SOUTH AUSTRALIA

Department of Mines

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

BULLETIN No. 23

The Occurrence, Composition, Testing, and Utilization of Underground Water in South Australia, and the search for further supplies

By L. KEITH WARD, I.S.O., B.A., B.E., D.Sc.,
Consultant Geologist

Issued under the authority of
The Honourable A. Lyell McEwin, M.L.C., Minister of Mines

K. M. STEVENSON, Government Printer, Adelaide.

1946

SOUTH AUSTRALIA

Department of Mines

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

BULLETIN No. 23

The Occurrence, Composition, Testing, and Utilization of Underground Water in South Australia, and the search for further supplies

By L. KEITH WARD, I.S.O., B.A., B.E., D.Sc.,
Consultant Geologist

Issued under the authority of
The Honourable A. Lyell McEwin, M.L.C., Minister of Mines

K. M. STEVENSON, Government Printer, Adelaide.

1946

LETTER OF TRANSMITTAL.

Geological Survey Office, Department of Mines,
Adelaide, 13*th September,* 1945.

Sir,

I have the honour to submit herewith a report, dealing with many aspects of underground water supplies in South Australia, by L. Keith Ward, I.S.O., B.A., B.E., D.Sc., Consultant Geologist to the Government.

During the last 33 years a great deal of geological work has been done in the elucidation of the mode of occurrence of underground water in all parts of the State; and this work must be continued in a systematic way, in the interests of the public generally and of individual farmers, horticulturalists and pastoralists, as an essential part of the application of geological science to the needs of development.

In this report the principles governing the storage of underground water are expounded in some detail, with many explanatory maps and diagrams. In addition, there is a full discussion of the way in which the composition of the salts dissolved in water is recorded, and also of the significance of salinity in the utilization of water, whether for human consumption, for watering stock, for irrigation, for industrial purposes generally, and for engineering use.

The general features of the artesian basins of South Australia are described, and also the factors that determine the occurrence of groundwater supplies in parts of the State over which the artesian basins do not extend.

The latter portion of the report deals with the search for further supplies of underground water, and sets out the procedure to be followed in the location of wells and boreholes according to the requirements of climatic, structural, and other conditions which are far from constant. It is believed that the careful study of this exposition, which is based upon the principles discussed in the earlier pages of the report, will afford material help to those who require supplies of water to increase the productivity of their holdings, and that it will reduce wasteful expenditure on the testing of unsuitable sites.

I have, etc.,
S. B. DICKINSON,
Government Geologist.

The Hon. A. Lyell McEwin, M.L.C., Minister of Mines.

Submitted for approval to print as a Bulletin of the Geological Survey of South Australia.

Approved,
A. LYELL McEWIN, Minister of Mines.

TABLE OF CONTENTS.

PAGE.

I. INTRODUCTION 9
II. THE SOURCE OF UNDERGROUND WATER 13
III. CLIMATE AND UNDERGROUND WATER 15
IV. HOW WATER IS STORED BENEATH THE SURFACE 21
V. THE MOVEMENT OF UNDERGROUND WATER 23
VI. THE VERTICAL DISTRIBUTION OF UNDERGROUND WATER 26
VII. FLUCTUATIONS OF WATER LEVEL 31
VIII. THE DIFFERENCE BETWEEN GROUND WATER AND PRESSURE WATER 33
IX. THE GENERAL FEATURES OF ARTESIAN BASINS 34
X. SPRINGS 40
XI. SOUTH AUSTRALIAN ARTESIAN BASINS— 40
- (*a*) Early exploration and development 42
- (*b*) The broader features of the Great Australian Artesian Basin—
  - (1) The extent of the basin as a whole 43
  - (2) The structure of the basin 46
  - (3) The geological formations occurring within the basin 46
  - (4) Earth movements within the basin, subsequent to sedimentation . 48
  - (5) The hydraulic surface of the basin, and the movement of the water 48
  - (6) Observations of temperature and pressure 49
  - (7) The source of the water 50
  - (8) The causes of the rise of the artesian water 52
  - (9) Intakes and outlets 53
  - (10) The utilization of the water 54
- (*c*) The South Australian portion of the Great Australian Basin— 55
  - (1) The continuity of the stratigraphical horizons and the distribution of aquifers 55
  - (2) The structural features of the basin 58
  - (3) The chemical character of the water 59
  - (4) The mound springs 61
  - (5) The temperature gradient within the basin 61
  - (6) The far southwestern margin of the basin 64
  - (7) Subsidiary basins perched above or marginal to the Great Basin . 64
- (*d*) The Murray River Artesian Basin—
  - (1) Geological history 67
  - (2) The underground waters of the basin 68
- (*e*) The Eucla Artesian Basin— 74
  - The underground waters of the basin 75
- (*f*) The Adelaide Plains Artesian Basin— 78
  - The use of the water to supplement reservoir supplies 79
- (*g*) The Pirie-Torrens Artesian Basin 87
- (*h*) The Walloway Artesian Basin 87
- (*i*) The Willochra Valley Artesian Basin 88
- (*j*) The Cowell Artesian Basin 88
- (*k*) The Inman Valley Artesian Basin 89
- (*l*) Minor Artesian Basins 89

XII. SOUTH AUSTRALIAN GROUNDWATER SUPPLIES—
- The influence of climate, lithological character, topography and structure ... 89
- Some groundwater basins 98

XIII. THE COMPOSITION, TESTING AND UTILIZATION OF UNDERGROUND WATER—
- (*a*) General Statement 99
- (*b*) The estimation of salinity by the observation of density 103
- (*c*) Chemical analyses—
  - (1) Method of calculation and showing composition 104
  - (2) The determination of hardness 105
- (*d*) The significance of salinity in the utilization of underground water..— 108
  - (1) For human consumption and domestic purposes 109
  - (2) For watering stock 114
  - (3) For irrigating plants of all kinds 118
  - (4) For industrial purposes 120
  - (5) For engineering purposes and locomotive boiler feed 122

PAGE.

XIV. THE UNRELIABILITY OF DIVINING OR DOWSING IN THE LOCATION OF WATER SUPPLIES— 123
- (*a*) The origin and history of divining 124
- (*b*) The literature on divining 124
- (*c*) The practice of divining and the instruments used 128
- (*d*) Why the rod, or pendulum, moves 130
- (*e*) The claims made for divining 131
- (*f*) Water-finding machines 132
- (*g*) The testing of the claims of the diviner 133
- (*h*) Instances of failure that show the unreliability of divining 137
- (*i*) The psychology of divining 144
- (*j*) Conclusions regarding divining 147

XV. THE SELECTION OF SITES FOR BOREHOLES AND WELLS, THE TESTING OF THESE SITES, AND THE RECORDING OF RESULTS 149

XVI. MEMORANDA DEALING WITH WATER 157

XVII. TABLES OF WATER ANALYSES 158

XVIII. TABLES OF BOREHOLES IN ARTESIAN BASINS.. At the end of the bulletin

FIGURES IN THE TEXT.

Fig. 1. Circulation of water in relation to sea, air and land 14
2. Australia, mean annual rainfall 16
3. Australia, variability of rainfall 18
4. Australia, annual net evaporation 19
5. The relation of rock texture and structure to porosity 21
6. Section showing the position of the Capillary fringe 27
7. Section showing occurrence of ground water in dense rocks 27
8. Section showing the cone of depression in water table during pumping ... 29
9. Block diagram of an artesian slope with two aquifers 35
10. Block diagram of a valley artesian basin 36
11. Section across an artesian slope with an outlet to the ocean 37
12. Plan and section of an artesian slope showing isopotential lines and hydraulic grade 38
13. Sections to illustrate structural features of springs 41
14. Plan of the Great Australian Artesian Basin, with mound springs sites.... 44
15. Plan of the Great Australian Artesian Basin, showing the general direction of movement of the water 45
16. South Australian portion of the Great Australian Artesian Basin, showing the distribution of carbonated and sulphated waters 60
17 & 18. Mound Springs south-west of Lake Eyre .... 62 & 63
19. Sections across south-western portions of the Great Australian Artesian Basin 65
20. Plan of the Murray River Artesian Basin .... facing 67
21. The hydraulic surface in part of the Murray River Artesian Basin 69
22. Bores and wells north of Murray River 71
23. Section showing how structure affects pressure and quality of water 73
24. Plan of the Eucla Artesian Basin 77
25. Block diagram of an artesian slope on a shore affected by faulting 78
26. Boreholes in Adelaide Plains Artesian Basin used to supplement reservoir storages 82
27. Section across the Pirie-Torrens Artesian Basin 87
28. Block diagram of the Cowell Artesian Basin 88
29. Section showing well with a drive to intercept underflow 92
30. Section showing the effect of transpiration on the quality of groundwater . 94
31. Section showing successful and unsuccessful boreholes in dense rock 95
32. Block diagram showing underground water conditions in County Buxton . 97
33. Section to show danger of pollution by organic waste 107
34-38. Examples of failure on the part of diviners 138-143
39. Section along the valley of intermittent stream showing the feeding of joints in dense rocks from alluvium 152
40. Section showing a suspended water table on Eyre Peninsula 154

PLATES.

I. South Australia, showing relief and annual rainfall .... facing 20
II. South Australia, showing artesian and ground-water basins.......... } At the end of the bulletin
III. South Australia, north-eastern portion, showing the Great Australian Artesian Basin and northern part of Pirie-Torrens Artesian Basin } At the end of the bulletin
IV. The south-western portion of the Great Australian Artesian Basin.. } At the end of the bulletin
V. The suspended basins of the Lake Frome region .... } At the end of the bulletin
VI. Government boreholes in the Murray River Artesian Basin .... } At the end of the bulletin

TABLES OF ANALYSES OF UNDERGROUND WATERS.

Table.		Page.
I.	Extremely saline waters used for human consumption in times of drought ..	110
II.	Underground waters used for town and district supplies in South Australia..	113
III.	Modification of analytical results by the use of factors	116
IV.	Underground waters used for boiler feed, S.A. Railways	158-159
V.	Underground waters used for boiler feed, Commonwealth North-South Railway	160
VI.	Great Australian Artesian Basin waters, showing excess or deficiency of carbonic acid	161-163
VII.	Great Australian Artesian Basin, carbonate waters of eastern origin, northern group..	164
VIII.	Great Australian Artesian Basin, carbonate waters of eastern origin, eastern group..	165
IX.	Great Australian Artesian Basin, sulphate waters of western origin	166
X.	Great Australian Artesian Basin, waters of south-western margin...........	167
XI.	Great Australian Artesian Basin, waters of perched and marginal basins	168
XII.	Great Australian Artesian Basin, waters of mound springs	169
XIII.	Murray River Artesian Basin waters	170
XIV.	Adelaide Plains Artesian Basin waters	171
XV.	Adelaide Plains Artesian Basin, waters used in 1934 to supplement metropolitan reservoir supplies	172
XVI.	Pirie-Torrens Artesian Basin waters	173
XVII.	Eucla, Willochra, Walloway, Willunga Artesian Basins waters and Polda, Robinson, and Uley-Wanilla ground waters..........................	174
XVIII.	Ground waters occurring in South Australian Highlands..................	175
XIX.	Ground waters of western South Australia..............................	176
XX.	Ground waters west of Lake Torrens..................................	187

INDEX TO WATER ANALYSES.

	Tables.
Abdul	VII.
Abminga	V.
Adelaide Oval Well	XIV.
Alawoona	IV.
Alberga	V.
Alberrie Creek	V.
Anacoora, N.T.	IX.
Andado, N.T., No. 1 and No. 2	IX.
Anna Creek	V.
Arboola	VIII.
Arcoona, No. 4	III.
Arthur's, Walloway	XVII.
Balhannah Mine	XVIII.
Barna	XIX.
Beltana	V.
Beresford	V.
Billa Kallina Spring	XII.
Birksgate	XI.
Blanche Cup Spring	XII.
Bleeze's, Ettrick	I.
Blood's Creek	IX.
Blue Lake, Mount Gambier	II. and XIII.
Bluff Paddock, Arcoona	XVIII.
Boettcher's, Seaton Park	XIV.
Bon Accord Mine, Burra	II.
Bon Bon, Nos. 8 and 10	X.
Boondi	XVI.
Bopeechee Spring	XII.
Bordertown	II., IV. and XIII.
Brachina	V.
Brook's	XIII.
Brooklyn Park	XV.
Broken Hill Associated Smelters, Port Pirie	XVI.
Bulgunnia Well	X.
Bull Island Well	IV.
Bull's Hole	XI.
Cadnaowie Spring	XII.
Cannuwaukaninna	VII.
Carmichael's Well	XVI.
Catt's Spring	XII.
Charlotte Waters, N.T.	IX.
Chintulda Well	XIX.
Clare Hospital	XVIII.
Clayton	VII.
Cooinchina	IX.
Coonanna	VIII.
Coonee Creek	VIII.
Cordillo	XI.
Corporation Well, Peterborough	XVIII.
Corryaninna	VII.
Cotton	XIII.
Coward	VII.
Coward Spring	XII.
Culberta	VIII.
Curdimurka	V.
Curraworra	VIII.
Darke Peak	XIX.
Depot Creek	XVIII.
Dorothy Well	XX.
Drualat	XIII.
Dulkaninna	VII.

	Tables.
East Painter, No. 2	XVIII.
Edwards Creek	V.
Edwardstown	XV.
Elizabeth Paddock, Arcoona	XX.
Elwomple Trench	II.
Ettenna	XVI.
Ettrick, Bleeze's	I.
Eucla Basin, Nos. 2 and 5	XVII.
Farewell	XVI.
Fountain Spring	XVII.
Four Corners	XI.
Francis Spring	XII.
Fred's Spring	XII.
Gammon Range	XVIII.
General Motors-Holden's	XIV.
Giffen's Well, Bulgunnia	X.
Gilgurabbie	III. and XVII.
Glenelg	XIV.
Glenelg East	XV.
Glenmanyie	VIII.
Glenroy	XI.
Goyder's Lagoon	VII.
Government Bores, Nos. 1 and 9, north of Tarcoola	X.
Graphite Company's, Uley	XIX.
Guinewarra	XVII.
Gunyah Dam	XIII.
Gypsum	IX.
Hamilton	IX.
Hawker	V.
Hergott Spring	XII.
Hiltonia	XV.
Hookina	V.
Illeroo	XIX.
Imbitcha	IX.
Jacobs	XIX.
Jewellery	VIII.
Kalladeina	VII.
Kapunda Brewery	XVIII.
Karoonda	IV.
Kopperamanna	VII.
Kooyonga, Nos. 1 and 2	XIV.
Kruger	XIII.
Kruger Dam	XIII.
Kruger's No. 3	XIX.
Lake Charles	XI.
Lake Crossing	VIII.
Lake Harry	VII.
Lake Letty	VII.
Leigh Creek Colliery	XVIII.
Lockhart	XI.
Loftia Park	XVIII.
Loveday	XI.
Mallabie	XVII.
Marleston	XV.
Marree	V.
Miller's Creek, Nos. 1 and 2	X.
Millicent Well	IV

	Tables.
Milly Millyana	XVI.
Mindarie	IV.
Mirackina	IX.
Mirra Mitta	VII.
Mitchell Park	XV.
Montecollina	VIII.
Morphettville	XV.
Morphettville Racecourse	XIV.
Mount Clarence, Nos. 2 and 6	X.
Mount Dutton	V.
Mount Gason	VII.
Mount Hamilton Spring	XII.
Mount Painter Well	XVIII.
Mount Sarah	IX.
Muddaugna	XVII.
Muddaugna ground water	XIX.
Mulgathing Rocks, nitrated waters	XX.
Mulka	VII.
Mulpata	IV.
Muloowurtina, No. 2	VIII.
Naracoorte	II., IV., and XIII.
Nectar Brook	XVI.
Needle Hill	XI.
New Era Mine	XVIII.
Nields, No. 3	XIX.
Nilpinna Spring	XII.
Nitrated Waters, Mulgathing Rocks	XX.
Norwood Oval	XIV.
One Gum	XI.
Oodnadatta	V. and IX.
Oolgelima West, Nos. 1 and 3	X.
Opossum	IX.
Pan Well	XX.
Paralana Hot Spring	VIII.
Paringa Park	XV.
Patchawarra	VIII.
Peachawarrinna	VII.
Pearlah Spring	IV.
Pearson's, Netley	XIV.
Pedirka	V.
Peebinga	IV.
Peela Well, bore near	XX.
Penola	IV.
Peterborough Well	II.
Petermorra	VIII.
Petina Well	I.
Pinera	XVI.
Pinnaroo	II., IV., and XIII.
Pine Valley	III.
Plympton	XV.
Polda test trench	XVII.
Produce Department	XIV.
Pulchra	XVI.
Quinyambie New Homestead	VIII.
Quondong Vale	XIII.
Quorn	IV., V., and XVII.

	Tables.
Racecourse Spring	XIII.
Raspberry Creek	IX.
Reichstein's	III.
Robert's Well	XVII.
Robinson pumping trench	XVII.
Rodda's	XIX.
Rothsay	XIII.
Royal Adelaide Golf Club, Nos. 1 and 7	XIV.
S.A. Gas Co.	XIV.
Saltia	XVI.
Scammell's	XVII.
Schmidt's	XVII.
Schmidtke's	XIX.
Searle's, Pirie	XVI.
Seaton Gardens	XV.
Sinclair	VII.
Sliding Rock	XVIII.
Snuggery Spring	XIII.
South Park Lands	XIV.
Spring Creek Mine	II.
St. aBeckett's	XVIII.
State Wool Committee's	XIV.
Strangways	IX.
Strangways Spring	XII.
Stuart's Range, Nos. 1 and 2	X.
Sulphur Spring	XII.
Sundown	XVI.
Thebarton Oval	XV.
Thomas', Aldgate	XVIII.
Thurlooka	VIII.
Tintinara	IV. and XIII.
Tooligie Well	IV.
Troudaninna	VIII.
Twins Well, 13 miles west of	X.
Uley, No. 17	XVII.
Umberatana Well	XVIII.
Urabi Well	XIX.
Wanbi	IV.
Weedina Spring	XII.
Wilcherrie	XIX.
Wilgena, Nos. 4 and 17	X. and XX.
Wilkalinsie pumping trench	II.
Wilkawatt	IV.
William Creek	IX.
Willunga Well	IV.
Wizzo Well	XIX.
Wolseley	IV.
Wongyarra	XI.
Woodgate	XI.
Woodroffe's Well	XIV.
Wookata Well	XIX.
Wooltana, Nos. 12, 27, 38, and 41	XI.
Yarrawurta	XVI.
York	XV.

THE OCCURRENCE, COMPOSITION, TESTING, AND UTILIZATION OF UNDERGROUND WATER IN SOUTH AUSTRALIA, AND THE SEARCH FOR FURTHER SUPPLIES.

1. INTRODUCTION.

So familiar are most people with water that they take for granted its existence in the liquid state, and do not think of it as an important mineral constituent of the earth's crust. Those, however, who live at high levels or in high latitudes see much water in the solid state frozen into ice, and are better able to appreciate its significance in the role of a mineral. Yet there is no valid reason why water should not be regarded as a mineral and, indeed, as the most important of all mineral resources, even though it is a liquid at ordinary temperatures.

The part played by water in many geological processes—in the formation of the mineral veins, in the accumulation of sedimentary deposits of all kinds, in the moulding of the surface features of the earth, in the weathering and alteration of rock masses, and in the composition of many minerals—is fundamental. This bulletin, however, is concerned rather with water as such, with the manner of its occurrence and with its distribution and the way in which to discover concealed supplies.

Water must be regarded as the basal factor of life itself, being an important constituent of all living things, both animal and vegetable, and essential to their production and growth. It has been stated that on the average the plant tissue of annuals is three-fourths water, and of perennials three-eighths. Animals, including human beings, contain 80 per cent of water in their substance. The modern dehydration plants for treating meat and vegetables are provided to get rid of the greater part of this water for the conservation of space and the reduction of weight. All organic tissues are produced only through the agency of an amount of water many times their weight. From this aspect it is clear that water transcends all other minerals in importance; and no substitute can be devised to replace it.

Since the occupation of Australia by the white race there has been an ever-increasing demand for water, and there is destined to be a still greater demand in the future as the population density increases with the more complete utilization of the land. Much more dependence upon the underground resources in all portions of the continent will follow upon the growth of population, and this development will affect all parts of South Australia, those that are well placed with respect to the amount and distribution of the rainfall as well as the more arid regions.

Prior to the white occupation of Australia the demand for water by human beings and other animals was limited. The aborigines and the native fauna gathered in numbers only in those places where there were easily got supplies of water, generally surface water, and they travelled long distances only after big rains when such surface supplies were temporarily numerous. The arid region, in those times, was very sparsely peopled, and the animals were those which can exist for long periods with little or no water other than that taken into the body from dew on the herbage or derived from succulent plants like parakylia, or those which were able to travel long distances from water. There was but little reliance on the water stored beneath the surface. The rockholes, springs, and the waterholes in the river channels were the chief camping places of the aborigines and these were guarded jealously through their supreme importance. The history of Carnegie's explorations in the central portion of the continent gives clear proof of the tenacity with which the possession of watering places was defended.

Yet in some places within the arid region there were native wells where water was to be obtained at the very shallow depths that could be reached with the poor tools at the command of the blacks. Most of these native wells are shallow "soaks" in sand. In many cases they were of temporary service only, and dried up in times of drought. To-day such soaks are used in some very dry districts by the dingo, which digs down to the water by scratching out the sand. In the case of the larger and more dependable soakage wells, such as that a few miles north of Ooldea, there must have been a centre of more continuous occupation, determined by the presence of the water; for the traces of human work are exceptionally abundant at this place.

Although the very shallow supplies are still found useful and are turned to account, the white man is not subject to the limitations that prevented his black predecessor from seeking supplies far below the surface. Modern methods of sinking wells and boreholes and of raising water to the surface have made available the supplies that are stored at immense depths.

The thoughtful visitor to South Australia from countries well endowed with high mountain ranges which are covered with snow during at least a part of the year, or which receive on the average a much more abundant rainfall, cannot fail to be struck by the general absence of rivers and streams that carry water throughout the year. He notes that the River Murray alone, with the help of locks along its course and barrages at its mouth, is a permanent stream, and that its waters are derived from sources far beyond the State boundaries. He sees that only in the far south-eastern portion of the State is there such an excess of water that drainage operations are necessary. In every other part of South Australia it is essential to take measures to conserve rainfall in surface reservoirs, or to develop supplies from underground sources, in order that the normal domestic and industrial demands of the towns may be satisfied, that sewerage schemes may be possible, that railways may be provided with supplies, that flocks and herds may be watered, and crops irrigated. The visitor sees major schemes of reticulation, including the pumping of water from the River Murray across the highlands, designed to satisfy these needs and make possible the permanent occupation and full productivity of the land; and he observes that, despite all that has been done in the past, this developmental work is always in progress. He will find, if he makes inquiry, that there is a general appreciation of the fact that all sources of water must be developed; and that the limited supplies that can be drawn from surface storages must be supplemented by contributions from the underground accumulations in and near the towns and also throughout the country districts, if all demands are to be met.

He may call to mind that the late Lord Bryce, in his "Modern Democracies," stated that the Australian Governments, in selling land, really sell the water rather than the land; and, while conceding that this statement is essentially true, he would be tempted to broaden it by altering the word "water" to "water supplies, natural and artificial, superficial and subterranean, actual and potential."

However great may be the part played by the State in affording water facilities, there remains ample scope for the individual to help himself by providing his own supplementary supplies where such are obtainable. In the more remote areas, particularly those under pastoral occupation, the public supplies are chiefly restricted to stock routes, and additional waters for the use of stock are mostly the product of private initiative. The special public service, to supply the coal mining centre at Leigh Creek, is exceptional and involves the transfer of the water from an underground source by a 25-mile pipe line. One of the first considerations of the wise outback pastoralist, whether he is thinking about the best site for his homestead or shearing shed, or whether he is planning the subdivision of his holding by fences, is invariably the available water supply, which is derived in most cases from boreholes and wells. The city dweller, who is apt to rely upon the Government for all his water requirements from surface reservoirs and to expect a copious supply at all times, has nevertheless received contributions from subterranean sources when drought conditions have enforced such action in the Adelaide district.

One of the outstanding features regarding the distribution of underground supplies is the sharp distinction between the areas in which water may be obtained at almost any desired spot, namely, in the artesian basins, and on the other hand the limited areas within which specially favourable structural conditions must exist before success can be attained. It is the latter areas that call attention to the necessity for the study of the occurrence of underground water under all manner of conditions. The absurdity of making an arbitrary selection of new sites for wells or boreholes without a sound reason for every selection, becomes most apparent in those regions where supplies are most difficult to locate. No one can afford to disregard the empirical facts that have been gathered with regard to the occurrence of underground water generally nor with regard to the structural features of the district in which water is desired insofar as these features concern the subterranean storage of water.

The search for underground water is facilitated in some countries, to a degree that is not yet realized in South Australia, by reason of the existence of fairly complete maps showing the relief of the land on a scale that permits the use of small contour intervals. While it is true that some such topographic maps have been prepared in this State, much remains to be done. There has been some such mapping by the Military Forces, and some of these are of value for underground water investigations. The sheets of the millionth map of Australia which embrace South Australian territory are of little value for the purposes here discussed, on account of the scale. Outside the scope of these comprehensive maps there are data regarding relief obtainable from engineering surveys made in connection with water reticulation, sewerage schemes, and railway routes. All this information, correlated and reduced to map form, would provide a network within which the relief of the enclosed country could be surveyed fairly rapidly. In the south-eastern region it would not be a lengthy task to prepare a complete topographical map of the area within which very many determinations of the heights of individual points have been made for the design of the drainage operations. A topographic map of a large part of the Middleback Range has been made by The Broken Hill Proprietary Co. Ltd. as a basis for considering the development of the iron ore resources of that region. Some reservoir basins, actual and potential, have been surveyed by the Engineering and Water Supply Department. Yet the sum total of this fragmental work is small in comparison with the areas still unsurveyed, and many of the places at which underground water investigations are required lie beyond the closely settled areas in which data concerned with relief are available.

It may be possible, when this necessary mapping is well advanced, to define closely the areas within which supplies of useful water may be obtained, especially where the low-level underground water is of much poorer quality than the water beneath the somewhat higher country. Such areas are those on Upper Eyre Peninsula, and on the marginal flange or rim of the Great Artesian Basin on the northern side of the Transcontinental Railway. The significance of the topographic control of the salinity of the water has been noted already in these regions, and investigations in other districts may reveal the importance of the same influence.

During the early stages of development of underground water resources the features to which attention is naturally drawn are largely qualitative, although, of course, the quantity of water obtainable from an individual well or borehole is of great importance. With the passage of time, however, the demands for water may increase rapidly so that the drain upon an aquifer may become large by the multiplication of openings and continuous draughts. Places at which such conditions are found are large centres of population that give rise to large domestic and industrial demands and, during the war, camp sites at which many men are stationed. Questions then arise as to the extent to which aquifers may be expected to maintain their yield for protracted periods. The modern studies of underground water resources tend towards the investigation of these quantitative problems, in accordance with the recognized principles governing the yield from ground-water storages and artesian aquifers, and with the observations that have led to the realization that artesian aquifers are compressible and in some measure elastic. Recent papers dealing with these matters are published in "Economic Geology" for May, 1945. Future developments in South Australia, connected with the supply of water from underground sources for the city of Adelaide during periods of drought, and with the normal draughts upon groundwater basins such as the Robinson basin at Streaky Bay, the Uley-Wanilla basin near Port Lincoln, and the Polda basin on Eyre Peninsula, will probably demand investigations similar to those which have been carried out in recent years in the United States of America.

The study of the occurrence of water and of structure is essentially a branch of geology, and the problems involved can best be dealt with by geologists who are experienced in this particular work. This statement does not imply that the geologist can point unerringly in every district to a site at which a useful supply is obtainable. No capable geologist would be so foolish as to make a claim of that character. He might be able, in some districts, to do no more than point out the least unsuitable places at which to make trials. The information to be gained from such trials, if studied conscientiously by a capable man, may perhaps point the way to success, even if the first trial is unsuccessful; and may well prevent wasteful expenditure on further futile testing.

This bulletin has been prepared to enable those who are in need of underground water supplies to understand the principles governing their occurrence; to induce them to rely upon logic and common sense in the selection of sites for new supplies rather than upon magic and superstition, and to play their part in the full development of the State by preserving detailed records of all their exploratory efforts. It is a publication that should not be regarded as a comprehensive statement dealing with the underground water resources of the State. It should be studied in conjunction with the more detailed accounts of limited areas such as are dealt with in the *Bulletins* numbered 1, 3, 11, 17, and 19 of the Geological Survey of South

Australia, and the special treatment of geological structure in relation to underground water supply in *Bulletin* 14 of the same series.

At the end of the bulletin there are printed tabulated analyses of South Australian underground waters which have been selected from an immense number—over 4,900—that have been made, mostly during the last 33 years. Those selected for printing have been chosen to show the composition of waters occurring under different conditions. Some of these waters are used extensively for many purposes; others are useful stock waters; and others again are barely useful for watering sheep. There are on record many analyses of waters that are much too saline to be used for any ordinary purpose and do not appear in the tables. Yet one of them (the water in the Leigh Creek Colliery) is shown, as it is possible that this water may find a use in quenching fires.

II. THE SOURCE OF UNDERGROUND WATER.

The ultimate origin of all water is one of the questions involved in hypotheses dealing with earth-genesis, and it is not proposed to deal with such matters in this bulletin, which is concerned with the exact data, collected in abundance within recent years, showing the manner of distribution of water in accessible parts of the earth.

So far as concerns the rocky framework of this planet, we know, from very numerous analyses, that even the igneous rocks, which ascend from great depths and are still extremely hot when they reach the outer portions of the crust, contain gases that include aqueous vapour. Water has been condensed by A. L. Day and E. S. Shepherd from other gases escaping from the molten lava of the Hawaiian volcano Kilauea. In addition to the aqueous vapour emitted from an active crater there is hydrogen which unites with oxygen to form water. The more deeply seated portions of a molten magma contain aqueous vapour and other gases under pressure, and the quantity of such vapours is probably large, for there is evidence to show that much escapes before the magma becomes a solid mass. It has been found by chemists that the solidified igneous rocks still contain, on the average, nearly 2 per cent of water, one-fourth of which is free and the balance is contained in minerals which have water of combination in their composition.

Water derived thus from the deeper portions of the earth and emitted by igneous rocks is referred to as *magmatic, plutonic,* or *juvenile* water, the latter adjective having been introduced by Suess to indicate that this water is newly arrived at the surface. A further discussion of this juvenile water is given in a later chapter dealing with the composition of underground water (see p. 100).

The amount of water contained in the liquid oceanic envelope of the earth is enormous. The volume of the ocean is estimated to be 320 million cubic miles, and its area is 140 million square miles, or 71 per cent of the surface of the globe. A portion of this vast reservoir is being continually taken up by the atmosphere and a proportion falls on the land in the form of rain or snow. The radiation from the sun is the source of energy that creates the movement of the air which is the medium wherein water vapour is transferred from one place to another. The circulation, relatively to sea, air, and land, is shown diagrammatically in the drawing printed herewith (Fig. 1) which shows the main processes in continuous operation at one place or another, although not all of them acting together at one locality. Beginning with the evaporation over the ocean the water vapour taken up by the air is condensed as the temperature falls. Some of the

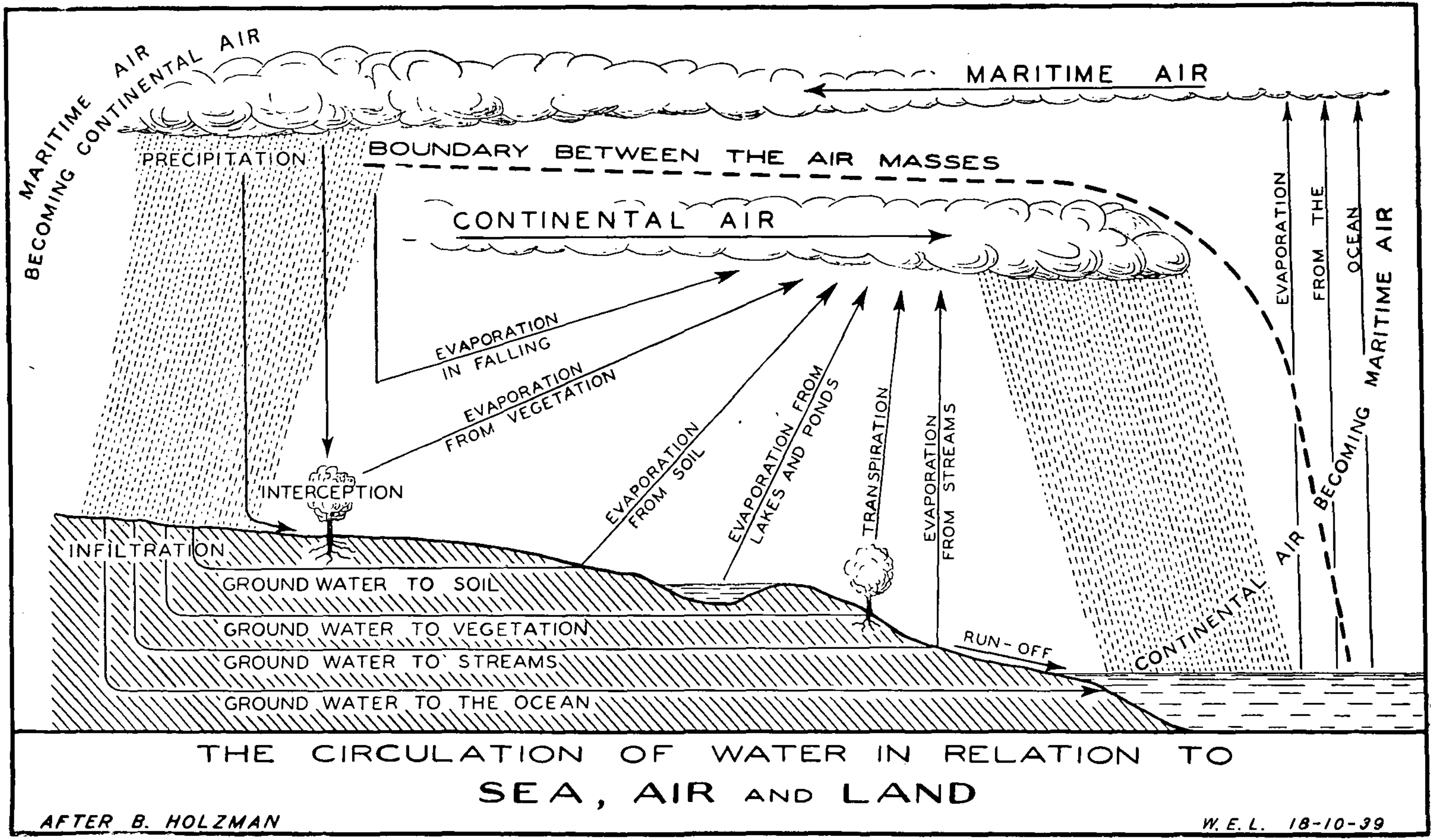

MARITIME AIR BECOMING CONTINENTAL AIR
MARITIME AIR
PRECIPITATION
BOUNDARY BETWEEN THE AIR MASSES
CONTINENTAL AIR
EVAPORATION IN FALLING
EVAPORATION FROM VEGETATION
EVAPORATION FROM SOIL
EVAPORATION FROM LAKES AND PONDS
TRANSPIRATION
EVAPORATION FROM STREAMS
EVAPORATION FROM THE OCEAN
CONTINENTAL AIR BECOMING MARITIME AIR
INTERCEPTION
INFILTRATION
GROUND WATER TO SOIL
GROUND WATER TO VEGETATION
GROUND WATER TO STREAMS
GROUND WATER TO THE OCEAN
RUN-OFF
THE CIRCULATION OF WATER IN RELATION TO
SEA, AIR AND LAND
AFTER B. HOLZMAN
W. E. L. 18-10-39

Fig. 1.

condensate falls back as rain into the ocean, but some is carried by sea breezes over the land and falls there as rain. A fraction of this rain is evaporated during its downward passage through the air, and some is intercepted by vegetation to be returned to the air by evaporation. The rest falls upon the land and some portion of this water returns to the ocean by surface streams. The balance sinks down below the surface to form soil water and underground water generally, to nourish vegetation, to replenish low level streams, and even to return to the ocean by hidden channels. Evaporation is always operative, causing a return to the air from the surface water, from vegetation by the action of transpiration, and from the soil.

Man is powerless to influence or modify the main factors in this circulation. He can increase the rapidity of run-off by providing artificial channels over limited areas. He can increase or decrease the vegetable cover of the earth and thus affect both run-off and percolation. He can place weirs in valleys and impound much of the run-off in certain places. He cannot yet, however, do anything that will affect the main atmospheric circulation which governs the rainfall. The relief of the land; the major geographical features; the directions of the winds and the succession of cyclones and anticyclones; and the yearly march of the sun from tropic to tropic with its seasonal effect on the weather lie entirely beyond human control, so that man must accept the facts and adapt himself accordingly.

The name *meteoric* is given to the water that is derived from the atmosphere, and meteoric water constitutes by far the greatest proportion of underground water.

The water contained in the sedimentary rocks which were deposited in terrestrial depressions or on the oceanic floor may be entrapped in these rocks by earth movements and subsequently tapped by boreholes or wells. Such water has been called *connate* water. Further reference will be made to connate water in the discussion of the dissolved salts contained in underground water (see p. 101).

Many elaborate classifications of underground water have been formulated, but the most important groups concerned in the problems discussed in this bulletin are those mentioned above. Their relation to other groups may best be appreciated by the study of such detailed papers as R. A. Daly's "Genetic Classification of Underground Volatile Agents" contained in *Economic Geology,* 1917, Vol. XII., pp. 487-504, and O. E. Meinzer's "Outline of Ground-water Hydrology," published as *Water Supply Paper* 494 of the United States Geological Survey.

III. CLIMATE AND UNDERGROUND WATER.

So far as concerns the subject matter of this bulletin some climatological factors are of greater importance than others because of their direct influence.

It is true that climate exercises an indirect control of underground water storage in many ways, since it has much to do with the creation of soil types; the destruction of soil commonly known as soil-erosion; the growth of certain kinds of vegetation, both natural and artificial; the distribution of flocks and herds; and the settlement of the land. The sum total of these indirect controls may be important, influencing, as they do, the amount of water absorbed, the quantity returned to the atmosphere by transpiration, and the quantities withdrawn from the underground storage to maintain animal and vegetable life.

Yet the most significant factors of a climatic character directly governing the accumulation of underground water of meteoric origin are the rainfall, its incidence and reliability, and the losses by evaporation. Temperature and pressure features are, of course, significant in relation to rainfall and the distribution of moisture in the atmosphere, and are involved necessarily in any discussion of rainfall, but are not dealt with separately in this publication.

There is good evidence to show that there have been major differences between the climate of to-day and those of certain periods in the past, some of which are remote in time and are measurable in extremely large numbers of years. One such period is mentioned on a later page (see p. 61) where the ancient mound springs of the Great Artesian Basin are discussed. Other changes of climate have been recorded in different parts of the world as having occurred since man has occupied the earth. There is, however, no satisfactory proof that any appreciably progressive change in climatic conditions has taken place at any point of the earth's surface within the short period over which exact measurements have been made and recorded by meteorologists. For the purpose of this bulletin it is not material to consider whether the earth's climate of to-day is that of the waning phases of the Pleistocene ice age. It suffices to say that no measurable secular change can be indicated as being in progress at the present time, and that recent data, particularly averages over as many years as possible from the many meteorological stations that have been established throughout developed countries, may be taken as a sound basis for the preparation of maps. The data used in drawing the climatological maps here published are those which have been obtained from the Commonwealth Meteorological Bureau.

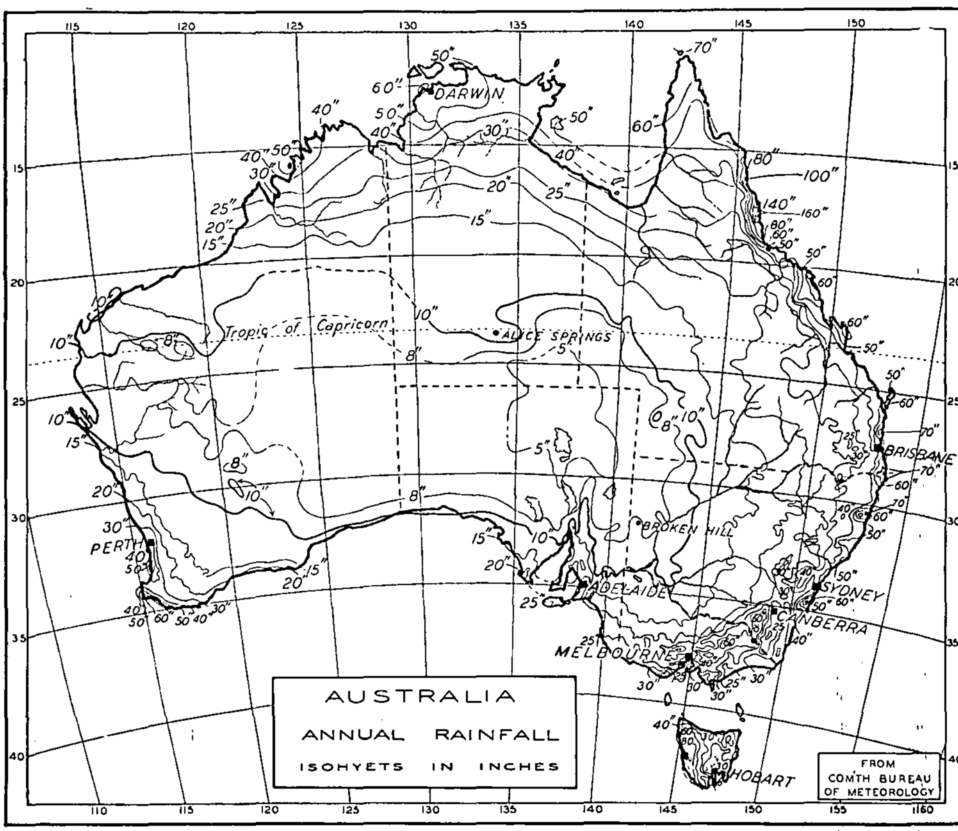


Fig. 2.

The rainfall of the Australian continent is influenced most strongly by latitude, by the fact that the longer axis of this broad land mass lies east and west and therefore with the climatic zones, and by the presence of highlands on the eastern margin of the great island. A great part of Australia lies in the broad zone of high atmospheric pressure situated on the poleward side of the trade-wind belt. This zone moves northwards and southwards with the annual march of the sun between the tropics, and on its southern and northern margins the winter and summer rains affect the southern and northern portions of Australia respectively. The eastern highlands cause precipitation of moisture from the south-easterly trade-winds which bring moisture from the ocean; but these winds bring no rain to the inland and western portions of Australia, since the moving air is being heated during its passage across the land and its capacity for absorbing moisture is being increased. So the regions traversed by the south-easterly trade-winds are arid on the leeward sides of the continents. Features similar to those existing in Australia are exhibited also by South America and South Africa in like latitudes.

On the northern or equatorial side of the trade-wind belt is the zone of tropical rains characterized by low atmospheric pressure, while on its southern side lies the zone of the westerly winds. In the latter zone a succession of cyclonic or low-pressure eddies travels from west to east, each cyclone being wedged as a rule between areas of higher atmospheric pressure, known as anticyclones, which lie to the northward. The rate of travel of the high pressure eddies is somewhat variable, being usually between 400 and 500 miles per day, so that similar climatic conditions sometimes recur at weekly intervals. As the sun moves northwards in winter the cyclones overlap the southern part of the continent and bring the familiar rains of that season. The cyclones are upward-moving eddies of the air, which is chilled as it rises and drops its moisture. The anticyclones, on the other hand, are downward-moving eddies of the air that is being warmed, and are not accompanied by rain except where the currents of air blow from the sea on to the land. Further seasonal modifications of the general atmospheric circulation are caused by the unequal absorption and radiation of heat by land and sea, and monsoonal rains result from summer onshore winds in the far northern part of the continent.

These are the factors that have contributed to produce the rainfall over Australia which is for the most part very unevenly distributed over the year. In the northern part of the continent the rains are typically those of summer and in the south those of winter, while between the two types lies a relatively dry region that may receive some rain from the unusual extension southwards of the summer rain or the extension northwards of the winter rain. The division between the summer and winter rains is a rather ill-defined belt that follows a course diagonal to the continent from Onslow to Sydney. The most uniform region, so far as concerns the rainfall received annually, is the south-eastern margin of the continent.

Griffith Taylor has made an interesting detailed examination of the statistics of rainfall throughout Australia, and in his "Australian Meteorology" has published a map (see Fig. 3) showing the percentage variations from the mean and another map showing the number of months in the year during which over an inch of rain is received in different portions of the continent. These maps of rainfall reliability and uniformity have an important bearing on the absorption of water in different regions. South Australia shows up reasonably well in the reliability map only with regard to its agricultural lands, but the northern parts of the State show extreme unreliability. With regard to uniformity no part of South Australia is so well favoured as the eastern and south-eastern coastal areas in Queensland, New South

Wales, Victoria, and Tasmania or the extreme south-western corner of Western Australia.

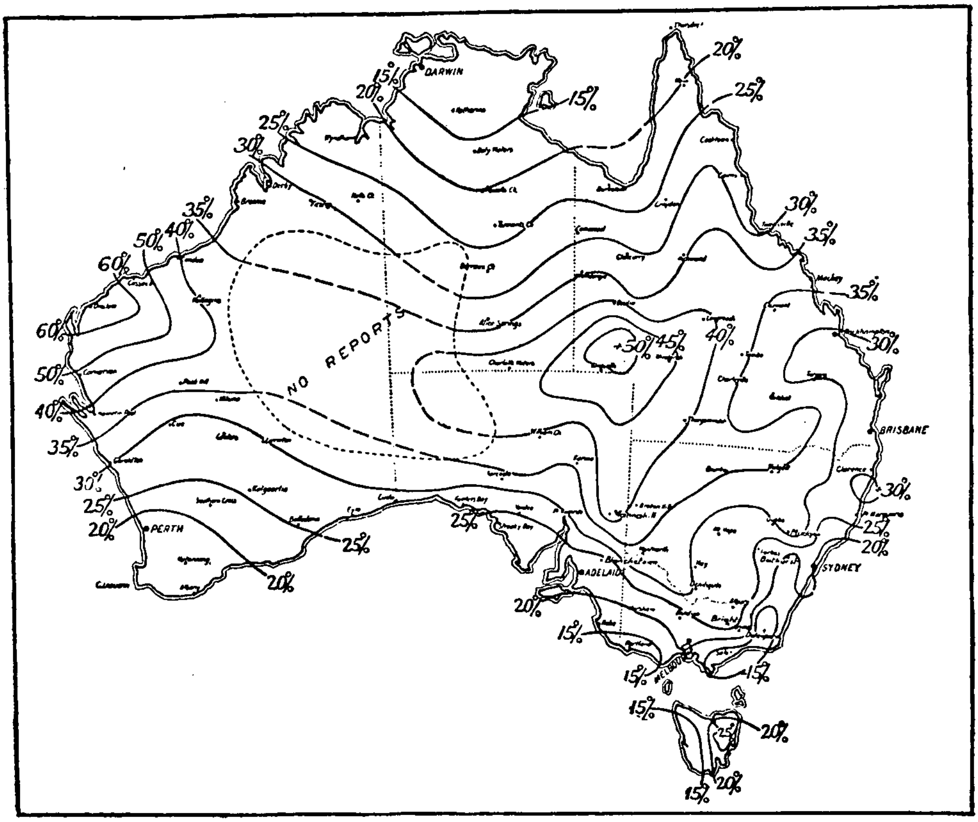


Fig. 3.—The variability of rainfall. Percentage variations from mean annual rainfall are shown.

When the rainfall of Australia is studied in relation to the territorial boundaries of the several States it is seen that the distribution of arid and well-watered country is irregular. The following table, taken from the Commonwealth Year Book, shows the relative positions of the States according to the Meteorological Bureau:—

Average Annual Rainfall Distribution.

Average Annual Rainfall.	N.S.W. (a) %	Vic. %	Qsld. %	South Aust. %	W.A. %	Tas. (b) %	N.T. %	Total. (b) %
Under 10in.	19·7	Nil	13·0	82·8	58·0	Nil	24·7	37·6
10in.-15in.......	23·5	22·4	14·4	9·4	22·4	Nil	32·4	19·9
15in.-20in.......	17·5	15·2	19·7	4·5	6·8	0·7	9·7	10·9
20in.-25in.......	14·2	17·9	18·8	2·2	3·7	11·0	6·6	9·1
25in.-30in.......	9·1	18·0	11·6	0·8	3·7	11·4	9·3	7·3
30in.-40in.......	9·9	16·1	11·1	0·3	3·3	20·4	4·7	6·6
Over 40in.......	6·1	10·4	11·4	Nil	2·1	56·5	12·6	8·6
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

(*a*) Including the Australian Capital Territory.
(*b*) No records are available over an area of 2,777 square miles.

These statistics show at once the difficulties that South Australia is surmounting in fostering permanent agricultural settlement, and those which have to be overcome in maintaining the productivity of the large proportion of the State which is occupied by pastoralists.

Before passing to the consideration of the special features of rainfall in South Australia it is necessary to look briefly at the ascertained facts regarding evaporation. The annual evaporation over almost the whole of Australia is greatly in excess of the annual rainfall and the amount of this excess is shown on the map (see Fig. 4) drawn to record the net

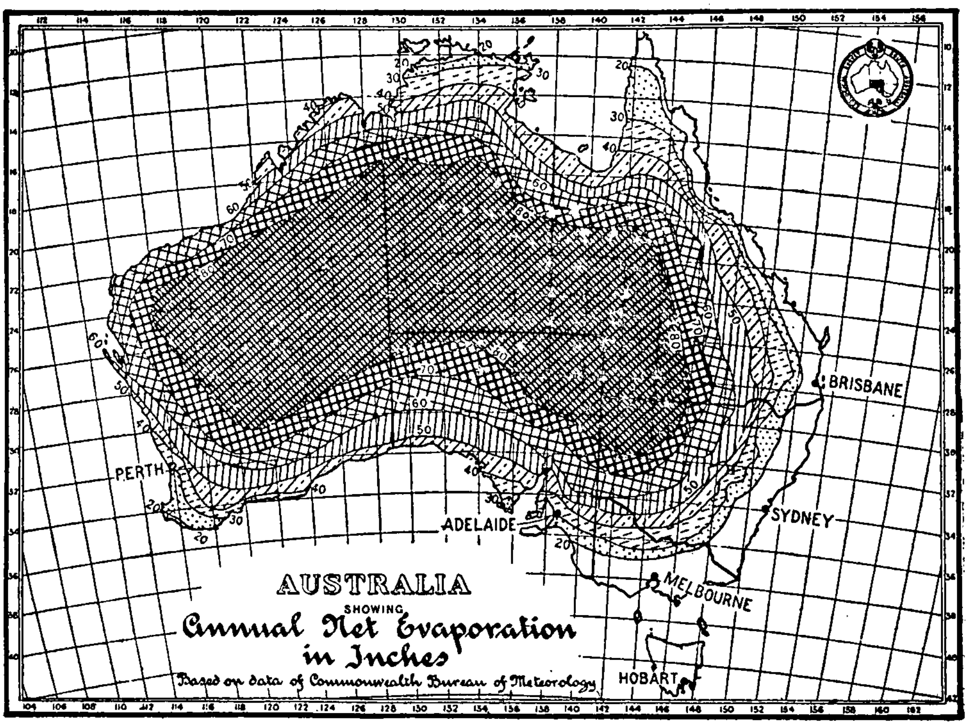


Fig. 4.

evaporation. This information must be ever kept in mind, when considering all questions concerning the amount and quality of the underground water obtainable in a given region, for in a large part of South Australia the proportion of the rainfall lost by evaporation greatly exceeds that which sinks into the ground or returns by streams to the sea. Much of the rainfall in this State finds its way directly or indirectly into shallow lakes or depressions which are quite dry during the greater part of the year through the rapid evaporation of the water that reaches them at intervals. Even where there are no defined lakes or clay-pans, evaporation aided by some percolation suffices to dispose of the rain water leaving some parts of the South Australian highlands as soon as it reaches the piedmont plains. For this reason there is remarkable paucity of streams which actually discharge their waters into the sea along the South Australian coast. Where stream channels persist as far as the shore it must be remembered that many of these are occupied only for a brief space following upon exceptionally heavy falls of rain.

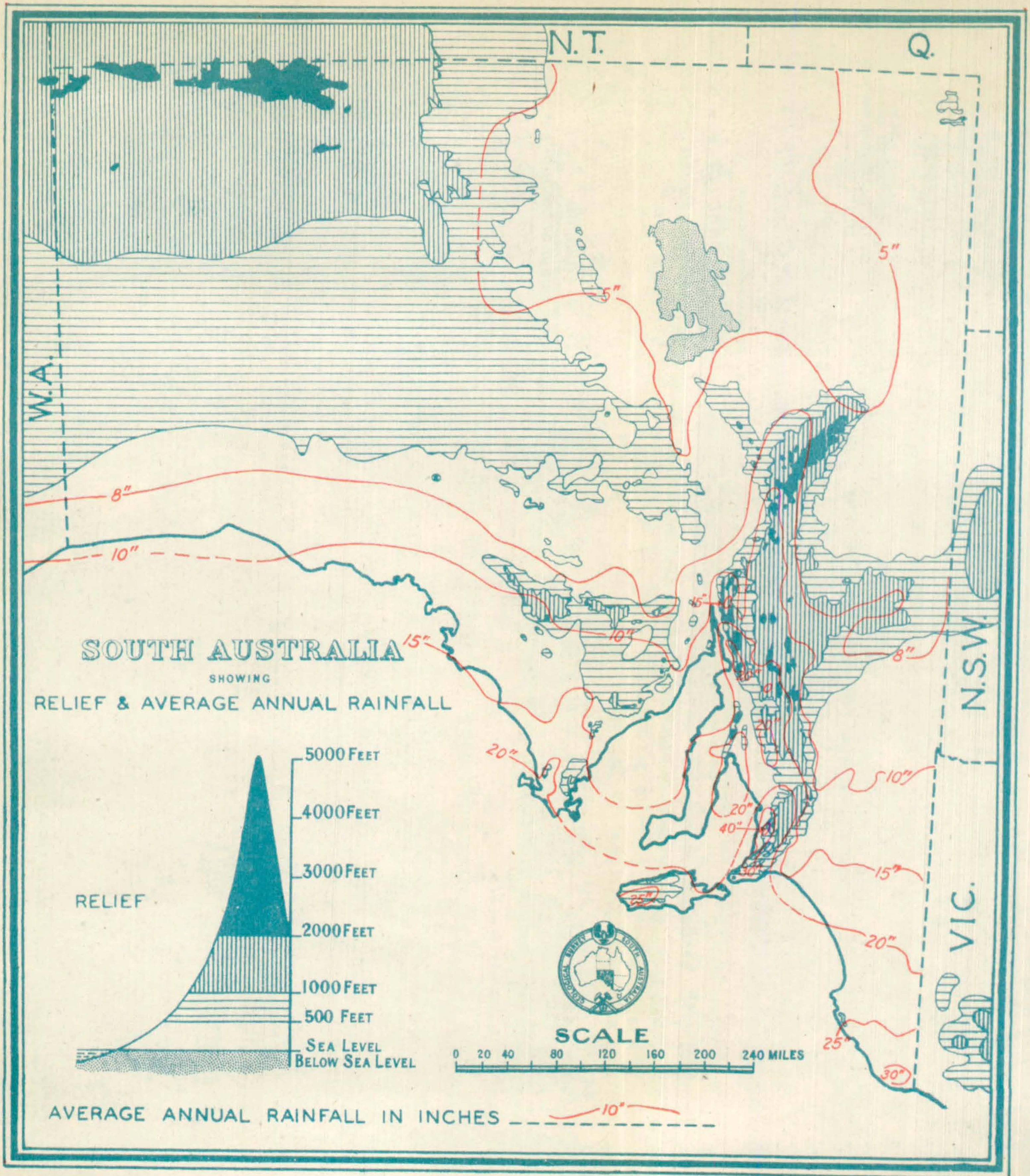
Returning to the map of Australia showing the average annual rainfall, we see that the isohyets are arranged in general conformity with the continental coastline, but that they are displaced towards the west by the eastern coastal precipitation. On looking more closely at the portion of Australia that includes South Australia and the Northern Territory we observe a rough parallelism of the isohyets with a general east-west trend. The lowest rainfall of the continent is centrally situated, in the Lake Eyre basin, whence the annual precipitation increases in both southerly and northerly directions. In the north the curves of the isohyets are smooth, but in the south there are marked meridional "promontories" in both the 10-in. and 20-in. isohyets. To understand these irregularities in the lines of equal annual rainfall we must examine South Australia more closely. The map showing the relief of the land and, superimposed upon it in red, the annual rainfall (See Plate I) shows at once how intimate is the relationship between elevation and rainfall, and how this connection is accentuated by the meridional disposition of South Australian highlands. If attention is fixed upon the 10-in. isohyet it will be seen that it has a general easterly trend from the western boundary of the State to Port Augusta, where it turns sharply northwards and clings to the Flinders Range. On the eastern side of the range this isohyet resumes its easterly course between Morgan and Renmark, but the action of the highlands in causing precipitation has displaced this isohyet about 100 miles farther to the south than it was on the western side of the range. There is a corresponding deflection and displacement of the 15-in. isohyet by the lower Flinders and Mount Lofty Ranges. Isolated areas receiving over 20in. of annual rainfall occur in the most elevated portions of the highlands. A break occurs in the isohyets at the Kapunda gap, and they resume their position on the northern side of the gap where the land rises.

It will be noted that the high region in the far north-western part of the State, including the Musgrave Range, does not affect the rainfall, so far as we know. High country, thus placed in the heart of a continent and within a few degrees of the tropic of Capricorn, cannot be expected to induce rainfall, since the winds reaching the ranges are not moisture-laden.

So far as evaporation is concerned it will be observed that the lines of equal net evaporation conform more closely to the general continental outline than do the isohyets. The evaporation is greatest in the northern part of South Australia, where the variations from the mean are more pronounced and where the number of months during which rain is received is smallest.

These features regarding rainfall and evaporation accentuate the need for the pastoralist to rely upon water that is stored beneath the surface and thus protected from the evaporative influence of the sun's rays.

Most people in any community have no difficulty in understanding the occasional failure of a surface reservoir in time of drought, but many fail to appreciate that an underground storage must be replenished periodically if supplies are drawn from it, and that this restoration is directly dependent upon rainfall. Certainly it is true that in some cases, such as that of the Great Artesian Basin, many of the subterranean supplies were absorbed far from the sites of the boreholes in this State, and that the artificial draught at any one spot is small in proportion to the quantity stored in the aquifer, but such cases are exceptional and are due to special conditions of occurrence. The great majority of underground water supplies is derived from water that has fallen as rain in the immediate vicinity of the site of the borehole or well. For this reason the features of rainfall are of primary importance in the selection of any site.

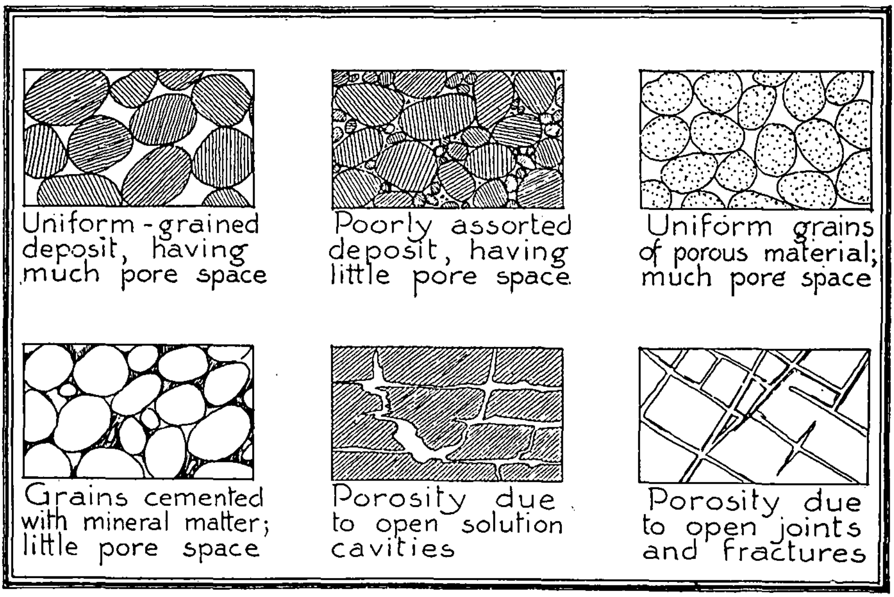


T.E.E. MOORE, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE

IV. HOW WATER IS STORED BENEATH THE SURFACE.

The very common popular belief in underground "streams of water" occupying narrow channels, comparable with the beds of surface streams, is almost wholly wrong. While it is true that in some districts where limestones occur there do exist openings that are not unlike pipes and that carry water, these occurrences are restricted to such rocks and are concerned with a mere fraction of the underground water supplies. In general very different conditions exist, and it is fortunate for those who have to rely upon underground supplies that such is the case, since a small restricted channel would be depleted rapidly by an artificial draught.

The storage of water in the rocks of the earth's crust is effected by the filling of cavities, spaces, or openings of different kinds, which owe their form, size and continuity to the textural and structural features of the particular rocks present at each locality. Since the variety of the rocks is great there is also great variety in the characters of the storage spaces. Some rocks are incoherent aggregates of grains; others are made of such grains tightly packed and consolidated; others again are compact masses



After O. E. Meinzer.

Fig. 5.—The relation of rock texture and structure to porosity.

of crystals closely interlocked; and yet others are composed of dense homogeneous glass. Such rock types and many others exhibit notable differences in their water-carrying capacity. (See Fig. 5).

Of all rocks, the sediments, consisting of fragments of mineral matter deposited by the agency of wind and water, are those which are the most common sources of the water stored underground and tapped by wells and boreholes. The constituent fragments of sedimentary rocks are variable in shape and size. Some are rounded, others angular, and others again are subangular. Where natural sorting of the fragments according to size has taken place the most porous aggregates are formed. It may be shown by a simple mathematical calculation that the porosity—that is the percentage of the whole rock aggregate occupied by voids or interstices—is greatest and 47.64 per cent when the particles or grains are spherical and so packed that the lines joining their centres form cubes. This arrangement, however, is not a stable one, and the most compact aggregate of equal round particles is that in which the grains are so placed that the lines joining their centres form equilateral rhombohedra having facial angles of 60 and 120 degrees. In this most compact arrangement of equal spherical grains the porosity is 25.95 per cent. The actual size of the individual grains is quite immaterial in such cases, the porosity being entirely independent of size. It is, however, a rare thing to find rock masses composed of grains all of which are equal and between which there is no filling. It is usual to find sedimentary aggregates composed of constituent particles the sorting of which according to size is far from complete, or having a portion of the interstitial spaces filled with mineral matter deposited from solution. In unsorted aggregates the smaller particles occupy portions of the voids between those of larger size and the porosity is thereby reduced. Those who are familiar with the construction of the modern bituminous-concrete road will best appreciate this point; for they will remember that stone of various sizes is mixed in the aggregate with the object of reducing the percentage of spaces that must be filled with the expensive bitumen used as a cementing medium. Similarly the amount of portland cement required in concrete is reduced to a minimum.

In many sandstones the deposition of silica from solution may proceed so far that a rock originally consisting of loosely coherent grains becomes a dense crystalline quartzite with a very low porosity. In sandstones of other types there may be clay, carbonate of lime, or limonite between the grains of silica and the porosity may be reduced accordingly.

Less commonly found cavities occurring in very porous rocks are the vesicular spaces in volcanic rocks, and the cavities in the constituent fragments of which some limestones such as the polyzoal limestone of the Mount Gambier district are composed. In such rocks the porosity is high, but the rock types are not found in many places and are on that account of less general importance.

The more compact rocks such as the crystalline igneous rocks—granite, basalt, diorite, syenite—as well as the metamorphic rocks such as gneiss, schists, slate or quartzite, may possess some measure of porosity when considered in large masses, although the material of which such rocks are made is itself dense and almost free from interstitial cavities. In these cases the porosity is due to cracks, crevices and fissures of all kinds. Openings of this character are important where they are numerous or large. In certain rocks which are soluble in water, such as limestone and dolomite, the openings may be so enlarged by solution as to constitute important reservoirs for underground storage.

O. E. Meinzer in his paper on "The Occurrence of Ground Water in the United States," published as *Water Supply Paper* 489 of the United States Geological Survey, in giving an account of actual determinations of porosity, states that a porosity of over 40 per cent is rare except in soils and recent deposits; that 5 per cent is a small porosity; one between 5 and 20 per cent is a medium porosity; and over 20 per cent is large. The actual determinations recorded by Meinzer show the following ranges in porosity, expressed as percentages by volume:—

0.02—1.85 per cent for granite, schist and gneiss.
4.81—22.8 per cent for sandstone.
0.53—13.36 per cent for limestone, marble and dolomite.
3.4—37.7 per cent for gas and oil-bearing sandstone.

Some of the openings in rocks of dense texture are those which owe their origin to the conditions under which the rocks were formed, such as the bedding planes between successive layers of sedimentary material, or the parting planes between sheets of lava that has filled a depression in a series of flows.

On the other hand there are, in practically every kind of hard rock, joints which result from strains developed in the rocks after their formation, by shrinkage, pressure or deformation. The result is that a hard rock is separated into blocks the shape and size of which are determined by the position and spacing of the joint planes. In most sediments there are two sets of joints, approximately at right angles to each other and normal to the bedding. Where the sedimentary rocks are undisturbed the joints are vertical, but they are to be seen inclined at all angles in the tilted and folded beds. There is much less regularity in the spacing and disposition of the joints traversing the massive igneous rocks such as granite. Here there may be three sets of joints varying in the degree of development, the strongest and most regular being those parallel to the surface of the igneous rock at the time of its consolidation. The joints due to shrinkage on cooling are remarkably regular in some lava sheets, and prismatic or columnar jointing results. This type is well shown by the basalt near Kingscote on Kangaroo Island.

Joints are accentuated by weathering and hence they are less pronounced as they are followed downwards, a fact that may be seen in any deep rock-quarry. Further reference will be made on a later page to this important fact, which has a direct bearing upon the water-bearing capacity of the hard rocks in depth.

In addition to the bedding planes and joints, the openings due to the actual breaking of the rock mass and the relative displacement of the two sides of the fracture call for mention here. These fractures are called "faults," and they are found in rocks of all kinds. The fault surface or fault plane may be an important source of underground water, whether it is a simple fissure or a "shear zone" composed of a number of minor fault planes. These latter zones may be filled in part with fragments of broken rock which constitute a "fault breccia," and from such shear zones come some important supplies of underground water. A typical case is that situated at the Bird-in-Hand mine near Woodside.

These openings or spaces vary greatly in size, and the size has an important bearing upon the occurrence of water found beneath the surface, since other forces than that of gravity become effective in very small openings. The molecular attraction between adjacent molecules of water (cohesion) and between adjacent molecules of rock and water (adhesion) is real and important, especially in rocks of fine grain, since in fine-grained aggregates the surfaces of the interstitial spaces are increased proportionately with the diminution of the size of the component grains. According to the size of the openings they are classified as super-capillary, capillary, and sub-capillary. In the super-capillary openings molecular attraction has no appreciable effect, and the ordinary laws of hydrostatics are applicable, but in the capillary openings water rises above the level of that into which the opening extends. It will be seen on a later page that capillarity is observable just above the water table. (See Fig. 6).

V. THE MOVEMENT OF UNDERGROUND WATER.

The water contained in the cavities and pore spaces of rocks is practically invariably in motion, even though the rate of movement is exceedingly slow. It is nearly impossible for any body of underground water to be stationary. Even a closed basin suffers loss by the movement of its contained water under the action of capillarity, the transpiration of vegetation and atmospheric evaporation. A perfect state of balance is almost impossible of achievement, and, if achieved, movement begins as soon as the balance is disturbed.

There is clear evidence of the motion of underground water from several ascertained facts, the most significant of which are those concerned with the chemical work performed beneath the surface. Mineral matter is ever being transformed in chemical character; some is removed in solution; and some is deposited elsewhere. In a few places it is possible to observe the motion of the general body of ground water, as, for example, in limestone caves deep enough to expose portions of the water table. Objects floating freely on the surface of underground "lakes" and "rivers" in these caves acquire the motion of the water, and the rate and direction of movement may be observed readily.

It will be apparent also that there must be a movement of water through an aquifer from which large quantities are drawn in order that the supply may be maintained. In the case of an aquifer that is relatively small when compared with the draught it is all the more necessary that water should flow freely into the depleted portion.

The chief cause of the movement of underground water is slope or difference of pressure. Gravity is the controlling influence and water always moves down a slope or down the pressure gradient. The water table and the hydraulic surface, described later, are respectively real and imaginary surfaces that express the distribution of water level and hydraulic pressure. Ground water moves down the steepest slope of the water table, and pressure water moves down the hydraulic grade. Such movement is inevitable, and no assumption is involved in the statement that it takes place. The freedom of ground water to move is inherent in its definition, and gravity will cause the flow of water from higher to lower levels. In the case of pressure water the hydraulic surface represents the fall of pressure, at all points within the basin from the intake of the aquifer towards its outlet, and the movement at each point is in the direction of the lowest pressure under the influence of gravity.

In this discussion of the motion of underground water from an economic standpoint, in connection with the development of supplies for domestic and other uses, it is not proposed to deal with such matters as movements due to crustal deformation, the consolidation of sediments, expansion and contraction on change of temperature, and the action of capillarity. Those who desire to consider them will find them discussed in the XIX. *Annual Report of the United States Geological Survey*, Part ii., 1897-1898, where there is printed a paper by F. H. King entitled "Principles and Conditions of the Movements of Ground Water"; and in *Water Supply Paper* 67 of the United States Geological Survey where C. S. Slichter deals with "The Motions of Underground Waters."

The rate of movement of underground water is governed by a number of factors. The porosity of the aquifer, both as regards the degree of porosity (the percentage of empty spaces or voids) and the size of the pores, is most important, as the rate of flow rises greatly with an increase in the percentage and size of the openings used by the moving water. The pressure gradient measured in the direction of the flow gives a greater velocity as the grade steepens. Other conditions being equal, the rate of movement increases as the temperature rises.

It is difficult to state with confidence what the rate of movement will be in any natural aquifer because of the variability of porosity and of the size of the pore spaces from point to point. Temperature and the pressure gradient as well as the distance between two points in the aquifer are more readily measured. Formulae have been devised to provide an estimate of the rate of movement for certain conditions, but the actual results obtained may not correspond with the calculated rate through the intervention of variations of character in different parts of the aquifer.

It is possible to make direct observations of the motion of underground water and some such observations have been made in South Australia. In the case of ground water within an area that receives periodic accessions of water representing part of the rainfall on an up-grade catchment, in addition to the locally absorbed proportion of the rainfall over the area, it is found that the rise of the water table moves forward with a defined crest, rather like a slowly advancing wave. An excellent example of this movement is given by the records preserved by the South-Eastern Drainage Board for a number of wells situated in Counties Robe and Grey in South Australia. The rise and fall of the water level in three wells of the series is shown in Plate II. printed in *Bulletin* 19 of the Geological Survey, which contains also contours of the water table at specified dates. On page 16 of that publication the contours for dates separated by five months are given, and the westerly displacement during that period shows how slow the movement of the advancing wave really is—from one to two miles in five months. The lateral motion of the deeper ground water is probably much slower than that of the crest of the wave, which must be influenced strongly by local absorption in this particular area.

On Western Eyre Peninsula R. Lockhart Jack has recorded the rise of water in Condodringie Well in 1911 after wet winters in 1909 and 1910 by an amount of over 30ft. The water had travelled underground for a distance of about two miles from its point of absorption about 200ft. higher. A similar rise was noted for Yantanaby Well in 1911 (See *Bulletin* 1, Geological Survey of South Australia, p. 22).

The case of pressure water is rather different, where an aquifer has been depleted during a drought by excessive artificial draught or by loss through natural outlets. The supply of water to the upper part of the aquifer, on the breaking of the drought, will gradually re-establish the normal conditions of pressure after the level in the uppermost part of the aquifer reaches its normal position. The first water obtained on the rise of pressure has not travelled all the way from the intake to the borehole during the time between the replenishment of the aquifer and the observed time of rise in the borehole. It is water that has been stored in the aquifer forced upwards by the restoration of the head or pressure when the aquifer fills.

Several different methods have been used in tracing the movement of underground water for the purpose of ascertaining the rate of circulation, and more often for detecting sources of contamination in domestic water supplies. In some cases soluble salts have been introduced into the aquifer and have been carried along with the water to points where samples are drawn from wells, springs or even temporary boreholes drilled for the purpose. Sal ammoniac has been found the most satisfactory electrolyte to use for tests of this kind and can be detected very readily by electrical apparatus. In a few cases use has been made of materials such as flour or starch, suspended in the water; and many underground circulation problems have been investigated by the help of soluble stains introduced into the aquifer. The most satisfactory of these stains is fluorescein which is a coal-tar product. Any such indicator should traverse the aquifer at the same rate as the water; it should be easily detected in the samples taken; and it should not be subject to decomposition, nor should its intensity be altered by any materials with which it comes into contact. These methods are discussed in detail in several publications of the United States

Geological Survey, notably *Water Supply Papers,* 67, 140, 160 (use of fluorescein) and *Professional Paper* 44.

O. E. Meinzer and L. K. Wenzel, in the recent book *Physics of the Earth—Hydrology,* draw attention to the variability of the rate of travel in the following statement:—

> "In field tests rates of movement of several feet a day have been found and in one place a rate of 420ft. a day was reported. The most permeable material that has been tested in the hydrologic laboratory is a gravel which under a hydraulic gradient of 10ft. to the mile will carry water at the rate of 60ft. a day. In nature rates of more than a few feet a day are exceptional. The lowest rate at which water has been observed to move through a natural material in the tests made in the hydrologic laboratory was about 1ft. in 10 years. Probably in nature, under much lower gradients, even much slower rates of movement are common in dense and poorly permeable materials. In the recognized water bearing formations, from which wells obtain their water supplies, the natural rate of movement of the ground water is generally not greater than 5ft. a day and not less than 5ft. a year. An example of a more or less average performance of a moderately productive water-bearing formation is afforded by the Carrizo sandstone in the Winter Garden region of Texas, in which the water was computed to be moving at an average rate of about 50ft. a year."

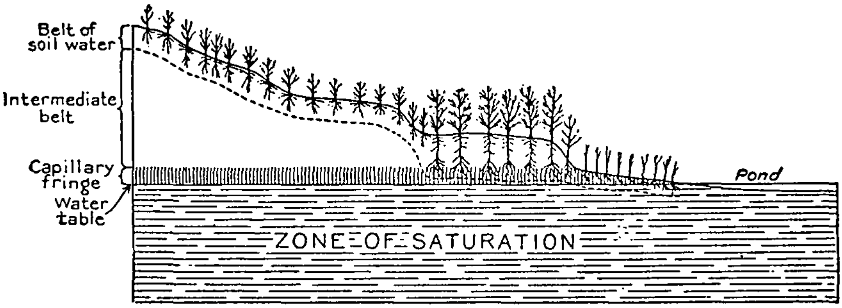
Figures such as these should be borne in mind. It is commonly believed that the rate of motion of underground water is comparable with that of water moving in open channels at the surface, but this belief is quite false. The chief factors controlling the rate are the grade and the resistance offered to movement by the nature of the material through which the water has to pass. Many people have noticed the time lag between rainfall and the rise of water in a well, and have failed to take into account the time taken for water to percolate both downwards and laterally.

To quote another case of actual measurements, made with the utmost care, the instance of Long Island, New York, U.S.A., may be taken. Here the rate of movement near the surface (16ft. to 24ft. below the water table) was found to be as much as 5ft. to 12ft. a day; and at somewhat greater depths (30ft. to 42ft. below the water table) it was 15in. a day. In this case the slope of the water table is between 10ft. and 12ft. to the mile, and the area examined has an average annual rainfall of 44in.

VI. THE VERTICAL DISTRIBUTION OF UNDERGROUND WATER.

Water that is absorbed at the surface is held in part by molecular attraction in the soil and subsoil, but most of it sinks under the influence of gravity to the level at which all the rock openings are full of water. This level is called *"water level,"* and the free upper limit of the ground water which fills the rock openings is called the *"water table."* It is visible where a well or other artificial opening is sunk deeply enough to enter the *"zone of saturation,"* of which the water table is the upper surface, and is sometimes visible also where exposed in natural openings, such as caves or deep volcanic craters like those at Mount Gambier. The water table reaches the surface at the points of emergence of spring water and along the course of a running stream.

Meinzer has suggested the term *"zone of aeration"* for the permeable rocks above the zone of saturation. In the lower part of this zone of aeration and immediately above the water table is a moist zone that has been called the *"capillary fringe,"* since water is drawn up into it from the zone of saturation by capillarity. It is a zone of small but variable thickness, and is recognized by well sinkers in all parts of the world as a sign of the proximity of water. (See Fig. 6.)



After O. E. Meinzer.

Fig. 6.—Section showing position of the capillary fringe.

The accompanying diagrammatic section (Fig. 7) indicates the relative positions of the several zones in an area within which there occur dense rocks undergoing normal weathering and the development of a soil cover.

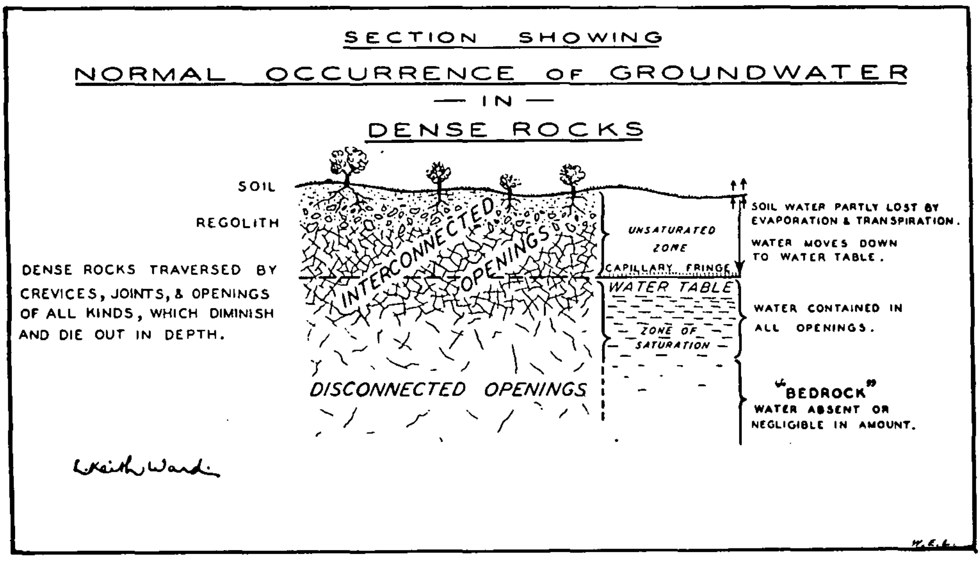


Fig. 7.

In the zone of saturation the ground water is stored in the interstices of loose sediments, in the joints and bedding planes of those which are compact in texture, and in the joints of the older dense foundations of the sedimentary superstructure.

Little is known regarding the lower limits of porosity except in mining fields, in many of which it has been found that the lower level workings are quite dry, although water was encountered at shallow levels, being discharged from fissures. The evidence available points to the rarity of joints and other openings large enough in depth to be capable of storing water in appreciable quantities, apart from the major fault planes and shear zones in which ore bodies occur.

It seems certain that in the deepest portions of the crust all openings disappear from even the strongest rocks by the yielding and flowage of the mass, but this zone of flowage is beyond the reach of exploitation and need not be considered further here.

On a later page of this bulletin it will be noted that there are instances in South Australia of very deep boreholes from which large supplies of water are obtained, but these are special cases due to peculiar structural conditions under which porous sediments are penetrated by drilling at great depths below the surface. Such conditions differ in essential respects from those which exist in the dense rocks.

The depth below the surface at which the water table occurs is by no means constant. The local conditions, especially those concerned with the character of the rocks and the geological character, are governing factors, and topography and rainfall are always important. Consequently no general statement is applicable to even a small area unless the rock structure and relief are uniform within its boundaries.

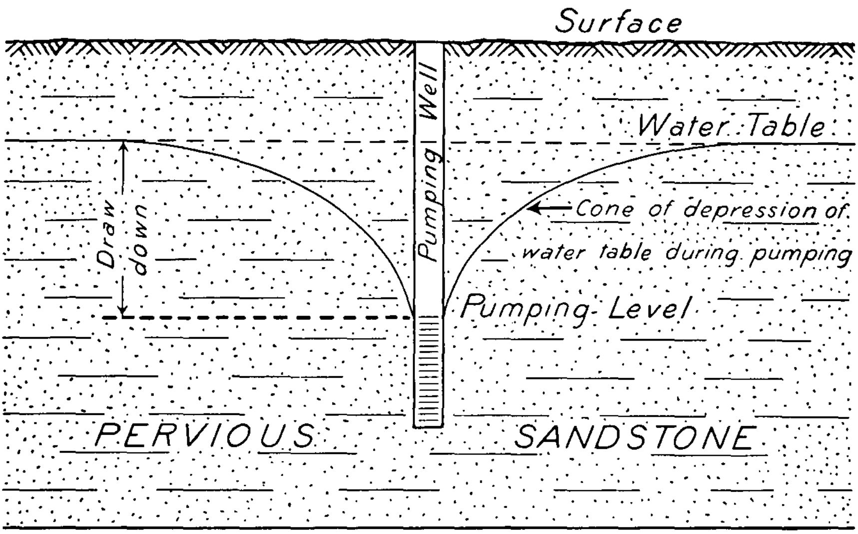
The water table is not a plane surface. It has some resemblance to the surface of the area within which it lies, but its irregularities are less pronounced. It is deepest beneath ridges and actually touches the surface in low-lying places where springs, creeks, or lakes exist. If it is desired to give an accurate representation of the water table in any particular district, this is done by means of contour lines in precisely the way adopted for showing the relief of the land. An example of such mapping in South Australia appears in *Bulletin* 19 of this Geological Survey (see p. 16 of that publication). The usual method is to refer the contours to the sea level datum that is used for showing surface topography. The slope or gradient of the water table at a given place is measured in the direction in which the slope is steepest.

From maps showing the relief of an area and the contours of the water table the depth of the ground water below the surface at any point within the area is readily obtainable.

It is most important to remember that a time factor affects all measurements of the height above sea level or the depth below the surface of the water table. For the water table is subject to fluctuations caused by influences which vary from time to time. In regions of uniform rainfall there may be little variation, but there is a marked seasonal variation in a large part of South Australia where the proportion of the annual rainfall that falls in the winter months is large. The draught on a well during the dry season accentuates the natural variation in water level. Any map representation of a water table should, therefore, bear a date to show the time to which the plotting has reference. The seasonal variation in water level may be over 100ft.—a figure that has been observed in a well near Melrose.

Other natural influences that affect the water level are floods in river channels, and, in the case of wells close to the shore, the rise and fall of the tide. Less commonly noticed are the small effects of changes in atmospheric temperature and pressure.

Any artificial draught upon the water stored underground will be reflected in the level of the ground water, a depression resembling an inverted cone being formed temporarily in the water table round the pump. (See Fig 8). An obstacle, such as the impervious foundation for a structure placed in the alluvium of a river channel, will play the part of an underground dam and raise the water level appreciably above the obstacle. An instance will be given on a later page (see p. 33) to indicate a South Australian locality where fluctuations of this kind have been observed.



SECTION SHOWING HOW WATER TABLE IS DEPRESSED DURING PUMPING FROM WELL SUNK IN PERVIOUS MATERIAL

Fig. 8.

In some localities, where the ground water is stored in porous sediments occupying valleys or depressions, there may be buried beds of clay which prevent the sinking of the absorbed water to the full depth of the basin filled with alluvium. A well sunk at such a place may reveal an upper water table above the impervious layer and appreciably higher than the main water table. The upper water table in such a case is described as a *"perched," "suspended,"* or *"hanging"* water table. Useful supplies of water have been obtained from them in some parts of western Eyre Peninsula, where their importance is great on account of the much higher salinity of the main body of water found at a lower level.

There is a problem connected with the search for supplies of underground water by boring or well-sinking that calls for detailed comment in this place. This problem is that concerned with the decision to continue or stop operations when no water has been found or when the supply is insufficient for requirements. The term *"bedrock"* has been used in many conditions of contract between farmers or pastoralists on the one hand and drilling contractors on the other, and it is necessary to consider carefully the limitations of this term. No exact scientific definition can be framed regarding the nature of the rock or the attainable depth at which it is impossible for water to be obtained. Yet the conception is a useful one in actual practice, and some discussion is given here in explanation of the meaning that should be given to the term "bedrock."

Many boreholes and wells penetrate the sediments deposited by the action of wind, water, or ice, or the superficial mantle of detrital matter overlying undecomposed and dense-textured rocks. It has been explained above that these latter rocks may be traversed by cracks, fissures or crushed zones which may afford the openings in which water may be stored in appreciable quantities. Some of these openings are numerous in the zone of weathering, but do not extend far downwards into the compact unweathered rocks. Yet others—the fault planes and crush zones—are of deep-seated origin and descend into the deeper parts of the crust of the earth. These fissures, however, are not always visible, being covered by the later deposits, so that a vertical borehole may tap an inclined fissure unexpectedly after piercing a notable thickness of dense rock having no openings in which water can be stored.

It is known, from actual experience, that the normal cracks, crevices, and joints, occurring near the surface are interconnected. They become smaller, less abundant and disconnected as depth is attained. In most cases they are too few and too constricted to be of practical value at depths of from 200ft. to 300ft. from the surface. Exceptions may exist where weathering has proceeded to an abnormal depth or where surface streams have dissected the country deeply, but such cases are comparatively rare.

If dense rocks (such as granite, slate, quartzite, schist), wherein water is contained only in fissures, are covered with sand and gravel a borehole may pass through these overlying sediments into the dense rock below, and the question of the advisability of continuing or stopping boring arises. The problem is much the same as that discussed above, but differs in that there is a probability that erosion has removed the portion of the dense rock that carries the greatest number of fissures in which water can be stored. Hence it is generally inadvisable to continue boring to so great a depth as if the dense rock were continuous to the surface. In many cases it has been found that, after penetrating 20ft. to 30ft. of the rock no further supplies were obtained. Each case, of course, must be treated as a separate problem, and deeper penetration would be advisable if the drilling showed that weathered and fissured rock was still present at the bottom of the hole.

From this statement it will be apparent that there cannot be said to exist any such thing as a "bedrock." The character of the rock itself counts for little in the search for water as contrasted with the openings, cracks, or fissures, of whatsoever kind existing in the rock. Yet, however undesirable it may be, the term "bedrock" seems likely to be retained in actual practice. If used, a proper meaning should be attached to it, and this meaning should be as follows:—

> *"Bedrock" is the limit below which there is no reasonable expectation of obtaining commercial supplies of water.*

This is the meaning attached to it by the Interstate Conference on Artesian Water and published in the report of that body.

The valleys of many rivers and streams are partly filled with sand or gravel and the water channels of the present day are in many cases excavated in these porous materials. A considerable amount of water may flow beneath the surface in the porous sediments beneath or close to the stream channel. This subterranean body of moving water is generally referred to as the "*underflow*" of the surface stream.

Where the valley is constricted the underflow has dimensions similar to those of the stream, but it tends to merge, where the valley opens out upon a plain, into the broad sheet of underground water. The underflow may augment the surface flow at points along the valley where the rock bottom is closer to the surface or where the valley becomes narrow. There may be even a small underflow through the crevices and joints of hard rocks close to the bed of the stream. The underflow is an important source of water where the surface stream is intermittent, as in the case of many streams in South Australia which flow for a few days or weeks only after heavy rain, but which may have a perennial underflow.

VII. FLUCTUATIONS OF WATER LEVEL.

All who have depended upon water supplies drawn from wells have noted the alterations in the standing level of the water from time to time. These changes of level are generally the major fluctuations, those of a minor character with a small vertical range being seldom observed. Yet careful observations will reveal fluctuations in practically all wells. The standing level of water in a well is, of course, that of the water table at that time and in that place. The water surface in the well is an exposed portion of the water table, and all variations in the character of the water table are reflected in the wells sunk in that area.

The most obvious fluctuations are those which are the direct result of irregularities in the precipitation of rain. There would be no changes of level if the quantities absorbed did not vary and if no artificial draught existed, for a state of equilibrium would be reached and the water table would remain fixed in position. However rainfall varies from day to day, from season to season, from year to year, and over longer periods embracing groups of years. In the southern part of South Australia there is a strongly marked seasonal preponderance of rainfall during the winter months; and in the northern part of the State, where the seasonal influence is not so marked, the variations from the mean annual rainfall are most striking.

From what has been written above regarding the movement of underground water it will be appreciated that the rise of the water table depends not only on the amount of rainfall absorbed at the site of the well, but also on the amount absorbed at higher levels. Excellent examples of this influence are given by the records made by the South-Eastern Drainage Board in the wells situated in Counties Robe and Grey, and described in *Bulletin* 19 of the Geological Survey of South Australia. The influence of the water absorbed at a distance may not be felt for so long a time that the rise of the ground water may seem to be anomalous. The apparent anomaly is explained at once if a study is made of the changes of level in different wells along the slope of the watertable, for it will be seen that the water level rises in each well at a date subsequent to that of the rise of level in the wells higher up the slope.

In *Geological Survey Bulletin* 19 the writer has analysed in some detail the features of the rise and fall of water level in the Blue Lake at Mount Gambier, and has shown that there is some connection with the local rainfall, when the annual precipitation is plotted cumulatively. Minor variations in the water table are, however, not accounted for by this procedure, and the problem is a complex one by reason of the fact that both ground water and pressure water apparently mingle in the Blue Lake in proportions that cannot be estimated with any certainty. The predominant influence, however, appears to be that of the rainfall in County Grey within which Mount Gambier is situated.

A few miles to the north of Mount Gambier there is a flooded area known as the Dismal Swamp, where attempts have been made to drain away the swamp water by conveying it into sinkholes in the limestone. Such a method can succeed only where the sinkholes connect with a water table at a lower level than that of the swampy ground, for the water table coincides with the level of the water in the swamp and has been observed to vary as much as 20ft. between wet and dry seasons.

There are many wells throughout South Australia in which a noteworthy fall of the water level is observed in summer, and a still more notable fall during a drought. One case that has been brought under official observation is that of the wells in coarse gravel at the Mount Remarkable training farm, near Melrose, where the water stands almost at the surface in wet seasons but falls over 100ft. in drought periods. This is an exceptional case in which the magnitude of the fall is due to the permeability of the alluvium and the consequent free escape afforded to the water. In many other cases water levels in wells have fallen many feet, so that the wells have become dry. It may be possible in such cases, by deepening the well sufficiently, to recover a supply from the sunken water table.

From the consideration of these facts it will be seen that, in the case of rock wells in many parts of South Australia, it is advisable to carry out the work of well-sinking in the summer season or at least to complete it in March or April, before the winter rains begin, in order to make sure that the excavation is deeper than the summer level of the water table.

Less important fluctuations of the water level in wells take place under the influence of changes of air pressure. In the case of many wells sunk in porous rock such as cavernous limestone it is possible to observe the inflow of air when the barometer is high and the outflow of air when the pressure falls. Such conditions exist in parts of the Murray River Valley and on the Nullarbor Plain in South Australia, and many have observed the phenomena of these "blowing" or "breathing" wells or boreholes. The level of the water in a well depends on the balance between the atmospheric pressure and the hydrostatic pressure. If the atmospheric pressure falls the confined air in the rocks forces the water up in places, such as a well, where a smaller pressure is to be supported. On the other hand a rise of atmospheric pressure forces the water of the well back into the rock pores. Careful observations of the exact position of water level and of the barometric pressure at the same time over a number of hours will show the relation of air pressure to the water level in an unmistakable way. Just such observations have been made and correlated in the case of the North Well at Kingoonya, where it has been shown that barometric influences were the cause of fluctuations wrongly attributed to the effect of pumping from distant wells.

In the case of springs an increased flow may result from a fall in barometric pressure; and another feature connected with the decrease of pressure is milkiness shown by well water owing to the transport of clay or other mineral material into the well from the rock pores owing to the greater velocity of flow.

Wells and springs situated close to the sea shore have been observed to fluctuate under tidal influence. Many of these are sunk in sand dunes on the shore so that the bottom is between high and low tide level. They may be dry at low tide, but may give useful supplies at high tide, when the sea water checks the outflow of fresh water and raises its level.

Moreover, in addition to the fluctuations due to natural causes there are others due to human agencies, to which brief reference should be made.

It is obvious that the action of man in clearing timber, in draining swampy areas, in breaking up the surface of the soil by cultivation, and in planting crops will be reflected in the supply of underground water to wells or, in other words, in the level of the ground water table. It follows that the level of water in the wells shows a change, although there has been no appreciable alteration in the amount and distribution of rainfall, when the records of newly settled lands are compared with those of the same districts when settlement is established. It has been claimed that in Victoria the run-off has been reduced materially by an increase in the growth of vegetation induced by top-dressing for pasture. The planting of forests may cause enhanced transpiration and thus affect water level. Observations are now being made in the forest reserves of the south-eastern part of South Australia to ascertain whether ground water level in the forest-planted areas has been affected, but these have not yet been carried on for a sufficiently long period to enable conclusions to be drawn.

Again, interference with the natural aquifers may result in the alteration of water level in wells. For example, if a reservoir is constructed by excavating an opening in a bed of alluvium filling a relatively narrow valley and by rendering the excavation watertight by a clay or cement lining, the water level in the more restricted underground channel of the aquifer may be raised materially. The conclusion reached by many persons in such cases may be that the artificial reservoir is leaking. The plotting of the water table or the hydraulic surface will enable a correct conclusion to be drawn as to the direction of movement of the water. An investigation of just such a case was made in respect of the valley of the Gilbert River at Manoora in South Australia, and the procedure adopted is described in the writer's *Annual Report* for 1919.

Moreover it is a not uncommon practice to place sunken obstructions across valleys that are filled with alluvium, or across valleys in jointed and weathered rocks, in order to force the water to the surface or to raise the level of the water in a well sunk in the alluvium or jointed rock. If the walls and floor of the valleys are impervious, and if the obstruction is carried far enough both vertically and laterally, satisfactory results may be obtained by the use of these sunken barriers which are commonly called "subsurface dams." They are particularly effective in cases where relatively small supplies are wanted; and the underflow behind the barriers is in most cases protected from evaporation.

VIII. THE DIFFERENCE BETWEEN GROUND WATER AND PRESSURE WATER.

In the foregoing discussion care has been taken to point out that the upper surface of the zone of saturation is called the "water table" *where this upper limit is free.* In other words, the water table adjusts itself by reason of the ease with which water passes from one portion to another of a system of connected pore spaces or other cavities which have no appreciable separate continuity as individual openings. The storage system is open on its upper side and the contained water supports only the pressure of the atmosphere. This water is known as *ground water,* or, according to American authors, as *phreatic* water.

When, however, the cavities in which water is stored in the rocks are not interconnected, with free access to the air, a different set of phenomena is introduced. The bounding surfaces of an individual cavity or of a porous bed confines the water as if in a flattened pipe, in the lower part of which the water supports the pressure of the overlying column of water in addition to the pressure of the atmosphere that has contact with upper surface of the water filling the cavity. This water is known as *pressure water,* and must be distinguished from ground water. In America pressure water is termed *piestic.*

The cavities in which pressure water is stored may be single cracks formed by faulting or jointing; they may be the spaces in porous beds of sand, sandstone or limestone intercalated between impervious beds of clay and shale; or they may be shattered zones, partly filled with rock breccia or mineral veinstuff, traversing relatively impervious rock masses. The general term used to include every kind of water-carrying bed, opening or cavity in rocks is *aquifer*.

When a well is sunk or a borehole drilled to a depth sufficient to tap an aquifer containing pressure water, the water rises in the artificial opening above the level at which it is met. On the other hand, when a body of ground water is entered by a well or borehole, the water does not rise above the water table, at which level it is met. It is easy to ascertain in most cases whether the water in the aquifer does or does not rise; and this observation should be made and the measure of the rise recorded in the course of boring or well-sinking operations.

IX. THE GENERAL FEATURES OF ARTESIAN BASINS.

When a borehole taps an aquifer containing pressure water, this water may be under such pressure that it rises above the surface of the ground and is said to be *artesian water*. The borehole from which it flows is termed an *artesian bore*. In those cases in which the pressure suffices to cause the water to rise above the level at which it is met but does not suffice to cause it to rise above the surface it is customary to speak of *subartesian water* and *subartesian bores*. The difference between artesian and subartesian water is established by the quantitative amount of the pressure and its relation to the present land surface. If a serious diminution of pressure results from any causes—and this does take place in many cases—an artesian bore may become subartesian. Less often it may be noted that a borehole drilled to tap an aquifer which has been depleted by a long-continued drought, although subartesian when first drilled, may become artesian through the rise of pressure when the aquifer is replenished after the breaking up of the drought. This phenomenon was exhibited by a borehole near the Morphettville racecourse, between Adelaide and Glenelg, drilled in 1914 to relieve the drain on the reservoirs supplying the city, which gave a subartesian supply when water was first struck but from which the water flowed over the surface after the winter rains of 1915 caused the pressure to rise.

An *artesian basin* is the whole of an area within which pressure water exists and from which artesian or subartesian water is obtained by boring, together with the area occupied by the ground water contained in the upper and marginal unconfined portions of the water-bearing beds. Since pressure water is in most cases stored in aquifers consisting of incoherent or loosely compacted sediments it follows that such water is usually drawn from basins in which such sedimentation has taken place, with the deposition of porous beds the thickness of which is small in proportion to their lateral extent. These basins of sedimentation are river and lake beds, estuaries and the marine areas bordering the continents.

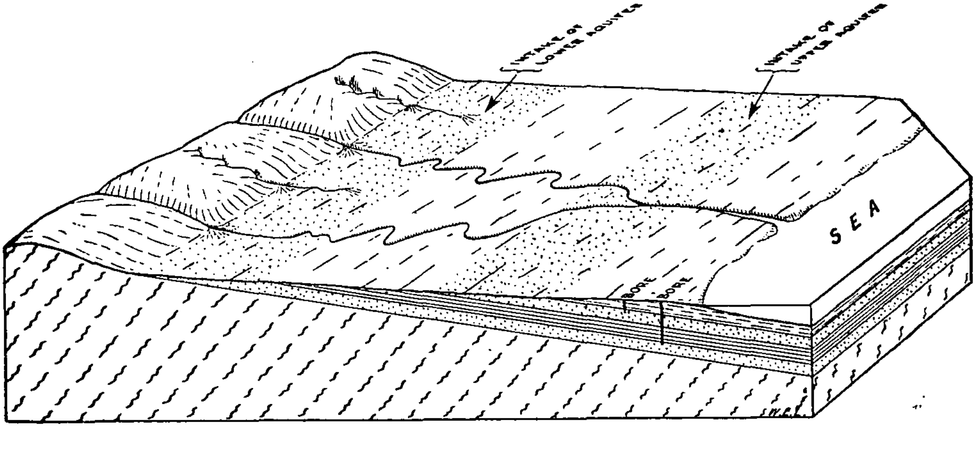
An *intake area* is the area from which one or more aquifers of an artesian basin receive accessions of water by absorption of a proportion of the direct rainfall or run-off from the catchment area upstream. *Intake beds* are the upper extensions (usually outcropping at the surface) of porous sedimentary formations constituting the aquifers of artesian basins. The *outlet* of an artesian basin is the locality where a discharge of water takes place, whether visible on the surface or concealed on the floor of the sea.

