Drysdale (B) and Isdell (C) have rather smaller catchments; the Fitzroy (D) has

a much larger one but the river's value for irrigation may be less because the alluvial plain in the lower part of its course is extensively broken by meanders.

TABLE 5.—WESTERN AUSTRALIA (NORTH AND CENTRAL ZONES.)

Catchment.				River.				Effective Catchment Area.
								Million acres.
A	..	..	..	Ord	..	..	..	11.5
B	..	..	..	Drysdale	..	..	..	2.4
C	..	..	..	Isdell	..	..	..	2.0
D	..	..	..	Fitzroy	..	..	..	20.2
E	..	..	..	De Grey	..	..	..	8.6
F	..	..	..	Fortescue	..	..	..	5.4
G	..	..	..	Ashburton	..	..	..	12.2
H	..	..	..	Gascoyne	..	..	..	12.2
I	..	..	..	Murchison..	..	..	..	10.9

1708. In the central zone the low and unreliable nature of the rainfall would make the task of impounding water specially costly. At present the sands of the river bed in the Gascoyne are used as a source of irrigation water for bananas and apparently the amount of water so diverted is sufficient to exhaust most of the available supply in those dry years when the river has not flowed at all. Possibly this type of usage might be made more efficient and also developed in the other rivers on an inexpensive basis which would make it possible to use the water economically for other crops.

1709. The southern zone is shown in greater detail in the map of Figure 5. Some of these rivers, the Avon, Hotham, Murray and Blackwood, have their sources on the eastern side of the Darling Range and are at present rather too saline for irrigation. The others, which have smaller catchments, have suitable water. Table 6 sets out the effective catchment area of each river, the existing storages and those which are proposed.

TABLE 6.—SOUTH-WEST OF WESTERN AUSTRALIA.

Catchment.	River.	Effective Catchment Area.	Existing Storage.		Proposed Storage.*		Remarks.
			'000 acres.	'000 acre feet.	'000	'000	
J	Avon	5,100	..	..	..	..	Saline Goldfields scheme. City and S. & D. supply
K	Helena	360	Mundaring	17	..	56	
L	Canning	172	Canning	76	..	..	Saline
M	Serpentine	183	..	..	..	..
N	Hotham-Murray	1,400	..	..	..	..	Saline
O	Harvey	90	Harvey	8	..	44	
P	Collie	640	Wellington	28	..	156	Saline
Q	Blackwood	2,300	..	..	..	..
R	Donnelly	300	..	..	..	..	Saline
S	Warren	700	..	..	..	..
T	Frankland	1,000	..	..	..	..	Saline
U	Kalgan	400	..	..	..	..
V	Pallinup	700	..	..	..	..	Saline

* Including present storage where it is a case of enlargement.

1710. The data of this table suggest that while numerous irrigation schemes will be possible in these areas in the future, none of them will be very large. The absence of gauging observations precludes the possibility of making effective estimates but the catchments themselves are relatively small. The mean annual rainfall is usually not more than 36 inches and in some of the rivers in this part of the State where gaugings have been taken the percentage of run-off to rainfall is very low.

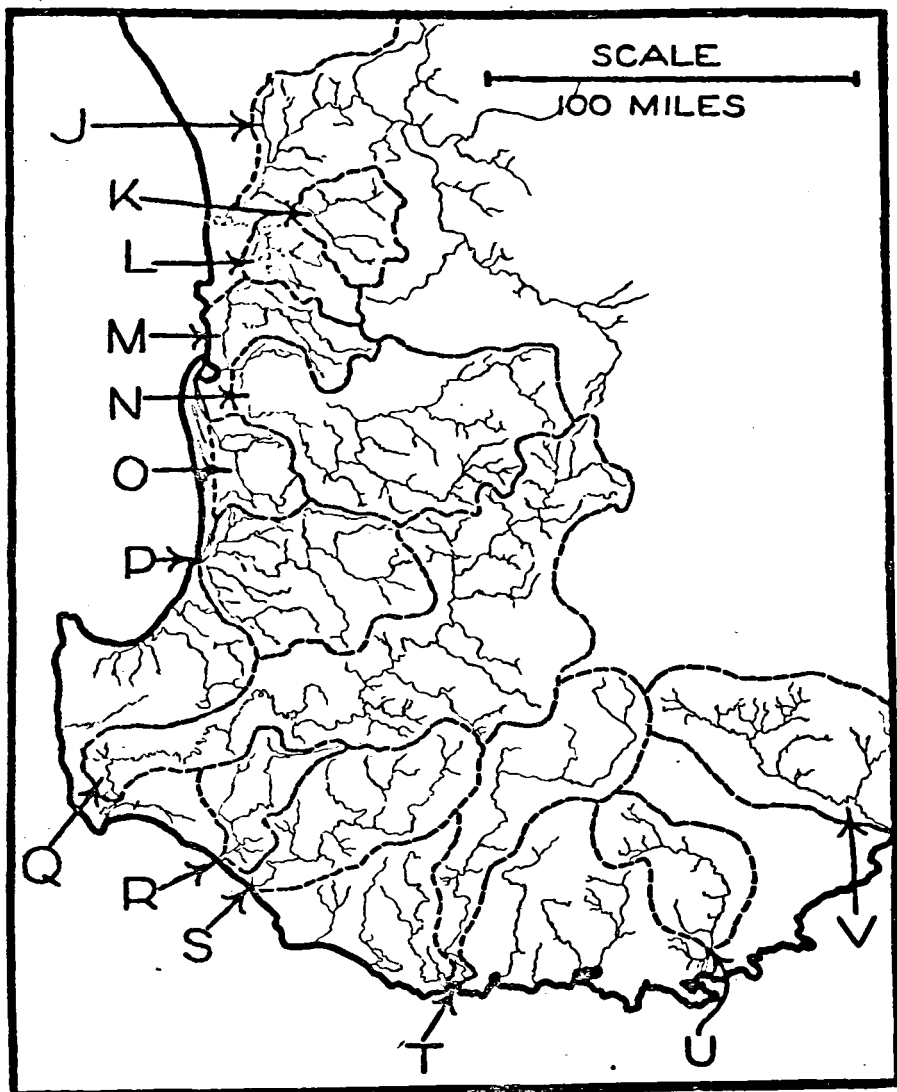


Figure 5.—South-western Portion of Western Australia—Approximate boundaries of main river catchments. Letters refer to catchments as listed in Table 6.

1711. In *Queensland* the problem is somewhat different. The catchment areas of the rivers which flow toward the sea are, with few exceptions, relatively small and the rainfall often comes in large falls of short duration; during the dry season the rivers are either very restricted or may cease flowing above ground. The coastal districts on which irrigation might be practised are generally not wide, while some of them already have a good rainfall. These circumstances render the planning of large-scale irrigation projects somewhat difficult and so far the number of storages is small. The Barron River north of Cairns is used for the generation of electricity. The delta of the Burdekin is irrigated by small-scale pumping plants operating on wells sunk into the river gravels. The Somerset Dam on the Stanley impounds a storage of 780,000 acre feet and a series of small streams are used for water supplies for Brisbane and other cities.

1712. Figure 6 is a map of the State on which the main catchments and rivers are shown. On the coastal side many of the rivers are very small and consequently it has been necessary to group the catchments in zones on the map and in the following table:—

TABLE 7.—QUEENSLAND.

Catchment.	Principal Rivers in Catchment or Zone.	Area.
		*000 sq. miles.
A	Jacky Jacky, MacMillan, Pascoe, Stewart	5
B	North Kennedy, Normanby	10
C	Jeannie, Endeavour, Daintree, Mosman	4
D	Barron, Mulgrave, Russell, Johnstone	3
E	Tully	1
F	Herbert	4
G	Ross, Haughton, Barratta	3
H	Burdekin	50
I	Don, Proserpine, O'Connell, Pioneer, Styx	9
J	Fitzroy	55
K	Calliope, Boyne, Kolan	5
L	Burnett	13
M	Elliott, Burrum	1
N	Mary	4
O	Moosa, Maroochy, Mooloolah, Caboolture, Pine	2
P	Brisbane	5
Q	Logan, Albert, Coomera, Nerang	2
R	Condamine	34
S	Macintyre, Dumaresq	9
T	Moonie	6
U	Mungallala	14
V	Warrego	26
W	Paroo	12
X	Bulloo	21
Y	Cooper's, Barcoo	94
Z	Diamantina	46
a	Hamilton, Burke, Georgina, Mulligan	57
b	Settlement, Cliffdale	5
c	Gregory	14
d	Leichhardt	12
e	Morning Inlet	2
f	Flinders, Cloncurry, Saxby	42
g	Norman	20
h	Gilbert, Einasleigh, Staaten	28
i	Nassau, Mitchell	27
j	Coleman, Edward, Holroyd, Kendall	9
k	Archer, Watson	8
l	Embley, Mission	2
m	Wenlock, Dulhunty, Jardine	7

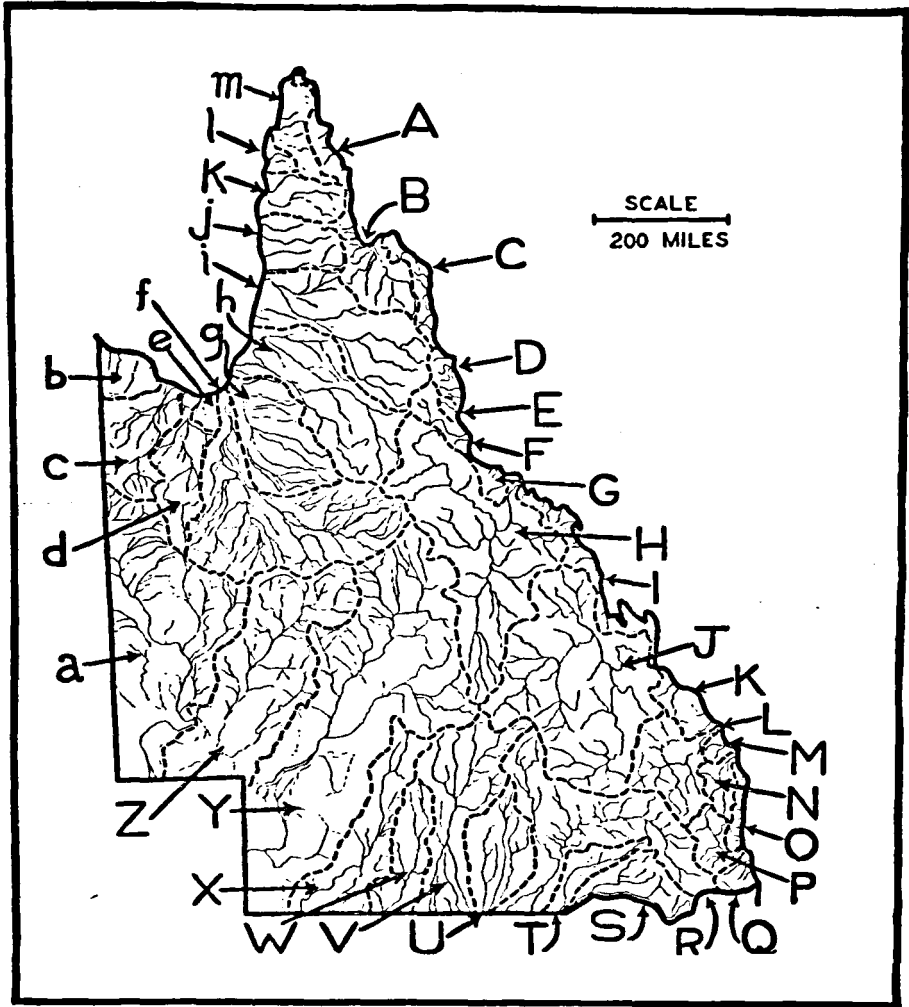


Figure 6.—Queensland—Approximate boundaries of main river catchments. Letters refer to catchments as listed in Table 7.

1713. The difficult nature of much of the coastal country from the point of view of irrigation suggests that future development is likely to consist of the construction of numerous small schemes. So far the staff available for taking gaugings has been small and the records of stream flow are few in number and mostly cover only a short period. These defects will need to be remedied before

much progress can be made. More important is the uncertainty as to the purposes to which areas brought under irrigation should be put. The intensive culture of tropical crops other than fruits has not been undertaken on a large scale, while pasture development in these latitudes also needs more critical study before success can be assured.

1714. West of the main range the rainfall is relatively light and very variable. In certain seasons watercourses such as the Diamantina and Cooper's Creek convey vast flows, in other years the amount is small. The late Dr. Bradfield's interesting suggestion that these waters should be reinforced by diverting the headwaters of the eastern rivers through the ranges is examined in Chapter VI.

Possibilities of Further Irrigation Development.

1715. The preceding brief survey of catchments and potential irrigation waters in the various States leads to the conclusion that in the southern half of the continent there will be room for the development of a good many irrigation schemes, but with the exception of the Snowy and the Clarence most of them will be small in comparison with those already existing on the Murray and the Murrumbidgee. In the northern half of the continent we may expect some large schemes, e.g., that on the Ord River, and others, which are as yet problematical, on the western side of the Queensland ranges, and in addition a number of smaller enterprises. However, even if all these schemes come to fruition, the area of land which can be profitably irrigated from them will still only represent a very small fraction of the continent as a whole. If we recognize that the existing irrigation areas are already responsible for maintaining our production of dried and canned fruits and rice, and for much of our citrus, and that they play an important, though as yet somewhat subsidiary part in dairy production and in fattening sheep and lambs, it becomes clear that if Australia ever becomes at all densely populated the strain on irrigation waters and on their products would become relatively great. A population of 25,000,000 with an export trade proportionately as large as at present would probably require the development of irrigation from every catchment in the southern half of Australia mentioned in the above lists and probably most of those in the northern half as well.

1716. Need for Co-ordination in Irrigation Planning.—The above broad generalization suggests that if the Australian nation takes its future seriously it should carefully construct a co-ordinated plan for the development of its water resources, especially for irrigation, and should ensure that in the formulation of such a plan the long-term needs should be given a deciding influence. Bringing irrigation into a district is always an attractive venture. It has the excitement of a novelty. All the advantages are stressed, while little notice is taken of the difficulties and problems which will arise. It may mean new industries and more

population for the district. More money will be spent. It is not surprising, therefore, that the need for an irrigation scheme was stressed in evidence to the Commission at many country centres. However, it may easily happen that small schemes developed in haste in the interests of isolated localities may ultimately create vested interests which will stand in the way of larger schemes of far greater national importance to which the water should be devoted at some later time.

1717. Hydro-electric Schemes.—A further problem arises in connexion with generation of electricity. Some districts in which there are no main generating stations are extremely anxious to obtain the advantages of a central electric supply. They may have big water resources at present unused, and, somewhat naturally, they clamour for the construction of hydro-electric generating stations in their locality. Yet if the plans which they have in mind were put into operation they would result in the permanent allocation of water for the generation of electricity, whereas the future national interest would possibly be far better served if that water were used for irrigation purposes. The Commission takes the view that in general water should be allocated primarily to ensure stock and domestic supplies for man and beast, secondly for irrigation, and finally for electricity generation. This does not mean that no provision should be made for the immediate or ultimate installation of an electric generating plant in conjunction with an irrigation water storage.

1718. Investigations Prior to Irrigation Development.—The Commission points out that, before any irrigation scheme is adopted, it is necessary that the proposal should have been examined and favorably reported on from the point of view of the purposes to which the impounded water is to be put. In most States it is now generally recognized that detailed soil surveys of the land to be irrigated are essential if success is to be achieved, but in districts where long experience in irrigation is lacking the importance of this point is not so well appreciated by all parties.

1719. Any new irrigation project requires examination not only from the points of view of the engineer, of the soil technologist and of the agronomist, but also from the standpoint of the industries which are to be assisted by, or set up as a result of the use of, the irrigation water. The attitude of mind which is satisfied with the thought "Here is a nice stream, let us use it for irrigation" without considering what the effect of the new development will be is not much more useful than that of the alleged sportsman who is supposed to have said, "It's a nice day, let's go out and shoot something". On the other hand, the Commission emphasizes that a period of about ten years must elapse between the acceptance of any large irrigation scheme and the development of the full production of the area affected. As the task of forecasting the prospective economic development of any industry in ten years' time is a difficult one, it is clear that some measure of courage is necessary in making irrigation plans. However, it is equally clear that even on a ten-year basis some forms of rural production have better prospects than others, and irrigation areas which can be used for improving the general efficiency in, and reducing the losses of, existing industries, e.g., meat and dairy production, are obviously preferable to those

which will be devoted in the main to the expansion of forms of production in which Australia already has a volume of export several times larger than the needs of her own community (e.g., dried fruit).

1720. From this viewpoint, it will be wiser for the time being to develop irrigation projects which will tend to stabilize existing industries, rather than those which will have as their main purpose the additional production of dried or canned fruits, the marketing of which may offer even greater difficulties in the future than it has in the past. For instance, the recent cycle of drought years which has afflicted many of the southern parts of Australia has resulted in a loss of about 21,000,000 sheep, and to-day the flocks of Australia are little larger than they were in 1891. It is certain that if the relatively small amount of irrigation land used for pastoral purposes had not been able to carry a considerable number of additional sheep and other livestock, the losses would have been very much greater. If areas of irrigated pasture had been more widespread and greater in extent they would, if effectively managed from the stocking point of view, have been able to exercise a much greater influence and reduce the losses of this recent disastrous period.

1721. It is also necessary to point out that before irrigation farming can be effectively introduced into a climatic zone for which irrigation knowledge and experience are lacking, it is necessary to have technical advice not only from engineers and soil scientists but also from agronomists who must be expected to provide a detailed scheme of the methods of cultivation and management which, if adopted, will lead to success. Unfortunately, the necessary basic information is not yet available in the northern half of the continent.

Sub-artesian Water.

1722. The water which passes underground is not necessarily completely lost. Some of it passes to great depths into the artesian water storages, some moves through the more superficial layers of the earth's crust and is available for tapping through the medium of wells. Probably considerable quantities of it ultimately emerge under the sea. The basic idea that this underground water is slowly moving and could be used in appropriate localities is by no means new. It was stressed in evidence before the Commission by Mr. Youhotsky of the New South Wales Forestry Commission.

