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Groundwater in the Barkly Tableland, N.T.

BY

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SUMMARY

The Barkly Tableland, which contains some of the best cattle-breeding country in northern Australia, lies between Camooweal to the east, Tennant Creek to the west, and the Gulf Divide to the north; the southern boundary is conveniently taken as the Barkly Highway in the west, and the valleys of the Ranken and Georgina Rivers in the east. Only the part of the tableland between the Queensland border and longitude 135°E is discussed.

Because of the high evaporation (100-110 inches per annum), the low and seasonal rainfall, and the low relief in the downs country, the cattle industry must rely on groundwater during the dry season. Over 450 waterbores have been drilled since 1890, and the data from them were examined to assist the geological mapping of the Tableland, an area of very sparse outcrop.

Proterozoic rocks crop out in the northern and north-eastern part of the region (Dunn, Smith, & Roberts, in prep.), but only the youngest unit—the Mittiebah Sandstone—has some influence on the groundwater system; and then only in a small way. The greater part of the Barkly Tableland is occupied by Middle Cambrian rocks, which form part of a widespread mainly carbonate sequence which extends into the adjoining parts of the Northern Territory and Queensland (Öpik, 1956a, b; Nichols, in prep.). The Cambrian sediments are overlain by Mesozoic and Tertiary rocks, but in the Barkly Tableland they are too thin and restricted for the storage of large amounts of groundwater.

The Cambrian rocks comprise dolomite, dolomitic limestone, limestone, leached carbonate rocks, chert, sandstone, and siltstone. Water is stored under pressure in fissures, cavities, and fractures in the carbonate rocks, and in porous sandstones.

Drillers' logs record up to four aquifers in some bores, but aquifers could not be correlated because of the inadequate descriptions of the rocks given in the logs and the meagre stratigraphic knowledge of the region. The aquifer system, however, can be broadly defined: its surface ranges from 15 to 600 feet above sea level in the north-western part of the region and from sea level to 600 feet in the south-east.

The piezometric surface indicates that the groundwater system is divided into two areas. One coincides approximately with the internal drainage basin occupied by the swamps between Alroy Downs and Anthony Lagoon homesteads; the piezometric surface ranges from 530 to 750 feet above sea level, and indicates semistagnant conditions with restricted outflow to the north-west and west. The second is generally coextensive with the Georgina River Basin; the piezometric surface ranges from 530 to 650 feet above sea level, with a general direction of slope to the south.

Over three-quarters of the working bores produce more than 1500 gallons per hour, and most produce more than 1000 gallons per hour, but the potential yield of many of the bores has probably been underestimated. The supply and drawdown characteristics of the bores have not been systematically recorded, and the permeability of the aquifers cannot be determined from the data available. The relationships between the withdrawal of groundwater, the annual rainfall, and probable intake areas indicate that considerable groundwater reserves are available for future development.

The quality of the groundwater is extremely variable, but it is generally suitable for watering stock. In the groundwater system coincident with the internal drainage basin in the central part of the region, the water is unsuitable for human consumption because of the high salinity. The variations in the total salinity agree with the general directions of groundwater flow.

The study of the geochemistry of the groundwater is based on the analyses of 265 borewater samples; the results have been used to determine the groundwater environment in relation to hydraulics and geological structure. All the borewaters have been analysed for sodium, potassium, magnesium, calcium, chloride, sulphate, bicarbonate, carbonate, fluoride, silica, and total dissolved solids, and about half the samples were analysed for nitrate, nitrite, phosphate, manganese, iron, aluminium, boron, lead, strontium, and lithium. The specific conductivity and pH values have also been determined. The waters have been classified into groups and types on the basis of the predominance of the chloride, sulphate, or bicarbonate anions. The maps of the main geochemical types and contour maps of the ionic concentrations and ionic ratios support the division of the region into two groundwater provinces, and also suggest lithological and structural control of the geochemical types. Until more is known about groundwater flow and its effect on the geochemistry only a limited geological interpretation can be made.

Some results of the survey are of immediate benefit: for proposed bores the depth to adequate supplies can be estimated, the probable pump position calculated, and some estimate of supply given; the total salinity and concentration of individual constituents can also be predicted within close limits. The survey has shown the need for further intensive study before the borewaters are used for agriculture on the clayey black soil because some are rich in sodium. Recommendations are made for further investigations. The more important of these are: accurate drilling records, geological examination of cuttings from waterbores, accurate levelling of bore-sites, construction of observation wells, and the use of radioactive tracers.

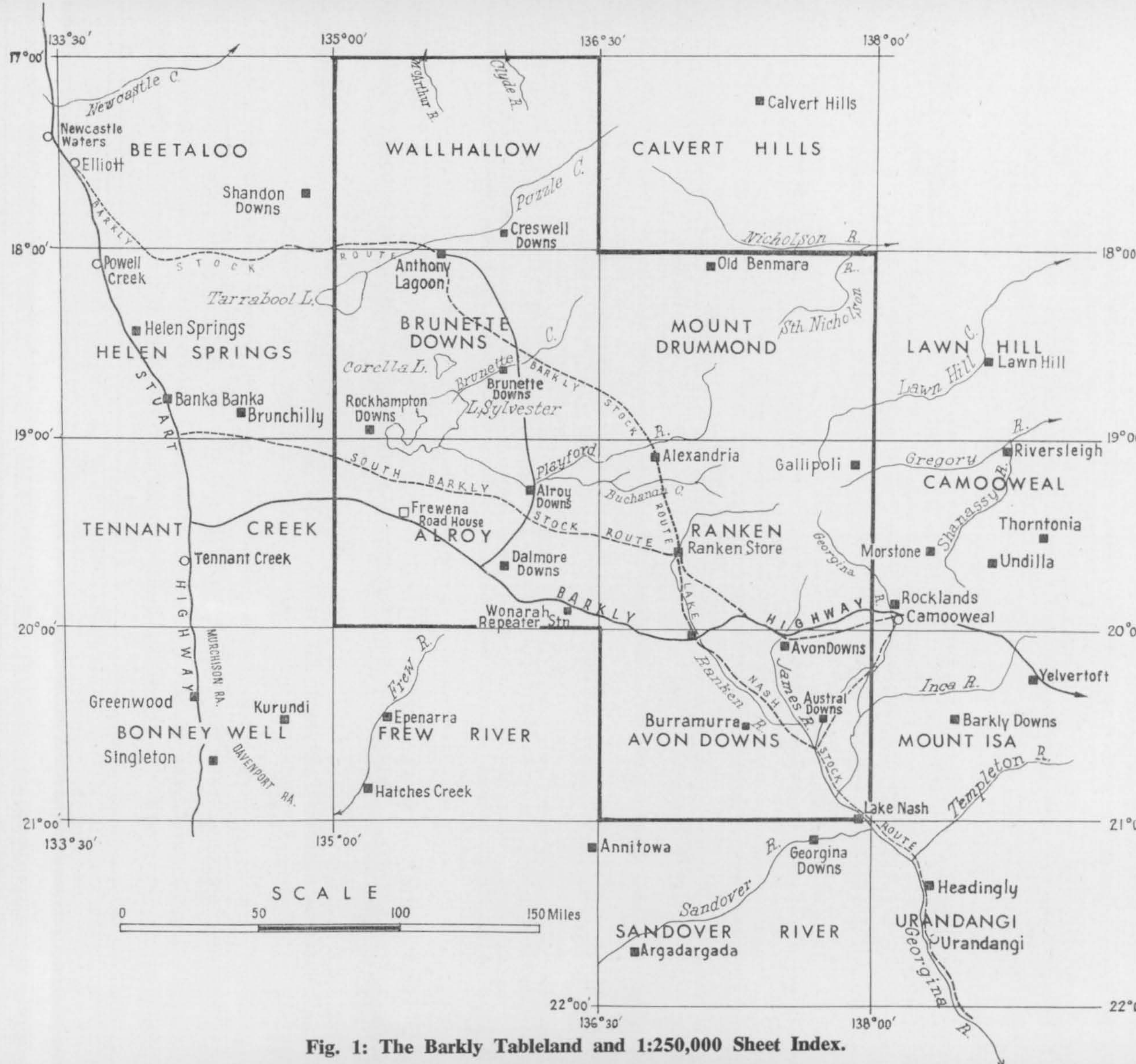

Fig. 1: The Barkly Tableland and 1:250,000 Sheet Index.

INTRODUCTION

This Bulletin deals with the groundwater resources of the central and eastern parts of the Barkly Tableland from the Queensland border westward to Tarrabool Lake and Rockhampton Downs homestead. This region comprises the Wallhallow, Brunette Downs, Alroy, Mount Drummond, Ranken, and Avon Downs 1:250,000 Sheet areas; it is bounded in the north by the headwaters of the McArthur, Clyde, and Nicholson Rivers, and in the south by the semidesert area which extends from near Tennant Creek east-south-eastwards to within a few miles west of Lake Nash homestead (Fig. 1). The region is served by the townships of Camooweal, 8 miles to the east on the Barkly Highway, and Tennant Creek, 70 miles to the west on the Stuart Highway. The bitumen-sealed Barkly Highway connects Mount Isa to Tennant Creek via Camooweal, and provides access to numerous station tracks and stock routes.

The eastern and central parts of the Barkly Tableland are traversed by four major stock routes: The Barkly Stock Route from Camooweal to Newcastle Waters (Elliott), the South Barkly Stock Route from Ranken store to Attack Creek on the Stuart Highway, the Lake Nash Stock Route from Ranken store to Lake Nash homestead via Soudan homestead, and a stock route which follows the Georgina River from Camooweal to Urandangi via Lake Nash homestead; minor stock routes provide outlets for other stations. A new road has been constructed from the Barkly Highway near Dalmore Downs homestead to Anthony Lagoon homestead via Alroy Downs and Brunette Downs homesteads. Police stations are situated near Anthony Lagoon, Lake Nash, and Avon Downs homesteads.

Twelve cattle stations occupy the region—Anthony Lagoon, Creswell Downs (including Wallhallow), Brunette Downs, Rockhampton Downs, Alroy Downs, Dalmore Downs, Alexandria Downs (including Gallipoli and Soudan), Austral Downs (including Burramurra), Avon Downs, and portions of Georgina Downs, Lake Nash, and Rocklands. Rocklands homestead lies east of the region near Camooweal, and Georgina Downs homestead is south-west of Lake Nash homestead (Fig. 1).

Wonarah repeater station and Frewena roadhouse are on the Barkly Highway in the west of the region; a store is situated on the Ranken River between Soudan homestead and Alexandria homestead. Most homesteads are connected by radio network to the Royal Flying Doctor Base at Alice Springs; Lake Nash, Avon Downs, Austral Downs, Soudan, Wonarah, and Frewena have a telephone service.

PHYSIOGRAPHY

It is difficult to define the Barkly Tableland as a physiographic entity. Most maps of the Northern Territory show the Tableland extending from about the Queensland border to near Newcastle Waters, and bounded on the north by a north-facing escarpment, but the southern margin is not clearly defined. Only on the northern part of the north-eastern margins does the region have the aspect of a Tableland. The western margin is regarded loosely as the Stuart Highway, which follows the high discontinuous ridges from Elliott to Tennant Creek in the south-west. The region is adjoined on the south-west and central-west by a large area of semidesert of higher elevation than the Tableland. To the south-east, the rolling downs of the Georgina River Basin are contiguous with those of the Tableland north of the Barkly Highway, and no physiographic boundary is readily apparent. East of the Queensland border, the northern escarpment merges with the canyon topography north of Camooweal, and is not apparent east of Camooweal.

Noakes (1954) regards the term 'Tableland' as a misnomer and describes the Barkly Tableland as 'a long shallow depression which forms part of two of the three physiographic units into which the Barkly Region has been divided—the Barkly Internal Drainage Basin and the Georgina Valley'. CSIRO (1954) described the Barkly Region as 'the area popularly known as the Barkly Tableland, a contiguous portion of the Georgina River basin and the inland "desert," and the country extending to the Gulf of Carpentaria'. In the same report the Barkly Region has been divided into three geomorphological units—the Gulf Fall Division, the Georgina Basin, and the Barkly Basin; in the south-east and east the boundaries of these divisions cut across the indistinct boundaries of the so-called Tableland. These geomorphological divisions have been adopted in this report, but Noakes' term Barkly Internal Drainage Basin is used in preference to Barkly Basin.* Their extent is illustrated by the surface contours (Pl. 1).

The north-western boundary of the Barkly Tableland is ill defined. The north-facing scarp which forms the northern margin swings north-westwards near the headwaters of Newcastle Creek and is well defined east of Mataranka. The country to the west of the scarp is identical with much of the northern part of the Barkly Tableland farther east, and Dunn, Smith, & Roberts (in prep.) have introduced a physiographic division known as the Barkly-Birdum Tableland. Such a division is certainly valid in the northern and north-western parts of the region because it coincides with, and is an extension of, the northern boundary of the Barkly Internal Drainage Basin; also the country south of the scarp is underlain by mainly subhorizontal Mesozoic and Cambrian rocks and presents a very different landform from the folded and faulted Precambrian rocks of the hilly and dissected Gulf Fall Division to the north. Smith & Roberts (1963) extend the division on to the Mount Drummond Sheet area, in the eastern part of which it transgresses the divisions based on drainage: this is justified on the grounds of geology and landform.

The *Georgina River Basin* includes the Georgina, Ranken, and James Rivers; it occupies the south-eastern part of the region, and includes the downs east of Soudan homestead. The downs have a clayey black soil which supports a good growth of Mitchell grass and some swamp Flinders grass. Low stony and sandy rises are common, and red clayey soil occurs in small patches; the sandy and red soils support small areas of mallee and turpentine scrub. Gidyea scrub is widespread in the north-east and along the watercourses; some stands of eucalypts occur near permanent and semipermanent waterholes; bluebush swamps are common. The watercourses are generally confined to single well defined channels, but in places the larger streams are braided, particularly the Georgina River north of Austral

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* It emphasizes the nature of the unit, and avoids confusion with the so-called Barkly Basin shown on some geological maps as the connecting link between the Daly River Basin and the Georgina Basin, which are both geological features containing Lower Palaeozoic sediments. For the same reasons the term Georgina River Basin is used in this report.

Downs homestead. Near the headwaters the streams are poorly defined depressions in the monotonous and uniform grassy downs; in the south-east the streams have well defined shallow profiles.

To the north-west of Soudan, the low divide between the Georgina River Basin and the Barkly Internal Drainage Basin is well defined, but in the semi-desert area to the south the divide can no longer be recognized. The divide between the Georgina River and the Gregory River of the Gulf Fall Division is located in the elevated downs south of Gallipoli homestead.

The *Gulf Fall Division* occupies an area in the north-east and another in the north-west which are linked on the Calvert Hills Sheet area.

The north-eastern area is drained by the Gregory, Nicholson, and South Nicholson Rivers. With the exception of Buddycurrawa Creek, which mainly traverses sandy plains, the major streams rise in low ranges, and flow mainly through dissected Precambrian rocks. The headwaters are well developed stony gullies; soils are mainly skeletal and in part lateritic, and support various eucalypt trees and shrubs. In the south-east, the streams drain part of the Barkly Tableland; the Gregory River and Carrara Creek rise in gently undulating downs country, but farther east they form part of a large area of well developed canyon topography (Öpik, Carter, & Randal, in prep.) in Middle Cambrian carbonate rocks.

The north-western area of the Gulf Fall Division contains the upper reaches of the McArthur, Kilgour, and Clyde Rivers. The southern boundary is the north-facing scarp of the Barkly Tableland. Only a few of the streams drain from the Tableland, which slopes slightly to the south. Plumb & Rhodes (1964) have divided the Gulf Fall Division in this area into the Dissected Gulf Fall Division, the Bukalara Plateau, and the Top Springs Erosion Surface; the latter unit adjoins the Tableland. The entire area is moderately dissected and the gently undulating plains and hillocks merge into hilly country in the north. The streams are well entrenched and contain steep rocky gullies in their headwaters. Vegetation is mainly snappy gum, silver box, and bloodwood on the slopes, lancewood and bloodwood on the plains, and coolibah and paperbark along the valleys. Some Mitchell and blue grasses occur on the more open plains, particularly around the Kilgour River.

The *Barkly Internal Drainage Basin,* in the western part of the region, is the largest physiographic division of the Barkly Tableland. The Basin consists of a number of bluebush swamps or lakes each of which forms an internal drainage centre. The largest is Lake Sylvester (including Lake De Burgh) in the centre of the Basin, which receives water in the wet season from a large area in the central part of the region. The area is drained by Brunette, Fish Hole, Mittiebah and Boree Creeks, and the Playford River and its tributaries Buchanan and Desert Creeks; the main streams join Lake Sylvester as deltas and long lagoons.

The second largest drainage centre is Tarrabool Lake in the north-west which receives water from Creswell and Puzzle Creeks and from minor streams. Corella Lake, in the central part of the Basin, is fed by Corella and Edwards Creeks. In addition to the large lakes, smaller bluebush swamps and claypans are found south of the Playford River, between the Playford River and Boree Creek, north of Creswell Creek, and west of Lake Sylvester. They act as foci for small gullies and runnels during brief periods of local seasonal flooding. In the south, the Frew River, which rises in the Davenport Ranges (Fig. 1), empties into a local claypan or swamp.

The streams in the Barkly Internal Drainage Basin are braided in their lower courses and have broad shallow valley profiles; in the upper reaches they are well entrenched with sharp though not deep valleys. The major streams rise in the ridges in the western part of the Mount Drummond 1:250,000 Sheet area, referred to by Smith & Roberts (1963) as the Mittiebah Uplands.

The area south of the Barkly Highway has a different type of vegetation and topography from the northern part of the Basin. It is part of a semidesert with an internal drainage system flowing northwards from the Davenport Ranges, and was included in the Barkly Internal Drainage Basin by Stewart (1954a).

The Barkly Internal Drainage Basin contains some of the land-systems used by Stewart et al. (1954); the characteristic landforms and vegetation are summarized in Randal & Nichols (1963). The main land system is the rolling black soil downs, which are essentially grasslands with various types of Mitchell grass and subordinate Flinders, couch, and blue grasses. The country undulates gently, with low gravelly rises supporting various species of eucalypts and acacias, which also occur along the watercourses. The drainage is well developed and dendritic, but the major watercourses are widely spaced owing to the low runoff. The downs occur mainly on the Cambrian and Tertiary carbonate rocks.

The downs are separated on the west and south by timbered areas from the semidesert area of mallee scrub and acacias. The vegetation consists mainly of box and bloodwood associated with sparse shrubs and grasses, but west of the lakes coolibah and acacias, bluebush, blue grass, and occasional Mitchell and Flinders grasses occur.

The surface contours are based on barometric spot heights obtained by the Division of National Mapping and the Bureau of Mineral Resources.

GEOLOGY

The geology of the area (Pl. 1) has been mapped at 1:250,000 scale by the Bureau of Mineral Resources. Oil exploration companies have carried out supplementary surface and subsurface investigations. The Wallhallow Sheet area (Plumb & Rhodes, 1964) and Mount Drummond Sheet area (Smith & Roberts, 1963) were mapped during the survey of the Proterozoic rocks bordering the Gulf of Carpentaria; the Ranken, Avon Downs, Brunette Downs, and Alroy Sheet areas (Randal 1966a — d) were mapped as part of the regional survey of the Georgina Basin. In 1962, four coreholes — Grg 15, 15a, 16, and 17 — were drilled by the Bureau of Mineral Resources in the central southern part of the region (Milligan, 1963).

The Precambrian rocks cropping out in the north-west and north-east form part of the large area of Proterozoic rocks extending from the Queensland border north-westwards to Arnhem Land. They occur mainly in the Gulf Fall Division beyond the northern margin of the Barkly Tableland (Plumb & Rhodes, 1964;

Smith & Roberts, 1963). Only the Mittiebah Sandstone, which is the youngest exposed unit of the Precambrian sequence, has some influence on the groundwater of the Barkly Tableland. The springs and waterholes in the Precambrian rocks in the north-east are briefly described on page 16.

Most of the region is underlain by Proterozoic, Cambrian, Mesozoic, and Tertiary rocks. The Proterozoic rocks crop out only around the margin of the region, and their subsurface distribution is unknown. In the west, the Cambrian succession may be underlain by the Lower Proterozoic Warramunga Group and the Carpentarian Tomkinson Creek Beds* (Noakes & Traves, 1954; Ivanac, 1954; Randal, Brown, & Doutch, 1966). In the north and north-east, the Cambrian succession may be underlain by the Adelaidean Mittiebah Sandstone, and in the south and south-west by the Lower Proterozoic Hatches Creek Group (Smith et al., 1961).

The Cambrian rocks are poorly exposed, and large areas are covered by black soil or sand with loose blocks of dolomite, limestone, and sandstone, or by superficial deposits of chert pebbles and pisolitic ironstone gravel. The sandstone and siltstone outcrops are heavily lateritized, and in places it is impossible to differentiate between the Cambrian and Mesozoic rocks. There are about 450 water-bores in the region, but the drillers' logs are generally of little stratigraphic value.

Because of the lack of stratigraphic information, it is difficult to define rock units, and most of the Cambrian units are described by the general term Beds.

Adelaidean

The *Mittiebah Sandstone* is the youngest exposed Proterozoic unit (Dunn, Smith, & Roberts, in prep.). The Sandstone crops out in high ridges in the western part of the Mount Drummond Sheet area. Isolated outcrops occur in high country around the headwaters of Creswell Creek, and between the Playford River and Buchanan Creek, south of Alexandria homestead.

The unit consists mainly of fine to medium-grained quartz sandstone; glauconitic sandstone is present near the base, and rare pebbles and cobbles occur sporadically throughout. The rock is friable, but in places it is extensively silicified. Bedding ranges from medium to very thick; cross-beds are common, ripple marks are rare, and the rocks are jointed.

The Mittiebah Sandstone is gently folded: around the headwaters of Creswell Creek the rocks dip at less than 5° to the south-south-west; south of Alexandria homestead they are gently folded in a small anticline trending east-north-east; north of Alexandria the rocks are gently folded. Smith & Roberts (1963) estimate that the Mittiebah Sandstone is 9000 feet thick; the unit conformably overlies the Adelaidean Mullera Formation and is unconformably overlain by Middle Cambrian rocks.

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* Originally named Ashburton Sandstone.