In order that there may be developed sufficient pressure within the aquifer of an artesian basin to cause a notable rise of the water in a bore-hole, or its flow over the surface, the following conditions must be fulfilled:—

1. There must be adequate rainfall to supply water to the aquifer.
2. The relatively porous rocks constituting the aquifer must be so disposed as to admit the water and allow its passage.
3. There must exist less porous or relatively impervious rocks so disposed as to confine the water within the more porous beds.
4. The porous beds must be so included that the intake is sufficiently high above the level of the bore site to compensate for loss of pressure due to frictional resistance, leakage, and the artificial draught.
5. There must be no easy escape for the water at a lower level than that of the bore site.

There are several structural types of basins within which these conditions are satisfied. Perhaps the least common occurrence is that of the complete basin in which the aquifer dips from all sides towards the centre. Such a basin may result from the filling of a great depression or by the sinking of portion of an area of sedimentation. It will be seen, from later pages of this bulletin, that the Great Australian Basin is of this type, occupying as it does an immense area of low-lying country with higher land marginal to it in many places. This particular basin is tilted so that the north-eastern rim is higher than the south-western. Water in such a basin tends to become saline by the solution of mineral matter, and the water may become useless unless there is some escape at the lowest portion so that circulation can take place. Moreover, unless there is some escape at low levels, or unless evaporation more than suffices to remove the total annual rainfall, the area of depression will become a lake.

Much more common is the one-sided basin or *artesian slope* in which the aquifer slopes downwards from the intake towards a more or less restricted outlet at a lower level—in many cases on the floor of the ocean. The Adelaide Plains basin is of this type, to which also the Cowell basin and the Pirie-Torrens basin belong. (See Figs. 9, 28, 27).



BLOCK DIAGRAM OF AN ARTESIAN SLOPE WITH TWO AQUIFERS

Fig. 9.

A third type which may be called a valley basin, is that which is developed in a valley partly filled with sediments. Most instances of this type are relatively narrow in proportion to their length, and the depth of the aquifer is seldom great at any point. The Willochra Valley basin is a South Australian example of the type. (See Fig. 10).

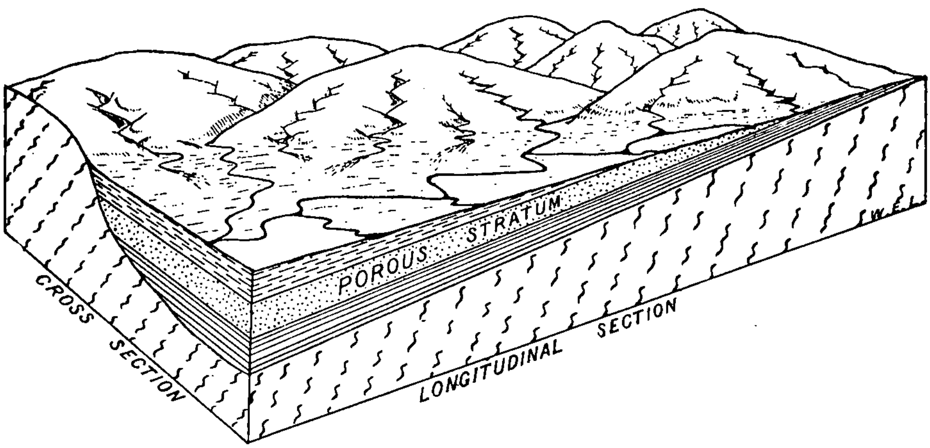


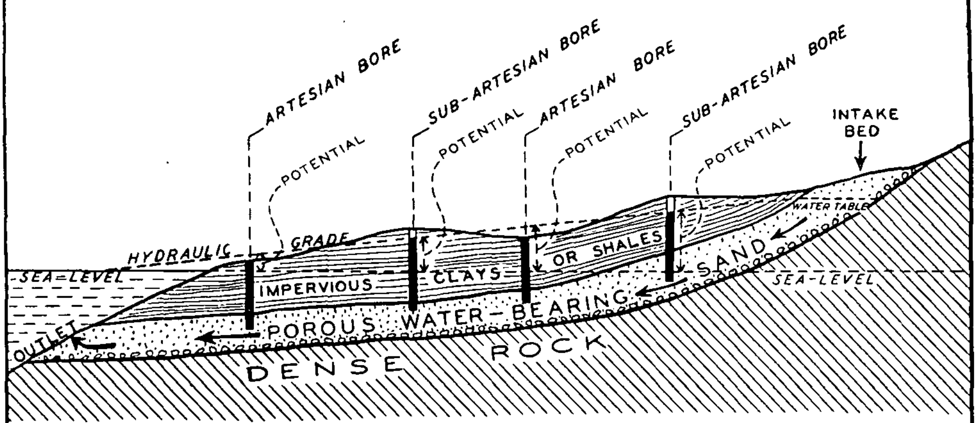
Fig. 10.

Perched, hanging, or suspended artesian basins are those in which supplies of pressure water are obtainable at levels above those at which further supplies of pressure water are obtainable. Typical cases of perched artesian basins are those situated at the northern extremity of the Flinders Range, where portions of the relatively shallow basins carrying pressure water are tapped by boreholes which do not penetrate the Cretaceous shales imprisoning the main artesian water of the Great Australian Basin.

Another case is that situated in the far north-eastern corner of South Australia where aquifers in the fresh water Upper Cretaceous rocks afford useful supplies from levels far above the main aquifer of the Great Australian Basin.

Many of the diagrams used to explain the phenomena of artesian basins are merely sectional drawings concerned with two dimensions only. Yet in actual practice a third dimension (breadth, in addition to length and depth) must be considered. The reduction of the hydraulic data to map form involves the use of methods comparable with those used in preparing a contour map of the surface, and a few definitions of terms are required.

The *potential* is the height above an assumed datum (usually sea level) to which subartesian water will rise in a borehole, or to which artesian water would rise freely in a vertical pipe joined to the top of the bore casing and continued upwards above the ground surface. In practice the potential at the site of an artesian bore is not determined by constructing a continuation of the casing or by attaching a pipe extending above the surface. It suffices to measure the pressure exerted by the water at ground level, since the possible rise of the water in feet is equal to the pressure in pounds per square inch multiplied by 2.311. In other words, for every pound per square inch registered by the pressure gauge there will be a column of water 27.73in. high.



GENERALIZED SECTION OF AN ARTESIAN SLOPE

WITH AN OUTLET TO THE OCEAN

Fig. 11.

Isopotential lines are those drawn through all points in the artesian basin at which the potential is the same. By drawing a series of isopotential lines at chosen heights and regular intervals it is possible to build up an imaginary surface known as the *hydraulic surface* which depicts the potentials of all points within an artesian basin. The isopotential lines are contours of the hydraulic surface which is not necessarily a closed surface, and differs in this respect from a real surface the contours of which must close. In American practice the hydraulic surface is termed the *piezometric surface,* and the isopotential lines are termed *isopiestic lines.*

The *hydraulic grade* in any part of an artesian basin must be measured in a direction normal to the isopotential lines at that locality and is the line of steepest grade in the hydraulic surface at that place. This point must be kept in mind continually, for failure to observe it has led to misunderstandings regarding the movement of the water in the Great Australian Basin. It is not correct to draw a line between any two points within a basin, and speak of the hydraulic grade between them unless these two points are situated on the line of the steepest grade in that portion of the basin. In comparing the pressure data for any two points the potentials at each should be stated, or their relative positions on the hydraulic surface indicated. The movement of the water in an artesian basin is down the hydraulic grade at every point, and, if this movement is due entirely to hydraulic pressure, there can be no reversal of grade in any portion of a basin, provided always that measurements are made in the direction of the flow; *i.e.,* normal to the isopotential lines.

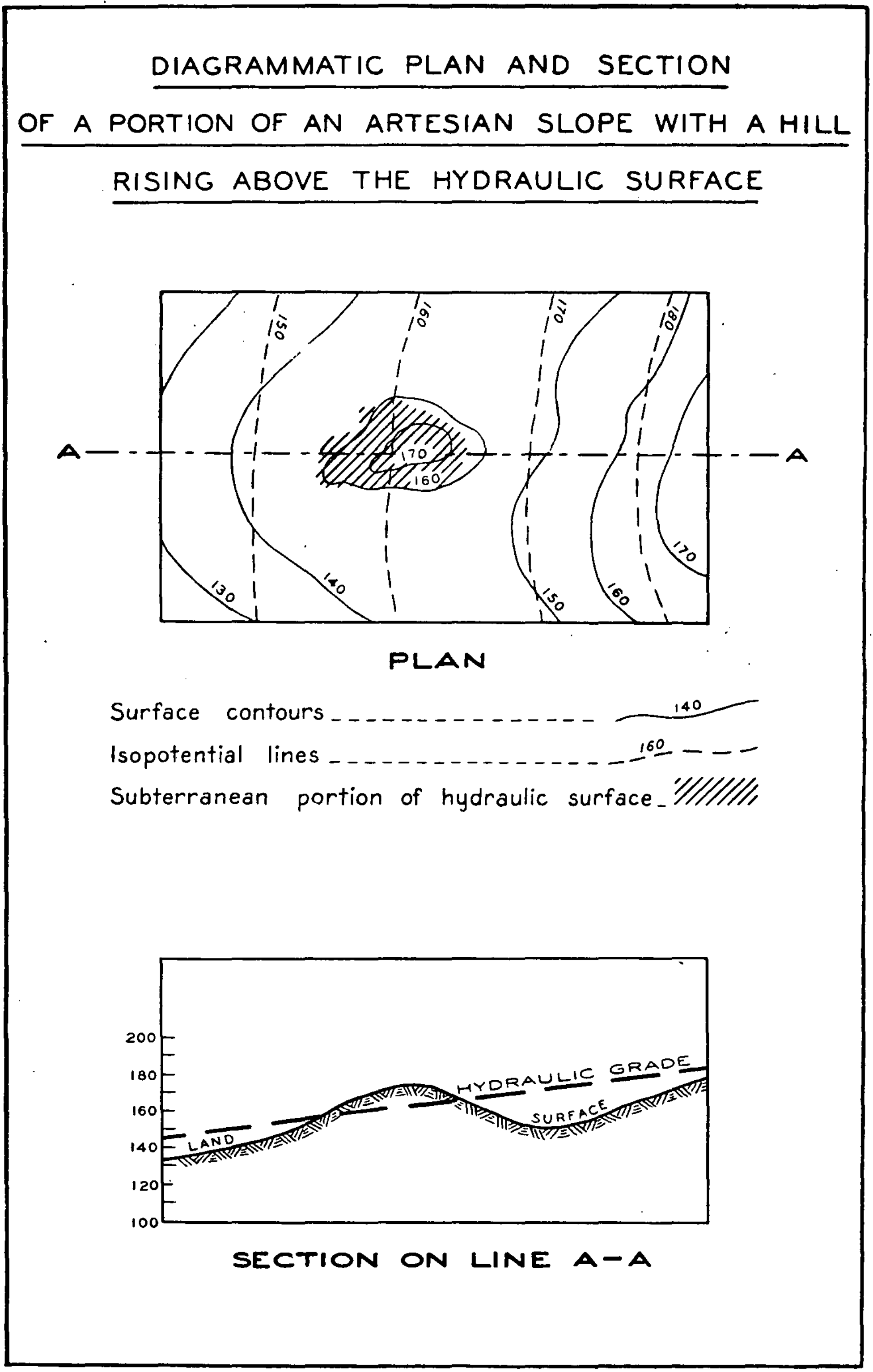

DIAGRAMMATIC PLAN AND SECTION
OF A PORTION OF AN ARTESIAN SLOPE WITH A HILL
RISING ABOVE THE HYDRAULIC SURFACE
150
160
170
180
A
A
170
160
170
130
140
150
160
PLAN
Surface contours
140
Isopotential lines
160
Subterranean portion of hydraulic surface
200
180
160
140
120
100
HYDRAULIC GRADE
LAND
SURFACE
SECTION ON LINE A—A

Fig. 12.

Abnormal pressures, which are revealed by depressions or prominences on the hydraulic surface, are probably due in most cases to the plotting together of data from different hydraulic surfaces in cases where there is more than one aquifer, each with its distinct hydraulic surface. Such instances are rare, but care must be taken to guard against such confusion when dealing with an area in which perched artesian basins occur. Further reference will be made to this matter later in the discussion of the origin of the water in the Great Australian Basin.

From these explanatory statements it will be understood that the hydraulic surface may be partly above the surface of the ground, and in this part artesian conditions will prevail; partly below the surface, beneath an area in which subartesian bores only are possible. The line of junction between the actual ground surface and the imaginary hydraulic surface is the limit of flowing boreholes. In many artesian basins these phenomena are observable, and on later pages of this bulletin it will be noted that portions of the hydraulic surfaces are above the ground in the case of the Great Australian, Murray River, Adelaide Plains, and Willochra Valley basins, so that flowing boreholes exist. (See Fig. 12).

It is to be remembered that, although the topography of an artesian basin may be reduced finally to map form, the hydraulic surface is continually varying under the influence of the seasons and the artificial draught upon the basin. Hence the hydraulic surface must be replotted periodically to conform with the hydraulic data which are not constant. Moreover, the pressure at any one borehole may diminish progressively as time passes, and data from a borehole drilled some years ago may not be properly comparable with those from a newly drilled hole. The neglect of these variables may lead to misunderstandings.

When wells are sunk or boreholes drilled in dense and compact rocks results are obtained in some cases which have features in common with wells or boreholes in artesian basins. From the explanation given on an earlier page regarding the mode of storage of water in such rocks it will be seen that a long and continuous fissure such as fault plane or shear zone may act as an aquifer within the lower portions of which pressure water is stored. Such fissures are inclined for the most part at much steeper angles than the beds of sand or gravel that constitute the aquifers of artesian basins, but the laws governing the rise of pressure water are constant, and the features of an artesian basin are observable. Yet the area within which pressure water is obtainable from vertical boreholes is rarely large on account of the angle of inclination of the aquifer. There are several cases of the existence of artesian bores drilled in the compact rocks and obtaining supplies from fissures in the Mount Lofty Range, and very many cases of the occurrence of sub-artesian bores in the same area. In all such cases the site of the borehole is sufficiently far below the place of absorption (corresponding to the intake area of an artesian basin) to enable the pressure at the point where the aquifer is tapped to force the water above or close to the surface. Similar conditions may give artesian supplies from bedding planes in sedimentary rocks; from major joints in crystalline rocks; from a jointed stratum occurring within compact rocks that are unjointed; from solution cavities in limestone; and in fact from any occurrence of a cavity in which water is confined with a rise of pressure in its lower portions. (See Fig. 31).

There are few cases in which the quantity of water obtainable from fissures or cavities of any kind in the compact rocks is comparable with the amount obtainable from the beds of sand or gravel which ordinarily form the aquifers of artesian basins. The fissures that are usually recognized as aquifers are the vein-fissures which are partly or almost completely filled with solid mineral material, but these fissures are not tapped in many cases for use as sources of water.

X. SPRINGS.

When underground water issues in a stream or where water stands in a pool replenished from an underground source, such a place is called a spring. In some cases there is a defined point of emergence, and in others a distributed seepage from some water bearing rock. The term spring is not applied to artificial openings, although in many cases natural springs are improved in different ways to conserve and utilize their supplies and to prevent the pollution of the water.

The yield from springs is extremely variable, some giving millions of gallons daily and others only a mere trickle of water. The flow from some springs varies a good deal from season to season and from year to year, while the effluent water from others remains practically constant.

The temperature of spring water is normally that of the mean annual temperature of the surface at the place of occurrence, but in some instances it differs materially from that figure. If this difference amounts to a rise of as much as 20 to 25 degrees Fahrenheit, the springs are termed "thermal" or "hot." Bubbling or boiling springs are those in which the water is accompanied by gas.

Many springs contain dissolved mineral salts in noticeable amounts, and have been termed "medicinal" where the water is claimed to possess valuable therapeutic properties. When the mineral matter dissolved in spring water is deposited at the surface, a cone, generally composed for the most part of carbonate of lime, may be built up and the springs are called "mound springs."

Those springs which are formed by the rise of juvenile or magmatic water, around centres of expiring volcanic activity and possibly also along the outcrops of deep-seated fractures, are as a rule perennial and mineralized, and they may become gaseous.

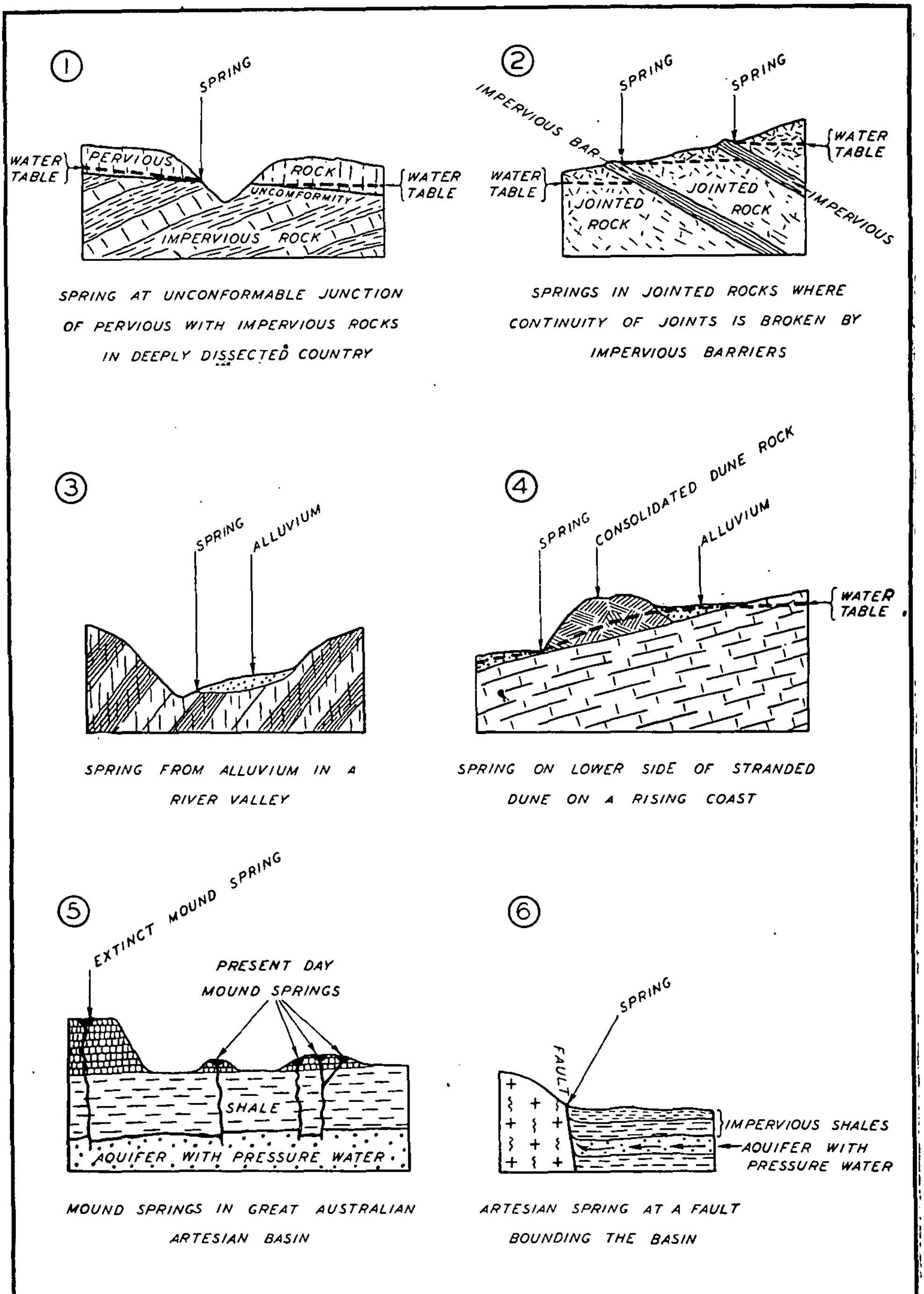
Much more common are those springs which are situated at the points of emergence of the water table through the dissection of the country, or by reason of the existence of an impervious rock mass which prevents the underground water from sinking to a lower level and causes its return to the surface at the lowest point in the water table.

A few typical cases of the occurrence of springs are shown in the accompanying diagrams. Examples of the types illustrated occur in South Australia. (See Fig. 13).

Where pressure water is confined by impervious rocks a spring may appear at the lowest point of the outcrop of the aquifer, if the hydraulic surface is higher than the ground surface at that place; or a spring may be found where the upper confining stratum of rock has been fractured and the pressure suffices to force the artesian water to the surface.

XI. SOUTH AUSTRALIAN ARTESIAN BASINS.

It will be seen, by reference to Plate II., that South Australia is well endowed with artesian basins, some of which are large and extend beyond the boundaries of the State, while others are relatively small. The extent of the basins is indicated in accordance with the structural features of the areas within which sedimentation has taken place, such areas being treated as whole entities. It is, however, to be borne in mind that, within an individual basin, there exist conditions which vary from point to point



SECTIONS SHOWING STRUCTURAL FEATURES OF SOME TYPES OF SPRINGS

Fig. 13.

and which affect the distribution of artesian water. For example, the eastern portion of the Adelaide Plains Basin yields very little water, while large supplies are derived from the portion lying to the west of the city. Many other cases of variability in the quantity and quality of the water in other basins will be mentioned in the accounts given on subsequent pages. For this reason it is always advisable to consider the features presented by the particular portion of any basin at which developmental problems arise and to refer the matter for advice rather than to rely upon generalizations. There are, of course, wide areas in the larger basins, within which conditions are practically constant, save for differences in depth between the surface and the aquifer; and in such areas no developmental difficulties are experienced. The continuity of the aquifer in these latter areas being unbroken, success will result from drilling operations at any spot where water is required; and there is a sharp contrast between the prospects of obtaining supplies in such districts and those which exist in places where there is no widespread bed of water-bearing rock.

(a) EARLY EXPLORATION AND DEVELOPMENT.

South Australians played a significant part in the exploration of the Great Australian Artesian Basin, the development of which was tardy owing to its geographical position in relation to the earliest settlement of the continent. By 1878 an appreciation of the occurrence of structural conditions favourable to the existence of artesian water in the central region certainly did exist. On 17th September of that year a paper by T. E. Rawlinson with the title of "Subterranean Drainage in the Interior" was read before the Philosophical Society of Adelaide, and was printed in abridged form in the transactions of the society for 1877-1878. It contains an appeal for inquiry:—

> "into the cause of the disappearance of the vast bodies of river water which collect on the inner watershed of the coast ranges of Australia."

Rawlinson expressed the opinion that the interior of Australia would:—

> "ultimately be proved to be the storage reservoir where are conserved the rain and river waters which other theories fail to account for."

In 1879 H. C. Russell, Government Astronomer of New South Wales, took up the problem and read a paper before the Royal Society of New South Wales with the title "The River Darling—the water which should pass through it," and has been credited with the earliest recognition of the probable occurrence of artesian water derived from surface streams, but he was evidently anticipated by Rawlinson.

Professor Ralph Tate, who visited the Lake Eyre region in 1879, published a statement to the effect that the mound springs occurring to the south and west of the lake were natural artesian wells, and definitely indicated the probable success of boring for artesian water, if it were tried.

These pronouncements roused great public interest and induced pastoralists to drill trial holes, the earlier sites of which were close to mound springs. The first proof was afforded by the tapping of an artesian flow in 1880, between the Darling and Paroo rivers, the water being struck at a depth of 144ft. In 1881 a successful borehole was drilled at Anna Creek in South Australia, also in the vicinity of mound springs. These successes created a demand for action on the part of governments, and in South Australia the first borehole was started in 1883 at Tarkanina at a place where a well had been put down in 1880.

The early exploration of the Murray River Basin was begun in Victoria in 1886 near Nhill, and in South Australia in the same year at Coonalpyn. The latter hole, which carried down into bedrock, proved the existence of salt water only, having been located too far to the westward where the underground flow is impeded by a barrier of old rocks, as explained on a later page.

In 1887, however, much better water was obtained in the Ki Ki borehole, and in the same year a flowing supply of good water was obtained at Tintinara and a subartesian supply of like quality at Emu Flat. These successful results led to widespread boring activity which has continued ever since. Following upon the development of the Pinnaroo district and the construction of the railway many successful boreholes were drilled. Yet it was found that the area within the basin from which water of good quality is obtainable is limited both in Victoria and in South Australia. This matter is discussed on a later page where the features of the Murray River Basin are mentioned.

The exploration of the Eucla Basin was begun in South Australian territory and a number of boreholes had been drilled by the close of the nineteenth century. The quality of the water in these boreholes was not good, although in a few cases the water could be used by sheep, and no great encouragement was given towards the search, especially as the water had to be pumped to the surface from depths averaging about 200ft. The South Australian portion of the basin is at a higher level than the site of the Madura borehole in Western Australia where a flowing supply has been obtained. At a much later date, when the location of the Transcontinental Railway had been decided, a series of boreholes was drilled, and water of much better quality was obtained, especially in the western portion of the basin at Rawlinna, Loongana, and Forrest.

The earliest use of isopotential lines to delineate the hydraulic surface of the Great Australian Basin is due to J. B. Henderson, Hydraulic Engineer of Queensland, in the closing years of the nineteenth century. This work was carried on in later years by the Water Conservation and Irrigation Commission of New South Wales for the portion of the basin included within that State.

It was considered at one time possible that the water of the Great Artesian Basin might reach the Victorian mallee by underground channels, and in 1897 there was an investigation by R Logan Jack of Queensland, and J. Stirling of Victoria, to report on the matter. It was found that the interposition of a barrier of Palaeozoic rocks between the Great Basin and the Murray River Basin prevented the passage of the artesian water to the south-west, and that hydraulic data supported the geological reasoning. The possibility of an outlet to the Southern Ocean by way of the Eucla Basin was suggested at this time, but subsequent geological investigations showed that the suggestion was ill-founded, and hydraulic data available when the survey of the Transcontinental railway had been made supported the conclusions reached by geological reasoning.

(b) THE BROADER FEATURES OF THE GREAT AUSTRALIAN ARTESIAN BASIN.

(1) The Extent of the Basin as a Whole.

Before dealing with the features of that portion of the Great Artesian Basin which lies within the boundaries of South Australia it is necessary to consider the broader features of the basin as a whole. It is of enormous extent and occupies over 22 per cent of the whole area of the Australian Commonwealth.

The limits of the basin are shown on Figs. 14 and 15, in accordance with the map accompanying the report of the Interstate Conference on Artesian Water, prepared in 1928. The following table shows the portions of the basin comprised within the four political divisions concerned:—

	Square Miles.
Area in Queensland	432,117
Area in New South Wales	78,517
Area in Northern Territory	30,143
Area in South Australia	119,820
Total area of the whole basin	660,597

The degree of development differs in the various portions. Quite a large portion of the basin is located in a region of low and irregular annual rainfall, the permanent occupation of which would not be possible but for the unfailing supplies of water obtainable by boring. Those parts of the basin which have not yet been probed by boreholes are the unoccupied areas the

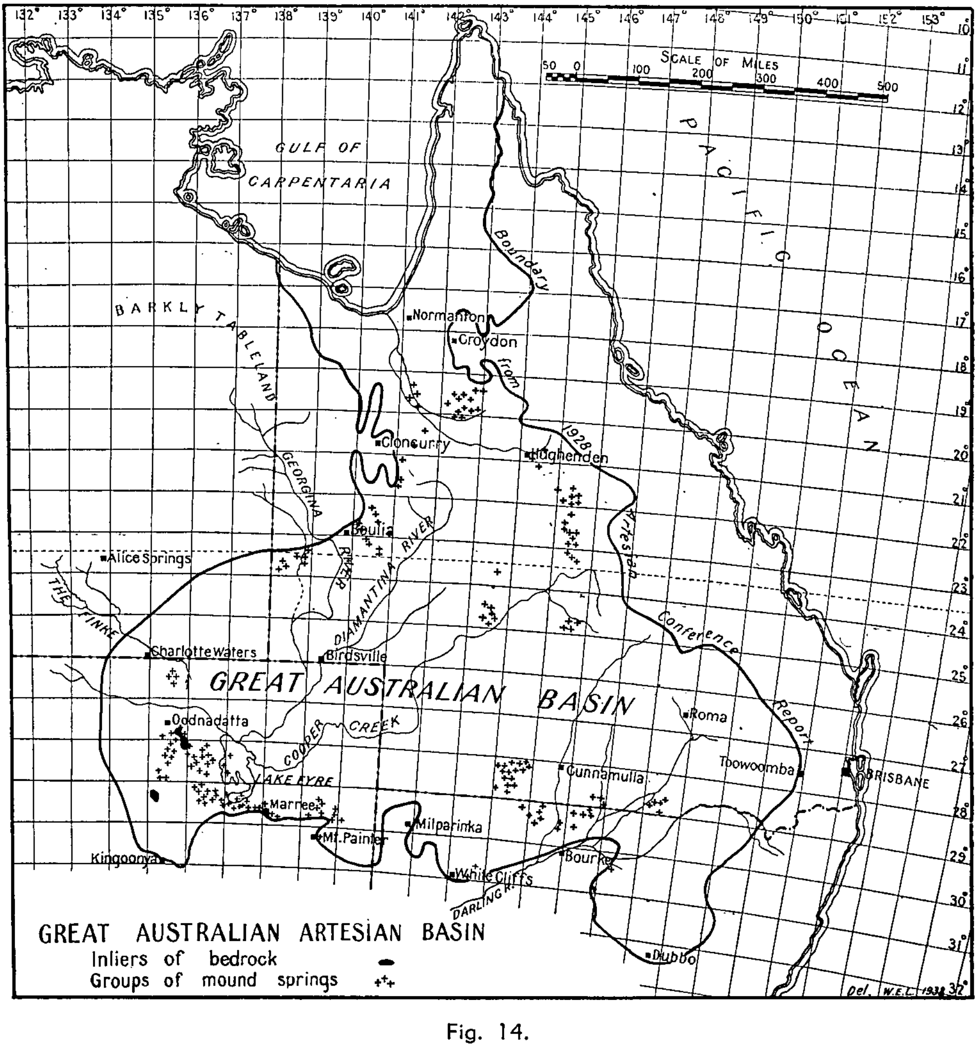


Fig. 14.

surface of which is covered by drifting sand and supports too sparse a growth of vegetation for pastoral use. Happily these inhospitable areas constitute but a small fraction of the whole basin, and are restricted to the parts of South Australia and the Northern Territory which lie to the north of Lake Eyre.

The Great Artesian Basin has an approximately triangular form, the apex being situated at Cape York, and the base being an irregular line extending from Kingoonya in South Australia, to Dubbo in New South Wales. The greatest breadth, on a line passing through Oodnadatta and Toowoomba is about 1,120 miles, while the distance from the apex at Cape York to the boundary near White Cliffs is about 1,395 miles.

The figures here quoted, especially those relating to area, must be regarded as subject to modification, as systematic surveys, especially on the eastern margin, and exploration by drilling may require.

The area of the Queensland portion of the basin, according to the authorities mentioned below, is taken to be about 350,000 square miles, the reduc-

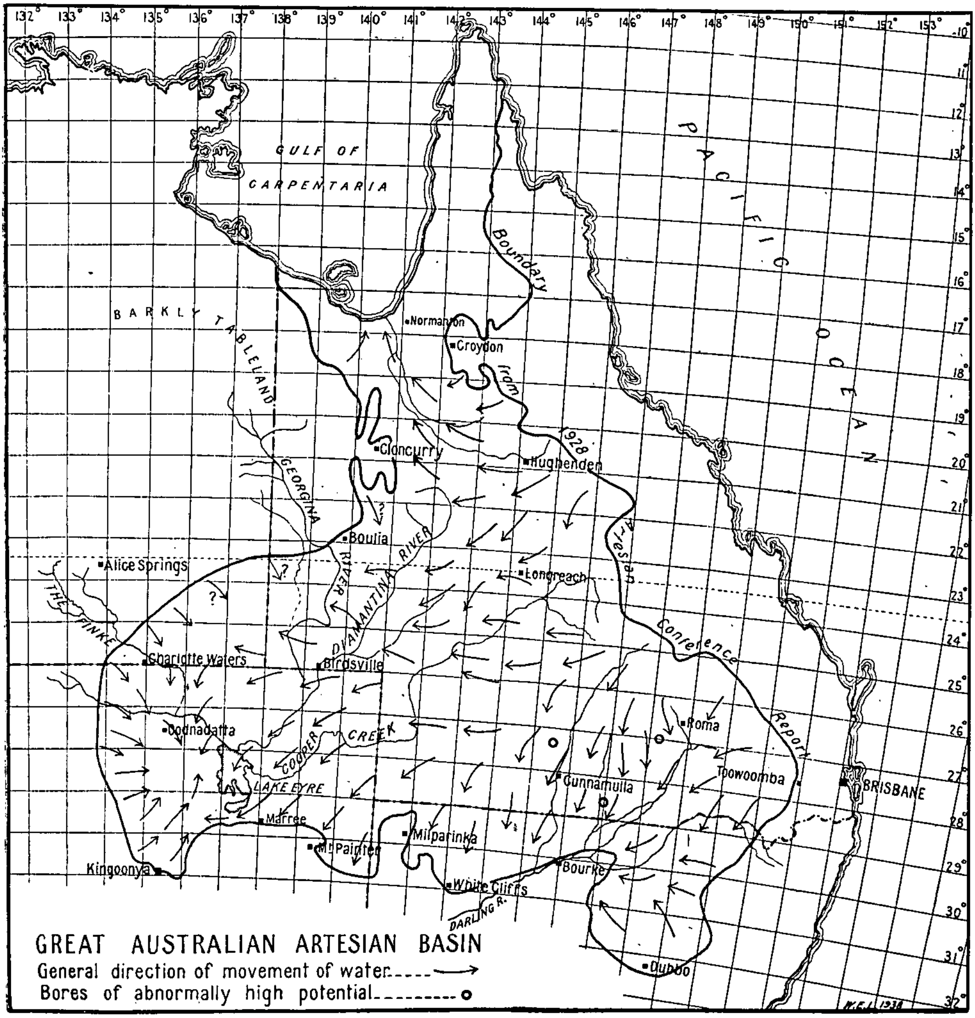


Fig. 15.

tion from the figures here given (derived from the map of 1928) being due chiefly to the truncation of the far northern portion embracing a large part of Cape York Peninsula.

(2) The Structure of the Basin.

The area of the artesian basin proper is rather less than that of the depression in which Permo-Carboniferous and Triassic sediments were deposited, since rocks of these ages outcrop on the eastern and western margins beyond the limits of the aquifer. Within this wider depression were deposited carbonaceous beds and fresh water sands of Jurassic age, and from the sands of this great lake basin the greater part of the artesian water is derived.

The fresh water lake was invaded by the sea in Lower Cretaceous time, and marine sediments were deposited upon the sands. The sea withdrew in Upper Cretaceous time, and shales with lignitic beds were deposited upon the marine shales. Some erosion of these sediments took place before the Lower Tertiary or "Eyrian" sediments accumulated.

The last stages in the formation of the basin as we find it to-day included the orogenic disturbances which raised the eastern Australian cordillera and the Flinders Range in South Australia. These movements resulted in the formation of the Lake Eyre depression, nearly 40ft. below sea level, far to the south-west of the deepest portion of the Mesozoic depression which is close to the north-eastern corner of South Australia.

The superficial drainage of the greater part of the structural basin conforms in a general way to the movement of the artesian water. Yet the divide on the eastern margin of the basin does not cut off all contributions of water to the subterannean storage, since it has been shown that some of the easterly flowing streams in Queensland cross the outcrops of porous sandstones which dip to the westward. These latter beds, belonging to the Bundamba and Ipswich series, are of Triassic age, and are probably tapped by some of the boreholes on the eastern margin of the basin.

It will be seen from the map showing the direction of movement of the artesian water that there is a portion which passes northwards towards the Gulf of Carpentaria, while the remainder of the water having its origin in Queensland passes towards the south-west. This parting of the waters appears to have been caused by some buried structural barrier between Cloncurry and Saxby Downs which controlled the form of the depression in much the same way as did the Peake and Denison Ranges in South Australia and the promontory of ancient rocks between Broken Hill and Tibooburra through their stout resistance to the general downward movement.

Many aspects of the Great Artesian Basin have been treated in the recently published interim report of a committee appointed to make an examination of the artesian water supplies of Queensland, with particular reference to the problem of diminishing supply. This report which contains much information regarding the geology of the Queensland portion of the basin and the interaction of flow and control, was available to the present writer only after this chapter had been written, and should be consulted for details regarding the stratigraphy of the basin, the variations in the aquifers and the effectiveness of different portions of the intake beds.

(3) The Geological Formations Occurring Within the Basin.

The series of sediments which occupy the basin are the following described in descending order:—

1. The recent windblown sands and fluviatile deposits of the Lake Eyre region, masking the whole of the surface of the Arunta desert.

2. The Eyrian series, consisting of argillaceous and arenaceous sediments of white, buff, pink, or red colour, and attaining a thickness of 360ft. on Cordillo Downs Station in the far north-east of South Australia. These beds which overlie the Winton beds unconformably, were formerly embraced within the so-called "Desert Sandstone," which is now known to have no significance as a stratigraphical unit. The beds are affected to a notable degree by silicification, and the sandy members contain useful supplies of ground water.

3. The Winton series, of Upper Cretaceous age, consisting of fresh water shales with thin intercalated sandy beds and some coaly or lignitic matter. The maximum thickness attained by the series is 3,695ft. at the site of Patchawarra bore near the north-eastern corner of South Australia. The sandy beds contain useful supplies of pressure water in a suspended artesian basin that has been tapped by boring at Cordillo Downs.

4. The Rolling Downs formation, consisting of Cretaceous marine beds that have been subdivided by F. W. Whitehouse into three series named, in descending order, the Tambo series (Upper Albian), the Roma series (Aptian), and the Morven bed (Upper Hauterivian). In addition to the marine fossils there are present many fragments of silicified wood; and boulders, to which a glacial origin is ascribed, occur in the Roma series. The greater part of the formation consists of dark bluish-grey shale which is calcareous in places and contains thin beds of impure bluish limestone. The greatest thickness of the formation is 2,433ft. at Goyder's lagoon. The basal member of the formation in the Roma district of Queensland was called Blythesdale Braystone by R. Logan Jack and A. Gibb Maitland, but this bed is probably a little higher than the main aquifer of the artesian basin. The Rolling Downs and Winton formations are both affected by superficial silicification which renders their outcrops lithologically similar to those of the Eyrian formation. All three were formerly embraced in the discarded "Desert Sandstone."

5. The Walloon series, of Jurassic age, consisting of porous sandstones and shales, some of which are calcareous, and containing seams and fragments of coaly matter, gases of variable composition, and traces of mineral oil. The maximum thickness of this fresh water series in the Ipswich district is about 6,000ft., but borings within the limits of the Great Artesian Basin do not reveal such a thickness since the drill has not penetrated deeply into the series, the uppermost portion of which probably constitutes the principal aquifer of the basin and is an exceedingly porous rock which extends across its whole width.

6. The Bundamba and Ipswich series, of Triassic age; comprising massive sandstones, shales, conglomerates, and coal seams which outcrop on the eastern margin of the basin in Queensland, and probably act as intake beds in some places; and containing the lower aquifers.

7. The Upper Bowen series of Permo-Carboniferous age, consisting of coarse current-bedded sandstones and outcropping on the margin of the basin in Queensland between latitudes 20 and 25 degrees south. These rocks are to be regarded as probably constituting portion of the eastern intake area, and, in some place, actual

aquifers. They dip beneath the rocks of Mesozoic age and probably underlie them in some of the deeper parts of the basin.

(4) Earth Movements Within the Basin, Subsequent to Sedimentation.

There is definite evidence of both folding and faulting of the strata within the basin, possibly in connection with general tectonic movements of the Late Tertiary (Kosciusko Epoch) which affected a large part of the continent. Observations of faulting have been made on the western margin, close to the inlier of the Peake and Denison Ranges and at the northern extremity of the Flinders Range. There is chemical evidence also of the upward leakage of water from the main aquifer into porous overlying beds to the east of Lake Frome, probably by way of a concealed fault plane, marginal to the main basin.

There are definite anticlinal structures on the northward prolongations of the Flinders Range and the Peake and Denison Ranges, caused by differential vertical movements rather than by tangential pressure; and the depths of the main aquifer beneath the surface have been reduced on the anticlinal axes.

In 1925, during a rapid traverse of south-western Queensland in connection with the search for oil, L. C. Ball obtained evidence of both faulting and folding within the basin to the east of Cannamulla; at the Grey Range; on the Thomson-Alice divide; on the Barcoo-Nive divide; and between Charleville and Muckadilla. He noted that the faulting was to be observed in east-west sections, and inferred that the general trend of the fault planes in this region was meridional. It seems possible that the accurate plotting of bore sections, combined with the exact determinations of the surface levels at bore sites, may reveal further faulting within the basin. The great number of boreholes drilled in Queensland renders it probable that more data regarding vertical displacements of the strata will be obtainable there than elsewhere in the basin, if such displacements are general. The determination of the altitudes of bore sites over so immense an area is a task of no mean size, but it is work that should be carried out systematically at the earliest possible date, since the data so acquired will serve as the foundation for the detailed investigation of the basin.

(5) The Hydraulic Surface of the Basin, and the Movement of the Water.

It is not possible to draw an accurate map of the whole basin showing the isopotential lines as they existed at any particular time. Very many observations have been made in different parts of the basin, but they have been made at different times, separated in some cases by intervals of several years. Accurate determinations have been made in portions of Queensland and New South Wales, and much work of this standard remains to be carried out in South Australia. The interference with the natural condition of the basin by the drilling of numerous boreholes involves an ever-changing modification of the hydraulic surface, and some portions of the basin have been much more affected by drilling than others. The vast extent of the basin precludes the achievement of even a reasonable approximation to simultaneity of observations unless a very large number of field parties is maintained. Moreover, there is no accurate topographical base map of a large part of the area included in the basin. So the attempts that have been made to correlate the data acquired at different times can be regarded only as approximations that indicate the general form of the hydraulic surface of the basin as a whole, although fragments of this surface have been delineated accurately at various times. Full correlation demands a co-operative scheme of investigation in which uniform methods are employed simultaneously.

Subject to these reservations the writer did prepare an isopotential map of the basin for publication in his *Annual Report* for 1921, and a map of the same character was included in the report of the Fourth Interstate Artesian Water Conference held in Perth in 1924. In this bulletin, however, it has been considered wiser to withhold any isopotential map that might be regarded as an exact representation of the pressure conditions of the present day. In its place is reproduced a map (Fig. 15) showing by arrows the general direction of movement of the water. Despite the reservations above mentioned, it should be noted that there are only three places within the whole basin, all of them in Queensland, at which abnormally high potentials have been observed. These spots are marked by circles on the map showing the direction of movement of the water. Apart from these three local variations there is no reversal of the hydraulic grade, when it is properly measured in the direction of the flow, in any part of the basin. Controversial discussions of reversed grades have been based on a misconception of what hydraulic grade really means. The explanation of the abnormally high potentials at the three localities in Queensland is not yet forthcoming as a result of the critical investigation of each case. The most probable cause of abnormalities of this kind is the correlation of observations dealing with different aquifers separated from each other by impervious beds of clay and carrying water under varying pressures. In the absence of detailed analyses of the waters, notes as to what gases if any are present in them, as well as similar information regarding the surrounding boreholes, it is idle to speculate on a plutonic source for the water tapped by these three holes or to attribute the higher pressure to gas pressure. Nor, in the absence of definite evidence of faulting in the near vicinity of the boreholes, is it proper to attribute the extra high potentials to some local manifestations of rock pressure.

In the preparation of the plan showing the movement of the artesian water down the steepest slopes of the hydraulic surface the arrows have been drawn in directions normal to the isopotential lines. Their trend shows very clearly the position of the intake areas round the margin of the basin and, equally clearly, the natural outlets of the water at the groups of mound springs, especially in the southern portion of the basin. Interesting corroborative evidence has been obtained in South Australia by R. Lockhart Jack by the critical study of the chemical composition of the bore waters, which revealed essential differences between the water absorbed on the western intake and that moving into South Australia from sources in Queensland. The extension of this type of investigation to the waters yielded by the boreholes on the eastern margin of the basin may provide useful results leading to a better understanding of the problems of the eastern intake areas.

(6) Observations of Temperature and Pressure.

Some statements have been made regarding variations in the temperature of the water issuing from the boreholes, but investigations made in New South Wales with every precaution to insure accuracy indicate that the temperature remains constant over long periods, some of them over 20 years, despite the diminution of pressure and flow during the same periods.

With regard to pressure and flow, however, it has been found that there is a steady fall. In many cases of boreholes in Queensland and New South Wales flowing supplies have ceased, and it has been necessary to resort to pumping. In other cases, in which the falling pressure is still sufficient to produce a flow over the surface, measurements have been taken and the loss of pressure and the decrease of the flow have been ascertained. It was reported to the fifth Interstate Conference on Artesian Water in 1928 that, for the 233 boreholes at which there have been gaugings from 1914 to 1928 the flow had diminished by 39.92 per cent over the whole period, or by an average annual amount of 3.07 per cent. This figure for the rate of the annual decrease in flow has diminished, and is now 2.18 per cent of the 1914-1915 flow. Late figures, quoted by H. H. Dare in his paper on "Water Conservation in Australia" in 1939, show that, whereas in New South Wales there were 316 flowing bores in 1910, with a flow of 109,560,972 gallons per day, there were in 1938 some 453 flowing bores with a total discharge of 67,349,317 gallons per day, the lessening of the flow being accompanied by a decrease in pressure at the bore head in all cases.

A similar set of phenomena has been observed in Queensland where over 700 boreholes situated in the high eastern marginal area have ceased to flow, and also in South Australia, and it is clear that there has been a general lowering of the pressure in the basin. The peak flow from artesian boreholes in Queensland was 355 million gallons per day of 24 hours in 1914, when 1,229 boreholes were contributing to the total yield. In 1943 there were 2,008 boreholes, the total yield from which was 229 million gallons daily. Apparently the main reason for this decrease has been the over-multiplication of boreholes tapping the stored water, with the consequent release of elastic pressure. To conserve the supplies it is obvious that every precautionary measure should be taken during the construction of every new borehole to enable the flow to be controlled and shut off when the issuing water is not being turned to account.

This reference to the need for conservation and the widespread diminution of pressure does not imply that the aquifer is becoming exhausted. The area of the whole basin and of the intake beds is enormous, and the total quantity of water discharged from boreholes in Queensland since the drilling of the first hole in 1884 is calculated by the Committee of investigation to suffice for lowering the water level in the intake beds by 5 feet, even if there has been no replenishment whatever in the 60 years that have elapsed. The extent of the intake beds in Queensland alone is estimated by the same authorities to be about 30,000 square miles, and the average rainfall upon them is taken to be 25 inches per annum. The present annual flow from all the bores in Queensland represents a sheet of water only one fifth of an inch in depth over the whole of the intake beds in that State. While the quantity of stored water is beyond doubt very great, numerous artesian boreholes closely spaced and allowed to discharge water continuously even if the flows are not fully utilized, cause a loss of pressure over wide areas and necessitate recourse to pumping long before these measures need be adopted if a wise control is exercised.

(7) The Source of the Water.

There does not appear to be any necessity for dealing in detail with the fanciful suggestions put forward by uninformed persons who have considered that the water stored in the Great Artesian Basin was absorbed in remote and mountainous parts of the world, to appear in central Australia after a long subterranean passage. The favourite sources, according to these flights of the imagination, have been the Owen Stanley Range in New Guinea, the Himalaya Mountains of Asia, and the Andes of South America. The known facts regarding geological structure and hydraulic phenomena are wholly opposed to such contentions.

The old classical hypothesis, which attributed the source of underground water, especially that which appears at the surface in springs, to the ocean whence it travelled by concealed channels through the earth's crust and suffered purification during its passage by some mysterious processes before reaching the surface, was revived in 1926 by W. W. Bond, whose paper appeared in the February number of *Chemical Engineering and Mining Review* of that year. According to this view the oceanic water descends into the deeper and highly heated part of the earth's mass under the influence of the pressure of the ocean, and is converted into superheated steam which escapes upwards and is condensed. Mineral matter is supposed to be absorbed during the passage to higher levels and the water enters the porous water-bearing strata. It is not explained by the hypothesis why all regions bordering on the ocean are not equally endowed with artesian water, nor how such an origin for the water accounts for the hydraulic phenomena observed within the basin. Meinzer, in a paper on the "History and Development of Groundwater Hydrology," mentions an astonishing explanation for the rise of the water according to such views, namely that the water in the middle of the ocean, because of the curvature of the earth, is at a higher level than the springs and thus furnishes the necessary head to force the water to the surface. Such views do not seem to call for serious consideration and discussion.

With the exception of holders of the extraordinary views about extremely remote sources for the artesian waters, most Australians who had thought about the matter attributed to the water a meteoric source prior to the publication in 1906 of Professor J. W. Gregory's book "The Dead Heart of Australia," in which other opinions were put forward. According to Gregory the meteoric theory of origin for the water was untenable, and he held that the water is largely connate and that part of it is of plutonic or magmatic origin, the latter derivation accounting for high gas pressure which forces the water to the surface, this rise being assisted by the weight of the rocks overlying the aquifer.

This statement on the part of J. W. Gregory brought forth a counter statement by E. F. Pittman, Government Geologist of New South Wales, which was followed by a rejoinder by Gregory under the title of "The Flowing Wells of Central Australia," which appeared in *The Geographical Journal* for July and August, 1911. Two more papers by Pittman followed and the discussion became very controversial in tone. It must be admitted that serious consideration must be given to some of Gregory's contentions even if it is not possible, as he himself admitted, to calculate the amount of plutonic water contributed to the basin. Gregory's challenge of H. C. Russell's argument regarding the discrepancies between the discharges of the Darling and Murray Rivers was probably justified in the light of subsequent data; but, even if this be granted, the main reason for the rise of the artesian water in the boreholes may be assumed to be gravitational force, and this explanation is accepted by most of those who have studied the problem most carefully. Gregory's earliest statement regarding contributions of plutonic water from areas containing mineral veins, notably at Cobar, Broken Hill, and Cloncurry, is not to be taken seriously, since the period of igneous invasion and mineralization in these districts is geologically remote. Yet his later references to the evidence of late vulcanism along the eastern highlands of Australia are deserving of close investigation, with special attention to the chemical character of the water and the gases associated with it.

A later paper by a South African geologist, A. L. du Toit, entitled "The Problem of the Great Australian Artesian Basin," was published in the Proceedings of the Royal Society of New South Wales in 1917, and lent support to Gregory as against those who considered the meteoric origin for the water satisfactory. The source of the water, according to du Toit, is threefold, namely:—(1) residual or connate, contained in the basin since Mesozoic time; (2) plutonic; and (3) rainfall of an earlier (Tertiary) epoch. It seems that du Toit did not fully appreciate the complexity of the intake areas of the basin and the variability of the chemical character of the water absorbed, as for example, in western South Australia. Moreover, if his own figures for the rate of movement of the water are taken and the period of 20,000 years is required for the water to cross the widest part of the basin, this period is but a small fraction of the time that has elapsed since the deposition of the Jurassic sediments (about 130 million years according to the radioactive time scale) and even longer since the Triassic and older sediments were laid down. The connate water that may have been entrapped in the Jurassic lake bed would seem likely to have been completely washed out in the interval. There is probably truth in the contention that in Tertiary time the basin received much more water, as shown by the immense extinct mound springs, but it is doubtful whether any of this water remains in the basin at the present time.

A connate origin has been suggested for the water in an isolated aquifer at Julia Creek in North Queensland, but, if accepted, this case does not affect the argument favouring a meteoric origin for the great part of the water in the basin.

When all the known information regarding the water in the basin is reviewed, it is difficult to see how a meteoric origin for at least the greater part of the water can be questioned. Granted that there may be accessions of plutonic water on the eastern margin in areas of expiring vulcanism, the general regularity of the hydraulic surface at all places where the isopotentials have been plotted accurately is most impressive. The variable altitude of the intake areas, especially in Queensland, is reflected in the rise of the hydraulic surface towards such areas. The progressive rise of the salinity of the water as its distance from the intake areas increases, and the differences noted in the chemical character of the waters derived from different intake areas in South Australia point unmistakably to a meteoric origin. The absence of isolated areas where abnormlly high temperatures exist indicates that no concealed foci of vulcanism beneath the basin have been located.

If the pressure data relating to the water in the pipes of a city's reticulation are plotted, a hydraulic surface for the system can be generated, and it will rise towards the reservoir whence the water is drawn. So too the hydraulic surface of the Great Australian Basin rises towards the intake areas on its margins and points to the main source of the water in no uncertain way.

(8) The Causes of the Rise of the Artesian Water.

As has been indicated above, the main cause behind the rise of the water is hydraulic pressure which is merely an expression of gravitational force. There are, however, other factors that must be taken into consideration when a tolerably complete explanation of pressure data is attempted. The rise of temperature experienced by meteoric water, as it leaves the intake areas and descends into the deeper parts of the crust, will cause expansion and a consequent decrease in density, which will be reflected in the rise of the water in a borehole tapping the aquifer. Again, in very many parts of the basin there are gases (nitrogen, methane, hydrogen, carbon dioxide, oxygen, sulphuretted hydrogen) associated with the water and probably dissolved in it. These gases are released when the pressure is lowered by the penetration of a borehole into the aquifer, and the bubbles formed expand as the water rises towards the surface, producing the effect of an air-lift pump. Although gas has been observed to be discharged from many boreholes there have been relatively few analyses made to determine its nature and few measurements of the quantities present.

The compression of the aquifer by the weight of the overlying rocks, commonly known as "rock pressure," was put forward by Gregory as a principal cause of the rise of the artesian water, and this contention was strenuously opposed by Pittman. The influence of rock pressure in artesian aquifers, with special reference to the Dakota basin of North America, has been discussed at length by several investigators in the United States. Papers by W. L. Russell on "The Origin of Artesian Pressure," and by O. E. Meinzer on the "Compressibility and Elasticity of Artesian Aquifers," appeared in Economic Geology in 1928, and led to further papers by A. M. Piper, C. Terzaghi and D. G. Thompson. The whole question is reviewed in detail by C. F. Tolman in his book "Ground Water," published in 1937. So far as the writer is aware the only detailed investigation of the Great Australian Basin with a view to the quantitative evaluation of the influence of rock pressure, which is regarded by Meinzer as being intimately associated with hydraulic pressure, is that now in progress in Queensland. It would appear that rock pressure must be taken into account as a contributory factor to the rise of the artesian water, even if it is not the main cause, as contended by Russell for the Dakota basin.

It would be of considerable interest to ascertain whether there are any differences in pressure attributable to rock pressure in localities within the Great Australian Basin where faulting occurs. In any case the utmost care must be taken to avoid correlating pressures from different aquifers separated by impervious beds of clay or shale. There are places in South Australia in the Murray River Basin where pressure is found to rise in each successive aquifer of a basin as a result of the higher elevation of the intake area of each such aquifer, and where consequently the increases are due primarily to hydraulic pressure without the necessity for invoking rock pressure. In the eastern marginal portion of the Great Australian Basin similar structural features may exist and may give rise to like phenomena. The danger of confusing pressure data from different aquifers hardly exists in South Australia, where only a single aquifer is tapped by most of the boreholes in the Great Australian Basin.

(9) Intakes and Outlets.

The chief intake areas for the Great Australian Basin are situated in eastern New South Wales and Queensland. Their area in New South Wales has been estimated to be 9,500 square miles and their elevation above sea level to range from 900ft. to 2,000ft. There are great differences in elevation in Queensland also, the highest being situated to the north-east of Charleville where they rise to 1,500ft. above sea level.

Less exact information is available with regard to the intake areas on the western margin of the basin, especially to the north and north-north-west of Cloncurry. It was once thought that there was a subterranean intake from the ground water of the Barkly Tableland which follows the course of the Georgina River on the west of Boulia; but Dr. F. W. Whitehouse, after examining this region, has thrown doubt upon the possibility.

Farther to the south-west it appears possible that the occasional flood waters of the Todd, the Hale, and the Hay Rivers, which rise in the MacDonnell Ranges and terminate abruptly on the margin of the Arunta desert, contribute water to the basin.

Still farther to the west there is water taken in along the valleys of the Finke and Goyder Rivers, and also where the Alberga River and Arckaringa Creek cross the outcrops of the Jurassic sands. Reference will be made to this far south-westerly portion of the basin in dealing with South Australia.

So far as outlets are concerned the only free outlet of normal type into the ocean is that which discharges water into the Gulf of Carpentaria. As has been mentioned above, geological structure prevents the escape of the water southwards into the Murray River Basin or into the Southern Ocean to the south of the Nullarbor Plain. The only other means of escape for the water are the numerous mound springs, most of which are situated on the southern and south-western margins of the basin, and the boreholes of which there are great numbers in Queensland.

(10) The Utilization of the Water.

The artesian water has been used in a few places for township supplies, and the natural pressure under which it reaches the surface has been employed for the production of power to drive shearing and electric lighting plants. Attempts to use the water for horticultural purposes cannot be said to have been generally successful, even where the quantity of salts in solution is small. The argillaceous soils in particular become saturated with salts in areas within which the rainfall is insufficient to carry off the mineral matter deposited from the bore water, and ultimately become unproductive although attempts to irrigate may appear to be temporarily successful. The sandy soils give better results, even with water more highly charged with dissolved solids, but the application of artesian water to horticulture is practically restricted to the small gardens attached to homesteads. In a few places the water has been used for wool-scouring and for thermal baths, but such uses are not important. The railways make use of the artesian water for all purposes, where other sources of supply do not exist.

By far the widest application of the artesian supplies is for watering stock, either at public watering places and on stock routes, or within private pastoral holdings.

The most interesting application of the artesian water for pastoral use is that which is found on the western plains of northern New South Wales within the Trust Districts established under the Water and Drainage Act. The area of each district ranges from 50,000 to 90,000 acres, according to the flow obtainable from the borehole after allowing up to 40 per cent for the diminution of the flow. No such district is approved unless it embraces a sufficient number of holdings to fully utilize the flow. The country watered has an average fall to the westward of 1ft. to 2ft. to the mile, and the borehole is drilled at the eastern end of the country to be served. The reticulation is effected by cheaply constructed drains or channels of uniform depth and with a minimum fall of 9in. to the mile. The flow is subdivided exactly as required by means of stop-plate divisors, in which the width of the slots is proportional to the area to be served by the channel. The design of the reticulation provides that the boundary of a holding is not more than two miles from a channel, to enable the whole of the land to be used by stock. By the adoption of these methods it has been found possible to serve with seven boreholes the same area of country that would have required 10 boreholes under individual control.

This great achievement in the interests of conservation of the artesian water resources has been rendered possible by the systematic study of the whole region by the Water Conservation and Irrigation Commission of New

South Wales. This authority has reduced to map form all data regarding the reduced level of the ground surface, the reduced level of the hydraulic surface, the reduced level of the main aquifer, the depth of the main aquifer below the surface, the thickness of the aquifers, the original and present flows from the boreholes, the original pressure of the water at the surface, the temperature of the water tapped, and the salinity of the water. Moreover, every care is taken to record all ascertainable facts during the progress of boring operations. It has been recorded by H. H. Dare that in 1939 there were altogether 4,691,294 acres served in the Water Trusts by 3,174 miles of channels.

In other parts of Australia, where topography and soil conditions are not favourable for the carrying out of such systematic reticulations of the water, the usual practice is to allow the bore water to discharge into a natural water channel or depression. Open drains cannot be maintained in sandy country generally, but it has been found possible to keep them in operation where the surface is covered with a mantle of "gibbers" from the disintegration of the duricrust.

(c) THE SOUTH AUSTRALIAN PORTION OF THE GREAT AUSTRALIAN BASIN.

The foregoing account of the major features of the basin deals broadly with its structure as a whole, and refers principally to those features which are continuous over wide areas, extending far beyond the limits of South Australia. When detailed consideration is given to the portion of the basin that lies within this State it is found that there are many matters to which attention must be drawn in order to get a full understanding of this great natural resource. The basin is far from simple in character. There are several suspended or perched basins above the main aquifer, or marginal to it, on different stratigraphical horizons—some of them shallow enough to encourage development in areas the stock-carrying capacity of which does not justify the expense of drilling to the Jurassic sands where these are very deep. In some places the main aquifer is so far below the surface that only stock-route boreholes have been drilled to tap supplies. The quality of the water obtainable is variable, although it is almost universally good enough for watering stock. There is more than one source for the artesian water, the chemical character of which changes in conformity with the slopes of the hydraulic surface. Many natural outlets, marked by mound springs, occur; some of them on the extreme margin of the basin, but others well within its boundary. The pressure water gives place to ground water on the south-western margin for reasons dependent upon structure, yet the stratigraphical units persist, although dismembered in part by erosion. These are points, *inter alia,* which it is proposed to discuss in the following paragraphs.

(1) The Continuity of the Stratigraphical Horizons and the Distribution of Aquifers.

The lowest beds of the basin are the Jurassic sands which have been proven to be continuous from the deepest part, near the north-eastern corner of the State, to the margin close to the Transcontinental Railway. In fact, these sands are probably the source of much of the great sandy cover that extends far to the westward of the basin. Very little is known of their thickness in South Australia, save in the marginal areas. When once water has been struck in the deepest part of the basin on the stock route between Marree and Birdsville the difficulty of coping with the boiling water is considerable, and it has been necessary to abandon drilling operations immediately after the aquifer has been tapped. However, on the north-western margin at Charlotte Waters (total depth of borehole 1,474ft.), where subartesian conditions prevail, drilling has been carried deeply into the sands which are known to be at least 860ft. thick at this place. Similarly, at Blood's Creek, a short distance to the southward of Charlotte Waters, the borehole (total depth 2,002ft.) 652ft. of sands were pierced from 1,350ft. downwards. On the eastern side of the South Australian part of the basin the full thickness of the sandy aquifer was penetrated at the sites of Yarra Hill, Toopawarrina, Glenmanyie, and Quinyambie New Homestead boreholes where it was found to be respectively 107ft., 88ft., 13ft., and 69ft.

So far as is known the sand of the aquifer carries little in the way of clay or shale bands, save on the margins where these have been recorded at Charlotte Waters, Blood's Creek, and Quinyambie New Homestead. Nothing is known of the continuity of such bands, which may be merely lenses of small extent. They have not affected the level to which the water rises.

On the western rim of the basin the sandy bed carries coarse grains so that the aquifer is essentially a siliceous grit composed of bluish-grey quartz. In the deeper portions of the basin, however, the sand, though somewhat variable in grain, is typically fine-grained and grey to pale-buff in colour. Some parts of the sand are loosely coherent and are called by the drillers "sand rock," and in a few places there has been some secondary silification. Sizing tests have been carried out on samples recovered from some of the boreholes, with the results shown in the accompanying table.

Tyler's Standard Sieves.			Mirra Mitta, 3,529ft.-3,534ft.	Cannuwaulkaninna, 2,838ft.-2,847ft.	Clayton, 1,704ft.	Charlotte Waters, 1,263ft.-1,363ft.	Stevenson, 1,150ft.-1,170ft.	Stevenson, 1,192ft.-1,193ft.	Imbitcha, 255ft.-345ft.	Raspberry Creek, 260ft.-280ft.	Arboola, 1,015ft.-1,060ft.	Currawarra, 1,065ft.-1,075ft.	Yandama, 1,600ft.-1,625ft.
Aperture.		Mesh.											
Inch.	Millimetre.												
			%	%	%	%	%	%	%	%	%	%	%
0·0328	0·833	+ 20	nil	0·30	18·34	1·84	0·14	65·95	2·80	33·44	0·14	0·44	1·88
0·0232	0·589	+ 28	2·30	1·96	29·34	4·24	0·10	9·77	6·88	18·04	5·76	5·40	1·86
0·0164	0·417	+ 35	7·02	5·08	29·74	11·96	1·64	2·88	14·98	19·38	11·94	9·32	6·66
0·0116	0·295	+ 48	11·34	8·96	14·40	26·40	27·98	2·52	18·02	13·78	12·84	13·26	11·32
0·0082	0·208	+ 65	16·12	24·60	6·86	28·14	58·04	2·64	22·94	8·24	20·14	23·2C	22·72
0·0058	0·147	+ 100	29·22	30·10	0·80	17·32	11·40	6·69	22·46	4·18	27·44	28·76	43·84
0·0041	0·104	+ 150	20·60	13·40	0·10	5·92	0·20	5·98	7·56	1·60	14·46	13·50	8·90
0·0029	0·074	+ 200	6·04	6·30	0·04	1·76	0·08	1·20	1·40	0·50	3·64	3·28	1·54
0·0029	0·074	− 200	7·36	9·30	0·38	2·42	0·42	2·37	2·96	0·84	3·64	2·84	1·28
			100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The Cretaceous marine shales, dark bluish-grey in colour, which overlie the Jurassic sands are on the whole fine-grained and homogeneous. In some places, however, there are present boulders to which a glacial origin is assigned, and fragments of silicified wood occur also. The shale is calcareous in some spots and thin beds of impure limestone have been recorded in some boreholes. Near the bottom of the formation there are somewhat sandy beds which carry a little artesian water, as in the Clayton and Mulka boreholes. In the far-western part of the basin these lowest beds are typically ferruginous and sandy. When weathered the shales are bleached and exhibit several pale tones of colour. Superficial silicification is common where the rocks outcrop, as on the Stuart Range opal field.

The greatest thickness of the formation proved by drilling is 2,433ft. at the site of Goyder's Lagoon borehole (total depth 4,850ft.), but there may be a greater thickness to the eastward, in the deepest part of the basin. The Patchawarra borehole (5,458ft.) did not penetrate the whole of the formation, although it entered it at 4,040ft. These shales overlap the Jurassic sands on the margin of the basin to the east of Lake Frome, but on the western margin they do not extend as far as the limits of the sands.

So far as water is concerned, very little has been proved to exist in any part of the formation, except near the bottom, and the water that does occur is almost invariably saline. The Lake Harry, Clayton, Dulkaninna, and Kopperamanna boreholes, on the Marree-Birdsville stock route, have revealed an aquifer carrying salt water a little above the centre of the formation; and there is water of better quality (¾oz.) a little below the centre of the formation in the Mount Gason borehole. A flowing supply of good water has been recorded from an aquifer, 970-985ft. from the surface, in the Coonanna borehole (total depth 2,030ft.), but no analysis was made. Several boreholes in the eastern part of the basin, to the north of Lake Frome, namely, Woolatchi, Yerilla, Lake Crossing, and Montecollina proved the existence of an aquifer in the central portion of the formation; and, of these four, Yerilla and Lake Crossing were not continued, like the other two, to reach the Jurassic sands. The upper aquifer in the Cretaceous formation carries water different in character from that in the deeper sands, being apparently derived from a separate intake area, as explained later in the discussion of the composition of the water in the basin.

Above these marine shales lies another great series of shales, corresponding with the Winton series of Queensland and carrying no marine fossils, but being associated with coaly or lignitic matter and containing some sandy beds. Their greatest known thickness is 3,695ft., at the site of Patchawarra borehole (total depth 5,458ft.). These shales overlap the marine shales only in the far south-eastern portion of the basin in South Australia. The lowest beds of the formation are distinctly sandy and carry water at several points, the most notable occurrence being that which affords a flowing supply from a depth of about 4,000ft. at Patchawarra. Salt water has been recorded in aquifers in the lower part of the formation at Dulkaninna and Kopperamanna; and at several levels in the upper part there are useful waters which have been developed on Cordillo Downs and recognized at Patchawarra. The intake area for the deeper aquifers is considered by R. Lockhart Jack to be situated in Queensland and to be fed by the Diamentina River or its tributary, Farrar's Creek. There may be also an accession of water to some of the aquifers from Cooper's Creek.

The significance of these upper aquifers is greatest where the main Jurassic aquifer is very deep, and little notice has been taken of them in the shallower parts of the basin where the lower sands, with their more abundant yield, were considered to be within commercial reach. They are being drawn upon by several boreholes on Cordillo Downs, as described in detail in *Bulletin* 11 of the Geological Survey of South Australia.

Still higher stratigraphically than the Winton beds are the Eyrian sediments, of probable Lower Tertiary age, developed rather extensively in the north-eastern corner of South Australia, but largely removed by erosion from the more southerly region over which they formerly extended and in which many outliers remain. They rest unconformably upon the Winton shales in the Cordillo Downs area. The total thickness of the formation is small when compared with that of the underlying shales, since its maximum observed thickness is only 360ft. The upper third of the formation is arenaceous, the middle third argillaceous, and the lower third both arenaceous and argillaceous. All the beds have been affected by weathering and are pale in colour, from white through yellow and pink to reddish. The uppermost beds have suffered silicification and their outcrops resemble those of the Cretaceous shales on which a duricrust has formed. Small supplies of ground water have been obtained from the upper third of the formation in the Cordillo Downs area; and pressure water rising from 147ft. to 50ft. below the surface in the Cordillo bore, and also from 102ft. rising to 84ft. in the Union bore, has been obtained from the lower third.

The Eyrian beds are regarded as extending southwards into the Lake Frome district to the east of the northern Flinders Range, where some useful water has been obtained above the Cretaceous horizons. The Mulga bore also, between the far northern outcrops and Lake Frome, derives its small supply of water from Eyrian beds, and so too does Nappacoongie Well on the Strzlecki Creek.

The highest stratigraphical horizon of the basin is that comprising the Late Tertiary to Recent sediments deposited in the outwash fans and the plains bordering on the northern Flinders Range. These alluvial deposits carry water on more than one horizon and the quality of the water is variable in the different aquifers. Naturally the aquifers are not so continuous as those at lower stratigraphical levels, but they have afforded many useful supplies on Wooltana Station between Lake Frome and the Flinders Range, in the valley of the Siccus River, near the New South Wales border, and on Mount Lyndhurst Station at the northern extremity of the Flinders Range.

The variable quality of these upper waters depends principally upon the conditions existing at the intakes of the several aquifers. The best waters are found opposite the debouchures of the main creeks which rise in the higher country. Rapidity of absorption by the coarser deposits close under the range accounts for the better quality of the water in the deeper aquifers.

(2) The Structural Features of the Basin.

The best appreciation of the structure of the basin will be acquired by the study of the coloured sections prepared by R. Lockhart Jack and published in Geological Survey Bulletin 14. From these sections the following features will be found:—

1. The greater part of the basin is a sediment-filled depression the deepest part of which lies near the north-eastern corner of South Australia, perhaps in south-western Queensland close to the border between the two States.

   The foundations upon which the sediments rest are Pre-Cambrian in age, so far as is known, and these ancient rocks outcrop round the South Australian margin of the basin. They form inliers which appear to have been islands in the Mesozoic lakes and seas at places where the crustal structure was strong enough to resist the general downward movement of the great inland depression. The inliers outcropping in the Peake and Denison Ranges and Mount Dutton are the highest portions of larger areas of resistance which have produced an anticlinal structure in the overlying sediments, through the deeper foundering of those parts of the basin which had weaker support. A similar anticlinal structure has been observed farther to the east where there is a concealed prolongation of the Flinders Range.

   In these anticlinal structures the depth of the Jurassic aquifer below the surface is reduced materially as in the case of the Mount Sarah bore north of Oodnadatta; and the Yarra Hill, Toopawarrinna, Chapallana and Nick o' Time bores between Lake Eyre and Lake Blanche.

2. In conformity with the definition of an artesian basin, given on page 34, the upper and marginal unconfined portions of the water-bearing beds are mapped as constituting portions of the basin. These marginal beds form a broad flange or rim on the south-western limits of the basin and carry some useful supplies of ground water. It is not yet possible to define the limits between the ground water areas and those in which pressure waters occur. Near the southern border of the flange or rim the continuity of the Cretaceous shales has been interrupted by erosion and normal characteristics of ground water areas in the regions of low rainfall are to be noted. These features are discussed later in describing the character of the water and are illustrated by the diagrammatic sections on page 65. There has been a great deal of drilling for water in this marginal area and the distribution of the boreholes is shown on Plate IV.

(3) The Chemical Character of the Water.

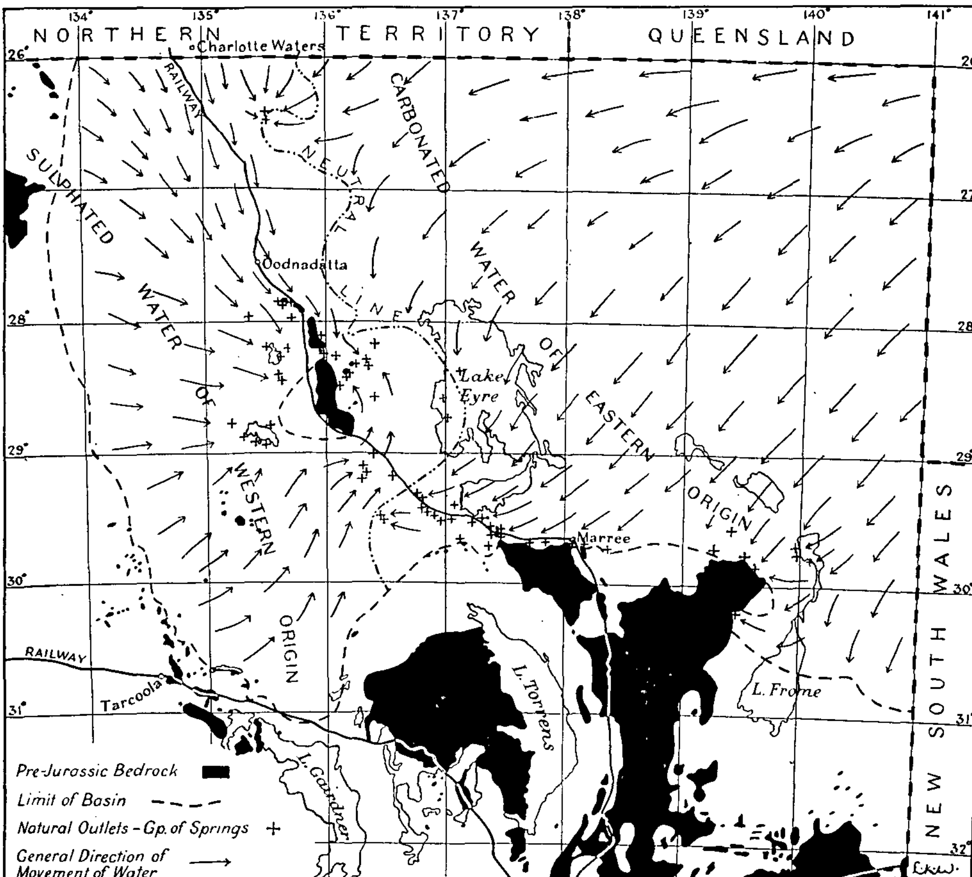
Many analyses have been made of the water occurring in different parts of the basin over a period of many years, and the outstanding characters of composition are shown in the table printed herewith. Where more than one analysis has been made of the water from the same source the table shows the composition as determined on each occasion and, when possible, the date. See table VI.

This table has been expanded slightly from one prepared by R. Lockhart Jack when he made a study of the composition of the water in 1923, and read a paper on the subject before the Royal Society of South Australia, in whose transactions, Vol. XLVII., it appears. Dr. Jack drew attention to the essential difference between the water shown by the contours of the hydraulic surface to be moving in a south-westerly direction from Queensland and that which enters the basin in the western intake areas. The water from an eastern source has predominant carbonates while that from the westward is characterized by predominant sulphates. The eastern water of the carbonated type shows increasing salinity with the length of underground travel, but is on the whole good. The western water of the sulphated type is of very good quality near the northern boundary of the State where the basin receives accessions of good water from the Goyder, Finke, and Alberga Rivers, but it deteriorates to the southward where the gathering ground for the water is less extensive and the conditions for percolation less favourable. According to the most recent mapping of the basin approximately 70 per cent of the water comes from an easterly source and 30 per cent from the westward.

In plotting the analytical results Dr. Jack used the ascertained values of the carbonic acid, CO_3, radicle, and the chemical equivalents of the sulphuric acid, SO_4, radicle expressed as deficiencies of carbonic acid. The figures used by him are shown in the table, the last column of which expresses the excess or deficiency of carbonic acid. He pointed out also that the analytical data show clearly that the water moves towards the natural outlets or mound springs.

All this information has been embodied in the map printed herewith, Fig. 16, showing the direction of movement of the water in the basin.

One interesting feature of this chemical study of the water has been the recognition of faulting in the eastern part of the basin whereby the typical carbonated water has risen into aquifers high above the Jurassic sands. These occurrences have been observed to the north of the Flinders Range where the Meteor and Petermorra bores are situated; to the east of Paralana Springs; and on the northern boundary of Mulyungarie Station east of Lake Frome. These places are marked on Plate II., showing the artesian basins of the State.



SOUTH AUSTRALIAN PORTION OF THE GREAT AUSTRALIAN BASIN

Fig. 16.

The table VI. of analyses shows also how constant has been the composition of the water drawn from almost all the boreholes by pumping or issuing from them under its own pressure. The analyses have been made at long intervals and by several different analysts, and yet there is a marked constancy of composition in almost every case. The two exceptions are those relating to the Hamilton and the Murnpeowie boreholes. In each of these two cases several aquifers were cut before the Jurassic sands were reached, and it is possible that saline water may have intermingled with the better water of the lowest aquifer through corrosion or some other defect in the casing. If such a leakage has occurred it is, nevertheless impossible to explain satisfactorily the alterations in the salinity of the Murnpeowie water unless the more saline samples suffered concentration by evaporation prior to analysis. The waters in the upper aquifers of both Hamilton and Murnpeowie boreholes were not analysed when tapped, so that any changes of composition due to leakage cannot be traced by chemical methods.

(4) The Mound Springs.

It will be seen, by reference to figure 14 on page 44 that there are very many natural outlets whence the water of the Great Artesian Basin escapes and that these occur not only in South Australia, but also in Queensland and New South Wales. Many of the outlets are marginal to the basin or close to the outcrops of inlying foundation rocks; but others, such as the great group known as Dalhousie Springs, occur well within its boundaries and distant from any outcrops of dense rocks.

These outlets are marked by the existence of mounds or rounded cones composed partly of sand and clay, but mostly of calcareous material which takes the form of massive limestone and travertine, containing numerous structures suggestive of fossilized plant stems, Recent fresh water shells and concretionary forms. In cleaning out the vent at Hergott Springs, near Marree, teeth of the diprotodon were found, the animal having evidently been trapped in the soft mud just as the bullock is occasionally bogged to-day.

The range of size of the mounds is remarkable. Some rise only a few feet above the level of the plain and have bases only 60ft. or 70ft. in diameter. The remnants of the older mounds rise to heights of 130ft. above the present general surface level, and some of these ancient mounds covered individually an area of several square miles. Some of the mounds are simple and have a single outlet. Others are composite, with many outlets at different levels on the same mound, the most active being those at levels below those from which the flow has ceased. In a few cases, as for example at Blanche Cup and Warburton Spring, there is an almost circular water-filled crater on the crest, with a small notch on the rim, whence the artesian water overflows and escapes. (See fig. 18).

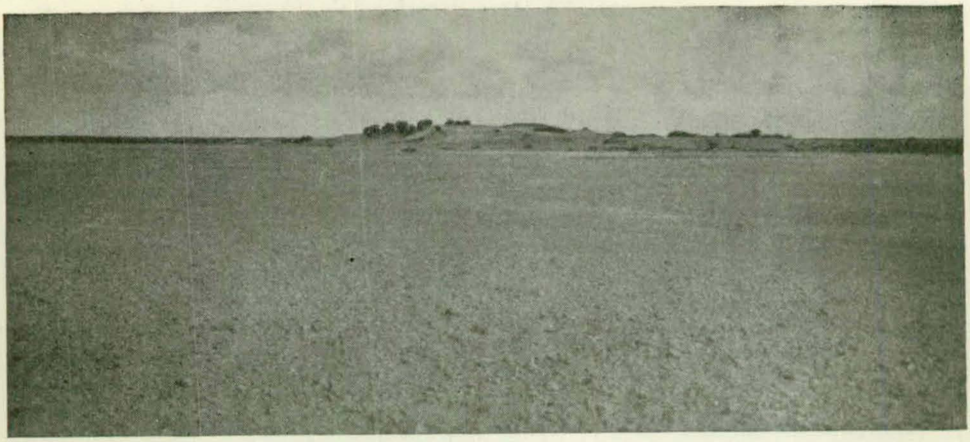
The ancient mounds of Hamilton's Hill, Kewson's Hill, Beresford Hill, and Petermorra Springs indicate a much more abundant discharge of water under greater pressure at the time of their formation than the present vents exhibit. The dense travertinous limestone of the old mounds has been dissected by erosion, and flat-topped remnants are left. The emission of water from the springs is for the most part steady and regular, but there are exceptions near Blanche Cup, south of Lake Eyre, where the water rises in a succession of "eruptions." These pulsating springs have been called "bubbling springs," but there is no noticeable emission of gas bubbles with the water in which a considerable amount of sand is carried in suspension. Between successive eruptions the pool occupying the crater of the mound is quiet and unruffled.

It is noticeable that, in the parched region round Lake Eyre, the effluent streams in no case extend far from the natural vents, the water being lost by evaporation. No measurements have been made yet to ascertain the quantities of water discharged from these mound springs which constitute the main natural outlets of the basin. There can be no doubt but that the distribution of the mound springs guided the early pastoral settlement of the Lake Eyre region, and through these holdings determined the location of the northern railway from Marree towards Oodnadatta.

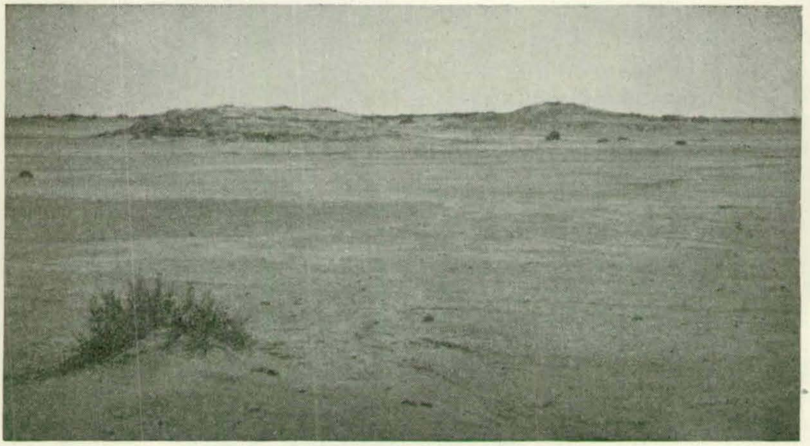
Analyses of waters issuing from the mound springs are given in table XII.

(5) The Temperature Gradient Within the Basin.

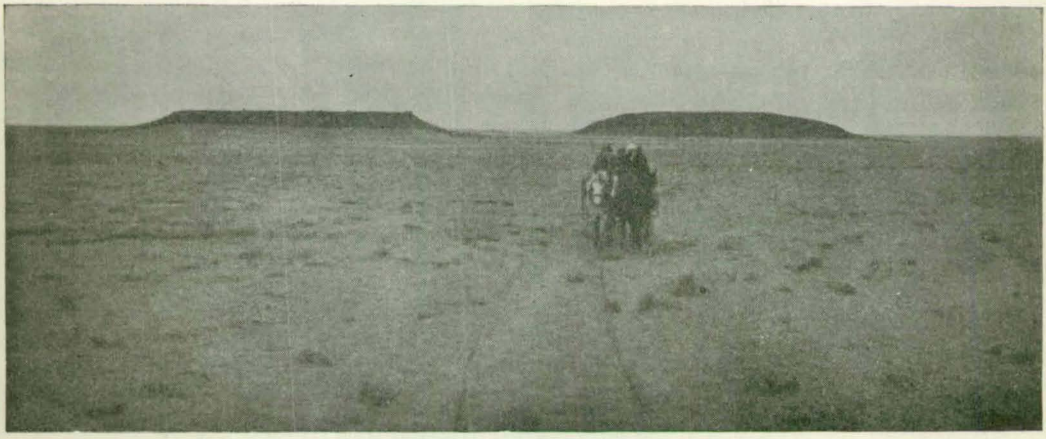
In the tables showing the principal features of the boreholes within the basin (Tables VII. & VIII.) it will be noted that the temperature of the water is recorded, where observations have been made. The temperature gradient has been calculated on the assumption that the zone of invariable temperature lies 50ft. below the surface, and that at this depth in the Lake Eyre region the mean annual temperature is 70° Fahrenheit.



Coward Spring.

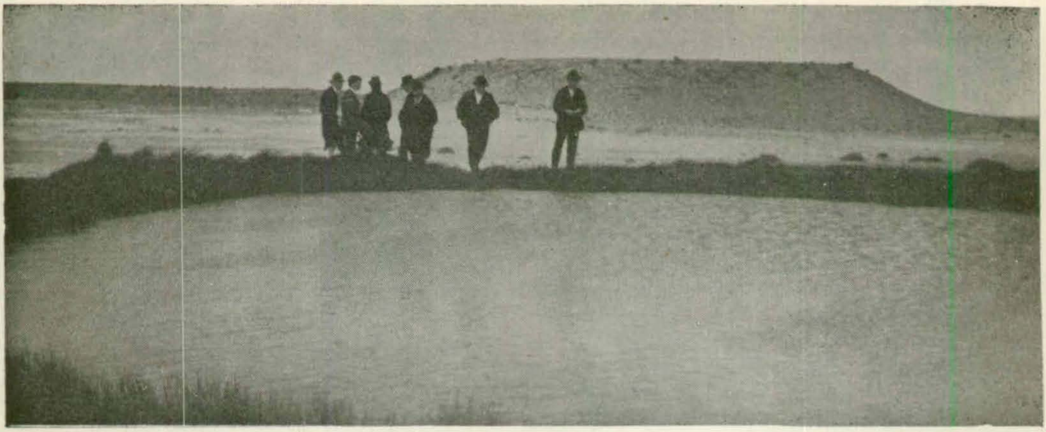


Two Mound Springs near Blanche Cup.



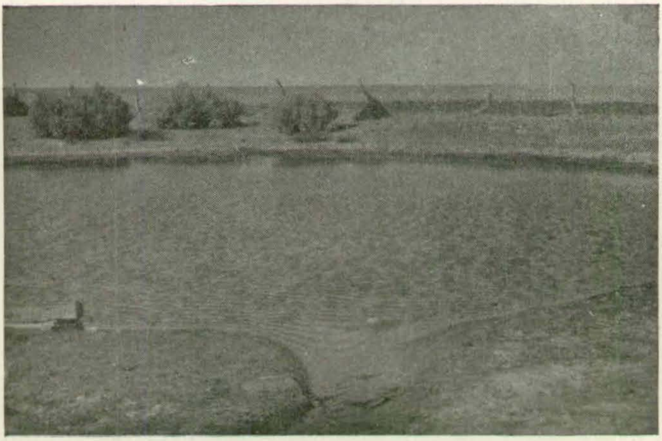
Beresford Hill, remnants of extinct mound.

Fig. 17.—MOUND SPRINGS SOUTH-WEST OF LAKE EYRE.



Crest of Blanche Cup. Hamilton Hill, portion of extinct mound, in background.

Pulsating spring near Blanche Cup in eruption.



Cup on crest of mound, Warburton Spring.

Fig. 18.—MOUND SPRINGS SOUTH-WEST OF LAKE EYRE.

The temperature gradients will be noted to be abnormally steep in all cases. The deeper boreholes, such as Mount Gason and Goyder's Lagoon, have penetrated into the Jurassic sands only a few feet, and the water emerging from them may have connection with deeper water at those sites and with water contained in the continuous aquifer extending into still deeper parts of the basin. Thus there may well be a transfer of heat both by conduction and convection, processes that are responsible also for the abnormally high temperatures of water tapped at relatively shallow depths on the margin of the basin.

(6) The Far South-Western Margin of the Basin.

Just as the pressure water of the basin gives place to ground water on the eastern margin, so too the south-western margin carries water that is contained in the Jurassic sands and is not confined by continuous overlying shales. Hence it is under atmospheric pressure only and no appreciable rise of the water is observed when the water is struck in boreholes. The accompanying diagrammatic sections show the typical modes of occurrence in this region, Fig. 19.

On the extreme margin, where there is an extensive intake and a quick run-off from dense and non-absorbent rocks, such as granite, supplies of useful water are found. The run-off from outliers of the Cretaceous shale assists in providing water of useful quality, which may entirely displace the saline water or overlie it in the form of a "cream." The existence of inliers of the dense foundation rocks are responsible for the occurrence of useful water in depressions of the hard rock or at the places where the Jurassic sands rest upon the foundations at water level.

It is noticeable that the relation of the useful to the saline water in this area is similar to that in the upper western portion of Eyre Peninsula where there are deep sediment-filled valleys in a terrain that has been dissected deeply. The Jurassic sands of the basin play the same part as the Tertiary to Recent sands of the ground water areas to the southward.

The direction of the movement of the water in the several portions of this region is shown by arrows in Fig. 16, on page 60.

There is only one deep borehole in the whole area, near Lake Phillipson, 3,161ft. deep, where only saline water, 4oz. per gallon, was found. The Jurassic sands rest upon a great thickness of carbonaceous shales which give place to granite at 3,140ft. These shales may be of Triassic age, but no fossils have been seen in the bore core. The coaly matter is sub-bituminous in character, and the beds are correlated tentatively with the coal measures of Leigh Creek. They evidently occupy a deep depression in the Pre-Cambrian foundations. Erratic boulders occur in the lowest portion of the shales, and there has been some speculation as to whether they are outlying remnants of the widespread Permo-Carboniferous glaciation. Salt water was found in the Jurassic sands, which extended from 73ft. 10in. to 166ft. 10in.

Typical analyses of waters from this marginal part of the basin are set out in Table X. The positions of the numerous boreholes in this region are shown in a separate plan, Plate IV.

(7) Subsidiary Basins Perched Above or Marginal to the Great Basin.

The map showing the artesian basins of the State, Plate II., reveals the presence of several artesian basins containing aquifers which are at much higher levels than the Jurassic sands where the principal supplies are obtained. The importance of these perched basins is great, since they afford supplies at relatively shallow depths and provide water suitable for sheep in a region the climatic features of which permit only light stocking.

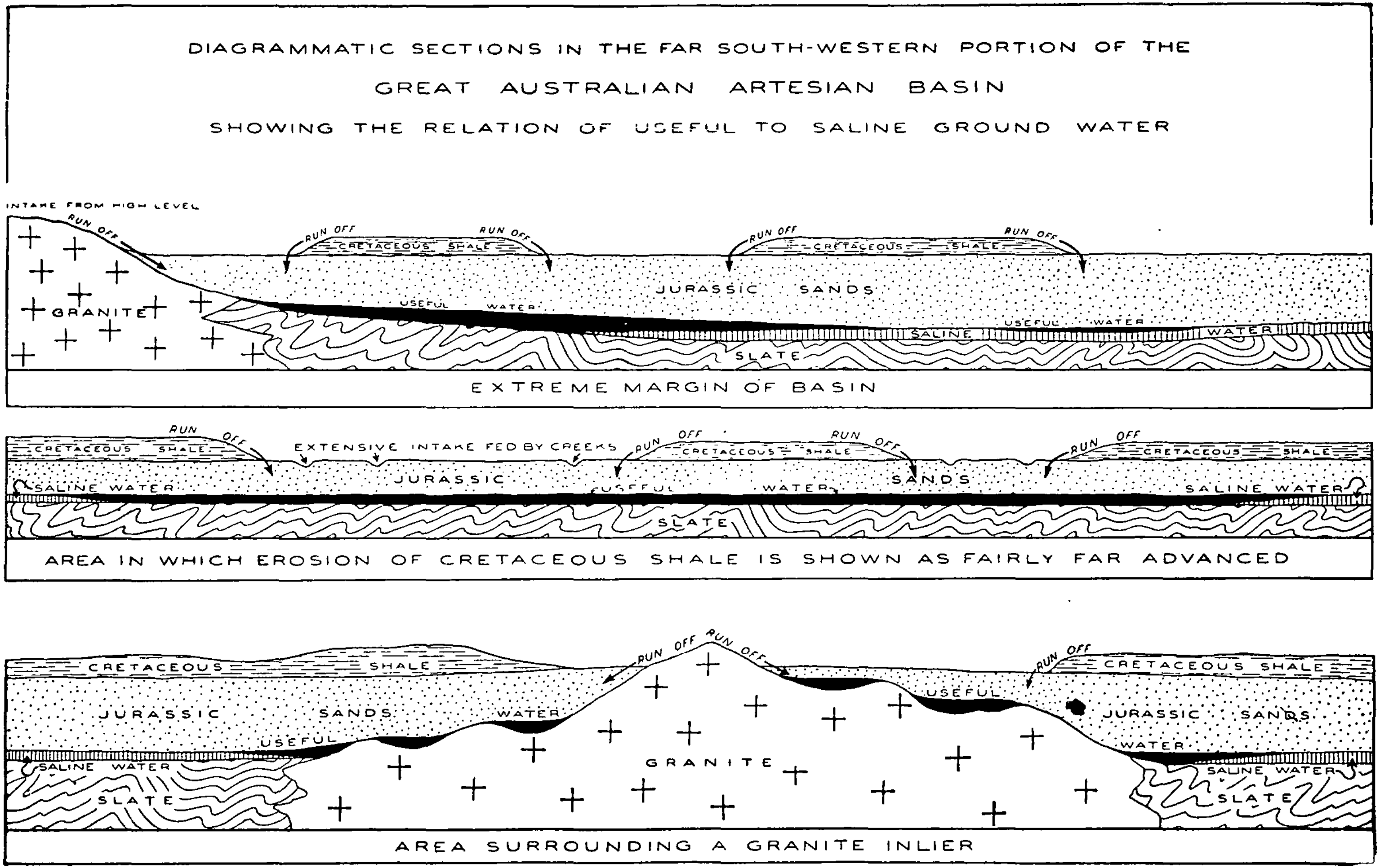

DIAGRAMMATIC SECTIONS IN THE FAR SOUTH-WESTERN PORTION OF THE
GREAT AUSTRALIAN ARTESIAN BASIN
SHOWING THE RELATION OF USEFUL TO SALINE GROUND WATER
INTAKE FROM HIGH LEVEL
RUN OFF
CRETACEOUS SHALE
JURASSIC SANDS
GRANITE
USEFUL WATER
SALINE WATER
SLATE
EXTREME MARGIN OF BASIN
EXTENSIVE INTAKE FED BY CREEKS
AREA IN WHICH EROSION OF CRETACEOUS SHALE IS SHOWN AS FAIRLY FAR ADVANCED
AREA SURROUNDING A GRANITE INLIER

Fig. 19.

A. In the far north-east, on Cordillo Downs Station, there are two superimposed basins, the upper of which occurs in the Eyrian beds and the lower in the Upper Cretaceous or Winton beds. The sediments of both series have been folded into domes. The sequence in each series and the unconformity between them are regular and are shown in the sections prepared by R. Lockhart Jack and printed in Bulletin 11. The principal aquifers occur in the lower third of the Eyrian series, and on several horizons in the Winton series, namely:—

1. The Needle Well bed.

Interval of 250ft.

2. The Main bed.

Interval of 200ft.

3. The Wongyarra bed, with three water-bearing horizons, the second being 140ft. below the uppermost, and the third 40ft. below the central one.

Interval of 630ft.

4. The Bull's Hole bed.

Pumping supplies, up to 1,000gall. per hour, have been obtained from boreholes in this area. Analyses of the water tapped are given in Table XI.

B. The Eastern Border Basin, on the eastern boundary of the State, extends into New South Wales whence the deeper beds receive accessions of water shed from the Barrier Range. The sediments are regarded as being of Pleistocene to Recent age, and there are four water-bearing horizons, the quality of the water improving as each successive aquifer is cut. The northern part of this basin rests upon the Cretaceous shales, and the southern portion upon Pre-Cambrian rocks. It will be noted from the map that the typical carbonated water from the main Jurassic aquifer is considered to have migrated upwards along some fracture or fractures and to have displaced the normal sulphated water near the northern boundary of Mulyungarie Station to the East of Lake Frome.

C. The Siccus Basin, to the south of Lake Frome and north of the Boolcoomata Ranges, fed from streams flowing from the west and south and carrying sulphated water. The chief source of the water drawn from the basin is the Pleistocene to Recent alluvium of the broad Siccus River valley. Some of the water escaping from natural vents has built up mound springs at the south-eastern end of Lake Frome, whence saline (2.31oz. per gallon) water emerges. On the west of the Siccus River water is obtained from shallow wells and bores which tap the water absorbed from the run-off from the Flinders Range, where this basin merges into that marked D on the map of the State. The basin is, however, separated from that marked B by a subterranean ridge of old rocks.