1723. In the popular mind an air of mystery is commonly attached to underground waters. In fact, the matter is not mysterious at all unless weight is attached to the old theory of deep underground waters which were once assumed to have little or no connexion with those in the more superficial layers. This theory has had few supporters in recent years and there seems every reason for supposing that the more logical outlook should be adopted. Artesian water supplies have been sought laboriously in most parts of Australia and have been put to great use over wide areas of country; less attention has been given to other supplies which are under insufficient pressure to reach the surface unaided. With modern methods of collection these shallow underground stores may offer considerable possibilities for the development of better water supplies either for stock or for irrigation.

1724. Methods of Tapping.—In recent years a new technique has been developed for obtaining water from sub-artesian sources. In the old days it was customary to put down a bore and to continue drilling until a sufficient volume of water had appeared in the hole to justify pumping. The new development, which is sometimes known as the “Ranney system”, consists of sinking a shaft to a horizon where water begins to appear, even if only in relatively small quantities. The next stage is the development of the water-bearing surface by a series of more or less horizontal drillings into which perforated collecting pipes are inserted. In this way the volume of the water-bearing strata which is being tapped by the shaft can be greatly increased and consequently much greater opportunities are available for obtaining larger supplies which can be pumped up to the surface. This method, which is really a development from the older spear wells which had been used on the Burdekin in Queensland, on the Gascoyne at Carnarvon in Western Australia and at other places, gives considerable promise. There is reason to suppose that it should be successful in some locations, but as each installation is more expensive than a simple bore it is particularly desirable that the locations in which it is tried should have been satisfactorily reported on by competent geological advisers.

1725. It must not be assumed that water obtained in this way will necessarily be cheap enough to be useable for general irrigation purposes. The Commission understands that its protagonists state that the method is only worthy of consideration when a flow of 1,000,000 gallons per day can be expected. Even so it seems likely that there are many centres in Australia which at present have very indifferent and erratic water supplies and which could use such schemes with advantage.

1726. While accepting the view that in some places in Australia there are probably large sources of underground water available near the surface and as yet untapped, the Commission points out that the problem is more complex than in the case of surface water. In the case of the latter it is possible to measure the volume available and its reliability before any expensive construction need be undertaken. Unfortunately this is much more difficult and less certain in the case of underground waters.

1727. The factors determining the presence and value of underground water are various. The permeability of individual layers in the strata is obviously of major importance. In some places the salinity of the soil is so great that these waters would be too highly mineralized for use. In districts which are remote from rock outcrops and in which the rainfall itself is of such a nature as to give rise to little penetration, the chances of finding water are not good. For example, the existence of considerable quantities of water near the surface in the neighbourhood of the barren Macdonnell Ranges in Central Australia is accepted, but the chances of obtaining satisfactory underground flows in plain country hundreds of miles away from any range or from any recognized line of intermittent stream flow are slight.

1728. Need for Careful Survey.—It is important that full investigation should be made of this matter on a wide basis in Australia but it would be most unwise to set out on such a scheme without taking full advantage of geological advice from competent men trained in this science. The water

diviner has a great vogue, but there is no evidence to show that on the average the results achieved by the use of these alleged powers are in any way superior to those obtained by the logical use and application of orthodox knowledge.

1729. It is interesting to note that in some States authorities charged with the development of water supplies have already appointed geologists for this purpose and it is to be hoped that others will not fail to follow this lead. During the war an enormous amount of experience on these matters has doubtless been gained in the Northern Territory which is under the Commonwealth's jurisdiction. The Commission recommends that geologists should be appointed specifically to undertake the collation of the information thus gained and to make further investigations along scientific lines in these areas.

1730. The Commission has learned that in oversea countries great advances have been made in methods of drilling which enable the work to be performed very much more expeditiously and at much lower cost than was previously thought possible in this country. It is to be hoped that the States concerned will ensure that their drilling organizations are equipped with the most efficient machinery.

1731. The Commission understands that all the mainland States have Government-owned drilling plants which are available for putting down bores on private properties; unfortunately, the number of applications from private individuals for their services usually greatly exceeds the capacity of the plants to meet them. The Commission sees some danger in this fact because there will be a continuous pressure for all boring apparatus to be used in this way, which will prevent its use for exploratory purposes. Therefore, in addition to the plants available for doing work on private properties, there should also be a limited number of other boring plants available for putting down bores in places designated by scientific investigators for the purpose of studying the problem in a scientific way. The Commission urges that the matter is of sufficient national significance to warrant such investigation. It points out that thousands of bores have been put down in the past, and although some notes have been taken as to the strata through which these have passed, the information available is often too perfunctory to be of great scientific value. In addition, the results of all these bores had never been satisfactorily assembled until the U.S. Forces arrived in this country in 1941. This is a sad reflection on the neglect of a matter which should be of major technical and economic significance to Australia.

1732. Need for Salinity Studies.—In some areas the waters obtained from underground sources are more or less heavily charged with saline matter. This factor will have to be taken into consideration in deciding the practicability of any scheme for obtaining water from these sources, particularly if it is to be used for irrigation. Numerous attempts to use bore and other waters with too high a degree of salinity for irrigation have led to disastrous results. The study of water salinity is of particular importance to Australia; and many investigations have been carried out. Fortunately, the basic principles have recently been re-surveyed and the known facts reviewed by Mr. V. G. Anderson of Melbourne,* who, using new methods of collating and interpreting the analysis of salts in waters, has shown the extent to which sea salt is deposited over various districts in

* *Australian Chemical Institute Journal and Proceedings*, 1940, 1941 and 1945.

rain water. Later studies of the salts in stream and bore waters have provided a basic line of approach to the problem which could be valuable in the analysis of salinity in inland underground waters. The Commission recommends that in the event of investigations into borings being made on a larger scale in the future, the opportunity should be taken to ensure that the mineral content of all waters is determined and the results collated by a special investigation. The Commission points out that it is possible that such investigations might lead to the discovery of sources of potash and bromine of commercial value, quite apart from the primary objective of developing a fuller understanding of the suitability of waters for stock, domestic and irrigation use, and of the location of saline beds and their geological and geographic distribution. The discovery of potash at Lake Campion in Western Australia followed from analysis of waters made as a result of intelligent anticipation based on geological knowledge.

The Need for Interstate Agreement.

1733. River catchments and the courses which rivers follow have no respect for State boundaries. Consequently it is inevitable that in some cases the control of rivers and river water must be determined by the joint action of various governments. We already have experience of the River Murray Agreement to which New South Wales, Victoria, South Australia and the Commonwealth were parties. Other instances in which interstate agreement is necessary are those of the Snowy River, the course of which is distributed through New South Wales and Victoria, the Dumaresq and the Macintyre which for part of their courses form the boundary between Queensland and New South Wales, and the Darling, the headwaters of which are drawn from Queensland and New South Wales. Before any of these streams can be used, interstate agreement will be necessary. It would be useless for New South Wales to produce plans for the utilization of the Darling waters in the lower reaches of that river unless it has some assurance as to the way in which irrigation is going to be developed in the regions of Queensland from which much of that water comes. Similarly, South Australia which obtains some of its irrigation water from the Darling through the Murray is also an interested party.

1734. The Commission recognizes that in matters of this kind interstate agreement will not always be easily obtained. State Governments, which in matters of development within their boundaries are still paramount, are likely to look at each proposal from the point of view of the particular welfare of their own section of the nation. It is only natural that they should be somewhat prone to take short views favouring the development of their own districts in opposition to long views which might be ultimately preferable from the point of view of the nation as a whole. In some cases it may be possible to arrive at a solution of such problems on a satisfactory long term basis by a process of bargaining. In other cases obstructive obstinacy on the part of one State may be the only obstacle to an agreement which would be of great and lasting good to the nation as a whole. The Commission has considered the attitude which the Commonwealth Government should adopt in connexion with discussions of this kind, and it urges that the technical soundness of the project and its economic value to the nation

should be the ultimate basis on which the adoption of the plan should be decided. Neither political advantage nor the ambitions of districts should play any part in such a matter. If the Commonwealth Government decides that the basis put forward by its technical advisers is one which should be adopted in the national interest, and if differences between the States are the only barrier to the attainment of such objectives, then it should endeavour through the appropriate publicity channels of the press or broadcasting services to give ample publicity to the scheme and its merits, and should explain in unequivocal terms the fact that one particular State is adopting an intransigent attitude on the matter and the reasons which the State puts forward for so doing. Such a plan, however novel, is based upon the fundamental ideal of a democracy—that the views of individual citizens in the aggregate should prevail.

1735. The Commission believes that if such a procedure were adopted no State would be prepared to be obstructive if the arguments on which its case rested were based unsoundly or on other than the maximum national interest. If the Australian democracy is not sufficiently interested in plans for its development to express opinions in matters of this kind it is not worthy to make progress.

Recommendations.

1736. In view of the vital importance of irrigation in the future of Australia's rural development, the Commission recommends—

- (a) that the maximum economic development of irrigation should be regarded as a national objective;
- (b) that an all-Australian co-ordinated plan for irrigation development should be drawn up in which the long-term needs should be carefully considered. This point was stated in paragraph 439 of the Third Report where it was pointed out that—

“Each new venture makes a change in the volume of supply of every commodity produced. The amount may be so small that its result is insignificant, but some of the schemes are large enough to have an appreciable effect on the marketing of a commodity. If, for example, New South Wales, Victoria, South Australia and Western Australia all established schemes for irrigation areas, based on growing vines for dried fruit of which Australia already exports over 75 per cent. of her production, the result would throw the marketing of that product into chaos unless there were a sudden opening for greater volumes of such fruit overseas. Some co-ordination between the States in planning new irrigation is, in fact, essential if trouble is to be avoided.”
- (c) that the survey of river catchments and the recording of river gaugings should be encouraged so as to supply the fundamental data on which future satisfactory irrigation schemes may be based;
- (d) that the methods of distributing and using water in existing irrigation schemes should be studied so as to devise means whereby water may be more effectively used in the future than it has been in the past;

- (e) that schemes for using water for stock and domestic supply or for irrigation should be given priority over schemes for generating electricity unless adequate means of using the available water for irrigation cannot be developed;**
 - (f) that before adoption every irrigation scheme should be examined carefully from the points of view of the engineering problems involved, the suitability of the soils for irrigation, the type and methods of farming to be carried on, and the long-range prospects of the industries concerned;**
 - (g) that at the present juncture at least, it would be wisest to accept only such irrigation projects as would stabilize existing industries; or expand those which have reasonable market prospects;**
 - (h) that in the interests of developing irrigation on sound lines the Commonwealth should endeavour to promote interstate co-operation and co-ordinated development in all irrigation matters;**
 - (i) that where interstate agreements are necessary for any desirable irrigation development and such agreements are not forthcoming, and where the Commonwealth Government has satisfied itself that the proposal is clearly in the interests of sane and desirable national development, then the said Government should prepare a clear statement of the case and devote money to the publicity necessary for such a statement, in the belief that the Australian people are primarily Australian and not primarily members of one State;**
 - (j) that the possibility of using suitable underground waters by large-scale pumping methods should be investigated in regions where geological study indicates that satisfactory results are most likely to be obtained.**
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CHAPTER III.—TECHNICAL PROBLEMS OF IRRIGATION.

1737. In the present chapter the Commission does not propose to present any detailed consideration of the many problems of various types which occur in the development of an irrigation system. However, insofar as some of these problems affect to a very marked extent the success of any irrigation scheme, and as the importance of some of them has been imperfectly recognized it has seemed desirable to refer to them in outline. For the sake of convenience, these matters may be grouped under the headings of the problems of storages, of distribution and of water use on the farm.

Problems of Storages.

1738. World history affords many instances of dams which have given way and thereby brought ruin and death to considerable areas of country. It seems scarcely necessary to emphasize that the construction of dams must be beyond reproach from the engineering standpoint. In this connexion there have been numerous scares in Australia, and a great deal of information is available in regard to the safeguarding of dams from the constructional point of view.

1739. Erosion Control on Catchments.—A further point not quite so generally understood is that the value of a storage may be rapidly depreciated unless care is taken to protect the catchment area from undue erosive action. So far the amount of siltation which has taken place in Australian water storages is relatively small, but in the case of one Victorian river the head waters of which were used for sluicing certain gold deposits, the value of the storage has almost disappeared. However, it is necessary to emphasize the fact that unless the appropriate water supply authority also has control of the method of land use on the catchment from which the water is drawn, there is always a chance that bad farming methods will lead to continued decrease in the capacity of the reservoir. It is for this reason that the Commission recommended in paragraph 449 of its Third Report that each State should establish a land utilization council under the control of its Premier, and that this Council should have the task of co-ordinating the policy of the State on all phases of land use concerning the allocation of land for farming, forest development, water resources, national parks and reserves, and erosion control, and further that this Council should consist of the heads of the various departments, including that of Water Supply. Naturally the Commonwealth should endeavour to ensure that, before capital moneys are allocated to any water conservation project, adequate steps have been taken to avoid the risk of erosion within the catchment area concerned.

1740. Catchment Efficiency.—The most effective means by which catchments can be managed so as to make the storages as effective as possible by increasing the efficiency of run-off is a matter which requires some research. It does not follow that the method which is most appropriate in a catchment which has one kind of climate will necessarily be the most effective in one with a different climate. The problem is, however, always the same; namely, how to provide a volume

of water which is as large as possible and at the same time is delivered to the reservoir as gently as possible. If these objectives are attained then the ratio of average output of the reservoir to the total volume of water which can be impounded will be high because it will be receiving water not only at times of high rainfall but also at times when no rain falls but the soaks and springs are still running.

1741. *Provision for Hydro-Electric Plant.*—As already suggested in paragraph 1717 above, the Commission is of the opinion that it would be generally advisable to make provision in the construction of any dam for the ultimate incorporation of plant for the generation of electricity. It is necessary to emphasize that irrigation storages normally aim at holding water back for long periods of the year and liberating it in quantity only when the areas to be irrigated require it. This periodic availability of water is diametrically opposed to the needs of a power generating scheme under which a continuous flow of water is desirable; the installation of plant for generating current may therefore be of secondary importance but the Commission anticipates that sooner or later most of the higher rainfall districts of Australia will have interlocked power supply lines running through them. Under these circumstances the amount of current which could be generated from each potential source of supply may prove valuable in the scheme as a whole, and this value may easily outweigh the disadvantage of having somewhat expensive generating plant relatively idle during portions of the year.

1742. The positions at which storages are sited must in many instances be governed by the existence of appropriate geological and topographic structures and requires no further comment.

Problems of Distribution.

1743. *Waste through Seepage.*—Sometimes it will be impossible to avoid long systems of channels leading the water from the storage to the area in which it is to be used. In the course of such transference, water is continually lost both through evaporation and by seepage from the channel. It is frequently possible to design main channels through country which has a good holding sub-soil and on which seepage losses are light. On the other hand, it is inevitable that some seepage will occur; and it is often considerable in the smaller branches into which the main channels divide within the irrigated area itself. In some districts where soils are predominantly porous, seepage has often been marked and water supply authorities have already had to take steps to reduce it by lining the channels with concrete or other impervious materials. It is possible that research might indicate some methods of treating channels which will diminish the amount of seepage. The extra expense involved is obviously one which no supply authority is likely to incur with equanimity.

1744. *Possible Use of Piping.*—Piping the water would be the ideal method as it would prevent evaporation as well as seepage, but it is very expensive. For instance, the Commission was informed that the piping of the 6,600 miles of the Wimmera Mallee stock and domestic supply system would cost not less than £16,000,000, a capital investment which at 4 per cent. would cost £640,000 per

annum in interest, which is practically the equivalent of making a complete new set of earth channels each year. The fact that the irrigation demands on the waters of the Murray and other streams are already sufficiently great to call for water rationing in years when the Hume and other storages are low, suggests that a continuous policy of improvement in the water-holding efficiency of channels should be maintained. If the Commission is correct in its view that water supply is likely to prove a limiting factor to Australian rural development and population in the more distant future, then the point of view here set out is important. It may be that in the long run it will prove necessary to use pipes for conveying the water. Some district water-supply schemes (e.g. Kalgoorlie in Western Australia and Tod River in South Australia) are based on this practice. The high cost of installing such a system is the main objection to its adoption for irrigation which requires great volumes of water. The important point is that the need for preventing channel seepage should be generally recognized and improvements effected as opportunity offers. As the need for water becomes greater individuals will be more prepared to share the cost.

1745. Need for Measured Distribution.—Probably the point in most irrigation schemes at which water is most frequently wasted is on the farm itself. Unfortunately, the attitude of mind of many of the irrigators is one which tends to a somewhat prodigal use of water, often in amounts which are in excess of those needed by the pastures, crops, or trees. While education will do much to remedy this state of affairs, there will always be some individuals to whom the easy and inefficient method will be more attractive than one which demands care and skill. In some irrigation districts the water is measured on to each farm, usually through a device known as a “Dethridge wheel”. Where these are installed and function without interference the water-bailiffs can check the amount used on each property. In other districts the installation of these devices is more difficult because the slope of the supply channels is too gradual to give the necessary fall. In other areas the authorities have not thought it necessary to install measuring devices, and each farmer is permitted to have “an irrigation” at appropriate periods. The Commission considers it is generally desirable that the water used on each property should be measured, and that the amount used above the basic quantity should be charged for at a separate rate. It seems unlikely that some irrigators would ever be prevented from using too much water and if they do so they might as well pay for it. In any case, any such payment is a deterrent to wastage.

Problems of Water Usage on the Farm.

1746. Soil and Drainage Troubles.—The history of irrigation settlements in this and other countries shows that a number of the farms have run into soil troubles a few years after the water was first provided. Sometimes large areas have been severely damaged by the emergence of salt on the soil, and what was, under dry conditions, poor pasturage, has become almost worthless. In other cases large numbers of trees have been killed by a rise in the water table which has led to severe damage to the roots. During the past fifteen years a considerable

amount of reclamation has been done on some of the areas concerned and a great deal more work is in progress in various districts on the Murray and Murrumbidgee. The acute nature of some of these failures has brought tragedy to many irrigation farms. Settlers who started out with high hopes have been ruined and the authorities which advanced money on the properties concerned have found it impossible to collect their dues, while the decline in productivity has reacted unfavorably upon some of the local townships. Despite all this experience and the fact that the reasons for these troubles and the methods by which they can be obviated are now well known, it is quite clear that in some of the recent settlements the lessons have not been learned and further troubles are likely to occur on some farms in the future. The Commission has been somewhat surprised at this state of affairs and has been at pains to arrive at the reason for it.