TABLE 1: STRATIGRAPHY

Age		Rock Unit & Symbol	Lithology	Thickness (ft)	Stratigraphic Relationship
CAINOZOIC		Superficial deposits Cza Czb Czs Czl Czt	 Alluvium Clayey soils Sand Laterite Travertine	50	
CAINOZOIC	TERTIARY	Cleanskin Beds Tl	Chalcedonic limestone, chert	50	Post-Mesozoic
CAINOZOIC	TERTIARY	Austral Downs Limestone (Ta)	Limestone, siliceous limestone, some dolomite. Chert nodules, sandy lenses	45+	Unconformably overlies Cambrian rocks
CAINOZOIC	TERTIARY	Brunette Limestone (Tb)	As above	60+	As above
MESOZOIC		M	Sandstone, pebbly conglomerate	Unknown	No contacts, but presumably unconformably overlies Cambrian rocks
MESOZOIC	LOWER CRETACEOUS	Kl	Mudstone, sandstone, siltstone, conglomerate	200	Unconformably overlies all older rocks
CAMBRIAN	UPPER CAMBRIAN	Meeta Beds (Cum)	Dolomite and sandstone	1000+	Apparently overlies Camooweal Dolomite
CAMBRIAN	MIDDLE CAMBRIAN	Border Waterhole Formation Currant Bush Limestone	Limestone, chert, sandstone, siltstone, shale	250	Relationship with Camooweal Dolomite not clear
CAMBRIAN	MIDDLE CAMBRIAN	and undifferentiated Middle Cambrian (Cm)	Crystalline dolomite and chert	Unknown	On Ranken Sheet area may be equivalent to Ranken Limestone; on Alroy Sheet area may be equivalent to Wonarah Beds
CAMBRIAN	MIDDLE CAMBRIAN	Anthony Lagoon Beds (Cmy)	Limestone, dolomite, dolomitic limestone, quartz sandstone and siltstone	1050	Unconformably overlies Mittiebah Sandstone. May be equivalent to other Middle Cambrian units
CAMBRIAN	MIDDLE CAMBRIAN	Ranken Limestone (Cmk)	Crystalline limestone, silicified limestone, and coquinite. Some chert nodules	Unknown	Contains some upper Middle Cambrian fossils at one locality, but is mainly lower Middle Cambrian. May intertongue with Wonarah Beds to the west
CAMBRIAN	MIDDLE CAMBRIAN	Wonarah Beds (Cmw)	Silicified limestone, siltstone, sandstone, chert, silicified dolomite and shale. Leached carbonate rocks	At least 350 may exceed 1000	May be continuous with Gum Ridge Formation (Ivanac, 1954) and other Middle Cambrian rocks in the Barkly Tableland

CAMBRIAN	MIDDLE CAMBRIAN		Burton Beds (Cmb)	Siltstone and chert, calcarenite, coquinite, crystalline limestone	300+	Unconformably overlies Mittiebah Sandstone
			Peaker Piker Volcanics (Cmp)	Basalt and trachyte, minor sandstone	120	Unconformably overlies Mittiebah Sandstone. May be equivalent to volcanics regarded elsewhere as Lower Cambrian
	MIDDLE OR LOWER CAMBRIAN		Top Springs Limestone (Ct)	Massive fine-grained and crystalline limestone	30	Possibly underlies Anthony Lagoon Beds. Unconformably overlies Bukalara Sandstone
	LOWER CAMBRIAN		Bukalara Sandstone (Clb)	Quartz sandstone and conglomerate	200	Unconformably overlies Adelaidean rocks
			Camooweal Dolomite (Cd)	Crystalline dolomite with chert nodules and bands, dolomitic limestone. Minor sandstone	1000	Interfingers with Middle Cambrian rocks in the Camooweal area (Randal & Brown, 1962c); overlies Middle Cambrian rocks in the Avon Downs (Randal, 1966c) and Mount Drummond Sheet areas (Smith & Roberts, 1963); and underlies Middle Cambrian rocks in the Lawn Hill Sheet area (Carter & Öpik, 1961)
PRECAMBRIAN	ADELAIDEAN	South Nicholson Group	Mittiebah Sandstone (Pui)	Quartz sandstone	9000	The South Nicholson Group unconformably overlies the McArthur and Tawallah Groups, the Benmara and Bluff Range Beds, the Carrara Range Formation and the Murphy Metamorphics. It is probably equivalent to the Roper Group
			Undifferentiated (Ps)	Sandstone, siltstone	20,000	
			Roper Group (Pr)	Quartz sandstone and siltstone	4000	Unconformably overlies McArthur Group
	CARPENTARIAN		McArthur Group (Pm)	Sandstone, siltstone, dolomitic sediments	4000	Conformably overlies Tawallah Group in Northern Wallhallow area but unconformably overlies Tawallah Group in Calvert Hills area (Roberts et al., 1963)
			Tawallah Group (Pt)	Sandstone, siltstone, dolomitic sediments	4000+	Unconformably overlies Murphy Metamorphics in Calvert Hills area (Roberts et al., 1963)
	LOWER (?) PROTEROZOIC		Benmara Beds Bluff Range Beds Carrara Range Formation Murphy Metamorphics (Pl)	Sandstone, siltstone, volcanics, limestone, dolomite, conglomerate, schist, greywacke	1700 9000 7650 ?	Unconformably underlies South Nicholson Group

Cambrian

The Cambrian rocks in the Barkly Tableland form part of a widespread Cambrian succession which extends into Queensland. The regional geology and palaeontology of the Cambrian sequence have been studied by Öpik (1956a, b). The distribution, rock types, and stratigraphic relationships of the Cambrian units are given in Table 1. The position of the units in the table does not necessarily imply superposition, as some may be partly equivalent.

The Lower Cambrian *Bukalara Sandstone* crops out in the northern parts of the Wallhallow and Mount Drummond Sheet areas; it does not occur in the Georgina Basin and has no bearing on the groundwater of the Barkly Tableland. The *Peaker Piker Volcanics* crop out in the western part of the Mount Drummond Sheet area. Smith & Roberts (1963) regard them as Middle Cambrian and consider that they underlie the Burton Beds. The Volcanics probably have a restricted distribution: Bore No. 1 Alexandria penetrated the Cambrian sequence and intersected the Mittiebah Sandstone without encountering them. They are not evident beneath the Cambrian sequence in the eastern part of the Brunette Downs Sheet area: Papuan-Apinaipi Brunette Downs No. 1 spudded in Cambrian limestone and passed into the Mittiebah Sandstone at 1060 feet (Randal, 1966a).

The fossiliferous Middle Cambrian *Currant Bush Limestone* and *Border Waterhole Formation* crop out in small areas north of Don Creek in the eastern part of the Mount Drummond Sheet area. These formations have not been identified in the waterbores.

The distribution and nature of the Cambrian rocks have a marked influence on the distribution of the groundwater in the Barkly Tableland (see p. 22). The Cambrian sediments consist predominantly of carbonate rocks, but a number of distinctive units can be recognized.

The Ranken and part of the Avon Downs Sheet areas are mainly underlain by the *Camooweal Dolomite,* which consists of dolomite with bands and nodules of chert. The colour ranges from white, cream, or buff to light brown. The white dolomite is generally more coarsely crystalline and porous than the darker dolomite and in places is sugary and friable. The Camooweal Dolomite is medium to thick-bedded, and cavernous. Its relationship with other Cambrian units is uncertain (Randal, 1966b, c; Nichols, in prep.) (see also Table 1). The sandstone boulders found on the surface of the dolomite may represent sandstone interbeds. No fossils have been found in the outcrops, but Cambrian fossils have been recorded in two stratigraphic wells (Randal, 1966c). The Dolomite is generally concealed by black soil and Mitchell grass. It may have been deposited as a carbonate mud in a warm shallow sea under quiet conditions—presumably an environment of evaporation and precipitation (Nichols, 1963, and in press; Randal & Brown, 1962c). The beds previously mapped as Camooweal Dolomite near Lake Nash homestead are now regarded as the Upper Cambrian *Meeta Beds,* which crop out in the Sandover River Sheet area (Nichols, 1966).

The *Ranken Limestone,* which crops out in the valley of the Ranken River in the western part of the Ranken Sheet area, consists of fine-grained limestone with pellets and fossil fragments in a fine-grained matrix; sandstone and siltstone are rare, but silicified coquinite and fossiliferous chert pebbles are common. Its relationship with the Camooweal Dolomite in the eastern part of the Ranken Sheet area is obscure. East of the Ranken River it grades into a white fossiliferous dolomite. Corehole Grg 16 (Milligan, 1963) was drilled to determine the relationship of the Ranken Limestone to the Camooweal Dolomite near the Ranken River; Milligan reports dolomite overlying fossiliferous limestone, but the fossils have not yet been determined. Milligan also records that the limestone is similar to the Burton Beds described by Randal & Brown (1962a). Fossil evidence suggests that the Ranken Limestone is a lens in the Wonarah Beds (Öpik, 1956b), and it has been interpreted by Öpik as a shoreline deposit. The thickness is unknown.

The *Burton Beds* crop out in the north-western part of the Ranken Sheet area and the south-western part of the Mount Drummond Sheet area. They consist of lateritized shale and mudstone which are siliceous in part, chert, limestone, and siltstone. The limestone is commonly fragmented and generally consists of coquinites; oolitic rocks and chert pebbles are common. The relationship of the Burton Beds to the Camooweal Dolomite is uncertain, as the contacts are not exposed; on the Mount Drummond Sheet area the Camooweal Dolomite appears to overlie the Burton Beds (H. G. Roberts, BMR, pers. comm.). D. R. G. Woolley (BMR, pers. comm.) reports that a new quarantine bore north of Connells Bore on the Barkly Stock Route intersected 200 feet of dolomite overlying limestone, but it is not known whether or not this dolomite is continuous with the Camooweal Dolomite to the south-east. A similar dolomite is known to occur in the eastern part of Brunette Downs both on the surface and in waterbores; the dolomites north of the Playford River may be continuous with the Anthony Lagoon Beds.

Some of the wells and waterbores, which have penetrated to basement, indicate that the Burton Beds probably fill depressions in the basement surface. Nichols (1963) considers that the Burton Beds were deposited in shallow water in an open shelf area. The thickness is unknown, but may exceed 300 feet (Randal, 1966b). The fossil assemblages in the Burton Beds indicate a lower Middle Cambrian age; Öpik (1956b) has suggested that the Burton Beds* may be continuous with the Wonarah Beds, and Randal & Nichols (1963) have supported this opinion.

The *Wonarah Beds* crop out to the west of the Ranken River and south of Alroy Downs homestead. The contact with other Cambrian units has not been observed.

The Wonarah Beds comprise fossiliferous siltstone, chert, sandstone, silicified shale and oolitic limestone, leached carbonate rocks, and blue-grey silty limestone. Milligan (1963) has recorded limestone, calcareous siltstone and sandstone, calcarenite, coquinite, and dolomite in the coreholes, but not all these rock types occur in each bore. Fossils from the outcrops of the Wonarah Beds indicate a lower Middle Cambrian age; the total thickness to magnetic basement at Wonarah is 800 feet (Jewell, 1960), but the section may include rocks older than lower Middle Cambrian. Similarly, it is uncertain whether the 1024 feet of limestone and dolomite in Frewena No. 1 (E. A. Webb, pers. comm.) is all referable to the Wonarah Beds.

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* Öpik referred to these rocks as the 'Alexandria beds'.

The waterbore at Wonarah telegraph station penetrated 366 feet of dolomite and limestone containing lower Middle Cambrian fossils (Randal, 1966d).

The Wonarah Beds can probably be correlated with the Burton Beds (Randal & Nichols, 1963), and possibly with the Sandover Beds and Gum Ridge Formation. They may also be partly contemporaneous with the Anthony Lagoon Beds to the north.

The *Anthony Lagoon Beds* crop out in the central and northern parts of the Brunette Downs Sheet area and extend northwards into the Wallhallow Sheet area. The outcrops consist of dolomite, dolomitic limestone, algal dolomite, sandstone, and leached carbonate rocks, but the drillers' logs suggest that siltstones and sandstone are more abundant than indicated by the outcrops. The carbonate rocks show the same marked effects of leaching noted in other carbonate rocks elsewhere on the Barkly Tableland; the sandstones are extensively lateritized and ferruginized. The driller's log of Brunette Downs waterbore K5 records 707 feet of limestone, and in Papuan-Apinaipi Brunette Downs No. 1 1060 feet of carbonate rocks overlie the Precambrian sediments (Randal, 1966a).

No diagnostic fossils have been found in the Anthony Lagoon Beds; algal and sponge(?) remains have been found in dolomitic limestone, fragments of trilobites and echinoderms have been seen in thin sections, and fragments of brachiopods were found in the interval from 1010 to 1019 feet in Brunette Downs No. 1. The Anthony Lagoon Beds may overlie the *Top Springs Limestone* (Plumb & Rhodes, 1964) to the north, and may be equivalent in part to the Burton Beds and Wonarah Beds.

The Anthony Lagoon Beds were deposited in shallow water. Shallow lagoonal conditions favoured the growth of algae and sponge-like organisms while more open shelf conditions favoured the accumulation of intraclastic and pelletal limestones.

Mesozoic

Remnants of the Mesozoic sediments crop out on low rises to the east of the Ranken River; they consist of rubbly quartz sandstone and pebble conglomerate. On the Wallhallow Sheet area, Mesozoic rocks crop out along the scarp on the northern edge of the Barkly Tableland; they extend southwards under the black soil to near Collabirrian Waterhole. The sediments include white quartz sandstone overlain by massive grey calcareous siltstone containing gypsum and claystone. The beds are heavily lateritized. Plumb & Rhodes (1964) estimate the thickness to be 200 feet, but the beds probably thin to the south. No aquifers occur in the Mesozoic sediments, but they may influence the recharge and chemical composition of the water in the northern part of the region.

Cainozoic

The Tertiary Brunette Limestone in the Barkly Internal Drainage Basin and the Austral Downs Limestone in the Georgina River Basin were named by Noakes & Traves (1954). They consist of white to brown fine to coarse-grained crystalline limestone and dolomite. They contain chert and opaline nodules and smears; much of the limestone is irregularly nodular. The limestones are thin deposits resting unconformably on the older rocks from which they were derived. The

Tertiary limestones do not appear to contain much groundwater; but percolating waters recharging the Cambrian reservoirs may pass through them or their weathering products.

Outcrops of travertine are widespread in the south-western part of the region. The travertine is partly opaline and siliceous like the Tertiary limestones, but it contains more detrital quartz and is less cohesive. It is at least 15 feet thick.

Unconsolidated Cainozoic deposits are widespread; they consist of black and grey clayey soils, alluvium, sand and sandy soils, river gravels, and residual gravelly rises of chert and ironstone pebbles.

The grassy downs are underlain by black and grey pedocalcic soils, which are moderately to weakly leached and contain horizons rich in gypsum and carbonate minerals. Stewart (1954b) considers that the soils were formed in swamplands during the Tertiary lateritic cycle. The pedocalcic soils overlie the Cambrian carbonate rocks and the Tertiary limestones; they are formed partly of residual material derived from the carbonate rocks and partly of sediment deposited in the Tertiary swamp. The widespread chert gravel has probably been derived from the chert nodules and bands in the underlying carbonate rocks. The rises of pisolitic ironstone gravel probably represent remnants of lateritic horizons, but in places they consist of detrital material.

Sand and sandy soils are found in the southern part of the Alroy Sheet area and the western part of the Brunette Downs Sheet area. Although the quartz sand is generally subordinate it imparts a sandy texture to the soil which is readily distinguished from the clayey black pedocalcic soils, particularly in the timbered area west of Lake Sylvester, where the texture of the grey pedocalcic soils and the vegetation are similar to those in the sandy areas. The soils shown on the map as sand and sandy soils have been described by Stewart (1954b) as red desert alluvial soils, calcareous desert soils, lateritic red sand, and lateritic red earths.

SURFACE WATER

The annual rainfall on the Barkly Tableland ranges from about 11 inches in the south to about 21 inches in the north. The rain falls mainly during the north-west monsoon, from November-December to March. Figure 2 shows the isohyets based on the average rainfall for the period 1950-62.* The figures for 1950-62 and those given by Slatyer & Christian (1954) for the period 1911-40 are as follows:

	1950-62 (inches/yr)	1911-40 (inches/yr)
Newcastle Waters	17.86	17.32
Camooweal	16.26	14.35
Alexandria	12.48	14.07
Tennant Creek	13.08	13.85
Avon Downs	13.77	12.74

* Obtained from monthly rainfall figures for eleven stations in the region and adjacent to it for the period 1950-62, made available by the Commonwealth Bureau of Meteorology, Melbourne.

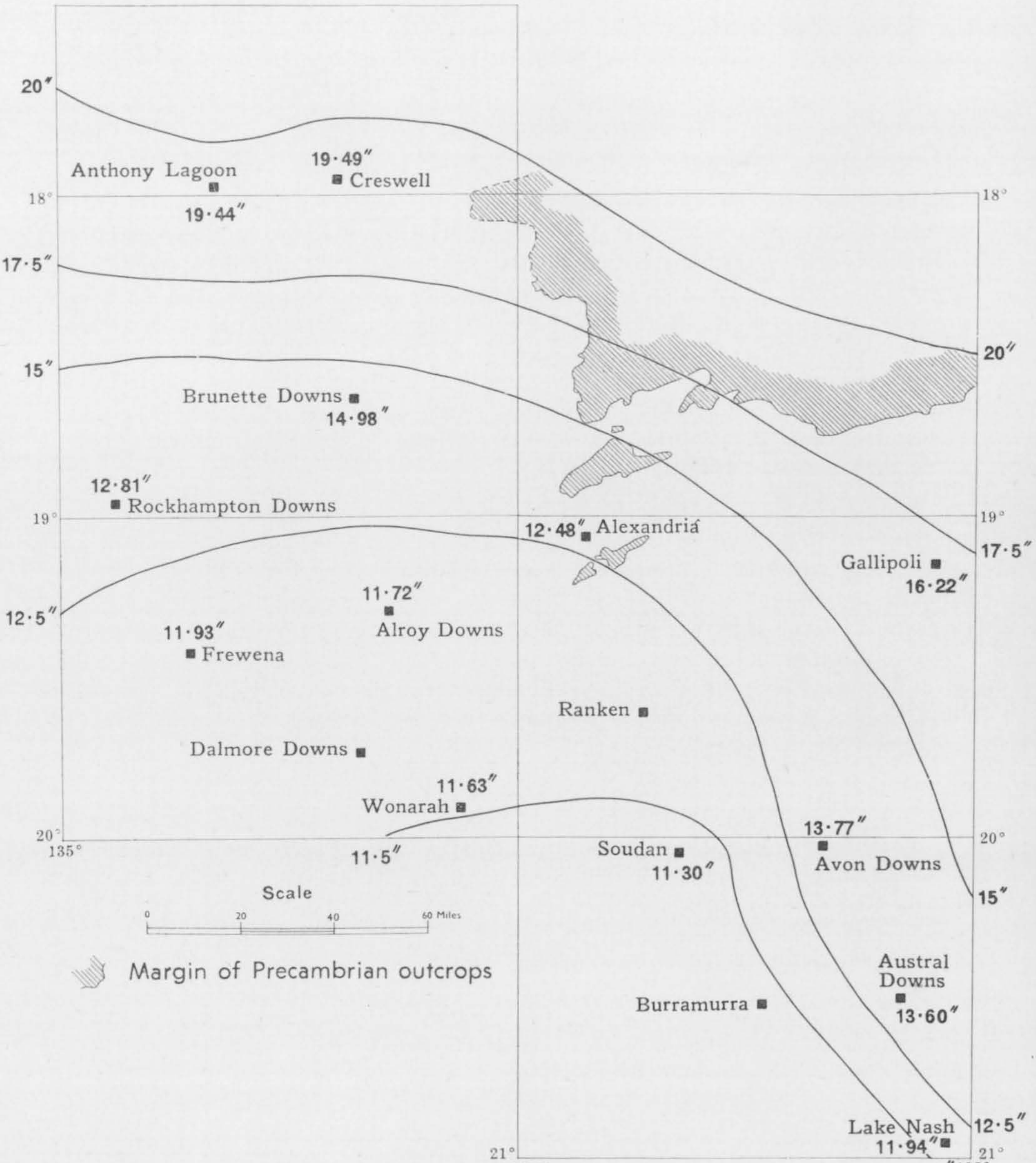

Fig. 2: Isohyets, 1950-62.

The driest parts include the area between Alroy, Frewena, Wonarah, and Ranken, and the area to the west of the Ranken River and southern part of the Georgina River. The dry areas merge into a large semidesert which extends southwards to the Sandover River.

Figure 3 shows the seasonal variation of rainfall at Alexandria homestead and clearly indicates the separation of wet and dry seasons, and the incidence of occasional winter rains.

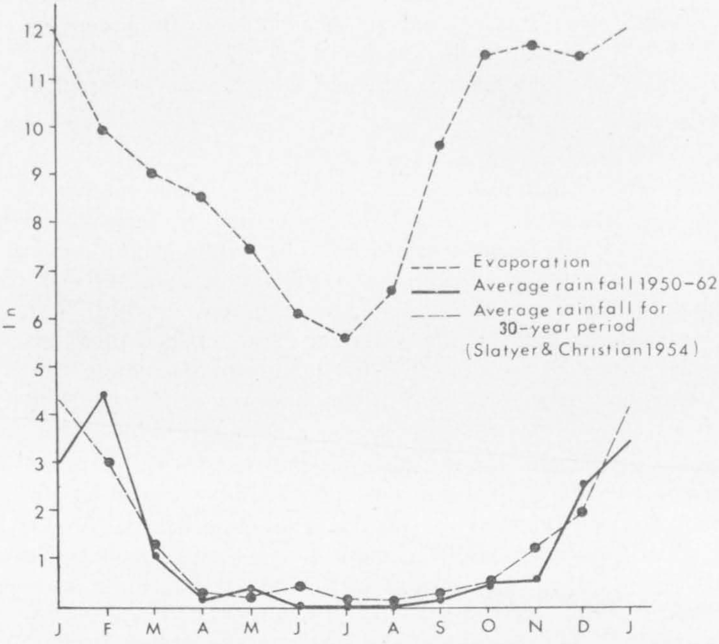

Fig. 3: Mean Rainfall and Evaporation at Alexandria station.
Information provided by Commonwealth Bureau of Meteorology, Melbourne.

The annual evaporation rate ranges from 100 inches in the north to over 110 inches in the south. Evaporation is at its highest during the wet season and lowest during the dry season. The evaporation/precipitation ratio is lowest in the wet season (about 2.75 in January) and highest in the dry season (over 200 in August). This factor is important because it implies the improbability of accretion to the groundwater storage from occasional low-intensity rainfall during the normal dry season. Figure 3 also shows the variation throughout the year of evaporation at Alexandria homestead.

Because of the low seasonal rainfall and the high evaporation, surface water on the Barkly Tableland is not only inadequate for the present stock population, but is also unreliable. Foley (1957) states that in 70 years of rainfall records the region has experienced periods of drought totalling 25 years 8 months up to 1955. This period was followed by dry years in 1958 and 1961: Alexandria's total of 353 points for 1958 is the lowest on record, and in 1961 Alexandria received only 503 points. Serious droughts occurred in the period 1911-16, with 1911-12 and 1916 the worst years. One of the worst droughts was from March 1951 to

October 1952; hundreds of cattle died in January and February 1952—months during which normally more than half of the annual precipitation occurs—and by April 1952 very little grass was available and most of the permanent waterholes were dry.

There are few permanent waterholes on the Barkly Tableland owing to the low relief, scarcity of streams, and the arid climate. There are no permanent streams; even the Nicholson River in the north-east shrinks to a series of waterholes during the dry season. Most of the permanent waterholes occur in the Gulf Fall Division, where the streams are entrenched in small canyons; in the rich downs country to the south in the Georgina River Basin and the Barkly Internal Drainage Basin, where the demand for water is greatest, waterholes are few.

Gulf Fall Division

In the north-eastern part of the Gulf Fall Division the major watercourse is the Nicholson River, which flows across the Mount Drummond Sheet area towards the Gulf of Carpentaria; its principal tributaries are the South Nicholson River, Carrara Creek, and Buddycurrawa Creek. The South Nicholson and Nicholson Rivers carry large volumes of water during the wet season, but in the dry season they dry up into a series of isolated waterholes, many of which persist until the following wet season. Most of the waterholes are simple depressions in the river beds, or in the numerous anabranches, but many are associated with rock bars—the water either being dammed by resistant sandstone beds, or forming a pool on the downstream side of the bars.

Numerous permanent springs occur in the eastern and central parts of the Mount Drummond Sheet area at the contact between the sandstone hills and the less resistant and relatively impervious siltstone and shale below. In the folded and faulted Proterozoic rocks groundwater appears to move not in a regional aquifer system, but rather in small isolated systems with local recharge areas. The piezometric surface lies close to the ground surface, and frequently above it because of the topography. This is in direct contrast to the groundwater system of the Barkly Tableland and farther south, where the piezometric surface of the groundwater in the undisturbed Cambrian rocks remains well below ground level.

The north-western part of the Gulf Fall Division is drained by the headwaters of the McArthur River, the Kilgour River, and Clyde Creek, which flow north towards the Gulf of Carpentaria. The streams dry up into a series of isolated waterholes during the dry season; the waterholes are especially common in the deep gorges and valleys where the Kilgour and Clyde, and their tributaries, flow over Proterozoic rocks. They occur in depressions in the stream bed, or behind rock bars.

Small springs of clear water occur in the north and north-eastern parts of the Wallhallow Sheet area. Many of them are situated around the edge of the Bukalara Sandstone Plateau, and probably emerge at the base of the Bukalara Sandstone; others occur in folded and dissected Proterozoic rocks.

Georgina River Basin

The annual rainfall in the Georgina River Basin ranges from 11 inches in the south and west to over 16 inches in the north, but over most of the area it is less than 15 inches. The streams, which are mature and in places braided, have well defined, but low, valley profiles. Few sites suitable for dams are available.

Low overshot dams have been constructed at Avon Downs and Austral Downs, but dams are generally unreliable as the drainage is frequently incised and storage areas are limited, or the dams are breached in the wet season.

The Georgina, Ranken (including Lorne Creek), and James Rivers are the only streams which normally contain permanent waterholes; those at Soudan, Avon Downs, Austral Downs, and Lake Nash are normally adequate for the homesteads even in moderate droughts. The surface water is commonly milky because of the high content of suspended clay, and towards the end of the dry season, the dissolved salts are concentrated by evaporation and the water becomes commonly less palatable than some borewaters.

The Georgina River Basin is relatively better endowed with surface water than the Barkly Internal Drainage Basin; there are over 50 known waterholes, about 20 percent of which are normally permanent. No springs have been recorded in the area.

Barkly Internal Drainage Basin

The Barkly Internal Drainage Basin is poorly endowed with surface water: it contains about 60 known waterholes, less than a quarter of which are permanent. Even the normally permanent waterholes are unreliable in moderate droughts. The waterholes have been deepened on some stations and overshot dams constructed, but only two dams are in existence at present—the Buchanan Dam east of Alroy Downs homestead, and a system of small dams impounding water in the lagoon at Brunette Downs homestead. Buchanan Dam is the largest dam on the Tableland: the water is backed up for over 1½ miles and in places is 200 yards wide; the depth is unknown but in places exceeds 10 feet.

Most of the major streams contain permanent waterholes, the most reliable of which are at Alroy Downs homestead, Anthony Lagoon, Brunette Downs homestead, and Corella Lagoon. There are no permanent waterholes in the Basin north of Creswell Downs and Anthony Lagoon homesteads.

