COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 16

Groundwater in the Northern Wiso Basin and Environs,

Northern Territory

by

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CONTENTS

CONTENTS

APPENDICES

CONTENTS

TABLES

PLATES

FIGURES

SUMMARY

The northern Wiso Basin and its environs lie in the central part of the Northern Territory between the Barkly Tableland to the east and the Victoria River district to the west and northwest. The northern and northeastern limits are the upper reaches respectively of the Daly River system and the Gulf Drainage system. The southern environs (which are not discussed in this bulletin) merge into the semidesert country between the Stuart Highway in the east and Tanami and The Granites in the west. The region is arid to semi-arid, but notwithstanding good grazing lands occur in the eastern, northern and western parts, and both cattle stations and small towns and settlements have been established. Because of seasonal and sparse rainfall the surface water resources of the region are meagre and both pastoral and community development are largely dependent on the availability of reasonable quality groundwater.

This study examines the data from over 500 waterbores and the regional geological mapping, supplemented by scouthole drilling and 176 chemical analyses of groundwater from selected bores, in an attempt to relate the groundwater regime to the geological environment.

The region comprises three Palaeozoic basins of mainly carbonate rocks and their surrounding basement rocks of Lower Cambrian and Precambrian ages. From a groundwater point of view the most important of the basement rocks are Lower Cambrian volcanics which crop out in the west and are shown to extend considerable distances eastward in the subsurface. Most of the groundwater is obtained from the carbonate sequences. Over large parts of the region these sequences are overlain by flatlying Lower Cretaceous rocks which have a profound effect on the groundwater regime. Geomorphology also is important to the groundwater regime. The region contains a gently undulating plateau which slopes northward and is bounded by the dissected country of the main coastal river systems. Depth to economic quantities of water is governed by the depth below the surface of suitable aquifers and throughout the plateau these are generally deeper than on its dissected margins.

The main aquifers occur in volcanic and carbonate sequences, and about the dissected margins the groundwater regimes of both are very similar because they are both relatively close to recharge zones. The salinity of the groundwater in these situations is low. But beneath the Lower Cretaceous rocks and in the plains country in the southeast many bores in the carbonate rocks are obtaining groundwater which has travelled considerable distances from recharge zones and accordingly is saline. But throughout the entire region the known groundwater reserves are suitable for stock; only in a few places is the quality below domestic standards.

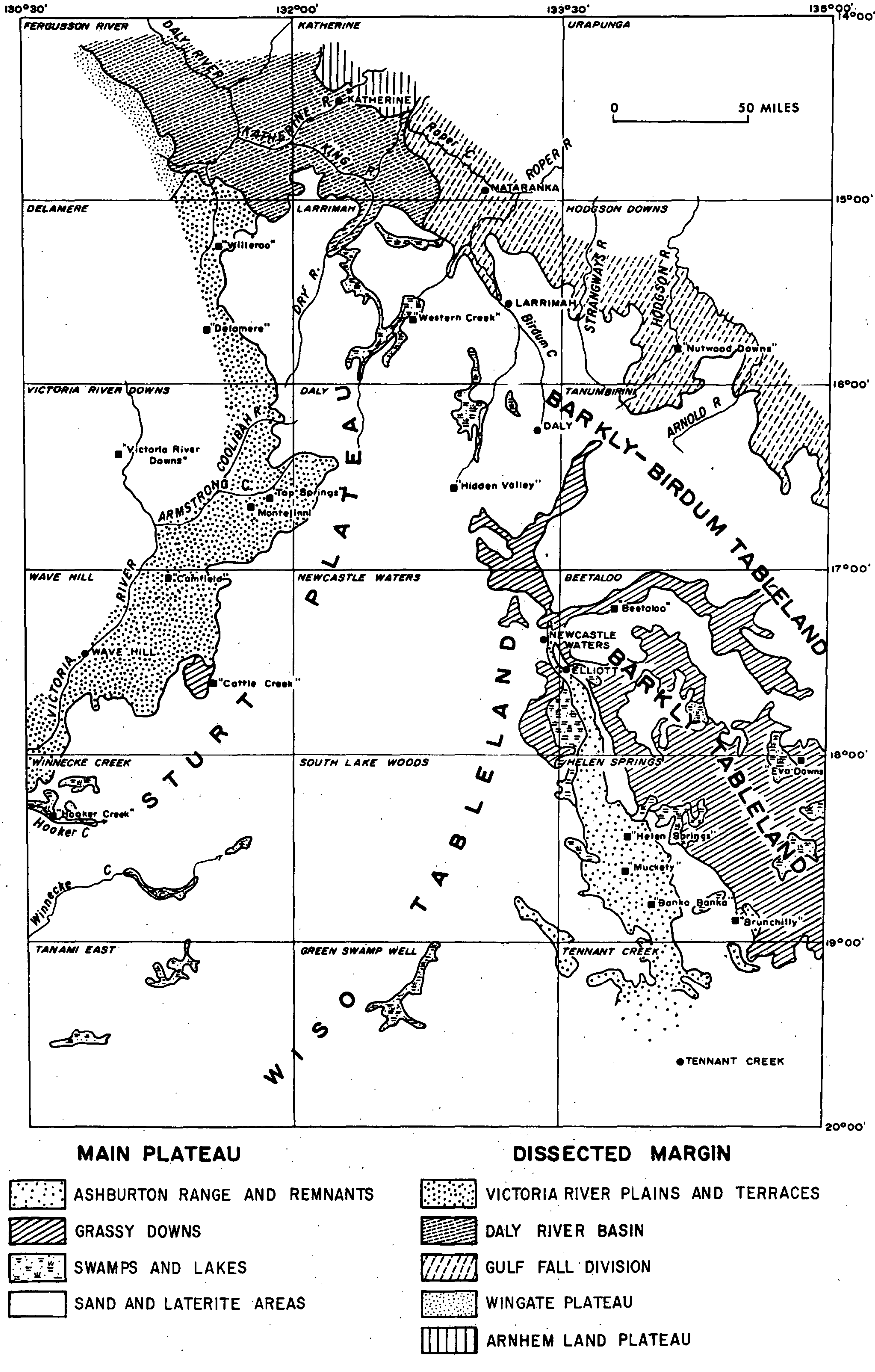
The availability of groundwater varies throughout the region depending on the essential geological control. Water is stored in the volcanics in joint and fracture zones and the supplies are related to the incidence of these below the watertable in the borehole intersection, and the presence of recharge paths to them. Good supplies have been obtained, but the occurrence of poor supplies or failures is common. Recent work has shown the presence of stratigraphic control of aquifers by means of overlapping flows and sedimentary interbeds. Additional work on these aspects may minimise the incidence of unsuccessful drilling. The water in the carbonate rocks is stored in cavities and joints but because of the solubility of the rock these are considerably enlarged and hence provide greater storage and supply than the volcanics. Further, recharge is probably more effective because of open sinkholes and joints in Karst topography.

The Lower Cretaceous rocks are generally poor aquifers. Although the sequence contains a basal sandstone of good aquifer characteristics beneath impermeable claystone units, it is generally above the potentiometric surface and has little storage. Bores commenced in the Cretaceous rocks commonly need to be drilled several hundreds of feet to reach the more favourable underlying carbonate formations.

The groundwater resources are more than adequate for the present pastoral and community development. Although the rainfall is low in the southern parts the probable recharge areas are very large and the withdrawal rate is very low. In the north rainfall is high and recharge situations extensive. Isolated cases of overdevelopment or failure of existing bores may occur but these are mainly due to poor boresite locations rather than depletion of resources. Pollution may be a hazard at settlements where local recharge to groundwater occurs, particularly in the areas of karst carbonate outcrops.

Fig. 1

PHYSIOGRAPHIC SKETCH MAP WISO BASIN AND ENVIRONS



INTRODUCTION

GEOGRAPHY

The Wiso Basin, which contains mainly Lower Palaeozoic rocks, occupies a region between the Stuart Highway and the eastern and southern watershed of the Victoria River, and lies between latitudes 15°S and 21°S in the Northern Territory of Australia. The name is derived from the Wiso Tableland, a term used by Hossfeld (1954) to describe the elevated desert country between Newcastle Waters, Wave Hill, The Granites, and Barrow Creek. Hossfeld (op. cit.) believed the Tableland was underlain by Cambrian sediments continuous with those in the Buldiva Basin to the north - the whole sequence occurring in the Buldiva - Wiso Basin. Hossfeld's term "Buldiva Basin" refers to the Daly River Basin of Noakes (1949); most workers have followed Noakes' terminology but have simplified the name to Daly Basin. *

The western environs of the Wiso Basin are the country east of the Victoria River to the edge of the Wiso Tableland; the northern environs are the southern parts of the Daly River Basin and the southern headwaters of the Roper River system; and the eastern environs are the western and north-western parts of the Barkly Tableland (Fig. 1). The southern part of the Wiso Basin and its southern environs are not discussed in this report.

The region contains the following 1:250,000 sheet areas: Tanami East, Green Swamp Well, Winnecke Creek, South Lake Woods, Helen Springs, Beetaloo, Newcastle Waters, Tanumbirini, Daly Waters and Larrimah; and portions of Tennant Creek, Hodgson Downs, Katherine, Fergusson River, Delamere, Victoria River Downs, and Wave Hill. It is about 75,000 square miles in area.

The two major road networks of the northern part of the Northern Territory traverse the region: The Stuart Highway from Darwin to Alice Springs traverses the eastern part, together with the Roper River road from Mataranka, the Borroloola road from near Daly Waters (also known as the Cape Crawford road), and the Barkly Highway to Mount Isa from near Tennant Creek; and secondly, the road networks from Katherine to Western Australia via Willeroo and Timber Creek and via Willeroo and Wave Hill traverse the north-western and western parts. A main road from Dunmarra on the Stuart Highway to Top Springs connects the eastern and western road networks: it replaces the historic Murranji Track to the south which is now infrequently used. Most of these are all-weather roads, but some lowlevel crossings are impassable for short periods after heavy rain. The Stuart Highway and the road from Katherine to Top Springs are bitumen-sealed.

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* This name refers to the geological basin; the term Daly River Basin is used for the physiographic entity which is approximately co-extensive with the geological one.

The major settlements are the townships of Katherine, Tennant Creek, Daly Waters, Larrimah, Mataranka, Elliott, and Newcastle Waters. Larrimah*, Mataranka and Katherine are linked to Darwin by the North Australian Railway, and all the towns are situated near important road junctions. Tennant Creek, Daly Waters, and Katherine are served at least twice a week by Australia's two main commercial airlines. Other settlements, apart from cattle stations, are the small township of Top Springs in the west, the Native Settlements (Welfare Branch, N.T.A.) at Wave Hill, Hooker Creek, and Beswick, and two road-side inns on the Stuart Highway. There are many cattle stations in the region: these occur mainly in the dissected western and northern margins of the region, in the Barkly Tableland and its northern extension, and along the Stuart Highway. There are no stations south of the Murranji Stock Route in the semi-desert area between Tennant Creek and Hooker Creek: it contains few well defined watercourses, no permanent waterholes, and only inferior grazing land. Most stations are regularly served by light aircraft operating from either Alice Springs or Darwin. Stations along the Stuart Highway have a telephone service: the others are in radio communication with either Alice Springs, Wyndham or Darwin. With the exception of a few small farms and agricultural research stations about Katherine township, there is no intensive agriculture.

There are several important stock routes in the region: the Barkly Stock Route from near Elliott eastward to Eva Downs and beyond to Queensland; a stock route from Mataranka eastward along the Roper Valley; the North-South Stock Route from the Barkly Stock Route near Helen Springs homestead southwards approximately along the Stuart Highway to Alice Springs; the Birdum Stock Route from near Larrimah also approximately along the Stuart Highway, southwards to Newcastle Waters, and its northern extension to Katherine via Mataranka and Maranboy; the Murranji Stock Route from Newcastle Waters to Top Springs; the Dry River Stock Route from Katherine along the valley of the Dry River to Top Springs; the Wave Hill Stock Route from Top Springs to Wave Hill and beyond to the west; the Auvergne Stock Route westward from Top Springs; the Coolibah Stock Route from Katherine to Coolibah via Willeroo; a stock route connecting Willeroo to Wave Hill through Victoria River Downs; and the South Barkly Stock Route eastward from Attack Creek on the Stuart Highway and passing between the Brunchilly/Rockhampton Downs Road and the Barkly Highway. Since the inception of cattle-trucking rather than droving these routes are little used, except where they follow the made roads, but the watering facilities along them are still maintained, and in some instances are leased to the surrounding cattle stations.

The climate of the region is discussed in the chapter on surface water.

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* This township is now the virtual railhead; although the railway continues on to the historic town of Birdum, which is in ruins, the line is not used.

PREVIOUS INVESTIGATIONS

(i) Geological.

The entire region has been mapped at 1:250,000 scale by the Bureau of Mineral Resources, but not all the geological maps are available at this scale. The southern and central parts of the Wiso Basin south of latitude 18°S were mapped in 1965 (Milligan, Smith, Nichols & Doutch, 1966), and the maps are available in the preliminary geological series at 1:250,000 scale and a composite at 1:1,000,000 scale. During this work portion of the western part of the Tennant Creek Sheet area was mapped.

Also in 1965, the Helen Springs, Beetaloo, and the eastern portion of the Tennant Creek Sheet area were mapped as a continuation of the regional mapping of the Barkly Tableland portion of the Georgina Basin (Randal, Brown & Doutch, 1966). The Helen Springs and Beetaloo geological sheets will shortly be published in the standard edition series at 1:250,000 scale (Randal & Brown, 1969; Brown & Randal, 1969). The northern part of the Wiso Basin - between latitudes 15°S and 18°S, and west of longitude 133° 30'E was mapped in 1966 (Randal & Brown, 1967) in an attempt to establish the relationships between the Middle Cambrian rocks of the Wiso, Daly, and Georgina Basins. The Newcastle Waters and Larrimah (Randal, 1969, a, b,) and the Daly Waters (Brown, 1969) 1:250,000 geological sheets will shortly be published in the standard editions. All five are available in the 1:250,000 preliminary series. Only the eastern portions of the Wave Hill, Victoria River Downs, and Delamere Sheet areas were mapped in 1966 - these have been issued as composite photogeological and preliminary 1:250,000 sheets.

The Fergusson River (Randal, 1962) and Katherine (Randal, 1963) Sheet areas were mapped during the regional mapping of the Katherine - Darwin Region between 1953 and 1959 (Walpole, Dunn & Randal, 1968). The Tanumbirini (Paine, 1963) and Hodgson Downs (Dunn, 1963a) Sheet areas were mapped during the regional study of the Carpentaria Proterozoic Province which lies between Arnhem Land and the Queensland Border. Within the area of the Palaeozoic basins several oil companies have carried out supplementary geological and geophysical investigations, and the entire region has been covered by helicopter gravity traverses by contract for the Bureau of Mineral Resources (Flavelle, 1965; Whitworth, in prep.).

Investigations in the region prior to the regional 1:250,000 scale mapping are referred to and incorporated in the reports listed above.

(ii) Hydrogeological

In 1909 (Chewings, 1930, 1931) passed through the southern part of the region during a survey for bore-sites between Barrow Creek and Wave Hill, and constructed small wells and carried out shallow boring at selected sites. Winters (1915) journeyed along the Telegraph Line from Pine Creek to Newcastle Waters in 1914; together with notes on the Cambrian and Cretaceous rocks, he commented on the groundwater environment along the route and considered it similar to that of the Barkly Tableland. Woolnough (1912) and Jensen (1915) passed through the eastern part of the region and commented on the Cambrian geology and the subartesian water resources of the Barkly Tableland. Ward (1926) travelled through much of the region during 1925 and collected bore-data and selected bore-sites along several of the stock routes.

Between 1949 and 1953 Traves (1955) examined the western portion of the region during the geological reconnaissance of the Ord-Victoria Region, and also examined water supply problems at Wave Hill Station (Traves, 1953). Since 1950 Resident Geologists of the Northern Territory Administration and the Bureau of Mineral Resources have selected bore-sites and provided geological opinions on bore-sites for pastoralists in the region. Most of these investigations are described in file notes and have not been prepared as complete reports. However Barclay & Hays (1965) prepared a report on groundwater investigations carried out on Victoria River Downs and Wave Hill Stations in 1963, and Mackay (1957) prepared a report on groundwater investigations on Nutwood Downs Station. Both Barclay & Hays and Mackay describe the difficulties of obtaining supplies of water from volcanic sequences. Laws (in prep.) gives a preliminary appraisal of the hydrogeology of the Daly River Basin and sets out a programme of investigation currently being done by the Water Resources Branch of the Northern Territory Administration. He has also made (N.T.A. & B.M.R. file notes) a re-appraisal of the results of ten bores drilled along the Daly Waters - Borroloola Road (Cape Crawford road) in the Daly Waters and Tanumbirini Sheet areas.

Noakes (1954), Traves & Stewart (1954), and Randal (1967) examined the groundwater regime of the central and eastern Barkly Tableland, and this work has some bearing on the eastern part of this region.

This report discusses groundwater data obtained by the author in 1965 and 1966 during the regional mapping of the western Barkly Tableland and the northern part of the Wiso Basin, and incorporates information obtained by Milligan et al. (1966) during scouthole drilling in the Wiso Basin in 1965.

PHYSIOGRAPHY

The region contains two major physiographic units: a gently undulating plateau with sparse surface drainage, and a dissected area bordering it on the west, north, and northeast (Fig. 1). These two units are respectively parts of the 'Main Plateau' and 'Dissected Margin' of the northern part of the Northern Territory as described by Hays (1967).

The Main Plateau

Previous workers have used different names for different parts of the Main Plateau. Hossfeld (1954) used the term Wiso Tableland for the area between Newcastle Waters, Wave Hill, The Granites, and Barrow Creek. The term therefore covers the south-western quarter of this region. Traves (1955, Fig. 6) uses the term Sturt Plateau for the western part of the Main Plateau, from north of Willeroo to south of Hooker Creek Settlement.

There is no definition for the eastward extension of Traves' unit, but it is clearly implied that it continues eastward of the border of his map-longitude 132°E. Dunn (1963) and Paine (1963) referred to the plateau on the Hodgson Downs and Tanumbirini Sheet areas as the Barkly - Birdum Tableland. This term is used by Dunn, Smith & Roberts (in prep.) for the elevated country lying between the headwaters of streams flowing to the Gulf of Carpentaria and the grassy downs of the Barkly Tableland, and trending south-eastward from the southern headwater tributaries of the Roper River. It is continuous with the northern part of Traves' (op. cit.) Sturt Plateau. The Barkly Tableland is shown on most maps of the Northern Territory as extending south-eastwards from near Newcastle Waters to the valley of the Georgina River and beyond into Queensland. It includes the vast grassy treeless downs of the black soil plains and their margin of sandy areas covered by low scrub. Randal (1967) states "It is difficult to define the Barkly Tableland as a physiographic entity" and supports Noakes' (1954) opinion that the term "Tableland" is a misnomer. The portion of the Barkly Tableland in this region is part of the Barkly Internal Drainage Basin of Noakes (1954) and Randal (1967) - a long shallow depression extending for 275 miles south-eastward from Newcastle Waters, and containing unconnected endoreic and areic drainage. Although these various names refer to true physiographic divisions of the regions in which they were originally applied, within this region the areas described by them are merely local geographic variants of the same thing - Hays' Main Plateau, and are separated by no natural boundary.* Hays' term is preferred as it emphasizes the regional extent of the plateau. The Main Plateau is divided into four minor units.

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* A possible exception is the Barkly Tableland which here virtually coincides with the grassy downs, which have been treated as a sub-division of the Plateau. Hays' definition of the Main Plateau clearly includes the Barkly Tableland and there is no justification for treating it as a separate major unit.

<u>The Ashburton Range and its remnants</u> occur in the south-eastern part of the region: the unit consists of dissected strike ridges and plateaux of Precambrian sandstone and siltstone of the Tomkinson Creek Beds. The hills rise up to 300 feet above the surrounding sandy plains. The summit surface is about 1,200 feet above sea level at its highest point and slopes northwards. Remnants of this surface, which Hays (op. cit.) called the Ashburton Surface, occurs to the southwest of the region. Hays considered the Ashburton Surface to be pre-Lower Cretaceous in age, and Randal et al. (1966) cite supporting evidence.

Less resistant intervals in the Tomkinson Creek Beds are eroded preferentially into broad valleys, generally parallel to the strike of the rocks. However, the main drainage of the Ranges is at right angles to them, and the streams terminate either in floodouts in the sand plains flanking the ranges, or in swamp and lakes in the downs country.

<u>The grassy downs</u> occur in the eastern part of the region. The unit consists mainly of treeless black soil plains, although low stunted trees and shrubs occur in the valley of Newcastle Creek. The downs are developed over Cambrian and Tertiary carbonate rocks and Lower Cretaceous siltstones. The downs country has low relief with broad low rises, and closed drainage basins of varying size fed by widely spaced non-perennial watercourses. Small gravelly rises and patches of sandy soil are common. The main area is the northwestern limit of the Barkly Tableland and is a linear depression, ranging from 650 feet to 750 feet above sea level. To the north the downs attain an elevation of about 800 feet. To the east the downs form part of the Barkly Internal Drainage Basin (Randal, 1967) which contains numerous swamps and lakes.

<u>Swamps and lakes</u> occur in the eastern part of the region both in the downs country and flanking the Ashburton Range. They occur in the northern part of the Main Plateau and in the main part of the Wiso Basin. Many small ones are not shown on the map. The swamps and lakes are the foci for the endoreic drainage systems of the Plateau, although in places they are only alluvium-choked flanking depressions at gradient changes for streams which ultimately flood out many miles downstream from them. They contain reworked clayey black soil, and silt and sand size particles of recent alluvium. They support a growth of bluebush, swamp flinders grass, and various types of reeds and swamp shrubs.

<u>The sand and laterite areas</u> occupy the greater part of the Main Plateau. The laterite areas mainly occur north of the Murranji Stock Route and in the Barkly - Birdum Tableland, although in the predominantly sandy areas to the south admixed laterite gravel or lateritic rises are not rare. The laterite areas in the north consist mainly of low rises, covered with ironstone pisolites and thin soils, separated by valleys with a thick cover of reddish sandy and loamy soils. The valleys have a system of tributary valleys but the majority no longer contain active streams. The ancient streams which

occurred in these sandy valleys strongly dissected the laterite rises, and now, apart from the lack of sand dunes, the northern areas of sand and laterite are very similar to those in the south. Probably owing to the higher rainfall the vegetation is denser in the north: grassy savannah woodlands of turpentine, acacias, and eucalypts, and open plains in the north, and turpentine and wattle scrub with spinifex in the south. A piedmont sand plain flanks the eastern side of the Ashburton Range.

The surface of the Main Plateau has a general northward slope, but strong undulations in it markedly influence the drainage. Elevated country occurs immediately to the north of the valley of Newcastle Creek and in discontinuous areas as outlined by the 800-foot contour strikes westward to the margin of the Plateau and acts as a divide between exoreic streams flowing northward to the coast and endoreic streams flowing towards a zone of depressions outlined by the 700-foot contour between Lake Woods and Cattle Creek. Possible down-warping in this zone and headward erosion has made Cattle Creek an exoreic stream which, by further headward erosion, may capture and change the course of the essentially endoreic Hooker Creek. South of this zone the streams are generally directed northwards although remnants of high country have made the pattern rather random. North of the elevated zone between the Barkly - Birdum Tableland and Top Springs homestead the Main Plateau maintains its northward descent and the major streams are directed towards the Gulf Fall Division and the Daly River Basin. In the upper reaches the streams are not well defined and their beds become lost in alluvium-choked valleys, but towards the Plateau edge they become moderately well entrenched and do not cross it with any dramatic change in gradient. Furthermore, the headward erosion by these streams coupled with the northern slopes of the plateau has destroyed the escarpment of the plateau in many places and it becomes ill-defined. On the northern slopes of the Plateau numerous small watercourses are areic.

The Dissected Margin

The country marginal to the Main Plateau is dissected by the tributaries of three major drainage systems; these are the Victoria River, the Daly River, and the rivers flowing northward and eastward to the Gulf of Carpentaria. Consequently the Dissected Margin can be readily subdivided into divisions previously erected by other workers: the Victoria River Plains and Terraces (Traves, 1955) the Daly River Basin (Noakes, 1949), and the Gulf Fall Division (Stewart, 1954). In the northwest of the region the Daly River Basin is flanked by the Wingate Plateau and its marginal tablelands (Randal, 1962). The Wingate Plateau is not relevant to this discussion and is shown merely to illustrate the margin of the Basin: it is not further discussed. Neither is the Arnhem Land Plateau which partly flanks the Basin on the east. Further regional aspects of the drainage systems are discussed in the chapter on surface water.

The Victoria River Plains and Terraces flank the entire western margin of the Main Plateau. They are formed by the sub-horizontally bedded volcanics and sediments of Lower Cambrian age and, in places near the scarp, the Middle Cambrian carbonate rocks. Resistant bands form terraced mesas and plateaux, but the main topography is undulating rounded hills and stony plains. The topography is controlled by differential erosion. Stream trends appear to be controlled by jointing and many streams trend at 130°. Some of the long straight reaches of the major streams may be controlled by fracturing: a prominent feature is a line along the Victoria River from northwest of Hooker Creek Settlement to near Camfield homestead; from there it is taken up by the Armstrong River and Coolibah Creek to the edge of the Plateau, thence downstream along the Dry River to the King River, thence along the upper reaches of the King River into Arnhem Land. This major trend is reflected by many streams both in this division and also within the Plateau. The vegetation is mainly open forest grasslands and grasslands.

The Daly River Basin is developed in Lower Palaeozoic sandstones, siltstones and carbonate rocks; its headwater margins are in Lower Cambrian volcanics and Precambrian sandstones, siltstones and granite; residuals of Lower Cretaceous rocks occur throughout the Basin. The main topographic control has not been by differential erosion although such effects are present. The Daly River and the lower reaches of its tributaries have broad sweeping meanders, but the topography is not as mature as it appears. Erosion of the Basin is retarded by high country of Precambrian rocks which forms a barrier across the Daly River downstream beyond the region. Furthermore, the horizontal strata within the Basin which have encouraged the development of meanders and which themselves add to the appearance of maturity, have actually hindered the downward erosion by the streams. The streams must cut through all the flat-bedded rocks, and cannot evade more resistant rock types by changing course and differentially eroding softer material. Hence local base levels have been imposed on the streams and small falls and rapids are characteristic of them. Despite this the rocks of the basin, mainly soluble limestones and soft friable sandstones, are relatively non-resistant to erosion compared to the harder rocks on the margins e.g. Wingate and Arnhem Land Plateaux.

In the Daly River Basin the sandstones and interbedded carbonate rocks of the Jinduckin Formation occur as rounded hills and mesas with shales being preferentially eroded particularly in the upper reaches of streams. The carbonates of the Tindall Limestone occur as heavily dissected karst outcrops and boulders and slabs. Sinkholes and caves are common, and together with reasonably permeable soils give considerable subsurface drainage. The surface drainage is consequently dendritic and of low intensity.

TABLE 1: STRATIGRAPHY OF THE WISO BASIN AND ENVIRONS N.T.

ERA	PERIOD	STRATIGRAPHIC UNIT AND SYMBOL	DISTRIBUTION	LITHOLOGY	MAXIMUM KNOWN THICKNESS (feet)	TOPOGRAPHY	REMARKS
CAINOZOIC		Superficial deposits	Widespread				
		Cza		Alluvium	10	Various	
		Czb		Black soil	20		
		Czt		Travertine	10		
		Czs		Sandy, sandy soil, pisolitic lateritic gravel	70		
	TERTIARY	Golliger Beds Tg	Tanumbirini Sheet area	Impure grey limestone	10	In shallow depressions	Abundant gastropod and plant remains
		Brunette Limestone Tb	Helen Springs Sheet area	White limestone with chalcedonic silica nodules and laminae; some massive chalcedony, minor sandstone	15	Low rises in downs country	Gastropods and forams
		Birdum Creek Beds Ti	Larrimah Sheet area	White limestone and chalcedony	50	Low rises and rubble in black soil plains	Gastropods
		Camfield Beds Tc	Wave Hill Sheet area	Conglomeratic limestone and calcilutite with chalcedony, siltstone, sandstone	70	Low hills and mesas	Vertebrate bones and gastropods
		Tt	Southern and south-western part of region	Limestone, sandstone, claystone	90(?)	Low karst outcrops	
MESOZOIC	LOWER CRETACEOUS	Mullaman Beds Klm	Northern and eastern parts of region	Sandstone, mudstone, claystone	475	Escarpments on plateau edges, rocky knolls on plateau, mesas	Contains fossiliferous freshwater unit over-lain by fossiliferous marine units.
		M	Helen Springs Sheet area	Sandstone, pebble and boulder conglomerate, siltstone	80	Laterite capped plains and residual mesas in major valleys within the ranges	Plant impressions
PALAEOZOIC	UPPER DEVONIAN	Dulcie Sandstone Dud	Tanami East Sheet area	Quartz sandstone, argillaceous sandstone	60	Bluffs	
	LOWER ORDOVICIAN	Oolloo Limestone Olo	Katherine and Fergusson River Sheet areas	Limestone, cherty and silicified in places, dolomite	200(?)	Karst outcrops	
	CAMBRIAN OR ORDOVICIAN	Jinduckin Formation Є/Oj	Extensive outcrops in Daly River Basin	Sandstone,siltstone,dolomite, marl, silicified limestone	460	Mesas and rocky hills. Some outcrops in stream banks	Upper beds contain Lower Ordovician fossils.No apparent break with underlying Middle Cambrian rocks.
		Manbulloo Limestone Member Є/Ou	Daly River Basin	Dolomite and silicified limestone	200(?)	Mesas	Local development of carbonate rocks of Jinduckin formation

ERA	PERIOD	STRATIGRAPHIC UNIT AND SYMBOL	DISTRIBUTION	LITHOLOGY	MAXIMUM KNOWN THICKNESS (feet)	TOPOGRAPHY	REMARKS
PALAEOZOIC	MIDDLE CAMBRIAN	Merrina Beds Ɛme	Extensive outcrops in southern and south-western part of Sheet area	Dolomite, dolomitic siltstone, sandstone, siltstone, chert	770	Undulating desert country. Low hills and rises	Lower part of sequence probably correlate of Montejinni Limestone
		Anthony Lagoon Beds Ɛmy	Helen Springs and Beetaloo Sheet areas	Feldspathic sandstone; chocolate and red siltstone, often calcareous and dolomitic; limestone, dolomitic limestone, dolomite	285	Low rubbly rises	Contains unidentifiable fragments of echinoderms and brachiopods. Regarded as early Middle Cambrian.
		Tindall Limestone Ɛmt	Daly River Basin, and headwaters of Roper Valley. Probably occurs in subsurface as far south as Newcastle Waters	Limestone, dolomitic limestone, dolomite	3000	Karst outcrops	Contains early Middle Cambrian fossils. Equivalent to Gum Ridge Formation
		Gum Ridge Formation Ɛmg	Within and marginal to Ashburton Range	Siliceous siltstone and chert, sandstone and silicified limestone. Limestone and dolomite in subsurface	170	Low rubbly rises	Contains early Middle Cambrian fossils
		Montejinni Limestone Ɛmm	Longitudinal belt in western part of area	Limestone, dolomite, calcareous siltstone, mudstone, chert	200	Karst topography or savannah woodlands	Contains early Middle Cambrian fossils. Contains three units which are discussed in the text.
	LOWER CAMBRIAN	Antrim Plateau Volcanics Ɛla	Western and north-eastern part of region. Known in subsurface in central part of region	Basalt, tuff, agglomerate, sandstone, limestone, chert	800	Rounded, blocky hills; ill-defined plateaus and mesas	
		Nutwood Downs Volcanics	Hodgson Downs Sheet area	Basalt, agglomerate sandstone	400	Low rounded hills	Presumably continuation of Antrim Plateau Volcanics from the north, and from (subsurface) the west
		Helen Springs Volcanics Ɛlh	Helen Springs Sheet area	Basalt, sandstone, siltstone	120	Rounded hills and ill-defined mesas	Probably equivalent to Antrim Plateau Volcanics
		Bukalara Sandstone Ɛlb	Hodgson Downs Sheet area	Quartz sandstone, siltstone	200	Tableland	
		Pzl	South-western corner of the region	Limestone, dolomite, sandstone siltstone	-	Low hills	Overlain by Dulcie Sandstone. May be equivalent to Middle Cambrian Merrina Beds or Ordovician Hanson River Beds (Milligan et al, 1966)
PRECAMBRIAN	LOWER PROTEROZOIC	Tomkinson Creek Beds* (Blt)	South-eastern part of region	Quartz sandstone, siltstone, carbonate rocks, leached carbonate rocks, chert, minor conglomerate. Dolerite sill. Volcanics in Tennant Creek Sheet area	50,000?	Sandstone forms strike ridges, siltstone and carbonates occur in valleys	

* This is the only Precambrian unit whose groundwater potential is discussed in this report. The Precambrian units on the western and eastern margins of the Palaeozoic sequence are only briefly referred to in the text: their stratigraphy is discussed in the references cited.

The vegetation is mainly low scrub and open savannah woodlands with various types of grasses.

The northwestern part of the Gulf Fall Division in this region (particularly along the Roper Valley) is very similar in landform to the Daly River Basin, and the northeastern part of the Main Plateau. This is mainly due to the underlying flat-bedded Lower Cretaceous Mullaman Beds and the Middle Cambrian Tindall Limestone which occur beneath all three land divisions. Further to the east and the southeast the division is heavily dissected. Topography is essentially controlled by differential erosion of various rock types and is strongly controlled by jointing and geological structure. The Bukalara Sandstone forms a dissected tableland of incised gorges marginal to the Main Plateau; and the Nutwood Downs Volcanics with adjoining outcrops of the Bukalara form the drainage basin of the Upper Hodgson River in country similar in landform to the undulating rounded hills of the Victoria River Plains and Terraces. The streams are well defined and dendritic.

GEOLOGY

The region contains rocks of Precambrian, Palaeozoic, Mesozoic, and Tertiary ages, but there is an extensive cover of Cainozoic superficial deposits. A summary of the stratigraphy is given in Table 1. The geology is illustrated in Plate 1.

The region contains three Palaeozoic basins of mainly carbonate deposits - the Wiso Basin in the south and central west, the Daly Basin in the north, and the Georgina Basin in the central east and southeast. The Wiso and Georgina Basins are separated in the south by the elevated block of the Ashburton Range of Precambrian rocks. To the north these two basins and the Daly Basin appear to merge, but the contacts are obscured by a large area of Cretaceous sediments which are nearly 500 feet thick. The Palaeozoic basins are bounded on the west and the east by Lower Cambrian volcanic rocks and by Precambrian arenite and carbonate sequences.

PRECAMBRIAN

The Precambrian rocks on the western margins of the region consist of sandstone, siltstone, and carbonate rocks of the Victoria River Group (Traves, 1955) and the Tolmer Group (Randal, 1962), and undifferentiated greywacke, schist and intrusives in the southwest mapped by Milligan et al. (1966). The groundwater resources of the Tolmer Group and the undifferentiated rocks are not discussed in this report. Geologists of the Mines Branch, Northern Territory Administration, are compiling considerable information about the groundwater potential of both the Victoria River Group (J. Shields, N.T.A., pers. comm.) and the Tolmer Group (Laws, in prep.).

In the northeast the margins to the Palaeozoic succession are formed by the Lower Proterozoic Finniss River Group, the Carpentarian, Katherine River and Mount Rigg Groups, and the Adelaidean Roper Group. The Finniss River Group consists of mainly greywacke and siltstone with subordinate volcanics deposited in the trough of the Pine Creek Geosyncline (Walpole, Dunn & Randal, 1968; Randal, 1963). The Katherine River and Mount Rigg Groups consist of a mainly arenite-volcanic sequence overlain by a clastic-carbonate sequence deposited in the western part of the McArthur River Basin (Dunn, Smith & Roberts, in prep; Dunn 1963; Paine, 1963). The Roper Group overlies the Carpentarian rocks and consists of a sandstone-shale sequence with subordinate carbonate rocks. The groundwater resources of these four groups are not discussed in this report.

In the southeastern part of the region the rocks of the Wiso and Georgina Basins are separated by the Lower Proterozoic Warramunga Group cropping out about Tennant Creek, and the Lower (?) Proterozoic Tomkinson Creek Beds, which form the Ashburton, Short, and Whittington Ranges between Tennant Creek and Newcastle Waters. The Warramunga Group (Ivanac, 1954; Crohn & Oldershaw, 1965) consists of greywacke, siltstone, and shale deposited in the Warramunga Geosyncline (Noakes, 1953). The groundwater resources of this group are not discussed in this report. The groundwater contained in it varies considerably in quality and availability and these aspects are briefly mentioned by Bracewell, Crohn, & Hays (1962).

The Tomkinson Creek Beds (Randal et al., 1966)* are a sequence of mainly sandstone and siltstone, but contain subordinate carbonate and conglomerate beds. The stratigraphy of the rocks are imperfectly known as, according to Randal et al., the rocks crop out in four structurally separate blocks, with actual continuity of beds being apparent between only two of them. Nevertheless Randal et al. suggest a possible correlation between all four blocks and estimate the thickness of the unit at 50,000 feet. The oldest part of the unit occurs west of the Stuart Highway, south of Muckety Homestead, and in the northern part of the Tennant Creek Sheet area. The youngest rocks crop out in the Beetaloo and Newcastle Waters Sheet areas.

The Tomkinson Creek Beds consist mostly of fine, medium, and coarse-grained clean quartz sandstone, but throughout the sequence there are beds several hundred feet thick of pebbly sandstone or conglomerate and argillaceous sandstone. Siltstone beds up to two thousand feet thick occur throughout the sequence. Chert, derived from the alteration of carbonate rocks, occurs extensively southwest of Banka Banka homestead; limestone and leached carbonate rocks occur in the headwaters of Bootu Creek, east of Muckety homestead; dolomite,

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* This unit was named Ashburton Sandstone by Noakes & Traves (1954), but the name was invalid and the unit renamed (Randal et al., 1966; Randal & Brown, 1969).

limestone, dolomitic limestone, and calcareous sandstone occur southeast of Helen Springs homestead and west of Renner Springs; and chert and leached carbonate rocks are extensive in the central part of the ranges between Tomkinson Creek northward to the headwaters of Hunter Creek. A dolerite sill intrudes the upper beds of the unit between the Stuart Highway and the southern part of Lake Woods, and Ivanac (1954) reports basalt and porphyry in the unit in the Tennant Creek Sheet area.

Cross-bedding, ripple-marks, primary current lineation, halite casts, mud clasts, clay blebs, and mud cracks occur in the clastic sediments; some of the carbonate rocks and chert contain algal stromatolites. The sandstones are cemented by siliceous or argillaceous material. Rocks having either cement are tough and extremely hard. In addition to a siliceous skin on the surfaces of outcrops much of the sandstone has a quartzitic appearance. This is due to overgrowths of quartz filling the interstices between quartz grains rather than by complete recrystallization through metamorphic processes. There are few very friable sandstones known in the sequence.

The Tomkinson Creek Beds are extensively folded and faulted, but the intensity decreases from south to north, and from lower to higher stratigraphic positions. The major faults and the fold axes are predominantly north-south, i.e., parallel to the trend of the Ashburton Range, although there are some exceptions southwest of Muckety homestead and southeast of Helen Springs homestead. The folding and faulting appear to be genetically related; the unit shows no signs of metamorphism, which implies the thick sandstones did not yield significantly by plastic flow, but rather by block faulting. The major faults, which appear to be high angle ones, are accompanied by a zone about $\frac{1}{4}$ mile wide of brecciation, strong jointing, and slickensiding, with the strata dragged into steep and locally overturned attitudes; they are accompanied by extensive silicification of the sandstones.

The age of the Tomkinson Creek Beds is shown on the geological map as Lower (?) Proterozoic, following Smith (1967) who considers the unit to be the same age as the Hatches Creek Group in the Davenport Ranges, 50 miles south of Tennant Creek. Some workers believe the age of both units is Carpentarian because of isotopic ages determined for granites intruding the Hatches Creek Group, but Smith questions the validity of the determinations.

PALAEOZOIC

Lower Cambrian

Three suites of Lower Cambrian volcanic rocks crop out in the region: the Antrim Plateau Volcanics in the west, northwest, and north; the Nutwood Downs Volcanics in the east; and the Helen Springs Volcanics about the Ashburton Ranges in the southeast.

The Antrim Plateau Volcanics crop out in a broad north-northeast trending belt from near Hooker Creek in the south to the valley of the Flora River in the north; from there it occurs in discontinuous outcrops to the northern part of the Daly Basin near the headwaters of the Reynolds and Adelaide Rivers. Randal (1963) regarded identical rocks cropping out on the eastern side of the Basin near Katherine Township and along the Roper Valley as being continuous beneath the younger sediments with the main mass of the Volcanics. This correlation was followed by Dunn (1963), and Randal et al. (1967) reported supporting evidence for it from waterbore and scouthole drilling west and southwest of Larrimah.

Tholeiitic basalt is the dominant rock type in the Antrim Plateau Volcanics, but trachyte and other lava types are known. The sequence contains considerable amounts of sandstone, limestone, chert, and siltstone (Randal et al.,1967). The lavas are usually compact and well crystallized, but the tops and bottoms of flows are aphanatic and vesicular or amygdaloidal. The vesicles are often filled with banded agate, smoky and amethystine quartz, prehnite and zeolite minerals, but many are open and are interconnected. Jointing in the basalt is common, but the spacing and tightness of the joints are widely variable. Deep weathering is common, particularly where tuffaceous interbeds crop out in stream beds and banks.

Although Traves (1955) recognized the presence of agglomerates and tuffs in the Volcanics, the presence of sandstone, limestone, and chert interbeds within the sequence has been realised only recently. Barclay & Hays (1965) report sandstone interbeds in drill cuttings from Wave Hill and in outcrops near Pigeon Hole homestead; Shields (N.T.A. pers. comm.) reports sandstone interbeds in the Volcanics from waterbores near the Western Australia border; and photo-interpretation of the Delamere and Victoria River Downs Sheet areas (Perry, 1966) suggested the presence of sandstone interbeds in the Volcanics, and this was confirmed by field mapping (Randal & Brown, 1967).

Two main types of sandstone have been recognized in outcrop. The first is a friable medium-grained rock, with large scale cross-beds in sets commonly 10 feet or more thick. The outcrops are frequently elongated in a west-northwest direction and the cross-beds dip west or northwest. This sandstone was apparently deposited as elongated sand-ridges under aeolian conditions and subsequently covered by lava flows. The sandstone is strongly indurated for several inches below the basalt and its surface has shallow elongated ridges and furrows presumably caused by viscous drag of the lava moving across the surface. The second type of sandstone is fine to medium-grained, and is either flat laminated with current lineations on the bedding surface or is ripple-bedded. It is commonly interbedded with siltstone or chert. Both sandstones are mainly composed of quartz, rock fragments and feldspars. The rock fragments are siltstone and basalt with glass, and the feldspars are microcline and orthoclase. Quartz-mullite(?) intergrowths occur in the interstices between the grains in the indurated sandstones. The cement is usually quartz, but calcite cement is known, and at Pandanus Spring southwest of Willeroo homestead a barite or celestite cement gives the rock a pseudo fontainebleu appearance. In the cross-bedded sandstones the grains are well sorted and rounded, but in the others the grainsize is more variable.

Randal & Brown (op. cit.) describe an extensive chert bed about the Armstrong River and Illawarra Creek where erosion clearly reveals the contacts of the chert with basalt above and below; they describe other chert interbeds sometimes associated with limestone which occur west of Top Springs, south and southwest of Camfield homestead, and south and east of Wave Hill homestead. Three separate chert beds, separated by basalt flows, form benches in the hills south of Moolooloo homestead. Chert occurs as a replacement of limestone and calcareous siltstone. Thin sections of chert show textures similar to those of the limestone, and in outcrop bedding laminations in limestone can be traced laterally into massive cherts. Ghosts of intraclasts and of shell fragments have been recognized. The limestones are laminated microcrystalline with some sand, silt, and clay impurities. They appear to have been deposited as laminated carbonate muds and subsequently recrystallized. Some of the chert may be silicified tuffs or silicified tuffaceous siltstones: fragments of basaltic glass, with typical outlines of glass shards are common in thin section, and some cherts, especially near Camfield homestead are vuggy and brecciated and contain geodes with copper stained and amethystine quartz. The chert and limestone beds are fractured and jointed; the thicknesses appear to be variable.

The Antrim Plateau Volcanics were deposited sub-aerially, but some flows were deposited in shallow water under either marine (inter-tidal) or lacustrine conditions.

There is an angular unconformity between the Precambrian rocks and the Antrim Plateau Volcanics. The old land surface had considerable relief: Traves (1955) states that the Volcanics occur in old valleys, some 200 feet deep, along the Victoria River between Coolibah & Willeroo. The Volcanics are overlain with a slight unconformity by the Middle Cambrian carbonate rocks, and are regarded as Lower Cambrian.

The thickness of the Antrim Plateau Volcanics is extremely variable. They are thickest in this region near Moolooloo homestead where the borehole intersection of 590 feet of volcanics at Shoeing Tool Replacement bore is supplemented by about 200 feet of volcanics in nearby hills. The sequence becomes thinner both to the north and to the south: Randal (1962) reports 200 feet in the Fergusson River Sheet area, and Randal & Brown (op. cit.) record about 460 feet in the eastern part of Wave Hill Station; Randal (1963) records 100 feet in the Katherine area, and Dunn (1963, a,b) records 200 feet in the Hodgson Downs and Urapunga Sheet areas. In the northeastern part of the region the Antrim Plateau Volcanics consist of amygdaloidal basalt, tuffaceous sandstone, and red feldspathic sandstone.

<u>The Nutwood Downs Volcanics</u> crop out in the valley of the Hodgson River in the Hodgson Downs 1:250,000 Sheet area in the northeastern part of the region. Bore data from Nutwood Downs station suggest they extend into the northern part of the Tanumbirini Sheet area. The unit consists of tholeiitic basalt, andesite, agglomerate, tuff, and flaggy feldspathic sandstone. The basalt contains numerous amygdales filled with quartz jasper and chalcedony; it is fractured and jointed. Dunn (1963) estimates the thickness of the unit at 400 feet. The Nutwood Downs Volcanics is conformably underlain by the <u>Bukalara Sandstone</u> and disconformably overlain by fossiliferous Middle Cambrian carbonate rocks.

The Antrim Plateau Volcanics and the Nutwood Downs Volcanics are petrographically similar and occupy a similar stratigraphic position - disconformable beneath lower Middle Cambrian carbonate rocks. They are believed to belong to the same widespread Lower Cambrian volcanic sequence which covered large parts of the Northern Territory. To the west of the Hodgson River the Nutwood Downs Volcanics disappear beneath the cover of Lower Cretaceous rocks, and isolated outcrops occur in the eastern tributaries of the Strangways River. This is 60 miles eastward of BMR Scouthole L2, near Western Creek homestead, in which amygdaloidal basalt was encountered below fossiliferous Middle Cambrian limestone at about 165 feet. The scouthole is itself about 60 miles eastward of the nearest outcrop of the main western mass of the Antrim Plateau Volcanics in this region, but between the scouthole and the outcrops bores on the Dry River Stock Route and the Willeroo - Top Springs Road intersected basalt at depth. Also the most northerly outcrops of the Nutwood Downs Volcanics in the Strangways River watershed are a mere 16 miles from outcrops of the eastern mass of the Antrim Plateau Volcanics in the Roper valley.

The Lower Cambrian Bukalara Sandstone conformably underlies the Nutwood Downs Volcanics in the Hodgson River Valley and its environs. The rock is a medium to coarse-grained well sorted quartz sandstone. It is cross-bedded and jointed. The outcrops in this region have been equated by Dunn (1963) to other outcrops of the unit further east on the basis of lithological similarity and the unconformable relationship with the underlying Roper Group. The formation is 200 feet thick. Paine (1963) considers that sandstone intersected at 70 feet in N.A. Bore in the Tanumbirini Sheet area is an Upper Proterozoic (Adelaidean) unit, but it could also be part of the Bukalara Sandstone.

The Helen Springs Volcanics crop out in the Helen Springs Sheet area on the eastern and western flanks of the Ashburton Range and in valleys within it. They form mesas capped by thick laterite or lateritized rocks, and grassy plains of black or brown clayey soil in the surrounding lower country. A basal sandstone sometimes forms well developed strike ridges. The Volcanics consist of massive coarse-grained tholeiitic basalt, vesicular aphanatic basalt near and at the base, silicified basalt, and sandstone.

The basalts consist essentially of plagioclase and augite: olivine and its pseudomorphs are absent. Deep weathering and lateritization is common: plagioclases are albitized and sericitized and the augite is partially or completely altered to chlorite or pale green fibrous amphibole. In the silicified basalts the original igneous textures are still visible usually only in thin section: silicification is most common in the fine-grained rocks. Chert interbeds occur in outcrops on the western side of the Ashburton Range. In the pallid zone of the laterite profile the basalt is kaolinized but the original textures can be recognized: they are usually recognizable in the mottled zone, but are obliterated in the ferruginous zone.

Sedimentary rocks underlie the basalt at several localities: the contact is conformable and the rocks have been mapped as part of the volcanic sequence. The predominant rock is a laminated semi-friable sandstone with large scale cross-beds in sets up to 20 feet thick. The rock is fine to medium-grained, but within individual laminae the sorting is good. The grains consist of quartz, quartzite, chert, and siltstone. The cement is mainly siliceous. Interbeds of sedimentary breccia occur in the cross-bedded sandstone. The clasts are quartzite and siltstone and the matrix sandstone. At the base of the basalt the underlying sandstones are indurated and in thin sections the sandstone matrix contains intergrowths of quartz and sillimanite or mullite. The contact surface of the sandstone has shallow ridges and furrows apparently caused by viscous drag of the lava moving over the surface. Both these features have been noted in the sandstones within the Antrim Plateau Volcanics in the western part of the region. The sandstones have been interpreted as aeolian dune deposits.

The maximum thickness of the Helen Springs Volcanics is not known. At Muckety homestead a bore penetrated 120 feet of basalt without encountering the underlying rocks. Near Helen Springs homestead a thickness of 60 feet is exposed in the mesas: several nearby bores were drilled in basalt at the surface but no lithological logs are available for them. The basal sandstone varies considerably in thickness from 6 inches to 40 feet.

Noakes & Traves (1954) regarded the Helen Springs Volcanics as Lower Cambrian in age and equated them to the Antrim Plateau Volcanics in the Ord-Victoria Region. Subsequent mapping (Randal et al., 1966) proved the presence of the volcanics on the western flanks of the Ashburton Range where they apparently underlie the Middle Cambrian Gum Ridge Formation on the eastern side of the Wiso Basin. Also,the Volcanics have been reported in the Hidden Valley Bore in the Daly Waters Sheet area, and are suspected in Burge Bore near the southern part of Lake Woods. It is possible that the two volcanic units are semi-continuous beneath the younger Cambrian rocks of the Wiso Basin. Similarly the Helen Springs Volcanics and the Nutwood Downs Volcanics may be connected by discontinuous occurrences beneath the younger deposits in the Beetaloo and Tanumbirini Sheet areas.

Middle Cambrian

The Montejinni Limestone crops out in the western part of the region on the western side of the central and northern parts of the Wiso Basin. It occurs in a long and narrow meridional belt from the headwaters of the Camfield River in the south to east of Delamere homestead in the north. Isolated outcrops occur in the valley of Cattle Creek northeast of Hooker Creek Settlement. The formation flanks the western margin of the Main Plateau: in the central part of the meridional belt the formation forms a rugged dissected terrace flanking the plateau; in the southern part the terrace merges imperceptibly into the plateau. The unit also forms isolated mesas some miles west of the terrace and scarp, and west of Birrimba homestead crops out as boulders in grassy plains and woodlands. In the northwest the Montejinni Limestone dips gently eastward beneath the Lower Cretaceous rocks of the Plateau, and limestones reported at depth in some waterbores on the Plateau are referred to this formation, or to its northern and northeastern equivalent - the Tindall Limestone. To the south it passes beneath the sand/cover and re-appears in the central part of the Wiso Basin where it underlies the upper part of the Merrina Beds, but appears to be equivalent to the lower part of this unit (Milligan et al., 1966). These aspects are discussed later.

The Montejinni Limestone consists of limestone, dolomite, dolomitic limestone, silty carbonates, and calcareous mudstone or siltstone. In places it contains abundant chert nodules and stringers. Milligan et al. (op. cit.) record thin to medium-bedded quartzose microcrystalline limestone, dolomitic siltstone, and crystalline limestone northeast of Hooker Creek. Between Cattle Creek and Delamere homesteads, Randal & Brown (1967) recognized a three-fold division of the formation in both outcrop and in waterbore and scouthole cuttings - an upper and a lower limestone unit separated by a middle mudstone unit. A composite section is presented below:

Top

Unit 3	100 feet	Grey to brownish limestone with stromatolites near the base, overlain by dark-grey dolomitic limestone and grey crystalline limestone with *Redlichia*, Biconulites, and *Girvanella*. Contains small patches of dolomite and is partly silicified. Minor chert nodules. Medium,thick, and massive bedding.
Unit 2	60 feet	Red to buff calcareous siltstone, red-brown and yellow-buff calcareous mudstone. Silty carbonates. Contains persistent band of silicified rocks at its base. The unit is poorly exposed. It frequently produces a red-brown soil with rubble of red travertine. It is thin-bedded and laminated.
Unit 1	10 feet	Stromatolitic limestone, dolomitic limestone, foetid black and grey crystalline limestone; chert nodules and stringers. Thick bedded.
	60 feet	Thin bedded light-grey crystalline limestone.
	40 feet	Thick-bedded dark-grey crystalline limestone with abundant chert nodules. *Redlichia*.

The age and stratigraphic relationships of the formation are discussed later in this section.

The Tindall Limestone is the basal Middle Cambrian unit of the Daly Basin in the northern part of the region. In the northwest it crops out from the valley of Mathison Creek northwestward to near Banyan homestead and beyond to the northern part of the Daly Basin; in the northeast it crops out along the eastern margin of the Daly Basin from beyond Jindare homestead in the north southeastward to the valley of the Roper River and its southern tributaries; it also crops out in the valley of the Dry River near its confluence with the King River. The eastern and western outcrops are linked by a continuous line of outcrops around the northern margin of the Daly Basin (Walpole, Dunn, & Randal, 1968). From bore data the formation appears to extend in the subsurface to near Newcastle Waters and the Daly Waters - Borroloola Road in the south. Outcrops of fossiliferous limestone in the Hodgson Downs Sheet area are referred to this unit. The formation crops out as scattered blocks in grassy plains or woodlands, as low karst outcrops, or as pavements and banks in watercourses.

No sections have been measured in outcrops of the Tindall Limestone: Randal & Brown (1967, Appendix 1) give detailed cuttings descriptions of incomplete parts of the unit intersected in scoutholes and waterbores. The formation consists of light brown, grey-brown, buff and yellowish calcilutite, fine crystalline limestone, dolomitic limestone and dolomite. It contains chert nodules and stringers, but these are not as prevalent as in the Montejinni Limestone. Outcrops of two-tone grey and yellow or brown limestone occur in several outcrops and in the subsurface. In many outcrops the lighter coloured material - consisting of coarser recrystallized calcite - has been extensively dissolved producing a honeycombed rock with high storage capacity, but it is not known if this phenomenon occurs in the subsurface. The limestone is fossiliferous: Biconulites, ptychoparioid trilobites, phosphatic brachiopods, obolidae, and cystid plates have been found in drill cuttings; and Biconulites, phosphatic brachiopods, obolidae, Girvanella, Helcionella, Hyolithes, Redlichia, and sponge spicules have been found in outcrop.

The Tindall Limestone disconformably overlies the Lower Cambrian volcanics and in places appears to overlap them to rest unconformably on the Precambrian rocks. The age and the relationship of the unit to other Middle Cambrian rocks is discussed later in this section.

The Tindall Limestone is at least 100 feet thick in the northern part of the Sturt Plateau, but further north in the Daly Basin the thickness may be 500 feet or more.

The Gum Ridge Formation (Opik, 1956) crops out along the eastern and western flanks of the Ashburton Range, in valleys within the Range, and in the eastern and western parts of the Tennant Creek 1:250,000 Sheet area. Thus it is a marginal unit of both the Georgina Basin to the east and the Wiso Basin to the west. The formation usually occurs as low rubble covered mounds and rises on which dip measurements are impossible.

The Gum Ridge Formation consists of impure sandy limestone, chert, siliceous shale, and sandstones in the Tennant Creek area; Randal et al. (1966) extended the unit to include chert, siliceous shale, altered carbonate rocks and sandstone cropping out around Banka Banka homestead and on the flanks of the Ashburton Range, and dolomite, dolomitic limestone, limestone and chert occurring in water-bores to the east of the Range.

As with other Cambrian units to the east the Gum Ridge Formation has been extensively altered and lateritized (Randal, 1966 a,b,). Most of the surface exposures now consist of fossiliferous chert, silicified shale and sandstone and altered carbonate rocks. The surfaces of the outcrops are frequently covered by a brecciated and recemented mixture of chert and silicified sandstone or siltstone, identical to that formed on the Wonarah Beds to the east (Randal 1966 a,b). How deeply this silicification affected the rocks is unknown but it is probably only shallow. It is laterally extensive.

The Gum Ridge Formation is richly fossiliferous: Opik (1956) and Gatehouse (in Randal et al., 1966) report Xystridura, Peronopsis, Pagetia, Chancelloria, Eiffelia, Biconulites, Billingsaella, and Redlichia in the Tennant Creek area, and further north Xystridura, Redlichia, Billingsella, Biconulites, Wimanella, ptychoparioids, and inarticulate brachiopods. Most of the determinations were at species level and clearly indicate an early Middle Cambrian age for the formation.

The thickness of the Gum Ridge Formation is unknown. In the Tennant Creek area 45 feet of rocks are exposed with the upper part eroded. If all the rocks penetrated in No. 12 South Barkly Stock Route are referrable to the Formation then its thickness exceeds 170 feet.

In the Helen Springs Sheet area there is a strong angular discordance between the Gum Ridge Formation and the Tomkinson Creek Beds, and a disconformity between it and the Helen Springs Volcanics. Similar relationships between the formation and the older rocks occur in the Tennant Creek Sheet area.

The relationship with other Middle Cambrian units is discussed later.

The Anthony Lagoon Beds crop out in the eastern part of the Helen Springs Sheet area and the southern part of the Beetaloo Sheet area. The unit is known in the subsurface in the Beetaloo Sheet area and may extend northward into the Tanumbirini Sheet area. It is the most widespread unit in the central and western Barkly Tableland portion of the Georgina Basin.

Surface exposures consist of limestone, dolomitic limestone, dolomite, sandstone, chert, siltstone, and silicified and leached carbonate rocks. Scouthole and waterbore drilling indicate considerable amounts of calcareous and dolomitic siltstone and sandstone, dolomitic limestone, limestone, and dolomite. Chert is present but is not common. The texture and nature of the carbonate rocks are varied: some dolomites have a fine pelletal texture with the pore spaces between pellets incompletely filled, but there are also dolomites which are uniformly micro to finely crystalline and compact. Limestones also are pelletal or crystalline, and some contain fine rhombs set in a calcilutite matrix. Both limestone and dolomite contain in places zones of abundant solution vughs. The sandstones in the Anthony Lagoon Beds are flaggy and ripple marked; surface silicification is common but many bore-cuttings are friable. The rocks are fine to medium-grained. Much of the chert contains ghosts of dolomite rhombs and is clearly the replacement products of original carbonate rock.

The maximum known thickness of the Anthony Lagoon Beds in this region is 258 feet in No. 6 Bore Barkly Stock Route, however, to the east it appears to be over 1000 feet (Randal, 1966b).

The age and relationship of this unit is discussed later in this section.

The Merrina Beds crop out in the southwestern and central part of the region. It is the most widespread unit of the central and southern Wiso Basin. The unit crops out as low hills or rubble covered rises in the scrub covered sand plain west of the Stuart Highway and the Ashburton Range. Much information about the sequence comes from a series of scoutholes between Tennant Creek and Hooker Creek Settlement (Milligan et al., 1966). The Beds may extend in the subsurface as far north as the Murranji Stock Route (Randal & Brown, 1967).

The lithology of the Merrina Beds is varied: the vertical variation is dolomite at the base, dolomitic siltstone and claystone and fine-grained sandstone with interbedded dolomite, and medium and coarse-grained sandstone at the top. In the northern part of the Wiso Basin the rocks consist of dolomite, dolomitic limestone, chert, silicified carbonate rocks, and sandstone. The dolomites are microcrystalline but recrystallization has produced some coarser rocks. The sandstones are porous, fine-grained, and well-sorted although some are poorly sorted. Bedding within the units ranges from thinly laminated to massive.

Milligan et al., (1966) describe the following composite section from the outcrop and subsurface data:

Top

330 feet	White and grey sandstone (leached and decemented rocks) Red brown quartz sandstone, partly dolomitic, interbeds of brown siltstone and dolomite. Claystone.
250 feet	Interbedded dark-brown siltstone and claystone, partly dolomitic, and thinly bedded microcrystalline dolomite. Stromatolites. Lingula, Biconulites, Girvanella and fragments of trilobites and echinoderms.
190 feet	Brown-grey to dark grey dolomite, partly argillaceous and partly calcareous. Chert fragments. Biconulites and trilobite fragments, Acrotreta, and Acrothele.

The age of the unit and its relationship to other Middle Cambrian rocks are discussed later.