1747. It seems likely that the most important contributing factor originates in the time-worn belief that Australian soils are highly fertile, and that only the shortage of rain restricts the amount of plant growth which occurs on them and the period in which that growth can occur. Belief in this common fallacy naturally impels the new irrigationist to assume that a native pasture which normally dries off in the summer can be made to give much greater growth in that period merely by leading water on to it. Alternatively, if the farmer is engaged in cropping he tends to assume that during a dry period water can be applied to the crop, and the result will inevitably be very beneficial. The dry farming operator seldom has to think in terms of damage done by excess water, for under such conditions the extra rain usually gets away somewhere through the normal drainage system of the countryside but where he begins to apply water under irrigation the amounts he uses may be far too large for the natural drainage of the soil.

1748. In actual fact most of the plants which constitute pastures in the drier parts of Australia are attuned to alternating wet and dry periods during which growth is luxuriant or absent. The mere alteration of the amount of the moisture available to the plant during the dry part of its yearly cycle does not result in prolonging growth far into the season in which it would otherwise be dormant. Again, in the case of crop cultivation, methods which will produce satisfactory results under dry farming are in many cases quite unsatisfactory if irrigation is applied. As for the soils, if excess water is added to many types, a large number of changes occur in the structure of the soils, while wherever there is an impervious layer within a few feet of the surface a new water table can easily be developed with disastrous results to any deep-rooted plants.

1749. These basic facts stress the point that irrigation farming is a new technique which must be developed and understood by irrigators if success is to be achieved. The Commission was therefore somewhat surprised to notice in several new irrigation areas in various parts of Australia that pastures were being irrigated by the method known as "wild flooding" under which water is led on to the natural ungraded surface of a paddock, sometimes of native pastures, so that the distribution of the water is extremely uneven. Some plants are drowned and others insufficiently watered, with results which for the time being are only partially successful and may, in the long run, prove disastrous.

1750. Need for Extension Programme.—No new irrigation scheme should be developed without the installation of a carefully devised and intensive programme of extension work in the hands of trained officers who have had experience in the art. It is extremely doubtful whether any irrigation (other than one run by the spray system) can ever be a success without a preliminary grading of the land, and if satisfactory results are to be obtained it will almost always be necessary to introduce new species or varieties of crop plants which are known to be successful under the new conditions.

1751. Use of Correct Quantity of Water.—The aim of the irrigationist should be to give the plants of pasture, crop or orchard the exact amount of water which is required for their satisfactory development at the precise times when they need it. In some cases the nature or contours of the land may make spray irrigation highly desirable. This method, though costly in plant and in the time required for its operation, has certain advantages and is already used in some places. Several systems of distribution and several types of sprinklers are available but little has been done to attack the problem from a scientific point of view, and investigations on the matter are overdue. Whatever the method of distribution the basic principle to be followed is that any addition of water in excess of the plants' requirements is waste. All it succeeds in doing is to percolate to deeper layers where it either drains away and is lost or raises the water table and causes damage to soil and/or crop. Unfortunately, in some cases faulty irrigation, although it may not do much damage on the property on which it occurs, may lead to disaster on others which are at lower levels. Water transference through the sub-soil depends upon the way in which the beds of clay and sand are arranged in the vicinity. Farmer A may do no harm on his property by using twice as much water as he needs, but there may be excellent grounds for belief that he is ruining Farmer B half a mile away, though it might be very difficult to prove it in a court of law.

1752. A nicety of judgment as to the amount of water to be used upon any given paddock or orchard can only be developed if the irrigator takes pains to ensure that he is not using an excess of water, and this can only be determined as a result of frequent observations in test holes or by the use of the auger. The layout of the farm is also of great significance. The length of run of irrigation water in the individual paddock must be related to the type of soil of that paddock. Thus on a sand, if the runs are too long the top end of each may be hopelessly over-watered before the bottom end receives enough to support the plants. The runs should therefore be short; while on a clay, particularly where the slopes are marked or the vegetation thin, they need to be longer, otherwise the water may accumulate at the distant end before the nearer part has had enough to satisfy the plants.

1753. Soil Drainage.—If due precautions are taken and irrigators live up to their responsibilities, it will be possible to avoid major difficulties connected with soil deterioration. However, in certain areas where soils vary widely and conditions are difficult, the only feasible method of ensuring against soil troubles consequent on irrigation is the installation of a drainage system. The great

benefit which many irrigators on the more difficult soil areas in the Mildura district have received from the installation of the underground drainage system shows very clearly in increased yields and a recovery of the properties concerned.

1754. In many areas there will always be some difficulties which will make trouble for particular types of crops. Thus experience in the Shepparton area over a period of years has shown that it is unwise to use the heavier types of soil for peaches, while pears are less sensitive. On the Murrumbidgee irrigation area the general rise in the water table of the district in recent years has caused much alarm. It seems likely that this has been partly caused by permitting the irrigation of rice (which requires enormous volumes of water) on soils which are too permeable. This has led to the introduction of great quantities of irrigation water into a sandy drift which seems to underly large sections of the area. The results have been greatly accentuated by the occurrence of very heavy rainstorms just at the time when the soils had been given their autumn watering.

1755. The work on reclamation done by the Victorian Department of Agriculture in the Kerang area has shown very promising results and has demonstrated that pastures which have lost much of their productivity through partial salting caused by bad irrigation methods can often be renovated by the use of careful techniques.

Development of New Irrigation Areas.

1756. In formulating a new irrigation scheme it is necessary to allow the purpose for which the water will be used to be partly determined by the cost of installing and running the system. If the water has to be pumped to considerable heights, as at Mildura, the cost per acre foot delivered will be relatively high and the prospective returns per acre must be good enough to bear that cost. Under such circumstances dairying cannot easily become the basic industry because it will seldom return more than £15 gross per acre. On the other hand a gravitational scheme may provide water at a cheap enough rate to permit of economic dairying, while lamb raising or fattening may also be satisfactory especially if the irrigated area is used in conjunction with adjacent dry land.

1757. This fact is well recognized; in some irrigated regions the land is subdivided into relatively small holdings, the whole of which can be irrigated, while in others each farmer is given a water right which permits him to irrigate a proportion of his holding. The water right varies with the district. In many of the Victorian areas it is one acre foot in four acres held while in the more recently developed districts of New South Wales it is one in ten. The water right naturally governs the ratio of land which should be irrigated on any holding.

1758. Under existing conditions the tendency is to allocate these "proportional" water rights to all the farms in an irrigation district irrespective of the nature of the soils on those farms. Probably an equal distribution of this kind is almost inevitable in order to create a sense of justice in the minds of the farmers holding the land. In the long run, however, unless irrigation experts are able to determine satisfactory methods by which every class of soil can be effectively irrigated, such a scheme may be wasteful in the use of water, because the owners of farms lacking areas of suitable soil types will naturally use it to less advantage. To some extent this difficulty can be avoided by ensuring that

a satisfactory soil survey is made before any irrigation scheme is launched and that the scheme is based on the information thus provided. It is only natural that, if there is a chance that water will become available in a region, many farmers will press for the inclusion of their particular localities or farms in the scheme. In the national interest such pressures should be resisted and great care exercised in selecting the boundaries which are to define the region.

1759. The type of production which can be developed in any area is also partly limited by the frequency and ease with which water can be supplied to the farms. Each type of tree, crop or pasture requires watering at fairly specific intervals. A water roster is therefore constructed setting out the approximate dates on which water will be available to each holding. The district roster should be drawn up by a meeting of irrigators but if the local irrigation officer is wise his views will carry much weight. If the supply is good it may be possible to have other waterings at shorter intervals or whenever called for; on the other hand such an ideal may be unattainable. In some of the Victorian irrigation districts lucerne is the only high grade perennial pasture plant which can be grown, whereas in others water is available often enough in the normal season to maintain mixed pastures such as cocksfoot and white clover; the development of the latter has, in some cases, been so good as to place them among the most productive mixed pastures in the world.

1760. The water supply authority must always be conservative in its allocation of water rights because the volume of water is bound to vary from year to year. In seasons of high rainfall it is customary to sell the excess to farmers, many of whom prepare extra land in the expectation that they will be able to buy this excess water. This practice is sound provided that the water supply authority accepts no responsibility for delivering water in excess of the water right. The irrigation farmer who prepares an extra area of land and takes the risk of not being able to obtain excess water should maintain reserves of fodder and other food stuffs which will enable him to face an occasional shortage without disaster. The fact that he will have to do so must be allowed as one of his working costs.

Administration of Irrigation Areas.

1761. Need for Decentralized Control.—Reference has already been made to the need for local irrigators' committees to discuss and draw up the watering roster for a district. Such committees can be invaluable not only for this purpose but also for discussing the problems which affect their localities. Irrigation is partly a co-operative enterprise. Unsound irrigation practices on a few farms often affect whole districts; at times momentous decisions will have to be taken as to how to eke out meagre water supplies; new techniques will require discussion and investigation; new pests or deficiencies will appear from time to time. These matters can all be usefully considered by local committees. The objective of a wise central irrigation authority is to co-operate with the State agricultural department and to encourage these committees and to see that they are kept fully informed as to the position of water supplies, the progress of investigations and the nature of the problems which are being faced. A centralized authority which is not in touch with its districts will soon become a dictatorship while its local officers may easily be reduced to a condition of impotent frustration.

1762. Need for Extension and Investigation.—Experience shows that as irrigation becomes established in a district most farmers learn the technique and become more or less irrigation minded. Sometimes the process is very slow but it can be greatly accelerated by wise advice from efficient officers. The tragedy is that in so many cases advisory services and demonstration farms have only been installed after a good many years of floundering, during which much harm has often been done to the soils of parts of the district, to the financial credit of many of the farmers and to the reputations of all concerned. The reasons for this are the attitude of mind towards irrigation referred to in paragraph 1747 and also the lack of finance and personnel to undertake soil surveys and plot investigations. Fortunately much information is now available as regards southern irrigation areas, thanks to the investigations of the Council for Scientific and Industrial Research and the State Agricultural Departments of Victoria, South Australia and New South Wales, and it is to be hoped that fewer mistakes will be made in the future. In the northern half of the continent, where little irrigation has so far been attempted, the results of the work in the southern States will only be applicable in part. The action of the Government of Western Australia in setting up a small research station on the Ord River as part of the preliminary investigation of the potentialities of that region is most progressive and the co-operation between the Departments of the State and the Commonwealth Council for Scientific and Industrial Research on the soils of this area is an excellent example of the way in which these problems should be approached. It is to be hoped that similar co-operative investigations will be inaugurated in other new schemes.

Recommendations.

The Commission makes the following recommendations, based on the matters considered in this chapter:—

1763. Protection and Use of Storages.—The Commission recommends—

- (a) That the appropriate water supply authority of each State concerned, acting under the Land Utilization Council of that State, should have control over methods of land use on its catchment areas with a view to preventing erosion and to maintaining an efficient run-off.
- (b) That research should be instituted into methods of increasing the efficiency of run-off from catchments.
- (c) That in the construction of dams provision should be made for the ultimate installation of plant for the generation of electricity.

1764. Efficiency of Distribution.—In view of the need for the economical use of our limited water resources, the Commission recommends—

- (a) That efforts be made to reduce water losses in distribution due to channel seepage and other causes; and
- (b) That the principle of measuring water on to the holdings where it is used be generally adopted.

1765. Use on the Farm.—The Commission recommends—

- (a) That from the inception of any irrigation scheme an efficient extension service be available through local advisory officers and demonstration farms so that irrigators may be properly guided as regards the lay-out of irrigation on their paddocks, the balanced management of their farms, and the types of tree, crop or pasture most suited to the area.
- (b) That the boundaries of any proposed irrigation area or district should be determined on the basis of a soil survey in order to ensure that as far as possible farms lacking land suitable for irrigation are not included within the area or district.

CHAPTER IV.—FINANCIAL AND POLITICAL ASPECTS OF IRRIGATION.

Resistances to Irrigation Development.

1766. In the perfect State with its highly trained staff of expert engineers, soil technologists and economists, and with its citizens fully aware of the needs of the nation and also imbued with a marked sense of public spirit, although land-owners might have a legal right to withhold their consent from an irrigation proposal yet there would actually be no such obstacle to the development of a project when once it had been examined and its merits shown.

1767. In the real world the situation is not so simple. Experts have sometimes made mistakes in the past and the individual farmer frequently pays little attention to developmental policies and is somewhat sceptical of the suggestion that the result of any irrigation or drainage project is likely to benefit him personally. Although in the past the fear of droughts and the capacity of irrigation to increase and stabilize the productivity of farming areas have generally ensured that an irrigation scheme would receive the support of the majority of the land-holders in a district, yet it is not clear that this will always be so; while drainage projects have sometimes been resisted firmly and successfully.

1768. The reasons for resistance are various; some farmers doubt the efficacy of the irrigation or drainage system to improve their prospects, others recognize that the introduction of such a system would require a greater re-organization of their system of farming than they are technically able to undertake, while a third group doubt whether they could get the financial support, without which they could not develop their land effectively on the new basis. At the same time it will be apparent to all three that they will be called upon to pay the irrigation or drainage rates which will have to be levied under the scheme.

1769. Of these three types of difficulty it should be possible to overcome the first two through careful propaganda and advice and with the assistance of local public opinion, because irrigation or drainage schemes, if soundly conceived, will increase the intensity of the agriculture of a district to a marked degree and thereby give more employment. As a result the whole district will be able to make marked progress in the numerous directions which follow from an increased concentration of population.

1770. As to the third objection, the financial obstacles to the acceptance of a scheme for irrigation or drainage can be serious for the individual farmer who may be faced with the need for a large capital expenditure. Thus, if a man, having a farm of 1,000 acres carrying one sheep to the acre, were allotted a water right of one in ten under a new irrigation scheme, he would have to pay

water rates on 100 acres and also find the capital to grade, subdivide and fence that area and construct the necessary channels. The sum involved would vary but might often exceed £500. In addition the irrigated area would have to be re-cultivated and sown with improved pastures, and more livestock would be needed, possibly 200 or more extra sheep, all of which would involve more outlay, while increased returns might not materialize for a year or two. It is therefore essential that adequate financial resources should be available to all farmers in new irrigation areas, and the scheme of agricultural credit recommended by the Commission in its Fifth Report would be well adapted to this purpose, particularly since it would make it easy for the farmer to get expert advice as to the details of the method which he should follow in developing his property on the new basis.

National Policy on Provision of Capital for Irrigation Works.

1771. At the inception of many irrigation schemes it was expected that the rates levied would cover the interest and amortization charges on headworks and channels as well as the cost of distributing the water. Experience has shown that this ideal has seldom been attained. Thus, in Victoria the State has had to accept responsibility for four-fifths of the total capital cost of its schemes. Sometimes the rates which are levied cover the cost of running the irrigation scheme and sometimes they also cover part of the cost of servicing the national capital invested. The State receives considerable benefits of an indirect character through the increased productivity which follows and through the general improvement in employment which the resultant trade brings. It is therefore reasonable that part of the cost of the State's initial capital outlay be made a charge upon public revenue. On the other hand this is no argument for providing the water at an unnecessarily low cost which only encourages its wasteful application. Further, the higher the proportion of the capital charge borne by the State the greater will be the demand on the national exchequer and the smaller the amount which will remain to finance other social services and developments necessary for the general progress of the nation.

1772. Control of Speculative Land Values.—The introduction of irrigation into a district or even the formulation of plans for such introduction commonly leads to a speculative rise in the price of land in areas which are likely to be affected. It seems reasonable that if a Government is prepared to instal a scheme for irrigation or drainage and to meet part of the capital cost, then it should have the power to prevent the land owners concerned from making capital profits as a result of the State's expenditure and with no effort on their part. Various devices can be used to avoid this difficulty. The land concerned can be resumed and sub-divided for re-settlement, or the sale of the land without Government consent can be prohibited. In either case it would be necessary to ensure that the rights of existing land owners are respected to the extent that no man should be put in such a position that he cannot obtain a better return after the installation of the new scheme than he did before.

Legal Ownership of the Water.

1773. In some countries the right to use water from a stream for irrigation purposes is vested in the owner of the adjoining land. Under such circumstances the questions of how much water any individual may take, and the relationship between individual owners, often become contentious issues, to the great benefit of the legal profession. Happily, uncertainties of this type have been avoided in Australia, largely owing to the courageous action taken under the Victorian Water Act of 1905. In this remarkable measure the State took away from the owners of land abutting on any natural water the right to use such water free of charge, and vested in the Crown the possession of beds and banks of all streams and other natural sources of water supply. This remarkable piece of legislation has been copied by most of the other States and is an essential feature in the satisfactory regulation of the use of irrigation water.

1774. As matters now stand, anyone wishing to draw from a natural source of water must obtain a licence for that purpose. Such licences are normally granted at a small charge and it is generally desirable that this practice should continue, always provided that in his operations no licensee prejudices the general development of the community or the welfare of other individuals. At present permits to draw water from natural sources are not always issued by the authority controlling irrigation schemes. The Commission recommends that this anomaly should cease and that the authority controlling irrigation and water supply should also control the rights of individuals to use natural waters independently. Without such uniform control, inter-departmental difficulties are almost certain to occur, and a properly co-ordinated scheme for the use of irrigation waters will not be readily obtained.

Control of Purposes for which Irrigation Water is Used.

1775. As a general rule irrigation authorities have not endeavoured to control the kinds of products which irrigators have produced on their properties. The exceptions to this broad statement are as follow. In the first place, the size of the blocks into which any irrigation area is divided must to some extent affect the kind of activity which occurs on it. Thus the small 15-acre fruit holdings would not be large enough for any farming purposes other than the production of fruit and vegetables. Secondly, the amount of water which is available to the farmer also limits his capacity to produce certain types of crop or pasture. But apart from these limitations the irrigator has generally been able to try his hand at any form of production which seemed good to him. The Commission takes the view that this scope for initiative should be retained as far as possible. Circumstances change, new varieties of crop plants are produced and new markets may open up for new products from a district. It is most undesirable that those farmers who have the capacity, the courage and the financial resources to try new ventures should be hindered by restrictions on their enterprise, always provided that they are not damaging their neighbours' properties in so doing and are not unduly complicating some economic problem with which the nation is confronted by producing a commodity which is already over-supplied.