The surface waters have a high content of suspended clay, and some of the waterholes are encrusted with gypsum. Samples from Brunette Downs Lagoon and Long Waterhole, collected in October and November 1960, have been analysed by the Animal Industry Branch of the Northern Territory Administration in Alice Springs.

		Na	K	Mg	Ca	Cl	SO_4	HCO_3	F	NO_3	TDS
Brunette Downs Lagoon	ppm	6	7	6	12	1	2	92	0.2	—	126
	epm*	0.26	0.18	0.5	0.6	0.03	0.4	1.5			
Long Waterhole	ppm	66	15	55	287	15	909	155	1.0	2	1505
	epm	2.87	0.38	4.52	14.35	0.42	18.94	2.54			

The dominance of calcium and sulphate ions in the Long Waterhole on Brunette Creek appears to be due to gypsum in the nearby black soil. The salts in the Brunette Downs Lagoon appear to be derived mainly from the solution of dolomitic rocks.

* Milli-equivalents per litre (equivalents per million).

There are no permanent waterholes in the desert in the southern part of the Internal Drainage Basin. Water lies in the bluebush swamps and claypans for only a short period after heavy rain. As the vegetation is unsuitable for cattle grazing there are no bores in the area except for those along the Barkly Highway, and corehole Grg 17, 1½ miles south of Frewena, which was completed as a waterbore.

The large lakes of the Internal Drainage Basin contain water only during the wet season and, in a good year, for some weeks after it. The lakes are shallow and quickly dry out. Large perennial waterholes occur in the distributaries of the streams feeding the lakes, e.g. Adder Waterhole in Creswell Creek, Corella Lagoon in Corella Creek.

GROUNDWATER

DEVELOPMENT

Collection and Reliability of Data

Information on bores has been obtained mainly from drillers' logs, but the depths of the aquifers and standing water levels have not always been recorded accurately. Additional information has been obtained from station owners and managers, and from the Water Resources Branch of the Northern Territory Administration. Noakes and Traves (Traves & Stewart, 1954) collected some information between 1947 and 1953, and the logs of bores drilled since then were collected in 1961-63.

Many of the logs are incomplete, and no information is available for some of the bores. Drillers are now required by regulation to submit a log to the Water Resources Branch: the information recorded includes the location and total depth of the bore, the depth and number of aquifers, the standing water levels, the pump depth and drawdown during pumping, and a record and samples of the strata penetrated.

The data on 447 bores are summarized in Appendix 1. Other bores have been drilled, but the records have been lost and the locations are unknown.

A little over half the bore-logs examined record the depths of the aquifers; 315 record the depth of the standing water level, but only a few record the standing water level for the individual aquifers; 200 record the pump depth and 309 the supply. Only 86 of the logs record all measurements. Very few logs record the supply for the shallower aquifers, and the supply quoted for the main aquifer is either the capacity of the pump used to test the well, or else is an estimate only. Very few of the logs record the drawdown and the recovery times during pumping tests. The various parameters have not always been measured accurately, and in some areas an error of $\pm$ 5 feet can be significant. Standing water levels are measured at the time of completion of the bore and only occasionally are they remeasured later. Since some of the levels were recorded more than 60 years ago, it may not be correct to equate them to levels measured recently. Most pastoralists regard the standing water level as virtually constant, but this may not be so.

Surface elevations are based on barometric heights by the Division of National Mapping and, later, by the Bureau of Mineral Resources. Barometric stations were reoccupied at least once during the survey, and some have been tied to a line of third order levels established by the Department of the Interior along the road from the Barkly Highway to Anthony Lagoon homestead. The barometric levels are considered to be sufficiently accurate to indicate the standing water levels on a regional scale.

The lack of accurate topographic levels, and the inaccuracy in the measurement of some of the standing water levels, make it difficult to determine the direction of groundwater movement, particularly in the central part of the Barkly Internal Drainage Basin, where the topographic relief and hydraulic gradients are small. Over the entire region the topographic relief and the differences in standing water levels are sufficiently large to establish that the elevation of the piezometric surface varies about 250 feet. In some areas the variation in the elevation of the piezometric surface is about 40 feet or more which is greater than the expected error caused by faulty measurements and levelling. The piezometric surface illustrated in Figure 8 is considered to be regionally valid.

Samples were obtained in 1962 and were analysed by the Bureau of Mineral Resources, Canberra, and the Australian Mineral Development Laboratories, Adelaide. Other analyses were made available by the Animal Industry Branch of the Northern Territory Administration. The collecting of the samples and the reliability of the chemical results are discussed on pages 34-35.

History of Drilling

Pastoralists introduced cattle into the Barkly Tableland during the 1870's, and when it soon became apparent that the industry would be severely hampered by the inadequacy of surface water drilling contractors were brought in to seek groundwater (Fig. 4).

The first bores drilled in the Northern Territory part of the Tableland were Rocklands Nos 5 and 6; they were both drilled in 1892 and obtained good supplies of subartesian water. Alexandria No. 1 was drilled about 1893; it is the deepest waterbore on the Tableland (1760 feet) and apparently was the first and only serious attempt to seek artesian water in the region. It obtained a good supply of subartesian water at 238 feet, but the drillers' log records no other aquifers.

The number of bores drilled was small until about 1902, when the rate of drilling increased, presumably owing to the 1899/1906 drought. By 1906 the total was 36. The first recorded dry holes were drilled in 1904—Alexandria Nos 6 and 8. Drilling increased during the First World War and immediately afterwards, perhaps owing to the lessons learned during the drought of 1911/16. The first recorded Government bores were Nos 1 and 2 on the Anthony Lagoon Stock Route (now regarded as the western extension of the Barkly Stock Route). The first bores on the Barkly Stock Route south-east of Anthony Lagoon were the Ranken Plain Bore in 1929 and Connells Lagoon Bore in 1930. These sites were selected by Ward (1926).

The effects of the depression are apparent in the period 1930-35, when little drilling was done. During the war years little drilling was done on private holdings, but several government bores were drilled along the stock routes and the Barkly Highway. Drilling began again slowly after the war, but by 1950 200 bores had been drilled. The greatest rate of drilling occurred during the expansion of the cattle industry in the region from 1950 to mid-1963. In the 1960's the greatest activity was on Brunette Downs, which drilled over 70 bores in 3 years.

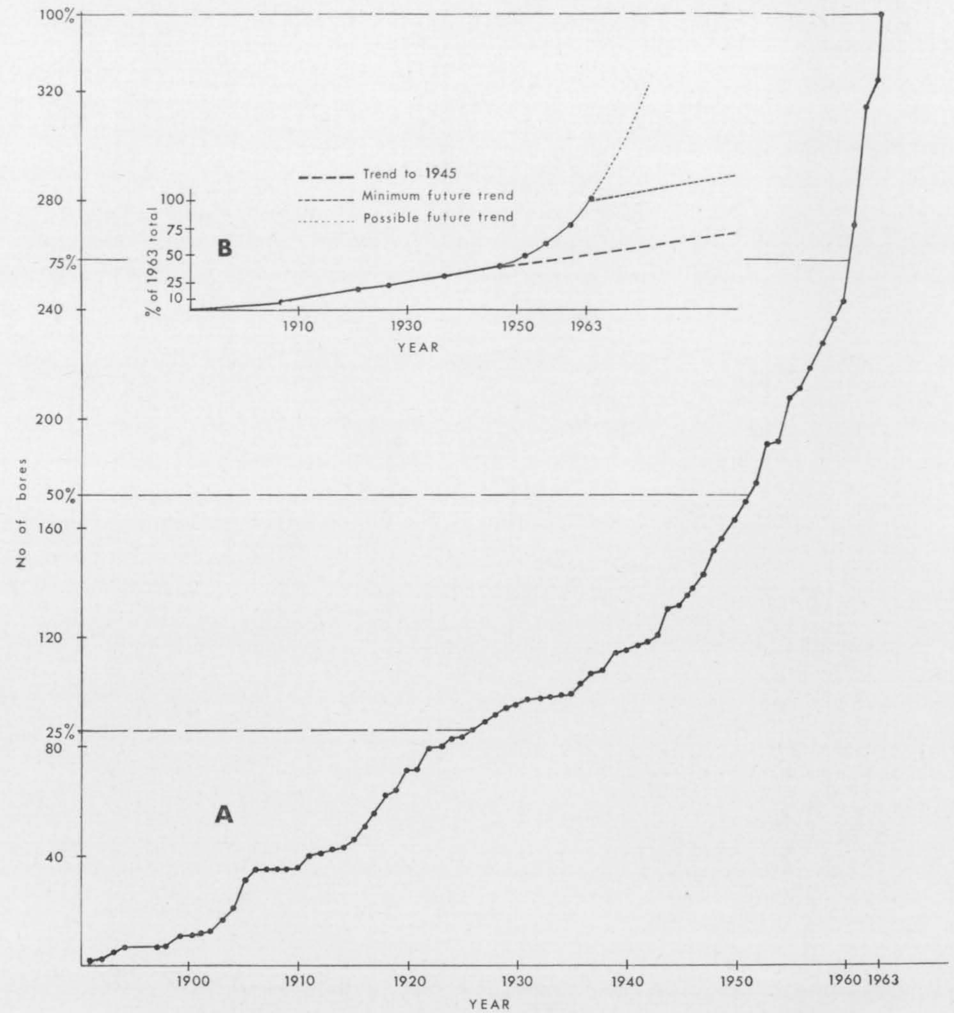

Fig. 4a: Progressive total of waterbores drilled from 1890-1963.
b: Development expressed as a percentage of 1963 total.

Present Density of Bores and Future Development

During the 1961-62 geological survey of the Barkly Tableland, 447 bores were located; 86 of the bores have not been equipped or have been abandoned after some time in use for the following reasons:

Dry holes	4
Poor supply	6
Poor-quality water	9
Collapse of casing	15
Silting	5
Not required/Temporary shut down	18
Drilling difficulties	9
Reasons unknown (but not dry)	20
Total	86

Adequate supplies of usable water were obtained in over 95 percent of the bores. The salinity level at which pastoralists consider that a bore should not be equipped has varied from station to station; but nowadays the pastoralist usually forwards a sample of water for analysis to the Animal Industry Branch at Alice Springs or Darwin, and their recommendations are usually, but not always, followed. Some pastoralists will not equip a bore with a yield of less than 1500 gph, but others consider 1000 gph adequate.

There are more than 360 working bores in the area, or about 1 bore per 100 square miles. If the stock route bores, miscellaneous government bores, and tracts of unleased land are excluded, the average density of bores in the pastoral holdings is about 1 per 84 square miles (Table 2).

TABLE 2: BORE DENSITY — BARKLY TABLELAND

Station	Area (sq. miles)	No. of working bores	Square miles per bore	No. of bores below maximum density*
Alexandria	8200	48	170	157
Alroy	1550	25	60	14
Anthony Lagoon	2400	24	100	36
Austral Downs	1620	16	100	24
Avon Downs	1430	16	90	20
Brunette Downs	4730	119	40	—
Creswell	2000	21	100	29
Dalmore Downs	1260	13	100	18
Rockhampton Downs	2000	33	60	17
Rocklands	1400	12	120	23
Total pastoral leases	26,600	327	84	338

* Based on maximum density of 1 bore/40 square miles on Brunette Downs.

The highest density of bores on the private holdings is 1 per 40 square miles on Brunette Downs station, where an extensive development programme has recently been completed for the introduction of Santa Gertrudis cattle. The ultimate aim on some stations is about 1 bore per 25 square miles in some areas. The last column in Table 2 shows the number of bores required on each station to reach the same density as on Brunette Downs. To achieve this density for the region as a whole, the number of producing bores would have to be doubled. Expansion is controlled largely by the amount of capital available for property improvements.

Kelly (1963) considers that the Barkly Tableland has some potential for cattle fattening; if this is developed, a great many bores will be needed on the majority of holdings. Figure 4 shows the progressive bore totals from 1890 to mid-1963; Figure 4b shows these totals converted to percentages of the mid-1963 total. The development to about 1945 is essentially linear, but since then has risen sharply. If the present trend continues, at least 150 additional bores will be drilled by 1970.

Occurrence

Aquifers

Most of the bores in the Barkly Tableland obtain groundwater from the Cambrian carbonate sequence. No aquifers have been found in the Mesozoic rocks in the north or the Tertiary limestones in the centre and south. In the bores which pass through the younger rocks, the aquifers recorded are below their probable base, but the younger sediments may permit the passage of water from the surface into the older rocks. Noakes (1954) believes that 'water has been drawn from these limestones [the Tertiary limestones] in the Georgina Valley (farther south) but probably not in the Barkly Basin'. Farther north, in the Beetaloo Sheet area, groundwater is obtained from the Mesozoic rocks, which are there much thicker (Randal, Brown, & Doutch, 1966).

Only a few bores draw water from aquifers in the Adelaidean Mittiebah Sandstone. Five bores have penetrated the unit: one, near Alexandria aerodrome, was completely dry; the driller's log for another indicates no aquifer other than one in the Cambrian sequence many hundreds of feet higher in the hole (Alexandria No. 1); but two others, Creswell Downs Nos 14 and 16, obtain supplies of 1300 and 4000 gph respectively from 'cavities' in a hard red sandstone. The chips from these two bores are identical with the Mittiebah Sandstone which crops out nearby. An unsuccessful bore (R.N. 2747) in the Calvert Hills Sheet area also penetrated the Mittiebah Sandstone: it obtained only 60 gph of very salty water from the overlying limestone and clay sequence.

In the north-east the piezometric surface slopes away from the Proterozoic outcrops, which suggests that they are at or near an intake area for the groundwater system. The water taken in along the Cambrian/Precambrian boundary may pass into aquifers in the Cambrian sequence abutting against the unconformity, rather than into the less permeable Mittiebah Sandstone.

The drillers' logs and the position and total depth of the bores indicate that the aquifers occur in a carbonate sequence, and that lithology varies more in some areas than in others. In most of the Ranken and parts of the Avon Downs Sheet areas, the 'limestone' and ribbonstone or flints recorded in the logs can be interpreted as the chert-bearing Camooweal Dolomite. There is little variation in individual bores in the north-eastern part of the Alroy Sheet area and in the eastern and north-eastern parts of the Brunette Downs Sheet area. In the western part of the region, on the other hand, the drillers' logs indicate considerable amounts of sandstone and siltstone in the carbonate sequence. In many bores the producing aquifer is sandstone or 'porous' limestone overlain by siltstone or tight hard limestone. The drillers' logs of the waterbores frequently refer to caves, cavities, and fissures in the limestones. Figure 5 is a diagrammatic interpretation from the drillers' logs showing where the occurrence of groundwater is controlled by the presence of cavities etc., the lithology, or a combination of both. The main boundary between the areas in the west, where the control is lithological, and the areas in the north-east and east, where cavities are the predominant feature, may prove to be related to the change in the subsurface from the mainly dolomitic rocks in the east to the more varied rocks in the west. Circulation was lost in several stratigraphic wells drilled on the Barkly Tableland owing to the abundance of cavities.

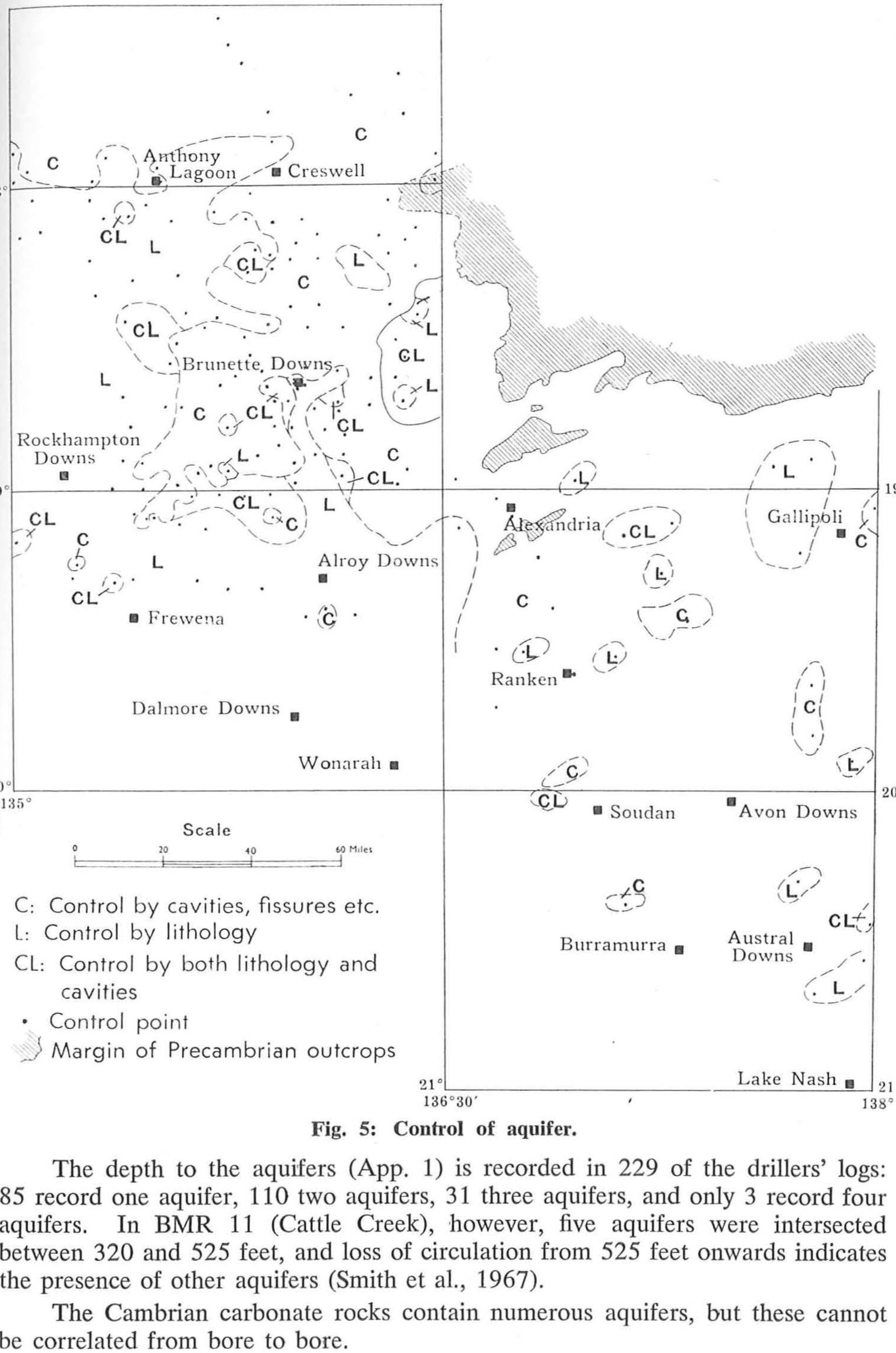

Fig. 5: Control of aquifer.

The depth to the aquifers (App. 1) is recorded in 229 of the drillers' logs: 85 record one aquifer, 110 two aquifers, 31 three aquifers, and only 3 record four aquifers. In BMR 11 (Cattle Creek), however, five aquifers were intersected between 320 and 525 feet, and loss of circulation from 525 feet onwards indicates the presence of other aquifers (Smith et al., 1967).

The Cambrian carbonate rocks contain numerous aquifers, but these cannot be correlated from bore to bore.

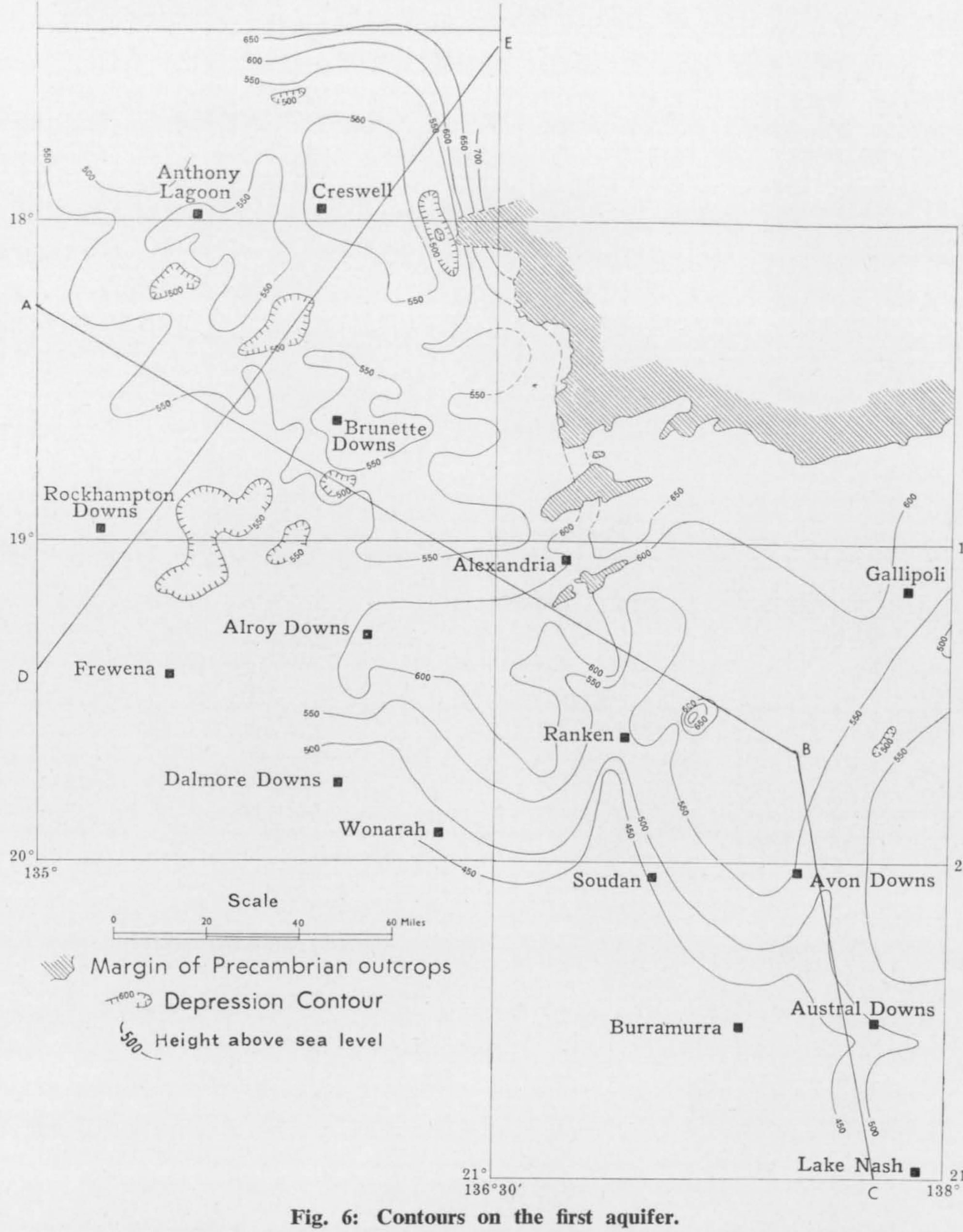

Fig. 6: Contours on the first aquifer.

In some bores, the supply from the first aquifer encountered was inadequate and drilling was continued until a deeper aquifer giving a sufficient supply was intersected. The poor supply from the shallow aquifers is presumably due to low permeability and lack of available drawdown as the aquifer is at or close to the piezometric surface. If the same shallow aquifer is encountered well below the piezometric surface it may yield a larger supply, particularly if there is also an increase in permeability; but there may be an increase in salinity because the aquifer lies at a deeper level in the geological structure. The drillers' logs and the pastoralists frequently report that the first aquifer encountered produces much less saline water than the deeper aquifers, and there may be a position where a compromise between reasonable salinity and reasonable supply can be obtained. It may be possible to obtain water of better quality for domestic and agricultural purposes by exploiting the upper aquifers.

The depth to the main aquifer depends on the porosity or the presence of cavities and fractures, and although the contours on these depths may not represent structure contours, they do have some hydrological significance.

Figure 6 illustrates contours on the depths of the first aquifers converted to heights above sea level. The elevation of this surface varies from 700 feet east of Creswell Downs homestead and near Ranken store to below 450 feet in the southern part of the region. The zone of high contours south-west of Alexandria homestead divides the region into two areas: one to the south-east, and one to the north-west where the regional slope forms a complex basin, with high areas, and then declines north-westerly. The zone has the same trend as that of the inlier of Mittiebah Sandstone near Alexandria, and broadly conforms to the hydraulic divide in the piezometric surface and in several of the chemical characteristics of the groundwater.

Figure 7 illustrates the surface of a hypothetical aquifer based on the height above sea level of the main aquifer encountered in 229 bores. There is no stratigraphic correlation between bores, and the depth to the main aquifer is partly dependent on the decision of the pastoralist or driller that the supply was adequate. In areas where the density of bores is high, adjacent bores may be drawing their supplies from the same aquifer, and the contours may represent local structure contours.

The contours on the hypothetical aquifer give some indication of the depth at which adequate water supplies may be obtained.

Despite the limitations of Figure 7, some interesting observations can be made. The contours show the same regional pattern as those on the first aquifer, and the region is also divided into two areas—one in the south-east, and one in the north-west. The ridge between the south-eastern and north-western areas is not well defined: it extends from Alroy Downs to near Alexandria homestead, but only vaguely resembles the pattern of the piezometric and chemical zones.