Cambrian/Ordovician

The Jinduckin Formation crops out in the Daly Basin in the northern part of the region. It forms isolated mesas and rubble-covered hills, sometimes capped by Lower Cretaceous rocks, and occurs on the northwestern slopes of the Main Plateau. Siltstone beds overlying carbonates in Scoutholes L1, L2, L3, and in the Maryfield homestead bore, all near Larrimah Township, are similar to those in the Formation, but their equivalence has not been proved.

In this region the Jinduckin Formation consists of interbedded sandstone, siltstone, dolomite, and dolomitic limestone. It is thin to medium-bedded, flaggy, and in part silicified. It contains thin chert bands and nodules. Outcrops of sandstone and siltstone are characteristically red, chocolate, or buff. The carbonate rocks are frequently pinkish-grey on the weathered surface; they are microcrystalline to finely crystalline and are stromatolitic. The sandstones are well sorted and are fine to medium-grained; they are cross-bedded and cross-laminated. Halite pseudomorphs occur in both the sandstone and the siltstone. Local developments of mainly dolomite and dolomitic limestone have been mapped as the Manbulloo Limestone Member.

The Jinduckin Formation appears to conformably overlie the early Middle Cambrian Tindall Limestone. In this region no definite contacts between the two have been seen in outcrop but in many places the two formations are concordant in strike and amount of dip. Furthermore, in Scouthole K1 the contact between the two seems gradational (Randal & Brown, 1967). Randal (1962, 1963) considered the contact conformable and regarded the Jinduckin Formation as Middle Cambrian although no diagnostic fossils were found. Subsequently trilobites and brachiopods of Lower Ordovician age (Opik, 1964) were found in rocks near the top of the formation near Claravale homestead. It is not known if the formation represents continuous, but slow, sedimentation from early Middle Cambrian to Lower Ordovician, or if there are breaks in the sequence.

Randal & Brown (1967) report at least 450 feet of the formation in this region.

Dolomite, limestone, sandstone, and siltstone crop out in the south-western portion of the region, and are shown on the map as undifferentiated Lower Palaeozoic rocks following Milligan et al. (1966). The rocks are grey dolutite, with chert nodules red sandy calcilutite, and fine-grained argillaceous quartz sandstone and siltstone. The sandstone and siltstone contain halite pseudomorphs. The rocks are unfossiliferous, and are overlain by rocks equated to the Devonian Dulcie Sandstone by Milligan et al., who regard the older rocks as possible equivalents of either the Middle Cambrian Merrina Beds or the Ordovician Hanson River Beds which crop out to the south of this region.

Ordovician

The Oolloo Limestone is the uppermost Palaeozoic unit in the Daly River Basin. It conformably overlies the Jinduckin Formation, and consists of limestone and dolomite. It is about 200 feet thick (Randal, 1962).

Devonian

Medium to thick-bedded argillaceous sandstone and clean friable quartz sandstone crop out in the south-western part of the region. The rocks are referred by Milligan et al. (1966) to the Dulcie Sandstone of the Georgina Basin (Smith, 1967). It is 60 feet thick.

Relationships of the Cambrian units

The Montejinni Limestone, the Tindall Limestone, the Gum Ridge Formation and the lower parts of the Merrina Beds all contain shelly fossils which indicate generally an early Middle Cambrian age for these units. Milligan et al. (1966) report the upper sandstone and siltstone unit of the Merrina Beds conformably overlies the Montejinni Limestone and equate this formation with the lower part of the Merrina Beds. Randal & Brown (1967) equate the upper part at least of the Montejinni Limestone with part of the Tindall Limestone by means of lithological similarity and subsurface data provided by waterbores and scoutholes. Bore data suggest the lower parts of the Merrina Beds may occur in the subsurface as far north as the Murranji Stock Route and that the Tindall Limestone may extend in the subsurface as far south as Newcastle Waters and eastward across the Tanumbirini Sheet area. The fossil assemblages in the Tindall Limestone and the Gum Ridge Formation as listed by Opik (1956) clearly establish the time equivalence of these two formations, and limestones intersected by bores north of Daly Waters are very similar to fossiliferous limestone in South Barkly Stock Route No. 12 bore. Similarly the fossil assemblages in the lower Merrina Beds and in the Gum Ridge Formation on the western flanks of the Ashburton Range, and their spatial distribution suggest they are equivalent in part.

Hence the fossiliferous early Middle Cambrian units in the Daly, Wiso, and Georgina Basins in this region appear to be the result of contemporaneous or nearly contemporaneous deposition of mainly carbonate rocks over a very large area: the variations in the rock types being controlled by the amount of terrigenous material available, minor changes in environment, and the time and degree of dolomitization and silicification of the original carbonate muds.

Because of the lack of diagnostic fossils the exact stratigraphic relationship of the Anthony Lagoon Beds with other Cambrian rocks is indefinite. Randal (1966b) lists a number of localities from which unidentifiable fossils have been recovered and states"....... since the Anthony Lagoon Beds appear to form part of the widespread carbonate rocks of the Barkly Tableland which in adjoining areas contain early Middle Cambrian fossils........this unit is provisionally assigned to the Middle Cambrian." Randal & Nichols (1963) believed that in addition to the Wonarah Beds and the Burton Beds, the Anthony Lagoon Beds may be in part equivalent to the Top Springs* Limestone which crops out on the northern margin of the Barkly Tableland some 30 miles east of this region. This limestone contains fossils which suggest an upper Lower Cambrian or lower Middle Cambrian age, and it may be an equivalent of the Tindall Limestone which it markedly resembles in outcrop.

Brown (1968, and pers.comm.) has been studying the palaeogeography and environment of the Cambrian rocks of the northern part of the Northern Territory from outcrop and subsurface data, and believes two main units can be recognized in superposition. The lower unit is the mainly carbonate early Middle Cambrian rocks containing shelly fossils - represented by the Tindall Limestone and its equivalents as discussed above, the Top Springs Limestone, and other mainly carbonate rocks intersected in boreholes to the east of this region. The younger unit is a dolomite, sandstone, siltstone sequence characteristically red-brown, buff, or chocolate in outcrop and in the subsurface. This unit is represented in the Daly Basin by the lower part of the Jinduckin Formation; in the Wiso Basin by the upper part of the Merrina Beds, and in the western Georgina Basin by rocks in the upper part of the Anthony Lagoon Beds. Brown suggests the age of this unit is post early Middle Cambrian to (?) Upper Cambrian, and that most of the surface outcrops of the Anthony Lagoon Beds are part of this unit. Although outcrops of limestone similar to Brown's older unit occur within the outcrop area of the Anthony Lagoon Beds, he cites considerable evidence to support his concept in general. The concept is extremely important hydrogeologically and should be investigated by further scouthole or stratigraphic drilling: in the upper unit, because of its interbedded and varied rock types, potential aquifers are more likely to be controlled stratigraphically than in the lower mainly carbonate unit where the occurrence of aquifers is more likely to be controlled by the incidence of cavities and fissures.

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* Not to be confused with Top Springs in the Victoria River District in the west of this region.

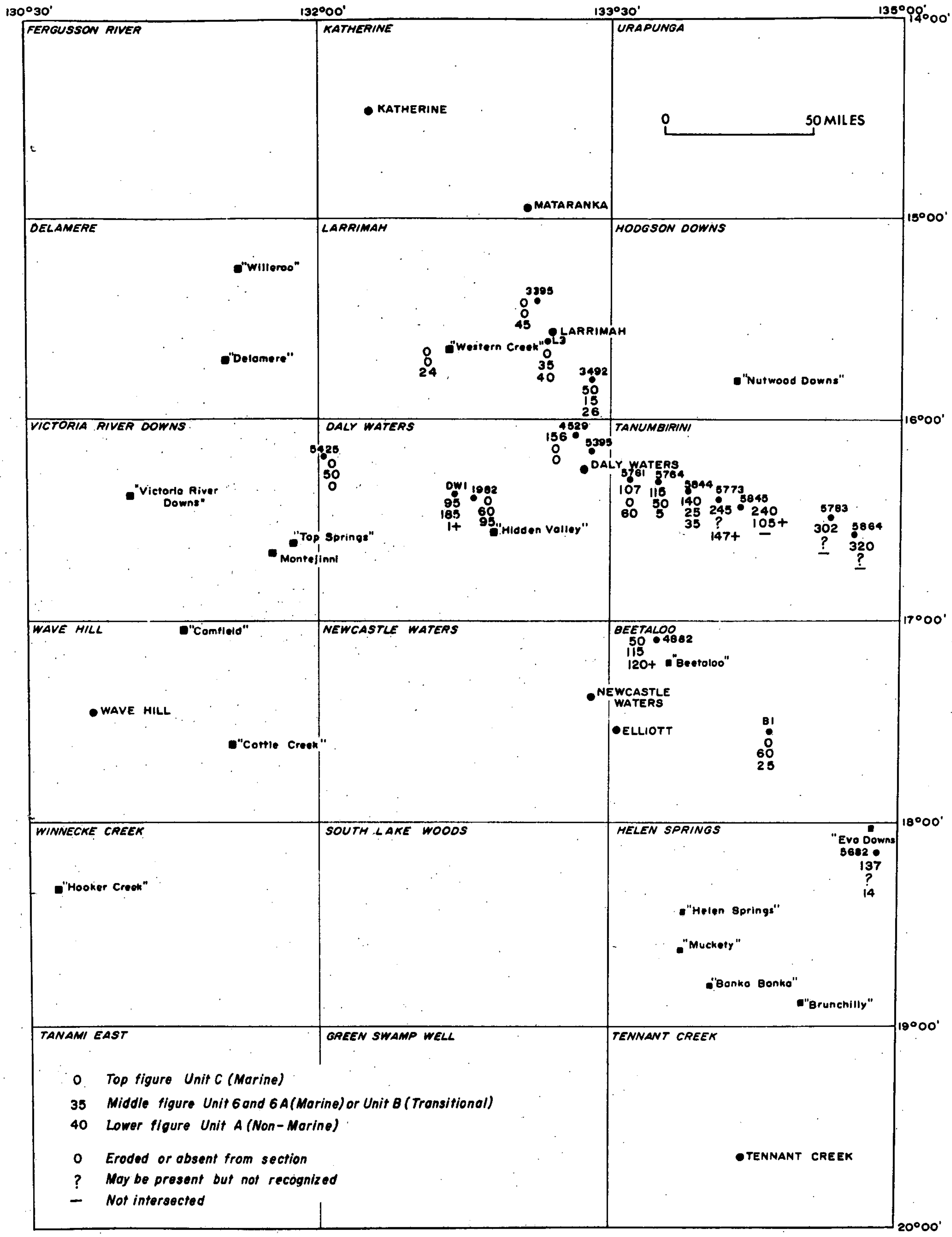

Fig. 2 Thickness of units within Mullaman Beds

To accompany Record 1969/16

NT/A270

MESOZOIC

Unnamed Mesozoic sediments occur in broad valleys eroded below the summit plain of the Ashburton Range. They have been partly removed by erosion and hence sometimes occur as cappings on low mesas. The rocks are boulder conglomerate, sandstone, pebbly sandstone and siltstone. The outcrops are widely scattered and no correlation between sections has been established; Randal et al. (1966) estimate the rocks are 80 feet thick. They contain plant impressions which have been determined as Jurassic or Lower Cretaceous in age. The sediments are tentatively correlated with the lower non-marine part of the Mullaman Beds which are exposed to the northeast.

Flat-lying sediments of the Lower Cretaceous Mullaman Beds crop out over much of the northwestern, northern, and eastern parts of the region. Outcrop is especially good as mesas and escarpments on the dissected margins of the Main Plateau; within the Plateau the unit occurs as low rocky knolls or as scattered rubble in the sand and soil, but considerable information has been obtained from scoutholes and waterbores (Randal & Brown, 1967; Randal et al., 1966; Brown, B.M.R. file notes). Skwarko (1966, 1967) examined the Mullaman Beds in this region and the following comments are based on his results supplemented by the mapping and subsurface data compiled by Randal & Brown.

The lowermost unit exposed on the Plateau and along its margins is a non-marine saccharoidal sandstone with in places basal beds of grit and pebble and boulder conglomerate. This unit is equated with Skwarko's 'Unit A' of the Inland Belt and with the Lees Sandstone named in the Mt. Isa area by Opik, Carter, & Noakes (1961). The age of the unit is ?Neocomian-Aptian. It is overlain by marine claystone and siltstone, with sandy interbeds, of Aptian age, which Skwarko (1967) refers to Unit 6 of his Coastal Belt (Skwarko, 1966). Unit 6 is overlain by an Aptian marine unit of yellow, brown or red, medium-grained micaceous quartz sandstone. Skwarko refers to it as Unit 6a; it occurs in the Coastal Belt but because of poor definition he previously included its outcrops within Unit 6. The uppermost unit within the Mullaman Beds is a marine siltstone and claystone of Albian age; it disconformably overlies the Aptian rocks and in places overlaps them. Skwarko (1967) refers to this subdivision as the Polland Shale, named in the Mt. Isa area (Opik et al., 1961), which is the same as Unit C of his Inland Belt. In addition Skwarko (1966) records that in places Unit A and Unit C are separated by a transitional sequence which in the Inland Belt he has named Unit B. This unit occurs in the northern and northeastern part of the region, but has been recognized within the Main Plateau area only from scoutholes in the northern part of the Barkly Tableland. The thickness of the units varies considerably; thicknesses known from bore data are illustrated in Figure 2.

These separate units are not shown on the geological map: the outcrop width of the divisions along the margins of the Plateau is too narrow to show at 1:1,000,000 scale, and on the Plateau itself too few outcrops have been visited to delineate the boundaries even approximately. But general observations are possible. Most of the Lower Cretaceous outcrops in the central part of the Daly Waters Sheet area are considered to be Polland Shale equivalent - Unit C - and those in the central and northern part of the Larrimah Sheet area are the Lees Sandstone equivalent - Unit A. Units 6 and 6A may crop out along the boundary between these two Sheet areas and north of Hidden Valley homestead.

The Mullaman Beds unconformably overlie the Precambrian rocks, the Lower Cambrian volcanic sequences, and the Lower Palaeozoic rocks of the Wiso, Georgina, and Daly Basins. The unconformity at the base of the sequence is illustrated by structure contours in Figure 3. This contoured surface is extremely important hydrogeologically and is discussed in a later chapter.

Skwarko reports at least 165 feet of Lower Cretaceous rocks in the western escarpment of the Sturt Plateau. The maximum known thickness is from waterbore CCE on the Borroloola road where 475 feet of only Units C, and 6 and 6a where encountered: waterbore CCD to the west encountered about 150 feet of Unit A beneath Unit 6. Figure 4 illustrates isopachs based on the present thickness of the Mullaman Beds below the Plateau surface. Because the top of the Mullaman Beds is an erosional surface the isopachs do not illustrate the depositional thickness. But the map is important hydrogeologically: it indicates the depth of overburden covering the Middle Cambrian rocks which are more reliable water producers than the Lower Cretaceous sequence. This is discussed further in a later chapter.

CAINOZOIC

Most of the Palaeozoic and Mesozoic rocks have been extensively altered by a Tertiary episode of lateritization. All three zones of the classical laterite profile -- ferruginous, mottled, pallid -- occur, but are not everywhere present. Some sections of ferruginous zone material show apparent bedding and size sorting of ironstone pisolites and may be recemented detrital laterite. Much of the northern and eastern part of the Main Plateau is covered by a gravel of ironstone pisolites. The laterite cannot be precisely dated: it overlies Lower Cretaceous rocks, and appears to underlie Tertiary limestones in the northern Wiso Basin (Randal & Brown, 1967) and in the northwestern Georgina Basin (Randal et al., 1966). Lateritic gravels are reputedly 80 feet thick in some waterbores.

Tertiary limestone units occur in widely scattered areas in the region, mainly within the plateau but also along its western margin. The units are an unnamed limestone and clay sequence in the southern and central Wiso Basin; the Brunette Limestone which crops out extensively in the central and western parts of the Barkly Tableland; the Camfield Beds which crop out on the western margin of the Main Plateau between Camfield and Cattle Creek homesteads;

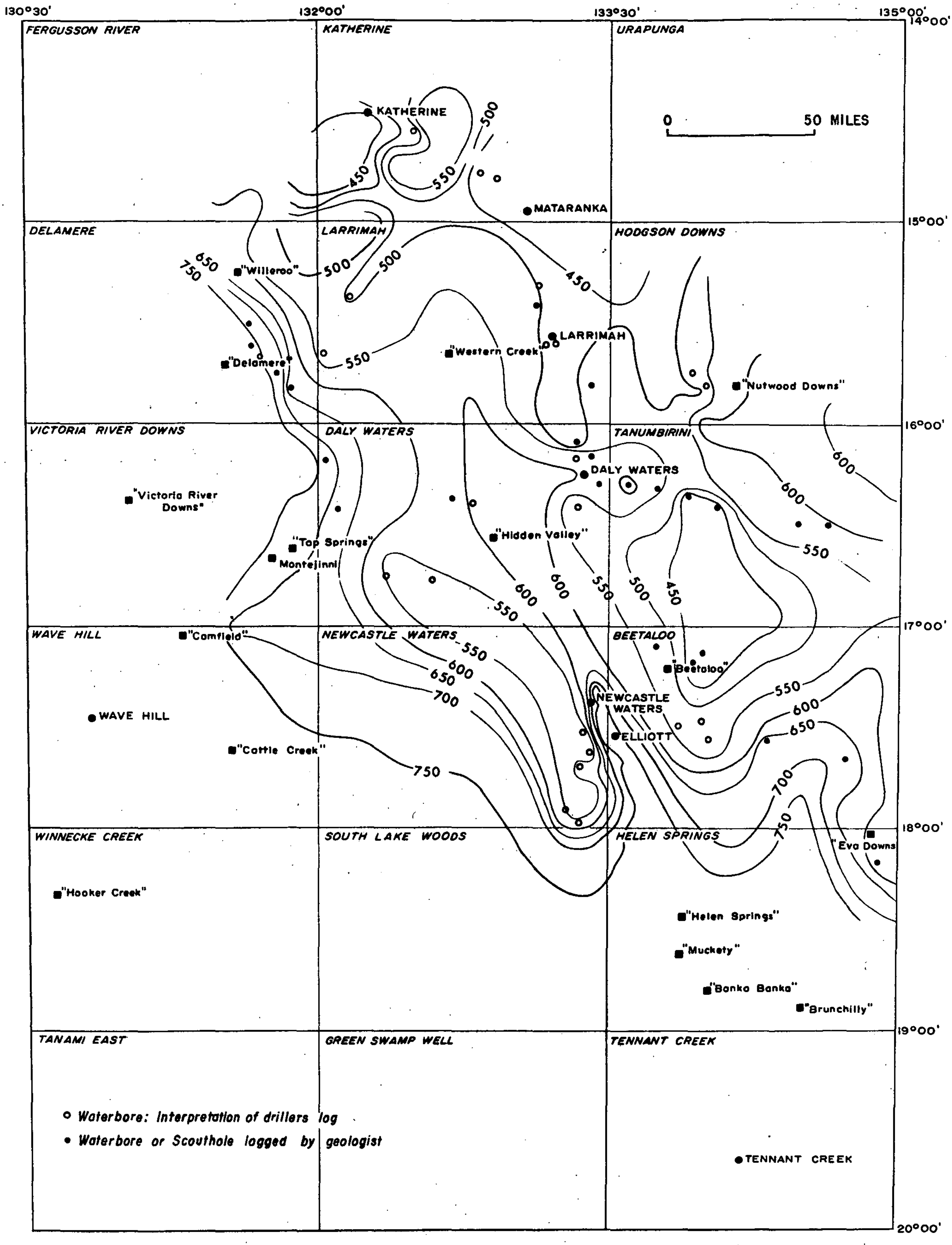

Fig. 3 Structure contours on unconformity at base of Mullaman Beds

To accompany Record 1969/16

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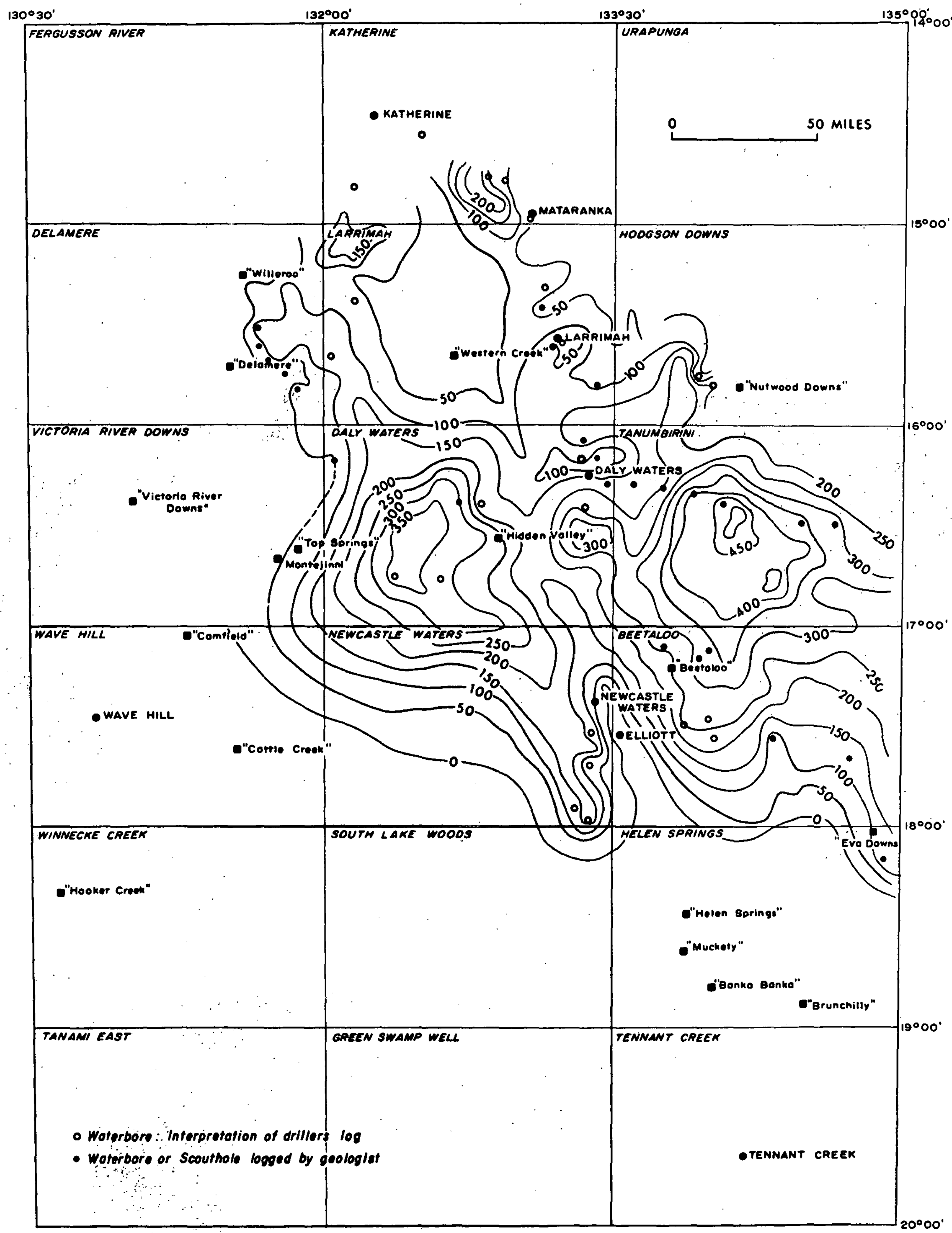

Fig. 4 Isopachs on thickness of Mullaman Beds

To accompany Record 1969/16

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the Birdum Creek Beds which occur between Larrimah Township and the Dry River; and the Golliger Beds which are small isolated outcrops in the Tanumbirini Sheet area. With the exception of the unnamed unit in the southern part of the region these units are not being exploited for groundwater. They may have some bearing on the amount of recharge and quality of the water entering underlying rocks (Randal, 1967) and this is discussed later. Fossils from the Brunette Limestone, the Birdum Creek Beds and the Camfield Beds suggest an early Miocene age for these deposits.

Superficial unconsolidated deposits are widespread throughout the region: they consist of sand, sandy soil, and pisolitic gravels; travertine, black, grey, and brown pedocalcic soils; and alluvium.

The most extensive sandy areas occur in the desert area of the Main Plateau south of the Murranji Stock Route and west of the Ashburton Range. North of the Murranji the sand contains a great deal of admixed pisolitic ferruginous gravel, and low rises composed almost entirely of pisolitic gravel are common not only there, but also in the Beetaloo and Tanumbirini Sheet areas in the eastern part of the region. On the eastern flank of the Ashburton Range sand covers a piedmont desert which slopes down gradually from the range and terminates abruptly against the black soils and alluvia of the Barkly Tableland. The sand is mainly colluvial, but probably contains some wind and stream transported material. The sand has probably been derived from the Tomkinson Creek Beds, the upper part of the Merrina Beds, and the basal unit of the Mullaman Beds.

Travertine occurs as calcareous deposits over basic volcanic and carbonate rocks. Its occurrence is more widespread than shown on the geological map: most outcrops are very small and cannot be realistically shown at scale.

The grassy downs of the Barkly Tableland and the grassy plains west of the Stuart Highway are underlain by black and grey pedocalcic soils developed over Cambrian and Tertiary carbonate rocks and Cretaceous siltstone and claystone. Brown and red-brown clayey soils are developed over basic volcanic rocks and carbonate rocks in the northern part of the region. The clayey soils are moderately to weakly leached and contain horizons rich in carbonate and gypsum.

The areas mapped as alluvium include flood plains and floodouts of streams, lakes, and swamp areas; and some flat areas of heavy grey and brown soils in old valleys on the Main Plateau.

SURFACE WATER

Climate

The climate in this region is mainly semi-arid and rain falls mostly under the influence of the northwest monsoon, normally lasting in the northern part from November to March - the Wet Season. The duration of the rainy season is longest in the northern part and shortest in the south. The remainder of the year usually is without useful rain, although some winter showers do occur. The average annual rainfall throughout the region is variable, ranging from 1124 points at Tennant Creek and 1525 points at Cattle Creek in the south to 3362 points at Katherine in the north. Figure 5 shows the isohyets based on the average rainfall for the period 1950-1965*. The driest part of the region is the desert country south of Cattle Creek homestead and west of Tennant Creek. This tract of country extends westward and southwards of this region and is part of the vast dry interior of the continent. Figure 6 illustrates the mean monthly rainfall at Daly Waters and clearly shows the separation of the summer wet season from the winter dry season.

The temperature and humidity in the region are not well documented except for the larger towns. Table 2 illustrates these climatic characteristics for Daly Waters and Tennant Creek obtained from land research studies by C.S.I.R.O. (1953, 1954) for the Katherine-Darwin and Barkly Regions respectively, both of which used records for the period 1911-1940.

TABLE 2: CLIMATIC DATA

	TENNANT CREEK	DALY WATERS
Mean maximum temp.	89.4	94.0°F
" minimum "	65.3	66.7°F
" temp. (hottest month)	87.1 (December)	88.3°F (Nov.)
" " (coolest month)	63.7 (July)	68.8°F (July)
" Relative humidity (driest month)	28% (October)	39% (September)
" " " (wettest month)	50% (February)	67% (February)

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* Obtained from monthly rainfall figures for 17 stations within the region for the period made available by the Commonwealth Bureau of Meteorology, Melbourne.

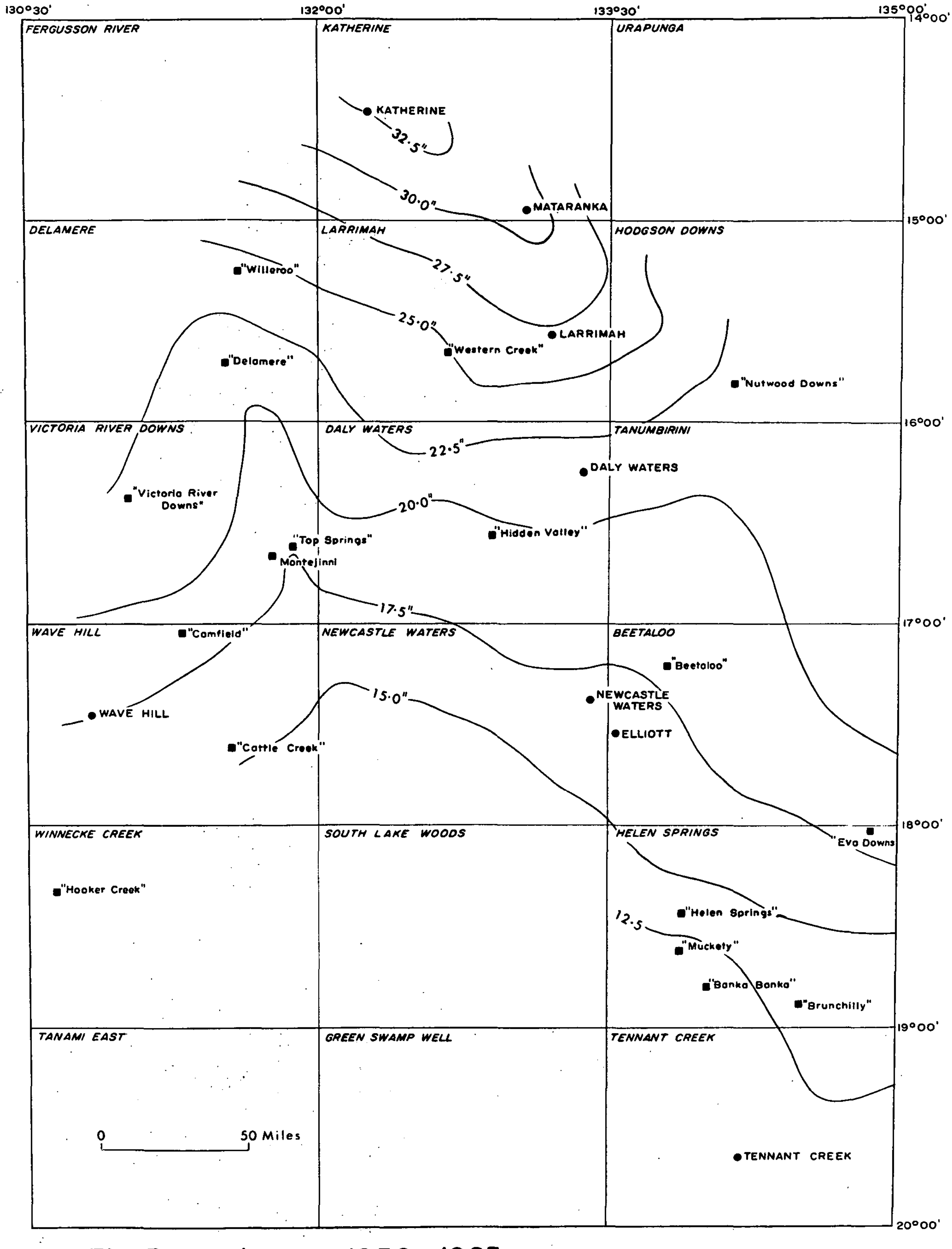

Fig. 5 Isohyets, 1950 – 1965.

To accompany Record 1969/16

NT/A 273

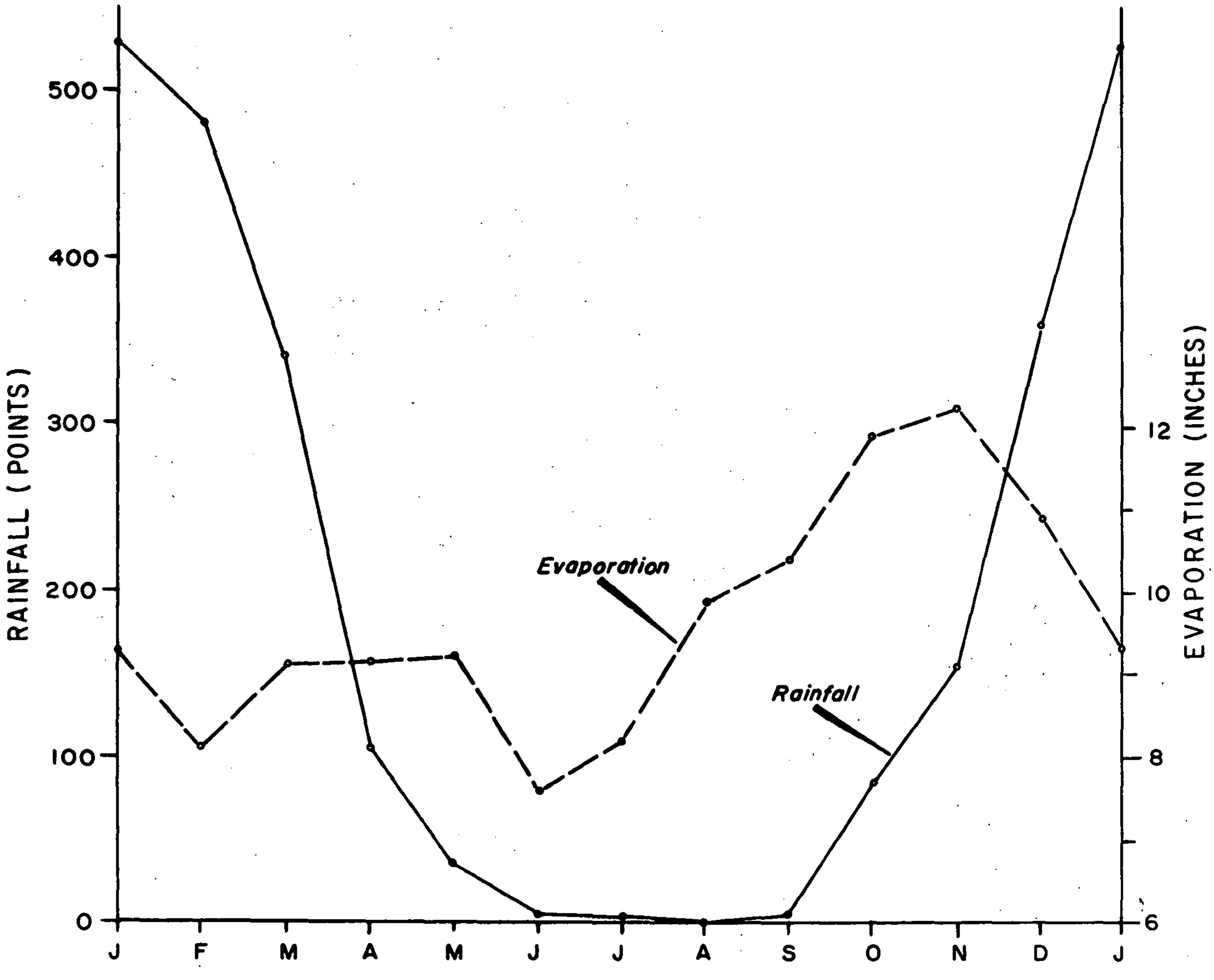

Fig.6 Mean monthly rainfall and evaporation Daly Waters N.T.

To accompany Record 1969/16

NT/A 274

The evaporation over the region is least in the north and greatest in the south. Figures for the period 1950-65 indicate the average annual evaporation is 88 inches at Katherine, 112 at Daly Waters, and in excess of 120 inches at Tennant Creek. The average monthly evaporation at Daly Waters is illustrated in Figure 6. It is highest in the wet season and lowest in the dry season. Nevertheless, as in the central Barkly Tableland (Randal, 1967), the evaporation/precipitation ratio is lowest in the wet season and highest in the dry season. This implies that accretion to groundwater supplies is achieved more by the summer rains rather than by the low intensity winter rainfall.

To some extent the density of watercourses in the region is proportional to the amount of rainfall: there are fewer streams on the Main Plateau where the rainfall is lowest, but numerous well defined streams on its western, northern, and eastern flanks where the rainfall is higher and run-off greater. But because the dissection is greater more waterholes occur on the flanks of the Plateau than on it.

Because of the seasonal and semi-arid climate of most of the region, surface water is not only inadequate for full pastoral development but is extremely unreliable. The droughts on the Barkly Tableland described by Foley (1957) and referred to by Randal (1967) affected the southeastern part of this region i.e. the western and northwestern extensions of the Tableland. In addition Foley (op. cit.) describes some of the drought periods in the Darwin-Daly Waters - Wave Hill area, and since 1896 to 1955 the region has experienced drought periods totalling about 19 years; and in addition periods of below normal rainfall which though not severe in themselves prevented the pastoral industry from weathering the bad drought years which followed soon after. Drought conditions lasted for 16 months from October 1899, and 22 months from April 1901. There was a total of nearly 5 years drought conditions between 1907 and 1920, and nearly 6 years between 1925 and 1938. Victoria River Downs, Powell Creek and Tennant Creek had their lowest recorded rainfall in 1928, 1931, and 1935 respectively. From March 1946 to January 1949 rainfalls were below average, and in December 1951 and early 1952 most of the Territory entered into one of the worst droughts it has experienced. Over 10,000 head of stock died on Helen Springs station alone, and it was reported that there was virtually no grass from the Queensland border to the Victoria River District. Most of the permanent waterholes dried out, even the large ones at Newcastle Waters.

The pastoral industry therefore does not in the main rely on surface waters, but uses them merely to supplement groundwater obtained by boring.

Distribution

Elements of three of the major drainage systems of Australia occur in this region - the Western Plateau Division, the Timor Sea Division, and the Gulf of Carpentaria Division (Australian Water Resources Council, 1965). Within the region the Timor Sea Division contains the Victoria River and the Daly River Basins, and the Gulf of Carpentaria Division contains the Roper River and the Limmen Bight River Basins. The boundary between the two divisions is approximately that shown in Figure 1 as the boundary between the Daly River Basin and the Gulf Fall. The Western Plateau Division is a large area of unco-ordinated drainage occupying about one third of the Northern Territory, two thirds of Western Australia, and about half of South Australia. In this region the Western Plateau Division is approximately co-extensive with Hays (op. cit.) Main Plateau except for the northern limits. As discussed earlier the Main Plateau has a consistent northward slope north of latitude 16°30'S and much of the northern drainage of the Plateau connects with the main drainage systems of the Dissected Margin. Consequently the northern stream-courses of the Plateau have been included in the appropriate coastal drainage divisions by AWRC and in the central part of the region the northern limit of the Western Plateau Division is about 90 miles south of the northern boundary of the Main Plateau. To the southwest and southeast the discrepancy narrows and the drainage and physiographic boundaries ultimately become congruent. The partial transgression of the physiographic concepts over the drainage divisions is justified on the grounds of geology and geomorphology. The gently sloping northern part of the Main Plateau is for the most part bounded in the north by a well defined escarpment formed by the Lower Cretaceous Mullaman Beds, and this escarpment is a much stronger feature than the low divide about latitude 16°30'. Furthermore the country which is nowhere as well dissected as the main parts of coastal drainage divisions, is underlain by the same flat-lying sequences as the central part of the Main Plateau and is contiguous with it. The presence of coastal drainage within the Main Plateau is due to headwater encroachment by the coastal streams and their capture of originally random drainage. This is shown by the distribution of large areas of alluvium on the Main Plateau. Remnants of the Main Plateau - as indicated by mesa-form outliers of the Mullaman Beds - occur in the coastal divisions. The coastal streams are actively eroding the Main Plateau, and reducing its areal extent, but the resultant physiography is far from being mature enough to warrant strict adherence to the idea of physiographic boundaries coinciding with drainage basin boundaries. Because the distribution of long-lasting surface water is strongly controlled by the physiography it will be described by physiographic divisions rather than drainage basins.

Within the Main Plateau long-lasting and permanent water occurs only in and on the flanks of the Ashburton Range, in the downs and sandy country east of the highway, and north of the Murranji Stock Route (Fig. 7). Very little is known about the occurrence of surface waters in the desert south of the Murranji Track.

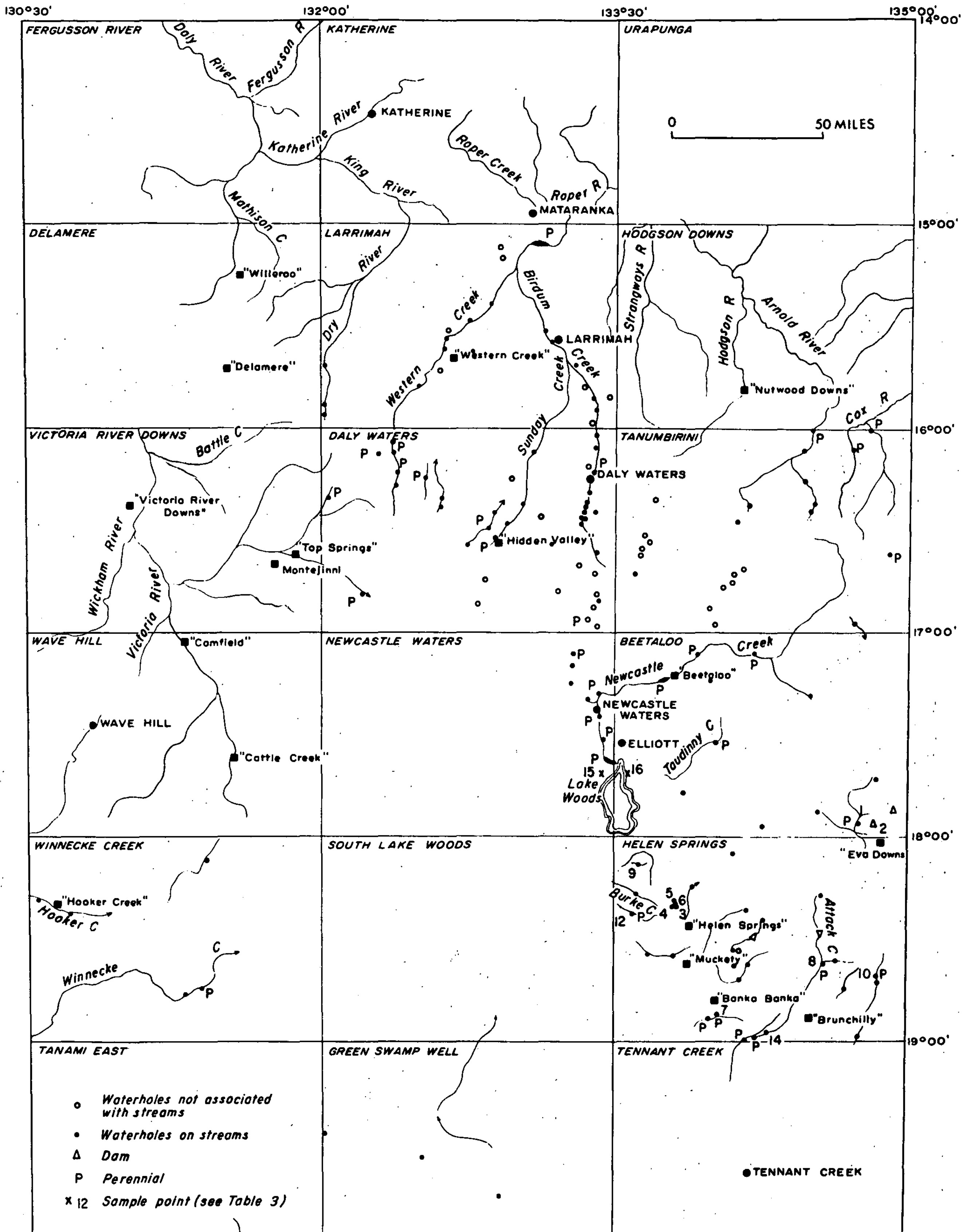

Fig. 7 Distribution of waterholes in the Main Plateau

NT/A 275

To accompany Record 1969/16

Because of the arid seasonal climate there are no permanently flowing streams in the Main Plateau. There are very few permanent waterholes and these are generally restricted to the incised watercourses on the flanks of the Ashburton Range. The more important are in Attack Creek, Morphett Creek, Tomkinson Creek, and Burke Creek. Small permanent waterholes are fed by springs in Gleeson and Powell Creeks, and small semi-permanent rockholes occur in Bootu Creek. These waterholes occur mainly in large depressions in the rocky and sandy floors of the watercourses or are associated with rock-bars forming natural barriers. Most of the waterholes in and adjacent to the ranges occur in country which is not the most suitable for cattle grazing, most of which is carried out in the grassy downs east of the ranges, in the sandy and lateritic areas to the east of the Stuart Highway, about Newcastle Creek, and north of the Murranji Track.

In the downs country Coolunjie Waterhole on Brunchilly Creek and Munkaderry Waterhole on the northern extension of Attack Creek are the largest permanent surface waters. Indamilly Waterhole on Mckinlay Creek, though large, is regarded by local pastoralists as being not normally perennial. Numerous depressions in the watercourses in the downs country form waterholes of varying importance, but most are dry by the middle of the dry season. North of Eva Downs normally perennial water is available at Surveyors Waterhole on Broad Creek. Conservation of surface water has been achieved by the construction of dams - the largest of these is Brunchilly Dam on Brunchilly Creek in which permanent water is backed up for $\frac{5}{8}$ mile (in June). Other permanent supplies occur at 6-mile dam and 10-mile dam, north of Eva Downs. Small dams on Carmilly and Attack Creek have insufficient depth and catchment and are not normally perennial.

Permanent waterholes are numerous in Newcastle Creek. Important ones east of the Stuart Highway are Mundah and Hollomo Noon east of Beetaloo, and a large one at Beetaloo homestead. Newcastle Waters station and township are named from an almost continuous line of waterholes - many permanent - extending from the causeway crossing on the Stuart Highway, 30 miles southward to near Lake Woods. The permanent waterhole near the township is a mile long and that near Lake Woods over four miles long. There are several waterholes, some normally perennial in the northern tributaries of Newcastle (Waters) Creek. The more important of these occur along Bucket Creek which is followed for 16 miles by the Murranji Stock Route. Surface water along the Murranji Stock Route is scarce, and between Howell's Pond on Bucket Creek and Yellow Waterhole 75 miles to the northwest the only notable waterhole is the Murranji, after which the route is named, and this is usually dry by August. Hence until bores were constructed along the route about 1920 it was considered one of the most hazardous in the Northern Territory. *

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* The improved watering facilities did not however alleviate the difficulties of droving cattle through close tangled scrub and stands of lance-wood which are traversed for most of the journey from No. 10 bore westward to the edge of the Plateau.

There are numerous waterholes in the western, central and eastern parts of the Plateau north of the Murranji Stock Route, but most are not perennial and very few can be safely regarded as permanent. The waterholes along Daly Waters Creek are numerous but frequently fail by the end of the dry season. Similarly the waterholes northward from Daly Waters in the valley of Birdum Creek cannot be relied upon as perennial supplies. Brown (1895) describes his difficulties in obtaining water along this creek in December 1894 despite the incidence of heavy rainstorms. Stuart Swamp, four miles north of Daly Waters is normally perennial. In the central part of the Daly Waters Sheet area several streams are partially incised on the northern flanks of the low divide about latitude 16°30'. Many waterholes occur in these streams at points of reduced gradients. Several are regarded as perennial but some of these even may fail if the wet season is either abnormally late or is abortive for some years in succession. The most important occur in the upper reaches of Western, Middle, and Sunday Creeks. On the western side of the Plateau permanent water occurs in Nelly Creek. Several waterholes occur in the headwaters of the Dry River but few are perennial.

South of the Murranji Track waterholes occur in Winnecke and Hooker Creeks. Some may be perennial for a few years following successive good wet seasons but they are not regarded as reliable. The most important are Merrina Waterhole and the Duck Ponds on Winnecke Creek. Chewings (1930) did not consider the waterholes he visited to be permanent, and suggested that most surface waters would be dry three months after the end of the wet season. K.G. Smith and H.F. Doutch (B.M.R. pers. comm.) flew over most of the Wiso Basin in 1965 and reported several pools of water lying in claypans and in interdune corridors but consider these would have been dry in a few weeks. They resulted from heavy storms a few weeks earlier. Three weeks after heavy winter rain the author noted damp mud in shallow depressions in August 1966 in country 80 miles south of the Murranji Track. Several waterholes have been mapped from aerial photographs but appear not to be permanent.

An interesting feature of the Main Plateau is the occurrence of waterholes - both perennial and ephemeral - not on defined watercourses, but in subcircular or elliptical depressions with the drainage from a small area directed towards them. They mostly occur in the outcrop or shallow subcrop areas of the Lower Cretaceous rocks or in the areas of sand and recemented lateritic gravel. They appear to be the reflection at the surface of collapse in the Cambrian carbonate rocks beneath the younger sediments.

Many have banks of recemented detrital laterite or soft lateritized Lower Cretaceous sandstone and siltstone, but in several erosion has bevelled the edges permitting some ease of access, and in some very little of the original banks are left - the hole being now merely a depression with a silty or clayey floor and marginal slopes of the same material with a few remnants of sandstone, siltstone, or ironstone, e.g. Murranji Waterhole, and Huddleson Lagoon neither of which is perennial. In addition to these other water holes of this type are Frew Pond and Brolga Waterhole (Western Creek homestead) which are normally perennial and Moorak, Mering Mering, and others between Hidden Valley homestead and Daly Waters, which last throughout the dry season only after successive good wet seasons.

The holes are replenished by direct precipitation, surface drainage and lateral percolation through surrounding soil and unconsolidated sediments. The retention of water appears to be caused by a mulch of vegetable matter and fine silt. Some are losing storage capacity through excessive silting.

In the Victoria River Plains and Terraces there are numerous waterholes in most of the creeks and rivers but very few are permanent. Although flow in the Victoria River ceases some weeks after the end of the Wet Season, long pools of permanent water occur in the river for almost its entire length from Wave Hill settlement to its mouth. Smaller permanent waters occur in the Camfield and Armstrong Rivers, and Coolibah Creek. The permanency of the holes in the Victoria River is due to the depth of the holes - the river is deeply entrenched - and the protection from wind afforded by the abrupt and heavily wooded banks. Spring flow may be a contributing factor but this has not been established.

In the Daly River Basin, only the Daly, Flora, and Katherine Rivers are perennial. The other major watercourses normally flow only during the wet season and for a few weeks at the beginning of the dry season, however they contain numerous large waterholes, many of which are permanent. Even the Flora and Katherine River may cease flowing towards the end of the dry season after an abnormally short wet season but they always contain very large and deep waterholes. Two important normally perennial waterholes are Kowai and Wongala on the King River; they supported the Dry River Stock Route before the construction of bores along it.

In the Dissected Gulf Margin within this region only the Roper River is perennial; it may cease flowing towards the end of the dry season after abnormally short wet seasons but like the major streams in the Daly River Basin it always contains long pools of water. Elsey Reach in Elsey Creek - a southern tributary of the Roper - contains numerous holes some of which are perennial for some seasons but none are permanent. The Warloch Ponds along Elsey Creek - famous as the locale of the factual novel. 'We of the Never Never' by Mrs Aeneas Gunn- is a wide depression six miles in length and of varying depth between the railway and highway crossings of the creek. By the middle of the dry season it has shrunk to a chain of mostly shallow waterholes only a few of which are normally perennial. The Hodgson, Arnold and Cox Rivers contain numerous waterholes some of which are permanent.

Springs and shallow groundwater

There are several springs within the Ashburton Range, along the western edge of the Main Plateau on the watershed of the Victoria River, and in parts of the Daly River Basin and in the Gulf Fall Division, but very few are permanent. "Springs" have been reported in the featureless sand-dune country of the Wiso Basin but Chewings (1930) visited some of these in 1909 and regarded them more as native wells and soakages.*

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* In the case of the wells no water would have been visible at the surface before they were dug, and even after, water merely collected in the bottom of the holes and did not rise to the surface. In the case of the soakages water lying in small depressions was replenished after removal - by exploitation or evaporation-by movement of water from the adjacent saturated alluvium.

Within the Ashburton Range the most important springs are those at Renner Springs. Probably there are several non-perennial springs in this locality but three permanent ones have been developed and apparently provide an adequate supply to the roadhouse for domestic and stock purposes. Their output is discharged into earth dams and is supplemented by surface run-off to the dams during wet weather. The springs are situated as follows: one east of the highway and immediately north of the roadhouse (north spring), one east of the highway, near the racecourse (southeast spring) and one west of the highway and a few hundred yards south of the roadhouse (southwest spring). The springs occur on the flanks of a low rise of quartzitic sandstone and the water appears to come from coarse gravel and sands abutting it. The north spring issues from a depression in the side of a mound of gravel, sand, and sandstone boulders, and the flow is directed to an earth dam nearby. A corrugated iron water tank has been inverted over the depression to protect it from stock. The water temperature was 80°F and air-temperature 90°F. The southeast spring is a depression developed by excavation in which the water rested close to the rim of clayey black soil. At the time of inspection wind pumping apparently was keeping pace with the flow as the level remained constant. There was some evidence that the water overflowed the rim on occasions. The water temperature was 85° F. The southwest spring has been developed as a well with a shaft about 9 feet deep. The well was making water at the time of the visit but only a few inches of water lay in the bottom and the pump was on the point of forking. Flow into the well was by seepage in partially compacted sand, sandy clay and gravel to within a few feet of the top of the well. There was no indication of water overflowing from the well, and it may have been an exploratory well rather than the development of a true spring. The water temperature was 82°F. Although no detailed work was done in this area, the impression gleaned was that no regional aquifer was providing the supply and that the springs could fail after successive dry years. The area about the springs, though studded with small outcrops, is a plain of superficial deposits forming part of the watershed of Renner Creek which flows eastward through high strike-ridges of the Tomkinson Creek Beds. Possibly the main water storage and movement is in these superficial deposits, with discontinuous clayey bands confining water in places and perching the watertable in others. Some meagre evidence for this is available from the water temperature. Brown (1895) measured the water temperature at 92°F with an air temperature of 98°F in January a hot month. In October 1965 the author measured the water temperatures at 80, 82 and 85° with an air temperature of 90°F. These readings suggest the water temperature is affected by air temperature and hence the storage may be very shallow.

No flowing springs were found at Helen Springs at the time of the author's survey, but Brown visited them in 1895 and states 'The spring rises from an uptilted bed of flaggy sandstone over-laid by decomposed amygdaloidal basaltic rock'. This sandstone is the basal rock of the Helen Springs Volcanics and is the aquifer supplying the garden and homestead wells at Helen Springs Homestead. The basalt in the vicinity is lateritized and heavily weathered and the resulting kaolinitic debris apparently acts as a confining bed. The basal sandstone also provided a good supply of water in scouthole HS6.

In a small creek south of Powell Creek and in Gleeson Creek Springs issue from jointed sandstones of the Tomkinson Creek Beds and maintain small permanent waterholes. There are other springs along the flanks of the range but these are not perennial and have not been investigated in detail. They occur in alluviated valleys bordered by large elevated areas of jointed sandstone, or issue from joints and fissures on the slopes of sandstone ridges. Some may be controlled by faulting, but this has not been clearly established. Deep circulation of groundwater is not necessarily the situation in the Tomkinson Creek Beds: the Powell Creek Telegraph Station was adequately served by a well 38 feet deep in sandstone and quartzite in which the water stands 14 feet below ground level, and water possibly from the same body occurs in a soakage in the creek nearby. Similarly Wiggenty Well on Mucketty Station is constructed in this unit and the water stands at 10 feet below ground-level.

Springs are reported in the folded Precambrian rocks in the Hodgson Downs and Tanumbirini Sheet areas, but they were not visited during the survey. Warm springs associated with faulting in limestone occur in the Waterhouse River near its confluence with the Roper River east of Mataranka. Similar springs occur in the Douglas River in the northern part of the Daly River Basin. Several springs have been noted over the years on the western terraces bordering the Main Plateau. Only a few were visited during the survey and only one, Pandanus Springs southwest of Willeroo, appeared to be perennial. But green vegetation at the sites of others testified that water was about long after other holes nearby had dried out. Pandanus Springs is associated with sandstone interbeds in the Antrim Plateau Volcanics and other springs in the Volcanics owe their existence to impermeable chert interbeds. Some reported springs may occur at the disconformity between the Volcanics and the overlying Montejinni Limestone, but this was not confirmed during the recent survey.

As indicated earlier Chewings investigated shallow groundwater in the Wiso Basin in an attempt to establish watering points for a proposed stock route from Barrow Creek to Wave Hill; he sank several shallow wells in the vicinity of existing native wells and soakages and in this region obtained water at Hit or Miss, Native, Green Swamp and Cattle Swamp Wells. The water occurs in travertinous limestone or in sandstone immediately below it. The wells are less than $9\frac{1}{2}$ feet deep and the water, which Chewings described as fresh, rose to within a few feet of the surface. Chewings also made shallow trial borings and reported some salty water. He regarded the wells as permanent but he travelled through this country in April through to July i.e. the early and middle parts of the dry season, and it cannot be assumed that a watertable will be maintained above the level of shallow wells throughout the dry season. Scouthole GSW4 drilled in July encountered a seepage at 21 feet in Tertiary sediments and the water rose to within 11 feet of the surface. Also, Bobs Well in the Lander River Sheet area to the south of this region obtains 750 g.p.h. of brackish water from a depth of 35 to 45 feet, and the standing water level is 35 feet.

Quality of surface and spring water

The spring and surface waters of this region are chemically suitable for stock and domestic use, but there is obvious pollution of some holes by stock. This can of course be controlled if necessary by suitable fencing and reticulation. Table 3 presents the analyses of waters in the eastern part of the region.

The waters are generally low in salinity - only three contain more than 200 ppm of total dissolved solids, and to some extent the higher values - up to 412 ppm - may have been due to non-filtrable matter in suspension being included in the determination. A very striking feature of most waters in the area of the Main Plateau is moderate to extreme milkiness caused by colloidal suspensions of clay particles apparently derived from the clayey soils over which the water has passed. The effect is not restricted only to the downs country but waterholes in the laterite and sandy areas north of the Barkly Stock Route and north of the Murranji Track also exhibit it. The water issuing from the north spring at Renners Spring roadhouse is clear but that in the dam in which it accumulates is very milky. On the flanks of the Ashburton Range Attack Creek contains many waterholes containing very clear water, but some miles downstream in the downs country Attack Creek Dam contains milky water. The total dissolved solids could not be determined for two samples - Nos. 15 & 16 - from Lake Woods because too much finely suspended matter (0.5 microns or less) passed through the filter paper. Waterholes in the Ashburton Range and on its flanks normally contain clear water. So do those in the major streams of the Daly River Basin, the Victoria River System, and the main watercourses of the Gulf Drainage System.

The waters are very low in fluoride content: water from the dam at Renners Spring contained 1.3 ppm but all the other samples contained less than 0.8 ppm. The nitrate content is normally low (less than 10 ppm) although two values - comparatively higher than the others - suggest pollution by stock. These are from the samples taken at Brunchilly Dam (19.8 ppm) and Coolunjie Waterhole (16.5 ppm). Coolunjie hole is not fenced, and although Brunchilly Dam is, at the time of sampling the fencing was in disrepair and stock had direct access to the water. The springs at Gleeson Creek and Renner Springs are interesting inasmuch as the determined nitrate content for the spring water is somewhat higher than that for the same water lying on the surface.

The samples from Renners Springs (Nos. 5 & 6) and Gleeson Spring (Nos. 9a and 9b) clearly show the effects of concentration by evaporation. In both the total salinity has been more than doubled, but the increase of various constituents has not been by a constant factor. Randal (1967) noted similar effects in the chemical concentration of groundwater stored in a raised earth tank. An interesting feature is the very high increase of potassium and sodium compared to a decrease in magnesium and calcium.

TABLE 3: ANALYSES* OF SPRING AND SURFACE WATERS

Name	Ca	Mg	Na	K	Cl	SO_4	HCO_3	F	SiO_2	NO_3	S.C.	pH	T.D.S.
(Numbers shown on Figure 7)													
							BEETALOO						
1 Surveyers W.H.	8.4	5.0	2	3	6.9	12.8	21.6	0.4	29.8	9.8	78.3	6.10	51.4
2 6-Mile Dam	4.6	2.8	2	2	1.0	8.2	27.8	0.3	16.1	4.0	48.5	6.70	178
							HELEN SPRINGS						
3 Renner Springs (South-East)	9.2	8.1	23	7	22.0	17.3	89.5	0.4	20.5	9.6	238	7.30	147
4 Renner Springs (South-West)	8.4	9.7	27	7	23.5	19.3	104.9	0.8	25.1	7.7	275	7.00	182
5 Renner Springs (North) Spring	27.7	8.8	26	8	240	15.6	154.3	0.4	23.4	3.9	349	7.50	183
6 Renner Springs (North) Dam	22.2	17.6	95	27	61.0	25.5	345.6	1.3	31.7	3.5	751	7.40	416
7 Morphett Ck. Water-Hole	6.7	3.6	7	7	11.8	5.3	43.2	x0.1	1.0	7.1	126	6.50	72
8 Monkaderry	31.5	10.5	9	17	23.6	10.7	151.2	0.2	8.1	8.4	315	6.80	197
9a Gleeson Creek	3.9	4.5	26	5	0.94	0.12	49.4	0.5	66.3	2.3	183	5.80	346
9b Spring Spring	6.9	5.3	11	4	14.7	2.1	53.7	0.1	36.2	5.0	162	6.60	136
10 Coolunjie Waterhole	20.9	3.8	6	9	1.5	11.5	89.5	0.4	31.6	16.5	169	6.95	131
11 Brunchilly Dam	21.7	11.5	6	12	5.4	9.1	132.7	0.3	28.3	19.8	246	7.00	174
12 Burke Ck Water Hole	12.6	5.1	6	8	13.5	6.6	77.2	0.1	14.6	1.5	160	6.95	137
13 Attack Ck Dam	41.8	16.2	33	35	87.5	35.8	160.5	0.6	4.8	x0.10	585	6.90	412
14 Attack Ck Waterhole	18.6	8.6	20	8	30.5	6.6	96.9	0.1	30.6	1.2	266	7.30	186
15 Lake Woods (West)	8.2	0.71	2.3	9.0	x	10.7	39.4				69.9	6.9	
16 Lake Woods (East)	14.0	1.26	1.2	7.6	x	8.7	59.1				96.2	7.3	

* Analyses in parts per million (p.p.m.); specific conductivity (S.C.) in micromhos/cm.