1776. The need for exercising some supervision in regard to the former of these two provisos arises where thoughtless irrigators tend to over-water their land to the detriment of neighbours at lower levels. The latter proviso requires further consideration. In the case of certain irrigated products, notably dried and canned fruits, it was clear during the pre-war period that world production of these commodities had reached levels which made it difficult for producers in any country to sell their products at prices which represented a reasonable return for labour and other expenditure. During the war period the extra demands for these and other industries has completely removed any marketing difficulties; but unless the conditions governing international trade in these commodities after the war are much more satisfactory than they previously were it is reasonable to expect that difficult times will recur, particularly if Imperial preferences disappear. It follows, therefore, that any large increase in the production of these commodities under irrigation could easily lead to economic distress in the industries concerned. Actually before the war there was a gentleman's agreement between the various States that fresh plantings of irrigated vineyards would not be made. This arrangement was generally adhered to by the irrigation authorities, but instances were not lacking in which land holders with blocks adjacent to streams secured pumping rights from the issuing authority and proceeded to plant vineyards for the purpose of growing dried fruit, thus, to some extent, nullifying the general efforts to prevent production from increasing. In the case of canned fruits, virtual control of expansion was also exercised by the canneries' refusal to admit more members or to process fruit except from their recognized suppliers. Before the war the rice acreage was controlled by the refusal of the appropriate water supply authority to make available for more than a limited acreage the large amount of irrigation water required for this crop.

1777. The Commission recognizes that the capacity of Australia and of other countries to produce, under irrigation, such products as those referred to is very large indeed and it expects that the need may arise for international agreements to control the volumes of production of these and other commodities. In view of the possibility of such an event it would be most unwise for individual States to launch irrigation schemes which permitted the use of extra land for the purpose of growing these crops; nor would the Commonwealth be justified in assisting in any way to arrange for the finance required in the capital construction of these schemes.

1778. The Commission recognizes that the preceding paragraph in fact proposes some limitation on the individual irrigator's right to grow particular crops, but such restriction seems to be a necessary part of the evolution of a new international order which it is to be hoped will replace the jungle-like struggles of the past. In order to ensure that restrictions of this kind are not imposed unnecessarily or in opposition to the legitimate rights of the individual to do what he likes with his own property, it might well be enacted that no such restrictive action on the supply of water for any form of production should be taken until the circumstances of the industry have been fully investigated by the Tariff Board or some other form of public inquiry, at which evidence from the representatives of the industry and those in touch with local and world markets could be taken.

Recommendations.

The Commission makes the following recommendations based on discussions in this Chapter:—

1779. Capital Costs and Values of Water and Land.—The Commission recommends:—

- (a) **That attention be paid to determining the most equitable allocation of the capital costs of any irrigation work between the State and the water-users.**
- (b) **That without penalizing existing land-owners, steps be taken to prevent them from making capital profits out of a rise in land values consequent on irrigation proposals and plans.**

1780. Control over Activities of Irrigators.—The Commission recommends:—

- (a) **That the authority controlling irrigation and water supply should also control the issue of permits to individuals to use natural waters independently.**
 - (b) **That within the limits set by the amount of water they require and the provisions of paragraph 1736 (b) the minimum of control should be placed on the activities of irrigators in respect to the types of production in which they engage.**
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CHAPTER V.—LAND DRAINAGE.

The Land Drainage Problem.

1781. Australia being a dry country, thought naturally runs in the direction of providing more water and little attention is given to the removal of any surplus. However, agricultural experience in other countries has shown that very great improvement can sometimes be effected in crop yields and pasture growth by the drainage of land. Two forms of drainage are in common use. The first is surface drainage for the removal of surface water by open channels, the second is underground tile drainage which, on some soils, has most important effects in lowering a temporary water table and maintaining healthy conditions for the roots of plants.

1782. *Surface Drainage Systems.*—The reclamation of swamps by surface drainage, often accompanied by tile drainage as well, has resulted in the development of some of the richest agricultural land in the world. The English fens and the Dutch polders are good examples. In Australia some of the coastal swamps in the south-west of Western Australia, the Millicent area in South Australia, the Mowbray in North Western Tasmania, and Kooweerup in Victoria are good examples of channel drainage work which has given very beneficial results. Further inland, flood prevention on a large scale has been undertaken at various places in some river valleys, and on many individual properties simple forms of superficial drainage have been arranged for the improvement of adjacent paddocks.

1783. Despite all this work, a great deal more remains to be done in the way of flood protection and of surface drainage both in large-scale schemes and on individual properties. The obstacles are sometimes cost, occasionally inertia, and always some uncertainty as to the ultimate financial result. A suitable system of agricultural credit linked with an adequate agricultural advisory service would remove the difficulty of obtaining credit in cases where the expenditure was justified. A competent authority for dealing with soil problems would be able to give a reasonable forecast of the prospective benefits to crops and pastures from drainage; for, although swamps are of various types and require different treatments, sufficient scientific investigation has been carried out on the matter to make prediction satisfactory.

1784. *Tile drainage* is a more expensive procedure and has not been carried out to any great extent in Australia except where the type of production gives a return sufficient to cover the cost of the installation during the period of its usefulness. The comprehensive scheme in the Mildura area is probably the largest of its kind in this country and its results have been striking. On agricultural land in Australia relatively little use has been made of tile drainage but in Britain, with its wetter climate and its close proximity to markets, tile drainage is common on many soils: it was one of the chief ways in which farming was improved during the great period of agricultural prosperity between 1840 and 1870: again during the war, when extra supplies of foodstuffs were urgently required, it was found

that one of the main necessities in bringing heavier soils to higher production was the installation of tile drainage, and in certain cases mole ploughs have been used with good results.

1785. A programme of tile draining can be carried out very effectively if the tiles are available at low cost, if modern machinery is used to dig the trenches, lay the tiles and replace the earth, and if some watercourse is available into which the water can be led. Unfortunately these essentials are often unavailable. Possibly this is not of great significance for the time being, but in the future, as it becomes necessary to use the land in the better rainfall areas of the Commonwealth more intensively, the point will be reached at which it will be worth while expending the capital for tile drainage on certain land used for cultivation or grazing. In the meantime some areas could probably be improved with profit by the periodic use of a mole plough.

1786. *Need for Information.*—The Commission considers it very desirable that accurate information should be available as to—

- (a) the basic physics of water movement in the more common soil types;
- (b) the most modern methods and costs of drainage in oversea countries whether by the use of channels, tiles or by mole plough;
- (c) any experience of methods and costs of land drainage which has been obtained in Australia by public authorities or individuals.

The task of obtaining and collating this information would be appropriately undertaken by the organization recommended by the Commission in Chapter II. of its Sixth Report.

1787. *Problems Caused by Drainage.*—The problem of disposal of drainage waters is by no means simple. The natural watercourses of an area develop to a size sufficient to carry off normal rains, while excessive falls may cause floods. When the use of land is changed, either by removal of forest or by cultivation, the rate of run-off changes; in those cases where it increases, erosion may begin, water channels may be deepened and flooding may be accentuated until the stream or creek system has accommodated itself to the new conditions. If an extensive system of farm drainage is developed on a property, water will begin to flow across its boundaries unless a local storage is created. This water will cause a problem on adjacent properties and ultimately along the lower stretches of the streams into which it flows. Simple instances of damage done in this way can often be seen where thoughtless road engineers, anxious to secure the foundations of their highways, have turned the flow of water from their roadside ditches on to adjacent lands at lower levels.

1788. Any land owner who diverts water from his property onto that of another landowner in such a way as to cause damage is legally liable, and from time to time litigation takes place on the point. It follows that any drainage scheme must take into account the available means of disposal of the water. Where a drainage problem is very intense it is usually not difficult to get land-owners to agree to a district scheme in which all participate, but when a farmer who is convinced of the desirability of drainage has neighbours who are of different opinion, the result is not so certain. The only way in which drainage can be brought to such a district is through propaganda, demonstration and district action.

Drainage Schemes in the South-eastern District of South Australia.

1789. One particular large-scale drainage scheme which has been investigated intensively calls for some specific comment. This concerns the south-eastern portion of South Australia in the region shown in Figure 7. The Commission spent some days in this particular area and heard much evidence regarding the proposals.

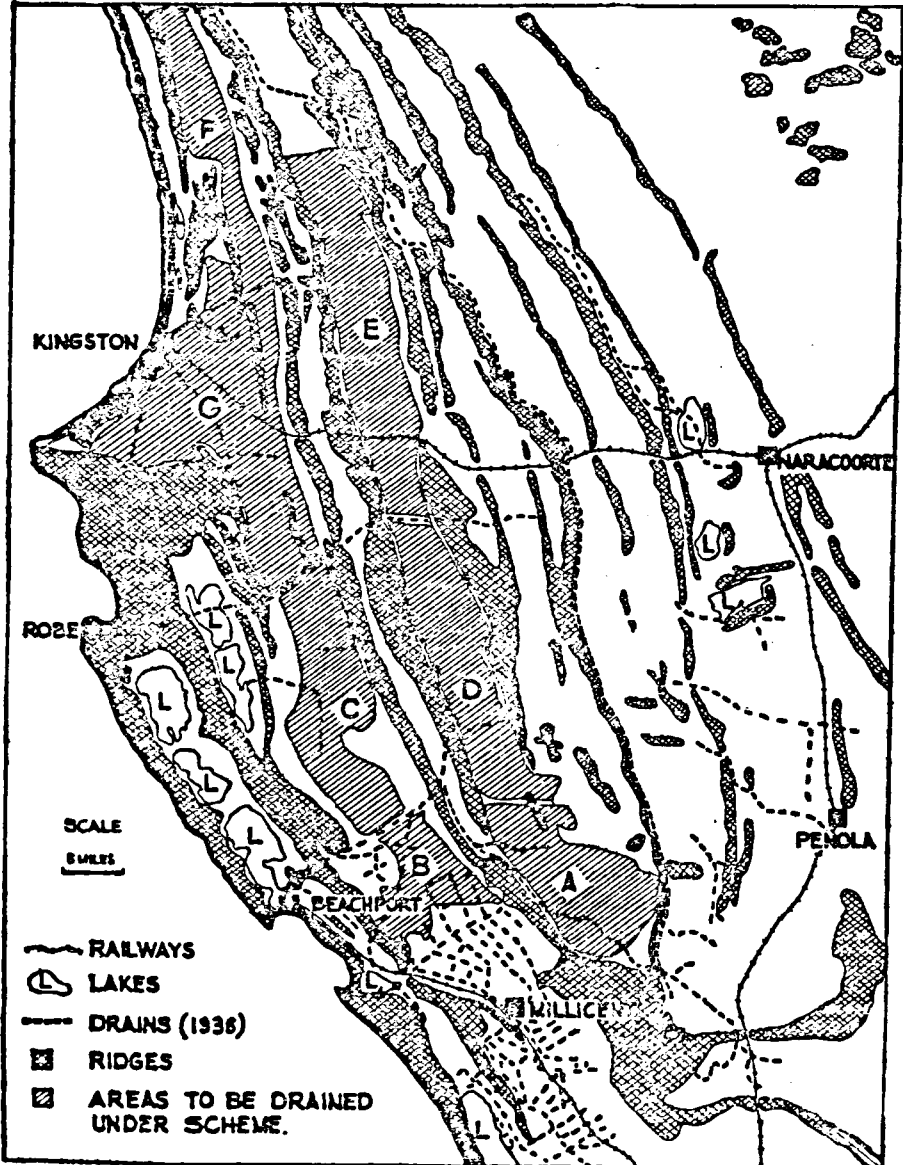


Figure 7.—South Australia—South-eastern District Drainage Scheme.

1790. The recent geological history of this particular district seems to have involved the gradual emergence of the coast-line from the sea, during which process a series of coastal sand dunes were formed parallel with the shore. Between these lines of dunes are areas of relatively flat land, much of which was probably once salt marsh. As a result, while the general fall of the land is westwards towards the sea, these old dunes, now much modified, run roughly at right angles to this general line and constitute a series of barriers preventing drainage from going in what would otherwise be the normal drainage direction. In the long period of time during which this process has been going on, the old dune ridges have been modified by the rainfall and each has developed a rather hard core of rock. Some idea of the scale of this development may be gained from the fact that on a line running roughly eastwards from Robe for about 54 miles the land rises approximately 200 feet and in that distance eight of these "ranges" are crossed, the highest of which is about 40 feet above the adjacent land.

1791. It has long been recognized that if the rainfall of this district and the water which naturally flows to it from the higher land on the Victorian border to the east, could be prevented from flooding the lower regions between the ranges, it would be possible to put these lower areas to much more effective agricultural and pastoral use than is at present possible. The soils on the ranges are thin and poor and do not readily lend themselves to improvement. Some drainage works in isolated areas were actually carried out in 1863 in the vicinity of Millicent and a considerable area of good land has been reclaimed in this locality since that date. Various drainage schemes have been proposed from time to time and some have been put into effect with results which, though beneficial, have not been quite as good as was anticipated. It is fairly clear that a comprehensive scheme which would deal with the problem as a whole might be expected to give a level of improvement which is higher than that obtainable by partial schemes.

1792. Of the drains which have been constructed up to the present, some were installed as national works in order to encourage development. These cost about £230,000 and for these the land-holders pay a maintenance rate but do not bear any of the interest charges. After 1900, other drains were constructed under an Act which provided that on receipt of a petition from land-holders the Government would do the work on condition that the land-holders agreed to repay the cost of the drains over a period of 42 years. These drains cost about £37,000. Another scheme was launched in 1908; under this the land-holders were to be responsible for half the cost. This has not been quite so successful. It cost £433,000 instead of £300,000 as estimated, and it is anticipated that the land-holders still owe some £89,000 to the Government. The present scheme envisages the drainage of a further 400,000 acres at a pre-war estimated cost of £3 7s. 5d. per acre.

1793. The matter of drainage in this area was the subject of a Royal Commission set up by the Government of South Australia in 1923. Land-owners in the various districts are somewhat divided in their opinions on the matter. They are adverse to committing themselves to the whole or partial financial support of a scheme, of the ultimate success of which they are not always convinced. Many of them appreciate that the benefits would only appear gradually. They also know that in order to make use of the improved agricultural status of

the land consequent upon drainage they would be called upon to provide considerable capital sums for additional subdivision, cultivating machinery and pasture improvement generally. Such opposition is not at all surprising. On the other hand, provided these soils of the proposed drainage areas when examined by the most modern methods show no signs of serious inherent deficiencies and give good promise of being agriculturally and pastorally valuable, there is every reason why the area should be regarded as one of the most satisfactory in the Commonwealth for development. Its rainfall is relatively high and reliable and the growing season reasonably long. The proximity to the sea coast is a very definite amenity and the climate is not oppressive. Main roads pass through it and railways have been constructed. The developmental scheme has much to commend it if the soils are of such a nature as to suggest that with drainage they could make progress comparable with that achieved by pasture improvement in the region of Naracoorte.

1794. It was suggested to the Commission that the State should acquire the land and subdivide into holdings, put through the drainage and then re-allot. This seems the only sound method to adopt in view of the somewhat uncertain future of the values of agricultural land and the time which might be required to develop the area on the new basis. The Commission has already expressed the opinion that the nation will find it necessary to provide most of the cost of head works necessary for the development of irrigation areas. There seems no reason whatever why the same principle should not apply to drainage works of a major character.

CHAPTER VI.—CERTAIN SPECIAL IRRIGATION AND WATER SUPPLY PROBLEMS.

Dr. Bradfield's Schemes for Watering Inland Australia.*

1795. The late Dr. J. J. C. Bradfield, whose successful career as an engineer is well known, was an enthusiastic exponent of the possibility of developing inland Australia by overcoming the arid conditions which prevent intensive agriculture. At various times the Commission's attention has been directed towards the potentialities of these schemes, and in view of their somewhat glamorous appeal to the public mind, and the importance of making every effort to develop economically the large areas of Australia which are at present relatively unproductive, it seems desirable to report on them briefly.

1796. Climatic and Topographic Factors.—A great portion of inland Australia possesses a climate which, throughout most of the year, is unfavorable for the production of luxuriant vegetation without the artificial application of water. This climatic problem has been outlined in Chapter II. of the Commission's Third Report. Australia's lack of high mountain ranges in most parts of the continent and her position on the earth's surface result in a markedly uniform dry climate over large parts of the continent. Such mountains as exist are largely confined to the eastern coastal belt and intercept much of the water in the rain-bearing ocean winds. This is precipitated more or less heavily on the seaward slopes, giving rise to many short perennial rivers and leaving relatively little for feeding the two great inland drainage basins of the Murray and Lake Eyre. (See Figure 8.)

1797. The drainage lines of these two basins originate on the western side of the eastern highlands but none of the northern streams, i.e. those rising in Queensland, are perennial throughout their courses, and even the Darling ceases to flow on occasions. Consequently the water courses known as the Cooper, Thompson, Diamantina, Georgina, Finke and many others are normally dry over most of their length; they frequently have ill-defined channels and only a few reach Lake Eyre during occasional floods.† The tributaries of the Finke River are unusual in that in earlier geological times of higher rainfall they cut narrow passages for themselves through the east-west Macdonnell and Musgrave Ranges, the elevations of which reach 3,000 feet.

1798. At present grazing is the only agricultural use to which the Lake Eyre Basin can be put. Most of it is cattle country but considerable areas are devoted to sheep. In many places stock water is derived from underground sources. The pasturage consists in part of perennial plants—edible shrubs or hardy grasses which become dormant during the dry period—or annuals which burst into activity after each heavy rain and give a luxuriant herbage for a month or two before seeding and then dry off. During much of the average year the climate is warm to hot and the air very dry and it is doubtful whether the world contains any species of nutritious plant which could, without irrigation, maintain growth and give better grazing in this dry period than the perennial native species.

* *Rydges*, October, 1941; *Walkabout*, July, 1941; *The Australian Quarterly*, Vol. XIV., No. 1, March, 1942.

† Cooper's Creek rarely passes Innamincka and has seldom if ever reached Lake Eyre since 1917. According to Madigan, the Finke River never reaches Lake Eyre.