Supply

The supply from most bores is generally adequate; the range recorded in 271 logs is as follows:

Supply (gph)	*No. of Bores*
less than 500	6
500-1000	15
1000-1500	47
1500-2000	107
2000-2500	40
2500-3000	37
3000 or more	19

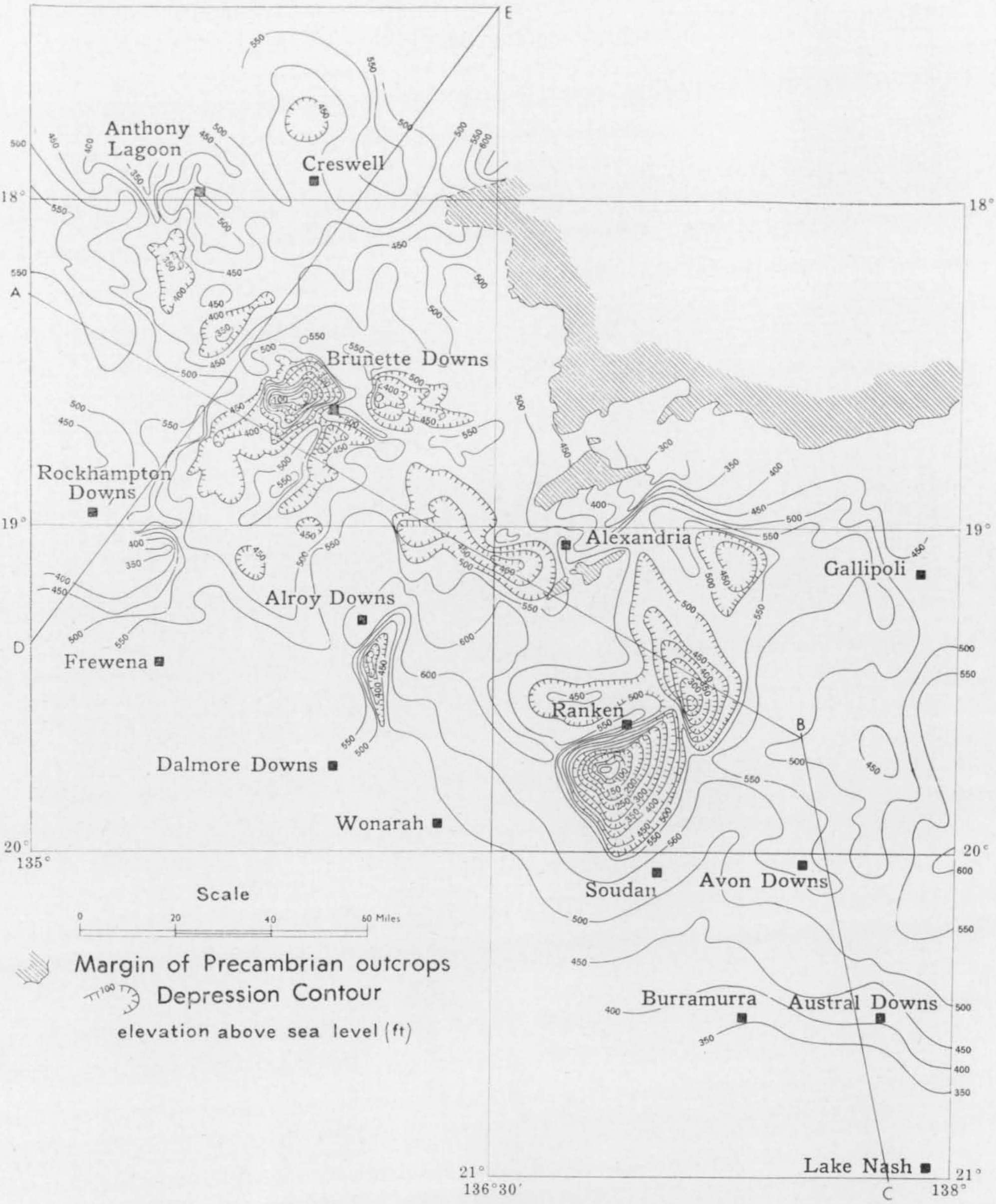

Fig. 7: Contours on a hypothetical aquifer, based on the height above sea level of the main aquifer in 229 bores.

About 75 percent of the bores are capable of producing more than 1500 gph, which is generally regarded as adequate, although some pastoralists will equip bores producing considerably less. Smaller supplies are adequate for domestic purposes, but the quality of the water is important (see p. 35).

Some of the yields recorded are the limits of the pumps used to test the bores, and the supply recorded has increased steadily from the 1890's to the present day.

Some logs give no indication of the supply, some merely record whether it is good, poor, or fair, and some give an estimate only. Very little has been recorded on drawdown and recovery time. If the supply in the first test is considered to be inadequate, the pump is generally lowered and a further test carried out. Should the supply be adequate for a few hours, the test is completed. Later, permanent pumping equipment is erected over the bore, with the risk of forking and possible damage owing to sanding or silting, and possible damage to the aquifer. Very few pumping tests are continued long enough to indicate the safe yield; many underestimate the potential of the bore, and a few probably overestimate the safe yield. The time available for pumping tests is limited, and the present practice of quick tests, though undesirable, is usually satisfactory as supplies are generally adequate. Should intensive drilling be required for future closer settlement, careful pumping tests will be required, particularly if the reputedly better-quality water in the shallow aquifers is utilized.

The supply/drawdown ratio, i.e. the yield per foot of drawdown under test, has been calculated for 108 bores. Because the data for different pump positions in the same bore are not available, because the supply given in the logs is sometimes misleading, and because the ratio has generally been calculated on the maximum possible drawdown (i.e. standing water level minus pump depth) only general inferences can be drawn. Most of the values obtained are minimum ones.

The ratio ranges from less than 20 gal/ft to 660 gal/ft. Values of over 100 gal/ft occur in the area from the headwaters of Desert Creek north-eastwards to Buchanan Creek, thence along the Playford valley to Lake Sylvester and northwards to Boree Creek. High values occur in the area of the Camooweal Dolomite bounded by the upper reaches of Buchanan Creek, Six Mile Creek, and Gallipoli homestead; they also occur in small areas along Lignum Creek to Tarrabool Lake, east of Creswell Downs homestead, east of Rockhampton Downs homestead, and in a narrow belt from Corella Creek through Brunette Downs homestead to Mittiebah Creek. All these areas of high values are ringed by bores for which the ratio lies between 50 and 100 gal/ft. Values of less than 50 gal/ft occur between Creswell and Fish Hole Creeks, near Alexandria homestead, between Wonarah and the north-western part of the Alroy Sheet area, south of Anthony Lagoon homestead, and around Lakes Corella and Sylvester.

There is a very general relationship between the supply drawdown ratio and the direction of groundwater flow: low values occur in areas near recharge, and higher values in areas of accumulation as indicated by the piezometric surface. The ratio also tends to be high in the areas where the drillers' logs indicate cavities and fissures.

Hydrodynamics

Piezometric Surface

The standing water levels have been converted to heights above sea level and contoured to produce the piezometric surface (Fig. 8). There are several aquifers in the Cambrian carbonate sequence, and the surface illustrated in Figure 8 refers to the composite piezometric surface of the aquifer system, rather than a single aquifer. The standing water levels for individual aquifers in each bore are rarely recorded in the drillers' logs, and it is impossible to determine the piezometric

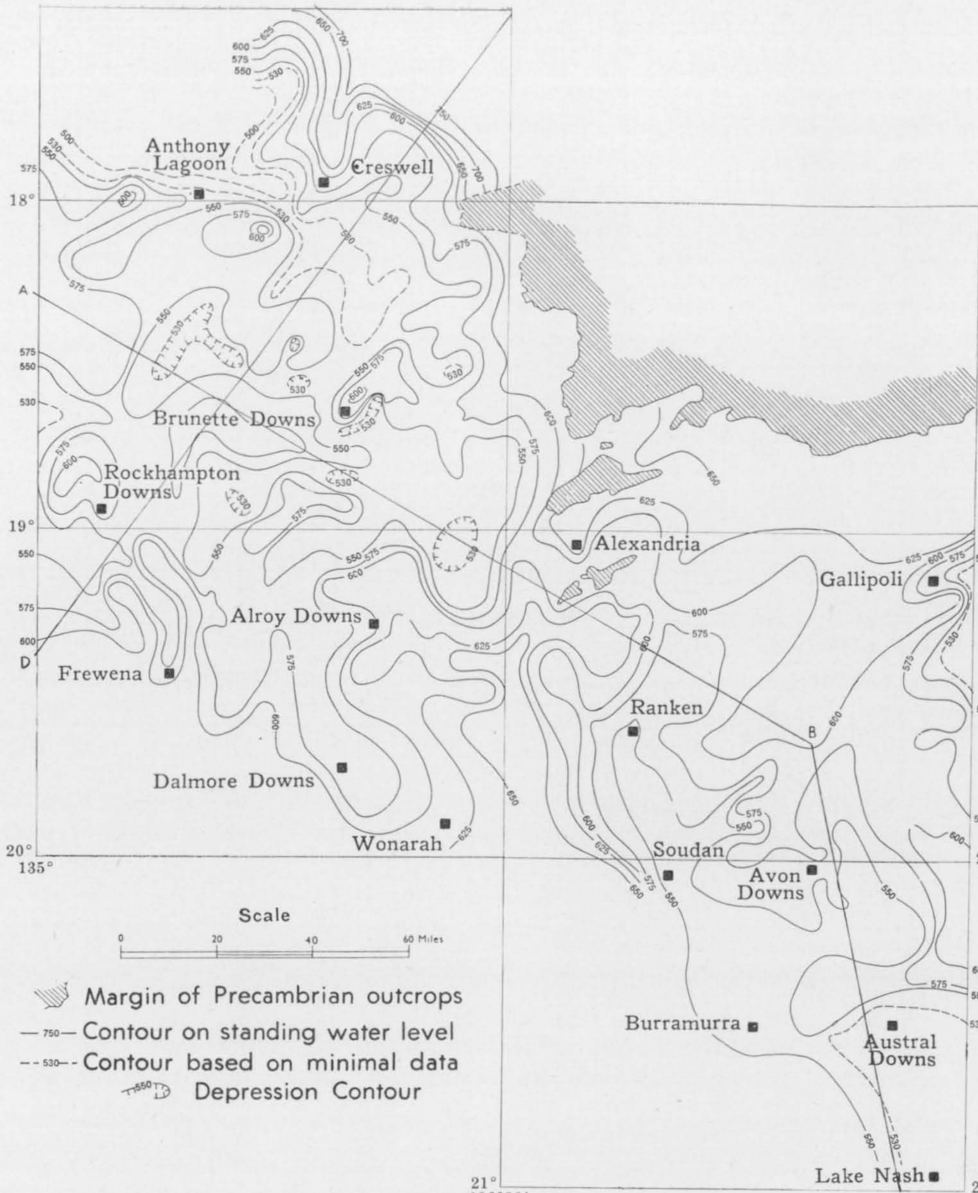

Fig. 8: Contours on the piezometric surface.

surface for each aquifer; and in any case the aquifers cannot be correlated from bore to bore. In places, the piezometric surface represents the first aquifer encountered.

In 12 widely separated bores small amounts of water were encountered at depths above the standing water levels for the deeper aquifers, but these minor perched aquifers have no connexion with the main body of groundwater.

The water in the main groundwater system is mostly confined; none of the aquifers is artesian, but most are subartesian. Table 3 lists the difference between the standing water level and the depth of the first aquifer in 193 bores.

TABLE 3. FREQUENCY DISTRIBUTION: HEIGHT OF STANDING WATER ABOVE FIRST AQUIFER

Height (ft)	Number of Bores	Percentage
Nil (no rise)	65	34
1- 10	45	66
11- 20	31	
21- 30	19	
31- 40	11	
41- 50	5	
51-100	9	
101-150	4	
150 or more	4	
Total	193	100

Of the 65 bores in which the standing water level and the first aquifer are coincident, only 11 obtain adequate supplies from the first aquifer: the other 54 were drilled deeper to obtain adequate supplies of confined water. In the 11 wells obtaining water from the first aquifer the permeability is high enough to offset the lack of available drawdown. A total of 128 bores intersected confined water in all aquifers.

The piezometric surface broadly reflects the regional physiography. The zone of high standing water levels outlined by the 600-foot contour extends from east of Alexandria homestead to near Wonarah and corresponds to the main surface divide. The groundwater system is divided into two basins—the Central Basin, which is coextensive with the Barkly Internal Drainage Basin, and the South-eastern Basin, which is coextensive with the Georgina River Basin.

The groundwater system and surface drainage systems are not intimately connected: bores along watercourses do not necessarily obtain supplies at shallower depths than other bores. But the geological structure has controlled both: the regional geological structure controls the physiography, and the piezometric surface is controlled by the distribution of the aquifers and recharge areas, which are themselves controlled by structure.

The Central Basin is outlined by the 575-foot contour in the north-west, the 600-foot contour in the south and east, and the 625-foot contour in the north-east. The piezometric surface reaches an elevation of 750 feet in a small area in the north-east, and 670 feet near Desert Creek in the south-east. The Central Basin may be connected with two small basins, one to the north of Anthony Lagoon homestead and another to the west of Rockhampton Downs homestead.

The South-eastern Basin is outlined by the 650-foot contour in the west, the 600-foot contour in the north-west, and the 625-foot contour, and Precambrian rocks, in the north. It extends beyond the southern margin of the area described. The eastern boundary has not been defined, but preliminary work indicates that it extends into the western part of the Camooweal Sheet area (Öpik, Carter, & Randal, in prep.); to the north-east, it appears to be connected to a basin corresponding with the surface drainage area of the Gregory River.

The division of the groundwater system into two basins is supported by the salinity (p. 35), chloride ion content (p. 41), ionic ratios (p. 52), and chemical types of groundwater (p. 59).

GROUNDWATER MOVEMENT

Regional

The regional directions of groundwater flow into the Central and South-eastern Basins have been established, but the directions of flow within the basins, particularly in the Central Basin where the hydraulic gradients appear to be low, are most difficult to ascertain. Although accurate elevations of the bores, standing water levels, and piezometric contours are not available, the difference in the elevation of the piezometric surface at the margins of the basins and the lowest points is very much larger than the expected errors due to the inaccuracies in the heights of the boreholes. It is assumed that groundwater flow is normal to the piezometric form lines and in the direction of fall of the piezometric surface.

In the Central Basin, the direction of flow is generally towards the centre of the basin with outlets to the north-west and west. The piezometric surface slopes to the west from the Precambian outcrops in the east, and to the north from the desert areas in the south and south-west. In the north-west, the piezometric form lines indicate groundwater movement mainly to the east with some flow to the north and south-west. Within the basin, movement is mainly directed towards an arcuate elongated area which extends from Anthony Lagoon homestead to Brunette Downs homestead and thence south-eastwards to midway between Alroy Downs and Alexandria homestead. This area corresponds with a trough in the piezometric surface which is outlined by the 550-foot contour; it has two smaller troughs extending to the west, one north-west and another south-west of Brunette Downs homestead. The 530-foot and 500-foot contours indicate that the main trough is open to the north, but within it the 530-foot contour is closed north-east of Alroy Downs homestead and in several places near Brunette Downs homestead. The main trough, and in particular the areas of closure, correspond to the most saline zones (p. 36; Fig. 10).

To the north of Anthony Lagoon homestead, where the piezometric surface is at its lowest elevation of 500 feet, the gradients indicate movement to the north away from the main part of the Central Basin. These contours may represent the southern margin of another groundwater basin to the north-west, and the 530-foot contour north-west of Rockhampton Downs homestead may indicate the presence of another basin to the west.

In the South-eastern Basin, the groundwater flows east from the desert country near Wonarah in the west, south-east from north of Ranken store, and south from the Precambrian rocks in the north. The main direction of flow within the basin is to the south, which is also the general direction of increasing salinity. To the east, the South-eastern Basin extends into the Camooweal and Mount Isa Sheet areas.

Interconnexion

In 65 of the bores, the piezometric surface lies at the level of the first aquifer, which appears to contain unconfined water (Fig. 9). In 1954, Noakes noted that there was no subartesian rise in 20 percent of the bores, and that 16 of the 28 bores showing no rise are situated in one relatively small area on Alroy

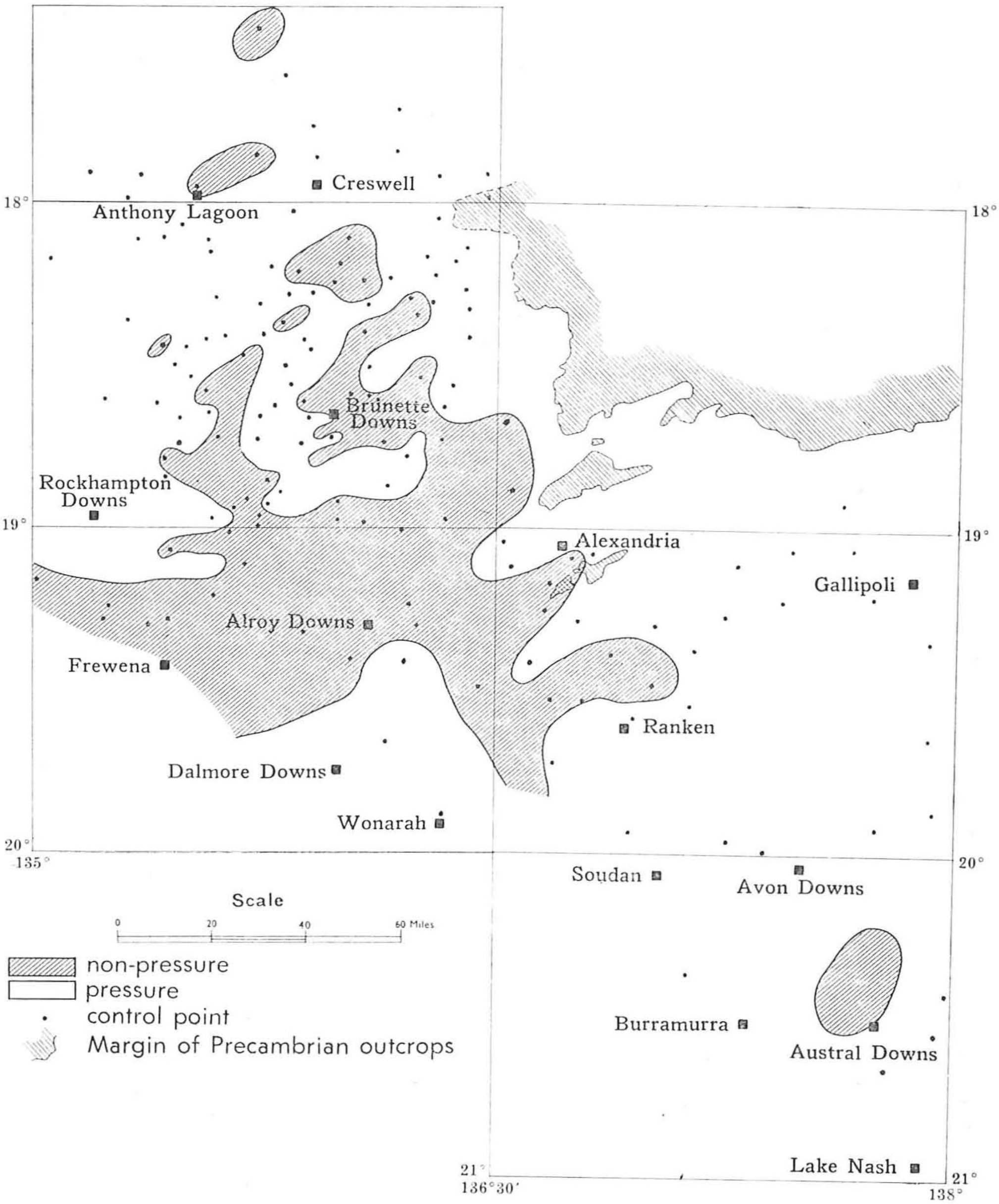

Fig. 9: Areas of confined and unconfined water from first aquifer.

station. Extensive drilling since 1947 has shown that the area is much larger than Noakes originally thought (Fig. 9). Despite the large size of this zone of unconfined water, the piezometric surface and chemical character of the groundwater appear to be continuous with the confined groundwater system over the rest of the Barkly Tableland. In 54 bores there was a rise of water above the deeper aquifers (p. 29), and the unconfined water in the first aquifer may be interconnected with the confined water in the deeper aquifers by leakage through joints, fissures, and cavities. Slow leakage may also occur across the confining beds where there is an increase in permeability.

Interconnexion is also evident in some bores where the standing water level is above the level of the first recorded aquifer: for these the logs indicate that the standing water level is the same for the various aquifers encountered. In these cases confining beds overlying the first recorded aquifer have prevented the groundwater from fully adjusting to the regional piezometric surface.

A good example of interconnexion is afforded by the stratigraphic well BMR 11 (Cattle Creek) in the eastern part of the region. This well, which was air-drilled to 525 feet, penetrated aquifers at 220-230, 280-290, 320-370, 415-425, and 515-525 feet. The standing water level for all aquifers was 191 feet. Repeated lost circulation was encountered in the well below 525 feet.

Interconnexion is suggested by the closed contours on the lowest levels (530 feet) of the piezometric surface in the Central Basin. The closures may indicate hydrodynamic sinks caused by water passing from one aquifer system into a deeper one, but they may also be due to the absence of the higher parts of the aquifer system.

The groundwater is most saline in or close to the areas of closure and depressions in the piezometric surface. If the good-quality water in the higher aquifers is exploited, interconnexion may result in the influx of the saline water from deeper aquifers if withdrawal is excessive, and the problem would have to be studied carefully.

RECHARGE

In the Central Basin, recharge appears to be from the desert country to the south, and the ridges of Precambrian rocks to the east and north-east; small areas of recharge within the basin are indicated by the closure of high-value contours south of Anthony Lagoon homestead, north-east of Brunette Downs homestead, north of Rockhampton Downs homestead, in the eastern part of Lake Sylvester, and between Rockhampton Downs and Brunette Downs homesteads. These areas are also characterized by groundwater of low salinity.

In the South-eastern Basin, recharge appears to be from the north and west. There is a small area of recharge around the headwaters of Western Creek in the east, and the trilobate spur in the 575-foot contour near Avon Downs homestead is reflected by the chemistry of the groundwater and appears to outline an area of recharge. The spur separates two depressions in the piezometric surface, one centred on the Ranken River, and the other between the James River and Happy Creek.

The recharge to the groundwater basins is governed by the amount of rainwater percolating through overlying rocks into the aquifers, or brought in from the margins of the basin by streams and subsurface flow. These factors are controlled by the annual rainfall and the characteristics of the sediments above the aquifer. Table 4 indicates the surface area of the various geological units in the intake areas, which exclude most of the Gulf Fall Division drainage, but include the areas drained by Carrara, Don, and Corporal Creeks, and the Gregory River, all of which traverse Cambrian outcrops.

TABLE 4: AREAL DISTRIBUTION OF GEOLOGICAL UNITS

Unit	Area (sq miles)	Distribution
Alluvium .... (Cza)	1000	Internal drainage lakes, some river valleys
Black soil .... (Czb)	17,000	Widespread over entire region
Sand and lateritic material (Czs, Czl)	12,000	Large areas in west, north, and south: discrete areas in black soil country
Travertine .... (Czt)	750	Southern part of region
Tertiary limestones .... (Ta, Tb, Tl)	1000	Mainly in Barkly Internal Drainage Basin; some about Alexandria homestead and Georgina River Valley
Mesozoic sandstone, siltstone, and conglomerate .... (M, Kl)	250	Northern and southern parts of region
Cambrian carbonate sandstone and siltstone (Cm, Cmb, Cmw, Cmk, Cmy, Cd)	1500	Small outcrop areas over entire region
Precambrian .... (mainly sandstone)	1500	Between Puzzle and Buchanan Creeks on eastern margin, and north of Gallipoli homestead

Noakes (1954) considers that the most likely areas of recharge are outcrops and lateritized outcrops on the margins of the basin, the upper portions of the stream channels where sand occurs over sediments, and low rises where lateritization occurred and where light-textured soils now remain. The total area of possible intake areas based on Table 4 is about 17,000 square miles, made up of 12,000 square miles of sandy and lateritic soils and 5000 square miles of outcrop. Assuming an average annual rainfall of 15 inches, and that only 50 percent of the possible intake areas are effective, the amount of rain falling on the recharge areas is 1785 $\times$ 10^9 gallons per year. If the 360 working bores draw 2000 gph continuously (17 $\times$ 10^6 gals each) the total annual withdrawal is 63 $\times$ 10^8 gallons. The amount of water required to replace the groundwater removed is about 0.35 percent of the precipitation over the effective recharge areas. This is a maximum figure, which does not take into consideration intake areas outside the region, particularly to the south, and probable intake in some of the black soil areas, and the probability that the maximum annual withdrawal for each bore would average 5 $\times$ 10^6 gallons instead of the assumed 17 $\times$ 10^6 gallons. The figure, 0.35 percent, is more than adequately compensated for any errors in the assumed average annual intake. The low value of the withdrawal to precipitation ratio indicates that the groundwater reserves are very large, and that much larger amounts could be withdrawn without serious effects.