Generally the waters are dominant in bicarbonate* ion reflecting the availability of atmospheric carbon dioxide, and in the limestone areas the availability of carbonate ions (which normally are transformed to bicarbonate ions). However the sample from Surveyors Waterhole showed a higher proportion of sulphate ion, and that from Attack Creek Dam a higher proportion of chloride ion than normally encountered in surface waters. Nevertheless the waters were both dominantly bicarbonate in composition and in the terminology of Randal (1967) would be classified as sulphato-bicarbonate and chloro-bicarbonate respectively. The others would be classified as mainly bicarbonate. The source of sulphate is readily apparent - the soils are in places gypsiferous - but the source of chloride is not.

The surface waters are generally dominant in calcium and magnesium, but some, particularly in non-carbonate areas, are dominant in sodium.

GROUNDWATER

DEVELOPMENT

History of groundwater use

Other than the use of springs and the sinking of wells by explorers, the first use of groundwater in this region was by construction workers building the Overland Telegraph Line. Field work for this project commenced in 1871 and the lack of progress in construction towards the end of the dry season was attributed to the diversion of manpower to sink wells as the surface waters were rapidly failing (Bauer, 1964). Unlike the Powell Creek station Well which was reputed to be 38 feet, not all the wells were shallow: some of the wells along the line near Birdum Creek were reported by Brown (1895) to be 100 feet into limestone, and he records a dry well 200 feet deep in limestone at Daly Waters.

Stock were introduced into the region early in the history of the Northern Territory. Spring Vale station near the present Manbulloo homestead was taken up in 1876 and stocked with sheep and cattle in 1879. About 1881 the sheep were moved to the Delamere country from Spring Vale and the same interests opened up Newcastle Waters. Elsey Station was taken up about 1877. Eva Downs, Helen Springs, Renner Springs, Wave Hill, and Victoria River Downs were taken up and stocked in the early 1880's. Brown (1895) referred to the springs at Helen Springs and Renner Springs and noted that the latter had been developed for us by stock, and he referred to a well in Cretaceous rocks at Eva Downs.

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* The relative dominance of the constituents is based on the concentration expressed as equivalents per million, not parts per million.

But, generally, stock were dependent on waterholes, some of which were spring fed for part of the year.

Whereas the eastern part of the Barkly Tableland was mainly influenced by pastoral practices in Queensland, the activity in this region reflected the lethargy and ill-luck that dominated most enterprises in Darwin and the top end of the Northern Territory generally.* Hence, although drilling for groundwater commenced in the Barkly Tableland in the early 1890's (Randal, 1967) shortly after the early successes in Queensland, it did not commence in this region until nearly twenty-five years later. The first recorded drilling was Wave Hill bores Nos. 1 and 2 in 1915, about three years after the station had been acquired by the Vestey organisation. The bores were successful and several bores were drilled in the following years. The first failure was No. 8, drilled in 1919. The early successes are remarkable inasmuch as following the first failure many of the holes drilled on the station have been dry or yielded quite inadequate supplies. Although approval had been given in 1908 by the South Australian authorities for the provision of bores along the stock routes nothing appears to have been done until about 1916-1919 when some bores were constructed along the Dry River Stock Route. Presumably some of the bores along the Birdum Stock Route were drilled about the same time. The Murranji Track and the Barkly Stock Route were probably the most important stock routes in the early development of the region particularly after Buchanan found a crossing of the Barkly Tableland in 1877, for they permitted access to the Kimberley country for cattle from Queensland and later gave pastoralists in the west access to eastern markets. Yet the bores (Nos. 1-8) along the Anthony Lagoon Stock Route (now the western part of the Barkly Stock Route) from Anthony Lagoon to Newcastle Waters were not drilled until 1920 and 1921. Murranji No. 9 was drilled in 1921 and the remainder in 1923. Muckety bore drilled in 1925 and an unsuccessful bore near Renner Springs appear to be first drilled between Newcastle Waters and Tennant Creek on the North-South Stock Route. Most of the others followed in 1934. Following on the recommendations of Ward (1926) three bores were drilled on the Wave Hill Stock Route between 1928 and 1931. In 1928 Banka Banka Station drilled its first two bores and appears to have been at that time the only station in the region to follow the example of Wave Hill and Victoria River Downs. In 1934, as well as the bores on the North-South Stock Route, bores were drilled both at Newcastle Waters township and at Newcastle Waters homestead. Eva Downs in the western Barkly Tableland drilled its first bore ("A" bore) in 1938. By 1940 there were only about 60 bores in the region, and about 20 were on the one station** (Wave Hill) and about 20 were stock

* The early history of the pastoral industry in the Northern Territory generally and the northern part of the Territory is described in some detail by Duncan (1967) and Bauer (1964) respectively.

** Including replacement drilling alongside earlier bores.

route bores. At this time there were twice as many in the central and eastern part of the Barkly Tableland. Although drilling on private holdings in that part of the Tableland virtually ceased during the war years (1939-45) it continued in this region on Wave Hill, Banka Banka, and Helen Springs, and on stock routes. During this period numerous bores at Army and Air Force establishments were drilled along the Stuart Highway, notably at Birdum, Larrimah and Katherine, and at Gorry, Venn and Tindall Aerodromes between Birdum and Katherine. In the late 1940's drilling continued on those stations which had already commenced; additional bores and replacements were drilled along the stock routes. In 1949 Brunchilly No. 1 bore was drilled. The early 1950's saw an expansion of the cattle industry which was reflected in the incidence of drilling in this region as well as to the east (Randal, 1967), but even so most of the drilling was done in the western Barkly Tableland part of this region. However during the 1950's several blocks were separated from Victoria River Downs, and early improvements on these - Killarney, Montejinni, and Camfield - maintained the activity fairly evenly throughout the region in the later 1950's. The early 1960's saw added activity in the region mainly as a result of the government advice scheme for pastoral bores. In this scheme the Commonwealth provides technical advice on the selection of boresites and advances money for the cost of successful bores, and underwrites the cost of failures. During this period bores were drilled on most of the stations in the region. From the mid-1960's to the present there has been a great deal of drilling in the region but not all of it has been directly for pastoral activity. Numerous bores have been drilled for developing town centres and villages and for construction purposes. Important amongst these are exploratory bores at Katherine for an improved town supply, bores at Top Springs and Wave Hill, and construction and domestic bores at Tindall and Venn Airfields. Since about 1963 these bores have been far in excess of those drilled for direct pastoral use.

Present Development

Although the general pattern of drilling activity in this region has followed that in the Barkly Tableland to the east (Randal, 1967), it has been somewhat distorted by the number of holes drilled for public utilities not directly associated with pastoral development. These are the bores mentioned above - developed town supplies, exploratory bores for additional town supplies, and road and airfield construction bores. This region is astride the major lines of transport between Darwin and the south (and east) and between Darwin and Western Australia. Accordingly it contains several towns of varying size, and is subject to considerable work on road improvements: the first factor is negligible in the Barkly Tableland and the second greatly reduced in comparison. Despite the large number of bores in the region most are concentrated in the better grazing lands of the western Barkly Tableland and the eastern Victoria River Region, and along the Stuart Highway particularly between Larrimah and Katherine townships. Large tracts of land between the Katherine-Top Springs Road and the Stuart Highway contain very few pastoral bores and there are none south of the Murranji Track between those on the western environs of the Ashburton Range and at Hooker Creek.

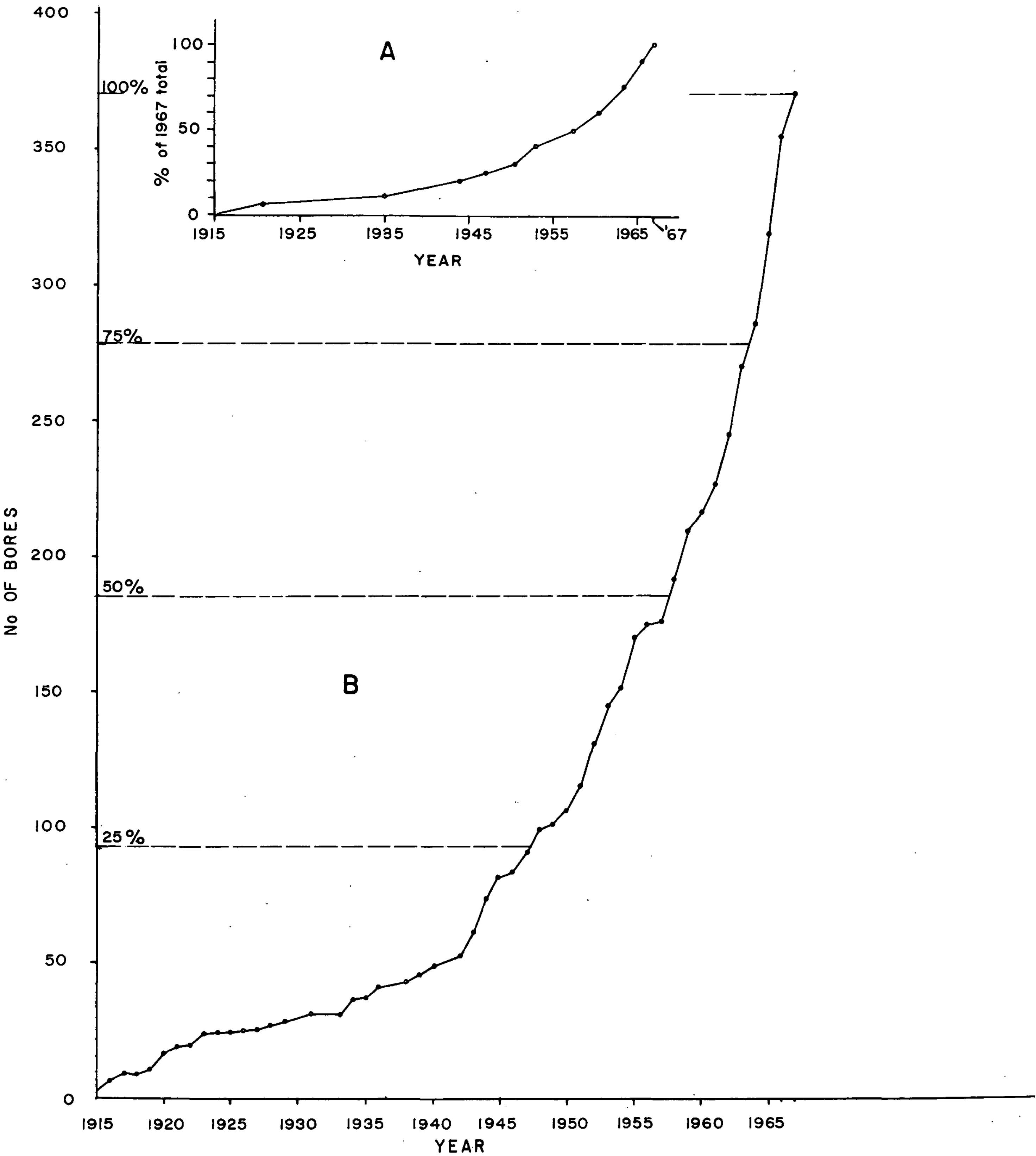

Fig.8 (A) Progressive total of waterbores drilled from 1915 – 1967

(B) Development expressed as a percentage of 1967 total

To accompany Record 1969/16

NT/A276

Table 4 illustrates the density of working bores on selected pastoral properties. Those properties which rely mainly on surface water or are in the early stages of development are not listed.

TABLE 4: Bore density on pastoral holdings

Station	Area (sq.miles)*	No.of working bores**	Area served per bore (sq.miles)
Banka Banka	1280	16	80
Brunchilly	1250	16	78
Camfield	1052	12	88
Eva Downs	1082	14	77
Helen Springs	2082	21	100
Killarney	1097	10	110
Montejinni	1216	8	152
Newcastle Waters	4005	27	150
Ucharonidge	958	7	137
Wave Hill	2000***	24	83

* As shown on the Pastoral Map of the Northern Territory, 1967

** Includes bores lying idle but able to be put in service.

*** The pastoral map indicates the area of Wave Hill (including Cattle Creek) as 6158 sq. miles. However the bores under discussion are concentrated east of the Victoria River and north of latitude 17°50'S, in an area of about 2000 sq. miles.

The highest density is on Eva Downs and Brunchilly stations in the western Barkly Tableland, and other Tableland stations also have a high density of bores compared to most of the others in the west. Newcastle Waters is an exception, which with Montejinni station has the lowest bore density listed. However, Newcastle Waters contains a large tract of unsuitable grazing land west of Lake Woods and if this is excluded the density of bores on the holding is more in keeping with other stations on the Tableland. It is interesting that in the areas of flinders and mitchell grasses on Wave Hill Station the bore density is very close to that of the central and eastern Barkly Tableland - 84 square miles per bore (Randal, 1967).

Table 5 illustrates the linear density of bores between selected points on the major stock routes in the region.

TABLE 5: Density of stock route bores.

Stock Route	Section considered	No.of bores	Average distance between bores
North-south	No.6 Barkly to Banka	5	15
	Banka - 60 miles		
Barkly	Eva Downs to Elliott- 102 miles	8	14½
Murranji	Newcastle Waters to Top Springs - 145 miles	9	18
Dry River	No. 1 to Top Springs - 170 miles	10	19
Wave Hill	Top Springs to Wyalong - 56 miles	5	14
Birdum	No. 1 to 8A Causeway - 150 miles	9	19

Although the better grazing areas in the region have a comparable bore density to that of the well-grassed Barkly Tableland, additional bores will certainly be drilled in them. But it is extremely difficult to predict a trend in the expansion. There are no signs that any of the stations intend to embark on such a programme as occurred on Brunette Downs in the early 1960's when over 70 bores were drilled in three years. The graphs in Figure 8 indicate that development is expanding and even allowing for the distortion caused by construction drilling an increase of at least five pastoral bores per year can be reasonably expected. This is especially so if the pastoral economics warrant the further development of the smaller holdings under individual ownerships. Several pastoralists throughout this region recently have sought technical advice for the selection of bore sites: many sites have been selected by the resident geologists of the Northern Territory Administration, but at the time of writing most had not been drilled.

Very little expansion can be expected in the occurrence of drilling on the existing major stock routes. Since the inception of cattle trucking along improved roads the stock routes are now infrequently used although the bores along them are maintained. The distances between watering points on the major routes are reasonable for walking stock and further development is unlikely. Further drilling could be expected for replacement bores or for bores along newly developed stock routes. Drilling was carried out in 1966/67 along the Auvergne Stock Route to the west of the region.

There are four small towns and two large native settlements in the region obtaining water supplies from groundwater sources. An additional small town is being developed, and a larger one - Katherine - draws most of its requirements from surface water.

At Newcastle Waters (population 91) a bore providing 1440 gph * was drilled to 188 feet in 1934 but the supply dropped back to 600 gph. A new bore was drilled to 328 feet in 1959 but the supply recorded is only 650 gph. But this is presumably adequate for present needs. Daly Waters (population 29) obtains its supply from a bore on the aerodrome. A standby bore on Daly Waters Creek is Birdum Stock Route No. 4A. Little information is available about these bores but the aerodrome bore is engine pumped and the flow is of the order of 1000 gph. Larrimah (population 59) also has an engine pumped town bore. There are many bores in the Larrimah area put down by the Armed Services and the Department of Works. The records are scant and it is difficult to relate them to the bores in use. However one bore described as being near the Police Station recorded 3600 gph and one of the railway bores recorded 1600 gph. The small settlement of Mataranka is served by railway bores. At Wave Hill Settlement (population 109) the police and school bores each provide a supply of the order of 1000 gph, from sediments of the Victoria River Group. Hooker Creek Settlement (population 429) obtains groundwater from the Lower Cambrian Antrim Plateau Volcanics and the Victoria River Group. There are three producing bores at the settlement capable of a total supply of 3700 gph. However the main producing bore (2000 gph) is in a position of high pollution potential and may be taken out of service. Because of this and further development of the settlement additional sites are currently being investigated (Laws, N.T.A. and B.M.R. file notes) .

Katherine (population 1302) obtains its main water supply from the Katherine River, but investigations are under way to supplement it from groundwater. This is mainly to reduce the problem of seasonal high turbidity in the river water. Several bores have been drilled in the alluvium adjacent to the river channel and some high yields - up to 8800 gph - have been obtained at depths of about 30 feet. Although some high yields are recorded from Lower Palaeozoic aquifers in the vicinity of the town the yields are variable, and the quality presumably is not as acceptable for a town supply as that of the water from the alluvium. In addition to the exploratory bores for town water, bores have been drilled in the vicinity of the town for other purposes: 2 bores on the sportsground and bores on nearby experimental farms. The supplies range from 1000-6000 gph, and one bore is reputed to yield 25,000 gph.

Numerous bores have been drilled in the vicinity of Tindall (mainly) and Venn Airfields for reconstruction work and domestic requirements, but it is difficult to estimate what the usage has been. However only the domestic supplies will be a continuing draft on the groundwater reserves.

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* gallons per hour

Considerable development is taking place in the region owing to highway reconstruction, particularly along the Katherine-Top Springs road and most gave yields from 2000-4000 gph. Fourteen bores including four replacements were drilled in 1967 along a 100 mile stretch of the Cape Crawford Road. The bores will be used for watering the gravel subgrade preparatory to sealing, and each will presumably provide the requirements for a ten-mile stretch of road. Assuming a 10 percent moisture content is required for a total of twelve inches of gravel subgrade and a pavement 21 feet wide the water requirement per bore is about 700,000 gallons. This could be met by a bore which yields 2000 gph being pumped for 8 hours a day for 40 days which rates could be supplied by a reasonably good pastoral bore. Further, the total withdrawal per bore is about one-seventh of that considered by Randal (1967) to be the maximum annual withdrawal per bore in the central and eastern Barkly Tableland.* Consequently the main consideration in the development of construction bores is not so much the ability of the groundwater reservoir to withstand the total withdrawal, but rather the finding of an aquifer with sufficient transmissivity to permit the peak withdrawal rate; or if such an aquifer cannot be found can a lesser one be economically used by providing surface storage or additional bores.

The situation with town water supplies is rather similar. Assuming a consumption of 100 gallons per day per person a town bore serving 50 people withdraws 1.8×10^6 gallons per year which is less than most pastoral bores. On the other hand, unlike the case of construction bores, the withdrawal by town bores is a permanent feature of the groundwater budget. Although overdevelopment is locally possible, particularly in agricultural areas, it is not regionally important at this stage.

Collection and Reliability of Data

The known hydrological data on over 500 waterbores is presented in Appendix 1. The information has come from drillers' logs as recorded in station records and in the files of the Water Resources Branch of the Northern Territory Administration. Many of the bore logs are incomplete and for some bores on information whatever can be found. Also there are some records referring to bores which can no longer be located on the ground. Most of the bore logs record the depth of the bore, but less than half record the depths of the various aquifers: a little more than half record the depth of the standing water level. About three-quarters of the logs record the supply but frequently it is an estimate only or is the limit of the equipment used to test the bore on completion. Despite the limitations of the bore logs it has been possible to identify with reasonable certainty the producing formation or unit for about three-quarters of the bores. This aspect is discussed in some detail in the section on aquifers (p. 43).

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* Experience in that region shows that many engine pumps operate continuously for 2 days per week at about 2000 gallons per hour i.e. they withdraw about 5×10^6 gallons per year.

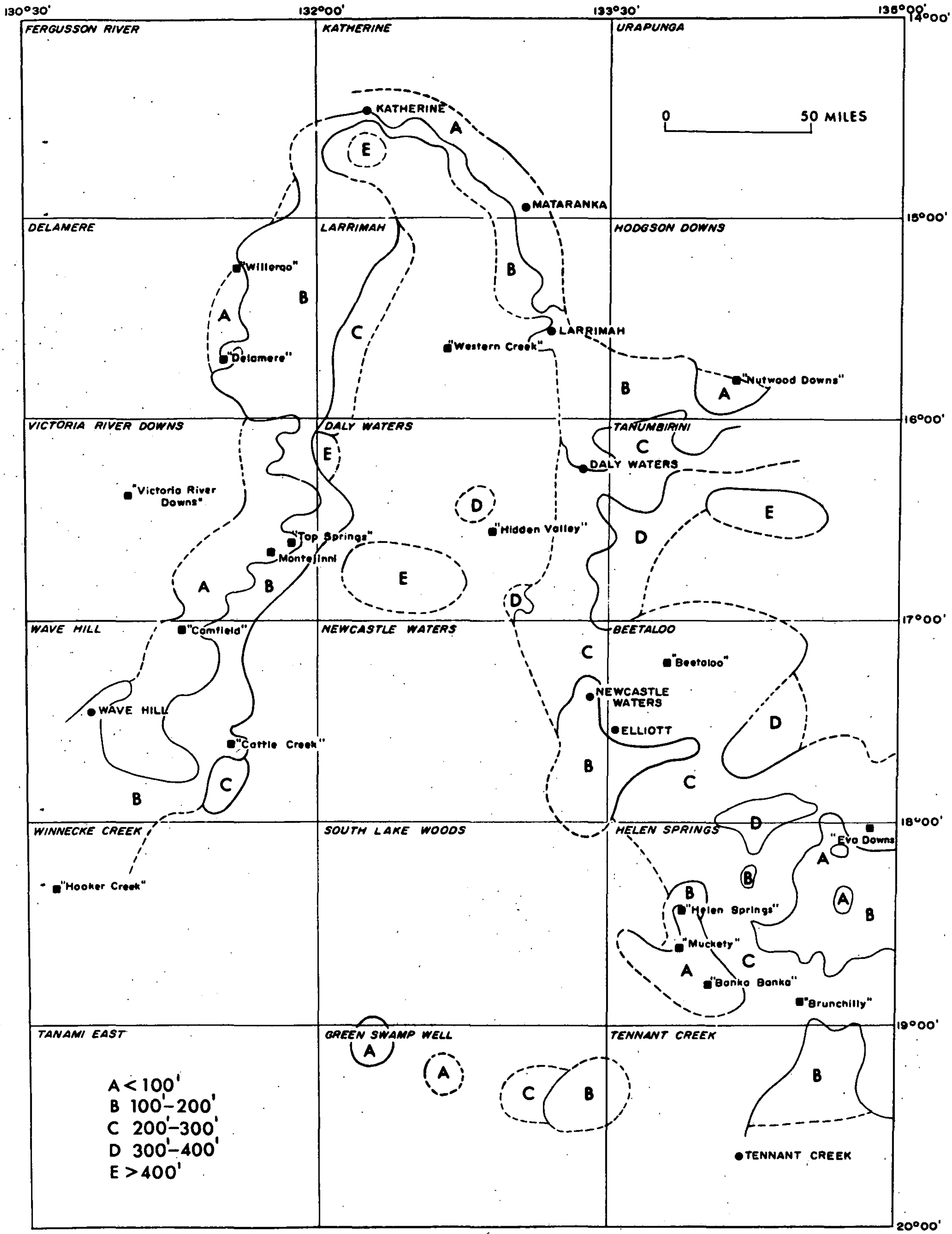

Fig. 9 Zones of depth to groundwater

To accompany Record 1969/16

NT/A 277

The information obtained from the records was usefully supplemented by scouthole drilling by the Bureau of Mineral Resources in 1965 and 1966: during this work 22 holes were drilled and nine of them obtained water. Data on these bores are presented in Appendix 4. In addition several construction and pastoral bores were drilled and completed during the 1966 survey and the author was able to obtain at first hand the relevant data from them.

Surface elevations have been obtained by barometric traverses tied to a network of third order instrument levelled benchmarks erected by the Department of the Interior. The benchmarks are along most of the major and secondary roads, and some - particularly from Wave Hill to Powell Creek - are across country. The barometric traverses were carried out concurrently with the helicopter gravity survey during which stations were erected at a density of approximately one per 50 square miles i.e. on a seven mile grid. Additional carborne barometric traverses were carried out during the 1965 and 1966 geological surveys. The contours shown on Plate 1 have been obtained from the barometric and instrument levelled heights: the elevations and their positions are shown on most of the published and preliminary geological maps of the 1:250,000 Sheet areas contained within this region. The elevations of the bores are listed in Appendix 1.

Borewaters for analysis were collected in 1965 and 1966 under the same general conditions as outlined in Randal (1967, p. 34): one hundred and sixty-eight samples were analysed by the Australian Mineral Development Laboratories in Adelaide. In addition to the concentration of the major anions and cations, several trace constituents were also determined as well as total dissolved solids, conductivity, and pH. An additional 42 analyses were obtained from station records and files but some of these are incomplete or are suspect. The latter are analyses which show a gross anion-cation imbalance although determined values for all major anions and cations were reported. They cannot be used for classifying the groundwater type nor can they safely be used for calculating ionic ratios, but the determined total dissolved solids can be regarded as a reasonable estimate of the salinity. The chemical analyses are presented in Appendices 2 and 3. Chemical analyses were also obtained for samples from several of the B.M.R. scoutholes and these are presented in Appendices 5 and 6.

OCCURRENCE

Aquifers

Groundwater is available throughout this region at varying depths from aquifers ranging in age from Precambrian to Tertiary. However there is a marked variation in the availability of groundwater owing to the strong geological control on its occurrence caused by the variations of the rock types, their physical properties, and the structure (Fig. 9). In areas of volcanics the incidence of failures and poor supplies is high, and in others good supplies are assured virtually at any site selected. The density of bores in many areas, particularly in the central south, is extremely low and hence few inferences can be made about the groundwater regime in large parts of the region. The occurrence of flat-lying Mesozoic rocks over the northern and northeastern part of the Plateau has a marked effect on the depth to aquifers: the Mesozoic rocks generally are poor prospects and hence aquifers in the underlying sequences have a considerable overburden of unproductive rocks.

Precambrian aquifers

Groundwater has been obtained in varying amounts from most of the Precambrian sequences in the region, but only the Tomkinson Creek Beds and briefly the Victoria River Group will be considered in this report.

The Tomkinson Creek Beds form the strike ridges and dissected plateaux of the Ashburton and Whittington Range, and hence, because the ranges are generally inferior grazing land and also contain some large waterholes, there are far fewer bores in this unit than in the others. Many bores within the ranges are shallow ones drawing supplies from outliers of younger sequences.

Several bores on Banka Banka station obtained supplies from this unit - notably Nos. 14, 15, 16, and the homestead bore. Both 14 and 16 have been abandoned because of failing supply and poor quality water. The bore-logs support the inferences drawn from the evidence of wells and springs that groundwater is available at shallow depths. Bores commenced in the Tomkinson Creek Beds have obtained supplies at depths less than 110 feet, others have drilled through unproductive Cambrian sediments and have obtained water in the older rocks at depths between 200 and 300 feet. An exception is Muckety No. 1 which although commenced in the Tomkinson Creek Beds, was drilled to 220 feet before water was obtained; but the standing water level of 90 feet suggests the groundwater regime is a shallow one. At the northern end of the Ashburton Range conditions seem somewhat different. Newcastle Waters station bore and two bores at the township obtained mediocre supplies apparently in this unit at depths of about 170 feet and the water rose but a few feet. One of the township bores was deepened to over 300 feet but there was no improvement in the supply. In the central part of the range at Renner Springs, a stock route bore was drilled to over 500 feet but only a small supply of brackish water was obtained at 65 feet.

Drillers' logs for bores in the Tomkinson Creek Beds are inadequate for determining the essential geological control on groundwater occurrence, and an appraisal can only be made on the basis of surficial rock types and structure. Although the Tomkinson Creek Beds contain considerable amounts of sandstone, the permeability and storage characteristics of the unit are probably controlled by fracturing. Very few friable quartz sandstones have been seen in outcrop: most sandstones have an argillaceous or siliceous cement which has effectively reduced their porosity. The rocks are tough and extremely hard and are difficult to drill. Although the development of a regional aquifer system was possible because of interbedded sandstone, siltstone, and carbonate rocks in the sequence, this has not happened -

mainly because the continuity of potential aquifers has been broken by the folding and block faulting. Probably the groundwater regime consists of small independent basins with local recharge areas and fairly shallow potentiometric surfaces. The depth to water is probably largely controlled by the incidence of joints, and fractures along fault zones and fold axes. Except along the crests of anticlines and fault zones considerable closing up of openings can be expected at depth, and even with these secondary silicification may severely restrict storage. Although carbonate - mainly dolomite - and leached carbonate rocks are known in the sequence they probably are neither thick enough nor sufficiently continuous for cavities and fissure openings to have developed to a large degree. However heavily weathered carbonate rocks close to local recharge areas may provide small supplies. A possible example is Ladabah Bore on the floodout of Tomkinson Creek where the drillers log records 700 gph from 70 feet in limestone beneath sand and clay. Probably the highest potential for the unit is the development of shallow bores along major faults and lineaments: Banka Banka homestead bore, from which 1500 gph are obtained from several aquifers between 14 and 70 feet in rocks described as hard sandstone and quartzite, is alongside a zone of major faulting.

Because of the probable shallow groundwater conditions, geomorphological situations may markedly influence the groundwater storage. Bore-sites along major streams, and in alluviated plains bounded by elevated country and with constricted outlets for the surface drainage may be productive. However the latter type in this arid climate may produce salty water.

Although most bores which withdraw water from the Victoria River Group occur to the west of this region, the unit is important as within the region it underlies the Antrim Plateau Volcanics. A number of bores have drilled through apparently unproductive volcanics to successfully obtain water in the older rocks. Hooker Creek No. 8 is an example: it was drilled through 180 feet of basalt and 120 feet of alternating shale, basalt, and limestone overlying a limestone sandstone sequence to 330 feet with mediocre supplies being obtained at 106 and 123 feet. On further drilling a supply of 2000 gph was obtained at 317 feet in the Victoria River Group. Similarly bores on Wave Hill, Delamere, and Victoria River Downs have successfully obtained water in the older rocks beneath the basalt. Wave Hill "WR" bore commenced in basalt and unsuccessfully penetrated 205 feet of volcanics before entering sediments of the Victoria River Group from which it obtained 1650 gph at 285 feet. Also, No. 48 bore on the Wave Hill Stock Route obtained mediocre supplies at 32 feet, and at 232 feet - the base of the basalt. Below this the bore penetrated sediments of the Victoria River Group and obtained water at 250 feet, but the main supply came from 321 feet. Two bores on Camfield Station - homestead bore and Rara bore - are obtaining supplies from sandstone beneath the basalt. At the house bore particularly, the thickness of sandstone penetrated beneath the basalt is many times that of the sedimentary interbeds normally encountered within the basalt, and its description 'hard and soft sandstone - mainly pink' is more aptly applied to the Victoria River Group, but the interpretation is not conclusive.

On the other hand drilling through the basalt to obtain water from the Victoria River Group may not necessarily be an economic proposition. The basalt is extremely difficult to drill and in some areas is several hundred feet thick. Furthermore the results of drilling deeper may be extremely disappointing. Wave Hill No. 24 bore was drilled to 744 feet in an area (west of the homestead) where the volcanics are less than a few hundred feet thick: it was unsuccessful. WS bore (4 miles south of the homestead) drilled 167 feet of basalt and continued unsuccessfully to 900 feet in the Victoria River Group. WQ bore obtained 100 gph at the base of superficial deposits over basalt, 400 gph at 327 feet in the basalt, and 3600 gph in the Victoria River Group, but it was abandoned owing to high salinity. Similarly one of the test bores for the new Wave Hill homestead site was drilled 1144 feet into the Victoria River Group and at 1025 feet obtained a mere 180 gph of water containing nearly 2000 ppm of chloride ion. Hays (in Barclay & Hays, 1965) investigated the groundwater associated with the Victoria River Group on Victoria River Downs Station and his observations are pertinent: not only are arenaceous beds beneath the basalt better producers than argillaceous rocks in similar positions but also in the arenaceous beds the availability of water is dependent more on open bedding-planes and joints than on grainsize. Hays also highlights the importance of bore position in relation to recharge. He noted that where bores were positioned down-dip from the probable main recharge area yields were high, but if they were up-dip from the recharge area yields were low.

Lower Cambrian aquifers

Lower Cambrian volcanic sequences provide groundwater in the western, northeastern, and southeastern parts of the region. "ND" bore on Nutwood Downs Station obtains 2000 gph from an unknown aquifer which may be the Lower Cambrian Bukalara Sandstone beneath the Nutwood Downs Volcanics, but this has not been established.

The Antrim Plateau Volcanics in the western part of the region contain aquifers in a large area from Hooker Creek Settlement in the south to beyond Willeroo homestead in the north, but difficult hydrogeological conditions in the unit have resulted in a high percentage of unsuccessful bores. As indicated in Figures 9 and 17 the groundwater regime in this unit is essentially a shallow one. The depths of the aquifers are generally less than 200 feet and frequently less than 100 feet below ground surface. Also the potentiometric surface is generally less than 100 feet below groundsurface. In many areas the potentiometric surface is less than 50 feet below ground surface particularly on Wave Hill and Camfield Stations and in large parts of Killarney and Delamere Stations.

Bores deeper than 100 feet and drawing supplies from this unit appear to occur in three main situations. The first is in the northwestern part of the Main Plateau where locally the Mesozoic and Cambrian rocks either are above the water table or do not contain exploitable aquifers. Their thicknesses are relatively low but they combine to cause a substantial amount of non-productive drilling before the aquifers in the Volcanics are reached. In this situation the standing water level may or may not be above the disconformity at the top of the Volcanics. The second situation is that where bores have been positioned on elevated basalt plains at considerable heights above the main local recharge areas - i.e. the valleys of the major watercourses. These bores are readily identified from the map and Appendix 1 - they commence in the Volcanics and both the depth to water and the standing water level are well below the ground level. Both these situations can be readily recognised for future bore-sites and can be either accepted or avoided as the circumstances determine. But the third situation is rather more difficult to assess on present knowledge. The ability to obtain water from the Volcanics is largely dependent on bore intersections with open bedding planes, joints, and fractures not only of sufficient size and interconnexion to contain and transmit water, but also beneath the zone of saturation. As stated earlier this appears to happen at fairly shallow depths over much of the outcrop area of the volcanics but it is not universal. The number of abandoned holes on Wave Hill Station alone is evidence enough, and Table 6 illustrates that too early cessation of drilling was not entirely responsible for the failures.

TABLE 6: Bores at Wave Hill homestead

Regd. No.	Depth (feet)	Standing Water Level (feet)	Supply gals/hr.
818	62	30	300
819	219	26	300
820	45	30	900
846	60	-	DRY
847	60	-	DRY
848	65	-	40-160

Clearly the top of the zone of saturation at the homestead is at a shallow depth and even allowing for small variations in elevation at the sites all bores penetrated it. No. 820 obviously intersected a zone of highly fractured or jointed rocks with a high transmissivity, but the results of Nos. 818 and 819 suggest less fracturing or fewer joints. The results of the other three holes indicate the formation was extremely tight. Although the records of No. 819 are not sufficiently specific they do suggest that the openings in the rock are fewer at depth and no improvement in the supply was obtained by drilling a deep hole. To some extent the experience of this hole justified the pastoralist's reluctance to drill the last three holes to a greater depth. On the other hand the chance of intersection with many openings is obviously greater for a higher amount of penetration, but obviously there must be a point where this advantage is lost owing to closing up of the joint and fracture system. Figure 10 illustrates eight bores in which deepening the hole greatly improved the supply. These bores were drilled solely in volcanics i.e. they commenced and terminated in them. Most of them occur in the northern part of the outcrop area of the volcanics, but this situation cannot be related to geographical position. The bore-records simply are not detailed enough to exclude its possible occurrence in the southern part. Further, there are instances in the north in which the deepening of bores was not successful: a bore a few miles south of Killarney homestead obtained 150 gph at 38 feet and was drilled to 593 feet without improving the supply.

Considerable information has been obtained in recent years from bore-site investigations (Barclay & Hays, op. cit; J.W. Shields, N.T.A. pers. comm.) and regional mapping (Randal & Brown 1967) to suggest that the groundwater regime is controlled not only by fracturing and jointing, but that there may be important stratigraphic control. Chert lenses, limestone lenses, and sub-aerial and sub-aqueous sandstone interbeds are widespread in the volcanics. And the basalt itself is made up of several overlapping flows of variable thickness. In the zones between flows the basalt is vesicular, ashy, and brecciated. The chert lenses are frequently brecciated and vuggy with very large openings. The chert and limestone both are jointed, and, though massive in outcrop, are laminated and contain widely spaced open bedding planes. Suitably situated they would be aquifers although the transmissivity would be very variable. The physical characteristics of the interbedded sandstones are ideal for containing and transmitting water; however the upper contact with the basalt is indurated and recrystallized to a tightly bonded rock with low permeability and hence these rocks would need to be broken by joint systems before they could acquire recharge. Jointing is developed in them but it is variable.

The basalt in the main part of the flows is well crystallized and compact, and has a low permeability; hence the zone between successive flows may act as an aquifer under confined conditions, and depending on the areal dimensions of the flow it may be of local or regional extent. Similarly the interbedded sediments may contain groundwater under confined conditions and depending on their size and continuity may be of local or regional significance. The occurrence of standing water levels which are higher than zones of unconfined water in the same bore certainly suggest recharge from different sources. These aspects are discussed further in the section on hydrodynamics. Figure 11 illustrates different situations of the groundwater regime in the Volcanics. Figure 12 illustrates interpretations of waterbore logs.

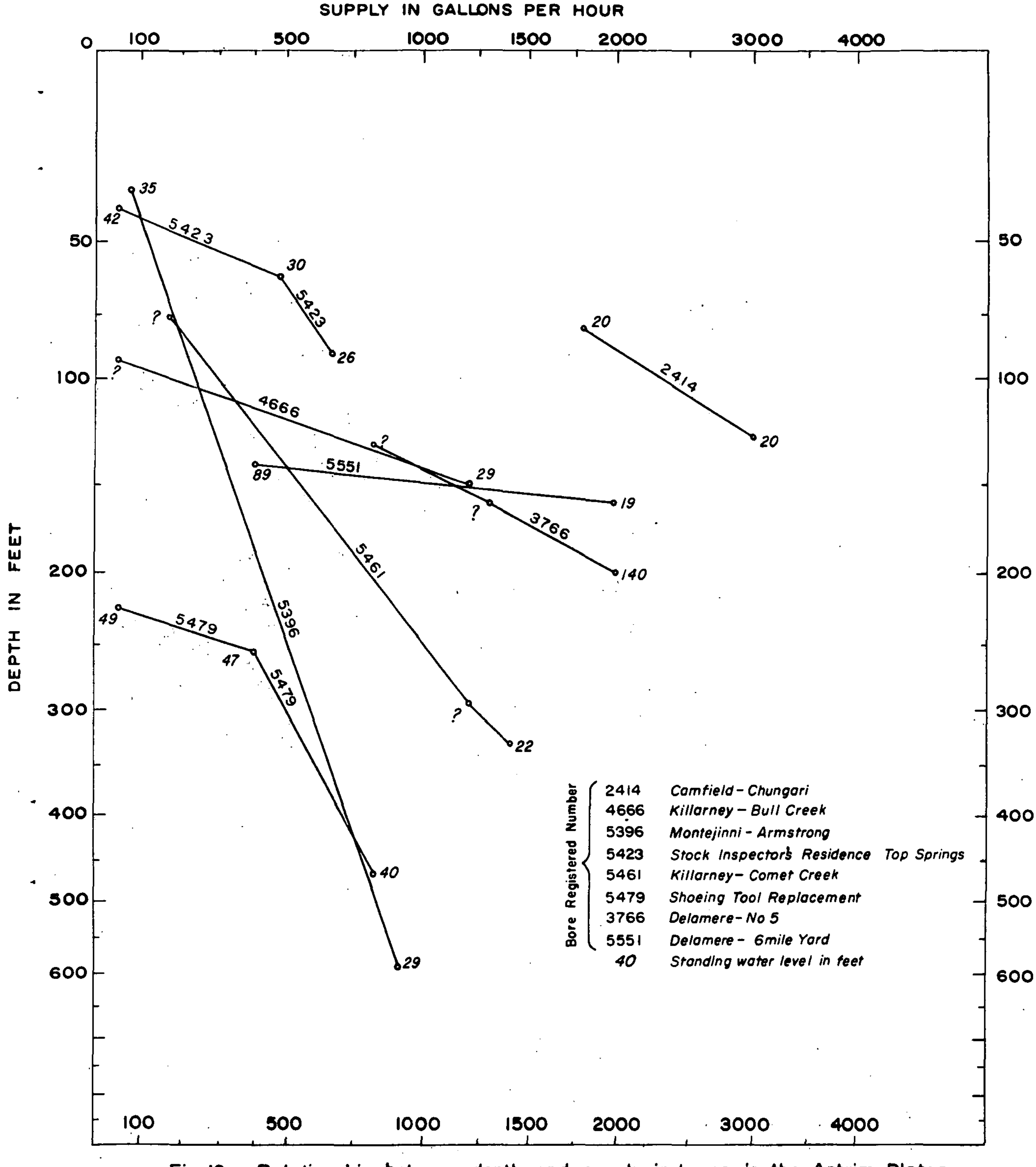

Fig.10 Relationship between depth and supply in bores in the Antrim Plateau Volcanics

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To accompany Record 1969/16

PROGNOSES OF BORES

(Reference to Figure 11).

1. On penetration of bore to upper interflow zone water will rise to level of potentiometric profile originating at zone B. On further penetration to deep interflow zone supply will be increased and static water level will lie at profile originating from recharge zone B.

2. Water will be obtained from interflow zone and static level will be at the lower profile. Unless both bores 1 and 2 are well documented as regards aquifer zones and their individual standing water levels, an incorrect assessment on the direction of slope of the potentiometric surface is inevitable.

3. Dry hole: interflow zone is above potentiometric surface and bore does not intersect joints. Deepening to next interflow zone required.

4. Situation where supply can be improved by deepening to intersect as many joints as possible.

5. Upper interflow zone produces unconfined water as bore intersects aquifer at same elevation as potentiometric surface. On deepening as shown, supply will be improved because of greater penetration of aquifer but standing water level remains the same.

6. Dry hole despite penetration beyond level of potentiometric surface.

7. Situation where bore may be subject to failing supply as dry season progresses. As potentiometric surface is lowered with time the bore intersects fewer joints with adequate storage. Date from bores 5 and 8 would give some indication of the relative positions of the sandstone and the potentiometric surface below this hole and hence indicate if deepening is worthwhile.

8. No water obtained at boundary between formations. Water from first interflow zone stands at level for recharge zone C, but on deepening water from lowermost interflow zone stands at level for recharge zone A which is final static level in bore. Sandstone interbed is dry as it is above potentiometric level relevant to that system.

9. Water obtained at formation boundary stands at level relevant to recharge zone C. Volcanics to total depth of penetration are dry.

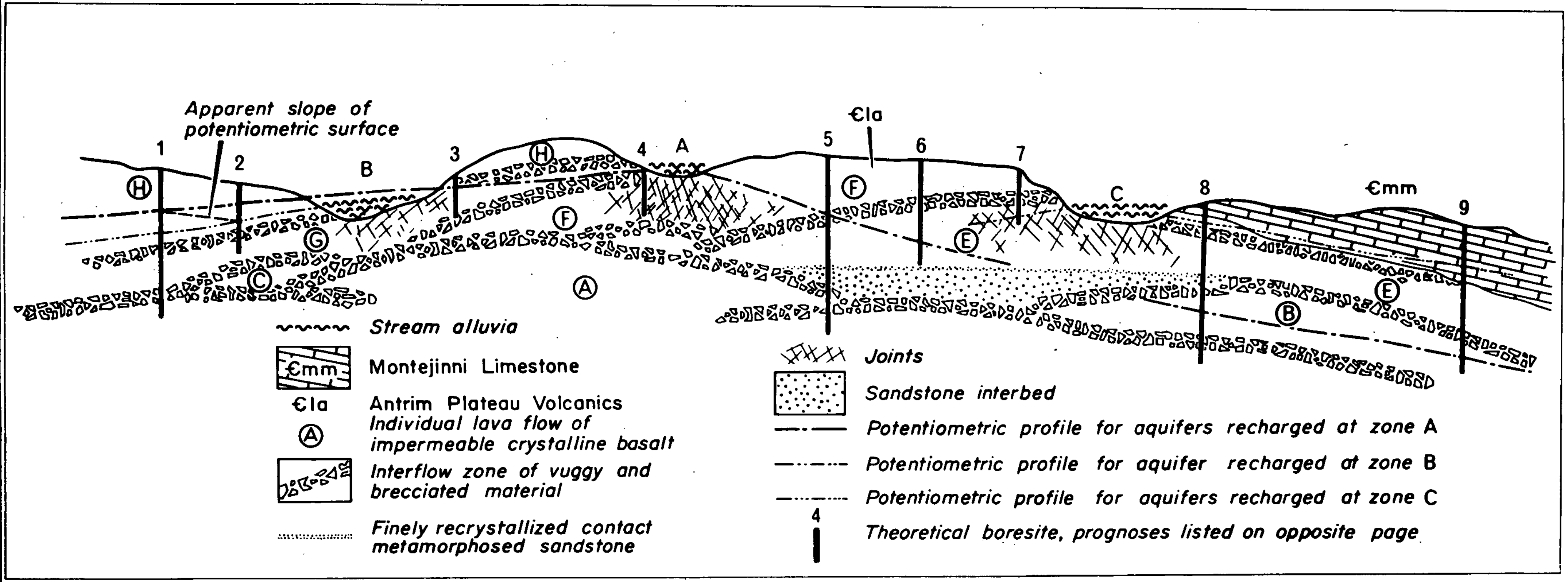

Fig. 11 Groundwater regime of the Antrim Plateau Volcanics

To accompany Record 1969/16

NT/A 279

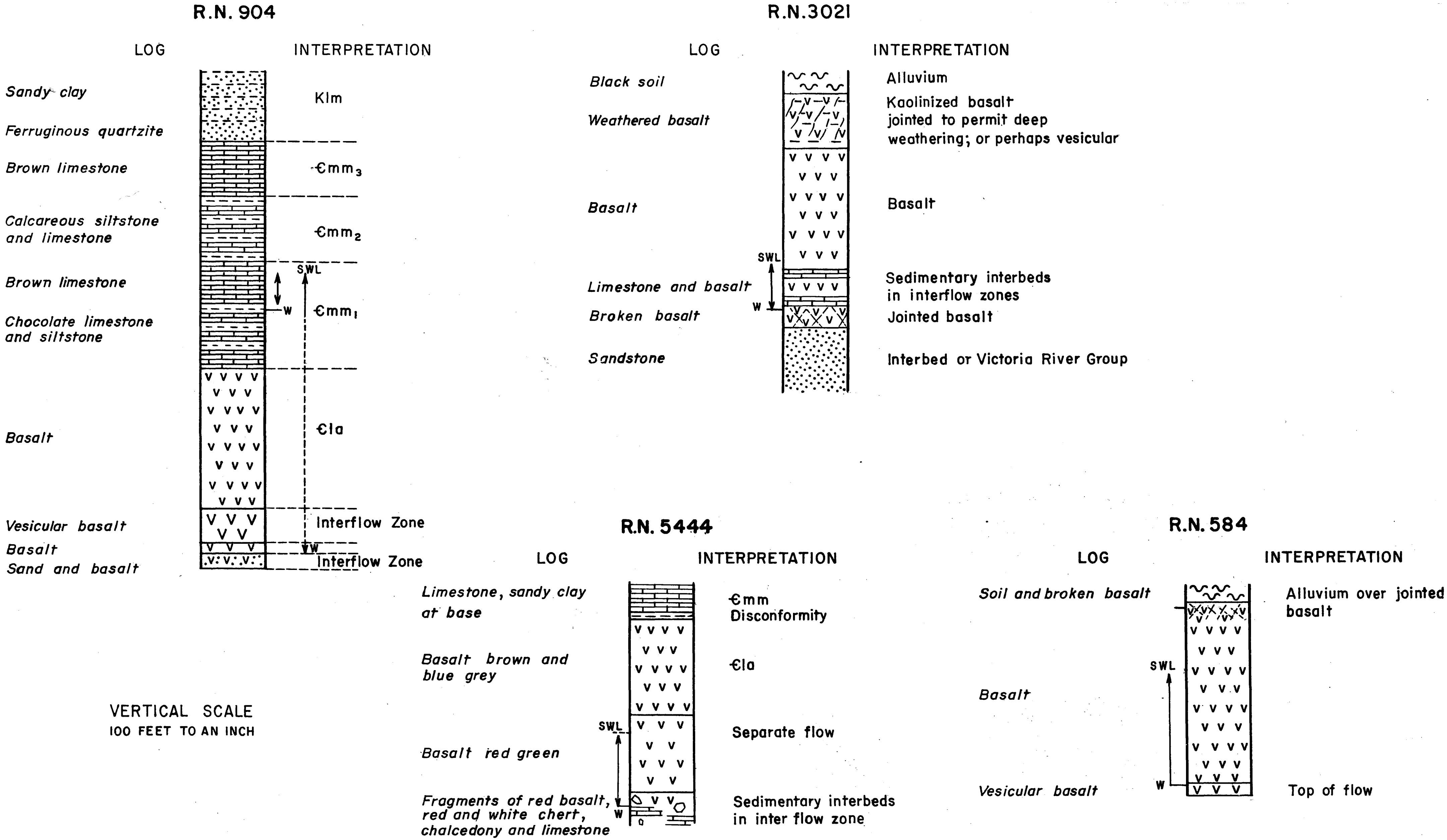

FIG. 12 INTERPRETATION OF LOGS OF WATERBORES IN THE ANTRIM PLATEAU VOLCANICS

To accompany Record 1969/16

Although the disconformity zone between the Antrim Plateau Volcanics and the Middle Cambrian carbonate rocks is not necessarily the top of a flow, it is in places highly permeable owing to ancient weathering and the accumulation of debris which is now partially compacted and forms the basal few feet of the carbonate sequence. Several bores obtain their main supplies in this zone.

The results of waterbore drilling in the Lower Cambrian Nutwood Downs Volcanics - a probable correlate of the Antrim Plateau Volcanics - have been extremely disappointing. Although the sequence contains lavas and interbedded sediments several holes drilled into it were unsuccessful. Three holes were abandoned owing to hard drilling in the volcanics. Nutwood Downs Nos. 2, 8 and "NA" obtained reasonable supplies in sandstone but the regional geology suggests the aquifers may be in the Precambrian Roper Group. Bore "ND" obtained 2000 gph in a sandstone underlying 340 feet of basalt. This may be an interbed within the volcanics but the regional geology suggests it is more likely the Bukalara Sandstone. The drill terminated in the sandstone after penetrating 25 feet of it.

The Helen Springs Volcanics - also a correlate of the Antrim Plateau Volcanics - has been successfully drilled both within and on the eastern flanks of the Ashburton Range. As with the volcanics to the west, groundwater is contained in joints, fractures, and porous zones in vesicular and ashy lavas. The incidence of interbedded sedimentary rocks is not as high as in the Antrim Plateau Volcanics, but a friable and jointed sandstone member at the base of the sequence is extremely porous and permeable, and wherever it occurs beneath the watertable it yields ample supplies of water. The bore records are not sufficiently detailed to evaluate the relative abundance of the various hydrogeological situations within this unit. The volcanics are deeply weathered and lateritized: the importance of these effects on supply and recharge are discussed later.

Middle Cambrian aquifers

Groundwater is obtained from Middle Cambrian rocks over most of the Main Plateau, and in the terrace on the western flanks. Middle Cambrian rocks contain groundwater also in the Daly River Basin to the north of the Plateau. The main producing formations are the Tindall Limestone in the Daly River Basin and in the northern environs of the Barkly Tableland, the Montejinni Limestone in the central western part of the Plateau, the Anthony Lagoon Beds in the Barkly Tableland, and the Merrina Beds in the central southern part of the Plateau. It is not known if any producing bores are obtaining groundwater from the Gum Ridge Formation which crops out in the Barkly Tableland and the Ashburton Range, but a bore on the South Barkly Stock Route was tested at 1000 gph from rocks believed to be part of that formation. The Middle Cambrian units are mainly carbonate sequences and most of the producing bores are obtaining water from cavities, joints, and fissures in them, although sandstone and siltstone interbeds are known and may be important hydrogeologically.

Groundwater is also produced from the base of some of these sequences at the unconformity with underlying units and also at the upper unconformity with the overlying Mullaman Beds.

The <u>Tindall Limestone</u> is a massive well jointed limestone, with dolomitic patches and interbeds, which in outcrop forms fluted Karst pinnacles and blocks with large open bedding planes. It is extremely cavernous. It is frequently a mottled two-tone limestone and in exposures in watercourses the lighter material - of coarser recrystallized calcite - has been dissolved thus producing a honeycombed rock with high storage capacity. The unit is the main producing aquifer in the southern part of the Daly River Basin, along the country bordering the Stuart Highway as far south as Daly Waters, and in the northern environs of the Barkly Tableland between the headwaters of the Hodgson River and the Daly Waters - Borroloola Road. The drillers' and geologists' logs of the waterbores suggest that the groundwater occurs in the unit in a variety of situations (Figs. 13,). Although no regional aquifer resulting from stratigraphic control has been recognized within the unit there is evidence that lithological control is important at least locally. Bore CCA on the Daly Waters-Borroloola Road obtained water at the junction between siltstone and underlying limestone, and Bore CCC, twenty miles to the east obtains its supply from a calcarenite bed between beds of calcilutite. Similarly many of the bores in the Katherine area obtain water from interbeds of different texture or composition to that of the enclosing rocks. But the main control on the groundwater regime is the occurrence of joints, fractures, cavities, and debris within the larger cavities. A bore on the Katherine Showground obtained good supplies at 78 and 80 feet after entering a cavity at 76 feet, and Birdum Stock Route No. 5 obtains water from a zone described by the driller as "broken limestone and caves". The producing zone for Birdum Stock Route No. 1 has been described as "limestone gravel and buff clay" and for an old Army bore north of Gorry as "medium gravel limestone and quartz pebbles": this type of zone is interpreted as a sink-hole fill of weathered or collapsed debris.

The groundwater regime of the Tindall Limestone is in its outcrop areas essentially a shallow one. On the northern flanks of the Main Plateau, aquifers in this unit are generally less than 100 feet deep and the potentiometric surface is correspondingly shallow. The groundwater normally is confined even in the shallow zone. Further south the depth to the groundwater increases markedly, and this can be related to the cover of flat-lying normally unproductive Lower Cretaceous rocks which overlie the limestone. Good water-producing zones may occur at the unconformity between the units but if it is not, experience shows that the Tindall Limestone needs to be penetrated usually for the best part of 100 feet before adequate supplies are obtained. The effects of the Lower Cretaceous rocks are discussed under aquifers of that age.

The <u>Montejinni Limestone</u> is the main producing aquifer in the western part of the Main Plateau and in its immediate western flanks. As discussed earlier (p.21) this unit is in part a correlate of the Tindall Limestone and it is not known precisely how far eastward it extends. [illegible] Hence aquifers referred to the Tindall Limestone in the central part of the region may actually be within the Montejinni Limestone.

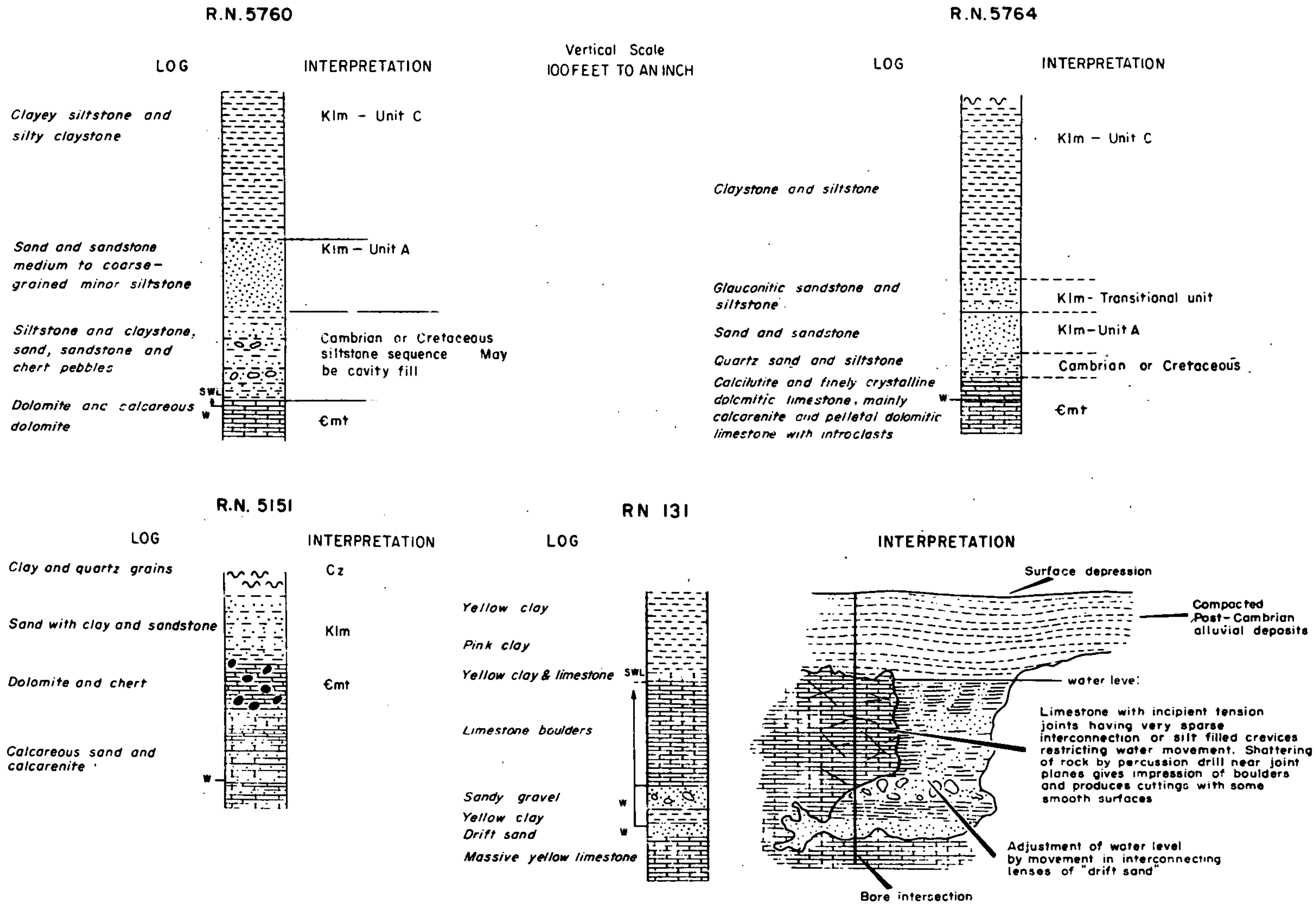

FIG. 13 INTERPRETATION OF LOGS OF WATERBORES IN THE TINDALL LIMESTONE

To accompany Record 1969/16

NT/A 281

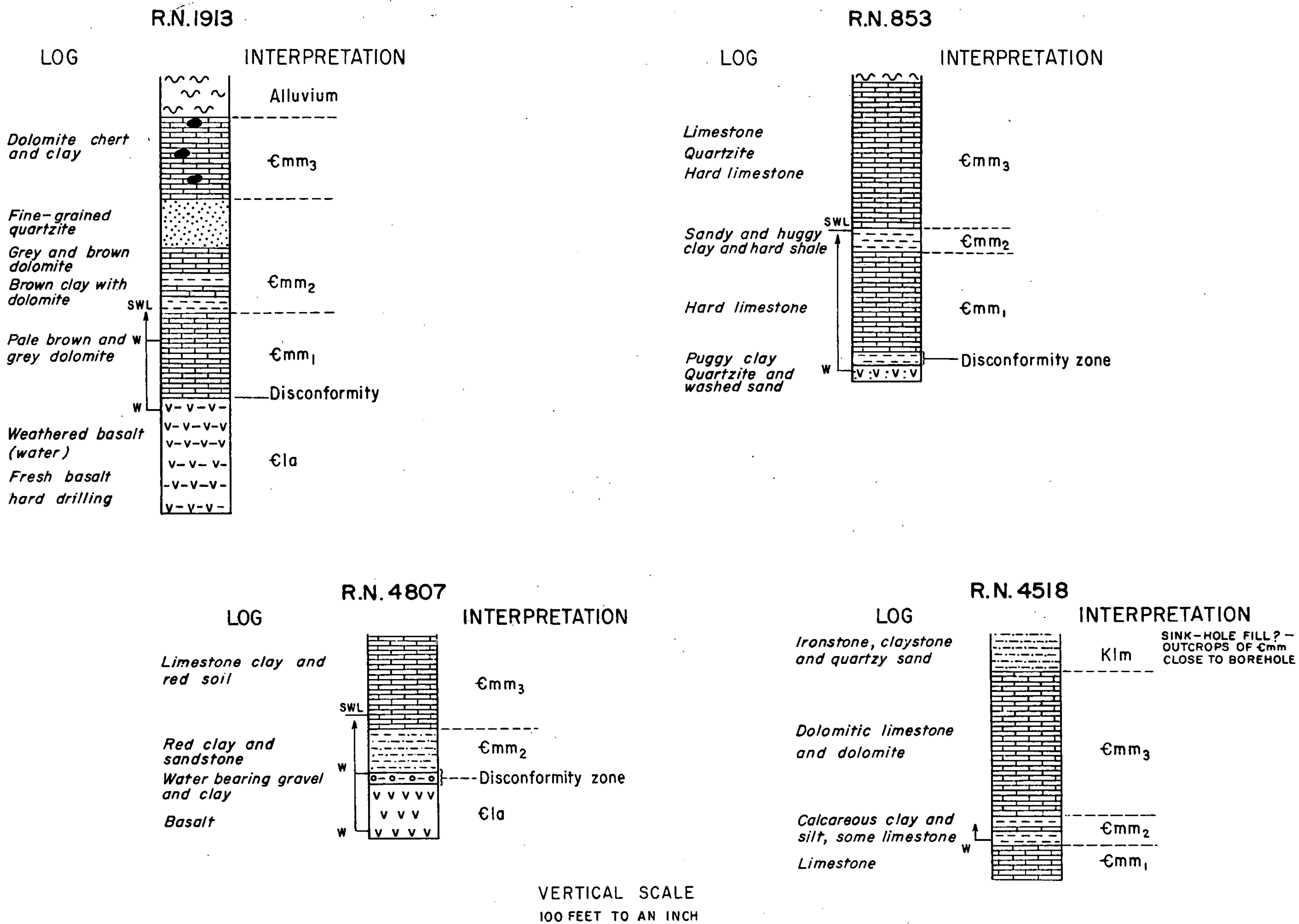

FIG. 14 INTERPRETATION OF LOGS FROM BORES IN THE MONTEJINNI LIMESTONE

To accompany Record 1969/16

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The occurrence of groundwater in the Montejinni Limestone is controlled by similar situations to that in the Tindall Limestone - viz joints, fissures, cavities, and some lithological control (Fig. 14). Probably there are strong regional effects caused by the middle mudstone unit within the formation, but the drillers' logs of bores are not specific enough to evaluate what these effects may be. The present knowledge suggests that water is available best from the bottom unit, reasonably well from certain parts of the middle unit, and least likely from the upper unit of the formation. However as the formation is flat-lying or nearly so this observation may merely be a reflection of the relative positions of the units to the watertable: clearly the highest stratigraphic unit is the least likely to occur below the watertable, particularly in the outcrop areas of the unit. Monster Bore on Killarney Station commenced in the upper limestone unit of the formation and obtained its water near the base of the middle mudstone unit, but the main supply came from the underlying basalt. Dry River Stock Route No. 5 commenced in the Lower Cretaceous sediments and penetrated all three units of the Montejinni Limestone. It obtained an unknown supply at 182 feet in the lower limestone unit but it was deepened and also obtained its main supply from the underlying volcanics. Birrimba homestead bore commenced in the upper unit and drilled through the middle unit into the lower one, obtaining its supply in the middle unit near its base. No. 9 Dry River Stock Route (Charlie's Hole) commenced in the lower unit and obtains an excellent supply from that unit at 73 feet. A bore drilled along the new road alignment from Willeroo to Top Springs (R.N. 5578) commenced in the Lower Cretaceous rocks and obtained its main supply at the base of the upper unit of the Montejinni Limestone. Bauhinia bore on Killarney station commenced in the upper unit and the log records the aquifer at 29 feet although the hole is 60 feet deep: if no other aquifer was encountered below 29 feet then the main supply is in the upper unit. Although the driller's log records only limestone this hole would certainly have intersected the middle mudstone unit at about 40-50 feet as evidenced by a gully section a few miles to the south.