D. The piedmont plain, extending eastwards from the old rocks of the Flinders Range in the direction of Lake Frome, carries useful water in the Pleistocene to Recent sediments composed of waste from the highlands and also in the underlying beds regarded as being part of the Eyrian series. A great deal of drilling has been done on Wooltana Station, and many of the boreholes yield water suitable for stock. The best water is obtained in proximity to the Range and at places where the main creeks, Big John Creek, Bolla Bollana Creek, and Pontana Creek, debouch upon the plain. The quality of the water deteriorates in the direction of Lake Frome. The water is characterized by predominant sulphates, save for that

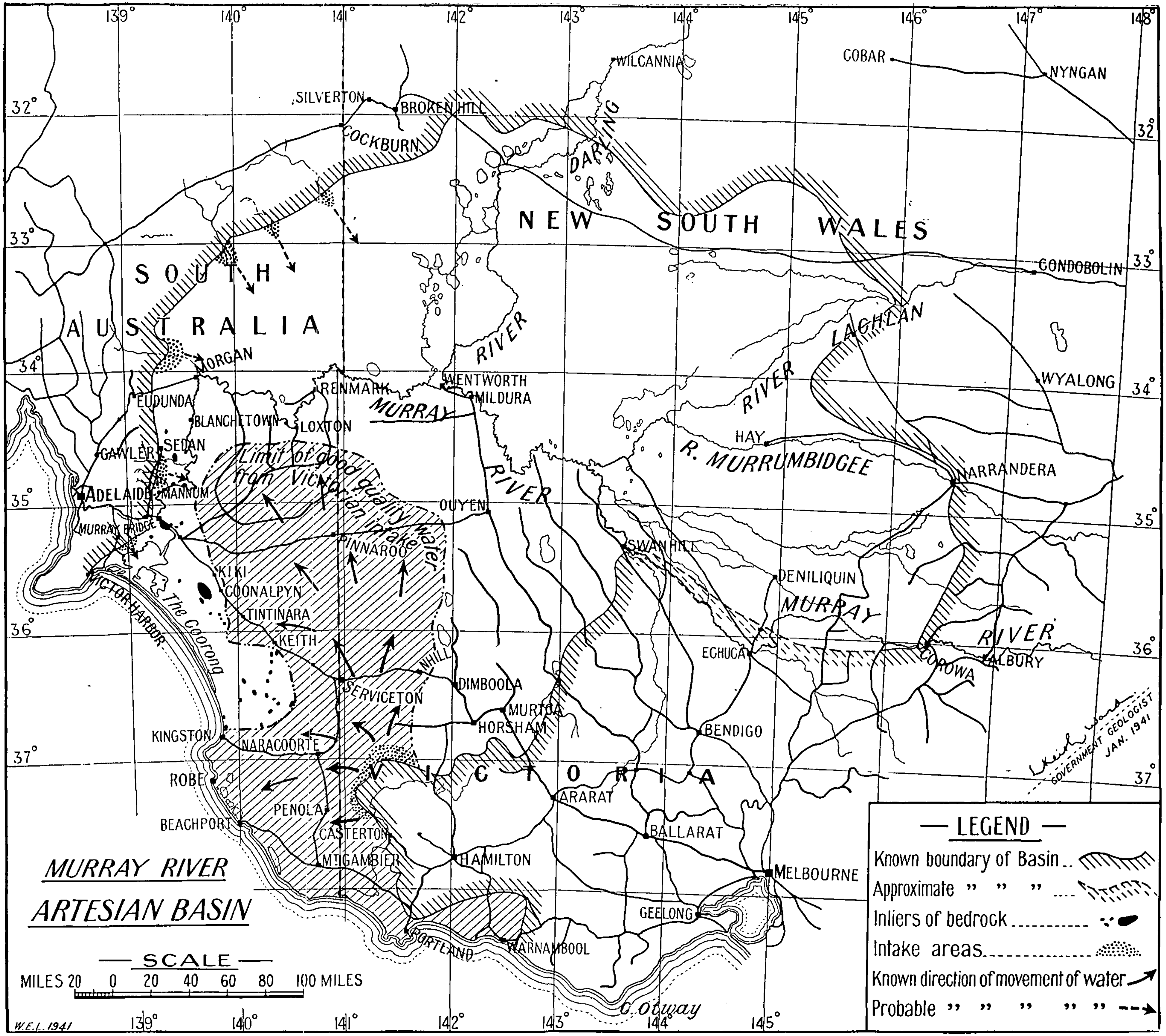

MURRAY RIVER ARTESIAN BASIN
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
LEGEND
Known boundary of Basin
Approximate " " "
Inliers of bedrock
Intake areas
Known direction of movement of water
Probable " " " " "
SCALE
MILES 20 0 20 40 60 80 100 MILES
W.E.L. 1941
Keith Ward GOVERNMENT GEOLOGIST JAN. 1941
Limit of good quality water from Victorian intake
COBAR
NYNGAN
WILCANNIA
SILVERTON
BROKEN HILL
COCKBURN
DARLING
RIVER
CONDOBOLIN
LACHLAN
RIVER
WYALONG
HAY
R. MURRUMBIDGEE
NARRANDERA
MORGAN
EUDUNDA
BLANCHETOWN
RENMARK
MURRAY
WENTWORTH
MILDURA
LOXTON
SEDAN
GAWLER
ADELAIDE
MANNUM
MURRAY BRIDGE
OUYEN
PINNAROO
RIVER
SWAN HILL
DENILIQUIN
MURRAY
RIVER
KIKI
COONALPYN
TINTINARA
KEITH
VICTOR HARBOR
The Coorong
NHILL
SERVICETON
DIMBOOLA
MURTOA
HORSHAM
ECHUCA
COROWA
ALBURY
BENDIGO
KINGSTON
NARACOORTE
ROBE
PENOLA
BEACHPORT
CASTERTON
MT GAMBIER
HAMILTON
ARARAT
BALLARAT
MELBOURNE
GEELONG
PORTLAND
WARNAMBOOL
C. Otway
139°
140°
141°
142°
143°
144°
145°
146°
147°
148°
32°
33°
34°
35°
36°
37°

Fig. 20.

in an area near Paralana Spring where carbonated water has apparenlty migrated upwards from the Jurassic aquifer along fault planes. This area is marked on the map of the State, Plate II. This perched basin extends northwards as far as Lake Callabonna and swings round the northern extremity of the Flinders Range as far as the eastern boundary of the Lyndhurst Basin. Woolatchi, Lake Crossing, and Yerilla boreholes tap this sulphated water. Petermorra borehole cut the same water-bearing bed, but the water is of the carbonated type, having escaped by a fault plane from the underlying Jurassic aquifer. The existence of the fault is confirmed by the presence of mound springs. Much information regarding this basin has been provided by R. Lockhart Jack and is printed in Bulletins 11 and 14. Analyses of water from the basin are printed herewith in Table XI.

E. There is a restricted area between the Pre-Cambrian rocks of the northern Flinders Range and the extreme southern limit of the Jurassic sands wherein water has been obtained from sediments derived from the Range, which have absorbed the run-off carried northwards by The Frome, Taylor's Creek, Yerelina Creek, and Tindelpina Creek. The water is characterized by predominant sulphates, as is the case with other waters having their source in this dry country. The results of drilling operations indicate the successive overlapping of the Jurassic sands by the Cretaceous shales, and these in their turn by the Eyrian beds and the Pleistocene to Recent alluvium.

Analyses of waters from this area are given in Table XI.

(d) THE MURRAY RIVER ARTESIAN BASIN.

(1) Geological History.

The large artesian basin generally known by the name of the Murray River Artesian Basin is of very great importance to South Australia. Although far less extensive than the Great Australian Basin, it is much more favourably situated as regards accessibility, climate, and general productivity. The total area of the basin, as determined by measurement of the map printed with this Bulletin, is 107,250 square miles, of which 52,173 square miles lie within the boundaries of New South Wales, 26,808 square miles in Victoria, and 28,269 square miles in South Australia.

The area included within the basin, as shown on the map, differs in some respects from that formerly occupied by a broad gulf to which the name "Murravian Gulf" has been given. The geological history of this region is concerned with earth movements that are far more complex than those involved in a mere simple subsidence and subsequent uplift. The subsidence began far back in Tertiary time, and followed upon a long period of erosion during which a large part of southern Australia was reduced to the condition of a peneplain. The muds and clays containing lignite and the beds of sand and gravel that are characteristic of the lower horizons and are interbedded with marine strata indicate oscillations of level, with alternating emergence and submergence of coastal swamps. The general tendency, however, was one of subsidence, and as the sea became deeper the fragmental polyzoal limestone (Janjukian) was deposited in a broad gulf that extended far beyond the limits of the mapped basin. Some of the country now constituting the highlands of the southern part of the Mount Lofty Ranges was submerged beneath the ocean, for we find remnants of the polyzoal limestone 800ft. above sea level near Myponga. Probably also this Tertiary sea covered a wide expanse of Palaeozoic and Mesozoic rocks in western Victoria, although most of the sediments deposited in that sea have been stripped by erosion from the foundations outcropping near Casterton, Coleraine, and Hamilton. An upward movement round the eastern margin of the basin gave rise to a westerly flowing drainage system, and the Darling, Lachlan, Murrumbidgee, and Murray (Hume) rivers are thought to have had separate entities as far as their mouths in the Murravian Gulf. They brought down silt which covered much of the marine sediments in the deeper parts of the basin and extended over a much wider area than that in which the marine beds were deposited. The pattern of the drainage during these later stages of sedimentation is not known. River-borne waste from the land may have caused material changes in the form of the Murravian Gulf, but it is not possible to indicate the outlets of the rivers.

At a later date, probably at the close of the Tertiary, there was a general uplift of southern Australia, wherein some regions rose to much higher elevations than others. While the area occupied by the Murravian Gulf rose perceptibly, the highlands on its margin rose much higher, to the accompaniment of extensive faulting round the rim of the basin. These differential movements raised the barrier of the Mount Lofty Ranges between the Murray River Basin and the Gulf region of South Australia. With the rise of the great Tertiary depression the rivers draining into it became engrafted, and the present Murray River carried their waters to the sea. Irregularities in the uplift determined the actual course of the Murray, the general trend being westwards as far as North-West Bend at Morgan, and then southwards to the mouth close to the eastern faulted margin of the highlands. This drainage system removed much of the silt deposited over the limestone in the western part of the basin, and corroded a narrow gorge through the limestone itself below Overland Corner. The channel above Overland Corner is cut through lacustrine and fluviatile deposits which are much softer and the valley of the river is consequently wider and marked by more gently sloping banks. The lowest part of the River Murray below Wellington traverses lacustrine deposits. The configuration near the mouth, with the arrangement of lakes and the long sand spit of Younghusband Peninsula separating the Coorong from the ocean, is strikingly similar to that of the Lakes Entrance in Gippsland. If plans of these two districts are drawn to the same scale and placed side by side they resemble each other in many ways, but their orientation is opposed like that of right-hand and left-hand gloves.

Within the limits of the basin there are no breaks in the continuity of the Tertiary and Post-Tertiary rocks except in the south-western portion along the River Murray and in the district lying between the Murray Bridge-Serviceton railway and the sea. In these latter areas there are numerous outcrops of Pre-Cambrian rocks, mostly granites, which represent places at which there must have been shallow water in the Murravian Gulf. Probably these outcrops of the old rocks were once covered by marine sediments which have since been removed by erosion. None attains any great height and it is doubtful whether there were any actual islands on the seaward side of the Murravian Gulf. The existence of the numerous outcrops on the south-western side of the Murray Bridge-Serviceton railway suggests a strong foundation which resisted the tendency towards subsidence and perhaps formed a hinge between the earth blocks now marked by the South Australian highlands and the Dundas Peninsula of Victoria, while the deeper portions of the Murravian Gulf to the north-east of the hinge subsided to a far greater extent.

(2) The Underground Water of the Basin.

There are notable differences in the quality of the water stored in different parts of the basin, and this variability is such that the uses to which the water can be put are far from constant. Thus, in the far south the water, if a little hard, can be used for practically any purpose, while in the central portion the quality deteriorates but is nevertheless good enough for watering farm horses. Still farther north the salinity is so high that only some of the water is suitable for watering sheep. On the far west much of the water has been used for the irrigation of lucerne. Having regard to these features it is considered best to deal with the waters of the basin in separate sections.

A. *The southern part of the basin*: In Bulletin No. 19 the present writer has dealt at some length with the underground water of the south-eastern part of South Australia, which embraces much of the most southerly portion of the Murray River Artesian Basin. The best pressure-water is found

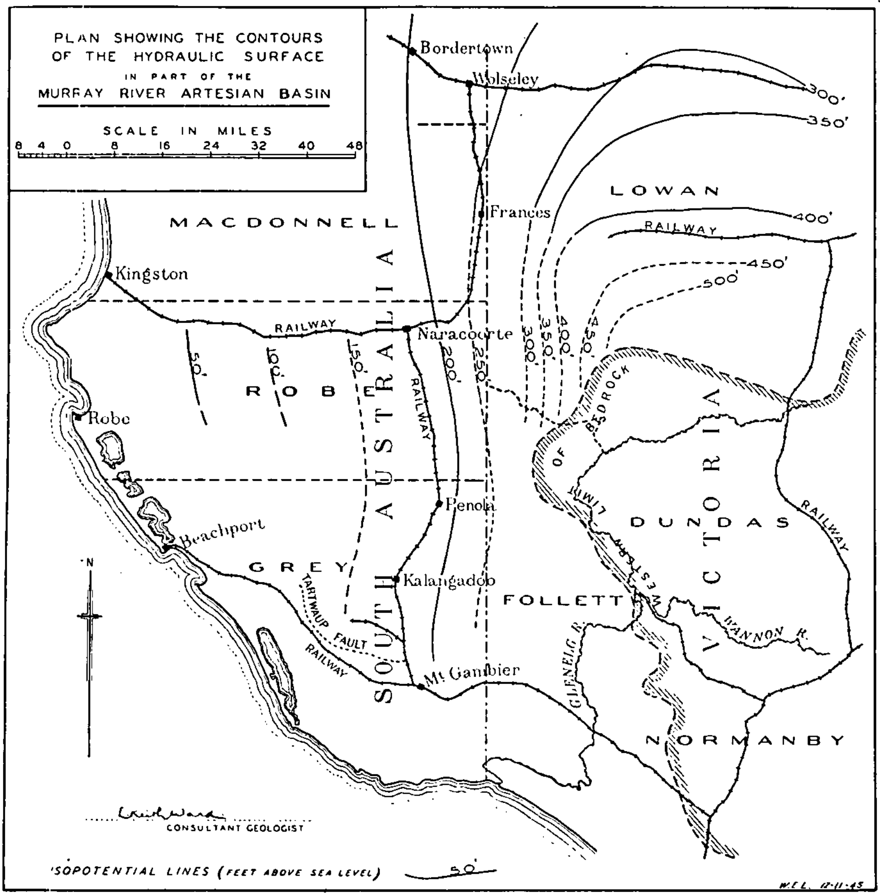


Fig. 21.

in this State and in the adjoining part of Victoria, where the water moves radially outwards from an intake area in counties Lowan and Follett of the latter State, where there is an area of about two million acres receiving an annual rainfall of twenty-three (23) inches and from which there is no run-off, even in the wettest seasons. Fragmental contours of the hydraulic surface in this region have been drawn and are shown in Fig. 21. Beyond the area covered by this map it is not yet possible to fix the positions of the isopotential lines for lack of the necessary data. There is a major fault, to which the name of the Tartwaup Fault has been given, extending in a general south-easterly direction from near Millicent to Tartwaup which is about five (5) miles to the north of Mount Gambier. On the south-western side of this fault the pressure water appears to merge with the ground water, being enabled to ascend by the fault plane and also along the funnels of volcanic origin such as the Blue Lake at Mount Gambier. Several very strong springs occur along the line of the fault. See Fig. 3 on page 14 of *Bulletin* No. 19. There are several places near the south coast, in the hundreds of MacDonnell and Caroline, at which large quantities of water emerge from underground and flow into the sea. These are the visible outlets of the basin, and there is probably a large amount of water discharged into the ocean by outlets that are concealed from sight.

Water for township and district reticulation at Mount Gambier is drawn from the Blue Lake, and for the towns of Naracoorte and Bordertown from boreholes that have been continued beyond the polyzoal limestone into the underlying sands and gravels which are interbedded with lignitic clays. It has been found necessary to use Johnson screens at Bordertown and Naracoorte to prevent the rise of sand with the water when pumping, and these have proved effective.

Analyses of these waters that are utilized for township supplies will be found in Table II.

The following table gives particulars regarding the borehole supplies:—

	Depth of Aquifer. (Feet.)	Static Level Water Below Surface. (Feet.)	Supply, Gallons per Hour.		Salinity, Grains per Gallon.
			Maximum During Test.	Pumping Rate.	
Naracoorte No. 1	462-482	13	42,800	21,500	93·7
Naracoorte No. 2	490-510	26	26,000	17,500	96·6
Bordertown	565-585	88	17,000	10,000	89·7

There are large supplies of ground water contained in the limestones which overlie the sands bearing pressure water, and most of the private supplies are obtained from this source. In Bulletin No. 19 the writer has published maps giving the contours of the water table which show that there is a general movement of the ground water in a westerly direction. The latter contours are not exactly parallel to the isopotential lines relating to the pressure water, save in two small areas. Yet it is clear that the ground water moves westwards from Western Victoria in much the same way as the pressure water. One interesting minor matter connected with this ground water is the occurrence of small mound springs in the south-western corner of the hundred of Symon where the water that has traversed the calcareous stranded dune ridge known as the Woakwine Range emerges at the surface.

In drilling boreholes in search of oil, two places near Kingston have shown that the hydraulic surface rises above the natural surface, so that flowing supplies occur.

B. *The central portion of the basin*: It will be seen by reference to the map of the basin as a whole, Fig. 20, that the limit of the better water derived from a Victorian source is indicated. This limit is drawn where the salinity reaches 1oz. of total salts per gallon, for the reason that the

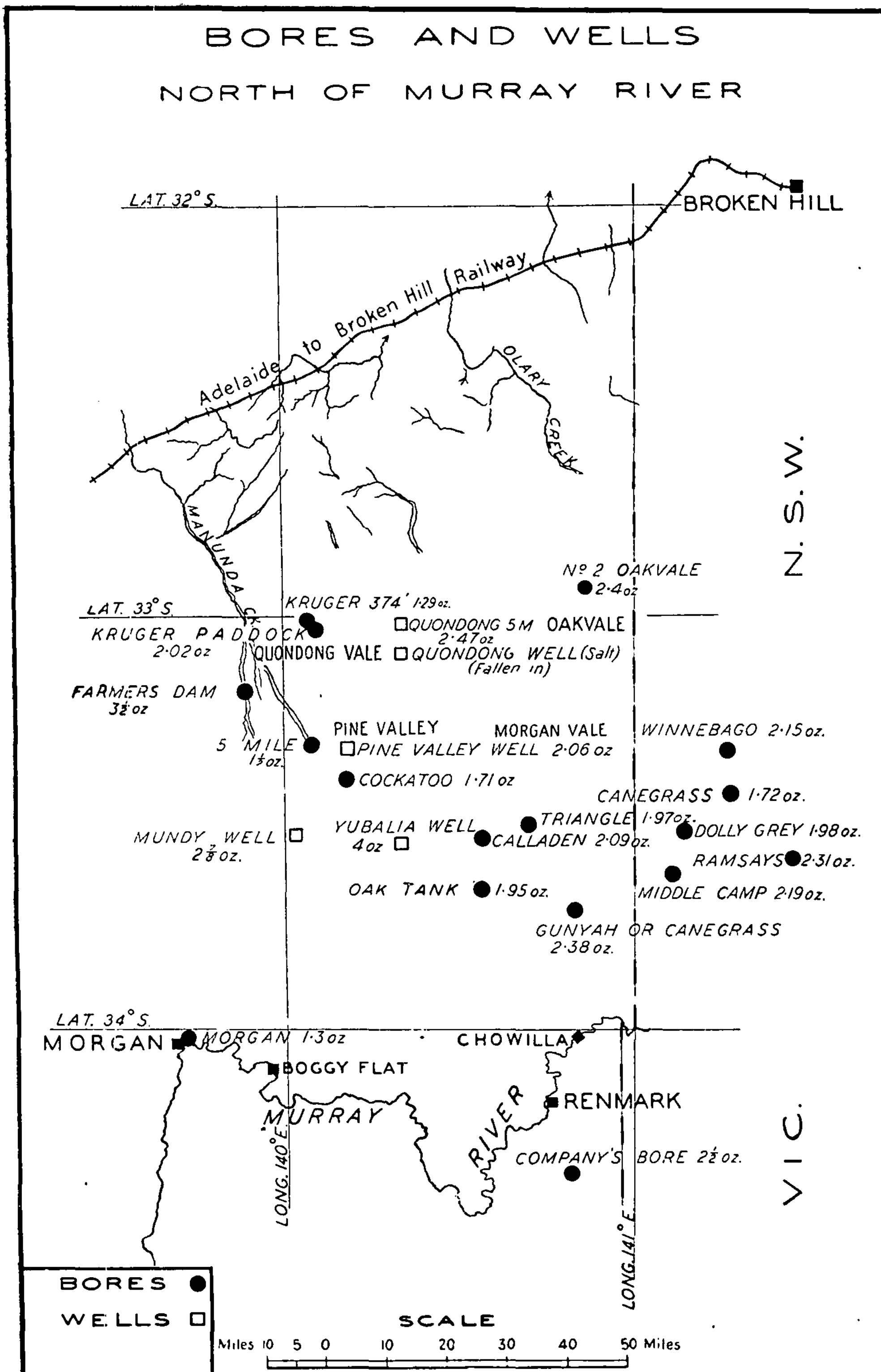

BORES AND WELLS
NORTH OF MURRAY RIVER
LAT. 32° S.
BROKEN HILL
Adelaide to Broken Hill Railway
OLARY CREEK
MANUNDA CK
N.S.W.
No 2 OAKVALE 2·4oz
LAT. 33° S.
KRUGER 374' 1·29oz.
KRUGER PADDOCK 2·02oz
QUONDONG 5M 2·47oz
OAKVALE
QUONDONG VALE
QUONDONG WELL (Salt) (Fallen in)
FARMERS DAM 3½ oz
5 MILE 1½oz.
PINE VALLEY
PINE VALLEY WELL 2·06 oz
MORGAN VALE
WINNEBAGO 2·15oz.
COCKATOO 1·71 oz
CANEGRASS 1·72oz.
MUNDY WELL 2⅞oz.
YUBALIA WELL 4oz
TRIANGLE 1·97oz.
CALLADEN 2·09oz.
DOLLY GREY 1·98oz.
RAMSAYS 2·31oz.
OAK TANK 1·95oz.
MIDDLE CAMP 2·19oz.
GUNYAH OR CANEGRASS 2·38 oz.
LAT. 34° S.
MORGAN
MORGAN 1·3oz
CHOWILLA
BOGGY FLAT
RENMARK
MURRAY RIVER
LONG. 140° E.
COMPANY'S BORE 2½ oz.
VIC.
LONG. 141° E.
BORES
WELLS
SCALE
Miles 10 5 0 10 20 30 40 50 Miles

Fig. 22.

main use of the water has been for working horses on the farms. To the southward of the limit marked on the map there are many waters with much less saline matter than 1oz. to the gallon. For example, there are several borehole waters used by the South Australian Railways for boiler feed, and the town of Pinnaroo has been supplied with water of very good quality. See Tables II. and IV.

This portion of the basin does not extend as far as the coast, its western boundary being defined by the existence of a barrier of Pre-Cambrian foundation rocks, many outcrops of which occur between the railway to Serviceton and The Coorong. The aquifers containing the pressure water are truncated by this barrier, and any underground water supplies obtainable in the area occupied by the barrier are due to percolation into the relatively shallow cover overlying portions of the foundation rocks from rainfall in the immediate vicinity of the boreholes and wells.

C. *The northern part of the basin*: See Fig. 22. Between the River Murray and the railway to Broken Hill there have been many attempts to locate water of good quality by boreholes and wells, but with results that are disappointing. In a few places the water discovered has been found useful for watering sheep, and these supplies have been developed. The intakes for this water are situated where the south-flowing creeks rising in the higher country traversed by the railway disappear as they debouch upon the plains. The chief of these feeders are Olary Creek and Manunda Creek, and the best waters occur opposite the outfall of the latter creek. There are a few boreholes yielding flowing supplies of similar water in New South Wales, possibly receiving some water brought down by Olary Creek and perhaps by the northern part of the Anabranch of the Darling River. The occurrence of the pressure water in this region was investigated by R. Lockhart Jack, who found that supplies exist in two distinct aquifers, the upper of which is about 200ft. above the lower. The upper water has been tapped by wells but it is not serviceable, even for sheep. The lower aquifer carries water containing from 1¾oz. to 2½oz. of dissolved salts to the gallon, and the quality deteriorates as distance from the intake increases. It seems probable that the 2½-oz. water struck at 712ft. in Company's bore, in the hundred of Gordon south of the River Murray, occurs in this aquifer, although there is a still deeper aquifer, at 1,102ft., with 7½-oz. water.

Whether these northern saline waters move southwards until a balance is effected between them and the much better waters moving northwards from the Victorian intake area has yet to be proved by the mapping of the hydraulic surface. Should it be discovered that there is a broad trough or depression in the hydraulic surface in the area where the salinity alters appreciably the distribution of the salinity may be explained. In the event of such a trough being found it will be of interest also to note whether it has a pitch to the westward to account for the supposed outlet of the pressure water into the River Murray at or near Bowhill.

D. *The western portion of the basin*: Considerable variations in the quality of the water occur along its western margin. The best water is found, as may reasonably be expected, near the extreme edge where creeks rising in the Mount Lofty Ranges disappear where they reach the plains between the highlands and the River Murray. This better water is obtained from the polyzoal limestone in most cases. The quality deteriorates as the distance from the highlands increases. Places at which better water has been proved to exist are situated near Sedan and Cambrai. One noticeable feature of this portion of the basin is the existence of several aquifers separated from each other by layers of impervious clay and carrying waters that improve in quality with depth, each successive water being less saline than that above it. During the exploration of this district for deposits of lignite several of these aquifers were tapped by boreholes and the waters were analysed separately with the results set out in the following table:—

Borehole.	Hundred and Section.	Depth of Aquifer. (Feet.)	Salinity (Oz. per Gallon.)
Swan Reach, No. 6	Fisher, Section 21 .	125	2·09
Swan Reach, No. 6	Fisher, Section 21 .	166	1·36
Swan Reach, No. 7	Fisher, Section 13 .	148	1·33
Swan Reach, No. 7	Fisher, Section 13 .	166	1·19
Finniss, No. 1	Finniss, Section 426	41	1·33
Finniss, No. 1	Finniss, Section 426	130	0·21
Finniss, No. 4	Finniss, Section 243	68	0·70
Finniss, No. 4	Finniss, Section 243	134	0·39
Finniss, No. 5	Finniss, Section 444	155	0·45
Finniss, No. 5	Finniss, Section 444	250	0·43
Finniss, No. 6	Finniss, Section 210	179	0·52
Finniss, No. 6	Finniss, Section 210	269	0·35
Finniss, No. 8	Finniss, Section 413	50	4·86
Finniss, No. 8	Finniss, Section 413	146	0·43

The reason for the improvement of quality with depth is structural, the deeper aquifers being fed by good water shed from the highlands and absorbed rapidly by outwash gravels on the upper margin of the plain. The shallower water is absorbed at a distance from the highlands, where rainfall is lighter and evaporation greater and where surface water from higher levels seldom spreads out to suffer absorption. The accompanying diagram, due to R. Lockhart Jack, explains the manner of these occurrences. See Fig. 23.

Farther to the south, in the vicinity of Milang, and on the north-western shore of Lake Alexandrina, there is an area deriving its pressure water

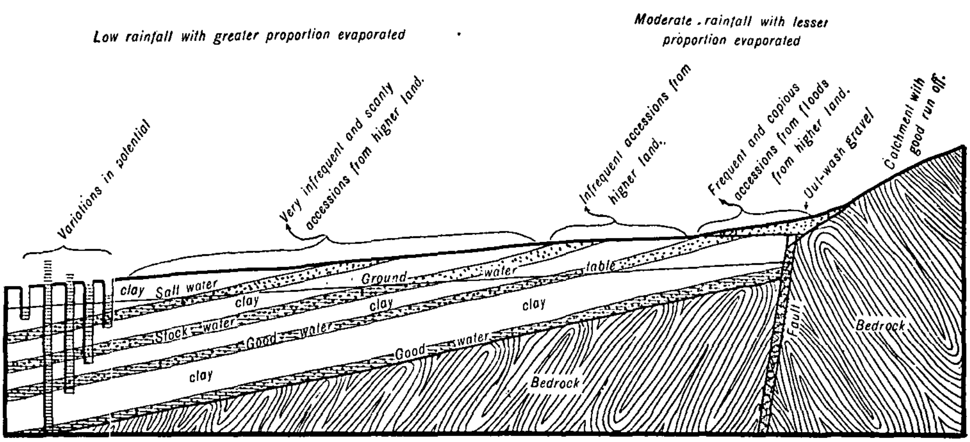


Fig. 23.

from intake areas crossed by the Bremer and Angas Rivers, within which large supplies have been obtained from boreholes. In low-lying sites the pressure is sufficient to produce artesian flows. The quality of the water is, at best, rather poor, but is sufficiently good for use in the irrigation of lucerne on the well-drained soil occurring on the shore of the lake.

The places within the Murray River Basin at which artesian flows occur are: on Lake Victoria and Belmore Station in New South Wales; near Boinka in Victoria; and at Chowilla, Tintinara, Kingston, Morgan, Mannum, and Milang, in South Australia.

(e) THE EUCLA ARTESIAN BASIN.

This basin, occupying 68,460 square miles, is shared by Western Australia and South Australia, the larger part being on the western side of the interstate boundary. The portion lying in South Australia is 16,460 square miles in extent, and that lying in Western Australia occupies 52,000 square miles.

The basin is situated in a region where, in Mid-Tertiary time, there was a deep embayment of the southern coastline of Australia contemporaneously with that which formed the great Murravian Gulf to which reference is made in dealing with the Murray River Artesian Basin.

On the floor of old Pre-Cambrian rocks, mostly granite or granitic gneiss, there were deposited normal sediments—sandy shale, glassy quartzose sand and gravel, and clay that is lignitic in part, in relatively shallow beds. These were covered by a considerable thickness (335ft. at Robert's Well, Nullarbor Station) of clay containing Miocene marine fossils. On this clay was deposited the typical Miocene limestone similar to that which accumulated elsewhere in the Tertiary coastal seas along the southern margin of the Australian continent. This limestone attains a maximum thickness of 570ft. at Guinewarra borehole, but is less thick in the eastern and northern parts of the basin. Above the limestone there is a very thin mantle of reddish soil, and at no place is there any great extent or thickness of this cover, so that it is hard to find places at which retentive tanks can be excavated.

The surface of the Nullarbor Plain, which comprises a large proportion of the basin, is not absolutely level, but the undulations are broad and the slopes very gentle. There is, however, a general rise from the southern coastal cliffs towards the interior. On the coast the cliffs are from 200ft. to 265ft. in height along an unbroken line from the Head of the Bight to Wilson's Bluff at the far south-western corner of the State, save for a short stretch of sand at Merdayerrah Sandpatch near the western boundary, and the plateau rises gradually to a height of about 500ft. where it is traversed by the transcontinental railway.

On the northern and eastern sides of the plain or plateau lies the great expanse of sand dunes that cover a large portion of Western Australia and South Australia. The sand composing these dune ridges is partly calcareous, and the dunes have become fixed by the solution and redeposition of carbonate of lime. They are clad with vegetation. The treeless portion of the Nullarbor Plain, whence its name is derived, does not extend to the southern coast. There is a vegetation embracing shrubs and trees, including acacias, mallees of more than one variety, and sandalwood, occupying a belt between 15 and 20 miles wide between the treeless area and the sea. The best pastoral country lies within this belt, which receives a higher annual rainfall than the treeless plain.

The limestone outcropping over the whole of the treeless plain and the sparsely timbered belt to the southward is traversed by extensive cavities due to the selective solution of portions of the calcareous rock, as happens in limestone regions throughout the world. The whole country is cavernous and extremely porous. Hence there are no surface channels conveying rainwater to the sea. All the rain that falls is lost by percolation and evaporation. The cavities assume numerous forms, and many have openings to the surface known as "blowholes," through which air currents blow inwards or outwards according to the barometric conditions. In a few places there are large surface depressions where the roofs of large caves have collapsed.

In drilling for water in this region it has been found advisable, on account of the difficulty of boring a straight hole through the cavernous limestone, to sink a shaft to a depth of about 200ft. and to drill in the bottom of the shaft.

The Underground Waters of the Basin.

There are two separate waters—ground water in the Miocene limestone, and pressure water in the sands and gravels beneath the clays that underlie the limestone.

The ground water in the southern portion of the basin occurs at an average depth of 220ft., with a maximum of 290ft. at Albala Karoo borehole and a minimum of 162ft. at Gilgurabbie borehole. In every case this water is too salt for use. In some cases this water has been recorded merely as "salt," and in a few cases salinometer tests have been made, with the following results:—

Delisser borehole, 2¼oz.; No. 7 borehole, 5oz.; Murrawijinnie borehole, 2¾oz.; Robert's Well borehole, 3½oz.; No. 8 borehole, 4oz.; and Albala Karoo borehole, 3½oz. per gallon.

The similar water from the more recently drilled Muddaugna borehole has been analysed and found to contain 3.22oz. of dissolved salts per gallon. Such water is not of value even for sheep in a region where the feed consists of saltbush and bluebush.

The more northerly boreholes, drilled along the transcontinental railway, proved the existence of shallow saline water, the quality of which improves towards the Western Australian border.

The writer, from many aneroid readings taken at the bore sites, has found that the reduced level of the water table is very close to sea level in each case, and that there is a gentle seaward slope of the water table, as might have been expected when the porous and cavernous character of the limestone is taken into account.

The depth of the water table is such that the shallow caves are dry. Yet the deeper caves, known as Koonalda, Warbla and Weebabbie (W.A.), provide access to exposed portions of the water table. At different times it has been reported that the salinity of this ground water has decreased and that the water is usable, but investigations have shown that the improvement is only temporary, due to accessions of storm water. A "cream" of better water may occur in some places above the salt water, but it is not to be expected that, in such porous rocks, a substantial amount of useful water can be drawn continuously. The writer noted, on the occasion of a visit to the Weebabbie cave the groundwater was rather better (1⅞oz. per gallon) than that in the South Australian caves. The ground water mentioned is separated from the pressure water by a bed of clay that is on the average about 300ft. thick, with a maximum thickness of 376ft. at the Guinewarra borehole. Beneath the clay is a series of relatively thin beds of sand and gravel separated by clay seams. A few of the boreholes, namely, Albala Karoo, Guinewarra, No. 7 and No. 8, entered gneissic rock below these sandy beds; and borehole No. 6 entered slate. The other boreholes lying to the south of the railway did not reach the hard rock foundations, but the borehole at Fisher on the Transcontinental Railway pierced some hundreds of feet of a red sedimentary rock (Pre-Cambrian) before being abandoned at 912ft.

The pressure water stored in the beds of sand and gravel that lie between the thick bed of clay and the foundation rocks is probably absorbed in the sandy tract lying to the north of the Nullarbor Plain, but the exact position of the intake area is not known. It may be deduced, from the variable salinity of the water at different places, that conditions along the intake area vary from point to point, with most rapid absorption to the westward where the quality of the water is best.

Most of the drilling records do not show differences between the pressure under which the water exists in the several beds of sand or gravel, but in a few cases details have been preserved and these (with one exception) indicate the normal existence of higher pressures in the deeper beds, as a result of the higher position of the outcrops of the deeper beds in the intake area. Thus, in No. 2 borehole water struck at 735ft. rose to within 187ft. of the surface, while that from 818ft. 5in. rose to within 183ft. of the surface. In Mallabie borehole water from 826ft. rose to within 126ft. of the surface, while that from 846ft. rose to within 116ft. of the surface. So too in Muddaugna borehole water from 787ft. rose to within 190ft. of the surface, while that from 794ft. rose to within 131ft. of the surface. In Murrawijinnie borehole water from 743ft. rose to within 240ft. of the surface, while that from 775ft. rose to within 157ft. of the surface. The single exception is Guinewarra borehole, where water from 975ft. is recorded as having risen to within 203ft. of the surface, while that from 1,004ft. rose to within 216ft. of the surface.

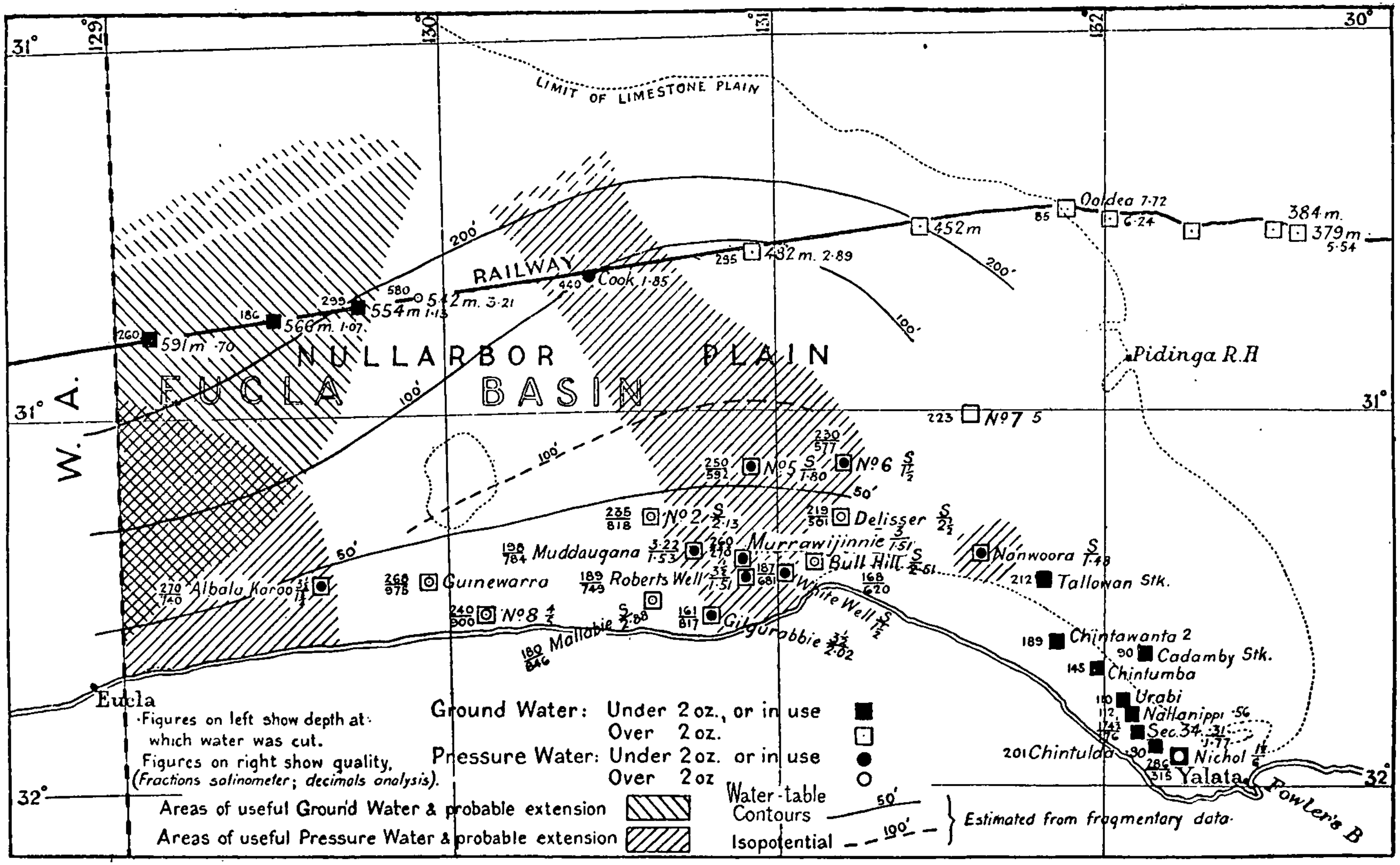
It is noteworthy that the hydraulic surface of the pressure water rises above the groundwater table at most places at which boreholes have been drilled. However, at Albala Karoo the recorded level of the deeper water is the same as that of the ground water and in this case the deeper water came from a porous layer in the thick clay rather than from separate sand or gravel beds underlying the main body of clay. In No. 8 borehole the water from 900ft. stood 27ft. below the groundwater table, which is 240ft. below the surface. The average distance above the groundwater table to which the pressure water rises in the boreholes in which these measurements have been made is 57ft.

In the map of the basin, printed as Fig. 24; R. Lockhart Jack has drawn tentative isopotential lines for the pressure water and contours of the groundwater table based on the information available.

The quality of the deeper pressure water is unfortunately inferior at all points within the South Australian portion of the basin. The best water is that occurring in Robert's Well, Muddaugna, Murrawijinnie, White Well, and No. 6 boreholes, where the salinity is about 1½oz. per gallon and the water is therefore useful for sheep. It seems highly probable that the area embracing these boreholes, together with that including the rather more saline water of No. 5 (1.80oz.) borehole extends in a general north-westerly direction towards and beyond Cook on the Transcontinental Railway where the salinity is 1.849oz. per gallon. It would appear that the Gilgurabbie (2.02oz.), Mallabie (2.88oz.), and No. 2 (2.13oz.) boreholes lie to the westward of this belt of rather better water, while the Delisser (2½oz.) and Bull Hill (2.51oz.) boreholes lie to the eastward of it.

It is noteworthy that the total salinity of the Robert's Well borehole has improved materially between October, 1886, when it was first analysed and found to be 2.08oz. per gallon, and April, 1914, when analysis showed 1.51oz. per gallon of total dissolved salts.

Fig. 24.



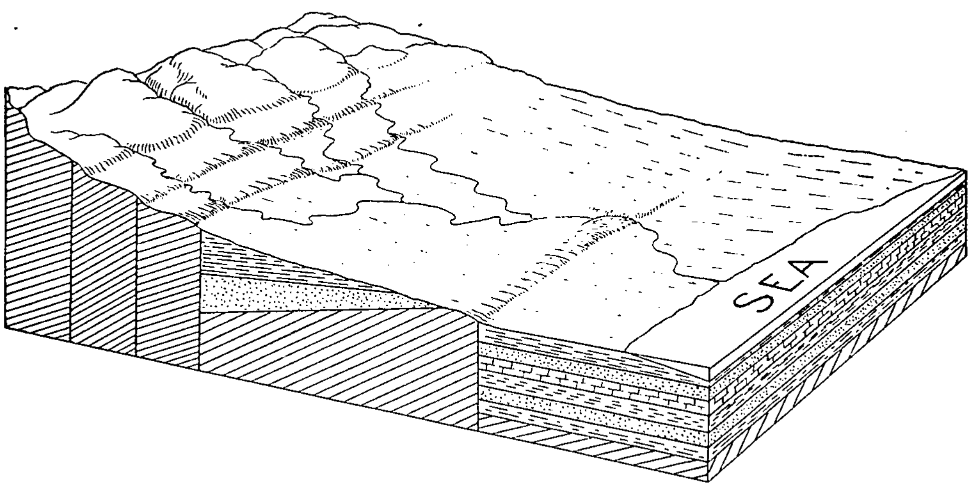
Eucla Basin, showing the quality of the Ground and Pressure Waters,

The drilling carried out in South Australia on the Transcontinental Railway has proved disappointing except in the far-western part of the basin, where the groundwater supplies show marked improvement of quality.

Analyses of water from the Eucla basin are set out in table XVII.

(f) THE ADELAIDE PLAINS ARTESIAN BASIN.

This basin, which has an area of about 1,130 square miles, lies between the highlands of the Mount Lofty Ranges and Gulf St. Vincent. Its eastern margin is the multiple-fault front of the highlands, and some of the fault blocks of the Mount Lofty horst have been concealed, wholly or in part, by the deposition of the Tertiary and Post-Tertiary sediments of the basin. The structural features have been generalized in the accompanying block diagram, Fig. 25. Much remains to be done before the structure is fully understood, but the details are known to exhibit no little complexity, which is reflected in the variations in the composition of the water obtained in different portions, as well as in the quantities obtainable from boreholes, and the depths to which boring must proceed before the principal aquifers are reached.



AN ARTESIAN SLOPE ON A SHORE AFFECTED BY FAULTING

Fig. 25.

The basin certainly has an outlet to Gulf St. Vincent on the westward, and there is evidence of many different intake areas along its eastern margin where the numerous creeks and rivers debouch upon the plain. The main feeders are the rivers Sturt, Torrens, and Little Para, percolation from which supplies the deeper aquifers through fault zones bounding the fault blocks.

No general map of the hydraulic surface has yet been prepared, and it will not be a simple matter to reduce to map form the hydraulic data from a considerable number of distinct aquifers. It is, however, known that the hydraulic surface or surfaces rise above the ground surface at many low-lying sites along the western side of the basin. Hence there are many flowing supplies at the following places:—South-west of Edwardstown; north-east of Glenelg; at Plympton; on Netley Estate south of Grange; east of Grange, and west of Adelaide; at Ascot Park; west of Woodville; at

Largs Bay; near and south-west of Dry Creek; between Salisbury and the coast; at Bolivar; at St. Kilda; at Buckland Park; near Two Wells; and near the coast to the west of Two Wells.

The city of Adelaide is built upon a portion of the basin beneath which the Pre-Cambrian foundation rocks are relatively shallow; having been reached at 303ft. at Kent Town; at 325ft. below the West End Brewery; and at 670ft. beneath Kensington Gardens. The foundation upon which this portion of the basin rests has been called by Dr. C. Fenner the Para Fault Block, and it is bounded on the west by a fault scarp traceable for many miles. On the downthrow, or western side of the fault a borehole at Croydon has shown the Pre-Cambrian rocks to lie at a depth of 2,242ft. below the surface. These four boreholes only have penetrated deeply enough to reach the foundations in the metropolitan area, all the others being still in Tertiary sediments when boring ceased.

Most of the water drawn from the basin comes from the area lying to the west of the Para fault, and from many different aquifers that carry water of very variable quality. It is known that there is a considerable area to the west of the city of Adelaide, whence large quantities of rather saline water are obtainable at shallow depths from an aquifer far above the level of that which carries the main supplies of pressure water. Some of this shallow water is used for the irrigation of lucerne plots. There are also numerous small supplies of ground water of fair quality not far below the surface at many places in the metropolitan area and suburbs, the best of them being derived from gravel beds close to the River Torrens and its tributaries. The quantities, however, available in these shallow aquifers at higher levels to the east of the Para fault are not comparable with those proved to exist to the westward at the lower levels of the Adelaide plain. It is for this reason that the boreholes used to furnish supplies for the city in times of drought are located to the west and south-west of Adelaide. Several exploratory drillings were made in the endeavour to find high-level supplies, but only one of them, at Wattle Park, succeeded in proving quantities large enough to merit consideration as a source of water that would justify the installation of a pumping plant. This exceptional case was not used in the drought of 1934, since it was fully developed at a late stage when the summer rains had relieved the position.

The Use of the Water to Supplement Reservoir Supplies.

The first occasion on which recourse was had to the introduction of underground water into the Adelaide mains was that due to the drought of 1914-1915. Six boreholes were used at that time and jointly made a material contribution to the supplies reticulated. The salient characteristics of these installations are set out in the following table:—

Boreholes Used in 1914-15 *to Supplement Reservoir Supplies.*

Borehole.	Total Depth.	Depth Below Surface at Which Water Stood.	Depth Below Surface at Which Pump was Fixed.	Yield per Hour by Pumping.	Salinity of Water.
	Ft.	Ft.	Ft.	Gall.	Grains per Gall.
Morphettville	280	3½	73	10,072	118·28
Plympton	232	14½	77	10,072	56·98
Hiltonia	218	26	85	10,072	78·57
Marleston........	255	40½	101¼	7,551	53·95
Edwardstown	196	54¼	126	4,540	59.73
Marion	310	60¼	126½	4,540	97·53

Between that period of drawing upon the subterranean storage and the drought of 1934, when the necessity again arose, a considerable amount of information had been gathered with regard to private supplies which had been developed in the interval, and this information was applied to the quest for water to be distributed by the Engineering and Water Supply Department.

It appeared that the best water in the basin, so far as known, was to be obtained in the Lockleys district, when both quality and quantity were taken into consideration; but it seemed necessary to explore a wider region, lest heavy draughts in a restricted area might affect the yield from a few boreholes. The new exploratory boreholes were rather widely spaced, and one of them, at Mitchell Park, was developed for production at an early stage.

The sequence of beds penetrated by boreholes in the Lockleys district may be seen from the following generalized table:—

Depth.	Description.
Surface to 300ft.	Particoloured clays with a few sandy aquifers carrying supplies up to 1,500 gallons per hour of rather saline water unsuitable for reticulation.
300ft. to 340ft.	Interbedded white fossiliferous limestone, white clay, and fine siliceous sand. Water in this sandy aquifer is rather variable in quality, some carrying only 60 or 70 grains of total solids per gallon but in other places more saline water.
340ft. to 348ft.	Hard grey sandy fossiliferous limestone.
348ft. to 418ft.	Grey sand and large ostrea shells and lamellibranchs with much fine matter. This horizon is an important aquifer and carries good water with 50 to 60 grains of dissolved salts per gallon.
418ft. to 625ft.	Particoloured clay.
625ft. to 630ft.	Rather coarse siliceous sand with good water carrying 45 to 55 grains of dissolved salts per gallon.
630ft. to 740ft.	Particoloured clay.
740ft. to 745ft.	Coarse siliceous sand with water similar to that in the next aquifer above.
745ft. to 830ft.	Particoloured clay.
830ft. to 833ft.	Coarse siliceous sand with water similar to that in the aquifers at 625ft. and 740ft.

The usual practice in developing the aquifer between 348ft. and 418ft. is to use an air-lift pump and remove the finest material, after which a yield of 10,000 gallons per hour can be obtained from a 6in. borehole. In most cases the draught does not exceed 2,000 gallons per hour from one individual hole, for the requirements of a single user.

The technique of development had improved greatly by 1934, and the necessity for testing each successive aquifer for both quality and quantity was realized. The use of compressed air and an air-lift pump made it possible to carry out protracted tests during which large quantities of water were raised, and the discharges were measured.

In two cases the supplies used in 1934 were obtained from places where old boreholes existed, namely at Morphettville and Edwardstown. In the former case the casing has suffered corrosion and saline water from an upper aquifer mingles with the better water below. At Edwardstown a new hole was drilled, near the old borehole of 1914, in which the casing has corroded and collapsed, so that more saline water (147.42 grains per gallon) from an upper aquifer joins the better water below.

In one case, that of the York borehole, an unexpected aquifer was met at a relatively shallow depth, namely 228ft. This water carried 122.7 grains of dissolved solids per gallon, and it was proposed to use it in order to conserve the deeper supplies. The initial pumping test, by air lift, indicated a yield of 15,500 gallons per hour, but this supply was rapidly exhausted and drilling was continued to a total depth of 573ft., where the main aquifer was tapped. It seems probable that the upper aquifer is lenticular in form and has therefore only a limited capacity. A sample taken when the lower aquifer was reached showed only 56.42 grains per gallon of dissolved salts, but the final sample taken at the time when pumping was in progress was more highly charged, as can be seen from the table below.

In the case of the Glenelg East borehole the lowest water is too saline for use and has been shut out by filling the hole to 240ft. with concrete. At 343ft. an aquifer with 231.45 grains to the gallon, and at 402ft. another with 242.91 grains to the gallon of dissolved salts were cut, and each of them yielded over 18,000 gallons of water per hour.

At Black Forest a borehole was drilled to 382ft., but the salinity was 295.29 grains per gallon and the hole was abandoned. The supply was tested to 7,200 gallons per hour.

A shallow hole at Lower Mitcham proved excellent water (32.63 grains per gallon) at 69ft., but the supply was only 1,440 gallons per hour, and the rock bottom is known to be only a few feet below the bottom of the hole.

A rock borehole at Mitcham Reserve was abandoned at 225ft., being quite dry.

At the Glanville Railway Station supplies, believed to be large but not tested by pumping, were proved to exist at 290ft., 385ft., 420ft., 530ft., 550ft., 594ft., and 650ft. The least saline of these supplies occurred at 385ft., and carried 238.43 grains per gallon of dissolved salts.

The following schedule gives the salient features of the underground waters pumped into the mains of Adelaide in 1934 from several contributing aquifers, the salinities shown in the table being those of the resultant waters from the aquifers tapped:—

Boreholes from which Metropolitan Reservoir supplies were supplemented by pumping into mains during 1934.

Borehole.	Hundred of Adelaide, Section No.	Total Depth.	Depth of Water Level Below Surface.	Gallons per Hour Raised by Air-Lift.	Salinity, Grains per Gallon.
		Ft. In.	Ft. In.		
Hiltonia	4	325 0	22 0	18,000	68·56
Marleston........	50	219 6	33 0	17,500	65·47
Edwardstown	53	205 0	45 0	7,500	139.26
Mitchell Park	85	228 0	34 6	15,000	81·11
Paringa Park	147	254 0	28 6	8,000	97·25
* Glenelg East....	174	402 0	24 6	5,000	148·06
Morphettville	136	367 0	3ft. above surface	16,500	132·16
† Plympton	108	232 0	30 0	15,500	65·07
Kurralta Park....	93	260 0	26 0	20,000	57·22
‡ Brooklyn Park..	163	530 0	at surface	13,000	52·30
Seaton Gardens ..	443	492 0	10 0	12,000	51·71
Thebarton Oval ..	47	431 0	44 0	10,500	47·05
York	394	573 0	27 0	16,000	118.37

The weighted average salinity of the water from all the boreholes was 81·26 grains per gallon. The average yield per borehole was 13,423 gallons per hour.

* Glenelg East borehole was filled by sand to 338ft. Water from this level being unsuitable the borehole was filled with concrete to 240ft.

† Plympton borehole was used in 1914. The hole has an obstruction at 180ft., and water was raised from above this level in 1934.

‡ Brooklyn Park borehole has the 6in. casing slotted between 330ft. and 370ft., 390ft. and 400ft., 450ft. and 460ft., and 470ft. and 480ft.

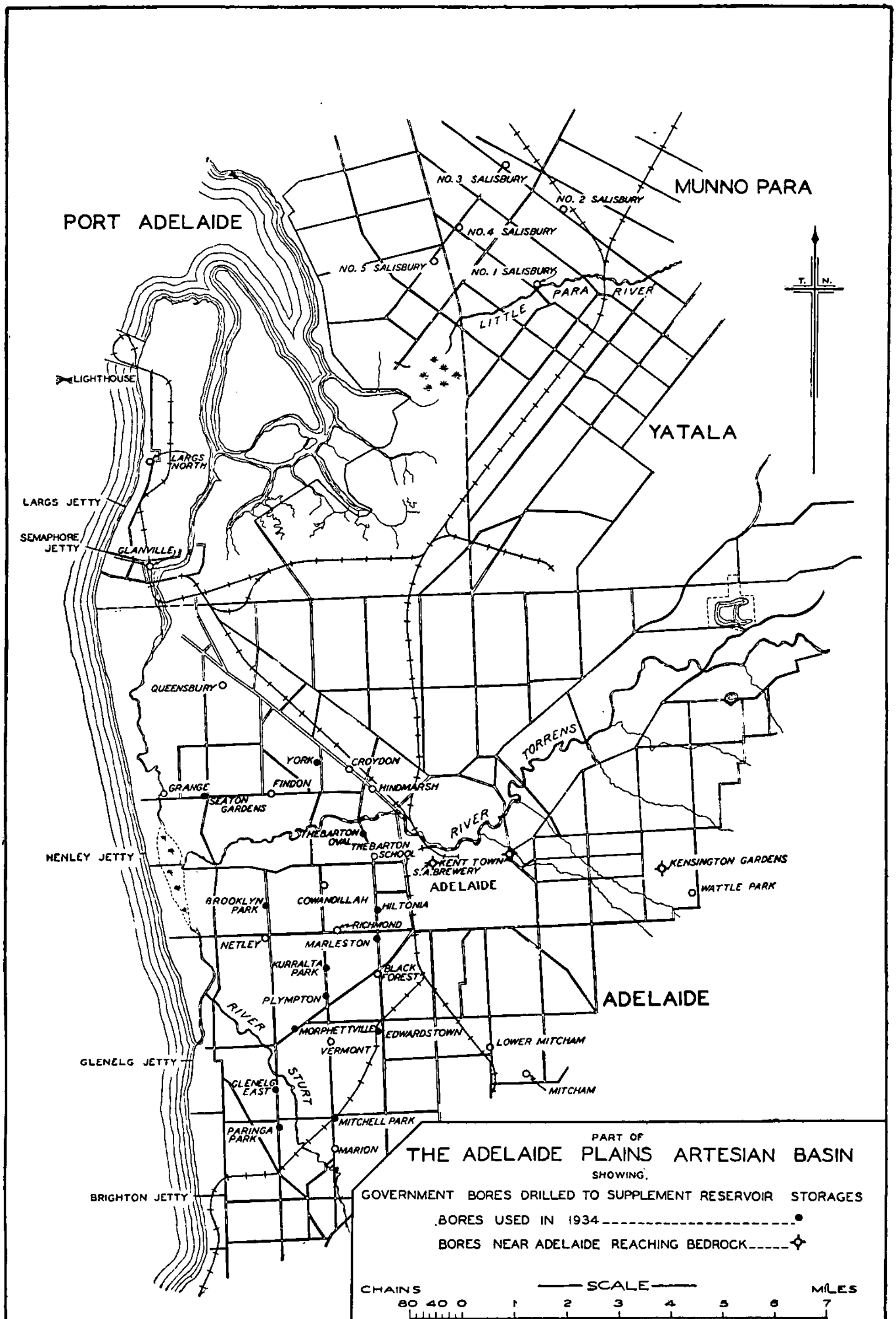

PORT ADELAIDE
MUNNO PARA
YATALA
ADELAIDE
NO. 3 SALISBURY
NO. 2 SALISBURY
NO. 4 SALISBURY
NO. 5 SALISBURY
NO. 1 SALISBURY
LITTLE PARA RIVER
T. N.
LIGHTHOUSE
LARGS NORTH
LARGS JETTY
SEMAPHORE JETTY
GLANVILLE
QUEENSBURY
TORRENS
RIVER
YORK
CROYDON
HINDMARSH
GRANGE
FINDON
SEATON GARDENS
THEBARTON OVAL
THEBARTON SCHOOL
KENT TOWN
S.A. BREWERY
HENLEY JETTY
KENSINGTON GARDENS
WATTLE PARK
BROOKLYN PARK
COWANDILLAH
HILTONIA
RICHMOND
NETLEY
MARLESTON
KURRALTA PARK
BLACK FOREST
PLYMPTON
RIVER STURT
MORPHETTVILLE
EDWARDSTOWN
VERMONT
LOWER MITCHAM
MITCHAM
GLENELG JETTY
GLENELG EAST
PARINGA PARK
MITCHELL PARK
MARION
BRIGHTON JETTY
PART OF
THE ADELAIDE PLAINS ARTESIAN BASIN
SHOWING.
GOVERNMENT BORES DRILLED TO SUPPLEMENT RESERVOIR STORAGES
BORES USED IN 1934
BORES NEAR ADELAIDE REACHING BEDROCK
CHAINS
SCALE
MILES
80 40 0
1 2 3 4 5 6 7
B.C.B.

Fig. 26.

During the month of August, 1934, there were 34,633,000 gallons of water from these sources pumped into the Adelaide mains, this quantity rising to 49,522,000 gallons in September, and to the maximum figure of 89,690,000 gallons in October. Pumping continued into November, when 28,857,000 gallons had been drawn from the underground storage and reticulated before a useful rain partly filled the reservoirs and further pumping from the boreholes became unnecessary.

The inorganic analyses of the waters comprised in this schedule are set out in detail in Table XV., on page 172.

The positions of the Government boreholes mentioned in the above schedule and in that following are shown on the plan printed as Fig. 26.

Boreholes that were tested during the period of exploration in 1934 but which were not used by the Government during the water shortage.

Borehole.	Hundred of Adelaide, Section No.	Total Depth.	Depth of Water Level Below Surface.	Gallons per Hour Raised by Air-Lift.	Salinity, Grains per Gallon.
		Ft.	Ft.		
Grange	900	660	35	5,000	72·42
Marion	83	250	70	9,000	90·83
Cowandilla	92	670	40	25,000	48·79
Richmond	332	372	24	9,000	43·39
Findon	410	468	20	14,000	70·94
Thebarton School.	2	525	52	12,000	45·39
Netley	154	460	5	5,000	56·90
Black Forest	53	382	48	7,200	295·29
Vermont	92	250	25	—	174·94
Glanville	1,108	650	—	—	238·43+
Largs North	720	331	13	—	120·59
Wattle Park	289	150	18	5,000	59·11
Mitcham	248	225	—	nil	—
Lower Mitcham	234	69	5	1,440	32·63
Queensbury	424 (Yatala)	519	30	18,000	71·01

Several other sites were selected for testing by drilling, but it was not found necessary to make trials at them. The sites were Section 136 Adelaide, Section 147 Adelaide, Section 144 Adelaide, Section 353 Adelaide, Section 390 Yatala, Section 298 Adelaide, Section 809 Yatala, Section 90 Adelaide, Section 94 Adelaide, Section 3 Adelaide, Section 97 Adelaide, Section 373 Adelaide, and Section 425 Yatala.

When the water from the boreholes mentioned above was being pumped into the mains, or being subjected to testing with an air-lift pump, several aquifers were not contributing to the supplies, being excluded by the use of casing or, in the case of Glenelg East, by filling up the lower part of the borehole. Some of the water thus excluded by being cased off is of good quality and can be made available by slotting the casing at the appropriate depths. The excluded waters are shown in the following table:—

Borehole.	Depth of Aquifer.	Salinity.	Supply.
	Feet.	Grains per Gallon.	Gallons per Hour.
Edwardstown	28	147.42	1,000
Edwardstown	44	198·11	Less than 300
Edwardstown	100	105·89	Less than 300
Mitchell Park	29	310·87	Less than 300
Mitchell Park	74	344·24	Less than 300
Mitchell Park	95	70·90	250
Paringa Park	33	71·26	400

Borehole.	Depth of Aquifer.	Salinity.	Supply.
	Feet.	Grains per Gallon.	Gallons per Hour.
Paringa Park	70	72·73	400
Paringa Park	133	65·97	250
Glenelg East	44	113·83	750
Glenelg East	74	97·31	100
Glenelg East	179	97·10	1,500
Glenelg East	343	231·45	20,000
Glenelg East	402	246·17	16,000
Kurralta Park	23	30·36	100
Kurralta Park	190	68·87	Less than 300
Brooklyn Park	14	88·41	Less than 300
Brooklyn Park	130	261·40	1,000
Brooklyn Park	248	233·89	1,000
Brooklyn Park	265	205·85	1,000
Brooklyn Park	330	82·65	1,500
Seaton Gardens	15	193·52	Less than 300
Seaton Gardens	52	252·12	Less than 300
Seaton Gardens	298	399·75	100
Seaton Gardens	335	121·26	3,000
Seaton Gardens	357	83·95	1,000
Seaton Gardens	415	87·62	?
Thebarton Oval	38	170·15	400
Thebarton Oval	67	170·00	Less than 300
Thebarton Oval	179	139·86	Less than 300
Thebarton Oval	310	79·61	1,500
Thebarton Oval	351	80·50	1,000
Thebarton Oval	376	46·16	600
Thebarton Oval	399	44·03	9,000
York	30	107·78	200
York	110	88·19	1,000
York	182	77·08	300
Marion	38	112·56	200
Marion	63	112·87	1,000
Cowandilla	12	223·31	1,000
Cowandilla	216	131·58	600
Cowandilla	283	78·66	600
Cowandilla	386	85·67	400
Cowandilla	428	120·33	500
Cowandilla	485	98·96	?
Richmond	36	108·76	500
Richmond	73	108·07	1,000
Richmond	135	65·53	—
Richmond	169	48·76	200
Richmond	236	45·88	3,000
Richmond	314	40·17	3,000
Thebarton School	31	190·45	650
Thebarton School	95	178·02	650
Thebarton School	152	166·03	Less than 300
Thebarton School	197	133·97	1,000
Thebarton School	307	188·14	600
Thebarton School	382	53·22	600
Thebarton School	402	67·39	600
Thebarton School	460	48·52	Over 2,000
Black Forest	20	102·85	Small
Black Forest	95	71·11	Small
Black Forest	225	69·86	600
Black Forest	260	68·50	720
Black Forest	373	231·24	7,000
Vermont	25	493·87	100
Vermont	250	174·94	Small
Glanville	290	998·71	Large
Glanville	385	238·43	—
Glanville	420	293·66	Large
Glanville	530	249·85	Large
Glanville	550	238·81	—
Glanville	594	286·35	Large
Largs North	40	64·52	Small

Borehole.	Depth of Aquifer.	Salinity.	Supply.
	Feet.	Grains per Gallon.	Gallons per Hour.
Largs North	110	2,340·38	—
Largs North	204	265·01	4,000
Largs North	210	220·23	Flowing
Largs North	266	160·68	Flowing
Largs North	330	120·59	—
Queensbury	26	912·00	2,000
Queensbury	95	1,017·91	1,000
Queensbury	138	4,293·36	800
Queensbury	195	721·78	800
Queensbury	296	95·89	8,000
Queensbury	445	49·32	—
Queensbury	519	70·99	8,000

Much of the information dealing with these Government boreholes has been supplied by the Engineering and Water Supply Department. The analytical work was carried out in all cases by T. W. Dalwood, Analyst and Assayer to the Department of Mines.

To the north of Adelaide and near Salisbury there has been a considerable amount of drilling and some of the aquifers tapped have provided water of excellent quality. It appears that the chief aquifers have a dip to the westward, and it is known that the quality of the deeper water is much better than that occurring at shallower levels. These matters guided the selection of sites for boreholes to supply water to the Salisbury Munition Works in 1940, the positions selected being to the westward of the Munitions Reserve to avoid, if possible, the complete draining of the upper parts of the aquifers by a continued draught. The first borehole drilled for this purpose failed in respect of supplies, the sequence of the beds penetrated being abnormal, perhaps owing to contemporaneous erosion in that area. This hole, situated close to the Little Para River in Section 3062, Hundred of Munno Para, showed the existence of six different aquifers, with progressively improving quality, at 36ft. (88.60 grains per gallon of total dissolved salts); 67ft. (74.82 grains per gallon); 87ft. (69.01 grains per gallon); 100ft. (66.46 grains per gallon); 130ft. (51.56 grains per gallon); and 215ft. (43.63 grains per gallon). Two other boreholes were then drilled in Sections 4019 and 4016, Hundred of Munno Para, and it is noticeable that the quality of the water in the several aquifers decreases as the distance from the Little Para River increases, especially in those occurring at shallow depths. The aquifers yielded waters that were separately analysed with the results shown in the following table:—

No. 2 Borehole, Section 4019.		No. 3 Borehole, Section 4016	
Depth of Aquifer.	Salinity.	Depth of Aquifer.	Salinity.
Feet.	Grains per Gallon.	Feet.	Grains per Gallon.
30	160·96	20	354·73
80	157·1	50	370·39
185	149·5	103	248·98
305	47·93	147	106·90
340	37·59	347	51·72
Yield : 6,000gall. per hour.		Yield : 12,000gall. per hour.	

A fourth borehole, situated in Section 4007, Hundred of Munno Para, was drilled also, to serve as a reserve if required, and proved a pumping supply of 8,000 gallons per hour of water containing 42.99 grains of total dissolved salts per gallon. The full depth of this hole was 365ft. A fifth borehole, in Section 3232, Hundred of Port Adelaide, was drilled to a depth of 375ft., but no pumping test was carried out as the plant was required elsewhere. There was a small flow over the surface. The borehole is cased to 296ft., and the quality of the water below that depth is good, ranging from 51.0 to 57.3 grains of dissolved salts per gallon.

The yield from the four effective bores (excluding No. 1), on pumping continuously, has been between 2½ and 3 million gallons per week, and this quantity has been supplied to the Munition Works and the Barossa reticulation in 1945.

There are several private boreholes to the west and north-west of Salisbury from which flowing supplies have been obtained.

Still farther to the westward, near St. Kilda, there are several flowing supplies, and a full record has been preserved of a drilling in Section 320, Hundred of Port Gawler, where several aquifers have been penetrated and where the upper water-bearing beds carry some remarkably saline water. Samples taken from these aquifers were analyzed with the following results:—

Aquifer	at	10ft.	carried	water	with	9.76oz.	per	gallon	of	dissolved	salts.
"	"	80ft.	"	"	"	12.59oz.	"	"	"	"	"
"	"	150ft.	"	"	"	7.22oz.	"	"	"	"	"
"	"	190ft.	"	"	"	4.52oz.	"	"	"	"	"
"	"	210ft.	"	"	"	2.07oz.	"	"	"	"	"
"	"	215ft.	"	"	"	3.14oz.	"	"	"	"	"
"	"	240ft.	"	"	"	1.86oz.	"	"	"	"	"
"	"	241ft.	"	"	"	64.12gr.	"	"	"	"	"
"	"	266ft.	"	"	"	67.54gr.	"	"	"	"	"

The supplies in the two lowest aquifers were artesian, the flow being 60 gallons per hour. The upper saline water was excluded by casing, and a pump was installed to turn to account the water in the two lowest aquifers.

Between Two Wells and Dry Creek fragmental records indicate that the water deteriorates in quality with depth, each aquifer carrying generally more saline water than that in the aquifer above it.

The northern part of the basin has not been explored fully, and very few boreholes have penetrated the full thickness of the Tertiary strata. The foundation rocks were, however, entered near Mallala at 527ft.; four miles north of Two Wells at 689ft.; eight miles north of Two Wells at 651ft.; Roseworthy College at 320ft.; Dublin at 432ft.; five miles north of Dublin at 373ft.; in the vicinity of Kallora at about 300ft.; and Inkerman at 450ft. The intake in this northern part of the basin is probably largely from the River Light. Further references to this area will be found in the writer's annual report for 1915.

(g) THE PIRIE-TORRENS ARTESIAN BASIN.

This basin is one of the typical one-sided variety, bounded on the east by the marginal fault system that marks the western limit of the Flinders Range, and on the west by the major structural break which brings Spencer Gulf as far to the northward as Port Augusta, and which continues still farther north for about 150 miles to the extremity of Lake Torrens. The area occupied by the basin is large, not less than 3,585 square miles, and the quality of the water varies from point to point between wide limits. Use has been made of the water, where good enough, for irrigation and formerly for general purposes at Port Augusta, but most of the supplies are turned to account for the watering of stock.

In *Bulletin* 11 R. Lockhart Jack has described in some detail the structural features of the northern part of the basin, to the eastward of Lake Torrens, and has illustrated the mode of occurrence of the water by a section which is reproduced here. See Fig. 27. Much work remains to be done on the more southerly portions of the basin before its full potentialities can be assessed, but the general features recognized hitherto indicate that the best water is to be obtained on the eastern margin of the basin where there is a rapid absorption of flood water shed from the ranges. The deeper water obtained from boreholes situated between the main creek channels is more saline than that from shallow levels at places close to the drainage channels.

The northern portion of the basin is shown on the map printed as Plate III., and the southern limit extends as far as Port Broughton.

Analyses of waters from the basin are printed in Table XVI.

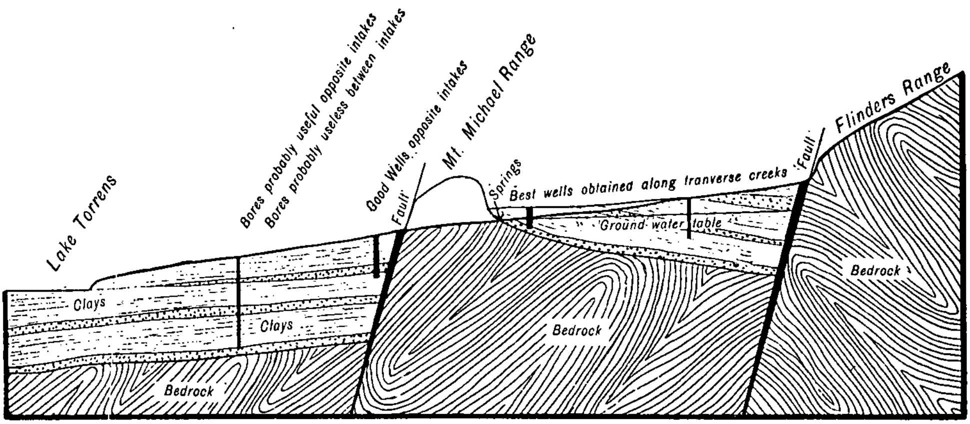


Fig. 27.

(h) THE WALLOWAY ARTESIAN BASIN.

A relatively small artesian basin of the valley type has been found to exist in the broad plain which extends northwards from the Hundred of Black Rock Plain through the Hundred of Walloway, where its width is greatest, and the Hundred of Oladdie. The town of Orroroo lies on its western margin in the south-western corner of the Hundred of Walloway, and Johnburgh is situated on the northern part of the plain. Six boreholes have been drilled, five of them to the north-east of Orroroo and the other at Gallwey in the south-eastern corner of the Hundred of Oladdie.

The plain is flanked by outcrops of Upper-Pre-Cambrian rocks, including tillite and slate, which have suffered folding and at a much later period have been subdued by erosion. A deep valley has been corroded through the old rocks; and fluviatile deposits, consisting of sands, clay, and lignitic matter, have been laid down along its course, probably in early Tertiary time. The sandy members of this series of sediments have been found to carry pressure water which has provided flowing supplies. Unfortunately poor records of the drilling have been preserved, but it is known that one of them reached a depth of 597ft. without reaching the basement rocks.

The original borehole, 591ft. deep, put down at the western extremity of the Pekina Irrigation Area, north-east of Orroroo, afforded an initial flow of 115,000 gallons per day, but this discharge fell to 45,000 gallons per day in about five weeks as a result of the choking of the hole by sand, and the flow has now almost ceased. A flow of 100,000 gallons per day is now obtained from J. F. J. Arthur's borehole, which is 405ft. deep, and is situated just beyond the north-western corner of the Irrigation Area. This water contains 128 grains of total salts per gallon, and is used for the irrigation of lucerne.

A recent examination of the basin by R. C. Sprigg has shown that the effective area of the basin cannot yet be defined with precision. An earlier estimate of its extent was 45 square miles, but this figure may understate its size. Sprigg has indicated that the intake area for the basin lies in the neighbourhood of Orroroo, and that ground water occurs at much shallower levels than the pressure water on the western side of the basin. These groundwater supplies have not been tested for supply or quality, but some have been used for horticulture and most of them are suitable for watering stock.

(i) THE WILLOCHRA VALLEY ARTESIAN BASIN.

The broad flat valley traversed by Willochra Creek, which finds an outlet through the Flinders Range to Lake Torrens, has a well-defined fall towards the north, and constitutes a typical basin of valley type. See Fig. 10. There is a fall of 550ft. between Booleroo Centre, at the southern end of the valley, and Bruce, and another 100ft. between Bruce and Willochra. The intake beds consist of coarse sands and gravels which are fed by the numerous tributaries of Willochra Creek which rise in the high country on the western side of the valley where the rainfall is relatively large when compared with that of the valley floor which lies in the "rain-shadow" of Mount Remarkable.

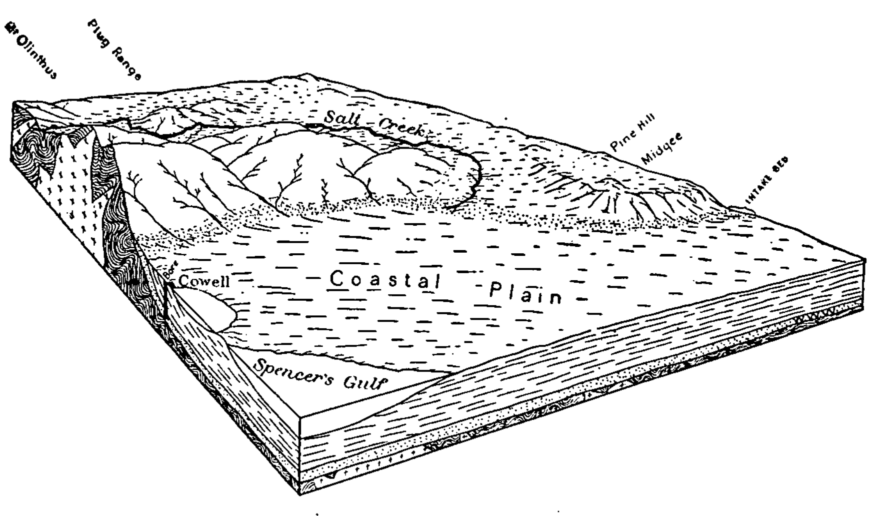
The effective area of the basin has not been determined in detail, but it seems probable that it is not less than 595 square miles.

Several flowing supplies of water have been obtained from depths up to 300ft., but few analyses have been made of this pressure water which is used by stock.

The boreholes at Quorn, whence water is drawn for railway purposes, are situated in a westerly lobe of the basin.

(j) THE COWELL ARTESIAN BASIN.

There exists a typical one-sided artesian basin or slope on the eastern side of Eyre Peninsula, to the north-east and south-west of Franklin Harbour, occupying an area of about 635 square miles. The value of the



Sketch showing the Intake of the Cowell Artesian Basin.

Fig. 28.

basin is almost negligible on account of the high salinity of the contained pressure water. The intake beds absorb salt water except at a few places where rare stream channels, such as Yeldulknie Creek, bring accessions of good water from the adjoining highlands. Where this better water is tapped, as at Boothby Well, close to the extreme margin of the basin, useful supplies are obtainable, but not elsewhere. The block diagram, printed as Fig. 28, explains the origin of the saline water in the basin. The water-bearing beds are of upper Tertiary to Recent age, some of them having been deposited under marine conditions.

(k) THE INMAN VALLEY ARTESIAN BASIN.

This basin, which embraces an area of about 92 square miles, is quite exceptional in that it occupies a valley once traversed by a glacier and now filled with the rock debris left behind on the melting of the ice. No fossil evidence of the age of the glacial deposits has been found, as there are no associated sediments bearing organic remains. The age of the glacial material is not known with certainty for this reason, but it is presumed to be Permo-Carboniferous and it is certainly pre-Miocene. The valley filling consists of tumultuously bedded clays and sands, with many striated boulders of all sizes. The sandy portions are lenticular in form; some large, others comprising only a few cubic feet. Groundwater occurs at shallow levels in several places, notably near spots where the deeply striated foundation rocks are exposed, as at Selwyn's Rock, Section 259, hundred of Encounter Bay. Some fairly deep drilling was done in the southern part of the valley with the object of discovering whether any beds of coal were associated with the tillite and, although unsuccessful in this respect, one of these boreholes proved the existence of artesian water rising from a depth of 292ft.

(l) MINOR ARTESIAN BASINS.

Little systematic work has been done in the minor basins wherein pressure water is known to occur.

Fragmental data show that in the Willunga district marine Tertiary beds exist near McLaren Flat and that water of good quality is obtainable from sandy beds beneath lignitic material that underlies the fossiliferous marine beds. The water rises noticeably when the aquifer is cut.

In the Bumbunga district water under pressure was found in a borehole drilled at Snowtown. The top aquifer was cut at 55ft., another at 181ft. whence "fresh" water rose to within 92ft. of the surface, and a further supply in sand occurring between 230ft. and 299ft. rose to within 32ft. of the surface. A Government borehole at Percyton, 1,030ft. deep, cut several aquifers. At 230ft. there was a small supply, at 342ft. the water rose to within 327ft. of the surface; at 770ft. the water rose to within 300ft. of the surface; and from 901ft. the water rose to within 345ft. of the surface. The supply from the lower aquifers was 500 gallons per hour, and the quality is described as "good stock water."

XII. GROUND WATER SUPPLIES.

When consideration is given to the ordinary ground water contained in crevices or spaces of all kinds that are open to the atmosphere, so that the level of the water exposed by a well or borehole does not rise above the level at which it is found as soon as the artificial opening reaches the water table or upper limit of the zone of saturation, there are several different ways in which the occurrences may be studied.

The climatic factors, especially the amount and seasonal distribution of rainfall and the amount of annual evaporation, obviously find themselves reflected in the quality and quantity of the ground water. Modified, as they must ever be, by geological structure, topography, and the characters of the soil and rocks in any region, these climatic factors are of primary importance, since groundwater does not depend upon the rainfall in distant regions as does much of the artesian water of the Great Australian Basin. It is true that there is clear evidence of the movement of a great body of ground water from Victoria through the far south-eastern part of South Australia on its way westwards to the sea, but this case is exceptional. In no other part of this State is there such a widespread and almost unbroken extent of water-saturated country. On referring to the map of South Australia (Plate I.) it will be appreciated that latitude is the most significant factor in the distribution of rainfall and that topography is of secondary importance. Hence it follows that the most southerly parts of the State are the most favourably situated as regards the source of groundwater supplies. Moreover, the quality of the water is in general much better in the regions of higher rainfall, where evaporation is relatively much lower, and where the cyclic salt is largely washed out by the winter rains. In places where the permeability of the soil and rock is high, as in the far south and in the localities where absorbent sand dunes occur, there is a large proportion of the rainfall absorbed and protected from evaporation. Where, in the wetter highlands, favourable conditions for percolation exist, as where there are outcropping porous-textured sandstones or fault-fissures partly occupied by quartz reefs, the areas receiving heavier rainfall afford large supplies of excellent water. Such conditions exist in parts of the Mount Lofty Ranges. Yet it must be remembered that a relatively high rainfall is not the only prerequisite for a good supply of ground water, since the existence of dense unjointed and impermeable rocks will prevent percolation, and in such localities it is essential to pay close attention to these geological factors when the search for supplies is undertaken. Where the annual rainfall is less than 15in., the useful supplies come only from places so situated that there are rapid absorption of the rain that does fall and special structural conditions which maintain the quality of the water at a standard higher than that of the normal ground water of the region.

The geological factors influencing the occurrence of useful groundwater supplies are primarily those related to the cavities existing in the rock masses and competent to store and yield water. In the areas within which the firmly consolidated rocks occur these water-bearing spaces are for the most part joints, crevices, fault planes or zones, and, in the case of the soluble rocks, cavities that have been enlarged by solution from smaller openings due to jointing. In a few cases the rocks, although coherent, are porous in texture and store water in the interstitial spaces between the constituent grains. The age of the solid rocks concerned is immaterial provided always that the spaces for water storage exist. Yet the Pre-Tertiary rocks of all types are almost invariably much more compact in texture than those of Tertiary or Recent age. The sandy portions of the presumably Permo-Carboniferous tillite are incoherent, and water-bearing in places, but the older Pre-Cambrian tillite is compact on the whole, although a large supply is drawn from it at Peterborough.

The Pre-Cambrian igneous rocks are sources of water where disintegration by jointing have permitted percolation and storage. Successful wells have been developed in the granite and porphyrite of Tarcoola and the felspar porphyry of the Gawler Ranges, where due consideration has been given, in selecting the sites, to the topography—especially to the existence of gathering ground for surface water above the well sites and the presence of a deeply weathered zone to absorb the rain water and feed the deeper joints below the water table.

The massive slates, phyllites, and mica schists, are on the whole unfavourable as sources of ground water, since there is a tendency for any crevices or cracks in such rocks to be sealed by the clay resulting from their weathering. Yet these rocks, also, where traversed by major fault planes and especially where these have been occupied by quartz veinstuff, may yield supplies. Examples of large supplies of good water in the parts of the rocks of this type that are fractured by faulting and traversed by quartz reefs are to be found near Woodside in the Bird-in-Hand and New Era mines, and in the ridge penetrated by the tunnel conducting the water from the Torrens gorge to the Millbrook reservoir. Little is known with regard to the full capacity of such supplies in very many cases, since the rate of pumping is insufficient to prove the quantity that can be withdrawn continuously; but in the cases wherein mine workings must be kept drained the yield is ascertained.

It has been observed in many places that there exist beds of limestone (or marble), and, in others, beds of jointed quartzite interstratified with the slate and mica schist, and useful supplies have been obtained from such beds. Where the beds have been tilted, as throughout the South Australian highlands, the more massive and unjointed rocks act as barriers or natural subsurface dams behind which the ground water tends to accumulate. The water table behind the barriers in some cases rises to the surface, and springs appear. An example of such springs is to be found on the hill above Eudunda, whence this town once obtained its supply.

The water-yielding properties of quartzites occurring thus are dependent wholly on the presence of sufficient joints which are interconnected to constitute an efficient aquifer. The close study of the outcropping portions of the quartzite is necessary, as a massive and unjointed rock cannot yield a supply. Drilling in quartzite is slower and more expensive than in slate, but should be continued if the quartzite is traversed by joint planes and the normal depth of the water table has not been reached. The borehole designed to tap a quartzite bed should aim at intersecting it several feet below the water table.

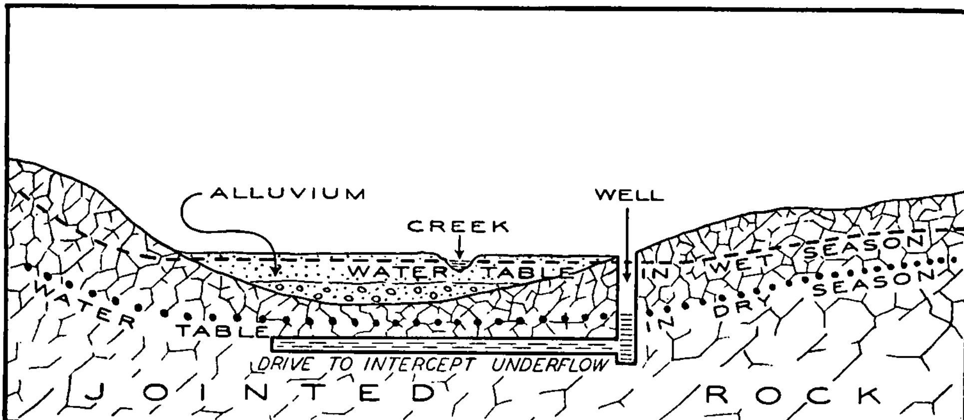
Limestones or marbles are more favourable than quartzites. They are generally brittle by comparison with the slates with which they are associated, and their ready solubility enables percolating water to enlarge the joint planes so that there is ample storage space for water below the water table, and better provision for surface water to percolate to the underground storage. Very many supplies are drawn from such limestones in the highlands of South Australia, and the most prolific of these are found where the limestone outcrops are traversed by stream channels. Even an intermittent stream may serve to replenish the quantity withdrawn by an artificial draft, but a protracted drought may result in a serious diminution of the yield. Cases have been observed by S. B. Dickinson, in the Flinders Range near Beltana, where supplies are greatest in anticlinal folds. The folding of the limestone beds into arches or domes has been accompanied by the fracturing of the brittle rock and the underground water circulation has increased the size of the fracture planes by solution until an extensive system of openings for storage has been generated. The water supply for the coalfield at Leigh Creek is derived from an anticlinal fold in the limestone near the Sliding Rock mine to the east of Beltana.

The loosely compacted sandstones occurring in some parts of the Mount Lofty Ranges, as at Aldgate and Loftia Park, although essential portions of the Pre-Cambrian, are highly absorbent, and yield useful supplies of extraordinarily good water, comparable in quality with that obtained from roof catchments. See Table XVIII. for typical analyses.

The fragmental Miocene limestone of the south-eastern part of the State, of a few coastal areas, and of the Nullarbor Plain, is an exceedingly porous rock on which no surface streams exist. The percentage of the rainfall precipitated on this rock and lost to sight by percolation must necessarily be high. Marly beds occur, but the permeability of the formation as a whole is great, and ground water is abundant below the level of the water table. The contours of this water table for part of the south-eastern region have been plotted by the present writer in *Geological Survey Bulletin* No. 19, and those for part of the Nullarbor Plain by R. Lockhart Jack, whose plan is reproduced herein, see Fig. 24.

Of the loosely aggregated rocks the most important as sources of groundwater are the outwash gravels and sands occurring on the upper margins of the plains where the streams rising in the highlands deposit their load of transported material at the change of grade. These outwash fans occur on the borders of plains marginal to the sea or to depressions which constitute the final destination of internal drainage. Typical examples are those on the eastern margin of the Pirie-Torrens artesian basin, and the fans on the eastern side of the Flinders Range where the drainage is towards Lake Frome. Such groundwater occurrences are in many cases the intakes of artesian basins, since the deeper and confined portions of the water-bearing beds carry water under pressure.

The river gravels and sands have afforded useful supplies in some places, even if the streams are intermittent, since there is an underflow that may be continuous through the dry season. A typical example is Yudnamutana Well in the Flinders Range. Wells sunk in the gravels marginal to the River Torrens in the metropolitan district have afforded supplies that have been turned to account. In some cases the water table of the dry season may fall below the level of the bottom of the alluvium, and the well must



WELL WITH A DRIVE ACROSS THE CHANNEL OF A CREEK BELOW THE WATER TABLE OF THE DRY SEASON TO INTERCEPT THE UNDERFLOW

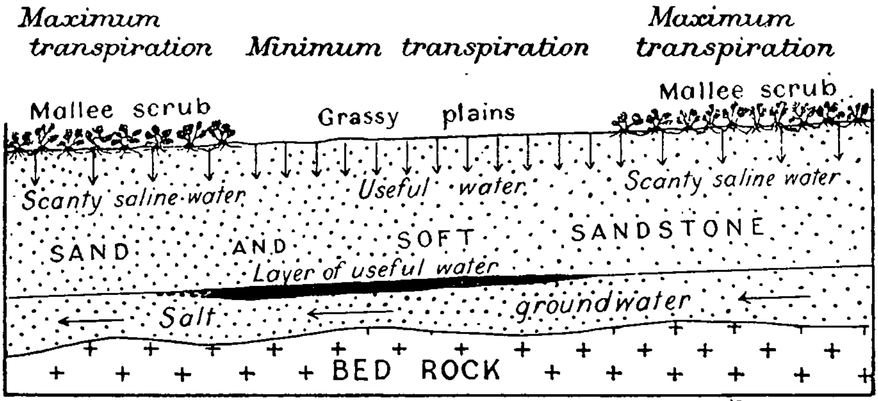
Fig. 29.

be sunk more deeply to reach the saturated zone of the underlying rock where it is weathered and traversed by fissures that carry water. In such cases it may be found advisable to put in a drive below the level of the water table, across the direction of the stream channel, in order to intercept that portion of the underflow that might otherwise pass downstream beyond the sphere of drainage by the well. (See Fig. 29.) In the drier parts of the State the water contained in the main valleys may be found to be too saline for use, and under such circumstances it may be possible to obtain water of useful quality in the alluvium of the heads of the valleys, or in that of any tributary channels that may exist above the level of the saline water.

Limited supplies of ground water of useful quality have been obtained from a number of places on the South Australian coast where dunes of unconsolidated sand occur. Early settlers obtained supplies from these sources prior to the discovery of underground supplies in more convenient localities, and, at a few places, the sandhill wells have continued to furnish water up to the present time. Typical examples of such wells are located to the north of Wallaroo; on the northern coast of Kangaroo Island; on the western coast of Eyre Peninsula at Point Brown; on the eastern coast of Eyre Peninsula, where the Ethla wells are situated on the southern boundary of the Hundred of Hutchison, south of Tumby Bay; and also at Arno Bay. Where the wells are very close to the shore the depth of good water is small, and the salinity is affected by the tides, so that useful water may be drawn from the wells only at low tides.

Similar occurrences of water in unconsolidated sand dunes have been noted inland. One somewhat unimportant example is that situated on the shore of the saline Lake MacDonnell, to the south of Penong. A much more valuable storage of the same type is that of the Ooldea Soak, a short distance to the north of the Transcontinental Railway on the edge of the Eucla artesian basin, whence considerable quantities have been drawn for railway purposes from very shallow wells. The quality of the water at this place was found to deteriorate after heavy draughts had been made, without falls of rain to replenish the storage, and the deeper water is known to be saline as in many other places on Eyre Peninsula. Hence the storage can be regarded as one that must be conserved carefully, and drawn upon heavily only in good seasons and for a short time. The Ooldea Soak has been an aboriginal camping ground for a very long period, but the demands of the natives upon the supply cannot have been significant at any time, since the country could not support a large native population.

Of somewhat greater age, Pleistocene, but not very different in character from the unconsolidated sand dunes, are those which have attained a degree of coherence by the solution and redeposition of the calcareous shelly matter of which they are largely composed. In many places on Eyre Peninsula, where they occur, they preserve not only the internal structure, but also the external contours of dunes. They are highly absorbent, but the main body of the groundwater contained in them is saline. Useful water has, however, been obtained from them where careful exploration has tapped only the shallow layer of better water that rests upon the larger body of more saline water. There is a noteworthy development of such supplies in the wells situated to the north-west of Fowler's Bay and the south-east of the Eucla artesian basin. The depth of the water table varies with the undulations of the dune surface, but is clearly controlled by sea level, all the wells having reached water just above sea level. In one case R. Lockhart Jack noted that a well 174½ft. deep had 18in. of water, the salinity of which was 0.31oz. per gallon and the daily supply 2,000 gallons. An effort to get a larger quantity by deepening the well by another 21in. was successful and the supply was increased to 14,000 gallons a day, but the quality of the water was spoilt, the salinity being raised to 1.77oz. per gallon. The quality was restored by plugging the lowest part of the well with clay. The present writer has knowledge of a similar case in the same region, but no samples were taken for analysis. The transpiration effect of vegetation on the quality of the water in this dune country was noted by Jack, to whom the accompanying diagram is due. The higher proportion of the rainfall that reaches the water table beneath areas from which mallee scrub is absent is regarded as being responsible for the layer of good water. As in the case of other ground waters in this region, the saline matter dissolved in the water is regarded as being of cyclic origin.



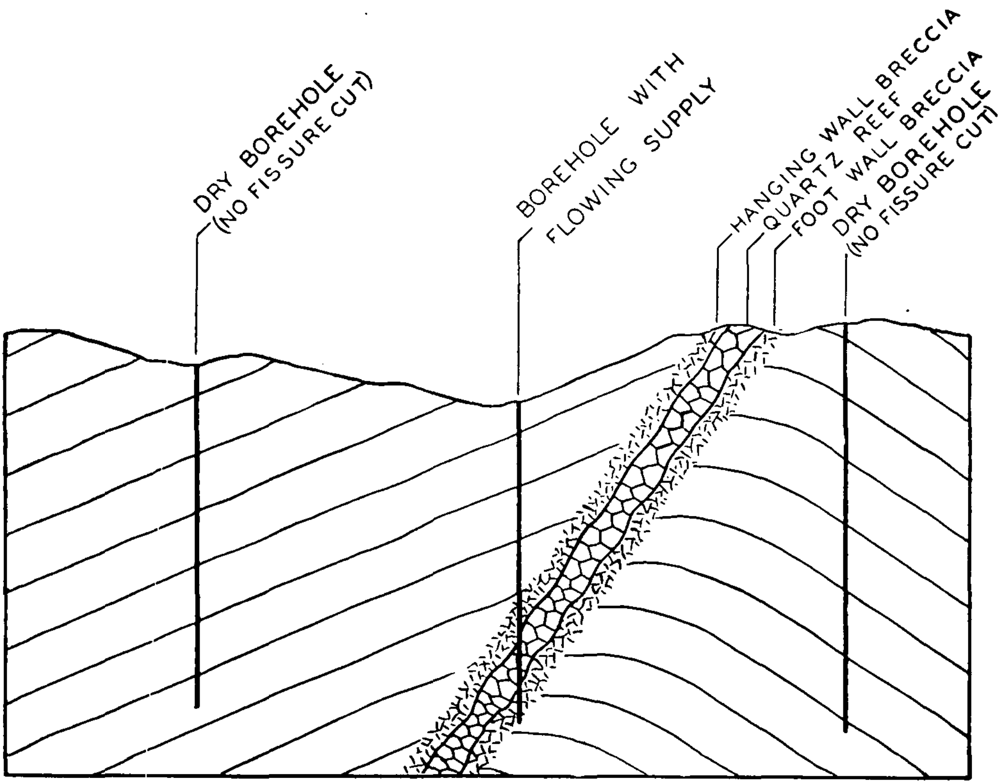
The Influence of Transpiration by Vegetation on Ground Waters.

Fig. 30.

While there are very many boreholes drilled to tap the ground water contained in fault zones or fissures wholly or partly occupied by vein quartz in the dense rocks (predominantly slates) of the South Australian highlands, few of these have been fully tested for yield. However, in the case of the Bird-in-Hand mine, situated within Section 5279, Hundred of Onkaparinga, near Woodside, accurate knowledge was obtained regarding the amount of water that was pumped to enable mining operations to be carried out between 9th June, 1934, and 13th July, 1935. Two 21-stage Pomona pumps were used, and the water level was reduced from 112ft. below the surface at the start of operations to 410ft. below the surface, where it was kept from 10th December, 1934, until the mine was closed down on 13th July, 1935. While the mine was being drained, over a period of 147 days, there were 142 million gallons pumped out, and thereafter, while the workings were kept drained over a period of 234 days, the quantity pumped was 238 million gallons. The yield can therefore be taken as a million gallons a day for a period of 12 months. The water is of good quality, containing 77.52 grains of total dissolved salts per gallon.

At a distance of about a mile to the northward, in Section 5267, Hundred of Onkaparinga, a vertical diamond-drill hole on the New Era mine reached a depth of 200ft. in the testing of a quartz reef distinct from that worked in the Bird-in-Hand mine, and struck a flowing supply at the rate of 6,480 gallons per hour of water carrying 43.27 grains of dissolved salts per gallon.

The accompanying diagrammatic sketch (Fig. 31), illustrates the mode of occurrence of the water in the New Era mine, where the borehole started at a low site and the pressure of the stored water sufficed to give an artesian supply. In this same district, and within a very short distance of the Bird-in-Hand fissure, a deep borehole was put down in the footwall slate and was quite dry, since no fissure was cut. These results, both positive and negative, show the necessity for the existence of fissures which must be tapped in order to obtain appreciable supplies from rocks of this character.



SUCCESSFUL AND UNSUCCESSFUL BOREHOLES IN DENSE SLATE TRAVERSED BY A FAULT ZONE CARRYING VEIN QUARTZ.

Fig. 31.

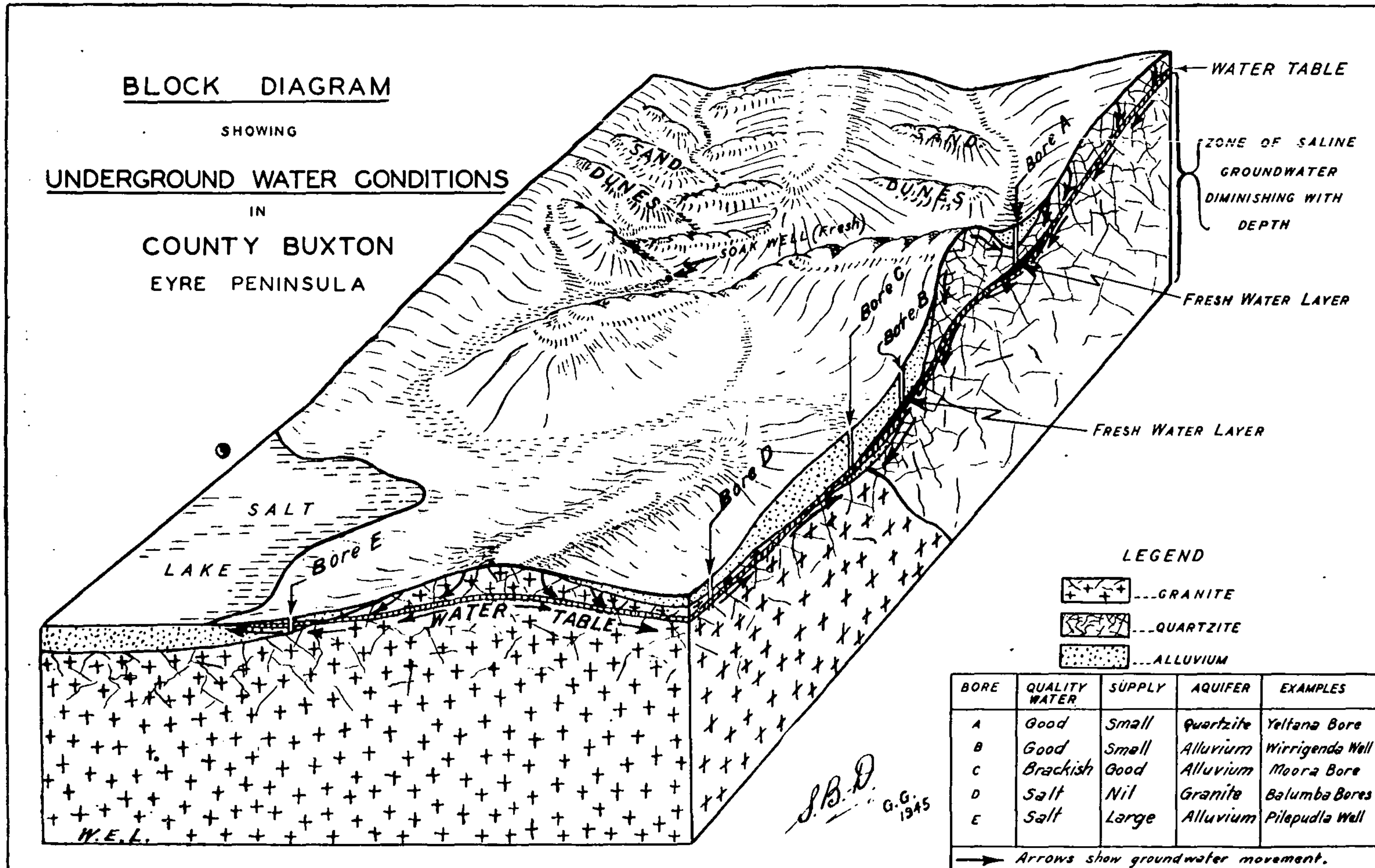
It will be noted that the ground water in the upper-most part of an aquifer consisting of a fissure merges into pressure water in depth, if the walls of the fissure are so impervious as to confine the deeper water. In this respect the aquifer resembles in some ways the water-bearing bed of an artesian basin, which carries ground water in the intake area. These features are not found in places where the wall rocks of the fissures are traversed by joints and other openings, so that the water can move with some measure of freedom through the country outside the fissures.

In the concluding chapter of this bulletin, dealing with the search for further supplies, attention is drawn to the necessity of paying attention to a number of points bearing upon the occurrence of ground water, particularly to the topography and channels of superficial drainage, to the character of the rocks present in the area, and to the degree of jointing observable in the outcrops that facilitates percolation and underground storage.

