1952/67
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COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS.

RECORDS.

1952/67

SUB-SURFACE WATER SUPPLY IN THE BARKLY TABLELAND

by

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(Read at A.N.Z.A.A.S., Sydney, 1952).

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INTRODUCTION.

The information presented in this paper was collected in 1947-8 by a combined scientific team composed of officers from the Commonwealth Scientific and Industrial Research Organization and the Commonwealth Bureau of Mineral Resources, Geology and Geophysics, who carried out a reconnaissance of the natural resources of the Barkly Region.

The writer should, therefore, first acknowledge the contributions of other members of this team and in particular that of his colleague D. M. Traves of the Bureau of Mineral Resources. Previous workers in the region had provided some basic information on the occurrence of underground water and principals among these are R. L. Jack, W. E. Cameron, W. G. Woolnough and F. W. Whitehouse.

The importance of the Barkly Tableland to the pastoral industry of both the Northern Territory and Western Queensland and its situation, astride the Northern Territory-Queensland border are, by now, well known to most.

The pastoral potential of the Tableland is based on extensive areas of pedocalcic soil, which supports mitchel, flinders and other useful grasses, and on abundant supplies of underground water. These supplies are so essential because rainfall which ranges between 10 inches per year in the south and 23 inches in the north, is seasonal and natural supplies of surface water are, in most years, totally inadequate for the watering of stock between June and November.

Some note on the morphology and geology of the Tableland provides an essential introduction to the study of sub-surface water supplies. The name Barkly (Formerly Barkley's or Barclay) Tableland was apparently first used in the last century to describe an area east of Camooweal which, to a western-bound traveller, presented the relief of a tableland. Subsequently, the term was extended to cover the downs county north-west and south-west of Camooweal, and, ~~is~~ in present common usage which is followed here, the Barkly Tableland refers to that vast tract of near flat downs country which extends from Walhollow and Newcastle Waters in the north to Urandangi or beyond in the south and from west of Camooweal westward nearly to Tennant Creek.

The term "Tableland" applied to this vast tract is strictly a misnomer and is likely to ~~observe~~ obscure, from the casual reader, essential features of the morphology of the region. Essentially the Barkly Tableland is a long but shallow depression which forms part of two of the three physiographic units into which the Barkly Region has been divided - the Barkly Internal Drainage Basin and the Georgina Valley. The Barkly Internal Drainage Basin includes the northern part of the Tableland - an extensive plain sloping gently up to low hills which form an irregular rim to the basin. The southern part of the Tableland lies within the upper reaches of the Georgina valley - a wide shallow valley drained by the Georgina and its tributaries flowing southward into the inland drainage system of south-western Queensland. The land forms in both of these provinces are, to a large degree, relicts of an older Tertiary land surface which has been modified, to some extent, in the present cycle of erosion in the Georgina Valley and even less in the Barkly Basin.

The Geological history shows how ancient is the origin of this Barkly depression. It is apparently situated on a stable block between two less stable Pre-Cambrian welts - one the east and north-east, the other on the west and south-west.

It has been transgressed by epieric seas on three occasions - in late Pre-Cambrian, in Middle Cambrian and finally in Lower Cretaceous time, and sediments representing each of the three transgressions, together with Cainozoic terrestrial deposits are still preserved in the depression. There are few outcrops of sediments laid down in the late Pre-Cambrian transgressions and most outcrops in the Tableland are of Middle Cambrian limestone, dolomites, sandstone, shales and cherts. These are overlain in the northern portion of the Barkly Basin, by up to 500' of shale with some sandstone and limestone, deposited in the third transgression in Lower Cretaceous time. These sediments probably extended farther south than the present boundary, and remnants have recently been found east of Camooweal.

The cycle of erosion which began after the retreat of the Lower Cretaceous sea brought the land surface of the region almost to peneplanation in Tertiary time, when the surface of the Tableland was not very much different from that to today. Laterite developed on the slopes but much of the central portions of the depression were evidently swampy and the residual pedocalcic soils on sediments or alluvium show no laterisation. Siliceous limestones were eventually deposited in some shallow lakes. Finally, the present cycle of erosion has been unable, so far, to bring about significant changes in the Barkly Basin although more alluviation has taken place in the Georgina Valley and the Georgina River has suffered some rejuvenation.

The geology and morphology therefore indicate that conditions in the Barkly Tablelands - shallow depression underlain for the most part by dolomite, limestone, sandstone and shale with some alluvial cover - are emminently suitable for the collection and underground storage of water.

Sub-Surface Water Supplies.