Chemistry of the Groundwater

CHEMICAL DETERMINATIONS

Two hundred and thirty samples of groundwater were collected from selected bores during 1962: 38 of the samples were analysed by the Bureau of Mineral Resources in Canberra, and 192 by the Australian Mineral Development Laboratories, Adelaide.

Bores operated by windpumps were sampled only during periods of moderate to strong winds; engine pumps were operated for at least 30 minutes before a sample was taken. Most of the working bores sampled were operated by the stations at least once a week, but for those that had not been in operation for several weeks or longer, the sample was taken only after clear water had been flowing from the outlet pipe for 30 minutes. Samples were collected in plastic bottles and air-freighted to the laboratories shortly after collection. In some instances there was a delay of several weeks between sampling and analysis, and the pH values have therefore been ignored in this study. A sample from the turkey nest* at Brunette Downs Bore K6 was analysed by the Animal Industry Branch, Alice Springs, in October 1960. This analysis and an analysis of the water collected from the borehead in 1962 are listed in Table 5.

This comparison clearly indicates the effect of concentration by evaporation; it also shows that this effect varies for different components. This is probably caused by variations in solubility products, by fixation of constituents by living matter in the water, by base-exchange reactions with the clayey walls of the tank, by the length of time between successive periods of pumping borewater into the tank, and by the duration of the periods of pumping.

The variations show the futility of sampling the turkey nest to ascertain the geochemistry of water in the aquifers, though it may give a truer picture of the

TABLE 5: ANALYSES OF WATER FROM BRUNETTE DOWNS BORE K6

	Borehead (ppm)	*Turkey Nest* (ppm)	*Difference* %
Sodium	937	1248	+33
Potassium	50	54	+ 8
Calcium	215	289	+35
Magnesium	141	206	+46
Chloride	1365	1820	+33
Sulphate	983	1442	+49
Bicarbonate	297	285	− 4
Carbonate	Nil	Nil	—
Fluoride	4.75	4.0	−18
Total dissolved solids	3900	5349	+27
pH	7.35	7.8	—

content of the water the stock are actually drinking at the time of sampling. The chemistry of recently-pumped water from the bore is the best guide for comparison between bores provided it is realized that it indicates the minimum concentration of total solids the stock will receive. These variations also indicate the need for continual sampling throughout the year of surface waters (or groundwater stored at the surface) if these are used for extensive agriculture.

In addition to the sampling by the Bureau, some of the borewaters had previously been sampled by station staff and drillers, and forwarded for analysis to the Animal Industry Branch (AIB), Alice Springs. Several station managers consider that some of the samples were taken from the turkey nest, or incorrectly labelled, or taken in contaminated containers. In the case of sampling on completion, errors can be introduced by the use of contaminated containers, or by contamination by drilling fluids and aquifers in upper levels.

* A raised circular or square earth tank for storage of water from bores.

Because of these potential sources of error and the age of many of the AIB analyses, many of the bores were re-sampled in 1962. Thirty-five AIB analyses have been selected and are included in this study. Another 7 AIB analyses have been included for comparison.

About half of the 1962 samples were analysed for 20 ions and the remainder for 10 ions. In addition the pH, total dissolved solids, and specific conductivity were determined for all samples, but these data are not always recorded on the AIB analyses.

Total Dissolved Solids

The total dissolved solids (TDS) listed in Appendix 2 have been determined by evaporation to dryness at 180°C. The TDS provides a general indication of the salinity of a water sample and is used as the general guide of water quality.*

The salinity tolerance for domestic use varies from area to area. Rainwater & Thatcher (1960) report that the US Public Health Service recommends a maximum of 500 ppm but permits 1000 ppm. Ward (1951) has discussed various opinions on the salinity of domestic water supply, and much depends on the tolerance of the individual and on what the individual expects; the specifications determined by E. S. Simpson in Western Australia are as follows:

Water for a large town	70 gr/gallon (1000 ppm)
Water for a small town	105 gr/gallon (1500 ppm)
Water for individual farms	210 gr/gallon (3000 ppm)

Jephcott (1956) gives the same figures, and considers 3000 ppm as a maximum limit if the consumer is used to saline water. In any case the potability of saline waters is generally determined by the concentration of one or more individual ions, and a perfectly palatable water may be rejected because of a high concentration of some harmful constituent.

Tolerances for stock vary, but most Australian workers agree within close limits; variations occur mainly through the type of feed available to the stock, season of the year, and climate. Ward (op. cit.) gives the following figures determined by Dr R. L. Jack:

Horses in work	437 gr/gallon (6250 ppm)
Horses at grass	547 gr/gallon (7800 ppm)
Cattle	656 gr/gallon (9400 ppm)
Sheep on saltbush feed	857 gr/gallon (12,400 ppm)
Sheep on grass feed	1094 gr/gallon (15,650 ppm)

As with water for human consumption, the usability of water for stock purposes, as determined by TDS, is still subject to acceptable concentrations of certain individual constituents. These are discussed later.

No land is cultivated in the Barkly Tableland except for small vegetable plots on some stations. The plants grown are tolerant to the local water supplies, and by the rotation of plots acceptable results are obtained.

The salinity of the borewaters in terms of the total dissolved solids is given in Appendix 2. Isosalinity contours are given in Figure 10. The total dissolved solids range from 31 ppm for Alexandria No. 47 to 10,850 ppm for Brunette Downs D10.

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* The concentration of individual constituents must be taken into account in determining the suitability of water for specific purposes.

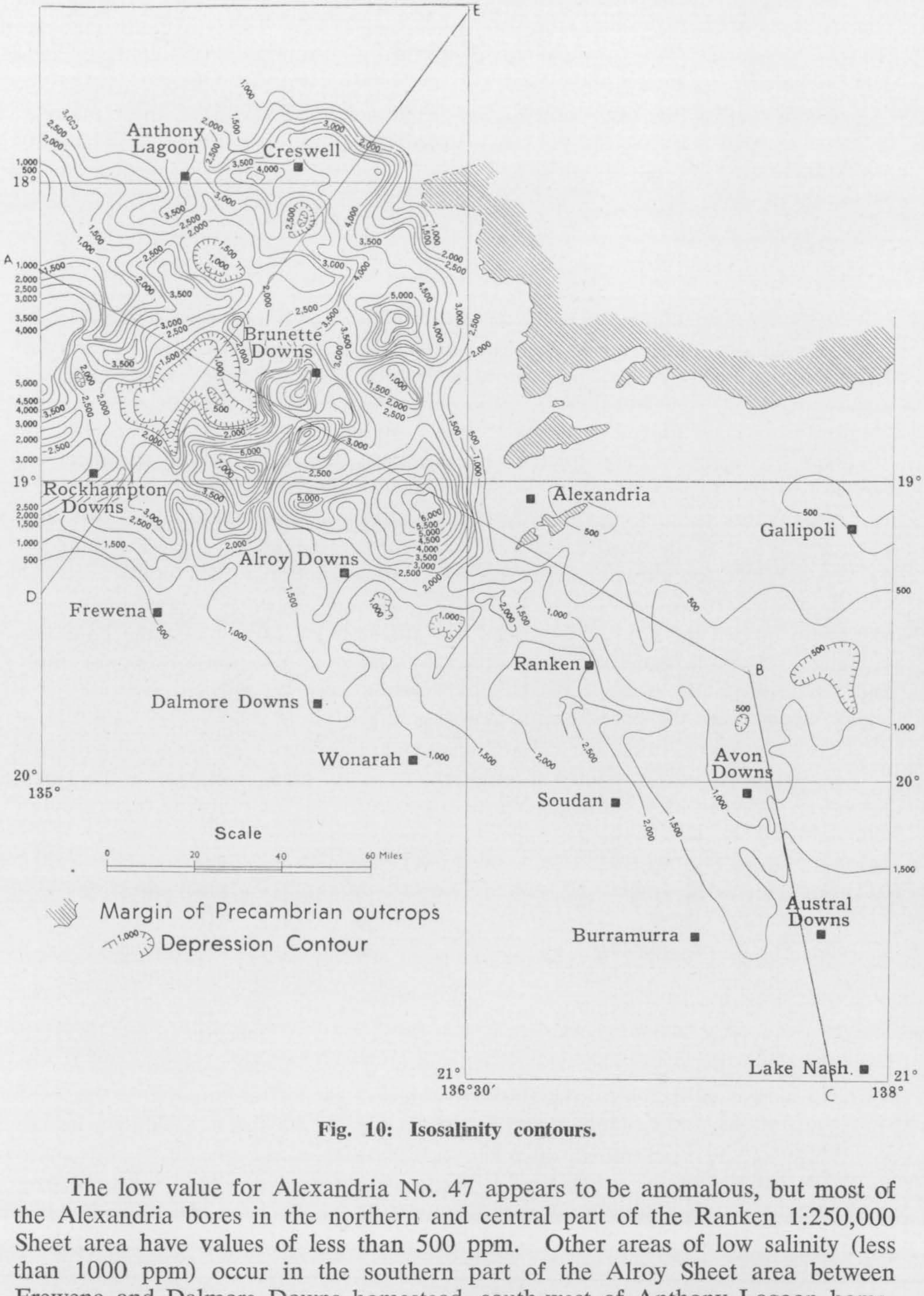

Fig. 10: Isosalinity contours.

The low value for Alexandria No. 47 appears to be anomalous, but most of the Alexandria bores in the northern and central part of the Ranken 1:250,000 Sheet area have values of less than 500 ppm. Other areas of low salinity (less than 1000 ppm) occur in the southern part of the Alroy Sheet area between Frewena and Dalmore Downs homestead, south-west of Anthony Lagoon homestead, between Brunette Downs and Rockhampton Downs homesteads, and in a linear discontinuous belt trending north-north-west from Alexandria homestead along the eastern margin of the Internal Drainage Basin. An area of moderately high salinity occurs north-east of Alroy Downs homestead (6000 ppm), two occur south-west of Brunette Downs homestead (7000 ppm), and one north-east of Brunette Downs homestead (Fig. 10). Areas of moderate salinity are outlined by the 4000-ppm contour, mainly in the western and central part of the region. Most of the water in the western part of the region is unpalatable to humans; an area of groundwater with a salinity of over 3000 ppm extends from near Anthony Lagoon eastwards to Creswell Downs homestead, southwards through Brunette Downs to north-east of Alroy Downs homestead; thence it swings westwards and in discontinuous areas extends to the west and north of Rockhampton Downs homestead. This general trend is observed in the values of individual constituents discussed later. The partial, but abrupt, westerly displacement of the contours east of Brunette Downs homestead is also apparent in other sets of contours.

Schoeller (1959) considers that the total salinity is a function of both the transit of water through the aquifer (i.e. the time of contact) and the availability of soluble material in the aquifer. Water in or near the recharge areas can be expected to contain smaller amounts of dissolved matter than water which has progressed farther through the aquifer. Water in areas of low hydrodynamic gradients will contain more dissolved matter than waters elsewhere, and the highest concentrations of dissolved matter will occur where the water is stagnant or semi-stagnant. Schoeller also notes the effect of climate, saline content of the water reaching the aquifer, pore space, and other factors.

The isosalinity contours (Fig. 10) show a general regional similarity to the piezometric surface (Fig. 8). The belt of low salinity (less than 1000 ppm) between Wonarah and Alexandria homestead lies between two areas of higher salinity, to the west and south-east. The area of low salinity corresponds to an area of high piezometric surface which strikes northwards from between Wonarah and Soudan homestead, and with deviations passes to the east of Alexandria homestead (Fig. 8).

The western area of higher salinities broadly corresponds to the groundwater basin centred on the Barkly Internal Drainage Basin as outlined by the piezometric surface, and the salinity and piezometric surface are reciprocally related. On the north-eastern, eastern, and southern margins the fall of the piezometric surface is accompanied by a marked rise in the content of total dissolved solids. This is particularly evident in the north-eastern part, which is a probable recharge area or close to the recharge area. The belt of moderate to moderately high salinity values as outlined by the 3000-ppm contour closely approximates an area of low piezometric surface as outlined by the 550-foot contour. The 550-foot contour also outlines the saline areas to the west and north-west of Rockhampton Downs homestead. The 530-foot contours outline in part the areas of highest salinity, suggesting stagnation or semistagnation of some of the groundwater. In the vicinity of Anthony Lagoon homestead an increase in the salinity in a northerly direction is accompanied by a slope in the piezometric surface from above 550 feet to below 500 feet. An area of low salinity (1000 ppm) to the west and south-west of Anthony Lagoon homestead is outlined by an area of high piezometric surface (575 feet above sea level). A probable recharge area outlined bv the 575-foot contour, west of Brunette Downs homestead, is well reflected by an area of low salinity outlined by the 1000-ppm and 500-ppm contours. The displacement of salinity contours and the consequent peninsula of low salinity values east of Brunette Downs homestead is repeated, but to a lesser extent, in the elevation of the piezometric surface.

The south-eastern area of higher salinities corresponds to the groundwater system which appears to be coextensive with the Georgina River Basin. Salinities increase in a south-easterly direction, and the elevation of the piezometric surface decreases. An area of low salinities (500 ppm) in the northern part of the Ranken Sheet area corresponds to an area of high piezometric surface (600 feet above sea level), and suggests a recharge area. Two lobes in the 1000-ppm contour near Avon Downs homestead are reflected, though attenuated, by lobes in the 550-foot contour of the piezometric surface.

The relationship between the total dissolved solids and the position of the water in the hydrodynamic system as indicated by the standing water level is amplified in the discussion on the chemistry of the waters.

Specific Conductivity

The specific conductivities listed in Appendix 2 have been determined at 25°C. The conductivity of a water solution is a function of the dissolved matter in the solution and is largely controlled by ionic dissociation and the concentration of the solution. For simple solutions there is a simple relationship between concentration and conductance, the graph of which is linear for low concentrations; but for increasing concentrations the slope of the graph will alter by an amount and direction which varies for different salts. In addition, the linear relationship is different for various salts (Hem, 1959). Consequently, no simple exact relationship can be expected between specific conductivity and total dissolved solids in such heterogeneous solutions as may be found in borewaters. Waters which contain one very dominant anion and one very dominant cation may tend to give a simple relationship, but such waters are rare. The ratio of total dissolved solids (in ppm) to specific conductance (in μmhos at 25°C)—'A'—lies between 0.5 and 1.0, and usually between 0.55 and 0.75 (Hem, 1959).

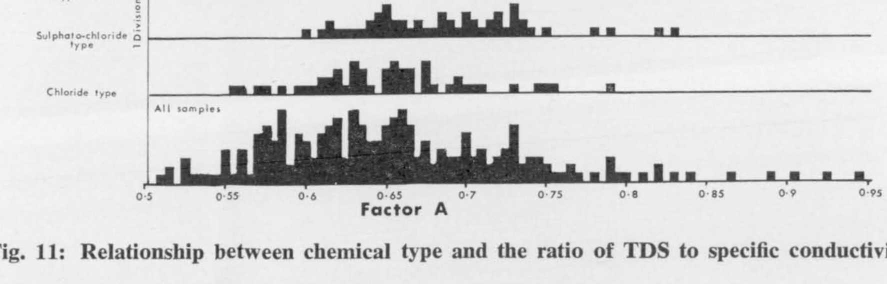

Fig. 11: Relationship between chemical type and the ratio of TDS to specific conductivity.

The ratio for the groundwaters on the Barkly Tableland was found to range from 0.5 to 0.945, but only 16 percent lies outside the range 0.55 to 0.75. Figure 11 shows the frequency distribution of this ratio for the nine chemical types of water. The chloride-type waters are ranged about the centre of the diagram between values 0.555 and 0.785; the sulphate waters range over the right hand side of the diagram between 0.745 and 0.945, and the bicarbonate waters lie to the left between 0.51 and 0.74 (85 percent between 0.51 and 0.645). The sulphato-chloride waters show a slight shift to the right, and those in which bicarbonate is the secondary anion tend to move to the left. The variations are more marked with the sulphate-type waters, and are less well defined in the bicarbonate waters. The variation of the ratio is also modified by the cationic content of the solution, which may also partly explain the wide range in values.

Both the TDS and specific conductivity can be measured in the field by portable equipment, and can be used as a guide to sampling.

Specific conductivity may be used as a quick field check on bores which have been previously sampled. A variation of 10 percent or more in the value indicates a substantial change in salinity, which should be checked immediately by a field salinometer. An increase of salinity is likely to be caused by the influx of water of a different chemical type from another aquifer, and waters showing such a variation should be forwarded to a laboratory for a complete analysis. When field values of specific conductivity are compared with those tabulated in a laboratory determination a temperature correction must be applied: conductivity increases by 2 percent for every 1°C rise in temperature.

Sodium and Potassium

In the BMR and AMDL analyses, sodium and potassium have been determined by flame-photometry; the method used by the Animal Industry Branch is not known, but because of some imbalance between anionic and cationic values in epm* the alkali content is probably given as determined rather than computed values. For some of the earlier AIB analyses, in which sodium and potassium were not determined, computed equivalents have been calculated to enable the samples to be classified (See Appendix 3).

Rainwater & Thatcher (1960) state: 'sodium is not particularly significant in drinking and culinary water except for those persons having an abnormal sodium metabolism'. E. W. Moore (in Rainwater & Thatcher, 1960) reports 1000-2000 ppm of potassium as the limit in drinking water. It is highly probable that water would be condemned because of the concentration of some other component long before it was rejected for high soda or potash content.

The tilth and permeability of soils are seriously affected if waters containing high concentrations of sodium are used for irrigation. The sodium in the water is exchanged by calcium and magnesium in the soil, and the resulting alkaline soil becomes rich in sodium and deficient in calcium and magnesium. The effect is lessened as the magnesium and calcium content of the water is increased. The sodium absorption ratio $[Na^{+}/(\frac{1}{2}\ Ca^{++} + \frac{1}{2}\ Mg^{++})^{1/2}]$ is used by soil scientists to gauge how waters may affect the soils ('sodium hazard'), and its application is discussed by Hem (1959). The sodium absorption ratios have not been calculated, because no irrigation is planned on the Tableland. The chloride waters around

* equivalents per million.

Brunette Downs are very high in sodium relative to calcium and magnesium and would have a high salinity and sodium hazard. If agriculture is undertaken even on a small scale, it may prove worthwhile to utilize the shallower aquifers, which are believed to contain less saline water than the deeper aquifers.

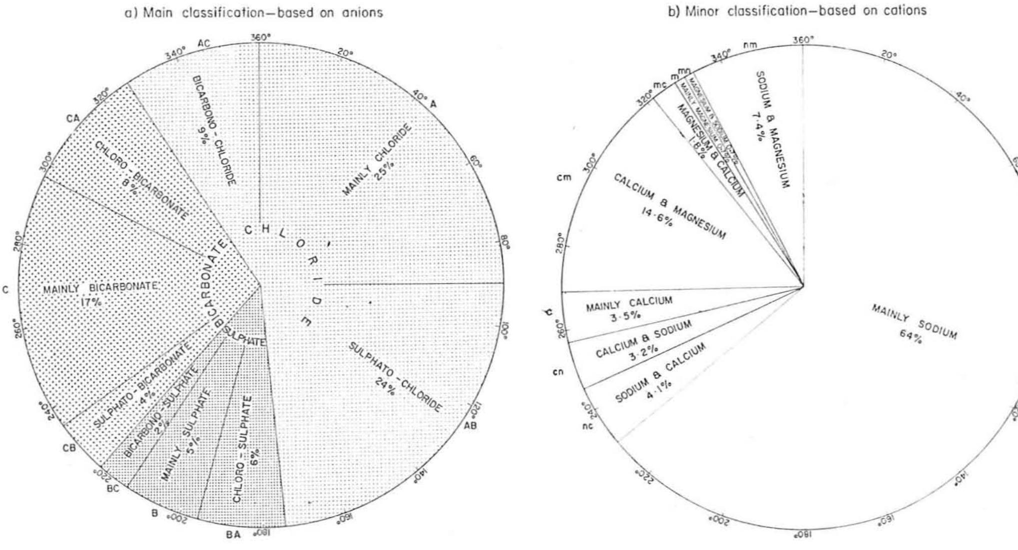

Fig. 12: Distribution of chemical types of borewater.

The sodium content ranges from 11.9 ppm in Alexandria No. 39 to 2790 ppm in Brunette Downs D10*. (Alexandria No. 47 has 6.1 ppm sodium, but the sample, which contains only 31 ppm of TDS, is anomalous). Sodium is the dominant cation in the groundwaters of the Barkly Tableland (Fig. 12): it is the dominant cation in all but fourteen of the thirty-one chemical classes of waters (p. 61), and in eight of these fourteen the difference between the sodium concentration and that of the major cation is less than 10 percent of the total cationic concentration. The highest potassium concentration is 160 ppm in Brunette Downs No. D44. The potassium content generally varies directly with the sodium content, and in classifying the water types the potassium and sodium equivalents have been combined.

Hem (1959) considers that waters associated with carbonate rocks are normally low in sodium unless evaporites are also present. Sodium can be released from a carbonate rock only in proportion as calcium and magnesium are taken into solution: and as their solubility is comparatively low, the sodium content of the water also remains low. Only if considerable amounts of shale or silt are contained in the sequence does the sodium content rise; and sodic clays will increase the content still further by base exchange with calcium and magnesium. In point of fact the drillers' logs of bores in the Internal Drainage Basin indicate a greater proportion of non-carbonate rocks in the sequence than is apparent in the outcrops.

*This bore, though equipped in 1960, has been abandoned because of the high salinity.

Calcium

All the water samples have been analysed for calcium, and if strontium has not been determined it is included with calcium.

Calcium is not significant in determining the potability of water for humans or stock if it is present as sulphate or bicarbonate; if present as chloride it is harmful to stock, but not many waters have an excess of calcium over sulphate plus carbonate. Calcium gives little or no taste to water, and even high concentrations do not seriously detract from its palatability.

Calcium is important in agriculture: it lowers the sodium absorption ratio of waters and soils and tends to counteract the effects of sodium in base exchange reactions (p. 39). Calcium and magnesium cause hardness in water: temporary hardness is caused by the bicarbonates of calcium and magnesium, and permanent hardness by the sulphates and chlorides.

Calcium is an important constituent of the borewaters of the Barkly Tableland (Fig. 12) and has been used in the subclassification of the water groups. It is the dominant ion in eight of the thirty-one classes, but is subordinate to both sodium and magnesium in seven of them. It is dominant in three bicarbonate types, in three sulphate types, and in two chloride types. Hem (1959) considers that high calcium associated with high sulphate may indicate gypsiferous deposits in the aquifer; he also suggests that low values of calcium may indicate base exchange between water and aquifer.

The calcium content ranges from 2.9 ppm in Alexandria No. 47 and 31 ppm in Brunette Downs D39 to 634 ppm in Rockhampton Downs No. 22. The relationship between calcium and magnesium and its indication of dolomite and dolomitic rocks is discussed on page 54.

Magnesium

The magnesium content of water for consumption by humans and stock is important because of its cathartic and diuretic properties. A high concentration of magnesium can cause scouring in cattle, and Jephcott (1956) recommends the following limits for stock: 300 ppm for horses, 400 ppm for cattle, and 500 ppm for sheep; he lists domestic limits at 125 ppm for cities, and 200 ppm for small towns and stations. The US Public Health Service (quoted in Rainwater & Thatcher, 1960) recommends 125 ppm.

Magnesium is beneficial in waters used for agriculture: it flocculates the soil colloids and maintains good soil structure and permeability; and it complements calcium in reducing the sodium hazard in irrigation waters.

The borewaters of the Barkly Tableland have a magnesium content ranging from 2.3 ppm in Alexandria No. 47 and 21.7 ppm in Anthony Lagoon No. 18 to 424 ppm in Brunette Downs D20. The magnesium content, though it may cause some discomfort to humans, presents no serious stock problems. The relationship between magnesium and calcium in waters from the carbonate rocks is discussed on page 54.

Chloride

The chloride ion is the predominant anion in the borewaters of the Barkly Tableland (Fig. 12). It is the major anion in eight of the classes, secondary to sulphate in six, secondary to carbonate in ten, and is the minor anion in only seven.

Fig. 13: Concentration of chloride ion in equivalents per million.

The ion is mainly responsible for the unpleasant taste of many of the borewaters in the central and western parts of the region, and renders many of them unsuitable for continuous domestic use. Some of the borewaters are also unfit for human consumption because of the high content of sulphate, magnesium, or fluoride. Chloride ion imparts a distinct salty taste to water, but the threshold of detection varies with the individual. Rainwater & Thatcher (1960) report 250 ppm as the limit for water for domestic use; Jephcott (1956) gives the same figure for city water supplies, and 375 ppm and 750 ppm for town and station supplies respectively. Magnesium chloride can be dangerous in boilers or hot-water systems because on heating it produces hydrochloric acid; excessive chloride in water can corrode and tarnish fittings. Chloride can be harmful to stock if present as calcium or magnesium salts; referring to sodium chloride, Jephcott (1956) writes 'if the content does not pass 75 percent of the total maximum tolerance of soluble salts stock suffer no injury'. Chloride ion can be injurious to some crops, and is considered to be twice as toxic as sulphate.