The geological conditions existing over a large part of central and western Eyre Peninsula are on the whole different from those of the South Australian highlands. The outcrops of the rocks constituting the eastern portion of the great Pre-Cambrian shield of Australia are relatively few in number and of limited extent. These old foundations consisting mainly of granites and granitic gneisses, have suffered a considerable amount of mature dissection so that an undulating land surface was generated by the close of early Tertiary time. Subsequently, Upper Tertiary to Recent sediments, predominantly sandy in character, were deposited in the valley and depression. Percolation in this terrain is high and the groundwater at the bottom of the sedimentary cover is almost invariably saline. The slopes of the water table are towards the sea. Some useful waters have been found where wells and boreholes have reached the foundations on their upper slopes, above the level of the deeper salt water. More rarely good water has been obtained from suspended water tables created by the burial of clay pans in the sandy sediments. These features are set out in detail in *Geological Survey Bulletin* No. 1, wherein R. Lockhart Jack revealed, in convincing manner, the circumstances governing the occurrence of both the saline and the better water. In a few localities on western and southern Eyre Peninsula there are special conditions to which reference will be made later.

Farther to the northward, and on the eastern side of upper Eyre Peninsula, the outcrops of the foundation rocks are much more extensive, but the difficulty of obtaining useful water is just as great. Many exploratory boreholes have been drilled, but the proportion of successes is small. A preliminary geological exploration of this area was carried out by R. Lockhart Jack in 1912 and 1913, and was followed by a much more detailed investigation of County Buxton by S. B. Dickinson in 1940, with special reference to the water supply problems of "marginal lands." Dickinson prepared geological and topographical maps of the greater part of the county, and also a plan showing the distribution of the relatively small areas within which possible supplies of useful water might be proved to exist. The accompanying block diagram, Fig. 32, shows the underground water conditions found to exist. The superficial sand dunes are not productive of water supplies, and the alluvium due to sheet flood erosion carries too much clay to be of value as an aquifer. Water has been found in the basement quartzites which are hard but jointed, and no useful water has been obtained from the gneisses, granites and schists. The salinity of the water at most places is due to the accumulation of cyclic salt in the soil within an area of low rainfall (11.98in. per annum at Kimba), low relief and poor drainage. The only supply of potable ground water is that obtained in the Yeltana borehole in the Wilcherry hills. This borehole is 273ft. deep and the water table is 180ft. below the surface. The supply is 4,000 to 5,000 gallons a day, and the content of dissolved salts is 0.32oz. per gallon. The water comes from joints, foliation planes and bedding planes in hard quartzite. Deep drilling in such an area would be futile and, when once saline water has been proved, there is no possibility of an improvement of quality by deepening the borehole.

In the western coastal portion of southern Eyre Peninsula there are important groundwater storages, one of which has been developed for use and two others that have been investigated in considerable detail.



BORE	QUALITY WATER	SUPPLY	AQUIFER	EXAMPLES
A	Good	Small	Quartzite	Yeltana Bore
B	Good	Small	Alluvium	Wirrigenda Well
C	Brackish	Good	Alluvium	Moora Bore
D	Salt	Nil	Granite	Balumba Bores
E	Salt	Large	Alluvium	Pilepudla Well

Fig. 32.

The developed area is situated in County Robinson immediately to the south-east of Flinders (Streaky Bay), where there is a shallow basin, about 200 square miles in extent, carrying sandstone and sand capped with travertine limestone that rest upon Pre-Cambrian foundations which have been subjected to mature dissection. The geology of the area and the steps taken to develop the useful water contained in it are set out in Geological Survey Bulletin No. 17, by R. W. Segnit and J. R. Dridan. The special problem to be solved was that concerned with the utilization of a "cream" of good water without contamination, under heavy draught, by the under-lying saline water. The investigation continued over a long period, and involved the plotting of the watertable contours month by month. Following upon this work the site for a pumping trench was selected and excavations were made of sufficient depth to reach the cream of good water. The bottom of the pumping sump was made impervious by a concrete lining to prevent the rise of saline water when the pump was in action, and only the good water was allowed to enter the sump from above the lip of the concrete lining. The cream water is of good quality, containing between 40 and 50 grains per gallon of total dissolved salts, whereas the underlying saline water, which is not separated from the cream water by any layer of impervious clay, carries 3oz. or more of dissolved salts per gallon. The success of this scheme was due entirely to the thoroughness of the preliminary investigation.

Another area, situated farther to the southward and generally known as the Polda basin, has some points of similarity with that of County Robinson mentioned above in that its successful development will depend upon the capacity of the basin to provide a continuous supply of "cream" water without the lowering of quality by the entry of saline water into the wells from which supplies are drawn. A great deal of investigatory work has been carried out already, but much more remains to be done. The ground water in this area is contained in a broad valley filled with calcareous sand which is capped with travertine limestone and it is known that the watertable contours fall towards the sea near Elliston. Work on this area was discontinued when a much more promising source of water for general use on Eyre Peninsula was found farther to the southward.

This promising source is known as the Uley-Wanilla fresh water basin, and is situated about 15 miles to the north-west of Port Lincoln. The features of the basin have been examined by R. W. Segnit, whose published report appears in the report of the Parliamentary Standing Committee on Public Works on the Eyre Peninsula (Uley-Wanilla) Water Supply, Parliamentary Paper No. 36 of 1944. The whole basin has an area of nearly 20 square miles, only one portion of which is under consideration for development. The basin consists of an eroded hollow in Pre-Cambrian rocks that has been filled with wind-blown shelly sand on which a capping of travertine limestone has formed. From numerous boreholes it has been found that the maximum depth of the sand is 80ft. The porosity of the sand has been found by experiment to be a little over 28 per cent. On the assumption that mean depth of the water-bearing sand is 48ft., it has been estimated by Segnit that the main portion of the basin carries a storage of 7,331 million gallons. The water is of excellent quality, containing between 20 and 30 grains per gallon of total dissolved salts. There is no known saline water in the deeper part of the basin. The reasons for the absence of accumulated cyclic salt in the deeper water, as has been found in so many portions of Eyre Peninsula, are probably the limited intake for the basin, the great permeability of the shelly sand with which it is filled, and the existence of easy outlets for the excess water. On the assumption that 25 per cent of the annual rainfall (average 23in.) reaches the water table, the annual replenishment is expected to be over 919 million gallons. Present proposals to draw 500 million gallons per annum from the basin therefore appear to be well within the capacity of the basin.

There is a large area between the Alberga River and Hamilton Creek in the far north of the State in which some groundwater occurs in fluviatile and wind-blown sand. Most of the water is saline; but a few wells, sunk on or near creeks which carry occasional flood waters, have afforded useful supplies to Mount Todmorden Station. In one case good water was struck after penetrating 170ft. of drift sand. See Geological Survey Bulletin No. 5, p. 53. This groundwater area is perched above the Great Artesian Basin.

XIII. THE COMPOSITION, TESTING, AND UTILIZATION OF UNDERGROUND WATER.

(a) GENERAL STATEMENT.

Absolutely pure water may be said to be non-existent in the state of nature. When pure water is required it must be obtained by the tedious process of distillation—a fact known to all owners of motor cars who want pure water for their batteries.

Many natural waters contain organic matter and also mineral matter in suspension, and filtration will remove the greater part of such impurities. The water remaining after filtration is nevertheless impure through the presence of dissolved matter that cannot be detected by the eye. Some waters that are clear and sparkling are heavily charged with saline material, the existence of which may be shown by putting a sample of such water in a clean glass vessel and heating it until the water has evaporated. A residue, representing the dissolved solids, will be found in the vessel at the end of the operation. If this experiment be performed with any natural underground water a residue will be seen. The amount of dissolved solids in different waters is variable. No two samples from different sources are exactly alike when they are examined in full detail as regards the quantity and character of the matter in solution.

Although very many persons classify waters as "fresh," "brackish," or "salt," these terms are entirely inadequate and unsatisfactory. Nor is their significance the same in different places. An engineer requiring water with very little dissolved matter for raising steam or for industrial purposes, in a region of relatively high rainfall or in places where perennial streams bring supplies from mountain ranges not far distant, would not regard as "fresh" the water that would be thus described by a farmer on upper Eyre Peninsula. Again, the farmer who has so-called "fresh" water in a borehole used for watering stock might be unable to use this water to advantage for horticultural purposes. The use of these relative terms is therefore to be discouraged; and exact statements of the salinity, based on analytical data, should take their place.

The origin of the saline matter in underground waters is best understood by considering the history of the water up to the time when it is collected for examination or use. It has been pointed out that most natural waters are obtained at some point in the circulation of water between the sea and the land, with an intermediate stage when, as aqueous vapour, the atmosphere is the vehicle in which the water is carried. The processes which cause the atmosphere to be charged with aqueous vapour are responsible for the presence in the air of other materials also. The greater part of the aqueous vapour is taken up by the atmosphere from the sea, and the saline constituents of sea water are found in the air in which salt spray has evaporated. The condensed moisture that falls as rain is already impure when it reaches the earth's surface, having absorbed gases from the air and having also washed out of the air some of its mineral content.

This washing of the atmosphere is effected by every shower, and measurable amounts of mineral material (chiefly sodium chloride) are brought down in the rain. Localities near the coast are found to receive rainfall with a greater proportion of these so-called "cyclic salts" than places farther inland. Again, at localities in which the annual rainfall is received in a great number of light showers, the rain carries more cyclic salt down to the earth from the air than at places where the year's rain is received in a few heavy falls.

As soon as the rainwater reaches the earth it takes more mineral matter into solution, being assisted in this work by the gases absorbed from the air. The soil is washed and mineral ingredients that are themselves readily soluble in water alone, or that are dissolved in water containing oxygen or carbon dioxide join in the circulatory movement of the water. Some of this mineral matter is merely transferred from one part of the earth to another, being redeposited by chemical action or by the evaporation of the water which returns to the atmosphere. The most familiar evidence of the former existence of mineral matter in solution is that afforded by the crust of solid or nodular travertinous limestone found in all parts of South Australia where calcareous rocks occur, this travertine having been deposited on the evaporation of water charged with calcium bicarbonate when it has been brought to the surface by capillarity. Mineral deposits are found also in all caves and artificial openings in which water that has travelled through the rocks meets currents of air that cause evaporation. Stalactites and more irregularly shaped deposits are formed, the composition of which is determined by the nature of the mineral matter taken into solution. The commonest of such deposits in South Australia are those composed of carbonate or phosphate of lime, hydrous oxides of iron or manganese, and hydrous sulphates of iron or copper. The non-metallic rock-forming minerals are not wholly insoluble in water, although some of them resist solution much more strongly than others. Limestone is peculiarly susceptible to the action of water containing carbon dioxide, and other rocks are attacked less vigorously. The nature of the surface soil and the underlying rocks traversed by underground water determines the character of the water tapped by boreholes and wells in practically every case, the chief exceptions being those where artesian waters are absorbed at a distance from the places at which they are tapped.

Where there is apparently an absence of relationship between the substances held in solution in the water and the composition of the rocks of that locality, and if geological structure does not indicate a distant source for the water, there may be some contribution of "juvenile," "plutonic," or "magmatic" water from deeper portions of the earth's mass. Great caution must, however, be exercised before a juvenile origin to any underground water can be attributed with confidence, since there are no certain criteria whereby juvenile and meteoric waters may be distinguished. It has been suggested that a low content of chlorine and the presence of boric acid in localities where there are known compounds of boron in the rocks of the vicinity, may indicate a plutonic source for underground waters. Again it has been claimed that juvenile waters carry sodium bicarbonate, alkaline silicates, heavy metals, etc., with chlorides only as accessories and practically no carbonates of the alkaline earths. These matters are much in dispute and no final judgment is yet possible in respect of the several claims.

Moreover, it is to be borne in mind that juvenile waters of the present day are largely restricted to areas in which there has been recent volcanic activity, or areas where there has been very pronounced fracturing of the crust by fissures which extend downwards to great depths. So far as South Australia is concerned there is no satisfactory proof of the existence of any juvenile sources of water. The only districts in this State in which volcanic activity has been revealed in late geological time are those near Mount Gambier, and near Kingscote on Kangaroo Island. In neither district is it possible to point to any thermal spring or any source of water to which a magmatic origin can be attributed on reasonable grounds. In the Mount Gambier district the immense amount of meteoric water present in much of the country, as described in Bulletin 19 of this Geological Survey, is sufficient to mask any other than a very large contribution from the depths; and no signs of material differences in the composition of the waters taken from different places and analysed have been observed.

The margins of the South Australian highlands are lines of powerful faulting, but there too it would be unreasonable to assign a juvenile origin to the only thermal springs—at Paralana—known to exist on the boundary of the Great Artesian Basin. The mode of occurrence of these springs and the chemical character of the issuing water indicate rather that the water is the normal water of the artesian basin emerging along the margin of the Mesozoic rocks, or even escaping through fissures in the faulted Pre-Cambrian rocks of the highlands on the upthrow side of the major fault lines.

The older volcanic rocks of South Australia—the felspar porphyries of the Gawler Ranges and elsewhere, and the melaphyre of Wooltana—are products of igneous activity that antedates the Cambrian period, and cannot be held to be connected with any juvenile springs of the present day, since the volcanic action was extinct in all its phases before the opening of the Palaeozoic era. The same remarks apply to other localities at which plutonic and hypabyssal igneous rocks occur in various parts of the State.

Another possible source of saline matter in underground water must be taken into consideration—namely, the so-called "fossil salt" that may occur in solution in "connate" or residual water, or that may be taken into solution by water now circulating between the land and the ocean through the leaching of sediments that were deposited in salt water.

It is known that a large portion of the settled part of South Australia lying to the east of Spencer Gulf and Lake Torrens was submerged beneath a shallow epicontinental sea in Cambrian time. Much later, during the Cretaceous period, the sea invaded Australia from the north and occupied the north-eastern part of this State for a long time before it withdrew. Much later still the southern part of the Australian continent was submerged to such an extent that the Miocene sea covered the whole of the Nullarbor plain, probably much of Eyre Peninsula, all Yorke Peninsula, the Adelaide Plains, much of the southern Mount Lofty Ranges and Fleurieu Peninsula, and all the great plains traversed by the River Murray, as well as the south-eastern part of the State. It was later still that the highlands rose far above sea level and many low-lying areas emerged from beneath the ocean. It is therefore pertinent to inquire into the time intervals between these successive periods of submergence beneath the sea and the present day, in order to judge whether fossil salt can be expected to occur in the rocks that were deposited in the former seas.

Assuming, as seems proper, that the time-scale based on radio-active measurements is reliable, we may reflect that the submergence during the Cambrian period occurred about 500 million years ago. The Lower

Cretaceous submergence dates back to a time about 120 million years from to-day, and the Miocene seas which spread over a large part of the southern portion of the Australian continent persisted for some millions of years, the earliest of which were some 25 million years distant from the present day. It is more difficult to fix the exact age of the great earth movements which resulted in the elevation of the great Murravian Gulf to make the plains now traversed by the River Murray and in the much greater elevation of the Mount Lofty Range; but these movements probably began in late Pliocene time and continued into the early Pleistocene period which is estimated to have begun about a million years ago.

The enormous periods of time that have passed since the deposition of the Cambrian strata, during which these rocks have been high above sea level, have provided ample opportunity for the complete removal of fossil salt from the rocks of that age. The same remarks apply, if in a smaller degree, to the Cretaceous marine sediments. It might appear that the shorter period that has elapsed since the elevation of the Miocene and Pliocene beds is insufficient for the complete washing out of fossil salt from these beds. Yet, when consideration is given to the amount of water that has traversed these rocks, if only a small proportion of the rainfall of the existing climatic cycle is regarded as the leaching agent, it is difficult to see how an appreciable amount of fossil salt can remain. Moreover, the rainfall of at least portions of the Pleistocene period was probably very much heavier than that of to-day. Again, it is known that the Miocene polyzoal limestone affords water of varying salinity in different parts of South Australia, the salt content being high in regions of low rainfall, such as the Nullarbor Plain and the plains north of the River Murray, and low where the absorbed meteoric water is more abundant as on the Adelaide plain and the far south-eastern district generally.

It is to be remembered that cyclic salts, derived as they are largely from salt sea spray in the first instance, are precisely the salts which might be expected in water that is derived from marine deposits; and it is known that the saline content of water from wells and boreholes in formations to which a marine origin cannot be attributed does not differ from that which is characteristic of waters from the marine deposits themselves. Hence it is felt that it is far wiser to attribute a cyclic origin to much of the saline matter than to look to the effect of the leaching action of rain upon a residuum of sea water entrapped within the rocks themselves when they were raised above sea level.

So far as is known at the present time, there is no concentrated body of salt contained in any formation in South Australia that was deposited prior to Recent geological time. The salt deposits in the dry lakes are entirely superficial. It is not, therefore, probable that any buried bed of salt can have rendered underground water saline, although it is probable that superficial concentrations of salt have contributed to the salinity of water that has traversed natural basins of evaporation before being absorbed and before joining the body of underground water. The surface salt may have contributed also some material to the soil by the action of the wind, thus augmenting the body of cyclic salt which ultimately suffers solution and enters the ground water.

If it be desired to examine more closely the relationship between the mineral matter dissolved in underground waters and that contained in sea water reference should be made to a paper by V. G. Anderson, under the title of "Old and new systems for reporting the inorganic constituents in natural waters," which appeared in the *Journal and Proceedings of The*

Australian Chemical Institute, June, 1940. The same relationship, within a district situated on the northern margin of the Gawler Ranges, has been studied in detail by S. B. Dickinson, whose conclusions are published in his paper entitled "The Moonarie Station saline ground waters and the origin of the saline material," which appeared in the *Transactions of the Royal Society of South Australia*, Vol. 66 (1), 1942. Both these papers contain tables of analyses and graphs which show conclusively the cyclic origin of much of the inorganic matter contained in waters obtained from boreholes and wells.

(b) THE ESTIMATION OF THE SALINITY OF WATER BY THE OBSERVATION OF DENSITY.

An approximate idea of the salinity of a sample of water may be obtained by the use of a salinometer, which is a variable-immersion hydrometer with which the specific gravity of the sample may be determined. The form commonly used in South Australia is a brass instrument, with a brass stem graduated to show each quarter of an ounce between zero and 3oz. to the imperial gallon. These graduations are placed at the points at which, with solutions of common salt at a temperature of 60° F. (or in some cases 65° F.) and with the degree of concentration indicated, the free surface of the liquid touches the stem. The higher the salinity the greater is the length of stem projecting above the water surface, and *vice versa*. The observation of the temperature of the water is most important, since the specific gravity of water is lowered appreciably by a rise of temperature, and it must be ascertained whether the salinometer is graduated for 60° F. or 65° F. If the water to be tested is not at that temperature it should be brought to that temperature, or a correction should be made for the difference between the actual temperature of the water and the basal temperature used in the graduating of the instrument. With the salinometer here described it is found that a correction of ⅛oz. should be added to the salinity indicated on the stem of the instrument for each 5° F. rise of temperature above the figure at which the graduations were made. Care must be taken to see that the stem is kept perfectly clean, since a trace of grease or oil will affect the reading.

This method, although only an approximate one, for determining salinity is quite useful within its proper limitations. Good results may be obtained for waters containing similar salts in solution, if each particular instrument is tested carefully with waters the salinity of which has been determined by analysis, and if due corrections are made to the figures obtained by reading the graduations on the stem. If, however, waters with different dissolved salts are tested, the figures indicated by the varying specific gravities of the water samples will not give accurate and consistent ideas of the salinity, since the specific gravity is not equally affected by equal weights of different salts.

The determination of salinity by the salinometer, which is so easily and quickly made, is therefore a method that must be used with caution; and it must never be attempted without a temperature correction after the determination of the temperature of the water that is being tested. It will be found useful, if many salinometer tests are to made, to have available a few winchester quart bottles of waters, the salinities of which have been determined by analysis, for purposes of calibration.

The chief value of the salinometer lies in its extreme portability. It can be used in the field for giving approximate results, which should be regarded as subject to rejection when a chemical analysis of the water has been made.

(c) CHEMICAL ANALYSES.

It will be noted that the analyses of underground waters made by the departmental analyst, and recorded in this bulletin, are set out in accordance with the requirements of a standardized procedure that is of general application.

Firstly, it must be stated that the proportions of dissolved solids are shown in grains per imperial gallon, mainly for the reason that those who make use of the analyses have become accustomed over a period of very many years to the statement of determinations in this manner. Many chemists exhibit a preference for the statement of results in parts per 100,000, or in parts per million. The latter can readily convert the figures showing grains per imperial gallon into those for parts per 100,000 by multiplying the number of grains by 10 and dividing the product by 7. Since there are 7,000 grains in one pound avoirdupois, and one imperial gallon weighs 10 lb., figures for grains per imperial gallon are equal to the number of parts per 70,000. The ounce, avoirdupois, contains 437.5 grains.

The following table is provided to enable results to be converted readily from one mode of expression to another:—

Unit.	Grains per Imperial Gallon.	Grains per U.S. Gallon.	Parts per 100,000.	Parts per Million.
1 grain per Imperial gallon	1·00	0·835	1·43	14·3
1 grain per U.S. gallon	1·20	1·000	1·71	17·1
1 part per 100,000..................	0·70	0·583	1·00	10·0
1 part per million	0·07	0·058	0·10	1·00

(1) Method of Calculating and Showing Composition in Water Analyses.

In the analytical tables it is the practice to set out separately the results obtained in two forms—the ions and radicles, and combinations of the acids and bases according to an order of preference that is to some degree arbitrary. Differences of opinion may exist regarding the assumptions made in these calculations; but the method, for the statement of which the writer is indebted to T. W. Dalwood, Analyst and Assayer to the Department of Mines, is one which is widely used. All the results obtained by the consistent use of this method are strictly comparable among themselves, and those who hold different opinions regarding the composition of the salts can recast the figures to their own satisfaction from the ionic tables. The procedure in use is as follows:—

The calcium, Ca, is first calculated to the carbonate, $CaCO_3$. If there is an excess of calcium it is assigned to the sulphate, $CaSO_4$, and the remaining calcium, if any, is calculated to the chloride, $CaCl_2$.

The magnesium, Mg, is first calculated to the carbonate, $MgCO_3$ (if the CO_3 is in excess of that required by the calcium). The excess of magnesium is assigned to the sulphate, $MgSO_4$; and any magnesium remaining to the chloride, $MgCl_2$.

Any excess of carbonate, CO_3, sulphate, SO_4, and/or chloride, Cl, and also nitrate, NO_3, are then calculated to the sodium salts (potassium being estimated only in special cases wherein a separate determination is required). A calculated figure is thus obtained for the sodium, Na, and this result is checked by a direct determination of the sodium. If potassium is determined it takes precedence over sodium in these calculations.

If iron, Fe, and/or aluminium, Al, are present in only very small amounts they are reported as the sesquioxides, Fe_2O_3 and Al_2O_3, either separately or together; but, if present in considerable quantity, the iron is calculated to the carbonate, $FeCO_3$, in the case of alkaline waters, and to the sulphate $FeSO_4$ or $Fe_2(SO_4)_3$ according to the state of oxidation of the iron in acid waters. Aluminium is always calculated to the sulphate $Al_2(SO_4)_3$. In the latter case iron and aluminium take precedence over calcium.

Thus it is seen that the acid radicles are allotted in the following orders of preference:—

Carbonate, CO_3—(Iron), Calcium, Magnesium, Sodium (Potassium).
Sulphate, SO_4—(Iron and Aluminium), Calcium, Magnesium, Sodium (Potassium).
Chloride, Cl—Calcium, Magnesium, Sodium (Potassium).
Nitrate, NO_3—Sodium (Potassium).

If determined, silicon, Si, is reported as the oxide, SiO_2.

(2) The Determination of Hardness.

Hardness is calculated from the calcium and magnesium salts (together with those of iron and aluminium, if present) shown in the figures obtained for the "assumed composition," and is expressed in degrees, one British degree of hardness representing the equivalent of one grain per gallon of calcium carbonate, $CaCO_3$. This convention requires that the salts of calcium, magnesium, iron and aluminium must be expressed in terms of the equivalent amounts of calcium carbonate, $CaCO_3$. The required factors are given in the following table:—

Ca	x 2.497 =	the amount equivalent to $CaCO_3$.
Mg	x 4.115 =	" " " " "
Fe	x 1.792 =	" " " " "
Al	x 5.566 =	" " " " "

The hardness due to carbonates is termed "temporary hardness" or "carbonate hardness," while that due to sulphates or chlorides is termed "permanent hardness" or "non-carbonate hardness." Thus, for example, if the assumed composition is—:

Calcium (as carbonate), Ca	= 10	grains per gallon.
Calcium (as sulphate), Ca	= 4	" " "
Magnesium (as sulphate), Mg	= 6	" " "
Magnesium (as chloride), Mg	= 10	" " "

The hardness expressed in English degrees would be:—

Ca 10 x 2.497	= 24.97	degrees.
Ca 4 x 2.497	= 9.99	"
Mg 6 x 4.115	= 24.69	"
Mg 10 x 4.115	= 41.15	"
Total	100.80	degrees.

In the example selected there is no magnesium present as carbonate, so that the "temporary" hardness is that due to the calcium carbonate present, namely 24.97 degrees, the remainder being reported as "permanent." So the table reads:—

Hardness, total	= 100.80
" temporary	= 24.97
" permanent	= 75.83
" due to Ca	= 34.96
" due to Mg	= 65.84

If sodium carbonate, Na_2CO_3, is present according to the assumed composition, the whole of the calcium and magnesium present must be in the form of carbonates, so that the whole of the hardness will be "temporary." For the purpose of calculation the following factors are used:—

To Convert Ions into Salts.	To Convert Salts into Ions.
Ca x 2·497 = $CaCO_3$	$CaCO_3$ x 0·4005 = Ca
Ca x 3·397 = $CaSO_4$	$CaSO_4$ x 0·2944 = Ca
Ca x 2·769 = $CaCl_2$	$CaCl_2$ x 0·3611 = Ca
Mg x 3·467 = $MgCO_3$	$MgCO_3$ x 0·2884 = Mg
Mg x 4·950 = $MgSO_4$	$MgSO_4$ x 0·2020 = Mg
Mg x 3·916 = $MgCl_2$	$MgCl_2$ x 0·2554 = Mg
Fe x 2·0745 = $FeCO_3$	$FeCO_3$ x 0·482 = Fe
Fe x 2·72 = $FeSO_4$	$FeSO_4$ x 0·3676 = Fe
Fe x 3·58 = $Fe_2(SO_4)_3$	$Fe_2(SO_4)_3$ x 0·2793 = Fe
Al x 6·317 = $Al_2(SO_4)_3$	$Al_2(SO_4)_3$ x 0·1577 = Al.

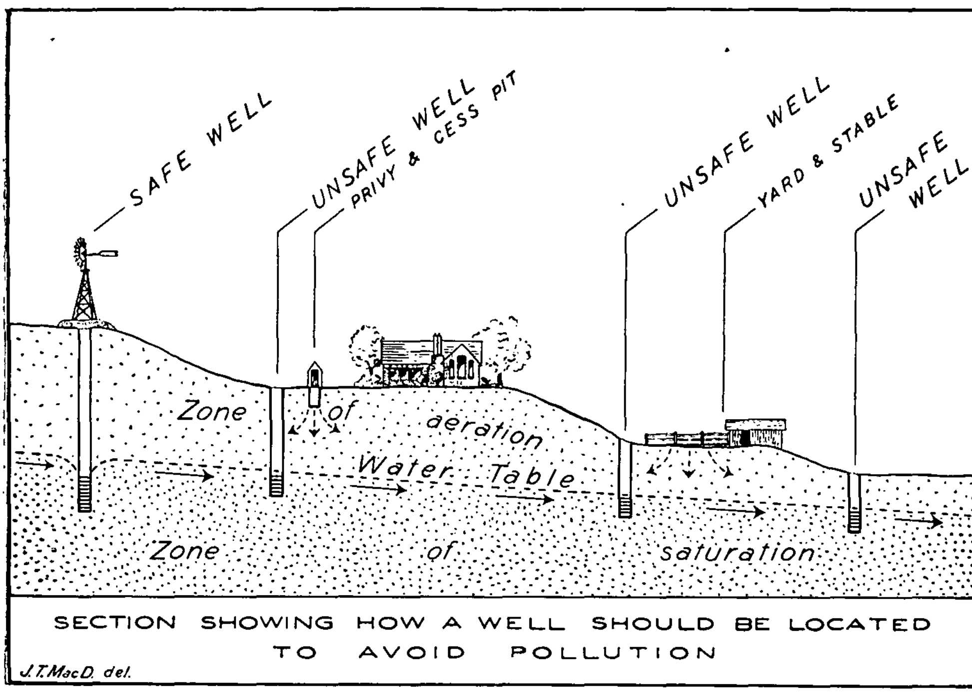
If it is desired to compare analyses which do not make use of Clark's scale of hardness, which is expressed in the English degrees mentioned above, it is to be remembered that one French degree of hardness is equivalent to 1 part per 100,000 of calcium carbonate; and that one German degree of hardness is equivalent to 1 part per 100,000 of calcium oxide. The following table shows the factors for the conversion of results from one scale to another:—

Unit.	Hardness.			
	English Degrees.	French Degrees.	German Degrees.	Parts per Million.
One English degree	1·00	1·43	0·80	14·3
One French degree	0·70	1·00	0·56	10·0
One German degree	1·24	1·78	1·00	17·9
One part per million	0·07	0·10	0·056	1·0

It has been felt by some chemists that the ionic statement of the analysis of a water, although necessary as a basis for interpretation and classification, is not sufficient. From this viewpoint it is held that the physical weights of the ions and radicles in solution should be replaced by figures expressing their chemical value or "reaction capacity." H. Stabler has defined, in *U.S. Geological Survey Water Supply Paper* 274, the "reaction coefficient" as the chemical reacting power of a unit weight of a radicle or ion, that is by the valency of the radicle or ion divided by its atomic weight. The weights of the constituent ions and radicles when multiplied by the corresponding reaction coefficients are claimed to give chemically comparable figures. The question is discussed at some length in Chase Palmer's paper entitled "The Geochemical Interpretation of Water Analyses," published as *Bulletin* 479 of the U.S. Geological Survey, and in G. Sherburne Roger's paper "The Interpretation of Water Analysis by the Geologist," published in *Economic Geology*, January, 1917. The latter author, using this method, has classified natural waters into five groups, of which two are intermediate between three main groups. The principal classes are those in which: (1) the value of the strong acids (such as Cl and SO_4) is less than the value of the alkalies (Na,K); (3) the value of the strong acids is greater than the value of the alkalies, but less than that of the alkalies plus the alkaline earths (Ca, Mg); and (5) the value of the strong acids exceeds that of the alkalies plus the alkaline earths.

It appears to the writer that this method of attack on problems concerned with the origin of the ions and radicles in solution may be productive of useful results; but a great deal of work must be done before analyses converted into this form can be used with confidence in determining the value of natural waters for specific uses.

It is, of course, advisable to give consideration, in all cases concerned with water used for domestic purposes, including human consumption, to the question of possible pollution, especially if the water is drawn from a well or borehole in porous rocks. The chemical analysis of the water that has suffered organic pollution may be revealed by the presence of nitrites



After Weidman and Schultz.

Fig. 33.

and nitrates which may indicate derivation from sewage or other waste from abattoirs, stables, yards, and pens. A case has been noted in South Australia in which the withdrawal of stock from troughs placed beside a well in very porous limestone has been followed by a rapid diminution in the amount of nitrates present in the underground water stored in the surrounding area.

Nevertheless it does not necessarily follow that the presence of nitrates is invariably a sign of contamination from an objectionable source, for it has been noted in Western Australia that there is a notable proportion of soluble nitrates present in many of the underground waters occurring in the drier parts of that State in places where there is no possibility of the waters having suffered organic pollution. The areas in which these nitrate-bearing waters are found are characterized by mulga scrub, which has been considered to be responsible for the accumulation of nitrates in the soil by processes such as are set in operation by other leguminous plants.

These nitrated waters are not unknown in South Australia, and analyses of several will be found in Table XX. All these samples came from bore-holes situated near Mulgathing Rocks to the north-west of Tarcoola.

The foregoing discussion of the analyses of natural waters which indicate the substances dissolved in them does not deal with organic impurities or growths, since these are seldom present in underground waters. Where pollution is suspected special precautions should be taken in the collection and preservation of the samples, and special methods must be applied for the determination of nitrates (calculated as ammonia); ammonia, free and saline; ammonia, albuminoid; and oxygen, absorbed in 15 minutes and in four hours. In addition, bacteriological examination may be called for and counts made of the number of bacteria present per cubic centimeter, with a separate search for *baccillus coli.* Tests of this character must be performed in a properly equipped bacteriological laboratory.

(d) THE SIGNIFICANCE OF SALINITY IN THE UTILIZATION OF UNDERGROUND WATER.

While it is obvious that the usefulness of water depends largely upon its quality, that is to say, its comparative purity or freedom from large amounts of dissolved material, it is nevertheless necessary to take into consideration the actual proportions of such material present in every natural water and the limits of tolerance for specific uses. In most cases there is no practicable way of rendering useful a saline water in which the limits of tolerance are exceeded, although it has been found possible in some places to mix available surface water of better quality with saline underground water to extend the life of the supplies of the higher grade water. Such expedients are generally of a temporary nature, since the surface waters are seldom available in large amounts and, indeed, would be used alone if their existence were to be relied upon for long periods. On the whole the underground waters have to be judged on their own individual merits, as they occur in nature and without beneficiation by dilution.

There are two matters to consider in every case; namely, the total salinity, and the relative proportions of the substances in solution. These factors have to be considered in relation to the use which is to be made of the water and to the conditions under which it is to be used.

Much investigatory work remains to be done before analyses in the ionic form can be used authoritatively for establishing exact criteria by which availability for any specific purpose can be judged. Meanwhile the table showing the assumed composition of the salts in solution plays a useful part, despite the recognition of the fact that the combinations shown are dependent upon arbitrary assumptions.

In general the chief uses to which underground water is put in South Australia are the following:—

1. For human consumption and domestic purposes.
2. For watering stock.
3. For irrigating plants of all kinds.
4. For industrial purposes.
5. For engineering purposes.

In reviewing each of these uses in turn it will be noted that the limits of tolerance imposed by South Australian conditions—largely those conditions that are dependent on climate or on the absence of better water—are less stringent than the limits recognized elsewhere in many applications of water to industry.

(1) Water Used for Human Consumption and Domestic Purposes.

There can be no immutable limit specified for the salinity of water upon which human beings have to depend. Quite naturally the best water available is sought, but circumstances governing availability are extremely variable.

H. B. Woodward in his "Geology of Water Supply" quotes Dr. J. C. Thresh as stating that "the total amount of saline matter permissible in a drinking water depends in a great measure upon the nature of the salts. No hard-and-fast line can be drawn, but the best waters rarely contain more than 20 grains of mineral matter per gallon. When 100 grains is reached the water becomes rather of the character of a 'mineral' than a 'potable' water."

Others, not so fortunately placed as the people of England, would take a much more tolerant view of salinity. In many parts of South Australia those who have to depend upon underground water for drinking and culinary use would be glad to have supplies containing less than ¼oz. or 109 grains of total solids per gallon. In fact, some of the surface water stored in reservoirs in this State, at Bundaleer and Tod River, and widely reticulated has a higher salinity.

In India the Director of Public Health in the Punjab is quoted by Dr. A. L. Coulson as specifying the upper limit of salinity for drinking water to be 70 grains per gallon.

F. Dixey in his "Practical Handbook of Water Supply" mentions 40 grains per gallon as the extreme limit of mineral content in drinking water used in England and the eastern United States, according to the older authorities, but states that desert experience has shown that water containing 175 grains of dissolved salts per gallon may be used for many days without serious discomfort, but that those containing as much as 231 grains can be used only by hardened travellers. In North Mexico and in California, according to this author, water with more than 280 grains per gallon is used for drinking and other domestic purposes, and water with only 140 grains per gallon is regarded as good. The latter figures are reasonably conformable with South Australian experience in the driest parts of the State.

As a matter of interest in the capacity of human beings to live without suffering noticeable loss of health and vigour, and as a testimony to their extraordinary endurance and courage in continuing to remain in possession of their holdings when other supplies (of tank water) had failed in periods of drought, two analyses of waters, from western Eyre Peninsula and the Murray lands, are here set out. In each case families lived on the water of which the salinity is shown for periods of several months, no other water being available.

TABLE I.

Extremely Saline Waters Used for Human Consumption in Times of Drought.

	Petina Well Sec. 6 Hd. Perlubie Co. Dufferin.	Bleeze's Borehole Sec. 47 Hd. Ettrick Co. Russell.
Ions and Radicles (grains per gallon)—		
Chlorine, Cl	315.98	234.20
Sulphuric acid, SO_4	46.87	59.04
Carbonic acid, CO_3	2.70	20.40
Sodium, Na	97.58	154.37
Potassium, K	8.06	8.06
Calcium, Ca	77.24	9.54
Magnesium, Mg	22.86	13.34
Total saline matter (grains per gallon)	563.23	501.40
Total saline matter (ounces per gallon)	1.29	1.14
Assumed Composition of Salts (grains per gallon)—		
Calcium carbonate	4.50	23.85
Calcium sulphate	66.42	—
Calcium chloride	154.75	—
Magnesium carbonate	—	8.53
Magnesium sulphate	—	54.50
Magnesium chloride	89.52	—
Sodium sulphate	—	22.83
Sodium chloride	248.04	373.85
Potassium chloride		15.39
Hardness (English degrees)—		
Total	287.20	79.41
Temporary	4.50	34.00
Permanent	282.70	45.41
Due to calcium	193.13	23.85
Due to magnesium	94.07	55.56

In his paper on "Problems of Water Supply in Western Australia" printed in the transactions of the Australasian Association for the Advancement of Science, Perth, 1926, E. S. Simpson discussed at some length the desirable standards of quality for Australian conditions, and drew attention to the fact that European or eastern American standards are unattainable. He placed stress on the desirability of providing the best possible waters for cities and large towns, where waters are required for industrial use as well as for human consumption. Simpson quotes modern authorities as setting the following standards for the public supplies of cities:—

	Max. grains per gallon.
Total solids	70
Magnesium	3
Iron	0.035
Hardness	7
Oxygen, absorbed from $KMnO_4$	0.2
Albuminoid ammonia	0.07
Nitrogen as nitrites	0.035
Nitrogen as nitrates	0.14
Free ammonia	0.004
Hydrogen sulphide	Trace, to be removed before circulating.
pH	Between 5.5 and 8.6

So far as concerns the supplies for small towns, Simpson suggests a less exacting standard, namely:—

	Max. grains per gallon.
Total solids	105
Magnesium	4
Iron	0.07
Hardness	21
Nitric nitrogen, in nitrate-bearing areas	1.0

Other factors, as mentioned above for cities.

For individual farms or mines a still lower standard is suggested, namely:—

	Max. grains per gallon.
Total solids	210
Magnesium	8.5
Hardness	35

Other factors, as mentioned above.

So far as hardness is concerned, those who have to use water containing mineral matter in solution usually refer to it as being "hard" or "soft," without any real standard of hardness or softness by which to classify them. It has been explained how hardness is determined quantitatively and shown in analyses; but opinions vary as to what is the upper limit for a water to be designated as soft.

The Director of Public Health in the Punjab, India, regards 21 grains per gallon of permanent hardness as the upper limit for drinking water.

A. Beeby Thompson is quoted by Dr. A. L. Coulson, in his Memoir on the Geology and Underground Water-Supply of Calcutta, Bengal, as stating that water with less than 5 grains of hardness per gallon would be very soft, 5 to 20 grains fairly soft to moderately hard, and above 20 grains hard to very hard.

F. Dixey quotes the United States Geological Survey as classifying waters by hardness as follows:—

3.5— 7 degrees of hardness	soft
7 —14 " " "	medium hard
14 —21 " " "	hard

W. P. Mason in his book "Water Supply" quotes Dr. J. C. Thresh, of Essex, England, as using the following classification of waters by hardness:—

10 degrees of hardness or under	soft
10-20 " " " " "	moderately hard
20-30 " " " " "	hard

In the use of hard water for domestic purposes the noticeable features are the difficulty in obtaining a lather without an excessive consumption of soap, and the scale formed in vessels in which the water is boiled.

With regard to the taste of water containing dissolved mineral matter it is noticeable that the sensitiveness of individuals varies appreciably. F. Dixey quotes H. Keller as stating that water containing:—

28	grains	per	gallon	of	sodium	chloride	has no taste of salt.
35	"	"	"	"	"	"	" a brackish taste.
70-175	"	"	"	"	"	"	" a strong taste of salt, but is bearable
175-350	"	"	"	"	"	"	" is unbearable for continuous use.
Over 350	"	"	"	"	"	"	" cannot be used as drinking water.

The water in the Great Artesian Basin, through its content of sodium carbonate, has a strong taste of washing soda, and some travellers who have had to depend on this water for drinking have corrected the alkaline taste by dropping a few crystals of citric acid into the water before use.

When it is necessary to rely wholly upon rather saline water for drinking it has been found by many that coffee is more palatable than tea, and cocoa more than coffee.

Some waters carry sufficient of the magnesium and sulphate ions to acquire an unpleasant taste. Iron, if present in greater proportions than ¼ grain to the gallon, can be distinguished by taste, and larger amounts render the water unpalatable as well as unsuitable for some purposes.

It is seldom that water from underground sources has any appreciable smell. However, some boreholes discharge water that carries sulphuretted hydrogen, which can be dispelled readily by boiling the water. Such water, still charged with this unpleasant gas, should not be placed in sealed containers before boiling or thorough aeration.

There are several South Australian towns and districts supplied with water from underground sources, regarding which the particulars have been supplied by the Engineering and Water Supply Department, together with analyses of the water made by the Department of Chemistry. These data are set out in the following tables:—

Schedule of Underground Water Supplies.

Source of Water.	Town or District Served.	Millions of Gallons Pumped per Annum.			Salinity, Grains per Gallon.
		1941-42.	1942-43.	1943-44.	
Spring Creek Mine	Wilmington	—	8	12½	20·2
Peterborough Well	Peterborough	22½	27¾	29½	110·4
Bon Accord Mine (Burra)	Kooringa and district	17¼	—	—	105·8
Wilkalinsie pumping trench (Streaky Bay)	Flinders and district	13	13	15½	48·16
Blue Lake	Mount Gambier and district	150½	146¼	142	26·8
Pinnaroo bore	Pinnaroo	10½	14½	17½	55·4
Naracoorte bores	Naracoorte	24½	25¾	27½	96·6
Bordertown bore	Bordertown	8¼	7¾	12¼	88·6
Elwomple pumping trench	Moorlands water district	2¼	2½	3	280·1

The analyses of samples, taken on the dates shown, are as follow.—

TABLE II.

Source.	Spring Creek Mine.	Peterborough Well.	Bon Accord Mine.	Wilkalinsie Trench.	Blue Lake.	Pinnaroo Bore.	Naracoorte Bores.	Bordertown Bore.	Elwomple Trench.
Date	15/4/35	5/7/44	5/7/44	25/6/41	12/3/45	2/3/43	17/7/44	14/9/44	29/6/43
Ions and radicles (grains per gallon)—									
Carbonic acid .	3·3	13·5	9·6	11·26	7·2	10·6	13·2	13·6	20·7
Chlorine	7·5	44·8	44·1	16·28	8·1	16·0	34·3	32·7	120·0
Sulphuric acid.	1·1	11·6	13·1	2·68	1·3	7·5	12·3	7·7	35·0
Sodium..... } Potassium .. }	4·7	27·0	19·9	8·69	5·4	13·4	25·8	27·3	88·7
Calcium	1·0	6·1	7·7	7·72	2·5	4·5	4·2	2·5	5·4
Magnesium ...	1·1	5·8	7·4	1·53	1·7	1·9	4·1	2·9	8·6
Silica	1·5	1·5	2·8	—	0·6	1·4	2·6	1·5	2·0
Assumed Combinations (grains per gallon)—									
Calcium carbonate	2·4	15·3	16·0	18·76	6·2	11·2	10·5	6·2	13·5
Calcium sulphate	—	—	4·5	0·75	—	—	—	—	—
Magnesium carbonate	2·6	6·1	—	—	4·9	5·5	9·7	10·0	17·7
Magnesium Sulphate	1·4	14·4	12·5	2·69	1·2	1·6	6·2	—	17·1
Magnesium chloride	0·2	4·5	19·1	3·88	—	—	—	—	—
Sodium carbonate	—	—	—	—	—	—	—	4·9	—
Sodium sulphate	—	—	—	—	0·6	9·2	10·8	11·4	31·6
Sodium chloride } Potassium chloride } ..	12·1	68·3	49·2	22·08	13·3	26·1	56·5	54·0	197·9
Silica	1·5	1·5	2·8	—	0·6	1·4	2·6	1·5	2·0
Undetermined	—	0·3	1·7	—	—	—	0·3	0·6	0·3
Total salts (grains per gallon)	20·2	110·4	105·8	48·16	26·8	55·4	96·6	88·6	280·1
Total salts (oz. per gallon)	0·05	0·25	0·24	0·11	0·06	0·13	0·22	0·20	0·64
Hardness (English degrees)—									
Total	7·0	39·2	49·8	25·61	13·0	19·0	27·2	18·1	48·7
Temporary ...	5·5	22·5	16·0	18·76	12·0	17·7	22·0	18·1	34·5
Permanent....	1·5	16·7	33·8	6·85	1·0	1·3	5·2	—	14·2
Due to calcium	2·4	15·3	19·3	19·31	6·2	11·2	10·5	6·2	13·5
Due to magnesium	4·6	23·9	30·5	6·30	6·8	7·8	16·7	11·9	35·2

Further references will be found on earlier pages in respect of these underground sources of water for South Australian town supplies; and the details regarding the underground water used in Adelaide, at times of drought when the surface reservoirs have been depleted, will be found in the chapter dealing with the Adelaide Plains Basin (See pp. 79-85).

It will be noted that the schedule given above contains one water, used in the Moorlands district, that is of very much poorer quality than any of the others. The main use of this supply is for the watering of stock, whereas all the other supplies have quite general applications.

(2) Waters Used by Stock.

Animals of different kinds show differences in their tolerance of saline matter dissolved in the water they drink. Fortunately for Australian economy the sheep is the most tolerant of high salinity. In any attempt made to fix the upper limit of salinity in the water used by stock consideration must be given to the nature of the herbage on which the animals feed, since those living on saltbush cannot tolerate so much saline matter in the water as those feeding on more succulent herbage. The season also must be taken into consideration, and the limits prescribed must relate to the summer when feed is dry. Horses that are being worked require better water than those which are at grass. E. S. Simpson, in his paper on "Problems of Water Supply in Western Australia," states that the following standards have been adopted in that State, the figures in each case being the maxima permissible:—

	Horses.	Cattle.	Sheep.
Total salts, grains per gallon	450	700	900
Magnesium, Mg. grains per gallon	18	28	36
Aluminium, Al grains per gallon	0.35	0.5	0.7
Iron, Fe grains per gallon	0.07	0.07	0.07
Nitric nitrogen grains per gallon	1.5	2.0	3.0

pH value in all cases should lie between 5.5 and 8.6.

The figures quoted for iron and aluminium are for these metals in solution, not in suspension.

Much more saline water is regarded as useful in New South Wales, according to the figures provided to H. H. Dare for his work on "Water Conservation in Australia" by the Department of Agriculture, as a result of a questionnaire answered by a large number of stockowners. It seems highly probable that these upper limits refer to areas in which green-feed is available. The statement is as follows:—

"Horses will thrive on water containing 400 grains of salt, NaCl, per gallon, and 550 grains of total solids per gallon, and, if they are not working can be kept alive on water with 950 grains of total solids per gallon. They have lived on water with 1,022 grains of total solids per gallon for three months without suffering ill effects.

"Cattle will thrive on water with 800 grains of NaCl or 1,000 grains of total solids per gallon, but are injuriously affected when the salinity rises to 970 grains of NaCl or 1,300 grains of total solids per gallon.

"Sheep will thrive on water with 800 grains of NaCl, and will do well even up to 1,197 grains of NaCl, and 1,350 grains of total solids per gallon. They are injuriously affected when the concentration reaches 1,277 grains of NaCl, and 1,868 grains of total solids per gallon."

The upper limits quoted in this statement are considered to be higher than South Australian pastoralists would accept.

In South Australia a valuable contribution to the study of this subject was made by R. Lockhart Jack, who had a wide experience of the many waters used by pastoralists and farmers in all parts of the State.

Jack's conclusions as to the limits of usefulness, in terms of the total solids dissolved in the water, are summed up in the following table:—

Horses, at grass, can use water containing up to 546.875 grains, or 1¼oz., per gallon.

Horses, in work, can use water containing up to 437.5 grains, or 1oz. per gallon.

Cattle can use water containing up to 656.25 grains, or 1½oz. per gallon.

Sheep, on saltbush feed, can use water containing up to 875 grains, or 2oz. per gallon.

Sheep, on grass feed, can use water containing up to 1093.75 grains, or 2½oz. per gallon.

Since, however, the usefulness of the water does not depend wholly upon the total salinity, but is affected materially by the nature and the proportions of the substances in solution, Jack put forward a tentative scheme for recasting the analytical table of the assumed salts present in the water with the help of factors by which each of the arbitrary combinations is multiplied, values being assigned to each of the salts to express their toxicity in terms of sodium chloride, NaCl. The factors proposed, in consonance with the results of actual observations on the effect of different waters on stock, are as follow:—

Calcium carbonate, $CaCO_3$	x	0	=	equivalent to NaCl
Calcium sulphate, $CaSO_4$	x	0.8	=	" " "
Calcium chloride, $CaCl_2$	x	2.0	=	" " "
Magnesium carbonate, $MgCO_3$	x	0.2	=	" " "
Magnesium sulphate, $MgSO_4$	x	2.0	=	" " "
Magnesium chloride, $MgCl_2$	x	2.0	=	" " "
Sodium carbonate, Na_2CO_3	x	1.0	=	" " "
Sodium sulphate, Na_2SO_4	x	1.8	=	" " "
Sodium chloride, NaCl	x	1.0	=	" " "
Silica, SiO_2	x	0	=	" " "

After multiplying the grains per gallon for each of the assumed salts present in the water by the factors given above, and adding up the products a new figure for total salinity, in terms of NaCl, is obtained, and this total is regarded as providing a better measure of the salinity than the unmodified result obtained directly from the analysis. In a paper on this matter, printed in the transactions of the Australasian Association for the Advancement of Science, Perth, 1926, Jack gave four examples of South Australian waters having almost identical amounts of total solids in solution, but with different salinities, in terms of NaCl, when the factors mentioned are applied. The waters and their analyses are as follows:—

1. Gilgurabbie bore, on the southern margin of the Nullarbor Plain, which has carried sheep for five months in summer on feed consisting of grass, herbage, and a little saltbush.
2. Arcoona No. 4 bore, west of Lake Torrens, which is carrying sheep on feed consisting of saltbush and herbage.
3. Reichstein's bore, south-east of Port Augusta, which is of doubtful utility.
4. Pine Valley well, north of the Murray River, which has carried sheep through a drought, the feed being saltbush, bluebush, and other bush.

TABLE III.

	Gilburabbie Bore.	Arcoona No. 4 Bore.	Reichstein's Bore.	Pine Valley Well.
Ions and radicles (grains per gallon)—				
Chlorine, Cl	453·07	438·78	370·37	394·98
Sulphuric acid, SO_4..............	106·79	117·70	204·43	170·18
Carbonic acid, CO_3	7·20	8·40	17·10	5·85
Sodium and potassium, Na and K	254·51	262·48	222·56	237·73
Calcium, Ca	34·45	40·09	29·30	34·72
Magnesium, Mg	31·06	20·10	49·55	34·50
Silica, SiO_2	0·90	1·30	1·50	—
Total salinity (grains per gallon)	887·98	888·85	895·17	877·96
Total salinity (ounces per gallon)....	2·03	2·03	2·05	2·01
Assumed composition of salts (grains per gallon)—				
Calcium carbonate, $CaCO_3$	12·00	14·00	28·50	9·75
Calcium sulphate, $CaSO_4$	100·81	117·26	60·86	104·78
Magnesium sulphate, $MgSO_4$....	44·54	43·68	201·84	120·57
Magnesium chloride, $MgCl_2$	87·67	44·94	36·34	39·75
Sodium chloride, NaCl	642·06	667·67	566·11	603·11
Silica, SiO_2	0·90	1·30	1·50	—
Total salinity, modified by factors, expressed as equivalent to NaCl, ounces per gallon	2·26	2·14	2·50	2·30

In putting forward this method, Jack drew attention to the fact that it would be preferable to work on the ionic results of analysis if agreement could be reached as to the toxic effect of each of the ions and radicles. In a subsequent discussion, arranged by the Chemical Society of Western Australia, Professor Wilsmore stated that, although data now available are meagre, evidence seemed to indicate that sodium was the least toxic positive ion and chlorine the least toxic negative ion; and that, of the common ions likely to be present in stock waters, the ions of magnesium and sulphuric acid were the most toxic, especially when present together, and that the nitrate ion was to be regarded as injurious. Professor Wilsmore considered also that there was evidence to show that salinity due only to sodium and chlorine ions could be tolerated in greater concentration than if these were accompanied by other ions.

It certainly appears most desirable that controlled experimental work be carried out in Australia with the object of finding out what are the limits of tolerance, in regard to each separate salt and combinations of salts, for different animals, due consideration being given to the nature of the feed on which they subsist during the test. An investigation of this character would need to be placed in the hands of those who are trained in such work, in order to keep an exact check on all the factors that might affect the experiments. No authoritative results are likely to be obtained in any other way.

The results of a systematic examination carried out in Oklahoma, U.S.A., by V. G. Heller have been set out by W. J. Spafford, Director of Agriculture, in *Bulletin* 369 of the South Australian Department of Agriculture. The conclusions reached by this American investigator, after six years of work, include the following:—

(*a*) All animals are injuriously affected when salinity is excessive, and the quantity of total soluble salts is the controlling factor. The limit of tolerance depended on the kind of animal, its age, the season of the year, whether in milk production, etc.

(*b*) Sheep are more resistant than cattle, and cattle more than pigs. Sheep can exist on water with 1,750 grains of sodium chloride per gallon. Cattle, not in milk production, have existed on water with 1,400 grains of sodium chloride per gallon, but 1,050 grains per gallon should be regarded as the upper limit. For lactating animals the limit is lower. When pigs get accustomed to the saline water they are not injured by 700 grains of sodium chloride to the gallon. Young pigs died within 30 days on water with 1,050 grains of sodium chloride to the gallon. As regards poultry, laying hens can tolerate 1,050 grains of sodium chloride per gallon, although egg production ceases temporarily when they are first placed on such water; but, when the salinity rises to 1,400 grains per gallon, they cease to lay, lose weight, and some die.

In order to ascertain the actual experience of landholders in South Australia in regard to the use of saline water by stock, Spafford sent a questionnaire to those making use of waters known from analyses to contain over 200 grains of sodium chloride per gallon, and received 120 replies which disclosed rather contradictory opinions. Hence it is not regarded as possible to state, on the basis of experience, hard-and-fast rules for guidance. Nevertheless the following general conclusions were reached:—

1. If the total of soluble salts is less than 300 grains per gallon all farm livestock can use the water without suffering any harm.
2. An appreciable amount of magnesium sulphate, when other injurious salts are present also, is harmful.
3. Practical tests with livestock are required to ascertain the effect of waters containing over 300 grains per gallon of total soluble salts.
4. Most South Australian waters containing up to 500 grains per gallon of total soluble salts can be used for pigs, dairy cows, and working horses.
5. Beef cattle and sheep, being more tolerant, usually do well on waters containing up to 700 grains per gallon of total soluble salts; and so also do poultry when they are accustomed to the water.
6. Beef cattle and sheep, in some cases, have used waters containing over 1,000 grains per gallon of total soluble salts; but it is necessary to ascertain by actual trial whether such waters are suitable.
7. Animals feeding on grass can withstand more saline water than those living on bush, and so too do those whose feed is luxuriant and nutritious rather than dry, poor, and scanty.

The present writer has seen cases in which the relation of the sulphate radicle, SO_4, to the basic ions has been such that, according to the arbitrary method of grouping together the ions and radicles, the assumed composition has shown a large amount of calcium sulphate, $CaSO_4$, in the water, and it has been noted that stock using the water have not been satisfied on drinking it but continue to sip at it, if allowed, throughout the day. In such cases, and indeed in all cases where water of high salinity is used for lack of better, stock should be allowed to drink only in the morning and evening at troughs that are surrounded by fencing. Otherwise the stock tend to remain near the water, the feed near the water gets eaten out, and the animals lose condition.

When stock are using water such that the analytical table showing the assumed composition of the salts indicates a high proportion of sulphates of magnesium and sodium they suffer scouring. If the proportions of magnesium and sodium sulphates are not too high, their initial effect wears off as the animals acquire tolerance, and it may be possible to use such water continuously.

It has been claimed by some stock owners that travelling stock may be permitted to drink poor water on a stock route, if they have access to better water before and after the journey.

(3) Waters Used for Irrigation.

It has to be remembered that plants exhibit marked differences in their tolerance of salts in solution. At the one extreme there are such plants as mangroves and samphire which are, of course, not cultivated. Yet asparagus requires abundant salt (NaCl) for its successful cultivation. Of the fodder plants lucerne is tolerant of much more saline matter than most trees, shrubs and edible vegetables. Among the common vegetables French beans are regarded as the least tolerant.

Again, the nature of the soil and the drainage are important, since sandy or well-drained soils permit the use of more saline waters than are suitable for heavy clayey soils. The incidence of rainfall, also is important, especially where the soil is heavy, since the failure of the normal rains means that the saline matter, which accumulates at the surface on the evaporation of the water, does not get washed away.

Provided always that the water does not carry exceptionally high proportions of calcium and magnesium chlorides, sulphates of sodium and magnesium and/or sodium carbonate, the following table shows the limiting figures of total salinity, under ordinary conditions of soil character and drainage:—

Plants.	Limits of toleration in grains of total solids per gallon.
French beans, lettuce, cucumbers, and citrus trees	65-70
Tomatoes, under glass	70
Flowers and shrubs	75
Fruit trees, generally	75-80
Most vegetables	80
Root growths, including potatoes	90
Almond trees	100
Lucerne	210

A much more detailed scheme was put forward by Dr. E. S. Simpson at the Perth meeting of the Australasian Association for the Advancement of Science in 1926, and has the undoubted merit of taking into consideration the chemical character of the water as well as the nature of the soil and the rainfall. Simpson made use of analytical results expressed in terms of the assumed composition of the salts, after these had been calculated to a basis of parts per million. In the following table Simpson's figures have been converted to enable the method to be used directly from analyses in which the results are stated in grains per imperial gallon. This method permits the rejection or omission of all figures relating to $CaCO_3$, $MgCO_3$, $CaSO_4$, KCl and $NaNO_3$ or KNO_3, as the proportions of these salts are not regarded as injurious. From the remaining salts a sum, S, is obtained by the use of the following formula:—

Sum, $S = NaCl + Na_2SO_4 + 2\ CaCl_2 + 2\ MgCl_2 + 2\ MgSO_4 + 3\ Na_2CO_3$.

When S is less than 35 the water is considered excellent on any type of soil with high or low rainfall.

When S is between 35 and 70 the water is good for irrigation on loose soil or well-drained heavy soil with a rainfall of not less than 15in. annually.

When S is between 70 and 105 the water can be used only on well-drained light to medium soils with high rainfall.

When S is over 105 the water is probably valueless for irrigation.

In addition Simpson would condemn waters that are strongly acid or strongly alkaline, the limits of hydrogen ion concentration being between 6.2 and 8.2, when measured 24 hours after the water has reached the surface from a borehole. The figures stated are subject to slight modification in accordance with the tolerance of different plants.

So far as the present writer is aware, this method of assessing the suitability of underground waters for irrigation has not been tested in South Australia, but some such method even if the limits are not so severely drawn, appears to be desirable for determining the probable effect of applying waters of which the composition has been determined by analysis. The nearest approach to this scheme is that of the late A. J. Perkins, but the individual salts are not weighted by him, as was done by Simpson.

This method of involving the separation of the component dissolved salts into two groups—harmless and injurious—was devised by the late A. J. Perkins, formerly Director of Agriculture in South Australia, to determine the suitability of water for irrigation. Using analytical results showing the assumed combinations of the ions and radicles, Perkins classified the salts in the following categories:—

Harmless: Calcium carbonate, magnesium carbonate, calcium sulphate, sodium nitrate, iron oxide and alumina .

Injurious: Sodium chloride, magnesium chloride, calcium chloride, sodium sulphate, magnesium sulphate.

From a consideration of the actual results of the use of various waters, Perkins arrived at the following conclusions:—

1. Under Adelaide conditions, *i.e.*, with winter and spring rains aggregating 14in. to 15in., irrigation water containing up to 140 grains of injurious salts to the gallon may be used for fruit trees and vegetables, with the exception of citrus trees and French beans, providing that natural drainage conditions are satisfactory.
2. Under similar conditions, citrus trees and French beans may safely be grown with water carrying 75 to 80 grains of injurious salts to the gallon.
3. In the absence of data regarding irrigation waters containing over 140 grains of harmful salts to the gallon; it may be concluded that, judging from the experience of other countries, a total of even 200 grains to the gallon will not prove disastrous to plants other than citrus trees and French beans, providing that drainage conditions are perfect.
4. Given satisfactory drainage, saline irrigation water should be used freely rather than sparsely, since small quantities lead to rapid concentration of salts through surface evaporation.
5. Saline irrigation water can be used in summer with greater safety where there are heavy winter rains than in places where such rains are light.

It will be noted that Perkins placed much stress upon good drainage conditions as being essential if saline waters are used. The limits mentioned by him appear to be much higher than can be prescribed for average soil conditions, and very much too high where the soil is stiff.

The South Australian Director of Agriculture, W. J. Spafford, states that he finds it extremely difficult to place a value for irrigation purposes upon certain waters because the position is affected by so many factors such as soil drainage, the amount of organic matter in the soil, the quantities of injurious salts in the soil, general fertility, rainfall and climatic conditions. He regards it to be absolutely essential, in a climate such as that of South Australia, that good under-drainage must exist wherever irrigation is practised, and that the more saline the water the better must be the drainage. Spafford's conclusions, subject to the above-mentioned provisoes, for South Australian waters are as follow:—

(*a*) Waters containing not more than 100 grains per gallon of sodium chloride are suitable for growing most garden plants, except citrus trees and French beans, provided that the drainage is reasonably good.

(*b*) When the sodium chloride content exceeds 100 grains per gallon, or the total of all injurious salts (sodium chloride, magnesium chloride, calcium chloride, sodium carbonate, sodium sulphate, magnesium sulphate) exceeds 150 grains per gallon, the danger point has been reached. Few such waters are safe for irrigation and can be used in this way only on light-textured soils rich in organic matter and possessing particularly good under-drainage.

A further examination of the whole problem is to be undertaken by the Department of Agriculture, as soon as circumstances permit.

In any case water that approaches in composition the limit of toleration for the plants to be irrigated should be applied in flood waterings. Sprinklers, which cause enhanced evaporation and a consequent concentration of the salts in solution, should not be used in hot weather and unless there is an ample margin of safety. Even lucerne has been observed to wilt when watered in midsummer by sprinkers, although the water used was of reasonably good quality.

It has been found that poor water is inimical to the germination of seeds; and that seedlings are adversely affected, even though well-established plants, which have been given a start during the period of winter rains, are able to survive on summer floodings with poor water.

(4) Water Used for Industrial Purposes.

Although the detailed discussion of the industrial applications of underground water lies outside the scope of this bulletin, brief mention may be made of the effect of material dissolved in water upon industries in which considerable quantities of water are used. A more comprehensive treatment of the subject will be found in various textbooks dealing with the industrial chemistry of water, and in a recent Canadian publication on the "Industrial Waters of Canada," published by the Mines and Geology Branch of the Canadian Department of Mines and Resources.

The textile industry requires water low in alkaline earths and iron in order to avoid the precipitation of insoluble soaps which adhere to the fibre, and iron causes rust stains also or produces dark stains in the dyed material.

In dyeing, hard waters are undesirable, as some colours are difficult to dissolve or afford precipitates which give rise to uneven shades if lime is present. There are, however, some colours that are not affected by hard water.

In the retting of flax there is some advantage in the presence of calcium salts in moderate amounts, but iron is objectionable on account of the brown stain which it imparts to the flax.

In soap-making hard water is regarded unfavourably at all stages of the process, on account of the wastage of alkali. The chloride and sulphate of sodium and potassium are objectionable even if the water is soft.

The laundry industry requires soft water, since soap does not act as a detergent until the hardness has been entirely neutralized. Iron is a serious drawback on account of the stain it imparts to clothing. If hard water is used about 2oz. of soap are wasted for every 100 gallons of water used for each grain per gallon of calcium carbonate or its equivalent.

In the manufacture of ice high-grade water should be used, since salts of calcium and magnesium give rise to opacity. If iron and manganese are present a coloured core in the ice blocks will be formed.

In the brewing industry it is interesting to note that certain waters are specially suitable for the production of varieties of beer. Thus the wells of Burton-on-Trent acquired a reputation for the brewing of pale ale, while those of London and Dublin are excellent for the making of stout. The Burton water carries 70 grains of calcium sulphate to the gallon, and also 12 grains of sodium sulphate, 10 grains of sodium chloride and eight to 10 grains of calcium carbonate. The alkaline chlorides, up to 30 grains per gallon, are claimed to be beneficial in brewing.

The tanning industry requires water low in calcium, magnesium, and iron, since these metals are precipitated by tannin, with consequent loss of tannin in the leaching vats. The treatment of the leather requires water with little calcium carbonate, but sulphates of lime and magnesia are not regarded as harmful. Iron is objectionable at all stages.

In sugar refining waters high in calcium carbonate are objectionable, and so too are those with much sulphate of calcium and magnesium and alkali salts. Water-softening treatment does not produce any improvement, since the exchange of bases produces products that are equally bad for sugar extraction.

In wool-scouring the water used should be free from suspended matter and discolouring agents, and the hardness should not exceed 5 grains per gallon. In Geelong, where the hardness of the water is about 6.5 grains per gallon, most scouring plants are equipped with zeolite softeners, which reduce the hardness almost to zero. The softening process may give the scoured wool a dingy appearance which has to be corrected by special treatment.

In the mining industry large quantities of water are required for concentration by flotation and the recovery of gold by the cyanide process. In each case the water used must be alkaline, and this condition is assured by the use of lime in quantities sufficient to raise the pH value to 9 or 9.5.

In the canning industry hard water can be used without ill effects upon meat, and is stated to be advantageous in dealing with vegetables and fruit that tend to soften, but it is not suitable for use with peas. Calcium sulphate is said to toughen vegetables.

In bread-making any potable water may be used, and it is claimed that a moderate amount of hardness is desirable, especially if this quality is permanent—due to the presence of calcium sulphate. Carbonates interfere with fermentation; but sodium chloride, which is added to bread, is not harmful.

It is not proposed to deal in this bulletin with the methods in use for the purification, sterilization, and softening of water. Many processes are employed according to the character of the water treated and the uses to which it is to be put. These matters are dealt with exhaustively in the technical literature concerned with water treatment.

(5) Water Used for Engineering Purposes.

Although a certain amount of underground water is used for cooling purposes, as in wine-making, the preponderating demand from the engineering industry comes from the requirements of steam boiler plants.

Cooling water should have as low a temperature as possible, and if drawn from wells or boreholes the depth of which is not great, say, between 50 and 200ft., the temperature may be expected to be that of the mean annual surface temperature of the site of the well or borehole. If drawn from greater depths the temperature of the water will be higher than that figure. In another part of this bulletin it will be found that some of the water tapped in the Great Artesian Basin has a high temperature, and that yielded by the deepest boreholes is actually boiling; but this contained heat has no industrial application to-day.

The use of water in boiler plants to furnish power is so extensive that much study has been given to the eradication of troubles arising from the use of waters containing impurities. Although good water is in all cases desirable, it is not always available. The troubles experienced in steam boilers using water of poor quality are those caused by the formation of scale, priming and foaming, and corrosion.

Scale consists, as a rule, of calcium and magnesium carbonate or sulphate, and in some cases contains also silica and iron. If the proportion of sulphate in the water is low the scale is relatively soft and may be removed readily. Harder scale, more difficult to remove, results when the sulphates present in the water are relatively abundant.

Priming, involving the carry-over of the boiler water with any suspended or dissolved matter into other parts of the plant such as superheaters or turbines, and foaming (which is the generation of immense numbers of small bubbles from the boiling water) are attributable to the concentration of the dissolved salts together with any finely divided solid particles that may be present in the water. The foaming of boiler waters used in South Australia by the Railways in locomotive engines has been investigated by W. A. Hargreaves with results set out in *Bulletin* 5 of the Department of Chemistry.

Corrosion is not effected by water of good quality. The most active corroding agents are sulphates of iron and aluminium, calcium chloride and nitrate, and magnesium sulphate. Hard waters, from which scale is deposited, are less corrosive than soft waters, since the scale forms a protective coating on the metal. Soft waters are in many cases acid; and, if carbonic acid is present in the free state, and oxygen also is dissolved in the water, active corrosion is apt to occur. Preheating of boiler water containing oxygen and carbonic acid will remove the cause of trouble, if this method is practicable. Carbonic acid may be neutralized by lime or soda treatment.

(6) Underground Waters Used for Locomotive Boiler Feed.

Since reliable supplies of water are required as boiler feed for locomotives on the railway systems of South Australia, and provision has been necessary to prevent the cessation of traffic during times of drought or during periods of exceptionally heavy demands due to the war, several underground waters have been turned to account. In some cases these underground waters have been used only to supplement the supplies stored in surface reservoirs at watering stations, or to top up tenders on sections between watering stations where good boiler feed waters are available. In other cases the underground sources alone furnish the water required.

The information given in the accompanying tables has been supplied by R. H. Chapman, Chief Engineer of the South Australian Railways, and by P. J. Hannaberry, Chief Civil Engineer of the Commonwealth Railways. The analyses have been made by the staffs of the two Railways departments concerned. See Tables IV. and V.

Several other sources of supply have been used in the past by the S.A. Railways, but have since been abandoned so far as boiler feed is concerned. Some of them are used now only for domestic purposes, for watering stock, or for washing out boilers.

The table showing the sources of boiler feed water used on the North-South Commonwealth Railway gives the analyses of several waters drawn from the principal (Jurassic) aquifer of the Great Australian Basin, and provides evidence of the disabilities under which railway traffc is maintained across the driest part of the continent. When the composition of these waters is compared with those used for a similar purpose in better-favoured regions it is possible to appreciate the facts that standard specifications elsewhere are quite inapplicable in the heart of Australia, and that, despite the difficulties, the railway engineer is able to provide a service dependent upon steam locomotives.

XIV. THE UNRELIABILITY OF DIVINING OR DOWSING IN THE LOCATION OF WATER SUPPLIES.

There is undoubtedly a widespread belief in many countries that there are certain gifted individuals, commonly known as "diviners" or "dowsers," who are able to indicate without fail the places at which supplies of water are obtainable from underground sources. Some of these individuals act as unpaid advisers; others receive fees for their services. Some are content to be known as diviners or dowsers; but others adopt more impressive designations and prefer to be known as "radio locators" or "radio perceptors." In the following discussion they will be referred to as diviners or dowsers, since these names are most familiar to the general public and there appears to be no good reason for making any distinction between them so far as concerns their methods of procedure.

We may accept, it is presumed, that the references quoted by the diviners to individuals and public bodies who have consulted them and adopted their advice are on the whole correct, and many persons have been influenced by such references. Nevertheless it is proper to make careful inquiry as to whether the claims of the diviners are so soundly based that appeal should be made to them in all places.

Much of the literature on divining is based upon experience gathered in regions favoured with a higher rainfall than is received by many parts of South Australia, and where the distribution of abundant underground water is far wider than that in many of the drier portions of the Australian continent. In the examination, therefore, of the value of divining it is to be borne in mind that care must be exercised before accepting without question the experience relating to dissimilar areas and attempting to apply it to every part of this State. This bulletin has been prepared to explain the ways in which water is stored beneath the surface, and to show the wide differences between the occurrences in various regions as a result of the differences in rainfall, topography, and geological features. These controlling factors are all-important, as all must admit who give any consideration at all to the subject; yet many diviners who have a genuine belief in their powers do not take them into account. It is essential to inquire fully regarding the nature of the terrain and its geographical position when the attempt is made to assess the validity of the claims made by any diviner.

(a) THE ORIGIN AND HISTORY OF DIVINING.

The divining rod, used as it is to-day for locating underground water and mineral deposits, is an instrument of relatively recent development. One of the first published descriptions is that contained in Georgius Agricola's De Re Metallica, which appeared in 1556 and is now available in an English translation by H. C. and L. H. Hoover. Yet there can be little doubt but that the practice of divining for water and minerals with a rod was developed from the use of rods, wands or arrows for forecasting future events, or for determining courses of action and detecting criminals —a practice that dates from the most remote periods. R. W. Raymond, in a paper contained in the transactions of the American Institute of Mining Engineers, 1883, and in United States Geological Survey Mineral Resources, 1882, wrote as follows:—

> "The Scythians, Persians, and Medes used them. Herodotus says that the Scythians detected perjurers by means of rods. The word rhabdomancy, originated by the Greeks, shows that they practiced this art; and the magic power of Minerva, Circe, and Hermes or Mercury is familiar to classical students. The lituus of the Romans, with which the augurs divined, was apparently an arched rod. Cicero who had himself been an augur says, in his treatise on divination, that he does not see how two augurs, meeting in the street, could look each other in the face without laughing. At the end of the first book of this treatise he quotes a couplet from the old Latin poet Ennius, representing a person from whom a diviner had demanded a fee as replying to this demand 'I will pay you out of the treasures which you enable me to find.'
>
> "Marco Polo reports the use of rods or arrows for divination throughout the Orient, and a later traveller describes it among the Turks. Tacitus says that the ancient Germans used for this purpose branches of fruit trees. One of their tribes, the Frisians, employed rods in church to detect murderers. Finally, if we may trust Gonzalez de Mendoza, the Chinese, who seem to have had everything before anybody else, used pieces of wood for divination."

The divining rod was in common use in the Hartz Mountains in the time of Agricola, and there is an illustration in his book showing its use. Miners brought to Cornwall in the time of Queen Elizabeth are considered to have introduced the rod to England, whence it has spread far and wide. At first it was used largely for locating mines and buried treasure, but there is a reference as far back as 1568 to the use of a rod for locating a spring of water for Saint Teresa of Spain. Its use in England for revealing sources of underground water cannot be traced back beyond the end of the eighteenth century.

(b) THE LITERATURE ON DIVINING.

An immense amount of literature dealing with the divining rod has been published and a detailed bibliography of the subject, up to 1917, is contained in A. J. Ellis' "The Divining Rod, a history of water witching," which has been printed as *Water Supply Paper* 416 of the United States Geological Survey. Reference should be made to this paper by those who may desire to follow up the subject and study the various conclusions of different investigators. Ellis quotes at some length from the writings of Georgius Agricola and Rossiter W. Raymond, mentioned above. Other references, probably readily available, will be found in Sir Ray Lankester's "Diversions of a Naturalist," in Daniel W. Hering's "Foibles and Fallacies of Science," in A. S. E. Ackermann's "Popular Fallacies Explained and Corrected," in H. B. Woodward's "The Geology of Water Supply," in R. F. Legget's "Geology and Engineering," in F. Dixey's "Practical Handbook of Water Supply," in S. Baring Gould's "Curious Myths of the Middle Ages," in J. Jastrow's "Wish and Wisdom," and in J. Ennemoser's "History of Magic."

In his book entitled "Psychical Research," printed in the Home University Library in 1911, Sir William Barrett dealt with the divining- or dowsing-rod, and arrived at the conclusions that—

1. Those who possess the faculty of divining are rare and many pretenders exist, and the good dowser is specially endowed by nature; he does not acquire his skill by study and practice.
2. The involuntary motion of the forked twig which occurs with certain persons is due to a muscular spasm that may be excited in different ways.
3. The explanation of the success of good dowsers, after prolonged and crucial tests, is a matter for further physiological and psychological research, though provisionally we may entertain the working hypothesis of unconscious clairvoyance, an aspect of what has been called telaesthesia or perception at a distance.

To this latter conclusion Sir Ray Lankester objected on the grounds that it is an attempt to explain what is not understood by reference to something which is still less well understood. This criticism is certainly valid in the judgment of those who are sceptical of the objective reality of psychic phenomena.

In 1926 a book entitled "The Divining Rod" was published in England. The joint authors were Sir William Barrett and Theodore Besterman, but the former died before the publication of the book. It contains a detailed account of the history of divining and a description of the methods followed by some well known exponents of the art. In the discussion of the rationale of divining (or dowsing, as these authors prefer to call it), the conclusion is reached that:—

> "The phenomena of dowsing are due to the following causative chain of psychological happenings; a suggestion is received by the dowser's subconsciousness by means of a sensibility as yet unknown to us, and therefore admirably named by M. Richet cryptaesthesia."

It is claimed that:—

> "dowsing is a purely psychological problem, and that all its phenomena find their origin in the dowser's mind; that no physical theory can bear close consideration; and that the movements of the rod and the dowser have no more direct relation to the discovery of, say, water than as giving physical and visible expression to a mental and abstract cognition."

This book contains also a lengthy bibliography which is notable for its references to the writings of those who mention divining in papers dealing with folklore, psychical research and mythology. The detailed exposition in this book appears to the writer to be based on the assumption that the faculty of "cryptaesthesia" (which is evidently identical with the earlier "telaesthesia") is really possessed by some persons, and that it calls for no explanation. The critical reviewer of the claims of dowsers is far from satisfied that such an assumption is justifiable.

Several cases put forward by Barrett and Besterman in this book, as instances in which the diviner was phenomenally successful, have been discussed by J. W. Gregory in a paper read at the session of the British Waterworks Association, Public Works, Roads and Transport Congress, 1927, and published with the papers from the geological department of Glasgow University, Vol. XII. Prof. Gregory's conclusion was:—

> "the happy selection of the sites in these four cases was in accordance with common sense and did not require cryptaesthesia."

In 1930 a translation from the French was published under the title of "The Modern Dowser," the author being Le Vicomte Henry de France to serve as a guide to the use of the divining rod and pendulum. This author is a firm believer in the capacity of certain persons, with the help of a hazel rod, to indicate with certainty where subterranean water can be found, and in the value of the rod for diagnosing the diseases of plants, animals, and human beings. This book contains directions on the use of the pendulum and the divining rod, the movements of which, according to the author, are to be explained by the well-known properties of electricity and electro-magnetic waves. Yet this claimed relationship is not explained in a way that can be accepted as affording proof of the assertion.

In 1931 there was printed in England, under the title of "Water Diviners and their Methods," a translation of the fourth edition of the work of Henri Mager, who is stated by the translator to be one of the foremost exponents of the art of location. This book is of interest for more than one reason. It contains an account of the location of springs of water by "intuitive perception" on a property by working over a plan of the locality with a pendulum and without actually visiting the place. It carries accounts of tests of French diviners who use different methods, and contains a statement that water vibrates, as also do colours. It is claimed that when water is sought a violet detector should be used to eliminate the vibrations due to possible buried metals, pipes, bedding planes in rocks, fissures in the subsoil, and manifestations of undrinkable waters. H. Mager gives a great deal of information about the use of the pendulum, which he declares to be an amiable instrument, accommodating itself to man's wants and not refusing to follow the thoughts of the operator. He states that the divining rod does not exhibit this complaisance.

In 1939 a book entitled "The Physics of the Divining Rod," by J. C. Maby and T. C. Franklin, was published in England to prove that the water diviner's technique rests on a foundation of genuine physical facts, and that dowsing reactions are understandable in terms of normal physiological processes resulting from physical stimuli, as well as to provide the diviner with practical information for the improvement of his art and to bring together curious phenomena more or less related to the exploits of dowsers. The authors claim to show that the causes of the ordinary dowsing reflexes and rod reactions are to be found in certain penetrating electrically excitory rays. Unfortunately their arguments are based on such assumptions as that dowsers react reflexly and involuntarily to a something that has every appearance, in most instances, of a physiological stimulus of external origin; that such reactions are truth-telling in the case of skilled dowsers and are associated with certain physical objectives such as underground water, certain minerals, ground cavities, and metallic bodies; that electrical conductors are more active in the dowsing sense than non-conductors and that the greater the mass, other things being equal, the stronger the physiological reaction; that the reaction is sometimes accompanied by other physiological sensations indicative of a possible electrical action on the nerve, muscles, and perhaps other body tissues; and that the dowser's health and fatigue, *inter alia,* are evident factors of importance. Assumptions such as these are not admissible in a treatise purporting to show the connection between the phenomena of dowsing and those which are observable by the physicist who does not take for granted that the diviner is responding to radiation of some kind. Much more convincing would have been a series of plans, drawn accurately in detail and thus capable of being checked by unbiassed investigators, to show the relation between the zones of reaction indicated in specified areas covered by dowsers and any that can be recorded over the same areas by modern geophysical methods. A treatment of the matter in this way would furnish data that could be examined independently at any time and supply the investigator with information that cannot be afforded by unco-ordinated generalities. And there would still remain the testing of the area, as explained in a later part of this chapter, to ascertain whether any phenomena observed can be accounted for by facts of occurrence.

A much less pretentious book, under the title of "Radial Detection," by A. A. Cook, was published in Australia in 1941 to set out the procedure recommended for use by a person using a detector (divining rod). The author of the book considers that the movement of the detector is actuated by the passage of a radiation or wave along the superficial nerves of the body, which should not carry any metal or colours that will attract any radiation other than the one required. The detector if properly manipulated is regarded as being employable, not only for locating supplies of water and oil, but also for selecting a suitable diet and for indicating the correct sires in arranging the mating of stud cattle.

A book, with the title of "Springs of Water and how to discover them by the Divining Rod," by B. Tompkins, was printed in a third edition in England in 1925, and is notable chiefly for the long list of patrons for whom the author claims to have discovered supplies of water, among them being English estate agents, country and town councils, architects and surveyors, engineers, manufacturers, companies, and university colleges. Mr. Tompkins holds the view that "there is an almost infallible method possessed by a specially gifted few of finding water if and where it is to be found and tracing the stream to its spring-head," and that the action of the divining rod lies in the electro-corpuscle theory which is: "the rod, through its porous nature, becomes charged with small molecules or particles of the matter operated upon, and an immediate affinity ensues between them and the person holding the rod, who is highly charged with electricity." It has apparently not occurred to the propounder of these views that if sound they should be capable of proof by the use of apparatus that is not influenced by a personal factor, rather than revealed by the intervention of an individual claiming endowment with a special gift.

In 1941 the British Society of Dowsers published a book entitled "Dowsing," by W. H. Trinder, who holds the view that "all matter gives off a ray; which, in certain people who are sensitive to it, causes a change of tone in certain muscles of the forearm. This in turn causes a reflex action of the muscles which moves the rod. The reflex action is not felt in any way by the dowser; the movement of the rod is without his volition." This exposition includes descriptions of various instruments and the author's methods of using them, as well as an elaboration of H. Mager's views regarding the vibrations of colours. It contains also a description of dowsing over maps or photographs in lieu of going over the ground itself; of the manner of determining the affinities between soils and seeds; of the use of the pendulum in medical and dental diagnosis; and of the use of the pendulum in archaeological investigations. The treatment of the subjects discussed in this work is quite unconvincing, and it is noticeable that, in dealing with underground water, the usual reference is made to "streams of water" in which so many dowsers believe. No proof is offered of the real existence of the assumed "rays" or "vibrations" to which repeated references are made, and the exposition is unacceptable to any other than one who has blind faith in divining.

Literature of another type, dealing for the most part with much more limited experience of the behaviour of the rod, is to be found in the many accounts of divining that have appeared in the daily, weekly, or monthly newspapers and journals. Few indeed of these give indications of being based on evidence derived from more than a small number of cases and they are almost invariably lacking in an exposition of the geological conditions existing at the places to which reference is made.

There has been little systematic treatment of divining in Australian literature so far as the writer is aware. However, in his presidential address to the Australasian Institute of Mining and Metallurgy in 1928 A. S. Kenyon dealt at some length with the use of the divining rod to locate underground water supplies. He drew attention to a method used in northern Italy for determining the places at which to sink a well by observing the spots at which there is excessive condensation at night, as revealed by crude balances fitted with earthenware pans or by balanced pinepoles. This method is, of course, merely a rather crude way of observing humidity and is not, as Kenyon pointed out, a system of divining such as is here discussed.

In 1920 Griffith Taylor read a short paper entitled "A Geologist's Note on Water Divining" before the Royal Society of Victoria, which is printed in the society's proceedings, Vol. XXXIII., 1921, and deals with two cases in the vicinity of Canberra. The diviner was successful in one case and failed in the other. In the successful case the diviner determined the course of an underground stream only 100 yards wide in a broad valley in which water is probably obtainable at any point when the water table is reached in a well.

In 1924 the *New Zealand Journal of Science and Technology* printed in November an article by M. Ongley on "The Divining Rod," in which the author deals with the history of the subject, and refers to the activities of diviners in New Zealand, regarding which it was found hard to obtain full records. It was possible to obtain authentic accounts of 14 failures and five successes. Four of the successful wells are on alluvial plains where, presumably, the distribution of water is extremely wide and failures would be almost impossible.

Reference is made, in another part of this chapter, to the records of the Water Conservation and Irrigation Commission of New South Wales, which contain factual data of great importance, and supply statistics regarding the proportion of failures to successes that many inquirers have hitherto sought in vain.

(c) THE PRACTICE OF DIVINING AND THE INSTRUMENTS USED.

Although some diviners or dowsers profess to be able to detect the existence of underground water by the bodily sensations which they experience and without the assistance of any instrument, the great majority employs some form of apparatus which is commonly quite simple in character. More complicated varieties have been introduced by a few individuals, but the method of using them does not differ materially from that used with the simpler forms.

(1) *The forked rod* is much the most common, the two arms of the fork being usually from 10in. to 18in. in length, and the butt being 2in. to 6in. long. The material of which the ordinary rod is made is usually wood, cut freshly from a living tree so that it may be pliable and strong. Euro-

pean dowsers have expressed a strong preference for those cut from the willow, the mistletoe, the hazel, and in some cases from fruit trees. In Australia eucalypts, acacias, and other trees have been used. Other exponents on divining have employed forked rods made of metal or of whalebone. One of these that the writer has seen in operation had each of the arms made of three strands of piano wire. The six wires were joined in a metal socket and the other ends were grouped in sets of three with suitable grips for the hands. The instrument so made was strong and the arms were so flexible that they yielded readily to the slightest pressure.

It is of interest to note that the wooden rods made in several European countries, in order that they might be really effective, had to be gathered at the midsummer solstice which is the only time of the year at which plants were thought to be endowed with magical properties. Sir J. G. Frazer has recorded several instances in "The Golden Bough," Vol. XI., pp. 67-69, of these precautions and has drawn attention to the religious ceremonies performed over the rods selected in some parts of central Europe.

It is usual to hold the forked rod in such a way that the plane containing the two arms is horizontal at the start of a traverse and it is assumed that the presence of water (or some mineral) is detected by the downward (or more rarely upward) movement of the forward-pointing butt as the operator reaches the spot above the substance sought.

Some practitioners believe that the rod will move only if they hold in their hands or in their mouth some of the object of the search. The writer has seen a diviner searching for oil pour kerosene on his hands lest the rod be affected by water and lose its value as an indicator of oil, and he has been asked to advise whether the wearing of a gold watch chain would interfere with the action of the rod which was being used in searching for gold.

A quite elaborate instrument that has unique features has been used near Adelaide. It consists of two flexible metal tubes made of spirally wound wire joined in an ivory cap fitted with a hollow space to carry a small phial of the substance sought (water or oil). The end of one tube was held in the teeth and the end of the other in one hand. This instrument was held differently from the ordinary forked rod in that the plane containing the two tubes was held vertically when the operator started his traverse, and it was assumed that the substance sought caused the ivory cap with its contained phial to swing to one side when the operator reached a spot over the place of occurrence.

(2) *The swivelling rod,* a wire with a right angled bend, is preferred by some diviners. The wire is bent so that one arm is much longer than the other, commonly in the proportion of about two to one. The shorter arm is held more or less vertically in the hand or is placed in a tube which is held vertically, the longer arm projecting forward in the direction of the traverse. In the use of this type the swinging of the end of the longer arm to the right or left is supposed by the operator to take place only when he crosses an underground "stream of water" during his traverse of the ground under examination.

(3) *The pendulum* in some countries, and especially in France, has displaced the forked rod in the hands of many dowsers. It is commonly a wooden ball, weighing from 1oz. to 3oz. and suspended by a hempen cord. Some operators use a watch suspended by its chain. When such a pendulum is suspended over water during an exploratory traverse it is claimed by some that a circular motion is induced, the movement being

counter-clockwise. This instrument has not been used in South Australia, so far as the writer is aware, in the search for water, but it has been employed at Parafield without success for predicting the sex of chickens when suspended over eggs.

It is a common practice of the diviner, who has been brought to a property to select a site for a well or borehole, to ask the owner of the land where he desires that water be found. In many cases the landholder indicates the most elevated part of his property, with the object of making use of the natural slopes of the land to distribute by gravity the water which he hopes to get. The diviner has indicated high sites, in many cases, as a response to this desire, and has been responsible for waste of money in some places where the most favourable sites are located in the valleys.

In the estimation of depth very many diviners feel grave difficulty, however confident they may be about the presence of water below the points which they select. Several rules have been formulated, but there have been many disappointments. One such rule gives the depth to water in feet as one-half the width of the stream in yards, *i.e.*, the water is 50ft. below the surface if the stream is 100yds. wide. Such a rule would be absurdly false in an alluvial plain, where the water-bearing stratum may be very broad.

An examination of the literature mentioned above shows that there is no consensus of opinion as to how a diviner can answer the natural inquiry of his patron as to how deep a well or borehole should be.

One method that has been used in South Australia is to rely upon the angle of dip of the rod when a traverse is made across the path of the supposed narrow "stream of underground water," the assumption being that the rod points vertically downwards when it is being held directly over the buried watercourse, and at less steeply inclined angles as the operator moves away from the vertical line drawn from the watercourse to the surface.

Another method, used in this State and one which is more difficult to rationalize, is employed by the diviner who first makes a series of traverses until he can mark out the course of the "underground stream." Then his assistant, holding a bucket filled with water which is kept swirling round with a stick, walks away from the line of the stream course at right angles to it. The diviner meanwhile stands with his rod on the stream course; and the rod, which is at first attracted towards the swirling water in the bucket, gradually turns back towards the course of the stream. At the moment when it regains its position in the direction of the buried stream the assistant carrying the bucket is told to stop. The distance between the assistant's position and the stream course is taken to be the depth to water.

(d) WHY THE ROD (OR PENDULUM) MOVES.

Taking first the case of the forked rod, the explanation of its movement in the hands of the diviner is quite a simple one. The grip of the dowser may vary somewhat according to individual fancy, but the rod is usually maintained horizontally in front of the operator, at the moment of starting a traverse, in a state of balanced or unstable equilibrium. Any change in the tenseness of the grip or in the relative position of the hands affects this balance and the plane containing the two arms of the rod becomes tilted from the horizontal position in which it was held when the traverse was begun. The most common way for the balance to be disturbed is due to an alteration in the spacing of the hands, as was observed by J. Ennemoser when carrying out a series of tests of diviners, recorded in his

''History of Magic,'' English translation, Vol. II. p. 463. This investigator found that in his experience the hands of those operators who are walking forwards are unconsciously brought together in the majority of cases, while those induced to walk backwards generally spread their hands apart. When the hands are brought closer together and the usual grip is maintained the butt of the rod falls, but it rises when the hands are borne apart. If the spacing of the hands is kept constant by any means, the rod neither rises nor falls. Any subconscious influence, such as the belief in the presence of water at a certain spot, may cause an involuntary change in the grip upon the rod or in the spacing of the hands; and the mere uneven nature of the ground traversed may have this result, with the corresponding reaction.

It is an easy matter to learn how to manipulate the rod at will, and thus to imitate the result obtained quite unconsciously by many diviners who are perfectly honest and who believe that this movement is due to their special endowment. The spectator is convinced that the rod ''works with'' the diviner, whereas in reality the diviner works with the rod, and in many cases quite innocently.

When the swivelling rod—the wire with a right angle bend—is used the grip is not significant if only the shorter arm is kept in a vertical position, but a small deviation from the vertical in the attitude of the shorter arm necessitates a marked lateral movement of the end of the longer arm and this movement continues until the two arms are contained in a vertical plane. The adjustment of position is entirely gravitative. It is, of course, extremely difficult to maintain an exactly vertical position for the shorter arm while making a traverse, and if there is only a small inclination of the short arm downwards towards the right or left of the line of traverse the longer arm will swing to the left or right accordingly. The only movement out of the vertical on the part of the shorter arm that does not cause the longer arm to swing laterally is an inclination downwards and backwards in the direction of the line of traverse. Those who find it difficult to follow the geometry of these movements can quickly find out how the force of gravity affects the longer arm by consciously tilting the shorter arm.

In the case of the pendulum it will be found, on experiment, how hard it is for the bob to be kept hanging in one position during a traverse, without acquiring some oscillatory movement. The movement of the swinging pendulum may be a simple to-and-fro motion at the outset, but usually becomes an elliptical movement quite soon as a result of the operation of some lateral component imparted from the source of suspension. Movements that can be observed call for no complex explanation, nor for any origin outside the place of support.

The reason for the movement of any one of the instruments used is so simple and obvious that it is hard to understand why any other explanation should be sought or accepted.

(e) THE CLAIMS MADE FOR DIVINING.

Those who will turn to the literature of divining mentioned in an earlier part of this chapter, will discover that an extraordinary number of claims has been made at different times and in different places regarding the useful applications of the art. In *Water Supply Paper* 416, of the United States Geological Survey, A. J. Ellis lists the following:—

1. To locate ore deposits.
2. To discover buried or hidden treasure.
3. To find lost landmarks and re-establish property boundaries.
4. To detect criminals.

5. To analyse personal character.
6. To cure diseases.
7. To trace lost or strayed domestic animals.
8. To insure against ill fortune when preserved as a fetish.
9. To locate well sites.
10. To trace the courses of underground streams.
11. To determine the amount of water available by drilling at a given spot.
12. To determine the depth at which water or ores occur.
13. To determine the direction of the cardinal points.
14. To determine the heights of trees.
15. To analyse ores and waters.

Yet even this long list is not exhaustive, since the literature of the subject shows that believers in the power of the rod (or pendulum) consider that it can be used also:—

16. To reveal letters hidden in sealed envelopes.
17. To answer questions when used as a planchette.
18. To determine whether medicines or foods are suitable.
19. To control the mating of stud stock.
20. To determine the vitality, fecundity, and vigour of poultry.
21. To determine the sex of unhatched chickens in eggs.
22. To select the right plants to grow in different soils.
23. To guide archaeological excavations.

So long and varied is this list of applications that suspicion should surely be aroused. It is probably true with regard to every panacea that the wider the range claimed for it the smaller is its value for any particular objective.

Moreover, very few of those who have faith in divining for one specific purpose, such as the location of underground water supplies, can be aware that divining has been practised with equal confidence to guide human action in respect of so many other matters of entirely different kinds.

It is true that not all of these applications have survived to the present day, and that the abuse of divining for tracking criminals and heretics in the 17th century led to a decree of the Inquisition in 1701, forbidding its use in criminal prosecutions. Yet some of the other applications, however unreasonable they may appear to the critical mind, are quite modern.

(f) THE WATER-FINDING MACHINES.

Because of the manner of using certain patented instruments, for the location of supplies of water and oil, these devices should be considered together with the divining rod and pendulum. For they are set up arbitrarily without reference to the geological or topographical features of the sites, and it is claimed that the information desired is given by the instruments alone.

Two such instruments—the Mansfield and the Schmid—have been in use in South Australia, and are similar in external appearance, consisting of a closed cabinet which rests on a small table supported on a tripod. There is a magnetic needle on the top of the cabinet which it is stated remains stationary in the direction of the magnetic meridian where there is no disturbance caused by subterranean springs, but which oscillates when the apparatus is over subterranean flowing water. Such are the claims made by the Patent Automatic Water Finder Co. Ltd., who manufacture the machine under the Schmid patent. Ellis, in the American report abovementioned, states that the letters patent show this device to consist of a hollow-glass cylinder having an axis around which is spirally wound a soft-iron wire in layers that are separated from one another by paraffined paper, and at intervals by layers of tin foil. The outside layer of the spool is covered with paper. The wire of this spool forms an open circuit. The end of the spool is covered with a glass dial plate having at its centre a pivot on which a pointer or needle oscillates.

Ellis, in the same report, states that the Mansfield instrument was denied a patent in the United States on the ground that it was anticipated by that of Schmid, but that the advertising matter published by the makers claim that the instrument works by indicating the presence of currents which flow between earth and atmosphere, and which seeking the path of greatest conductivity are always strongest in the vicinity of subterranean water courses, the waters of which are charged with electricity to a certain degree. The instrument is said to indicate water courses flowing underground in a natural state and not water pipes or sources that have sprung up to daylight. In South Australia it was claimed also that the machine would give indications of the presence of fresh water only, the needle not being affected by salt water.

It is noteworthy that those who have made use of these machines in South Australia have made two assumptions; firstly, that underground water is restricted to very narrow channels, and secondly, that some electro-magnetic influence exerted by these buried streams operates only in a vertical direction.

The writer witnessed an exhibition of the way in which the Schmid instrument operates at two sites close to the main entrance of Kensington Gardens, Adelaide.

At one of these sites the needle remained stationary, and yet at a spot only a few feet distant it oscillated appreciably. Yet no material horizontal variation of the strata could be expected to occur within such a short distance, although the behaviour of the instrument was interpreted to indicate that the influence of the supposed "underground stream" diminished to zero within a few feet of the emergence of a vertical line drawn from the assumed "stream of water" to the surface of the ground. No drilling followed upon this exhibition of the way in which the machine worked, so that it is impossible to state whether the indications at these two spots were correct. The results obtained in two borings made on behalf of the South Australian Government at sites selected with the Mansfield instrument are mentioned in another part of this chapter (see pp. 141 and 143).

So far as concerns the principles underlying the operation of these machines, Ellis has pointed out that "The practical use of such instruments seems to be incompatible with the known instability of the magnetic and electric state of the earth and the atmosphere in which disturbances of greater or less degree are constantly taking place. Investigations have shown that magnetic disturbance is nearly continuous; that an entirely undisturbed day is abnormal. Some magnetic disturbances are local, others affect the whole earth simultaneously . . . . No confidence can reasonably be placed in any claim that the oscillations of a magnetic needle indicate the occurrence of available groundwater, much less the depth at which water can be reached or the quantity that can be obtained; and it confirms the opinion that, in the present state of knowledge, any such claim is purely speculative."

(g) THE TESTING OF THE CLAIMS OF THE DIVINER.

There are very many cases in which the success of the diviner has been claimed, but in which there has been no adequate testing of the whole area examined to find out whether there has been a real success in an area where underground water is sparsely distributed rather than the unavoidable result obtainable by any method whatever of locating a site for a well or borehole in an area within which water is to be found everywhere. When a successful result is attained at a given spot it is seldom that other localities near by are tested, since no necessity exists. Yet it is commonly implied by the diviner, and in many cases actually stated by him, that the spot "indicated" by the rod is the only one at which developmental work can prove successful. Clearly such a claim can be tested conclusively only by making actual trials over the whole area, at the spots where no "indications" are given as well as at those which are "indicated" as favourable. The writer has been informed on many occasions that water has been "found" at certain spots by divining methods, but has discovered on inquiry about particulars that no trial whatever has been made by sinking or boring. The "finding" in these cases amounted merely to the selection of sites, and yet there were credulous folk who were so satisfied with the advice of the diviner that they regarded the supply as already proven and referred to it as such. The diviner himself often declares that he has "found" water at certain places, when he has only selected sites.

Again, individual examples of success can seldom be accepted as evidence of the efficacy of the rod. The failures are easily forgotten and overlooked, and complete records of all tested locations must be preserved faithfully in order that a sound judgment on the reliability of the rod may be formed. Unfortunately this recording is seldom done and the prospective patron of the diviner is commonly referred to former patrons on whose properties wells or boreholes have been put down with successful results at sites selected by the diviner.