The sinking of water bores in the Tableland apparently commenced toward the end of the last century and Camerson (1901) records 8 bores in the Camooweal area in 1900. There are few details of these bores beyond the fact that they were not artesian i.e. not flowing bores. Woolnough (1912) in his reconnaissance trip across the Tableland was struck by the consistent rise of underground water once the water-bearing strata had been penetrated by the bore and stated that the supply was sub-artesian. David, probably following Woolnough, also regards the underground water supply of the Tableland as sub-artesian in his Explanatory Notes to accompany a new Geological Map of Australia, published in 1932. In a paper published in 1940 F. W. Whitehouse suggested that, where a considerable thickness of alluvial cover is present, supplies of groundwater are restricted downward by the surface of buried limestone, producing a perched or natural watertable and W. R. Browne, editor of David (1950), has discussed sub-surface water supply of the Tableland under the heading of "Groundwater".

Faced with these rather different ideas, the survey team in 1947 tackled the problem by systematically collecting all bore logs and bore data available at each pastoral holding on the Tableland. This produced an impressive amount of data to which was added information from pastoralists and from the two drillers operating on the Tableland at the time.

Analysis of Bore Logs.

Many of the logs are incomplete in that they do not provide full data on both the behaviour of sub-surface water and on the strata penetrated in the bore but most of the logs provide some information.

The first analysis made of bore data dealt with the behaviour of water in the bores to determine to what extent supplies are under pressure.

The result of this analysis is given in Table I. The 139 bore logs, which were sufficiently complete for analysis, fortunately represented, between them, most of the major holdings in the Tableland and provide a reasonably representative sample. The data required were:- The depths at which supplies of water were struck, the depth to the main supply, the static water level at completion of the bore, and the depth to the pump. Many of the 139 bore logs did not provide all of this information, but sufficient to indicate the amount of the rise if one had occurred.

The results indicate that 20% of the logs show no rise and indicate the existence of ground water, but this percentage is less significant than it seems because no less than 16 of the 28 bores which show no rise are situated in one relatively small area on Alroy Station. The other 12 bores which show no rise are distributed across the Tableland.

Eighty percent. of the bores show some rise, 61% show rises greater than 10 feet and nearly 50% of all bores in the sample show rises greater than 20 feet.

TABLE 1.

RISE* OF WATER IN BORES - BARKLY TABLELAND.

Total No. of Bore Logs	No. of logs with insufficient data.	No. of logs with sufficient data.	No. of bores with no rise.		No. of bores with 0-10 ft. rise.		No. of bores with 10-20 ft. rise.		No. of bores with 20-100 ft. rise.		No. of bores with more than 100 ft. rise.	
406	267	139	28/	20%	26	19%	18	13%	53	38% 28%	14	10%

* Where two or more aquifers are recorded, only the minimum rise is recorded in the table.

/ 16 of these from one area - Alroy Downs.

Moreover, forty bore logs provided complete information on the behaviour of water, including the depth of the pump and in no less than seventeen of these, the pump is placed between the main supply and the static water level - complete proof of the existence of pressure water.

This analysis of bore data therefore indicates two main points:

(1) Main water supplies in most places in the Tableland are under pressure.

(2) Over restricted areas, such as Alroy Station main supplies are not under pressure and behave as groundwater, although the relationship between the two types of supply is not readily evident.

Aquifers.

Turning to a further examination of the first point, the pressure water occurs in a sedimentary basin and we should be able to trace the aquifers in which the water is stored. Information on possible aquifers may be provided by the character of outcrop of Cambrian and Cretaceous sediments and by the bore logs.

Unfortunately outcrops in the Barkly Tableland, in general, are few and far between, and even on higher ground many outcrops are lateritized. However, what evidence is available indicates that the Cambrian sediments consist of dolomites, limestones and sandstones with interbedded shales and cherts. In many places, these sediments are fairly thinly bedded and both dolomite and limestone beds show varying degrees of porosity due to solution cavities fracturing or jointing. Basin dips of from 0-5 degrees have been noted. The evidence therefore strongly suggests that some of the gently dipping beds - sandstones, due to original porosity or dolomite and limestones due to porosity from induced solution cavities or from fracturing - probably do act on aquifers within the Cambrian sequence, and these, in places at least, are probably sealed by overlying impervious shales.

Comparatively few of the bores appear to tap main supplies within the Cretaceous sediments, at the northern end of the

Tableland, where the lithology consists mainly of shales and siltstones with some limestone and sandstone. Main supplies tapped under pressure from Cretaceous sediments almost certainly are held in basal sandy beds which underly the finer grained sediments.