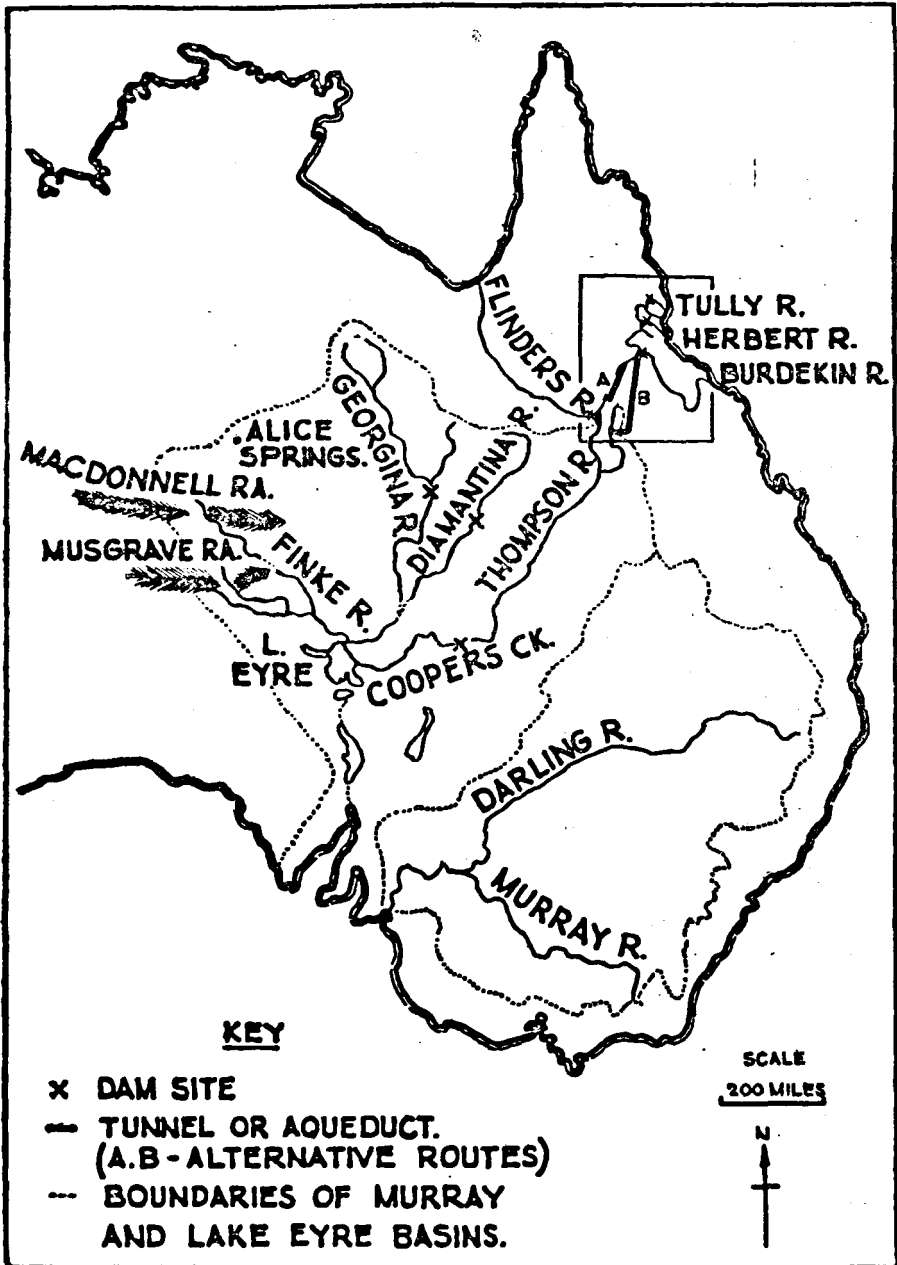


Figure 8.—Central and eastern portions of Australia showing the boundaries of the Murray and Lake Eyre drainage basins and the streams involved in Dr. Bradfield's proposals. For details regarding the diversion of water from certain Queensland streams across the Great Dividing Range refer to Figure 9.

1799. *The Schemes in Outline*.—Dr. Bradfield hoped to overcome the natural climatic disability of the Lake Eyre basin in two ways—

- (a) by irrigation projects, based partly on recovery of portion of the water intercepted by the eastern highlands, and partly on the storage of rain falling in the central area;
- (b) by the lowered temperatures and increased local rainfall which he anticipated would be caused by evaporation from the large water surfaces of the proposed inland storages and channels.

These schemes are listed in what is felt to be a descending order of practicability, and even if the premise mentioned in (b) above is incorrect, and the water resources of the inland area are less than was anticipated, this should not prejudice the consideration given to the proposal to divert the coastal rivers across the Divide.

1800. Schemes for irrigation development included—

- (a) Damming the head-waters of the Tully, the Herbert and the Burdekin Rivers at present flowing easterly into the sea, and diverting all the waters through the North Queensland Divide by aqueducts and tunnels either into the Flinders River (also dammed), or through a gorge farther south, and thence in both cases to the channel of the Thompson River to flow across central and south-western Queensland towards Lake Eyre. A dam has also been suggested at Kullymurra Gorge on Cooper's Creek as part of the inland scheme.
- (b) Damming the Diamantina River, the channel of which also leads south-west across Western Queensland into South Australia.
- (c) Damming the head-waters of the Georgina River, which drains the Western Queensland tablelands, by a channel leading ultimately to Lake Eyre.
- (d) A series of dams on the Finke River and its tributaries at gaps in the Macdonnell-Musgrave Ranges to store flood waters normally dissipated on the way to Lake Eyre.
- (e) A series of subsidiary dams and earthworks along the courses of the foregoing inland rivers, and the excavation and rehabilitation of their beds.

Using the water drawn from the Tully, Herbert, Burdekin and Flinders Rivers. Dr. Bradfield planned to irrigate annually 3,200 square miles of land in Western Queensland with 2 acre feet, and with water drawn from the Finke River scheme to irrigate 500 square miles south of Alice Springs with 4 acre feet. (The former area is about twice as big as the present irrigated area on the Murray and its tributaries).

1801. *Practicability from the Engineering Point of View*.—Dr. Bradfield did not claim to have made any detailed investigation of the engineering aspects of these proposals, and the feasibility of the plan has not yet been fully checked by survey. The Commission has, however, been favoured by the assistance of Mr. H. P. Moss, A.M.I.E. Aust., who has taken great interest in Dr. Bradfield's schemes

and who was good enough to provide us with a map (on the basis of which Figure 9 was prepared), and the following statement:—

“The accompanying map has been prepared to show Bradfield’s diversion scheme; this has been compiled from the latest available information and although such information is far from being complete there is sufficient to show that further investigation into certain points is justifiable.

The first point which can be demonstrated is that Bradfield’s proposal to divert the head waters of the Flinders River which flows into the Gulf of Carpentaria and turn it into a stream flowing south into Cooper’s Creek or some other stream, is feasible.

The Flinders River rises at about 2,600 feet above sea level near lat. 20 deg. S. and flows due south for about fifty miles when it turns south-west for twenty miles and then flows due west for a few miles near Hughenden, ultimately flowing due north into the Gulf of Carpentaria. A few miles before reaching Hughenden the stream is 1,250 feet above sea level.

Ten miles south of this, the Charters Towers-Hughenden Railway line runs for several miles at an elevation between 1,100 feet and 1,200 feet above sea level. To the south of the railway the country rises slightly forming a low watershed between the basins of the Flinders River and the Tower Hill Creek—a tributary of the Thompson River which flows in a south-westerly direction into Cooper’s Creek.

Within a few miles of the railway the country falls to an elevation of 1,100 feet so that the diversion of the Flinders into the Tower Hill Creek would not appear to present any insuperable engineering difficulties.

This diversion does not involve the transfer of water from the eastern to the western side of the Great Dividing Range. The area above the point where diversion would take place is about 1,000 square miles with an average rainfall of only 20 inches to 24 inches per annum so that it is doubtful if any useful volume of water could be transferred to the southward even if this could be spared, although water might be stored in the deep gorge about 30 miles north of Prairie Railway Station and used locally for irrigation. Dr. Bradfield’s main proposal, however, visualized impounding streams which are fed by the copious rains occurring north of lat. 19 deg. on the eastern side of the Main Dividing Range, and diverting their waters to the western side, either into the Flinders River or Torrens Creek.

The scheme as outlined by Dr. Bradfield proposes a diversion of the Tully River above the Tully Falls at an elevation of about 2,100 feet. (There is a drop of about 900 feet in the first mile or so from the top of the falls). By building a dam above the falls sufficient difference in level can be obtained to divert water into Blunder Creek, a tributary of the Herbert River.

Latest information available indicates that there is a fairly high ridge between the two streams so that probably some tunnelling as well as deep cutting may be necessary to enable water to flow into Blunder Creek.

A close survey is necessary to determine the actual amount of work which would be required.

From Blunder Creek the diverted water would flow into the Herbert River and with the head waters of the Herbert would flow down to the top of the falls on the Herbert where the elevation is about 1,850 feet above sea level. At a ford across the Herbert just above the falls the level is 1,870 feet on the bank and a point slightly above this on the bed of the river is 1,840 feet above sea level.

Due south of this portion of the Herbert River is Wairuna on the Burdekin River at an elevation of 1,770 feet. It will be clear that the Herbert could be diverted into the Burdekin at this point but here again a close survey must be made to determine the extent to which tunnelling or channelling, or both, would be necessary. The shortest distance between the two streams is of the order of eleven or twelve miles and it is known that fairly high ground occurs between them but there appear to be no insuperable engineering difficulties to making this diversion.

From Wairuna or a little down-stream from that point the combined Tully, Herbert and Burdekin waters would flow down the bed of the Burdekin to its junction with Clarke River some 80 miles from Charters Towers.

Below the junction with the Clarke the Burdekin passes through a gorge about 400 feet deep and half a mile wide known as Hell’s Gate, and it is proposed to dam the river above that point by a 500 foot dam, banking the water into both Burdekin and Clarke Rivers.

There is at present no reliable information available regarding the elevation of the river at Hell’s Gate and it will therefore be necessary to have this accurately determined as well as making certain surveys of the areas which would be submerged in the Burdekin and Clarke Rivers to determine the storage capacity of the reservoir formed.

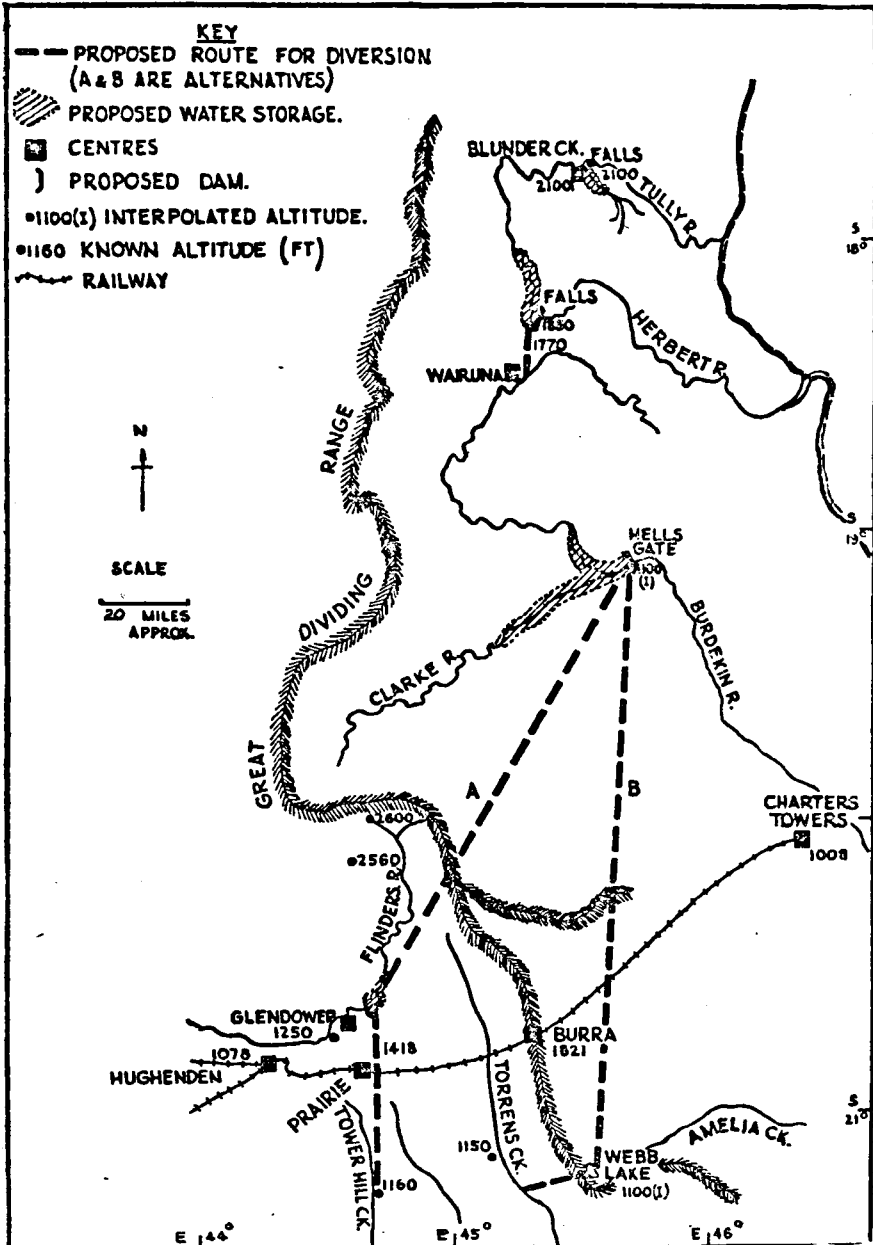


Figure 9.—Illustrates the available information regarding the proposal to divert portion of the waters of certain Queensland rivers from the eastern to the western side of the Great Dividing Range. (Based upon map kindly provided by Mr. H. P. Moss, A.M.I.E. Aust.)

It is reasonable to assume however, that the river above Hell's Gate is about 1,150 to 1,200 feet above sea level and if this be so the nearest points on the other side of the Great Dividing Range at which this or a lower elevation may be found is on the Torrens

Creek some twenty or thirty miles south of the Charters Towers to Hughenden railway line and near Glendower on the Flinders River some ten miles north of the railway line.

The distance in a direct line from Hell's Gate to the first point is not much less than 150 miles and this would render necessary the building of a dam of considerable height near Hell's Gate to ensure that sufficient fall could be obtained to cause a satisfactory flow of water between the two points mentioned.

To transfer water to any point north of the Charters Towers—Hughenden railway would involve the construction of a dam, sufficiently high to ensure that water would rise to a point about 1,500 feet or 1,600 feet above sea level, and the construction of pipe lines or tunnels and channels some ninety miles long through the ranges.

It must be pointed out that as the dam at Hell's Gate would be required principally for diversion of waters to the western side of the Dividing Range, it would be limited in useful storage capacity to the volume above the diversion channels, water below that level being of little, if any, use.

Dr. Bradfield reckoned that impounded water could be conveyed from Hell's Gate reservoir to Webb Lake at the head of Amelia Creek by means of two 26 foot diameter pipe lines; and by utilizing a gorge at an elevation of about 1,200 feet through the Dividing Range he thought it would be possible to avoid tunnelling through the main range to transfer the water to the other side.

The success of this proposal depends upon the difference in level between Hell's Gate and Webb Lake being great enough to ensure that water can flow from the one to the other. If this is possible then this particular part of Bradfield's plan is feasible. This, however, can only be ascertained definitely by complete surveys.

It might be mentioned that the railway from Charters Towers to Hughenden, which crosses the proposed routes, rises from an elevation of around 1,000 feet at Charters Towers to over 1,800 feet above sea level at Burra, where the line crosses the Dividing Range, so that it is possible that Bradfield's two pipes may be replaced in part at least by open channel. While this may be cheaper, it involves greater loss in head between the two terminal points.

It may also be found that it would be better to have two separate dams on the Burdekin and Clarke Rivers respectively at a much higher level than Hell's Gate in order to avoid an excessively high dam below the junction of the two streams.

It appears to be fairly clear that water can be made to flow from some point above Hell's Gate on one side of the Dividing Range into the Flinders River or Torrens Creek on the opposite side of the Range by spending very large sums of money in constructing suitable channels, pipe lines and tunnels.

The Tully Falls are a very important potential source of hydro-electric power and should water be diverted from the top of the falls Queensland would lose one of its principal water power resources.

It can only be a matter of a few years before the exploitation of this power resource would be justifiable in conjunction with the Barron Falls and other power resources and the same may be said of the Herbert Falls although they may not be so important as those on the Tully.

The disastrous floods which occur on the Burdekin from time to time point to the desirability of exercising some control over the flood waters, and for that reason the damming of the Clarke, the Burdekin and the Belyando Rivers could possibly be justified for flood control purposes alone, and the stored water employed for irrigation in the coastal areas.

Assuming that it is possible to divert streams as proposed by Dr. Bradfield, it still has to be demonstrated that anything like the volume of water required is available for diversion.

The Tully River has a catchment of about 125 square miles above the falls with an average rainfall of perhaps 80 inches.

The Herbert River has a catchment of about 2,000 square miles above the falls with an average rainfall of about 40 inches.

The Burdekin and Clarke Rivers above their junction have a catchment of about 5,500 square miles and the average rainfall may be of the order of 27 inches per annum over this area.

Taking the above figures as a basis the total number of acre feet of water precipitated on the three areas concerned would on the average be approximately as follows:—

	Acre feet.
Tully River	570,000
Herbert River	4,200,000
Burdekin and Clarke Rivers	7,900,000

It must be remembered, however, that every year is not an average year neither does all the water which falls as rain find its way into the streams.

An examination of rainfall records indicates that at more or less frequent intervals the rainfall for two or three years in succession may be only about half of the average while even in the wetter parts of the areas under consideration there have been periods when the rainfall has been as low as two-thirds of the average for two years in succession.

We must therefore reduce the above figures to arrive at the precipitation in bad years. Even in average years the whole of the rainfall will not find its way into the streams and in those years having much lower rainfall, it is doubtful if 25 per cent. of the total fall will be available as stream flow in the Herbert and Burdekin Rivers.

Applying both these corrections to the average precipitation, we would arrive at the following stream flow in low years:—

	Acre feet.
Tully River (possibly)	400,000
Herbert River	500,000
Burdekin River	1,000,000

This amount is equivalent to 2,600 cubic feet per second throughout the year, which is considerably below the amount estimated by Dr. Bradfield of 6,000 cubic feet per second.

Allowing for losses in transit, evaporation from reservoir surfaces, &c., the amount available for distribution in lean years would probably amount to sufficient to provide 12 inches of water over one and a half million acres, or say, 2,300 square miles, but the area which could be satisfactorily irrigated would be much less than this.

Turning now to that part of Bradfield's proposal which envisaged the construction of a number of large barrages for conserving flood waters in the interior streams without any reference to the diversion of any water from the coastal side of the Dividing Range.

Bradfield proposes dams across Cooper's Creek near Innamincka in South Australia; across the Diamantina River at Hunters Gorge south-west of Winton in Queensland and across the Georgina River near Marion Downs.