In the borewaters of the Barkly Tableland the chloride concentration ranges from 7.1 ppm in Alexandria No. 47 and 13.4 ppm in Alexandria No. 39 to 3860 ppm in Brunette Downs No. D20. The distribution of chloride ion in equivalents per million is shown in Figure 13. There is a strong similarity between the chloride ion contours and the isosalinity contours, which emphasizes the predominance of the chloride ion in the total salinity of the borewaters. The high values (greater than 30 epm, i.e. 1065 ppm) extend in a sigmoidal belt from about Creswell Downs homestead southwards through Brunette Downs homestead to north of Alroy Downs homestead, from where the belt swings westward to north of Frewena, with an isolated area north-west of Rockhampton Downs homestead. The areas of high chloride content correspond approximately to the areas of high TDS, and the highest chloride values (50 epm) broadly correspond to the very high TDS values (6000 ppm).

The probable direction of groundwater flow indicated by the piezometric surface and isosalinity contours is also reflected by the contours of the chloride ion content. The separation of the region into two basins is evidenced by the marked constriction in the 15-epm contours south-west of Alexandria homestead. The probable areas of recharge in the north-east, east, south, and north-west are outlined by the 1 and 5-epm contours, as is the probable recharge area west of Brunette Downs homestead. The ridge of low salinity values east of Brunette Downs homestead (Fig. 10) is reflected by a similar trend in the chloride values. In the east, the chloride content and total salinity increase to the south.

The origin of the chloride in groundwater is uncertain. The contrast of the abundance of chloride in natural waters, including the oceans, with the low chloride contents of most rocks has been discussed by Hem (1959).

The occurrence of chloride in rainwater has been established, and the term cyclic salt has been used for the minute particles of salt derived from ocean spray, and returned to the ground by subsequent showers of rain. Hem (1959) has shown that the concentration of cyclic salt in rainwater decreases progressively inland. The rain on the Barkly Tableland originates off the coast with the north-west monsoon. The nearest point on the coast is about 150 miles to the north-east of the Tableland, and it seems unlikely that the chloride in the groundwater was derived from rainwater. Some concentration by evaporation may occur, but it does not explain the apparent rapid increase in the concentration of chloride ions during the passage of groundwater through the aquifers. It is unlikely that concentration by evaporation would produce the high concentrations of chloride encountered in the borewaters, because the chloride contents of two samples of surface-waters taken towards the end of the dry season were found to be only 1 and 15 ppm (see p. 17).

Because of the abundance of chloride in sea water, marine sediments may contain large amounts of chloride ion, either as salts in connate water or adhering to mineral particles; chlorides are also common in evaporites. The Cambrian rocks on the Barkly Tableland are marine in origin, but it is improbable that the groundwater is connate. The most likely sources of the chloride are the chloride salts in the rocks and interbedded evaporites. Some of the dolomitic rocks were possibly deposited under evaporitic conditions (Randal & Brown, 1962c), and gypsum, which is often associated with evaporites, is known in the sequence. Other possible sources of chloride are the marine transgression, and the development of extensive brackish lakes during the Mesozoic (Skwarko, 1965). The vertical transmissibility of the seabed or lake floor may have been very low, but the existence of the sea and lakes for long periods may have facilitated the entry of large volumes of water into the Cambrian rocks. Subsequent leaching of the surface sediments after the drying-up of the sea and lakes would introduce further dissolved matter into the groundwater system.

Sulphate

The determination of sulphate is necessary because of its cathartic effect on humans; sulphate has some effect on cattle, but it partly offsets the toxicity of selenium. The US Public Health Service recommends an upper limit of 250 ppm of sulphate in water for domestic use (Rainwater & Thatcher, 1960); Jephcott (1956) gives the same figure for city water supplies, 375 ppm for small towns, and 500 ppm for stations.

Sulphate in groundwater can be derived from gypsum and anhydrite, which are common in evaporitic sediments, and from the oxidation of sulphides in shales. Sulphate may be present in evaporitic sediments as soluble salts of sodium, potassium, and magnesium. In semiarid areas, surface waters may be heavily charged with salts because of the incomplete leaching of the soils and the accumulation of soluble weathering products in the soil. Most salts are affected by low runoff, and sulphate is the ion most affected (Hem, 1959). Gypsum crystals are widespread in the black soils in many parts of the Barkly Tableland, and the water in Long Waterhole has a very high sulphate content. Some of the surface waters may have contained considerable amounts of sulphate before they entered the groundwater system, but the high concentration of sulphate in the central parts of the basin suggest that most of the sulphate has been acquired during transit through the aquifers. Some of the drillers' logs record gypsum at or near the main supplies, and pyrite is known in some of the shales and carbonate rocks.

The sulphate content ranges from 1.6 ppm in Alexandria No. 47 and 13.6 ppm in Creswell Downs No. 14 to 3485 ppm in Brunette Downs No. D10. Contours on the sulphate content in equivalents per million are shown in Figure 14. The upper limits for city, small town, and station water supplies are 5, 7.5, and 10 epm respectively. Most AIB analyses in which sulphate is above 250 ppm (about 5 epm) carry the remark that the water is not suitable for human consumption, but even if Jephcott's (1956) more liberal figure of 500 ppm (about 10 epm) for station supplies is accepted, Figure 14 shows that the water from many of the bores is unsuitable for continuous human consumption. The zones of high sulphate include most of the Brunette Downs Sheet area, the southern part of the Wallhallow Sheet area, the northern part of the Alroy Sheet area, and a

Fig. 14: Concentration of sulphate ion in equivalents per million.

small area west of Ranken store, but some of the bores in these areas have provided drinking water for homesteads for many years, despite the high sulphate content.

The contours of the sulphate content reflect features already noted in the sets of contours previously discussed. A saddle in the 5-epm contour between Alexandria homestead and Wonarah tends to divide the region into two separate basins, but the lack of information in the south-east prevents a detailed assessment of the trends between Wonarah and Ranken store. Nevertheless, low values in the northern part of the Ranken Sheet area give way to higher values in the south. Areas of recharge and directions of groundwater flow, as postulated from increasing sulphate content, conform to the patterns previously established from contours on other parameters, and again there is a ridge of low values east of Brunette Downs homestead.

Further discussion on the sulphate ion is given on pages 56 and 63.

Bicarbonate

All the borewaters were analysed for bicarbonate and carbonate, but carbonate was detected in only one sample. A sample from Rockhampton Downs No. 11 was analysed by the AIB in 1956 and contained 35 ppm of carbonate and 229 ppm of bicarbonate, but its pH was not recorded; normally carbonate ion is not present in waters below pH 8.2.

The bicarbonate is determined by an alkalinity titration and the result may include an equivalent amount of the alkalinity due to the presence of silicates, phosphates, borates, and ferrous chloride, which hydrolize. However, silica, phosphorus, boron, and iron make little difference to the total alkalinity in these borewaters, and A. D. Haldane (BMR, pers. comm.) considers that the bicarbonate values provide a valid comparison between the bicarbonate contents of the borewater samples.

The bicarbonate ion is not physiologically important to man or stock, but magnesium and calcium bicarbonates contribute to the temporary hardness of the water. The deposits in the boilers of some of the old steam engines used for driving the bore-pumps are due to the presence of magnesium and calcium bicarbonates.

The bicarbonate content ranges from 21.4 ppm in Alexandria No. 4 and 98 ppm in Avon Downs No. 14 to 658 ppm in Dalmore Downs No. 9, originally drilled as Barkly Highway No. 14A. Carbonate and bicarbonate ions, derived from carbonate minerals and atmospheric carbon dioxide, are present in most surface waters and groundwaters; but Hem (1959) states that waters in limestone terrains do not commonly exceed about 500 ppm (i.e. about 8 epm). This is confirmed by the contours (Fig. 15); for the only values above 8 epm are in a large area on the Alroy Sheet area and small areas west of Brunette Downs, south-west and south of Anthony Lagoon homestead, and north of Creswell Downs.

The bicarbonate contours present a somewhat confused pattern and do not apparently conform with those of other anions. A constriction in the 6 epm contours west of Alexandria homestead tends to divide the region into two areas, but the high values to the south-west of this constriction are not fully repeated to the north-east, and consequently the effect is masked. In addition numerous lobes on the 5-epm contour in the Brunette Downs Sheet area mask the general trends of the contours.

The bicarbonate values generally decrease in the probable direction of groundwater flow, and during the transit of the groundwater through the aquifer, the carbonate or bicarbonate is apparently replaced by sulphate. Values of 4 epm or less generally correspond to the most saline areas indicated by the isosalinity and chloride contours, except in the east.

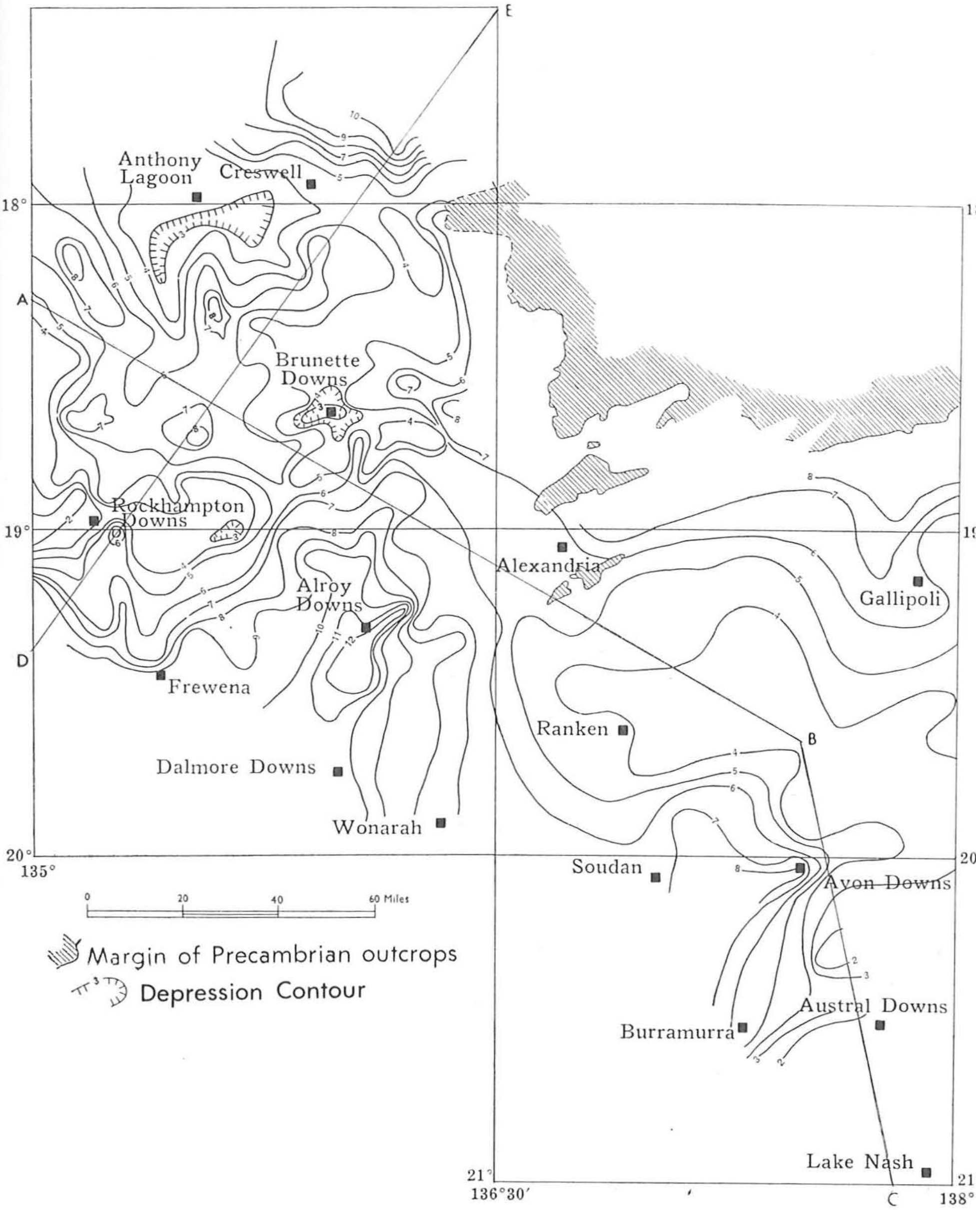

Fig. 15: Concentration of bicarbonate ion in equivalents per million.

The bicarbonate content is discussed further on pages 59 and 64.

Fluoride

The fluoride content of waters, especially of water for domestic consumption, has been the subject of considerable controversy in recent years. Excess fluoride is harmful to humans and animals, and the safe limits are uncertain. Jephcott

(1956) states that 'Fluorides are a source of controversy but broad limits can be suggested. The best values are about 1 ppm, although in an arid climate, like Central Australia, a limit of 0.8 ppm is sometimes set. If people are willing to accept the pitting or mottling of teeth, the limit can be raised to 2 ppm'. With respect to stock he says 'The upper safe limit is considered to be 6 ppm with a safe breeding level of 4 ppm. This is an arbitrary figure as stock are known to live

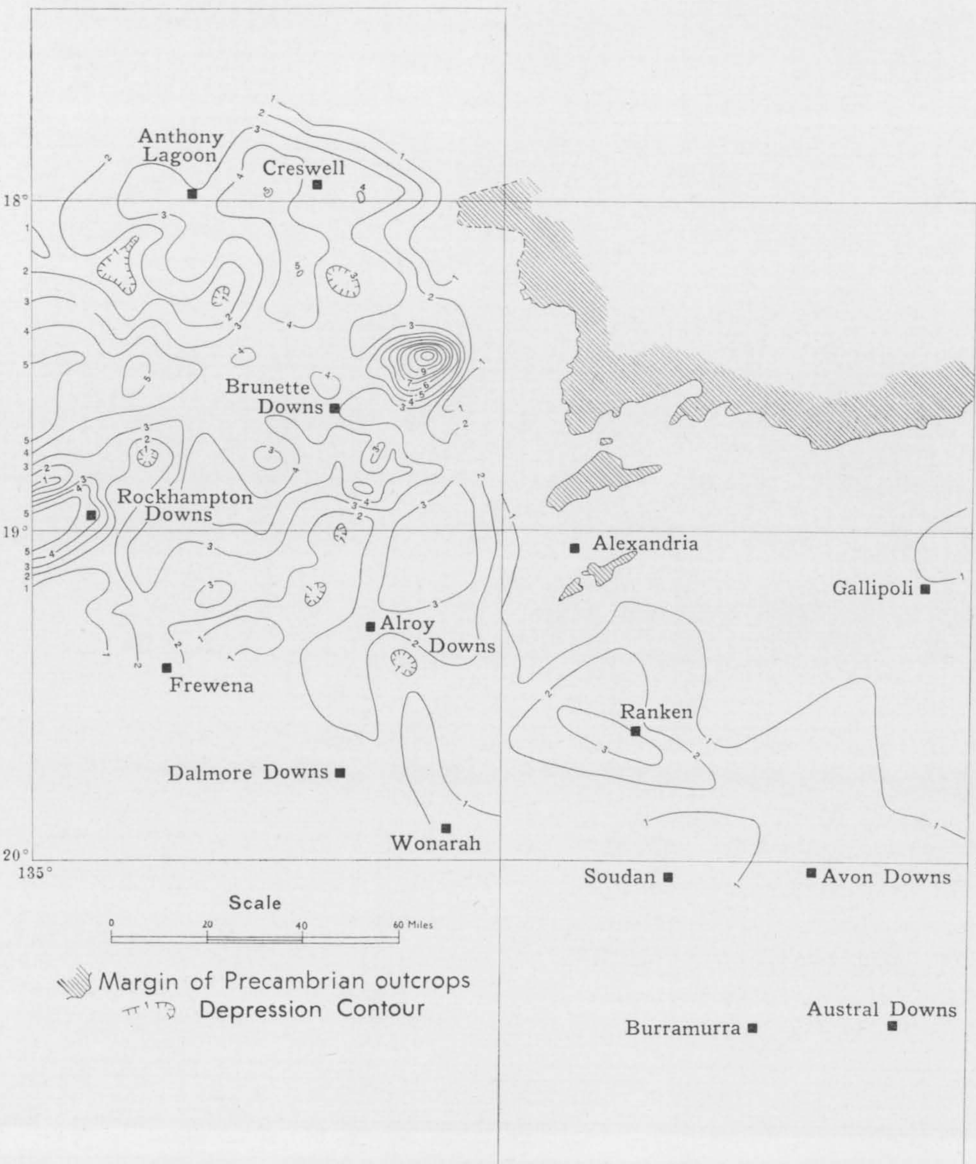

Fig. 16: Concentration of fluoride ion in parts per million.

at a level of 15 ppm without ill effects. The diet may influence the issue by converting the fluorine into non-utilizable forms, as in the case with aluminium salts'. The South Australian Department of Mines reports that cattle ingest 5 to 10 ppm of fluoride in the Maree-Birdsville area without apparent ill-effects, but that sheep have been seriously affected by the fluorine content of water (Dep. Min., 1959). Fluoride is not generally toxic to plants.

The fluoride content ranges from 0.05 ppm in Alexandria No. 47 to 12.1 ppm in Brunette Downs No. 49. Low values of 0.1 ppm occur in Creswell Downs No. 14, and Alexandria No. 4 and No. 12.

Figure 16 shows contours of the fluoride content in parts per million: two areas are outlined by the 1 ppm contours between Alexandria homestead and Wonarah, and these areas broadly correspond to the divisions previously noted in other sets of contours. Increasing fluoride content is related to the direction of groundwater flow and increasing salinity. There is sufficient diversity between the fluoride contours and the others to suggest that the fluoride content of the waters varies in part because of changing fluoride content of the aquifers, but analyses of aquifer rocks will be required to confirm this.

Even if an upper limit of 2 ppm of fluoride in domestic water is accepted, most of the borewaters in the western part of the region and a small area about Ranken store are unsuitable for human consumption, and many of the homesteads use water above the recommended limit.

Silica

Silica is not physiologically significant to humans or stock. The silica content of waters used for irrigation is unimportant, but waters used in industry, especially in boilers, should be low in silica.

The silica in groundwater is commonly derived from the weathering or reconstitution of silicate minerals, particularly feldspar, and from the solution of cryptocrystalline forms of silica such as chert and chalcedony. Chert is probably the main source of the silica in the borewaters on the Barkly Tableland. Chert bands and nodules occur in most of the Cambrian carbonate rocks, especially the Camooweal Dolomite, and are abundant in the Tertiary carbonate rocks. Many of the carbonate rocks have been silicified and the porosity is commonly due to partial solution of the rock. The secondary silica occurs as tiny quartz crystals in vugs in some of the carbonate and silicified carbonate rocks. Cambrian rocks at or near the laterite profile are extensively silicified.

Silica has been determined in all samples analysed by AMDL and BMR. Values range from 10 ppm in nine bores to 65 ppm in Brunette Downs D5 and 64.5 in Dalmore Downs No. 8*. Contours in parts per million are given in Figure 17: west of Alexandria homestead a saddle in the contours divides the region into the same two areas as are demarked by contours of other ions. An interesting feature is the general decrease in silica content in the directions of increasing salinity.

Boron

Boron is not physiologically important to humans or stock in the concentrations normally encountered in natural waters: Hem (1959) considers concen-

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* Originally Barkly Highway No. 18A.

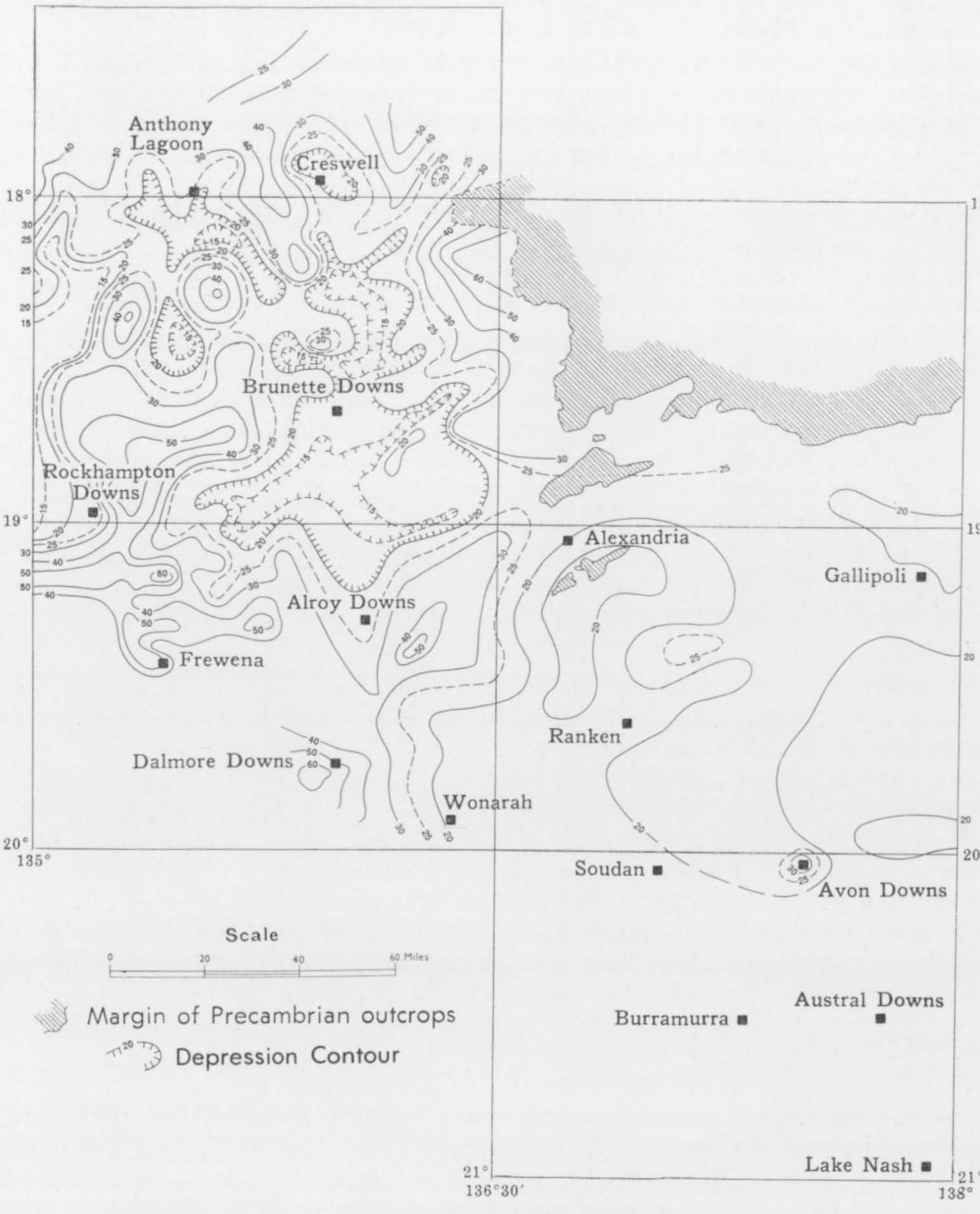

Fig. 17: Concentration of silica in parts per million.

trations above 10 ppm are very unusual and generally are derived from thermal springs. Traces of boron are necessary for plant growth, but concentrations above 1 ppm are toxic to some plants, and concentrations of over 3.75 ppm render water unsuitable for irrigation. Average sea water contains 4.6 ppm of boron.

Calcium or sodium borates are present in evaporites; complex silicates, notably tourmaline; and igneous and metamorphic rocks. The boron in the borewaters of the Barkly Tableland probably originated in evaporitic interbeds in the carbonate sequence. The boron concentrations range from 0.1 ppm in Alexandria No. 16 to 2.77 ppm in Brunette Downs No. D14.

Of the twelve values available in the eastern part of the region, only three are above 0.2 ppm and the maximum is 0.26 ppm. Values greater than 1 ppm occur mainly in the central part of the region, broadly in the areas of higher salinity and lower hydrodynamical gradient. Values greater than 2.0 ppm are confined to a small area about the western part of Lake Sylvester. The values in the west are generally less than 0.5 ppm. The higher boron values are generally associated with waters high in sodium.

Lithium

Lithium is rare in natural waters. In the borewaters of the Barkly Tableland the maximum concentration is 0.4 ppm in Anthony Lagoon No. 7. Only 71 samples were analysed for lithium: in 21 the lithium content was below, and in 7 at, the detection limit of 0.05 ppm. Because of the numerical paucity of samples, only general observations are possible. Twelve samples from bores in the eastern part of the region did not contain sufficient lithium for detection. Values between 0.1 and 0.4 ppm lie mainly in a belt which extends from east of Anthony Lagoon homestead through Brunette Downs homestead to Alroy Downs homestead and Frewena. The higher values are associated with areas of higher salinities, but the main trend is displaced a few miles to the west.