Many years ago the claims of a diviner who desired employment by the Government of South Australia were subjected to a test near Adelaide under the supervision of Mr. T. Parker. The area selected for the test was a portion of the Adelaide plains lying to the west of the city. A committee was appointed to watch the test. The diviner made a traverse which was marked out on the ground and special marks were placed in position where the rod dipped. These spots were claimed by the diviner to be those at which water would be found. He was asked whether, in his opinion, water would not be found at other points situated on the line of traverse, but refused to answer. The committee ruled that the question was a fair one, but the diviner would not answer it. Parker sank holes at the spots indicated by the rod and found water within a few feet of the surface. He then sank holes at other places along the traversed line where the rod did not dip, and found water in all of them at the same depth. In this case, where the testing was fairly complete, the water was at such a shallow depth that it was easy to prove the absurdity of the claim of the diviner in a very short time and at no great expense.

A South Australian farmer, whose property is situated near Wirrabara, has described to the writer his method of testing the reliability of a diviner. When he bought the land he found that there was no water supply, but there was a well on the adjoining property, and the diviner was invited to trace the course of the "stream of water" from the well across the boundary into this farmer's land. This was done and the site for a well was marked. The farmer, however, was dubious about the wisdom of his action in consulting a diviner and, instead of sinking a well for himself, arranged with his neighbour for the use of the existing well. During a succeeding period of drought the supply in this well did not suffice to supply the needs of both farms and another source of supply was needed urgently. Some eleven years had elapsed since the diviner's visit, and the farmer thought it advisable to see whether the same man could confirm his previous location. The "stream of water" marked out by the diviner on this second occasion was at right angles to that previously indicated, and an entirely different site for a well was located. The diviner, on being charged with inconsistency, declared that the "stream of water must have changed." In this case no well was sunk at either of the sites indicated, so that no proof was forthcoming to show whether water was obtainable at one or other site, or at both sites. The procedure was therefore a test only of the diviner's consistency.

The writer is aware of another test of a diviner that is out of the ordinary, the locality concerned being a sheep station in central western New South Wales, where it had been decided to drill a fresh borehole. A diviner was engaged and asked to indicate a place at which no underground water existed. This was done and a borehole was drilled at the site selected, with the result that the normal supply of water expected by the owner of the property was obtained. This result was inevitable, as the place lies within the boundary of the Great Artesian Basin.

There is no body of evidence, so far as the writer is aware, so valuable for assessing the claims of divining as that which has been gathered and recorded by the Water Conservation and Irrigation Commission of New South Wales in connection with the shallow drilling carried out for settlers in central New South Wales. The drills are operated by the Commission, and the drill foreman has to report at the outset of the work whether or not the site has been divined. The settlers are not influenced in any way in the fixing of bore sites, and some of them have made their own selection, while others have taken the advice of diviners. From these reports the Commission has compiled the following table, which deals with all the boreholes drilled between 1918 and the end of 1943.

Classification of Boreholes.	Divined.		Not Divined.	
	Number Drilled.	Per Cent.	Number Drilled.	Per Cent.
Bores in which supplies of serviceable water, estimated at 100gall. per hour or over, were obtained	1,284	70·5	1,474	83·8
Bores in which supplies of serviceable water, estimated at less than 100gall. per hour, were obtained	184	10·1	93	5·3
Bores in which supplies of unserviceable water were obtained	87	4·7	60	3·5
Bores which were absolute failures, no water of any kind being obtained	268	14·7	131	7·4

The districts within which these boreholes were drilled have a yearly rainfall ranging from nearly 30in. to under 15in. in the extreme west, and therefore more favourably placed than the greater part of South Australia. The northern part of the area embracing the boreholes lies largely within the Great Artesian Basin, with a consequent material reduction in the risk of failure. Yet it will be seen that the proportion of failures at divined sites is nearly double that at sites not divined, while the percentage of highly successful drillings is far greater at the sites not divined than that at the divined sites. The very large number of boreholes embraced in this tabulation corrects the deficiency that has been felt by those who have tried to discuss divining in the light of the records dealing with a small number of cases, some of which may have been selected, and omitting any reference to the failures that must certainly have occurred.

In 1913 arrangements were made to test the claims of diviners at Guildford, in England. Six English diviners and one German took part in the test, all being accredited exponents of the art of divining. They were taken without previous notification of their destination, to Guildford, and were tried out in three places, their findings being observed and recorded. The official report was illustrated with maps which are reproduced in the above-mentioned paper on water divining by Professor J. W. Gregory. The three areas and the diviners' results have been described as follows:—

(*a*) The first locality was a field where shallow gravel lay on London clay. The gravel held water at a depth of 20ft. on the southern side, but none at the swampy north-eastern part of the field. Water could be obtained in the chalk underlying the clay at a depth of 150ft. equally well under all parts of the field. The diversity of indications by the diviners was very marked. One found a small stream across the northern part of the field and a broader stream a little farther south. Others found springs scattered irregularly over the field. Some of the indications were quite isolated, although with so large a number on the small field there were naturally some coincidences.

(*b*) The second site was a reservoir covered by a lawn. On part of the lawn was an iron pipe which all the diviners saw and reported water beside it, though it was dry. In the distribution of the water the diviners were utterly at variance, although most of them were sure that there was no water in the middle. One found water at the northern corner; another found water at two places; a third found it at three places on the margin; a fourth at two places on the margin; a fifth found two streams and; a sixth found one stream equidistant from the other two.

(*c*) The third site was a field on chalk with water under all parts of the field, a spring had been found on the eastern margin years before, and a sewer containing running water crossed the field diagonally. In this case the diviners agreed better among themselves, but their findings generally were at variance with the facts. Four of the diviners inferred a stream of water under the eastern part of the field, but did not agree as to its position. The western part of the field was reported to be practically devoid of water. Nothing was found over most of the sewer. One diviner detected water near the hidden spring, but others found nothing near it.

Professor J. Wertheimer, of Bristol University, carried out some tests with similarly contradictory results. One of the diviners claimed that he could tell with his rod when water was flowing through an iron pipe, but on being tested failed completely to tell when the water was flowing and when it was turned off, being incorrect in every one of ten attempts.

It does not seem necessary to deal further with such tests at this point, but some cases of local interest are mentioned in the following part of this chapter where examples are given of failures.

There are records of cases in which attempts have been made to test the claims of diviners by blindfolding them and then leading them over traverses on which they have indicated, by the dipping of the rod, that there are places where water may be found. Some of these tests as recorded by Sir Ray Lankester and J. Ennemoser have shown marked inconsistency; but in other cases as recorded by Sir W. Barrett and Besterman it has been claimed that the diviners were not adversely affected by blindfolding. Here again it is necessary to distinguish between mere inconsistency and the presence or absence of water, if there is no attempt made to prove where the water does or does not occur.

It is not a difficult matter to devise a test that will show whether the diviner possesses the power to which he makes a claim. It may, however, be necessary to spend a considerable sum of money to prove whether the claims are true or not.

In any case a test should be carried out in an area with which the diviner is not familiar, and should embrace more than one locality in a district not previously visited by him. The places should be chosen carefully, and should certainly include spots at which there occur, at or near the surface, rocks of variable character that there are marked differences in their water yielding properties, or where fractures and fault zones exist. Alluvial deposits in stream valleys or widespread beds of porous sediments should be avoided, except for ascertaining whether the diviner denies the presence of water in areas within which its distribution is universal. Should more than one diviner be subjected to testing, the same areas should be covered by all, and their findings should be recorded and plotted separately, but the ground should not be marked in any way that might reveal to one diviner what another working over the same ground has indicated.

In the judgment of the present writer no such expenditure on a test can be justified, since ample evidence is available to show that no reliance can be placed on divining of any kind. Few individual believers in divining are likely to furnish the funds to carry out an adequate test, and appeals to the Government for a test do not, in the great majority of cases, show any understanding of what is involved in making a test conclusive. Diviners who ask to be tried out over a main carrying reticulated water, are influenced by the usual erroneous idea that underground supplies are derived in all cases from pipe-like openings in the rocks. Should they prove more successful than the diviner tested by Professor Werthcimer, in regard to the presence or absence of flowing water in a pipe, their capacity to locate underground supplies would have to receive separate investigation in the manner described above, before any importance could be attached to their claims.

(h) INSTANCES OF FAILURE THAT SHOW THE UNRELIABILITY OF DIVINING.

Most diviners are silent regarding their failures, however loudly they proclaim their successes. Yet all faithful and complete records show that failures do occur. The geologist, to whom reference is sometimes made when a well or borehole has failed to prove water at a divined site, is conscious of many failures, although he does not hear of all of them. Some of those who engage the services of a diviner are ashamed to confess that they have done so, when the sinking is unsuccessful, and remain silent over their disappointment and monetary loss.

There can be no doubt but that the European specification as to the necessity for cutting a divining rod at midsummer, and as to the performance of a religious ceremony over the rod when cut, is based on the experience of failures. Some excuse had to be found for disappointment; some rite had not been observed in such a case. Ritual plays an important part in procedure based on superstition, and any lapse in observance is followed by untoward consequences.

The writer has found that some diviners seek to explain failures by casting doubts upon the status of the practitioner responsible for the failure—he could not have been properly qualified. This charge, however, could not be levelled at the seven men concerned in the Guildford test mentioned above, since all of them were fully recognized exponents of the art.

The failures at many sites in central New South Wales have been mentioned already and call for no further discussion.

A few cases, selected from those which have come under the notice of the Geological Survey of South Australia, may serve to illustrate some of the points to which attention has been drawn in general terms.

Case a. (Fig. 34). At *Woodside* a landowner wanted a flowing supply of water and consulted three local exponents of the art of divining. These men selected a site and guaranteed a large flow from a place situated on a narrow alluvial flat on the northern bank of a bend in the Onkaparinga River. The drill penetrated 10ft. of alluvium, 1ft. of gravel, and 126ft. of quartz-mica schist. A limited amount of water, derived from the upper fractured portion of the schist, was obtained and rose to the level of the gravel under-lying the river alluvium. Boring ceased at 137ft. from the surface. The geologist, consulted subsequently, selected a site upstream, where the rocks are exposed

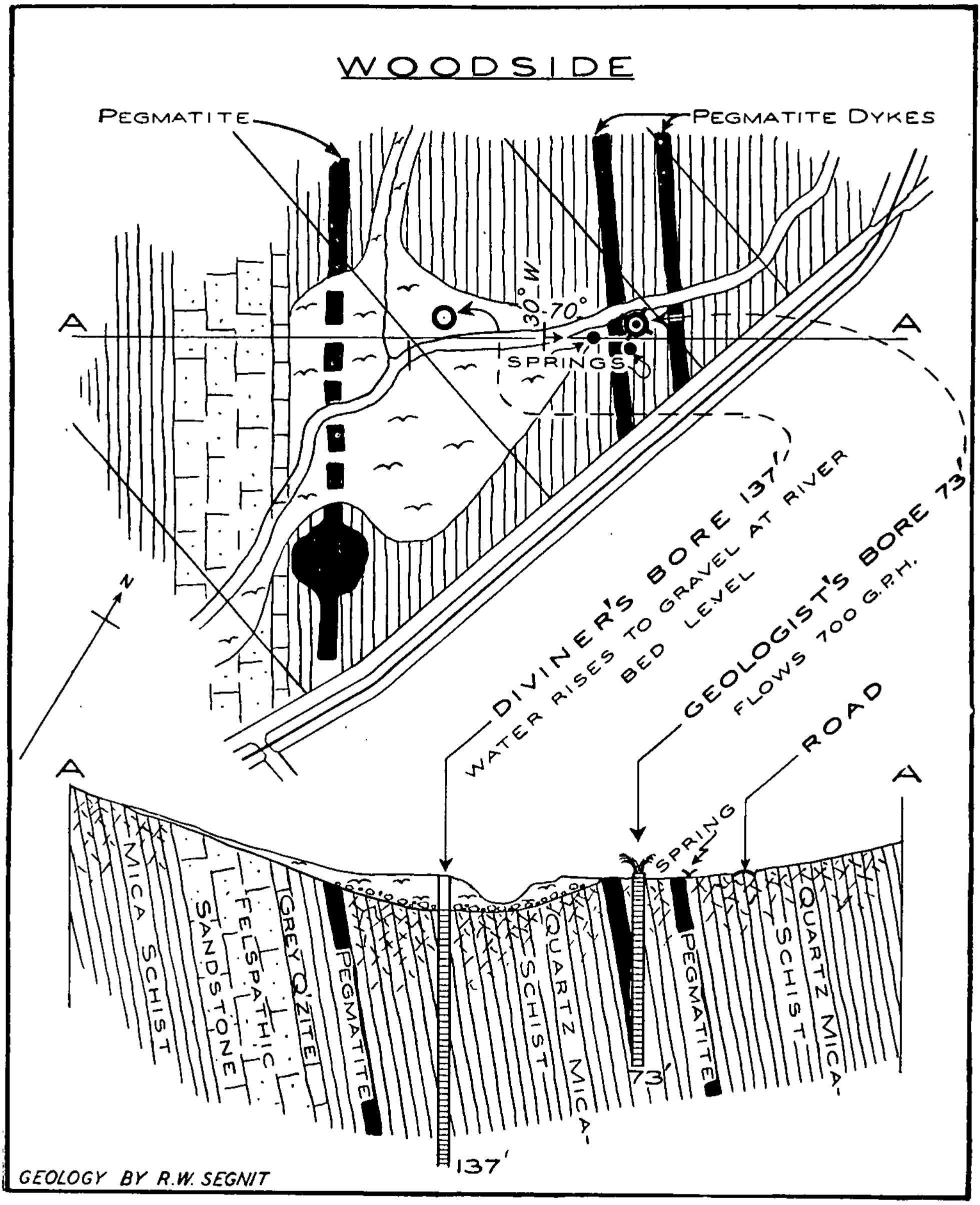


Fig. 34.

on both banks of the river as well as in its bed. There are two springs on the eastern bank, indicating the checking of the movement of the underground water by some impervious barrier, a pegmatite dyke. The site selected was between the high-level spring and the river, and on the line of strike of the schist.

This site was definitely condemned by the three diviners who chose the downstream site, but the owner of the land decided to test out the geologist's site. Boring ceased at 73ft. when water was flowing at the rate of 700 gallons per hour, six inches above the surface.

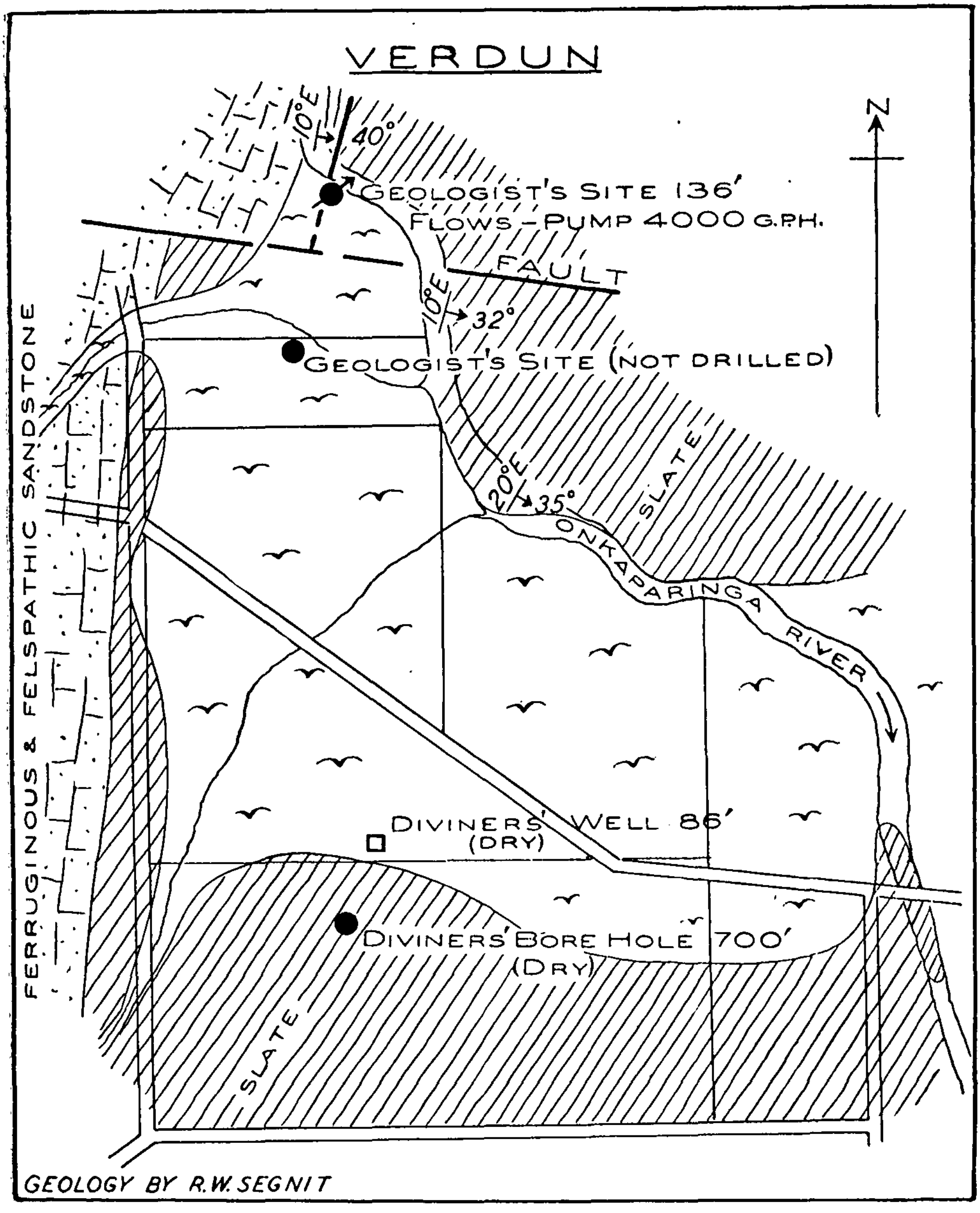


Fig. 35.

Case b. (Fig. 35). At *Verdun* a borehole was drilled on a site selected by three diviners who declared that three streams converged at the site. When the borehole was 200ft. deep geological advice was sought and the site was condemned, the land owner being urged not to continue beyond 300ft. in any case. The diviners, however, encouraged him to continue and the borehole, which was quite dry, was abandoned at 700ft. after penetrating massive blue slate from the surface to the bottom of the hole. The diviners then announced that the streams had altered their course, and selected a new site a short distance from the borehole and below it, on the margin of shallow recent alluvium, resting on the slate. The two sites were on the line of strike of the slate. As the diviners reported that a very large stream could be tapped, at a depth of 45ft. on the second site, a well was sunk.

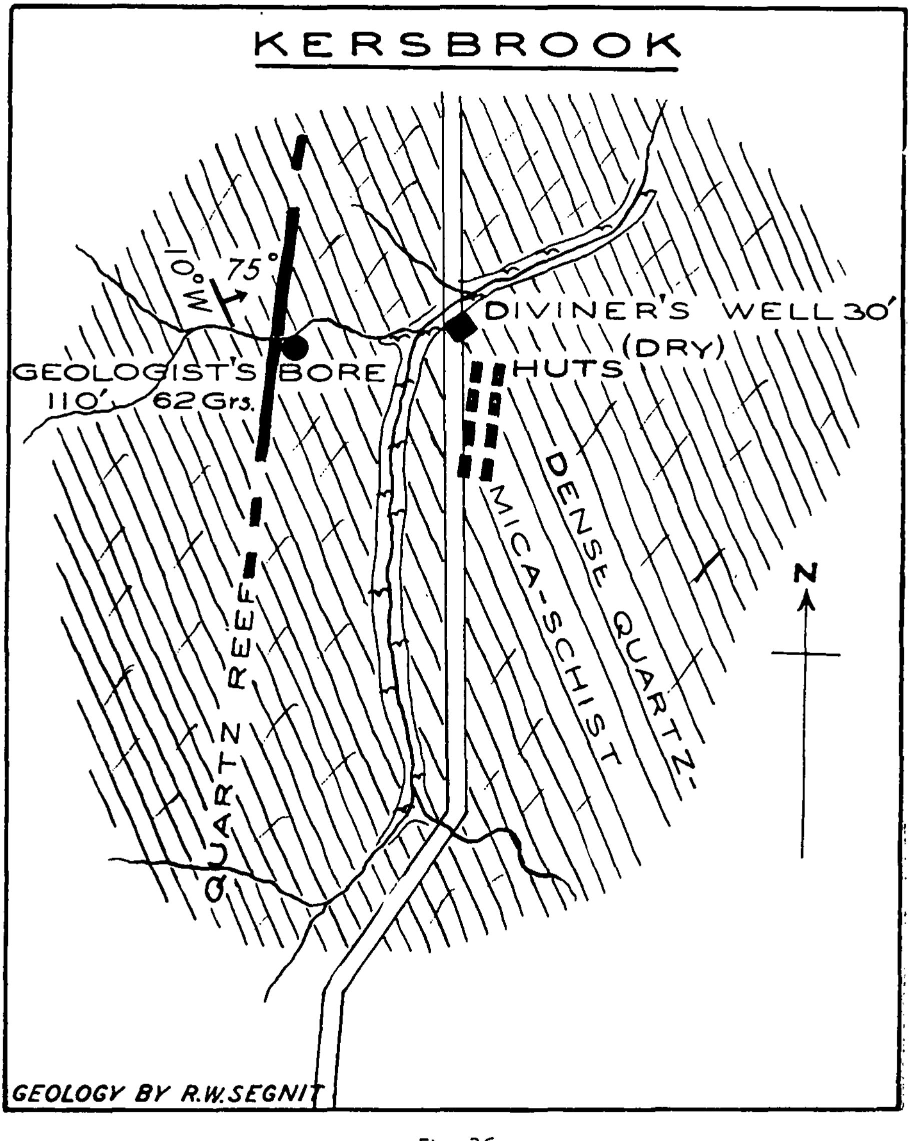


Fig. 36.

It was abandoned when 86ft. and was quite dry. The cost of the work entirely drained the landowner's resources, so that he was unable to sink at a site selected later by the geologist near the northern boundary of his property with the object of reaching the sandstone that underlies the slate.

Another site, selected by the geologist in the adjoining property to the northward, was successful, a flowing supply being obtained at a depth of 136ft. from the sandstone. When a pump was installed, a supply of 4,000 gallons per hour was obtained.

Case c. (Fig. 36). At *Kersbrook* a diviner was brought from Mount Lofty to select a site for an unemployment relief camp, the requirements being a reasonably large supply of water suitable for human consumption. The diviner foretold that the requirements would be met at 15ft. When the well had reached a depth of 30ft. in dense quartz-mica schist and was still dry it was abandoned and geological advice was sought. The geologist picked a site on the bank of the creek for a borehole to cut a quartz reef. This site was drilled and at 110ft. water of good quality was struck in the quartz body.

Case d. (Fig. 37). At *Upper Sturt* the diviner who selected a bore site did not neglect geological features altogether. He sought for a place in the slate near the outcrop of a sandstone, but did not recognize the fact that the sandstone was dipping away from the borehole instead of towards it. The hole went to 118ft. in hard slate and was quite dry. The geologist who was consulted at this stage, selected a site in a dry well which was 30ft. deep. A borehole drilled in the bottom of this well reached a depth of 55ft. when it entered the bed of quartzite which it was designed to tap. A flow of 1,000 gallons per hour over the surface was obtained.

Case e. (Fig. 38). At *Morphett Vale* there is a property on which various owners had sunk in search of water one borehole 95ft. deep and three wells up to 35ft. in depth, all of them being dry. The property is said to have changed hands eight times in about 20 years. Diviners from the district and from more distant places had traversed the surface and reported that no streams crossed the property. The geologist called in subsequently picked a site for a borehole on a fault plane marked by a change of rock character and a line of small springs. One owner actually started to drill on this site, but was discouraged after reaching a depth of 24ft. by the adverse report of local diviners and sold the property. The present owner heard that a geological inspection had been made, and, on being supplied with a copy of the report, drilled a hole alongside that which had been abandoned at 24ft. When the borehole had reached a depth of 113ft. there was a supply of excellent water standing 10ft. below the surface.

The writer has seen rather extravagant press statements regarding the use of the divining rod in Egypt and Palestine during World War I., and how it saved the Army. The official report of the Royal Engineers on their work in this region, pp. 33 and 43, mentions two successful results at divined sites at Abu Ghalyum, and a failure at a site in the Judean Hills, similarly located.

One of the water-finding machines was subjected to actual tests by the Government of South Australia. The geology of the area in which the tests were carried out, lying between the Iron Knob tramway and Cowell, had been studied specially with the object of ascertaining those features that have a bearing upon underground water supplies (see *Geological Survey Bulletin* No. 3), and it was known that the difficulty in finding water of useful quality was great. Any mechanical device capable of locating good water in such an area would be of inestimable value. One of the sites chosen

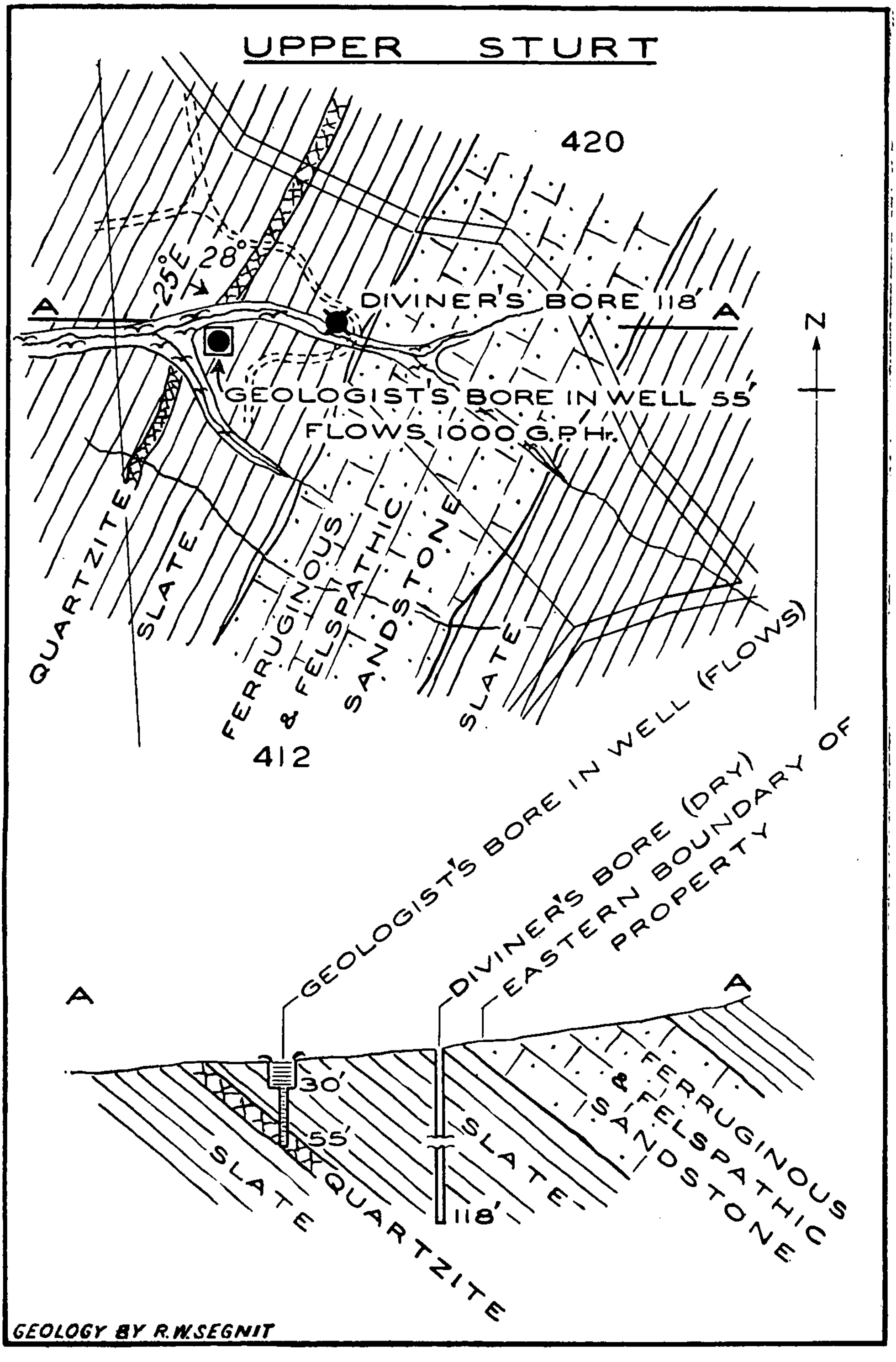

UPPER STURT
420
25°E
28°
A
DIVINER'S BORE 118'
A
N
GEOLOGIST'S BORE IN WELL 55'
FLOWS 1000 G.P.Hr.
QUARTZITES
SLATE
FERRUGINOUS & FELSPATHIC SANDSTONE
SLATE
412
GEOLOGIST'S BORE IN WELL (FLOWS)
DIVINER'S BORE (DRY)
EASTERN BOUNDARY OF PROPERTY
A
A
30'
55'
118'
SLATE
QUARTZITE
SLATE
FERRUGINOUS & FELSPATHIC SANDSTONE
GEOLOGY BY R.W.SEGNIT

Fig. 37.

for a drilling test is situated in block G, hundred of Poynton, within a well-defined artesian basin, the Cowell basin, known from previously existing boreholes and wells to carry salt water at most places, and the prospects prior to drilling, were reported by the operator to be "good." A borehole was drilled to a depth of 374ft. and salt water was encountered at various depths. The best water obtained from this borehole proved more highly charged with mineral matter in solution than sea water.

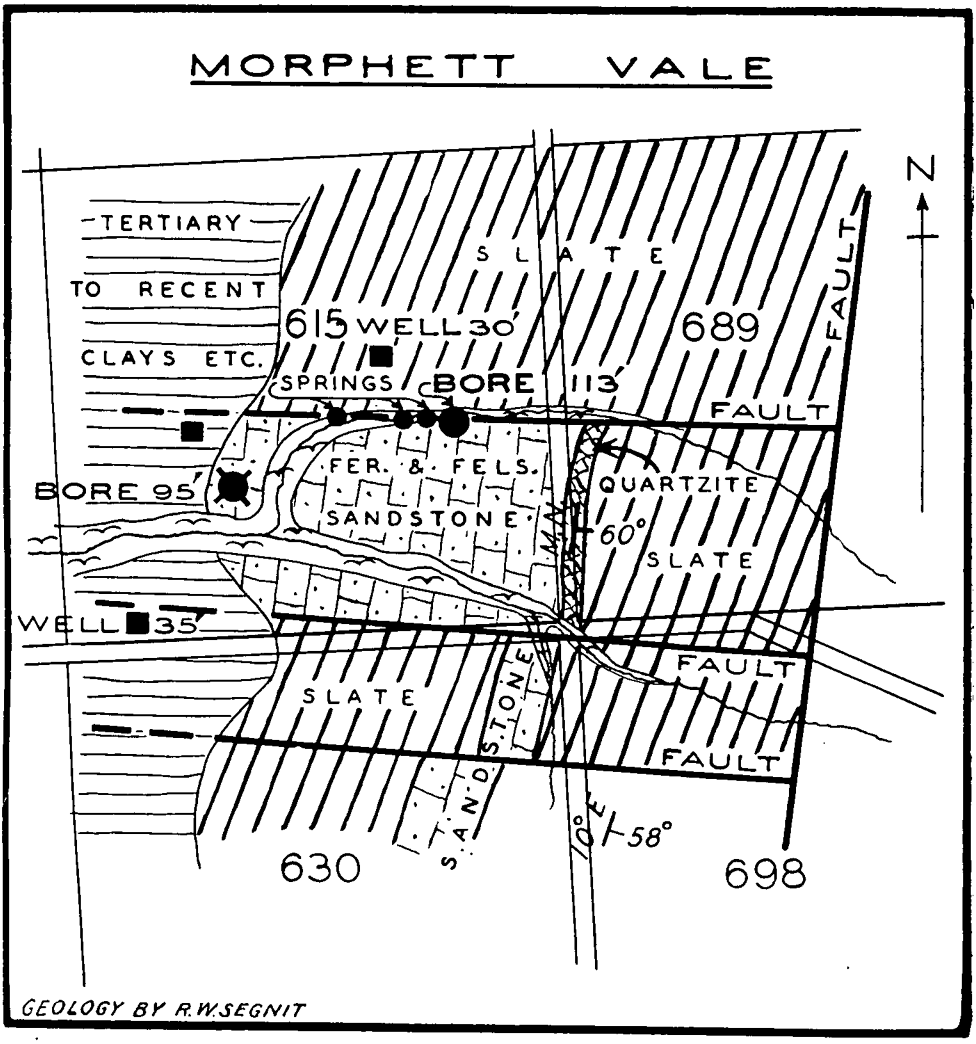


Fig. 38.

The second trial was made at a spot in the hundred of Ash, between two outcrops of granite rocks. At this place, known as Carrolby Rocks, the operator working the instrument reported an "abnormal reading" and declared the indications to be "very good." The drill traversed a few feet only of surface soil, and was abandoned at 121ft. in massive crystalline rock, without any water whatever having been found.

At the same time the Transcontinental Railway, linking Port Augusta with Kalgoorlie, was under construction, and this machine was used to try and locate water for railway purposes, wholly without success.

It is a pity that reliance cannot be placed upon this instrument, for it is extremely portable, and readings are easily and rapidly obtained. Those who are aware of the difficulties in obtaining supplies of useful water in districts such as those in which it has been tested in South Australia would be only too glad to have some reliable mechanical help to support conclusions reached by geological examination and reasoning.

From what has been written here concerning failures at sites selected by the divining rod or by the water-finding machine it will be seen that the primary cause of disappointment has been the neglect or even defiance of facts ascertainable by geological investigation.

(i) THE PSYCHOLOGY OF DIVINING.

The investigator who attempts to assess the value of the claims made by the diviner must take into account the mental attitude not only of the diviner himself, but also that of his patrons and supporters.

As for the diviner himself, there can be no doubt but that many exponents of the art have an honest belief in their powers, despite failures that are more or less numerous according to the features of the areas in which they operate. Those who select sites in areas where underground water is far from universal through the unsuitability of some of the rocks for storing water cannot but be conscious of failures. Yet the diviner remains silent regarding these, and probably he does forget them with the passage of time. It is a characteristic of mankind that the memory of fruitless toil and pain fades, while that of success and pleasure survives. One does not hear the prospector talk of his long and arduous testing of unproductive fields, for he has forgotten all about such profitless labour. He does, however, remember every detail of his successes, and delights in telling the stories of these discoveries.

If, on the other hand, the diviner has practised wholly in a district where underground water is obtainable almost everywhere, he may come to consider himself infallible, and he may acquire an undeserved reputation for uncanny skill. While he restricts his operations to such a field his faith in himself may remain unshaken, but he may be tempted to try his hand at locating water supplies elsewhere.

Turning to the case of the believers in divining, it is essential to bear in mind that there are comparatively few in a community who are possessed of a trained and developed critical faculty that will guide them to formulate a correct judgment. Very many have made no attempt to study the mode of occurrence of underground water and do not realize how much is definitely known regarding this subject. Few are aware of the high proportion of failures where the distribution of underground water is limited. Nor do they appreciate that there are wide differences in this distribution from one place to another. There are so many who believe what they wish to believe, and who are captivated by anything that savours of mystery, that support for divining is always forthcoming. It is easy to appreciate the viewpoint of the farmer or pastoralist who is faced with the cost of providing a water supply which he needs, by sinking a well or borehole. He hears accounts of successes at sites picked by diviners and in many cases is unable to distinguish between the successes which are inevitable and those which are merely fortuitous. So he consults a diviner. It has been said that a belief in divining is most common where the distribution of underground water is widest, but the writer has found that this is hardly true in South Australia where diviners are consulted in very many districts where successes are far from universal. It is the urge of necessity that provides the stimulus, and the wide diffusion of the faith in divining that influences their action. A fortuitous success serves to infect others who are not immune.

In his book "Totemism and Exogamy" Vol. I., pp. 169-172, Sir J. G. Frazer has expressed the opinion that in regions where the changes of the seasons are most marked the belief in the efficacy of magic is strongest. In a region with the climatic features of South Australia one might expect that, if this generalization is accepted, the practice of magic would be much greater than in equatorial lands. The need for water is more marked where there is a sharp differentiation between wet and dry seasons than in places where rainfall is distributed more uniformly, and man has been tempted to invoke magic to remedy the inequality.

The writer has been asked more than once whether he would not be quite convinced of the efficacy of divining if he was given proof of half a dozen cases of success without a single failure. The reply given was that such a "proof" was quite unconvincing if it related to an area where there is a bed of sand or gravel charged with water, or a porous limestone of broad lateral extent, in a region of fairly high annual rainfall. The inquirers were told of the test on the Adelaide plains supervised by Parker and described above. Uncritical acceptance of the evidence of success at such places may have the serious result that those who have been impressed by it may be persuaded to place their faith in divining and put it into practice where utterly different geological conditions prevail and where the detailed consideration of these conditions is essential for attaining the end desired. This is the danger of yielding to the argument of those who think that it is wise to place reliance upon divining in the location of sites because it must be admitted that supplies of water have been obtained at a number of places where diviners have recommended the sinking of boreholes or wells. The instances of failure recorded in this bulletin serve to show clearly that their number is far from negligible.

Moreover it is to be remembered that divining proper, that is to say complete reliance upon the behaviour of the rod or other appliance in the hands of the operator, such as is almost invariably the case, takes no account whatever of the variations of geological structure. There are comparatively few diviners whose knowledge of rock structures and the other factors governing the occurrence of underground water is such that they can make effective use of it. Those who do understand how water is stored beneath the surface have no need for a divining rod, and should not pretend that they are influenced by its movements. There is no compromise possible between divining and scientific investigation, since the two methods are wholly incompatible. The diviner who bases his choice of sites primarily upon the study of the features of the country examined may properly be regarded as fraudulent as far as his divining is concerned.

It is highly improbable that the superstition with regard to divining will be eradicated at an early date. Mankind, despite the spread of education, remains in the mass saturated with a belief in magic of some kind or another. It is not proposed to discuss in this bulletin the comparisons between divining and other manifestations of magical practice, but such similarities do exist. If we may accept the authority of J. G. Fraser, man placed his faith in magic before he relied upon religion, trying to influence nature by enchantment to satisfy his desires. Long aeons have imbued him with a hereditary weakness which will persist until the fallacy involved is destroyed by ridicule or by reason.

A psychological factor which operates in favour of the diviner is the certainty with which he makes his decision. The patron hears a definite pronouncement and sees the dipping of the rod at the site selected. These assurances are more satisfying to him than a recommendation to make a trial drilling, to ascertain whether a supply may be tapped. Yet such a recommendation may be all that can be justified on the evidence available. There are many places at which exploratory drilling may be urged, but at which it must be recognized that there is a serious risk of failure. With the progressive exploration of the region for underground supplies of water this risk is diminished, but in the early stages of testing it may be very difficult to assess the degree of hazard. The greater the experience of the trained investigator the more thorough is his appreciation of the difficulties involved, and a sound report from him will contain such reservations as he feels compelled to state. One sometimes hears such a report described as "indefinite," whereas it is the very opposite, and is far more valuable than an unqualified recommendation to drill a hole or sink a well at a divined site. The results obtained from a comparative or complete failure may be applied to the work of further exploration if the initial sinking has been planned with an understanding that it may not succeed for stated reasons. Data may be acquired from an unsuccessful trial that may point the way to subsequent success. Examples or such localities may be found on upper Eyre Peninsula, where one of the major difficulties is the avoidance of the saline water which is common at low level sites and where the level at which useful water is obtainable must be ascertained by actual trial.

There is, however, one thing that can be said in favour of the diviner, namely, that he has influenced many credulous persons to make trials at sites which they would not have been courageous enough to test but for the assurances that they have been given by him, even though these promises may be falsely based and his claimed past successes may be purely fortuitous. The writer has known cases in which boring contractors have relied upon divining, although declaring that they had themselves no belief in it, to persuade prospective clients to authorize drilling. He has knowledge also of at least one site selected by himself for a trial boring that was not tested until a confirmatory report from diviners had been obtained. In another case, within the writer's personal knowledge and where topographic factors were all-important, the pastoralist used his own personal judgment as to the area within which useful water could be found, and then consulted a diviner as to the exact position at which to drill a borehole. So far as could be ascertained about this case the primary selection of the area within which the diviner's activities were confined was not based upon any reasonable analysis of the topographical or geological conditions, much less on a survey to ascertain relative levels.

The geologist is sometimes charged with the harbouring of unfair prejudice against the diviner, but this accusation is not just. The geologist, through his training and experience, is aware of the conditions under which water is stored in the earth, and he sees the accumulated knowledge of these matters being neglected or defied by the diviner who relies wholly upon the movements of his rod. Moreover, the geologist has been educated to reject any claim which investigation has shown to be illfounded, and he is usually aware of the numerous failures which are not so well known to the enthusiastic supporters of divining or which are conveniently overlooked by them. The method of science involves searching criticism of all statements, whosoever may be the person making the claims, and the rejection of those which the available evidence shows to be false.

(j) CONCLUSIONS REGARDING DIVINING.

If we except those who display a marked disposition to attach weight to so-called psychic phenomena, and to believe in the claims made by some individuals to be endowed with some super-normal sensibility, it will be found that all whose experience is wide are aware of the inefficacy of the divining rod.

R. W. Raymond, in the paper mentioned above, stated his conclusions thus:—

> "In itself it is nothing. Its claims to virtues derived from Deity, from Satan, from affinities and sympathies, from corpuscular effluvia, from electrical currents, from passive perturbatory qualities of organo-electric force are hopelessly collapsed and discarded. A whole library of learned rubbish about it which remains to us furnishes jargon for charlatans, marvellous tales for fools, and amusement for antiquarians; otherwise it is only fit to constitute part of Mr. Caxton's "History of Human Error." And the sphere of the divining rod has shrunk with its authority. In one department after another it has been found useless. Even in the one application left to it with any show of reason it is nothing unless held in skilful hands, and whoever has the skill may dispense with the rod. It belongs, with the magic pendulum and planchette, among the toys of children. Or, if it be worthy the attention of scientific students, it is the students of psychology and biology, not of geology and hydroscopy and the science of ore deposits, who can profitably consider it."

In his introductory note to A. J. Ellis' paper on the divining rod Dr. O. E. Meinzer wrote:—

> "It is difficult to see how for practical purposes the entire matter could be more thoroughly discredited, and it should be obvious to everyone that further tests by the United States Geological Survey of this so-called 'witching' for water, oil, or other minerals would be a misuse of public funds . . . . To all inquirers the United States Geological Survey therefore gives the advice not to expend any money for the services of any 'water witch'; or for the use or purchase of any machine or instrument devised for locating underground water or other minerals."

Such being typical judgments of experienced specialists, whose knowledge both of the mode of occurrence of underground water and also of the manner of locating useful supplies is very wide, it appears to the writer to be unnecessary to elaborate further the account of final conclusions. There was a time, not very distant from the present-day, when there was an equally widespread belief in witchcraft the reality of which was acceptable by Courts of Law. This superstition has perished, although others such as those concerned with astrology and palmistry have survived. The judgment of the majority does not constitute a proof of the truth of the belief in divining or other delusions. The verdict of a ballot-box cannot be trusted in such a matter, especially as few individuals have any proper understanding of the way in which water is stored in the ground. It is infinitely better to trust the considered opinions of those who are well-informed on the subject.

On reviewing the whole subject of divining one finds that there are two questions that call for decision, namely:—

1. Whether there is any basis for the claim that certain persons are supersensitive to some hidden influence which causes the dipping of the rod (or the swivelling of the bent wire, or the oscillation of the pendulum).

2. Whether the dipping of the rod is an indication of water beneath the spot where it is observed.

The present writer is wholly unconvinced that any such special gift is possessed by those who claim to be endowed with it; nor has he seen, when watching expositions of divining, anything that is not to be explained simply by the operation of purely physical forces other than "rays" or "vibrations" of any kind, even if these have been influenced by the action of the conscious or sub-conscious mind upon the muscles. He is aware that there are many diviners who are entirely honest in their operation, and who do not deliberately control the rod in support of their claim to the gift which they believe themselves to possess. Yet he is conscious of the difficulty of detecting fraud in this matter.

In a recent publication printed in London, Professor A. M. Low gave an account of numerous tests he had made over many months to discover whether dowsing was a "fact." The conclusion that he reached was that the movement of the twig was purely imaginative, the result of psychological and not physical forces—the dowser's wrist muscles moved in response to a command from his nervous system, probably entirely subconscious.

As for the interpretation of the dipping of the rod as a sign of subjacent water, the facts recorded in New South Wales and elsewhere, as mentioned in this bulletin, are opposed to the acceptance of any such claim. In view of the wide range of subjects on which information has been stated to be given by the rod, it is surely arbitrary to assume that a concealed source of water is the cause of its movement, as many diviners claim. It is with this restricted claim that the present discussion of the efficacy of the rod is concerned, and on which an adverse judgment is passed.

The case for the mechanical water-finding machines, used in the same manner as the divining rod, is in no way different. Although reliance cannot yet be placed upon their indications, it is possible that ultimately some geophysical method may be developed to supplement geological investigations in the search for underground water.

The detailed research, undertaken chiefly on the oil fields of the world, now being carried out to determine concealed structural conditions by the exact measurements of differences of gravity, temperature and radioactivity, or by the observation of variations produced on wave systems artificially generated, may eventually assist the geologist. Yet geophysical methods alone do not seem likely to displace geological investigation, for the variety of possible structural conditions is very great and there is always some difficulty in interpreting geophysical results. No interpretation which neglects geological considerations can be expected to prove valid.

There are many places at which the search for water involves considerable expenditure, and at which failure may mean a loss greater than the sum spent on boring or sinking a well. Such cases are those in which water is wanted urgently to save flocks and herds in the dry regions when it is not possible to transfer them to better favoured country. Under such circumstances any person responsible for guiding the steps taken to relieve the water shortage would welcome any reliable device for determining, in advance of sinking, whether or not supplies exist at the sites to be tested. Yet no such device has yet been able to withstand the critical investigation of trained minds.

In the drier regions such as the Lower North of South Australia, there are localities where it is difficult to locate useful supplies of underground water, and at which there is a large measure of uncertainty as to results before actual trial. The boundaries of many properties are such that the most suitable site or sites for testing do not lie within the holdings of the settlers who desire to have their own independent supplies. Consequently they may be forced to test less promising sites or to arrange terms with neighbours for sharing the supplies obtainable beyond the limits of their own land. In such cases it has been noted that the landholder is inclined to disregard the reasoned advice of the trained investigator and to turn to the diviner. Yet it is in areas such as this that the percentage of failures at divined sites is likely to be greatest, because of the restriction of distribution of the underground water; and the diviner's recommendation does not include any statement of the degree of risk involved in the testing of a site that may not compare favourably with others that might have been selected but for the arbitrary position of boundary fences. Divining does not furnish a remedy for deficiencies imposed by nature.

The writer has reached the conclusion, after the careful consideration of the claims made by diviners of all kinds and the actual results obtained at sites selected by them, that there is at the present time no mechanical device, nor any group of men possessing special gifts and powers, that can be relied upon to indicate without fail the presence or absence of water at a given site.

XV. THE SELECTION OF SITES FOR BOREHOLES AND WELLS, THE TESTING OF THESE SITES, AND THE RECORDING OF RESULTS.

From the consideration of the many matters discussed in the earlier pages of this bulletin it will be understood that there is no possibility of setting out a mode of procedure for the location of bore sites or well sites that is applicable to every case. Yet it is possible to indicate, in a broad way, how to go about the search for new supplies under the conditions existing in very many cases, provided always that each case is treated as an individual problem with its own special features and requirements.

The first thing to do is to reach an understanding as to the mode of occurrence of underground water generally, as set forth in this bulletin or in the books to which reference is made. A primary necessity is to realize how water is stored in the rocks, and to discard the widely-spread belief in the existence of narrow "underground streams of water" that are comparable with small superficial rivulets.

At the earliest stage observations should be made to ascertain whether the area to be tested is occupied by beds that lie horizontally or are tilted at low angles, and which include porous layers that may act as aquifers. If such beds exist they are usually composed of loosely compacted granular materials. Information regarding them is obtainable from existing boreholes and wells or from exposures in the banks of any creeks crossing the area. Should such features be recognized it is possible that an artesian basin may exist and that success may attend sinking operations over a large part of the area. In most of such areas in South Australia the surface of the ground shows little relief, and the basins are either broad, flat valleys, such as the Willochra Valley, or wide coastal plains, such as the Adelaide plain. The upper margins of the basins should be examined carefully to find out whether there exist porous beds of gravel or sand crossed by creeks which carry water of good quality from the adjoining highlands, even if these streams only run intermittently. Effective intake beds may absorb much water; but if, as in the case of the northern part of the Cowell basin, the water reaching the intake area is saline, the artesian basin may carry stored water that is useless on account of its excessive salinity.

Assuming that such a basin has been found to exist, and that portions, at least, of it have been explored by drilling, all possible information should be gathered with regard to the occurrence of the water, particular attention being given to the following matters:—

1. The distribution of artesian and subartesian boreholes, and their relation to the relief of the surface.
2. The existence of continuous aquifers, and the regularity of the succession of beds; and the depth to the aquifer, or aquifers if there is more than one.
3. The quality of the water in each aquifer, and the quantity of water obtainable with or without pumping appliances.
4. The nature of the beds overlying the aquifer, noting especially whether any coarse gravel or boulder beds exist to make drilling operations difficult unless a heavy plant is used.

The size of any such basins is important, since the largest may derive their supplies from distant sources where the rainfall may be heavier than that in the area being explored, as in the case of the Great Artesian Basin; whereas the smaller basins depend on the rainfall in their immediate vicinity.

In exploratory drilling within an artesian basin, beyond the limits of the portions already tested by drilling, it is not always possible to predict with accuracy the amount of drilling necessary to reach the aquifer. It is easier to tell whether a flowing or a pumping supply is likely to be proved, as the hydraulic surface is likely to be sufficiently regular for its altitude to be fixed at any spot by extrapolation, and the height of the surface at the proposed bore site can be determined by survey. If the ground surface is above the hydraulic surface a subartesian borehole only can be developed, but if it lies below the hydraulic surface an artesian flow will result. The imaginary hydraulic surface is a concept based on the pressure conditions and is quite independent of the thickness of cover overlying the aquifer. The writer has found that those who do not understand these points have difficulty in grasping the fact that the thickness of rock to be penetrated by the drill in order to pierce the aquifer may be unknown, although a confident assertion may be made about the prospect of obtaining artesian or subartesian supplies. The greater the distance from the nearest existing borehole the more difficult is it to estimate the required depth of a new hole.

As prospecting operations approach the margin of a basin the intervals between the sites tested should be reduced; for the aquifer may not have so wide a lateral extent as the upper beds forming its cover, and marginal holes may reach the underlying rock foundations without penetrating the aquifer at all.

Irregularities in the surface of the rock foundations below the horizontal sediments may not be ascertainable by the examination of the surface and may be revealed only by exploratory drilling. Where such irregularities are so pronounced that the rock bottom is relatively shallow beneath overlapping beds of the basin dry holes may be drilled. However, as exploration accompanied by the full recording of results proceeds, the risk of ineffective drilling is greatly reduced. The eastern part of the Adelaide plains basin is an example of this kind of occurrence.

Where the examination of the area in which water is wanted shows that no basins of sedimentary deposition occur, so that the objective of drilling or well-sinking is not a more or less horizontal bed of sandy material having a broad lateral extent, but a selected portion of a terrain occupied by hard rocks that may be tilted at high angles, a rather different procedure is called for.

As in the case of artesian basins it is, however, necessary to find out all the facts available in regard to the nearest underground sources of water that have been developed, noting the depth, yield, salinity, the range of seasonal variations, the relation of sites to topographical and geological features, and the nature of the rocks penetrated—especially the extent to which they are traversed by joints and fissures.

It is equally important to investigate all cases of failure, whether due to the existence of no supplies at all or to the finding of water too saline to be useful. Should there be found a dry hole that has been carried down to the full normal depth of the water table the possibility of a successful hole at a lower site should be considered. On the other hand, the presence of excess salinity indicates the need for considering whether a higher site might prove the existence of water of better quality.

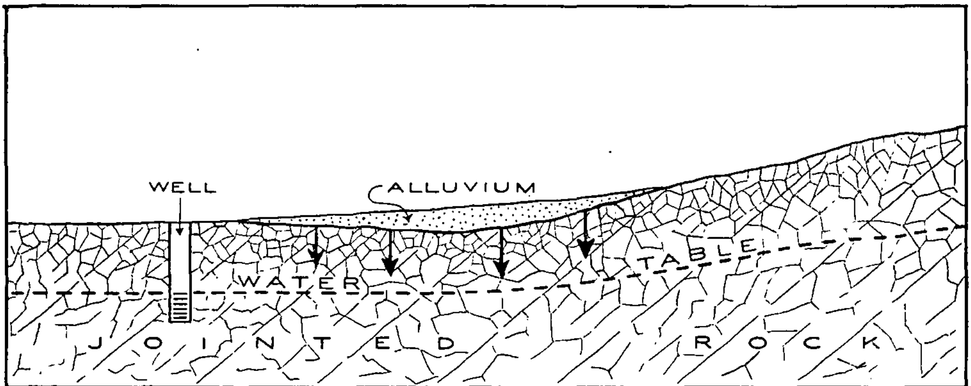
It is advisable to keep away from hill tops and the crests of ridges, since the opportunities for the absorption of rainfall are most slender in such places. Moreover, the water level is generally deeper below the high country so that deeper sinking is necessary. Few exceptions to this general rule are found, and most of them are due to the existence of fault planes which have been occupied by quartz veins the resistance of which to weathering enables them to stand in bold relief above the surrounding country; and, even in such cases, better results are to be obtained by tapping the lower portions of these fault planes. The existence of suspended water tables in relatively high country is rare where only hard rocks are present.

Where topographical features are not prominent and the country is either nearly flat or characterized by gentle slopes, search should be made for outcrops of rock showing through the cover of soil. In many cases it may be necessary to continue this search well beyond the limits of the property on which the water supply is desired. These outcrops should be examined carefully and the character of the rock as well as its attitude (both strike and dip) should be noted.

Particular attention should be paid to those topographical features that affect the disposal of rainfall in the area concerned, especially to the extent of local catchment areas and the nature of the channels or valleys through which the run-off must pass. Sandy deposits in valleys or sandy soil on the higher ground favour the absorption of rain water, whereas clayey soils are non-absorbent and cause the water falling upon them to pass beyond the limits of the rocks which the clay covers. Sandy alluvium in the valley of an intermittent stream may hold a certain amount of water even when the surface flow ceases and thus continue to augment the storage of water lost to sight by percolation through joints. A favourable site for a well is one immediately downstream from any such occurrence of the alluvium. (See Fig. 39.)

Should the valley disposing of the rainfall exhibit any constriction that may be the result of the occurrence of more resistant rock masses, it is wise to examine carefully the area immediately upstream from the narrowest part of the valley, and to consider the advisability of putting down a well or borehole as close as possible to the channel without incurring the danger of having the equipment carried away by flood waters. Where these valley constrictions are so marked as to constitute sharply defined gaps in the ridges of rock that have resisted erosion excellent supplies of water may be obtainable, provided always that joints or other fissures are present in the rocks occurring on the upstream side of the gaps.

In those cases in which shallow wells sunk in the alluvium of creek channels afford supplies during the wet season but fail in the latter part of the summer, it may be necessary to put down boreholes in the bottom of the wells to tap any supplies that may exist in the rocks beneath the alluvium. The successes of any such boreholes is entirely dependent upon the existence of joints or fissures in which water is stored, and the depth of the exploratory boreholes in rock should not exceed 200ft. in the majority of cases.



SECTION ALONG VALLEY OF AN INTERMITTENT STREAM WITH ALLUVIUM ACTING AS FEEDER OF WATER TO JOINT PLANES

Fig. 39.

It has been found by S. B. Dickinson that there are several places in the Flinders Range where moderate to large supplies of water may be developed where the rocks have suffered folding and incidental fracturing. Limestones involved in such folding are specially favourable, and the places to be tested are those located on the axes of anticlinal folds, that is to say, where the rocks are buckled up in the form of an arch or dome, the crest of which has been removed by erosion. The borehole whence the water supply for the Leigh Creek coalfield is obtained at Sliding Rock is an example of this type of occurrence.

When the search for water is concerned with areas in which rock outcrops are well-marked and extensive special attention must be directed to the nature of the rocks represented and to the degree of jointing exhibited by them. If the rocks present consist of such dense types as massive slates or mica schists, their trend or strike and their dip should be noted, but rocks of this type should be avoided unless they are observed to have suffered shattering, while search is made for any sandstones, jointed quartzites or limestones that may be interbedded with the unfavourable rock types. Failing the presence of the more favourable rocks search should be made for fault zones or quartz reefs, preferably in places immediately above the outcrops of the dense rocks that may play the part of underground dams. In such cases it is wise to pay attention to the places where the fissures or reefs are crossed by channels which may bring surface waters to augment or replenish the underground storage whenever rain falls. In all such cases the dip of the rocks considered favourable should be observed and an effort should be made to tap them below the water table. In the case of fissures, which are likely to be very steeply inclined, it may be necessary to locate the sites for sinking on their outcrops rather than upon their flanks.

Where intermittent streams have cut down channels across areas in which hard rocks occur suitable sites for wells may be selected on the banks of these channels. During the wet season the water table may be close to the surface, but may fall appreciably when the season changes. Whether or not the channel carries any alluvium it is wise to deepen the well sufficiently to penetrate the water table of the dry season and to put in a drive *across* the channel to intercept the underflow and prevent the escape downstream of water that would otherwise pass beyond the influence of the pump. The underflow may be passing through the joints of the upper weathered part of the rock foundations below any alluvium that may occur. (See Fig. 29).

In a large part of upper Eyre Peninsula where outcrops of solid rock are extensive the salinity of the water in many of the low-lying areas is too great for any use to be made of the fairly abundant supplies that are obtainable. Under such conditions it is useless to seek for supplies of useful quality at any other than relatively high sites, even though smaller quantities can be developed. The structural conditions are such that water of local origin only exists, and in very many cases the water is stored, not in alluvium, but in the crevices and joints of hard rocks. Although it is possible that a "cream" of better water may occur above the main body of saline water in some places, it is futile to expect that better water will be found at any depth greater than that of the salt water. Hence it follows that, in such a region, consideration must be given primarily to high ground above which there is a gathering ground or catchment for any rain that falls. Supplies from sites satisfying these requirements have been obtained at the northern end of the Darke's Peak Range and in the hundred of Wilcherry, but similarly situated locations are certainly difficult to find in that region. It is not expected that supplies large enough to satisfy the demands of many settlers will be discovered at any one spot.

In those localities in which experience has shown that the ground water deteriorates abruptly and materially with a very slight increase of depth, due to the existence of a large body of saline water beneath a relatively shallow layer of better water, in porous material and without any separation of the "cream" from the salt water by any layer of impervious clay, sinking operations, whether by well or by borehole should be carried on with the utmost caution. Should these precautions fail, and the saline water enter the opening, the excavation should be filled with clay or concrete to the level of the top of the salt water. It is much easier to deal with a problem of this kind in a well than in a borehole; and, if a well is sunk, storage can be provided by shallow lateral openings that do not penetrate into the salt water. It is a simple matter to construct a cement-lined sump at the bottom of the well from which supplies may be drawn. Localities in which these conditions have been noted are situated on western Eyre Peninsula at Streaky Bay and to the west of Fowler's Bay; and to some degree, also, on the far south-western flange or rim of the Great Artesian Basin, north of the Transcontinental Railway. It has been noted by R. Lockhart Jack that the best places at which to seek the shallow "cream" of useful water are those at which there is an absence of mallee vegetation, which causes so much loss of water by transpiration that cylic salt accumulates in the soil and is carried down by any water that percolates to the water table. In the marginal portion of the Great Artesian Basin the better water occurs where rain is shed from residual outcrops of Cretaceous shale (See Fig. 19) and the best places at which to sink in search of water are those situated on the margins of such outcrops.

In the central and western portions of upper Eyre Peninsula, where the outcrops of the foundation rocks, chiefly granites, are small and few in number, and where the valleys or depressions between these outcrops have been filled with sediments of Tertiary to Recent age, it is admittedly very difficult to locate useful supplies. Exploratory work should be confined principally to the search for buried gutters in the foundations that are high enough above the main valley bottoms to reach a water table above the level of the saline water that saturates the lowest portion of the sedimentary deposits. The procedure would involve a series of shallow boreholes, dispersed peripherally round the granite outcrops and carried down only as far as the hard rock. In the event of any such borehole proving to be dry, the drill should be moved farther away from the granite outcrop, in order to reach bottom at a greater depth.

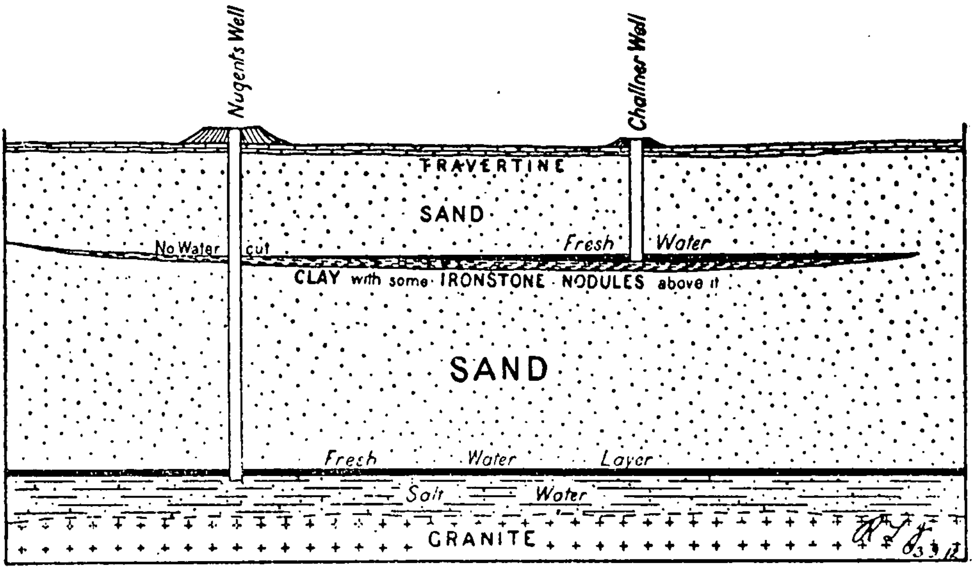


Fig. 40.—Section showing suspended water table at Challner Wells.

In this region some small supplies have been located where buried clay pans have given rise to suspended water tables at much higher levels than the main water table. Where the lenticular beds of clay are shallow there may be developed a superficial mass of tabular travertine limestone, and where such travertine occurs shallow boring with a hand-drill can be used to prospect for water. Care must be taken to avoid penetrating the clay bed that holds up the water, since it may be only a few inches in thickness. (See Fig. 40.)

In the search for water in coastal sand dunes it has to be borne in mind that the useful supplies occur only above sea level, and that, if too deep an excavation is made the rise of the tide may cause sea water to enter a well that is close to the shore. Coastal wells may, therefore, afford water good enough for use only at low tide, when the better water absorbed by the dunes may be drawn from the opening. There are several localities on the South Australian coast from which such supplies are drawn, and there is a similar occurrence on the margin of Lake MacDonnell, south of Penong. Failing other supplies, stock water may be sought wherever sand dunes occur.

In all cases consideration should be given to the avoidance of pollution through the downward seepage of contaminated water until it joins the underground storage. Since the water table conforms in a general way with the surface contours, although its slopes are less pronounced as a general rule, it follows that the site for a well or borehole should be sufficiently high above possible source of pollution to avoid this danger. It is, of course, best to establish the water supply first, and to arrange the location of stables, yards, pens, etc., at lower levels subsequently. The cost of piping water from a safe site is small in comparison with the benefits enjoyed.

Unless the underground water is of exceptionally high quality it should not be brought to the surface until it is required for use, since evaporation increases the salinity, and the water left underground is protected from evaporation.

Whatever method may be adopted to develop an underground supply of water it is important to remember that the quantity and quality of any water discovered should be ascertained. In very many boreholes several aquifers are pierced in succession as the work proceeds and in far too many cases some of these occurrences remain untested. The driller may express an opinion that the quantity available is small, without having made an actual test to find out what the yield is. *Every supply of water should be tested separately as soon as it is struck in drilling.* Drillers who are working on a contract basis, and who are drilling in soft country that permits rapid progress, may yield to the temptation to continue drilling when they should stop and carry out a pumping test; and many cases have been noted in which unnecessary drilling has been paid for. Every drilling contract should contain a clause providing for the testing of every supply under some arrangement for a specified payment per day while the test is being carried out. A sample for analysis should be obtained at the end of the pumping test.

Lest it be thought that the omission of adequate testing is the fault of private drilling contractors only, a case in which the Government itself was concerned may be cited. The Croydon borehole, drilled in the Port Road plantation was begun in 1890 and completed in 1893, having eventually reached a depth of 2,296ft., and ended in the slate that underlies the Adelaide plains. The presence of water was actually recorded at depths of 25ft., 75ft., 215ft., 245ft., 315 ft., and 960ft., but in no case was either the quantity or quality available tested and recorded. During the drought of 1934 it became clear, from the records of drillings in this district, that considerable supplies of useful water were to be obtained there. Boreholes were drilled at Hindmarsh, 38 chains distant from the Croydon borehole, and at York, 58 chains from it. At Hindmarsh it was found that 10,000 gallons per hour could be pumped from an aquifer at 56ft., and at York the lower of two aquifers, at 573ft., gave a pumping supply of 16,000 gallons per hour. The Hindmarsh water carried 56.66 grains, and that at York 56.42 grains of total solids per gallon. More recently, during 1945, a borehole drilled in the Wolseley Plantation on the Port Road, and only 18 chains distant from the old Croydon borehole, gave proof of the existence of water carrying 59.21 grains per gallon in an aquifer from which, between 600ft. and 650ft. below the surface, it was shown that a pumping supply of 6,500 gallons per hour was obtainable. There can be no doubt but that a valuable yield could have been derived from the Croydon borehole had it been put to the test.

Other cases of similar character could be quoted, but it seems unnecessary to make separate mention of them.

In order that a proper record should be kept of any borehole or well sunk in search of water the following particulars should be preserved:—

1. The exact position of the well or borehole, by reference to the hundred, the number of the section, and the part of the section where the opening is made.
2. The altitude of the site above the surrounding country and above sea level.
3. The detailed log, showing all the rocks penetrated.
4. The total depth.
5. The exact depth at which each supply of water was struck, and the thickness of the aquifer.
6. The details regarding each supply separately, including:—
    - *a.* The depth below the surface at which the water stands before pumping.
    - *b.* The quantity available by actual pumping test.
    - *c.* The quality of the water, as determined by analysis.
    - *d.* The depth below the surface at which the pump was fixed during the test.
    - *e.* The effect of pumping on the water level during the test.
    - *f.* The time taken after the test for the water to rise to its former level.
    - *g.* Particulars regarding the rise of sand, or other difficulties.
    - *h.* The details regarding the casing left in the borehole.
7. In the case of a well, particulars regarding the amount of timber used, and the depth, length, and dimensions of any drives.
8. The nature of the surface equipment for raising and storing water.

If the water is used, the manner of its use should be recorded. If used in horticulture the kinds of plants that will tolerate the water should be noted. If used for stock any noteworthy features of its effect on the animals should be recorded, especially if the salinity is near the limit of toleration.

It has happened on more than one occasion that some trouble has been experienced long after the well or borehole has been put down, and the absence of such detailed information has made it difficult to advise as to what remedial measures should be adopted.

In conclusion it is urged that the information set forth in this Bulletin with regard to the several artesian basins and ground water areas should not be thought to be complete and final. Much investigatory work remains to be done, and this work may well indicate possibilities of further development. Yet the basic principles governing the occurrence of underground water, founded as they are upon the experience gained in many parts of the world, must remain unchanged in any essential respect. It is in the application of these principles that wise development will take place and the resources of the State will be conserved.

XVI. MEMORANDA DEALING WITH WATER.

1in. of rain yields 22,622.5 gallons per acre.

1in. of rain yields about 14 million gallons per square mile.

1in. of rain yields about ½ gallon per square foot of catchment.

1in. of rain yields about 100 tons per acre.

1 cubic foot of water contains 6.23 imperial gallons (nearly 6¼).

1 cubic foot of water weighs 62.5 lb. at a temperature of 40° F.

36 cubic feet of water weigh 1 ton of 2,240 lb.

1 imperial gallon weighs 10 lb.

1 imperial gallon is equivalent to nearly 1⅕ U.S. liquid gallons.

1 U.S. liquid gallon weighs 8.34 lb.

1 imperial gallon is equivalent to 4.5449 litres.

1 litre is equivalent to 1.759 pints, or 0.22 gallon.

1 foot of head gives a pressure of 0.43 lb. per square inch.

1 lb. of pressure per square inch is due to 2.309ft. of head.

1 cubic foot per second (cusec) is equivalent to 22,428 imperial gallons per hour.

1 cubic foot per second (cusec) is equivalent to 538,272 imperial gallons per day.

To convert cubic feet per minute into gallons per day multiply by 8,971.2 nearly 9,000).

1 ounce, avoirdupois, contains 437.5 grains.

1 lb. avoirdupois, contains 7,000 grains.

Average sea water contains 3.5 per cent of dissolved salts.

Average sea water contains 5.6oz. of dissolved salts per imperial gallon.

TABLE IV.

UNDERGROUND WATERS USED FOR BOILER FEED, SOUTH AUSTRALIAN RAILWAYS.

Source of Supply—	Willunga Well.	Alawoona Bore.	Bull Island Well.	Karoonda Bore.	Millicent Well.	Mindarie Bore.	Mulpata Bore.	Naracoorte Bore.	Peebinga Bore.	Penola Bore.
Hundred—	Willunga.	Allen.	Townsend.	Marmon Jabuk.	Mount Muirhead.	Mindarie.	Cotton.	Naracoorte.	Peebinga.	Penola.
Date of Sampling—	—	April, 1945.	3/5/37.	April, 1945.	20/4/34.	April, 1945.	19/1/29.	30/11/39.	21/9/29.	21/6/37.
Dissolved salts (grains per gallon)—										
Calcium carbonate	11·5	11·3	16·5	13·7	11·4	7·2	13·2	10·0	7·7	19·0
Magnesium carbonate	7·6	11·8	6·5	13·3	—	9·9	2·8	8·8	8·7	0·6
Sodium carbonate	—	—	0·6	—	—	4·9	—	—	—	—
Calcium sulphate	—	—	—	—	6·5	—	—	—	—	—
Magnesium sulphate	4·4	5·3	—	13·1	5·4	—	18·2	4·0	10·1	3·2
Calcium chloride	—	—	—	—	—	—	3·5	—	—	—
Magnesium chloride	2·4	—	—	—	3·0	—	—	—	—	4·5
Sodium chloride	53·3	78·9	37·5	106·3	8·6	56·0	111·9	57·6	50·2	36·6
Sodium sulphate	—	23·1	2·9	5·7	—	13·0	—	12·6	3·6	—
Undetermined	8·6	2·5	1·4	—	0·8	—	6·8	0·7	4·3	2·4
Suspended matter	—	—	—	—	—	0·5	—	—	—	—
Total solids	87·8	132·9	65·4	152·1	35·7	91·6	156·4	93·7	84·6	66·3
Hardness (degrees)—										
Total	22·6	29·6	24·2	40·3	23·7	18·9	35·3	* 23·8	26·4	27·1
Temporary	17·0	25·3	24·2	29·5	11·4	18·9	16·5	20·5	18·0	19·7
Permanent	5·6	4·3	—	10·8	12·3	—	18·8	3·3	8·4	7·4
Due to calcium	10·0	11·3	16·5	13·7	16·2	17·1	13·2	10·0	7·7	19·0
Due to magnesium	12·6	18·3	7·7	26·6	7·5	11·8	22·1	13·8	18·7	8·1

* Softening (base exchange) process used. Analyses by S.A. Railways.

TABLE IV.—*continued.*

UNDERGROUND WATERS USED FOR BOILER FEED, SOUTH AUSTRALIAN RAILWAYS—*continued.*

Source of Supply—	Pinnaroo Bore.	Tintinara Bore.	Wanbi Bore.	Wilkawatt Bore.	Wolseley Well.	Quorn Bore.	Pearlah Springs.	Bordertown Bore.	Tooligie Well.
Hundred—	Pinnaroo.	Coombe.	Mindarie.	Cotton.	Tatiara.	Pichi Richi.	Wanilla.	Tatiara.	Peachna.
Date of Sampling—	2/7/37.	23/8/30.	17/6/12.	26/6/37.	Aug., 1937.	Nov., 1942.	18/9/34.	10/11/39.	June, 1944.
Dissolved salts (grains per gallon)—									
Calcium carbonate	11·0	5·4	9·0	11·0	13·5	16·2	13·1	7·0	10·5
Magnesium carbonate	5·3	6·8	15·6	3·9	4·2	22·9	2·4	9·6	5·0
Sodium carbonate	—	6·9	19·6	—	—	2·5	—	5·8	—
Calcium sulphate	—	—	—	—	—	—	—	—	—
Magnesium sulphate	3·2	—	—	8·1	7·4	—	2·4	—	2·6
Calcium chloride	—	—	—	—	—	—	—	—	—
Magnesium chloride	—	—	—	—	7·3	9·3	3·0	—	0·7
Sodium chloride	26·4	43·9	70·4	52·5	59·0	64·0	12·2	55·6	15·8
Sodium sulphate	7·4	7·4	25·1	0·2	—	11·5	—	11·5	—
Undetermined	0·2	3·5	—	0·9	0·7	1·0	2·5	—	—
Suspended matter	—	—	—	—	—	2·4	—	—	—
Total solids	53·4	74·0	147·5	76·6	91·1	112·7	35·6	89·5	34·6
Hardness (degress)—	*	*		*				*	
Total	20·0	13·5	27·5	22·5	32·3	42·0	21·2	18·4	19·4
Temporary	17·4	13·5	27·5	15·6	18·5	16·0	16·0	18·4	16·4
Permanent	2·6	—	—	6·9	13·8	26·0	5·2	—	3·0
Due to calcium	11·1	5·4	9·0	11·0	13·5	18·9	13·2	7·0	10·5
Due to magnesium	8·9	8·1	18·5	11·5	18·8	23·1	8·0	11·4	8·9

* Softening (base exchange) process used. Analyses by S.A. Railways.

TABLE V.

SOURCES OF BOILER FEED WATER ON COMMONWEALTH NORTH-SOUTH RAILWAYS.

Source.	Flinders Range.					Great Artesian Basin										
	Quorn Bore.	Hawker Bore.	Hookina Bore.	Brachina Bore.	Beltana Bore.	Marree Bore.	Alberrie Creek Bore.	Curdimurka Bore.	Beresford Bore.	Anna Creek Bore.	Edwards Creek Bore.	Mount Dutton Bore.	Oodnadatta Bore.	Alberga Bore.	Pedirka Bore.	Abminga Bore.
Reduced level (ft.) datum 100ft. below L.W. Port Augusta ..	1,061	1,230	749·5	555·5	—	240	194·5	94	198	437	517	373	483	494	631	816
Static water level (ft.) below surface	45	111	57	125	30	Flows	Flows	Flows	Flows	80	120	Flows	Flows	Flows	113	230
Total depth (ft.)	305	350	90	362	303	392	690	450	310	410	623	367	1,571	1,128	1,310	860
Depth of pump (ft.)	—	—	—	202	120	—	—	—	—	242	240	—	—	—	—	—
Depth of aquifer (ft.)	193	144	87	335	50	380	232	306	310	?	580	325	1,570	1,077	1,020	—
Yield (gallons per hour)	10,000	4,000	2,800	10,000	1,440	3,000	480	3,600	6,000	4,080	7,200	4,000	3,000	6,500	14,000	1,000
Composition (grains per gallon)—																
Calcium carbonate	16·0	7·8	12·0	5·7	—	2·5	1·8	3·4	12·0	—	14·9	7·2	12·1	11·7	1·1	8·4
Calcium sulphate..........	—	44·2	19·6	10·8	—	—	—	—	—	—	16·9	21·4	—	3·1	14·3	16·1
Magnesium carbonate......	17·9	—	13·7	7·0	—	3·2	3·4	3·6	10·9	—	—	5·9	4·5	4·6	8·1	—
Magnesium chloride	—	31·8	—	6·2	—	—	—	—	—	—	14·5	—	2·0	—	—	13·7
Sodium carbonate	5·6	—	—	—	—	53·2	63·1	60·6	17·1	—	—	—	—	—	—	—
Sodium sulphate	8·5	—	14·7	—	—	—	1·5	5·7	20·3	—	21·2	43·1	30·3	35·4	7·1	4·0
Sodium chloride	53·1	127·4	38·6	41·8	—	99·9	159·1	120·2	212·2	—	64·2	128·2	80·1	77·8	57·7	64·4
Total salts	101·1	211·2	98·6	71·5	139·7	158·8	228·9	175·6	272·5	220·5	131·7	205·8	129·0	132·6	88·3	106·6
Hardness (English degrees)—	*	*				*		*	*		*		*			
Total	37·3	73·0	41·3	28·6	56·9	6·3	5·8	7·7	25·0	91·56	42·6	29·9	19·6	18·7	21·3	34·6
Temporary	37·3	65·2	28·3	14·8	29·4	6·3	5·8	7·7	25·0	20·65	14·9	15·7	17·5	17·2	10·8	8·4
Permanent	—	7·8	13·0	13·8	23·4	—	—	—	—	80·71	27·7	14·2	2·1	1·5	10·5	26·2
Due to calcium	16·0	39·6	25·1	13·7	22·3	2·5	1·8	3·4	12·0	54·81	27·3	22·9	12·2	13·9	11·6	20·2
Due to magnesium	21·3	33·4	16·2	14·9	34·6	3·8	4·0	4·3	13·0	36·75	15·3	7·0	7·4	4·8	9·7	14·4

* Softening plants installed.

Analyses by Commonwealth Railways.

TABLE VI.

ANALYSES OF WATER IN THE MAIN (JURASSIC) AQUIFER OF THE GREAT AUSTRALIAN ARTESIAN BASIN SHOWING THE EXCESS OR DEFICIENCY OF CARBONIC ACID.

Bore.	Date.	Total Salts.	Chlorine.	CO_3.	SO_4.	CO_3 Equivalent of SO_4.	Excess or Deficiency of CO_3.
		Grains per Gall.	Grains per Gall.	Grains per Gall.	Grains per Gall.	Grains per Gall.	Grains per Gall.
Abdul (Marree)	21/1/15	141·31	47·35	34·71	Nil	Nil	34·71
Allinga	16/11/22	53·69	19·74	4·80	8·94	5·63	0·83
Anacoora (N.T.)	1900	61·40	22·00	5·31	9·58	6·04	0·73
Andado No. 1 (N.T.)	28/3/27	234·89	115·13	8·55	27·31	17·20	−8·65
Andado No. 2 (N.T.)	27/10/26	82·97	34·58	5·40	12·52	7·88	−2·48
Anna Creek	1891	366·33	176·22	10·02	42·81	26·97	−16·95
Appatina	20/2/22	70·42	17·08	8·25	17·84	11·24	−2·99
Appreetinna	30/11/22	378·92	165·81	7·65	71·69	45·16	−37·51
Apperinna	28/6/23	146·13	58·06	9·30	22·12	13·94	−4·64
Arboola	1/12/24	123·20	29·11	41·10	0·99	0·62	40·48
Bangaboorana	18/2/15	361·10	146·51	10·05	77·22	48·65	−38·60
Billa Kalina Sp.	1891	366·15	165·97	35·11	29·07	18·31	16·80
Birribirriana	26/2/15	169·81	61·77	9·30	36·50	22·99	−13·69
Blanche Cup Sp.	1891	282·40	132·58	29·16	10·46	6·59	22·57
Blood's Creek	16/11/22	77·44	30·62	4·20	13·92	9·77	−4·57
Bopeechee Sp.	1891	178·28	60·48	37·14	9·02	5·68	21·46
Breaden	16/11/22	139·22	49·22	10·65	27·68	17·44	−6·79
Brown's Creek	28/6/23	165·11	68·25	9·90	23·52	14·82	−4·92
Cadnaowie Sp.	1891	163·50	59·85	10·44	30·37	19·13	−8·69
Cannuwaukaninna	5/10/16	85·83	17·63	28·40	0·12	0·08	28·32
Cannuwaukaninna	16/11/22	72·96	14·31	26·70	Nil	Nil	26·70
Cat. Sp.	1891	317·56	119·42	22·18	56·89	35·84	−13·66
Charlotte Waters (614ft. 6in.)	24/9/24	87·57	38·93	5·10	11·49	7·23	−2·13
Clayton	30/9/22	76·10	10·81	31·95	0·37	0·23	31·72
Clayton Dam	5/12/14	118·46	30·14	36·00	2·10	1·30	34·70
Clayton Dam	15/12/22	118·29	29·73	36·30	2·31	1·45	34·85
Corryaninna	5/12/14	70·81	9·55	29·61	Nil	Nil	29·61
Cooinchina	25/5/23	385·11	184·24	10·05	45·44	28·63	−18·58
Coonanna	31/8/23	159·26	34·89	57·30	Nil	Nil	57·30
Coonanna	1/12/24	159·75	35·38	56·10	1·11	0·70	55·40
Coonee Creek	1/12/24	134·53	27·30	49·50	1·03	0·65	48·85
Cootanoorinna Sp.	26/2/15	216·17	83·05	13·80	40·95	25·80	−12·00
Coward	1891	252·74	106·12	34·62	13·27	8·36	26·26
Coward	1894	245·50	102·20	34·63	12·57	7·92	26·71
Coward	13/2/15	233·62	95·80	36·30	7·74	4·88	31·42
Coward	27/10/22	230·11	93·62	34·80	10·75	6·77	28·03
Coward Sp.	1891	239·22	97·44	34·14	13·92	8·77	25·37
Culberta	31/1/22	116·19	31·63	35·85	0·62	0·40	35·25
Curraworra	31/8/23	121·76	25·12	44·85	Nil	Nil	44·85
Dalhousie Homestead Sp.	1913	79·17	31·16	16·67	Nil	Nil	16·67
Dalhousie Hot Sp.	1913	62·39	23·82	7·20	7·00	4·41	2·79
Dulkaninna	1898	65·95	8·16	29·99	Nil	Nil	29·99
Dulkaninna	30/9/22	67·98	8·04	29·55	0·45	0·28	29·27
Emerald Sp., 50,000 g.p.d.	23/5/23	263·55	110,27	30·90	20·47	12·90	18·00

TABLE VI.—*continued.*

Bore.	Date.	Total Salts.	Chlorine.	CO_3.	SO_4.	CO_3 Equivalent of SO_4.	Excess or Deficiency of CO_3.
		Grains per Gall.	Grains per Gall.	Grains per Gall.	Grains per Gall.	Grains per Gall.	Grains per Gall.
Francis Sp.	1891	373·61	179·34	9·66	45·16	28·45	−18·79
Fred's Sp.	1891	125·73	36·68	36·18	1·61	1·01	35·17
Giddigiddinna Sp.	17/10/19	273·34	115·59	10·65	50·14	31·59	−20·94
Glenmanyie	31/8/21	140·19	29·62	49·35	3·29	2·07	47·28
Goyder's Lagoon	1905	56·20	5·04	23·26	Nil	Nil	23·26
Gypsum	16/11/22	502·75	271·85	1·50	52·08	32·81	−31·31
Hamilton	1896	112·79	43·80	8·39	19·33	12·18	−3·79
Hamilton	28/4/14	80·46	28·36	6·30	14·58	9·19	−2·89
Hamilton	16/11/22	84·51	32·62	6·30	14·62	9·21	−2·91
Hawker's Sp.	5/6/23	329·58	153·88	8·25	44·74	28·25	−20·00
Hergott Railway Yard	December, 1909	212·00	92·00	31·37	0·82	0·52	30·85
Hergott (Marree)	December, 1909	162·22	57·00	35·92	Nil	Nil	35·92
Hergott Sp.	1891	157·22	46·41	42·36	Nil	Nil	42·36
Hope Creek	5/6/23	329·47	157·37	8·70	40·37	25·40	−16·70
Hopeless Well	15/8/28	227·63	107·10	5·55	31·81	20·04	−14·49
Horseshoe (Macumba)	1913	169·96	67·96	8·70	28·42	17·90	−9·20
Horseshoe	28/6/23	167·13	67·55	9·60	26·94	17·98	−7·38
Imbitcha	13/2/15	279·14	109·20	9·15	63·28	39·87	−30·72
Imbitcha	12/11/22	260·75	106·13	6·15	58·46	36·84	−30·69
Jewellry Creek	5/12/14	66·83	8·07	26·68	Nil	Nil	26·68
Kalladeina	23/10/41	62·29	4·85	30·50	0·29	0·18	30·32
Kopperamanna	1898	55·03	10·35	21·64	Nil	Nil	21·64
Kopperamanna	16/11/22	72·71	15·74	25·35	Nil	Nil	25·35
Lake Crossing	1897	735·38	364·00	4·20	82·86	52·05	−48·85
Lake Harry	1896	92·08	18·15	35·32	Nil	Nil	35·32
Lake Harry	1909	96·20	17·80	34·84	Nil	Nil	34·84
Lake Harry	30/9/22	95·12	18·99	35·40	0·33	0·21	35·19
Lake Letty	10/8/21	96·14	17·91	37·85	Nil	Nil	37·85
Little Perry	5/6/23	235·49	106·78	7·20	33·66	21·25	−14·05
Macumba H.S.	28/6/23	205·01	93·87	8·25	24·39	15·36	−7·11
McLeod's	13/2/15	272·88	100·59	9·30	67·94	42·80	−33·50
McLeod's	16/11/22	270·13	100·16	9·30	67·44	42·49	−33·19
Meteor	5/12/14	86·98	11·78	36·00	0·24	0·15	35·85
Mirackina	8/3/15	250·04	90·80	10·65	59·99	37·79	−27·14
Milne	5/6/23	164·46	67·00	10·05	25·21	15·90	−5·85
Mirra Mitta	23/10/41	51·35	4·93	22·72	2·14	13·48	+9·24
Molehill Sp.	26/2/15	193·77	73·26	9·00	42·18	26·57	−17·57
Montecollina	11/9/20	280·36	156·60	10·05	3·33	2·10	7·95
Montceollina	15/12/22	273·93	131·50	11·10	Nil	Nil	11·10
Mt. Gason	23/10/41	51·25	4·84	23·65	1·07	0·67	22·98
Mt. Hamilton Sp.	1891	308·47	137·76	26·22	25·26	15·91	10·31
Mt. Sarah	10/6/40	112·53	44·31	8·70	17·82	11·22	−2·52
Mother's Well	21/2/22	145·03	46·01	8·85	39·10	24·63	−15·78
Mulka	23/10/41	59·54	5·95	27·71	0·53	0·33	27·38
Muloowurtinna No. 2	1/12/24	114·04	26·75	38·70	0·70	0·44	38·26
Mungeranie	1900	62·80	5·90	25·52	Tr.	Tr.	25·52

Murnpeowie	March, 1912	104·00	28·20	20·70	10·95	6·75	13·95
Murnpeowie	May, 1912	83·80	14·40	32·35	1·67	1·05	31·30
Murnpeowie	September, 1912	117·03	13·70	51·14	2·57	1·62	49·52
Murnpeowie	September, 1912	124·18	14·10	54·70	1·88	1·18	33·52
Murnpeowie	5/12/14	84·91	14·18	32·40	1·44	0·91	31·49
Murnpeowie	15/12/22	86·44	15·58	31·05	2·64	1·66	29·39
Nilpinna One Mile	8/3/15	145·08	52·98	9·60	28·80	18·14	−8·54
Nilpinna Four Mile	26/2/15	161·48	58·88	10·20	32·92	20·74	−10·54
Nilpinna Five Mile	8/3/15	163·72	58·47	10·80	33·29	20·97	−10·17
Nilpinna Garden	26/2/15	148·77	53·88	9·90	30·49	19·21	−9·31
Nilpinna House	26/2/15	149·08	53·89	9·90	30·62	19·29	−9·39
Nilpinna Sp.	1891	201·67	72·27	16·14	41·15	25·92	−9·78
Opossum	16/11/22	56·02	22·89	4·05	7·95	5·01	−0·96
Oodnadatta	1894	125·59	48·50	9·29	21·87	13·78	−4·49
Oodnadatta	1910	131·70	50·40	9·60	21·45	13·51	−3·91
Oodnadatta	14/2/11	129·50	47·70	9·57	20·57	12·96	−3·49
Oodnadatta	8/3/15	125·99	49·04	16·20	11·29	7·11	9·09
Oodnadatta	16/11/22	127·60	48·50	9·45	21·96	13·83	−4·38
Paralana Hot Sp.	1913	77·72	22·50	10·35	10·56	6·65	3·70
Peachawarrinna	30/9/22	109·90	32·99	30·30	0·24	0·15	30·15
Petermorra	14/11/22	75·97	14·01	29·40	Nil	Nil	29·40
Piarooka	5/6/23	3,006·56	1,794·25	5·70	47·76	30·00	−24·03
Primrose Sp.	5/6/23	202·07	88·63	11·70	25·95	16·03	−4·60
Quart Pot	5/12/14	81·74	11·05	34·50	Nil	Nil	34·50
Raspberry Creek	26/2/15	224·95	82·91	10·20	52·65	33·17	−22·97
Raspberry Creek	16/11/22	223·23	81·84	9·30	54·26	34·18	−24·88
Sinclair	4/9/40	72·03	11·24	30·55	Nil	Nil	30·55
Snake Creek	28/6/23	134·21	52·62	8·55	21·09	13·29	−4·74
Spring Hill Sp.	5/6/23	284·79	131·20	7·65	39·59	25·00	17·35
Stevenson	16/11/22	142·49	51·22	9·45	28·76	18·12	−8·77
Strangways	8/3/15	393·69	192·10	15·15	35·02	22·06	−6·91
Strangways Sp.	1891	416·53	203·84	15·24	39·02	24·58	−9·34
Stuart Range, No. 1	6/5/20	1,329·36	621·12	Nil	240·32	151·40	−151·40
Stuart Range, No. 2	16/9/20	351·58	149·29	6·60	70·70	44·54	−37·94
Stuart Range, No. 2	15/1/21	275·67	113·12	5·40	58·01	36·55	−31·15
Sulphur Sp.	1891	429·47	197·54	25·93	45·57	28·71	−2·78
Thora Soak, bore east of	5/6/23	161·37	65·60	10·95	23·75	14·60	−3·65
Thurlooka	31/1/22	123·07	26·71	44·25	0·62	0·40	43·85
Troudininna	5/12/14	68·54	8·17	29·52	Nil	Nil	29·52
Warrangarrana	13/2/15	224·86	91·79	13·95	37·39	23·56	−9·61
Warranarea	20/7/23	242·84	102·24	8·85	46·06	29·02	−20·17
Weedina Sp.	1891	256·87	103·74	18·55	48·68	30·67	−12·12
Weedina Sp.	8/3/15	264·92	109·77	10·80	49·07	30·91	−20·11
William Creek	13/2/15	353·48	167·48	8·20	44·41	27·98	−19·78
William Creek	24/10/22	354·25	168·31	9·00	43·84	27·62	−18·62
William Creek Railway	1913	365·25	168·48	9·60	42·84	26·99	−17·39
William Creek Station	1913	351·17	167·74	13·50	35·92	22·63	−9·13
Wire Creek (Storm)	16/11/22	148·39	54·94	10·05	26·45	16·66	−6·61
Wood Duck	5/6/23	149·08	59·32	9·60	23·28	14·70	−5·10
Woolatchi	12/7/16	141·20	?	55·98	Nil	Nil	55·98
Yarra Hill	5/12/14	83·27	14·26	32·10	Nil	Nil	32·10
Yerilla	15/7/15	889·73	431·59	2·31	125·74	79·22	−76·91

TABLE VII.

GREAT AUSTRALIAN ARTESIAN BASIN.—WATERS OF EASTERN ORIGIN, WITH EXCESS OF CARBONIC ACID.

Northern Group.

Source.	Abdul Bore. (Marree)	Lake Letty Bore.	Coward Bore.	Lake Harry Bore.	Clayton Bore.	Dulka-ninna Bore.	Peacha-warinna Bore.	Cannu-waukan-inna Bore.
Date—	21/1/15	10/8/21	27/10/22	24/10/41	30/9/22	30/9/22	30/9/22	16/11/22
Ions and Radicles (grains per gallon)—								
Chlorine, Cl	47·35	17·91	93·62	18·21	10·81	8·04	32·99	14·31
Sulphuric acid, SO_4	Nil	Nil	10·75	Nil	0·37	0·45	0·24	Nil
Carbonic acid, CO_3	34·71	37·85	34·80	34·62	31·95	29·55	30·30	26·70
Sodium, Na	54·66	39·66	84·47	38·10	30·11	25·97	42·65	28·09
Potassium, K	2·46							
Calcium, Ca	0·78	Nil	2·72	0·22	0·86	0·93	1·36	1·00
Magnesium, Mg	0·15	0·52	2·55	Nil	0·30	0·54	0·26	0·26
Silica, SiO_2	1·20	0·20	1·20	—	1·70	2·50	2·10	2·60
Total saline matter (grains per gallon)	141·31	96·14	230·11	91·75	76·10	67·98	109·90	72·96
Total saline matter (ounces per gallon)	0·32	0·22	0·52	0·21	0·17	0·15	0·25	0·17
Assumed Composition of Salts (grains per gallon)—								
Calcium carbonate	1·95	—	6·78	0·55	2·15	2·32	3·40	2·50
Calcium sulphate	—	—	—	—	—	—	—	—
Calcium chloride	—	—	—	—	—	—	—	—
Magnesium carbonate	0·52	1·82	8·93	Nil	1·05	1·89	0·91	0·91
Magnesium sulphate	—	—	—	—	—	—	—	—
Magnesium chloride	—	—	—	—	—	—	—	—
Sodium carbonate	55·26	With Pot. Carb. 64·61	43·04	60·58	52·84	47·36	48·78	43·37
Sodium sulphate	—	—	15·90	Nil	0·55	0·66	0·35	—
Sodium chloride	78·03	29·51	154·26	30·02	17·81	13·25	54·36	23·58
Potassium chloride	Pot. Carb. 4·35							
Silica	1·20	0·20	1·20	—	1·70	2·50	2·10	2·60
Hardness (English degrees)—								
Total	2·01	2·17	17·42	0·55	3·40	4·57	4·48	3·58
Temporary	2·01	2·17	17·42	0·55	3·40	4·57	4·48	3·58
Permanent	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Due to calcium	1·95	Nil	6·78	0·55	2·15	2·32	3·40	2·50
Due to magnesium	0·06	2·17	10·64	Nil	1·25	2·25	1·08	1·08

Source.	Kopper-amanna Bore.	Mulka Bore.	Mirra Mitta Bore.	Mount Gason Bore.	Goyder's Lagoon Bore.	Kalla-deina Bore.	Corrya-ninna Bore.	Sinclair Bore.
Date—	16/11/22	7/11/40	23/10/41	23/10/41	23/10/41	23/10/41	5/12/14	4/9/40
Ions and Radicles (grains per gallon)—								
Chlorine, Cl	15·74	5·84	4·93	4·84	5·59	4·85	9·55	11·24
Sulphuric acid, SO_4	Nil	0·25	2·14	1·07	2·55	0·29	Nil	Nil
Carbonic acid, CO_3	25·35	26·66	22·72	23·65	22·48	30·50	29·61	30·55
Sodium, Na	27·90	23·60	20·99	21·58	21·15	26·44	26·92	29·53
Potassium, K							2·19	
Calcium, Ca	0·79	0·21	0·57	Nil	0·57	0·21	0·21	0·21
Magnesium, Mg	0·43	0·24	Nil	0·11	0·15	Nil	0·23	0·50
Silica, SiO_2	2·50	—	—	—	—	—	2·10	—
Total saline matter (grains per gallon)	72·71	56·80	51·35	51·25	52·49	62·29	70·81	72·03
Total saline matter (ounces per gallon)	0·17	0·13	0·12	0·12	0·12	0·14	0·16	0·16
Assumed Composition of Salts (grains per gallon)—								
Calcium carbonate	1·97	0·52	1·42	—	1·42	0·52	0·52	0·52
Calcium sulphate	—	—	—	—	—	—	—	—
Calcium chloride	—	—	—	—	—	—	—	—
Magnesium carbonate	1·50	0·83	—	0·38	0·52	Nil	0·80	1·73
Magnesium sulphate	—	—	—	—	—	—	—	—
Magnesium chloride	—	—	—	—	—	—	—	—
Sodium carbonate	40·81	45·51	38·34	41·31	37·56	53·34	47·79	51·25
Sodium sulphate	—	0·31	3·16	1·58	3·77	0·43	—	Nil
Sodium chloride	25·93	9·63	8·13	7·98	9·22	8·00	15·73	18·53
Potassium chloride							Pot. Carb. 3·87	
Silica	2·50	—	—	—	—	—	2·10	—
Hardness (English degrees)—								
Total	3·76	1·51	1·42	0·38	1·94	0·52	1·48	2·58
Temporary	3·76	1·51	1·42	0·38	1·94	0·52	1·48	2·58
Permanent	Nil	Nil	Nil	Nil	Nil	Nil	—	Nil
Due to calcium	1·97	0·52	1·42	Nil	1·42	0·52	0·52	0·52
Due to magnesium	1·79	0·99	Nil	0·38	0·52	Nil	0·96	2·06

TABLE VIII.

GREAT AUSTRALIAN ARTESIAN BASIN.—WATERS OF EASTERN ORIGIN, WITH EXCESS OF CARBONIC ACID.

EASTERN GROUP.