The Anthony Lagoon Beds contain the prolific aquifers of the central and western Barkly Tableland (Randal, 1967), and its northern environs. As discussed in the chapter on geology this unit and the Tindall Limestone are in part correlates and although the cuttings from bores along the western part of the Cape Crawford Road are recognizably Tindall Limestone, cuttings from those along the eastern part more closely resemble the rock types of the Anthony Lagoon Beds. It appears that bores which unsuccessfully penetrated the Lower Cretaceous rocks in the Beetaloo Sheet area to the south of this road are obtaining supplies from the Anthony Lagoon Beds.

Generally the groundwater regime of the Anthony Lagoon Beds is considerably deeper than that of the Tindall and Montejinni Limestones. Over much of the outcrop area of the unit bores must be drilled 200-300 feet before encountering adequate supplies of groundwater, and the depth to the potentiometric surface is correspondingly greater. However about the northern extension of Attack Creek and eastward from it groundwater is usually obtained less than 200 feet below ground level.

The area corresponds to a similar one to the east on the adjoining Brunette Downs Sheet area, and it is presumably related to the topographic depression which contains the floodout areas of Attack Creek (northern extension), Brunchilly Creek, and the south-flowing creeks which rise to the north of Eva Downs homestead.

Much evidence for the general groundwater environment in the Anthony Lagoon Beds has come from the adjoining part of the Barkly Tableland where it is the main groundwater producer (Randal, 1967), because in the western tableland there is very little coherent and unaltered outcrop of the unit on which to assess those physical characteristics of the rocks which are hydrogeologically important. Furthermore, drillers' logs of strata from bores in this part of the tableland are few and are grossly misleading. However additional information was obtained from a few scoutholes drilled by the Bureau of Mineral Resources in 1965. The occurrence of groundwater in the unit is - as in the other carbonate formations - controlled by the incidence of cavities, joints, and zones of fracturing, but there is some evidence of strong lithological control.

Cuttings from some waterbores and from the scoutholes indicate more sandstone and siltstone interbeds in the carbonate sequence than is apparent from surface mapping. And some of these interbeds, particularly the sandstones, would be good aquifers wherever they occur beneath the watertable. The sandstones, though fine-grained, are clean and well sorted, and commonly are porous and friable. Variations in texture of the carbonate rocks also are of importance. In scouthole B1 dolomite and limestone both had a pelletal texture, but whereas the pore spaces were incompletely filled in the dolomite, they were completely filled with calcite cement in the limestones. Sandy limestones of variable textures have also been recorded from the scoutholes. Both the dolomites and the limestones contain vughs but they are more widespread in the dolomites or dolomitic rocks.

Groundwater in the Anthony Lagoon Beds normally is in confined conditions.

In the central and southern parts of the Main Plateau west of the Ashburton Range groundwater is available from the Merrina Beds. But only in the central part of the Wiso Basin - along the line of scoutholes in the Green Swamp Well Sheet area - can the aquifer be unequivocally referred to this unit. The Merrina Beds, as discussed previously, may extend as far north as the Murranji Track and eastward to the region about Lake Woods, but the description of strata in the bore-logs is generally not specific enough for any degree of certainty: in most there is no clearly defined boundary between the Lower Cretaceous sediments and the underlying units; neither is there always clear distinction between the various Middle Cambrian units.

The driller's log for Bradman bore refers to limestone clay, yellow limestone, clay and boulders down to 137 feet, yet the bore commenced in an area covered by rubble of Lower Cretaceous rocks. There is conclusive evidence from drillers' logs in other parts of the region that the compacted Cretaceous mudstones are frequently recorded as limestone. The description of very hard limestone, quartz, and ribbonstone in the log for Benaud bore on Newcastle Waters can be readily described as a chert-bearing dolomite which is more in keeping with the Merrina Beds than any other formation, and rare outcrops of dolomite occur in the region. But the sequential description "yellow limestone, red clay, limestone and gravel with water" from the log of No. 12 Murranji Stock Route could equally as well refer to the Montejinni Limestone.

Because of the isolation of the line of scoutholes in the Green Swamp Well Sheet area in relation to the areas of high bore density, and because of the consequent lack of control points in such a large area, it is extremely difficult to relate the groundwater regime of the Merrina Beds to that of the region as a whole. The data in Appendix 4 indicate the depth of aquifers from hole to hole is extremely variable, but to some extent this is caused by the undulating terrain. Similarly the depth to the potentiometric surface is extremely variable but it lies within the zone 725 to 785 feet above sea-level. GSWI and GSW2 obtained reasonable supplies of water from the section of vughy dolomite and dolomitic rocks in the lower parts of the Merrina Beds, whereas GSW5 and probably GSW4 obtain groundwater from friable sandstone in the upper part of the sequence. The holes in the Winnecke Creek and Tanami Sheet areas all commenced in the section of siltstone and claystone with dolomite interbeds which occurs in the middle part of the Merrina Beds. With the exception of WC3 which was the shallowest, they passed into the basal dolomite section and penetrated it to varying depths. But only TE1 and WC2 encountered water and then only as minor seepages. It appears that the middle parts of the sequence are either above the potentiometric surface or are too tight and impermeable to be useful aquifers. Consequently in the western parts of the Wiso Basin it may be necessary to drill deep holes to encounter the vughy dolomite below the watertable.

The Gum Ridge Formation is not definitely known as a producing aquifer; however on the eastern environs of the Ashburton Range bores whose supplies are attributed to the Anthony Lagoon Beds may actually be obtaining water from the Gum Ridge Formation. Scoutholes HS6 commenced in surface outcrops of the formation and obtained a good supply from the disconformity with the underlying Helen Springs Volcanics at 66 feet. The water rose 19 feet in the hole which indicates the younger formation is in part beneath the potentiometric surface, and wherever permeable should provide water. But the upper exposed parts of the formation are extremely silicified or are weathered claystones and very fine siltstones with low permeability.

Within the ranges the outliers of the formation are thin erosional remnants and are well above the potentiometric surface. However Bore No. 12 (not equipped) on the South Barkly Stock Route obtained on test 1000 gph from aquifers between 280 and 309 feet in fossiliferous limestone referred to the Gum Ridge Formation or its correlate the Anthony Lagoon Beds.

Other Palaeozoic aquifers

The Jinduckin Formation of Cambrian/Ordovician age contains several aquifers in the bore-hole intersection of scouthole K1, 40 miles south of Katherine. Aquifers encountered in bore-holes west of Katherine township have been attributed to the Manbulloo Limestone Member of this formation. Although there is some evidence that the formation occurs in the subsurface about Larrimah it appears to be either too thin or above the watertable and hence is not there regarded as a potential aquifer. In scouthole K1 all the aquifers were interbeds of dolomite which owed their porosity and permeability to vughs and inter-granular and inter-crystalline porosity. Sandstone occurred in the hole above 80 feet and hence above the watertable, whereas the non-carbonate rocks below this depth were impermeable siltstones. The upper aquifer (100-105') was a perched one in an unconfined situation; the remaining aquifers all had a standing water level of about 180 feet. The sandstone is fine-grained, well sorted and porous, and should be a reasonably good aquifer at depth - perhaps it would be below the regional watertable further northwards in the central parts of the Daly Basin. The Scotts Creek Bore in the Fergusson River Sheet area obtained good supplies from numerous shallow aquifers described as interbedded shale and porous and vughy calcilutite. Several bores obtained shallow groundwater in the vicinity of Manbulloo homestead and Manbulloo Aerodrome and presumably intersected aquifers in the Manbulloo Limestone Member. One bore reputedly flowed after reaching an aquifer at 91 feet and is rated at 4000 gph, but it is not known if this was the artesian or pumped supply. Owing to the high density of bores in the Katherine Manbulloo area they are not all shown on the geological map, but their described locations and known hydrological data are listed in Appendix 1.

A bore at the King River Crossing on the Katherine-Willeroo road commenced in soil probably derived from Lower Cretaceous rocks which there overlie the Ordovician Oolloo Limestone and is presumably obtaining groundwater from aquifers within the older unit between 90 and 133 feet. The rocks have been described as porous calcarenite, sometimes argillaceous, and rare seams of clay and calcareous sandstone.

Nothing is known about the groundwater regime of the undifferentiated Palaeozoic rocks mapped in the southwestern part of the region, but the rock types are similar to the Merrina Beds and groundwater would be in situations similar to those in the latter unit. Similarly, nothing is known about groundwater conditions in the Devonian Dulcie Sandstone in this region, but to the southeast there are springs at the unconformity between it and the underlying rocks (Smith, 1963).

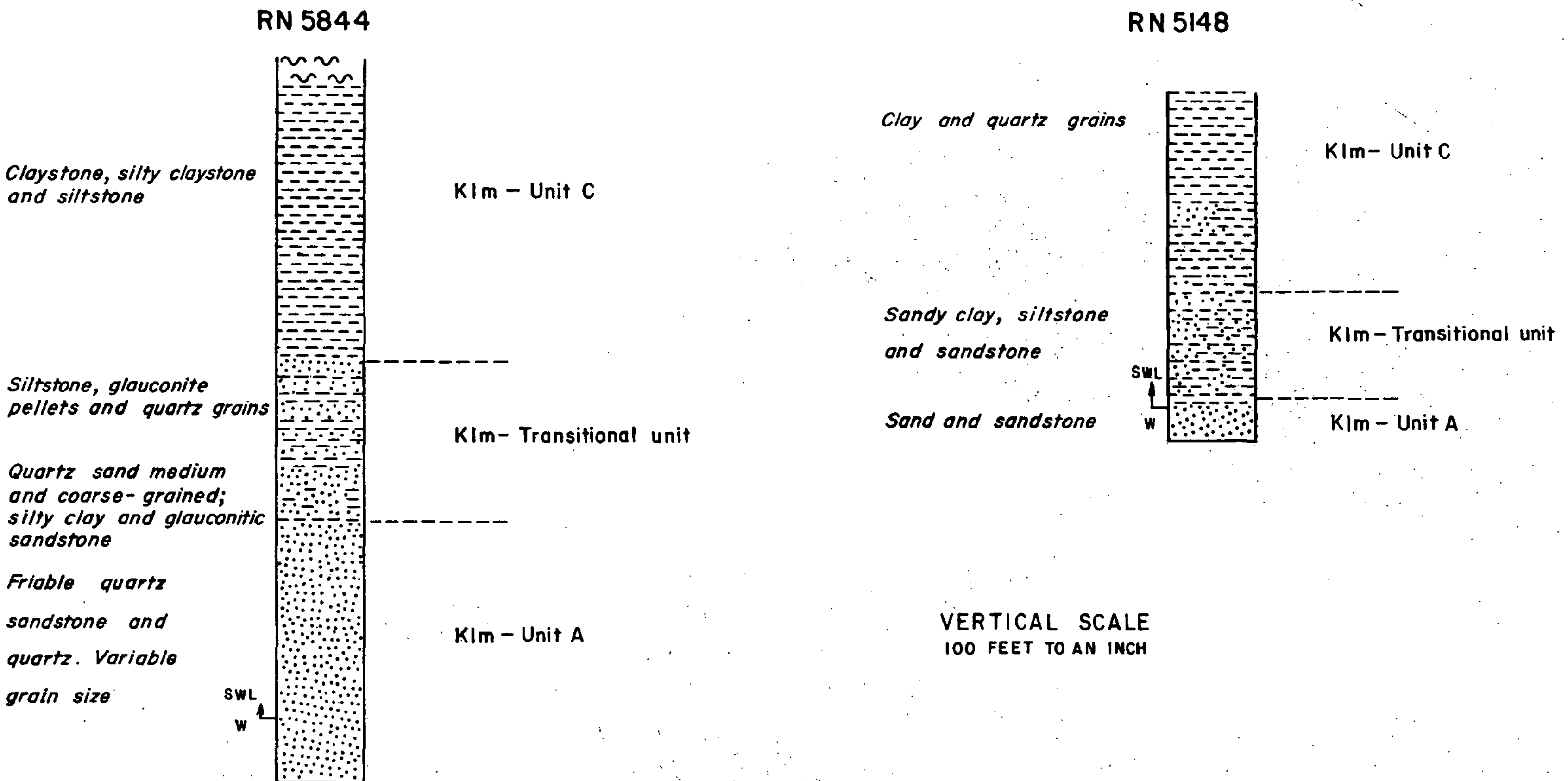


Fig. 15 AQUIFERS IN LOWERMOST SANDSTONE IN THE CRETACEOUS MULLAMAN BEDS

To accompany Record 1969/16

NT/A 283

Lower Cretaceous aquifers

Aquifers in the Lower Cretaceous Mullaman Beds are definitely known from only a few bores in the region, but their presence is inferred in several others from considerations of the total depths of bores in relation to the probable thickness of the Lower Cretaceous sediments. Also, some of the drillers' logs have been specific enough to permit some stratigraphic interpretation of the producing sequences. Over much of the region the Lower Cretaceous rocks are absent or are too thin to be important as aquifers; elsewhere there is a far greater amount of impermeable claystone and mudstone in the sequence than sandstone. This last factor is very important in the area about the Murranji Track and the Cape Crawford Road where the sequence attains its greatest thickness and is virtually without aquifers. The presence of the Cretaceous sequence in this area has been responsible for the need to drill deep holes to intersect the more favourable Cambrian aquifers.

As discussed earlier the Mullaman Beds consist of non-marine sandstone of (?)Neocamina-Aptian age, overlain by marine siltstone, claystone and sandstone interbeds of Aptian age, in turn overlain by Albian marine claystone and siltstone. The sandstone parts of the sequence have aquifer characteristics but their continuity has not been established, and frequently they are at high elevations and hence above the watertable. The basal non-marine sandstone, which often contains chert pebbles derived from the Cambrian sequences,is definitely known as the producing aquifer in bores drilled (1965) on Beetaloo Station by Southern Cross Development Pty Ltd, in a bore drilled on Mataranka Station, and in Bore CCD on the Cape Crawford Road (see Fig. 15). Bore CCA on the same road obtains water at the unconformity between the basal Cretaceous sandstone and the Cambrian rocks. Although no aquifers were contained in them intersections with proven Cretaceous rocks occur in two bores on Eva Downs station - "O" Bore and the Government Stock Route Bore near the homestead. Geologists familiar with the subdivisions of the Mullaman Beds have examined cuttings from all these bores except the stock route bore, from which however Crespin (1949) records Cretaceous micro-fauna. The verbal descriptions of rocks by the owners of Ucharonidge Station, who also drilled the bores on the station, strongly suggests that several successful bores did not penetrate to the Cambrian limestones and hence are obtaining water from the Mullaman Beds. The drillers' logs for several bores on Newcastle Waters Station are descriptive enough to suggest a boundary position for the Cretaceous/Cambrian unconformity, and some bores record aquifers at depths commensurate with being within the younger sequence. The driller's log of No. 9 Murranji Stock Route records an aquifer in sand and gravel below white clay, yellow clay, and white sand and clay: this log strongly suggests that the aquifer is the basal sandstone of the Cretaceous sequence.

A natural well occurs in a joint cleft 12 miles south-southwest of Hidden Valley homestead. Although very narrow at the surface the cleft widens at depth into a low chamber 15 feet in diameter in which on a sandy floor water lies $1\frac{1}{2}$ feet deep, and about 20 feet below the surface. The rock is a very fine-grained -- in part argillaceous-quartz sandstone, and water movement is partly along close joints and partly through the non-argillaceous parts of the rock. This sandstone is either an interbed in the upper marine unit of the sequence or, less likely, in the middle marine unit. In either case it is underlain by relatively impermeable claystone and the groundwater in this situation is perched. It is the shallowest groundwater in the Cretaceous rocks in the region. The owner of Hidden Valley reports he has had at times several hundred head of stock continuously watering from the well which therefore can yield several thousand gallons per day.

Groundwater is obtainable from Cretaceous aquifers in parts of the region but it cannot be relied upon to do so at any given site. Successful bores which commenced in the Mullaman Beds have all been drilled well into the basal sandstone or, more often, beyond the basal unconformity into the Cambrian units below. Therefore any bore sited in the outcrop area of the Mullaman Beds must be programmed to drill below their base if necessary; and the Cretaceous sequence is better regarded as non-productive overburden. This is the main reason for the failure of some deep bores (up to 475 feet) to obtain water along the Cape Crawford road, the need for deep bores along the Murranji Stock Route, and the generally greater depth of bores in the northern part of the Main Plateau than on its flanks. In this connexion Figure 4 illustrates the thickness of the Mullaman Beds: the contours are not true isopachs as at any point the top of the sequence is an erosional surface. The contours have been obtained from control points provided by bore-hole intersections supplemented by values obtained at the intersection of topographic contours and structure contours on the unconformity with the underlying Cambrian rocks.

Figure 3 illustrates contours on the unconformity at the base of the Mullaman Beds - it has been compiled with no regard taken of the underlying formation. It has some bearing on the groundwater regime inasmuch as several bores obtain water in the unconformity zone; particularly in sink-hole fill in the Cambrian carbonates.

Cainozoic aquifers

It is improbable that any bore is obtaining groundwater from either the Tertiary <u>Birdum Creek Beds</u> or the Tertiary <u>Camfield Beds</u>. Only one bore - Larrimah Scouthole No 3 - is known to have commenced in the Birdum Creek Beds which it penetrated to the underlying Tindall Limestone. Water was obtained in the older formation and the standing water level was about 50 feet below the base of the younger unit.

Bores on Wave Hill, Cattle Creek, and Camfield Stations may have commenced in alluvium overlying the Camfield Beds but the recorded depth to the aquifers is far in excess of the probable thickness of the Tertiary rocks. Similarly some bores in the Helen Springs Sheet area may have commenced in the Brunette Limestone but there is no reason to suppose that groundwater is being obtained from that unit.

Outcrops of massive Tertiary limestone occur in the central part of the Wiso Basin but its groundwater potential in this region is unknown, although it is a known producer to the south (Milligan et al. 1966). Chewings (1930) obtained shallow confined groundwater in wells which he sank through surface travertine and sandstone but the relationship of these rocks to the massive limestone is not known. In some areas unconsolidated clays and sand are associated with the Tertiary limestone, and the sandstone, sand, and claystone section down to 135 feet in GSW 4 which contained several aquifer zones may be part of the Tertiary sequence. They may however be younger deposits belonging to a compacted alluvial sequence in the old bed of the Lander River.

Groundwater occurs for varying periods as soakages in unconsolidated alluvium along the valleys of several watercourses. Water was obtained in a shallow well in the bed of Coolibah Creek and was used for road construction purposes. Copious quantities of water have been found in alluvium bordering the Katherine River in the vicinity of Katherine township. As the river contains permanent water, these latter supplies also are probably permanent.

Supply

Only a broad evaluation of aquifer characteristics in terms of supply can be made from the bore-logs of this region. Very few bores have been adequately pump-tested. Some logs give no indication of the supply, and many merely state whether it is good, poor, or fair; many give merely an estimate only, and for some the supply recorded is the capacity of the pump used in the test or the equipment at present used on the bore. Very little has been recorded on the amount of drawdown under test and nothing on recovery.

Whereas about 75 percent of the bores in the central and eastern Barkly Tableland are capable of producing more than 1500 gph only 37 percent in this region are recorded as producing more than that amount: 13 percent are recorded as producing 1500 gph. This reflects the general incidence of low yields from bores in the Antrim Plateau Volcanics for which nearly 50 percent of the bores obtaining water from it yield less than 1100 gph and only 37 percent yield more than 1500 gph. Similarly 50 percent of the bores in the Anthony Lagoon Beds yield less than 1500 gph. The best producers in the region appear to be the Tindall Limestone and the Montejinni Limestone: 75 percent and 60 percent of bores obtaining groundwater from the Tindall Limestone and the Montejinni Limestone respectively produce 1500 gph or better. There is insufficient data to gauge the supplies obtainable from the Merrina Beds and the Mullaman Beds, but most producing bores in these units yield 1400-1800 gph; but there is a high incidence of failure to obtain water from them.

Because few actual drawdown figures have been recorded, for most bores minimum values only for the yield per foot of drawdown (specific capacity) can be obtained by assuming maximum drawdown i.e. standing water level minus pump depth (or aquifer depth). Table 7 illustrates the average minimum specific capacity for some bores in the Tindall Limestone, the Montejinni Limestone, the Anthony Lagoon Beds, and the Antrim Plateau Volcanics.

TABLE 7: Average minimum specific capacity of selected bore

Rock Unit	Average Specific Capacity	Range	No bores
Tindall Limestone	103	9-360	35
Montejinni Limestone	87	10-240	9
Anthony Lagoon Beds	68	13-300	26
Antrim Plateau Volcanics	36	1.5-300*	33

* For this unit only two values, one each of 225 & 300, are greater than 100 gph/foot.

Despite the limitations of the data presented in Table 7, the minimum specific capacity does reflect the relative ease of obtaining groundwater from the various units - easiest from the Tindall Limestone but rather difficult from the Antrim Plateau Volcanics. In addition to the above data the drawdown during pumping tests of several hours duration has been recorded for nine bores in the Tindall Limestone, two in the Mullaman Beds, two in the Antrim Plateau Volcanics and one in the Oolloo Limestone, and one in river alluvium. The data is presented in Table 8.

TABLE 8: Pump tests on selected bores

Reg.No.	Aquifer	Drawdown (feet)	Yield under test (gph)	Duration of test (hr.)	Specific capacity (gph/foot)
150	Tindall Limestone	6	1700	24	280
154	" "	19	1800	48	100
557	" "	25	1500	-	60
1443	" "	48	6000	-	125
1827	" "	4	1300	-	325
2522	" "	3.8	25000	26	6600
2946	" "	10	1800	19	180
4709	" "	5.6	1745	7	300
5329	" "	29	5000	10	170
1533	Mullaman Beds	2.7	1440	7	550
4882	" "	2	1200	-	600
5423	Antrim Plateau Volcs.	64	750	-	12
5444	" " "	7	1100	-	160
5012	Oolloo Limestone	1.2	652	2	540
4918	Alluvium	5.3	8800	-	1660

This table also illustrates that the availability of water is greater in the Tindall Limestone than in the Antrim Plateau Volcanics.

The relatively low value of 60 gph/foot for RN 557 is interesting. There is no lithological log for this bore which is at the site of Birdum Stock Route No. 5, but the log of a bore (RN53) at the same site indicates water was obtained in a zone of "broken limestone and caves" at about the same depth as that recorded for RN 557. Probably these bores intersected groundwater in a cave system which is replenished by water movement along joints and fractures and these have impressed their hydrodynamic characteristics on the aquifer system. Certainly there is little likelihood of direct recharge to the cave system by interconnexion to open sinkholes as the log for RN53 suggests an overburden of 230 feet of the impermeable mudstone and claystone of the Mullaman Beds. On the other hand the very large value of 6600 gph/foot for RN 2522 near Katherine township strongly suggests the bore is tapping a large flooded underground cave system which has a nearby direct connexion to a recharge zone. Certainly cave systems are known in the area which have direct connexion to the surface by means of open sinkholes and very open vertical joints. Probably saturated alluvium adjacent to the permanent Katherine River abuts subcrops of the Tindall Limestone and may transmit considerable quantities of water to the cave systems. The high transmissivity of the alluvium is evidenced by the specific capacity of 1660 gph/foot for the test bore RN 4918. The variation in the values for the specific capacity of the other bores in the Tindall Limestone presumably reflects the varying hydrogeological characteristics of the aquifers - jointing, fracturing, presence of caves, and differences in grainsize and texture of various rock types. The big differences in specific capacity which can be expected in different hydrogeological situations is well shown by the two bores listed in Table 8 which are obtaining groundwater from the Antrim Plateau Volcanics. RN 5423 (Stock Inspector's Residence Top Springs) is drawing water presumably from joints in a rock described as very fine-grained hard basalt and has a specific capacity of 12 gph/foot. But RN 5444 (New Town Bore, Top Springs) which is obtaining water from sedimentary interbeds in an inter-flow zone within the volcanics (see Fig. 12) has a specific capacity of 160 gph/foot. The specific capacities of the two bores obtaining water from the Mullaman Beds are of the same order i.e. about 600 gph/foot: both are obtaining water from the coarse beds of the freshwater Unit A at the base of the sequence, and the high values indicate the potential of the beds. Unfortunately, as discussed earlier, these rocks are generally above the watertable or, being discontinuous, are cut off from recharge by the overlap of the impermeable mudstones and claystones of the younger marine units. I.R. Binch (N.T.A., pers. comm.) advises that the aquifers tapped by bores on the Cape Crawford road east of Daly Waters have a very high transmissivity. Because of technical difficulties they could not be pumped at rates greater than 1200 gph, but at this yield there was very little or no observable drawdown. Producing aquifers are the Tindall Limestone along the western part of the road, the Anthony Lagoon Beds along the eastern part, and one bore -CCA- obtains water at the unconformity between the Mullaman Beds and the Tindall Limestone.

In terms of geographic distribution the highest values - greater than 100 - of the specific capacity (based on the maximum possible drawdown) occur on the eastern flanks of the Ashburton Range and about Brunchilly homestead; along the Stuart Highway north of Newcastle Creek to the vicinity of Katherine; between Birrimba, Old Birrimba, and Killarney homesteads; and along parts of the Murranji Track and the western environs of Lake Woods. Moderate values - greater than 50 gph/foot occur north of the Barkly Stock Route and between Ucharoridge and Newcastle Waters. Low values occur between Toudinny Creek floodout and the Attack Creek floodout, along the Dry River Stock Route and about Wave Hill and Cattle Creek homesteads.

HYDRODYNAMICS

The Potentiometric Surface

The recorded standing water levels for 300 bores have been converted to heights above sea level and contoured to produce the potentiometric surface illustrated in Figure 16. The contouring has been done with no regard to the age and stratigraphic position of the producing aquifer.

Randal (1967) has shown that the Anthony Lagoon Beds and other carbonate units in the central and eastern part of the Barkly Tableland contain several aquifers which in most of the bores have a common potentiometric surface and are regionally interconnected. Data presented in Appendix 1 of this Bulletin show that in this region also many of the bores in the Anthony Lagoon Beds have each intersected two or more aquifers whose standing water levels are at the same elevation i.e. the hydrostatic pressures in the aquifers have been equalized by interconnexion. Consequently on a regional scale the unit may be regarded as a single aquifer system. Similarly the data in Appendix 1 show that the Tindall Limestone also may be regarded in the regional sense as an aquifer system, particularly as there is strong geological as well as hydrological evidence for interconnexion between aquifers in this unit. Several aquifers have been encountered in bores in the Merrina Beds and again the standing water level often has been the same for different aquifers intersected in the same bore. Although a relatively impermeable mudstone unit separates two limestone units in the Montejinni Limestone, there is some evidence of interconnexion within the formation. Because the Anthony Lagoon Beds, the Tindall Limestone, and the Montejinni Limestone are correlates, as discussed earlier, and are contiguous along adjacent parts of the Daly, Wiso, and Georgina Basins over the large region under discussion, they may be regarded hydrogeologically as the one rock body. Hence the potentiometric surface illustrated in Figure 16, even though it is a composite one, very probably depicts the true regional groundwater regime of the Middle Cambrian sequences. Furthermore there is some evidence of groundwater interconnexion between the Middle Cambrian rocks and the underlying Lower Cambrian volcanics and between the volcanics and the underlying Precambrian rocks. This aspect is discussed in the section on groundwater movement. Hence, despite some evidence for local isolation between aquifers in the same rock unit and between

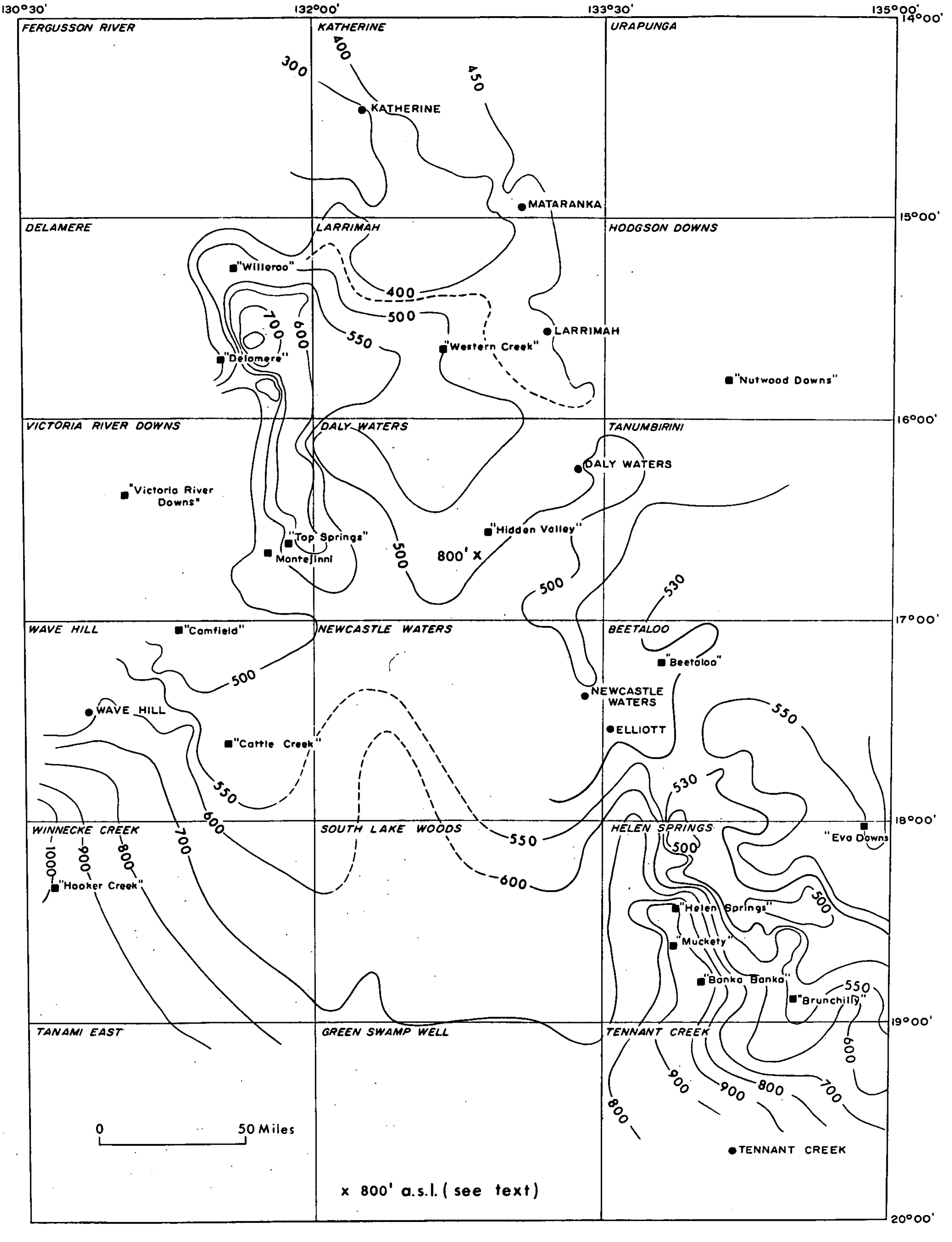


Fig.16 Contours on the potentiometric surface (datum sea level)

To accompany Record 1969/16

NT/A 284

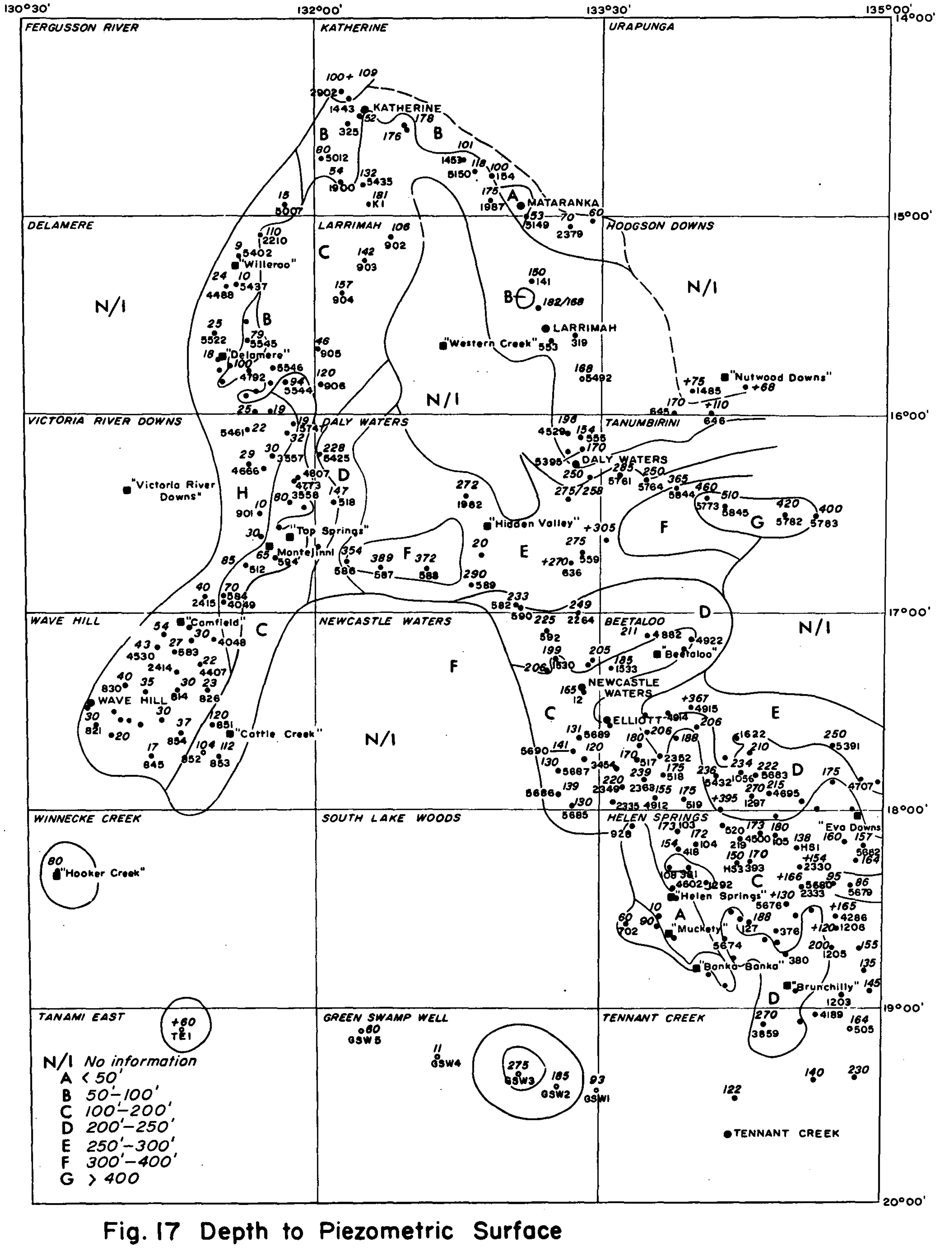


Fig. 17 Depth to Piezometric Surface

To accompany Record 1969/16

NT/A285

aquifers in superimposed rock units the potentiometric surface is considered to be regionally representative of the groundwater regime of the Wiso Basin and its environs.

The potentiometric surface broadly reflects the regional physiography. The regional slope of the landsurface on the Main Plateau is from south to north: the regional slope of the potentiometric surface is from about 800 feet above sea level along the line of scoutholes in the Green Swamp Well Sheet area to less than 300 feet above sea level in the Daly River Basin. Also, physiographic features within the Main Plateau are reflected by the potentiometric surface. The surface attains an elevation of 900 feet about the Ashburton Range between Tennant Creek and Helen Springs, and drops rapidly to the east and the west into the lower country bordering the ranges. The northern extension of the range is reflected by spurs in the 550, 600 and 700 foot contours trending towards Elliott township.

In the western part of the region about Hooker Creek homestead the surface is about 1000 feet above sea level and slopes eastward in the direction of the surface drainage of Hooker Creek. The slope gradually swings northeasterly in the drainage direction of Cattle Creek towards Cattle Creek homestead and thence northwesterly, following the Camfield River towards and beyond Camfield homestead. The western part of the Main Plateau from north of Top Springs to south of Willeroo homestead is elevated country. It slopes sharply to the Victoria River Plains and Terraces to the west and slopes gently to the east where it forms the western watershed for the Dry River, and, below latitude 16°S, the western watershed for the southern tributaries of the Roper River. A strong ridge in the potentiometric surface occurs about the Plateau in this vicinity. The ridge rises to over 750 feet above sea level east of Delamere homestead and is outlined by the 550-foot contour between Willeroo and Montejinni homesteads. Near Delamere homestead the ridge slopes steeply westward but very gently eastward. About Top Springs homestead in the south the differences in the eastern and western slopes are not so pronounced but the western one is the steeper.

The elevated country about Hidden Valley homestead in the central part of the region is reflected by a strong northeast trending spur in the potentiometric surface outlined by the 500 foot contour. In the west of the Daly River Sheet area this spur is complemented by a slight eastward displacement of the north-trending ridge in the surface which is co-extensive with the western escarpment of the Main Plateau. The 500-foot contour also outlines a depression in the potentiometric surface between these two elevated portions of it: the depression is rather anomalous in shape and position, and may simply be the reflection of too few control points for realistic contouring. On the other hand other characteristics in the groundwater regime do at least justify the existence of such a depression even if not the shape of it as drawn. This is discussed in the section on groundwater chemistry.

A value of 800 feet above sea level for the potentiometric surface is indicated on Figure 16 a few miles to the south-southwest of Hidden Valley homestead, but has been ignored in the contouring. This value represents the standing water level in the natural well which was described on page 56 . Although it indicates a potential recharge situation for the deeper aquifers the standing water level here clearly relates to a perched watertable and cannot be equated to the regional potentiometric surface which, from records of the bores along the Murranji Track and bores to the northwest and northeast of Hidden Valley, lies at about 500 feet above sea level in this area.

In the northern part of the region i.e. about the Daly River Basin and its southern environs, the potentiometric surface accords with the disposition of the Daly Basin. There is insufficient data in the eastern part of the Katherine Sheet area and in the western part of the Hodgson Downs Sheet area to define the surface in relation to the Roper River system. But some data from bores north of Mataranka suggest it slopes from about 450 feet in the east to below 300 feet about the King and Katherine Rivers to the west.

East of Lake Woods a saddle occurs in the potentiometric surface and is outlined by opposing sets of 530-foot contours in the northeasterly sense. This saddle virtually separates the groundwater regime of the southeastern corner of the region from that in the central part of it. To the northwest of the saddle the potentiometric surface slopes towards Newcastle Waters near which the 500-foot contour outlines a depression in the surface. This depression approximately coincides with the grass-covered Sturt Plain and thence swings northeastward through Dunmarra towards the headwaters of the Gulf Drainage system about Nutwood Downs. Unfortunately, beyond the line of bores along the Cape Crawford road there is no information to delineate the trend of the surface which cannot be defined in the area where the Cambrian sequences abut against the Precambrian rocks. Neither is it possible to gauge possible effects on the surface caused by so large a drainage system as the Roper River and its major tributaries.

To the southeast of the saddle the 530-foot contour outlines a well-defined depression in the potentiometric surface which strikes southeastward and is bordered by the ridge in the surface coincident with the Ashburton Range and by a plateau in the surface which extends from near Ucharonidge homestead to the floodout area of Brunchilly Creek. The depression continues beyond the eastern margin of the region into the central part of the Barkly Tableland, where it joins a depressed area in the potentiometric surface outlined by the 530 and 550-foot contours near Rockhampton Downs homestead (Randal, 1967, pp. 29 and Fig. 8). Hence in the Helen Springs and Tennant Creek Sheet areas the groundwater regime in the Cambrian rocks is continuous with that in the central part of the Barkly Tableland.

Figure 17 illustrates the depth to the potentiometric surface throughout the region. The groundwater regime is a shallow one - less than 100 feet below ground surface - in the country bordering the Main Plateau in the west and in the northeastern part of the region between Katherine and Mataranka. It is also shallow in the Ashburton Range between Lake Woods and Banka Banka. In the area about Lake Woods,

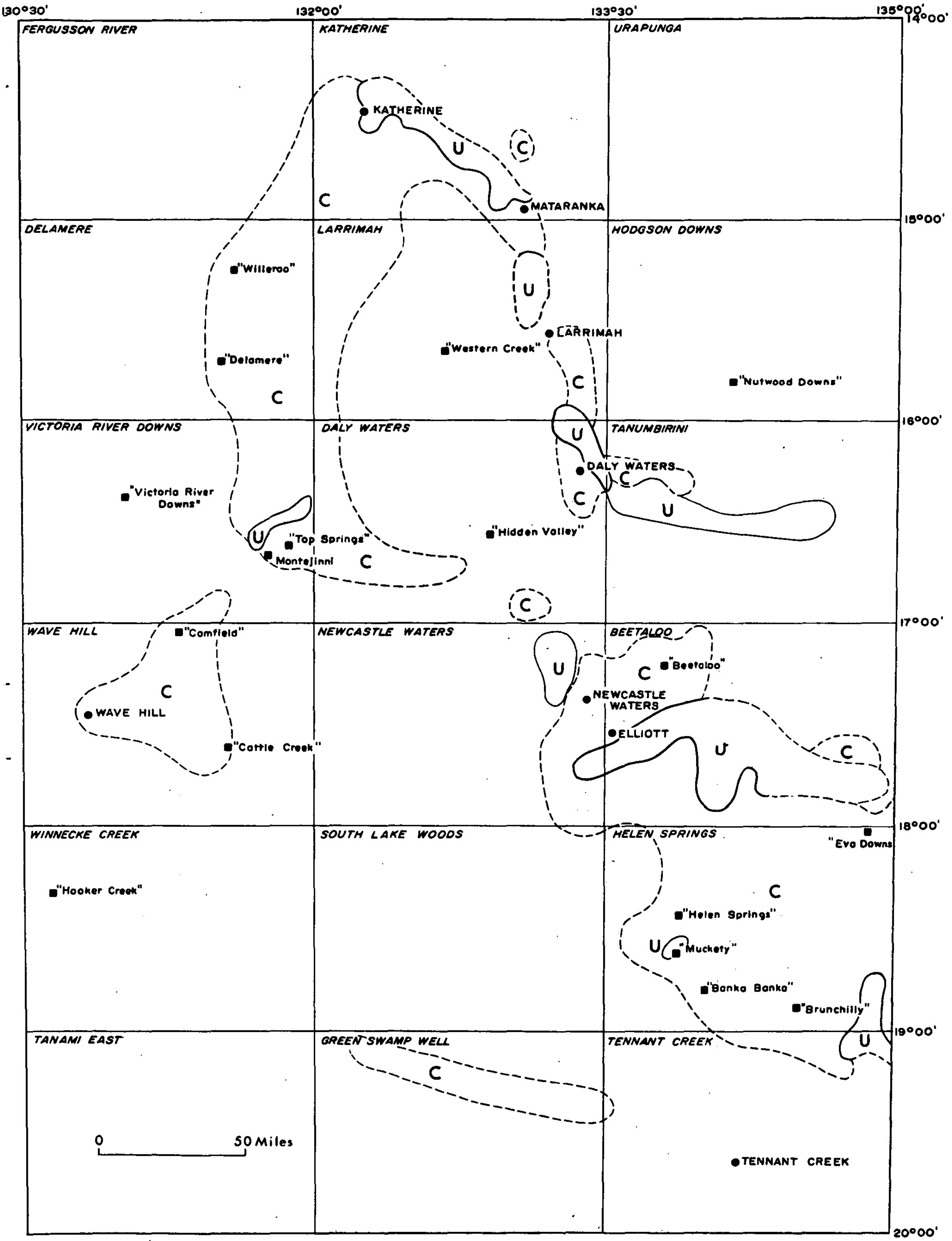


Fig. 18 Areas of confined (c) and unconfined (u) water from first aquifer

NT/A 286

To accompany Record 1969/16

Newcastle Creek and the grassy downs of the northwestern Barkly Tableland the potentiometric surface lies at a moderate depth - between 100 and 200 feet below ground level - but it is greater than 200 feet deep in a large area centred on Bruchilly homestead. In the central part of the Main Plateau the potentiometric surface is generally more than 250 feet deep: along parts of the Murranji Track it is nearly 400 feet, and along parts of the Cape Crawford road about 500 feet deep.

The depth to the potentiometric surface over much of the Main Plateau is greater than the thickness of the Lower Cretaceous Mullaman Beds; hence in much of the region these rocks are above the zone of saturation and do not provide adequate storage nor good drawdown situations to be effectively exploited as aquifers. But in isolated areas as discussed in earlier sections the basal Lower Cretaceous sandstone which has ideal physical characteristics as an aquifer lies well below the potentiometric surface and produces large quantities of water for little drawdown (see Table 8).

In several bores the potentiometric surface lies at the same level as the first aquifer encountered i.e. the groundwater is unconfined. In general bores in this category occur in well defined areas (Fig. 18). Several bores encountered unconfined water in a strip from the northwestern edge of Lake Woods, eastward through Ucharonidge station to the vicinity of Shandon Downs homestead. Several of these bores are presumed to be obtaining supplies from the basal Cretaceous sandstone; as discussed earlier this unit has a high transmissivity which apparently offsets the lack of available drawdown. Unconfined groundwater occurs in the Anthony Lagoon Beds east of Brunchilly Creek in an area which adjoins one of similar groundwater regime to the east (Randal, 1967, Fig. 9). Unconfined groundwater occurs in the Tindall Limestone north and east of Daly Waters, and in an elongated strip between Katherine and Mataranka along the southeastern margin of the Daly Basin. There are only isolated instances of unconfined water in the Antrim Plateau Volcanics. Unfortunately very few logs specifically state the standing water level of the first aquifer encountered if there are several and the areas of unconfined groundwater may be larger than shown.

Groundwater Movement

Regional

The following discussion on regional groundwater movement is based on the assumption that flow is normal to the potentiometric form lines and is in the direction of fall of the potentiometric surface. It is apparent from Figure 16 that there are several directions of groundwater flow within the region and in many respects they are coincident with the direction of surface flow.

Although there is a regional slope in the potentiometric surface from south to north it cannot be assumed that groundwater flow is uninterruptedly in that direction. From the line of scoutholes in the Green Swamp Well Sheet area to the areas of high bore density in the northwest, north, and northeast, there is a very large area of no information whatever, and many undulations in the surface may be obscured by the paucity of control points. There is some evidence from the salinity of the groundwater that the directions of flow in this area are more complex than indicated on Figure 16 and this is discussed on pages 90,91.Furthermore this northward slope is partially interrupted about Hidden Valley homestead and south of Western Creek homestead where the disposition of ridges and valleys in the potentiometric surface suggest groundwater flow is directed southwestwards, southwards, and south-eastwards for some distances. Changes in the
/* direction of flow/is eastward but gradually swings northwards and thence northwestward becoming coincident with the drainage system of the Camfield River and its main tributaries. Along the northern part of the western escarpment groundwater flow is westward to the drainage area of the Victoria River system and eastward to that of the Daly River and Roper River systems. Between Daly Waters and Hidden Valley groundwater movement is northwestward to the headwaters area of the Roper Drainage system and southeastward to an area of black soil which trends towards Nutwood Downs. About Western Creek homestead groundwater movement is eastward towards the drainage area of the Roper River system. Despite the tendency for the direction of groundwater flow about Western Creek homestead and Daly Waters to seek and then follow the direction of surface drainage of the southern tributaries of the Roper River, this parallelism does not continue north of Larrimah. Although the surface drainage swings northwards and thence eastwards towards the Gulf of Carpentaria the general direction of groundwater flow maintains a steady northwestward course to the area of the Daly River Basin where the 300 and 400-foot contours on the potentiometric surface broadly outline the shape of the basin. Elongated areas of old alluvium in the Larrimah Sheet area connect the tributaries of the Roper River to the Dry River, a tributary of the Daly, and Randal & Brown (1967) suggest that the upper reaches of the southern part of the Roper System may have been part of the Dry River system prior to Tertiary warping in the region. Hence in this area the direction of groundwater flow may be controlled by elements of the earlier drainage systems i.e. the warping although sufficient to change the direction of slope on the surface has merely changed the amount of slope but not the direction of slope on the potentiometric surface.

There is very little evidence in the northeastern part of the region on which to base concepts of groundwater movement in the central and lower reaches of the Roper River system. But on physiographic grounds it is probable that the potentiometric surface reaches a maximum height somewhat east of the 450-foot contour drawn in the eastern Katherine and Hodgson Downs Sheet areas and thence slopes eastward. Groundwater movement towards the main Roper system is evidenced by the 530 and 500-foot contour to the southeast and east of Daly Waters township.

/* ... are also apparent on the western and eastern flanks of the Main Plateau. About Hooker Creek Settlement the direction of flow.....

Groundwater movement is westward and eastward away from the area of the Ashburton Range. To the west movement is towards the central part of the Wiso Basin, but west of the Tomkinson Creek floodout there is no information to define the trend. To the east of the Ashburton Range movement is east and northeast to the shallow depression of the northwestern extension of the grassy plains of the Barkly Tableland. This movement is complemented by a southwestward direction of flow from the area about Ucharonidge and Eva Downs homesteads. Both these directions are consistent with those described by Randal (1967) in the adjoining areas of the central Barkly Tableland. About Toudinny Creek groundwater flow is northwestward towards Newcastle Waters and southeastward towards the grassy plains of the tableland.

Interconnexion

From some of the bores in which the first aquifer is unconfined, insufficient supplies were obtained and the bores were drilled deeper. In several of these, subsequent aquifers had a standing water level commensurate with the depth of the first aquifer. Also in several instances where the groundwater in all aquifers was confined the potentiometric surface was at the same position for all aquifers. Randal (1967) discusses these situations in respect to the carbonate sequences in the central Barkly Tableland and suggests interconnexion as an explanation for the phenomenon. In the first situation hydrostatic pressures have achieved equilibrium by the upward movement of water through permeable zones, and the process is complete if a permeable rock lies at the level of the potentiometric surface. In the second situation the presence of confining beds above the first aquifer prevents further upward movement and complete equilibrium is not achieved.

The effects of interconnexion are apparent in bores in the Anthony Lagoon Beds in the Helen Springs and Tennant Creek Sheet areas i.e. in the part of the region where the groundwater regime is contiguous with that in the carbonate rocks of the central and eastern Barkly Tablelands. Randal (1967) fully discusses interconnexion in this unit and it will not be further treated here. There is evidence of interconnexion between aquifers in the Tomkinson Creek Beds, the Antrim Plateau Volcanics, the Tindall Limestone, the Montejinni Limestone, the Jinduckin Formation, and the Oolloo Limestone. Selected examples are discussed below.

A bore drilled in 1959 to provide water for Newcastle Waters township (RN 1899) encountered an aquifer at 176 feet from which water rose 3 feet in the bore. The supply was not recorded, but apparently was insufficient . The bore was deepened to 328 feet, obtaining 650 gph at 326 feet, and the standing water level remained at 173 feet. Unfortunately the drillers' log is not detailed enough to permit interpretation of the geological conditions but interconnexion is presumably due to jointing or other fracture systems in the rocks. Similarly Banka Banka homestead bore (RN 5677) obtained increasing quantities of water from aquifers at depths of 14, 32, 58, 65 and 70 feet, and the standing water level stood at 5 feet for all five aquifers. The drillers log records "layers of quartzite and sandstone" but as the bore lies adjacent to a major fault interconnexion is presumably effected through shattered rock in the fault zone.

Numerous bores in the northern and central parts of the basalt country west of the Main Plateau gave evidence of interconnexion in the Antrim Plateau Volcanics. The effect is most probably present in the southern part of the belt but unfortunately the logs of bores in that part rarely record the depth of the main aquifer let along the depths and standing water levels for individual aquifers. A road construction bore on Humbles Creek (RN 5437) obtained a poor supply from an unconfined aquifer at 10 feet. Subsequent aquifers were encountered at 26 and 78 feet, and for both the standing water level was 10 feet. Willeroo homestead bore intersected aquifers at 64, 76 and 81 feet and for all three the standing water level was 17 feet. This situation is not restricted to shallow aquifers in the volcanics: deep aquifers also are in places interconnected with shallower ones. The road construction bore R.N. 5544 east-southeast of Delamere homestead obtained 900 gph at a depth of 135 feet. The standing water level was 94 feet. The bore was deepened to 406 feet where an additional 500 gph was obtained, and further deepened to 422 feet at which point the total supply from all three aquifers was 1600 gph. The bore was then drilled to a total depth of 585 feet without improvement in the supply. The standing water level was measured after each period of shutdown and was constantly recorded as 94 feet from when the drill penetrated the first aquifer until completion of the hole. Similarly Red Rock bore on the Wave Hill Stock Route obtained water at 32, 232, 250 and 321 feet with a standing water level of 30 feet for all four aquifers. Interconnexion in the Antrim Plateau Volcanics is most probably effected by joints, but hydraulic equilibrium may be obtained between inter-flow zones in the vicinity of their junction (see Fig. 11).

Numerous bores in the vicinity of Katherine township and Tindall aerodrome each encountered several aquifers with a common standing water level. The conditions are apparently very similar to those existing in the Anthony Lagoon Beds - viz. interconnected caves and large joints. Tindall Married Quarters bore intersected aquifer zones between 60 and 80 feet and between 97 and 112 feet and the water from both zones stood at 59 feet. The standing water level in a C.S.I.R.O. farm bore 5 miles south-east of Katherine is 61 feet for aquifers at depths of 88, 104, and 127 feet. Interconnexion exists in places between aquifers in the Tindall Limestone and the unconformity zone between that formation and the overlying Lower Cretaceous Mullaman Beds. Moorak Bore on Daly Waters Station obtained a small supply of unconfined water at 196 feet which level is interpreted as the unconformity zone at the base of the Mullaman Beds (see Randal & Brown 1967, p. 115). The bore was deepened to 220 feet and encountered various aquifers below 206 feet for which the standing water level was 196 feet.

Interconnexion is known within the Montejinni Limestone from Dry River Stock Route No. 9 bore - Charlies Hole. This bore commenced in the lower unit of the Montejinni Limestone and encountered two aquifers - the first, at 36 feet, contained unconfined groundwater: the second, which provided the main supply at 73 feet, had a standing water level also of 36 feet. Although some other bores in the Montejinni Limestone indicate interconnexion within the formation there is no definite evidence of interconnexion between the three units of this formation. Although some water has been obtained from limestone interbeds within the middle mudstone unit it is generally regarded as having a very low transmissivity. And this together with its regional extent would certainly tend to restrict the movement of water from aquifers beneath it to the overlying limestone unit. Monster bore on Killarney Station (RN 4807 in Fig. 14) commenced in the upper limestone unit but encountered no aquifers until the drill reached the unconformity at the base of the mudstone unit at about 102 feet. Although the supply was small the groundwater was confined and rose to 61 feet - about 10 feet above the top of the mudstone unit. Similarly the road construction bore RN 5496 east of Delamere homestead obtained a mere 300 gph eight feet above the base of the mudstone unit at 102 feet. The water rose to 73 feet - 13 feet below the top of the unit. Birrimba Homestead bore (RN4518 in Fig. 14) also obtained groundwater a few feet above the base of the middle mudstone unit but the rise was less than 10 feet. These examples suggest that the bottom part of the mudstone unit is an aquifer but the middle part of it at least is an aquiclude and would probably prevent vertical interconnexion throughout the formation. On the other hand several bores which have penetrated the middle unit of the Montejinni Limestone have encountered confined groundwater well below its base with standing water levels also below its base. Dry River Stock Route No. 5 bore (RN 904 in Fig. 12) penetrated all three units of the Montejinni Limestone and obtained groundwater from both the lower limestone unit and the underlying volcanics. Both aquifers have a common standing water level which is more than 10 feet below the base of the middle mudstone unit. Top Springs Police bore (RN 1913 in Fig. 12) and the road construction bore RN 5544 southeast of Delamere homestead have standing water levels at or just below the base of the middle mudstone unit. Consequently even though the mudstone unit has the regional distribution and characteristics to be a confining bed of some importance it appears to be above or only just at the water-table in parts of the region and in these parts exerts little influence on the hydrodynamics of the groundwater regime. But because few logs of bores which penetrate the Montejinni Limestone give detailed records it is impossible to assess where the mudstone unit is hydrodynamically important and where it is not.

There are few bores in the Jinduckin Formation but some logs indicate interconnexion in this unit also. A bore alongside Scott's Creek (RN 5007) intersected numerous aquifers between 50 feet and 126 feet and all had a common standing water level of 15 feet. Interconnexion within this formation is evidenced by the data from B.M.R. Scouthole Katherine No. 1 (Randal & Brown, 1967 Appendix 1). This hole encountered several aquifers in the formation and although the first contained perched unconfined groundwater, succeeding ones contained confined groundwater with a common standing water level of 180.2 feet.

A bore near the King River (RN 5012) gave evidence of interconnexion in the Oolloo Limestone. It encountered aquifers at 90, 124 and 133 feet, and the groundwater from all of them stood at 80 feet.

An interesting feature of the groundwater regime of this region is the interconnexion not only within the various formations but also vertically between them across the intervening unconformities. B.M.R. Scouthole Katherine No. 1 obtained 1000 gph from various aquifers within the Jinduckin Formation. At 355 feet the drill passed into the Tindall Limestone and at 376 feet the yield gradually increased until the bore could produce 5000 gph at 413 feet. The standing water level was the same for the aquifers in both formations. Dry River Stock Route No. 5 bore (RN 904 in Fig. 12) has a common standing water level of 157 feet for aquifers at 183 feet in the Montejinni Limestone and at 371 feet in the Antrim Plateau Volcanics. Top Springs Police Bore and Killarney Monster bore (RN 1913 and RN 4807 in Fig. 14) also have common standing water levels for aquifers in these same two formations. Horse Creek Spring bore (RN 5522) on Delamere station obtained groundwater at 35 feet in the Antrim Plateau Volcanics: standing water level was 25 feet. On deepening the bore intersected aquifers in the underlying Victoria River Group at 90 and 110 feet, but the standing water level remained at 25 feet.

Recharge

Recharge to the groundwater is governed by the amount of rainwater percolating through overlying soil and rocks to the aquifers or by the amount of water brought into the region by subsurface flow. Nothing is known in detail about the latter factor, but indeed the slope of the potentiometric surface rather suggests that the subsurface movement of water in this region is away from it, except in the south. But even there the available data are insufficient to define clearly the trend. The first factor is controlled by the annual rainfall, by the characteristics of the sediments above the aquifer, and by the physiography.