Lead

Lead is toxic to humans and stock. Rainwater & Thatcher (1960) report the upper limits for domestic and stock waters as 0.1 and 0.5 ppm respectively. Seventy-one borewaters were tested for lead, but only two yielded positive results; the lead concentration in these was at the detection limit of 0.01 ppm. The samples tested are considered to be representative of the region.

Aluminium

Aluminium is not toxic to humans or stock, and except in very high concentrations it is not important in irrigation waters. Water samples from 109 bores were analysed for aluminium. Aluminium was detected in 49 samples at or above the detection limit of 0.02 ppm: 80 percent of these contain concentrations less than 0.1 ppm.

Values higher than 0.1 ppm occur in a belt between Creswell Downs homestead and Kennedy Creek in the central part of the region, which corresponds approximately to areas of high salinity.

Iron and Manganese

The United States Public Health Service recommends that the concentration of iron and manganese in domestic water supplies should not exceed 0.3 ppm. The limit is based on palatability, as the metals are not toxic; they can also cause unpleasant deposits on food cooked in the water. Stock are also sensitive to the taste imparted to water by iron and manganese. The concentration of iron in irrigation waters is unimportant, but crops have widely varying tolerances to manganese. In the borewaters of the Barkly Tableland the highest concentration of iron encountered is 0.2 ppm, and of manganese, 0.04 ppm.

Phosphate

Seventy-one samples were analysed for phosphate, but in only 15 was the concentration above the detection limit of 0.001 ppm. Most values were 0.01 ppm and the maximum was 0.03 ppm.

Nitrate and Nitrite

Nitrate and nitrite analyses are frequently made on domestic waters to determine possible pollution; nitrogen as nitrate can cause cyanosis in infants (Hem, 1959). The recommended limit for nitrate nitrogen in drinking water is about 10 ppm nitrogen, i.e. 44 ppm of nitrate. The concentration of nitrate in Brunette Downs No. 26 was 42.6 ppm and in Rockhampton Downs No. 30 46.8 ppm, but fewer than 5 percent of the borewater samples contained more than 20 ppm.

The nitrogen in the samples presumably originates from chemical and bacterial action involving nitrogen in the soil.

IONIC RATIOS

Chloride/(Sodium + Potassium)

The ionic ratio $Cl^-/(Na^+ + K^+)$ of the borewaters ranges from 0.18 in Brunette Downs No. D42 to 1.7 in Rockhampton Downs No. 4 (Fig. 18).

A marked constriction in the 0.9 contours east of Alroy Downs homestead separates the region into two areas, but the division and the variations of the values within the two areas are not as well defined as some of the other sets of contours. Although the ratio tends to rise in the regional directions of groundwater flow, the variations only remotely conform to the variations of characteristics previously discussed, especially the piezometric contours (Fig. 8) and the isosalinity contours (Fig. 10).

The probable recharge area, the northward direction of groundwater flow, and the complementary rise in salinity about Anthony Lagoon homestead are reflected by the $Cl^-/(Na^+ + K^+)$ ratio. Similarly the recharge area between Brunette Downs and Rockhampton Downs homesteads is reflected by the ionic ratio contours 0.3 to 0.6, but the shape and extent are different from those indicated in Figures 8 and 10. The south-westerly flow direction along the north-eastern margin of the basin is only vaguely indicated by this ionic ratio, probably because of the apparent eastward displacement of the 1.0 contour and the development of higher values along the south-eastern margin of the Brunette Downs Sheet area. Although these high values form part of a steady increase in the ratio north-westwards from near Alexandria homestead, the orientation of the contours and the sudden reversal to a low value east of Brunette Downs homestead do not accord with the main direction of groundwater flow as indicated by the piezometric surface and the change in salinity. The northward direction of flow in the south-western part of the region is reflected by an increase in the value of this ratio, but the disposition and shape of the ratio contours and those on the salinity and piezometric surface are slightly different: the westward direction of flow near Rockhampton Downs homestead is not apparent in the contours of this ratio.

Although there is a general southward and eastward increase in the $Cl^-/(Na^+ + K^+)$ ratio in the Ranken Sheet area, which accords with the general direction of groundwater flow, the shape of the contours bears little resemblance to any other contours.

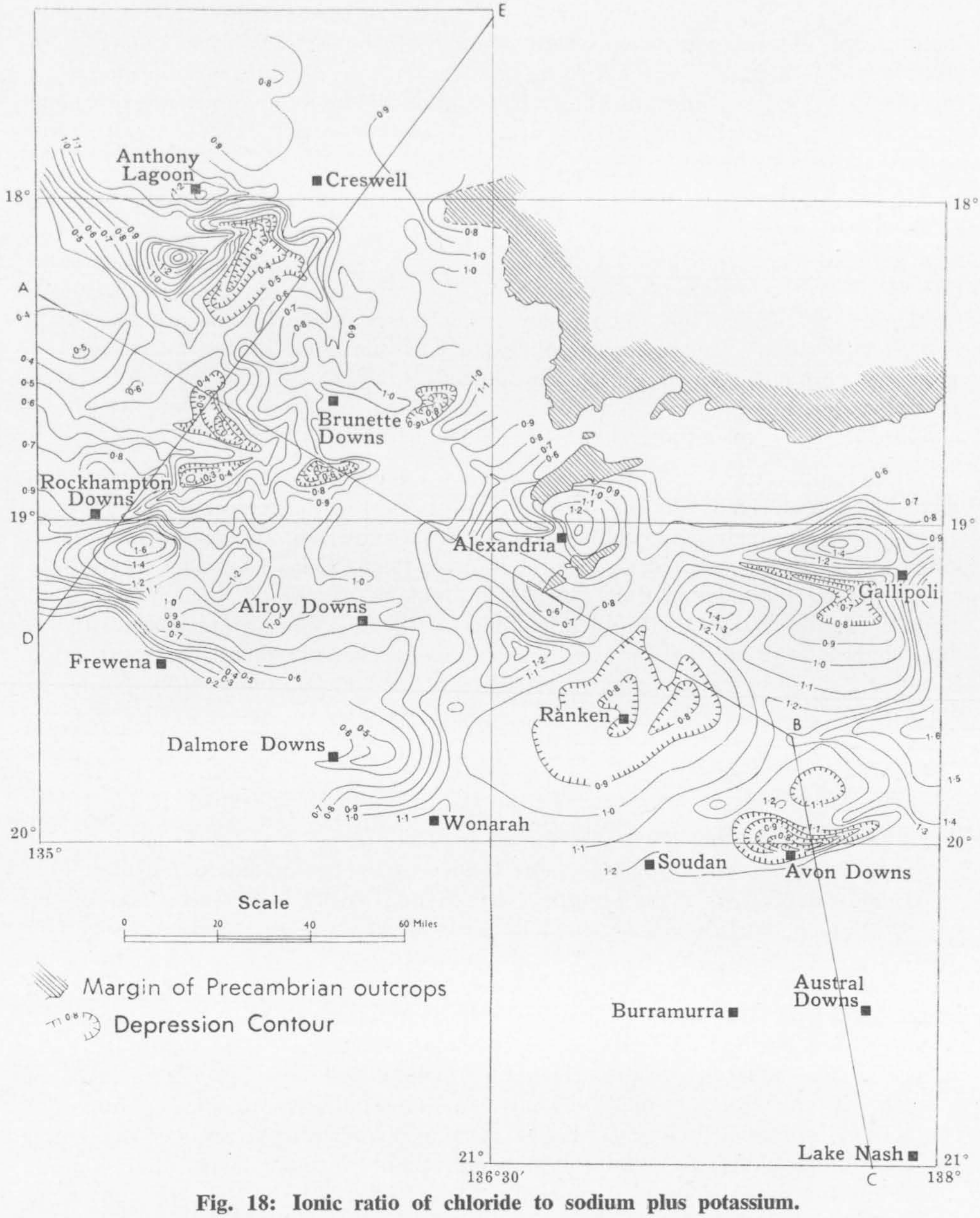

Fig. 18: Ionic ratio of chloride to sodium plus potassium.

These variations may be caused by unknown factors which vary the expected rate of change normally associated with hydraulic flow through an aquifer of constant composition. The most probable explanation is variation in the composition of the aquifer, but lack of data prevents its confirmation. The variation suggests that the sequence is not entirely composed of carbonate rocks. Evaporites are probably present in the sequence, and they could produce a marked change in the values of the ratio.

If salt beds are present it would be expected that the solution of alkali (mainly sodium) and chloride would be approximately stoichiometric, but the increase in alkali content could be expected to be greater than the increase in chloride in the carbonate rocks, particularly in the recharge areas. This is generally the case, and comparison between Figures 8, 10, and 18 shows that the $Cl^-/(Na^+ + K^+)$ ratio is lowest in the recharge areas.

Assuming that the stoichiometric increase of the two ions produces a ratio between 0.9 and 1.1, an interesting deduction can be made from Figure 18. The area outlined by the 0.9 and 1.1 contours forms a crescentic zone extending from near Anthony Lagoon homestead eastward to Creswell Downs homestead, southward to Alroy Downs homestead, and thence westward to beyond Rockhampton Downs homestead. This zone broadly reflects the area of high salinity, low hydraulic gradient, and areas of chloride and sulphato-chloride types of water. The area outlined by the 0.9 and 1.1 contours in the south-eastern part of the region does not form a pattern obviously related to other characteristics.

The ionic ratio exceeds 1.1 near Anthony Lagoon, Rockhampton Downs, and Alexandria homesteads, and in the south-eastern part of the region. The values in these areas, although mainly consistent with the direction of groundwater flow, indicate a much higher concentration of chloride than alkalis. Chemical equilibrium is maintained by calcium and magnesium ions in excess of those required to maintain equilibrium with the bicarbonate and sulphate ions. The implication is that magnesium or calcium ions are associated with chloride ions. This association is unlikely in an essentially carbonate sequence, and the presence of evaporites in the sequence is a possible explanation.

Magnesium/Calcium

The Mg^{++}/Ca^{++} ratio ranges from 0.2 in South Barkly Stock Route No. 9 to 2.62 in Alroy Downs No. 25 (Fig. 19).

The changing values of this ratio cannot easily be related to the directions of groundwater flow. Near Gallipoli and Avon Downs homesteads and in the eastern parts of the Brunette Downs and Alroy Sheet areas, the ratio increases with increasing salinity in the direction of groundwater flow. An increase in the ratio north-west of Rockhampton Downs homestead reflects an increase in salinity and the direction of flow, and low values of the ratio (about 0.6) are found in the recharge area north-east of Rockhampton Downs homestead. In other areas the value decreases markedly in the direction of flow, and the contour pattern takes on a confused appearance which virtually has no similarity to the contours of characteristics previously discussed. There is no obvious demarcation of the region into two areas along the Wonarah-Alexandria line as there is in other contour maps, and the shape of the area of high values centred on Alroy Downs homestead cannot be easily explained. The most likely explanation is the variation in the composition of the aquifer rocks, as postulated for the anomalies in the $Cl^-/(Na^+ + K^+)$ ratio. The Mg^{++}/Ca^{++} ratio will be affected by the amount of dolomite and dolomitic limestone in contact with the waters, and also by the solubility products [Ca] [CO_3] and [Ca] [SO_4] in the initial stages of groundwater circulation. In a simple dolomite it is difficult to visualize the groundwater dissolving more Mg^{++} than Ca^{++} once the [Ca] [CO_3] solubility product has been exceeded, since to dissolve further magnesium from the rock must involve the

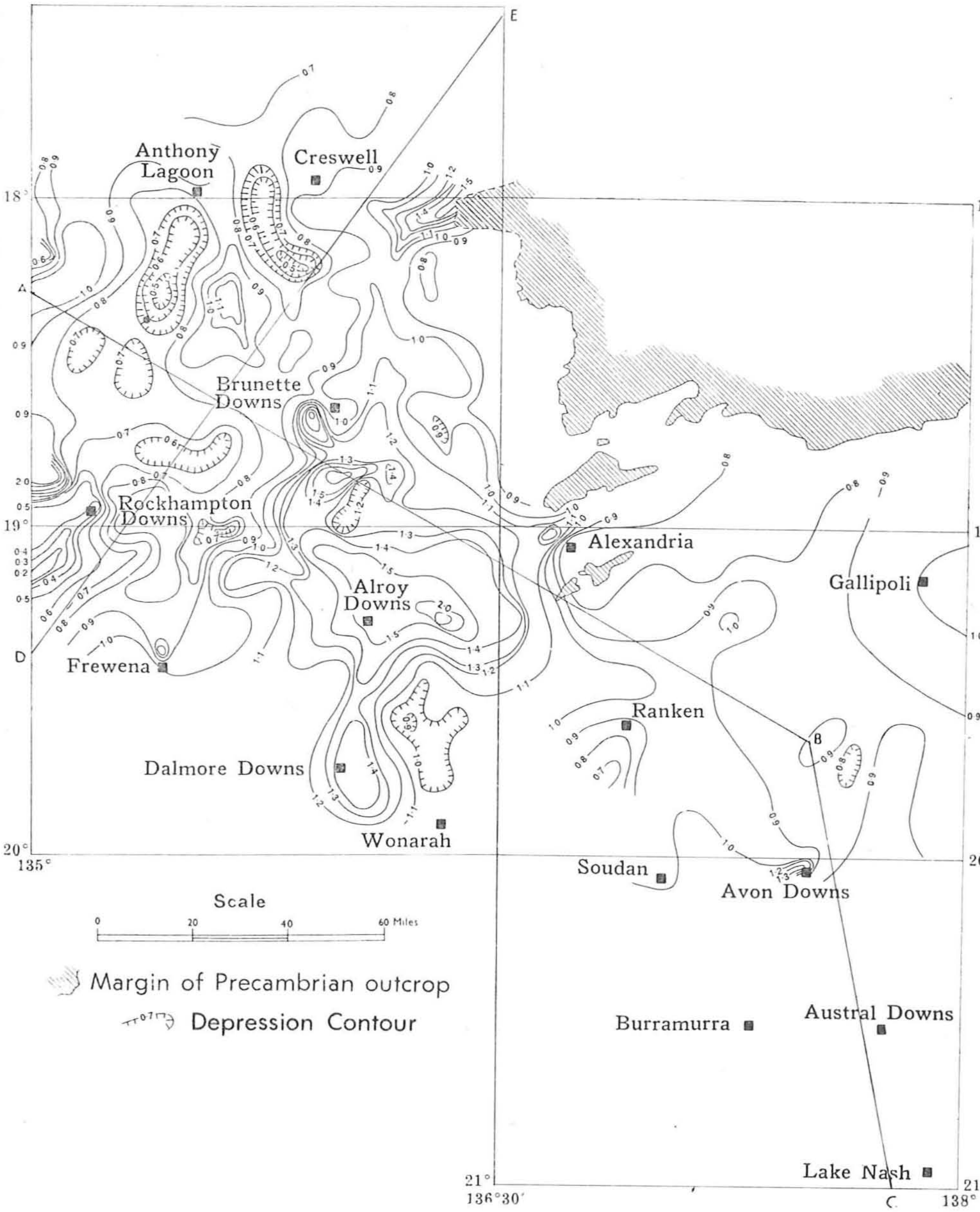

Fig. 19: Ionic ratio of magnesium to calcium.

removal of further calcium. A further complication is the presence of HCO_3^- rather than $CO_3^=$, but notwithstanding this the magnesium must be coming from rocks with a magnesium content much higher than its calcium content, or at least a rock in which the magnesium is more readily available than is the calcium. It is not easy to explain the situation by postulating the precipitation of calcium salts to permit solution of further calcium and magnesium.

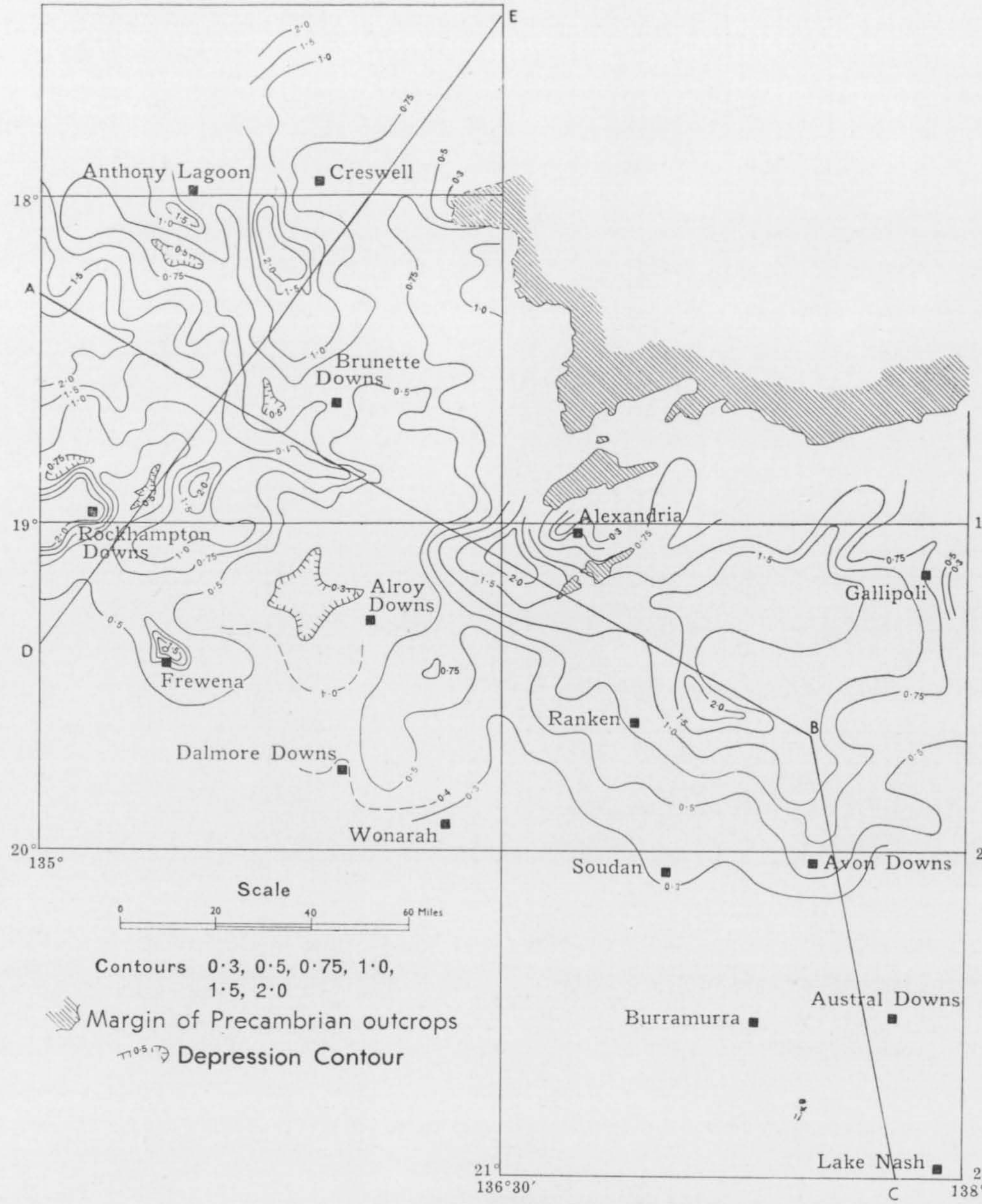

Fig. 20: Ionic ratio of sulphate to chloride.

Again, a possible explanation would be that the sequence contained evaporites.

Sulphate/Chloride

The ionic ratio $SO_4^{=}/Cl^{-}$ ranges from 0.14 in Avon Downs No. 3 to 8.37 in Rockhampton Downs No. 27. Values as high as 8.0 are rare, and most of the high values are less than 5.0 (Fig. 20).

The ratio generally decreases with increasing salinity, and in the direction of

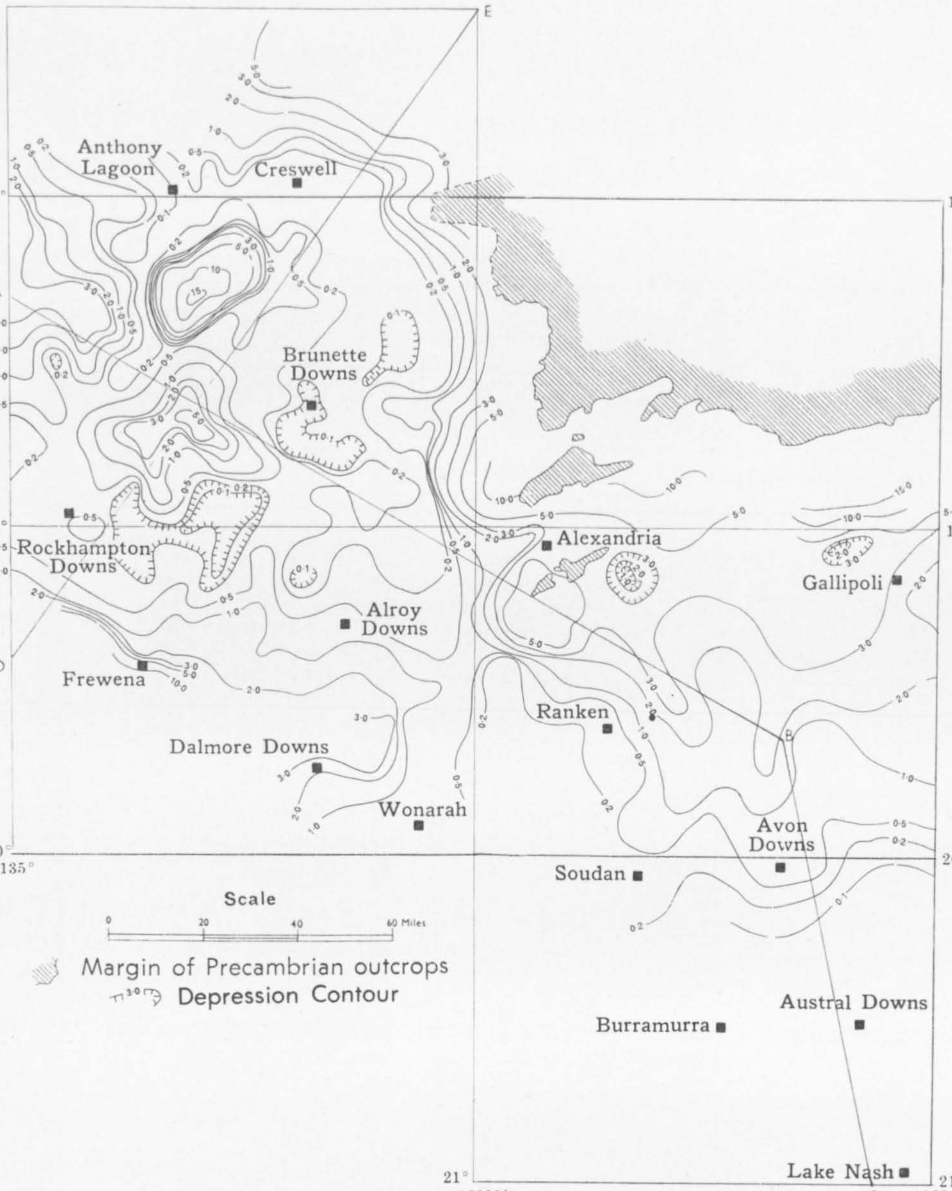

Fig. 21: Ionic ratio of bicarbonate to chloride.

groundwater flow; but, as in the case of the Mg^{++}/Ca^{++} ratio, the form lines do not divide the region into two distinct areas. As might be expected the lower values occur in areas of mainly chloride waters, but there are sufficient anomalies to suggest that factors other than hydraulic flow control the value of this ionic ratio. The 0.5 contour outlines an area of low values extending from near Brunette Downs homestead southward to Dalmore Downs homestead, where it bifurcates—one arm eastward to Avon Downs homestead and beyond, and the other westward to south

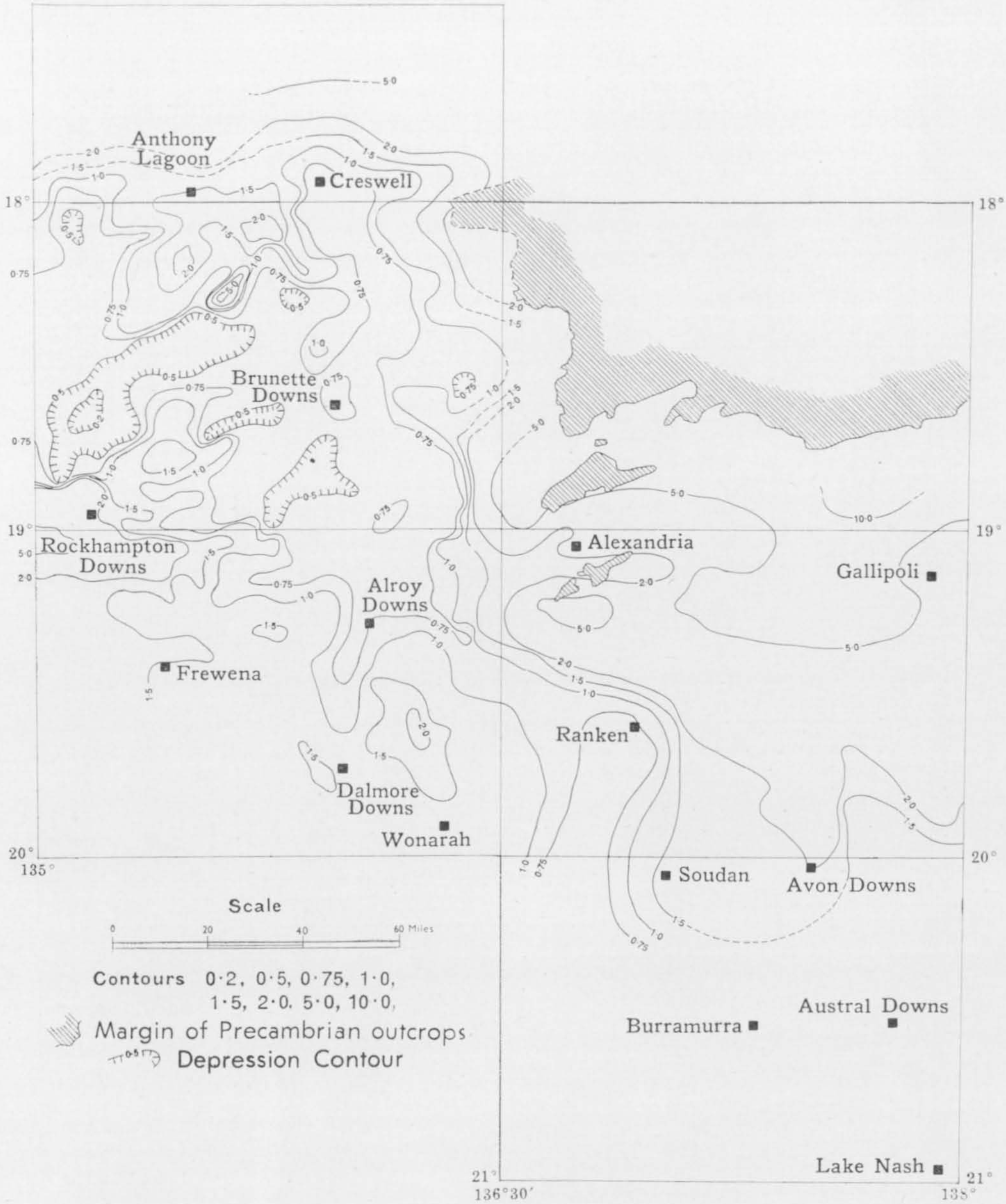

Fig. 22: Ionic ratio of calcium plus magnesium to sodium plus potassium.

of Rockhampton Downs homestead. The eastern arm fits a normal pattern inasmuch as it becomes part of a sequence of decreasing ratios in the regional direction of groundwater flow, but the western arm does not. The piezometric surface and the salinity indicate a regional northward flow about Frewena, but the $SO_4^{=}/Cl^-$ ratio increases in this direction. On the other hand this northward increase becomes normal again as it continues rising into the recharge area outlined by previous characteristics between Rockhampton Downs and Brunette Downs homesteads. Anomalous trends also occur west of Rockhampton Downs homestead, north-east and east of Creswell Downs homestead, and about Alexandria homestead.