Source.	Petermorra Bore.	Montecollina Bore.	Lake Crossing Bore.	Coonanna Bore.	Coonnee Creek Bore.	Arboola Bore.	Culberta Bore.	Muloowurtinna No. 2 Bore.	Currawora Bore.	Thurlooka Bore.	Glenmanyie Bore.	Quinyambie New Homestead Bore.	Patchawarra Bore. From 4,000ft.	Jewellry Bore.	Troudaninna Bore.	Paralana Hot Spring.
Date—	14 /11/22	11/9/20	1897	1/12/24	1/12/24	1/12/24	31/1/22	1/12/24	31/8/23	31/1/22	31/8/21	1/5/45	31/10/23	5/12/14	5/12/14	3/9/13
Ions and Radicles (grains per gallon)—																
Chlorine, Cl	14·01	156·60	—	35·38	27·30	29·11	31·63	26·75	25·12	25·51	29·62	35·38	87·10	8·07	8·17	22·50
Sulphuric acid, SO_4	Nil	3·33	—	1·11	1·03	0·99	0·62	0·70	Nil	Nil	3·29	Nil	0·33	Nil	Nil	10·56
Carbonic acid, CO_3	29·40	10·05	—	56·10	49·50	41·10	35·85	38·70	44·85	45·00	49·35	50·63	29·40	28·68	29·52	10·35
Sodium, Na }	30·13 }	102·74	— }	62·90	52·62	40·03	43·29	44·75	48·10	47·64	53·81	60·00	77·77	24·72	25·37	21·53
Potassium, K }		2·73	—											2·10	2·01	2·94
Calcium, Ca	0·64	3·93	—	2·43	2·14	1·07	2·00	1·64	1·14	1·64	1·07	0·36	0·64	0·75	0·75	3·82
Magnesium, Mg	0·39	0·98	—	0·43	0·54	0·30	1·40	0·30	0·65	0·78	1·85	0·79	0·32	0·21	0·27	1·39
Silica, SiO_2	1·40	—	—	1·40	1·40	1·60	1·40	1·20	1·00	1·60	1·20	—	2·50	2·30	2·45	4·63
Total saline matter (grains per gallon)	75·97	280·36	735·38	159·75	134·53	132·20	116·19	114·04	121·76	122·17	140·19	147·45	198·06	66·83	68·54	77·72
Total saline matter (ounces per gallon)	0·17	0·64	1·68	0·36	0·30	0·28	0·26	0·26	0·28	0·28	0·32	0·34	0·45	0·15	0·15	0·17
Assumed Composition of Salts (grains per gallon)—																
Calcium carbonate	1·60	9·82	7·00	6·07	5·35	2·67	5·00	4·10	2·85	4·10	2·67	0·90	1·60	1·87	1·87	9·55
Calcium sulphate	—	—	65·96	—	—	—	—	—	—	—	—	—	—	—	—	—
Calcium chloride	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	1·36	3·43	—	1·50	1·89	1·06	4·90	1·05	2·27	2·73	6·47	2·74	1·12	0·75	0·94	4·86
Magnesium sulphate	—	—	17·25	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium chloride	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium carbonate	48·53	3·02	--	90·78	79·39	68·46	51·85	62·59	73·35	71·71	76·19	85·05	48·83	44·93	46·27	2·03
Sodium sulphate	—	4·92	33·81	1·64	1·52	1·46	0·92	1·03	—	—	4·86	0·43	0·49	—	—	15·61
Sodium chloride }	23·08	253·96	611·36	58·36	44·98	47·96	52·12	44·07	41·39	42·03	48·80	58·33	143·52	13·29	13·46	32·67
Potassium chloride }		5·21	—											Pot. Carb. 3·71	Pot. Carb. 3·55	5·61
Silica	1·40	—	—	1·40	1·40	1·60	1·40	1·20	1·90	1·60	1·20	—	2·50	2·30	2·30	7·39
Hardness (English degrees)—																
Total	3·23	13·91	—	7·86	7·60	3·91	10·84	5·35	5·56	7·35	10·39	4·15	2·93	2·74	2·99	15·33
Temporary	3·23	13·91	—	7·86	7·60	3·91	10·84	5·35	5·56	7·35	10·39	4·15	2·93	2·74	2·99	15·33
Permanent	Nil	Nil	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Due to calcium	1·60	9·82	—	6·07	5·35	2·67	5·00	4·10	2·85	4·10	2·67	0·90	1·60	1·87	1·87	9·55
Due to magnesium	1·63	4·09	—	1·79	2·25	1·24	5·84	1·25	2·71	3·25	7·72	3·25	1·33	0·87	1·12	5·78

TABLE IX.

GREAT AUSTRALIAN ARTESIAN BASIN.—WATERS OF WESTERN ORIGIN, WITH DEFICIENCY OF CARBONIC ACID.

Source.	Strangways Bore.	William Creek Bore.	Oodnadatta Bore.	Hamilton Bore.	Opossum Bore.	Blood's Creek Bore.	Anacoora (N.T.) Bore.	Andado No. 1 (N.T.) Bore. From 705ft.	Andado No. 2 (N.T.) Bore. From 584ft.	Imbitcha Bore.	Gypsum Bore.	Mirackina Bore.	Raspberry Creek Bore.	Cooinchina Bore.	Mount Sarah Bore.	Charlotte Waters (N.T.) Bore. From 615ft.
Date—	15/12/22	15/12/22	16/11/22	16/11/22	16/11/22	16/11/22	1900	28/3/27	27/10/26	12/11/22	16/11/22	8/3/15	16/11/22	25/5/23	10/6/40	24/9/24
Ions and Radicles (grains per gallon)—																
Chlorine, Cl	192·61	168·31	48·50	32·62	22·89	30·62	—	115·13	34·58	106·13	271·85	90·80	81·84	184·24	44·31	38·93
Sulphuric acid, SO_4	33·08	43·84	21·96	14·62	7·95	13·92	—	27·31	12·52	58·46	52·08	59·99	54·26	45·44	17·82	11·49
Carbonic acid, CO_3	16·95	9·00	9·45	6·30	4·05	4·20	—	8·55	5·40	6·15	1·50	10·65	9·30	10·05	8·70	5·10
Sodium, Na } Potassium, K }	132·98	110·54	38·63	22·07	17·24	20·30	—	57·99	21·12	60·49	122·01	52·94	51·12	122·85	34·89	22·55
												6·21				
Calcium, Ca	13·22	15·72	5·14	4·79	1·86	4·22	—	16·78	5·22	18·58	32·66	17·58	17·08	16·94	5·15	5·00
Magnesium, Mg	2·83	4·34	2·42	2·81	1·23	2·38	—	8·83	2·83	10·24	22·25	9·87	8·03	3·39	1·66	3·30
Silica, SiO_2	1·80	2·50	1·50	1·30	0·80	1·80	—	0·30	1·30	0·70	0·40	2·00	1·60	2·20	—	1·20
Total saline matter (grains per gallon)	393·47	354·25	127·60	84·51	56·02	77·44	61·40	234·89	82·97	260·75	502·75	250·04	223·23	385·11	112·53	87·57
Total saline matter (ounces per gallon)	0·89	0·81	0·29	0·19	0·13	0·18	0·14	0·53	0·19	0·60	1·15	0·57	0·51	0·88	0·26	0·20
Assumed Composition of Salts (grains per gallon)—																
Calcium carbonate	28·25	15·00	12·85	10·50	4·65	7·00	8·85	14·25	9·00	10·25	2·50	17·75	15·50	16·75	12·87	8·50
Calcium sulphate	6·53	33·05	—	2·00	—	4·83	1·33	37·67	5·51	49·23	73·78	35·63	36·99	34·81	—	5·44
Calcium chloride	—	—	—	—	—	—	—	—	—	—	27·64	—	—	—	—	—
Magnesium carbonate	—	—	2·43	—	1·76	—	—	—	—	—	—	—	—	—	1·38	—
Magnesium sulphate	14·15	21·70	8·65	14·05	3·65	11·90	0·94	0·90	10·79	29·64	—	4·59	35·19	16·95	6·24	9·56
Magnesium chloride	—	—	—	—	—	—	—	34·25	2·65	17·06	88·07	43·55	3·92	—	—	5·50
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium sulphate	25·36	4·66	22·25	2·91	7·44	1·46	11·79	—	—	—	—	—	—	10·81	18·99	—
Sodium chloride } Potassium chloride }	317·38	277·34	79·92	53·75	37·72	50·45	36·31	147·52	53·72	153·87	310·36	134·66	130·03	303·59	73·05	57·37
							—					11·86				
Silica	1·80	2·50	1·50	1·30	0·80	1·80	2·18	0·30	1·30	0·70	0·40	2·00	1·60	2·20	—	1·20
Hardness (English degrees)—																
Total	44·86	57·41	22·95	23·70	9·78	20·48	—	78·80	24·86	89·19	174·52	85·14	76·22	56·50	19·70	26·27
Temporary	28·25	15·00	15·73	10·50	6·73	7·00	—	14·25	9·00	10·25	2·50	17·75	15·50	16·75	14·52	8·50
Permanent	16·61	42·41	7·22	13·20	3·05	13·48	—	64·55	15·86	78·94	172·02	67·39	60·72	39·75	5·18	17·77
Due to calcium	33·05	39·30	12·85	11·97	4·65	10·55	—	41·95	13·05	46·45	81·65	43·95	42·70	42·35	12·87	12·50
Due to magnesium	11·81	18·11	10·10	11·73	5·13	9·93	—	36·85	11·81	42·74	92·87	41·91	33·52	14·15	6·83	13·77

TABLE X.

GREAT AUSTRALIAN ARTESIAN BASIN.—WATERS OF THE SOUTH-WESTERN MARGIN.

Source.	Stuart Range No. 1 Bore.	Stuart Range No. 2 Bore.	Bon Bon No. 8 Bore.	Bon Bon No. 15 Bore.	Bulgunnia Well.	Bulgunnia, Giffen's Well.	Government Bore, No. 1.	Government Bore, No. 9.	Miller's Creek No. 1 Bore.	Miller's Creek No. 2 Bore.	Mount Clarence No. 2 Bore.	Mount Clarence No. 6 Bore.	Oolgelima West No. 1 Bore.	Oolgelima West No. 3 Bore.	13 Miles West of Twins Well.	Wilgena No. 17 Bore.
Date—	6/5/20	15/1/21	—	—	20/6/25	28/8/25	7/5/25	20/8/25	9/12/26	25/1/28	27/10/27	17/11/27	17/11/27	17/11/27	8/3/27	2/6/25
Ions and Radicles (grains per gallon)—																
Chlorine, Cl	621·12	113·12	—	—	102·35	27·63	859·80	378·97	289·43	36·76	424·87	202·40	69·88	109·93	91·67	292·58
Sulphuric acid, SO_4	240·32	58·01	—	—	48·12	24·43	328·65	131·01	128·54	11·93	149·20	81·84	37·94	66·28	28·67	98·50
Carbonic acid, CO_3	Nil	5·40	—	—	10·95	9·60	0·45	3·00	11·55	10·50	7·80	6·60	11·70	7·95	7·80	6·45
Sodium, Na } Potassium, K }	358·26	74·35	—	—	71·69	22·04	500·64	215·10	167·30	23·82	244·99	115·20	44·43	62·63	43·10	153·18
Calcium, Ca	56·46	18·08	—	—	10·43	6·86	71·04	36·59	49·38	8·22	43·30	28·29	14·15	23·86	16·93	31·87
Magnesium, Mg	50·37	6·11	—	—	7·34	3·67	69·12	27·86	17·66	2·29	30·77	14·72	6·74	10·09	8·62	27·02
Silica, SiO_2	2·83	0·60	—	—	—	3·10	3·50	1·90	1·60	—	—	—	—	—	1·70	3·00
Total saline matter (grains per gallon)	1,329·36	275·67	100·91	475·42	250·88	97·33	1,883·20	794·43	665·46	93·52	900·93	449·05	183·84	280·74	198·49	612·55
Total saline matter (ounces per gallon)	3·04	0·63	0·23	1·09	0·57	0·22	4·19	1·81	1·52	0·21	2·06	1·02	0·46	0·64	0·45	1·40
Assumed Composition of Salts (grains per gallon)—																
Calcium carbonate	—	9·00	15·75	5·50	18·25	16·00	0·75	5·00	19·25	17·50	13·00	11·00	19·50	13·25	13·00	10·75
Calcium sulphate	191·96	49·25	8·19	79·26	10·64	1·56	240·51	117·60	141·71	4·15	129·62	81·15	21·59	63·04	39·88	92·73
Calcium chloride	—	—	—	35·52	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium sulphate	122·99	29·07	6·87	—	36·70	18·35	198·60	60·00	35·64	11·28	72·28	30·80	28·44	27·31	0·65	40·42
Magnesium chloride	102·00	1·19	10·13	81·26	—	—	116·37	62·78	41·69	0·04	63·32	33·28	3·91	17·93	33·62	75·00
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium sulphate	—	—	—	—	16·64	12·80	—	—	—	—	—	—	—	—	—	—
Sodium chloride } Potassium chloride }	903·15	186·58	59·97	273·38	168·65	45·52	1,273·47	547·15	425·57	60·55	622·71	292·82	110·40	159·21	109·64	389·65
Silica	2·83	0·60	—	—	—	—	3·50	1·90	1·60	—	—	—	—	—	1·70	3·00
Hardness (English degrees)—																
Total	351·39	70·70	—	—	56·71	32·81	466·10	207·76	197·16	29·97	234·86	131·29	63·10	101·17	78·30	192·45
Temporary	Nil	9·00	—	—	18·25	16·00	0·75	5·00	19·25	17·50	13·00	11·00	19·50	13·25	13·00	10·75
Permanent	351·39	61·70	—	—	38·46	16·81	465·35	202·76	177·91	12·47	221·86	120·29	43·60	87·92	65·30	181·70
Due to calcium	141·15	45·20	—	—	26·07	17·50	177·60	91·47	123·45	20·55	108·25	70·72	35·37	59·65	42·32	79·67
Due to magnesium	210·24	25·50	—	—	30·64	15·31	288·50	116·29	73·71	9·42	126·61	60·57	27·73	41·52	35·98	112·78

TABLE XI.

GREAT AUSTRALIAN ARTESIAN BASIN.—WATERS OF PERCHED AND MARGINAL BASINS.

Basin—	Cordillo.				Border.				Siccus.		Lake Frome West.				Lyndhurst.	
Source—	Cordillo Bore.	Bull's Hole Bore.	Needle Hill Bore.	Wong-yarra Bore.	Birks-gate Bore. From 431ft.	Glenroy Bore.	Lake Charles Bore.	Lock-hart Bore.	One Gum (Eru-dina) Bore.	Love-day Bore.	Wool-tana No. 22 Bore.	Wool-tana No. 27 Bore.	Wool-tana No. 38 Bore.	Wool-tana No. 41 Bore.	Four Corners Bore.	Wood-gate Bore.
Date—	15/1/25	24/5/28	15/1/25	19/7/24	9/9/25	4/5/25	11/8/27	10/8/26	11/6/28	27/10/24	5/1/25	15/1/25	21/12/25	21/12/25	15/11/24	15/1/25
Ions and Radicles (grains per gallon)—																
Chlorine, Cl	67·16	262·64	234·02	191·10	54·33	137·54	178·36	168·71	371·70	87·27	25·90	15·32	16·03	83·32	235·76	156·57
Sulphuric acid, SO_4	34·11	105·38	12·32	65·05	2·35	55·99	4·89	58·99	82·30	26·13	19·36	5·27	6·26	17·67	116·47	82·93
Carbonic acid, CO_3	16·20	4·50	1·20	7·95	35·70	12·00	40·65	9·90	18·60	8·19	15·15	11·40	11·40	14·70	8·70	9·30
Sodium, Na } Potassium, K }	55·44	153·14	133·33	113·25	56·78	102·26	131·96	112·60	257·78	63·24	22·86	16·07	11·96	68·59	149·36	104·96
Calcium, Ca	8·86	46·09	19·80	25·73	2·00	8·00	6·00	12·86	9·21	3·50	7·28	2·36	3·86	2·57	25·58	21·44
Magnesium, Mg	3·49	9·60	1·21	9·50	2·40	7·13	5·46	9·37	13·93	4·20	3·34	1·25	2·98	1·10	19·01	9·74
Silica, SiO_2	—	—	1·40	0·80	0·60	0·40	1·10	1·00	—	1·12	1·90	2·30	2·50	2·80	1·10	1·70
Total saline matter (grains per gallon)	185·26	581·35	403·28	413·38	154·16	323·32	368·42	373·43	753·52	193·65	95·79	53·97	54·99	190·75	555·98	386·64
Total saline matter (ounces per gallon)	0·42	1·28	0·92	0·94	0·35	0·74	0·84	0·85	1·70	0·44	0·22	0·12	0·12	0·43	1·27	0·88
Assumed Composition of Salts (grains per gallon)—																
Calcium carbonate	22·15	7·50	2·00	13·25	5·00	20·00	15·00	16·50	23·02	8·75	18·20	5·90	9·65	6·41	14·50	15·50
Calcium sulphate	—	146·50	17·45	69·46	—	—	—	21·28	—	—	—	—	—	—	67·25	15·81
Calcium chloride	—	—	38·49	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	4·09	—	—	—	8·40	—	18·92	—	6·72	4·11	5·91	4·37	7·85	3·85	—	—
Magnesium sulphate	11·43	2·47	—	20·02	—	35·65	—	46·85	59·40	15·15	8·30	—	3·70	—	86·25	48·70
Magnesium chloride	—	35·63	4·79	21·77	—	—	—	—	—	—	—	—	—	—	6·96	—
Sodium carbonate	—	—	—	—	47·17	—	32·13	—	—	—	—	8·37	—	14·32	—	—
Sodium sulphate	36·87	—	—	—	3·47	40·63	7·23	9·60	51·60	20·72	18·81	7·79	4·88	26·13	—	10·94
Sodium chloride } Potassium chloride }	110·72	389·25	339·15	288·08	89·52	226·64	294·04	278·20	612·78	143·80	42·67	25·24	26·41	137·24	379·92	257·99
Silica	—	—	1·40	0·80	0·60	0·40	1·10	1·00	—	1·12	1·90	2·30	2·50	2·80	1·10	1·70
Hardness (English degrees)—																
Total	36·50	154·72	54·55	103·97	15·02	49·76	37·46	71·23	80·34	26·27	32·12	11·11	22·09	11·00	143·29	94·25
Temporary	27·00	7·50	2·00	13·25	15·02	20·00	37·46	16·50	30·96	13·63	25·20	11·11	19·00	11·00	14·50	15·50
Permanent	9·50	147·22	52·55	90·72	Nil	29·76	Nil	54·73	49·38	12·64	6·92	Nil	3·09	Nil	128·79	78·75
Due to calcium	22·15	115·22	49·50	64·32	5·00	20·00	15·00	32·12	23·02	8·75	18·20	5·90	9·65	6·41	63·95	53·60
Due to magnesium	14·35	39·50	5·50	39·65	10·02	29·76	22·46	39·11	57·32	17·52	13·92	5·21	12·44	4·59	79·34	40·65

TABLE XII.

ANALYSES OF WATERS FROM MOUND SPRINGS IN THE GREAT AUSTRALIAN BASIN, BY G. A. GOYDER, JUNIOR, SOUTH AUSTRALIAN GOVERNMENT ANALYST, 1891.

	Strangways Springs.	Bopeechee Springs.	Mount Hamilton Spring.	Coward Spring.	Francis Spring.	Blanche Cup Spring.	Fred's Springs.	Hergott Springs.	Catt's Springs.	Cadnaowie Springs.	Billa Kalina Springs.	Sulphur Springs.	Nilpinna Spring.	Weedina Spring.
Physical Properties—														
Reaction of water	Alkaline	Strongly Alkaline	Strongly Alkaline	Strongly Alkaline	Alkaline	Strongly Alkaline	Strongly Alkaline	—	—	—	—	—	—	—
Taste of water	Saline	Saline	Saline	Saline	Saline	Saline	Slightly Saline	—	—	—	—	—	—	—
Solids in Solution (grains per gallon)—														
Potassium, K	4·14	1·59	2·23	1·67	3·19	2·16	0·82	1·81	0·83	1·17	1·47	3·09	1·75	2·03
Sodium, Na	135·10	66·29	106·91	86·30	114·12	99·26	47·43	59·88	104·30	51·88	118·79	137·75	54·29	53·37
Lithium, Li	—	—	—	—	—	—	—	Nil	Nil	Nil	0·03	0·02	Trace	Trace
Magnesium, Mg	3·71	1·66	2·83	2·71	5·06	3·46	1·13	0·58	3·89	1·73	2·48	2·16	4·30	14·30
Calcium, Ca	15·48	2·10	6·96	3·04	17·08	5·32	1·88	1·12	8·04	5·72	10·04	14·58	8·85	14·30
Iron, Fe	—	—	—	—	—	—	—	1·15	0·70	0·02	0·05	Trace	0·09	0·04
Chlorine, Cl	203·84	60·48	137·76	97·44	179·34	132·58	36·68	46·41	119·42	59·85	165·97	197·54	72·27	103·74
Bromine, Br	Nil	Trace	Nil	Trace	Trace	Minute Trace	Nil	Nil	Nil	Nil	Trace	Nil	Nil	Trace
Iodine, I	—	—	—	—	—	—	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Hydrogen, H	—	—	—	—	—	—	—	—	—	—	0·58	0·43	0·27	0·31
Aluminium, Al	—	—	—	—	—	—	—	—	—	0·06	0·09	0·15	0·06	0·03
Sulphuric acid radicle, SO_4	39·02	9·02	25·56	13·92	45·16	10·46	1·61	Nil	56·89	30·37	29·07	45·57	41·15	48·68
Carbonic acid radicle, CO_3	15·24	37·14	26·22	34·14	9·66	29·16	36·18	42·36	22·18	10·44	35·11	25·93	16·14	18·55
Silicic acid radicle, SiO_2	—	—	—	—	—	—	—	3·29	0·89	1·82	1·81	1·43	1·67	1·39
Nitric acid radicle, NO_3	—	—	—	—	—	—	—	0·62	0·42	0·44	0·66	0·82	0·83	0·13
Total	416·53	178·28	308·47	239·22	373·61	282·40	125·73	157·22	317·56	163·50	366·15	429·47	201·67	256·87
Assumed Composition of Salts (grains per gallon)—														
Silicate of iron	—	—	—	—	—	—	—	3·49	1·34	0·06	0·15	Trace	0·27	0·10
Carbonate of iron	—	—	—	—	—	—	—	—	0·65	—	—	—	—	—
Calcium silicate	—	—	—	—	—	—	—	1·45	Nil	2·33	2·06	1·27	1·88	1·83
Calcium carbonate, $CaCO_3$	25·40	5·25	17·40	7·60	16·10	13·30	4·70	1·55	20·10	12·30	—	—	—	—
Calcium sulphate, $CaSO_4$	18·09	—	—	—	36·17	—	—	—	—	—	Nil	18·70	9·56	25·47
Calcium bicarbonate	—	—	—	—	—	—	—	—	—	—	37·78	35·00	21·80	25·04
Magnesium silicate	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate, $MgCO_3$	—	4·43	9·90	9·48	—	12·11	3·96	2·03	13·61	4·28	—	—	—	—
Magnesium sulphate, $MgSO_4$	18·55	—	—	—	24·54	—	—	—	Nil	2·55	5·20	10·80	21·49	38·39
Magnesium chloride, $MgCl_2$	—	—	—	—	0·59	—	—	—	—	—	—	—	Nil	26·21
Magnesium bicarbonate	—	—	—	—	—	—	—	—	—	—	8·68	Nil	—	—
Sodium carbonate, Na_2CO_3	—	55·15	15·39	40·30	—	22·14	53·93	70·63	—	—	—	—	—	—
Sodium sulphate, Na_2SO_4	16·88	13·34	37·81	20·59	—	15·47	2·38	—	84·15	41·90	36·53	34·89	25·46	Nil
Sodium nitrate	—	—	—	—	—	—	—	0·85	0·57	0·60	0·90	1·12	1·14	0·18
Sodium chloride, NaCl	329·71	97·06	223·77	158·05	290·11	215·28	59·16	73·77	195·56	96·87	271·47	320·86	116·40	135·62
Potassium chloride, KCl	7·90	3·05	4·20	3·20	6·10	4·10	1·60	3·45	1·58	2·30	2·69	5·92	3·35	3·88
Aluminium silicate	—	—	—	—	—	—	—	—	—	0·31	0·45	0·75	0·32	0·15
Lithium silicate	—	—	—	—	—	—	—	—	—	—	0·24	0·16	—	—
Carbonic acid, free (cub. in. per gallon)	—	—	—	—	—	—	—	—	—	—	2·60	4·10	—	—

TABLE XIII.

MURRAY RIVER ARTESIAN BASIN.

Source—	Cotton Bore.	Drualat Bore.	Tintinara, New Railway Bore.	Pinnaroo Bore.	Bordertown Bore.	Naracoorte No. 1 Bore.	Naracoorte No. 2 Bore.	Mount Gambier Blue Lake.
Hundred—	Cotton.	Ettrick.	Coombe.	Pinnaroo.	Tatiara.	Naracoorte.	Naracoorte.	Blanche.
Date—	24/9/04	10/7/14	7/4/45	26/1/27	15/10/37	30/11/39	6/3/40	24/5/33
Ions and Radicles (grains per gallon)—								
Chlorine, Cl	26·60	279·74	34·20	15·53	44·42	34·90	34·70	7·92
Sulphuric acid, SO_4	3·84	57·92	7·16	8·85	8·11	11·70	11·70	1·11
Carbonic acid, CO_3	14·10	28·20	14·66	9·75	13·95	12·30	12·90	6·45
Nitric acid, NO_3	—	—	Nil	—	Nil	—	—	—
Sodium, Na } Potassium, K	22·26	196·82	35·49	11·55	30·03	26·70	27·60	4·87
Calcium, Ca	2·58	7·00	0·21	4·35	3·86	4·00	3·60	1·86
Magnesium, Mg	2·51	13·43	0·59	2·72	4·72	3·40	3·50	1·90
Silica, SiO_2	1·11	2·60	—	2·50	—	0·60	1·90	—
Total saline matter (grains per gallon)	73·00	585·71	92·31	55·25	105·09	93·70	96·60	24·11
Total saline matter (ounces per gallon)	0·16	1·33	0·21	0·12	0·24	0·21	0·22	0·06
Assumed Composition of Salts (grains per gallon)—								
Calcium carbonate	6·45	17·50	0·52	10·87	9·65	10·00	9·00	4·65
Calcium sulphate	—	—	—	—	—	—	—	—
Calcium chloride	—	—	—	—	—	—	—	—
Magnesium carbonate	8·68	24·78	2·05	4·52	11·47	8·80	10·50	5·14
Magnesium sulphate	—	31·75	—	7·15	6·98	4·00	2·30	1·39
Magnesium chloride	—	—	—	—	—	—	—	0·55
Sodium carbonate	7·18	—	22·77	—	—	—	—	—
Sodium sulphate	5·68	48·10	10·59	4·62	3·76	12·60	14·60	—
Sodium chloride } Potassium chloride	43·90	460·98	56·38	25·59	73·23	57·60	57·30	12·38
Sodium nitrate	—	—	Nil	—	Nil	—	—	—
Silica	1·11	2·60	—	2·50	—	0·60	1·90	—
Hardness (English degrees)—								
Total	—	73·55	2·95	22·21	29·07	23·80	23·40	12·47
Temporary	—	47·05	2·95	16·25	23·27	20·50	21·50	10·74
Permanent	—	26·50	—	5·96	5·80	3·30	1·90	1·73
Due to calcium	—	17·50	0·52	10·87	9·65	10·00	9·00	4·65
Due to magnesium	—	56·05	2·43	11·34	19·42	13·80	14·40	7·82

Source—	Snuggery Spring.	Racecourse Spring.	Kruger Bore, Mutooroo.	Kruger Dam Bore, Mutooroo.	Brook's Bore, Oakvale.	Gunyah Dam Bore, Chowilla.	5 Mile Well; Quondong Vale, Groundwater.	Rothsay Bore, Mutooroo, Groundwater.
Hundred—	Hindmarsh.	Mount Muirhead.	—	—	—	—	—	—
Date—	23/6/33	23/6/33	1/12/24	19/2/14	28/9/26	21/1/27	22/1/26	11/3/25
Ions and Radicles (grains per gallon)—								
Chlorine, Cl	6·24	5·99	382·50	260·74	342·12	528·72	507·76	581·09
Sulphuric acid, SO_4	0·90	0·90	184·65	92·94	95·79	111·52	173·24	266·64
Carbonic acid, CO_3	11·25	11·25	12·60	13·80	9·60	17·55	20·55	7·20
Nitric acid, NO_3	—	—	—	—	—	—	—	—
Sodium, Na } Potassium, K	3·33	3·81	230·67	157·84	203·37	324·15	294·55	362·46
Calcium, Ca	6·57	5·65	31·80	17·72	21·08	32·44	36·52	50·74
Magnesium, Mg	1·18	1·40	41·23	24·75	24·66	25·01	47·56	46·39
Silica, SiO_2	—	—	0·90	0·80	1·20	2·30	1·30	1·30
Total saline matter (grains per gallon)	29·47	29·00	884·35	568·59	697·82	1,041·69	1,081·48	1,315·82
Total saline matter (ounces per gallon)	0·07	0·07	2·02	1·29	1·59	2·38	2·47	3·01
Assumed Composition of Salts (grains per gallon)—								
Calcium carbonate	16·42	14·12	21·00	23·00	16·00	29·25	34·25	12·00
Calcium sulphate	—	—	79·56	28·96	44·91	70·51	77·59	156·19
Calcium chloride	—	—	—	—	—	—	—	—
Magnesium carbonate	1·97	3·91	—	—	—	—	—	—
Magnesium sulphate	1·13	1·13	160·61	90·62	75·70	77·19	148·09	195·49
Magnesium chloride	1·49	0·16	—	26·24	37·69	37·89	71·01	28·85
Sodium carbonate	—	—	35·52	—	—	—	—	—
Sodium sulphate	—	—	—	—	—	—	—	—
Sodium chloride } Potassium chloride	8·46	9·68	586·76	398·97	517·32	824·55	749·24	921·99
Sodium nitrate	—	—	—	—	—	—	—	—
Silica	—	—	0·90	0·80	1·20	2·30	1·30	1·30
Hardness (English degrees)—								
Total	21·27	19·88	251·52	147·60	154·62	185·49	289·81	320·48
Temporary	18·76	18·77	21·00	23·00	16·00	29·25	34·25	12·00
Permanent	2·51	1·11	230·59	124·60	138·62	156·24	308·48	308·48
Due to calcium	16·42	14·12	79·50	44·30	52·70	81·10	126·85	126·85
Due to magnesium	4·85	5·76	172·02	103·30	101·92	104·39	193·63	193·63

TABLE XIV.

ADELAIDE PLAINS ARTESIAN BASIN.

Source—	S.A. Gas Coy's Bore, Osborne, From 456ft.	General Motors Holden's Bore, Port Road.	Kooyonga Golf Club No. 1 Bore, Lockleys.	Kooyonga Golf Club No. 2 Bore, Lockleys.	Royal Adelaide Golf Club No. 1 Bore, Seaton.	Royal Adelaide Golf Club No. 7 Bore, From 353ft. to 440ft.	State Wool Committee Bore, Rosewater, From 355ft.	Glenelg Town Hall Bore, From 300ft.	Adelaide Oval Well.	Norwood Oval Bore, From 260ft.	Produce Department Bore, Light Square.	Wood-rooffe's Well, Norwood, From 140ft.	Morphettville Racecourse Bore.	Boettcher's Bore, Seaton Park, From 620ft.	Pearson's Bore, Netley, From 548ft. to 572ft.	South Park Lands Bore, From 127ft.
Hundred—	Port Adelaide.	Yatala.	Adelaide.	Adelaide.	Yatala.	Yatala.	Port Adelaide.	Noarlunga.	Yatala.	Adelaide.	Adelaide.	Adelaide.	Adelaide.	Yatala.	Adelaide.	Adelaide.
Date—	26/3/28	22/4/43	4/12/40	4/12/40	24/12/34	8/4/37	15/7/42	25/2/15	15/9/14	16/6/15	22/10/14	25/11/14	6/11/14	1/3/34	14/8/35	15/1/15
Ions and Radicles (grains per gallon)—																
Chlorine, Cl	40·72	26·54	16·40	17·60	16·04	14·70	86·70	25·21	25·47	29·70	53·92	23·72	44·48	16·45	17·33	21·53
Sulphuric acid, SO_4	7·94	6·79	5·10	4·65	5·39	4·89	29·75	8·61	2·80	10·13	10·71	4·08	9·35	6·26	4·69	3·95
Carbonic acid, CO_3	10·80	12·26	11·85	11·85	10·35	10·37	16·08	14·40	18·45	13·20	17·85	15·90	15·75	11·85	15·30	16·50
Nitric acid, NO_3	—	Nil	Nil	Nil	—	Nil	Nil	—	—	—	—	—	—	—	—	—
Sodium, Na } Potassium, K	23·50	15·25	13·64	13·68	9·46	10·28	60·49	19·07	14·07	19·70	30·92	15·64	30·86	12·19	14·62	13·93
Calcium, Ca	6·43	5·86	3·29	3·57	4·64	3·07	6·93	4·21	6·36	5·72	8·15	4·14	5·50	3·91	4·00	5·72
Magnesium, Mg	4·02	4·17	2·51	2·62	3·23	3·17	7·60	3·95	5·53	4·14	7·02	4·75	4·27	3·21	3·17	4·17
Silica, SiO_2	1·70	—	—	—	—	—	—	2·00	1·50	3·30	1·80	1·30	1·90	—	—	2·00
Total saline matter (grains per gallon)	95·11	70·87	52·79	53·97	49·11	46·48	207·55	77·45	74·18	85·89	130·37	69·53	112·11	53·87	59·11	67·80
Total saline matter (ounces per gallon)	0·22	0·16	0·12	0·12	0·11	0·11	0·47	0·17	0·17	0·19	0·30	0·16	0·26	0·12	0·14	0·16
Assumed Composition of Salts (grains per gallon)—																
Calcium carbonate	16·07	14·63	8·22	8·92	11·60	7·68	17·31	10·52	15·90	14·30	20·37	10·35	13·75	9·77	10·00	14·30
Calcium sulphate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Calcium chloride	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	1·63	4·90	8·70	9·08	4·76	8·09	8·01	11·32	12·47	6·47	7·88	13·56	10·50	8·42	10·99	11·09
Magnesium sulphate	9·95	8·51	—	—	6·75	4·16	26·19	3·60	3·50	11·45	13·39	4·40	6·35	3·86	—	4·94
Magnesium chloride	6·03	4·07	—	—	1·96	—	—	—	5·02	—	8·27	—	—	—	—	0·04
Sodium carbonate	—	—	1·29	0·07	—	—	—	—	—	—	—	—	—	—	2·61	—
Sodium sulphate	—	—	7·54	6·88	—	2·32	13·09	8·47	—	1·43	—	0·83	6·31	4·70	6·94	—
Sodium chloride } Potassium chloride	59·73	38·76	27·04	29·02	24·04	24·23	142·95	41·54	35·79	48·94	78·66	39·09	73·30	27·12	28·57	35·43
Sodium nitrate	—	Nil	Nil	Nil	—	Nil	Nil	—	—	—	—	—	—	—	—	—
Silica	1·70	—	—	—	—	—	—	2·00	1·50	3·30	1·80	1·30	1·90	—	—	2·00
Hardness (English degrees)—																
Total	32·61	31·79	18·55	19·70	24·89	20·73	48·59	27·00	38·98	31·38	49·66	30·17	31·57	22·98	23·04	31·70
Temporary	18·00	20·43	18·55	19·70	17·24	17·27	26·82	24·00	30·76	22·02	29·76	26·50	26·27	19·77	23·04	27·53
Permanent	14·61	11·36	Nil	Nil	7·65	3·46	21·77	3·00	8·22	9·56	19·90	3·67	5·30	3·21	Nil	4·17
Due to calcium	16·07	14·63	8·22	8·92	11·60	7·68	17·31	10·52	15·90	14·30	20·37	10·35	13·75	9·77	10·00	14·30
Due to magnesium	16·54	17·16	10·33	10·78	13·29	13·05	31·28	16·48	23·08	17·28	29·29	19·82	17·82	31·21	13·04	17·40

TABLE XV.

ADELAIDE PLAINS BASIN.—ANALYSES OF WATERS PUMPED FROM BOREHOLES DURING 1934 AND USED TO SUPPLEMENT METROPOLITAN RESERVOIR SUPPLIES.

Borehole—	Hiltonia.	Marleston.	Edwardstown.	Mitchell Park.	Paringa Park.	Glenelg East.	Morphettville.	Plympton.	Kurralta Park.	Brooklyn Park.	Seaton Gardens.	Thebarton Oval.	York.
Ions and Radicles (grains per gallon)—													
Chlorine, Cl	28·59	25·73	61·57	24·98	33·61	71·38	58·00	26·72	20·71	16·30	17·50	16·86	55·44
Sulphuric acid, SO_4	2·55	3·42	9·79	8·80	12·22	9·42	11·56	3·46	2·76	4·49	5·39	2·55	10·08
Carbonic acid, CO_3	13·20	13·35	19·50	17·40	16·05	13·20	15·00	11·85	12·75	12·45	10·50	10·65	11·25
Nitric acid, NO_3	—	Trace	—	—	—	—	—	Trace	—	—	—	—	Trace
Sodium, Na Potassium, K	11·43	9·56	28·65	22·54	26·48	40·79	33·31	12·28	13·82	13·39	11·08	10·99	24·50
Calcium, Ca	7·72	8·58	8·65	3·72	4·50	6·72	7·65	6·15	3·86	2·50	3·79	2·72	10·00
Magnesium, Mg	5·07	4·83	11·10	3·67	4·39	6·55	6·64	4·61	3·32	3·17	3·45	3·28	7·10
Total (grains per gallon)—	68·56	65·47	139·26	81·11	97·25	148·06	132·16	65·07	57·22	52·30	51·71	47·05	118·37
Assumed Composition of Salts (grains per gallon)—													
Calcium carbonate	19·30	21·45	21·62	9·30	11·25	16·80	19·12	15·38	9·65	6·25	9·48	6·80	18·75
Calcium sulphate	—	—	—	—	—	—	—	—	—	—	—	—	8·49
Magnesium carbonate	2·28	0·67	9·18	12·72	13·07	4·38	4·96	3·68	9·78	10·99	6·76	9·23	—
Magnesium sulphate	3·20	4·29	12·27	—	3·07	11·80	14·49	4·34	2·47	—	6·75	3·07	5·13
Magnesium chloride	14·72	14·76	23·38	—	—	11·39	8·93	10·46	—	—	0·55	—	23·73
Sodium carbonate	—	—	—	4·89	—	—	—	—	—	1·55	—	—	—
Sodium sulphate	—	—	—	13·01	14·45	—	—	—	1·17	6·64	—	0·15	—
Sodium chloride Potassium chloride	29·06	24·30	72·81	41·19	55·41	103·69	84·66	31·21	34·15	26·87	28·17	27·80	62·27
Sodium nitrate	—	Trace	—	—	—	—	—	Trace	—	—	—	—	Trace
Hardness (English degrees)—													
Total	39·76	41·32	67·31	24·41	29·31	43·75	46·45	34·35	23·32	19·30	23·67	20·30	54·22
Temporary	22·02	22·23	32·53	24·41	26·76	21·98	25·00	19·74	21·26	19·30	17·50	17·75	18·75
Permanent	17·74	19·09	34·78	—	2·55	21·77	21·45	14·61	2·06	Nil	6·17	2·55	35·47
Due to calcium	19·30	21·45	21·62	9·30	11·25	16·80	19·12	15·38	9·65	6·25	9·48	6·80	25·00
Due to magnesium	20·46	19·87	45·69	15·11	18·06	26·95	27·33	18·97	13·67	13·05	14·19	13·50	29·22

TABLE XVI.

PIRIE—TORRENS ARTESIAN BASIN.

Source—	B.H.A. Smelters' Bore, From 575ft.	Searle's Bore, From 334ft. Sec. 132	Saltia Bore, From 178ft. Sec. 885.	Nectar Brook Bore, From 337ft.	Car-michael's Well, Sec. 25.	Pinera Bore, From 240ft. Beltana.	Farewell Bore, From 135ft. Beltana.	Pulchra Bore, From 405ft. Beltana.	Ettenna Bore, From 335ft. Beltana.	Boondi Bore, From 96ft. Beltana.	Sun-down Bore, From 90ft. Beltana.	Yarra-wurta Bore, From 213ft.	Millya Millyana Bore, From 58ft.
Hundred—	Pirie.	Pirie.	Daven-port.	Winnin-owie.	Telowie.	—	—	—	—	—	—	—	—
Date—	10/7/28	10/8/28	9/12/27	29/3/27	24/11/13	18/11/26	13/10/27	18/11/26	27/7/23	8/11/26	12/8/26	26/6/25	27/11/23
Ions and Radicles (grains per gallon)—													
Chlorine, Cl	229·25	185·85	38·75	448·56	112·32	119·28	169·68	170·10	229·61	354·53	48·89	687·98	126·97
Sulphuric acid, SO_4	31·23	22·96	7·86	22·82	32·79	47·21	62·27	57·84	73·09	91·95	20·64	176·83	39·43
Carbonic acid, CO_3	13·80	8·25	15·90	16·50	19·35	11·10	8·25	11·10	12·60	10·80	10·65	8·10	8·55
Sodium, Na } Potassium, K }	130·82	106·98	12·98	273·00	43·71	90·28	102·51	98·78	146·25	149·12	26·94	412·32	59·41
Potassium, K					2·80								
Calcium, Ca	19·58	14·08	15·43	18·87	23·87	10·50	13·00	22·51	19·01	45·88	10·07	58·89	16·79
Magnesium, Mg	11·05	7·77	4·95	10·15	13·30	3·15	15·20	11·34	13·20	41·77	6·04	34·76	15·12
Silica, SiO_2	—	—	—	0·60	3·00	1·70	—	1·90	0·90	2·30	1·10	1·10	0·90
Total saline matter (grains per gallon)	435·73	345·89	95·87	790·50	256·14	283·22	370·91	373·57	494·68	696·35	124·33	1,379·98	267·17
Total saline matter (ounces per gallon)	0·99	0·79	0·22	1·80	0·58	0·64	0·84	0·85	1·13	1·59	0·28	3·18	0·61
Assumed Composition of Salts (grains per gallon)—													
Calcium carbonate	23·00	13·75	26·50	27·50	32·25	18·50	13·75	18·50	21·00	18·00	17·75	13·50	14·25
Calcium sulphate	35·29	29·17	11·13	26·76	37·30	10·54	25·47	31·37	36·07	130·28	9·09	161·86	37·70
Calcium chloride	—	—	4·32	—	—	—	—	—	—	0·97	—	—	—
Magnesium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium sulphate	7·92	2·97	—	4·91	8·07	15·75	55·51	26·97	59·54	—	18·15	85·57	16·02
Magnesium chloride	37·00	28·08	19·38	36·30	46·27	—	15·61	23·56	5·10	165·33	9·54	68·99	47·18
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium sulphate	—	—	—	—	—	40·19	—	—	—	—	—	—	—
Sodium chloride } Potassium chloride }	332·52	271·92	34·54	694·43	123·90	196·54	260·57	251·27	372·07	397·47	68·70	1,048·96	151·12
Potassium chloride					5·35								
Silica	—	—	—	0·60	3·00	1·70	—	1·90	0·90	2·30	1·10	1·10	0·90
Hardness (English degrees)—													
Total	94·42	67·17	58·94	89·53	115·18	39·39	95·04	103·60	102·62	289·03	50·38	292·50	105·08
Temporary	23·00	13·75	26·50	27·50	32·25	18·50	13·75	18·50	21·00	18·00	17·75	13·50	14·25
Permanent	71·42	53·42	32·44	62·03	82·93	20·89	81·29	85·10	81·62	271·03	32·63	179·00	90·83
Due to calcium	48·95	35·20	38·57	47·17	59·67	26·25	32·50	56·27	41·97	114·70	25·17	147·22	41·97
Due to magnesium	45·47	31·97	20·37	42·36	55·51	13·14	62·54	47·33	63·11	174·33	25·21	145·28	63·11

TABLE XVII.
OTHER ARTESIAN AND GROUNDWATER BASINS.

Basin—	Artesian Basins.											Groundwater Basins.			
	Eucla.							Willochra.		Walloway.	Wil-lunga.	Polda.	Robin-son.	Uley-Wanilla.	
Source—	Robert's Well Bore.	Gil-gurabbie Bore.	Guine-warra Bore, From 975ft.	Mallabie Bore.	No. 2 Bore.	No. 5 Bore.	Mud-daugna Bore, From 798ft.	G. Schmidts Bore.	Quorn Bore.	Arthur's Bore.	Scam-mell's Bore.	Test Trench Sec. 4, Hundred Squire.	Pumping Trench Sec. 8NW, Hundred Forrest.	Fountain Spring, Hundred Wanilla.	Trial Bore, No. 17, Sec. 6, Hundred Uley.
Date—	21/4/14	1/2/21	16/5/92	14/1/20	10/6/21	21/3/93	5/7/23	6/1/27	25/1/26	9/2/26	23/4/14	15/8/34	2/8/39	22/10/40	10/6/40
Ions and Radicles (grains per gallon)—															
Chlorine, Cl	—	453·07	762·30	669·53	483·73	413·00	336·32	147·07	44·46	43·00	15·37	19·38	14·65	8·98	6·73
Sulphuric acid, SO_4	—	106·79	200·10	131·20	112·72	101·76	82·40	97·14	13·34	21·50	1·81	3·70	2·22	1·60	1·23
Carbonic acid, CO_3	—	7·20	9·60	7·50	3·60	9·00	7·35	10·05	27·45	13·20	5·55	12·60	11·23	9·42	7·50
Nitric acid, NO_3	—	—	—	—	—	—	—	—	—	—	—	Trace	Trace	Trace	Trace
Sodium, Na	—	246·08 }	375·12	362·77	270·71	206·13	197·05	70·11	33·75	27·85 {	8·15 }	12·77	7·36	4·46	3·35
Potassium, K	—	8·43 }									0·80 }				
Calcium, Ca	—	34·45	108·09	43·81	33·23	32·12	21·58	26·87	8·86	5·14	2·28	3·57	7·72	4·79	5·07
Magnesium, Mg	—	31·06	50·97	46·51	30·88	41·68	21·45	25·31	6·41	7·56	2·00	3·76	1·55	2·03	0·81
Silica, SiO_2	—	0·90	—	0·70	0·90	—	1·60	1·80	1·50	0·40	1·90	—	—	—	—
Total saline matter (grains per gallon)	663·80	887·98	1,506·18	1,262·02	935·77	803·69	667·75	378·35	135·77	118·65	37·86	55·78	44·73	31·28	24·69
Total saline matter (ounces per gallon)	1·51	2·03	3·44	2·88	2·13	1·83	1·53	0·86	0·31	0·27	0·08	0·13	0·10	0·07	0·06
Assumed Composition of Salts (grains per gallon)—															
Calcium carbonate	12·50	12·00	16·00	12·50	6·00	15·00	12·25	16·75	22·15	12·85	5·70	8·93	18·72	11·97	12·50
Calcium sulphate	82·30	100·81	283·47	131·95	104·82	88·80	56·71	68·57	—	—	—	—	0·78	—	0·24
Calcium chloride	—	—	50·84	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	—	—	—	—	—	—	—	—	19·82	7·68	2·98	10·17	—	3·15	—
Magnesium sulphate	21·60	44·54	—	47·57	48·41	48·85	52·96	60·93	3·75	26·87	2·26	4·11	2·09	2·00	1·33
Magnesium chloride	42·80	87·67	201·75	146·52	83·95	126·31	42·99	51·95	—	—	2·77	—	4·43	2·82	2·11
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium sulphate	—	—	—	—	—	—	—	—	15·29	—	—	0·62	—	—	—
Sodium chloride	504·60 {	625·96 }	954·12	922·78	691·69	524·73	501·24	178·35	73·26	70·85 {	20·73 }	31·95	18·71	11·34	8·51
Potassium chloride		16·10 }									1·52 }				
Sodium nitrate	—	—	—	—	—	—	—	—	—	—	—	Trace	Trace	Trace	Trace
Silica	—	0·90	—	0·70	0·90	—	1·60	1·80	1·50	0·40	1·90	—	—	—	
Hardness (English degrees)—															
Total	—	215·76	—	303·65	211·96	—	143·48	172·81	48·87	44·40	14·04	24·41	25·68	20·32	16·00
Temporary	—	12·00	—	12·50	6·00	—	12·25	16·75	45·77	21·99	9·24	20·99	18·72	15·71	12·50
Permanent	—	203·76	—	291·15	205·96	—	131·23	156·06	3·10	22·41	4·80	3·42	6·96	4·61	3·50
Due to calcium	—	86·12	—	109·52	83·07	—	53·95	67·17	22·15	12·85	5·70	8·93	19·30	11·97	12·67
Due to magnesium	—	129·64	—	194·13	128·89	—	89·53	105·64	26·72	31·55	8·34	15·48	6·38	8·35	3·33

TABLE XVIII.

GROUNDWATERS OCCURRING IN SOUTH AUSTRALIAN HIGHLANDS.

	South of Peterborough.								North of Peterborough.							
Source—	Corporation Well, Peterborough.	District Hospital Bore, Clare.	Kapunda Brewery No. 2 Shaft.	Bird-in-hand Mine, Woodside.	New Era Mine, Woodside.	Balhannah Mine.	R. S. Thomas' Bore, Aldgate.	Loftia Park Bore.	Sliding Rock Bore.	Umberatana Station Well.	Gammon Range Bore, Yankaninna.	Mount Painter No. 6 Camp Well.	East Painter No. 2 Bore.	Leigh Creek Colliery.	St. a'Beckett's Well, Myrtle Station.	Depot Creek No. 3 Bore.
Hundred—	Yongala.	Clare.	Kapunda.	Onkaparinga.	Onkaparinga.	Onkaparinga.	Noarlunga.	Noarlunga.	—	—	—	—	—	—	—	Yarrah.
Date—	18/6/14	4/10/37	9/9/14	24/4/41	15/10/36	17/4/42	17/8/37	2/10/35	7/10/44	20/2/40	20/2/40	13/11/44	14/2/45	12/8/41	17/6/27	1/4/38
Ions and Radicles (grains per gallon)—																
Chlorine, Cl	12·05	21·67	57·77	25·98	15·45	10·87	1·24	3·80	26·94	37·75	217·70	21·85	9·65	1,465·70	343·02	30·21
Sulphuric acid, SO_4	1·89	3·42	9·43	9·92	2·02	0·16	0·49	0·45	15·18	88·76	88·31	8·39	4·16	310·50	183·75	11·03
Carbonic acid, CO_3	9·30	17·70	11·40	13·50	9·32	10·46	0·75	2·25	17·43	19·54	19·39	21·30	16·38	21·79	4·50	17·25
Nitric acid, NO_3	—	Nil	—	Nil	Nil	Nil	Trace	—	Nil	Trace	Nil	Trace	Trace	Nil	—	Nil
Sodium, Na	4·62	14·54	33·29	19·01	12·85	6·56	1·33	3·22	16·81	45·20	130·89	13·60	9·92	840·35	211·58	12·62
Potassium, K	(with Na)	(with Na)	2·46													
Calcium, Ca	5·36	3·50	4·86	5·79	2·14	1·86	0·04	0·50	8·86	16·72	22·01	9·07	2·43	97·26	63·61	6·57
Magnesium, Mg	2·63	5·66	5·40	3·32	1·49	3·41	0·12	0·32	5·88	9·28	22·30	5·53	4·28	86·48	15·23	9·48
Silica, SiO_2	1·30	—	3·00	—	—	—	—	—	—	—	—	—	—	—	2·40	—
Total saline matter (grains per gallon)	37·15	66·49	127·61	77·52	43·27	33·42	3·97	10·54	91·10	217·25	500·60	79·74	46·82	2,822·08	824·09	87·16
Total saline matter (ounces per gallon)	0·08	0·15	0·29	0·18	0·10	0·08	0·01	0·02	0·21	0·50	1·14	0·18	0·11	6·45	1·88	0·20
Assumed Composition of Salts (grains per gallon)—																
Calcium carbonate	13·40	8·75	12·15	14·47	5·35	4·64	0·10	1·25	22·12	32·57	32·32	22·68	6·07	36·38	7·50	16·43
Calcium sulphate	—	—	—	—	—	—	—	—	—	12·53	30·84	—	—	280·81	206·07	—
Calcium chloride	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	1·76	17·50	5·75	6·77	5·17	10·79	0·42	1·11	5·86	—	—	10·80	14·84	—	—	10·39
Magnesium sulphate	2·36	3·02	11·79	6·68	—	0·20	—	—	19·02	45·94	83·40	10·51	—	140·81	47·86	13·82
Magnesium chloride	6·57	—	5·54	—	—	1·02	—	—	1·37	—	21·34	1·18	—	227·24	22·16	14·45
Sodium carbonate	—	—	—	—	4·29	—	0·69	1·25	—	—	—	—	3·85	—	—	—
Sodium sulphate	—	1·49	—	6·67	2·99	—	0·72	0·67	—	63·98	—	—	6·15	—	—	—
Sodium chloride	11·76	35·73	84·68	42·83	25·47	16·67	2·04	6·26	42·73	62·23	332·70	34·57	15·91	2,126·84	538·10	32·07
Potassium chloride	(with NaCl)	(with NaCl)	4·70													
Sodium nitrate	—	Nil	—	Nil	Nil	Nil	Trace	—	Nil	Trace	Nil	Trace	Trace	—	—	Nil
Silica	1·30	—	3·00	—	—	—	—	—	—	—	—	—	—	—	2·40	—
Hardness (English degrees)—																
Total	24·36	32·04	34·68	28·13	11·48	16·66	0·59	2·57	46·32	79·99	146·78	45·44	23·68	598·94	222·59	55·45
Temporary	15·48	29·53	18·99	22·49	11·48	15·43	0·59	2·57	29·08	32·57	32·32	35·48	23·68	36·38	7·50	28·78
Permanent	8·88	2·51	15·69	5·64	Nil	1·23	Nil	Nil	17·24	47·42	114·46	9·96	Nil	562·56	215·09	26·67
Due to calcium	13·40	8·75	12·15	14·47	5·35	4·64	0·10	1·25	22·12	41·80	55·02	22·68	6·07	243·06	159·02	16·43
Due to magnesium	10·96	23·29	22·53	13·66	6·13	12·02	0·49	1·32	24·20	38·19	91·76	22·76	17·61	355·88	63·57	39·02

TABLE XIX.
GROUND WATERS OF WESTERN SOUTH AUSTRALIA.

Source—	West of Fowler's Bay.					Eyre Peninsula.										
	Ground-water of Eucla Basin, Mud-daugna Bore, From 270ft.	Urabi Well, Hundred Russell.	Chin-tulda Well, Hundred Wook-ata.	Well, Sec. 34, Hundred Wook-ata, Depth of Water 18in.	Well, Sec. 34, Hundred Wook-ata, Depth of Water 39in.	Darke's Peak Govern-ment Bore, Sec. 24N, Hundred Darke.	Wil-cherrie Bore, Hundred Wil-cherrie.	Wizzo Well, Roo-pena Station.	Bore, Illeroo.	Graphite Coy's Bore, Hundred Uley.	Rodda's Bore, Sec. 5, Hundred Kelly.	Barna Bore, Sec. 1A, Hundred Kelly.	Kruger's No. 3 Bore, Sec. 5, Hundred Cam-poona.	Schmid-tke's Bore, Sec. 123, Hundred Hawker.	Nield's No. 3 Bore, Sec. 1A, Hundred Mann.	Jacobs' Bore, Sec. 53, Hundred Miltalie.
Date—	5/7/23	27/8/27	27/8/27	27/8/27	20/9/27	15/12/33	19/11/36	9/7/25	26/9/27	18/11/26	25/11/26	5/6/29	1/3/38	3/9/37	13/12/38	7/6/37
Ions and Radicles (grains per gallon)																
Chlorine, Cl	709·96	87·31	196·54	67·73	419·99	196·35	110·98	216·56	501·31	11·41	393·56	239·07	433·16	292·20	161·49	356·20
Sulphuric acid, SO_4	134·64	10·86	13·95	6·99	61·72	29·14	21·97	46·80	123·69	0·65	62·50	37·73	68·56	49·34	25·19	59·83
Carbonic acid, CO_3	5·70	6·00	31·50	12·15	10·20	1·20	9·47	9·30	7·05	12·00	8·25	11·10	11·25	33·97	25·95	25·25
Nitric acid, NO_3	—	—	—	—	—	—	Nil	—	—	—	—	—	Nil	Nil	—	Nil
Sodium, Na / Potassium, K	386·02	47·23	134·06	35·70	233·37	115·89	73·52	88·42	274·75	6·95	221·46	136·79	229·86	190·28	90·97	196·15
Calcium, Ca	47·67	6·50	8·00	5·57	19·51	4·43	4·43	32·23	57·95	5·57	14·93	12·86	22·15	8·00	11·86	25·80
Magnesium, Mg	45·90	6·20	7·95	7·66	28·54	11·24	5·90	22·61	25·59	1·85	27·43	15·90	35·49	20·99	16·97	28·15
Silica, SiO_2	2·20	—	—	—	—	—	—	1·10	—	2·40	1·00	—	—	—	—	—
Total saline matter (grains per gallon)	1,332·09	164·10	392·00	135·80	773·33	358·25	226·27	417·02	990·34	40·83	729·13	453·45	800·47	594·78	332·43	691·38
Total saline matter (ounces per gallon)	3·04	0·37	0·90	0·31	1·77	0·82	0·52	0·95	2·26	0·09	1·66	1·04	1·83	1·36	0·76	1·58
Assumed Composition of Salts (grains per gallon)—																
Calcium carbonate	9·50	10·00	20·00	13·92	17·00	2·00	11·07	15·50	11·75	13·92	13·75	18·50	18·75	20·00	29·65	42·08
Calcium sulphate	149·16	8·50	—	—	43·21	12·33	—	66·30	175·28	—	32·06	18·55	49·81	—	—	30·47
Calcium chloride	—	—	—	—	—	—	—	18·12	4·59	—	—	—	—	—	—	—
Magnesium carbonate	—	—	27·40	5·34	—	—	3·98	—	—	5·11	—	—	—	30·87	11·47	—
Magnesium sulphate	36·69	6·09	0·25	8·76	39·12	25·62	23·51	—	—	0·81	49·84	30·88	41·86	59·85	31·57	48·04
Magnesium chloride	152·63	19·46	—	17·03	80·82	23·73	—	89·53	100·21	0·91	69·14	37·83	105·85	—	28·51	72·21
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium sulphate	—	—	20·34	—	—	—	4·75	—	—	—	—	—	—	2·34	—	—
Sodium chloride / Potassium chloride	981·91	120·05	324·01	90·75	593·18	294·57	182·96	226·47	698·51	17·68	563·34	347·69	584·20	481·72	231·23	498·58
Sodium nitrate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Silica	2·20	—	—	—	—	—	—	1·10	—	2·40	1·00	—	—	—	—	—
Hardness (English degrees)—																
Total	310·75	41·76	52·71	45·44	166·21	57·32	35·35	174·94	250·17	21·68	151·80	97·58	201·46	106·38	99·47	180·33
Temporary	9·50	10·00	52·51	20·26	17·00	2·00	15·80	15·50	11·75	20·06	13·75	18·50	18·75	56·62	43·27	42·08
Permanent	301·25	31·76	0·20	25·18	149·21	55·22	19·55	159·44	238·42	1·62	138·05	79·08	182·71	49·76	56·20	138·25
Due to calcium	119·17	16·25	20·00	13·92	48·77	11·07	11·07	80·57	144·87	13·97	37·32	32·15	55·38	20·00	29·65	64·50
Due to magnesium	191·58	25·51	32·71	31·52	117·44	46·25	24·28	94·37	105·30	7·71	114·48	65·43	146·08	86·38	69·82	115·83

TABLE XX.

GROUNDWATERS WEST OF LAKE TORRENS.

Source—	Dorothy Well, Muckanippie.	Bore, 6 Miles north of Peela Well, Wilgena.	Elizabeth Paddock, Arcoona.	Bluff Paddock, Arcoona.	No. 4 Bore, Wilgena.	No. 17 Bore, Wilgena.	Pan Well, Roxby Downs.	Nitrated Waters Near Mulgathing Rocks, North-west of Tarcoola.								
								No. 27 Bore.	No. 34 Bore.	No. 36 Bore.	No. 38 Bore.	No. 41A Bore.	No. 47 Bore.	No. 45 Bore.	No. 42 Bore.	No. 62 Bore.
Date—	20/10/24	1/5/25	3/12/26	26/5/25	9/12/24	2/6/25	11/8/27	19/7/26	10/8/26	24/8/26	24/8/26	3/11/26	3/11/26	3/11/26	24/9/26	2/5/27
Ions and Radicles (grains per gallon)—																
Chlorine, Cl	4·60	26·77	76·43	172·87	281·87	292·58	321·97	300·84	233·41	216·09	133·05	451·66	263·95	10·44	23·21	6·62
Sulphuric acid, SO_4	Nil	9·92	30·07	41·20	57·80	98·50	136·37	97·40	117·79	59·16	38·06	238·46	229·97	4·28	9·14	6·55
Carbonic acid, CO_3	7·05	9·60	13·80	18·30	3·00	6·45	5·85	7·80	10·50	3·90	6·90	5·25	8·10	6·00	7·80	11·10
Nitric acid, NO_3	—	—	—	—	—	—	—	18·25	10·92	27·26	6·52	11·13	6·96	5·45	12·32	6·48
Sodium, Na } Potassium, K }	1·06	19·23	47·86	117·92	170·99	153·18	123·64	200·20	145·43	120·26	85·04	290·04	196·18	9·90	26·30	16·49
Calcium, Ca	3·07	5·36	15·00	13·58	11·83	31·87	106·04	15·29	41·30	25·58	12·50	74·54	44·59	2·57	1·50	0·64
Magnesium, Mg	1·98	2·11	4·90	6·37	14·55	27·02	15·96	19·07	13·99	16·56	6·63	20·47	22·18	1·33	1·01	0·58
Silica, SiO_2	4·20	3·20	3·70	2·60	1·30	3·00	6·41	3·50	4·70	3·20	2·80	2·20	1·60	1·30	5·30	1·30
Total saline matter (grains per gallon)	21·96	76·19	191·76	372·84	541·34	612·55	716·24	662·35	578·04	472·01	291·50	1,093·75	773·53	41·27	86·58	49·76
Total saline matter (ounces per gallon)	0·05	0·17	0·43	0·85	1·23	1·40	1·63	1·51	1·31	1·08	0·65	2·50	1·77	0·09	0·19	0·11
Assumed Composition of Salts (grains per gallon)—																
Calcium carbonate	7·66	13·40	23·00	30·50	5·00	10·75	2·77	13·00	17·50	6·50	11·50	8·75	13·50	6·42	3·75	1·60
Calcium sulphate	—	—	19·72	4·69	33·42	93·73	193·24	34·30	116·62	78·13	26·86	241·53	133·24	—	—	—
Calcium chloride	—	—	—	—	—	—	132·93	—	—	—	—	—	—	—	—	—
Magnesium carbonate	3·44	2·18	—	—	—	—	—	—	—	—	—	—	—	3·01	3·53	2·03
Magnesium sulphate	—	7·45	20·19	31·85	43·76	40·42	—	91·49	44·34	5·01	23·87	84·96	110·90	2·35	—	—
Magnesium chloride	3·96	—	3·40	—	23·76	75·00	62·38	3·05	20·27	61·61	7·36	13·78	—	—	—	—
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5·35	15·35
Sodium sulphate	—	5·85	—	18·35	—	—	—	—	—	—	—	—	69·82	3·55	13·52	9·69
Sodium chloride } Potassium chloride }	2·70	44·11	121·75	284·85	435·10	389·65	314·27	491·97	359·64	280·19	210·17	727·27	434·93	17·20	38·24	10·91
Sodium nitrate	—	—	—	—	—	—	—	25·04	14·97	37·37	8·94	5·26	9·54	7·44	16·80	8·88
Silica	4·20	3·20	3·70	2·60	1·30	3·00	6·41	3·50	4·70	3·20	2·80	2·20	1·60	1·30	5·30	1·30
Hardness (English degrees)—																
Total	15·97	22·19	57·95	60·54	90·30	192·45	340·64	117·82	161·68	133·07	58·92	271·79	204·04	11·96	7·96	4·02
Temporary	11·80	15·98	23·00	30·50	5·00	10·75	2·77	13·00	17·50	6·50	11·50	8·75	13·50	10·00	7·96	4·02
Permanent	4·17	6·21	34·95	30·04	85·30	181·70	337·87	104·82	144·18	126·57	47·42	268·04	190·54	1·96	Nil	Nil
Due to calcium	7·67	13·40	37·50	33·95	29·57	79·67	264·97	38·22	103·25	63·95	31·25	186·35	111·47	6·42	3·75	1·60
Due to magnesium	8·30	8·79	20·45	26·59	60·73	112·78	75·67	79·60	58·43	69·12	27·67	85·44	92·57	5·54	4·21	2·42

N

TABLES OF BOREHOLES AND WELLS IN ARTESIAN BASINS

Arranged according to longitude and latitude

Bore or well	Year completed	Approx. height of surface above sea level ft.	Total depth of bore, ft.	Depth at which water was struck, ft.	Quantity of water, g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each deg. F.	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
GREAT AUSTRALIAN ARTESIAN BASIN															
Charlotte Waters Bore, Northern Territory	—	636	1,474	18 155 353 to 515 614 852 1,233	25 72 90 46,700 — —	15 — 7 ½ ½ ½	— — — 90 86 90	— — — — — 59·1	18B 155B — 140B — —	— — — — — —	Gravel .... Blue shale....... Hard blue calc. shale Siliceous sand ... Siliceous sand ... White siliceous sand	White siliceous sand	— — — — — —	25-26	134-135
Charlotte Waters No. 2 Bore	1924	636	645	21 469 614½	Small Large 1,000 +	9·16 2·10 0·20	— — —	— — —	— 209B 101B	— — —	Mauve conchoidal shale Blue shale....... Fine quartz sand.	Fine quartz sand.	— — —		
Bitchera Well ..	—	—	81	81	800 g.p.h.	Excellent	—	—	45B	—	Whitish and bluish shale	Whitish and bluish shale	—	26-27	134-135
Ferber Well, 5 miles E. 34° N. of Mt. Britton	—	—	70	—	—	Good	—	—	40B	—	Quick sand	—	—		
Ludgate Well 2 miles W. 35° N. from Mt. Ross	—	—	45	—	Unlimited	Good	—	—	—	—	—	—	—		
Paddy Well, Stevenson	—	—	30	—	Large	Salt	—	—	—	—	—	—	—		
Top Camp Well.	—	—	45	40	7,200	Fresh	—	—	—	—	—	—	—		
Plew Well, Stevenson	—	—	65	65	Unlimited	Good	—	—	60B	—	White clay	White clay	—		
Wylie Well on Stevenson Creek	—	—	41	—	Small supply	Good stock	—	—	26B	—	—	—	—		

Bore or well	Year completed	Approx. height of surface above s.l., ft.	Total depth of bore, ft.	Depth at which water was struck, ft.	Quantity of water, g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Abminga Bore .	—	—	865	300	300 g/h	—	—	—	—	—	Blue shale.......	Sand and clay ...	1,000 g.p.h. .	26-27	134-135
			—	336½	700 g/h	—	—	—	—	—	Blue shale.......	—	—		
				372	900 g/h	—	—	—	—	—	Blue shale.......	—	—		
				534	12	2 5/16ths	74	121	—	—	Blue shale.......	—	—		
				645	Small supply	Salt	—	—	540B	—	Blue shale.......	—	—		
				853	—	0·24	—	—	230B	—	Sand		—		
Blue Bonnet Well and Bore Wintinna	—	—	—	—	Dry	—	—	—	—	—	—	—	Well 50ft., bore continues to 100ft.	27-28	133-134
Bracelet Well, Wintinna	—	—	100	—	400	Good	—	—	—	—	—	—	—		
Eagle Hawk Plain Well and Bore, Wintinna	—	—	—	—	Dry	—	—	—	—	—	—	—	Well 50ft., bore continues to 100ft.		
Marble Well, Wintinna	—	—	85	—	4,500	0·36	—	—	—	—	—	—	—		
Towalunginna Well	—	—	129	—	Poor supply	Good	—	—	—	—	—	—	—		
Trial Shaft P.L. 1447	—	—	106	—	Dry	—	—	—	—	—	—	—	Abandoned		
Wintinna Bore on Arckaringa Creek	1915	980 by An.	583	124	Small supply	¼	—	—	—	—	Pale grey shale with yellowish stones	Fine white sand	Water very hard		
				578	Large supply	½	—	490	—	—	Yellowish incoherent sandstone		—		
Rosevear Well, Wintinna	—	—	100	—	100	Good	—	—	—	—	—	—	—	27-28	134-135
Ruby Well	—	—	6	6	—	—	—	—	—	—	—	—	Water about 6ft. from surface		
Stanley Well, Wintinna	—	—	84	—	Good	0·08	—	—	—	—	—	—	—		

Willow Well, 5 miles from Wellbourn Hill	—	—	118	—	8,000	Good	—	—	—	—	—	—	—
Well and Bore, 6 miles from Table Pile, Wintinna	—	—	137	51	400	Good	—	—	—	—	—	—	2 miles upstream are well 50ft. and bore 50ft., dry
Warranarea Bore	1923	—	466	280 425 452	— — —	3 1½ 0·54	— — —	— — —	220B 358B 343B	— — —	Blue shale....... Fairly fine siliceous sand Medium siliceous sand	Coarse siliceous sand	— — 72 miles W. of Oodnadatta
Appatinna Bore.	—	700-720	402	370	Unlimited by pump	0·16	—	—	120B	—	Coarse grey siliceous sand	Coarse quartz sand with matrix of greyish clay	—
Vera Bore	—	—	310	300 abt.	Large	½ a little bitter	—	—	—	—	Sandrock	Sandrock	—
C. Brown and Russell Well, 3 miles N.-E. of Eavinna Hill	—	—	28	25½	Unlimited supply	Good	—	—	—	—	Chocolate cherty Upper Cretaceous	Chocalate cherty Upper Cretaceous	Water 1,500 cattle without failure
Carmen Well ...	—	—	45	—	24,000	Good	—	—	—	—	—	—	—
Christlieb Bore..	—	464	260	260	—	0·62	—	—	47B	—	—	—	—
Christmas Well, Wintinna	—	—	100	—	4,500	Good	—	—	—	—	—	—	—
Ethel Well, Wintinna, right bank of Wintinna Creek	—	—	63	54	7,000	0·17	—	—	—	—	Sandstone	Sandstone	—
Gypsum Bore...	—	710 est.	801	450	Large supply	1·15	—	—	247B	—	Sand	Sand	—
Hawk Nest Well	—	—	—	—	Good	—	—	—	—	—	—	—	—
Henrietta Well, 8 miles S. of Wellbourn Hill	—	—	58	—	2,000	—	—	—	—	—	—	—	Good stock water
Well ¾ mile upstream from Henrietta Well	—	—	50	—	15,000	Good	—	—	—	—	—	—	—
Well 1 mile upstream from Henrietta Well	—	—	60	—	Small	—	—	—	—	—	—	—	—

Bore or well	Year completed	Approx. height of surface above s.l., ft.	Total depth of bore, ft.	Depth at which water was struck, ft.	Quantity of water, g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Howard Well, Wintinna	—	—	102	—	1,500	—	—	—	—	—	—	—	—	27-28	134-135
Imbitcha Bore	1912	540 An.	345	300	—	0·60	—	—	215B	—	Light sandy shale	Sand	1915, 0·64,		
John Well, 3½ miles below Ethel Well	—	—	40	—	24,000	Good	—	—	—	—	—	—	—		
Joyce Well, Wintinna	—	—	40	—	12,000	Good	—	—	—	—	—	—	—		
Junction Well, Wintinna	—	—	35	—	4,000 overnight	—	—	—	—	—	—	—	Good stock water		
Mirackina Bore	—	438	280	235	—	0·60	—	—	30B	—	—	—	1915, 0·57 oz. p.g.		
No. 2 Well and Bore	—	506 An.	264	—	—	1·93	—	—	75B	—	—	—	Qual. spoiled by admixture with overlying saline ground water		
Todmorden H.S. Well	—	—	100	—	Good	Good	—	—	—	—	—	—	—		
Mother Well and Bore	—	700-720	200	188	Unlimited pump	0·33	—	—	179B prob. above	—	—	—	In filled basins of the Alberga and prob. above the level of main basin		
Appreetinna Bore	1915	775 An.	360	50 319 350	— — —	1¾ ¾ 0·87	— — —	— — —	— — 319B	— — —	Dark shale ...... Hard sandstone.. Sandstone	Sandstone	— — —		
Murloocoppie Bore	1929	—	486½	470	Large	0·34	—	—	468½B	—	White sand......	White sand......	—	28-29	134-135

No. 3 Bore Nilpinna Station. Bore 6 miles N. of Lignum Hole Wobna-Poorina Creek	1940	—	205	192	480 g.p.h	0·60	—	—	145B	—	Coarse gravel and sand	Light clay......	—
No. 6 Bore Nilpinna Station	—	—	194½	120 175	— 8,000	Bitter 0·92	— —	— —	— —	— —	Black sand ..... Sand	Sand	— —
Vera Camp Bore or S.M. Bore	—	—	325	310	Large	½	—	—	—	—	Sandrock	Sandrock	—
No. 1 Well, Arckaringa Creek	—	400 An.	42	—	—	4·68	—	—	—	—	—	—	Ground water
Oolgelina West No. 1 Bore	1927 —	— —	— 209	94 188	409 3,000+	Fresh 0·46	— —	— —	— 186B	—	Yellow ochreous clay. Fairly fine white waterworn sand	Fairly fine white waterworn sand	— —
Oolgelina West No. 2 Bore	1927	650 est.	248	230	3,000+	0·64	—	—	221B	—	Quartz sand, medium to fine grained	Quartz sand medium to fine grained	—
Oolgelina West No. 3 Bore	1927	—	288	276	3,000+	0·67	—	—	272B	—	Medium to fairly fine quartz sand	Grey quartz grit to sand with pyrites	—
Oolgelina West No. 4 Bore	1927	—	333	320	3,000+	0·72	—	—	308B	—	Jurassic quartz sand with some pyrite	Jurassic quartz sand with some pyrite	—
Oolgelina West No. 5 Bore	1927	—	354	340	3,000+	0·73	—	—	330B	—	Fine grey quartz sand and lignite particles	Fine grey quartz sand and lignite particles	—
Oolgelina West No. 6 Bore	1927	—	345	340	3,000+	0·70	—	—	330B	—	Sand, greyish and fairly fine with lignite at 340 ft.	Sand, greyish and fairly fine with lignite at 340 ft.	—
Stuart Range No. 1 Bore	1920	552 An.	485	220	—	3·04	—	—	200B	—	Fine sand with pyrite nodules and crystals	Grey shale	Abandoned
Stuart Range No. 2 Bore	1920 — —	400 — —	1,000 — —	51 343 364	— — } — }	1·15 0·63	— { — { —	— — —	— 38B 38B	— — —	Coarse quartz and quartzite sand and gravel Greyish siliceous sand Medium grained siliceous sand with pyritic nodules	Pale blue shale...	— Anal. from 509 ft. 0·80 oz. p.gall. —

Bore or well	Year completed	Approx. height of surface above s.l., ft.	Total depth of bore, ft.	Depth at which water was struck, ft.	Quantity of water, g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
McDouall Peak, J. Jacob	1928	—	130½	125	Small increasing to 6,000 at bottom	2·68 (top) 2·59 (bottom)	—	—	125B	—	Brown hard rock.	Brown hard rock.	—	29-30	134-135
McDouall Peak, J. Jacob	1928	—	92	92	3,000	—	—	—	80B	—	Sandstone mixed with white clay	Sandstone mixed with white clay	—		
McDouall Peak, Billie Bore	—	—	124	124	3,080	Fresh	—	—	112B	—	Very hard sandstone	Very hard sandstone	—		
Birthday Well, McDouall Peak	—	—	71	—	Large supply	—	—	—	—	—	Grits and sands (Jurassic)	Grits and sands (Jurassic)	2 oz. water below top 2ft. of good water		
Burntiltaby Trial	—	—	50	—	—	—	—	—	—	—	—	Jurassic grits ...	Rumoured to have almost reached water (sands wet)		
Mt. Brady No. 1 Bore 3 miles from Morton Rise	1927	—	215½	215	—	over 3½	—	—	203B	—	Hornblende granite	Hornblende granite	—		
Mt. Brady, No. 2 Bore, 7 miles E. Morton Rise	1927	—	227	223	Small	Very salt	—	—	—	—	Very siliceous cuttings, felspar scarce	Very siliceous cuttings, felspar scarce	—		
Mt. Brady, No. 3 Bore	1927	—	208	208	—	3½+	—	—	200B	—	Whitish sand and grit (Jurassic)	Whitish sand and grit (Jurassic)	—		
Mt. Brady, No. 4 Bore	1927	—	249	249	—	3½+	—	—	240B	—	Greyish coarse grit and sand. Trace pyrite (Jurassic)	Greyish coarse grit and sand. Trace pyrite (Jurassic)	—		
Mt. Brady, No. 5 Bore	1927	—	293	292	—	3½+	—	—	280B	—	Grey clayey sand (Jurassic)	Greyish quartz grit	—		
Mt. Brady, No. 6 Bore	1927	—	339½	337	—	3½+	—	—	325B	—	Greyish quartz sand	Greyish quartz sand (Jurassic)	—		

Mt. Clarence, No. 1	1927	—	207½	198	Big supply	2·13	—	—	178B	—	Fine sand to coarse waterworn quartz grit (Jurassic)	Fine sand to coarse waterworn quartz grit (Jurassic)	—
Mt. Clarence, No. 2	1927	—	179	168	—	2·06	—	—	168B	—	Coarse sand, sub-angular clay	Coarse sand, sub-angular clay	—
Mt. Clarence, No. 3	1927	—	115	115	—	3½	—	—	102B	—	Sub-angular and waterworn quartz sand	Sub-angular and waterworn quartz sand	—
Mt. Clarence, No. 4	1927	—	165	158	5,000+	2·02	—	—	158B	—	Quartz sand and grit	Quartz sand and grit	—
Mt. Clarence, No. 5	1927	—	115	114	—	3½	—	—	101B	—	Greyish quartz grit and sand	Greyish quartz grit and sand	—
Mt. Clarence, No. 6	1927	—	301	275 285	100 3,000+	Fresh 1·02	— —	— —	— 262B	— —	Grey quartz grit and sand	Grey quartz grit and sand	—
Mt. Penrhyn, No. 3	—	—	192	192	—	3½	—	—	188B	—	Quartz fine sand with water-worn grit (white)	Quartz fine sand with water-worn grit (white)	—
Mt. Penrhyn, No. 4	—	—	212	208	Large supply	3½	—	—	—	—	Quartz sand, fine to coarse slightly dirty	Dark shale carbonaceous rather than blue	Bore discontinued
Mt. Penrhyn, No. 5	—	—	51	—	Dry	—	—	—	—	—	—	Decomposed to fresh pink biotite granite	—
Mt. Penrhyn No. 6	—	—	107	—	Dry	—	—	—	—	—	—	Fresh pink fine-grained granite	Abandoned
Mt. Penrhyn No. 7	—	—	52	—	Dry	—	—	—	—	—	—	Waterworn quartz sand and chippings of fresh pink granite (some ironstone)	Abandoned
Mt. Penrhyn No. 8	—	—	148	125	1,000	¾	—	—	95B	—	Pink micaless granite	Pink micaless granite	—
Mt. Penrhyn No. 10	—	—	136	135	—	3	—	—	125B	—	Sandy clay and fragments of greyish shale	Sandy clay and fragments of greyish shale	Abandoned
Mt. Penrhyn No. 12	—	—	53	—	—	—	—	—	—	—	—	Quartz sand and grit. Granite boulders reported	Abandoned, struck granite boulders
Mt. Penrhyn No. 13	—	—	72	—	—	—	—	—	—	—	—	Decompsed granite with boulders	Abandoned

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Mt. Penrhyn No. 14	1927	—	125½	124	—	3½+	—	—	120B	—	Fine to medium grain quartz sand somewhat rounded, trace white clay	Fine to medium grain quartz sand somewhat rounded, trace white clay	—	29-30	134-135
Mt. Penrhyn No. 15	1927	—	194	193	—	3½+	—	—	181B	—	Coarse sub-angular quartz grit	Coarse sub-angular quartz grit	—		
Mt. Penrhyn No. 16	1927	—	210	210	—	2½	—	—	198B	—	Dense biotite schist	Dense biotite schist	—		
Mt. Penrhyn No. 17	1927	—	114	110	—	3½+	—	—	98B	—	Grey shale	Grey shale	—		
Mt. Penrhyn No. 18	1927	—	111	110	—	3½+	—	—	99B	—	Waterworn quartz and sand	Waterworn quartz and sand	—		
Mt. Penrhyn No. 19	1927	—	150½	150	—	3½+	—	—	135½B	—	Fairly coarse clean quartz sand	Fairly coarse clean quartz sand	—		
Bushman's Swamp No. 1	1925	—	143	42	—	4·19	—	—	40B	—	Coarse sand	Grey shale (dark) (possibly the the Lake Phillipson series Triassic)	—		
Bushmans' Swamp No. 1A	1925	—	60	50	—	4·42	—	—	46B	—	Coarse grey quartz and grit with a little clay	Coarse grey quartz and grit with a little clay	—		
Cane Grass Swamp No. 2	1925	430 est.	103	56	—	6·22	—	—	54B	—	Fine to medium grained white clayey sand	Blue shale (Lower Cretacious)	—		
Carringallana Bore No. 3	1925	—	105	46	—	8·17	—	—	37B	—	Light yellow coarse quartz sand	Grey shale (below Jurassic)	—		

Wurley Lagoon No. 4 Bore	1925	—	163	14	—	10·11	—	—	11½B	—	Fine quartz sand and some grit mixed with a little fine white clay	Dark grey shale with some fragments of lignite	—	
Longs Creek No. 4A	1925	—	60	55	—	Salt	—	—	—	—	Sand	Sand	—	
Longs Creek No. 4B	1925	—	80	16	—	3½+	—	—	14½B	—	Gritty sand with white clay	Sand with light grey clay	—	
Perfection Bore	—	—	46½	42	1,400 to 1,500	0·15	—	—	33½B	—	Hard brown rock (quartz-felspar porphyry)	Hard brown rock (quartz-felspar porphyry)	—	
No. 6 Government Bore	—	—	70	—	—	Salt	—	—	—	—	Light grey sand (and clay)	Light grey sand (and clay)	—	
No. 7 Government Bore	—	—	116	106	—	3½	—	—	83B	—	Coarse waterworn sand, some looks granitic	Coarse waterworn sand, some looks granitic	—	
No. 8 Government Bore	—	—	95	92	—	3	—	—	78B	—	Grey sandy clay and grit	Grey sandy clay and grit	—	
No. 9 Government Bore	—	—	125	—	6,000	1·81	—	—	—	—	—	Very siliceous angular fragments of granite and schist	Bedrock	
No. 10 Government Bore	—	—	86	—	3,300	2·01	—	—	—	—	—	Hornblendic dark gneiss (some mica)	—	
No. 11 Government Bore	—	—	107	97	—	3⅛	—	—	87B	—	Yellow sandstone	Granite	—	
No. 12 Government Bore	—	—	17	—	—	—	—	—	—	—	—	Granite	Abandoned	
No. 12A Government Bore	—	—	64	62	—	3	—	—	—	—	Drift sand.......	Drift sand.......	—	
No. 48 Government Bore	—	—	110	108	—	3	—	—	—	—	Light grey clay with traces of quartz grains and mica. Possibly decomposed quartz-mica schist	Light grey clay with traces of quartz grains and mica. Possibly decomposed quartz-mica schist	—	
No. 52 Government Bore	—	—	57	52	—	3	—	—	—	—	Decomposed granite	Decomposed granite	Abandoned	

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Lake Phillipson Bore	1902	450 est.	3,161	80	Small supply	—	—	—	—	—	Clay with yellow sand and water-worn pebbles	Gneissic red granite, hornblendic	Abandoned. Too saline for men and camels	29-30	134-135
McDouall Peak H.S. (New)	—	—	58	—	12,000	Fresh	—	—	—	—	Coarse gritty soft sandstone	—	—		
Mt. Eba, Roberts Well No. 1	—	—	58	—	Small	Fresh	—	—	—	—	Granite	Granite	—		
Mt. Eba, Roberts Well No. 2	—	—	44	—	Small	Fresh	—	—	—	—	—	—	—		
Tea Tree, Ingomar Station	1932	—	70	—	Large	1·87	—	—	—	—	—	—	Anal. 1933, 2·38		
No. 1 Woorong Bore	1929	—	138½	135	Unlimited	1·87	—	—	118B	—	Yellowish sand and sandstone bars	Yellowish sand and sandstone bars	—		
Bulgunnia Stn. Bore	—	—	75	70	—	0·09	—	—	—	—	Sub-angular quartz grit apparently with a little clay	—	—	30-31	134-135
Bulgunnia Stn. Giffen Bore	—	—	—	—	—	0·60	—	—	—	—	—	—	—		
Bulgunnia Stn., Giffen Well	—	—	112	—	—	0·22	—	—	83B	—	—	Quartz grit and greenish rock probably schist or gneiss	—		
Bulgunnia Stn. Lewis Bore	—	—	92	—	+ 4,000	Less than ¼	—	—	—	—	—	Decomposed granite (gritty kaolin)	—		
Bulgunnia Stn. Glynn Bore	—	—	104½	92	8,000	¾	—	—	79B	—	Coarse white sandstone	Pipe clay	—		
Bulgunnia Stn. Taits Bore	—	—	108	103	Unlimited	1½	—	—	72B	—	White sandstone with seams of blue clay	White sandstone with seams of blue clay	Stock water		

Wilgena Tea Tree Well	—	—	—	—	7,000-8,000	less than $\frac{3}{8}$	—	—	—	—	Silicious and silicified grit	—	—
Wilgena No. 8 Bore	1925	—	240	45	—	Salt	—	—	—	—	Coarse cemented sand	Red rock, supposed granite	Abandoned
				62	—	Salt	—	—	—	—	White gritty clay	—	—
				197	Large	Salt	—	—	—	—	Red rock, supposed granite	—	—
Wilgena No. 14 Bore	1925	—	385	—	—	—	—	—	—	—	—	Grey granite formation	Dry
Wilgena No. 15 Bore	1925	—	200	38	—	Salt	—	—	—	—	Soft limestone ...	Dark blue gritty clay	Abandoned
				86	—	Salt	—	—	—	—	Cemented grit ...		—
				163	—	Salt	—	—	—	—	Yellow gritty clay		—
Wilgena No. 17 Bore	1925	—	143	60	Small	—	—	—	—	—	Cemented grit with yellow clay	—	—
				120	Small	—	—	—	—	—	Cemented grit with yellow clay	—	—
				143	+400 g.p.h.	1·40	—	—	60B	—	Cemented grit with brown clay	—	—
Wilgena No. 18 Bore	1925	—	88	—	—	—	—	—	—	—	Cemented grit with brown clay	Bed rock (felsite)	—
Wilgena No. 20 Bore	1925	—	220	70	100 g.p.h.	—	—	—	—	—	White gritty clay	Grey sandy clay	Good stock water
				112	200 g.p.h.	—	—	—	—	—	Softsandstone ..		—
				173	250 g.p.h.	—	—	—	50B	—	Grey sandy clay		+ 570 g.p.h.
Wilgena No. 22 Bore	1925	—	188	92	—	—	—	—	—	—	White gritty clay	Cemented sand ..	Sheep water
				170	300 g.p.h.	Fresh	—	—	50B	—	Dark slatey coloured clay		—
Wilgena No. 23 Bore	1925	—	75	75	Large	Salt	—	—	—	—	White sandstone	White sandstone	Abandoned
Wilgena No. 24 Bore	1925	—	100	90	Small	Salt	—	—	—	—	Lake soil	Lake soil	Abandoned
Wilgena No. 25 Bore	1925	—	42	42	—	Salt	—	—	—	—	Sandy clay	Sandy clay	—
Wilgena No. 26 Bore	1925	—	106	106	Small	Salt	—	—	—	—	White clay and sand	White clay and sand	Abandoned
Wilgena No. 27 Bore	1925	—	121	100 } 121 }	Large	Salt	—	—	—	—	Blue clay	Blue clay	Abandoned
Wilgena No. 28 Bore	1925	—	124	60	No supply	1·32	—	—	—	—	Micaceous clay ..	White clay	First water stock
				124	—	Salt	—	—	—	—	White clay		Abandoned

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Wilgena No. 30 Bore	1925	—	76	65	400 g.p.h.	1·95	—	—	57B	—	Micaceous clay ..	Micaceous clay ..	Sheep and other stock water	30-31	134-135
Wilgena No. 31 Bore	1925	—	138	95	120 g.p.h.	1½	—	—	50B	—	Sandstone	Granite	—		
Wilgena No. 34 Bore	1925	—	66	32 66	Small Unlimited	— 1	— —	— —	— —	— —	Soft sandstone .. Red sandstone ..	Red sandstone	— Sheep water		
Wilgena No. 35 Bore	1925	—	25	25	—	Salt	—	—	—	—	Gypsum	Gypsum	Abandoned		
Wilgena No. 36 Bore	1925	—	43	43	—	Salt	—	—	—	—	Red sandstone ..	Red sandstone	Abandoned		
Wilgena No. 40 Bore	1925	—	100	100	—	1·65	—	—	—	—	White sand......	White sand......	Stock water, sheep		
Wilgena Mentor Well	—	—	106	—	Large	Fresh	—	—	—	—	—	Jasper rock over soft kaolin	—		
McDouall Peak Stn., Woolshed Well	1928	—	79	70	4,000	Fresh	—	—	61B	—	Hard rock.......	Red granite	Drive to bore 11ft. away		
McDouall Peak Stn., Woolshed Bore	—	—	—	—	Small	—	—	—	—	—	—	—	Supply insufficient so sunk well		
McDouall Peak Stn., Nins Bore	1928	—	46	40½	10,000	Fresh	—	—	40½B	—	Water washed pebbles	Water-washed pebbles	This bore was put down entirely with an earth socket. Sheep		
Anacoora Bore, N.T.	—	427	1,250	1,127	700,000	0·14	135	16·56	48A	—	Fine grained siliceous sand	Soft fine grained siliceous sandstone	—	25-26	135-136

Andado Bore No. 1 N.T.	1927	—	708	435 705	Small 550 g.p.h.	3 0·53	— —	— —	— 78B	— —	Typical blue shale Fairly coarse grey quartz sand and some shale fragments	Fairly coarse grey quartz sand and some shale fragments	—		
Andado Bore No. 2 N.T.	1926	—	591	280 584 to 591	Very small 11,000	4 0·19	— —	— —	— 104B	— —	Blue shale....... Light grey sandy shale to fairly fine greyish quartz sand	Light grey sandy shale to fairly fine greyish quartz sand	—		
Finke, C.A.R. .. N.T.	—	—	434	320	6,500 g.p.h.	0·106	—	—	265B	—	Boulders	Gravel	—		
Pedirka Bore, C.A.R.	—	—	1,310	65 107 113 200 218 1,020 1,049	1,000 g.p.h. — Small soak 3,000 g.p.h. 100 g.p.h. — Approx. 10,000 g.p.h.	— — — — 2 0·2 0·25	— — — — — — —	— — — — — — —	— — — — — 113B —	— — — — — — —	— Yellow clay ..... Yellow clay ..... — — — —	— — — — — — —	— — — — — — —	26-27	135-136
Allinga Bore....	1917	—	1,160	110 1,045 1,141	— 3,000 412,800	9 — 0·12	— — 112	— — 25·9	100B A —	— — —	Blue shale....... Soft fine grained sandstone Coarse siliceous sand	Coarse siliceous sand	— — —		
Bloods Creek Bore	—	658	2,002	864 1,320	— 26,000	Bitter 0·14	74 90	203·5 63·5	20B 100B	— —	Iron pyrites ..... Grey shale under blue shale	Coarse grey siliceous sand	— —		
Junction Bore ..	1908	—	1,448	147 1,145 1,294	— — 208,000	Brackish Fresh Fresh	— — 118	— — 25·9	32B 5B A	— — —	Dark sand ...... Sandstone ...... Shale and lignite	Fine and coarse sandstone	—		
Hamilton Creek Bore No. 2	1896	Abt. 500	1,417	38 1,140 1,290	— — 232,000	Salt Good 0·20	— — 120	— — 8·2	35B 5B 5A	— — —	White and yellow gypsiferous clay Argillaceous sandstone with iron pyrites Sand and very coarse quality gravel with Q. cherty crystalline igneous rock	Conglomerate gravel of Qte., Q. and pyrite, also pieces of limonite	—		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Memory Creek Bore, Dalhousie Stn.	—	—	803	500 to 803	125,000	—	—	—	—	—	—	—	—	26-27	135-136
Mount Sarah Bore	1919	Est. 600	1,025	153 925	— —	Bitter 2 0·26	— 95	— 35	23B 115B	— —	Blue shale....... Grey medium grained sandstone and clay	Coarse siliceous soft sandrock	—		
Opossum Bore .	1917	600	1,334	406 1,234	Small —	6 0·13	— —	— —	136B 116B	— —	Blue shale....... Greenish sandy clay	Fine grained sandy clay	—		
Stevenson Bore .	1907	392	1,193	25 1,116 1,153	— — 180,000	Salt — 0·31	— — 122	— — 26·2	— — A	— — —	Marly clay ...... Cemented Q. pebbles. Coarse Sand	Coarse sandstone	—		
Breaden Bore...	1910	500	1,117	800	—	0·32	—	—	66B	—	Sand	Sand	—	27-28	135-136
Macumba H.S. Well	—	—	—	—	—	Stock water	—	—	—	—	—	—	—		
Oodnadatta Bore	1894	395	1,571	233 1,417 1,570	— 2,640 270,000	Salt Good stock 0·29	— — —	— — —	35B 3A 34A	— — —	Grey sandy clay White sand...... Coarse sand and pebbles	Coarse sand and pebbles	—		
Mt. Dutton Bore, C.A.R.	—	—	—	90 256½ 325 336 339 391	— — 160 g.p.h. 1,500 g.p.h. 2,040 g.p.h. later changed to 4,000 g.p.h. 6,500 g.p.h.	Salt — — — — 0·47	— — — — — —	— — — — — —	— 15B A A A A	— — — — — —	— White sand...... — — — —	— — — — — —	— — — — — —		

Alberga Bore	—	—	1,200	106	12-15 g.p.h.	Very salt	—	—	95B	—	Blue shale, sand and rock	—	—		
				208	Approx. 15 g.p.h.	—	—	—	95B	—	Blue shale, sand and rock	—	—		
				1,077	—	—	—	—	A	—	—	—	—		
				1,092	Flowing 480 g.p.h.	—	—	—	A	—	—	—	—		
				1,127	6,500 g.p.h.	0·30	—	—	A	—	—	—	Hot water, 140° F. approx.		
Storm Creek Well	—	—	—	—	—	Stock water	—	—	—	—	—	—	—		
Storm Creek or Wire Creek Bore	—	440	1,550	70 app.	—	Brackish	—	—	—	—	White, yellow and fawn clays	Sandstone soft and fine grained white to pink	—		
				1,340	86,000	0·33	119	26·3	A	15	White siliceous sand				
Nilpinna Stn. Johnson No. 1	1940	—	284	131	—	Good	—	—	18B	—	Blue clay	Hard rock.......	—	28-29	135-136
				280	450 g.p.h.	0·49	—	—	24A	—	White sand......		—		
Nilpinna Stn. Johnson No. 2	1940	—	475	41	—	Very salt	—	—	10B	—	Silty sand	White sand rock .	—		
				105	—	Salt	—	—	—	—	Blue clay		—		
				184	—	Good	—	—	80B	—	Blue clay		—		
				215	—	—	—	—	9B	—	Silty sand		—		
				217	500 g.p.h. at 311 ft.	0·68	—	—	6½B	—	White Q. sand ..		—		
Nilpinna Stn., No. 1 Bore	—	—	81	—	—	—	—	—	—	—	—	Hard granite	Abandoned		
Nilpinna Stn., No. 2 Bore	—	—	135	131	5,000	—	—	—	—	—	Extremely fine yellow clay	Extremely fine yellow clay	—		
Nilpinna Stn., No. 3 Bore	—	—	52	—	Large	Salt	—	—	—	—	—	Hard blue shale .	Abandoned		
Nilpinna Stn., No. 4 Bore	—	—	149	144	5,000	1·49	—	—	—	—	Sand	Sand	—		
Nilpinna Stn., No. 5 Bore	—	—	228	68	Small	2	—	—	—	—	Blue shale.......	Blue shale	—		
				95	8,000	1·27	—	—	—	—	Hard blue rock ..		—		
Bangaboorana Bore	1911	—	825	150	25,000	0·82	—	—	137B	—	Sand rock	Shale with a few bands of rock	—		
Boorthanna Bore	—	—	2,088	146	—	1¼	—	—	140B	—	White pipe clay .	Blue shale with occasional thin layers of limestone	—		
Edwards Creek, C.A.R., No. 1	1942	R.L. 493	—	—	—	—	—	—	120B	—	—	—	Test at 201ft. 2,400 g.p.h.		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Edwards Creek C.A.R., No. 2	1943	517	623	140 580	— —	— —	— —	— —	125B 200B 120B	— —	Sand and clay ... Sandstone	—	Test 7,200 g.p.h. pump at 240ft.	28-29	135-136
Raspberry Creek Bore	—	348	416	380	1,250,000	0·51	—	—	—	—	Blue shale.......	Blue shale.......	—		
C. H. Jacob Bore	—	—	197	197	—	1·95	—	—	—	—	Coarse sand with bands of pipe clay	Coarse sand with bands of pipe clay	Deepening	29-30	135-136
No. 1 Beatram Downs Bore	1928	—	327	193 327	Large 10,000	2 1·12	— —	— —	172B 202B	— —	Black shale...... White sandstone	White sandstone .	— —		
No. 3 Beatram Downs Bore	—	—	305	130 304	12,000 Very large	1·72 4½	— —	— —	120B 150B abt.	— —	Gravel seam .... Blue sand	Blue sand	Bottom water sealed off		
No. 4 Beatram Downs Bore	—	—	277	277	8 gall. at 2 min. intervals	1¾	60	—	—	—	Fine sandstone	Fine sandstone ..	—		
No. 5 Beatram Downs Bore	—	—	178	178	12,000	1·20	—	—	—	—	Gravel	Gravel	—		
Millers Creek No. 6 Bore	—	—	407½	115 403	20 10,000	— 1·16	— —	— —	— 270B	— —	Gravel .... Drift sand.......	Drift sand.......	— —		
Millers Creek No. 14 Bore	1928	—	526	257 524½	Good 10,000	Salt 2·23	— —	— —	— —	— —	Blue shale....... Blue shale.......	Blue shale.......	— —		
Millers Creek No. 15 Bore	1928	—	655	318 648	Small 10,000	Fresh 1·97	— —	— —	— —	— —	Blue shale and sand Sand and gravel .	Sand and gravel .	— —		
J. Jacob McDouall Peak Hill, 6 miles S.S.W. of	1934	—	71	71	1,200	1·15	—	—	68B	—	Hard rock formation	Hard rock formation	Too much soluble magnesium sulphate		
New Year Well, McDouall Peak	—	—	117	—	5,000	1⅝	—	—	—	—	—	—	—		