Turning to evidence provided by bore logs, no less than 181 drillers logs have been collected, although as will be mentioned ~~alter~~ later, these do not add to our knowledge of the geology as much as might be supposed. However, one is struck by the number of logs in which the drill, penetrating sub-horizontal Cambrian beds, found water bearing strata sandwiched between beds which were obviosly more impervious than that from which the water was obtained. For example, in Government Bore No. 1, Anthony Lagoon, the main supply came from 36 feet of "red volcanic rock" (probably a sandstone) between two beds of limestone. Again, in Bore 15, Headingly Station, a main supply was found in 26 feet of "honeycomb limestones" between creamy hard limestone above and hard white limestone below. Water bearing strata have been logged as "rotten limestone", "honeycomb limestone", porous sandstone or "sand and gravel", etc., in mahy places between beds of limestones of "clay".

Therefore, there is sufficient evidence to indicate that supplies of water are stored under pressure in beds which because of relatively high effective porosity, act as aquifers. The next step should, of course, be an attempt to identify and correlate these aquifers but unfortunately our present knowledge of the stratigraphy of the Basin is quite inadequate for this task. The bore logs provide little reliable stratigraphic formation for a number of reasons. Firstly, they are drillers', and not geologists', logs from percussion drilling and all who have had experience with constructing a bore log from percussion drilling will appreciate the difficulties entailed. Secondly, both Cambrian and Cretaceous beds present monotonous sequences which provide no key beds likely to be recorded by the driller, and thirdly, the bores are too shallow (rarely above 250') and too widely spaced (about 10 miles apart) to enable correlation to be made with any certainty.

However, one may safely say there are a number of aquifers within the basin because two or three different aquifers, with slightly different pressures gradients have been proved in some bores (e.g. Brunette Down 22) and because the distribution and depth of major supplies throughout the basin can hardly be explained on any other hypothesis.

Intake Beds.

There are a number of additional facts which will help in determining the characteristics of underground water supply. In the first place, the conditions of re-charge bear on the problem. It might be assumed from the lack of relief in the Barkly Tableland that a relatively high proportion of the rainfall would soak into the soil and provide a widespread and fairly consistent supply of sub-surface water. However, this is not the case. The deep pedocalcic soils (perhaps 12-18 feet in thickness) which cover so much of the Tableland undoubtedly form an impervious layer which, although taking up water in its top layer in the wet season, cannot pass water down to underlying rock. It is true that these soils crack badly in the dry season and that cracks extend downward for perhaps 3-4 feet in places, but with the first rain, the clay swells again and the soil probably does become even wet below about 5 feet from the surface. The importance of this fact on the problem of re-charge needs no emphasis. It means that in the Barkly Basin, the main areas of intake are

(1) areas of outcrop or lateritized outcrop around the edge of the basin;

(2) the upper portions of stream channels, where the sandy beds of the stream is in contact with the underlying sediments;

(3) low rises within the Basin where lateritization took place and where light textured soils remain.

The lowest portions of the streams, particularly in the area of distributaries cannot contribute to the supply of underground water, and this is probably the main reason for the broad but shallow lakes which cover large parts of the Barkly Basin at the end of the wet seasons - water tables perched on the surface because of the impervious character of the surface soil. It is also obvious that underground water supplies in the central portion of the Basin ~~much~~ must have been migrated many miles from intake beds to reach their present position.

The position as regards re-charge is to some extent the same in the Georgina Valley, with the difference that weak rejuvenation of the Georgina River has provided an area of dissection and re-charge at the head of the main river, and probably along the entire course of the river. Apart from the river, the main intake areas are outcrops or lateritized outcrops on the slopes, although some of the alluvia in the eastern side of the valley are light-textured and some water soaks therein have been used.

Some of the Tertiary limestones probably form intake areas in both the Barkly Basin and the Georgina Valley but it is probably that this water is held in the limestone and is distinct from that held in the Cambrian sediments. Water has been drawn from these limestones in the Georgina Valley but probably not in the Barkly Basin.

Contours on the Hydraulic Surface.

Additional information has also been provided by the contouring of the static water level - a level which is given in most bore logs. This was found to be the only information from the bore logs which could satisfactorily be shown on the map.

However, it is essential to consider what these lines represent. In a few places, such as in the vicinity of Alroy Station, they mark a water table but in most places they do not represent a water table because no water is found at the surface they denote until underlying aquifers have been penetrated.