Noakes (1954) and Randal (1967) consider that recharge areas in the Barkly Tableland are outcrops and lateritized outcrops on the margins and within the basin, stream channels - mainly the upper portions - where sand occurs over sediments, and low rises, once lateritized, where light-textured soils now remain. All these situations occur extensively within the central Wiso Basin and environs. In addition, Randal (1967) gave some evidence that recharge can occur in the areas of black pedocalcic soils. Certainly these soils are very impervious when wet as is evidenced by the success of the raised earth tanks, or turkey nests, used for borewater storage. But during the dry season the clayey plains in some areas develop very wide and very deep cracks which could transmit large quantities of water to subcrops at considerable depth before closing up. The effects of wetting followed by dessication on these soils is evidenced by the behaviour of some of the turkey nests: these are extremely retentive if kept in a moist and vegetated condition, but if bores are temporarily taken out of service and the tanks allowed to dry out the walls crack, and when the tanks are refilled they are often very leaky for some years after and are prone to complete failure. Admixed sand also increases the permeability of these soils.

Recharge to the Tomkinson Creek Beds and the Victoria River Group is probably by direct infiltration through fault zones and joints in the outcrop areas, by movement of water under gravity from overlying formations and by percolation through overlying superficial sediments. Superficial deposits over the Tomkinson Creek Beds and the Victoria River Group are mainly sand, sandy soils, or gravels of varying texture and these would permit rainwater easy access to groundwater storage. The stream beds mainly consist of similar material and a considerable amount of the original run-off may find its way to the groundwater body. Hays (in Barkly & Hays, 1965) made pertinent comments on the relationship between recharge, structure, and yield of bores in the Victoria River Group and these are discussed on page 46.

The physiography, particularly within the Ashburton Range, may be of importance to recharge conditions. Although the upper portions of the streams, which receive considerable run-off from adjacent steep-sided hills, traverse bare rock surfaces and open joint and fault zones, the gradients are steep and hence favour quick run-off. But in the valleys between the strike ridges the gradients are reduced and infiltration may be favoured. Further downstream reducing slopes will of course be accompanied by finer and tighter alluvial deposits. Many of the streams have flood-outs on the flanks of the ranges and although some are covered by fine silt there is in places large areas of admixed sand over shallow subcrop. Unfortunately the valleys between strike ridges are often composed of the finer-grained sedimentary rocks and infiltration to those may be minimal. There are interbeds of sandstone in the siltstones and some valleys occur in softer sandstones than those on the ridges and infiltration may be favoured in these situations. But because of the structure - the rocks in the well defined strike-ridges and valleys are generally steeply dipping - the potential aquifer is taken rapidly below an economical depth. Probably the most effective recharge areas are where streams of moderate gradient in wide valleys are at right angles to the strike of jointed rocks, and where the rocks are gently dipping. Extensive sand plains occur at various levels on truncated plateaus of the Ashburton Range and these are potential recharge areas particularly where they have a well defined but moderate slope towards watercourses. In these situations silt particles may be removed from the surface by run-off thereby increasing the near surface permeability of the plain.

Recharge in the Antrim Plateau Volcanics is effected by infiltration through joints and weathered rocks and by the movement of water through the interflow zones as described earlier. But recharge in the volcanics is not necessarily always a local phenomena. As discussed in earlier sections there is some evidence that water movement may be affected by rock bodies or zones of large areal extent, and hence recharge to the producing aquifer at a given bore location may enter the groundwater regime many miles away. But until more definitive data is available some evidence of local potential recharge should be sought in selecting bore sites in this unit. The watercourses have sandy and gravelly beds and in reaches of moderate gradient should be influent streams. The rocks are well jointed and weathered, and well exposed in most of the streams. The soil cover on the volcanics is thin and is thus absent in even the shallowest of stream profiles. Most of the soil over the Volcanics is very clayey - in places it is a not too impure ironstained kaolin - and hence impervious. Consequently there is considerable run-off over some of the undulating hills and most recharge probably is effected by the streams. The clayey soils over the volcanics do not exhibit the same degree of cracking as those over the carbonate rocks, and hence away from the streams, recharge is effected only on outcrops containing open joint planes. Nevertheless raised earth tanks are unusual in the basalt country, as under head water can be transmitted through the very thin clayey soils to subcrops below, and the tanks thereby empty themselves with no sign of leakage through the walls. Earth tanks have been successfully used at sites only where the drill has penetrated a considerable depth of clayey soil. The recharge conditions in the Helen Springs Volcanics are probably similar to those in the Antrim Plateau Volcanics.

Recharge situations for the Montejinni Limestone and the Tindall Limestone are probably very similar to each other. Direct infiltration through open joint and bedding planes in massive Karst outcrops and through open sink-holes is probably very important in these units. Also, streams passing through outcrops of weathered honeycombed limestone are probably influent. In addition, considerable quantities of water are received by percolation through overlying superficial deposits, and through the overlying basal sandstone of the Lower Cretaceous Mullaman Beds, particularly in the northern part of the Main Plateau. In the Larrimah and in the northern part of the Daly Waters 1:250,000 Sheet areas numerous small depressions occur in the sandy soil overlying the basal Cretaceous sandstone which is there very thin (see Fig. 4). These depressions are believed to be the reflection at the surface of collapse in the carbonate rocks or infilled sink holes. Although there are some with silty matter in them, most have a sandy or ashy textured soil both in and around them, and are the foci for small runnels in their vicinity. Hence they probably receive surface run-off during heavy storms and may readily transmit water to the Cambrian aquifers. Although many of the stream beds contain silty and clayey material much of it develops large cracks and fissures. Early storms would probably produce some run-off to these streams but much of it could be transmitted to shallow subcrop through these fissures. Brown (1895) commented on the lack of surface water in Birdum Creek in December 1894 despite the incidence of heavy daily rainstorms and the fact the Lake Woods further south was full. Recharge to cavernous limestone from the Katherine River has been discussed on page 59.

The mechanism of recharge to the Anthony Lagoon Beds has been described by Randal (1967) for the central Barkly Tableland. Presumably similar conditions apply for the unit in the southeastern part of this region. Recharge is presumably effected in areas of outcrop and lateritized outcrop. Recharge may also be effected by groundwater movement along the eastward sloping unconformity between the unit and the Tomkinson Creek Beds. Recharge may possibly occur from the sandy parts of the flood out areas of the major watercourses. Recharge conditions for the Merrina Beds are probably similar although there is greater scope for recharge by percolation of rainwater as the sandy soils in the south and southwest of the region are more permeable: furthermore the scarcity of streams in the area implies low run-off, but on the other hand the rainfall is low.

Recharge to the Mullaman Beds also is effected in lateritized and sand covered areas. However in the areas underlain by the younger (claystone) units of the Mullaman Beds recharge can be hindered by the relative impermeability of the rocks. In the northern part of the region where the permeable basal sandstone crops out or is close to the surface, recharge could be extremely rapid; but because of the cavernous nature of the underlying carbonates, their high storage capacity, and the permeability of the sandstone, water rapidly passes from it to the carbonates. Hence the regional potentiometric surface is low and the sandstone is generally a non-producer. Further south, the periodic flooding of Newcastle Creek may make it an influent stream for the Cretaceous aquifers about Beetaloo and Ucharonidge Stations.

Unlike the Central Barkly Tableland this region contains very few closed prominences in the potentiometric surface which can be interpreted as recharge zones. There are however closed high-value contours along the northern part of the western escarpment to the Main Plateau. These suggest recharge to both the Antrim Plateau Volcanics and the Middle Cambrian carbonate rocks. In addition the linear ridge of high values about the Ashburton Range suggests it is a regional recharge zone. Although the groundwater regime in the Tomkinson Creek Beds within the central part of the range may be made up of several discrete systems, on the flanks continuity between the groundwater regime of the younger rocks and that of the older ones can be reasonably postulated, and parts of the Range may be recharge zones for the younger ones. Probable recharge areas are of course where the stream gradients are moderate and cross the flanking sandplains which overlie Cambrian and Precambrian rocks. Recharge zones may also be reflected by large lobes in the contours such as occur in the 500-foot contour south of Western Creek homestead and about Daly Waters, and in the 550 foot contour about Eva Downs homestead and east of Banka Banka Homestead. Most of these areas can be related to groundwater of relatively low salinity and of bicarbonate type.

Probably recharge is effected over a great deal of the region as, except in the northwestern extension of the Barkly Tableland, there are no closed depressions in the potentiometric surface. Furthermore, unlike the Barkly Tableland, the superficial deposits in the region are mainly sand or light-textured sandy soils and rubble of lateritized rocks, all of which have a reasonably high permeability. Probably as hinted earlier the recharge paths may be extremely complex and circuitous - water moving in different directions at different levels, but with an ultimate net transfer in the direction indicated by the regional potentiometric surface. This may explain some of the geochemical anomalies discussed in the following sections. It could only be checked however by the use of deep and shallow observation bores on an extensive network during the main recharge period i.e. the Wet Season. The practical difficulties are enormous. But some information could be obtained from observation bores along the bitumen roads in the east and west of the region, and in this connexion the bores put down for road construction could well form a sound nucleus as they are well documented.

Randal (1967) suggested that far less than 0.35% of the precipitation falling over the Barkly Tableland need be taken into groundwater storage to balance accretion against withdrawal. There is no reason to suppose that a higher percentage would be required in this region. On the contrary the available data suggest it would be much lower. At present, the pastoral requirements in terms of withdrawal per bore and numbers of working bores are much lower. Further as mentioned above there is a greater amount of potential recharge area because of the widespread superficial deposits of good permeability. And finally the rainfall in this region is greater than that in the Barkly Tableland. Over half the region received more than 17½" per annum and more than three quarters of it more than 12½ inches. Only half of the central Barkly Tableland receives more than 12½ inches per annum and less than a quarter of it receives more than 17½ inches.

GROUNDWATER CHEMISTRY

Quality

Standards of quality

The determination of the total dissolved solids by evaporation to dryness (at 180°C) provides a general indication of the salinity of a water sample and is used as a general guide of water quality. But the concentration of individual constituents must be taken into account in determining the suitability of water for specific purposes. Randal (1967) describes this aspect in some detail under the various chemical determinations and discusses the recommendations of various authorities and workers in this field - recommendations by the U.S. Public Health Service as reported by Rainwater & Thatcher (1960); recommendations by the Animal Industry Branch of the Northern Territory Administration as reported by Jephcott (1956); and recommendations based on the work of E.S. Simpson in Western Australia as reported by Ward (1951).

Table 9 summarises the recommended limit for various constituents in water to be used for domestic consumption.

TABLE 9: Recommended quality of domestic water.

Constituent	Recommended maximum concentration in ppm		
	Large Town	Small Town	Station
Total Dissolved Solids	1000	1500	3000
Hardness	200	300	
Magnesium	125	200	
Chloride	250	375	750
Sulphate	250	375	500
Nitrate	44-120		
Fluoride	0.8-2.0		
Lead	0.1		
Iron together with Manganese	0.3		

The variations between the limits for towns and stations are not of course based on any particular physiological reason, but experience shows that people in isolated areas will accept, because of necessity, somewhat poorer quality water. There are however medical grounds for keeping the upper limits at the levels indicated and this is discussed in the references cited above. The table lists only those important ions which are normally encountered. Considerable quantities of sodium, potassium, calcium, and bicarbonate ions are present in most groundwater but they are still harmless and tasteless at levels far higher than those usually found in most bore-waters. Water would be condemned because of the concentration of some other harmful constituent or because of total salinity long before the concentration of these relatively harmless constituents became physiologically important. There are other elements or ions which are very important, but as Jephcott (1956) states "... their rarity is their safety factor". The determination of hardness is important in water intended for domestic or industrial use because of the undesirable reactions between soap and the constituents - mainly calcium and magnesium - which cause hardness: hard water requires extra soap to neutralize the hardness, the water and soap are difficult to lather, and unpleasant scums are formed during the reactions. The hardness values of the borewaters have not been reproduced in the chemical analyses in Appendices 2 and 5, but the total hardness expressed as parts per million $CaCO_3$ may be obtained by multiplying the combined equivalents per million of calcium and magnesium from Appendices 3 and 6 by 50.05. The permanent hardness (non-carbonate hardness) may be obtained by multiplying by 50.05 the excess of any of calcium and magnesium over bicarbonate and carbonate expressed as equivalents per million. The temporary hardness is the difference between total and permanent hardness.

Although the quality of water for stock purposes does not have to meet the same standard as water for domestic use, certain limits are set for various constituents and the total salinity. These also are discussed by the authors cited above and are summarised in Table 10.

TABLE 10: Quality requirements for stock. (parts per million)

	Horses	Cattle	Sheep
Total dissolved solids	6250 (in work) 7800 (at grass)	9400	12400 (on saltbush feed) 15650 (on grass feed)
Magnesium	300	400	500
Lead		0.5	
Chloride		as sodium chloride, less than 75% of total maximum tolerance of dissolved salts	
Fluoride		6	
Nitrate		30-120	

There are many pertinent factors in dealing with water quality for stock - climate, type of feed, season of the year, and the salinity to which stock have become accustomed - and a great deal of variation can be expected in the reaction of stock to different waters.

Water quality and the rock units

The quality of groundwater as determined by its chemical constituents and their concentration is dependent on two broad factors: the nature of the rocks which contain the water, and the hydraulic environment within the rocks. The first factor is self explanatory: water moving in rocks containing matter readily taken into solution is more saline than water in those that do not. The second factor deals with the position of the groundwater in relation to the areas of recharge, areas of stagnation, and the hydraulic gradients: within the same aquifer water near the recharge zone is less saline than water which has travelled further into the aquifer system.

Consequently in describing the relative quality of groundwater from various formations the conclusions must be modified by consideration of the hydrological environment of the formation. Table 11 lists the average salinity of groundwater from the various geological units in the region.

<u>TABLE</u> 11: Average salinity of groundwater from the rock units

Formation or Unit	Salinity (in ppm)
Mullaman Beds	1000
Merrina Beds	1240
Montejinni Limestone	620
Tindall Limestone	960
Anthony Lagoon Beds	1450
Antrim Plateau Volcanics	650
Helen Springs Volcanics	600
Victoria River Group	600
Tomkinson Creek Beds	920

The table shows that most of the groundwater in the region is fit for domestic use. The water from the Anthony Lagoon Beds and the Merrina Beds are the most saline as expressed by the average salinity but in actual fact some of the water from these units is less saline than that from the others. The average salinity for these units is heavily weighted by samples taken from bores obtaining water at points far removed from recharge zones. This aspect is discussed on p. 90 .

The average groundwater salinity is lowest for the Antrim Plateau Volcanics, the Helen Springs Volcanics, the Victoria River Group */ . . ./ the low salinity is attributable to the sampled bores being mainly near recharge zones. The low salinity presented for the Victoria River Group is extremely misleading: only a few samples of water from this unit have been considered in this report and they too may be from bores close to recharge zones; but very saline water has been reported from some deep bores in the unit. Very saline water occurs in the Antrim Plateau Volcanics in a small area near Camfield homestead.

Except for the saline areas in the Beetaloo and Helen Springs Sheet area and near Camfield homestead the magnesium, chloride, and sulphate contents of the groundwater are low enough for the waters to be used for domestic consumption.

*/ and the Montejinni Limestone. With the exception of the Victoria River Group....

The fluoride content of the groundwater in all the formations is well below the recommended limit with only a few exceptions. These are the more saline waters from the Anthony Lagoon Beds in the eastern outcrop areas of the unit, groundwater from adjoining areas in the Beetaloo Sheet area, groundwater from some of the bores about Lake Woods and in the Green Swamp Well Sheet area, and from some of the bores near Cattle Creek homestead. There are single instances of high fluoride values (up to 2.5 ppm) elsewhere but they are not supported by adjacent high values.

Pollution: Although the nitrate ion may be derived directly from aquifer rocks and is itself important physiologically, its main importance in chemical analyses of groundwater is as an indication of possible organic pollution. Nitrate ion is one of the constituents of animal wastes, sewage effluent, and the degradation products of dead animal and vegetable tissue: these are all associated with bacterial activity. Pollution of a groundwater supply by man's activities generally occurs in situations of local recharge where percolating rainwaters pass over or through contaminated soil and rapidly move into the aquifer. It may also occur if faulty bore construction permits contaminated water to pass through the annulus between the casing and the walls of the bore. Polluted water may be carried considerable distances in groundwater regimes in limestone terrains because of the high permeability of the rocks and the consequent lower chances of mechanical filtration.

Laws (N.T.A. and B.M.R. file notes) describes pollution of a bore at Hooker Creek Welfare Settlement, and the pollution risk in two others. Large quantities of bacteria were found in No. 5 bore which is apparently located unfavourably in respect of piggeries and waste disposal areas. The nitrate content reported by Laws ranged up to 31 ppm and although reported as ppm NO_3 it is not clear if this is actual nitrate content or nitrogen content attributable to nitrate ion.

Bores in the outcrop areas of the Tindall Limestone are prone to pollution unless adequate precautions are taken. This formation is extremely cavernous and probably receives considerable direct recharge through open sinkholes. Disposal of waste material and dumping of garbage into sinkholes in areas of high population and bore density is extremely hazardous and if unavoidable should be carefully planned.

High nitrate values have been reported in samples of groundwater in the eastern part of the Helen Springs Sheet area from aquifers in the Anthony Lagoon Beds.

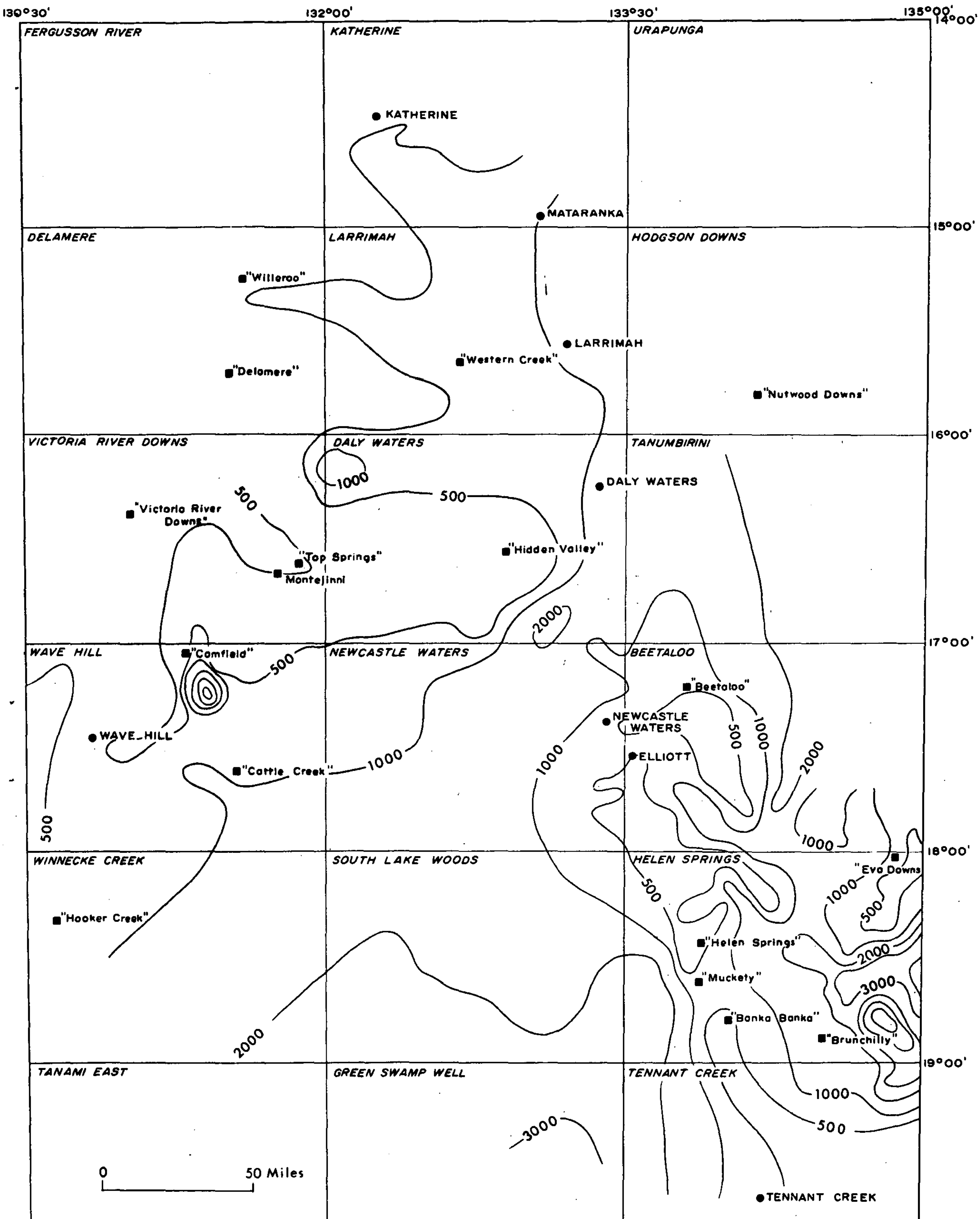


Fig.19 Isosalinity contours (based on total dissolved solids in parts/million)

To accompany Record 1969/16

NT/A 287

Geochemistry

Chemical Determinations

Total Dissolved Solids: The total dissolved solids listed in Appendices 2 and 5 have been determined by evaporation to dryness of the sample at 180°C. Isosalinity contours for the groundwater are presented in Figure 19. The range of groundwater salinity for the various rock units is given in Table 11.

Over most of the region the salinity is less than 2000 ppm although salinities in excess of this value occur in large areas in the Green Swamp Well Sheet area and in the eastern part of the Helen Springs Sheet area. In the former case the contours are based on the little data available from the line of B.M.R. scoutholes between Tennant Creek and Hooker Creek; the position of the 2000 ppm contour is speculative, although some high values are known along the Murranji Track to the north, and on the western flanks of the Ashburton Range to the east. In the Helen Springs Sheet area the sample density is very high, and the positions of the contours are validated by copious data and by the conformity of the trends with those in adjoining areas of high salinity in the central Barkly Tableland (Randal, 1967). The salinity here appears to be controlled partly by groundwater environment and partly by aquifer composition, and this is discussed on pages 89-91.

Groundwater of high salinity occurs in two bores near Camfield homestead. The water comes from aquifers within the Lower Cambrian Volcanics. One, RN 4767, near the Camfield River obtains water at a depth of 40 feet; its salinity is 2400 ppm. The other, RN 4707, four miles away obtains water of 4600 ppm total dissolved solids from 210 feet. The high salinity is anomalous as surrounding bores have a salinity of less than 750 ppm. The waters from these bores are exceptionally high in sodium and chloride and are very similar to bore-waters in the Barkly Tableland which owe their high salinity to hydraulic environment.

The low salinity of groundwater elsewhere in the region is attributed to local recharge conditions, shallow groundwater environment, and the low solubility of material within the aquifers. Bores obtaining water from areas somewhat removed from the recharge areas show a rise in salinity but it is nowhere as rapid as in the Barkly Tableland.

Specific Conductivity: The specific conductivity for the samples is listed in Appendices 2 and 5; it has been determined at 25°C. Randal (1967) discusses the relationship between this parameter and the total dissolved solids for groundwater in the Barkly Tableland, and similar relationships have been found for groundwater in this region. The ratio T.D.S./S.C. ranges from about 0.5 to about 0.75 although a few samples - particularly high in sulphate - are as high as 0.97. An average figure for the ratio for waters from the various rock units is presented in Table 12.

TABLE 12: Salinity/Conductivity Ratios for groundwater from selected rock units.

Formation	T.D.S./S.C.
Mullaman Beds	0.64
Montejinni Limestone	0.62
Anthony Lagoon Beds	0.66
Antrim Plateau Volcanics	0.64
Helen Springs Volcanics	0.58
Tomkinson Creek Beds	0.61

As discussed by Randal (op. cit.) the ratio changes for high salinities and varies for differing chemical types. Figure 20 illustrates the essential linearity of the relationship for waters of low salinity from the Mullaman Beds, the Tomkinson Creek Beds, and the Anthony Lagoon Beds, but above 2000 ppm salinity there is considerable dispersion in the plots of samples from the Anthony Lagoon Beds. Not only do these waters contain a relatively high salt content but they are also waters in which chloride and/or sulphate ions are assuming dominance over the bicarbonate ion.

The major cations: The sodium and potassium values listed in Appendices 2 and 5 have in the main been determined by flame-photometry: they are not computed values based on anion-cation balance. The effect of these alkali metals in drinking water has been discussed in previously cited references: it is regarded as innocuous. But the sodium content is important in deciding the suitability of water for irrigation. An outline of the problem, with references, is given in Randal (1967).

The sodium concentrations range from a few parts per million in recharge areas in the Tindall and Montejinni Limestones to nearly 1000 ppm in the saline waters from the Anthony Lagoon Beds. According to Hem (1959) waters in carbonate terrains are usually low in sodium content unless evaporites are present, as both calcium and magnesium must be dissolved to release the sodium. In addition the sodium content of carbonate aquifer rocks in this region (see Appendix 7) is very low, being less than 500 ppm as against the range of from 15,000 - 27,000 ppm for aquifer rocks from the Antrim Plateau Volcanics. Randal (1967) postulated evaporitic interbeds as providing high amounts of sodium to groundwater in the Anthony Lagoon Beds. The high values in the groundwater from the Anthony Lagoon Beds are highlighted by the generally low values in water from the volcanics despite the higher concentration in the latter rocks. The effect is of course partly explained by the fact that most bores in the Volcanics are close to recharge areas whereas many in the carbonate unit are not. High sodium values occur in the saline bores southeast of Camfield homestead.

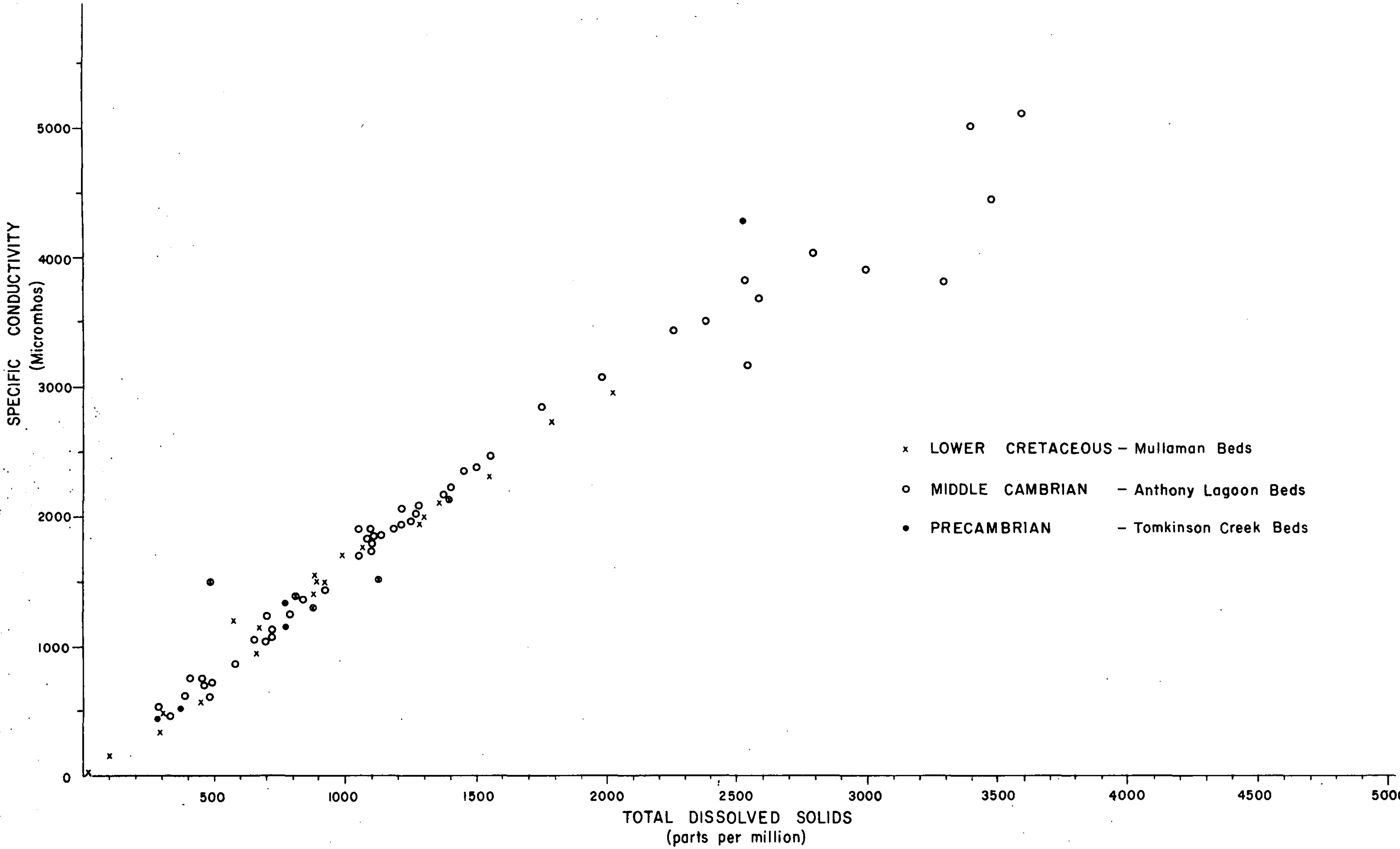
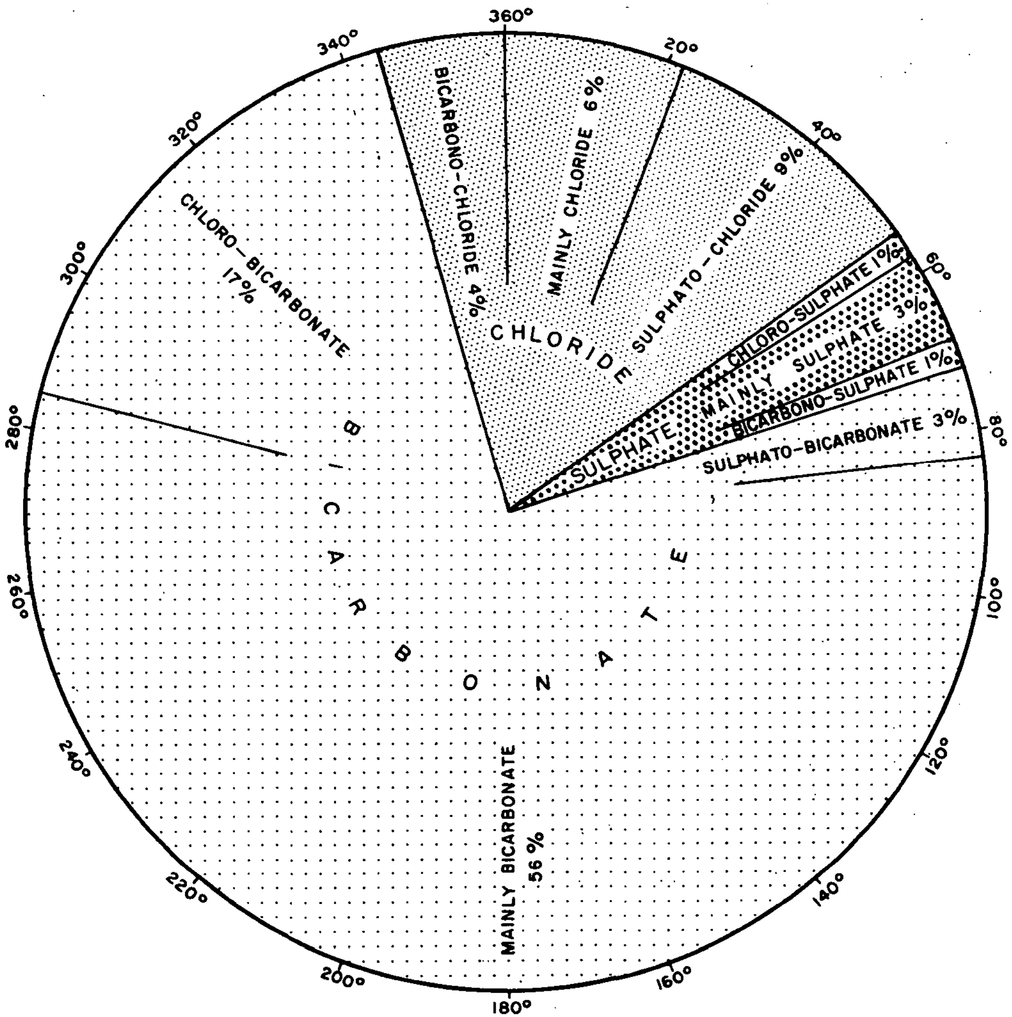


FIG. 20 RELATIONSHIP BETWEEN SPECIFIC CONDUCTIVITY AND SALINITY

To accompany Record 1969/16

NT/A288



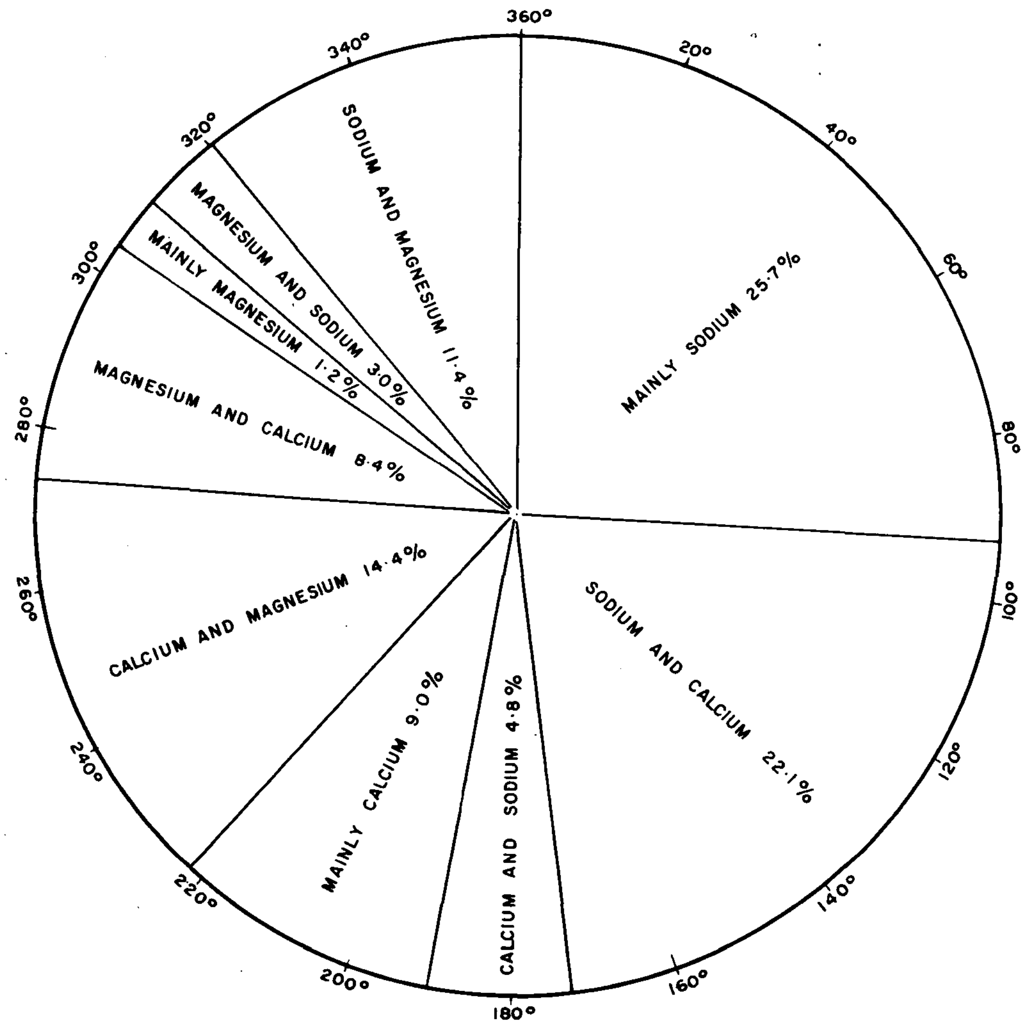


Fig. 21 Relative abundance of water types: classification based on anions and cations

To accompany Record 1969/16

NT/A 289

The potassium content of the water generally varies with the sodium content, but is usually much smaller in comparison. The relative amount of potassium to sodium is however generally higher in the water from the volcanic rocks than it is in the waters from the carbonate rocks. This occurs despite the greater amounts of potassium in relation to sodium which occurs in the carbonates (see Appendix 7): the abundance of the two alkalis in the volcanic rocks is about the same. The low relative amounts in the waters are probably explained by the effects of availability. The potassium in the carbonates probably occurs in included detrital feldspar and mica and in illitic clays and shales, and hence is not as readily available as the sodium which is more likely present in more soluble form - the postulated evaporitic interbeds or adhesing evaporitic particles. On the other hand in the volcanics both the sodium and the potassium generally occur in the feldspars: hence as sodium becomes available from the breakdown of the minerals so too does the potassium. The relative amounts of sodium and potassium in the groundwater then becomes a function of the relative amounts and dissolution of the sodic and potassic feldspars. Volcanics of unusually high alkali content are mentioned by Randal & Brown (1967) and one of these was exceptionally high in potassium.

The calcium content of the groundwater in this region ranges from 20 and 30 ppm in the west and north to several hundred parts per million in the east - again the highest values occur in water from the Anthony Lagoon Beds. An exceptionally high value of 600 ppm occurs in Dry River Stock Route No. 1. This bore is obtaining water from the Tindall Limestone in which groundwater usually has a calcium content less than 200 ppm. But the sulphate content of the sample also is extremely high - 1538 ppm - almost to the exclusion of sodium and chloride although the total salinity is high. The magnesium and bicarbonate contents, though somewhat depressed, are reasonable for a water moving in carbonate rocks. The surplus calcium and high sulphate strongly suggest the groundwater at some stage is moving through an interbed rich in gypsum.

The origin of the calcium in the carbonate rocks is obvious: in the volcanic rocks it is derived mainly from feldspars and probably from zeolitic minerals also. In two analyses (Appendix 7) of aquifer rocks from the volcanics the calcium content is higher than that of sodium; in another two it is less. Although sodium is somewhat more soluble than calcium the groundwater from the volcanics generally tends to be higher in calcium than sodium. This is explained by the possible presence of calcium rich zeolites in the amygdaloidal and vuggy interflow zones in which most groundwater movement occurs. Certainly calcite and prehnite are common in association with the zeolitic minerals in the Antrim Plateau Volcanics. Im some areas, particularly the western watershed of the Camfield River, the waters from the volcanics are sodium rich and this may be due to hydrodynamic environment particularly in areas of high salinity. In other instances it may be due to weathering of feldspars in joints etc. Generally, the calcium is subordinate to the sodium in the groundwater from the Helen Springs Volcanics in which rocks albitization of the feldspars is common (Randal, Brown, & Doutch, 1966). Hence with further investigation and more data, it may be possible to assess the geological factors affecting groundwater occurrence by means of the relative amounts of calcium and magnesium in the groundwater.

The importance of <u>magnesium</u> in drinking and stock waters has been previously discussed. It is beneficial in water used for agriculture as it flocculates the soil colloids and maintains soil permeability; it complements calcium in the reduction of sodium hazard in irrigation waters.

In this region the magnesium content of the groundwater is extremely variable: it is less than 40 ppm in many of the water samples from both the volcanic and carbonate formations, including the saline waters from the Anthony Lagoon Beds. But in some of the latter it attains a concentration slightly in excess of 200 ppm and in some of the samples from the Antrim Plateau Volcanics a concentration in excess of 150 ppm. Despite the generally low values it is dominant over calcium and sodium in several of the waters from the Antrim Plateau Volcanics between Killarney and Wave Hill, in two samples of water from the Helen Springs Volcanics near Banka Banka, from two samples from the Victoria River Group, and from bores believed to be in the Mullaman Beds near Ucharonidge homestead. Two bores near Shandon Downs which may be drawing water from the Anthony Lagoon Beds are dominant in magnesium. The source of magnesium in the carbonates is mainly from dolomitic rocks and in the volcanics the ferro-magnesium minerals.

The concentration of the major cations in the groundwater and their importance in classification of the water types is discussed on page 86 . The relative abundance of the cations in the waters is illustrated in Figure 21.

<u>The major anions</u>: The <u>chloride</u> ion content of the bore waters in this region is important only in those waters having high salinity. As found in the central Barkly Tableland there is a marked relationship between chloride content and salinity: and in this region it is most apparent in waters from the Anthony Lagoon Beds i.e. in the western and northwestern extension of the Barkly Tableland.

The chloride content ranges from a few parts per million in the western part of the region to 1700 ppm (nearly 49 epm) in the eastern part of the Helen Springs Sheet area. High chloride values occur also in the Green Swamp Well Sheet area. With the exception of two salty bores near Camfield homestead the chloride content in the western part of the region is low although it is moderately high in the areas drained by the upper reaches of the Victoria River, the Camfield River, and Cattle Creek. It is generally low in waters from the Tindall and Montejinni Limestones, particularly in low salinity waters near zones of recharge; these are usually dominant in the bicarbonate ion.

The very high chloride content - 52 epm (1800 ppm) - obtained for RN 4407 is unusual for the groundwater from the Antrim Plateau Volcanics. Certainly, to the south bores have drilled through the volcanics and obtained salty water in the Victoria River Group, but according to the driller's log this bore encountered mainly basalt to the total depth of 236 feet and obtained its main supply at 210 feet. This is deeper than most bores in the volcanics. And further, the high chloride is associated with a high alkali content, and other features which make the sample geochemically very similar to waters in semi-stagnant conditions in the Barkly Tableland.

The inference is that this is groundwater which may be derived from a saline groundwater body in the underlying Victoria River Group, which is entering the lower parts of the volcanic sequence by interconnexion across the unconformity.

In terms of absolute chloride concentration the values generally are not particularly high except in the areas discussed above. But the relative amounts of chloride have been important in the geochemical classification of the groundwater discussed on p. 85 .

The origin of chloride ion in groundwater is extensively discussed in the literature and this is summarized in Randal (1967). Although the occurrences may be readily explained by conditions of hydraulic environment, the levels of concentration can not unless a process of concentration by osmosis is envisaged. The gradual changes of salinity and the evidence of interconnexion tend to discount this possibility, at least on a regional scale, and for anomalously high values in the central Barkly Tableland Randal (op. cit.) postulates possible interbeds of evaporitic sediments. This situation may be pertinent in the southeastern part of this region i.e. in the western and northwestern extension of the Barkly Tableland. It may also be pertinent in those waters high in chloride in the Tindall and Montejinni Limestones and the Merrina Beds. Furthermore these are rocks deposited under marine conditions and the entrapment of chloride ion within the sediments during deposition is feasible.

The occurrence of chloride ion in other rock units such as the Victoria River Group, the various volcanic sequences, and the Tomkinson Creek Beds may simply be a function of the high solubility of chloride in relation to the other anionic particles. But intertidal conditions are postulated for the limestone interbeds in the Antrim Plateau Volcanics and minor accumulations ov evaporitic sediments are possible. Halite pseudomorphs in the Tomkinson Creek Beds (Randal, Brown & Doutch, 1966) indicate similar conditions for that unit. Appendix 7 lists chemical analyses of some aquifer rocks in the region and the chloride contents of these range up to 500 ppm. The highest values occur in samples from the Jinduckin Formation in which halite pseudomorphs are extremely common.

A further source of chloride is the possible intrusion of sea water to the groundwater body during the Cretaceous transgression, together with the leaching of salt areas after the seas had regressed and dried out.

The sulphate ion content of the groundwater in this region ranges from a few parts per million in the western part to over 1500 ppm (32 epm) in the eastern part of the region. The highest values occur in the water from the Anthony Lagoon Beds. Values higher than 5 epm (240 ppm) occur in the saline area southeast of Camfield homestead and in a large belt from near Elliott southeastward to the Attack Creek floodout area thence eastward to Rockhampton Downs in the central Barkly Tableland where it joins high sulphate areas previously investigated.

Abnormally high sulphate ion concentrations are not known in groundwater from the other Cambrian or Precambrian formations except in Ladabah bore which is in the Tomkinson Creek Beds west of the Ashburton Range, and in Dry River Stock Route No. 1 bore which apparently taps an aquifer in the Tindall Limestone southwest of Katherine. Some values higher than 5 epm occur in bores which may be obtaining water from Cretaceous aquifers in the Beetaloo and Newcastle Waters Sheet area.

The sulphate concentrations in the aquifer rocks reported in Appendix 7 indicate up to 2000 ppm in the Antrim Plateau Volcanics but most values for this formation are below 600 ppm. Values about 400-600 ppm occur in the Anthony Lagoon Beds and the Mullaman Beds. Values for the aquifer rocks of the Tindall and Monetjinni Limestones are about 400 ppm.

The high sulphate content of groundwater from parts of the Anthony Lagoon Beds has been attributed to the probable presence of evaporitic interbeds: certainly gypsum is known in the soil derived from these rocks and drillers have reported copi at depth. It may also be derived from pyritic material which is common in the carbonate rocks in the north and in dark grey shales from other formations. Milligan et al. (1966) record gypsum in the Merrina Beds.

All of the samples processed by A.M.D.L. were analysed for both carbonate and bicarbonate: carbonate was detected in only a few which had abnormally high pH values. Some of the other analyses reported carbonate as present but as the pH in these is below 8.0 they are suspect.

Although some abnormally high values of bicarbonate ion concentration (up to 750 ppm) occur in groundwater from the Anthony Lagoon Beds there is no clear distinction between groundwaters from the various formations in terms of absolute concentration of bicarbonate expressed either in parts per million or equivalents per million. There is some distinction however when it is expressed in terms of a percentage of the total anionic content and this is discussed in later sections. The importance of bicarbonate ion in the classification of the waters is evident in Figure 21.

Fluoride: As discussed in an earlier section the fluoride content of groundwater affects its potability. Apart from the high values in the eastern part of the region there appears to be little geochemical significance in its distribution. The rise in fluoride seems to be merely a reflection of the overall salinity increases in particular directions of groundwater flow. Admittedly one aquifer rock analysis of the Anthony Lagoon Beds has a value of 1500 ppm but the sole other has a value of 120 ppm; and in the other formations there are insufficient variations (or data) to detect any significant correlation between fluoride concentration in the groundwater and that in the rock.

Silica: In this region the silica in the groundwater is derived from the weathering or reconstitution of silicate minerals - notably feldspar - and from the solution of cryptocrystalline forms of silica such as chert or chalcedony. Chert is probably the main source of silica in waters from the carbonate rocks, and feldspars for that from the basalt. The mobility of silica in the region is evident in the development of silcrete over many of the surface exposures and the silicification of rocks at or near the laterite profile.

The concentration of silica in the groundwater ranges from less than 20 ppm in the most saline areas to nearly 70 ppm in areas which are considered to be either in or close to recharge zones. The apparent correlation between increasing salinity and decreasing silica content is probably a false one. The increase in salinity in this region is usually accompanied by an increase in sodium ion concentration which in turn favours the dispersion of the silica colloids. This would tend to keep the silica in solution and hence cause an increase of silica content with increasing salinity. However, with increasing distance from recharge zones there is a greater chance of adsorption of silica to the aquifer material, particularly in the calcium rich rocks (e.g. the carbonates) as calcium ion in solution tends to flocculate the silica colloid and remove it from the water. The correlation therefore is between decreasing silica content and increasing distance from recharge zone; since there is a correlation between the latter factor and increasing salinity, the pseudo-correlation between salinity and silica content is apparent. Similar effects have been noted in the central Barkly Tableland (Randal, 1967).

Boron: The importance of boron in water used for agriculture is discussed by Randal (op. cit.); boron is not physiologically important in the concentrations normally encountered in natural waters.

The concentration of boron in the groundwater in this region ranges from less than 0.1 ppm in the western part to nearly 3 ppm in the saline areas in the east. There is some apparent control by formations although the effect may be caused by environment of deposition. Values for water from the Antrim Plateau Volcanics are generally very low - less than 0.5 ppm - although in RN 904 and 905 on the Dry River Stock Route the values are anomalously high - 3.5 and 4.3 ppm respectively. The values for water from the carbonate rocks are low except for the Anthony Lagoon Beds. Groundwater from this unit in the eastern part of the region contains up to 2.8 ppm boron, and there is an apparent correlation between boron content and sodium content. The water from RN 6066 on the Cape Crawford road contains 4.8 ppm; the water is believed to be in the Anthony Lagoon Beds. Groundwater in the other rock units is generally less than 1 ppm. The amounts of boron in the aquifer rock analyses in Appendix 7 are extremely variable. They are up to 50 ppm for both the Anthony Lagoon Beds and the Antrim Plateau Volcanics, and less than half this for the other units. Presumably, it is not as readily available for solution by groundwater in the Volcanics as in the Anthony Lagoon Beds, and the presence of evaporites in the latter unit is a possible explanation.

Lithium: The lithium contents of the bore waters are very low, but again the highest values occur in the water from the Anthony Lagoon Beds. In the southeastern part of the region the values range up to 0.5 ppm, but with few exceptions they are elsewhere far less than 0.1 ppm. Moderate values 0.2-0.25 occur in water from presumed Cretaceous aquifers between Toudinny Creek and Ucharonidge homestead, and anomalous values of 0.14 and 0.11 occur in RN 904 and 905 on the Dry River Stock Route.

Iron and Manganese: The iron and manganese contents are low - less than 0.05 ppm. Four abnormally high values - 0.7 to 0.9 ppm - occur in the Helen Springs Sheet area, and although they are grouped in nearby pairs a more realistic explanation for the source is that of worn bore-head equipment.

Phosphate: The phosphate contents of the groundwater in the region are extremely low - usually less than 0.03 ppm. There is no definite geochemical correlation between groundwater phosphate and the rock units, although there is a very slight tendency for the amount to be somewhat higher in water from the volcanics than in that from the carbonates.

Nitrate: The nitrate contents range from less than 1 ppm along the Murranji Track and in the north of the region to almost 93 ppm in the southeastern part. High values also occur in the southern part of the Wave Hill Sheet area. The belt of very high values in the southeast (Fig. 22) generally coincides with the areas of high salinity, and the trends are suggestive of geochemical control by aquifer composition rather than control by bacteriological action. But at present nothing is known about the nitrate content of rocks in the Anthony Lagoon Beds. Although pollution by stock is a possible source of nitrate in the shallow groundwater of the Antrim Plateau Volcanics the high values between Wave Hill and Cattle Creek homesteads rather suggest aquifer control. An interesting feature there is the decline in nitrate content in the regional direction of groundwater flow: this may be the effect of gradual dilution away from the main source of the nitrate.

The ionic ratios: The ionic ratios $Cl^-/(Na^+ + K^+)$, Mg^{++}/Ca^{++}, $SO_4^=/Cl^-$, HCO_3^-/Cl^-, and $(Ca^{++} + Mg^{++})/(Na^+ + K^+)$ have been calculated and are presented in Appendices 3 and 6.

In the southeastern part of this region the trends of these ionic ratios are concordant with those established in the central part of the Barkly Tableland by Randal (1967), and support the general concepts of direction of groundwater flow, and aquifer composition suggested for that region. However in the remainder of the Wiso Basin and environs the paucity of the data at present precludes any useful geochemical interpretation of aquifer control on the ratio.

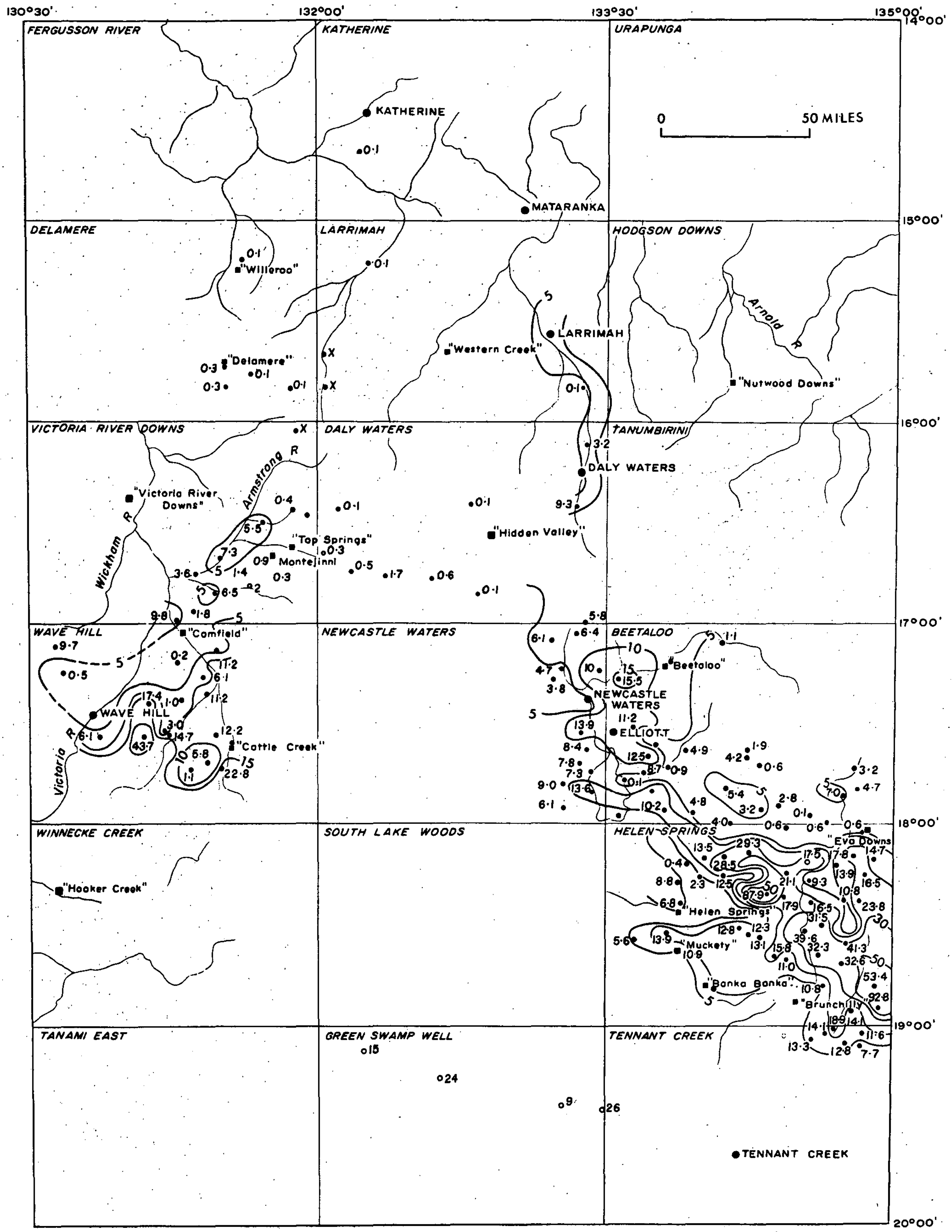


Fig.22 Concentration of nitrate ion (ppm)

NT/A290

To accompany Record 1969/16

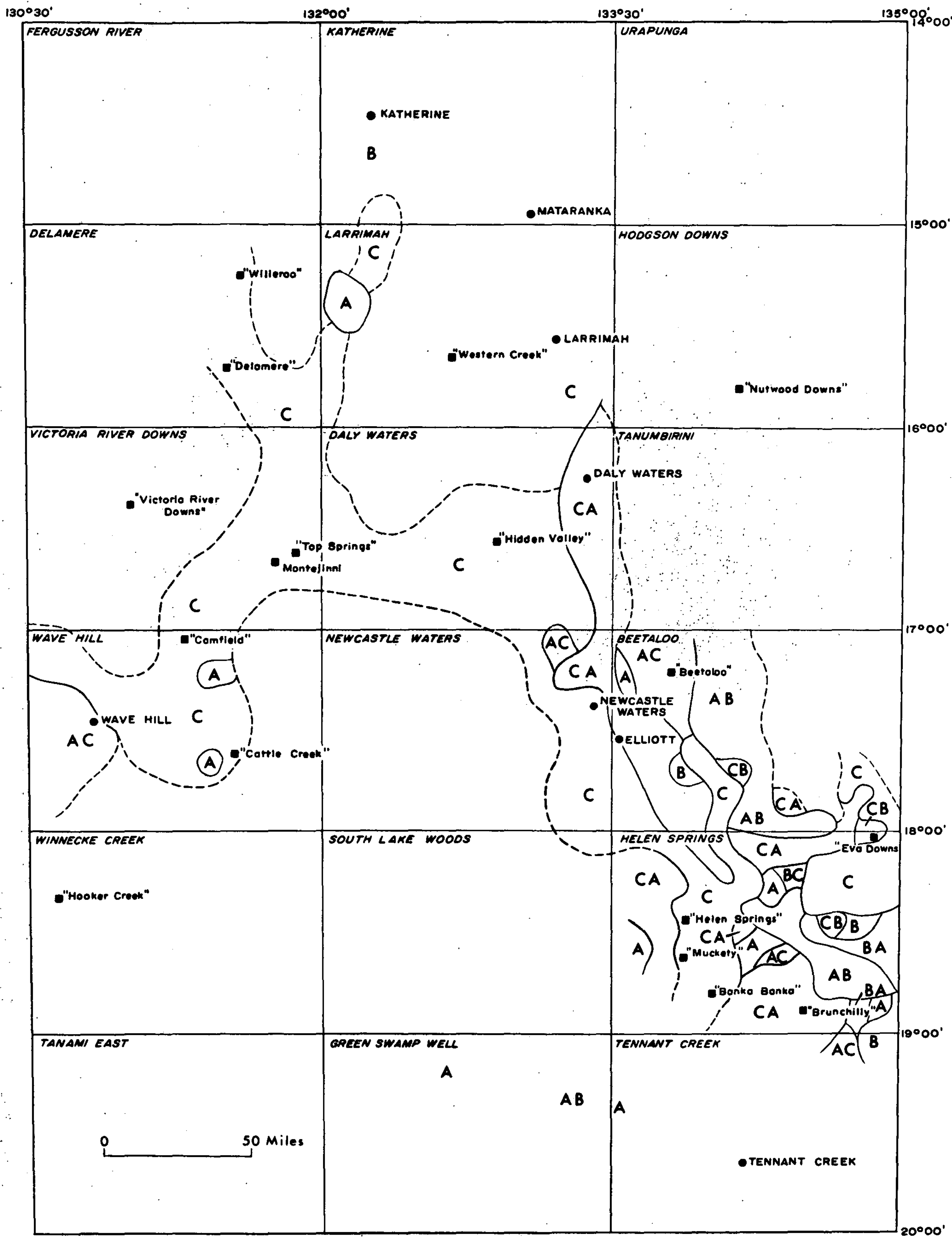


Fig.23 Areal distribution of chemical types of water (key to symbols given in table 13)

To accompany Record 1969/16 NT/A291

Chemical Types of Water

Two hundred and ten borewaters have been analysed but of these 42 have not been analysed in sufficient detail to permit classification of the water in terms of dominant and minor anions. However the remaining 168 analyses are supplemented by analyses of groundwater from 8 of the BMR scoutholes giving 176 analyses which can be so classified.

The waters are classified into three main groups based on the predominance of chloride (Cl^-), sulphate ($SO_4^=$), or bicarbonate (HCO_3^-) ion*, and each group has been subdivided into three types according to the next most common ion. For example the chloride group has been subdivided as follows:

i) mainly chloride type, in which $Cl^- \gg HCO_3^-$ or $SO_4^=$

ii) sulphato-chloride type in which $Cl^- > SO_4^= > HCO_3^-$ but $Cl^- - SO_4^=$ is not > 20 percent of total anions

iii) bicarbono-chloride type, in which $Cl^- > HCO_3^- > SO_4^=$ but $Cl^- - HCO_3^-$ is not > 20 percent of the total anions.

The corresponding subdivisions of the sulphate and bicarbonate groups have similar anionic relationships.

Figure 23 illustrates the spatial distribution of the various water types in the region, and Figure 21 and Table 13 indicate the numerical distribution based on the number of samples analysed.

TABLE 13: Numerical distribution of chemical types of groundwater

Secondary Anion \ Dominant Anion	Chloride	Sulphate	Bicarbonate	
Chloride	Mainly chloride (A) 12	Chloro-sulphate (BA) 3	Chloro-bicarbonate (CA) 30	
Sulphate	Sulphato-chloride(AB) 17	Mainly sulphate (B) 6	Sulphato-bicarbonate(CB) 4	
Bicarbonate	Bicarbono-chloride (AC) 8	Bicarbono-sulphate (BC) 1	Mainly bicarbonate (C) 95	
Totals	37	10	129	176

(A, AB, AC etc. refer to symbols in Appendices and Figures).

* In terms of equivalents per million not parts per million.

For the waters in the central Barkly Tableland, Randal (1967) further divided the anionic types into several classes based on the percentage composition of the cations sodium, magnesium, and calcium in relation to the total cationic content. This scheme was valid inasmuch as the groundwater was originating from essentially the one rock body - similar carbonate formations - and there was a total of 265 analyses with many of them falling into most of the cationic classes. However, in this region several dissimilar formations are involved, and further the total number of samples and the number of samples within each class is low enough (except for the chloro-bicarbonate and mainly bicarbonate types) to render the concept of an average composition rather misleading because of the potentially wide variations from the mean. It has proved more useful to work from the idea of an average ionic composition based on the formations, and to examine the cationic contents from the viewpoint of spatial rather than numerical distribution.

The spatial (and numerical) distribution of the various anionic types is briefly discussed below, together with comparisons with the central Barkly Tableland.

Chloride Group: The mainly chloride type are numerically small in direct contrast to their being the most dominant numerically in the central Barkly Tableland. They occur in several isolated areas in the Beetaloo and Helen Springs Sheet areas in the east and in the Larrimah and Wave Hill Sheet areas in the west. Mainly chloride waters occur in three scoutholes in the Merrina Beds in the Green Swamp Well Sheet area in the south. They occur in water from the Anthony Lagoon Beds mainly, but also in isolated samples from the Antrim Plateau Volcanics, and in one bore from the Tomkinson Creek Beds. In all samples, as found in the previous study, sodium is dominant over magnesium and calcium, and in half the samples from this region the sodium content was very much higher than the other cations. In most samples magnesium was dominant over calcium.