Records covering 25 years of floods in rivers flowing southward through central and western Queensland have been examined and it has been found that floods have been recorded as follows:—

Name of stream.	No. of floods
Thomson (or Thompson)	20
Barcoo River	37
Cooper's Creek	23
Bulloo Creek	45
Paroo	28
Warrego	54
Maranoa	13
Condamine	6
Langlo	8
Ward	10
Flinders	12

The only recorded floods in the same period for the Georgina and Diamantina were three and four respectively and this would appear to be in keeping with the fact that the average annual rainfall in the upper part of their catchments is only 15 inches. Only on rare occasions has the monthly rainfall approached an amount which could cause flooding.

Of these streams the Thomson combines with the Barcoo and continues as Cooper's Creek to Lake Eyre; Bulloo Creek ends up in the Bulloo Lake a few miles from the Queensland-New South Wales border. The Paroo joins the Darling to the north-east of Broken Hill.

The Warrego joins the Darling below Bourke in New South Wales but may at times send its waters via the Cuttaburra into the Paroo.

The Maranoa flows into the Balonne of which the Condamine is the head. The resulting stream is known lower down as the Culgoa River which joins the Darling or the Barwoon near Bourke.

The Langlo and Ward are tributaries of the Warrego.

The extent to which the streams may wander across country or to which water might be transferred from one part to another in the area where Queensland, New South Wales and the Northern Territory adjoin is well shown by the elevation of places very far apart such as Wilcannia 267, Bourke 361, Walgett 436, Thallon 570 along the course of the Darling; Quilpie 647, Yarka 708, Longreach 620, Winton 618, Windorah 390, Boulia 478, Urandangi 550, Camooweal 738, all of which are situated on streams or watercourses draining towards the interior.

From the very haphazard nature of such floods it is very doubtful if the construction of barrages on such a large scale as that proposed by Dr. Bradfield and others could be justified on any watercourse west of Winton in the Lake Eyre basin."

1802. It is noteworthy that some irrigation engineers are not convinced that Dr. Bradfield's estimates of the quantity of water which would be available under his scheme are well founded. Thus, Mr. J. D. Lang, B.C.E., A.M.I.E., Australia, in a recent paper to the Victorian Branch of the Institution of Engineers, Australia, estimated that the total available flow of the main Queensland rivers, excluding the Brisbane river and those of the Murray Basin, would not exceed 18.5 million acre feet and, judging by experience with irrigation supplies obtained from Victorian streams, it would be unwise to expect that more than 4 million acre feet could be applied to the land. This would be sufficient to provide 2 acre feet on about 3,200 square miles but it involves using many more rivers than were involved in Dr. Bradfield's scheme.

1803. *Agricultural and Economic Aspects.*—Apart from examination of these constructional and run-off aspects, extensive soil investigations would be essential in order to determine which areas are most suitable for the use of the impounded water. In addition, the best species and varieties of crop and pasture plants would have to be determined for irrigation farming in this particular climatic zone; while methods of management which would maintain soil fertility would require study. In this connexion the developments on the Ord River in the Kimberleys referred to in paragraph 1821 below, would almost certainly give valuable information which could be used as a guide in parts of the Lake Eyre basin.

1804. Dr. Bradfield estimated that the diversion scheme from the coastal rivers would probably cost £40,000,000, and the four main inland schemes another £40,000,000. Such expenditures are too large to warrant entering on such a scheme without every prospect of success. Further investigations of the types indicated in the preceding paragraph should therefore be made, and no effort should be spared to collect data on rainfall and other climatic factors, on river gaugings and catchment efficiency, so that in due course the matter can be viewed more clearly.

1805. The impounded water could either be used for forms of production which would stabilize the adjacent stock industries and mitigate the effects of drought, or it could be used for growing types of crop which are at present neglected, e.g. cotton. At the present time when the capacity of the world to produce cotton and other agricultural products under peace-time conditions will probably be in excess of world demand there seems little point in encouraging new areas for such production. Possibly by the time the appropriate surveys have been made and the necessary data collected, the lines of future development will be clearer. In the meantime the Commission observes that irrigation of some type or other seems to offer almost the only chance of increasing the intensity and efficiency of farming in the Lake Eyre basin.

1806. *Climatic Effects.*—Dr. Bradfield's second proposal for improving the moisture conditions of inland Australia was of a still more theoretical nature. Basing his arguments mainly on the published papers of Mr. E. T. Quayle, formerly Senior Meteorologist in the Commonwealth Meteorological Service, he claimed that the evaporation which would occur from the resultant water-storage surfaces and new irrigated settlement would cause substantial and progressive improvement in the rainfall of wide areas of inland Australia, particularly to the lee of the water surfaces. He also claimed that due to local increased water

vapour content of the atmosphere, lower temperatures would prevail in these areas, with consequent improvement in habitability and productivity. He postulated that evaporation from inland water surfaces aggregating 20,000 square miles would provide an additional 4 inches of rainfall per year over 500,000 square miles. The decrease and ultimately the prevention of erosion and inland aridity was forecast as an additional advantage.

1807. This theory of climate alteration has received strong and adverse criticism from a number of scientifically minded people. Dr. Bradfield's papers, though quoting certain figures, are of a popular rather than a scientific nature, and do not give sufficient detailed data for the reader to be able to make his own interpretations. It is considered that the figures presented by Mr. Quayle do not represent a sufficient number of stations, nor do they cover a long enough period to give a true picture. Moreover, many of the differences noted lack statistical significance, and the theory of climatic improvement by evaporation from artificial storages cannot be accepted on the evidence submitted. An expert committee of Australian meteorologists, including Mr. Quayle, was appointed in 1944 to consider the matter and they presented (Mr. Quayle dissenting) a majority report as follows:—

- (a) No material increase in rainfall in the regions concerned is likely to accrue from implementation of Dr. Bradfield's schemes.
- (b) The climate of the regions affected is unlikely to be materially altered either immediately or ultimately.

1808. These conclusions are in accord with the bulk of oversea opinion and experience of similar projects. It is also worthy of note that there are numerous instances throughout the world where the proximity of a large body of water has no apparent effect upon the climate of adjacent arid areas—the Sahara and the deserts of Arabia and Africa border the Mediterranean and Red Seas but remain arid, as does the Nullabor Plain area in spite of its proximity to the Southern Ocean. It seems most improbable that the artificial introduction of such a water surface into Central Australia would have any significant effect upon the climate of that area.

The Ord River Project.

1809. *Basic Considerations.*—During the last decade considerable attention has been given to the possibilities of irrigation on the Ord River in the Eastern Kimberleys near the border of Western Australia and the Northern Territory. This particular region has special interest as it is probably a fair sample of very large areas of Northern Australia* in which the growing season is often too short for crops other than millets and one or two legumes. As it is unlikely that it will be practicable to establish successful agricultural settlement on the basis of such crops, the development of irrigation where practicable seems to be the logical procedure in any attempt to utilize the country for farming purposes.

1810. So far the only large irrigation areas overseas which are comparable in climate and latitude are in French Sudan and in British Sudan south-west of Khartum. These areas may be expected to give some useful information as to

* This matter was briefly referred to in paragraphs 292-293 of the Commission's Third Report.

methods of land use, but the type of labour available and the social conditions of these African areas are very different from those of Northern Australia. It therefore seems probable that Australia will have to invent a new system of agriculture involving new crops and pastures and new rotations for any irrigation project in her drier tropical regions. The cattle industry which, although in an extremely primitive stage of development, already exploits these northern regions, might be enabled to increase its productivity and efficiency to a marked degree through the appropriate use of a well-planned irrigation scheme. In many ways the Ord area is particularly suitable as an initial irrigation district for the north. It is fairly near to the port of Wyndham so that any necessary railway or mechanical transport route would not be long or difficult. A large and well-equipped meat works is already in existence at that port. Considerable detailed investigation of the country which could be irrigated has been made in the last few years. From all these points of view the Ord River has advantages for development as the first large-scale irrigation project in this type of climate in Australia.

1811. Most Australians realize that the emptiness and primitive stage of development which characterize the north of Australia are a reproach in the eyes of the world. It is known that much of this area has many disadvantages from both agricultural and sociological aspects, but these are in fact the normal problems of such regions and Australia has made few and relatively insignificant attempts to solve them. In view of the recommendations of the Hot Springs Conference that irrigation schemes should be developed wherever possible in order to facilitate agricultural production in regions where rainfall is deficient, Australia would be in a much better position to face the assembled nations in conference if she were able to state unequivocally that she was committed to a scheme of this kind as a genuine endeavour to utilize the empty North.

1812. On the other hand the defence aspect of future developments in Northern Australia is of significance in this matter. The very emptiness of this region constituted an obstacle to attack from outside during the recent war, and was possibly its main safeguard. Whether in this condition it would remain as effective a barrier to the operations of a hostile attacking force in twenty years' time is less certain. In 1942 our enemies were ill-equipped with machinery to make aerodromes and large engineering structures with rapidity in the absence of coolie labour, while their shipping was inadequate for its task. It does not follow that the same circumstances would apply on a future occasion. This, however, is a matter for military authorities and strategic prophets.

1813. Description of the Area.—The Ord River rises in the vicinity of Hall's Creek in Western Australia and flows northwards near the eastern border of the State, through grassland country, first gently undulating and later relatively flat but broken by sandstone ranges, until it enters Cambridge Gulf north of Wyndham. (See Figure 10.) In traversing the Carr Boyd Ranges, about 120 miles upstream from Cambridge Gulf, the river has cut a considerable gorge some fourteen miles long and 500 to 800 feet deep, which provides a number of suitable dam sites. Leaving these ranges in the vicinity of Carlton Reach, the river drains large areas of very flat grassland country before entering the

mangrove swamp area at its mouth north-east of Wyndham. These flat grasslands are bordered by rough sandstone hills and provide some potentially irrigable areas. The soils are mainly formed from river deposits and include some alluvial soils which appear promising although full details of the recent soil surveys are not yet available. The pasturage growing on these areas is of native species which are not particularly high in yield or in nutritive quality and most of which will not respond to irrigation.

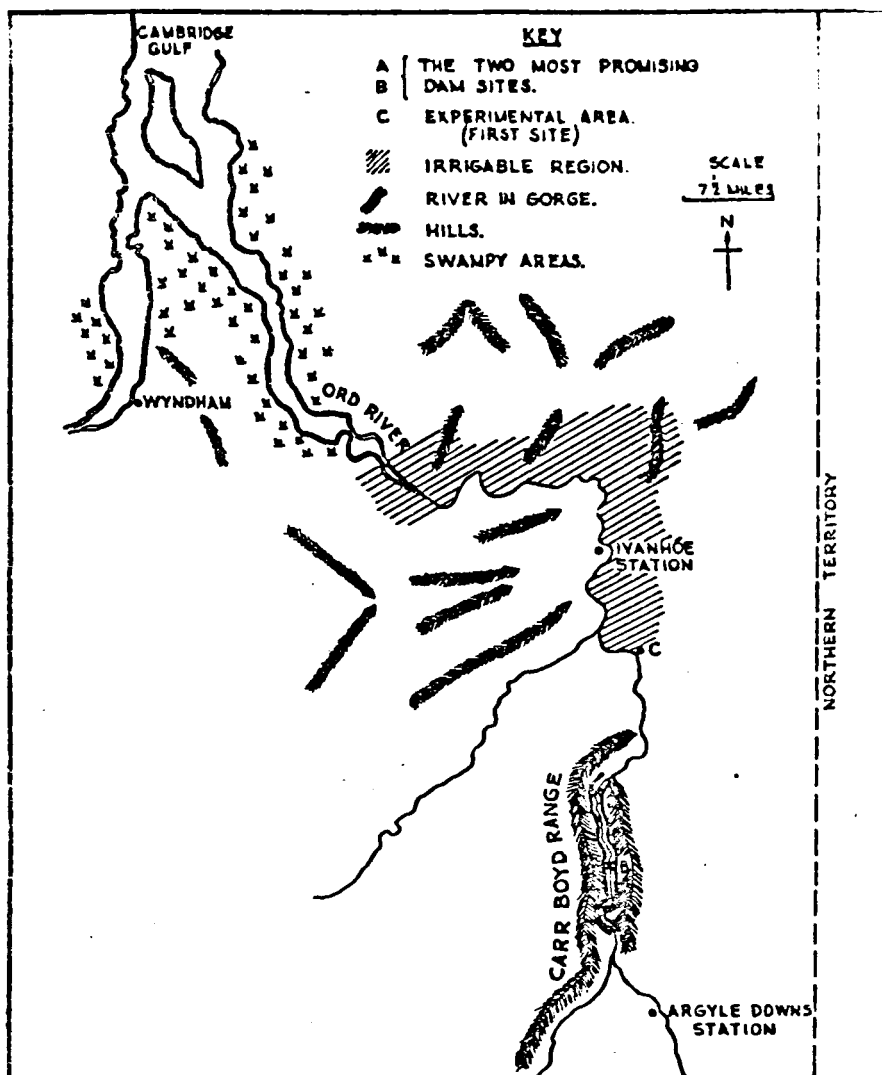


Figure 10.—Portion of the Eastern Kimberley district of Western Australia showing the main features of the valley of the Ord River, and indicating an area much of which is expected to prove irrigable.

1814. The climate is tropical with a monsoonal rainfall of irregular incidence and quantity, varying over the Ord River catchment from about 20 inches in the south to 30 inches in the north. There is a long dry season with high evaporation, so that dry-land agriculture for most of the valuable crops is impracticable. The hottest months, December to March, are normally the months of highest rainfall, and consequently most Europeans find manual labour extremely trying during the heat of the day in summer. Immediately before the war there were only about 120 white men employed in pastoral and agricultural production in the area. The communications are in proportion to the size of the population. Transport facilities consist of very rough tracks and primitive aerodromes, both often unuseable when wet. There are a few telephones and pedal radio transmitters associated with the Flying Doctor Service.

1815. The Government of Western Australia has before it a proposal to construct a dam to a height of approximately 130 feet above the present low-water river level and having a length along the crest of 750 feet, at an estimated cost of £1,500,000, excluding turbine house and turbines. This dam would conserve about 2,000,000 acre feet of water. The water would be diverted from the river by means of one or more diversion weirs approximately 40 miles downstream from the main dam. Hydro-electric power would be generated at the dam, and would provide power for the farms and also for purposes of all future industrial development. The precise location of the irrigation areas must depend on the results of various surveys now in progress, but already an area of 65,000 acres has been approved as suitable for irrigation after examination by soil experts. It is anticipated that a total of at least 100,000 acres will be located on the adjacent Ivanhoe and Carlton Stations.

1816. Utilization of the Water.—The uses to which the water could be put require careful consideration. Many types of vegetable crops and tropical fruits could be grown but the markets open to them would be mostly local and therefore very limited, unless the mining industry developed anew or some secondary industry found an economic location in this part of Australia. Rice and certain other grain crops could be produced if there were reason for expanding their production. Although the former crop has been grown successfully on a commercial scale on the Murrumbidgee for about eighteen years, experience has shown that its great water requirement puts an undue strain on the available supply, while the application of six or more feet of irrigation water to the soils in a district with a normal rainfall of sixteen inches has caused drainage troubles of a serious character. A gradual transference of part of Australia's rice production to another area might therefore be a wise development although naturally opposition from present growers might be strong. Cotton is a possibility but insect pests would require elaborate precautions and the world position of the cotton industry scarcely engenders confidence. The use of the area in conjunction with the cattle industry seems to offer most promise.

1817. The production of beef cattle is the most important industry in that part of Australia which lies to the north of the 18th Parallel and away from the Queensland littoral. It is easy to criticize this industry at the present time. The great majority of the runs are poorly fenced and often quite without

subdivision, watering facilities are inadequate, the quality of the stock is often low, while the losses through diseases, pests and malnutrition are high. The practicability of moving the cattle over the long distances to ports or fattening areas is reduced by poor stock routes and inadequate watering facilities. Many schemes for improving the industry by providing more facilities on the stock routes have been put forward and it is understood that much has been done during the period of military occupation, but in the opinion of the Commission these measures are relatively unimportant when compared with the need for improving the nutritive value of the grazing material available.

1818. During the wet season pasturage is abundant, the cattle put on condition and by March the selected mobs are moving towards the coast. As the rains cease the grasses dry off rapidly, the fodder becomes low in protein and by July it has a nutritive value little better than straw except in isolated places where there happen to be soaks or drying lagoons. The next three or four months are a period of semi-starvation unless some more or less exceptional rain falls and brings up a growth of annual plants. In the normal case the animals steadily lose condition and become debilitated and very susceptible to disease; moreover many of the cows are in calf so that the young are liable to be poor in type and losses are heavy. The industry is therefore in a primitive state of development and much criticism has been levelled at the station owners from time to time. They have been blamed for failing to spend money on equipping their runs, for having stock of poor quality and for "eating out" the country. While it is quite true that some of the individuals and organizations concerned seem to have given little thought to the development of a better state of management, yet it is clear that in many cases the investment of the large capital sums which would be necessary would be a risky venture.

1819. During the last few years visitors from America, familiar with the history of developments in the cattle section of the Great Plains region, have suggested that northern Australia could, with more enterprise, be similarly developed by dry farming methods, with the use of lucerne or other improved plants. In the opinion of the Commission such hopes are quite unjustifiable except possibly in limited regions with a rainfall which has a wider distribution through the year. The climates of the two regions are not the same—Northern Australia has a hot "dry" season, the Great Plains have a cool one in which the "water strain" on the plants is not high.

1820. Under irrigation, however, it would be possible to grow high protein plants for use either as supplementary grazing or as fodder reserves. If used effectively, this good quality food material could be the basis of improvement of the local sections of the cattle industry in many ways. It could "top off" some of the cattle on their way to the Wyndham meat works, thus making it possible for these to turn out a higher proportion of good quality beef. It would increase the length of the period in each year in which the works operate. It could improve the condition of a proportion of the cows prior to calving, and give a more secure basis for better animal husbandry than has existed in the past. In addition it would afford a centre of intensive agricultural development where various new methods and crops could be tested with a view to wider application in Northern Australia generally.

1821. Problems.—It is useless to neglect the fact that the effective use of irrigation water in a climate of this type is not easy. Emphatically it is not merely a question of providing extra water for use on the ordinary pastures in order to make up for the deficient rainfall in the winter and spring. Complete disaster will result if that idea is allowed to prevail. Much careful research will be necessary to find out what plants should be used, how they should be used, and the general system of farming which would succeed under these conditions. The project is in some respects a novel one in a climate of this type, but that should not mean that it is beyond the capacity of Australian technicians to solve the various problems. Their solutions will be largely applicable to all other big irrigation schemes in zones of comparable rainfall in Northern Australia.