Mt Penrhyn No. 1 Bore	—	—	188	186	Large	3½	—	—	182B	—	Yellow fine sand with some coarse Q. grit	Soft sandstone ..	—		
Mt. Penrhyn No. 2 Bore	—	—	281	277	Large	4+	—	—	227B	—	Dark Q. and red felspar	Dark Q. and red felspar	—		
Mt. Penrhyn Blk. No. 9 Bore	—	—	163	158	—	3	—	—	140B	—	Q. grit and a little grey clay probably decomposed granite	Q. grit and a little grey clay probably decomposed granite	Abandoned		
Mt. Penrhyn Blk., No. 11 Bore	—	—	96	—	Dry	—	—	—	—	—	—	Cuttings of somewhat weathered granite	Abandoned		
T. O. O'Leary Bore	1925	—	194	186	2,000	1·69	—	—	184B	—	Sandstone	Sandstone	—		
Twins Stn.	—	—	—	152	No supply	Good	—	—	152B	—	Coarse reddish gravel in brown sand	Seams of granite 167ft. probably bedrock	—		
Twins Stn.	—	—	235	185	Small	Poor	—	—	185B	—	—	—	—		
Twins Stn.	—	—	230	180	—	—	—	—	180B	—	White quartz ...	White quartz rock	—		
Twins Stn., Dresley Bore	—	—	215	204	15,000	0·90	—	—	204B	—	Blue shale.......	Blue shale.......	—		
Bon Bon White Well	—	—	110	—	600	Fresh	—	—	—	—	—	Purplish ste or qte	—	30-31	135-136
Bon Bon H.S. Well	—	—	146	86	4,000	Potable	—	—	—	—	Cretaceous	Cretaceous	—		
Bon Bon Colman Well	—	—	60	40	2,000	0·07	—	—	40B	—	Sandstone	Sandstone	—		
Bon Bon 4 Mile Well	—	—	90	—	5,000	0·36	—	—	—	—	Sandstone	Sandstone	—		
Bon Bon Gosse Well	—	—	60	—	—	1½	—	—	40B	—	Very little shale on grey Q. grit and gravel	Very little shale on grey Q. grit and gravel	—		
Bon Bon Hogarth N.E. Well	—	—	70	—	150,000	Good	—	—	30B	—	Hard sandstone	Hard sandstone .	—		
Bon Bon Hogarth S.W. Well	—	—	—	+30	Small	Fresh	—	—	30B	—	Horizontal indurated sandstone (Jurassic)	Horizontal indurated sandstone (Jurassic)	—		
Bon Bon Mt. Ernest Well	—	—	60	—	3,000	Good	—	—	50B	—	Quartz sand and gravel	Quartz sand and gravel	—		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Bon Bon Mt. Ernest Well	—	—	130	126	11,000	—	—	—	—	—	—	—	—	30-31	135-136
Bon Bon Mt. Sabine Well	—	—	60	—	— 30,000	½ —	— —	— —	56B	—	Sands and grits and waterworn Q. gravel	Sands and grits and waterworn Q. gravel	—		
Bon Bon Mulga Well West	—	—	60	—	1,500	Fresh	—	—	40B	—	Horizontal white gritty sandstone and sand	Horizontal white gritty sandstone and sand	—		
Bon Bon Mulga Horse Well East	—	—	60	—	Small	less ¼	—	—	—	—	Similar to Mulga Well West	—	—		
Bon Bon Mungillio Well	—	—	60	—	7,000	1·0	—	—	—	—	Reddish sandy clay	Reddish sandy clay	—		
Bon Bon Orwell Well	—	—	100	—	—	Fresh	—	—	70B	—	Coarse gravel ...	Coarse gravel ...	Water 5,000 sheep		
Bon Bon Little Orwell Well	—	—	—	40-50	Small	Fresh	—	—	—	—	White shale on coarse indurated yellow and brown ste	White shale on coarse indurated yellow and brown ste	—		
Bon Bon Red Hill Well	—	—	130	—	10,000	1·72	—	—	126B	—	Coarse gritty sandstone	Coarse gritty sandstone	—		
Bon Bon Scott Well	—	—	55	32	—	0·15	—	—	—	—	Sands	Sands	Degenerates to 2oz. at 55ft.		
Bon Bon Wallabyng Well	—	—	60	—	1,000	1·46	—	—	30B	—	Soft sandstone ..	Soft sandstone ..	—		
Bon Bon No. 1 Bore	—	—	96	—	—	1·99	—	—	—	—	—	—	—		
Bon Bon No. 2 Bore	—	—	72	—	—	2·37	—	—	—	—	—	Grit	—		

Bon Bon No. 4 Bore	—	—	97	—	—	2·01	—	—	—	—	—	Q. grit	—
Bon Bon No. 5 Bore	—	—	85	—	—	2·36	—	—	—	—	—	Gravel	—
Bon Bon No. 6 Bore	—	—	92	—	Dry	Salt	—	—	—	—	White argillaceous sandstone and gravel	White argillaceous sandstone and gravel	—
Bon Bon No. 7 Bore	—	—	72	—	7,000	0·50	—	—	46-48B	—	Grit	Grit	—
Bon Bon No. 8 (Tinsell) Bore	—	—	105	—	8,064	0·23	—	—	—	—	Probably Jurassic	Probably Jurassic	—
Bon Bon No. 10 Bore	—	—	198	—	400 700	Fresh 1·78	— —	— —	25B 25B	— —	Some purplish sandstone and clays	Some purplish sandstone and clays	—
Bon Bon No. 11 Bore	—	—	107	—	—	Salt	—	—	40-50B	—	—	Sub-Jurassic sands	—
Bon Bon No. 12 Bore	—	—	100	—	—	Salt	—	—	40-50B	—	—	Grey gritty clay	—
Bon Bon No. 13 Bore	—	—	250	—	—	Salt	—	—	—	—	Light chocolate coloured clay stone	Light chocolate coloured clay stone	—
Bon Bon No. 15 or Boolka Bore	—	—	127	—	6,000	1·09	—	—	—	—	—	Sand	—
Bon Bon No. 16 Bore (Wilson)	—	—	146	—	6,000	0·5	—	—	128B	—	—	Coarse grey quartz sands and grits	—
Bon Bon No. 17 Bore (Duncan)	—	—	210	—	4,000	1·64	—	—	—	—	—	Sandstone	—
Bon Bon No. 18 Bore (Darling)	—	—	201	—	—	0·50	—	—	—	—	—	Sandstone, Jurassic	—
Bon Bon No. 21 Bore	—	—	396	—	Very small supply	Useful	—	—	—	—	—	—	—
Bon Bon No. 22 Bore	—	—	140	—	—	Salt	—	—	—	—	—	Buff sandy clay .	—
Bon Bon No. 26 Bore	—	—	100	—	—	Salt	—	—	—	—	Coarse grit, Jurassic	Coarse grit, Jurassic	—
Bon Bon No. 29 Bore (Leak)	—	—	101	101	Big supply	1·62	—	—	83B.	—	—	—	—

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Bon Bon No. 30 Bore	—	—	115	—	Not very big supply	1·64	—	—	—	—	—	Sub-Jurassic	Clay clogs pump	30-31	135-136
Bon Bon No. 32 Bore	—	—	209	—	—	Salt	—	—	25-30B	—	Bluish shale on hard limestone	Bluish shale on hard limestone	—		
Bon Bon No. 35 Bore	—	—	160	—	—	Salt	—	—	—	—	White gritty clay	White gritty clay	—		
Bon Bon No. 36 Bore (McInerney No. 1)	—	—	120	—	—	Salt	—	—	—	—	—	Soft sandstone ..	—		
Bon Bon No. 37 Bore	—	—	—	—	—	—	—	—	—	—	—	Sandy clay	1927, in progress		
Bulgunnia Stn., Bulgunnia Well	—	—	65	—	—	0·57	—	—	—	—	—	Fine white sand which cakes when dry	—		
Bulgunnia Stn., Lena Bore	—	—	138	138	10,000	¼	—	—	128B	—	Coarse sandstone	Coarse sandstone	—		
Bulgunnia Stn., Marie Bore	—	—	116½	115	10,000	¼	—	—	102B	—	Coarse washed sandstone	Coarse washed sandstone	—		
Bulgunnia Stn., Grace Bore	—	—	130	120	12,000	½	—	—	103½B	—	Coarse yellow sandstone with clay	Coarse yellow sandstone with clay	—		
Bulgunnia Stn., Lloyd Bore	—	—	180	171	12,000	Fresh	—	—	160B	—	Yellow sandstone	Yellow sandstone with coarse wash at bottom	—		
Bulgunnia Stn., Vokes Bore	—	—	102	100	Unlimited	¾	—	—	86B	—	Coarse sandstone	Coarse sandstone	—		
Bulgunnia Stn., Pennefather Bore	—	—	94	92	Unlimited	¼	—	—	79½B	—	Coarse sandstone	Coarse sandstone	—		

Bulgunnia, Hayward Bore	—	—	123½	123	Unlimited	¾	—	—	108B	—	Coarse yellow sandstone	Coarse yellow sandstone	—
Bulgunnia Stn., Butterfield Bore	—	—	120	119	8,000	Fresh	—	—	99B	—	White sandstone	White sandstone	—
Bulgunnia Stn., Woolshed Bore	—	—	98	94	Unlimited	Fresh	—	—	62B	—	White sandstone	Coarse brown washed sandstone	—
Bulgunnia Stn., Harry Well	—	—	77½	77½	Unlimited	Fresh	—	—	72B	—	Sandstone, soft . .	Soft sandstone . .	—
Coondambo Stn., Bitter Well	—	—	30-40	—	—	Brackish to fresh	—	—	—	—	Grit, kaolin and sandstone	Grit, kaolin and sandstone	—
Coondambo Stn., Glendambo Well	—	—	30	—	Large supply	Good	—	—	—	—	—	—	—
Coondambo Stn., No. 10 Bore	1926	—	133	36	250	¾	—	—	20B	—	Soft white sandstone	Lake soil	For watering sheep
Coondambo Stn., No. 11 Bore	1926	—	40	36	250	¾	—	—	20B	—	Soft white sandstone	Soft white sandstone	To be used for watering sheep
Millers Creek Past. Co. No. 5 Bore	—	—	216	180 211	30 31,680	— 1·48	— —	— —	— —	— —	Drift sand. . . . . . . Drift sand.	Drift sand.	— —
Millers Creek Past. Co., No. 10 Bore	1928	—	562½	156 171 400-460	Small Small supply 26,000	Fresh Fresh 1·45	— — —	— — —	— 149B —	— — —	Loose sand . . . . . Soft sandstone Blue shale.	Brown shale	Good stock water and sheep do well on it
Millers Creek Past. Co. No. 11 Bore	1928	—	249½	240	17,280	1·49	—	—	209½B	—	Grey sand	Grey sand	Good stock water sheep do well on it
Mt. Eba Stn., No. 1 Bore or Lookout Bore	—	—	270	216 265 270	700 1,200 —	1¼ 1⅜ 3½	— — —	— — —	191B 195B —	— — —	Gritty grey shale. Gritty grey shale. Gritty grey shale.	Gritty grey shale.	— — —
Mt. Eba, Laurie Hill Bore or No. 2 Bore	—	—	325	245 +	—	1·31	—	—	245B	—	—	—	—
Mt. Eba No. 3 Bore	—	—	375	—	—	—	—	—	—	—	—	—	Dry, unfinished
Mt. Eba No. 4 Buckland Bore	—	—	342	—	—	1·87	—	—	200B	—	—	—	—
Mt. Eba No. 5 Gundaloo Bore	—	—	320	319 289	— Main supply	— 1·31	— —	— —	— —	— —	Blue sandy clay. . Blue clay and boulders	Blue sandy clay. .	— —

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Mt. Eba No. 6, Cheadle Bore	—	—	190	—	—	⅝	—	—	—	—	—	Wash sand	—	30-31	135-136
Mt. Eba No. 7 Septabyng Bore	—	—	203	203	—	1·59	—	—	143B	—	Sandy rubble and gravel	Sandy rubble and gravel	—		
Mt. Eba No. 8 Salt Ash Bore	—	—	195	193	—	1·91	—	—	163B	—	Black clay	Black clay	—		
Mt. Eba No. 9 Kangaroo Bore	—	—	222	220	—	1·57	—	—	195B	—	Black clay	Black clay	—		
Mt. Eba No. 10 Bald Hill Salt Bore	—	—	236	—	—	2+	—	—	—	—	—	—	—		
Mt. Eba No. 11 Bald Hill Bore	—	—	233	230	—	1·46	—	—	206B	—	Black clay	Black clay	—		
Mt. Eba No. 12 Sundown Bore	—	—	195	—	—	1·44	—	—	—	—	Rubble	Rubble	—		
Mt. Eba No. 13 Woolly Paddock	—	—	375	—	Small supply	1½	—	—	—	—	Blue shale and blue rock with seams of sand	Blue shale and blue rock with seams of sand	Abandoned		
Mt. Eba No. 14 Station Bore	—	—	—	—	4,500	¾	—	—	—	—	—	Sand and rubble .	—		
Mt. Eba No. 15 Bore	—	—	—	198	15,000	1·53	—	—	—	—	—	Sand and rubble wash	—		
Mt. Eba Boolka Well	—	—	145	—	12,000	—	—	—	—	—	Sandstone	Sandstone	Horse water		
Mt. Eba Horse Well (adjacent Boolka Well)	—	—	140	—	300	Fresh	—	—	—	—	—	—	—		
Mt. Eba Cavanagh Well	—	—	150	—	3,000-4,000	Slightly brackish	—	—	—	—	—	Crinkled yellow clay	—		

Mt. Eba Central Well	—	—	168	—	Big supply	⅝	—	—	—	—	—	—	—	
Mt. Eba Cork-screw Well	—	—	—	—	—	1⅝	—	—	—	—	Blue shale.......	Blue shale.......	—	
Mt. Eba H.S., House Well	—	—	130	—	Small supply	Fresh	—	—	95B	—	Grit	Grit	—	
Mt. Eba H.S. Yard Well	—	—	130	—	1,000	¼	—	—	126B	—	Fine sand	Fine sand	—	
Mt. Eba Bore, close to H.S.	—	—	210	—	—	—	—	—	—	—	—	—	—	
Mt. Eba Kalabyng Well	—	—	140	—	5,000	Good stock water	—	—	136B	—	Sandstone	Sandstone ...... —	—	
Mt. Eba Paisley Well	—	—	207	—	—	1·15	—	—	—	—	—	Sand	—	
Mt. Eba Studley Well	—	—	168	—	9,000	Fresh	—	—	—	—	Jurassic drift sand	Jurassic drift sand	40ft. water soakage	
Mt. Eba Trial Hole (Old)	—	—	100+	—	—	Salt	—	—	—	—	—	Sandstone	—	
Mt. Eba Valley Well	—	—	150	—	15,000	1⅜	—	—	145B	—	Jurassic.........	Jurassic.........	—	
Mt. Vivian Stn. Old Mt. Eba Wells	—	—	60-70	—	1,500	Fresh	—	—	—	—	—	—	—	
Twins Station, Twins Well	—	—	—	—	Unlimited	Fresh	—	—	—	—	White shale	White shale	Potable and garden	
Twins Station Glen Jacob Bore	—	—	258	247	Good supply	1·29	—	—	247B	—	Coarse sandstone	Coarse sandstone	—	
Twins Station Well 4 miles W. Twins Well	—	—	167	127	500	Fresh	—	—	—	—	Pebbles	Blue shale.......	—	
Twins Stn., 8 miles W. of Twins Well	—	—	185	—	—	—		—	—	—	—	Dry sand	Dry	
Twins Stn., 13 miles W. of Twins Well	—	—	150	150	—	0·45	—	—	—	—	Dry sand	Dry sand	—	
Wilgena Kin-goonya Well	—	—	63	—	15,000	0·61	—	—	48B	—	—	Hard limestone .	—	

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Wilgena North Well	—	—	60	—	24,000	Brackish	—	—	—	—	Sandstone with nodular boulders and coarse gravel	Sandstone with nodular boulders and coarse gravel	—	30-31	135-136
Wilgena Whymlet Well	—	—	85	—	7,000	Fresh	—	—	—	—	—	—	—		
Snake Creek Bore	—	—	2,327	—	—	0·31	—	—	—	—	—	—	—	27-28	136-137
Wood Duck H.S. Bore	—	—	820	—	—	0·34	—	—	—	—	—	—	—		
Bore 1½ Miles N.-W. of Junction Waterhole	—	—	800	—	—	—	—	—	—	—	—	—	—		
Bore on Peechar-Murranna Creek	—	—	1,275	—	—	—	—	—	—	—	—	—	—		
Piarooka Bore	—	50	1,014½	39	—	6·87	—	—	—	—	Sand	Layer of marine fossils	Abandoned	28-29	136-137
Cooinchina Bore	—	—	1,250	—	—	0·88	—	—	—	—	—	—	—		
William Creek Bore	—	250	229	— 229	— 3,840	Salt 0·81	— —	— —	— 7A	— —	— —	— —	— —		
Anna Creek Stn., Bore near Douglas Creek	—	—	380	365-367 378-380	— Unlimited	— 0·72	— —	— —	3B 2A	— —	White sandstone Driftsand	Driftsand	— —		
Anna Creek Railway Bore	1887	—	988	—	Dry	—	—	—	—	—	—	Very hard crystalline and slaty rock	By Goyder 1891, 366·33 gr. p.g., a sulphate water		
Anna Creek Well C.A.R.	—	—	92	6 12 84	— — 1,000 g.p.h.	— — 0·12	— — —	— — —	— — —	— — —	— — —	— — —	— — —		

Anna Creek Bore C.A.R.	—	—	410	98 107 —	— — 4,080 g.p.h.	Salt — 0·73	— — —	— — —	— 77B 80B	— — —	Soft slate with little clay Soft slate with little clay —	Harder slate	Water at 98ft. cased off. Pump at 242ft. —		
Millers Creek Pastoral Co. No. 1 Bore	—	—	240	200	1,000	1·52	—	—	—	—	Soft white sandstone	Soft white sandstone	—	29-30	136-137
Millers Creek No. 2 Bore	—	—	196	190	5,000	0·21	—	—	—	—	Coarse sand and pyrites	Coarse sand and pyrites	—		
Millers Creek No. 3 Bore	—	—	290	—	1,000	—	—	—	—	—	White sandstone	White sandstone	Fell in		
Millers Creek No. 4 Bore	—	—	226	216	—	1·16	—	—	—	—	Sandstone	Sandstone	—		
Millers Creek No. 7 Bore	—	—	710½	90/185 706	30/400 12,000	— 1·45	— —	— —	— —	— —	Drift sand, white, red, yellow and brown fine drift sand Drift sand.......	Drift sand.......	Last test at 300ft. —		
Margaret Creek Bore	—	220	691	149 478	— 9,600	Salt Salt	— 78	— 52·75	A A	— —	Blue clay, calc. sandstone	White sandstone	Abandoned. No prospects of good water		
Lake Eyre Stn., No. 1 Bore	1933	—	975	25 115 330 975	Small — 400 g.p.h. 150,000	3½ 2½ 3½ ⅛	— — — —	— — — —	— — — A	— — — —	White sandy clay Brown shale .... Grey shale ...... Q. sand	Quartz sand	— — — —		
Coward Bore ...	1886	70	308	Surface to 20 —	— 1,200,000	Salt 0·52 Slightly brackish	— 95	— 10·32	— A	— —	Surface loam and brown clay —	White sand with pyrites	— —		
Coorie Appa Bore	—	160	1,858	428 528 1,464 1,840	— — — —	2 Very brackish 2½ 6	— — — —	— — — —	19B 16½B 60B 37B	— — — —	Sand .... Coarse gravel conglomerate Indurated sand, fine Fine sand and white Q.	Fine sand and white Q.	— — —		
Strangways Springs Bore	—	146	365	308 —	5,000 30,000 g.p.h.	Fresh 0·89	— 95	— —	A A	— —	Indurated sand .. White sandstone	Sand	Quantity increased to 1,200,000 g.p.d.		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Beresford Bore, C.A.R.	—	—	310	46 65 310	— — 7,200 approx. g.p.h.	Salt Salt 0·62	— — —	— — —	— — A	— — —	Shale .... Shale .... Sandstone	Sandstone	Water at 46ft. cased off at 51ft. water at 65ft. cased off at 71ft.	29-30	136-137
Billakallina No. 1 Bore	—	—	33	33	+8,000	0·60	—	—	27B	—	Fine white sand and yellow sandstone	Fine white sand and yellow sandstone	—		
Billakallina No. 2 Bore	—	—	64	64	8,000	1·45	—	—	58B	—	Coarse sand	Coarse sand	Good stock		
Billakallina No. 4 Bore	—	—	—	—	—	1·79	—	—	—	—	—	—	Killed sheep		
Billakallina No. 5 Bore	—	—	—	—	Large	0·84	—	—	—	—	—	—	—		
Billakallina No. 6 Bore	—	—	—	—	—	1·36	—	—	—	—	—	—	—		
Billakallina No. 7 Bore	—	—	—	—	—	2·08	—	—	—	—	—	—	Later analysis 2·54 oz. p.g.		
Billakallina No. 3 Bore	—	—	223	—	—	1·41	—	—	—	—	—	—	Good stock	30-31	136-137
Billakallina No. 8 Bore	—	—	347	—	—	—	—	—	—	—	—	—	Good stock		
Millers Creek Past. Co. No. 8 Bore	—	—	204	198	26,800	1·65	—	—	—	—	Driftsand	Driftsand	Tested at 180ft.		
Millers Creek No. 9 Bore	—	—	240	220-240	30,000	1·91	—	—	—	—	Soft sandstone and pyrite sand coarse	Soft sandstone and pyrite sand coarse	Tested at 150ft.		
Millers Creek No. 12 Bore	1928	—	258	210 250	— +10,000	Salt 1·67	— —	— —	— 230B	— —	Soft sandstone . Driftsand	Driftsand	— —		

Millers Creek Past. Co. No. 13 Bore	1928	—	162	160	10,000	1·80	—	—	—	—	Rock	Rock	Sheep	—	
Andamooka Little Well	—	—	41	—	—	—	—	—	22B	—	Limestone.......	Limestone.......	Reputed fresh over salt. Now used for sheep		
Woolnomulla Well	—	—	180	—	—	3½	—	—	—	—	—	—	—		
Parakylia Stn. Lochs Well	—	—	80	—	3,000	0·48	—	—	—	—	—	—	20ft. drive		
Parakylia Stn., 13 mile Clay Pan Bore	1941	—	171	149 171	140 g.p.h. 1,000 g.p.h.	2 1⅜ oz.	— —	— —	— —	— —	Sandy clay ..... Sandstone	Sandstone	— —		
Parakylia Stn., 23 mile S. Bore	1941	—	160	155	250 g.p.h.	2	—	—	—	—	Pink rock	—	—		
Parakylia Stn. A. III. Bore	—	—	161	—	5,000	1·23	—	—	—	—	—	—	—		
Parakylia Stn. C I. Bore	—	—	196	195	—	1·97	—	—	—	—	—	—	Abandoned		
Lake Lettie No. 1 Bore	—	—	1,250	—	30,000	0·21	—	—	—	—	—	—	—	29-30	137-138
Callanna Stn. Brooks Bore Lake Lettie No. 2	1925	—	1,253	346 386 1,127 1,246 1,253	Little — 24,000 70,000 200,000 inc. to 1,500,000	Salt Salt Good — 0·22	— — — — —	— — — — —	— — — — A	— — — — —	Coarse Q. and sand Green silty sand and clay Hard streak over sand rock Sand rock ...... Sand and stones .	Sand and stones .	— — — — —		
Lake Lettie No. 3 Bore	1921	Est. 30	1,607	30 1,501 1,541 1,598	— Small flow 35,000 2,000,000	Salt Salt Good 0·22	— — — —	— — — —	— A A A	— — — —	Blue shale....... Green clay ...... Blue shale under small bands of brown rock Sand rock	Sand rock.......	— — — —		
Lake Lettie No. 4	—	—	—	—	70,000	0·20	—	—	—	—	—	—	—		
Morris Bore	—	—	1,100	1,100	Flow	—	88	58·3	A	—	Sand	Sand	—		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Alberrie Creek Bore, C.A.R.	—	—	690	232	480	0·52	—	—	A	—	Sand	Sandstone	No increase in supply when deepened	29-30	137-138
Curdimurka Bore C.A.R.	—	—	450	125 306 312 315 407/450	— — — 60 g.p.h. 700 g.p.h. inc. to 3,600 at btm.	Salt — — — 0·40 at btm.	— — — — —	— — — — —	— — 112B A 20A	— — — — —	— Blue rock .... Blue rock .... — —	— — — — —	First water cased off at 130ft. — — —		
Goyder Lagoon Bore	—	125	4,850	60 2,151 4,700	— — 600,000	2 3½ 0·12	73 80 208	3·33 210 33·7	14B 14B A	— — —	Pipe clay and siliceous sand Siliceous sand and clay indurated Sandstone, fine grained sand	Sand	— — —	27-28	138-139
Berlino Stn. Well No. 1	—	—	30	—	—	Brackish	—	—	—	—	Sandy gypseous rock	—	—		
Berlino Stn. Well No. 2	—	—	20	—	—	Fresh but only fair	— —	— —	— —	— —	Gypseous clay and soft sandstone	—	—		
Cowarie Stn. Well	—	—	40-50	—	—	Good	—	—	—	—	Gypseous clay and sand	—	—		
Mirra Mitta Bore	—	153	3,534	3,460 3,485 3,506 3,534	400 56,000 100,000 470,000	— — — 0·12	— 122 176 190	— 66·1 32·6 29·0	A A A A	— — — —	Soft siliceous sandstone	Soft siliceous sandstone	—		
Mt. Gason......	—	250	4,420	3,434 4,304	Small 9,000	¾ 0·12	— 204	— 31·7	34B A	— —	Blue shale....... Indurated sand ..	Sand and sandstone fragments	Flow increased to 480,000 g.p.d. from 4,403 ft. to 4,420 ft.		
Blaze Well	—	—	90	—	—	Good	—	—	—	—	—	—	—	28-29	138-139

Tidnacoordaninna	—	—	90·100	—	—	—	—	—	—	—	—	—	Good stock
Cannuwaukaninna Bore	1916	—	2,487	63 2,765-2,767 2,838-2,847	— 50,000 276,000	2¾ — 0·21	— — 170	— — 27·9	54B A A	— — —	Dark brown carbonaceous sandstone Blue shale and sandstone . . Coarser white sandstone with lignite traces	Coarser white sandstone with lignite traces	—
Etadunna Well .	—	—	70	—	—	—	—	—	—	—	—	—	High $MgSO_4$ content
Kopperamanna Mission Stn. Well	—	—	Shallow	—	Good	—	—	—	—	—	—	—	—
Kopperamanna Bore	—	50	3,000	960 1,022 1,940 3,000	— — — 800,000	Salt Salt Salt 0·29	— — — 176	— — — 29·5	126B 48B — A	— — — —	Blue shale with carbonaceous matter Hard crystalline limestone with iron pyrites Blue shale with bands of blue calcareous rock Fine grained quartzose sandstone slightly micaceous and ferruginous	Fine grained quartzose sandstone slightly micaceous and ferruginous	— — —
Mulka Bore	—	213	3,445	240 3,338 3,433	— — 530,000	Salt Fresh 0·14	— — 180	— — 30·7	— 54B —	— — —	Sand, dark . . . . . Fine sand . . . . . . Hard sandstone, very crystalline sand	Sand and lignite .	— — —
Mulka Well	—	—	100	—	—	Good drinking	—	—	—	—	—	—	—
Mungeranie Bore	—	250	3,370	70 3,360	Small supply 600,000	3 ozs. 0·12	— 187	— 283	55B A	— —	Yellow clay . . . . . Slightly indurated siliceous sand	Slightly indurated siliceous sand	— —
Mungeranie, Deep Well	—	—	—	—	—	Salt	—	—	—	—	—	Sandstone over pipe clay	—
Mungeranie, Shallow Well	—	—	—	—	—	Good	—	—	—	—	—	—	—
Scobies Well. . . .	—	—	—	—	—	—	—	—	—	—	—	—	Good stock water

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
White Well near Mulka Hill	—	—	100	—	Good	—	—	—	—	—	—	White sandstone and pipe clay	Well about the best on the road	28-29	138-139
Marree Bore, No. 1 C.A.R.	—	—	392	15	—	Salt	—	—	—	—	Yellow clay	Blue rock	At 345ft. water commenced to rise at 380ft. fairly strong flow	29-30	138-139
				180	—	Salt	—	—	—	—	Dark blue clay ..				
				345	—	—	—	—	—	—	—				
				380	—	—	—	—	—	—	—				
				385	3,000 g.p.h.	0·36	—	—	A	—	Blue rock		—		
Marree Bore, No. 2 C.A.R.	—	—	390	—	—	—	—	—	—	—	—	Grey sandstone ..	—		
Marree Bore ...	1907	155	575	347	25,000	0·33	86	18·6	A	—	Sandy layer	Very fine-grained sandstone rock	—		
Hergott (Railway) Bore	—	155	342	—	27,000	—	—	—	A	—	—	Hard blue calcareous rock	—		
Abdul Bore	1915	156	341	50	—	Salt	—	—	—	—	Blue shale with thin layers of calcareous rock	Sandy shale	—		
				301	600	¾	—	—	Surface A	—	Blue shale and pebbles		—		
				324	72,000	0·32	—	—		—	Sandy shale		—		
Clayton Bore ..	1908	—	1,704	80	Small	Fresh	—	—	—	—	Grey sandy shale.	Quartz sand	—		
				220	—	Salt	—	—	—	—	Pieces of lignite .		—		
				908	—	Salt	—	—	—	—	Quartz sand, coarse		—		
				1,640	—	—	—	—	—	—	Blue shale.......		—		
				1,704	800,000	0·17	128	28·5	A	—	Medium grained quartz sand		—		
Dulkaninna Bore	—	150	2,226	150	—	Salt	—	—	—	—	Dark shale with lignite	Micaceous sandstone	—		
				260	—	Salt	—	—	—	—	Dark shale with lignite		—		
				1,196	—	Salt	—	—	15B	—	Indurated siliceous sand				
				2,123	—	Good	—	—	—	—	Grey calcareous rock		—		
				2,129	1,000,000	0·27	148	26·6	A	—	Micaceous sandstone		—		

Lake Billy Bore.	1916	—	1,118	1,046	—	—	—	—	—	—	—	—	Horses, cattle and domestic purposes
				1,065	250,000	—	—	—	A	—	—	—	—
Lake Harry Bore	—	142	1,360	6/55	—	Very salt	—	—	—	—	Yellow argillaceous sand	Fine grey sand...	—
				580	—	Salt	—	—	25B	—	Gravel		—
				—	—	0·21	116	—	9A	—	—	—	—
Mundowdna Bore on Well Creek, 13 miles East of Marree	1915	—	973¾	832	3,000	Fresh	—	—	A	—	Sand .... Rotten rock	Grey slate, seams of quartz	Horses and cattle
	1915	—	—	850	7,000	Fresh	—	—	A	—	—		
				884	7,280	Fresh	—	—	A	—	Grey slate, seams of quartz		Total supply, 17,280 g.p.d.
Murnpeowie, Borehole Corner Well and Bore	—	—	200 or 300	—	Dry	—	—	—	—	—	—	—	Abandoned
Murnpeowie, Chappalanna Bore	1926	—	1,367	160/285	—	Salt	—	—	—	—	Sandy shale	Sandstone	—
				384/387	Big	Salt	—	—	—	—	Light shale		—
				1,103/1,107	6,000	0·18	—	—	A	—	Fine sand		—
				1,175/6	16,000		—	—	A	—	Coarse sand		—
				1,354/1,367	250,000		—	—	A	—	Sandstone		
Murnpeowie, Clayton Dam Bore	1914	1,139	1,139	100	—	Salt	—	—	—	—	Shale	Pipe clay and gravel	—
				960	400,000	0·27	—	—	18-20B	—	Sandrock		
				970			—	—	18-20B	—	Sandrock		
				1,100			—	—	A	—	Sandrock		
Murnpeowie, Corryanna Bore	—	—	1,597	13	—	Salt	—	—	—	—	Blue shale.......	—	—
				660	—	Good	—	—	8B	—	Gravel bed	—	—
				1,594	1,080,000	0·16	—	—	A	—	Under a hard streak of rock at 1,594ft.	—	—
Murnpeowie, Inakoo Well	—	—	100	—	—	Good stock	—	—	70B	—	—	—	7,000 sheep
Murnpeowie, Jewellery Creek Bore	—	—	1,733	96/100	—	Salt	—	—	—	—	—	Sand rock	—
				1,480/1,728	1,250,000	0·15	—	—	A	—	—		—
Murnpeowie, Nicko'. Time Bore	1926	—	1,400	Est. 470	Small	5·11	—	—	70B	—	Greyish siliceous sand	Coarser sand	Supply increased as deepened
				1,098/1,100	Little	—	—	—	—	—	Q. grit and angular slaty chippings		—
				1,268/1,271	—	—	—	—	60B	—	Coarse Q. sand		—
				1,280/1,400	20,000/250,000	0·17	—	—	A	—	Sand		—

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Murnpeowie, Tooperawarinna Bore	—	—	1,591	1,250/ 1,383	—	Fresh	—	—	68B	—	—	Bedrock	—	29-30	138-139
Murnpeowie, Troudaninna Bore	1910	—	1,609	80	Small	Salt	—	—	—	—	Dark clay	Grey sand rock ..	—		
				1,302	35,000	Fresh	—	—	A	—	Sand rock		—		
				1,337	100,000	—	—	—	A	—	Sand, coarse gravel		—		
				1,609	987,000	0·15	—	—	A	—	Grey sand rock ..		—		
Murnpeowie, New Troudaninna Bore	—	—	—	371	—	Salt	—	—	—	—	—	—	—		
				620	—	2·27	—	—	—	—	—	—	—		
				1,302	—	0·25	—	—	—	—	—	—	—		
				1,350	—	0·15	—	—	—	—	—	—	—		
Murnpeowie, Yarra Hill Bore	—	—	1,029	18	—	Salt	—	—	—	—	—	Bedrock	—		
				165	Small	—	—	—	A	—	Gravel		—		
				900/ 1,007	22,000/ 508,000	0·19	—	—	A	—	Sandrock to sand and clay		—		
Peachawarrina Bore	1917	—	2,484	85	Small	3	—	—	—	—	Kaolin with some siliceous sand	Coarser fine white sandstone with traces of lignite	—		
				351	—	+3	—	—	100B	—	Sand with carbonaceous traces		—		
				1,580	Some	—	—	—	1,580	—	Siliceous sand and blue clay		—		
				2,325	Some	—	—	—	2,325	—	Grey sandy clay .		—		
				2,348/ 2,355	4,320	1·78	92	104·45	A	—	White sandstone		—		
				2,464/ 2,484	500,000	0·25	152	29·44	A	—	Fine white sandstone		—		
Avon Downs, Sinclair Bore	1915	—	1,808	120	—	Salt	—	—	—	—	Grey shale with traces of lignite	White siliceous sand with pebbles of Q. and Qte.	—		
				550	—	Salt	—	—	120B	—	Sandy shale		—		
				939	—	¾	—	—	92B	—	Dark sand		—		
				1,806	432,000	0·16	130	29·27	A	—	White siliceous sand		—		

P

Tarkanina Bore	—	180	1,225	38/44	—	Salt	—	—	—	—	Blue sandy shale.	Grey shale	—		
				515/518	—	Salt	—	—	—	—	Quartz gravel with iron pyrite		Salt water in bore		
				587/590	—	Salt	—	—	29B	—	Grey sandy shale.		Later salt water got into it and bore abandoned		
				1,220	—	Fresh	—	—	20A	—	Grey shale				
Clifton Hills, Corkwood Well	—	—	—	—	—	1·01	—	—	—	—	—	—	—	26-27	139-140
Clifton Hills, Melon Creek Bore	—	—	600	51	—	—	—	—	—	—	White soft ste. slightly coarser	Greenish-grey shale	—	27-28	139-140
				80½	—	Salt	—	—	—	—	Soft siliceous silt		—		
				103	—	Salt	—	—	—	—	Creamy ste		—		
Kalladeina Bore	1913	200 est.	3,984	80	—	Salt	—	—	—	—	Sandy clay, green		—		
				130	—	Bitter	—	—	80B	—	Sandy clay, green	Sandstone	—		
				3,907	—	—	—	—	A	—	Sandstone		—		
				3,984	500,000	0·14	183	34·8	A	—	Sandstone		—		
Montecollina Bore	—	140	2,500	256	—	9	—	—	23B	—	White siliceous sand	—	Tested supply, 43,000 g.p.h. 6/6/40	29-30	139-140
				1,665/ 1,680	11,700 increasing to 30,000	1½	110	40·4	A	—	Fine to medium grained siliceous sand and blue shale	—			
				—	—	0·92	—	—	—	—	—	—			
Murnpeowie, Central Well	—	—	400	—	—	—	—	—	—	—	—	—	Failure		
Murnpeowie, Crombies Well	—	—	70 approx.	—	Dry	—	—	—	—	—	—	White organic limestone over lignitic clay	—		
Murnpeowie, Dean Lookout Bore	—	—	1,071	20	—	Salt	—	—	—	—	Mixed blue and yellow clay	Hard rock.......	Flow measured, 308,000gall.		
				158	14,000	Salt	—	—	—	—	Red sand and gravel				
				918	Very small flow increasing to 192,000 at 927ft. and 360,000 at 995ft.	—	—	—	A	—	Soft sandrock with clay				
Murnpeowie, Emu Well and Bore	—	—	200	—	—	—	—	—	40B	—	—	—	Poor stock water, 6,000 sheep		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Murnpeowie, Junction Well	—	—	90	—	—	—	—	—	—	—	—	—	Waters 5,000 sheep, good stock water	29-30	139-140
Murnpeowie, Koortanyaninna Well	—	—	100	—	No supply	Good	—	—	—	—	—	—	—		
Lake Crossing Bore, 1 or 2	—	—	353	—	—	—	—	—	—	—	—	Sand and lignite			
Lake Crossing Bore No. 3	—	150	1,703	427	—	Salt	—	—	20B	—	Sand	Blue shale.......	Water at 1,050ft. and 1,351ft. stock. Temp. 115°		
				740	—	Brackish	—	—	A	—	Grey shale with calc. sandy bands				
				1,050	—	1½	—	—	A	—	Blue shale.......				
				1,351	130,000	1·69	—	—	A	—	Quartzose sand ..				
Murnpeowie Station, Meteor Bore	1910	—	931	134	—	Salt	—	—	—	—	Sand	Granite	—		
				920/931	Small increasing to 460,800	0·19	—	—	—	—	Hard sandrock...		—		
Murnpeowie Bore	1912	—	1,300	87	—	Fresh	—	—	—	—	Blue shale.......	Sandrock	At 1,093 ft. depth 104·00 gr./g., after deepened, anal. 0·20 (1922)		
				314	—	Fresh	—	—	63B	—	Coarse gravel ...				
				1,025	—	—	—	—	A	—	Sandrock				
				1,075	128,000	—	—	—	A	—	Sandrock				
				1,185	300,000	—	—	—	A	—	Sandrock				
Murnpeowie, Petermorra Bore	—	200	1,243	130 abt.	—	⅝	76	13·3	—	—	Pipe clay, little sand	Grey sand	—		
				1,190 abt.	Small	3	76	190	186B	—	Blue shale.......		—		
				—	192,000	0·17	111	—	—	—	—		—		

Murnpeowie, Petermorra Springs	—	—	—	—	—	0·20	—	—	—	—	—	—	—		
Murnpeowie, Quart Pot Bore	1914	—	950	11/50	—	3½	—	—	—	—	Yellow clay	Cemented sandstone	—		
				61/724	106,000					—	Shale		—		
				724/725		0·18	110	—	A	—	Sandy clay and sandrock				
				862/3						—	Rock		—		
Murnpeowie, Red Banks Well and Bore	—	—	190	—	—	—	—	—	—	—	Lower Cretaceous ?	—	Well to 90ft., potable, 4,000 sheep		
Murnpeowie, Tooncatchyn Bore	1927	—	1,810	149	—	4·99	—	—	110B	—	Grey siliceous sand with pebbles like indurated shale or slate	Very fine sand with mica and black specks of carbonaceous material	—		
				886	—	Salt	—	—	64B	—	Siliceous sand with some grey slate		—		
				943	7,000	2·53	—	—	A	—	Grey siliceous sand with white mica and trace of pink felspar		—		
				1,748	30,000	—	—	—	A	—	Fine quartz sand, some mica		—		
				1,810	250,000	0·18	—	—	A	—	Very fine sand with mica and black specks of carbonaceous material		—		
Murnpeowie Station, Woolatchie Bore	—	316 an.	1,872	110	300 g/h	—	—	—	—	—	Clay and gravel .	Sandrock	—		
				243	600 g/h	—	—	—	143B	—	Yellow sand		—		
				1,177	—	Salt	—	—	80B	—	Merging into sandrock		—		
				1,821/ 1,872	280,000	0·32	158	20·1	A	—	Soft grey sandrock		—		
Murnpeowie Station, Yerila Bore	—	—	1,440	120	—	—	—	—	70B	—	Grey mud	Sandrock	Abandoned		
				217	Small	—	—	—	43B	—	Sand and clay ...				
				993	—	—	—	—	A	—	Sand and shells ..				
				1,246	14,400 increasing to 216,000 at 1,260ft.	2·03	—	—	A	—	Sandrock				
Wooltana No. 19	1923	—	156	140	50 g/h	Salt	—	—	130B	—	Gravel	Gravel	Abandoned .	30-31	139-140
				150	Unlimited	Salt	—	—	130B	—	Gravel				

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Wooltana No. 20	1923	—	162	140/162	Unlimited	0·21	—	—	110B	—	Sandy clay and drift sand	Driftsand	Sheep and other stock	30-31	139-140
Wooltana No. 23	1923	—	178	140	50 g.p.h.	2·24	—	—	—	—	Gravel	Gravel	Abandoned owing to salt water		
				150	Unlimited	3·24	—	—	130B	—	Gravel				
Wooltana No. 24	1923	—	144	136	50 g.p.h.	—	—	—	—	—	Gravel	Gravel			
				140	Unlimited	3·66	—	—	126B	—	Gravel		Abandoned owing to salt water		
Cordillo. Bathricoola Well	—	—	101	—	—	0·03	—	—	—	—	—	Yellow shale.....	—	26-27	140-141
Cordillo, Frew Well	—	—	80	—	Small	⅜	—	—	66B	—	—	White clays	—		
Innamincka Station, Bookabourdie Well	—	—	53	53	—	Good drinking	—	—	—	—	Sandy clay	Sandy clay	—	27-28	140-141
Innamincka Station, Packsaddle Well	—	—	64	—	Fair	0·15	70	—	62½B	—	—	—	—		
Innamincka Station, Walkers Well	—	—	100	—	Very Small	Good	—	—	—	—	—	—	—		
Innamincka, Nappacoongee Well	—	—	76	—	Good	0·10	69	—	70B	—	—	—	—	28-29	140-141
Coonanna Bore .	—	200 est.	2,030	238	—	—	90	9·4	200B	—	Grey sand with lignite	Coarse gravel, pebbles and lignite	—	29-30	140-141
				970	—	Fresh	103	26·8	160B	—	Soft sand, and sand rock		—		
				1,803	3,500 increasing to 64,000 at 1,833ft.	—	102 to 120	54·7 to 35·6	A	—	Calc. rock and coarse quartz gravel		—		
				2,025	500,000	0·36	134	30·8	A	—	Coarse gravel, pebbles and lignite		—		

Yandama Bore .	—	160	1,642	1,438	—	—	—	—	—	—	Sandstone	Sand and shale ..	—		
				1,566	192,000 increasing to 432,000 at 1,620ft.	Fresh	132	—	20A	—	Fine sand		—		
Tilcha Bore	—	—	2,345	—	750,000	—	—	—	A	—	—	—	Good stock water		
Arboola Bore ..	1913	170 est.	1,060	115	—	Salt	—	—	—	—	Blue sandy clay..	Sand and quartz	—	30-31	140-141
				1,015	230,000 at 1,045ft.	0·28	119	20·3	A	—	Sand and quartz		—		
Coonee Creek Bore	1912	200 est.	1,325	1,325	1,250,000	0·30	—	—	A	—	—	Sandstone, hard .	—		
Culberta Bore ..	—	210 est.	648	190	Small	Salt	—	—	—	—	Sandy pipe clay..	Red granite	Supply increased by pumping to 15,000gall.		
				274	—	Salt	—	—	—	—	Gravel				
				637	2,000	0·26	—	—	—	—	Red sand				
Curraworra Bore	1913	220 est.	1,156	126	—	Salt	—	—	—	—	Sand	Sandy clay with hard bands	—		
				155	—	2½	—	—	125B	—	Blue slaty clay ..		—		
				254	—	1⅛	—	—	150B	—	Sand		—		
				640	—	1¼	—	—	567B	—	Blue slaty clay with thin layers of hard rock		—		
				1,040	1,600	Fresh	—	—	—	—	Blue shale.......		—		
				1,140	280,000 falling to 230,000	0·27	119	22·2	A	—	Sandy clay with hard bands		—		
Glenmanyie Bore	1921	—	890	40	—	9	—	—	28B	—	White calc. clay .	Brown sandstone	—		
				234	—	½	—	—	40B	—	Coarse siliceous gravel		—		
				660	430 increasing to 1,150 at 689ft.	½	—	—	—	—	Blue shale.......		—		
				771	7,000	0·37	—	—	A	—	Plastic white clay		—		
				811	10,800	0·37	100	25·4	A	—	Siliceous sand and gravel		—		
Muloowurtina No. 1 Bore	—	—	710½	74	—	Salt	—	—	4B	—	Brown sand, little clay	Blue calc. slate	—		
				254½	—	Salt	—	—	—	—	Sharp light blue sand		Abandoned		
				452½	—	Salt	—	—	—	—	Indurated sand and mundic		—		
				496¼	—	3	—	—	60B	—	Sandy clay		—		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Muloowurtina No. 2 Bore	—	200	1,432	1,400	314,000	0·26	128	23·2	A	—	Sandstone	Sand	Top water was used in boilers	30-31	140-141
Lake Boolka or Boundary Bore	1941	—	1,676½	283/ 480 1,616/ 1,676½	Large 300,000	Good —	— —	— —	— —	— —	Drift sand and gravel Sandstone	 Sandstone	 Good stock water		
Thurlooka Bore, Lake Elder Pastoral Co.	1921	500 est.	1,104	154 177 234 260 383 547 1,050 1,092	Little — — — — — — 4,800	Salt Brackish Salt — Good Good Good 0·28	— — — — — — — —	— — — — — — — —	— 137B 154B — 183B 200B Rises —	— — — — — — — —	White sand...... White drift ..... White drift ..... White sand...... Coarse white sand Green silty sand . Sand rock with red in it White sand rock with decayed timber	Light clay.......	— — — — — — —		
Quinyambie, No. 1 (Kidman No. 1)	—	—	847	123 361 628 —	— — — —	10 1½ 1¼ 0·33	— — — —	— — — —	— — — —	— — — —	Sand and clay Coarse Q. grit ... Blue shale....... —	Micaceous sand and stone	— — — —		
Quinyambie New Homestead Bore	1945	—	1,452	203 269 286 1,179/ 1,183	Small — 1,800 g.p.h.	Salt 2 0·34	— — —	— — —	203B 195B 60B	— — —	Sandy grey clay . Fine to coarse drift sand Fine to coarse white sand	Mica schist with bands of quartzite	Water level 8ft., inflammable gas		

SUSPENDED BASIN "A"

Cordillo, Horse-shoe Well	—	—	—	—	—	0·42	—	—	25B	—	—	—	—	26-27	140-141
Indranie Bore ..	—	—	458	263 abt. 380-390	Little Good	Fresh 1·70	— —	— —	— —	— —	White sandy clay Blue sandstone ..	Blue clay	— —		
Cordillo, Haddon Jeffrey Well	—	—	40	—	—	2⅞	—	—	30B	—	—	—	—		
Cordillo, Haddon Jibley Well	—	—	55	—	Large	2⅜	—	—	40B	—	—	—	Has been used		
Cordillo, Kood-lannie Well and Bore	—	—	56	56	—	1·23	—	—	49B	—	Yellow arg. sand-stone or sand	Yellow arg. sand-stone or sand	—		
Cordillo, Koora Well	—	—	80	—	—	0·91	—	—	68B	—	—	—	3,000 sheep		
Cordillo, Haddon Macormac Well	—	—	122	—	—	0·12	—	—	—	—	—	—	4,000 sheep for 6 months then supply fell off		
Cordillo, Melon Well	—	—	100	—	1,000	Good	—	—	60B	—	—	White ste........	Supply for five weeks only		
Cordillo, Mirakoonda Bore	1922	—	720	70/76 557/575	Small Good	— 1·04	— —	— —	60B 60B	— —	Boulders .... Sandrock	Sandy clay	— —		
Cordillo, Cadelga Mirkadarrie Padd., Mirka-darrie Bore	—	—	76	—	Dry	—	—	—	—	—	—	Caving gravel....	—		
Cordillo, Mud-carnie Well	—	—	34	—	Big	⅛	—	—	31B	—	—	Reddish sandstone	—		
Cordillo, Nada Well	—	—	56	—	10,000+	0·06	—	—	30B	—	—	—	—		
Cordillo Downs, Needle Well and Bore	—	—	360	83 249 342	— — 840 g/h	— — 0·49	— — —	— — —	— — 80B	— — —	White clay ..... Blue sandstone .. Blue sand rock ..	Blue sandy clay..	Stock water, 1928 supply and quality degenerated — —		
Cordillo Downs, Needle Hill Bore	—	—	497	241	—	0·92	—	—	168B	—	Blue clay	Blue clay or shale	—		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Cordillo, Peetana Well	—	—	138	—	Small	1	—	—	57B	—	—	—	—	26-27	140-141
Cordillo, Peetana Bore	—	—	1,076	1,000/ 1,010	1,000 g/h	1·48	—	—	—	—	Sand rock	Hard blue shale .	—		
Cordillo, Pillathilparie Bore	—	—	510	73 109 484	Soak Small Good	— 0·18 0·16	— — —	— — —	— — 75B	— — —	Pipe clay .... Sandstone ...... Sandstone	Blue clay	— — —		
Cordillo, Pinandinna East Well	—	—	—	—	400	Fresh	—	—	60B	—	—	—	—		
Cordillo, Pinandinna West Well	—	—	100	—	1,000	Good	—	—	60B	—	—	—	Supply for 3 weeks		
Cordillo Downs, Pinlewirrie Bore	—	—	567	23 200 450/465	Soak Little Fair	— — 0·96	— — —	— — —	— — —	— — —	White rock ..... Green sandy clay. Blue sand	Blue clay	— — —		
Cordillo, Terrietcha Well	—	—	70	—	Large	Fresh	—	—	—	—	—	—	—		
Cordillo Downs, Union Bore	1917	—	341	102	700 g/h	0·24	—	—	48B	—	Yellow sandstone	Variegated blue clay	—		
Cordillo Downs, Wongyarra	—	—	883	90/111 125/153 608/621 747/772 789/800	Small — — — —	— — — — 0·94	— — — — —	— — — — —	— — — — 75B	— — — — —	Sandstone ...... Sandstone ...... Sandy rock ..... Sandstone ...... Sandstone	Clay	Supply 1,020 g/h for 2 hours		
Cordillo, Innamincka Well	—	—	45	—	—	Brackish	—	—	—	—	—	—	—		
Cordillo Downs, Bull Hole Bore	1923	—	1,872	— 1,628 abt.	— 1,000 g/h	1⅛ 0·91	— —	— —	66B 60B	— —	— Hard sandstone .	Blue shale.......	First water watered 30 horses With pumping water lowered to 240ft.		

Cordillo, Cadelga Well	—	—	40	—	Fair	Good	—	—	—	—	Reddish sandstone	Reddish sandstone	—		
Cordillo Downs, Cliffs Bore	—	—	524	28-74 406 to 429	Soakage Very little	— —	— —	— —	— —	— —	Yellow clay ..... Blue sandstone ..	Blue clay .... —	Failure —		
Cordillo, Cooroondoona Well	—	—	70	—	7,000	0·54	—	—	—	—	Red sandstone ..	Red sandstone ..	—		
Cordillo, Cordillo H.S. Bore	1917	—	510	99 130	Small Unlimited	— 0·42	— —	— —	— 50B	— —	Yellow clay and sand Yellow clay and sand	Sandy shale ..... —	— —		
Dooncoonara Bore	1918	—	680	185 595	Small 12,000	Fresh 1·40	— —	— —	— 75B	— —	Sandy clay ..... Green sandstone .	Blue clay .... —	Stock water at 595ft.		
Cordillo, Doonbara Well	—	—	52	—	2,000 g.p.h. (d?)	0·20	—	—	45B	—	Sandstone	Sandstone	—		
Cordillo, Dundoona Well	—	—	60	—	700 g.p.h.	Fresh	—	—	40B	—	—	—	Potable		
Cordillo, Durrumbene Well	—	—	60	—	Over 10,000	0·76	—	—	—	—	—	—	—		
Cordillo, Elbow Well and Bore	—	—	78	67	200/220 g.p.h.	0·66	—	—	34B	—	Sandstone	—	Well 78ft. When deepened, 800-900 g.p.h.		
Cordillo, Fresh Water Well, Haddon Creek	—	—	50	39	Very small	Fairly fresh	—	—	—	—	Clay, calc. material, trace of sandstone	Clay, calc. material, trace of sandstone	—		
Cordillo, Haddon Well	—	—	120	—	Very small	Good	—	—	36B	—	—	Clay	Filled to 60ft.		
Innamincka Station, Boomerang Bore	—	—	526	505	—	0·42	—	—	—	—	—	—	—	27-28	140-141
Innamincka Station, Coombangie Well	—	—	32	—	—	Fresh	—	—	—	—	—	Sand	—		
Innamincka Station, Driple Bore	—	—	585	—	—	0·58	—	—	90B	—	—	—	—		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Innamincka Station, Patchawarra Bore	1914	200 est.	5,458	83	—	—	—	—	—	—	Clay, yellow to reddish	Blue shale.......	Water at 83ft. Shut off	27-28	140-141
				450	Strong	⅜	—	—	94B	—	Grey sandstone ..				
				1,600	Little	—	—	—	—	—	Light grey shale changing to sand				
				2,910	—	—	—	—	63B	—	Light grey shale with trace of lignite. Trace of sand only				
				3,880	Little	—	—	—	—	—	Sandy shale				
				4,000	200	0·45	—	—	A	—	Sandy shale				
Innamincka Station, Tooroowatchie Well	—	—	62½	—	Good	1·22	68	—	40B	—	—	—	—		

MARGINAL AND SUSPENDED BASIN "B"

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Dewdney Bore .	1917	350 est.	1,072	140	—	Salt	—	—	—	—	Clay	Hard calc. slate and brownish calc. clay bands with pyrites	—	30-31	140-141
				960	—	⅜oz.	—	—	140B	—	Micaceous sandstone		—		
Banavie Bore ..	—	—	435	95	—	3½	—	—	—	—	Sandy light clay .	Sand and sand rock	—	31-32	140-141
				220	—	2½	—	—	142B	—	Fairly fine quartz sand		—		
				282	—	2½	—	—	—	—	Dark grey sandy clay and mica		—		
				313	—	3	—	—	—	—	Dark grey clayey sand and much mica		—		
				412	—	1·32	—	—	57B	—	Sand and sand rock		—		

Berber Bore ...	—	—	500	125	—	5	—	—	—	—	Fine white sand and sandy clay	Whitish sandy decomposed rock with greenish slaty fragment	Previous anal. at 345ft. 1·38 oz/g. Abandoned	
				—	—	¾	—	—	—	—	—			
				345	—	2½	—	—	100B	—	Coarse sand and coarse mica with slate shingle and pyrite aggregate			
Birksgate Bore .	—	—	441	68	—	10	—	—	30B	—	Fawn clay, trace lignite	Blue clay..	—	
				188	—	1·62	—	—	—	—	Sand		—	
				431	1,200 g.p.h.	0·35	—	—	31B	—	Medium grained grey quartz sand with mica		—	
Buckland Bore..	—	—	300	281	1,400 g.p.h.	0·55	—	—	145B	—	White clean quartz sand, trace mica	White silty clay..	—	
Crabb Bore.....	—	—	350	109	—	4	—	—	—	—	Yellowish grey clay	Coarse sand and grit loosely cemented	—	
				170	—	3	—	—	—	—	Grey clay		—	
				?	—	1·25	—	—	—	—	—		—	
Furlough Bore .	—	—	370+	160	—	4·09	—	—	140B	—	Very fine light-grey siliceous sand	Medium grained siliceous sand	—	
				201	—	2·61	—	—	141B	—	Grey clay		—	
				278	—	1·66	—	—	140B	—	Fine green clean siliceous sand		—	
				355	—	0·7	—	—	145B	—	Medium grey siliceous sand		—	
Lake Charles Bore	—	—	332	82	—	3½	—	—	—	—	White medium-grained siliceous sand	Greyish quartz sand fairly coarse	Much H2S when first struck	
				320	14,000	0·66	—	—	63B	—	Greyish quartz sands and lignites			
Lockhart Bore .	—	—	400	116/136	—	3½	—	—	—	—	Fine Q. sand to dark grey plastic clay	Fine quartz sand gradually becoming coarse	Pump at 206ft., 1,440 g/h	
				223	—	3	—	—	—	—	Fine siliceous sand			
				380	—	0·85	—	—	135B	—	Fine quartz sand			
Glen Roy	—	—	217	112	—	3	—	—	92B	—	Medium grained Q. sand	Brown sand, slightly coarser	—	
				203	14,000 g/h	0·74	—	—	85B	—	Fine siliceous sand		—	

Bore or well	Year completed	Approx. height of surface above s.l., ft.	Total depth of bore, ft.	Depth at which water was struck, ft.	Quantity of water, g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure n lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Mulyungarie, No. 2 Bore	—	—	1,909¼	690 1,030 1,120 1,692 1,710 1,890	— — — — — —	Salt Salt Salt Salt Salt Salt	— — — — — —	— — — — — —	125B 125B 125B 125B 125B 400B	— — — — — —	Hard dark calc. rock — — — — —	Rock	— — — — —	31-32	140-141
Mulyungarie, No. 8 Bore	—	—	403	117 170/180 345/8	— — —	4 3 1½	— — —	— — —	— — —	— — —	Light sandy clay Light blue sandy clay Sand	Greenish clay ...	Abandoned		
Mulyungarie, No. 9 Bore	—	—	312	50 60 262	— — —	6+ 3+ 3+	— — —	— — —	— — —	— — —	Yellow sandy clay Yellow sandy clay Very micaceous sandy clay	Bedrock	Abandoned		
Mulyungarie, Corona Bore	—	—	268	140 189 254	— — 700 g/h	2·24 2·00 0·93	— — —	— — —	— — 130B	— — —	Yellow sandy clay Clay with lignite Very fine siliceous sand	Blue clay	— — —		
Mulyangarie, Oban Bore	—	—	290	163 267	— —	3 1·70	— —	— —	— 113B	— —	Dark grey clay .. Medium grained sharpish quartz sand	Medium grained sharpish quartz sand	Water at 267ft. reported ⅝oz. when struck, then salt		
Mulyungarie, Watson Bore	—	—	365	169 336	— 1,200 g/h	3 0·66	— —	— —	— 145B	— —	Yellow clay ..... Fine sand, some coarse	Coarser sand	— —		
Mulyungarie, Wallace Bore	1941	—	385	60 147 368	Small Fair 1,000 g/h	Salt 4·52 0·93	— — —	— — —	55B 137B 147B	— — —	Yellow and blue gravel Sandy clay ..... White sand......	White sand......	— — —		

MARGINAL BASIN "C"

Erudina, One Gum Bore	—	—	370	370	—	1·70	—	—	—	—	Whitish marly limestone	Whitish marly limestone	—	31-32	139-140
Erudina, Terrell Well and Bore	—	—	80/90	—	—	—	—	—	—	—	—	Sand and gravel .	2,000 sheep		
Erudina, Two Gums Well	—	—	270	20/40 —	— —	— Salt	— —	— —	— —	— —	Sand .... Clay	— —	Should go deeper		
Erudina, Two Mile Well	—	—	70	—	—	Very good	—	—	20B	—	—	—	Has watered 20,000 sheep		
Erudina H.S. Well	—	—	—	—	—	—	—	—	—	—	—	—	Supply and quality not as good as Two Mile Well		
Erudina H.S. (on bank of creek)	—	—	155	71 152	700+ g/h	— —	— —	— —	— —	— —	Rounded quartz sand slightly coherant Coarse sand and fine gravel	Coarse sand and fine gravel	—		
Erudina Station, Well "A"	—	—	26	—	Small	Bitter 3·69	—	—	—	—	—	Clay and gypsum	When water first struck, potable		
Erudina Station, Well "B"	—	—	50	—	Small	Good	—	—	—	—	—	—	—		
Erudina Station Well "C"	—	—	22	22	—	Good	—	—	19B	—	Drift sand.......	Drift sand.......	2,500 sheep		
Erudina Station, Well "D"	—	—	72	72	—	Good	—	—	33B	—	Drift sand (Red)	Drift sand (Red)	—		
Eurinda Station, Well "E"	—	—	7	—	—	Good	—	—	—	—	White drift......	White drift......	1,500 sheep		
Erudina Station, Well "F"	—	—	45	—	—	Good	—	—	—	—	—	Drift	—		
Frome Downs, No. 3 Bore	1892	100	1,412	68 157 330	— — —	Salt Salt Salt	— — —	— — —	60B — 30B	— — —	Variegated clay Grey clay .... White sand......	Hard blue and red calc. rock	Abandoned		
Frome Downs, No. 4 Bore	1892	100	691	110 180 330	— — —	Salt Salt Salt	— — —	— — —	— — 145B	— — —	Yellow clay ..... Blue clay .... Red and yellow clay	Blue and brown calc. rock	Abandoned		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
														31-32	139-140
Frome Downs, Loveday Bore	1925	—	500	427	Big	0·44	—	—	—	—	Fine quartz sand	Slate	Water later went to 3ozs.		
Frome Downs, Napier Well No. 1	—	—	26	—	—	⅝	—	—	—	—	—	Clay	2,000/3,000 sheep watered per day		
Frome Downs, Napier Well No. 2, 100yds. E. of No. 1	—	—	28	—	—	¾	—	—	—	—	—	Clay	2,000/3,000 sheep watered per day		
Kalabity Station Bore, 34m. N. by N.-W. of Kalabity Station	—	—	363 or 373	135 abt.	—	2+	—	—	—	—	Blue rock like slate	Hard grey rock	Pumps 800/900 g.p.h.		
				210 abt.	—	2+	—	—	—	—	Hard grey rock				
				310 abt.	—	2·37	—	—	—	—	Hard grey rock ..				
Wilpena No. 1 .	1927	—	166½	140	6,000	Good	—	—	120B	—	Red clay	Sand and clay ...	Stock		
Wilpena No. 2 .	1927	—	100½	60	5,000	Good	—	—	60B	—	Clay	Clay and sand ...	Stock		
Wirrealpa Amphitheatre Well	—	—	20	—	—	¼	—	—	14B	—	—	—	Waters 1,200 sheep		
Billeroo West. Luckyhit No. 3 Bore	—	—	264	250	750 g/h	1·79	—	—	250B	—	Rock	Rock	—		
Billeroo West, No. 4 Bore	—	—	448	130 }	No Supply	{ 3	—	—	—	—	Whitish limestone	Coarse grey quartz sand	—		
				182 }		{ 2	—	—	—	—	Fine grained sandstone		Water at 237ft., could not pump owing to clay		
				237	—	1¾	—	—	—	—	Greyish clay with sand seams		—		
				260	Big	2·33	—	—	—	—	Whitish clay		—		
				310	No supply	2⅛	—	—	—	—	Sand		—		
				415	—	2½	—	—	—	—	Coarse grey quartz sand		—		

Curnamona, No. 1 Bore	—	—	402	109 234 242 261 282 300 315 340	— — — — — — Small —	$4\frac{1}{2}$ $2\frac{3}{8}$ $2\frac{1}{2}$ $2\frac{1}{4}$ $2\frac{1}{4}$ $2\frac{1}{2}$ 2 $2\frac{1}{4}$	— — — — — — — —	— — — — — — — —	— 115B — 100B — — — 96B	— — — — — — — —	Clay and rock ... Clay .... Clay .... Sand .... Clay and sand ... Clay .... Clay .... Clay	Rock and clay ..	— — 261ft. water is used and stands 90ft. from surface — — — —	
Curnamona, No. 2 Bore .	—	—	532	139 230 263 288 345 380 407 480	— — — — — — — —	— $2\frac{3}{4}$ $2\frac{3}{4}$ $2\frac{3}{4}$ $2\frac{3}{4}$ 4 4 $2\frac{7}{8}$	— — — — — — — —	— — — — — — — —	— — — — — — — —	— — — — — — — —	Clay .... Clay .... Clay .... Clay and drift sand Clay .... Clay .... Lignite .... Clay	Rock	— — — — — — — —	
Curnamona Bore at Box Swamp	—	—	150	—	—	Salt	—	—	—	—	—	—	—	
Curnamona Bore at Marches Dam	—	—	128	—	—	Salt	—	—	—	—	—	—	—	
Curnamona Bore W. of Marches Dam	—	—	103	—	—	Salt	—	—	—	—	—	—	—	
Curnamona, Sandyoota H.S. Bore	—	—	185	70	—	$\frac{1}{8}$	—	—	—	—	—	—	Well 80ft. deep	
Curnamona, N.-E. of Curnamona H.S. Bore	—	—	60	—	—	Salt	—	—	—	—	—	—	—	
Curnamona, Coondappie Station	—	—	30	—	12,000	$\frac{1}{4}$	—	—	—	—	—	—	—	
Curnamona, N.-E. of Curnamona H.S. Bore	—	—	165	—	—	Salt	—	—	—	—	—	—	—	
Curnamona, N.-E. of Curnamona H.S. Bore	—	—	100?	—	—	Salt	—	—	—	—	—	—	—	
Curnamona, N.-E. of Curnamona H.S. Bore	—	—	210	—	—	Salt	—	—	—	—	—	—	—	

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
														31-32	139-140
Curnamona, N.-E. of Curnamona H.S. Bore	—	—	198	—	—	Salt	—	—	—	—	—	—	—		
Curnamona, N.-E. of Curnamona H. S. Bore	—	—	201	—	—	Salt	—	—	—	—	—	—	—		
COUNTY DERBY. Curnamona Station, Toolaby or No. 3 Bore	1914	—	255	197 255	No supply Good	— 1·46	— —	— —	— 93B	— —	Grey sand, rotten marl, stiff clay Stiff marl, grey sand	Stiff marl, grey sand	— — —		
Curnamona Station, Dust-hole Well and Bore	—	—	150½	—	—	1·49	—	—	—	—	Sand drift	—	Well 98ft. deep		
Curnamona Station, Mulga Well and Bore	—	—	490	173	—	¼-1¼	—	—	—	—	—	—	Well 186ft. deep		
Curnamona Station, Station Well and Bore	—	—	456	146	—	⅛-¾	—	—	—	—	—	—	Well 156ft. deep		
Curnamona Woolshed Well and Bore	—	—	394	—	—	1·70	—	—	—	—	Sand drift	—	Well 94ft. deep		
Curnamona Station, Sand-drift Well	—	—	88	—	400 g/h	1·52	—	—	80B	—	—	—	—		
Curnamona Station, Round-Hill Well	—	—	142	—	—	1·49	—	—	93B	—	—	—	—		

Curnamona Station, Dust-Hole Bore	—	—	150	—	—	1·49	—	—	67B	—	—	—	—
Curnamona Station, Site "B"	—	—	592	72 100 150 186 320 350 372 401 449 463 577	Small Big Small Fair Small Fair Big Big — Big Small	2⅜ 2·32 1·94 1·92 1⅝ 1·66 2·18 2·57 3⅝ 3⅛ 1¾	— — — — — — — — — — —	— — — — — — — — — — —	70B 70B 70B 70B 141B 110B 152B 110B 151B 90B 90B	— — — — — — — — — — —	Red silt .... Gravel, coarse ... Red and grey clay Sandy gravel .... Grey clay .... Grey sandy clay . Grey sandy clay . White sand...... Fine grey sand... Quartz sand .... French grey decomposed slate	Grey slate	— — — — — — — — — — —
Curnamona Station Bore	—	—	377	—	—	Good	—	—	40B	—	Clay and sand drift	Clay and sand drift	—
Curnamona Station, Site "C"	—	—	410	95 257 274 400	— Little 250 g/h 150 g/h	3½ 2⅛ 1 1/5 1⅞	— — — —	— — — —	— — 70B 42B	— — — —	Yellow sandy clay or silt Grey sandy silt .. Greyish fairly hard shale White sand......	White sand......	— — — —
Wilpena Station, No. 6 Bore	1927	—	95	91	6,000	Good	—	—	82B	—	Good clay	Good clay	Station stock
Willippa Station, Glen Warwick	1926	—	260	—	800 g/h	Good	—	—	—	—	—	Brown ste.	Test at 244ft.
Willippa Station, Drennan No. 1 Bore	1920	—	555	195 262 375/381 515/555	— — Good 3 hr. at 800 g/h 1 hr. at 1,500 g/h	2 1½ — ½	— — — —	— — — —	— 112B — 140B	— — — —	Thin limestone... Fine white sand.. Chalky limestone and pipe clay Green slate and blue slate	Blue slate	— — — —
Willippa Station, Drennan, No. 2 Bore	1920	—	476	215 400/476	Little 500 g/h	— ⅜	— —	— —	— 120B	— —	Brown clay ..... Mostly yellow sand and clay	White pipe clay to very hard blue rock	—
Willippa Station, Drennan Second New No. 2 Bore	1925	—	671	263 305 507 656	Little — 1,400 g/h 800 g/h	— — — —	— — — —	— — — —	— — 206B 536B	— — — —	White sandy pipe clay White sand...... Yellow gritty clay Grey stone	Grey stone	— — — —

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Erudina Station Well in No. 10 Paddock	—	—	55	—	—	1·46	—	—	—	—	—	—	—	31-32	139-140
Billeroo West No. 2 Bore	—	—	253	160	—	—	—	—	—	—	—	Deep sand	Sheep look well on it	31-32	140-141
				216	—	1·88	—	—	—	—	Swelling clay		—		
				230	Good	1·99	—	—	—	—	Swelling clay		—		
MARGINAL AND SUSPENDED BASIN "D"															
Murnpeowie, Ooloo Bore	—	—	642	106	—	Salt	—	—	—	—	Grey clay	Very hard dark-blue clay.	—	29-30	139-140
				241/3	—	Salt	—	—	—	—	Hard streak		—		
				621/638	1,000 g/h	0·69	—	—	—	—	Light-blue clay ..	Bedrock	—		
Murnpeowie, Lignum Bore	1929	—	132	113 abt.	Small	—	—	—	—	—	Fine grey drift sand	Fine dark drift ..	—		
				120	Good	Fair	—	—	—	—	Red clayey sand .		—		
				130	480 g/h	0·67	—	—	—	—	Fine dark drift ..		—		
Murnpeowie Station, Mount Hopeless Well and Bore	1930	—	520?	285	—	0·52	—	—	75B	—	Fine grey quartz sand	Yellowish sand ..	Well to 120ft. with ¾oz. water		
				328	—	—	—	—	77B	—	Coarse sand and gravel				
Murnpeowie, Skeleton Bore	—	—	203	90	Small soak	Brackish	—	—	—	—	Red clay	White drift sand	—		
				153	180 g/h	Fresh	—	—	—	—	White clay ..... and gravel		—		
				190	600 g/h	0·31	—	—	—	—	Yellow clay		—		
Moolawatana, Putnamutana Well	—	—	27	—	2,800	1·27	—	—	23B	—	Bluish slate	—	—	30-31	139-140
Balcanoona Station, Mulga Bore	—	—	147	104	260 g/h	—	—	—	99B	—	Gravel and clay .	Gravel and clay with sand patches	Additional supply of good drinking water at 144ft.		

Balcanoona Station, Netting Well and Bore	—	—	351	185 304	Small Unlimited	— Good	— —	— —	— 280B	— —	Sandstone ...... Sand	Sand	— —
Balcoona Station Salt Bore No. 1	—	—	45	44	Large	Very salt	—	—	21B	—	Red clay	Red clay	Abandoned
Balcoona Station Salt Bore No. 2	—	—	95	68	Good	1½	—	—	45B	—	—	—	Bitter objectionable taste, abandoned
Poontana Bore .	—	325	1,692	121 815/8 828/845	— — —	Fresh Fresh Fresh	— — —	— — —	108B 100B 100B	— — —	Reddish sand, gravel and clay Gravel .... Gravel	Red sandstone rock	Abandoned
Wooltana No. 1	1921	—	120	100 110	100 g/h 300 g/h }	0·15	—	—	95B	—	—	—	Sheep, cattle, horses
Wooltana No. 2	1921	—	165	140 155	Small Unlimited	— 0·46	— —	— —	130B —	— —	— —	— —	 Livestock
Wooltana No. 3	1921	—	202	165 175	100 g/h 300 g/h	— 0·29	— —	— —	147B —	— —	— —	— —	— —
Wooltana No. 4	—	—	—	200	Unlimited	Salt	—	—	—	—	—	—	Abandoned
Wooltana No. 5	1921	—	72	61 67	50 g/h 300 g/h	— 0·85	— —	— —	— —	— —	— —	— —	Livestock. Water stands 51ft. Good stock
Wooltana No. 6	1921	—	210	180 195	100 g/h Unlimited	— 0·30	— —	— —	150B 150B	— —	— —	— —	Sheep, cattle and horses —
Wooltana No. 7	—	—	165	—	Dry	—	—	—	—	—	—	Hard rock.......	Abandoned
Wooltana No. 8	1922	—	220	180/220	280 g/h	0·35	—	—	170B	—	Sandy clay to red sand	Red sand	Sheep, cattle and horses
Wooltana No. 9	1922	—	152	130/5 145/152	100 g/h Unlimited	— 0·29	— —	— —	— 100B	— —	Clay and gravel . Gravel and red sand	Gravel and red sand	Livestock
Wooltana No. 10	1922	—	108	100/108	Unlimited	0·21	—	—	70B	—	Gravel and sand .	Gravel and sand .	Livestock
Wooltana No. 11	1922	—	118	70/118	Unlimited	0·33	—	—	60B	—	Clay and sand ...	Clay and sand ...	Livestock
Wooltana No. 12	1922	—	117	90/117	Unlimited	0·14	—	—	70B	—	Clay and sand ...	Clay and sand ...	Livestock
Wooltana No. 13	1922	—	145	125/145	Unlimited	0·12	—	—	90B	—	Gravel and sand .	Driftsand	Livestock
Wooltana No. 14	1923	—	64	—	—	—	—	—	—	—	—	Granite boulders in sand	Failure

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Wooltana No. 15	1923	—	23	—	—	—	—	—	—	—	—	Granite boulders in sand and red clay	Dry, abandoned owing to strata	30-31	139-140
Wooltana No. 16	1923	310	195	150-160	240 g/h	0·58	—	—	140B	—	Gravel and clay .	Clay	Sheep and livestock		
Wooltana No. 17	1923	—	87	60-70	Small	Inferior	—	—	—	—	Drift sand.......	Gravel	2,000 sheep, stock water		
				80-87	Unlimited	1·29	—	—	50B	—	Gravel				
Wooltana No. 18	1923	—	206	50	100 g/h	Fresh	—	—	40B	—	Clay	Clay	Not used until well sunk		
Wooltana No. 21	1923	—	139	130-139	Unlimited	0·24	—	—	100B	—	Heavy gravel ...	Heavy gravel ...	Sheep and other stock		
Wooltana No. 22	1923	—	288	200-210	Small	—	—	—	—	—	Gravel	Drift sand	Sheep and other stock		
				250-288	Unlimited	0·22	—	—	150B	—	Clay and sand to drift sand				
Wooltana No. 25	1923	—	284	85-90	Small	—	—	—	85B	—	Gravel	Driftsand	1,500 sheep and other livestock		
				270 to 284	Unlimited	0·59	—	—	210B	—	Gravel and drift-sand				
Wooltana No. 26	1924	—	179	154	200 g/h	0·18	—	—	147B	—	Hard blue rock ..	Hard blue rock ..	Sheep and other livestock		
Wooltana No. 27	1924	Est. 260	177	150	Unlimited	0·12	—	—	142B	—	Clay and sand ...	Driftsand	Sheep and other livestock		
Wooltana No. 28	1924	200 est.	122	90	400 g/h	0·13	—	—	80B	—	Gravel and clay .	Driftsand	Sheep and other livestock		
Wooltana No. 29	1924	—	96	70	540 g/h	0·53	—	—	60B	—	Clay and gravel .	Driftsand	Good stock water		
Wooltana No. 30	1924	—	51	40	Unlimited	2·03	—	—	30B	—	Clay and sand ...	Driftsand	Stock water		
Wooltana No. 31	1924	—	51	46	Unlimited	Salt	—	—	44B	—	Gravel	Gravel	Abandoned owing to salt water		

Wooltana No. 32	1924	—	60	50 55	100 g/h Unlimited	— 2·95	— —	— —	— 46B	— —	Gravel .... Gravel	Gravel	Abandoned owing to salt water		
Wooltana No. 33	1924	—	101	50	60 g/h	1·68	—	—	35B	—	Gravel	Clay	Not used till well sunk, sheep and livestock		
Wooltana No. 34	1924	—	192	50	212 g/h	1·66	—	—	50B	—	Heavy gravel and sand	Clay	Not yet equipped, sheep and livestock		
Wooltana No. 35	1924	—	48	12 20	50 g/h Unlimited	— Salt	— —	— —	— 10B	— —	Gravel and drift-sand Gravel and drift-sand	Clay	Abandoned owing to salt water		
Wooltana No. 36	1924	—	65	28 35	50 g/h Unlimited	— 7·98	— —	— —	— 28B	— —	Gravel .... Blue clay	Blue clay	Abandoned		
Wooltana No. 37	1924	—	177	160 170	100 g/h Unlimited	— 0·11	— —	— —	— 147B	— —	Gravel and sand . Gravel and sand .	Gravel and sand .	Not yet used, sheep and other livestock		
Wooltana No. 38	1924	—	312	150 300	80 g/h Unlimited	— 0·12	— —	— —	— 150B	— —	Drift sand....... Gravel	Gravel	Livestock, 1,500 sheep		
Wooltana No. 39	1924	—	120	28 75	40 g/h 80 g/h	— —	— —	— —	27B 27B	— —	Gravel .... Gravel	Dry clay	Total supply 120 g/h, barely stock water, abandoned		
Wooltana No. 40	1924	—	81	67	250 g/h	0·92	—	—	30B	—	Gravel.........	Dry clay	Good stock water		
Wooltana No. 41	1924	—	174	140 170	10 g/h Unlimited	— 0·43	— —	— —	— 30B	— —	Dry white clay Blue sand and gravel	Blue sand and gravel	— —		
Buxton Bore ...	—	—	—	—	—	0·42	—	—	—	—	—	—	Potable but not advised		
Wertaloona H.S. Well	—	—	—	—	—	0·29	—	—	—	—	—	—	—		
Paralana Hot Springs	—	—	—	—	—	0·18	—	—	—	—	—	—	—		
Wirrealpa, Leonards Well	1926	—	41	—	—	0·64	—	—	—	—	—	—	Waters 6,000 sheep	31-32	139-140
Murnpeowie Station, Fossil Bore	1930	—	279	100/130 252 260/2	Big — 220 g/h	Salt — 0·87	— — —	— — —	— — 20B	— — —	Drift sand....... Drift sand....... Black clay	Blue clay	Stock water	29-30	140-141
Putnamutana Bore	—	—	50	50	—	1·48	—	—	—	—	Gravel	Gravel	—	30-31	140-141

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
							MARGINAL BASIN "E"								
Murnpeowie, Mookwarrinna Bore	1913	—	1,002	85/105	Small	2½	—	—	—	—	—	Slate rock	Abandoned	29-30	138-139
				—	—	1½	—	—	48B	—	—		—		
Mount Lyndhurst Appolinaris Well	—	—	135	—	—	Fresh	—	—	—	—	—	Bluish clay	Waters 8,000 sheep		
Mount Lyndhurst 4 Corners No. 5 Bore	—	—	193	187	500 g/h	1·27	—	—	144B	—	White sandy clay	Boulders	—		
Mount Lyndhurst Junction Bore	1924	—	723	60	Small	Salt	—	—	—	—	Yellow sandy clay	Hard slate and quartz	Pump at 300ft., supply 350 g/h. In drought water level dropped to 300B		
				570	—	1¾	—	—	420B	—	Silty greenish clay				
				625	480	1·39	—	—	A	—	White sandrock .		—		
Mount Lyndhurst Nursery Bore	—	—	105	90	Small	—	—	—	—	—	White clay with bands of limestone	White sandy clay	—		
				95-100	Pumped 700 g/h	1·37	—	—	—	—	White sandy clay		—		
Mount Lyndhurst Saw Mill Well	—	—	50	—	—	Good	—	—	—	—	—	—	Waters 5,000 sheep		
Mount Lyndhurst Watson Well	—	—	200	—	Small supply	Good	—	—	—	—	—	Grey shale	—		
Mount Lyndhurst Pearl Hill	—	—	318	—	Small	¾	—	—	—	—	—	—	—		
Mundowdna, Tent Hill Bore	—	—	675	553	—	—	—	—	A	—	Below hard streak of rock	Black slate bed-rock	Stock water		
Mundowdna, Bore 2 miles N.-E. of	—	—	418	401	10,000	—	—	—	A	—	Sandrock	Blue slate	Stock water		

Mundowdna, Bore at Woolshed	—	—	346 5/6	285	10,000	—	—	—	14B	—	Rock	Blue slate	Horses and cattle		
Wilpoorinna Station, Wilpoorinna Old Well	—	—	200 approx.	—	—	Salt?	—	—	—	—	—	Sandstone	Fell in		
Wilpoorinna Deep Well	—	—	155	—	700 g/h	1·99	—	—	139B	—	—	Slate slightly weathered	—	30-31	138-139
Wilpoorinna, 2½ miles S.-E. of Deep Well, No. 1	—	—	25	—	—	Fresh	—	—	—	—	—	—	—		
Wilpoorinna, 2½ miles S.-E of Deep Well, No. 2	—	—	60	—	Dry	—	—	—	—	—	—	Blue shale.......	—		
Mount Lyndhurst Station, Government Bore	—	—	300	—	No supply	Fair	—	—	—	—	—	—	—		
Mount Lyndhurst, Twins Government Well	—	—	110	—	80 g/h	—	—	—	80B	—	—	—	64ft. Drive at btm.	29-30	139-140
Mount Lyndhurst, Woodgate Bore	1924	—	721	621	—	—	—	—	581B	—	Dark-blue clay...	Sticky clay	Supply 900 g/h. Anal. 0·88oz/g., water stands 80ft.		
				664	—	—	—	—	614B	—	White sand rock .		—		
				686	—	—	—	—	45B	—	Sticky clay		—		

MURRAY RIVER ARTESIAN BASIN

No. 1 Bore, Manunda Creek, Lilydale Station	1914	—	50	50	800 g/h	Good	—	—	22B	—	Under rock	—	—	33-34	139-140
No. 3 Bore, Manunda Creek, Lilydale Station	1914	—	100	97	No supply	Salt	—	—	66B	—	Yellow clay, about half gravel	Yellow clay, about half gravel	—		
No. 4 Bore Manunda Creek Lilydale Station	1914	—	410	300	—	3½	—	—	200B	—	Sandy clay	Light-brown clay with pipe clay	Abandoned		
Farmers Dam Bore, Lilydale Run	1914	—	374	330-340	No supply	—	—	—	—	—	Sand, shells	Black rock	Condemned		
Nicholls, S.P.L. 2, 4½ miles E. of W. corner, and 1 mile N.	—	—	260	260	15,000	—	—	—	—	—	—	—	—		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Quantity of water. g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Darling River No. 17 or Oakvale No. 1	—	—	300	150 abt.	Little	Fair	—	—	—	—	Black sand and hard shingle, mixed with lignite and hard quartz crystals	Drift	Not fit for stock	32-33	140-141
				229	—	Brackish	—	—	151B	—	Drift	—	—		
Oakvale No. 2 .	—	—	200	184	—	2·4	—	—	182B	—	Sand and clay ...	Black clay and layers of very coarse white sand	—		
Billing Bore, Oakvale Station	—	—	567	225	—	Salt	—	—	—	—	Sand	Driftsand	—		
				275	—	Salt	—	—	—	—	Black clay		—		
				459	400 g/h	1·59	—	—	210B	—	Drift sand.......		—		
Brook Bore, Oakvale	1926	—	420	369	Little	Fair	—	—	—	—	Green clay with shells and grit	Calc. ste.......	—		
				420	1,000 g.p.h.	1·59	—	—	150B	—	Calc. ste.		—		
Mulga Bore, Oakvale	—	—	502	189	Little increasing to fair	Salt	—	—	—	—	Sand	Boulders and rock	—		
				368 }	600 g/h	0·55	—	—	180B	{ —	Green clay and rubble		—		
				460 }						—	Boulders and rock		—		
Norwest Bore Oakbank Station	—	—	410	402	400 g/h	1·79	—	—	330B	—	Shells and shell grit	Shells and shell grit	—		
Borehole, N.N.-West of Quondong Vale, J. H. Gallagher	—	—	504	340	10-15 g/h	—	—	—	—	—	Hard bar (? limestone)	Decomposed slate	—		
				500	—	1·89	—	—	325B	—	Decomposed slate		—		
Kruger Dam Bore	1914	—	400	376	200 g/h	Slightly bitter 1·29	—	—	250B	—	Sand	Pipe clay	Sand trouble. Abandoned	33-34	140-141
Kruger Paddock Bore, Morgan Vale	1924	—	500	248	Small	2·02	—	—	—	—	Dark-grey clay apparently slightly carbonaceous	Bedrock slate ...	—		
Morgan Vale, Sampson Well and Bore	—	—	—	—	—	—	—	—	A	—	—	—	Fell in. Well was 200ft. salty. Bore water good flowing		

Three-quarters mile West of N.S.W., ¾ mile South of Oakvale, Postmark Bore	—	—	534	173 517	— 800 g/h	Salt 1·60	— —	— —	— 180B	— —	Sand .... Drift sand.......	Brown sandy clay	— —
Pine Valley H.S. Well	—	217 an.	220	—	Big	2·06	—	—	—	—	—	Quicksand.......	—
Pine Valley Gap Well 1	—	—	180	—	—	—	—	—	—	—	Sand	—	Never been used
Pine Valley Gap Well 2	—	—	—	—	—	—	—	—	—	—	Sand	—	Washed in. Never been used
Pine Valley South Well	—	—	—	210	—	Better than H.S. Well	—	—	—	—	Greyish clay with fragments of shells	—	Fallen in to 140ft. and dry
Pine Valley, Dick Pdk. Bore	—	—	487	487	6,000	1·57	—	—	190B	—	Sand bed	Sand bed	Good stock water
Pine Valley Station, Moonlight Bore	1929	—	486	450 476	Small 12,000	— Fair stock	— —	— —	— 200B	— —	Light blue clay .. Sandy green clay.	Mostly sand streaked with green clay	—
Postmark Station, 60-70 miles N. of R. Murray 10 miles W. of N.S.W.	—	—	—	570	—	1·6	—	—	160B	—	—	—	—
Quondong Station, 5-Mile Well	—	179 an.	180	—	1,100 g/h	2·34	—	—	—	—	—	—	Sheep have thrived on it
Quondong Station, Station Well	—	—	180	180	—	Very salty	—	—	—	—	—	—	Fell in
Quondong Station, Well W. of Dick Pug Hole	—	142 an.	—	—	Dry	—	—	—	—	—	—	—	—
Sturt Vale H.S. Well	—	192 an.	150-200	—	—	Salt	—	—	—	—	—	—	Never much used
Sturt Vale, ½ Mile W. of H.S.	—	—	40	—	Small	Good stock	—	—	20B	—	Sand	Clay	—
Sturt Vale, 5-Mile Well	—	—	—	—	—	1½	—	—	—	—	—	Yellow sand	Trouble with drift

Arranged by Counties.