The sulphato-chloride type waters are slightly greater numerically than the previous type, and come from two large discrete areas in the eastern part of the region. One area extends northwards from the Barkly Stock Route through Ucharonidge station to the eastern part of Beetaloo station: the other is a southeast trending belt east of Helen Springs homestead and north of Brunchilly homestead. These, like the mainly chloride type, are very saline waters. Their source is mainly the Anthony Lagoon Beds, but some in the Beetaloo Sheet area may be coming from Lower Cretaceous aquifers. As may be expected from a type in the chloride group sodium is the most dominant cation: there are no samples in which either calcium or magnesium is in excess of sodium. There are a few in which calcium is in excess of magnesium.

The bicarbono-chloride waters are few, but are widely scattered. They occur about Beetaloo homestead, in saline waters in the east of the Murranji Track, in two small areas northwest and southeast of Brunchilly homestead, and about Wave Hill Settlement and homestead. The main producing aquifers are the Anthony Lagoon Beds, but isolated samples have come from the Lower Cretaceous Mullaman Beds, the Lower Cambrian Helen Springs Volcanics, and the Precambrian Victoria River Group. All the waters are dominant in sodium but in most of them calcium is dominant over magnesium.

Sulphate Group: The sulphate group are both numerically and spatially the least important. But of course they are extremely important from the point of view of groundwater use as sulphate is an extremely undesirable constituent and in this group its concentration is generally above the recommended limits. Mainly sulphate type waters are the most numerous in the group, followed in descending order by the chloro-sulphate type and the bicarbono-sulphate type. The dominance of calcium in the mainly sulphate type is obvious, and rather suggests the presence of gypsum. The association of sodium with chloride is obvious in the chloro-sulphate types as in these sodium tends to be dominant, as it is also in the single bicarbono-sulphate sample.

The sulphate group waters occur, with only one exception, in the western extension of the Barkly Tableland and presumably originate in the Anthony Lagoon Beds. A single mainly sulphate type water comes from the Tindall Limestone at No. 1 bore Dry River Stock Route.

Bicarbonate Group: The bicarbonate group with 129 samples is numerically by far the most important of the groundwater groups in this region. This is in contrast to the central Barkly Tableland where although numerically greater than the sulphate group it contains only about half the number of samples as contained in the chloride group. Figure 23 shows its spatial importance; it is extremely important from the point of view of groundwater use as it is the least saline water.

Within the group the mainly bicarbonate type is the most important - it contains almost 75 percent of the samples in the group and tends to contain the least saline water. Its occurrence is extremely widespread. Except for a few pockets of chloride group waters it is universal on the western flanks of the Main Plateau and along the Murranji Track to near Newcastle Waters; from there the type occurs to the south about Lake Woods and on the western flanks of /* to other water types. It then strikes southwards to Helen Springs homestead and thence to Banka Banka homestead. This area is joined northeast of Helen Springs homestead by another coming from the north about Ucharonidge homestead. A large area of mainly bicarbonate type water occurs to the north, east, and south of Eva Downs homestead. It is contiguous with a large area of bicarbonate type water in the

*/ the Ashburton Range. Further southward, the area of this water type swings eastward to the central part of the range leaning the western flanks .....

central Barkly Tableland (Randal, 1967). Mainly bicarbonate type waters occur about Katherine and Larrimah and along the Cape Crawford road, but there are insufficient control points or variations in type to delineate discrete areas on Figure 23.

Mainly bicarbonate waters occur in all the formations which contain producing aquifers.

The dominance of the main cations in the mainly bicarbonate type is shown in Table 14.

<u>TABLE</u> 14: Numerical distribution of cations in mainly bicarbonate waters

Dominant sodium	11	
Dominant sodium and magnesium	10	← 35
Dominant sodium and calcium	14	
Dominant magnesium	2	
Dominant magnesium and sodium	4	← 19
Dominant magnesium and calcium	13	
Dominant calcium	11	
Dominant calcium and sodium	7	← 41
Dominant sodium and magnesium	23	

As may be expected in bicarbonate type waters calcium and magnesium are dominant, but there is a high proportion -nearly 37 percent - in which sodium is dominant or at least in excess of calcium or magnesium. Because of these sodium rich bicarbonate waters the sodium range shown in Figure 21 is reduced only to 75 percent, but the chloride range to 33 percent, of the respective ranges as shown in Figure 12 in Randal (1967) for the central Barkly Tableland. This is explained by the inclusion in the sampling for this region of groundwater from volcanic rocks in which sodium from feldspars can be present without the dominance of the chloride ion. As discussed in Randal (1967) and earlier in this bulletin there is a close association between chloride and sodium in the waters from the carbonate formations.

The sodium rich bicarbonate waters mainly come from the Antrim Plateau Volcanics and the Helen Springs Volcanics. They occur about Willeroo and Delamere Stations, about the Camfield River south of its confluence with Cattle Creek and about Helen Springs and Muckety Stations. An isolated occurrence is Hidden Valley bore in the centre of the plateau which drilled through the Cretaceous and Cambrian rocks to obtain water from the underlying volcanics. There are isolated occurrences for bores presumably drawing water from carbonate rocks about Sturt Plain and from either Cretaceous rocks or Middle Cambrian rocks about Lake Woods. These may be due to base exchange reactions with sodium contained in siltstones and shales. The process of base exchange does not increase the salinity of the water but merely the proportion of sodium in it: these waters are not unduly saline and are far less saline than those in the east in which sodium and chloride ion appear to be in association.

The sulphato-bicarbonate type waters are rare. They tend to occur adjacent to mainly bicarbonate waters near the boundaries between these and more saline sulphate or sulphato-chloride waters. Sodium is the dominant cation.

The chloro-bicarbonate type occur only in the eastern part of the region. They extend from about Daly Waters southward to Elliott and thence southeastward and eastward about the Barkly Stock Route to near Eva Downs and Shandon Downs homesteads. They occur in a large area about Brunchilly homestead in the southeast of the region, and isolated samples occur in the Ashburton Range and its western flanks. These waters are mainly produced from aquifers in the Anthony Lagoon Beds, although in the Beetaloo Sheet area some may be coming from the Lower Cretaceous Mullaman Beds. Wiggenty Well on Muckety Station produces this type of water from the Tomkinson Creek Beds, and Helen Springs No. 7 is also producing this type either from the Tomkinson Creek Beds or from the Helen Springs Volcanics. The type is marginal to the mainly bicarbonate types, separating them from the saline chloride type waters.

The influence of the chloride ion in this type is reflected by the dominance of the sodium cation. Calcium is dominant in only one of the samples but although exceeded by sodium it is still significant in over half the samples of this type.

Geochemistry and groundwater environment

Concepts of the changing composition of groundwater have been put forward by Schoeller (1959) and Chebotarev (1955) and have been summarized by Randal (1967, p. 66). Under normal conditions groundwater enters the aquifer system as a bicarbonate type water of low salinity and through the various physical and chemical reactions within the aquifer it gradually changes to a chloride type water of much higher salinity. Hence low salinity bicarbonate types occur at or near the zone of recharge; they are relatively closer to the zone of recharge than the saline chloride type waters or the intermediate types such as the chloro-bicarbonates, bicarbono-chlorides, and those containing dominant or sub-dominant sulphate ion. Anomalies may occur because of concentrations of particular ions in various rock types in the aquifer system.

Although anomalies certainly are present there is a definite correlation between the geochemistry and the groundwater environment in this region. It is most pronounced in the northwestern extension of the Barkly Tableland, probably because there is a greater density of bores to provide control points for contouring the various parameters.

To the east of the Ashburton Range the slope of the potentiometric surface indicates the movement of the groundwater is eastward and northeastward towards the central depression of the Barkly Tableland.

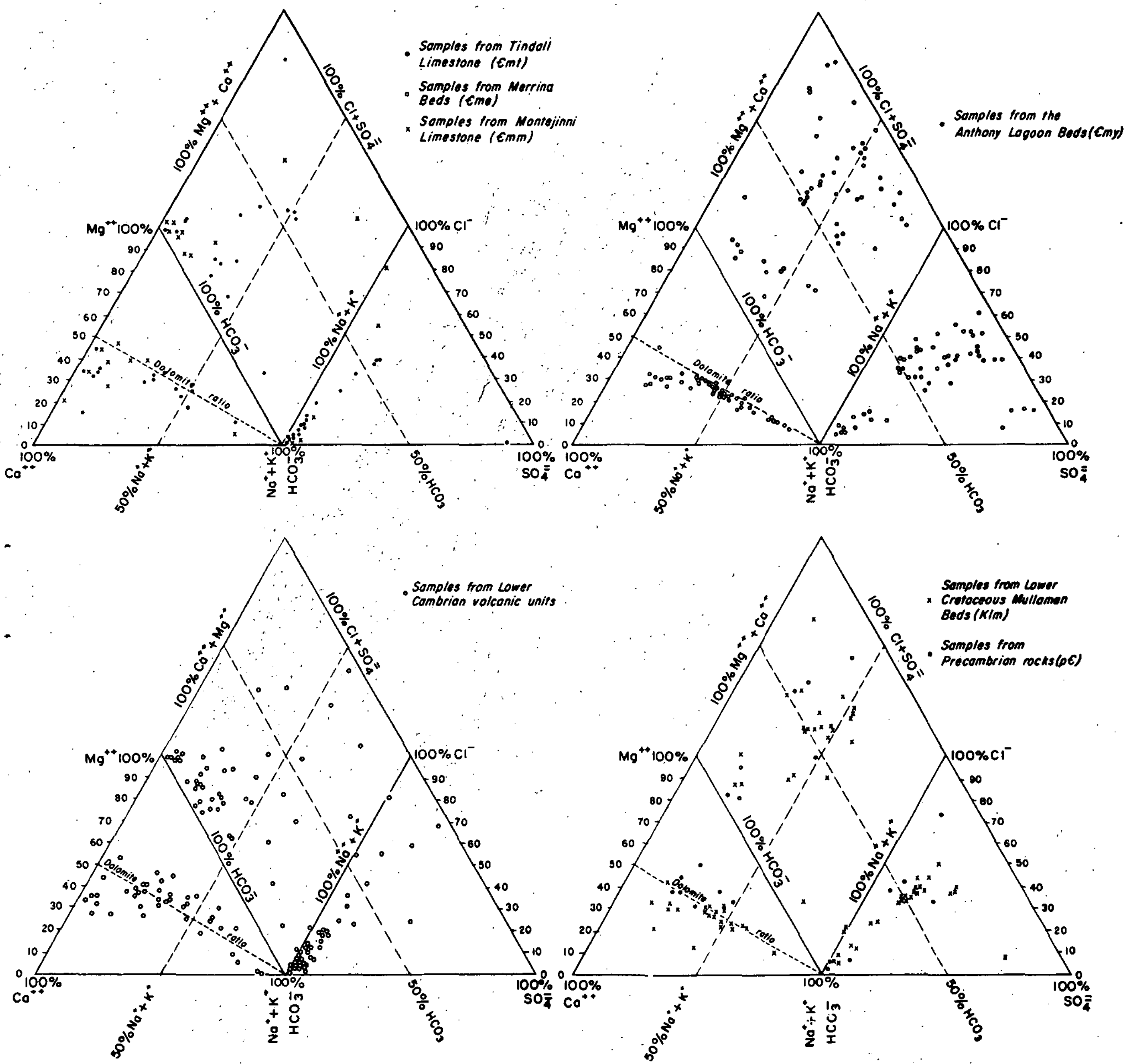
Figures 19 and 23 indicate a salinity rise and a progressive change from mainly bicarbonate type waters to various types of the chloride group in the same direction. All three parameters imply a zone of recharge along the eastern flanks of the range. Similarly a zone of recharge is indicated by the 550-foot contour on the potentiometric surface about Eva Downs; it is complemented by salinity increases in the direction of flow and is partially outlined by bicarbonate group waters. Along the eastern boundary of the region these trends are in accordance with the trends in the central Barkly Tableland.

Elsewhere the lack of control points prevents the relationships from being accurately defined. The water of relatively low salinity at Hooker Creek Settlement is a chloro-bicarbonate type. The potentiometric surface indicates water movement is to the north and northeast and there is an ill defined change to some chloride group waters in those directions; there is also a slight salinity increase towards the mainly chloride type waters near Cattle Creek and Camfield homesteads. But the surrounding areas are producing mainly bicarbonate type waters of relatively low salinity even though they are in an area of lower potentiometric levels. A possible explanation for this phenomenon is that although groundwater movement is northward and is accompanied by rising salinity efficient recharge to the volcanic aquifers is locally taking place throughout the western part of the region and the upper levels of the aquifer system contain recently acquired recharge water which has not travelled far. This implies that the saline water is moving through at depth. Certainly shallow bores are common in this area and although no analyses are available several deep bores were abandoned because of reputedly saline water. Possibly the sodium rich waters in this area (see page 78) may be the reflection of water having travelled some distance from the recharge zones. But with the present data it is virtually impossible to separate the effects of this phenomenon from that caused by the better availability in some areas of sodium from feldspars in the basalt.

Again, there is no marked increase in salinity or change in anionic composition westward from the ridge in the potentiometric surface between Top Springs settlement and Willeroo homestead. But the gradients there are very steep and hence groundwater movement tends to be rapid. Also there is ample opportunity for local recharge to shallow aquifers. Sodium rich waters occur there,and may be the effect of base-exchange as water moves away from the recharge zone. As mentioned earlier base-exchange may raise the relative sodium content without any great increase in salinity.

The marked spur in the potentiometric surface west and south of Western Creek homestead and its complementary south-flanking valley are reflected by a spur and re-entrant in the 500 ppm salinity contour, together with a closed 1000 ppm contour. This situation confirms that despite the general northward slope of the potentiometric surface there are reversals in the direction of groundwater movement. Situations like this may be responsible for the lack of accordance between apparent direction of flow and the direction of increasing salinity.

FIG. 24



TRIANGULAR PLOTS OF GROUNDWATER FROM SELECTED FORMATIONS

NT/A 292

To accompany Record 1969/16

The most striking discordance between the direction of sloping potentiometric surface and the direction of increasing salinity is in the southern central part of the region. Immediately west of the Ashburton Range the direction of slope of the potentiometric surface is westward towards the Wiso Basin and this is supported by the increase of groundwater salinity and by the progression from bicarbonate to chloride type waters. But from the line of scoutholes in the Green Swamp Well Sheet area, three of which produced moderately saline waters of the chloride group, the regional slope of the potentiometric surface appears to be northward towards the central part of the Murranji Track where the waters are less saline and of bicarbonate type. This discordance may be explained by the lack of control points in the intervening large area: possible reversals of slope or salinity changes may be present but are completely non-apparent. Another explanation is the same as envisaged further to the west: the saline water is in fact moving north but its effects are masked by recharge water entering the aquifer system and diluting it. But the intriguing point is that the direction of groundwater flow as suggested by the salinity contours is the general direction of dip and thickening of sediments in the Wiso Basin as postulated by Milligan et al. (1966). The problem can only be solved by extensive drilling south and southeast from Hooker Creek and Cattle Creek to Tennant Creek and in the southern part of the Wiso Basin below latitude 20°S.

Similar anomalies occur between Western Creek, Larrimah and Katherine. Probably the key to these areas lies in the sparsely drilled Larrimah Sheet area, and also in the hydrogeologically unknown area of the Roper River watershed.

Geochemistry and the rock units.

The chemical composition of the groundwater from some of the formations in terms of average percentage reacting values* is shown in Table 15. Triangular plots of actual analyses of groundwater from various formations are shown in Figure 24. Although there is some effect of formation geochemistry on the groundwater geochemistry a great deal of the latter seems to result from the structural position of the units in the groundwater regime.

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* In terms of 100 percent total anions and 100 percent total cations. The concept is the same as that shown in Appendix 3.

TABLE 15: Average composition of groundwater from selected formations.

Formation	Average percentage reacting values						
	$Na^{+}+K^{+}$	Ca^{++}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	Type
Mullaman Beds (Klm)	47	28	25	32	19	49	CAnc
Montejinni Limestone (Єmm)	18	48	34	14	4	82	Ccm
Anthony Lagoon Beds (Єmy)	45	31	24	32	28	40	CAnc
Antrim Plateau Volcanics (Єla)	36	34	30	16	6	78	Cnc
Helen Springs Volcanics (Єlh)	38	27	35	21	8	71	Cnm
Tindall Limestone(Єmt)	35	39	26	29	23	48	CAcn
Tomkinson Creek Beds (Plt)	32	32	36	36	13	51	CAmn

The Antrim Plateau Volcanics and the Helen Springs Volcanics have average groundwater compositions that are very similar although in the latter magnesium is significantly higher than calcium. Both formations tend to produce sodium rich waters and both produce mainly bicarbonate waters. Figure 24 illustrates that increasing sodium content is accompanied by a rise in the Mg^{++}/Ca^{++} ratio (the dashed line represents a ratio of unity and is called 'the dolomite ratio') although for the very sodium rich the trend is reversed because though the waters have very little calcium, they have even less magnesium. Possibly the reason is base exchange. The waters are particularly deficient in sulphate content, although there is a tendency for it to rise with increasing chloride. The clustering near the bicarbonate apex is dramatic and clearly indicates the proximity of recharge zones to most of the sampling points.

The average anionic composition and the anionic trends for the Montejinni Limestone and the Tindall Limestone are both similar to those for the two volcanic formations although there is a much stronger chloride influence in the waters from the Tindall Limestone. The very high sulphate (and calcium) plot for one of the samples from the Tindall Limestone is very much out of character. It refers to the Dry River Stock Route No. 1 bore, which has previously been discussed, and is certainly suggestive of the influence of gypsum. The magnesium content tends to remain well below the dolomite ratio line although some samples lie slightly above or below it. These are from the Montejinni Limestone in which there appear to be more interbeds of dolomitic limestone than there are in the Tindall Limestone.

The groundwater samples from the Anthony Lagoon Beds provide a very interesting geochemical trend. As indicated in the table of average compositions there is a very strong chloride and sodium influence. This is also immediately apparent from Figure 24 where in the rhombohedral portion of the graph the two are associated. This of course suggests the presence of interbeds of evaporitic material within the carbonates of the unit. At the same time there is some evidence of base exchange: some of the relatively high sodium values fall low in the rhombohedral graph towards the bicarbonate line. Base exchange could be effected by siltstone or shale interbeds which are known in the sequence.

But this process cannot be involved to explain fully the striking relationship noted between rising percentage chloride content, rising percentage sodium content, and rising salinity.

The dispersion in the anionic graph clearly reflects the passage from bicarbonate type waters to chloride waters i.e. near-recharge zone waters to near-stagnating waters, although there are marked breaks in the point density. This also is apparent in Figure 24 in Randal (1967) which is the same plot for averaged sample values in the carbonates of the adjoining region. The breaks are not as pronounced there as they are in Figure 24 in this bulletin probably because in this figure the plots are of actual samples and not averages of samples. The percentage cation graph (left-hand triangle) for the Anthony Lagoon Beds shows a definite trend towards the dolomite ratio particularly as the sodium content rises. The interesting point is that the dolomite ratio - $Mg^{++}/Ca^{++} = 1^{-}$ is rarely exceeded. The cluster of the points immediately below the line is completely different to the plots of the graphs described above for other formations.

Dolomitic interbeds - both siltstone and carbonates - are well known in the Anthony Lagoon Beds and it is reasonable to expect the Mg/Ca ratio in the water to approximate that of the rock with distance from the recharge zone i.e. with increasing salinity which in this area is concomitant with an increase in percent sodium. This affinity between the points and the dolomite ratio line also occurs in Figure 24 in Randal (op. cit.) although there the dispersion is greater and indeed there are points well above the dolomite ratio line. The comparative dispersion for the samples in the earlier work may well indicate the cation variation caused by aquifer composition which was being sought in that study, and certainly the analyses should be re-evaluated.

The average ionic composition of the groundwater from the Lower Cretaceous rocks is remarkably similar to that of the Anthony Lagoon Beds, as also are the percentage cation and anion graphs. The immediate implication is that these waters are in fact coming from the Anthony Lagoon Beds and not the overlying Cretaceous units. But for most of the samples this is not a tenable explanation as the total depth of the bores is insufficient for the bore to have penetrated deeper than the estimated base of the younger sequence: and for those bores which have been geologically logged this is a certainty. But a possible explanation is that the Cretaceous aquifers have obtained their contained water by pressure adjustment of confined water effected by water moving upward from the Cambrian aquifers into the porous and permeable sandstone at the base of the younger sequence. This may also be an explanation of the relatively low static rise encountered in most bores obtaining water from the Lower Cretaceous rocks.

ACKNOWLEDGMENTS

Thanks are due: to officers of the Water Resources Branch Northern Territory Administration for providing bore data and general information, especially I.R. Binch, Senior Engineer (Groundwater); to Messrs A.J. Gorey and S. Cole, drillers, for copious bore data, technical discussions and hospitality; to station owners, managers and book-keepers for permission to peruse station records, and for their hospitality, in particular Mr. and Mrs. R. Scobie of Hidden Valley, Mr. and Mrs. M. Elliot of Birrimba, Mr. & Mrs. W. Atkinson of Helen Springs, Mr. and Mrs. W. Tapp of Killarney, Mrs. Ward of Banka Banka, the Hagan family of Muckety and the Beebee family of Ucharonidge.

I am indebted to Messrs A. Rigg and R. Lawson, vacation students, Bureau of Mineral Resources who had the task of processing into usable form the chemical analyses and the wealth of data provided to the author by the above persons. Mr. A.D. Haldane, B.M.R., freely gave his time to the author for discussions on the chemistry of the groundwater, as did Messrs T. Quinlan, N.O. Jones, and G.M. Burton of the Bureau for discussions on the hydrogeology. In the course of the survey several geologists and assistants helped the author in many ways, notably M.C. Brown and K.J. Armstrong.

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GEOLOGY OF THE NORTHERN WISO BASIN AND ENVIRONS

PLATE 1

NT/A293

APPENDIX I: WATERBORES - WISO BASIN AND ENVIRONS

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
				BEETALOO 1:250,000 Sheet Area							
316	Newcastle Waters No. 2 (Arabunka)	14 miles south-east of Elliott	695	248	Mullaman Beds	180	180	-	-	990	
471	Elliott No. 2	Elliott Township	724	243	Cambrian	243	198	225	3600	-	
516	Barkly S/R No. 8	½ mile east of Elliott Township	690	400	"	300	182	-	3000	478	
517	Barkly S/R No. 7	15 miles south-south-east of Elliott	730	574	Mullaman Beds or Anthony Lagoon Beds	200	170	204	2500	872	
518	Barkly S/R (Tandyidgee)	26 miles south-east of Elliott	710	340	" " "	-	175	218	1600	1324	
519	Barkly S/R No. 6	38 miles south-east of Elliott	705	224	Anthony Lagoon Beds?	-	175	197	1100	1052	
522	Barkly S/R No. 3	14 miles west of Eva Downs homestead	690	175	Anthony Lagoon Beds?	144 175	139	-	1200	1128	
523	Barkly S/R (Eva Downs)	2 miles north-west of homestead	710	292	Mullaman Beds	275	146	275	1600	1186	
540	Elliott No. 1	Elliott	724	136	-	-	-	-	-	-	
541	Town Supply	Elliott	724	313	-	240 312	208 -	251 -	 1600	- 670	
1056	Ucharonidge No. 2	Old Homestead	775	280	Mullaman Beds?	245	234	260	1500	2033	
1186	Anthony Lagoon No. 24	2 miles south-west of Old Shandon Downs homestead	777	-	-	-	-	-	-	816	Also known as Shandon No. 1
1187	Anthony Lagoon No. 23	New Shandon Downs homestead	800	-	-	-	-	-	-	975	
1233	Beetaloo Homestead	Homestead	716	-	Mullaman Beds?	-	-	-	-	669	
1290	Helen Springs No. 10	46 miles west of Eva Downs homestead	740	395	Anthony Lagoon Beds	-	-	-	1700	1546	
1296	Helen Springs No. 16	19 miles south-east of New Ucharonidge	760	373	Anthony Lagoon Beds?	-	-	-	1200	-	Abandoned Refer R.N.4695
1297	Helen Springs No. 17	18 miles south-south-east of New Ucharonidge	785	335	Anthony Lagoon Beds?	-	-	270	1500	1418	
1529	Newcastle Waters No. 6	14 miles east by south of Elliott	725	243	Mullaman Beds?	206	206	-	1200	572	
1533	Newcastle Waters Lewis Ridge (Tent Pole)	20 miles north by east of Elliott	700	290	Mullaman Beds	225	185	-	1440	910	
1534	Newcastle Waters-E Bore	32 miles east of Elliott	755	233	Mullaman Beds	206	206	-	1800	-	
1622	Ucharonidge No. 1	4 miles north by west of homestead	800	330	Anthony Lagoon Beds?	-	240	310	900	1245	
1623	Ucharonidge No. 3	6 miles south-west of homestead	800	316	-	-	270	280	1500	789	
1888	Eva Downs - J Bore	19 miles west by north of homestead	765	355	Anthony Lagoon Beds	345	215	-	1800	930	
2165	Anthony Lagoon No. 22	14 miles north-west of Eva Downs	730	307	-	-	-	175	-	1769	
2335	Newcastle Waters Blue-Bush	Lake Woods - Hawker Creek	-	205	Gum Ridge Formation or Merrina Beds	-	-	-	1500	-	
2348	Newcastle Waters Orange Tree	13 miles east by north of Elliott	705	291	Mullaman Beds?	-	-	-	1440	890	
2349	Newcastle Waters Fergusson	Lake Woods-Fergusson Creek	666	289	Gum Ridge Formation?	-	-	220	2000	-	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
				BEETALOO (Cont.)							
2351	Newcastle Waters Reg Williams	7 miles north-east of Elliott	700	280	Mullaman Beds?	-	-	-	1650	880	
2352	Newcastle Waters One Tree	22 miles south-east of Elliott	725	329	Mullaman Beds or Anthony Lagoon Beds	-	-	240	1900	1130	
2353	Newcastle Waters Sweetwater	24 miles south-south-east of Elliott	693	255	" " " "	-	-	230	2000	486	
2380	Beetaloo - Huddleson Lagoon	Huddleson Lagoon on Newcastle Creek	737	270	Mullaman Beds	-	-	-	-	-	
2381	Beetaloo Martyrs Tree	21 miles east-north-east of homestead	721	280	Mullaman Beds	-	-	-	-	1554	
2382	Beetaloo No. 1 (A. Bore)	11 miles south-east of homestead	740	290	-	-	-	-	-	-	
3148	Anthony Lagoon No. 25	13 miles north-east of Eva Downs homestead	756	270	-	-	-	270	1800	-	
3454	Newcastle Waters Lawson	Lake Woods-Near Lawson Creek	660	171	Gum Ridge Formation?	-	-	145	1600	310	
4695	Helen Springs No. 16	19 miles south-east of New Ucharonidge	760	349	Anthony Lagoon Beds	-	215	-	2000	711	Replacement for R.N. 1296
4707	Anthony Lagoon No. 30	11 miles south-south-east of Old Shandon Downs homestead	c.800	340	Unconformity between Mullaman Beds and Anthony Lagoon Beds	285 315	285 -	306 -	- 1200	-	Also known as Shandon Downs No. 30
4882	Beetaloo-Southern Cross No. 2	10 miles north by west of homestead	c.750	280	Mullaman Beds	255	211	213	1200	-	
4912	Newcastle Waters A. Bore	31 miles south-south-east of Elliott	690	194	Mullaman Beds or Anthony Lagoon Beds	175 181	155 -	182 -	Unlimited -	808 -	
4913	Newcastle Waters B. Bore	25 miles east-south-east of Elliott	735	237	Anthony Lagoon Beds	190-215	188	208	2400	404	
4914	Newcastle Waters C. Bore	22 miles east by north of Elliott	765	270	Unconformity, Mullaman Beds/ Anthony Lagoon Beds	232	-	250	2400	-	
4915	Newcastle Waters D. Bore	30 miles east by north of Elliott	783	409	Anthony Lagoon Beds	-	-	367	1500	-	
4916	Newcastle Waters Spell Paddock	12½ miles north by west of Elliott	715	-	-	-	-	-	-	475	
4922	Beetaloo Southern Cross No. 1	14 miles east-north-east of Beetaloo homestead	715	285	Mullaman Beds	210 270-285	200 -	258 -	- 780	 Good	
5046	Eva Downs K. Bore	5 miles north by east of homestead	740	248	Mullaman Beds?	-	-	-	-	-	
5391	Anthony Lagoon No. 32	6 miles north-west of No. 24 (R.N. 1186)	790	308	Anthony Lagoon Beds	261 282 302	250	-	1200	Good	
5432	Ucharonidge No. 4	8 miles west by south of Old Ucharonidge	780	254	Mullaman Beds	236	236	-	2000	453	
5433	Ucharonidge No. 5	3½ miles south-east New Ucharonidge	795	300	Mullaman Beds?	210	210	280	1500	2021	
5439	Mungabroom Anthonys	6 miles east-north-east of homestead	785	252	-	-	-	-	1400	-	
5440	House Bore	Mungabroom homestead	803	286	-	-	-	-	2000	-	
5441	Mungabroom No. 3	1½ miles south by west of Mungabroom Waterhole	-	357	-	-	-	-	1500	-	
5621		8 miles east of Beetaloo homestead	715	310	Mullaman Beds	190	187	-	200	Good	
5683	Ucharonidge No. 6	11 miles south-south-east of New Ucharonidge	785	262	Mullaman Beds?	222	222	242	1500	-	
5684	Ucharonidge No. 7	New Homestead	790	398	Mullaman Beds or Anthony Lagoon Beds	-	250	368	2000	1392	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
					DALY WATERS 1:250,000 SHEET AREA						
53	Birdum S/R No. 5	14 miles south by west of Daly Waters	765	361	Tindall Limestone	275	275	347	950	1562	Abandoned See R.N. 557
552	Birdum S/R No. 7	22 miles south by west of Dunmarra	775	314	Mullaman Beds or Tindall Limestone	-	249	259	500	1187	Abandoned See R.N. 2264
555	Birdum S/R No. 4	11 miles north of Daly Waters - Roderick Waterhole	645	250	Mullaman Beds or Tindall Limestone	-	154	168	1500	1355	
556	Daly Waters Aerodrome	Daly Waters Aerodrome	700	244	Tindall Limestone?	-	199	220	-	1824	
557	Birdum S/R No. 5	14 miles south by west of Daly Waters	765	343	Tindall Limestone	270	258	-	1500	1337	
559	Birdum S/R No. 6	At Dunmarra	758	329	Mullaman Beds or Tindall Limestone	-	275	285	1500	-	
582	Murranji S/R 10 A	32 miles south-west of Dunmarra	753	276	Merrina Beds?	240-276	233	261	1450	-	
586	Murranji S/R No. 13	23 miles south by east of New Birrimba homestead	906	560	Antrim Plateau Volcanics or Montejinni Limestone	500	354	360	1500	454	
587	Murranji S/R No. 12	29 miles south-east by south of New Birrimba homestead	920	620	Merrina Beds/Montejinni Limestone	456 609	389	434	1500	485	
588	Murranji S/R No. 11	40 miles south-east of New Birrimba homestead	850	608	Merrina Beds	550	372	378	1000	488	
589	Murranji S/R, Murranji Waterhole Bore	Murranji Waterhole	800	588	Merrina Beds	-	290	350	3000	303	
590	Murranji S/R No. 10	1 mile east of 10A (R.N. 582)	750	600	Mullaman Beds or Merrina Beds	430	250	300	900	2117	
636	Dunmarra No. 1 Drought Relief	6 miles south-west of Dunmarra	760	296	Mullaman Beds?	-	-	270	1440	-	
908	Murranji S/R No. 14 (Pussycat)	24 miles south of Nelly Waterhole	723	264	Montejinni Limestone	-	117	145	1200	456	
1464	Army Bore 618	3 miles south of Daly Waters	-	251	-	-	-	-	-	-	Not located
1465	Army Bore 620	8 miles south of Daly Waters	-	352	-	-	-	-	700	-	Not located
1466	Army Bore 622	42 miles south of Daly Waters (Johnson's Lagoon)	c.747	283	-	-	-	-	100	-	Not located
1982	Hidden Valley Bore	12 miles north-west of Homestead	770	370	Montejinni Limestone, or Antrim Plateau Volcanics	-	272	-	-	426	
1989	Dry River S/R No. 8	Not located	-	370	-	-	-	-	-	-	See R.N. 2529 and R.N. 5425. 1st attempt, Dry hole, hard drilling, abandoned.
2263	Dunmarra No. 3	2 miles west of Frew Pond	760	300	-	-	-	-	-	-	
2264	Birdum S/R No. 7	-	775	-	-	-	-	-	-	920	See R.N. 552
2529	Dry River S/R No. 8	45 miles north-east Top Springs Not located	-	224	-	-	-	-	-	-	See R.N. 1989 and 5425. 2nd attempt - dry.
2778	Daly Waters Station Kallala Bore	Kallala homestead 6 miles north-north-west of Daly Waters	680	218	Tindall Limestone	192	186	-	1500	-	
4518	Widgee Bore	New Birrimba Homestead	685	180	Montejinni Limestone	155	146½	160	750	407	

DALY WATERS (Cont.)

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
4529	Daly Waters Station Moorak	8 miles north of Kallala homestead	675	220	Tindall Limestone (Below unconformity with Mullaman Beds)	196 206-220	196	-	1800	Fair	
4596	A.I.B. Johnsons	Johnsons Lagoon - 11 miles south of Dunmarra Roadhouse	-	-	-	-		-	-	-	Not located
5395	Daly Waters Station Enoa Noa	8 miles north-east by north of Daly Waters	656	187	Tindall Limestone	170-187	170	-	1200	1193	
5425	Dry River S/R No. 8	10 miles north of Nelly Waterhole	780	908	Antrim Plateau Volcanics	595 725 880	330 240 228	-	60 400 800	1457	
5760	C.C.A.	5 miles east of Stuart Highway on Daly Waters - Borroloola Road	750	270	Unconformity . Mullaman Beds and Tindall Limestone	253	250	-	1200	-	
	House Bore	Daly Waters Station	-	-	-	-	-	-	-	1338	Old Army Bore R.N. unknown.
	Natural Well	11 miles south by west of Hidden Valley homestead	825	-	Mullaman Beds	-	20	22	800	20	

DELAMERE 1:250,000 SHEET AREA

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
1346	Delamere No. 6 Well	Homestead	345	60	-	-	31	-	-	371	
1349	Delamere No. 4 Georges Bore	Georges Creek - 15 miles south-south-west of homestead	c.450	71	Antrim Plateau Volcanics	-	-	-	-	-	Not equipped
1350	Willaroo No. 2 Well	-	-	21	-	-	-	-	-	-	
1351	Willaroo No. 3	At Willeroo homestead	530?	22	Antrim Plateau Volcanics	-	-	-	-	-	
1352	Willeroo No. 4 Well	-	-	22	-	-	-	-	-	-	
1353	Willeroo No. 5 Well	-	-	-	-	-	-	-	-	-	Caved in
1354	Willeroo No. 14 Well	Near Mount Leonard	-	-	-	-	-	-	-	-	Not located
1355	Willeroo No. 1 Nemo Bore	-	-	105	-	-	-	-	-	-	Now dry
2210	Coolibah S/R Camp Oven Bore	-	c.500	167	Tindall Limestone?	-	110	140	700	-	
3546	House Bore	Willeroo homestead	530	81	Antrim Plateau Volcanics	64 76 81	17 - -	- - -	- - -	- - -	
3766	Delamere No. 5 Site 2	15 miles south-south-east of homestead	550	200	Antrim Plateau Volcanics?	131 160 200	140	-	800 1300 2000	-	
4029	-	6 miles east of Delamere homestead	590	-	-	-	-	-	-	-	Dry
4488	Willeroo-Horse Paddock Bore	8 miles south-west of homestead	600?	331	Antrim Plateau Volcanics	94 134 321	29 29 65	- - -	140 950 -	492	
4792	Delamere No. 2 Site 3	10 miles east by south of homestead	645	150	Antrim Plateau Volcanics	140	100	-	-	325	
4793	Delamere No. 3 Site 6	5 miles north-north-west of Tinker Hill	620	200	Antrim Plateau Volcanics	180	160	-	1800	-	
5402	Willeroo Beef Road No. 3	Near Mount Leonard	530	260	Antrim Plateau Volcanics	12 153 215-219	9	-	1000	397	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
			DELAMERE	**(Cont.)**							
5421	House Bore	Delamere homestead	415	490	Victoria River Group	475	18	-	6000	616	
5437	Willeroo Beef Road No. 4	Humbles Creek	625	101	Antrim Plateau Volcanics	10 26 78	10	-	1700	-	
5459	Delamere Station	6 miles south of homestead	595	500	Antrim Plateau Volcanics	270	102	-	126	218	Insufficient Supply
5460	" "	5 miles north-north-east of homestead	450	500	Victoria River Group	470	35	-	360	-	
5469	Willeroo Beef Road No. 5	17 miles south by east of Willeroo homestead	850	147	Antrim Plateau Volcanics	138	84	-	-	-	Approx. 50 feet east of R.N. 5945
5470	Willeroo Beef Road No. 5	-	850	249	-	86	-	-	-	-	1st attempt at R.N. 5469. Both replaced by R.N. 5945
5471	Delamere 10/32	3.2 miles south-west of homestead	360	330	Victoria River Group	310	30	-	-	-	
5496	Willeroo Beef Road D.W.H. No. 2	12 miles east by north of Delamere homestead	810	602	Montejinni Limestone (Middle Unit)	102	73	-	300	-	
5522	Delamere Horse Spring Creek	1 mile south of Johnstone Waterhole on Gregory Creek	430	295	Antrim Plateau Volcanics and Victoria River Group	35 90 110	25 25 25	-	550 700	-	
5543	Delamere 1022	3 miles east-south-east of homestead	590	610	Antrim Plateau Volcanics and Victoria River Group	155 460	100	-	360	-	Not equipped
5544	Willeroo Beef Road D.W.H. No. 3	23 miles at 109° from Delamere homestead	720	585	Antrim Plateau Volcanics	135 406 422	94 94 94	- - -	900 1440 1600	391	
5545	Willeroo Beef Road D.W.H. No. 4	7 miles south of D.W.H. No. 1	875	411	Antrim Plateau Volcanics	101 355	79 59	- -	900 1200	- -	
5546	Willeroo Beef Road D.W.H. No.5	18 miles at 95° from Delamere homestead	755	327	Antrim Plateau Volcanics	128 269	107 90	- -	150 2400	- -	
5547	Delamere Queuing Pen Bore	6 miles north-east of homestead	455	60	Antrim Plateau Volcanics	40	22	-	4000	-	
5551	Delamere 6 mile Yard Bore	6 miles south by west of Tinker Hill	545	174	Antrim Plateau Volcanics	140 155 162	? 89 19	? -	? 400 2000	- - -	
5554	Delamere Freds Yard Bore	16 miles south-east of homestead	530	370	Antrim Plateau Volcanics	125 255	24 -	- -	620 -	- -	
5610	Delamere Bullock Yard	21 miles south-east of homestead	c.500	445	Antrim Plateau Volcanics	150 425	30 25	-	400 600		
5945	Willeroo Beef Road D.W.H. No. 1	17½ miles at 160° from Willeroo homestead	850	448	Antrim Plateau Volcanics	127 442 448	100 ? 88	- - -	240 240 3600	- - -	
			FERGUSSON RIVER	**1:250,000 SHEET AREA**							
5007	Scott's Creek No. 1	42 miles south-west of Katherine on Willeroo Road	c.400	137	Jinduckin Formation	50 64 74 85-126	15	34	1600	Fair	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H)	Quality (ppm)	Remarks
					HELEN SPRINGS 1:250,000 SHEET AREA						
103	Helen Springs No. 2	23 miles north by east of homestead	665	285	Anthony Lagoon Beds?	-	173	-	780	-	
104	" " No. 3	21 miles north-north-east of homestead	700	270	Anthony Lagoon Beds	240 270	172 -	204 -	- 1150	1079 -	
105	" " No. 4	27 miles west-south-west of Eva Downs homestead	738	292	Anthony Lagoon Beds	-	180	252	1200	-	
108	" " No. 7	10 miles north of homestead	735	230	Helen Springs Volcanics or Tomkinson Creek Beds	-	220	220	800	780	
127	Banka Banka No. 1	26 miles north-north-west of Brunchilly homestead	727	215	Anthony Lagoon Beds?	198	188	-	3000	1460	
134	" " No. 8	18 miles north-north-west of Brunchilly homestead	747	259	Anthony Lagoon Beds or Gum Ridge Formation	227	208	246	1200	1271	
140	Rockhampton No. 8	29 miles east by south of Brunchilly homestead	720	210	Anthony Lagoon Beds	-	145	-	Good	4583	
180	Banka Banka No. 7	21 miles east-north-east of homestead	775	316	Anthony Lagoon Beds?	271	199	309	2000	-	
192	" " No. 2	15 miles north by west of Brunchilly	745	298	Anthony Lagoon Beds	217 291	 193	227	240 1200	1371	
219	Helen Springs No. 5	42 miles west-south-west of Eva Downs homestead	730	320	Anthony Lagoon Beds	-	176	220	1000	656	
229	Banka Banka No. 3	14 miles east-north-east of homestead	830	293	Gum Ridge Formation or Tomkinson Creek Beds	253	250	-	500	-	
237	Rockhampton No. 15	11 miles north-east of Brunchilly Dam	695	187	Anthony Lagoon Beds	135-153	135	160	Good	2255	
313	Banka Banka No. 5	25 miles north by west of Brunchilly homestead	712	280	Anthony Lagoon Beds	210-241	-	-	Good	-	
376	" " No. 6	20 miles north by west of Brunchilly homestead	720	190	Anthony Lagoon Beds	174	150	157	1800	-	
380	" " No. 4	11 miles north of Brunchilly homestead	740	266	Anthony Lagoon Beds	209	210	-	500	-	
381	Helen Springs No. 1	13 miles north-east of homestead	765	278	Anthony Lagoon Beds		250	260	1400	384	
393	Helen Springs No. 6	40 miles south-south-west of Eva Downs homestead	720	303	Anthony Lagoon Beds	-	170	270	1900	-	
410	Rockhampton No. 16	4 miles south-east of Coolunjie Waterhole	690	208	Anthony Lagoon Beds	-	155	175	Good	2302	
418	North-South S/R (Jingerah)	17 miles north by east of Helen Springs homestead	725	342	-	165 270	154	191	1600	410	
419	North-South S/R (Helen Springs)	1 mile east of Helen Springs homestead	930	63	Helen Springs Volcanics	-	33	54	3000	447	
420	North-South S/R (Muckety)	1½ miles east of Muckety homestead	940	60	" " "	-	16	50	Good	929	
421	North-South S/R (Banka Banka)	2 miles east by south of Banka Banka homestead	958	76	Helen Springs Volcanics	-	-	-	Poor	-	Abandoned See R.N. 927
520	Barkly S/R No. 5	2½ miles east of Monmoona Creek	707	286	Anthony Lagoon Beds	205	175	194	550	701	
521	" No. 4	28 miles west of Eva Downs homestead	753	268	" " "	235 265	204 -	252	- 1600	1498	Original bore 374 feet
702	Muckety Ladabah	15 miles west-north-west of homestead	825	72	Tomkinson Creek Beds?	70-72	60	-	700	2520	
927	North-South S/R Banka Banka	2 miles east by south of Banka Banka homestead	958	76	Helen Springs Volcanics	-	50	-	420	700	Replacement for R.N. 421

HELEN SPRINGS (Cont.)

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
928	Powell Creek Station Well	Powell Creek Station	763	38	Tomkinson Creek Beds	-	14	-	-	-	
979	North-South S/R Renner Springs	Near Mount Castle	-	548	" " "	65	-	-	-	-	Abandoned
1193	Banka Banka No. 10	Carmilly Creek - 20 miles north-north-east of homestead	722	216	Anthony Lagoon Beds	-	-	210	-	1085	
1194	" " No. 9	1 mile north of homestead	975	120	Helen Springs Volcanics?	-	-	-	1000	481	
1198	Brunchilly No. 1	Homestead	777	305	Anthony Lagoon Beds	285	-	-	1500	-	
1199	" No. 2	11 miles east by south of homestead	750	253	" " "	230	-	-	1200	1110	
1202	" No. 5	12 miles north-east of homestead	760	225	" " "	206	-	-	1200	2801	
1203	" No. 6	21 miles east by south of homestead	735	362	" " "	220	130	-	-	3487	
1204	" No. 7	20 miles east-north-east of homestead	720	306	" " "	270	-	-	1400	7320	
1205	" No. 8	21 miles north-east of homestead	700	228	" " "	200	-	-	1400	2590	
1206	" No. 9	28 miles north-north-east of homestead	690	280	" " "	120	-	-	1400	3596	
1286	Helen Springs homestead well	Homestead	-	19	Helen Springs Volcanics	-	10	-	-	-	
1287	Helen Springs Garden Well	Homestead	-	31	" " "	-	21	28	-	-	
1288	Helen Springs No. 8	32 miles west-south-west of Eva Downs homestead	690	208	Anthony Lagoon Beds	-	-	-	1200	1273	
1289	" " No. 9	37 miles south-west of Eva Downs homestead	c.700	325	Anthony Lagoon Beds	-	-	-	-	1978	
1291	" " No. 11	20 miles north-east of homestead	700	320	Anthony Lagoon Beds	-	-	-	2400	1211	
1292	" " No. 12	14 miles east-north-east of homestead	730	283	Anthony Lagoon Beds?	-	-	210	1000	-	
1293	" " No. 13	25 miles east of homestead	c.700	447	Anthony Lagoon Beds?	-	-	c.290	1500	1758	
1294	" " No. 14	32 miles east-north-east of homestead	690	290	Anthony Lagoon Beds	-	-	-	-	1097	
1295	" " No. 15	7 miles south of Monmoona Waterhole on Barkly S/R	680	237	" " "	-	-	-	1500	284	
1505	Muckety Station	-	-	-	-	-	-	-	-	-	
2230	Rockhampton No. 23	14 miles south-east of Brunchilly Dam	735	-	Anthony Lagoon Beds	-	-	-	-	-	
2231	Rockhampton No. 24	5 miles east-north-east of Brunchilly Dam	700	-	Anthony Lagoon Beds	-	-	-	-	-	
2327	Eva Downs - A.Bore	5 miles west-south-west of homestead	680	255	Anthony Lagoon Beds	-	-	-	1800	1492	
2328	Eva Downs - B. Bore	17 miles west-south-west of homestead	695	234	" " "	-	-	-	1800	1181	
2329	Eva Downs - C. Bore	6 miles south-south-west of homestead	715	264	" " "	-	200	-	-	458	
2330	Eva Downs - D. Bore	26 miles south-west of homestead	670	154	" " "	-	-	-	-	781	
2331	Eva Downs - E. Bore	16 miles south of homestead	665	164	" " "	-	-	-	-	471	
2332	Eva Downs - F. Bore	10 miles south-south-west of homestead	680	160	Anthony Lagoon Beds	-	-	-	1800	474	
2333	Eva Downs - G. Bore	31 miles south-west of homestead	665	166	" " "	-	-	-	-	690	
2334	Eva Downs - H. Bore	16 miles south-west of homestead	685	216	" " "	-	-	-	1800	577	
4141	Muckety Homestead	Near homestead		143	-	-	-	-	-	-	Dry
4286	Brunchilly No. 10	30 miles north-east of homestead	680	165	Anthony Lagoon Beds	-	-	-	1400	2993	
4305	Banka Banka No. 12	31 miles north-east of homestead	738	283	" " "	-	-	-	1000	2375	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
				HELEN SPRINGS (Cont.)							
4457	Helen Springs No. 20	18 miles east by north of homestead	c.700	262	-	-	196	-	1200	1382	
4500	Helen Springs No. 21	8 miles south-west of No. 4 Barkly Stock Route (R.N. 521)	c.700	246	Anthony Lagoon Beds	-	173	193	1200	-	
4519	Brunchilly No. 15	5 miles east-south-east of homestead	782	250	Anthony Lagoon Beds	-	241	-	1100	-	
4521	Brunchilly No. 3	29 miles north-north-east of homestead	675	227	Anthony Lagoon Beds	-	202	-	-	711	
4522	" No. 4	18 miles north-north-east of homestead	732	250	Anthony Lagoon Beds	-	-	230	1050	3417	
4569	Muckety No. 1	6 miles north-west of homestead	880	243	Tomkinson Creek Beds	220	90	160	800	Good	
4601	Helen Springs No. 18	½ mile south-east of Maryville	-	-	Helen Springs Volcanics or Tomkinson Creek Beds	-	-	-	-	364	
4602	" " No. 19	3 miles north by east of homestead	895	165	Helen Springs Volcanics?	-	-	150	1200	294	
4667	Muckety Homestead	Homestead	940	350	Helen Springs Volcanics	30 190	30	190	425	864	
4803	North-South S/R Junction Reserve	Junction North-South and Barkly S/R's	685	342		270	154	-	1600	384	
5671	Banka Banka No. 11	23 miles north-east of homestead	732	249		-	210	220	-	1400	
5672	Banka Banka No. 13	10 miles north-north-west of Brunchilly homestead	750	247	Anthony Lagoon Beds	247	-	-	-	-	
5673	" " No. 14	4 miles south-east of homestead	968	110	Tomkinson Creek Beds	-	-	-	-	-	Abandoned
5674	" " No. 15	14 miles north-east of homestead	805	310	Tomkinson Creek Beds	260	-	260	-	-	
5675	" " No. 17	5 miles north of Munkaderry Waterhole on Attack Creek	717	199	Anthony Lagoon Beds	-	-	-	-	2528	
5676	" " No. 18	29 miles north of Brunchilly homestead	727	130	" " "	-	-	-	-	-	
5677	" " - No Hope Bore	Homestead	975	70	Tomkinson Creek Beds	14-32 58-70	5	-	1500	-	
5678	Eva Downs - I Bore	Homestead	710	660	Anthony Lagoon Beds	-	-	-	-	821	
5679	Eva Downs - L Bore	25 miles south of homestead	660	141	" " "	-	86	-	-	332	
5680	Eva Downs - M Bore	25 miles south-south-west of homestead	665	165	" " "	95	-	-	-	440	
5681	Eva Downs - N Bore	About 12 miles south-west of homestead	-	345	" " "	81 190 310-345	- - -	- - -	5 100 200	Salty	Never equipped Abandoned
5682	Eva Downs - O Bore	11 miles south by east of homestead	675	191	" " "	137 151 182	157	- - -	 1800	449	
5794	Banka Banka No. 16	12 miles south-east of homestead on Morphett Creek	880	106	Tomkinson Creek Beds	90 106	c. 88	c.106	- -	- -	Abandoned
	Wiggenty Well	3 miles north by east of Muckety No. 1 (R.N. 4569)	940	-	Tomkinson Creek Beds	-	10	-	-	288	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
			HODGSON DOWNS 1:250,000 SHEET AREA								
644	Nutwood Downs No. 4	10 miles west of homestead	630	79	Nutwood Downs Volcanics	-	-	-	-	-	Dry hole
645	Nutwood Downs No. 5	22 miles south-west of homestead	c.650	225	Tindall Limestone?	222	170	-	1100	-	
646	Nutwood Downs No. 6	12½ miles south-south-west of homestead	580	110	Tindall Limestone?	-	-	-	1440		
877	Nutwood Downs No. 7	6 miles south-east of homestead	c.600	41	Nutwood Downs Volcanics	-	-	-	-	-	Abandoned owing to hard drilling
878	Nutwood Downs No. 8	8 miles south-east of homestead	620	68	Probably Roper Group	-	-	-	500	-	
881	Nutwood Downs No. 11	8 miles west by south of homestead	560	52	Nutwood Downs Volcanics	-	-	-	-	-	Abandoned owing to hard drilling
1485	Nutwood Downs No. 2	11 miles south-west of homestead	600	75	Probably Roper Group	-	-	-	Good	-	
1486	Nutwood Downs No. 1	13 miles south-south-east of homestead	570	127	Nutwood Downs Volcanics	-	-	-	-	-	Dry hole
1487	Nutwood Downs No. 3	8 miles west of homestead on Mickey Creek	600	87	Nutwood Downs Volcanics	-	-	-	-	-	Dry hole
	Nutwood Downs N.D. Bore	15 miles west by north of homestead	c.580	420	Nutwood Downs Volcanics	-	-	-	2000	-	
2878 4883	Nutwood Downs Station Well	Homestead	-	-	Nutwood Downs Volcanics	-	-	-	-	-	
			KATHERINE 1:250,000 SHEET AREA								
64	-	6 miles south of Mataranka homestead	460	72	Tindall Limestone	18	17	-	1600	-	
131	Army No. 474	Near Mataranka Township	444	116	Tindall Limestone	82-86 96-101	37 37	-	1400	-	
148	Tindall Aerodrome		450	65	" "	-	45	-	1500	-	
150	-			116	" "	54 100	51	-	1700	-	
154	-	Roper Creek: 14 miles south-west of Maranboy Siding	500	180	" "	100-110 115-130	100 100	-	 1800	-	
159	-	3½ miles east-south-east of Katherine	360	115	" "	-	25	-	1800	-	
309	-	2 miles east of Manbulloo homestead	340	128	Jinduckin Formation Tindall Limestone? " " ?	56 90 109	55	-	2000	-	
312	-	1 mile east of Manbulloo homestead	340	93	?Jinduckin Formation	39 60 81 91	30 22 10 Flowing	-	800 400 400 4000	-	
314	-	3 miles south of Mataranka	460	71	Tindall Limestone	43-62 65-69	26	-	1400	-	
325	-	2 miles south-west of Manbulloo homestead	320	206	Jinduckin Formation?	130-190 195-206	60	-	450	-	
406	-	Manbulloo Aerodrome	400	230	Jinduckin Formation	-	-	-	720	-	
407	-	" "	195	230	" "	-	-	-	720	-	
408	-	North-east of Tindall Aerodrome	425	68	Tindall Limestone	-	53	-	1000	-	
409	-	Tindall Aerodrome	425	70	Tindall Limestone	-	43	-	1500	-	
596	-	Abbattoirs Railwead	c.340	120	Tindall Limestone	70	70	-	750	-	
660	-	Beswick homestead	500	405	Mount Rigg Group	-	-	-	100	-	

KATHERINE (Cont.)