They denote in general, therefore, a hydraulic surface to which water will rise when major aquifers are penetrated. On the other hand, they cannot be contours on a simple hydraulic surface because a number of aquifers is known to be involved.

It is reasonable to assume that they are contours on what one may call a composite hydraulic surface. Furthermore, the fact that this composite hydraulic surface can be quite readily contoured seems to explain much about the conditions under which sub-surface water is stored. To some extent, the close coincidence of hydraulic grades may be due to the relatively small changes in relief in intake areas but the major factor, it is suggested, is that many of the aquifers are at one place or another, connected so that their pressure systems are reconciled. This is in keeping with the character of the aquifers, because many of them depend for porosity on fracturing or solution cavities so that the efficiency of a bed either as an aquifer or as a seal may vary both along dip and strike.

This is also advanced as the most probable explantion of the existence of major supplies at fairly shallow depth in the central portion of the basin. Aquifers at depth and under considerable pressure "leak" upwards into aquifers at high levels; and in places, pressure water is able to rise to its hydraulic surface - hence the sporadic bore in which no pressure is observed.

We, therefore, suggest that most of the sub-surface water supply in the Barkly Tableland is sub-artesian - under special conditions dictated mainly by the lithology of the Cambrian sediments. The main areas of intake are situated along the slopes of the great depression and along portion of the streams. However, largely because of the incidence of openings in dolomite or limestones, due to solution or fracturing, many of the aquifers are connected, giving a composite hydraulic surface which can be contoured.

It remains to deal with areas such as that at Alroy where conditions of ground water appear to apply. Unfortunately there are no drillers' logs for bores on either Alroy or Avon Downs Stations, and there is not sufficient evidence to decide whether the non-pressure conditions at these localities is due to the existence of a perched water table or whether the water supply is connected with the general system but has been able to rise to hydraulic grade due to locality lithology. There is, however, sufficient evidence to suggest that in any case the water is stored in Cambrian sediments, probably well below alluvial cover, which in logs of bores in the Playford River a few miles north of the Alroy area amounts to only some 40 feet in thickness.

QUALITY OF SUB-SURFACE WATER.

As one would expect from underground water STORED sotres in or traversing limestone and dolomite, most of the sub-surface water of the Tableland is mineralized to some extent. However, the record of potability is very good. There appears to have been only a few bores in which water was unfit for stock which suggests that over 90 per cent. of the bores sunk to water have been suitable for the watering of stock.

It is probably true also that over 50% of these bores have produced water fit for human consumption although this brings in the factor of the toughness of the individual and I do not mean to underestimate the hazards of the traveller who goes from bore to bore across the Tableland - since each bore provides a different concentration of epsom salts amongst other things.

We have been able to find only eight complete analyses of water from these bores and these show a maximum of total solids of 825 grains per gallon consisting mainly of sodium chloride and magnesium and calcium sulphate. One or two bores have shown a fluoride content above that considered safe for stock.

THE FUTURE DEMAND FOR WATER.

It is, of course, obvious that there is little difficulty in obtaining supplies of water, pumping to at least 2,000 galls. per hour, within 100 feet below the static water level (the hydraulic surface) in the down country of the Tableland. Considering the present wide spacing of bores, I think that most geologists would have little hesitation in predicting adequate supplies for additional pastoral development.

No sign of depletion have been reported from any of the bores, even at capacity pumping during tests, nor any during the recent drought. This is, of course, opinion rather than evidence, but actually it is very difficult to reach any conclusion of water reserved on a factual basis. However, one method has been applied in the Barkly Internal Drainage Basin. Our colleagues from C.S.I.R.O. estimate that for full pastoral development in this portion of the Tableland, watering points will have to be considerably increased, and the number of working bores approximately doubled.

Assuming that the increased number of bores are pumped at the rate of 20,000 gallons per day for 300 days in the year, we have an estimate of the volume of water to be withdrawn from sub-surface supplies ~~ear~~ each year. This figure is also the amount of re-charge needed to balance withdrawal and save depleting underground water supply. The average annual rainfall is known and we have mapped and calculated the approximate area of the main intake areas and can, therefore, calculate the percentage "run in" in intake areas to balance withdrawal by bores. From these calculations, a percentage run-in of 0.3% emerged. The figure itself may not be significant but the very low order of the result seems quite important. The figure can be increased twenty times or more, to allow for factors which cannot be measured, and would still be within the range of probability.

We therefore suggest that there is good evidence to indicate that sub-surface water supplies will be more than sufficient for the future development of the pastoral industry of the Barkly Tablelands.

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