1822. Research Centre.—The desirability of establishing a research centre before commencing the main development has been recognized and a small station at Carlton Reach has operated since early in 1942 on an irrigated area of 12 acres for the study of pasture and crop types and management. This station has proved to be unsatisfactory in that it is rather small, and is restricted to one soil type which is not characteristic of the main area to be irrigated. Work there has, however, shown that a fairly wide range of crops and pasture plants can be grown satisfactorily under irrigation on that particular soil type. Arrangements have now been made to move the station to a more representative area.

1823. The research so far undertaken is limited in extent. It has been carried out by officers of the Government of Western Australia but the Commonwealth Council for Scientific and Industrial Research has been associated with it by providing certain officers as assistants. If the irrigation scheme is accepted its whole success or failure will be bound up with the vigour and efficiency of this research station. The past history of experimental stations in the Northern Territory is gloomy. Numerous small units have been established from time to time but all have failed, largely because they were never staffed effectively and no individual Minister or Government Department was interested in them. The present project will also fail unless it is resolutely directed, adequately staffed with competent men and backed by official support of the governments concerned.

1824. A satisfactory research unit would have the following features:—

- (a) A staff of effective specialists in agronomy and farm management, animal nutrition and veterinary science, agrostology and entomology; while soil technologists versed in irrigation matters must certainly be present during the early years and available for consultation when necessary.
- (b) A fairly large acreage which, if possible, should include the main soil types in the irrigated area.
- (c) The capacity and equipment to investigate modern harvesting and other machinery designed to reduce the effort of labour to a minimum.
- (d) In view of its distance from other scientific institutions and laboratories, adequate laboratory accommodation and equipment.
- (e) Location on a reasonably good all-weather road connecting it with some main transport route.
- (f) The accommodation available for the workers must be reasonable and part of the project should be connected with the design of housing and house equipment suitable for life under these conditions.

A full-scale research scheme of this kind should, in addition to capital expenditure have at its disposal, a sum of the order of £25,000 a year. This sum and the technical staff involved are a big demand to make on any one State and its Agricultural Department. They could, however, be provided by the joint efforts of the State and the Council for Scientific and Industrial Research acting in co-operation.

1825. It is clear that if the area is to be developed for the purpose of raising the efficiency of the cattle industry it will not be satisfactory to design the settlement area on the same basis as that which is effective in irrigation districts of the South. Difficulties in determining stock prices and in ensuring that the irrigated land was used effectively, would necessitate some control over the methods on the farms. Difficulties of this order should not prove insuperable and could be faced before the scheme was finally put into operation. Agronomic experience accumulated on the research station during that period in which the dam was being constructed would be the guide as to the type of farming which would maintain the soils; this, in its turn, should be the main factor governing the system of land use and therefore the basis of settlement.

1826. *Initiation of the Scheme.*—Provided that—

- (a) Defence Authorities do not oppose the development of Northern Australia;
- (b) Satisfactory results are obtained in tests now being made by engineers as to the suitability of the dam site;
- (c) Investigations show that the proposed dam would not be subject to rapid siltation; and
- (d) The recent soil and topographic surveys show that a considerable area of suitable soil can be commanded by irrigation water without great difficulty,

the Commission is of the opinion that the scheme should be proceeded with and that the Commonwealth should offer to discuss with the Government of Western Australia, bases on which the whole scheme can be developed and on which the research station can be staffed and financed.

1827. The Commission suggests that it would be wise to send one or two Australian agronomists to those irrigation areas in North Africa which have a comparable climate, to obtain information about methods and conditions, in the expectation that such studies would be useful in any irrigation scheme in the Kimberleys or in other portions of Northern Australia.

1828. *Urgency of the Plan.*—While many will take the view that time is immaterial and a district which has been left in a primitive state for such a long time might as well be left in that condition for a further period, this may not be desirable. It will probably take four years to construct the dam: no settlement of any size could, therefore, occur before 1950. Some years of experience of irrigation on a large scale in the area would be desirable before any other similar project were launched in Northern Australia. Those responsible for national planning must decide whether the development of Northern Australia by this and similar projects is purely an internal business matter or whether the element of national defence enters into it. If rapid development is desirable the research

after the provisos mentioned in paragraph 1826 above have been satisfied, while the rest of the project should also be started promptly, even though full data has not been collected on all points. This method should permit construction and further research to proceed hand in hand while eliminating any likelihood of the subsequent emergence of awkward soil problems. Unexpected difficulties of one type or another will undoubtedly arise but are not likely to be insuperable if technical personnel of adequate calibre are available and are supported by those in charge of the scheme.

Projects for Utilizing the Waters of the Snowy River.

1829. Several proposals* for utilizing the Snowy River were submitted to the Commission and a brief outline of these proposals will be given before their individual merits or demerits are discussed.

1830. Physical Characteristics of the Snowy River.—The Snowy River rises in New South Wales on the slopes of Mount Kosciusko and flows approximately east then south, then west, before finally turning south across the Victorian border to the sea (see Figure 11). Together with its tributaries it drains the rugged mountainous country from Kiandra to the sea. Except in the vicinity of Orbost the catchment area is sparsely settled (the average population above Jindabyne is only about 2,000 persons) and has undergone little development; it consists mainly of rough summer cattle-grazing country with large areas of fairly heavy forest, many species of which have not so far proved attractive as timber. The Snowy River possesses no large irrigable flood plain nor is there any extensive area of level land in the vicinity. Except for a limited area of extremely fertile river flats near Orbost and one or two patches elsewhere, most of its soils are not particularly fertile. The average annual precipitation on the catchment varies from about 90 inches at Mount Kosciusko to less than 20 inches around Dalgety. Moreover as part of this falls as snow, which in some places may persist over eight months of the year, the rate of run-off is steadier over a longer period than for many other Australian streams. The average annual run-off for the period 1936-41 measured at Basin Creek near Orbost is recorded as 1,403 cubic feet per second, and 974 cubic feet per second at Jindabyne in New South Wales. The average at Jindabyne from 1903 to 1937 is recorded as 1,327 cubic feet per second.

1831. Utilization of the Waters of the Snowy River.—From the preceding data emerge four facts of major significance in any consideration of the utilization of this water. First, the river flow is substantial and largely snow-fed: consequently its seasonal fluctuations are relatively small. Secondly, the river rises in New South Wales and discharges through Victoria with the result that there is not the same community of interest in river use that occurs where the two States adjoin on opposite sides of the Murray. Thirdly, the immediate vicinity of the river is unattractive for irrigation or other types of settlement except for local areas. Fourthly, both the Murray and the Murrumbidgee rise in the vicinity of the headwaters of the Snowy River. The plans based upon these facts are outlined hereunder and in Figure 11.

* Much of this evidence was submitted in the form of a report by the Snowy River Investigation Committee, which was appointed by the New South Wales Government "to investigate and report upon proposals for the utilization of the waters of the Snowy River." The report was submitted in 1944.

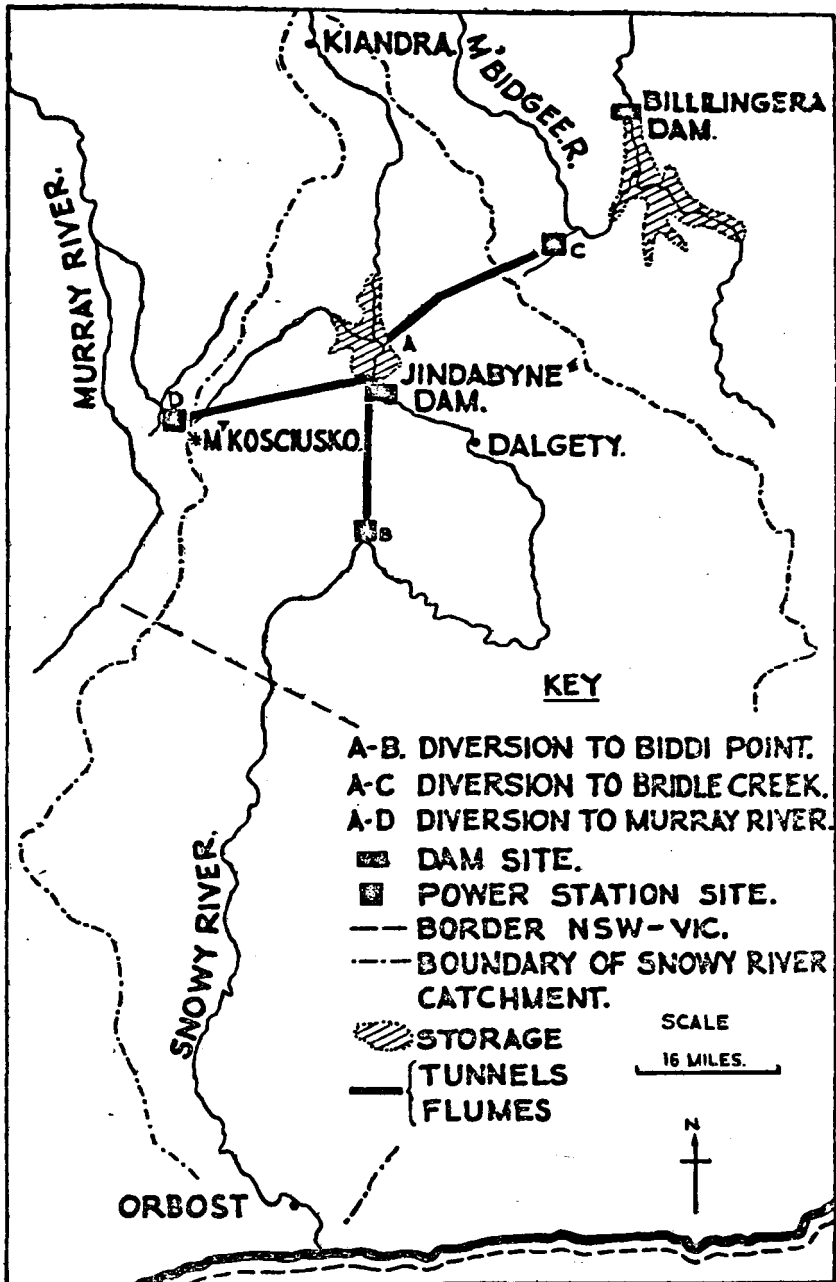


Figure 11.—The Snowy River Catchment Area. This indicates the relationships of the principal developmental schemes. Although few topographic features are shown, it should be realized that the whole area is extremely mountainous and rugged.

1832. New South Wales Hydro-electric Generating Scheme.—This scheme was first prepared by a British firm of consulting engineers in 1937 at the request of the New South Wales Government. It provided for a storage at Jindabyne of 250,000 acre feet capacity, from which the water was to discharge through 18 miles of tunnel and pipe-line across the bend in the river to two power stations at Bididi Point. The total power generated was to reach 250,000 kilowatts, most of which was to be led by transmission lines to Sydney to relieve the heavy load on the city steam-power generating stations, and to lessen dependence on coal supplies for this vital service. The latest estimate of the total capital cost of the completed scheme is £16,700,000, and allowing for consequent annual and working charges, the cost of the power supplied has been estimated at 0.193 pence per kilowatt hour. The desirability of this project was referred to the New South Wales Electricity Advisory Committee, which considered it technically sound, but stated that additional steam generating plant to provide a similar increase in metropolitan power supply would only require about half the capital outlay and the cost of current would probably not differ materially. It is important to note that implementation of this scheme would not lessen the flow of the Snowy River to Victoria, but would merely tend to equalize it throughout the year.

1833. Diversion for Use in the Murrumbidgee Irrigation Area.—The New South Wales Water Conservation and Irrigation Commission has proposed that the waters of the Snowy River be used to extend irrigation along the Murrumbidgee River. The full scheme involves a storage reservoir at Jindabyne of 647,098 acre feet capacity, to allow the diversion of an annual average volume of 1,200 cubic feet per second from the Snowy River through diversion works—which include a tunnel 22 feet in diameter and 22½ miles long—to a storage of 1,143,000 acre feet at Billilingera on the Murrumbidgee River. The water would then pass down the Murrumbidgee to the Burrinjuck storage. Associated with this construction is a scheme for hydro-electric generation of approximately 50,000 kilowatts. The total cost of the scheme is estimated by the Snowy River Investigation Committee at about £13,000,000. This figure includes the cost of road and rail diversions and township re-establishment, &c., consequent on extensive inundations caused by the dams. It is estimated that this augmenting and stabilizing flow would reinforce the Murrumbidgee at Gundagai so that from September to April an average regulated monthly flow of 4,000 cubic feet per second could be reached. To the 810,000 acre feet total volume at present passing Gundagai in this period, the Snowy River waters might be expected to contribute an additional volume of 1,110,000 acre feet. A very considerable expansion in irrigated acreage would thus be possible, as well as an improvement in the regularity of flow during the irrigating season.

1834. Combined Diversion to Sydney and the Murrumbidgee River.—This proposal involves much the same system of storages and hydro-electric installations as does the scheme just outlined; but of the resultant flow a proportion (maximum 210,000,000 gallons per day) would be diverted to the Sydney metropolitan water supply, leaving a minimum of 810 cubic feet per second as additional irrigation water for the Murrumbidgee area. The total cost of the scheme, including works for the delivery to Sydney of this quantity of water, is estimated by the Snowy River Investigation Committee at £47,050,000. On the other hand the Metropolitan

Water, Sewerage and Drainage Board has submitted a proposal for the provision of the necessary increase in Sydney water storage by a dam on the Warragamba River. It is estimated that this latter reservoir would be capable of providing a maximum average supply of 263,000,000 gallons per day for a capital cost of £12,416,732, and would provide for all expected increases in Sydney's consumption until at least 1982. A significant point is that in the case of both this and the scheme outlined in paragraph 1833, the water diverted would cease to be available for use by Victoria.

1835. *Diversion to the Murray River.*—In October, 1944, a proposal was submitted for the diversion of the waters of the Snowy River into the Murray River. Although this plan has received little publicity and so far as is known its practicability has not been fully investigated, yet it appears to merit consideration. It also is based upon a dam across the Snowy at Jindabyne. From there a tunnel about 20 miles long is proposed, running west under Mount Kosciusko to the vicinity of Geehi where there would be a hydro-electric generating plant and the water would pass into the Murray system, augmenting the existing irrigation supply of the Hume Weir. Utilizing the difference in level between Jindabyne and the Murray of about 2,000 feet, the projected average off-take from Jindabyne of 1,200 cubic feet per second is calculated to be capable of providing about 200,000 kilowatts of power for local use and transmission to Melbourne or Sydney, the former city being appreciably closer to the proposed power station site. In addition, the extra flow into the Hume Weir will extend the period for which the Hume hydro-electric station now under consideration could be operated at full output. As an alternative to passing water down the Murray for local distribution on either side, the plan envisages the possible use of some of the hydro-electric power generated to pump part of the water to such a level from the Hume Weir that it can flow along the Billabong Creek and over towards the Murrumbidgee for use in that area.

1836. Unfortunately, little or no information is yet available from detailed ground reconnaissance of this proposal which has been based entirely upon personal experience, maps, and aerial photographs. It is understood that the area concerned has already been accurately photographed from the air and that these photographs could readily provide reasonably accurate information regarding contours if the necessary trained staff were available.

1837. The plan provides for the maximum use of the water both for electricity generation and irrigation, while at the same time the ensuing benefits seem capable of being fairly equitably distributed between Victoria and New South Wales. Since no balanced verdict is possible without full knowledge of the factors involved it is desirable that this proposal be thoroughly investigated before a decision is made to adopt any scheme.

1838. *The Victorian Hydro-Electric Scheme.*—A proposal has been made for the installation on the Snowy River in Victoria of a hydro-electric plant for the generation of up to 65,000 kilowatts of power. The Victorian State Electricity Commission has estimated that the present potentialities of the Snowy River in Victoria will never justify plant with a capacity exceeding 130,000 kilowatts, in contrast with the 250,000 kilowatts expected by the consultants who drew up the hydro-electric scheme for New South Wales.

1839. Electricity Supply for the Australian Capital Territory.—In 1909 the following agreement was reached between the Commonwealth of Australia and the State of New South Wales and subsequently ratified by Acts of the Parliaments concerned—

“The State shall grant to the Commonwealth without payment therefor the right to use the waters of the Snowy River and such other rivers as may be agreed upon, or in default of agreement may be determined by arbitration, for the generation of electricity for the purposes of the Territory, and to construct the works necessary for that purpose, and to conduct the electricity so generated to the Territory.”.

However, subsequent construction of steam generating plants at Canberra and a transmission line from the Burrinjuck hydro-electric station appear to have provided adequately for present and future requirements of the Australian Capital Territory, and the Snowy River Investigation Committee recommends that the Snowy River Agreement be terminated to free the waters of the river for other development.

1840. Relative Merits of the Various Proposals.—Due to the inconvenient course pursued by the Snowy River an initial problem is that of interstate rights. The legal opinion hitherto obtained suggests that though the law in this matter is obscure, there is reason to suppose that if New South Wales acted without the consent of Victoria in utilizing the waters of the Snowy in a way which Victoria considered to be to her detriment, a “tort” would be committed. In such a case it is not clear whether the law of New South Wales or Victoria would apply, and long legal argument would ensue. Preliminary agreement is therefore most desirable.

1841. It is evident that should the proposed quantity of water be diverted to the Murrumbidgee, Victoria will be unable to develop a hydro-electric or irrigation scheme on the Snowy River. In spite of some controversy as to the accuracy of the deductions which may be drawn from certain of the gaugings available, it seems clear that diversion to the Murrumbidgee of 1,200 cubic feet per second at Findabyne would leave in the lower reaches of the Snowy in Victoria only about 45 per cent. of the previous total flow from the whole of the catchment. As this remaining flow would have lost its snow-fed component, seasonal variations in rainfall would be accentuated. The Victorian State Electricity Commission estimates that the nett result would be to eliminate any chances of Victorian hydro-electric development of the Snowy River. On the other hand the use of the water solely for the Snowy River hydro-electric scheme in New South Wales would benefit Victoria by stabilizing the flow somewhat and lessening the problem of destructive floods on the lower reaches.

1842. It is not essential that the water be used in the schemes for provision of power and water to the Sydney area, because reasonably acceptable alternatives are available which involve the consumer in similar or lower costs per unit supplied.