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
661	-	-	-	120	-	23 54 120	-	-	600	-	
1439	-	2 miles north-west of Katherine	350	110	Tindall Limestone	-	-	-	2000	-	
1440	-	6 miles north-west of Katherine	410	85	" "	-	-	-	2000	-	
1441	-	2 miles north-west of Katherine near R.N. 1439	350	90	" "	-	-	-	4000	-	
1442	-	Near Katherine Aerodrome	350	89	Tindall Limestone?	-	-	-	2800	-	
1443	-	Near low level crossing, Katherine	340	208	Tindall Limestone	-	52	-	6000	-	
1444	-	Near Katherine Aerodrome	350	200	Tindall Limestone?	-	-	-	1500	-	
1445	-	-	-	200	-	-	28	-	1500	-	
1447	-	Katherine Township	340	116	Tindall Limestone	54 100	51 -	-	1700	-	
1448	-	" "	340	82	" "	-	-	-	1500	-	
1450	-	Near Tindall Aerodrome	425	58	" "	-	-	-	1500	-	
1451	-	24 miles south-east of Katherine	553	203	" "	-	-	-	1800	-	
1452	-	Maranboy Siding	531	250	" "	-	-	-	800	-	
1453	-	9 miles east-south-east of Maranboy Siding	525	180	" "	100-150 170-180	101 101	-	1200	-	
1454	-	4 miles north-west of Mataranka	455	133	" "	-	-	-	3000	-	
1821	-	8 miles south-south-west of Beswick homestead	500	112	Antrim Plateau Volcanics or Mount Rigg Group	112	36	-	1200	-	
1827	-	9 miles north-west of Katherine	440	114	Mullaman Beds or Tindall Limestone	-	103	-	1300	Total hardness 430	
1900	-	9 miles west of Kowai Lagoon	450	85	Oolloo Limestone?	69	54	-	1760	-	
1901	Dry River Stock Route No. 1	15 miles south of Katherine	460	600	Tindall Limestone?	550-600	-	-	600	2404	
1950	-	-	-	85	-	69	54	-	1760	-	Maybe 1900
1987	-	9 miles west of Mataranka	620	200	Tindall Limestone	177 192	177 172	- -	1460	-	
1999	-	-	-	80	-	-	53	-	4000	-	
2522	-	Near R.N. 159	360	154	Tindall Limestone	63	54	-	25000	-	
2719	-	Venn Airfield	575	190	-	-	-	-	-	-	Dry hole
2720	-	" "	575	200	-	-	-	-	-	-	" "
2721	-	1 mile south-east of Venn	-	156	-	-	-	-	-	-	" "
2722	-	1 mile north-west of Venn	-	60	-	-	-	-	-	-	" "
2723	-	2 mile north-west of Venn	-	84	-	-	-	-	-	-	" "
2902	-	10 miles north-west of Katherine	440	198	Tindall Limestone	190	173	-	1800	331	
3025	-	Tindall Aerodrome	425	40	Tindall Limestone	-	-	-	-	337	
3027	-	" "	425	14	" "	-	-	-	-	434	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
				KATHERINE (Cont.)							
3032	-	North-west of Venn Aerodrome	550	210	Tindall Limestone	190 210	176 176	-	1800	-	
3544	-	Mataranka homestead	440	100	" "	4-100	15	-	1500	-	
3547	-	-	-	300	Burrell Creek Formation	210 266-274 284-288	57 57 57	-	120 120-220 720-1000	Total hardness 39	
4077	-	½ mile east of Tindall Aerodrome	450	107	Tindall Limestone	64	56	-	4800	-	
4143	-	½ mile east of Tindall Aerodrome	450	142	" "	123 136	56 56	-	2400 5800	Total hardness 345	
4159	-	East of Beswick homestead	-	-	Alluvium over Mount Rigg Group	60	-	-	550	-	
4160	-	Northern end of Beswick old Aerodrome	-	-	Dook Creek Formation	-	-	-	-	-	Dry hole
4278	4-mile Farm No. 2	Katherine	370	200	Antrim Plateau Volcanics	87	41	-	20	Good	
4281	15-mile Farm, 1st attempt	9 miles north-west of Katherine near R.N. 1827	440	233	Tindall Limestone	200	188	-	180	Good	
4282	-	3½ miles east-south-east of Katherine near R.N. 1159	360	182	Tindall Limestone Antrim Plateau Volcanics " " "	92 135 163	49 46 49	-	120 300 400	-	
4379	15-mile Farm, 2nd attempt	9 miles north-west of Katherine	440	410	Tindall Limestone	384	165	-	20	Good	
4420	-	2 miles south-east of Katherine	350	120	" "	60 120	60 60	-	4500	-	
4523	C.S.I.R.O Farm	5 miles south of Katherine ¼ mile east of road	370	128	" "	88 104 127	61 61 61	-	220 520 2400	453	
4524	Soccer Bore No. 1	Katherine Sports Oval	340	84	" "	78 80	48 48	-	1000 1100	524	
4525	Soccer Bore No. 2	Katherine Sports Oval	340	104	" "	94	38	-	1300	568	
4600	Tindall Airstrip No. 3	Tindall Aerodrome Northern end of Airstrip	425	152	" "	68 120	55 55	-	1800	428	
4627	-	10 miles north-west of Katherine near R.N. 2902	440	153	" "	-	13	-	1200	-	
4648	Tindall Airstrip No. 5	Tindall Aerodrome	425	80	" "	60	55	-	1600	-	
4709	-	Near R.N. 4077	450	104	" "	66	56	-	1750	518	
4859	Katherine Water Supply No. 2	Nixons Crossing near R.N. 4918	350	30	Alluvium over Burrell Creek Formation	10	7½	-	3400	Good	
4881	-	Katherine Snowground	340	114	Tindall Limestone	62 88 100	44 44 44	-	1000	-	
4886	Katherine Water Supply	Nixons Crossing	350	34	Alluvium	10-34	10	-	7800	409	
4918	" " "	" "	350	36	Alluvium	10-36	11	-	8800	-	
5012	Manbulloo King River No. 1	20 miles south-west of Katherine on Willeroo road	300	140	Oolloo Limestone	90 124 133	80 80 80	-	650	Good	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
				KATHERINE (Cont.)							
5019	Katherine No. 1	1 mile upstream from Nixons Crossing	c.350	29	Alluvium over Burrell Creek Formation	10	10	-	50	-	
5020	-	" " " " "	350	15	" " "	5	3	-	50	-	Abandoned
5032	15-mile Farm No. 6	1 mile south-south-west of farm buildings	425	200	Jinduckin Formation or Tindall Limestone	195	153	-	4800	-	
5042	15-mile Farm No. 7	-	410	150	Jinduckin Formation?	76 134 148	109 109 109	-	1800	442	
5082	-	-	-	200	-	-	-	-	-	417	
5148	Mataranka 47/65, 2nd attempt	16 miles south-east of Katherine	540	195	Mullaman Beds	176	162	-	750	330	
5150	Mataranka 40/65	16 miles south-east of Maranboy Siding	c.550	200	Unconformity Mullaman Beds Tindall Limestone	138	118	-	2000	Good	
5151	Mataranka 47/65, 1st attempt	16 miles south-east of Katherine	540	200	Tindall Limestone	178	178	-	1100	Good	Hole abandoned drilling difficulties.
5178	5-mile Creek No. 1	North-east of Katherine	350	94	Antrim Plateau Volcanics	60	35	-	800	-	
5329	Tindall Married Quarters	Tindall Aerodrome	425	117	Tindall Limestone	60-80 97-112	59 59	-	5000	-	
5435	Dry River S/R No. 2	Kowai Lagoon	360	210	-	-	132	-	-	-	Abandoned
5438	Mataranka 35/65	East-north-east of Mataranka homestead	-	350	Adelaidean	-	-	-	-	-	Seepage only
5705	Mataranka Town No. 2	Mataranka	444	66	Tindall Limestone	57-60	35	-	1700	Fair	
				LARRIMAH 1:250,000 SHEET AREA							
89	Army Bore 530B	333 miles from Darwin - Vicinity Larrimah Township	c.635	202	Tindall Limestone	181 200	175	-	1150	-	Not located
107	Army Bore No. 481	Gorry area	-	-	-	-	-	-	720	-	Not located
136	Army Bore No. 583	Gorry area	-	-	-	-	-	-	-	-	Not located
137	Army Bore No. 589	" "	-	195	-	-	182	-	700	-	Not located
138	Army Bore No. 584	" "	-	-	-	-	-	-	-	-	Not located
	R.A.A.F. 587	" "	-	220	-	-	168	176	1200	-	Not equipped Not located.
141	Army Bore No. 522	9 miles north of Old Gorrie homestead	580	170	Tindall Limestone or Lower Unit Montejinni Limestone	-	150	-	900	-	
142	Army Bore No. 591	Gorry area	-	211	-	120 180 211	15	-	500	-	Not located
143	Army Bore No. 582	Gorry area	-	213	-	60 190 213	35	-	1200	-	Not located
146	Army Bore No. 588	Gorry area	-	247	-	-	172	-	1000	-	Not located
152	Army Bore No. 585	Gorry area	-	-	-	-	-	-	-	-	Not located
307	Army Bore No. 394	Gorry area	-	200.5	Tindall Limestone	-	28	-	1500	-	Not located

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
				LARRIMAH (Cont.)							
311	Army Bore No. 386	Birdum	-	212	Tindall Limestone	-	60	-	-	-	Not located
319	" " No. 531	10 miles east by north of Birdum	-	187	-	152	144	-	1200	-	" "
320	" " No. 532	4 miles south by east of Larrimah?	600?	175	Tindall Limestone	150	145	-	1800	-	" "
326	R.A.A.F.527	-	-	-	-	-	-	-	-	-	" "
346	Army Bore No. 528	200 yards west of 336-mile Peg	-	-	-	-	-	-	-	-	" "
416	Gorry R.A.A.F.590	-	-	220	-	-	188	195	1000	-	" "
550	Birdum S/R No. 1	13 miles north-north-west of Larrimah	545	129	Tindall Limestone	-	90	107	1500	1322	See R.N. 3395
551	Larrimah No. 2	Near Police Station	635	258	" "	-	176	192	3600	1427	
553	Birdum S/R No. 2	4 miles south by east of Larrimah	590	150	" "	-	105	129	1500	-	
554	Birdum S/R No. 3	Ironstone Creek Waterhole on Birdum Creek	610	190	" "	160	146	170	1500	696	
558	Town Bore	Birdum	595	224	-	-	178	197	960	-	
902	Dry River S/R No. 3	48 miles west of Elsey Cemetery	495	228	Tindall Limestone	200	106	-	800	-	Abandoned
903	Dry River S/R No. 4	Road Crossing of Dry River	505	245	Tindall Limestone or Antrim Plateau Volcanics	200	142	160	700	382	
904	Dry River S/R No. 5	1 mile west of Dry River homestead	545	383	Lower Unit Montejinni Limestone Antrim Plateau Volcanics	183 371	157 -	200 -	1600 -	690 -	
905	Dry River S/R No. 6	13 miles north of Old Birrimba homestead	630	521	Unconformity Mullaman Beds/ Antrim Plateau Volcanics	67 445	46 -	200 -	700 -	295	
906	Dry River S/R No. 7	Old Birrimba homestead	707	206	-	180	120	-	500	335	
1456	Army Bore No. 475	1 mile north of Elsey Creek	520	101	Tindall Limestone	-	-	-	4000	-	Not located
1458	" " No. 523	200 yards west of 328-mile Peg	600	227	" "	-	-	-	780	-	" "
1459	" " No. 525	50 yards south railway track, Larrimah	635	200	" "	-	-	-	-	-	" "
1460	" " No. 524	100 yards south railway track, Larrimah	635	199	" "	-	-	-	1600	-	" "
1461	" " No. 526	200 yards west railway track, Larrimah	635	-	" "	-	-	-	-	-	" "
1462	" " No. 530	50 yards west of road, Larrimah	635	147	" "	-	-	-	-	-	" "
2186	Larrimah Bore	Larrimah	635	-	" "	-	-	-	-	1124	" "
2325	Elsey One Pull Bore	-	-	100	-	-	70	-	-	-	
2326	Elsey No. 1	-	-	100	-	-	75	-	-	-	
2379	Elsey Drum Bore	-	-	100	-	-	70	-	-	-	
3395	Birdum S/R No. 1	13 miles north-north-west of Larrimah	545	130	Tindall Limestone	95	95	-	1800	-	See R.N. 550
3545	Elsey No. 5 - Giles Bore	-	-	245	-	80	60	-	200	-	
5149	Mataranka 39/65	6 miles south-south-east of Mataranka Township	460	117	Tindall Limestone	180 55	60 53	- -	1000 5000	- 1039	
5492	House Bore	Maryfield homestead	606	190	Tindall Limestone	176-180	168	-	1800	1312	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
					NEWCASTLE WATERS 1:250,000 SHEET AREA						
12	House Bore	Newcastle Waters homestead	686	202	Unconformity? between Merrina Beds and Tomkinson Beds	170	165	-	1050	-	
218	Newcastle Waters (Lake Woods) No. 1	North-west edge Lake Woods	644	170	Mullaman Beds or Merrina Beds	120	120	-	-	657	
515	8A Causeway	8 miles north-north-east Newcastle Waters homestead	725	328	Mullaman Beds or Tindall Limestone	210 280	205 -	233 -	1400 -	1063	
591	Murranji S/R No. 9 (old)	23 miles north-north-west of Newcastle Waters	742	267	-	-	222	250	900	2860	See R.N. 592
592	Murranji S/R No. 9	23 miles north-north-west of Newcastle Waters	742	265	Mullaman Beds?	-	231	-	1800	1787	See R.N. 591
907	Hickety Bore	13 miles north-north-west of Newcastle Waters	710	241	Mullaman Beds?	199	199	223	1800	1309	
1463	Army Bore No. 687	Nelly Waterhole 460-mile Peg	690?	276	Mullaman Beds?	-	240	350	-	-	Probably near Causeway over Newcastle Creek.
1530	Newcastle Waters No. 3	Approx. 12 miles north-west of homestead	724	220	-	-	-	-	1300	-	
1896	Town Supply Bore	Newcastle Waters	686	188	Tomkinson Creek Beds?	170	-	-	600	811	
1899	Town Supply Bore	Newcastle Waters	686	328	Tomkinson Creek Beds	176 326	173 173	323 -	650 -	768	
2350	Newcastle Waters Windy Point	32¼ miles south-east of Newcastle Waters	674	197	Mullaman Beds or Merrina Beds	-	-	-	1900	452	
3950	Hotel Bore	Newcastle Waters	686	-	-	-	-	-	-	-	Not equipped
4579	Newcastle Waters (New) Hickety	14 miles north-west of Newcastle Waters	715	233	Mullaman Beds	-	206	214	1800	1281	
5685	Newcastle Waters-Burge	42 miles south by west of homestead	664	304	Unconformity? Merrina Beds/ Antrim Plateau Volcanics	60 121 156?	130	-	600	-	
5686	Benaud, Newcastle Waters	38½ miles south by west of homestead	657	175	Merrina Beds?	139 163	126	-	1500	695	
5687	Hassett, " "	31 miles south by west of homestead	658	203	Merrina Beds	132 200	130	-	1500	575	
5688	Bradman, " "	11 miles south by west of homestead	670	172	Merrina Beds	146-172	-	162	1800	553	
5689	Grimmett, " "	17 miles south of homestead	659	230	Merrina Beds	132 212	131 -	- -	1800 -	647	
5690	McKay, " "	22½ miles south by west of homestead	648	212	Merrina Beds	-	141	-	1500	475	
5793	Sturt Plain	Sturt Plain homestead	725	250	Mullaman Beds?	-	-	-	-	872	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
			TANUMBIRINI 1:250,000 SHEET AREA								
5761*	C.C.B., Borroloola Road	16 miles east of Stuart Highway	790	317	Unconformity Mullaman Beds? and Middle Cambrian	295	285	-	2000	Good	
5764	C.C.C., " "	25 miles east of Stuart Highway	745	277	Middle Cambrian	250	250	-	2000	Good	
5773*	C.C.E., " "	45 miles east of Stuart Highway	890	475	Mullaman Beds	-	-	-	-	-	Dry hole
5782*	C.C.H., " "	75 miles east of Stuart Highway	930	302	Mullaman Beds	-	-	-	-	-	Dry hole
5783	C.C.I., " "	85 miles east of Stuart Highway	920	441	Middle Cambrian	400	400	-	Unknown	Good	
5844	C.C.D., " "	35 miles east of Stuart Highway	845	407	Mullaman Beds	370	365	-	1400	Good	
5845*	C.C.F., " "	55 miles east of Stuart Highway	1010	483	Middle Cambrian	-	-	-	-	-	Dry hole
5846	C.C.G., " "	65 miles east of Stuart Highway	960	325	Mullaman Beds	-	-	-	-	-	Dry hole
5864	C.C.J., " "	95 miles east of Stuart Highway	900	300	Mullaman Beds and Adelaidean	-	-	-	-	-	Dry hole
2876	Nutwood Downs N.A.	Headwaters Hodgsen River	650	171	Upper Proterozoic or Mullaman Beds	-	-	-	950	-	
2877	Nutwood Downs N.B.	Headwater Red Ochre Creek	650	257	Tindall Limestone?	-	-	-	210	-	
879	Nutwood Downs No. 9	Headwaters of Brumby Creek	630	181	Tindall Limestone?	-	-	-	2000	-	
880*	Nutwood Downs No. 10	Near 8-mile Creek	620	113	Nutwood Downs Volcanics	-	-	-	-	-	Dry hole
2265	Dunmarra No. 2	10-mile east of Dunmarra Roadhouse	740	305	-	-	-	-	1200	-	
			TENNANT CREEK 1:250,000 SHEET AREA								
505	South Barkly S/R No. 10	28 miles east-south-east Brunchilly homestead	745	296	Gum Ridge Formation or Anthony Lagoon Beds	164 282	164	-	2000	3307	
1200	Brunchilly No. 16	26 miles east-south-east of homestead	745	228	Anthony Lagoon Beds	212	-	-	1200	2531	Originally No.3
1201	Brunchilly No. 14	24 miles south-east of homestead	755	221	" " "	203	-	-	1200	1230	Originally No.4
1208	Brunchilly No. 11	-	-	-	Anthony Lagoon Beds or Gum Ridge Formation	-	-	-	1400	1057	May be same bore as South Barkly S/R No. 11.
1209	Brunchilly No. 13	15 miles south-east of homestead	755	217	Anthony Lagoon Beds	-	165	150	1400	-	Abandoned - See R.N. 4189
3708	South Barkly S/R No. 12	17 miles south-south-west of Brunchilly homestead	850	325	Anthony Lagoon Beds or Gum Ridge Formation	280 309	270	-	- 1000	1017	Not equipped
3859	South Barkly S/R No. 12	17 miles south-south-west of Brunchilly homestead	850	188	-	-	-	-	-	-	Dry hole 1st attempt at R.N. 3708
4189	Brunchilly No. 13	15 miles south-east of homestead	755	216	Gum Ridge Formation?	183 194	177	164	1500	1100	
4521	Brunchilly No. 12	16½ miles south-east of homestead	745	230	Anthony Lagoon Beds	-	-	-	1200	1064	
	Barkly Highway 5A	242 miles west of Camooweal	825	445	Gum Ridge Formation	-	230	-	1600	-	Abandoned
	" " 12A	257 miles west of Camooweal	860	197	" " "	-	140	-	100	420	"
	" " 10A	284 miles west of Camooweal	1060	198	" " "	-	122	-	25	-	"

* See notes on replacement bores on page 19 this Appendix.

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
VICTORIA RIVER DOWNS 1:250,000 SHEET AREA											
157	Auvergne S/R Shoeing Tool Bore	6 miles south-east of Moolooloo homestead	525	81	-	-	-	-	-	-	Abandoned 2nd attempt A.I.B.
332	" " " " "	" " " " "	525	112	-	-	-	-	-	-	Abandoned 3rd attempt
511	" " " " "	" " " " "	525	156	Antrim Plateau Volcanics	-	82	-	-	-	See R.N. 5479
512	Wave Hill S/R No. 50 (Cullenjacky)	10 miles south-west of Montejinni homestead	650	170	Unconformity? Montejinni Limestone/Antrim Plateau Volcanics	-	85	-	2400	368	
584	Wave Hill S/R No. 49 (King Bore)	5 miles south of Townsend Creek	516	163	Antrim Plateau Volcanics	20 156	70	108	900	400	
593	Murranji S/R Top Springs Depot No. 1	-	c.640	51	-	20 50	20	-	1200	-	Not located
594	Montejinni Station McCraes Bore	4 miles south-south-east of homestead	620	141	Antrim Plateau Volcanics?	-	65	-	800	473	
595	Montejinni No. 2 (McGaskills)	11 miles east-north-east of homestead	680	89	Montejinni Limestone	-	61	-	1800	392	
622	Murranji S/R - Top Springs Depot No. 1	-	-	51	-	20 50	20	-	1200	-	1st attempt abandoned (not located)
901	Auvergne S/R (Companion)	Companion Creek	-	156	-	-	-	-	-	-	Dry (see R.N's 5424, 5426.)
1088	V.R.D. No. 3 (Waterbag)	-	-	97	-	-	-	-	-	-	
1090	Killarney No. 5	14 miles north-north-east of New Killarney homestead	690	216	Antrim Plateau Volcanics	-	32	-	-	-	Originally V.R.D. No. 5
1091	Killarney No. 6	New Killarney homestead	605	173	Antrim Plateau Volcanics	-	-	-	-	308	Originally V.R.D. No. 6
1340	House Bore	Montejinni homestead	570	78	-	-	-	-	-	493	
1501	Top Springs (Well)	-	-	-	-	-	-	-	-	-	Not located
1913	Police Station	Top Springs	579	61	Montejinni Limestone Unconformity Montejinni Limestone/ Antrim Plateau Volcanics	38 47	33	57	900	663	1st attempt
1988	Dry River S/R No. 9 (Charlies Hole)	11 miles north-east of New Top Springs Town site	637	110	Montejinni Limestone	36 73	36	-	2400	441	
2035	Top Springs Reserve	7 miles south-east of New Top Springs Town site	645	122	-	-	-	-	-	Good	A.I.B. Quarantine Reserve
2376	Killarney New Well	-	-	33	-	-	-	-	-	-	
2415	Camfield (Farquarson)	7 miles south-west of Karibaldi Yard	510	77	Antrim Plateau Volcanics	-	40	-	-	-	
3557	Killarney (Horse Creek)	5½ miles north-north-east of homestead	c.620	33	Antrim Plateau Volcanics	31	30	-	300	-	
3558	Killarney - Pikers Retreat	14 miles south-south-east of homestead	735	124	Antrim Plateau Volcanics	84 124	80 80	- -	1400	445	
3564	Killarney - Callighers	-	-	323	-	137 260	14	-	-	-	Not located
3565	Killarney - Bullock Hole	Near Battle Creek	-	20	-	-	-	-	-	-	
3747	Killarney - Bauhinia	18 miles north-north-east of homestead	705	60	Montejinni Limestone	29	19	-	2400	444	

Reg. No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks.
					VICTORIA RIVER DOWNS (Cont.)						
3767	Killarney Dowsett No. 1	3½ miles south-west of homestead	-	593	Antrim Plateau Volcanics	38	-	-	150	-	
3768	Killarney Dowsett No. 2	1½ miles east of homestead	-	250	Antrim Plateau Volcanics	210	-	-	1600	217	Supply dropped at end of dry season.
4049	Camfield Site No. 3 (Doleso)	2 miles south-south-east of No. 49 Wave Hill S/R (R.N. 584)	530	350	Antrim Plateau Volcanics	80 320 340	68	- - -	1100	367	
4628	Camfield Rara	12 miles south by east Pigeon Hole homestead	455	275	Antrim Plateau Volcanics	240	-	-	2500	456	
4666	Killarney - Bull Creek	5 miles west by north of homestead	-	170	Antrim Plateau Volcanics	92 149	29	- -	50 1200	- -	
4762	Montejinni - Isadore	26 miles west-south-west of homestead	-	60	Antrim Plateau Volcanics	-	-	-	1800	479	
4763	Montejinni - McCallum	4 miles west of Karibaldi Yards	450	51	" " "	-	-	-	1800	357	
4764	Montajinni - Winari	13 miles south-south-west of homestead	556	35	" " "	-	-	-	2000	451	
4765	Montejinni - Ogdens	16 miles west of homestead on Armstrong River	-	49	" " "	-	-	-	2000	430	
4769	Camfield - Bull Paddock (Stud Bore)	12 miles south-east of Pigeon Hole homestead	520	52	" " "	-	-	-	-	502	
4773	Killarney	10 miles east-south-east of Killarney homestead	740	121	Unconformity, Montejinni Limestone/Antrim Plateau Volcanics	55	57	-	2000	-	1st attempt see R.N. 4807
4807	Killarney (Monster)	11 miles east by south of homestead	740	150	Unconformity between Montejinni Limestone and Antrim Plateau Volcanics	102 148	61	- -	140 180-200	- -	2nd attempt
5208	Montejinni Station	-	-	99	-	-	-	-	2000	-	Not located
5396	Montejinni, Armstrong Bore	4 miles at 340° from homestead	530?	631	Antrim Plateau Volcanics	35 589	35 29	- -	70 800	570	
5423	Stock Inspectors Residence Top Springs	-	575	97	Antrim Plateau Volcanics	42 62 90	42 30 26	- - -	50 480 654	484	
5424	Killarney - Companion Water Hole Bore	Companion Creek Crossing	535	47	Antrim Plateau Volcanics	15	10	-	120	-	1st attempt see R.N. 901
5426	Killarney - Companion Well	" " "	530	41	" " "	12	10½	-	1440	-	2nd attempt see R.N. 901
5444	Town Bore	New Top Springs Town Site	650	177	" " "	171 173 176-177	114	-	1100	515	
5461	Killarney, Comet Creek	15 miles north-west of homestead - Comet Creek, near Battle Creek	-	349	" " "	77 292-297 331	22	- - -	160 1200 1440	- - -	
5462	New House Bore	Killarney homestead	590	100	" " "	34 62	24	-	2400	-	
5478	V.R.D. Waterbag Replacement	Waterbag Creek Crossing - 30 feet from existing bore	-	173	-	49 130	30 37	- -	- -	- -	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
				VICTORIA RIVER DOWNS (Cont.)							
5479	V.R.D. Shoeing Tool Replacement	6 miles south-east of Moolooloo homestead	505	591	Antrim Plateau Volcanics	226 256 466	49 47 40	- - -	50 400 800	- - -	
	Killarney homestead	New Killarney homestead	605	-	" " "	113 270	113	-	-	-	Replacement for V.R.D. No. 6
5578	-	24 miles north-east of new Top Springs Townsite on Willeroo Beef Road	799	262	Montejinni Limestone	175	170	-	500	-	
				WAVE HILL 1:250,000 SHEET AREA							
510	Wave Hill, Police Bore	Police Station	550	701	Victoria River Group	80 660 701	6	285	700 - 600	750	
583	Wave Hill S/R No. 47 (Wyalong)	10 miles south of Camfield homestead	485	-	Antrim Plateau Volcanics	30 115	27	80	3000	500	
585	Wave Hill S/R No. 48 (Red Rock)	5 miles east by south Camfield homestead	433	330	" " "	32 232 250 321	30	80	3000	543	
703	Camfield No. 2	-	-	50	-	-	35	-	50	-	Not located 1st attempt abandoned
704	Camfield No. 2	-	-	73	-	73	30	-	200	-	Not located 2nd attempt
813	Wave Hill No. 1	13 miles north-east of homestead	630	72	Antrim Plateau Volcanics	-	35	70	1200	566	
814	Wave Hill No. 2	Toby Creek - 24 miles east-north-east of homestead	555	254	" " "	-	30	70	1200	400	
815	Wave Hill No. 3	Camfield Creek - 18 miles east by south of homestead	605	105	" " "	-	30	90	420	700	See R.N. 816
816	Wave Hill No.3A	Camfield Creek - 18 miles east by south of homestead	605	110	" " "	-	-	-	420	-	See R.N. 815
817	Wave Hill No. 4	13 miles south-east of homestead	650	62	" " "	-	30	47	400	523	Originally 1000 gph.
818	Wave Hill No. 5	Wave Hill homestead	660	62	" " "	-	30	60	300	360	See R.N. 819,820
819	Wave Hill No. 5A	Wave Hill homestead	660	219	" " "	-	26	-	300	-	See R.N. 818,820
820	Wave Hill No. 5B	Wave Hill homestead	660	45	" " "	-	-	-	900	-	See R.N. 818,819
821	Wave Hill No. 6	Gordy Creek - 8 miles south-west of homestead	662	198	" " "	-	30	70	300	847	
822	Wave Hill No. 7	Camfield Creek - 8 miles south of homestead	710	82	" " "	-	20	-	1000-1200	-	
823	Wave Hill No. 8	Fergusson Creek - 16 miles south-east of homestead	-	100	" " "	-	-	-	-	-	Dry
824	Wave Hill No. 9	Gordy Creek - 25 miles south-south-west of homestead	c.900	600	-	-	-	-	-	-	Abandoned

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
				WAVE HILL (Cont.)							
825	Wave Hill No. 10	Camfield River - 20 miles south-east of homestead	c.615	-	-	-	-	-	-	-	No information - dry
826	" " No. 11	3 miles south-east of No. 22	550	73	Antrim Plateau Volcanics	-	23	-	-	-	Replaced by No.22
827	" " No. 11A	Beside No. 11	-	-	-	-	-	-	-	-	
828	" " No. 12	Croker Creek - 5 miles north-east of homestead	620	71	Antrim Plateau Volcanics	-	35	70	720	-	See R.N. 5450
829	" " No. 13	5-mile Creek - 4 miles north by west of homestead	c.630	-	-	-	-	-	-	-	No information, dry bore
830	" " No. 14	11 miles north-north-east of homestead	594	288	Victoria River Group?	288	40	110	1800	-	
831	" " No. 15	Camfield River - 7 miles south-east of homestead	680	93	Antrim Plateau Volcanics	-	20	-	300	-	Abandoned
832	" " No. 16	1 mile north-east of No. 17	c.670	85	" " "	-	20	-	600	-	Abandoned
833	" " No. 17	Camfield Creek - 6 miles south-east of homestead	675	155	" " "	-	30	100	750	-	
836	" " No. 20	1 mile south by west of bore WP (R.N. 2341)	-	196	-	-	-	-	-	-	Dry bore
837	" " No. 21	Near confluence Fergusson Creek, Camfield River	-	298	-	-	-	-	-	-	Abandoned
838	" " No. 22	Camfield River - 19 miles north-north-west of Cattle Creek homestead	520	158	Antrim Plateau Volcanics	-	-	-	1500	651	
839	" " No. 23	Fergusson Creek - 2 miles south-west of Bore WP	-	253	-	-	-	-	-	-	Dry bore
840	" " No. 24	4 miles west of homestead	-	744	-	-	-	-	-	-	Dry bore
841	" " No. 25	11 miles east of homestead	655	125	Antrim Plateau Volcanics	-	-	-	-	499	
842	" " No. 26	5 miles south-east of No. 2	-	-	-	-	-	-	-	-	Dry bore
843	" " No. 27	18 miles south-east of homestead	-	60-70	-	-	-	-	-	-	Dry bore
844	" " No. 28	Near Mindie Well	-	34	-	-	-	-	-	-	Dry bore
845	" " No. 29	Near confluence Camfield River, Fergusson Creek	720	74	Antrim Plateau Volcanics	-	17	73	1600	-	
846	" " No. 30	Wave Hill homestead	-	60	" " "	-	-	-	-	-	Dry bore
847	" " No. 31	Wave Hill homestead	-	60	" " "	-	-	-	-	-	Dry bore
848	" " No. 32	Wave Hill homestead	660	65	" " "	-	-	-	40-160	-	
849	" " No. 33 (WK)	1½ miles south of homestead	680?	38	" " "	36	12	-	270-800	-	
850	" " No. 34 (WA)	8 miles south-south-east of No. 22	c.600	146	" " "	110	-	-	300	-	Abandoned
851	" " No. 35 (WC)	6 miles north-west of Cattle Creek homestead	645	200	" " "	191	120	-	1250	595	
852	" " No. 36 (WF)	11 miles south-west of Cattle Creek homestead	640	200	Unconformity Montejinni Limestone/Antrim Plateau Volcanics	173	104	-	1600	1654	
853	" " No. 37 (WE)	9 miles south by west of Cattle Creek homestead	640	217	" "	217	112	-	-	1016	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
					WAVE HILL (Cont.)						
854	Wave Hill No. 38 (WG)	17 miles west of Cattle Creek homestead	650	128	Antrim Plateau Volcanics	125	37	-	1100	-	
855	" " No. 39 (WL)	Barry Creek - 24 miles south-south-east of homestead	-	53	-	-	-	-	-	-	Abandoned see R.N. 2340
856	" " No. 40 (WB)	11 miles north-north-east of Cattle Creek homestead	c.650	376	-	134	-	-	1100	-	Abandoned
882	Post Office Bore	Wave Hill homestead	660	83	Antrim Plateau Volcanics	-	-	-	small	-	
883	Post Office No. 2	Wave Hill homestead	660	70	" " "	-	-	-	-	-	
1016	Camfield No. 1	-	-	66	-	-	-	-	-	-	Not located dry hole
1034	Camfield No. 1	-	-	-	-	-	-	-	-	-	Not located 2nd attempt dry
1085	Camfield No. 2	-	-	46	-	30	30	-	50	-	Not located 3rd attempt abandoned
1096	Victoria River Downs No. 11	Black Gin Creek	-	153	Victoria River Group	-	-	-	-	399	
1099	Victoria River Downs	Poison Creek	-	-	" " "	-	-	-	-	563	
1704	Camfield No. 3	-	-	-	-	-	-	-	-	-	Not located
2336	Wave Hill No. 41 (WQ)	Cattle Creek - 10 miles north-north-west of Cattle Creek homestead	c.570	900	Antrim Plateau Volcanics Victoria River Group?	31 327 ?	- - -	- - -	100 400 3600	- - -	Abandoned due to salt
2337	Wave Hill No. 42 (WD)	Cattle Creek homestead	615	93	Montejinni Limestone?	83	-	-	3000	811	
2338	" " No. 43 (WT)	17 miles south-west of Cattle Creek homestead	630	138	Montejinni Limestone or Antrim Plateau Volcanics	83 121-123	- -	- -	- -	569	
2339	" " No. 44 (WS)	4 miles south-west of homestead	-	900	-	-	-	-	-	-	Dry bore
2340	" " No. 45 (WL)	Barry Creek - 24 miles south-south east of homestead	770	114	Antrim Plateau Volcanics	103	-	-	2000	-	See R.N. 855
2341	" " No. 47 (WP)	Fergusson Creek - 14 miles south-south-east of homestead	720	300	" " "	-	-	-	420	-	
2414	Camfield - Chungari	Chungari Creek - 18 miles south of homestead	560	157	Antrim Plateau Volcanics	79 122 127	20 20 23	- - -	1800 2900 2880	282	
2836	Wave Hill (WR)	Camfield Creek - near No. 3	c.600	304	-	-	-	285	1650	676	
4048	Camfield No. 2 (Horse Creek)	14 miles south-east of homestead	480	132	-	45 126	30	98	1800	492	
4303	House Bore	Camfield homestead	395	250	Antrim Plateau Volcanics	80 153 225	30	-	1250	451	
4407	Camfield-Sailor Jack	17 miles south-south-east of homestead	455	236	" " "	30 45 210	22	-	1400	4594	
4530	Camfield-Barry Knob	11 miles south-west of homestead	600	180	" " "	80	43	-	2880	631	
4531	Camfield-Ram Creek	6 miles south-west of homestead	535	200	" " "	107	54	-	1200	436	

Reg No.	Station No. or Name	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth Standing Water Level (feet)	Pump Depth (feet)	Supply (G.P.H.)	Quality (ppm)	Remarks
					WAVE HILL (Cont.)						
4766	Camfield-Rennie Creek	17 miles south-south-west of homestead	555	600	-	-	-	-	-	-	
4767	Camfield-Lignum	Camfield River 16 miles south-east of homestead	450	40	Antrim Plateau Volcanics	-	-	-	1800	2399	
4768	Camfield-Sheep Yard	5 miles south-east of homestead	-	42	" " "	-	30	-	salty	salty	Abandoned
4780	Wave Hill - New Homestead Site No. 6	2 miles east of Police Station	-	1144	Victoria River Group	1025	180	-	-	-	Salty abandoned
5429	Wave Hill New Homestead Site 6	-	-	100	" " "	40	40	-	1800	-	
5450	Wave Hill - No. 2 site for No. 12 Bore	7 miles north-east of homestead	-	500	Antrim Plateau Volcanics	73	-	-	-	-	See R.N. 828
5456	Wave Hill - New Homestead Site 6	-	-	100	" " "	44	-	-	-	-	Abandoned
5489	Wave Hill School Bore	Near Welfare settlement	-	705	Victoria River Group	60	40	-	10	Good	
						120	40	-	25		
						680-705	7	-	1200		
					WINNECKE CREEK 1:250,000 SHEET AREA						
	Hooker Creek No. 5	Homestead	1051	170	Antrim Plateau Volcanics?	-	85	-	1000	647	Polluted
	Hooker Creek 19-mile	17 miles north of homestead	1135	176	" " "	-	85	-	1900	-	
	Hooker Creek No.1	Homestead	1050	164	" " "	125	-	-	-	-	Supply failing
						164	-	-	1200	495	not in use
	Hooker Creek No.6	Homestead	1050	180	" " "	-	-	-	500	470	
	Hooker Creek No.7	Homestead	1050	200	" " "	139	-	-	120	820	Observation bore
	Hooker Creek No.8	Homestead	1050	330	" " "	106	-	-	-	-	
					" " "	123	-	-	-		
					Victoria River Group	317	-	-	2000	472	
	Hooker Creek No.9	Homestead	1050	147	Antrim Plateau Volcanics	92	-	-	800		Pump tested
						130	-	-	1000	424	at 1200 gph.
					TANUMBIRINI						
5942	15 mile Cape Crawford Road	-	-	342	Tindall Limestone or Anthony Lagoon Beds	290	285	-	1400	568	Replacement for R.N.5761
5954	48 mile Cape Crawford Road	-	-	495	as above	465	460	-	-	635	do for R.N.5773
6066	55 mile Cape Crawford Road	-	-	550	"	510	510	-	1500	-	do for R.N.5845
6067	75 mile Cape Crawford Road	-	-	455	"	420	420	-	1500	-	do for R.N.5782

APPENDIX 2.

CHEMICAL ANALYSES OF BORE-WATER

Analyses in parts per million.

x = not detected x0.02 = not detected, detection limit 0.02 ppm ... = not determined

Specific conductivity (S.C.) in micromhos/cm * Detailed analysis rejected owing to gross imbalance

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
							BEETALOO 1:250,000 SHEET AREA														
316	108.2	53.4	184	25	238.9	194.5	444.4	x	1.0	39.6	12.5	...	x0.02	0.017	0.5	0.12	1692	7.66	990	1966	A.M.D.L.
517	101.0	56.1	123	23	187.2	107.0	475.2	x	0.7	45.3	8.7	...	x0.02	0.032	0.4	0.03	1293	7.6	872	1966	A.M.D.L.
519	98.5	46.8	180	23	222.2	270.0	391.9	x	0.9	15.3	4.8	...	x0.02	0.01	0.3	0.11	1706	7.6	1052	1966	A.M.D.L.
522	71.7	45.6	238	13	272.2	281.1	327.1	x	1.3	27.8	0.6	...	0.02	0.018	0.4	0.07	1854	7.95	1128	1966	A.M.D.L.
541	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	670	...	A.I.B.
1056	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2033	...	A.I.B.
1186	105.8	69.4	78	11	141.4	132.9	476.8	x	0.5	32.1	3.2	...	x0.02	0.019	0.2	0.07	1288	7.00	816	1965	A.M.D.L.
1187	94.7	67.2	118	12	199.6	228.6	376.5	x	0.6	34.9	4.7	...	0.05	0.047	0.3	0.04	1553	7.60	975	1966	A.M.D.L.
1233	60.3	41.6	119	11	182.8	95.1	290.1	x	0.6	26.5	9.8	...	x0.02	0.003	0.3	0.03	1150	7.00	669	1965	A.M.D.L.
1290	110.7	50.1	316	28	347.3	427.1	404.3	x	2.2	23.7	4.0	...	x0.02	0.049	0.9	0.08	2435	7.55	1546	1966	A.M.D.L.
1297	119.9	62.2	243	11	390.1	396.7	216.0	x	0.6	36.1	8.2	...	0.02	0.062	0.4	0.01	2216	7.80	1418	1966	A.M.D.L.
1529	72.1	46.1	102	11	176.1	113.6	305.5	x	1.4	26.5	4.7	...	x0.02	...	0.3	0.06	1208	7.85	572	1966	A.M.D.L.
1533	72.5	57.5	148	22	274.0	167.5	266.1	x	0.8	14.3	15.5	...	x0.02	0.14	0.7	0.06	1503	6.80	910	1965	A.M.D.L.
1622	111.2	60.5	214	15	297.2	344.0	287.0	x	0.9	29.3	1.9	...	x0.02	0.029	0.5	0.06	1947	7.90	1245	1966	A.M.D.L.
1623	109.1	71.9	52	13	119.2	223.9	339.5	x	3.0	17.2	...	...	0.02	0.03	0.2	0.19	1219	7.95	789	1966	A.M.D.L.
1888	101.1	53.2	130	16	223.7	228.8	280.0	x	0.9	17.2	0.1	...	0.04	0.019	0.4	0.04	1443	7.10	930	1965	A.M.D.L.
2165	50	61	365	40	230	257	756	x	3.7	...	7	...	...	...	...	...	...	...	1769	...	A.I.B.
2348	94.7	55.4	144	24	217.2	149.5	450.6	x	0.9	39.0	10.0	...	x0.02	...	0.9	x0.01	1517	7.70	890	1966	A.M.D.L.
2351	109.8	57.4	148	24	218.2	148.5	493.8	x	1.0	40.3	11.2	...	x0.02	0.022	0.5	0.12	1555	7.50	880	1966	A.M.D.L.
2352	182.9	72.4	52	12	48.0	599.6	246.9	x	1.8	23.0	0.9	...	x0.02	...	0.3	0.24	1509	7.65	1130	1966	A.M.D.L.
2353	109.0	57.4	126	24	200.5	115.0	499.0	x	0.7	44.8	11.5	...	x0.02	...	0.4	x0.01	1490	7.50	486	1966	A.M.D.L.
2381	129.1	71.0	297	23	367.6	419.3	410.4	x	1.5	24.3	1.1	...	x0.02	0.006	0.6	0.08	2298	7.10	1554	1965	A.M.D.L.
3454	47.0	21.0	12	24	11.0	6.0	292.0	x	0.7	58	x0.1	0.03	x0.02	0.02	0.2	x0.01	473	7.40	310	1966	A.M.D.L.
4695	71.2	43.8	109	11	136.6	147.7	329.9	x	2.4	23.6	2.8	...	x0.02	0.013	0.5	0.06	1127	7.30	711	1965	A.M.D.L.
4912	103.5	56.1	112	21	195.6	105.3	493.8	x	0.6	45.1	10.2	...	x0.02	0.007	0.3	0.06	1372	7.55	808	1966	A.M.D.L.
4913	74.6	47.6	22	8	46.2	53.0	398.1	x	1.1	44.8	4.9	...	x0.02	...	0.1	0.25	751	7.70	403	1966	A.M.D.L.
4916	99.4	54.6	142	24	224.2	149.0	430.0	x	1.0	32.0	10.1	...	x0.02	...	0.5	x0.01	1593	7.55	475	1966	A.M.D.L.
5432	69.8	44.1	27	10	37.0	18.5	419.7	x	0.5	53.8	5.4	...	x0.02	0.032	0.1	0.01	679	8.10	453	1966	A.M.D.L.
5433	173.3	85.8	380	33	450.4	545.6	555.5	x	1.4	30.5	0.6	...	x0.02	0.015	0.9	0.08	2952	7.65	2021	1966	A.M.D.L.
5684	119.7	57.0	263	26	304.9	365.8	410.3	x	2.1	25.7	4.2	...	x0.02	0.021	0.9	0.09	2122	7.60	1392	1965	A.M.D.L.

DALY WATERS 1:250,000 SHEET AREA

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
53	110.0	67.0	235	42	310.0	206.0	588.0	...	...	...	3.5	...	...	...	...	...	...	...	1562	...	A.I.B.
* 552	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1187	...	A.I.B.
* 555	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1396	...	A.I.B.
555	115	64	235	36	326	216	573	...	0.6	...	6	...	...	...	...	...	...	...	1586	...	A.I.B.
555	136	61	230	32	297	196	599	x	0.5	43	8.2	0.02	x0.02	0.01	0.4	0.05	2103	6.95	1355	1966	A.M.D.L.
556	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1824	...	A.I.B.
* 557	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1427	...	A.I.B.
557	122	64	228	31	303	207	563	x	0.6	39.0	9.3	0.01	0.06	x0.01	0.4	0.06	2091	6.70	1337	1966	A.M.D.L.
* 586	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	645	...	A.I.B.
586	92	47	9	4	9	16	510	x	0.4	39	0.5	0.02	x0.02	0.11	0.1	0.06	792	7.20	454	1966	A.M.D.L.
* 587	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	689	...	A.I.B.
587	55	31	2	2.6	8	...	133	34	...	...	...	...	...	0.2	...	...	500	8.05	324	...	A.I.B.
587	106	40	16	5	28	16	495	x	0.4	35	1.7	0.01	x0.02	0.03	0.1	0.08	826	7.25	485	1966	A.M.D.L.
588	19	55	20	8	35	12	337	7	0.2	...	1	...	...	...	...	...	...	...	494	...	A.I.B.
* 588	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	419	1965	W.R.B.
588	106	38	15	6	25	22	492	x	0.3	36	0.6	0.01	0.03	0.02	0.1	0.04	811	7.15	488	1966	A.M.D.L.
589	59	30	2	3	2	3	331	x	x0.1	24	x0.1	x0.01	x0.02	0.03	x0.1	x0.01	420	7.9	303	1966	A.M.D.L.
* 590	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2117	...	A.I.B.
908	8	68	17	5	15	...	432	...	0.52	...	1	...	...	...	...	...	...	...	546	...	A.I.B.
908	84	52	14	3	10	15	516	x	0.4	34	0.3	0.02	x0.02	0.02	0.1	0.05	790	7.15	456	1966	A.M.D.L.
1982	106	34	3	5	2	4	504	x	0.2	30	x0.1	0.02	0.02	0.03	0.2	x0.01	620	7.6	426	1966	A.M.D.L.
2264	94	52	127	50	136	74	602	x	1.2	50	5.8	0.01	0.02	0.06	0.4	0.02	1345	7.75	920	1966	A.M.D.L.
4518	80	38	13	7	5	23	441	x	0.8	49	x0.1	x0.01	x0.02	0.03	0.4	0.02	619	7.7	407	1966	A.M.D.L.
* 5395	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1193	1966	W.R.B.
* 5425	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1457	1966	W.R.B.
DALY WATERS HOMESTEAD	141	60	216	30	292	194	593	...	0.7	37	6.1	0.01	0.12	x0.01	0.4	0.05	2043	6.7	1338	1966	A.M.D.L.
NATURAL WELL	2.5	0.4	1.4	1.9	2	1	11	x	x0.1	17	1.7	0.02	x0.02	0.03	x0.1	x0.01	29	6.6	20	1966	A.M.D.L.

DELAMERE 1:250,000 SHEET AREA

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
1346	50	24	60	7	8	9	414	x	0.6	28	0.3	x0.01	0.02	0.03	0.8	0.09	610	7.8	371	1966	A.M.D.L.
4488	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	492	...	...
4792	12	x1	112	1	9	12	298	x	0.2	44	x0.1	x0.01	x0.02	0.09	0.9	0.07	483	8.15	325	1966	A.M.D.L.
5402	25	40	98	2.1	13	...	234	8	0.1	...	...	...	...	0.2	...	...	530	7.85	476	1966	W.R.B.
5402	27	32	78	1	7	21	402	x	0.6	68	x0.1	x0.01	x0.02	0.03	1.1	0.04	618	7.8	397	1966	A.M.D.L.
5421	8	6	225	7.7	187	...	173	x	0.5	...	...	...	...	2.3	...	...	1020	7.5	616	...	W.R.B.
5459	16	22	185	...	45	...	143	...	...	...	0.3	...	...	...	...	...	225	7.56	218	1966	W.R.B.
5544	63	30	27	3	23	3	367	x	0.3	64	x0.1	0.02	0.03	0.01	0.5	0.07	624	7.3	391	1966	A.M.D.L.

HELEN SPRINGS 1:250,000 SHEET AREA

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
104	123.5	66.1	151	26	272.1	146.5	504.5	x	0.7	42.7	13.5	...	x0.02	0.2	0.5	0.03	1678	7.3	1079	1965	A.M.D.L.
108	112.9	66.9	77	4	220.6	81.9	410.3	x	0.4	64.9	8.8	...	x0.02	0.015	0.2	0.03	1361	7.60	780	1965	A.M.D.L.
127	140.3	84.9	224	33	451.8	269.5	410.3	x	0.8	35.3	13.1	...	x0.02	0.05	0.5	0.05	2360	7.6	1460	1965	A.M.D.L.
134	147.9	78.6	182	31	352.7	199.2	518.4	x	0.9	35.3	15.8	...	0.03	x0.001	0.4	0.04	2075	6.90	1271	1965	A.M.D.L.
140	446.7	204.8	880	23	1697.7	1273.6	238.4	x	0.9	41.2	92.8	...	0.02	0.005	1.0	0.06	6558	7.25	4583	1965	A.M.D.L.
192	144.6	78.3	218	31	373.5	254.3	459.8	x	1.2	31.0	11.0	...	x0.02	0.02	0.3	x0.1	2146	7.20	1371	1965	A.M.D.L.
219	73.1	33.6	84	16	115.6	102.9	308.6	x	1.1	46.6	29.3	...	0.02	0.027	0.8	0.01	1063	7.55	656	1965	A.M.D.L.
237	144.1	65.6	545	30	636.4	640.3	352.0	x	2.2	49.0	53.4	...	x0.02	0.019	1.0	0.06	3435	7.30	2255	1965	A.M.D.L.
381	48.8	27.7	56	2	33.4	23.5	348.7	x	0.4	36.8	2.3	...	0.02	0.019	x0.1	x0.01	630	7.50	384	1965	A.M.D.L.
* 410	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2302	...	A.I.B.
418	57.0	35.7	63	11	36.4	28.8	432.1	x	0.4	60.1	1.7	...	x0.02	0.686	0.2	0.04	757	7.45	410	1965	A.M.D.L.
419	56.6	34.7	59	2	19.7	3.7	484.5	x	0.5	52.2	7.5	...	x0.02	0.021	0.1	x0.01	724	7.70	447	1965	A.M.D.L.
420	31.8	41.4	250	4	127.8	120.6	586.3	x	1.2	24.3	13.9	...	0.02	0.009	0.4	x0.01	1462	7.45	929	1965	A.M.D.L.
520	49.0	26.9	156	19	139.6	145.3	364.1	x	1.7	34.0	15.7	...	x0.02	0.027	0.3	0.03	1231	7.85	701	1965	A.M.D.L.
521	146.7	71.0	235	23	376.5	494.6	277.7	x	0.6	16.9	0.1	...	x0.02	0.012	0.3	0.09	2379	7.80	1498	1965	A.M.D.L.
702	202.7	215.7	395	61	1203.2	267.5	432.0	x	0.9	58.5	5.6	...	0.02	0.012	0.6	0.07	4290	7.15	2520	1965	A.M.D.L.
927	58.2	71.4	91	5	84	49.8	598.8	x	0.7	86.1	10.9	...	x0.02	0.01	0.2	0.01	1079	7.55	700	1965	A.M.D.L.
1193	134.1	71.8	150	29	279.2	132.1	567.8	x	0.5	40.5	12.8	...	0.03	x0.001	0.2	0.03	1747	7.40	1085	1965	A.M.D.L.
1194	72.1	49.8	53	2	74.7	29.6	472.2	x	0.5	81.7	7.7	...	x0.02	0.607	0.1	x0.01	886	7.65	481	1965	A.M.D.L.
1199	134.4	69.7	162	31	304.9	137.9	532.2	x	1.1	31.2	15.4	...	x0.02	...	0.4	0.05	1850	7.10	1110	1965	A.M.D.L.
1202	270.0	129.0	500	34	849.3	789.7	370.3	x	1.4	31.9	10.2	...	0.02	0.027	0.7	0.13	4028	7.10	2801	1965	A.M.D.L.
1203	432.9	171.4	430	26	769.5	1460.4	243.8	x	2.4	22.7	14.1	...	0.03	x0.001	1.0	0.23	4426	7.10	3487	1965	A.M.D.L.
1205	110.7	60.5	720	27	616.1	852.6	379.6	x	2.7	36.6	32.6	...	0.02	0.019	1.3	0.08	3680	7.40	2590	1965	A.M.D.L.
1206	179.3	82.1	988	64	786.4	1429.6	391.9	x	2.1	35.7	41.3	...	0.02	0.007	2.8	0.08	5110	7.35	3596	1965	A.M.D.L.
1288	49.9	26.2	344	30	204.5	397.5	422.8	x	2.7	31.6	21.4	...	x0.02	0.02	0.8	x0.01	2074	7.80	1273	1965	A.M.D.L.
1289	129.5	62.4	450	17	514.1	625.1	280.8	x	2.2	18.9	17.9	...	0.02	0.015	0.9	0.11	3078	7.80	1978	1965	A.M.D.L.
1291	131.9	70.7	177	27	321.6	172.8	504.5	x	0.6	37.9	12.5	...	x0.02	0.01	0.4	0.04	1937	7.40	1211	1965	A.M.D.L.
1293	154.3	77.8	340	21	547.6	459.2	293.0	x	2.1	18.4	2.8	...	x0.02	0.651	0.5	x0.01	2841	7.55	1758	1965	A.M.D.L.
1294	90.5	50.3	219	12	323.4	245.7	206.6	x	0.9	37.5	87.9	...	x0.02	0.998	0.7	0.13	1900	7.75	1097	1965	A.M.D.L.
1295	59.5	21.6	17	20	14.7	16.9	321.0	x	0.8	60.5	28.5	...	x0.02	0.012	0.3	x0.01	563	7.70	284	1965	A.M.D.L.
2327	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1492	...	A.I.B.
2328	96.1	54.7	259	18	261.4	229.6	537.8	x	1.7	36.6	3.0	...	x0.02	0.002	0.5	0.04	1899	7.30	1181	1965	A.M.D.L.
2329	52.0	25.4	79	16	34.8	65.8	401.2	x	1.4	22.0	...	...	0.03	0.045	0.4	0.03	741	7.90	458	1965	A.M.D.L.
2330	78.0	46.1	115	51	71.3	77.0	651.4	x	2.4	61.9	9.3	...	x0.02	0.05	0.7	0.04	1248	7.30	781	1965	A.M.D.L.
2331	80.2	32.2	30	26	14.4	15.6	478.3	x	1.3	66.8	16.5	...	x0.02	0.045	0.3	0.02	600	7.60	471	1965	A.M.D.L.
2332	79.4	32.6	37	21	16.3	30.5	472.2	x	1.3	62.4	17.8	...	0.02	0.047	0.3	0.01	700	7.50	474	1965	A.M.D.L.
2333	52.7	27.1	139	34	47.5	119.3	487.9	x	2.1	48	16.5	...	x0.02	0.03	0.6	0.03	1059	7.50	690	1965	A.M.D.L.

HELEN SPRINGS (CONT.)

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
2334	57.2	34.1	74	47	20.6	29.2	558.6	x	1.9	58.0	13.9	...	x0.02	0.035	0.5	0.03	875	7.55	577	1965	A.M.D.L.
4286	79.2	39.5	852	46	251.5	1533.7	415.8	x	5.6	13.6	3.8	...	x0.02	0.02	2.6	0.07	3882	7.50	2993	1965	A.M.D.L.
4305	210.7	1109	426	26	704.9	678.6	322.6	x	1.2	23.7	12.7	...	0.04	0.01	0.7	0.10	3494	7.40	2375	1965	A.M.D.L.
4521	57.3	22.6	142	24	87.8	167.4	317.9	x	1.6	51.1	31.5	...	0.02	0.021	0.7	0.02	1085	7.60	711	1965	A.M.D.L.
4522	135.7	74.5	916	19	970.0	1067.4	307.7	x	2.1	22.8	32.3	...	0.03	0.09	1.1	0.05	4992	7.70	3417	1965	A.M.D.L.
4601	49.2	27.6	27	2	17.0	25.9	339.5	x	0.3	76.9	3.6	...	0.02	0.021	0.1	x0.01	525	7.25	364	1965	A.M.D.L.
4602	33.5	27.2	68	3	45.2	21.0	333.5	x	0.4	34.5	6.8	...	x0.02	0.694	0.1	x0.01	652	7.45	294	1965	A.M.D.L.
4667	36.8	58.2	208	6	175.8	71.2	574.0	x	0.8	59.0	6.9	...	0.02	0.018	0.3	0.02	1430	7.35	864	1965	A.M.D.L.
4803	38.6	27.2	69	18	17.7	47.3	410.4	x	1.7	13.3	2.8	...	0.10	0.027	0.1	0.14	686	7.85	384	1965	A.M.D.L.
5671	135.7	78.0	234	31	467.3	227.1	404.7	x	0.7	25.6	12.3	...	x0.02	0.02	0.8	0.07	2289	7.30	1400	1965	A.M.D.L.
5675	86.1	42.9	760	26	566.2	857.6	354.9	x	3.0	29.0	39.6	...	0.02	0.038	1.1	0.05	3785	7.45	2528	1965	A.M.D.L.
5678	55.8	30.8	180	12	141.5	202.9	370.3	x	1.9	17.4	0.6	...	x0.02	0.016	0.6	0.05	1387	7.80	821	1965	A.M.D.L.
5679	62.5	22.7	12	21	5.9	9.5	339.5	x	0.8	61.1	23.8	...	x0.02	0.046	0.2	0.01	443	8.00	332	1965	A.M.D.L.
5680	58.1	28.2	42	42	11.8	18.5	450.6	x	1.8	51.1	10.8	...	x0.02	0.066	0.3	0.02	633	7.60	440	1965	A.M.D.L.
5682	54.5	25.0	60	19	22.2	37.9	401.2	x	1.7	47.0	14.7	...	x0.02	0.042	0.4	0.01	741	7.75	449	1965	A.M.D.L.
WIGGENTY WELL	17.1	17.6	46	5	55.5	17.7	148.1	x	0.4	72.9	13.9	...	0.02	0.07	0.1	x0.01	454	7.80	288	1965	A.M.D.L.

KATHERINE 1:250,000 SHEET AREA

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
1901	601	63	9	14	11	1538	191	x	2.4	18	x0.1	x0.01	0.03	0.03	0.2	0.16	2477	6.95	2404	1966	A.M.D.L.
* 2522	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	729	7.38	450	1966	W.R.B.
2902	82	31	4.4	2.4	7.5	...	700	...	...	...	...	...	...	...	...	...	563	7.41	331	1966	W.R.B.
3025	64	...	...	...	12	...	266	...	...	...	...	...	...	...	...	...	735	7.08	337	1964	...
3027	40	...	...	...	11	...	270	...	...	...	...	...	...	...	...	...	779	6.96	428	1964	...
* 4523	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	729	7.51	453	1966	W.R.B.
4524	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	559	8.56	524	1964	...
4525	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	660	8.14	568	1964	...
4600	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	779	6.96	428	1964	...
* 4648	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	741	6.86	274	1965	W.R.B.
4709	5.64	0.99	...	...	6	24	277	x	x	...	x	...	...	0.6	...	...	...	6.91	518	1965	W.R.B.
* 4881	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	675	7.44	395	1966	W.R.B.
* 4886	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7.85	409	1966	W.R.B.
* 5042	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	675	7.38	442	1966	W.R.B.
* 5082	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	680	7.30	417	...	...
5148	30	42	2.2	7.2	19	...	162	...	...	...	...	...	...	0.7	...	...	530	6.55	330	1966	W.R.B.

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
										KATHERINE (CONT.)											
* 5149	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1900	8.6	1039	...	...
* 5329	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	578	7.38	436	1966	W.R.B.
										LARRIMAH 1:250,000 SHEET AREA											
* 551	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1427	...	A.I.B.
* 554	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	790	...	A.I.B.
554	103	47	80	8	115	69	495	x	x0.1	34	x0.1	0.02	x0.02	x0.01	0.2	0.01	1049	7.35	696	1966	A.M.D.L.
903	87	28	12	0.6	10	8	411	x	0.1	30	x0.1	0.01	0.03	0.06	0.1	x0.01	643	7.3	382	1966	A.M.D.L.
904	35	6.3	178	3	294	5	116	x	0.9	36	x0.1	0.01	0.02	0.04	2.5	0.14	1135	7.35	690	1966	A.M.D.L.
905	0.6	0.05	74	0.8	14	13	54	51	0.6	63	x0.1	0.02	x0.02	0.03	4.3	0.11	319	9.9	295	1966	A.M.D.L.
906	57	16	24	3	8	7	316	x	0.1	58	x0.1	0.02	0.38	0.03	0.1	0.07	484	7.4	335	1966	A.M.D.L.
2186	101	63	125	14	190	101	522	...	...	...	8	...	...	...	...	...	...	...	1124	...	A.I.B.
										NEWCASTLE WATERS 1:250,000 SHEET AREA											
218	30	23	135	49	20	21	566	x	2.5	63	7.3	0.01	x0.02	0.04	1.0	x0.01	951	8.0	657	1966	A.M.D.L.
515	111	61	171	16	249	157	465	x	0.7	44	10.1	0.01	x0.02	0.02	0.4	0.07	1753	7.3	1063	1966	A.M.D.L.
* 591	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2469	...	A.I.B.
* 591	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2860	1965	W.R.B.
592	121	75	367	58	459	305	629	x	1.1	44	6.1	x0.01	x0.02	0.01	0.6	0.08	2728	7.7	1787	1966	A.M.D.L.
907	57	77	340	84	355	234	698	...	1.4	...	7	...	...	...	...	...	...	...	1853	1953	A.I.B.
* 907	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1593	1965	W.R.B.
907	95	61	253	73	271	172	677	x	1.4	57	4.7	0.03	x0.02	0.01	0.6	0.04	2003	7.75	1309	1966	A.M.D.L.
1896	75	41	70	26	95	43	459	x	1.5	...	x	...	...	...	...	...	...	...	811	...	A.I.B.
1899	80	49	72	2.8	140	170	179	48	0.2	...	...	...	x	0.2	...	...	1150	7.94	768	1965	W.R.B.
2350	66	26	19	31	15	7	381	x	0.6	69	13.6	0.01	x0.02	0.05	0.2	x0.01	569	7.85	452	1966	A.M.D.L.
4579	89	58	237	73	244	146	677	x	1.3	55	3.8	0.01	x0.02	0.01	0.5	0.04	1948	7.7	1281	1966	A.M.D.L.
5686	74	47	78	58	79	24	569	x	1.1	69	6.1	0.03	x0.02	0.01	0.3	0.02	1069	7.8	695	1966	A.M.D.L.
5687	73	37	52	47	44	16	501	x	0.8	68	9.0	0.02	x0.02	0.02	0.2	0.01	914	7.35	575	1966	A.M.D.L.
5688	75	33	51	40	36	17	480	x	0.9	66	13.9	0.02	x0.02	0.01	0.2	0.01	876	7.3	553	1966	A.M.D.L.
5689	69	37	82	56	31	24	590	x	1.2	66	8.4	0.02	x0.02	0.07	0.3	0.02	1003	7.3	647	1966	A.M.D.L.
5690	61	33	37	39	20	11	453	x	1.0	66	7.8	0.03	x0.02	0.06	0.3	x0.01	732	7.75	475	1966	A.M.D.L.
5793	94	50	121	50	125	71	614	x	1.3	57	6.4	0.03	x0.02	x0.01	0.4	0.02	1415	7.65	872	1966	A.M.D.L.

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
										TENNANT CREEK 1:250,000 SHEET AREA											
505	558	220	225	32	323	2176	117	x	0.9	...	14	...	...	...	...	...	...	...	3666	...	A.I.B.
505	550.3	173.9	192	25	279.2	1916.4	157.4	x	2.8	19.4	7.7	...	...	0.032	0.7	0.50	3783	7.30	3307	1965	A.M.D.L.
1200	492.3	149.6	153	20	266.2	1574.8	243.8	x	2.8	19.2	11.6	...	0.02	x0.001	0.8	0.42	3162	7.10	2531	1965	A.M.D.L.
1201	142.1	75.6	186	36	329.3	183.1	518.4	x	1.3	37.3	12.6	...	0.08	0.036	0.3	0.03	2068	7.30	1230	1966	A.M.D.L.
1208	132.1	68.5	152	32	267.4	115.6	570.9	x	0.8	39.0	13.3	...	0.02	x0.021	0.3	0.05	1746	7.25	1057	1965	A.M.D.L.
4189	134.1	66.8	164	29	300.8	134.6	540.1	x	0.9	33.6	14.1	...	0.02	x0.001	0.4	0.07	1794	7.15	1100	1965	A.M.D.L.
4521	125.8	69.0	157	28	326.4	124.7	438.2	x	1.1	28.5	18.9	...	0.02	0.029	0.3	0.09	1891	7.40	1064	1966	A.M.D.L.
										VICTORIA RIVER DOWNS 1:250,000 SHEET AREA											
512	98	33	8	3	5	3	478	x	1.9	...	2	...	...	...	...	...	...	...	632	...	A.I.B
512	84	32	8	2	4	7	411	x	0.3	38	1.4	0.04	x0.02	0.03	x0.1	0.01	555	7.7	368	1966	A.M.D.L.
584	46	23	60	...	10	...	447	...	1.54	...	...	...	...	...	...	...	...	...	587	...	A.I.B.
584	49	20	59	0.8	7	24	376	x	0.5	65	x0.1	0.03	0.02	0.05	0.1	0.03	578	7.9	400	1966	A.M.D.L.
594	116	43	7	2	7	5	566	x	0.2	34	0.3	0.03	x0.02	0.07	x0.1	0.02	797	7.3	473	1966	A.M.D.L.
595	70	47	17	3	8	12	465	x	0.6	34	x0.1	0.04	x0.02	0.13	x0.1	0.07	674	7.65	392	1966	A.M.D.L.
* 1091	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	305	1966	A.M.D.L.
1340	122	33	17	2	4	21	548	x	0.4	35	0.9	0.03	0.05	0.05	0.1	0.02	825	7.2	493	1966	A.M.D.L.
* 1913	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	663	...	W.R.B.
1988	65	37	33	3	9	10	447	x	0.4	45	x0.1	0.02	0.07	0.01	0.3	0.06	699	7.35	411	1966	A.M.D.L.
3558	46	52	68	4	27	28	495	x	2.3	45	0.4	x0.01	x0.02	0.04	0.4	0.1	753	7.75	445	1966	A.M.D.L.
3747	134	21	4	1	2	13	507	x	0.1	27	x0.1	0.01	x0.02	x0.01	0.3	x0.01	740	7.0	444	1966	A.M.D.L.
3768	6	x1	65	x1	26	53	63	4	0.9	25	x0.1	0.01	x0.02	0.16	3.0	0.04	329	8.85	217	1966	A.M.D.L.
4049	1.5	0.06	137	0.3	9	17	313	13	0.4	40	x0.1	0.01	x0.02	0.09	0.5	0.05	547	9.0	367	1966	A.M.D.L.
4628	73	41	42	2	13	1	504	x	0.2	49	9.8	0.01	x0.02	0.03	0.2	0.01	768	7.3	456	1966	A.M.D.L.
4762	79	40	32	3	43	7	436	x	0.2	54	3.6	0.01	x0.02	x0.01	0.1	0.01	796	7.45	479	1966	A.M.D.L.
4763	65	28	44	2	4	7	435	x	0.3	59	6.5	0.02	x0.02	0.07	0.1	0.01	648	7.35	357	1966	A.M.D.L.
4764	78	21	9	4	5	21	349	x	0.4	43	2	0.02	x0.02	0.03	x0.1	x0.01	527	7.25	451	1966	A.M.D.L.
4765	61	42	41	0.7	20	4	465	x	0.3	62	7.3	0.04	x0.02	0.04	0.1	0.03	732	7.4	430	1966	A.M.D.L.
4769	59	51	67	1	9	x1	593	x	0.3	59	1.8	0.02	x0.02	0.08	0.1	0.01	855	7.3	502	1966	A.M.D.L.
5396	62	76	41	7.4	22	...	316	...	0.3	...	...	...	...	0.3	...	...	890	7.25	570	...	W.R.B.
* 5423	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	484	...	W.R.B.
5424	11	60	68	3.0	20	...	201	34	0.2	...	...	...	...	0.2	...	...	330	8.15	433	1965	W.R.B.
5424	62	37	44	2	17	12	453	x	0.6	43	5.5	0.02	x0.02	0.04	0.1	x0.01	709	7.3	424	1966	A.M.D.L.
5426	79	40	44	2	14	17	519	x	0.5	50	7.5	0.02	0.02	0.05	x0.1	0.03	798	7.3	484	1966	A.M.D.L.
* 5444	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	330	...	W.R.B.
5444	88	70	16	1	8	19	641	x	0.4	22	x0.1	0.01	x0.02	0.05	0.1	0.03	908	7.2	515	1966	W.R.B.