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l., ft.	Total depth of bore, ft.	Depth at which water was struck, ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water, g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
COUNTY ALBERT— Walsh Bore, 1909	Bandon	—	—	260	220	207B	260 g/h	½	Fossiliferous limestone ...	Fossiliferous sandstone....	—
Agincourt Bore, 1911 .	Chesson	—	—	223	188	180B	Good	¼	Sandstone	Calcareous sandstone	—
Kadli Government Bore	Chesson	—	214	218	170	158B	—	Good	Brown sandy rock with hard bands	Soft sandy rock	—
Searle, W. G. L., Bore No. 1	Forster	36	—	286	265	264B	500 g/h	0·33	Cream coloured fossiliferous (polyzoal) sand	Cream coloured fossiliferous (polyzoal) sand	—
Day, H. W. and A. J. Bore 1940	Forster	3A	—	231	165 195 212	— 191B 191B	— — 500 g/h	0·78 0·84 0·79	Cream coloured very fine-grained clayey sand Cream coloured very fine-grained clayey sand Ployzoal limestone and sand	Polyzoal limestone and sand	— — —
Verco Bore	Holder........	—	—	501	—	136B	Good	3	—	—	—
Cressy Bore 1911	Mindarie	—	243	225	176 190	— 175B	Good Larger	— 0·21	Calcareous sandstone ..... Calcareous sandstone	Calcareous sandstone	— —
Mindarie Government Bore	Mindarie	—	—	250	—	—	—	—	—	—	—
Wanbi Bore, 1912	Mindarie	—	256	250	184 234	— 187B	Small Large	— 0·33	Calcareous sandstone ..... Calcareous sandstone	Calcareous sandstone	Anal. by S.A.R. —
Shuni Bore	Mindarie	52	—	232	180	180B	Large	¾	—	—	Abandoned 1926
Areli Bore............	Mindarie	—	—	208	160	48B	Large	¾	Fossiliferous sandstone....	—	—
Francis, A. C. B. and Rowe, I. C., Bore	Waikerie	—	—	190	154	—	100 g/h	—	White clay and sand	Calcareous sandstone	—
Virgo Soakage Bore ...	Waikerie	—	—	170	25 77	— —	— 1,500 to 2,000 g/h	Salt —	Sand and clay .... Sand and calcareous sandstone	Sand and calcareous sand stone	Salt water shut off —

Osman, T. E.	Waikerie	35	—	180	—	150B	Very large	1·29		—	Horses, cattle and sheep
Francis Bore	Waikerie	—	—	303	—	120B	Good	2¾	—	—	—
COUNTY ALFRED— Alawoona Bore, 1912 .	Allen	—	230	211	167 197	— 164B	Small Large	— 0·30	Fossiliferous sandstone.... Calcareous sandstone	Calcareous sandstone	Analysis by S.A.R.
Cobera Bore, 1912.....	Allen	—	224	218	160	180B	100+	0·30	Calcareous sandstone	Calcareous sandstone	—
Boundary Bore	Bookpurnong .	—	—	400	—	76B	Good	Salt	—	—	—
Angus Bore	Gordon	—	85	778	—	—	Good	Salt	—	—	—
Company Bore........	Gordon	—	85	1,805	87 712 1,120	— 21B 30B	— — —	Salt 2½ 7·52	Dark sand and boulders .. Blue clay with fossil shells and pyrites Grey sand	Blue shale..............	— — —
Paruna Bore, Thompson, A.	Kekwick	—	—	169	109 145	109B —	— —	— Good	Sand .... Coralline limestone	Coralline limestone	— —
Wolowa Bore, 1912....	Kekwick	—	198	168	122	108B	—	¾	Shell rock with hard bands	Limestone...............	—
Brown Well Bore, 7 miles south of Brown Well, 1910	Kekwick	—	—	223	193 220	56B 52B	— —	Good ¼	Marine limestone .... Marine limestone	Marine limestone	— —
Enoomah Bore, 1913 ..	Kekwick	—	—	214	144 190	— 142B	Small Large	— ⅛	Yellow sand and clay .... Calcareous sandstone	Calcareous sandstone	— —
Paruna, Bore, 1913 ..	Kekwick	—	Approx. 200	254	254	112B	Good	½	Calcareous sandstone	Calcareous sandstone	—
Paruna Bore, Edwards N. J.	Kekwick	45	—	217	160	—	—	—	Calcareous sandstone	Calcareous sandstone	—
Paruna Bore, Fisher L.	Kekwick	40	—	169	102 148	— 100B	— Good	Salt —	Blue clay and shells ...... —	— —	— —
Paruna, Kingsford Government Bore	Kekwick?	—	—	240	148 160 203 240	144B 144B 144B 144B	— — — —	— — — —	Drift sand............... Dark clay and shells ..... — —	— — — —	— — — —
Korah Bore 1912	McGorrery	—	—	210	55 85 110 198	— — 85B 73B	— Small Small Large	Salt Good Good ⅜	Hard calcareous sandstone Sand .... Gravel .... Calcareous sandstone	Calcareous sandstone	— — — —
Meribah Bore, 1912....	McGorrery	—	119?	210	55 187	— 100B	Small Large	Salt ¾	Clay and gravel .... Calcareous sandstone	Calcareous sandstone	— —

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water. g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Meribah Bore No. 2, 1927	McGorrery	—	—	246	65 185	— 54B	— Large	3 0·53	Grey medium-grained sand Limestone..............	Polyzoal limestone	— —
Meribah Bore, Bailey, Mrs. E. J.	McGorrery	48	—	281	250 266 276	144B — —	— — —	Good — —	Calcareous sandstone ..... Clay .... Clay rock and shells	Clay rock and shells	— — —
Moonah Bore, 1913 ...	McGorrery	—	—	241	55 168	— 44B	Small Large	— 3/8	Yellow sand .... Hard rock..............	Calcareous sandstone	— —
Brown Well	McGorrery	—	—	223	193	56B	—	—	Marine limestone	—	—
Pata Bore	Pyap	—	—	290½	—	90B	Large	3/4	—	—	—
Christie, L. R., Bore, 1941	Pyap	1F	—	250	105 150	105B 110B	— 700/1,000 g/h	1·70 1·39	Fine sand and silt .... Bryozoal silt and limestone	Bryozoal limestone	Final analysis after pumping
COUNTY BUCCLEUCH— Baumgurtel L., Bore, 1936	Bowhill	21B	—	296	272	267B	200/300 g/h	0·61	Soft calcareous sandstone .	Soft calcareous sandstone .	Used for sheep, horses and cattle
Gribble Bore, 1909	Bowhill	—	—	320	280	271B	300 g/h	3/4	Calcareous sandstone	Calcareous sandstone	—
Semmler Bore, 1909 ..	Bowhill	—	—	374	338	320B	300 g/h	3/4	Soft sandstone	Soft sandstone	—
Griggs and Aunger Bore	Bowhill	34	—	200	175	—	—	·3	Calcareous sandstone	Calcareous sandstone	—
Jackson T. F., Bore No. 1, 1940	Bowhill	5	—	180	155	155B	500 g/h	0·45	—	—	—
Aunger, L. R., Bore ...	Bowhill	28	—	428	170 428	— 150B	— Big	Salt Good stock	Yellow sandstone .... Sand and shells	Sand and shells	— —

Jericho O. L., Bore, 1938	Coneybeer.....	34	—	186½	42 105 178	42B 42B 40B	— — 800 g/h	Salt Salt 2·12	White sandstone .... Sandstone, yellowish colour Hard and soft coral layers with specks of pipe clay	Soft coralline limestone (white)	First water when mixed with double amount of rain water, 2 oz./gall., shut off at 90ft. Second water when mixed with double amount of rain water 2 9/16ths. oz./gall., shut off at 105ft.
Angel, J. J., Well and Bore, 1919	Coneybeer.....	44	—	260	250	70B	—	Fresh	Sand in black clay	Hard sandstone	—
Coonalpyn Bore, Cold and Wet	Coneybeer.....	—	72	840	55	46B	—	3	White limestone	Hard blue slate	—
Bores and Wells	Coneybeer.....	1, 7, 14, 20, 21, 29, 33, 34, 36, 41	—	36/50	—	—	—	Salt	—	—	—
Bore	Coneybeer.....	4	—	—	225	37B	—	Good	—	—	—
Bore 4½ miles east of Coonalpyn Railway, 1926	Coneybeer.....	8	—	236	40 236	— 34B	— —	Salt Fresh	Sandstone .... Sand	Sand	— —
Cronin Bore	Coneybeer.....	9	—	212?	?	30B	—	0·74	—	—	—
Quinlan J. and Watson, Bore, 1933	Coneybeer.....	20	—	220	58 219	52B 48B	— 6 gall. per min. per baler	4 ¾	White sandstone .... Chocolate lignite to rock ..	Rock	— —
Pope, W. N. and G., Bore, 1936	Coneybeer.....	23	—	255	44 246	44B 40B	— 10 gall. per min. per baler	4 0·52	Soft yellow sandstone..... Sand in chocolate clay with pyrites	Chocolate clay with pyrites	200ft. salt water, shut off Water for horses and cows
Coonalpyn, Venning, G. E., Bore	Coneybeer.....	24	—	254	50 205 254	42B — 42B	— — —	3½ 2½ ½	Sandstone .... Sand in black clay .... Sand in black clay	Black clay	— — —
McArdle, F., Bore, 1928	Coneybeer.....	26	—	251	51 225 250	51B 51B 51B	— — —	— — ½	White sandstone .... Sand in black clay with spots of ironstone Sand in black clay with spots of ironstone	Black clay with spots of ironstone	— —
Burtt Bore	Coneybeer.....	34	—	375	—	—	—	2·18	—	—	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water. g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Thamm, R. H., 1940	Coneybeer	33	—	240	58 219/238½	58B 58B	— —	3¼ 1·12	Soft yellow coral Grey coral and small shells and brown clay	Coralline limestone	Bailed level to 61ft. —
Colton Bore	Hooper	22	—	—	—	—	—	Bad	—	—	—
Jury Bore	Hooper	23	—	—	—	—	—	Brackish	—	—	—
Valentine Well	Hooper	64	—	—	70-75	—	—	—	—	—	Sulphate water acted on tools.
Wingamin, Matthews, H. E.	Hooper	—	—	240	218	—	—	—	Sandstone	Calcareous sandstone	Windmill
Wynarka, Boyce Bros.	Hooper	—	—	250	—	234B	—	—	—	Calcareous sandstone	—
Wynarka, Dix, J. A.	Hooper	—	—	175	175	—	—	—	Dark sandy clay	Dark sandy clay	Windmill
Wynarka, Nosworthy, F., Bore	Hooper	—	—	280	260	250B	—	—	Sand rock to calcareous sandstone	Sand rock to calcareous sandstone	—
Wynarka, Nosworthy, J., Bore	Hooper	—	—	240	220	190B	—	—	Calcareous sandstone	Calcareous sandstone	Windmill
Wynarka, Rackham, A. W., Bore	Hooper	—	—	230	200	—	—	—	Calcareous sandstone	Calcareous sandstone	—
Wynarka, late S. Williams, Second Trial Bore	Hooper	—	—	256	126 226	— —	— —	— —	Sand and sandstone Sand and calcareous sandstone	Sand and calcareous sandstone	— —
Wynarka, George Taylor Bore, 1915	Hooper	17	—	332	—	310B	—	—	—	—	Water used for domestic purposes
Wynarka, Andrew Hood Bore, 1915	Hooper	18	—	270	—	258B	Good	—	—	—	Stock do well on this water
Yalwarra Bore, close to Kulde Railway Station, 1912	Hooper	10	292	357	256 354	— —	Small Large	2 1·44	Marine sandy clay and shells Marine sandy clay and shells	Marine clay and shells	— —

Hobab Bore	Hooper	—	—	296	263	26B	Large	½	Fossiliferous sandstone	—	—
S.A.R. Karoonda Bore	Hooper	—	—	900	200	177B	10,000	0·35	Greyish polyzoal limestone, dense and crystallized in parts	Quartzitic schist ?	Supply of lower aquifers not tested
					463	200B	—	0·41	Fine quartz sand with shell fragments		Water at 200ft. used
					475	200B	—	0·42	Fine quartz sand with shell fragments		—
					580	200B	—	0·43	Coarse quartz sand and polyzoal limestone fragments		—
					760	200B	—	0·38	Coherent quartz sand with pyrite and lignite		—
					828	200B	—	0·40	Greenish clay like semi-decomposed slate		—
Karoonda Government Bore	Hooper	—	222	184	—	145B	Good	0·35	—	—	
Wynarka Government Bore	Hooper	—	207	200	—	167B	—	0·65	—	—	Analysis by S.A.R.
Merari Government Bore	Hooper	—	—	—	—	—	—	—	—	—	
Harrington Bore	Hooper	1	—	—	—	—	—	1·56	—	—	—
Barnett Well	Hooper	4	—	70	—	—	—	Good	—	White stone, sharks teeth, and bones	—
Schrader Bore	Hooper	6	—	300	—	—	—	—	—	Practically all sand	—
Wynarka, Doyle (now Charlton) Bore	Hooper	14	—	383	376	353B	Good	—	Coralline limestone	Coralline limestone	—
Yates Bore	Hooper	19	—	—	—	—	—	Good	—	—	—
Hossfall, R., Bore	Hooper	—	—	180	180	175B	—	—	—	—	—
Bennett & Fisher Bore, 1929	Kirkpatrick	1A	—	315	148	147½B	—	1·67	Soft sand with white and yellow clay spots	Dark green oily sand and clay	Stock water
					296	147½B	About 180 g/h	1·50	Sandstone	—	—
Yumali, Applebee, H. G., Bore, 1937	Kirkpatrick	3	—	82½	64	63½B	—	3½	Bluish sand with white and green clay	Soft stone	—
					82	60B	—	1·82	Soft stone		—
Gibb, J. H., Bore	Kirkpatrick	—	—	64	58	56B	Permanent supply	Good	—	—	Stock and irrigation water
Yumali Government Bore	Kirkpatrick	1B	—	420½	295	—	—	2·43	—	—	—
					350	—	—	1·77	—	—	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water. g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Reohr Bore, 1928	Kirkpatrick ...	1A	—	412	103 120 245 398 410 412	103B — — — — —	— — — — — —	Salt 3 2 2 9/16th 2·10 1·74	Tough white sandstone ... Hard white stone .... Sand in soft green and blue clay .... Sandy quartz gravel Sand in soft chocolate clay Sand in soft chocolate clay	Soft chocolate clay	— —
Hodge, M. F., Bore....	Lewis.........	—	—	91	91	87B	350 g/h	Good drinking	Coarse sand	Coarse sand	Good water for domestic use
Coonalpyn, Fidges, T., Bore	Livingston	3	—	270	— 265/270	— 60B	— —	Salt 0·74	— Sand in black clay	Black clay	Horses and cattle drink the water freely
Kiki, Crowhurst, P. C., Bore	Livingston	9	—	295	96 237 262	96B 96B 96B	— — 180 g/h	4 — 1·07	Quicksand .... Sand and pipe clay Dark coralline limestone	—	Water for horses, cattle and sheep
Yumali, Lubke, A. E., Bore	Livingston	17	—	316	—	132B	—	0·36	—	—	—
Bore	Livingston	10	—	270	—	70B	—	1½	—	Echinoderm limestone (grey)	—
Kiki, Sexton, J. J., Bore	Livingston	23	—	255	82 254	82B 78B	— —	4 7/16th	Limestone............... Yellow coralline limestone	Yellow coralline limestone	—
Kiki Bore	Livingston	6	93	666	78 360	73B 73B	600 g/h 16,800	Very brackish 0·68	Soft whitish-yellow limestone Sand	Hard green slaty rock with quartz	—
Ladara Bore, 1914	Livingston	21	—	290	90 280	— 100B	— Large	3½ ½	Calcareous sandstone ..... Calcareous sandstone .	Calcareous sandstone	—
Lotnumpie Bore, 1915	Livingston	10	98	302	80 280	— 80B	— 8,000-9,000	1½ ½	White calcareous sandstone Sandy clay with shell fragments	Polyzoal and echinoderm limestone	—

R

Potter Bore	Livingston	14	—	—	—	—	Good	Fresh	—	—	—
Fyfe Bore	Livingston	34	—	—	—	—	Good	0·27	—	—	—
Paran Government Bore	Marmon Jabuk	—	—	196	—	168B	Large	½	—	—	—
Shoobra Government Bore	Marmon Jabuk	—	—	207	—	161B	Good	Fresh	—	—	—
Karoonda, Lockier, J. W., Bore	Marmon Jabuk	—	—	210	195	—	—	—	Calcareous sandstone	Calcareous sandstone	—
McNamara Government Bore	Marmon Jabuk	—	—	181	—	150B	Good	Fresh	—	—	—
Nanua Government Bore	Marmon Jabuk	—	—	212	—	157B	Large	¾	—	—	—
Enan Government Bore	Marmon Jabuk	—	—	196	—	168	Good	⅝	—	—	—
Halidon Bore, 1911....	McPherson ...	—	255	215	185 195	— 183B	— Large	— 0·21	Layers of shellrock and pipe clay Hard calcareous sandstone	Soft calcareous sandstone	—
Pilcherra Government Bore	McPherson ...	—	—	205	—	136B	Good	Good	—	—	—
Sandalwood Bore, 1911	McPherson ...	—	182	170	110 150	— 110B	Small Large	— 0·32	Soft dark calcareous sandstone Hard white calcareous sandstone	Light green calcareous sandstone	—
Warroo Government Bore	McPherson ...	—	—	190	—	115B	Good	Fresh	—	—	—
Sandalwood, Wood, T. S., Bore	McPherson ...	—	—	146	126 140	— —	— —	— 0·27	Sandy clay .... Sandy clay	Sandy clay	—
Pilambi Government Bore	Molineux......	—	—	250	—	196B	Large	½	—	—	—
Brown Bros. Bore	Peake	—	—	344	339	95B	—	—	Black clay and calcareous sandstone	Black clay and calcareous sandstone	—
Fuller Bore, 1909	Peake	—	100	360	72 340	43B 29B	— Good	1 Fresh	Sand and shells .... Shells and clay	Shells and clay	—
Gosden Bore, 1909	Peake	—	100	360	327	27B	2,000 g/h	Fresh	Clay with shells and pebbles	Lignite	—
Ritchie, A. J., Bore ...	Peake	Block 35 W	—	319	40 316	— 40B	— Good	Salt and bitter Fresh	Flinty sandstone .... Soft white sandstone	Soft white sandstone	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water. g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Bald, A., Bore	Peake	Block 35 W	—	279	271	20B	—	Good	Sandstone and sand	Sandstone and sand	—
Bald, A., Bore	Peake	40	—	357	59 354	57B 56B	— —	6·45 0·28	Calcareous sandstone .... Clay and shells	Clay and shells	Used for domestic and garden purposes
Lang, M., Bore	Price	79	—	220	—	—	—	Went salt	—	—	Abandoned
Geranium, Bowden, J., Bore	Price	84	—	156	130	—	—	—	Calcareous sandstone (polyzoal limestone ?)	Calcareous sandstone (polyzoal limestone ?)	Water used for sheep, cows and horses
Geranium Bore	Price	—	240	171	140	—	14,400	0·22	Soft limestone	Soft limestone and shells	
Hart, W. H., Bore	Roby	6	—	220	53 152 218	53B 53B 35B	— — —	4 4 7/8	Yellow sandstone .... Sand in chocolate clay ... Coralline limestone	Coralline limestone	Second water cased off at 180ft. Used for domestic purposes
Coomandook, Dugan, Thomas, Bore	Roby	X3	—	300	30-80	13B	—	3¼	Sand rock	Nearly white clay with some greenish streaks	—
Chapman, R., No. 1 Bore	Roby	9A	—	270	—	—	—	3	—	—	—
Chapman, R., No. 2 Bore	Roby	9A	—	232	—	—	—	1½	—	—	—
Chapman, A. S., Bore .	Roby	11	—	—	—	—	—	Good	—	—	—
Lymn Bore...........	Roby	17	—	270	—	25B	—	½	—	—	—
Wilkins Bore	Roby	18	—	270	—	30B	—	Good	—	—	—
Corde Bore	Roby	20	—	270	—	—	—	½	—	—	—
Nine Bore	Roby	21	—	250	—	—	—	Good	—	—	—

Legalley Bore	Roby	22	—	270	—	—	—	1¼	—	—	—
Chidlow Bore	Roby	23	—	—	—	—	—	1⅜	—	—	—
Kellet Bore	Roby	25	—	270	—	24½B	—	⅞	—	—	—
William No. 1 Bore ..	Roby	38	—	247	—	24B	—	1·26	—	—	—
William No. 2 Bore ...	Roby	39	—	300	—	26B	—	3	—	—	—
Well 1	Roby	W1A	—	29	—	—	—	1½	—	—	3½ft. water
Well 2	Roby	W1A	—	38	—	—	—	¾	—	—	3½ft. water
Well 3	Roby	W1A	—	28	—	—	—	1	—	—	2½ft. water
Coomandook Bore.....	Roby	40	—	764	29 128 248 412 709-764	— — — — 18B	— — — — —	9 Salt Salt Salt 20	Limestone and shells ..... Hard blue limestone . Sandy clay Soft sand Argillaceous sandstone	Argillaceous sandstone ...	Casing lifted to 240 ft.—18-oz. water Casing lifted to 215 ft.—10½-oz. water Filled bore to 280 ft.—21-oz. water
Bob Lookout or Sherlock Bore, 1907	Sherlock	—	50	283	270	15B	Good	0·45	Sand and shells	Sand and shells	—
Day Farm Bore	Sherlock	9	—	170¾	36 96	— 25B	— —	Salt 0·90	Sand .... Greenstone	Siliceous grit with pyrites .	—
Nock Bros. Bore, 1914	Sherlock	20	—	280	45 280	— 36B	— Large	3½ ⅜	Soft coralline sandstone .. Under hard rock	Hard rock	Used for domestic purposes, and garden with good results
Angel Bros. Bore......	Sherlock	32	—	310	280	—	Small	Good	—	Driftsand	—
Angel Bros., Bore, ½ mile N.E. of Bob Lookout Bore	Sherlock	39	—	300+	—	30B	—	Good	—	—	—
McCracken Bore	Sherlock	48	—	180	—	—	—	—	—	—	Windmill
Moorlands, No. 13 Government Coal Bore, 1921	Sherlock	53	—	64	39	—	—	Good stock	Shell and shell fragments	White clay	—
Moorlands No. 71C Government Coal Bore, 1929	Sherlock	8	—	224	135	—	—	1·55	Dark sand	White clay to decomposed schist	—
Moorlands, No. 76C Government Coal Bore	Sherlock	8	—	171	141	—	—	2⅜	Grey sand	White clay merging into bedrock	—
Gaskell, V., Bore	Strawbridge ..	1	—	90	90	85B	Good	—	Hard gravel	Hard gravel	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water. g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Gaskell, V., Bore	Strawbridge ..	2	—	96	96	92B	Large	1·31	Coralline limestone	Coralline limestone	—
Coonalpyn, Schottelius, A. G., Bore	Strawbridge ..	17	—	75	73½	73½B	300 g/h	1·48	—	—	—
Gibbs, J. H., Bore, 1929	Strawbridge ..	8,355	—	68	62	60B	Permanent supply	Good	—	—	Used for stock and irrigation purposes
Undula Bore, 1912	Vincent	—	—	270	240	—	—	¾	Calcareous sandstone	Calcareous sandstone	—
Perponda Government Bore	Vincent	—	—	300	265	246B	—	—	—	—	—
Hilka Bore	Vincent	—	—	186	150	140B	Large	⅜	Fossiliferous sandstone....	—	—
Borrika Bore, 1911 ...	Wilson........	—	170	150	110	105B	Large	0·35	Calcareous sandstone	—	—
Beula Bore	Wilson........	—	—	252	—	190B	Large	⅜	—	—	—
Burrawang Government Bore	Wilson........	—	185	200	—	140B	Large	⅜	Yellow sandstone	—	—
Garrik Government Bore	Wilson........	—	—	200	—	150B	Large	¼	—	—	—
Goloming Government Bore	Wilson........	—	—	155	—	110B	Good	½	—	—	—
Coates and Sundgrust, 3rd Trial Bore	—	—	—	277	274	34B	—	Good	Calcareous sandstone	Calcareous sandstone	—
COUNTY BUCKINGHAM—Bunn Springs Bore, 1909	Shaugh	—	—	330½	315	208B	Large	Fresh	Calcareous sandstone	Calcareous sandstone	—
Emu Flat Bore	Stirling	—	100	268⅔	34 52 166 264	— — — 28B	— 8,500 200,000 312,000	Brackish Fresh Fresh 0·22	Soft yellow limestone .... Light-yellow limestone Soft light-green limestone, marine fossil Light calcareous sand, marine fossils	Light calcareous sand, marine fossils	— —

Allen, James, Bore, S.-E. of Wolseley, on Border of S.A. and Vic.	Tatiara	—	—	180	158	—	—	—	Coralline limestone.......	Coralline limestone.......	—
Butler, H. W., Bore, 5 miles S.-W. of Wolseley	Tatiara	—	—	156	138	—	—	—	Coralline limestone	Coralline limestone	—
Easther, A. H., Bore, 4 miles N.-W. of Wolseley	Tatiara	—	—	130	117	—	—	—	Calcareous sandstone	Calcareous sandstone	—
Grosser, A. E. J., Bore, Wolseley	Tatiara	—	—	148	138	—	—	—	Calcareous sandstone	Calcareous sandstone	—
Bordertown Bore	Tatiara	—	—	601½	104 515-554 567	— 88B —	— — —	0·26 0·24 0·20	Yellow fossiliferous limestone (polyzoal) Fine black driftsand Coarse to angular brownish grits	Bedrock, coarse quartz-mica schist and mica schist	Fine sand clogs screen, 0·24 oz. per gall. after air compressor test (failure) and bore-hole sanded up
COUNTY BURRA— Mosey, Wm., No. 1 Bore, Eurovale Station	King	—	—	186	122	—	Little	2½	Hard quartzite and slate .	Hard quartzite and slate .	Pumped at 130ft., 2,500 g/h, 1½oz. per gall.
Mosey, Wm., No. 2 Bore, Eurovale Station	King	—	—	155½	—	—	500 g/h	3½	—	Quartzite	Pumped at 126ft.
Mosey, Wm., No. 3 Well Eurovale Station, Well and Bore	King	—	—	201	—	—	50	2½	—	—	—
Mosey, J. and W., No. 5 Bore, Finger Post, N.-W. of Florieton	King	—	—	226	188 226	— —	Little 500 g/h	— 2½	— Clay and shells	Clay and shells	—
Florieton Bore (Florieton Township)	Maude	—	—	300	150 250	135B 135B	600 g/h	— —	Dark-brown coarse water-worn sand Grey fossiliferous fine sand	Grey very fossiliferous fine sand	—
Mosey, John, No. 1 Bore, 4 miles N.-E. of Florieton	Maude	—	—	182½	175-180	150B	600 g/h	½	Sand and shells	Black clay	Excellent for domestic purposes. Pump at 160ft.
Mosey, John, No. 2 Bore, 2 miles E. of Florieton, 1924	Maude	—	—	169½	169½	147½B	300 g/h	½	Coarse sand, shells, and fossils	Coarse sand, shells, and fossils	Good for domestic purposes

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water. g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Mosey, John, No. 3 Bore, 3 miles N. of Florieton (Kingara)	Maude	—	—	250⅜	112 212	— —	Little 300 g/h	— 1¼	— —	— —	Abandoned
Mosey, John, No. 4 Bore, 3 miles N. of Florieton	Maude	—	—	182¾	164-170	—	—	¾	—	Blue clay	—
Schomburgk Bore	Maude	—	—	365	—	—	25,000	Brackish	—	—	—
Kings Well Bore, 18 miles S.-W. of Koomooloo	Rees	52	—	Abt. 300	245	215B	9,600	½	Light shale	Light shale	Used for sheep
Koomooloo Station, Carbine Bore	—	Block 63	—	300	300	150B	100,000	1¾	Blue rock	Blue rock	Used for sheep
Koomooloo Station, Bushy Paddock Bore	—	Block 77E	—	206	206	200B	50	4½	Shale	Shale	Not usable
Koomooloo Station, Seven Sisters Paddock Bore	—	Block 77E	—	340	304	294B	50	3¼	Shale	Shale	Not usable
Koomooloo Station, Giffen Paddock Bore	—	Block 77W	—	330	206	156B	10,000	3	Blue rock	Blue rock	Not usable
Sampson Well, P.L. 1083	—	Block 56	—	—	—	—	—	—	—	—	Water too bad to have ever been used
COUNTY CARDWELL — Tintinara Bore........	Coombe	—	62	253	14 252	— A	— 4,300	Salt 0·16	Hard crystalline limestone Fine quartzose sand, marine fossils	Fine quartzose sand with fossils	Used for locomotives
Tintinara, Lewis Bros., Bore	Coombe	M	—	393	8 248 310 350	7½B A A A	Soak — — —	4·62 0·89 0·47 0·38	Limestone rock (hard and soft) Black clay, sand and shells Sand Lignite with pyrite nodules	Hard rock	Salt water used for stock 1,800gall. for ½hr. then sanded up

Tintinara, Schultz, W. B., Bore, 1945	Coombe	101	—	283	11½ 265	10½B A	Soakage 2,000 g/h	0·91 0·19	Limestone, hard and soft bands of pipe clay Dark chocolate sandy clay	Dark chocolate sandy clay	—
Tintinara Bore, S.A. Railways	Coombe	—	159·16	254	12½ 250	9¾B A	— 6,500 g/h pumped	1·37 0·21	Massive travertine lime-stone Black sand with numerous small shells	Sandy clay with shell fragments	Pumping test draw-down was 63ft. Analysis 0·18oz. per gall. (S.A.R.)
Salt Creek Petroleum Co., Alfred Flat Bore	Messent	—	—	992	—	—	—	—	—	Red crystalline limestone	—
Bore 7½ miles 259° from Tintinara R. S.	Richards	—	—	380	—	—	—	Fresh	—	—	—
Bore, Tintinara, N.-E. Corner, Helling, G. A.	Richards	Block 5	—	260½?	15? 62 180 220	— 4B A A	— — 20,000 40,000	Salt — 1·92 1·66	Quicksand .... Sand Rotten porous sandstone (probably limestone) Light grey sand with many mica particles	Hard crystalline rock	—
Goode Bore, 9½ miles, 244° from Tintinara R.S.	Richards	Block 2	—	319	Surface to 140 231	— A	— 1,200	Salt 1·28	— —	Quartz Mica schist	—
Bore 4 miles 250° from Tintinara R. S., 1927	Richards	—	—	250	—	A	20,000	Fresh	—	—	—
Bore, 6½ miles 256° from Tintinara R. S.	Richards	—	—	340	—	—	—	Fresh	—	—	—
Filmer, B. G., Bore....	Richards	—	—	393	390	6½A	4,000 g/h	0·40	—	—	Used for stock and lucerne
Luhrs, V. A., Bore	Richards	—	—	343	—	5½A	—	0·35	—	—	Used for stock and lucerne
Prosser, A. E., Bore ..	Richards	Q1	—	287	—	3B	—	0·15	—	—	Used for stock and garden
Henderson, G. K., Bore	—	—	—	347	20? 295 347	— A A	— — —	Salt Salt Fresh	— Sand Hard rock	— Hard rock	—
COUNTY CHANDOS— Nobah Bore	Auld	—	—	235	—	145B	Large	¼	Fossiliferous limestone	Fossiliferous limestone	—
Anderson Bore, 1909 ..	Bews	—	—	252	192 252	— 157B	Small Good	Fresh Fresh	Fossiliferous limestone Fossiliferous limestone	Fossiliferous limestone	—
Bews Bore	Bews	—	350	350	227	193B	10,800	Fresh	Fossiliferous limestone	Fossiliferous limestone	—
Lameroo Bore	Bews	—	—	—	204	—	8,000	0·51	—	—	Analysis, S.A.R.

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore. ft.	Depth at which water was struck. ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water. g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Lameroo Station Yard Bore	Bews	—	—	—	—	—	—	0·15	—	—	Analysis S.A.R.
Zerah Bore	Billiatt	—	—	253	184	91B	Large	$\frac{3}{8}$	Fossiliferous limestone		—
Wilkawatt or Cotton Bore	Cotton	179	300	865	190 800	170B 182B	30,000 Small	0·19 0·17	Limestone............... Brown sand	Granite	Water at 682ft. contains 0·14oz. per gall.
Dingo Bore...........	Cotton	—	300	225	194	185B	14,400	Good	Limestone with perforated shells	Limestone with perforated shells	—
Urabirra Government Bore	Cotton	—	—	350	190	—	—	Good	Sand in blue clay	White clay	—
Ulai (Mantari)	Cotton	—	—	250	190	184B	Large	$\frac{3}{8}$	—	—	—
Karte Bore	Kingsford	—	274	250	203	186B	Large	$\frac{1}{4}$	Coralline limestone	Coralline limestone	—
Kumara Bore, 1915 ...	Kingsford	—	—	240	155 190	59B 144B	Small soak Large	— $\frac{1}{4}$	Shell limestone .... White marine limestone	White marine limestone	—
Kringin, Mews, H. A., No. 2 Bore	Kingsford	—	—	267	—	—	Good	—	—	White coralline limestone	—
Carter Bore, 1907	Parilla	—	340	260	207 250	— 207B	— Good	Fresh Fresh	Yellow sandstone .... Fossiliferous limestone and sand	Fossiliferous limestone and sand	—
Clay Pan Bore	Parilla	—	340	234	225	203B	13,440	Fresh	Limestone and shells	Limestone and shells	—
Minga Bore, 1914	Peebinga	—	227	250	39 133 192	— — 130B	Soakage Soakage Large	— — $\frac{1}{4}$	Hard sandstone .... Hard micaceous sandstone Coralline limestone	Coralline limestone	—
Quondong Bore, Bordertown to Pinnaroo Route, 1909	Pinnaroo	—	—	302	302	204B	Large	Fresh	Limestone...............	Limestone	—

Cow Plains Bore, 1906	Pinnaroo	—	—	217	140 210	— 167B	Small Good	— 0·16	Fine yellow sand .... Sandstone and shells	Fossiliferous limestone	—
McMahon Bore	Pinnaroo	10	—	304	304	212B	Large	Fresh	Fossiliferous limestone ...	Fossiliferous limestone ...	—
Pinnaroo Bore No. 2, 1927	Pinnaroo	—	—	605	235 510 555	230B 217B 212B	— — 6,000 g/h	— ⅛ 0·12	Grey soft limestone Polyzoal limestone Grey porous limestone	White chalky polyzoal limestone with grey chalky limestone	—
Flour Mill Bore, S.A.F.C.U.	Pinnaroo	—	—	270	216	208B	450 g/h	—	Coralline limestone	Coralline limestone	—
Rosey Pine Bore, 1906.	Pinnaroo	—	—	265	230	195B	Good	Fresh	Fossiliferous limestone ...	Fossiliferous limestone	—
Bell, D. L., Bore, Mac Lookout East, 6 miles E. of Emu Springs	—	—	—	95	92	86B	—	Good	Yellow and white sandstone	Yellow and white sandstone	Used for domestic purposes
Bell, D. L., Bore, Mac Lookout East, 11 miles E. of Emu Springs	—	—	—	122	120	110B	—	Good	Sand	Sand	Used for domestic purposes
COUNTY EYRE— No. 1 Government Coal Bore, N.-W. Corner	Anna	194E	—	277½	123	—	—	2·09	Grey sand and shells	Decomposed schist	—
No. 2 Government Coal Bore, N.-W. Corner	Anna	190	—	255	118	—	—	0·74	Coarse brown sand	Granite	—
No. 3 Government Coal Bore	Anna	194E	—	267½	—	115B	—	1·84	—	Decomposed schist	—
No. 4 Government Coal Bore	Anna	194E	—	234	121	—	—	0·72	Fine-grained sand and shells	White sand merging into decomposed schist	—
No. 5 Government Coal Bore	Anna	200	—	276	130 187 232	— — —	— — —	1·35 1⅜ 1½	Coarse sand .... Bluish sand Flinty concretions	White sand merging into decomposed schist	—
No. 6 Government Coal Bore	Anna	193	—	220	130	—	—	1·34	Yellow sand	Decomposed schist	—
No. 8 Government Coal Bore	Anna	199	—	283½	162 180	— —	— —	1·25 1·02	Tertiary limestone .... Tertiary limestone	Coarse granitic sand	—
No. 9 Government Coal Bore	Anna	201	—	281	125	—	—	1·70	Coarse-grained sand with shells and grit	Coarse granitic sand	—
No. 10 Government Coal Bore	Anna	195	—	290¾	120 136 153	— — —	— — —	0·96 0·90 1·02	Fine-grained sand with shells Medium-grained sand with shells Fine-grained sand and shells	Coarse sand, merging into bedrock	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
No. 11 Government Coal Bore	Anna	195	—	286	—	—	—	—	—	Coarse sand merging into bedrock	—
Bore	Anna	204	—	129	—	—	—	1·93	—	—	—
Spurling Bore	Anna	290	—	—	—	—	—	—	—	—	Unfit for stock
Bore	Anna	284	—	—	—	—	—	Salt	—	—	—
Bore	Bagot	45	—	—	—	—	—	—	—	—	Wind mill
Sedan Bore...........	Bagot	—	300	326½	124	119B	3,000	⅞	Honeycomb rock	Bedrock	—
No. 9 Government Coal Bore (Swan Reach series), 1926	Bagot	12	—	170	104	—	—	1·02	Soft limestone	Mica schist	No lignite
Burgomaster, T. W., Bore	Bagot	30	—	227	227	218B	—	0·72	Yellow hard rock, like granite	Yellow hard rock, like granite	—
Burgomaster, J. P., Bore	Bagot	31	—	—	180 250	— 200B	Small Large	— 0·55	— Shells	—	—
No. 1 Government Coal Bore	Bagot	205	—	237	127½	—	—	1·33	Brown sandy clay	Decomposed granite	—
No. 2 Government Coal Bore	Bagot	205	—	172	132	—	—	1·19	Yellow sandy clay........	Mica schist	No lignite
No. 3 Government Coal Bore	Bagot	148	—	127	105	—	—	2·22	Limestone, soft with harder layers	Decomposed granite	—
No. 4 Government Coal Bore	Bagot	165	—	268 5/6	193	—	—	1·99	Sand and shells	Granite	—
No. 5 Government Coal Bore	Bagot	165	—	186	—	156½B	—	—	—	Decomposed schist	—
Bore	Bagot	79	—	170	—	—	Large	Good	—	Calcareous sandstone	—

No. 1 Beatty Government Bore	Beatty........	21	—	490	—	—	—	—	—	Soft blue slate	—
No. 3 Bower Government Coal Bore	Beatty........	29	—	492½	—	—	—	—	—	Hard rock	—
No. 4 Bower Government Coal Bore	Beatty........	33	—	341	—	—	—	—	—	Quartzite with a little mica	No lignite
No. 7 Bower Government Coal Bore	Beatty........	29	—	488	—	—	—	—	—	Fine-grained gneissic biotite granite	—
No. 17 Bower Government Coal Bore	Beatty........	29	—	343	—	—	—	—	—	Decomposed granite	—
No. 21 Bower Government Coal Bore	Beatty........	31	—	479	—	—	—	—	—	White sandy clay showing mica	No lignite
No. 22 Bower Government Coal Bore	Beatty........	31	—	460	—	—	—	—	—	Coarse sand and pyrites	—
No. 24 Bower Government Coal Bore	Beatty........	52	—	462	—	—	—	—	—	Coarse sand and pyrites	—
Bower Bore	Bower	—	240	496	270	245B	—	Salt	Soft calcareous rock and clay with marine fossils	Highly decomposed micaceous rock	Abandoned
					382	245B	—	3	Sandy shale with fossils		
No. 1 Bower Government Coal Bore	Bower	156	—	463	—	—	—	—	—	Clay	—
No. 2 Bower Government Coal Bore	Bower	156	—	—	—	—	—	—	—	—	No lignite
No. 5 Bower Government Coal Bore	Bower	170	—	500	—	—	—	—	—	Decomposed granite	—
No. 18 Bower Government Coal Bore	Bower	14	—	480½	—	—	—	—	—	Dense argillaceous limestone	—
No. 19 Bower Government Coal Bore	Bower	14	—	474	—	—	—	—	—	Coarse sand and pyrites	—
No. 20 Bower Government Coal Bore, 1928	Bower	14	—	440	—	—	—	—	—	White slightly sandy clay	—
No. 23 Bower Government Coal Bore, 1928	Bower	14	—	479	—	—	—	—	—	White sandy clay	—
No. 6 Bower Government Coal Bore	Brownlow	162	—	451	—	—	—	—	—	Decomposed granite	—
No. 8 Bower Government Coal Bore	Brownlow	161	—	432	—	—	—	—	—	Decomposed granite	No lignite

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
No. 9 Bower Government Coal Bore	Brownlow	174	—	422	—	—	—	—	—	White micaceous clay merging into decomposed granite	—
No. 10 Bower Government Coal Bore	Brownlow	174	—	438	—	—	—	—	—	Decomposed granite	—
No. 11 Bower Government Coal Bore	Brownlow	162	—	428	—	—	—	—	—	White clay merging into decomposed granite	—
No. 12 Bower Government Coal Bore, 1926	Brownlow	162	—	432	—	—	—	—	—	Decomposed granite	—
No. 13 Bower Government Coal Bore, 1926	Brownlow	162	—	478	—	—	—	—	—	Coarse white clay and sand merging into decomposed granite	—
No. 14 Bower Government Coal Bore	Brownlow	174	—	470	—	—	—	—	—	White and greenish micaceous clay (decomposed granite)	—
No. 15 Bower Government Coal Bore	Brownlow	163	—	459	—	—	—	—	—	Decomposed granite	—
No. 16 Bower Government Coal Bore, 1926	Brownlow	174	—	412	—	—	—	—	—	Decomposed granite	—
No. 25 Bower Government Coal Bore	Brownlow	162	—	404	—	—	—	—	—	Decomposed granite	—
No. 26 Bower Government Coal Bore	Brownlow	161	—	351	—	—	—	—	—	White sandy clay merging into decomposed granite	—
No. 27 Bower Government Coal Bore	Brownlow	161	—	370	—	—	—	—	—	White clay (decomposed bedrock)	—
No. 28 Bower Government Coal Bore	Brownlow	162	—	362	—	—	—	—	—	White clay merging into decomposed granite	—
No. 29 Bower Government Coal Bore	Brownlow	162	—	371	—	—	—	—	—	White sandy clay with mica	—

No. 30 Bower Government Coal Bore	Brownlow	161	—	402	—	—	—	—	—	White clay merging into bedrock	—
No. 31 Bower Government Coal Bore	Brownlow	161	—	381	—	—	—	—	—	White clay merging into granite	—
Schaltz Bore	Brownlow	A	—	303	—	—	—	—	—	Black clay	Dry
No. 1 Brownlow Government Coal Bore	Brownlow	94	—	105	—	—	—	—	—	Purple slate	No lignite
No. 2 Brownlow Government Coal Bore	Brownlow	96	—	448	—	—	—	—	—	Decomposed granite	No lignite
No. 3 Brownlow Government Coal Bore, 1927	Brownlow	147	—	455	—	—	—	—	—	Soft grey slate	—
Wilcox, Sydney, Brenda Bore	Eba	240	—	195	121 151	— 114B	— 10,000	Bitter 1·52	— —	Hard rock	Water very good for cattle and sheep
No. 2 Brenda Bore	Eba	264	—	198	171 180½	— 142B	— 10,000	Salt Good	— River mud and shells	Hard rock	Used for cattle and sheep
No. 3 Brenda Bore ...	Eba	283	—	212	178	145B	10,000	Salt	River mud and shells	Hard rock...............	Sheep will drink this water
No. 1 Morgan Government Bore	Eba	239	—	644	—	—	—	—	—	Grey slate	—
No. 3 Morgan Government Bore, 1925	Eba	394	—	576½	—	—	—	—	—	Hard rock	—
No. 1 Swan Reach Government Bore	Fisher	62	—	125	—	—	—	—	—	Phyllite	—
No. 2 Swan Reach Government Bore	Fisher	94	—	146	—	—	—	—	—	Phyllite	—
No. 4 Swan Reach Government Bore	Fisher	11	—	196	113	—	—	0·88	Tertiary limestone, hard and soft layers	Bedrock, probably decomposed slate	—
No. 5 Swan Reach Government Bore	Fisher	19	—	214	118	—	—	4·32	Medium-grained sand	White clay	—
No. 6 Swan Reach Government Bore	Fisher	21	—	182½	125 166 176	— — —	— — —	2·09 1·36 1·09	Dark sandy clay .... Medium-grained grey sand Coarse sand and gravel	Phyllite	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
No. 7 Swan Reach Government Bore	Fisher	13	—	213	148 166 178	— — —	— — —	1·33 1·19 0·86	Dark sandy clay .... Grey clay, little sand and shells Fine-grained grey sand	Mica schist	—
No. 10 Swan Reach Government Bore	Fisher	26	—	187	177½	—	—	1·98	Grey sand and shells	Mica schist	No lignite
Roy, G. A., Swan Reach No. 1 Bore, 1940	Fisher	—	—	245	—	—	—	—	—	—	—
Roy, G. A., Swan Reach No. 2 Bore, 1940	Fisher	—	—	135	—	—	—	—	—	—	—
Roy, G. A., Swan Reach No. 3 Bore, 1940	Fisher	—	—	140	—	—	—	—	—	—	—
Winnall Bros., Haylands Bore	Hay	A	—	90	40	20B	—	4	Yellow calcareous sandstone	Yellow calcareous sandstone	Water not used at all
Winnall Bros., Haylands Bore	Hay	A	—	146	131	126B	300 g/h	1·60	Yellow gravel...........	Clay	Water used for sheep
Trevaill, T. J., Bore ...	Hay	—	—	171	146	—	—	Good	Gravel	Clay	This water is as good as river water
Well................	Jellicoe	157	—	20	—	10B	—	¼	—	—	—
Well................	Jellicoe	779	—	40	—	—	—	Good stock	—	—	Supply and quality variable
Schultz, J. E., Bore ...	Jellicoe	818	—	700	—	100B abt.	Large	0·32	—	Bedrock	Rebored to 275ft.
COUNTY GREY— Springs Bore	Blanche.......	150	—	1,160	—	—	—	—	—	Dark-grey lignitic and fossiliferous sandy clay	—
Forest Headquarters Bore	Blanche.......	225	—	Less than 50	—	—	—	—	—	—	Used to be 70ft. deep but sand blocked it up

Forest Cottage Well and Bore	Blanche.......	225	—	—	—	—	Inadequate	—	—	—	—
Woods and Forests Department, Mount Gambier, No. 1 Bore 1946	Blanche.......	—	—	308	60 216 302	50B 118B 92B	250 g/h 250 g/h 1,500 g/h	0·04 0·10 —	Black carbonaceous silt and grit Black lignitic clay with some grit Water-worn gravel and black silt	Water-worn gravel and black silt	Abandoned owing to silt
Woods and Forests Department, Mount Gambier No. 2 Bore, 1946	Blanche.......	—	—	134	60 to 134	50B	1,140 g/h	0·06	Bryozoal limestone with flints	Bryozoal limestone with flints	—
Woods and Forests Department, Mount Gambier No. 3 Bore, 1946	Blanche.......	—	—	70	69	26B	160 g/h	0·09	Coarse grey-black lignitic sands	Coarse grey-black lignitic sands	—
Pick No. 2 Bore	Caroline	336	—	—	—	—	—	0·06 0·12	—	—	First sample taken at 75ft., second at 1,560ft.
Myora H.Q., Woods and Forests Department	Gambier	575	—	38	—	34B	400 g/h	—	—	—	Potable water
Half mile S.-W. of H.Q., Woods and Forests Department	Gambier	575	—	48	—	44B	400 g/h	—	—	—	Potable water
Two miles S.-E. from H.Q., Woods and Forests Department	Gambier	578	—	49	—	38B	400 g/h	—	—	—	Potable water
Bore	Hindmarsh ...	455	—	—	—	—	—	—	—	—	—
Native Well	Kongorong ...	541	—	—	—	—	—	Stock water	—	—	A natural well in limestone
Cheese Factory, No. 1 Bore	Mount Muirhead	555	—	575	150 to 200	20B	800 g/h	—	Limestone with hard flinty bands	Limestone with layers of marl	Strong smell of gas which was lost when water exposed to air
Cheese Factory, No. 2 Bore	Mount Muirhead	555	—	522	—	22B	1,400 g/h	0·11	—	—	—
Millicent Station Yard Well	Mount Muirhead	—	—	—	—	—	—	0·08	—	—	—
Mount Burr Bore	Riddoch	—	—	425	148?	93B	Greater than 10,000 g/h	0·07	Flint fragments with polyzoal limestone	Puggy calcareous clay with polyzoal limestone fragments	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Well near Woods and Forests Department Saw Mill at Mount Burr	Riddoch	—	—	90½	—	87B	—	—	—	Coarse sandy limestone, open textured, hard, with abundant macro fossils	—
Well in Boiler Room of Mill	Riddoch	—	—	90	—	—	—	0·03	—	—	—
Dismal Swamp Bore ..	Young	Block F	133½	—	—	—	—	—	—	—	—
Dismal Swamp, No. 1 Bore	Young	Block E	240 abt.	133½	121	70B	—	—	Coarse driftsand with small quantity of crystals and water-worn gravel	Coarse driftsand with small quantity of crystals and water-worn gravel	—
Dismal Swamp, No. 2 Bore	Young	217	333	141	— —	5B 67B	Soakage —	— —	—	Silver siliceous sand	—
Dismal Swamp, No. 3 Bore	Young	164	Approx. 339	157⅛	—	9B	—	—	—	Fine micaceous sand	—
Bore at No. 2 Air-Observers School	Young	593	—	?	110 274?	— —	— —	0·04 0·06	Hard limestone with soft layers	—	Water stands at 28ft.
COUNTY HAMLEY— Calperum (J. McCormac) Bore, 200yds. S. of Nanych Dam	—	—	—	200	75	—	—	Salt	White and yellow sand ...	White and yellow sand	—
Calperum Station, Oak Tank Bore	—	—	—	644	160 305 644	— — 150B	Small — 1,250 g/h	Salt Salt 1·95	Fine black mud Fossiliferous clay and hard limestone bands Drift sand	Drift sand	—
Calperum Station, Calladen Bore, 4·4 miles E. of Nanych Dam	—	—	—	607	365 575	— 100B	Big Big	Very salt 2·09	Blue fossiliferous clay Drift sand with fossils and odd pebbles	Light-grey clay	—

S

Chowilla, Robertson, Canegrass, or Gunyum Bore	—	—	—	680	40 72 350 450 650-680	— — — A 18A	— Big — Small 2,000 g/h	Salt Salt Very salt 2½ 2·38	Fine grey sand.......... Fine grey sand Blue fossiliferous clay Sandstone and fossiliferous rock Drift, medium-grained sand with shell fragments	Drift, medium-grained sand with shell fragments	—
Canopus Station, Martin, H., Triangle Bore	—	—	—	574	110 125 216 400 574	— — — 200B 70B	— — — — —	Salt Salt Salt 3 1·97	Light-blue sandy clay Light-blue sandy clay Light-blue sandy clay Light-blue fossiliferous clay Drift sand	Drift sand..............	Shut off 110ft., salt water, again shut off, water at 186ft.
Renmark, Williams Bros. & Snow, Drainage Bore	—	—	—	88	—	—	—	—	—	Sand	No drainage obtained
Renmark, Yandilla Park, No. 1 Drainage Bore	—	—	—	304	—	—	—	—	—	Clay and sandstone	—
COUNTY HINDMARSH—											
Milang Jetty Bore.....	Alexandrina ..	—	—	—	—	A	—	—	—	—	—
Bore	Alexandrina ..	4	—	65	—	—	250,000	0·75	—	—	—
Bore	Alexandrina ..	5	—	—	—	A	—	0·69	—	—	—
Bore	Alexandrina ..	26	—	70	70	12B	—	0·30	—	—	—
Bore	Alexandrina ..	57	—	—	—	—	—	—	—	—	Stock water only
Bore	Alexandrina ..	60	—	72	72	9B	—	1·60	—	—	—
Bore	Alexandrina ..	80	—	80-90	—	—	—	Fresh	—	—	—
Landseer, Ltd., A. H., Bore at Wooralie	Alexandrina ..	168	—	110	—	70B	Good	1·23	Sand	Sand	Water for horses, cattle and sheep
Bore	Bremer	Bk. 42	—	—	75	—	—	—	—	—	—
Bore	Bremer	Bk. 43	—	—	113	—	—	—	—	—	—
Bore	Bremer	Bk. 44	—	—	95	—	—	—	—	—	—
Hill Bore	Bremer	Bk. 45	—	—	118	13B	—	—	—	—	Quality like Milang water
Mattesons Bore	Bremer	Bk. 48	—	125	25	—	—	—	—	—	Quality like Milang water

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Bore	Bremer	544	—	—	95	—	—	—	—	—	—
Bore	Bremer	546	—	—	70	—	—	—	—	—	—
Bore	Bremer	557	—	—	70	—	—	—	—	—	—
Ball, F. O., Bore No. 1	Bremer	582	—	65	54	62B	—	2·19	Sand	Limestone rock	—
Ball, F. O., Bore No. 2	Bremer	594	—	63	—	60B	—	2·05	—	Limestone rock	—
Ball, F. O., Bore No. 3	Bremer	582	—	80	—	56B	—	1·97	—	Limestone rock	—
Burnell, A. R., Bore ..	Bremer	613	—	110?	50 —	— 46B	Small —	Fresh 1·35	Sand .... Sand	Bedrock	—
Burnell, A. R., Well ..	Bremer	2004	—	23	15	—	—	0·65	—	—	Previous analysis 1934, 0·17oz. per gall.
Stirling, C. K., Bore, Strathalbyn	Bremer	2637	—	185	—	38B	—	1·05	—	—	—
Moores Bore	Bremer	2801	—	—	113	17B	—	—	—	—	Quality like Milang water
Bore	Bremer	2817	—	90	—	—	—	—	—	—	—
Bore	Bremer	2834	—	72	—	—	—	—	—	—	—
Bore	Bremer	2836	—	—	66	A	—	0·46	—	—	—
Bore at Belvidere	Bremer	—	—	178	178	60B	—	—	—	—	—
Bore	Bremer	Bk. 41	—	—	75	—	—	—	—	—	—
Welsh Oil Bore	Goolwa	26	—	200	18 60	— 6B	— Large	— 0·29	Alluvium .... Permo-Carboniferous tillite	Permo-Carboniferous tillite	—
Heyson Bore	Nangkita	272	—	97	95	20B	—	0·22	Sand	—	—

Heggaton, P., Bore ...	Nangkita	—	—	600	Surface to 280	—	—	All salt	—	Coralline limestone and clay and pyrites	Failure
Wilson, L. K., Ashbourne	Strathalbyn ...	52	—	92	90	—	500 g/h	0·87	Large quartz vein in phyllite	Large quartz vein in phyllite	—
Murray, D., Bore, Strathalbyn	Strathalbyn ...	53	—	101	74 92 96	66B — 66B	— — 400 g/h	— — 1·70	Phyllite .... Phyllite Quartz-mica schist and mica schist	Quartz-mica schist and mica schist	—
COUNTY MACDONNELL — Blackford Bore	Murrabinna ...	10B	—	1,365	343-848	—	Little	Very salt	—	Brownish ferruginous sand with quartz and grey slate	At 950ft. and 960 ft. inflammable gas.
COUNTY ROBE— Ryder, F. J., No. 2 Bore	Bowaka.......	198	—	395	36 108 143 180 214 229 395	3½B 3B 2¾B 2½B 2B 1½B A	Fair — — — — — 32,000-35,000 g/h	— — — — — — 0·10	Blue sandy clay Grey flint Sandstone White stone White sandy clay Coralline limestone Green clay and drift sand	Green clay and drift sand	Very bad smell in early part of bore
S.-E. Drainage Works Bore, 1911	Comaum	242	194	186	9	5B	—	—	Coarse nodular limestone in clay	Fine sand	—
Government Bore No. 1	Naracoorte ...	—	—	488+	—	13⅔B	45,000 g/h	0·18	—	Black lignitic clay	After test water level lowered to 44ft. Sample taken at 440ft.
Government Bore, No. 2	Naracoorte ...	—	—	537	—	—	—	0·22	—	—	—
Bowling Green Well ..	Waterhouse ...	—	—	23	—	17B	—	0·73	—	—	—
Brown, T. G., Well ...	Waterhouse ...	—	—	9½	—	7B	—	0·22	—	—	—
Esplanade, Robe, Bore	Waterhouse ...	—	—	16	—	—	Sufficient for pump	0·15	—	—	—
Hateley, A. C., Robe, Bore	Waterhouse ...	—	—	8	—	—	plenty for pump	0·11	—	—	—
Hateley, J. A., Robe, Well	Waterhouse ...	—	—	8	—	7B	Plenty for pump	—	—	—	—
Hateley, J. A., Robe, Bore	Waterhouse ...	—	—	10	—	—	Plenty for mill	0·12	—	—	—
Institute, Robe, Well .	Waterhouse ...	—	—	17¾	—	14B	—	0·14	—	—	Has odour of hydrogen sulphide

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Niehus, L. D., Well ...	Waterhouse ...	—	—	20	—	16B	—	0·15	—	—	—
Samwell, Miss, Bore ..	Waterhouse ...	—	—	10	—	—	Sufficient for mill	0·31	—	—	—
Watson, Miss, Well ...	Waterhouse ...	—	—	7½	—	5½B	—	0·10	—	—	—
Watson, Miss, Bore....	Waterhouse ...	—	—	27	—	15B	—	0·14	—	—	—
Wehrmuller, N., Well..	Waterhouse ...	—	—	12	—	10B	—	0·12	—	—	—
COUNTY RUSSELL— Lichman Dash, Bore ..	Baker	—	Abt. 130	150	130	130B	Large	Poor	Porous limestone	Porous limestone	—
Point McLeay Mission Station Bore	Baker	264	10-12	188	12 70 170	— 12B 10B	— — —	— — Saline	Sand and thin limestone Buff limestone, some dense and some with polyzoal fragments Creamy shelled sandrock to silica and shell fragments	Creamy shelled sandrock to silica and shell fragments	—
Bore	Baker	476	—	90	—	—	—	Very brackish	—	—	—
Bore	Baker	480	—	—	—	—	—	—	—	—	—
No. 1 Bore	Burdett	240	—	—	—	—	—	1·15	—	—	—
No. 5B Bore..........	Burdett	237	—	187½	186	—	240 g/h	—	Angular sub-rounded coarse and fine-grained clear quartz. Bryozoal limestone	Bedrock	—
Cookes Plains, Hawkes Nest Well	Coolinong	—	—	173½	166	—	2,000	—	Sand	Sand	—
Dohnt, C. E., Bore ...	Ettrick	25	—	223	223	187B	Good	0·91	Calcareous sandstone	Black mud	
Tuit, H. J., Bore	Ettrick	53	—	210	—	—	150 g/h	1·27	—	—	—

Kruger Bore..........	Ettrick	61	—	406	190 400	190B 246B	— 1,200 g/h	3 1·44	—	—	First water cut off
Chapman Bore, 1908 ..	Ettrick	—	170	346	235	Rising very little	Small	2½	Soft sandstone	Decomposed slate	—
Naturi, Calliss, G., Bore, 1932	Ettrick	45	—	338½	325	312B	60	2⅜	Black sandy clay	Lignite and pyrites	Stock
Naturi Government Bore	Ettrick	—	Approx. 70	410	—	—	Small	2¼	—	Soft grey slate	—
Poyntz Bore, 1908 ..	Ettrick	—	—	352	228	187B	Good	0·84	Sand, shell and ironstone..	Hard shale with iron pyrites	—
Thalaba Bore	Ettrick	—	—	410	395	—	—	2¼	Argillaceous sandstone ...	Blue slaty rock	Abandoned
Drualat Bore	Ettrick	—	210	264	—	232B	Good	1·33	—	—	—
Bowman, W. D.	Malcolm	591	6	179	30	6B	Big	Bad	Porous sandstone, pale green colour	Very hard rock	Water, pale green colour, killed grass
Bowman, W. D.	Malcolm	93	97	250	114	95B	—	Good	Limestone with great vughs	Limestone with great vughs	Lucerne and stock water
Down, F. J. C., Well ..	Malcolm	182	9	7½	—	5B	—	—	—	—	Idle for years
Gardiner, H. A.	Seymour	489	—	120	115	—	—	0·86	—	—	—
Oakley, E. N., Bore, 1945	Seymour	3C	—	144	—	—	—	—	—	Bedrock	Dry
Cookes Plains Bore ...	Seymour	—	20	224	15	—	Good	Salt	Sandy limestone	Igneous rock	Abandoned
Gardiner, W., No. 3 Well	Seymour	3B	—	110	110	100B	—	1·47	—	—	Water for horses
Gardiner, W., House Bore	Seymour	3A	—	275	240 to 275	143B	—	—	Sand	Sand	—
Gardiner, W., House Bore	Seymour	3A	—	225	159 225	150B 100B?	— —	— 1·09	Ironstone gravel .... Coarse sand and gravel with shells?	Coarse sand and gravel with shells	—
Gardiner, W., No. 1 Bore	Seymour	3A	—	158	158	151B	—	1·75	White calcareous sandstone with yellow clay	—	—
Gardiner, W., No. 3 Bore	Seymour	3A	—	135	—	—	Dry	—	—	Hard sandstone	—
Gardiner, W., No. 4 Bore	Seymour	3A	—	175	164/175	153B	—	2·20	Sandrock (decomposed granite ?)	Bedrock granite..........	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Gardiner, W., No. 5 Bore	Seymour	3A	—	97	—	—	—	—	—	Sandstone	Dry
Gardiner, R., No. 1 Bore	Seymour	3B	—	187	120 187?	— —	Soakage Good	— —	Sandstone .... Hard rock, pinkish in colour	Hard rock, pinkish in colour	—
Gardiner, R., No. 2 Bore	Seymour	3B	—	119	15 110 119	— — 99B	— Light 400-500 g/h	1·97 — 2·07	Red sandy clay Hard white sandstone Hard white sandstone	Hard white sandstone	—
Gardiner, H. R., Bore .	Seymour	3C	—	—	—	—	—	1·93	—	—	—
Gardiner, R., Bore	Seymour	3B	—	—	145 185	— 80B	10 g/h —	— —	—	—	Water at 185ft. unfit for stock
Jaensch Bore, 1914 ...	Seymour	Block E.	—	402	50	50B	—	Salt	—	—	—
Weinert Bore	Younghusband.	—	—	421	332 414	— 300B	Small Good	3/4 3/4	Calcareous sandstone ..... Grey sandy clay	Fine sand	—
Rosenberge Bore	Younghusband.	—	—	300	—	—	—	1·97	—	—	—
Knight Bore..........	Younghusband	—	—	319	—	271B	Good	7/8	—	—	—
COUNTY STURT— Well.................	Angas	88	—	—	20	20B	—	Good	—	—	—
2 Bores	Angas	123	—	—	—	—	—	—	—	—	Both used for irrigation
Falkenberg, R. F., Mannum, Bore No. 1, 1941	Angas	218	—	225	214	210B	50 g/h	—	—	—	—
Falkenberg, R. F., Mannum, Bore No. 2, 1941	Angas	218	—	—	165	150B	36 g/h	—	—	—	—
Melrose, R. T., Rosebank, Mount Pleasant Bore	Angas	282	—	—	—	—	Fair	—	—	—	After about 12 years quicksand ruined bore

Melrose, R. T., Rosebank, Mount Pleasant No. 1 Bore	Angas	282	—	230	198	—	—	—	Thin layer gravel and sand	—	Bore fell in. Failure
Melrose, R. T., Rosebank, Mount Pleasant No. 2 Bore	Angas	282	—	240	157-175 205-215	— —	— Big	— —	Yellow sand .... Yellow sand with some gravel and stones	Hard blue rock	Abandoned
Melrose, R. T., Rosebank, Mount Pleasant No. 3 Bore	Angas	282	—	281	157-175 203-212 278	— — 175B	— Big Pumps 4,000	— — 0·36	Yellow sand .... Yellow sand —	Cement-coloured rock.....	—
Winkler Bores, 2 Bores	Angas	295 and 304	—	—	Both about 150	—	—	Fresh	Calcareous sandstone	—	—
Hayden, W. A., Kongolia, No. 1 Bore, 1940	Angas	316	—	166	148	146B	—	—	—	—	—
Bore	Angas	321	—	130	—	—	—	Good	—	—	—
Bore	Angas	292	—	150	130	116B	Very large	Potable	Sand	Tertiary limestone	—
Well.................	Angas	201	—	180	—	150B	—	—	—	—	—
Well.................	Angas	Water Res. No. 7	—	—	—	—	—	—	—	—	30ft. to water
Miller Bore, 1910......	Brinkley	—	—	170	6 —	4½B 10B	— —	6 6·02	Blue and grey sand.......	—	Abandoned
Cross Roads Bore	Brinkley	—	—	—	—	—	Good	Salt	—	—	—
Zadow, H. G., Apamurra Bore	Finniss	35	—	300	79	—	Fair	2·46	Decomposed granite	Granite	—
Bore	Finniss	37	—	154	80/90	—	Small	1·54	Yellow mud	Yellow mud	—
Bore	Finniss	41	—	54	23	—	—	0·84	Alluvial clay and sand....	Decomposed granite	—
Strauss, J. H., Black Hill Bore No. 3, 1941	Finniss	173	—	173	148	—	1,000 g/h	—	—	—	—
Groth, M. J., Mannum Bore No. 1, 1941	Finniss	192	—	140	120	118B	1,000 g/h	0·57	—	—	—
Groth, M. J., Mannum Bore No. 3, 1941	Finniss	186	—	123	109	110B	1,000 g/h	0·58	—	—	—
Pese, R., Bore	Finniss	368	—	150	132	—	—	2·12	Sandy clay, very gritty ...	Hard rock..............	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Pietsch, W. A., Bore ..	Finniss	610	—	305+	170 305	25B —	— Good	2·19 2·29	Calcareous sandstone .... Shells mixed with sand	Shells mixed with sand ...	—
No. 1A, Finniss, Government Coal Bore	Finniss	426	—	165	41 130	— —	— —	1·33 0·21	Sandy clay .... White sand	Decomposed schist	—
No. 2A, Finniss, Government Coal Bore, 1927	Finniss	426	—	122	46	—	—	1⅛	Yellow sandy clay........	Decomposed mica schist ..	No lignite
No. 3A, Government Coal Bore	Finniss	24A	—	184	44 104	— —	— —	— —	Medium-grained brown sand Dark sandy clay .	Decomposed mica schist ..	—
No. 4A, Government Coal Bore	Finniss	243	—	211½	68 134	— —	— —	0·70 0·39	—	—	—
No. 5A, Government Coal Bore	Finniss	444	—	306	155 250	— —	— —	0·45 0·43	— —	—	—
No. 6A, Government Coal Bore	Finniss	210	—	303	179 269	— —	— —	0·52 0·35	—	—	—
No. 8A, Government Coal Bore	Finniss	413	—	182	50 146	— —	— —	4·86 0·43	—	—	—
No. 9A, Government Coal Bore	Finniss	—	—	199	177	—	—	0·40	—	—	—
Milendella Bore	Finniss	246	—	232	106 112 144 206	100B — — —	— Small Small 100	— Fresh Fresh Fresh	Sand .... Sand Sand Clay and sand	Hard granitoid rock	—
Mannum No. 1 Bore, on road between secs. 409 and 779	Finniss	—	—	342	188	—	—	0·45	—	—	—
Mannum No. 2 Bore ..	Finniss	580/1	—	290	—	—	—	—	—	Decomposed granite	—
Mannum No. 3 Bore ..	Finniss	576	—	160	120	A	5,760	0·49	—	—	—
Mannum No. 4 Bore ..	Finniss	1428	—	445	219	A	—	3·72	—	—	—

E

Framm Bore	Finniss	556	—	327	—	227B	Small	—	—	—	Windmill, stock water only
Hender, L., Langhorne Creek Bore	Freeling	3572	—	400	17 40 80 114 150-200 340	— 28B 38B 38B — 37B	— — — — Large Large	— — — — Good 0·24	Brown micaceous clay Very tough yellow clay Very tough yellow clay Fairly dense limestone Polyzoal limestone with hard bands Black mud and fossils	Slate or phyllite	—
Tolderol	Freeling	3371	—	—	95	16B	—	0·50	—	—	—
Bryan Bros., Hartley	Freeling	252	—	73	—	—	—	3¾	—	Phyllite and slate	—
Liebelt, A. M., Murray Bridge	Mobilong	223	—	147	—	—	—	Saline	Limestone	Limestone	—
Liebelt, A. M., Murray Bridge	Mobilong	148	—	130	—	—	—	—	—	—	Good stock water
Liebelt, A. M., Murray Bridge	Mobilong	172	—	250	100 250	— —	— —	Saline —	—	—	Water at 250ft. good for stock
Liebelt, A. M., Murray Bridge	Mobilong	168	—	180	—	—	—	—	—	—	Good stock water
Well	Mobilong	29	—	—	—	—	—	—	—	—	—
Egel, F. C., Black Hill, No. 1 Bore, 1941	Ridley	150	—	155	137	135B	1,000 g/h	0·20	—	—	—
Egel, F. C., Black Hill, No. 2 Bore, 1941	Ridley	154	—	126	116	106B	500 g/h	—	—	—	—
Nelson, P. H., Black Hill, No. 1 Bore, 1940	Ridley	171	—	120	107	102B	—	—	—	—	—
Nelson, P. H., Black Hill, No. 2 Bore, 1940	Ridley	170	—	126	122	116B	—	—	—	—	—
Rochow, A. R., Black Hill, No. 1 Bore, 1940	Ridley	193	—	—	—	—	—	—	—	—	—
Peters, L. G., Black Hill, No. 1 Bore, 1940	Ridley	202	—	190	190	140B	1,000 g/h	2·17	—	—	Stock water
Peters, L. G., Black Hill, No. 2 Bore, 1941	Ridley	201	—	204	202	191B	200 g/h	0·94	—	—	—
Roy, G. A., Swan Reach, No. 1 Bore, 1940	Ridley	218	—	245	245	—	—	Very salt	—	Dark greyish black fossiliferous (lignitic) clay	—

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Roy, G. A., Swan Reach, No. 2 Bore, 1940	Ridley	74	—	135	129	—	500 g/h	—	Bright yellow very sandy calcareous clay	Bright yellow, very sandy calcareous clay	Good stock water
Roy, G. A., Swan Reach, No. 3 Bore, 1940	Ridley	On stock road near 67	—	140	130	—	650 g/h	Very good	Bright yellow calcareous (fossiliferous) sandy clay	Bright yellow calcareous (fossiliferous) sandy clay	Drinkable
Roy, G. A., Swan Reach, No. 4 Bore, 1941	Ridley	246	—	120	110	105B	1,000 g/h	—	—	—	—
Swan Reach Government Bore No. 3	Ridley	221	—	142	—	—	—	—	—	Decomposed slate	—
Swan Reach Government Bore No. 8, 1926	Ridley	256	—	164	118 131	— —	— —	— 1·75	Brown sandy clay .... Hard and soft layers of limestone	Mica schist	—
Groth, M. J., Mannum, No. 2 Bore	Ridley	3	—	201	178	180B	500 g/h	—	—	—	—
Strauss, J. H., Black Hill, No. 1 Bore, 1941	Ridley	167	—	163	145	143B	1,000 g/h	0·24	—	—	—
Strauss, J. H., Black Hill, No. 2 Bore, 1941	Ridley	172	—	120	101	100B	1,000 g/h	0·23	—	—	—
Nagel, G. P., No. 1 Bore, 1941	Ridley	149	—	247	230	229B	500 g/h	0·30	Deep cream fine-grained sand	Deep cream fine-grained sand	—
Gower, W. R., 1940 ...	Ridley	146	—	198	180	177B	500 g/h	0·39	—	—	—
Batten, 4 Bores	Ridley	242	—	—	—	—	—	—	—	—	—
Palmer Government Bore, 1938	Tungkillo	960	—	121	45 110	— 7½B	700 g/h 1,000 g/h	0·19 0·19	Weathered fine-grained quartz-mica schist Dense quartz-mica schist with thin bands of grey micaceous quartzite	Granite	—

COUNTY YOUNG—Morgan Government Bore No. 2, 1925	Stuart	247	—	394	386½	—	210,000	1·30	Medium-grained fossiliferous sand	Medium-grained fossiliferous sand	—
Canegrass Station, Mundy Well and Bore	—	—	—	460	—	147B	—	2⅞	—	—	May be contaminated by upper water
Canegrass Station, Yabalia H.S. Well	—	—	—	136	132	—	—	4	—	—	—
Warnes, I. J., 3 miles E. of Lagoon Station, Koomooloo Station, P.L. 635	—	—	—	237	237	227B	100	3	Light-blue shale	Light-blue shale	Water not usable
Warnes, I. J., 4½ miles N.-E. of Long Plain Dam, Koomooloo Station, P.L. 635, 1924	—	—	—	340	340	200B	1,000	3½	Light shale	Light shale	Water not usable
Warnes, I. J., Lagoon Bore, 1 mile E. of Lagoon Station, Koomooloo Station, 1926	—	—	—	153	80	80B	3,600	½	Sand interbedded with yellow clay	—	Stock
Warnes, I. J., Bore, 1 mile N. of Old Koomooloo Station, Koomooloo Station, P.L. 983	—	—	—	95	90	90B	2 g/h	½	Yellow sandy clay	Shale	—
Warnes, I. J., Bore 1 mile N.-E. of Old Koomooloo Station, Koomooloo Station, P.L. 933	—	—	—	521	270	177B	100,000	3	Between shale and rock ..	Grey rock	Water not usable
Warnes, I. J., Bore at Old Koomooloo Station, P.L. 983	—	—	—	450	180	100B	300	3	Light shale	Pink clay	Water not usable
Warnes, I. J., Paradise Paddock Bore, 3 miles E. of Old Koomooloo Station, Koomooloo Station, P.L. 983	—	—	—	415	415	215B	50,000	3	Light shale	Light and black shale.....	Water not usable
Old Koomooloo Station, 1 mile S. of H.S. Well at 3 Dams, P.L. 983, Well and Bore	—	—	—	400+	—	—	—	2	—	—	Water was once used but well fell in

Bore or well and year completed	Hundred	Section	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Depth below surface at which water stands in feet —B Artesian —A	Yield of water g.p.d.	Quality of water (solids per gall.) oz.	Water-bearing strata	Nature of bottom	Remarks
Little Bunyung Well, P.L. 1066	—	—	—	—	—	—	—	—	—	—	Well fallen in
Pine Valley, Cockatoo Bore, P.L. 676	—	—	—	632	90-105	—	Little	Bitter	Coarse yellow sand	Black lignitic clay	Water at 172-182ft. rose 40ft.
					140-152	—	Little	Salt	Drift sand		
					172-182	—	—	2¼	Yellow sand with fine clay		
					350	150B	—	Salt	Soft calcareous sandstone		At 350ft. might be poor stock water
					511½	211½B	—	Salt	Drift sand		
					523½	127B	—	Salt	Drift sand		
					573	143B	—	1·71	Coarse yellow sand		At 573ft. good stock water
					585	445B	—	—	Brown clay and drift sand		
Finch, W., Parcoola Station, P.L. 1174 Bore	—	—	—	460	130	103B	Good	—	Sandy clay of various colours	Calcareous sandstone shells, and fossils, grey colour	Good stock water
Finch, W., Parcoola Station, P.L. 1298 Bore	—	—	—	640	130	—	—	—	Sandy clay of various colours	Calcareous sandstone, shells and fossils	Good stock water
					170	120B	Good	—	Sandy clay of various colours		
Scotia Blocks, Finch Bore	—	—	—	420	—	—	—	—	—	Limestone (sandy structure)	In progress 1928

Arranged according to longitude and latitude

Bore or well	Year completed	Approx. height of surface above s.l., ft.	Total depth of bore, ft.	Depth at which water was struck, ft.	Quantity of water, g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
EUCLA ARTESIAN BASIN.															
T.A.R., 591 m. Bore	—	—	362	260	15,000	0·70	—	—	—	—	White porous limestone, on white clay	Shale	—	30-31	129-130

T.A.R., 596 m. 50 ch.; 30 ch. N. of, Bore Nos. 1 and 2 (combined), Hughes	—	—	329	190	20,000	1·07	—	—	—	—	Soft limestone ...	Shale	—		
T.A.R., 554 m. 49ch.	—	—	—	299	760 g/h	1·13	—	—	—	—	—	—	—		
T.A.R., 542 m. 24 ch.	—	—	638	580	—	3·21	—	—	—	—	Sand	Sand	—		
Albala Karoo ..	—	300	1,084	290 665 740	400 500 700	3½ 1½ 1¾	— 65 68	— — —	270B 490B 420B	— — —	White polyzoal limestone Chocolate gravelly clay Blue clay	Red granite	— — —	31-32	129·130
Guinewarra Bore	—	300	1,277	268 975 1,004	Small — —	Salt 3·44 Salt	— — —	— — —	268B 203B 216B	— — —	Chalky limestone with flints Clay and coarse sand White pipe clay and coarse sand	Granite	— Abandoned —		
T.A.R., Cook Bore	—	—	1,208	424 731 742	— Fair —	1·09 2·19 3·29	— — —	— — —	— — —	— — —	Fine grey sandstone Grey shale ...... Shale	Shale and sandstone	S.W.L., 315ft. — —	30-31	130-131
T.A.R., 512 m. 49 ch.; 8 ch. S. of, Bore	—	—	500	317 } 440 }	660 g/h	1·85	{ — { —	— —	— —	— —	Blue shale....... Coarse gravel ...	Coarse gravel ...	Bitter, but camels drink it —		
T.A.R., 482 m. 54 ch., 25 ch. S. of, Fisher Bore	—	—	912	295 } 391 }	10,000	2·85	{ — { —	— —	— —	— —	Coarse sand ..... Blue shale.......	Soft rock........	— —		
Gilgurabbi Bore.	1913	211 approx.	850	162 817	Large 450 g/h	3½ 2·02	— —	— —	— 100B	— —	Opalized quartz . Coarse sand and gravel	— —	Analysis taken 1923, earlier analysis, 2·03 oz./gall., 1921 —		
Nullarbor Station, Mallabie Bore	1919	250/300	850	190 826 846	— — —	Salt 3 2·88	— — —	— — —	180B 126B 106B	— — —	Coarse sand ..... Sand .... Sand	— Sand .... —	— — —		
Muddaugana Bore	1923	—	794	198 270 784	— — —	3·22 3·04 1·53	— — —	— — —	198B 190B 190B	— — —	Soft white limestone White limestone . Blue clay with coarse gravel	Quartz, coarse sand	Gas in water at 220ft., 3·26 oz./gall. — —		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Quantity of water g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Murrawijinnie ..	1913	234 approx.	787	258	—	2¾	—	—	216B	—	Quartz pebbles...	Coarse sand and gravel	Stock	30-31	130-131
				738/787	Good	1¾	—	—	240B rising to 157B	—	Blue clay		—		
Nullarbor Plains No. 1, Roberts Well and Bore	—	—	777	192	1,500	3	—	—	—	—	Soft white limestone	Gravel	Analysis taken 1941. Earlier analysis, 1·51 oz/gall., 1914		
				760	62,000	1·26	—	—	130B	—	Quartz gravel and sand		—		
Nullarbor Plains No. 2 Bore	—	—	819	235/428	—	Salt	—	—	—	—	Limsetone.......	Sand and gravel with bands of white clay	Very brackish water		
				735	—	Salt	—	—	187B	—	White quartz gravel		—		
				818 5/12	19,200	2·13	—	—	183B	—	Sand and gravel with bands of white clay		—		
Nullarbor Plains No. 5 Bore	1893	300	669½	260	—	Salt	—	—	—	—	Chalky limestone.	Sand and clay ...	Good stock at 592½ft.		
				592½	—	1·80	—	—	27B	—	Quartzoze sand and gravel				
Nullarbor Plains No. 8 Bore	—	200	1,500	240	Good	4	—	—	—	—	White polyzoal limestone with flints	Igneous rock	Abandoned		
				900	—	5	—	—	267B	—	Sandy shale		—		
T.A.R. 452 m. 54 ch.; 53 ch. S. of, Bore	—	—	500	230 } 500 }	600	Salt	—	—	—	—	Sandy clay	—	—	30-31	131-132
T.A.R., Reid, No. 1 Bore	—	—	158	—	—	—	—	—	—	—	—	Brown clay with little limestone rubble	Lost tool started new bore		
T.A.R., New Reid, No. 1 Bore	—	—	420	—	—	—	—	—	—	—	—	—	Stopped boring		

T.A.R., Reid, No. 2 Bore	—	—	415	—	1,000 g/h	—	—	—	—	—	—	—	—		
T.A.R., Reid, No. 3 Bore	—	—	450	318	3,000 g/h	—	—	—	308B	—	Limestone rubble	—	Abandoned		
T.A.R., Reid, No. 4 Bore	—	—	450	—	1,000 g/h	—	—	—	—	—	—	Carbonaceous shale	Continuous pumping		
T.A.R., Reid, No. 5 Bore	—	—	450	—	2,000 g/h	—	—	—	—	—	—	—	Continuous pumping		
Bull Hill Bore ..	—	—	628	168 544 620	— Small Large	Salt — 2·51	— — —	— — —	— — —	— — —	White rock ..... Sand .... Sand	Loose sand	— — —	31-32	131-132
Delissa Bore ...	—	—	503	217/219 501	— —	Salt 2½	— —	— —	— —	— —	Sandy clay ..... Sand	Sand	— —		
Nullarbor Plains No. 6 Bore	—	170	1,000	230 450 577 588	— — — 28,000	Salt Brackish Stock 1½	— — — 72	— — — 269	— 184B — 170B	— — — —	Soft white polyzoal limestone Quartz gravel and sand Coarse gravel ... White micaceous shale	Red ferruginous rock	— — — —		
Nullarbor Plains No. 7 Bore	—	170	530	231	—	5	—	—	223B	—	Micaceous shale .	Hard gneissic rock	Abandoned		
Nullarbor Plains White Well Bore	—	—	684	178 681 1/6	— 1,200	Salt 1½	— —	— —	— 110B	— —	Chalk........... Quartz gravel....	Quartz gravel....	— —		

PIRIE—TORRENS ARTESIAN BASIN

Mirrabuckinna Bore	—	—	1,635	401 662 866 1,015	— — — —	Very brackish Very brackish Very brackish Very brackish	— — — —	— — — —	— 6½B 6½B 3A	— — — —	— — — Hard brown and blue rock	Hard brown and blue rock	— — — —	30-31	137-138
Yarra Wurta Bore	—	—	213	12½ 125 approx. 184/191 194/203 213	— — Large No quantity Large	Salt Salt 19 Brackish 3·18	— — — — —	— — — — —	— — — — 13B	— — — — —	Bands of gypsum White clay with yellow and brown clay White clay ..... White clay ..... Sandstone	Sandstone	— — — — —		

Bore or well	Year completed	Approx. height of surface above s.l.	Total depth of bore	Depth at which water was struck	Quantity of water	Solids per gall.	Temp.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude	Longitude
		ft.	ft.	ft.	g.p.d.	oz.	deg. F.							deg.	deg.
Hundred Warrakimbo, Section 3 Bore	1925	—	155	84 109 134	Big — 1,000 g/h	2½ 1½ 1·71	— — —	— — —	37B 37B 37B	— — —	Soft soil and sand Soft soil .... Sand	Broken quartzite.	Sheep — —	31-32	137-138
Hundred Warrakimbo, Old Station, Whim Well	—	—	80	—	Big	3/5ths	—	—	—	—	—	—	—		
Nilpena Station, Warrioota Bore	—	—	315	—	—	Salt	—	—	—	—	—	—	Abandoned	30-31	138-139
Nilpena Station, West Paddock Bore	—	—	515	150	—	Salt	—	—	—	—	—	Decomposed slate bed rock	Several waters, all salt		
Beltana, Boondi Bore	—	—	101	96	—	3·96	—	—	77B	—	Red sand	Red sand	Previous analysis, 1·59		
Beltana, Pinery Bore	—	—	661	159 337/342 425/473	Small — —	— — 1·71	— — —	— — —	— 58B —	— — —	White drift sand : Driftsand .... Gravel	Red slate	— — —		
Beltana, Millya Millyana Bore	—	—	250	33 58/61 65/8 192/5 210/212	— — — } 200 g/h	— — — 0·40	— — — —	— — — —	— — — —	— — — —	Conglomerated stones White sandy clay Yellow clay .... Soft blue rock ...	— — — —	Filled bore to 214 ft. supply decreased to 56gall.		
Beltana, Sundown Bore	—	—	89	85	700 g/h	0·28	—	—	73B	—	Gravel	Gravel, stones, boulders	—		
Beltana, Yerka Well	—	—	120	—	Big	1⅛	—	—	100B	—	—	—	—		
Beltana, Pinera Bore	—	—	329	48 83 235-240 250-254 329	10 g/hr — } 250 g/hr	— ⅝ 0·64	— — —	— — —	— 40B A	— — —	Brown clay...... White sand...... —	— — —	— — —		

Beltana, Pulchra Bore	—	—	405	110	—	4	—	—	—	—	Very pale grey siliceous clay	—	Previously reported from 299ft. rising to 149ft. +500 g/h of 1oz. water so went deeper owing to sand trouble		
				170	—	3	—	—	—	—	Very fine argillaceous silt	—			
				345	—	1½	—	—	—	—	Fine greyish Q. sand	—			
				405	—	0·85	—	—	150B	—	—	—			
Beltana, Mount James Well	—	—	30	—	Big	1½	—	—	16B	—	—	—	Poor stock		
Beltana, Etenna Bore	—	—	360	168	—	—	—	—	—	—	Red clay with conglomerated stones in layers	Red and white clay	Abandoned owing to sand troubles		
				255	—	—	—	—	155B	—	Yellow creek sand				
				335	—	1·09	—	—	200B	—	White sand and clay				
Beltana, Farewell Bore	—	—	315	125	Little	—	—	—	—	—	Red sandy clay	Red and white clay			
				135-145	260 g/h	0·84	—	—	—	—	Red sandy clay				
				182	10 g/h	1½	—	—	—	—	Red clay, patches of white		Filled in to 145ft.		
				300/303	Little	1	—	—	—	—	Red sandy clay				
COUNTY TAUNTON. Hundred Bunyeroo, Brachina Bore	—	—	362?	157	Soak	—	—	—	—	—	Red gravelly clay	Grey clay with traces of limestone	Pump at 202ft., 10,000 g/h, Anal. at 240ft., 71·5 gr./g, S.W.L. 125ft.	31-32	138-139
				203	Fair	—	—	—	—	—	Red gravelly clay				
				235	—	—	—	—	—	—	Sandstone				
				283	—	—	—	—	—	—	Grey clay with traces of limestone				
				362	—	—	—	—	—	—	Grey clay with traces of limestone				
Bunyeroo, Hundred, Government Reserve, Brachina Bore	—	—	207	183	—	0·11	—	—	160B	—	Dark sand	Clay and loose stones	—		
				206	1,360 g.p.h.	0·16	—	—	—	—	Dark slaty sand		—		
Bunyeroo, Hundred, section 35	—	—	180	—	—	0·08	—	—	—	—	Chocolate clays and small slaty gravel	Chocolate clays and small slaty gravel	—		
Bunyeroo, Hundred, section 119	—	—	180	—	—	0·17	—	—	—	—	Chocolate clays and some fine slaty gravel	Chocolate clays and some fine slaty gravel	—		

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Quantity of water g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
COUNTY BLACHFORD. Cotabena, Hundred, Cotabena Station	1937	—	121	57	Small	3	—	—	—	—	Light clay, veins of whitish sand	Yellow clay with gravel	—	31-32	138-139
				67	Fair	1¾	—	—	—	—	Brown sand, creek stones and gravel		—		
				101	Little	1½	—	—	—	—	Yellow sandy clay		—		
				117	400 g/h	1	—	—	—	—	Yellow rotten sand rock and clay		—		
Cotabena, Hundred, Wallerberdina Station, Conrick	1932	—	134⅛	120	400 g/h	2·26	—	—	65⅛B	—	Clay with white spots	—	Sheep		
Barndioota, Hundred, section 269	—	—	250	—	Dry	—	—	—	—	—	—	—	Sand trouble		
Warrakimbo, Hundred, Anderson Well, section 3	—	—	70	—	40,000	3/10ths	—	—	—	—	—	—	—		
Warrakimbo, Hundred, section 10, Horse Paddock Well	—	—	72	—	8,000/10,000	⅛ to 1/5th	—	—	—	—	—	—	—		

WILLOCHRA VALLEY ARTESIAN BASIN

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Quantity of water g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
COUNTY NEWCASTLE. Hundred Kanyaka, Gordon town, Schmidt	—	—	171	92	—	—	—	—	—	—	White clay	White sand......	—	32-33	138-139
				170	9,000+	0·86	—	—	—	—	White sand......		—		

Hundred Boolcunda Bore	1889	590	745	687	19,200	Good	—	—	A	—	—	—	—
Hundred Boolcunda, section 194, W. E. Saint	—	—	—	—	—	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 187, A. Hilda & Sons, Well	—	—	90	—	—	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 59 F. C. Noll, Well	—	—	50	—	—	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 172, A. Hilda & Son, Well	—	—	90	—	—	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 131, Well	—	—	50	—	—	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 128, Bore	—	—	550	—	—	—	—	—	A	—	—	—	—
Hundred Boolcunda, section 118, French Bore	—	—	450	—	—	—	—	—	A	—	—	—	—
Hundred Boolcunda, section 93, Finlay Well	—	—	43	—	—	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 247W, Bore	—	—	—	—	Good	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 247E	—	—	—	—	Good	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 112, Well	—	—	70	—	—	—	—	—	—	—	—	—	—
Hundred Boolcunda, section 112, Hooper Well	—	—	—	90	Good	0·28	—	—	90B abt.	—	—	—	—

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Quantity of water g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Hundred Pichi Richi, Railway Workshop Bore, Quorn	—	—	197	120	2,000	0·47	—	—	—	—	Hard yellow clay.	Hard sandstone .	—	32-33	138-139
				170	4,000+	0·43	—	—	—	—	Semi-decomposed ste.		—		
Hundred Pichi Richi, Quorn Bore No. 1	1926	—	220	20	—	—	—	—	—	—	Limestone and gravel	Pale chocolate clay, probably decomposed slate bedrock	—		
				158	—	—	—	—	—	—	Pale pinkish-brown clay with layers of slaty pebbles		—		
				220	50,000	0·31	—	—	26B	—	Pale chocolate clay		—		
Hundred Pichi Richi, Quorn C.A.R. Bore	—	—	305	153	1,000 g/h	—	—	—	45B	—	Slate	Hard blue to purple slate	Main supply at 193ft.		
				193	10,000 g/h	0·23	—	—	—	—	Grey purple slate				
Hundred Palmer, section 202S, Mrs. F. C. Brooks, Well and Bore	—	—	93?	—	—	2·16	—	—	—	—	—	—	—		
Hundred Palmer, Kingswood Bore	—	—	330	319	28,800	Slightly brackish	—	—	15B	—	Very hard blue argillaceous calcareous rock	Very hard blue argillaceous calcareous rock	Test at 65ft.		
COUNTY FROME. Hundred Willochra, section 128, S. Freeman	1914	—	235	—	—	Salt	—	—	—	—	—	Sandstone	—		
				205	—	Fresh	—	—	—	—	Sandstone		—		
				210	—	Fresh	—	—	A	—	Sandstone		—		
				220	—	Fresh	—	—	A	—	Sandstone		—		
Hundred Willochra, section 158, S. & M. Adam Bore	1925	—	193	11/65	—	Very salt	—	—	8½B	—	Clay with boulders	White sand over white clay	—		
				151	—	Salt	—	—	19B	—	Dark yellow sandy clay		—		
				192	50,000	Good stock	—	—	A	—	White sand over white clay		—		

Hundred Willochra, ½ m. S. of Bruce Bore	1931	—	196	37 125 190	— Very small 114,000	Salt Good 0·17	— — —	— — —	17B A —	— — —	Pink clay mixed with sand Very sandy white clay Solidified coarse white sand	— — —	Salt water cased off at 60ft.
Hundred Willochra, section 202, G. H. Voigt	1924	—	280	52 161 207½	100 — 14,000	Poor stock Fair stock Good stock	— — —	— — —	45½B 25B A	— — —	Reddish yellow clay with concretions Dark yellow sandy clay White sand......	White clay, very plastic	— — —
Hundred Willochra, Bruce No. 2	—	—	385	288	96,000	Good	—	—	2A	—	Hard dark red calc. rock with veins of blue and purple slate	Hard dark red calc. rock with veins of blue and purple slate	Pump at 20ft. Supply 3,600gall. flowing per day
Hundred Willochra, Wilmington Bore	—	—	646	250/300	43,000	Good	—	—	100B	—	—	—	—
Hundred Gregory, section 322, Willowie House Well	—	—	—	—	—	—	—	—	14B	—	—	—	—
Hundred Gregory, section 322, Lodge Well	—	—	140	—	Less than 5,000	—	—	—	3B	—	—	Gravel	—
Hundred Gregory, section 322, Willowie H.S. Stable Well	—	—	125	—	—	Good	—	—	—	—	—	Gravel	120ft. of drives
Hundred Gregory, section 322	—	—	30/40	—	—	—	—	—	10B	—	—	Coarse gravel ...	—
Hundred Gregory, section 355	—	—	299	80 abt. 297	— 400 g/h	Saline 0·16	— —	— —	— —	— —	— —	— —	S.W.L. 80ft.
Hundred Gregory, section 355 Well	—	—	85	—	No supply	Very brackish	—	—	82B	—	—	—	—
Hundred Gregory, section 148	—	—	415	—	—	Good	—	—	—	—	—	—	—
Hundred Gregory, section 130, Woods and Forests Bore	—	—	—	95 155	Small —	Salt Fair	— —	— —	— 123B	— —	— —	Gravel .... Gravelly sand ...	— —

Bore or well	Year completed	Approx. height of surface above s.l. ft.	Total depth of bore ft.	Depth at which water was struck ft.	Quantity of water g.p.d.	Solids per gall. oz.	Temp. deg. F.	Temp. gradient in ft. for each degree	Depth below surface at which water stands in feet —B Artesian —A	Pressure in lb. per sq. in. at the surface	Water-bearing strata	Nature of bottom	Remarks	Latitude deg.	Longitude deg.
Hundred Willowie, section 129	—	—	171	167	4,500	—	—	—	—	—	—	—	—	32-33	138-139
Hundred Willowie, section 53	—	—	—	—	—	0·47	—	—	—	—	—	—	—		
Hundred Willowie, section 22N, H. E. Reichstein, Bore	—	—	—	97	—	2·05	—	—	—	—	Chalk and pipe clay	—	—		
COWELL ARTESIAN BASIN															
COUNTY YORK—Hundred Poynton, Section N	—	—	150	150	—	Salt	—	—	60B	—	—	Blue clay Tertiary	—	33-34	137-138
Hundred Poynton, Section G., Pata Bore	—	—	374	105 166 374	— — —	Salt Very salt 11	— — —	— — —	— — —	— — —	Sandy clay ..... Calcareous clay .. Sand	Sand	— Abandoned —		
Hundred Poynton, section H, C. J. Schulz	—	—	200	—	—	Salt	—	—	148B	—	—	Highly altered siliceous rocks	—		
COUNTY JERVOIS. Hundred Playford, Cowell Bore	—	20	224	190	—	Salt	—	—	17B	—	White clay	Hard qte. rock ..	No prospects of good water	33-34	136-137
Hundred Boothby, Boothby Well, Government	—	—	127	—	14,400	$\frac{3}{8}$	—	—	62B	—	—	Gneissic and quartzitic wash	—		
Hundred Boothby, Carpa Bore	—	20	478	129	—	Salt	—		80B	—	Sandstone	Hard red quartz rock	Abandoned		

IN THE TABLES OF BOREHOLES THE FOLLOWING ABBREVIATIONS ARE USED:—

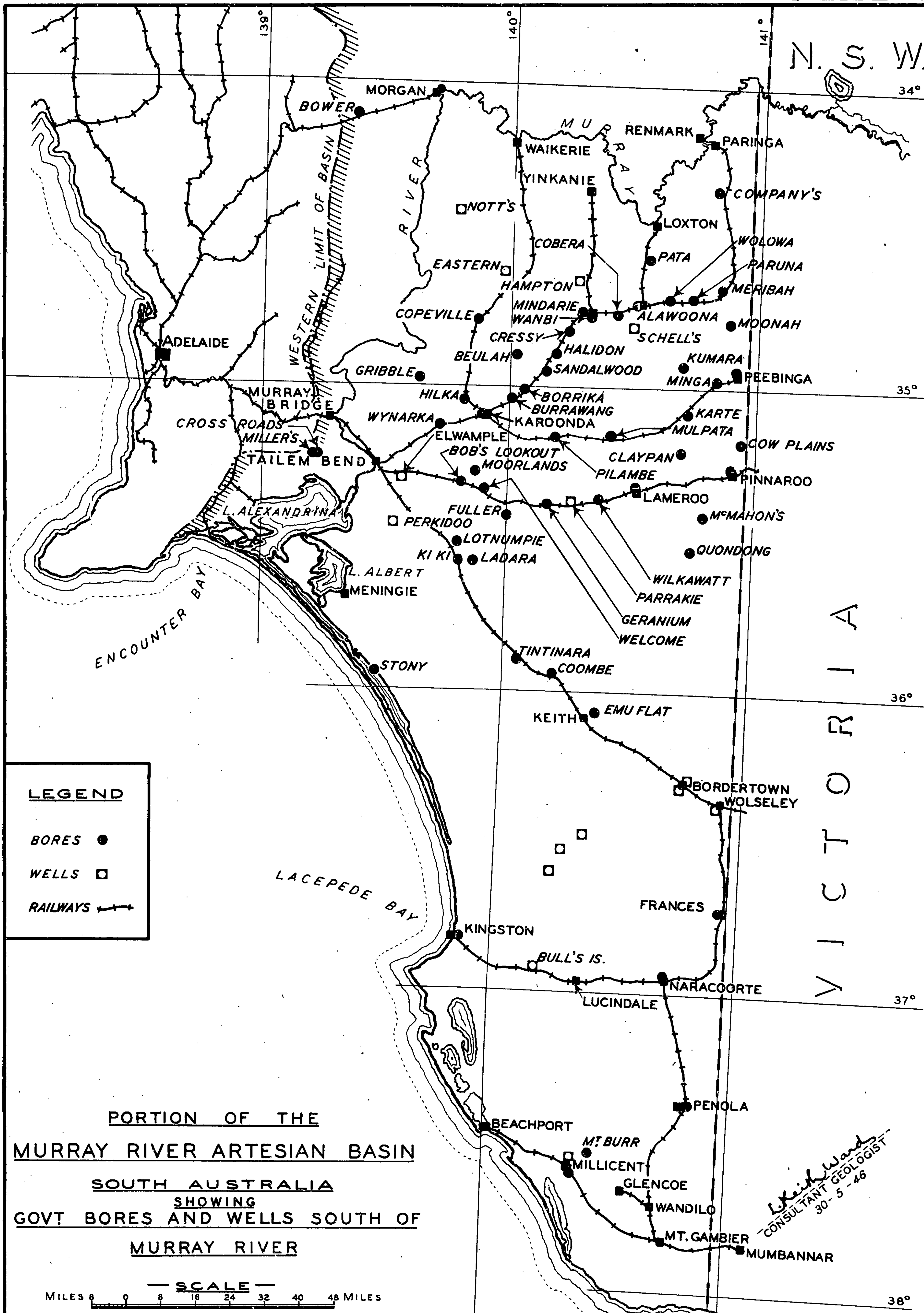
An.—determination by aneroid.
Arg.—Argillaceous.
Btm.—Bottom.
Calc.—calcareous.
C.A.R.—Commonwealth of Australia Railway.
Est.—estimated.
G.p.d.—gallons per day of 24 hours.
G.p.h. or g/h—gallons per hour.
Q.—quartz.
Qte.—quartzite.
S.l.—sea level.
Ste.—sandstone.
T.A.R.—Trans-Australian Railway.

Salinity, expressed in whole numbers and fractions, has been determined by salinometer.

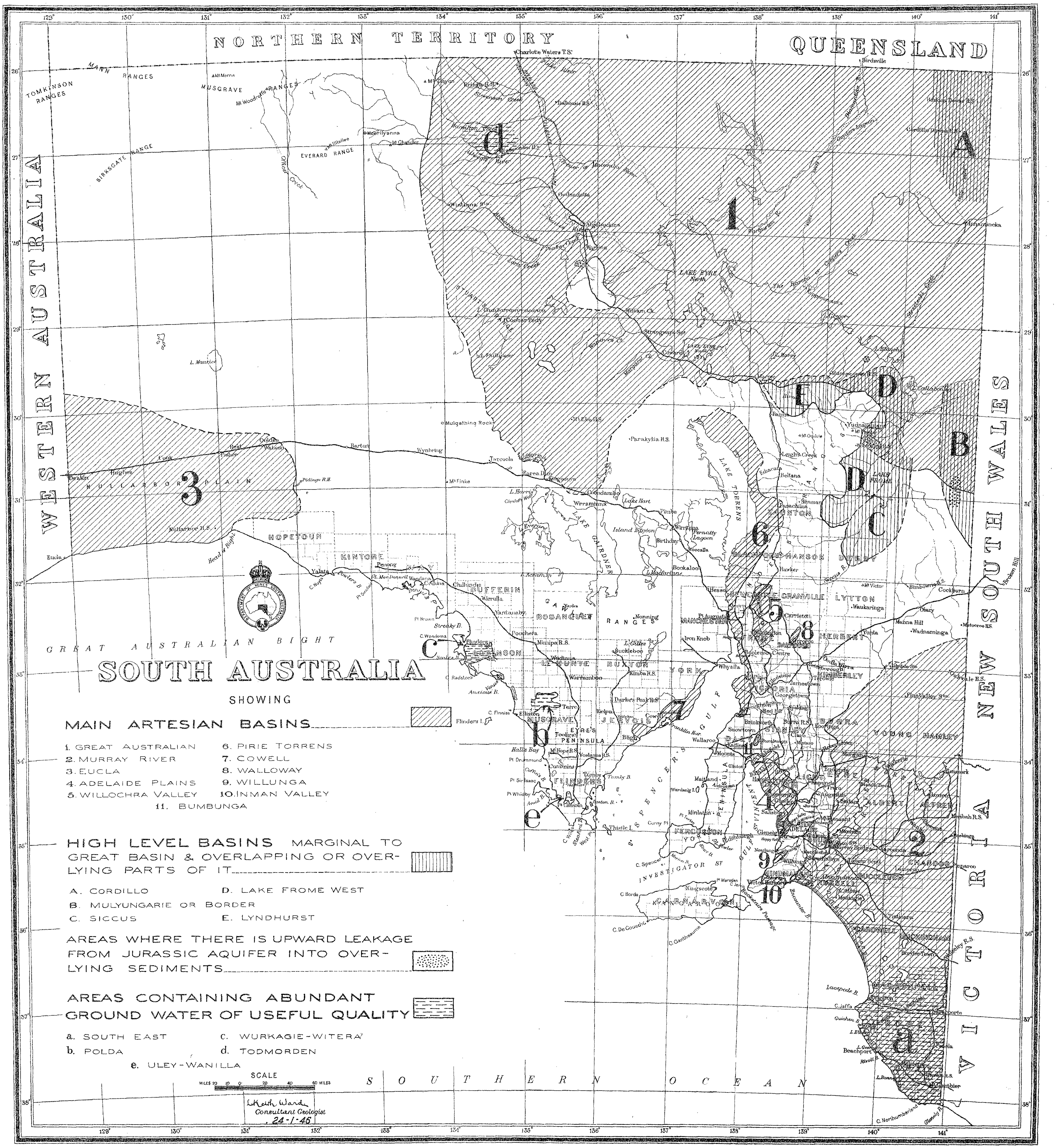
Salinity, expressed with decimals, has been determined by chemical analysis.

Details regarding the boreholes in the Adelaide Plains Artesian Basin will appear in a separate *Bulletin*, now in course of preparation.

PLATE VI

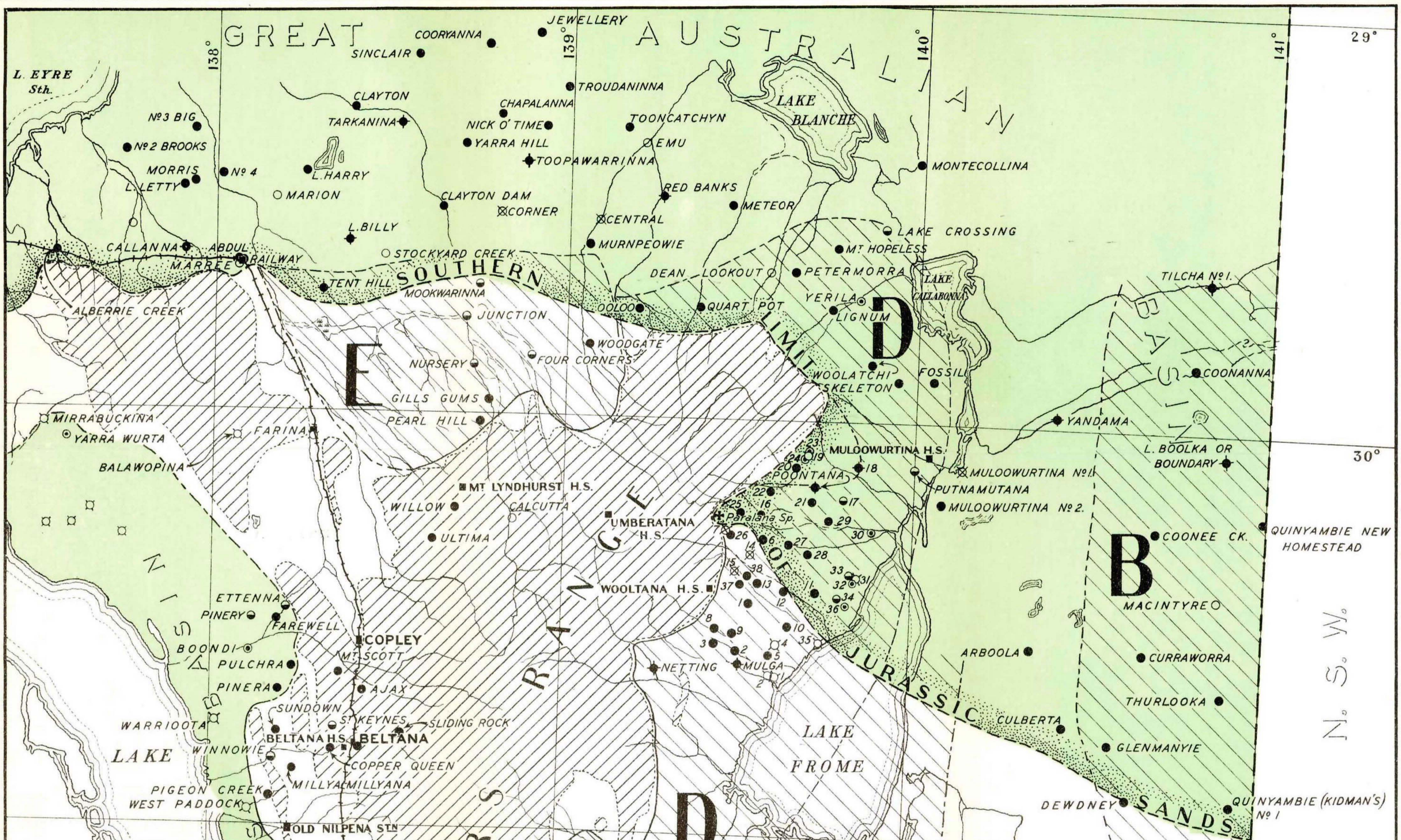


T. E. MOORE GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.



T. F. E. MOORE, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

PLATE V



—PORTION OF SOUTH AUSTRALIA—

EMBRACING

PART OF THE GREAT AUSTRALIAN ARTESIAN BASIN

WITH SUSPENDED BASINS OF THE LAKE FROME REGION

AND

NORTHERN PART OF THE PIRIE-TORRENS ARTESIAN BASIN

SALINITY

BORES
0 TO 1 OZ. ●
OVER 1 " 2 " ◒
OVER 2 " ◉
SALT ⌑

BORES
NO INFORMATION ○
"GOOD" WATER NO ANALYSIS ✦
FAILURE ⊠

BASIN BOUNDARIES KNOWN
INFERRED
ROCKS FORMING BASEMENT OF BASINS
SUSPENDED BASINS

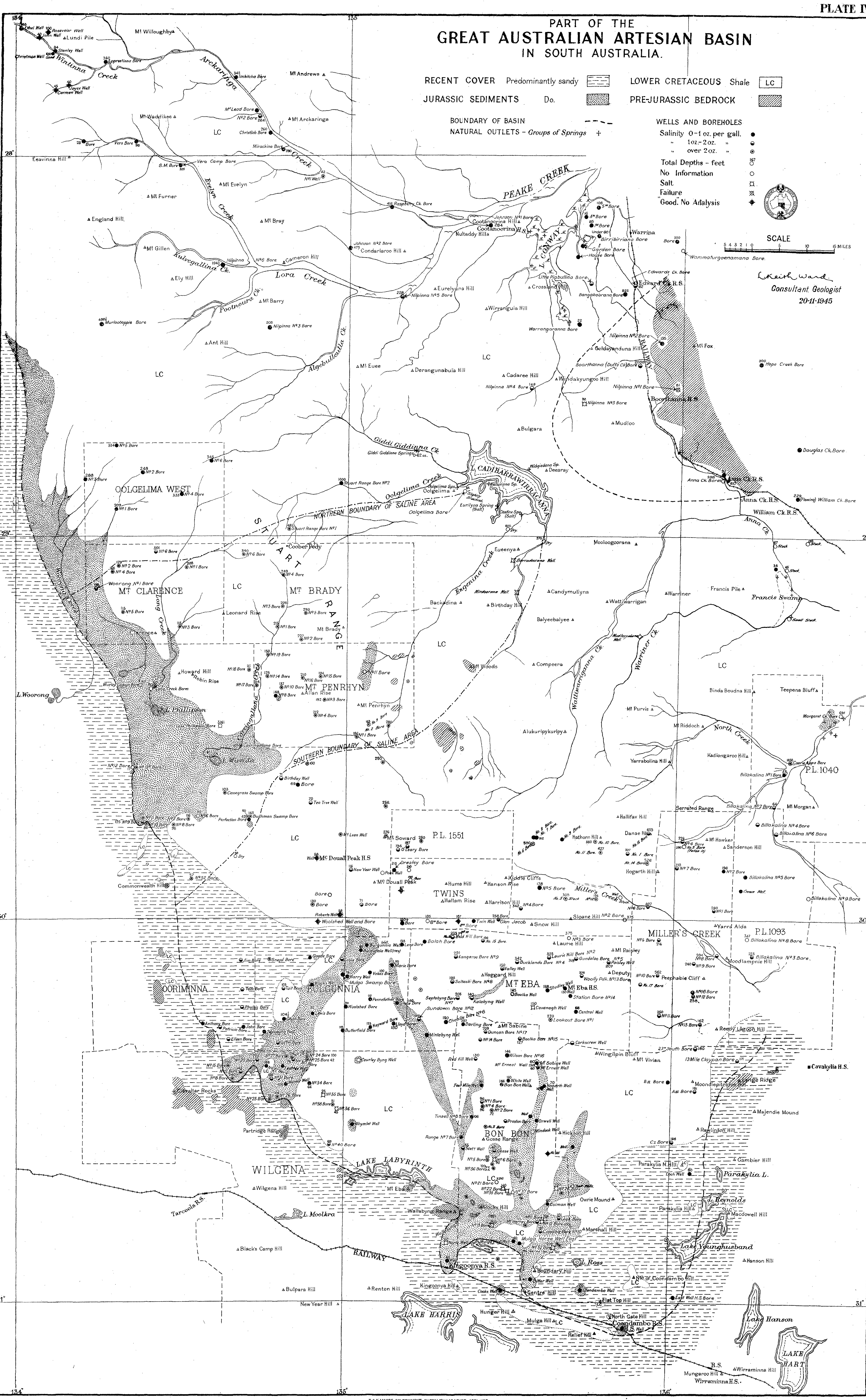
—SCALE—
MILES 10 5 0 10 20 30 40 50 MILES

del. J.T.MacD.

L. Keith Ward.
CONSULTANT GEOLOGIST. 11-4-46

T. E. MOORE, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE

PLATE IV



T. F. E. MOORE GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

PLATE III

THE SOUTH AUSTRALIAN PORTION

OF

THE GREAT AUSTRALIAN ARTESIAN BASIN

WITH SUSPENDED BASINS

AND

NORTHERN PART OF THE PIRIE-TORRENS ARTESIAN BASIN

LEGEND

Salinity	Bores	Wells	Salinity	Bores	Wells
0 to 1 oz.	●		No information	○	
1 " 2 "	◒		"Good" water no analysis	◆	◆
Over 2 "	⊙				
Salt	⊠	⊠	Failure	⊠	

Basin Boundaries .... Known .... Inferred

Suspended Basins A, B, C, D, E. shown

SCALE

MILES 10 5 0 10 20 30 40 50 60 70 80 90 100 MILES

L. Keith Ward
CONSULTANT GEOLOGIST
DATE 1-5-46

del. B.T.

T. E. MOORE GOVERNMENT PHOTOLITHOGRAPHER ADELAIDE