1843. The over-ruling long-term need of Australia is water. As time goes on the extension of irrigation will become more and more necessary if any marked increase in population is to be supported. Since the use of the Snowy waters for the sole purpose of hydro-electric generation or in part for the Sydney

water supply would prevent all or some of this water from being led to a place where it could be used for irrigating, the Commission feels that diversion of this water from the primary need of irrigation would not be to the best national advantage. These points are well stated in the Report of the Snowy River Investigation Committee as follows—

“Taking into consideration the immense potentialities for expansion of primary production in the Murrumbidgee Valley, the development of secondary industries that would be associated with agriculture, the attendant advantages of rural settlement and the consequent decentralization of population, and also having regard to the resulting increase in economic wealth to the nation, the Committee has reached the conclusion that from a National viewpoint the waters of the Snowy River should be utilized primarily for the purpose of irrigation and water supply.

Australia cannot, in the Committee’s view, afford to use the waters of any of its river systems for hydro-electric power development in circumstances where same will involve a total loss for the possible purposes of rural production and settlement.

The requirements of irrigation and stock and domestic supplies should therefore, in the National interest, have first call on the resources of the Snowy River”.

1844. Direction of Irrigation Development.—Should the decision be that the waters of the Snowy River are to be used primarily for irrigation, two important matters are pertinent.

- (a) If the diversion of the water to the Murray were proved practicable and the choice lay solely between that diversion and the one to the Murrumbidgee, the water could readily be used for a variety of types of irrigation in either valley including the production of dried or canned fruit, wine, dairy products, and rice, or for improving fattening facilities or for the provision of reserves of fodder against drought losses. In general when an increase in the crops is warranted it would be more economical to effect that increase in the regions nearer to the seaboard—i.e. on the Murray. On the other hand the use of the water in the Murrumbidgee areas for provision against drought would give a new stability to various centres located in one of the best livestock districts in Australia but in which variability of rainfall and liability to drought losses are dominant factors. If Victoria, acting in the national interest, were prepared to waive her claims to the water entering the Snowy above her boundary, she could obviously contend that such interest would not be well served by an amplification of the industries at present carried on in the Murrumbidgee Irrigation Area around Griffith and Leeton. It seems logical to suggest that in view of these facts, any compromise between States in regard to water rights should have regard to the type of production to be permitted on the new areas to be irrigated.
- (b) Should the Murrumbidgee irrigation plan be adopted, full advantage should be taken of any opportunities for generating hydro-electric power from the irrigation storages and the tributaries to the Snowy above Jindabyne, provided, in the latter case, that no water is lost to the Jindabyne storage.

Bore Waters of the Great Artesian Basin.

1845. Importance of These Waters.—Early settlers in the drier parts of Australia found that the problem of water supply for their stock was the most serious of the obstacles with which they had to contend. During the latter half of the last century the practice of sinking deep bores in order to tap underground sources of supply became very prevalent and in some parts of Australia these underground supplies were found to be under sufficient pressure to raise the water to the surface. They were therefore classed as artesian supplies. From 1878 onwards very large numbers of these bores were put down with success in the region known as the Great Artesian Basin. This covers over 500,000 square miles in Queensland, New South Wales, the eastern part of the Northern Territory and the north-east of South Australia. In 1943 there were 2,006 bores in the State of Queensland alone. Probably 20 per cent. of Australia's present sheep population and a considerable number of cattle are partly or wholly dependent upon supplies of artesian bore water for their maintenance.

1846. The water from the bores is used mainly for stock supply and also in some cases for domestic purposes, while some towns are supplied from such sources. The water is usually too saline in character to be of much value for irrigation; if it is so used, soil deterioration generally takes place within a few years. The bores are in most instances cased but sometimes this has not been done. Some of the cased bores have been fitted with a permanent head and appropriate valves which make it practicable to control the flow; in others the water gushes out uncontrolled. In pastoral country the stream from each bore passes along earthen channels to adjacent grazing lands. Some of these channels are miles in length and from them the stock obtain their water requirements. This method of distributing the water, although economic in cost of construction, is undoubtedly very extravagant in the amount of water used, particularly where bores are uncontrolled.

1847. Structure of the Basin.—In the early days bores were sunk without much thought as to where the water came from or how long the supply would last. Experience had shown that, once established, bores giving a good flow remained in operation for a long period and no further thought was given to the matter by those using the water. Scientific minds, however, soon became interested in these underground waters and advanced a number of theories regarding their origin and permanence. It is now generally considered that the water exists in special porous underground beds (aquifers) and that in many cases the water is now under considerable pressure caused by the weight of overlying rocks which have been subjected to elastic deformation by the head of water in the upturned ends of the aquifers in the ranges. Fresh supplies enter the upturned ends of the beds at places where they are exposed on the surface of the earth. These "intake beds" have been roughly mapped and it is possible to form an estimate of the approximate amount of the water-intake. It is, however, impossible for water to enter the aquifers through the intake beds unless the pressure in them is less than that due to the difference in level between them and the intake beds. However, as this pressure is decreased by the loss of the water through the bores, the capacity of the aquifers to be replenished through the intake beds at higher levels increases.

1848. The Problem of Declining Bore Flow.—Experience has shown that the rate of flow in any individual bore changes as time goes on. Normally the rate falls off, somewhat rapidly at first and then more gradually over a much longer period, until it reaches a phase during which the decline is slow. The flow in one bore is influenced by the opening or closing of other bores which tap the same water-bearing substratum, and this influence may extend over many miles. In some cases the decline in bore flow is due to the corrosion of the casing, but in some parts of the Artesian Basin no such corrosion occurs, and the gradual decline in bore flows has caused alarm among those financially interested in the welfare of the industries dependent upon this supply of water, and also among governments and others concerned.

1849. Investigations.—The basic concepts set out in paragraphs 1847 and 1848 are important if an attempt is to be made to determine the extent to which the falling off in pressure at the head of the bore indicates a probable cessation of flow in the near future. For some bores the rate of flow has been studied for years and the facts of the position are now fairly well known. Both in New South Wales and in Queensland much attention has been given to the problem and various interstate conferences on artesian water supply have been held. In recent years the matter has become more urgent as a larger number of bores have failed. Fresh steps have therefore been taken. In New South Wales an exhaustive report was prepared by a firm of engineers assisted by officers of the Water Conservation and Irrigation Commission in 1937. In Queensland a special committee was appointed “to investigate certain aspects relating to the Great Artesian Basin (Queensland section) with particular reference to the problem of diminishing supply”; its first Interim Report is a very informative document.

1850. In an appendix to this Interim Report Mr. F. W. Whitehouse, Ph.D., D.Sc., emphasizes that “in all great artesian basins the pressure of the water in the porous beds causes those beds to be unduly distended; and until by much close tapping that distension is released by normal elastic recovery there is no scope for the influx from the present-day rainfall to be markedly effective”. This means that some initial falling off in the flow of bores in a tapped artesian basin is virtually inevitable. Mr. Whitehouse goes on to suggest that the intakes to the basin to-day may be small compared to what they were in previous geological ages. It is therefore doubtful whether the influx of water reaching the basin at present is sufficient to maintain an adequate supply for future generations at the present rate of consumption. As yet too little data is available for this point to be determined but its importance is so far-reaching that it seems essential that continuous work should be carried out on the hydrology and geology of these regions so as to provide more information and keep the matter in the public view. Mr. C. Ogilvie, B.E., M.I.E., Aust., in another appendix to the report states—“We can, however, safely assert that the present total discharge from all bores is substantially greater than the recharge and that this total flow will ultimately continue to diminish, irrespective of the extent of new boring”. The same expert's conclusions as regards future flow are—

“North.—In the principal Northern areas it would appear as if the whole artesian system is approaching a steady state, with very little further diminution.

At some higher levels, low pressure areas will, however, experience diminution of flow.

South.—There is still a serious diminution of flow throughout the whole of Southern Queensland, and the high and intermediate level bores will probably eventually cease flowing. The history of the pressure diminution, however, suggests that this area, with the exception of the St. George district, may eventually reach a steady state, with a total discharge equal to about half of the present flow.”

1851. The New South Wales report already referred to suggests that the situation in that State is somewhat serious, some bores having reached the state of failing to deliver without pumping. It is only logical that the effects should be felt in some parts of New South Wales before they occur in south Queensland because the floor of this part of the basin dips to the north.

1852. *The Need for Conservation.*—In general it seems that while some diminution of supply appears inevitable in most parts of the basin, especially in the south, the rate of decline in flow of the bores may be diminished by better methods of controlling their flow. The fact that an asset is only being depreciated slowly, and that it is likely to persist in diminishing quantity for a long time, is no argument for its continued use in a profligate fashion.

1853. One consequence of such a policy in the past has been demonstrated in the south-eastern part of the basin where after considerable agitation, construction of the Keepit Dam on the Namoi River was commenced in 1939. This was originally intended to replace the failing artesian supply by providing water for stock and domestic purposes over a certain area. The cost of such procedure would be far in excess of the cost of artesian water and beyond the ability of the grazing interests to bear unaided. It is now possible, however, that the adoption of measures for conserving the artesian water may at least postpone the time when surface water in this area must be used for stock and domestic supply, while at best such use can be entirely obviated. As already emphasized, water storage potentialities in Australia are too limited, and therefore too valuable for irrigation and human use, to warrant their being allocated for purposes such as stock supply unless there is no alternative source available.

1854. *Remedial Measures.*—The matter is somewhat complicated both because two States are concerned, and because tapping of the basin in parts of south-eastern Queensland affects the bores in New South Wales; but both States are fully alive to the nature of the problem and should be capable of arriving at a satisfactory solution in their common interest.

1855. The change in the method of using a natural asset from one of exploitation to one of conservation almost invariably demands a considerable capital outlay, and the matter under discussion is no exception. Conservation involves a much more rigid control over the equipment and operation of bores already in existence and a complete control over the right to put down any more. Uncased bores will require casing and all bores with a continuous uncontrolled flow will need to be equipped with appropriate heads to permit control of the volume of water emerging. This volume may have to be varied from time to time according to the season. In other artesian basins of the world the problem of diminishing flow has been successfully solved by using these methods.

1856. The most difficult problem of all is the reduction of water losses by seepage and evaporation. It has been estimated that at the present time not more than 10 per cent. of the bore flow is actually used by the stock. The reduction in losses of bore water during distribution is largely a question of avoiding

seepage. This would involve piping the water, or renovating the bore channels and lining them with some impervious material. The total length of bore channels runs into tens of thousands of miles. A New South Wales estimate based on pre-war figures suggests that one mile of pipe would on the average serve 1,800 acres at a cost of £170 per 1,000 acres, giving an annual charge of between 2d. and 3d. per acre, which would be onerous in country with low carrying capacity. Lining the channels by various methods may involve a lower capital expenditure, but lined channels silt up and require manual labour to maintain them, whereas pipes would be free from this trouble.

1857. Financial Aspects.—In many parts of the area the land is held in grazing leases, and part of the extra cost of water supply could be offset by an adjustment of the rentals. This would mean loss of revenue but as emphasized in paragraph 1855 above, the transition from a system of exploitative management to one of conservation of resources generally involves extra expense. From the financial aspect it is preferable for the incoming revenue to be a small continuous flow rather than a larger stream which soon dries up altogether. The rental revenue from a large section of this country would follow the latter course if the bore waters fail, since the region would become relatively useless.

1858. Conclusions.—The Commission has come to the conclusions that immediate action is necessary to stabilize the diminishing supply of artesian water and that the following steps should be taken:—

- (a) The States concerned should acquire power to ensure that all bores are properly managed where such power does not already exist.
- (b) The next step would be to ensure that all bores are so equipped that their flow can be controlled.
- (c) Careful investigations should be continued as to the most appropriate methods of dealing with bore drains according to the type of soil through which they run.
- (d) Based on these investigations a progressive scheme of replacement by pipes or of treatment of the channels should be put into operation as soon as possible, in order to permit reduction of all bore flows to the minimum quantities necessary for watering the stock.

1859. The Commission is well aware that the matter is primarily one for the States concerned and that their officers are fully aware of its importance. From some points of view therefore the Commonwealth has no place in such a scheme, but—

- (a) The assurance of the continuation of a satisfactory water supply for these regions is a matter of national significance in view of the importance of the industries they support.
- (b) There would be great advantages in ensuring common action at least in respect to those sections of the Basin in which the aquifers are continuous beneath State boundaries.
- (c) Many of the geological and hydrological investigations of the Basin could be conducted on a joint plan by the officers of the respective States, and if so desired the Commonwealth Geological Survey might well take a part in such investigations.

- (d) The investigations in channel treatment and piping might well be carried out by a joint authority and their results applied appropriately. Neither of the two States concerned has a large soils organization but the Commonwealth Council for Scientific and Industrial Research has such a body in its Soils Division and its officers might be able to give valuable assistance.
- (e) Considerable capital expenditure may ultimately be necessary and if, as seems likely, an all-Australian policy for developmental work is adopted, it will be advantageous to all parties for the Commonwealth to be fully informed through its own officers of the nature and urgency of the problems.

It therefore seems reasonable for the Commonwealth to approach the States concerned with an inquiry as to whether they would be prepared to take joint action in the matter with Commonwealth participation in the directions suggested.

CONCLUSION.

In the present Report the Commission has reviewed the salient facts about irrigation and cognate matters in Australia. In so doing its aim has been to draw attention to those main principles which are of particular importance under Australian conditions owing to the uncertainty and poverty of our rainfall. The following are the more important of these principles:—

- (a) The possibilities of increasing Australia's irrigated acreage, although considerable, are not as great as is popularly supposed. Ultimately shortage of water will be the greatest of the obstacles to increased population.
- (b) For this reason, and because the allocation of the water of a catchment once made cannot easily be changed, it is desirable that the use of the available waters should be carefully planned, and that irrigation should be given priority over electricity generation; meanwhile catchments should be safeguarded and studied, and the efficiency of water distribution and use scrutinized, so as to safeguard future supplies.
- (c) The development of irrigation in a new area is a complicated process requiring much preliminary survey based on scientific investigation and advice, all of which should precede the adoption of the final plan for the agriculture of the area.
- (d) Some control is necessary in regard to the use to which new irrigated areas should be put, and this control should take into account the prospective demand for the extra production which will ensue.
- (e) An advisory service capable of helping and instructing the farmers on their farms in the principles and practices of irrigation as applied on their particular soils is an essential feature of every irrigation area, particularly of one which is in the early stages of development.
- (f) A research station, well-equipped and adequately staffed, should be regarded as an essential part of every large irrigation scheme.
- (g) Although we now have considerable experience of the problems associated with irrigation in the more temperate regions, yet so far we have little or no Australian experience of the difficulties likely to be encountered in irrigation on a large scale in tropical or sub-tropical areas. In such regions soil problems may be presumed to be similar in character to those in the south, but the problems of crop and pasture plants, of insect pests, and of rotations and farm management are likely to be very different. Yet in the Commission's opinion, irrigation where it is practicable, has a large part to play in the future development of the North. Research and investigation on these matters is long overdue.
- (h) Experience has shown that the cost of headworks and main supply systems in irrigated areas will, to a large extent, have to be borne by the nation or by the State concerned. In the long run it is reasonable to expect that this cost will be offset by the extra revenue

resulting from increased productivity and increased population, always provided that the precautions mentioned in (c), (d), (e) and (f) above have been taken.

- (i) In some districts, the most significant of which is at present in the south-east of South Australia, land drainage is an important means of improving productivity. The main obstacle is the cost. The adoption of mechanical methods will generally be important and research is desirable on this subject.
- (j) There is no reason why the national attitude towards a scheme for taking water away from an area in which there is too much should be different from one for putting water on an area where there is too little.
- (k) Particular attention should be given to the development of irrigation as an ancillary to live-stock industries in the drier regions. The opportunities which irrigation affords for increasing the production of citrus and dried and canned fruits enormously exceeds the capacity of Australia to sell such products. On the other hand, we know we have to face periodic droughts in the course of which both sheep and cattle die in large numbers. This wastage is often devastating to the individual and prevents progress in the industries concerned because as such large stock losses are possible the owners rightly hesitate to make the outlay necessary to improve them in type. If this view is correct the economic basis of such irrigation developments will mainly be in reducing losses by carrying stock more securely rather than in increasing the returns by carrying greater numbers. The additional stability of volume of production would be of value from the point of view of marketing the products. Such developments have not the sensational appeal of applying irrigation to new industries but their ultimate effects may be even more profound.
- (l) Four major water schemes—The Snowy, the Ord, the Bradfield and the Artesian Basin—have been reviewed in particular because they are large enough to be of considerable national importance and because they are of significance to more than one Government.

In general the Commission points out that if irrigation development is to be soundly based it must be according to an all-Australian plan which has the assent of the various Governments; otherwise co-ordination will be lacking and there is a danger that too many schemes will be developed simultaneously, thus stimulating greater production than markets can hope to absorb, with resultant distress to farmers, and financial embarrassment to Governments. Such co-ordination may not have been so essential in the past when European populations, and the markets they afford, were expanding, but the results of its absence have gradually become more apparent and will be of great significance in the future.

The joint action of Governments in promoting desirable schemes is not always readily obtained. In the United States of America the much advertised Tennessee Valley Authority scheme only came into being because the Federal Government

had powers in regard to the navigation of rivers and because the economic depression produced an urgent need for the provision of employment. In Australia the most notable success has been the River Murray scheme which has received such scant publicity. In this case a good many years passed before action was taken.*

The co-ordination of irrigation development by the States under the guidance of the Commonwealth is a matter which calls for statemanship in the highest degree. The extent to which those responsible for local pressures can be brought to see that the national interest should come first will determine whether Australia is to develop on a sound basis, or whether she is going to waste her limited resources of water and capital, or whether, in the words of an American author writing of his own country, "we are in for another long experience of the philosophy of stand-pat".

The members of the Rural Reconstruction Commission have the honour to submit their Eighth Report.

F. J. S. WISE, Chairman.
 J. F. MURPHY, Member.
 S. M. WADHAM, Member.
 C. R. LAMBERT, Member.

P. S. LANG, Acting Secretary.
 11th December, 1945.

* In 1902 an Interstate Royal Commission was appointed to report on the better utilization of the waters of the River Murray. In 1915 an agreement was reached between the Commonwealth and New South Wales, Victoria, and South Australia, ratified by the parliaments concerned, and the first of the proposed works commenced. The Hume reservoir was officially opened in November, 1936, with a capacity of 1,250,000 acre feet.