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
									WAVE HILL 1:250,000 SHEET AREA												
510	76	14.4	146	...	175	...	250	...	...	...	...	...	...	...	...	...	...	...	750	...	A.I.B.
583	33	61	57	1	15	...	505	...	0.44	...	2	...	...	...	...	...	...	...	674	...	A.I.B.
583	54	53	53	0.8	3	3	551	x	0.3	56	0.2	0.1	0.02	x0.01	0.1	0.01	809	7.7	500	1966	A.M.D.L.
585	60	51	58	1	75	...	588	...	...	...	9	...	...	...	...	...	...	...	843	...	A.I.B.
585	65	34	69	2	35	16	504	x	0.3	54	4.9	0.06	x0.02	0.09	0.1	x0.01	876	7.3	543	1966	A.M.D.L.
813	70	49	73	1	24	7	575	x	0.3	64	17.4	0.02	x0.02	0.11	0.1	0.01	906	7.55	566	1966	A.M.D.L.
814	21	7	107	1	27	11	322	x	0.2	46	1	0.01	0.02	0.05	0.2	0.01	581	7.9	400	1966	A.M.D.L.
815	39	30	170	3	77	21	545	x	0.4	65	3	0.03	x0.02	0.01	0.3	0.01	1068	7.55	700	1966	A.M.D.L.
817	54	37	74	3	37	8	426	x	0.3	60	43.7	0.02	x0.02	0.03	0.2	x0.01	804	8.0	523	1966	A.M.D.L.
* 818	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	360	...	A.M.D.L.
821	56	44	192	7	295	5	396	x	0.5	33	6.1	0.01	0.03	0.05	0.5	0.15	1557	7.75	847	1966	A.M.D.L.
838	63	33	119	2	68	27	495	x	0.3	74	11.2	0.02	x0.02	0.02	0.2	x0.01	994	7.4	651	1966	A.M.D.L.
841	78	45	39	1	16	3	516	x	0.3	54	15.4	0.02	x0.02	0.02	x0.1	x0.01	804	7.25	499	1966	A.M.D.L.
851	93	34	64	10	51	33	491	x	0.9	66	12.2	0.02	x0.02	0.01	0.1	0.02	952	7.2	595	1966	A.M.D.L.
852	187	118	223	28	562	152	599	x	1.5	79	5.8	0.02	x0.02	0.05	0.3	0.04	2753	7.0	1654	1966	A.M.D.L.
853	95	70	167	23	143	75	751	x	1.9	71	22.8	0.03	x0.02	0.03	0.3	0.04	1695	7.2	1016	1966	A.M.D.L.
1096	54	43	35	3	6	2	450	x	0.2	36	0.5	0.01	x0.02	0.01	0.1	0.01	685	7.2	399	1966	A.M.D.L.
1099	53	66	64	3	16	5	617	x	0.2	38	9.7	x0.01	x0.02	0.02	0.2	0.02	944	7.5	563	1966	A.M.D.L.
2337	111	74	82	17	64	43	748	x	1.5	61	12	0.04	x0.02	0.02	0.2	0.04	1279	7.3	811	1966	A.M.D.L.
2338	113	32	30	11	14	2	554	x	0.8	87	1.1	0.05	x0.02	0.03	0.1	0.01	812	7.25	569	1966	A.M.D.L.
2414	27	24	1.48	2.3	14	...	214	...	0.1	...	...	...	...	0.04	...	...	612	7.9	282	...	A.I.B.
2836	48	38	136	3	101	51	432	x	0.5	68	14.7	0.03	x0.02	0.05	0.3	0.02	1061	7.55	676	1966	A.M.D.L.
4048	71	32	58	6	26	12	474	x	0.5	64	4.6	0.02	0.02	0.02	0.1	x0.01	772	7.4	492	1966	A.M.D.L.
* 4303	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	478	1965	W.R.B.
4303	49	37	67	3	22	14	471	x	0.2	35	3.6	0.02	x0.02	0.05	0.1	0.03	751	7.55	451	1966	A.M.D.L.
4407	383	169	972	6	1828	975	253	x	0.4	38	6.4	0.02	0.04	0.07	1.3	0.08	7227	7.3	4594	1966	A.M.D.L.
4530	...	...	...	...	38	...	...	...	...	...	...	...	...	...	...	...	830	8.32	631	...	...
4531	...	...	...	...	36	...	...	...	...	...	...	...	...	...	...	...	625	8.37	436	...	...
4767	138	126	518	2	833	399	495	x	0.9	70	11.2	0.03	x0.02	0.06	0.5	0.01	3794	7.35	2399	1966	A.M.D.L.
									WINNECKE CREEK 1:250,000 SHEET AREA												
HOOKER CK No. 5	47	36	270	...	130	x	165	x	0.3	...	...	...	...	0.05	...	...	...	...	611	1965	A.I.B.
"	45	43	95	8	125	34	337	x	2.3	...	1	...	...	...	...	...	...	...	689	1957	W.R.B.
"	32	44	85	7	130	25	310	x	1.5	...	4	...	...	...	...	...	...	...	638	1957	W.R.B.

Reg.No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	LABORATORY
Winnecke Creek (Cont.)																					
HOOKER CK No.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	787	...	470	1967	W.R.B
" No.7	...	...	...	...	103	...	...	...	...	...	...	...	...	...	...	...	800	...	820	1964	W.R.B.
" No.9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	611	8.14	424	...	W.R.B.
TANUMBIRINI																					
5845	119	52	64	9	95	150	450	x	0.6	24	x0.01	0.12	0.04	x0.01	0.48	x0.05	1121	7.45	690	1968	A.M.D.L.
5783	115	56	70	12	105	145	470	x	1.1	20	x0.01	0.14	0.02	0.01	0.30	x0.05	1252	7.50	774	1968	A.M.D.L.
* 5942	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	900	7.9	568	1967	W.R.B.
* 5954	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1150	7.45	637	1967	W.R.B.

APPENDIX 3 : CHEMICAL ANALYSES OF BORE-WATER
Percentage Reacting Values and Ionic Ratios

BEETALOO 1:250,000 SHEET AREA

Reg. No.	Na epm.	K epm.	Na + K epm.	%	Ca epm.	%	Mg epm.	%	Sc epm.	Cl epm	%	SO_4 epm	%	HCO_3 epm	%	Sa epm	Cl/Na+K	Mg/Ca	SO_4/Cl	HCO_3/Cl	Ca+Mg/Na+K	T.D.S/S.C.	TYPE
316	8.00	0.64	8.64	47	5.40	29	4.39	24	18.43	6.74	38	4.05	22	7.28	40	18.27*	0.78	0.81	0.60	1.08	1.13	0.59	CAnc
517	5.35	0.59	5.94	38	5.04	32	4.61	30	15.59	5.28	34	2.23	15	7.79	51	15.44*	0.89	0.91	0.42	1.48	1.62	0.67	CAnc
519	7.83	0.59	8.42	49	4.92	29	3.85	22	17.19	6.26	35	5.62	30	6.42	35	18.30	0.74	0.78	0.90	1.03	1.04	0.62	CAnc
522	10.35	0.33	10.68	59	3.58	20	3.75	21	18.01	7.67	41	5.85	31	5.36	28	18.89	0.72	1.05	0.76	0.70	0.69	0.61	ABn
1186	3.39	0.28	3.67	25	5.28	36	5.71	39	14.66	3.99	27	2.77	19	7.81	54	14.57	1.09	1.08	0.69	1.96	2.99	0.63	Cmc
1187	5.13	0.31	5.44	35	4.73	30	5.53	35	15.70	5.63	34	4.76	29	6.17	37	16.56	1.03	1.17	0.85	1.10	1.89	0.63	CAmn
1233	5.18	0.28	5.46	46	3.01	25	3.42	29	11.89	5.15	44	1.90	16	4.75	40	11.96*	0.94	1.14	0.37	0.92	1.18	0.58	ACnm
1290	13.75	0.72	14.47	60	5.52	23	4.12	17	24.11	9.79	39	8.89	35	6.63	26	25.31	0.68	0.75	0.91	0.68	0.67	0.63	ABn
1297	10.57	0.28	10.85	49	5.98	27	5.12	24	21.95	11.00	48	8.26	36	3.54	16	22.93**	1.01	0.86	0.75	0.32	1.02	0.64	ABn
1529	4.44	0.28	4.72	39	3.60	30	3.79	31	12.11	4.97	40	2.37	19	5.01	41	12.35	1.05	1.05	0.48	1.01	1.57	0.47	CAnm
1533	6.44	0.56	7.00	45	3.62	24	4.73	31	15.35	7.73	50	3.49	22	4.36	28	15.83**	1.10	1.30	0.45	0.56	1.19	0.61	Anm
1622	9.31	0.38	9.69	48	5.55	27	4.96	25	20.2	8.38	41	7.16	35	4.70	24	20.24	0.86	0.89	0.85	0.56	1.08	0.64	ABn
1623	2.26	0.33	2.59	19	5.44	39	5.91	42	13.94	3.34	25	4.66	34	5.56	41	13.56	1.29	1.09	1.40	1.66	4.38	0.65	CBmc
1888	5.66	0.41	6.07	39	5.04	33	4.38	28	15.49	6.31	40	4.76	30	4.59	30	15.66	1.04	0.87	0.75	0.73	1.55	0.64	ABnc
2165	15.87	1.02	16.89	69	2.50	10	5.02	21	24.41	6.51	27	5.35	22	12.39	51	24.36*	0.39	2.01	0.82	1.90	0.45	...	Cn
2348	6.26	0.61	6.87	43	4.73	29	4.56	28	16.16	6.13	37	3.11	19	7.39	44	16.63	0.89	0.96	0.51	1.21	1.35	0.59	CAnc
2351	6.44	0.61	7.05	41	5.48	32	4.72	27	17.25	6.15	35	3.09	18	8.09	47	17.51*	0.87	0.86	0.50	1.32	1.45	0.57	CAnc
2352	2.26	0.31	2.57	15	9.13	52	5.95	33	17.65	1.35	8	12.48	70	4.05	22	17.88	0.53	0.65	9.24	3.00	5.87	0.75	Bcm
2353	5.48	0.61	6.09	38	5.44	33	4.72	29	16.25	5.65	35	2.39	15	8.18	50	16.40*	0.93	0.87	0.42	1.44	1.67	0.33	CAnc
2381	12.92	0.59	13.51	52	6.44	25	5.84	23	25.79	10.37	40	8.73	34	6.73	26	25.83	0.77	0.91	0.84	0.65	0.91	0.68	ABn
3454	0.52	0.61	1.13	22	2.35	45	1.73	33	5.21	0.31	6	0.12	2	4.79	92	5.22	0.27	0.74	0.39	15.45	3.61	0.66	Cc
4695	4.74	0.28	5.02	41	3.55	29	3.59	30	12.16	3.85	31	3.07	25	5.41	44	12.33	0.77	1.01	0.80	1.41	1.42	0.63	CAnm
4912	4.87	0.54	5.41	36	5.16	34	4.61	30	15.18	5.51	35	2.19	14	8.09	51	15.95*	1.02	0.89	0.40	1.47	1.81	0.59	CAnc
4913	0.96	0.20	1.16	13	3.72	42	3.91	45	8.79	1.30	15	1.10	12	6.52	73	8.92	1.12	1.05	0.85	5.02	6.58	0.54	Cmc
4916	6.18	0.61	6.79	42	4.96	31	4.49	27	16.24	6.32	38	3.10	19	7.05	43	16.63*	0.93	0.90	0.49	1.12	1.39	0.30	CAnc
5432	1.18	0.26	1.44	17	3.48	41	3.63	42	8.55	1.04	13	0.39	5	6.88	82	8.31	0.72	1.04	0.38	6.62	4.94	0.67	Cmc
5433	16.53	0.84	17.37	53	8.65	26	7.06	21	33.08	12.70	38	11.36	34	9.10	28	33.16	0.70	0.81	0.89	0.72	0.90	0.68	ABn
5684	11.44	0.67	12.11	53	5.97	26	4.69	21	22.77	8.60	37	7.62	33	6.72	30	22.94	0.71	0.78	0.89	0.78	0.88	0.66	ABn

* Includes epm attributable to NO_3; % NO_3^- included under % Cl^-

** Includes epm $CO_3^=$

Appendix 3.

Reg. No.	Na epm.	K epm.	Na + K epm.	%	Ca epm.	%	Mg epm.	%	Sc epm.	Cl epm.	%	SO4 epm.	%	HCO3 epm.	%	Sa epm	Cl/Na+K	Mg/Ca	SO4/Cl	HCO3/Cl	Ca+Mg/Na+K	T.D.S./S.C.	TYPE
										DALY WATERS 1:250,000 SHEET AREA													
557)	10.22	1.07	11.29	51	5.49	24	5.51	25	22.29	8.74	39	4.29	19	9.64	42	22.67	0.77	1.00	0.49	1.10	0.97	...	[illegible]
533)	9.92	0.79	10.71	48	6.09	28	5.26	24	22.06	8.54	38	4.31	20	9.23	42	22.23*	0.80	0.86	0.50	1.08	1.06	0.64	CA nm
555	10.22	0.92	11.14	50	5.74	26	5.26	24	22.14	9.19	40	4.50	19	9.39	41	23.18*	0.82	0.92	0.49	1.02	0.99	...	[illegible]
555	10.01	0.82	10.83	48	6.79	30	5.02	22	22.64	8.38	38	4.08	18	9.82	44	22.41*	0.77	0.74	0.49	1.17	1.09	0.64	CA nc
586	0.39	0.10	0.49	5	4.59	51	3.87	44	8.95	0.25	3	0.33	4	8.36	93	8.94	0.51	0.84	1.32	33.44	17.27	0.57	C cm
587	0.09	0.07	0.16		2.74		2.55		5.45	0.23		...		3.31**		...	1.38	0.93	...	9.48	33.06	0.65	[illegible]
587	0.70	0.13	0.83	9	5.29	56	3.29	35	9.41	0.79	9	0.33	3	8.11	88	9.23	0.93	0.62	0.42	10.27	10.34	0.59	C c
588	0.87	0.20	1.07	16	0.95	15	4.52	69	6.54	0.99	15	0.25	4	5.75**	81	6.76	0.93	4.71	0.25	5.58	5.11	...	[illegible]
588	0.65	0.15	0.80	9	5.29	57	3.13	34	9.22	0.71	8	0.46	5	8.06	87	9.23	0.89	0.59	0.65	11.35	10.53	0.60	C c
589	0.09	0.08	0.17	3	2.94	53	2.47	44	5.58	0.06	1	0.06	1	5.43	98	5.55	0.35	0.84	1.00	90.5	31.82	0.72	C cm
908	0.74	0.13	0.87		0.39		5.59		6.85	0.42		...		7.08		...	0.48	14.33	...	16.86	6.87	...	[illegible]
908	0.61	0.08	0.69	8	4.19	46	4.28	46	9.16	0.28	3	0.31	3	8.46	94	9.05	0.39	1.02	1.11	30.21	21.28	0.58	C c
1982	0.13	0.13	0.26	3	5.29	63	2.80	34	8.35	0.06	1	0.08	1	8.26	98	8.40	0.19	0.53	1.33	137.66	31.12	0.69	C nc
2264	5.52	1.28	6.80	43	4.69	30	4.23	27	15.72	3.84	25	1.54	10	9.87	65	15.34*	0.56	0.90	0.40	2.57	1.31	0.68	C nc
4518	0.57	0.18	0.75	10	3.99	51	3.13	39	7.87	0.14	2	0.48	6	7.23	92	7.85	0.19	0.78	3.43	51.64	9.49	0.66	C cm
DALY WATERS H.S.	9.40	0.77	10.17	46	7.04	32	4.93	22	22.14	8.23	38	4.04	18	9.72	44	22.09*	0.81	0.70	0.49	1.18	1.18	0.65	CA n
Natural Well	0.06	0.05	0.11	42	0.12	46	0.03	12	0.26	0.06	23	0.02	8	0.18	69	0.26	0.55	0.25	0.33	3.00	1.36	0.69	C cn
										DELAMERE 1:250,000 SHEET AREA													
1346	2.61	0.18	2.79	38	2.50	35	1.97	27	7.26	0.23	3	0.19	3	6.79	94	7.21	0.08	0.79	0.83	29.52	1.60	0.61	C nc
4792	4.87	0.03	4.90	88	0.60	11	0.08	1	5.58	0.25	5	0.25	5	4.88	90	5.38	0.05	0.15	1.00	19.52	0.14	0.67	C n
5402	4.26	0.05	4.31	...	1.25	...	3.29	...	8.85	0.36	...	...	...	4.11**	...	...	0.08	2.60	...	10.67	1.05	0.90	[illegible]
5402	3.39	0.03	3.42	46	1.35	18	2.63	36	7.40	0.20	3	0.41	6	6.59	91	7.23	0.06	1.93	2.20	32.95	1.16	0.64	C nm
5421	9.79	0.20	9.99	...	0.40	...	0.49	...	10.88	5.27	...	...	...	2.84	...	...	0.53	1.17	...	0.54	0.09	0.60	AC?
5459	8.05	...	...	...	0.80	...	1.81	...	...	1.27	...	...	...	2.34	...	...	...	...	...	1.84	...	0.97	
5544	1.17	0.08	1.25	20	2.56	41	2.47	39	6.28	0.65	10	0.06	1	6.02	89	6.73	0.53	0.96	0.09	9.26	4.02	0.63	C cm

** includes epm $CO_3^{=}$

Appendix 3.

HELEN SPRINGS 1:250,000 SHEET AREA

Reg.No.	Na epm.	K epm.	Na + K epm.	%	Ca epm.	%	Mg epm.	%	Sc epm.	Cl epm.	%	SO_4 epm.	%	HCO_3 epm.	%	Sa epm.	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	TYPE
104	6.57	0.67	7.24	38	6.16	33	5.44	29	18.84	7.67	40	3.05	16	8.27	44	19.21*	1.06	0.88	0.40	1.08	1.60	0.64	CAnm
108	3.35	0.10	3.45	24	5.63	38	5.50	38	14.58	6.22	42	1.71	12	6.72	46	14.79*	1.80	0.98	0.27	1.08	3.23	0.57	CAcm
127	9.74	0.84	10.58	43	7.00	29	6.98	28	24.56	12.74	51	5.61	22	6.72	27	25.28*	1.20	1.00	0.44	0.53	1.32	0.62	A nc
134	7.9	0.79	8.69	39	7.38	33	6.46	28	22.53	9.95	44	4.15	18	8.50	38	22.85*	1.14	0.88	0.42	0.85	1.59	0.61	AC nc
140	38.28	0.59	38.87	50	22.29	28	16.84	22	78.00	47.88	61	26.52	34	3.91	5	79.81*	1.23	0.76	0.55	0.08	1,01	0.70	A n
192	9.48	0.79	10.27	43	7.22	30	6.44	27	23.93	10.53	45	5.29	23	7.54	32	23.54*	1.03	0.89	0.50	0.72	1.33	0.64	AC nc
219	3.65	0.41	4.06	39	3.65	35	2.76	26	10.47	3.26	31	2.14	20	5.06	49	10.93	0.80	0.76	0.66	1.55	1.58	0.62	CAnc
237	23.71	0.77	24.48	66	7.19	19	5.40	15	37.07	17.95	48	13.33	36	5.77	16	37.91*	0.73	0.75	0.74	0.32	0.51	0.66	ABn
381	2.44	0.05	2.49	35	2.44	34	2.28	31	7.21	0.94	13	0.49	7	5.72	80	7,15	0.38	0.93	0.52	6.09	1.90	0.61	C nc
418	2.74	0.28	3.02	34	2.84	32	2.94	34	8.80	1.03	12	0.60	7	7.08	81	8.71	0.34	1.04	0.58	6.87	1.91	0.54	C nm
419	2.57	0.05	2.62	32	2.82	34	2.85	34	8.29	0.55	6	0.08	1	7.94	93	8.69*	0.21	1.01	0.15	14.44	2.16	0.62	C mc
420	10.88	0.10	10.98	69	1.59	10	3.40	21	15.97	3.60	23	2.51	16	9.61	61	15.94*	0.33	2.14	0.70	2.67	0.45	0.64	C n
520	6.79	0.49	7.28	61	2.45	21	2.21	18	11.94	3.94	31	3.03	23	5.97	46	12.94	0.51	0.90	0.77	...	0.64	...	CAn
521	10.22	0.59	10.81	45	7.32	31	5.84	24	23.97	10.62	42	10.30	40	4.55	18	25.47*	0.98	0.80	0.97	0.43	1.22	0.63	ABnc
702	17.18	1.56	18.74	40	10.11	22	17.74	38	46.59	33.93	73	5.57	12	7.08	15	46.58	1.81	1.75	0.16	0.21	1.49	0.59	Anm
927	3.96	0.13	4.09	32	2.90	23	5.87	45	12.86	2.37	18	1.04	8	9.81	74	13.40*	0.58	2.02	0.44	4.14	2.14	0.65	Cmn
1193	6.53	0.74	7.27	37	6.69	34	5.90	29	19.86	7.87	39	2.75	14	9.31	47	20.14*	1.08	0.88	0.35	1.18	1.73	0.62	CAnc
1194	2.31	0.05	2.36	23	3.6	36	4.10	41	10.06	2.11	20	0.62	6	7.74	74	10.59*	0.89	1.14	0.29	3.67	3.26	0.54	Cmc
1199	7.05	0.79	7.84	39	6.71	33	5.73	28	20.28	8.60	43	2.87	14	8,72	43	20.44*	1.10	0.85	0.33	1.01	1.59	0.60	CAnc
1202	21.75	0.87	22.62	48	13.47	29	10.61	23	46.70	23.95	52	16.44	35	6.07	13	46.62*	1.06	0.79	0.69	0.25	1.06	0.70	ABnc
1203	18.71	0.67	19.38	35	21.6	39	14.10	26	55.08	21,68	39	30.43	54	4.00	7	56.34*	1.12	0.65	1.40	0.18	1.84	0.79	BAcn
1205	31.32	0.69	32.01	75	5.52	13	4.98	12	42.51	17.37	43	17.75	42	6.22	15	41.87*	0.54	0.90	1.02	0.36	0.33	0.70	ABn
1206	42.98	1.64	44.62	74	8.95	15	6.75	11	60.32	22.18	39	29.76	51	6.42	10	58.36*	0.50	0.75	1.34	0.29	0.35	0.70	BAn
1288	14.96	0.77	15.73	77	2.49	12	2.15	11	20.37	5.77	28	8.28	39	6.93	33	21.32*	0.36	0.86	1.44	1.20	0.29	0.61	BC n
1289	19.58	0.43	20.01	63	6.46	20	5.13	17	31.60	14.50	45	13.01	41	4.60	14	32.41*	0.72	0.79	0.89	0.32	0.58	0.64	ABn
1291	7.70	0.69	8.39	40	6.58	32	5.81	28	20.78	9.07	43	3.60	17	8.27	40	21.14*	0.69	0.88	0.40	0.91	1.48	0.63	ACnc
1293	14.79	0.54	15.33	52	7.70	26	6.40	22	29.43	15.44	52	9.56	32	4.80	16	29.80	1.01	0.83	0.62	0.31	0.93	0.62	ABn
1294	9.53	0.31	9.84	53	4.52	24	4.14	23	18,50	9.12	55	5.12	27	3.39	18	19.03*	0.93	0.92	0.56	0.37	0.88	0.58	A n
1295	0.74	0.51	1.25	21	2.97	49	1.78	30	6.00	0.41	7	0.35	6	5.26	87	6.48*	0.33	0.60	0.85	12.83	3.8	0.50	C cm
2328	11.27	0.46	11.73	56	4.80	23	4.5	21	21.03	7.37	35	4.78	23	8.81	42	20.96	0.63	0.94	0.65	1.20	0.79	0.62	CA n
2329	3.44	0.41	3.85	45	2.59	30	2.09	25	8.53	0.98	11	1.37	15	6.58	74	8.93	0.25	0.81	1.40	6.71	1.22	0.62	C nc
2330	5.00	1.30	6.30	45	3.89	28	3.79	27	13.98	2.01	14	1.60	11	10.68	75	14.44*	0.32	0.97	0.80	5.31	1.22	0.63	C nc
2331	1.31	0.67	1.98	23	4.00	46	2.65	31	8.63	0.41	5	0.32	4	7.84	91	8.84*	0.21	0.66	0.78	19.12	3.36	0.78	C cm
2332	1.61	0.54	2.15	24	3.96	45	2.68	31	8.79	0.46	6	0.64	7	7.74	87	9.14*	0.21	0.68	1.39	16.83	3.09	0.68	C cm
2333	6.05	0.87	6.92	59	2.63	22	2.23	19	11.78	1.34	11	2.48	21	8.00	68	12.09*	0.19	0.85	1.85	5.97	0.68	0.65	C n

Appendix 3.

Reg. No.	Na epm	K epm	Na + K epm.	%	Ca epm.	%	Mg epm.	%	Sc epm.	Cl epm.	%	SO_4 epm.	%	HCO_3 epm.	%	Sa epm.	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	TYPE
2334	3.22	1.20	4.42	44	2.85	28	2.80	28	10.07	0.58	6	0.61	6	9.16	88	10.57*	0.13	0.98	1.05	15.79	1.28	0.66	Cnc
4286	37.06	1.18	38.24	84	3.95	9	3.25	7	45.44	7.09	15	31,93	70	6.81	15	45.83	0.19	0.82	4.50	0.96	0.19	0.77	Bn
4305	18.52	0.66	19.18	50	10.51	27	9.12	23	38.81	19.86	51	14.14	36	5.29	13	39.49*	1.04	0.87	0.71	0.27	1.02	0.68	ABn
4521	6.18	0.61	6.79	59	2.86	25	1.86	16	11.51	2.48	25	3.49	30	5.21	45	11.68*	0.37	0.65	1.41	2.10	0.70	0.66	CBn
4522	39.85	0.49	40.34	76	6.77	13	6.13	11	53.24	27.35	51	22.22	40	5.04	9	55.11*	0.68	0.91	0.81	0.18	0.32	0.68	ABn
4601	1.17	0.05	1.22	21	2.46	41	2.27	38	5.95	0.48	7	0.54	8	5.56	85	6.58	0.39	0.92	1.13	11.58	3.88	...	Ccm
4602	2.96	0.08	3.04	44	1.67	24	2.24	32	6.95	1.27	18	0.44	6	5.47	76	7.29*	0.42	1.34	0.35	4.31	1.29	0.45.	Cnm
4667	9.05	0.15	9.20	58	1.84	12	4.79	30	15.83	4.96	31	1.48	9	9.41	60	15.96*	0.54	2.60	0.30	1.90	0.72	0.60	Cn
4803	3.00	0.46	3.46	45	1.93	25	2.24	30	7.63	0,50	6	0.98	12	6.73	82	8.21	0.14	1.16	1.96	....	1.21	...	Cnm
5671	10.18	0.79	10.97	45	6.77	28	6.41	27	24.15	13.18	54	4.73	19	6.63	27	24.74*	1.20	0.95	0.36	0.50	1.20	0.61	Anc
5675	33.06	0.67	33.73	81	4.30	10	3.53	9	41.56	15.97	41	17.86	44	5.82	15	40.29*	0.47	0.82	1.12	0.36	0.23	0.67	BAn
5678	7.83	0.31	8.14	61	2.78	21	2.53	18	13.45	3.99	28	4.22	30	6.07	42	14.28	0.49	0.91	1.06	1.52	0.65	0.59	CBn
5679	0.52	0.54	1.06	18	3.12	51	1.87	31	6.05	0.17	9	0.2	3	5.56	88	6.31*	0.16	0.60	1.18	32.71	4.71	0.74	Ccm
5680	1.83	1.07	2.90	36	2.90	36	2.32	28	8.12	0.33	4	0.39	5	7.39	91	8.28*	1.10	0.80	1.18	22.39	1.80	0.70	Cnc
5682	2.61	0.49	3.10	39	2.72	35	2.06	26	7.88	0.63	8	0.79	10	6.58	82	8.24*	0.20	0.74	1.25	10.44	1.54	0.61	Cnc
Wiggenty Well	2.00	0.13	2.13	48	0.85	19	1.45	33	4.43	1.56	39	0.37	8	2.43	53	4.58*	0.73	1.71	0.24	1.56	1.08	0.63	CAnm

KATHERINE 1:250,000 SHEET AREA

Reg. No.	Na epm	K epm	Na + K epm.	%	Ca epm.	%	Mg epm.	%	Sc epm.	Cl epm.	%	SO_4 epm.	%	HCO_3 epm.	%	Sa epm.	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	TYPE
1901	0.39	0.36	0.65	2	29.99	83	5.18	15	35.92	0.31	1	32.04	90	3.13	9	35.48	0.48	0.17	103.35	10.10	54.11	0.97	Bc

LARRIMAH 1:250,000 SHEET AREA

Reg. No.	Na epm	K epm	Na + K epm.	%	Ca epm.	%	Mg epm.	%	Sc epm.	Cl epm.	%	SO_4 epm.	%	HCO_3 epm.	%	Sa epm.	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	TYPE
554	3.48	0.20	3.68	29	5.14	41	3.87	30	12.69	3.24	25	1.44	11	8.11	64	12.79	0.88	0.75	0.44	2.50	2.45	0.66	Ccm
903	0.52	0.02	0.54	8	4.34	60	2.30	32	7.18	0.28	4	0.17	2	6.74	94	7.19	0.52	0.53	0.61	24.07	12.30	0.59	Cc
904	7.74	0.08	7.82	78	1.75	17	0.52	5	10.09	8.29	81	0.10	1	1.90	18	10.29	1.06	0.30	0.01	0.23	0.29	0.61	An
905	3.22	0.02	3.24	99	0.03	1	0.0	..	3.27	0.39	12	0.27	8	2.59**	80	3.25*	0.12	...	0.69	6.64	0.01	0.92	Cn
906	1.04	0.08	1.12	21	2.84	54	1.32	25	5.28	0.23	4	0.15	3	5.18	93	5.56	0.21	0.46	0.65	22.52	3.71	0.69	Cc
2186	5.44	0.36	5.8	36	5.04	31	5.18	33	16.02	5.36	33	2.10	13	8.56	54	16.15*	0.92	1.03	0.39	1.60	1.74	...	Cnm

Appendix 3

Reg. No.	Na epm	K epm	Na+K epm.	%	Ca epm.	%	Mg epm.	%	Sc epm.	Cl epm.	%	SO_4 epm.	%	HCO_3 epm.	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S / S.C.	TYPE
										NEWCASTLE WATERS 1:250,000 SHEET AREA													
218	5.88	1.25	7.13	68	1.50	14	1.89	10	10.52	0.56	5	0.44	4	9.28	91	10.40*	0.08	1.26	0.79	16.57	0.48	0.69	Cn
515	7.44	0.41	7.85	43	5.54	30	5.02	27	18.41	7.02	39	3.27	18	7.62	43	18.07*	0.89	0.91	0.47	1.09	1.35	0.61	CAnc
592	15.96	1.48	17.44	59	6.04	20	6.17	21	29.65	12.94	44	6.35	21	10.31	35	29.70*	0.74	1.02	0.49	0.80	0.70	0.66	ACn
907	14.79	2.15	16.94	65	2.84	11	6,33	24	26.11	10.01	38	4.87	19	11.44	43	26.42*	0.59	2.23	0.49	1.14	0.54	...	
907	11.01	1.87	12.88	57	4.74	21	5.02	22	22.64	7.64	34	3.58	16	11.10	50	22.32	0.59	1.06	0.47	1.45	0.76	0.65	CAn
1896	3.05	0.67	3.72	34	3.74	35	3.37	31	10.83	2.68	24	0.90	8	7.52	68	11.10	0.72	0.90	0.34	2.81	1.91	...	Ccn
1899	3.13	0.07	3.20	28	3.99	36	4.03	36	11.22	3.95	33	3.54	29	4.53**	38	12.02*	1.23	1.01	0.90	1.15	2.51	0.67	CAmc
2350	0.83	0.79	1.62	23	3.29	47	2.14	30	7.05	0.42	9	0.15	2	6.24	89	7.03*	0.26	0.65	0.36	14.86	3.35	0.79	Ccm
4579	10.31	1.87	12.18	57	4.44	21	4.77	22	21.39	6.88	33	3.04	14	11.10	53	21.08*	0.56	1.07	0.44	1.61	0.76	0.66	CAn
5686	3.39	1.48	4.87	39	3.69	30	3.87	31	12.43	2.23	19	0.50	4	9.33	77	12.16*	0.46	1.05	0.22	4.18	1.55	0.65	Cnm
5687	2.04	1.20	3.24	33	3.64	37	3.04	30	9.92	1.24	13	0.33	3	8.21	84	9.93*	0.38	0.84	0.27	6.62	2.06	0.63	Ccn
5688	1.74	1.02	2.76	30	3.74	41	2.71	29	9.21	1.02	11	0.35	4	7.87	85	9.46*	0.37	0.72	0.34	7.72	2.34	0.63	Ccn
5689	3.57	1.43	5.00	44	3.44	30	3.04	26	11.48	0.87	9	0.50	4	9.67	87	11.18*	0.17	0.88	0.57	11.11	1.30	0.65	Cnc
5690	1.70	1.00	2.70	32	3.04	36	2.71	32	8.45	0.56	7	0.23	3	7.42	90	8.34*	0.21	0.89	0.41	13.25	2.13	0.65	Ccm
5793	5.26	1.28	6.54	43	4.69	30	4.11	27	15.34	3.53	24	1.48	10	10.06	66	15.17*	0.54	0.88	0.42	2.85	1.35	0.62	Cnc
										TENNANT CREEK 1:250,000 SHEET AREA													
505	9.78	0.82	10.60	19	27.80	49	18.09	32	56.49	9.10	16	45.30	80	1.92	4	56.55*	0.86	0.65	4.98	0.21	4.33	...	
505	8.35	0.64	8.99	18	27.46	54	14.30	28	50.75	7.86	16	39.93	79	2.58	5	50.49*	0.87	0.52	5.08	0.33	4.65	0.87	Bc
1200	6.66	0.51	7.17	16	24.57	56	12.30	28	44.04	7.51	17	32.79	74	4.00	9	44.49*	1.05	0.50	4.37	0.53	5.14	0.80	B c
1201	8.09	0.92	9.01	40	7.09	32	6.22	28	22.32	9.29	44	3.81	17	8.50	39	21.80*	1.03	0.88	0.41	0.91	1.48	0.59	ACnc
1208	6.61	0.82	7.43	38	6.59	34	5.63	28	19.65	7.53	40	2.41	12	9.34	48	19.49*	1.01	0.85	0.32	1.24	1.64	0.61	CAnc
4189	7.13	0.74	7.87	39	6.69	33	5.49	28	20.05	8.48	43	2.80	14	8.85	43	20.36*	1.08	0.82	0.33	1.04	1.55	0.61	CAnc
4521	6.83	0.72	7.55	39	6.28	32	5.67	29	19.50	9.20	49	2.60	14	7.18	37	19.28*	1.22	0.90	0.28	0.78	1.58	0.56	ACnc
										VICTORIA RIVER DOWNS 1:250,000 SHEET AREA.													
512	0.35	0.08	0.43	5	4.89	61	2.71	34	8.03	0.14	2	0.06	1	7.83	97	8.03	0.33	0.55	0.43	55.93	17.67	...	
512	0.35	0.05	0.40	6	4.19	58	2.63	36	7.22	0.11	2	0.15	2	6.74	96	7.00	0.28	0.63	1.36	61.27	17.05	0.66	Ccm
584	2.61	...	2.61	...	2.30	...	1.89	...	...	0.28	...	...	...	7.33	...	...	0.11	0.82	...	26.18	1.61	...	
584	2.57	0.02	2.59	39	2.45	37	1.64	24	6.68	0.20	3	0.50	7	6.16	90	6.86	0.08	0.67	2.5	30.80	1.58	0.69	Cnc
594	0.30	0.05	0.35	4	5.79	60	3.54	36	9.68	0.20	2	0.10	1	9.28	97	9.58	0.57	0.61	0.50	46.40	26.66	0.59	C c
595	0.74	0.08	0.82	10	3.49	43	3.87	47	8.18	0.23	3	0.25	3	7.62	94	8.10	0.28	1.11	1.09	33.13	8.98	0.58	C mc
1340	0.74	0.05	0.79	8	6.09	64	2.71	28	9.59	0.11	1	0.44	5	8.98	94	9.53	0.14	0.44	4.00	81.64	11.14	0.60	C c

Appendix 3.

Reg. No.	Na epm	K epm	Na+K epm	%	Ca epm.	%	Mg epm	%	Sc epm.	Cl epm.	%	SO_4 epm.	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	TYPE
1988	1.44	0.08	1.52	19	3.24	42	3.04	39	7.80	0.25	3	0.2	3	7.33	94	7.78	0.16	0.94	0.80	29.32	4.13	0.59	Ccm
3558	2.96	0.10	3.06	32	2.30	24	4.28	44	9.64	0.76	8	0.58	6	8.11	86	9.45	0.25	1.86	0.76	10.67	2.15	0.59	Cmn
3747	0.17	0.03	0.20	2	6.69	78	1.73	20	8.62	0.06	1	0.27	3	8.31	96	8.64	0.30	0.26	4.5	138.5	42.1	0.60	Cc
3768	2.83	0.00	2.83	90	0.30	10	0.00	...	3.13	0.73	24	1.10	38	1.16**	38	2.99	0.26	...	1.51	1.59	0.11	0.66	CBn
4049	5.96	0.01	5.97	99	0.07	1	0.00	...	6.04	0.25	4	0.35	6	5.56**	90	6.16	0.04	...	1.40	22.24	0.01	0.67	Cn
4628	1.83	0.05	1.88	21	3.64	41	3.37	38	8.89	0.37	6	0.02	...	8.26	94	8.81*	0.20	0.93	0.05	22.32	3.73	0.59	Ccm
4762	1.39	0.08	1.47	17	3.94	45	3.29	38	8.70	1.21	14	0.15	2	7.15	84	8.57*	0.82	0.84	0.12	5.91	4.92	0.60	Ccm
4763	1.91	0.05	1.96	26	3.24	43	2.30	31	7.50	0.11	3	0.15	2	7.13	95	7.49*	0.06	0.71	1.36	64.82	2.83	0.55	Ccm
4764	0.39	0.10	0.49	8	3.89	64	1.73	28	6.11	0.14	2	0.44	7	5.72	91	6.30	0.29	0.44	3.14	40.86	11.47	0.86	Cc
4765	1.78	0.02	1.80	22	3.04	37	3.45	41	8.29	0.56	8	0.08	1	7.62	91	8.38*	0.31	1.13	0.14	13.61	3.61	0.59	Cmc
4769	2.91	0.03	2.94	29	2.94	29	4.19	42	10.07	0.25	3	0.00	...	9.72	97	9.97	0.09	1.43	[illegible]	38.88	2.43	0.59	Cm(n?)
5396	1.78	0.19	1.97	..	3.09	..	6.25	..	11.31	0.62	..	...	...	5.18	...	...	0.31	2.02	...	8.35	4.74	0.64	[illegible]
5424	2.96	0.08	3.04	..	0.55	..	4.93	..	8.52	0.56	..	...	...	4.42**	..	...	0.18	8.96	...	7.89	1.80	1.31	[illegible]
5424	1.91	0.05	1.96	24	3.09	38	3.04	38	8.09	0.48	6	0.25	3	7.42	91	8.24*	0.24	0.98	0.52	15.46	3.13	0.60	Ccm
5426	1.91	0.05	1.96	21	3.94	43	3.29	36	9.19	0.39	4	0.35	4	8.51	92	9.37*	0.19	0.84	0.90	21.82	3.69	0.61	Ccm
5444	0.70	0.03	0.73	7	4.39	40	5.76	53	10.88	0.23	2	0.40	4	10.51	94	11.14	0.32	1.31	1.74	45.69	13.90	0.57	Cmc

WAVE HILL 1:250,000 SHEET AREA

Reg. No.	Na epm	K epm	Na+K epm	%	Ca epm.	%	Mg epm	%	Sc epm.	Cl epm.	%	SO_4 epm.	%	HCO_3 epm	%	Sa epm	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S. / S.C.	TYPE
510	6.35	...	6.35	..	3.79	..	1.18	..	11.32	4.94	..	...	..	4.10	..	...	0.78	0.31	...	0.83	0.78	...	AC
583	2.48	0.03	2.51	..	1.65	..	5.02	..	9.18	0.42	..	...	..	8.28	..	...	0.17	3.04	...	19.71	2.66	...	C
583	2.31	0.02	2.33	25	2.69	29	4.36	46	9.38	0.08	1	0.06	1	9.03	98	9.17	0.03	1.62	0.75	112.88	3.03	0.62	Cmc
585	2.52	0.03	2.55	..	2.99	..	4.19	..	9.73	2.12	..	...	..	9.64	..	...	0.83	1.40	...	4.55	2.82	...	C
585	3.00	0.05	3.05	33	3.24	36	2.80	31	9.09	0.99	10	0.33	4	8.26	86	9.66*	0.32	0.86	0.33	8.34	1.98	0.62	Ccn
813	3.18	0.03	3.21	30	3.49	32	4.03	38	10.73	0.68	9	0.15	1	9.42	90	10.53*	0.21	1.15	0.22	13.85	2.34	0.62	Cmc
814	4.65	0.03	4.68	74	1.05	17	0.58	9	6.31	0.76	12	0.23	4	5.28	84	6.27	0.16	0.55	0.30	6.95	0.35	0.69	Cn
815	7.40	0.08	7.48	63	1.95	16	2.47	21	11.90	2.17	19	0.44	4	8.93	77	11.59*	0.29	1.27	0.20	4.12	0.59	0.66	Cn
817	3.22	0.08	3.20	36	2.69	30	3.04	34	8.93	1.04	12	0.17	2	6.98	78	8.89*	0.33	1.13	0.16	6.71	1.79	0.65	Cnm
821	8.35	0.18	8.53	57	2.79	19	3.62	24	14.94	8.32	55	0.10	1	6.49	44	15.01*	0.98	1.30	0.01	0.78	0.75	0.54	ACn
838	5.18	0.05	5.23	47	3.14	28	2.71	25	11.08	1.92	20	0.56	5	8.11	75	10.77*	0.37	0.86	0.29	4.22	1.12	0.65	Cnc
841	1.70	0.03	1.73	18	3.89	42	3.70	40	9.32	0.45	7	0.06	1	8.46	92	9.22*	0.26	0.95	0.13	18.80	4.39	0.62	Ccm
851	2.78	0.26	3.04	29	4.64	44	2.80	27	10.48	1.44	15	0.69	7	8.05	78	10.38*	0.47	0.60	0.48	5.59	2.45	0.63	Ccn
852	9.70	0.72	10.42	35	9.33	32	9.70	33	29.45	15.85	55	3.16	11	9.82	34	28.92*	1.52	1.04	0.20	0.62	1.83	0.60	Anm
853	7.26	0.59	7.85	43	4.74	26	5.76	31	18.35	4.03	24	1.56	9	12.31	67	18.27*	0.51	1.22	0.39	3.05	1.34	0.60	Cnm
1096	1.52	0.08	1.60	21	2.69	34	3.54	45	7.83	0.17	2	0.04	1	7.38	97	7.59	0.11	1.32	0.24	43.41	3.89	0.58	Cmc
1099	2.78	0.08	2.86	26	2.64	24	5.43	50	10.93	0.45	6	0.10	1	10.11	93	10.82*	0.16	2.06	0.22	22.47	2.82	0.60	Cm

Reg. No.	Na. epm.	K epm	Na+K epm	%	Ca epm.	%	Mg epm.	%	Sc epm	Cl epm.	%	SO_4 epm.	%	HCO_3 epm.	%	Sa epm.	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	Ca+Mg / Na+K	T.D.S / S.C.	TYPE
2337	3.57	0.43	4.00	26	5.54	35	6.09	39	15.63	1.80	13	0.90	6	12.26	81	15.15*	0.45	1.10	0.50	6.81	2.91	0.63	Cmc
2338	1.31	0.28	1.59	16	5.64	57	2.63	27	9.86	0.39	4	0.04	..	9.08	96	9.51	0.23	0.47	0.10	23.28	5.20	0.70	Cc
2414	0.06	0.06	0.12	4	1.35	39	1.97	57	3.44	0.39	..	...	..	3.51	..	...	3.17	1.46	...	9.00	27.67	0.46	Cm
2836	5.92	0.08	6.00	52	2.40	21	3.13	27	11.53	2.85	28	1.06	9	7.08	63	11.23*	0.48	1.30	0.37	2.48	0.92	0.64	Cn
4048	2.52	0.15	2.67	30	3.54	40	2.63	30	8.84	0.73	8	0.25	3	7.77	89	8.82*	0.27	0.74	0.34	10.64	2.31	0.64	Ccn
4303	2.91	0.08	2.99	35	2.45	29	3.04	36	8.48	0.62	7	0.29	3	7.72	91	8.49*	0.21	1.24	0.47	12.45	1.84	0.60	Cmn
4407	42.28	0.15	42.43	56	19.11	25	13.90	19	75.44	51.55	68	20.30	27	4.15	5	76.10*	1.21	0.73	0.39	0.08	0.78	0.64	An
4530	...	...	...	..	...	..	...	..	...	1.07	..	...	..	...	..	...	...	...	...	...	...	0.76	
4531	...	...	...	..	...	..	...	..	...	1.02	..	...	..	...	..	...	...	...	...	...	...	0.70	
4767	22.53	0.05	22.58	57	6.89	17	10.36	26	39.83	23.49	59	8.31	21	8.11	20	40.09*	1.04	1.50	0.35	0.35	0.76	0.63	An
WINNECKE CREEK 1:250,000 SHEET AREA																							
Hooker Creek No.5.	11.74	...	...	..	2.35	..	2.96	..	...	3.66	..	...	..	2.70	..	...	...	1.26	...	0.74	...	...	
"	4.13	0.20	4.33	43	2.25	.22	3.54	35	10.12	3.53	36	0.71	7	5.52	57	9.76	0.81	1.57	0.20	1.56	1.34	...	Cnm
"	3.70	0.18	3.88	43	1.60	.17	3.62	40	9.10	3.67	39	0.52	6	5.08	55	9.27	0.95	2.26	0.14	1.38	1.35	...	CAnm
TANUMBIRINI																							
5845	2.78	0.23	3.01	23	5.93	45	4.28	32	13.22	2.68	20	3.13	24	7.38	56	13.19	0.89	0.72	1.17	2.75	12.6	...	Ccm
5783	3.04	0.31	3.35	24	5.73	42	4.61	34	13.69	2.96	22	3.02	22	7.70	56	13.68	0.88	0.81	1.02	2.60	11.9	...	Ccm

APPENDIX 4 : B.M.R. SCOUT HOLES
Groundwater Parameters

Scouthole No.	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth standing Water level (feet)	Pump Depth (feet)	Supply (G.P.H)	Quality (P.P.M.)	Remarks
				BEETALOO 1:250,000 Sheet Area						
B.1	8 miles at 10° from Ucharonidge	766	251	-	-	-	-	-	-	Dry Hole
				DALY WATERS 1:250,000 Sheet Area						
D.W.1	7.2 miles west by north of R.N. 1982	-	281	-	-	-	-	-	-	Dry Hole
				GREEN SWAMP WELL 1:250,000 Sheet Area						
G.S.W.1	54 miles west of Tennant Creek	880	305	Merrina Beds	119 160 187	93	-	2000	2330	-
G.S.W.2	10 miles west of Tennant Creek	970	228	Merrina Beds	197	185	-	800	3203	-
G.S.W.3	85 miles west-north-west of Tennant Ck.	1020	300	Merrina Beds	280	275	-	-	-	Only Seepage
G.S.W.4	110 miles west of Tennant Creek	790	589	Merrina Beds	21 - 145	11	-	6000	2740	Saline at 145'
G.S.W.5	130 miles west-north-west of Tennant Ck.	785	295	Merrina Beds	70 120	60	-	2000	2831	-
				HELEN SPRINGS 1:250,000 Sheet Area						
H.S.1	23.7 miles south-west of Eva Downs Homestead	700	177	Anthony Lagoon Beds	155	138	-	800	1339	-
H.S.2	7 miles west of H.S.1	-	132	-	-	-	-	-	-	Dry Hole
H.S.3	26.8 miles north-east of Helen Springs Homestead	690	225	Anthony Lagoon Beds	110 180	150	-	1000	250	-
H.S.4	14.3 miles north-north-east of Helen Springs Homestead	765	224	Anthony Lagoon Beds	205	-	-	-	421	-
H.S.5	19.6 miles south-west of Helen Springs Homestead	781	129	-	-	-	-	-	-	Dry Hole
H.S.6	15.2 miles south of Helen Sprigns Homestead	970	100	Unconformity Gum Ridge Formation/Helen Spring Volcanics	66	47	-	1200	-	-
				KATHERINE 1:250,000 Sheet Area						
K.1	33.8 miles south of Katherine	505	430	Jinduckin Formation " " " " Tindall Limestone	100 - 105 220 - 245 288 - 298 355 - 420	181	-	4800	441 314 242 266	-
				LARRIMAH 1:250,000 Sheet Area						
L.1	12 miles north-north-west of Larrimah	-	98	-	-	-	-	-	-	Dry Hole
L.2	38 miles west by south of Larrimah	-	176	-	-	-	-	-	-	Dry Hole
L.3	4.3 miles south-west of Larrimah	-	150	Tindall Limestone	-	108½	-	-	-	-

(Appendix 4.)

Scouthole No.	Position	Elevation (feet)	Total Depth (feet)	Aquifer	Depth of Aquifers (feet)	Depth standing Water level (feet)	Pump Depth (feet)	Supply (G.P.H)	Quality (P.P.M.)	Remarks
				TANAMI EAST 1:250,000 Sheet Area						
T.E.1	68 miles south-east of Wooker Creek	980	412	Merrina Beds	60 90	-	-	-	-	Seepage only
				WINNECKE CREEK 1:250,000 Sheet Area						
W.C.1	88 miles east-south-east of Wooker Creek	-	174	-	-	-	-	-	-	Dry Hole
W.C.2	48 miles south-east of Wooker Creek	-	238	-	-	-	-	-	-	Dry Hole
W.C.3	24 miles east-south-east of Wooker Creek	-	162	-	-	-	-	-	-	Dry Hole
W.C.4	52 miles east-south-east of Wooker Creek	-	177	-	-	-	-	-	-	Dry Hole

APPENDIX 5 : BMR SCOUTHOLES. ANALYSES OF GROUNDWATER.
(Parts per million)

Reg.No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	PO_4	Mn	Fe	B	Li	S.C.	pH	T.D.S.	YEAR	Laboratory
										GREEN SWAMP WELL											
G.S.W.1	61	72	560	87	675	421	426	x	2.2	...	26	...	...	...	...	...	...	...	2330	1965	A.I.B.
G.S.W.2	89	91	830	98	895	904	283	x	3.5	...	9	...	...	...	...	...	...	...	3203	1965	A.I.B.
G.S.W.4*	32	39	290	45	360	235	160	x	0.6	...	24	...	...	...	...	...	...	...	1186	...	...
**	378	71	380	61	455	1267	105	x	0.5	...	24	...	...	...	...	...	...	...	2740	...	...
G.S.W.5	108	184	575	315	1256	x	368	x	1.3	...	15	...	...	...	...	...	...	...	2831	1965	A.I.B.
										HELEN SPRINGS											
H.S.1	20.1	27.2	400	41	175	2403	780.8	x	3.2	50.2	17.5	...	x0.02	0.036	1.1	0.05	2164	8.15	1339	1965	A.M.D.L.
H.S.3	49.2	12.7	5	9	4.3	5.8	234.5	x	0.1	61.7	8.0	...	x0.02	0.048	0.5	x0.01	328	7.90	250	1966	A.M.D.L.
H.S.4	49.9	25.7	62	5	73.7	39.5	296.3	x	0.7	50.0	3.6	...	x0.02	0.036	0.1	x0.01	684	7.85	421	1966	A.M.D.L.
										KATHERINE											
K1 (a)	31	84	28	25	31	32	524	x	0.8	21	x0.1	x0.01	x0.02	0.04	x0.1	0.11	825	7.9	441	1966	A.M.D.L.
(b)	35	54	31	16	14	19	429	x	0.8	26	0.3	0.03	x0.02	0.15	x0.1	0.05	641	7.85	345	1966	A.M.D.L.
(c)	31	39	7	8	3	17	295	x	2.2	22	x0.1	0.04	x0.02	0.15	x0.1	0.05	423	7.9	282	1966	A.M.D.L.
(d)	37	38	6	8	6	10	304	x	2.3	21	x0.1	x0.01	x0.02	0.07	x0.1	0.08	433	7.85	242	1966	A.M.D.L.
(e)	43	37	13	5	12	21	313	x	0.5	34	x0.1	x0.01	x0.02	0.01	x0.1	0.03	464	7.6	266	1966	A.M.D.L.

* Sample taken while casing still in hole.

** Sample taken after casing pulled from hole. Better quality water presumably comes from unrecorded aquifer below 145 feet.

a Sample taken during drilling at 105 feet.

b " " " " 225 "

c " " " " 233 "

d " " " " 300 "

e " " " " 405 "

APPENDIX 6 : BMR SCOUT HOLES. ANALYSES OF GROUNDWATER
Percentage Reacting Values and Ionic Ratios

Reg. No.	Na epm	K epm	Na + K epm	Na + K %	Ca epm	Ca %	Mg epm	Mg %	Sc epm	Cl epm	Cl %	SO_4 epm	SO_4 %	HCO_3 epm	HCO_3 %	Sa epm	Cl/Na+K	Mg/Ca	SO_4/Cl	HCO_3/Cl	Ca+Mg/Na+K	T.D.S./S.C.	TYPE
GREEN SWAMP WELL																							
G.S.W.1	24.36	2.23	26.59	75	3.04	9	5.92	16	33.55	19.01	55	8.77	25	6.98	20	34.76	0.71	1.95	0.46	0.37	0.34	-	A n
G.S.W.2	36.11	2.51	38.62	76	4.44	9	7.48	15	50.54	25.21	52	18.83	39	4.64	9	48.68	0.65	1.68	0.75	0.18	0.31	-	AB n
G.S.W.4*	12.62	1.15	13.77	74	1.60	9	3.21	17	18.58	10.14	57	4.90	28	2.62	15	17.66	0.74	2.01	0.48	0.26	0.35	-	A nm
	16.53	1.56	18.09	42	18.86	44	5.84	14	42.79	12.82	31	26.40	65	1.72	4	40.94	0.71	0.31	2.06	0.13	1.37	-	B cn
G.S.W.5	25.01	8.06	33.07	62	5.39	10	15.13	28	53.59	35.38	...	...	...	6.03	...	...	1.07	2.81	...	0.17	0.62		AB nm
HELEN SPRINGS																							
H.S.1	17.40	1.05	18.45	85	1.00	5	2.24	10	21.69	4.93	22	5.01	22	12.80	56	22.74	0.27	2.24	1.02	2.60	0.18	0.62	C nm
H.S.3	0.22	0.23	0.45	11	2.46	62	1.04	27	3.95	0.12	3	0.12	3	3.84	94	4.08	0.27	0.42	1.00	32.00	7.78	0.76	C cm
H.S.4	2.70	0.13	2.83	38	2.49	34	2.11	28	7.43	2.08	27	0.82	10	4.86	63	7.76	0.73	0.85	0.39	2.34	1.63	0.62	C nc
KATHERINE																							
K.1 (a)*	1.22	0.64	1.86	18	1.55	15	6.91	67	10.32	0.87	9	0.75	7	8.59	84	10.21	0.47	4.46	0.86	9.87	4.55	0.53	C mc
(b)	1.35	0.41	1.76	22	1.75	22	4.41	56	7.92	0.39	5	0.40	5	7.03	90	7.82	0.22	2.52	1.03	18.03	3.50	0.54	C mc
(c)	0.30	0.20	0.50	10	1.55	29	3.21	61	5.26	0.08	1	0.35	7	4.84	92	5.27	0.16	2.07	4.38	60.50	9.52	0.67	C mc
(d)	0.26	0.20	0.46	8	1.85	34	3.13	58	5.44	0.17	3	0.21	4	4.98	93	5.36	0.37	1.69	1.24	29.29	10.83	0.56	C mc
(e)	0.57	0.13	0.70	12	2.15	36	3.04	52	5.89	0.34	6	0.44	7	5.13	87	5.91	0.49	1.41	1.29	15.09	7.41	0.57	C mc

* Includes epm attributable to NO_3^- included under % Cl^-

APPENDIX 7 : AQUIFER ROCK ANALYSES. (in parts per million)

B.M.R. REGISTERED SAMPLE	SiO_2	Cu	Fe	Mn	Ca	Mg	Na	K	Li	$CO^{=}_3$	$SO^{=}_4$	Cl^-	F^-	Ti	B	V	Sr	Pb	Zn	Co	Ni	PO_4
6667 - 0513	903,000	19,044	5,883	232	2,619	3,317	307	18,677	4	5,863	600	200	120	1,739	50	25	30	18	20	35	25	307
0514	898,000	6,295	8,315	232	16,369	3,076	460	664	4	3,000	400	300	1,500	540	5	20	25	30	140	10	35	19,928
0516	952,000	12,432	2,440	77	1,310	905	-	747	-	2,045	100	100	20	959	3	8	30	40	25	8	-	307
0518	970,000	2,433	13,287	77	946	483	-	332	2	545	600	200	100	480	5	15	40	12	55	10	5	153
0729	888,000	14,019	4,484	77	12,804	8,263	153	12,784	2	30,681	500	100	200	719	50	25	20	15	20	8	5	307
0730	735,000	43,643	42,824	465	12,149	25,032	15,103	11,289	11	1,364	2,000	200	120	4,496	30	150	90	15	60	25	25	766
0730	538,000	75,118	66,762	1,007	29,828	44,635	26,450	15,722	5	6,818	600	100	150	6,894	50	200	140	20	90	35	45	1,073
0738	509,000	72,473	94,344	852	20,370	36,793	18,017	18,262	11	4,773	200	200	470	13,789	25	150	90	55	350	50	30	1,840
0738	507,000	79,350	81,642	542	14,550	47,952	27,600	25,733	9	5,727	400	-	470	8,453	25	150	80	25	120	40	55	1,533
0722	68,000	6,983	7,298	465	202,245	119,428	153	3,984	4	569,985	-	500	380	-	5	10	120	5	25	20	20	613
0722	221,000	18,515	13,110	387	162,233	89,872	307	17,432	4	436,352	-	400	590	-	25	15	70	15	25	20	15	307
0722	92,500	17,986	7,936	465	190,605	109,777	153	6,807	-	545,440	-	400	180	-	5	15	60	20	12	20	15	307
0722	61,000	4,444	6,901	465	202,245	121,840	77	3,403	2	586,348	-	400	90	-	3	15	60	15	18	20	20	307
0722	15,100	370	2,239	387	214,613	130,285	77	166	-	635,438	-	400	120	-	1	8	80	15	18	15	20	-
0732	11,000	635	7,787	155	393,578	3,921	153	166	-	582,257	450	400	90	-	1	1	100	20	20	20	35	307
0734	30,400	27,244	45,695	155	210,248	12,365	153	-	-	328,628	100	100	220	-	5	10	70	30	35	20	30	1,380
0734	16,000	1,957	8,572	77	347,745	33,778	77	332	-	582,257	-	400	-	-	1	6	70	25	30	20	30	307

0513 - Helen Springs Scouthole No.3, 182' - 192', sandstone, Anthony Lagoon Beds.

0514 - Helen Springs Scouthole No.4, 200' - 210', chert and clay, Anthony Lagoon Beds.

0516 - Helen Springs Scouthole No.6, 60' - 70', claystone and sandstone, Helen Springs Volcanics.

0518 - Beetaloo Southern Cross No.1 bore, 270' - 275', sandstone, Mullaman Beds.

0729 - Wave Hill School Bore, 155' - 156', calcareous sandstone, Victoria River Group.

0730 - Shoeing Tool Replacement bore, (a) 255' - 275', basalt and quartz, Antrim Plateau Volcanics.
(b) 466' - 490', basalt, Antrim Plateau Volcanics.

0738 - Construction Bore DWH3, Willeroo Road
(a) 130' - 140', basalt, Antrim Plateau Volcanics
(b) 480' - 492', amygdaloidal basalt, Antrim Plateau Volcanics.

0722 - Katherine Scouthole No.1.
(a) 102'1" - 102'8", dolomite, some siltstone, Jinduckin Formation
(b) 220' - 230', " " " "
(c) 230' - 240' " " " "
(d) 290' - 300' " " " "
(e) 375'5" - 375'9" dolomite, Tindall Limestone.

0732 - Birrimba Homestead Bore, (Widgee) 155' - 156'1" limestone, Montejinni Limestone.

0734 - Daly Waters Moorak bore,
(a) 196' - 204' dolomitic limestone, and weathered rubble, Tindall Limestone
(b) 204' - 220 limestone, Tindall Limestone