The low $SO_4^{=}/Cl^-$ values and high Mg^{++}/Ca^{++} values about Alroy Downs homestead suggest an association of Mg^{++} with Cl^- and of Ca^{++} with $SO_4^{=}$. Gypsum ($CaSO_4.2H_2O$) is widely distributed in the black soils and has been reported by drillers from some of the waterbores.

Bicarbonate/Chloride

The ionic ratio HCO_3^-/Cl^- ranges from 0.01 in Alroy Downs No. 2 to 18.21 in Alexandria No. 39 (Fig. 21). The contours clearly reflect the division of the region into two major groundwater areas with a constriction of the 1.0 contours and the ridge of high values between Dalmore Downs and Alexandria homesteads. The values reflect the major directions of groundwater flow: the ratio decreases with increasing salinity, and reflects the geochemical type of water based on anionic content.

(Calcium + Magnesium)/(Sodium + Potassium)

The ionic ratio $(Ca^{++} + Mg^{++})/(Na^+ + K^+)$ ranges from 0.5 in several separate areas between Alroy Downs and Anthony Lagoon homesteads to 10.0 north of Gallipoli homestead (Fig. 22).

A constriction in the 1.0 contour along a line from Dalmore Downs to Alexandria homestead tends to divide the region into two areas of groundwater circulation, but the division is not well defined. Generally the ratio declines in the direction of groundwater flow and increasing salinity, but the existence of local anomalies suggests that in places the ratio is controlled by the composition of the aquifer rather than hydraulic conditions. The most striking anomalies are near Frewena and Anthony Lagoon homestead, where northward directions of flow and increasing salinities are accompanied by a rise in the $(Ca^{++} + Mg^{++})/(Na^+ + K^+)$ value.

CHEMICAL TYPES OF WATER

Two hundred and sixty-five borewaters have been analysed. The waters can be classified into three main groups based on the predominance of chloride (Cl^-), sulphate ($SO_4^{=}$), or bicarbonate (HCO_3^-). Each group has been subdivided into three types according to the next most common anion. For example, the chloride group has been subdivided into (i) mainly chloride, (ii) sulphato-chloride, and (iii) bicarbono-chloride types in which the following relationships hold:

(i) $Cl^- \gg HCO_3^-$ or $SO_4^{=}$

(ii) $Cl^- > SO_4^{=} > HCO_3^-$, with $Cl^- - SO_4^{=}$ not $>$ 20 percent of total anions

(iii) $Cl^- > HCO_3^- > SO_4^{=}$, with $Cl^- - HCO_3^-$ not $>$ 20 percent of total anions.

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

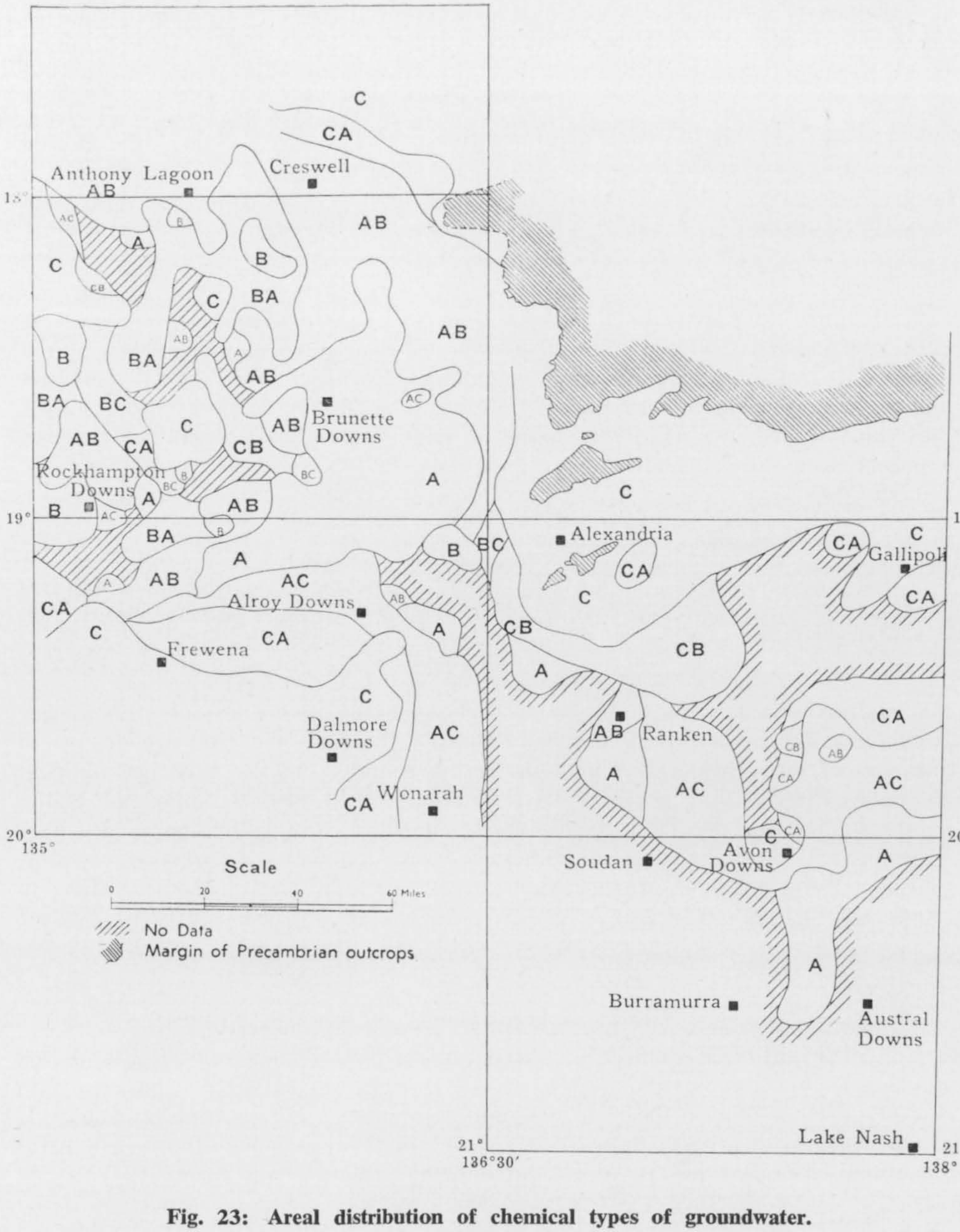

Fig. 23: Areal distribution of chemical types of groundwater.

Figure 23 illustrates the spatial distribution of the various water types in the region, and Figure 12 and Table 6 indicate the numerical distribution based on the number of samples analysed. The apparent discrepancy between Figures 23 and 12 is due to the greater density of bores on Brunette Downs station, an area of mainly chloride group waters.

TABLE 6: NUMERICAL DISTRIBUTION OF CHEMICAL TYPES OF GROUNDWATER

Secondary Anion \ Dominant Anion	Chloride	Sulphate	Bicarbonate	
Chloride	Mainly Chloride (A) 66	Chloro-sulphate (BA) 19	Chloro-bicarbonate (CA) 19	104
Sulphate	Sulphato-chloride (AB) 61	Mainly Sulphate (B) 15	Sulphato-bicarbonate (CB) 8	84
Bicarbonate	Bicarbono-chloride (AC) 22	Bicarbono-sulphate (BC) 6	Mainly Bicarbonate (C) 49	77
Totals	149	40	76	265

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

The main types can be further divided into 31 classes as illustrated in Tables 7, 8, and 9, and in Figure 24. The subdivision is based on the cationic content of the borewater, but at present no analysis has been made of the cationic distribution other than the ionic ratios previously discussed. The composition of the 31 classes is briefly described below.

Chloride Group

Mainly chloride waters

The mainly chloride types have been classified into two classes (Anm and Anc) based on the relative amounts of magnesium and calcium (Table 7; Fig. 24). In both classes the sodium content is far greater than either magnesium or calcium, and the waters have been included in the mainly sodium class in Figure 12. A further four samples of mainly chloride waters in which sodium is the dominant cation could not be classified as the magnesium and calcium content were not determined. These are shown in Appendix 3 under Avon Downs Sheet area.

TABLE 7: CHEMICAL ANALYSES OF CHLORIDE GROUP

Chemical Type	Mainly Chloride		Sulphato-chloride			Bicarbono-chloride		
Class (No. of analyses)	Anm (46)	Anc (16)	ABnm (9)	ABnc (50)	ABcn (2)	ACnm (9)	ACnc (8)	ACc (5)
	Average Percentage Reacting Values							
Na^{+} ($+K^{+}$)	59	56	63	54	34	50	44	32
Ca^{++}	18	23	18	24	37	22	29	36
Mg^{++}	23	21	19	22	29	28	27	32
Cl^{-}	61	55	52	48	39	50	46	42
HCO_3^{-}	12	15	10	13	24	30	32	35
$SO_4^{=}$	27	30	38	39	37	20	22	23

Distribution of mainly chloride types: the chloride types occur mainly in the central part of the region in an area which extends from south of Creswell Downs homestead southwards to near Alroy Downs homestead, thence south-westward to near Frewena. Chloride-type waters occur also between Soudan homestead and Ranken store, between Ranken store and Alroy Downs homestead, and between Avon Downs and Austral Downs homesteads. Small isolated areas occur between Anthony Lagoon homestead and Frewena.

Sulphato-chloride waters

The sulphato-chloride waters are those in which chloride is the dominant anion, but the sulphate ion has assumed some importance (Table 7; Fig. 24). The waters have been divided into three classes—ABnm, ABnc, and ABcn. For the first two sodium is the dominant cation and these waters are included under 'mainly sodium' in Figure 12b.

In class ABnm magnesium is usually slightly more common than calcium.

In the ABnc class calcium ion is more common than magnesium, and this reflects the association of calcium ion and sulphate ion which is also apparent in the sulphate group and sulphato-bicarbonate type.

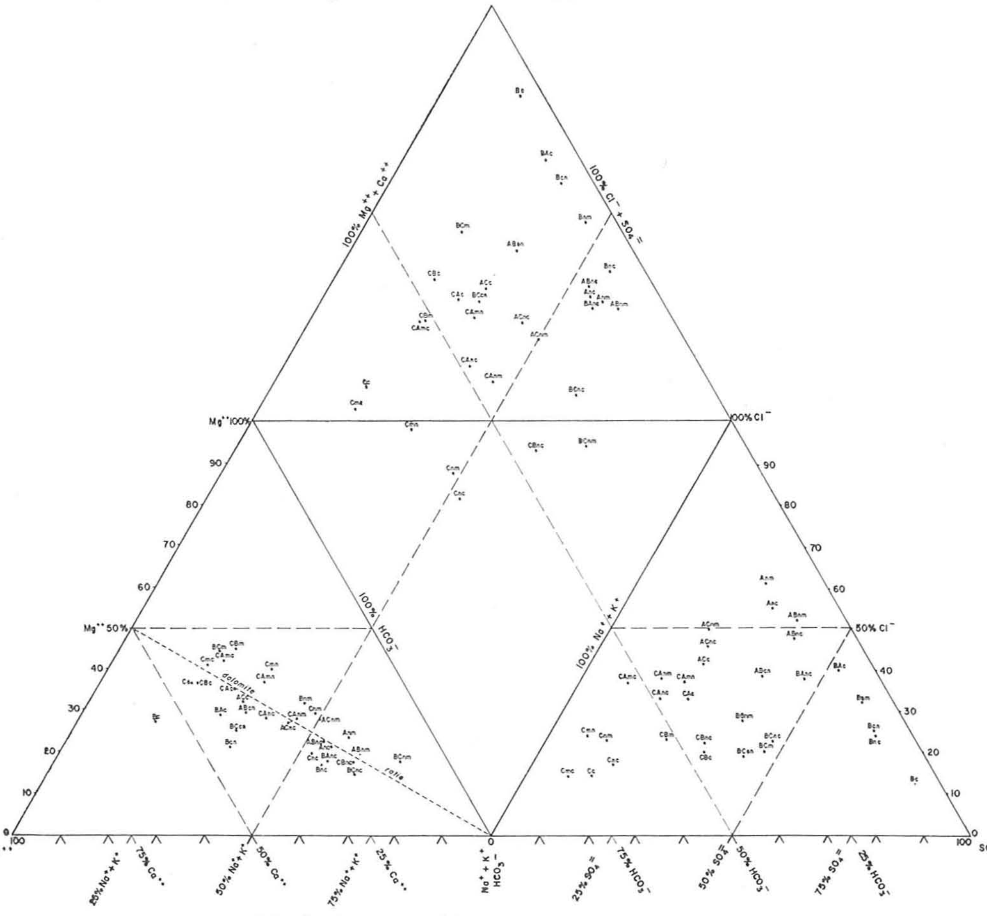

Fig. 24: Ionic composition of the classes of borewater.

In the ABcn class chloride is the predominant anion, but sulphate and bicarbonate are present in about equal amounts. The calcium value is higher than both sodium and magnesium.

Distribution of sulphato-chloride waters: The sulphato-chloride waters are widespread. They occur in an area from Anthony Lagoon to Creswell Downs homestead and thence southwards to near Brunette Downs homestead and south-eastwards along the north-eastern margin of the region. They occur in discontinuous areas southwards from Anthony Lagoon homestead to near Frewena, and in an area around Ranken store. The area of mainly chloride-type waters in the central part of the region is encircled by sulphato-chloride waters except in the south.

Bicarbono-chloride waters

The bicarbono-chloride waters have been divided into three classes—ACnm, ACnc, and ACc (Table 7; Fig. 24). In the first two sodium is the dominant cation.

Classes ACc and ABcn, represented by 5 samples and 2 samples respectively, are unusual inasmuch as they are the only waters of the chloride group — a total of 149 samples — in which the calcium ion has a dominant role, although only slightly in both cases. For class ACc sodium content is slightly higher or equal to that of magnesium.

Distribution of bicarbono-chloride waters: This type of water occurs mainly in the southern and south-eastern part of the region in a thin crescentic area from north of Frewena eastward to Alroy Downs homestead, and thence southwards to Wonarah, and in a U-shaped area from Ranken store to Avon Downs homestead and thence to the Queensland border. Very small areas occur south-west of Anthony Lagoon homestead, east of Rockhampton Downs homestead, and east of Brunette Downs homestead.

Sulphate Group

Mainly sulphate waters

The mainly sulphate waters have been classified into four classes, totalling 15 samples (Table 8). In none of the samples is magnesium the dominant cation, and for all of them the bicarbonate content is very low. The classes are Bc, Bcn, Bnc, and Bnm (Fig. 24).

TABLE 8: CHEMICAL ANALYSES OF SULPHATE GROUP

Chemical Type	Mainly Sulphate				Chloro-sulphate		Bicarbono-sulphate				
Class (No. of analyses)	Bc (5)	Bcn (3)	Bnc (5)	Bnm (2)	BAnc (15)	BAc (4)	BCnm (1)	BCnc (2)	BCcn (1)	BCm (1)	BCc (1)
	Average Percentage Reacting Values										
Na^+ $(+K^+)$	16	35	56	45	56	29	72	64	34	21	25
Ca^{++}	57	44	27	23	26	42	10	21	41	35	39
Mg^{++}	27	21	17	32	18	29	18	15	25	44	36
Cl^-	13	26	25	33	39	41	29	24	19	20	33
HCO_3^-	5	7	7	6	15	7	33	29	38	33	33
$SO_4^=$	82	67	68	61	46	52	38	47	43	47	34

Distribution of the mainly sulphate water: Mainly sulphate water occurs in small isolated areas near Rockhampton Downs homestead, near Anthony Lagoon homestead, and west of Alexandria homestead. It usually occurs close to areas of chloride or sulphato-chloride types of groundwater, and may be explained by a local concentration of gypsum in the aquifers.

Chloro-sulphate waters

The chloro-sulphate waters contain 19 samples in two classes (Table 8; Fig. 24). The rising influence of the chloride ion is reflected by the sodium content, which, in its relationship to the calcium content, has been used for the classification. It is noteworthy that in the class (BAnc) rich in sodium the disparity between the chloride and the sulphate contents is less than in the class (BAc) with little sodium; so sodium and chloride ions are probably associated.

Distribution of chloro-sulphate waters: Chloro-sulphate waters occur in one large and two small areas in the western part of the region. The areas are marginal to areas of mainly sulphato-chloride and sulphate type waters.

Bicarbono-sulphate waters

The bicarbono-sulphate waters are numerically the least important of the groundwaters of this region. The type contains five classes—BCnm, BCnc, BCcn, BCm, and BCc (Table 8; Fig. 24).

Distribution of bicarbono-sulphate waters: The bicarbono-sulphate waters occur in four small areas—south of Brunette Downs homestead, between Brunette Downs and Rockhampton Downs homesteads, west of Alexandria homestead, and near Frewena—and in a medium-sized area north of Rockhampton Downs homestead.

Bicarbonate Group

Mainly bicarbonate waters

The mainly bicarbonate waters have been divided into five classes—Cc, Cnm, Cnc, Cmc, and Cmn (Table 9; Fig. 24). With a total of 49 samples this type is numerically exceeded only by the mainly chloride and sulphato-chloride types. The bicarbonate ion is more than 60 percent of the total anionic content.

TABLE 9: CHEMICAL ANALYSES OF BICARBONATE GROUP

Chemical Type	Mainly bicarbonate					Chloro-bicarbonate					Sulphato-bicarbonate	
Class (No. of analyses)	Cc (23)	Cnm (11)	Cnc (9)	Cmc (5)	Cmn (1)	CAc (7)	CAnm (8)	CAnc (2)	CAmc (1)	CAmn (1)	CBc (6)	CBnc (2)
	Average Percentage Reacting Values											
Na^+ ($+K^+$)	19	48	52	20	34	28	45	39	23	34	20	62
Ca^{++}	44	22	28	39	26	39	26	33	35	29	43	20
Mg^{++}	37	30	20	41	40	33	29	28	42	37	37	18
Cl^-	14	24	18	14	24	34	39	33	37	37	21	23
HCO_3^-	72	64	66	77	68	42	45	48	53	41	45	44
$SO_4^=$	14	12	16	9	8	24	16	19	10	22	34	33

Distribution of mainly bicarbonate waters: The importance of the mainly bicarbonate waters is reflected in their areal distribution. They occur along the northern, north-eastern, north-western, and south-western margins of the region, in two areas between Anthony Lagoon homestead and Frewena, and in a small area about Avon Downs homestead. Geochemically they are very important as they are usually of low salinity. Their position in relation to the groundwater evolution is discussed later in this chapter.

Chloro-bicarbonate waters

The chloro-bicarbonate waters have been divided into 5 classes representing 19 samples (Table 9; Fig. 24). Although a cationic classification of the type is obvious there is not a great difference between the values of the two most important cations except in the sodium class.

Distribution of chloro-bicarbonate waters: The chloro-bicarbonate type is widely distributed; as a restricted belt in the north-east; as a discontinuous belt from west of Frewena eastwards to Alroy Downs and thence southwards to near Wonarah; and as a discontinuous belt in the eastern part of the region from Avon Downs to Gallipoli homestead. Small areas occur near Rockhampton Downs and Alexandria and Gallipoli homesteads.

Sulphato-bicarbonate waters

The sulphato-bicarbonate waters, together with the bicarbono-sulphate waters, are unimportant. The sulphato-bicarbonate type is divided into two classes—CBc and CBnc—but contains only 8 samples (Table 9; Fig. 24). The increase in sulphate content has been mainly at the expense of bicarbonate rather than chloride. Calcium is the most important cation, and sodium the least, despite its dominance in class CBnc.

Distribution of the sulphato-bicarbonate waters: The sulphato-bicarbonate waters have a restricted areal extent. They are marginal to a large area of bicarbonate waters south of Alexandria homestead, where they act as a buffer between these waters and chloride group waters to the south, and occur in a similar geochemical environment in a small area west of Brunette Downs homestead.

Chemical type as a function of groundwater environment

Schoeller (1959, p. 67), in discussing the progressive changes in the mineralization of groundwater, states 'that water completely changes its nature approximating progressively to a type of composition: $rCl > rSO_4 > rCO_3$, and $rNa > rMg > rCa$', where the prefix 'r' indicates that the values are expressed as milli-equivalents per litre (equivalents per million). Further he quotes (p. 74) the Ignatovitch-Souline sequence as applied to vertical zonation as:

'$HCO_3^- \rightarrow HCO_3^-\ SO_4^= \rightarrow SO_4^=\ Cl^- \rightarrow Cl^-\ SO_4^= \rightarrow Cl^-$'.

Chebotarev (1955, p. 203) reports his findings in similar vein: 'Because of the different mobility of the chemical elements and the nature of the physical-chemical processes in the subsurface reservoir, the geochemical types of water change with the increase of the total salinity as well as with increasing depth, and the following series holds good:

$$HCO_3^- \rightarrow HCO_3^- + Cl^- \rightarrow Cl^- + HCO_3^- \rightarrow Cl^- + SO_4^= \text{ or } SO_4^= + Cl^- \rightarrow Cl^-;$$

This sequence is correct in vertical zones as well as in the horizontal zones of subterranean waters'.

The two ideas above may be expanded in the following way for the anionic changes:

$$HCO_3^- \rightarrow HCO_3^- + SO_4^= \rightarrow SO_4^= + HCO_3^- \rightarrow SO_4^= + Cl^- \rightarrow Cl^- + SO_4^= \rightarrow Cl^-$$

$$\searrow HCO_3^- + Cl^- \rightarrow Cl^- + HCO_3^- \nearrow$$

This series may be expressed in terms of the geochemical type symbols (see Fig. 12) used in the figures accompanying this report as:

$$\begin{array}{ccccccccccccc} C & \rightarrow & CB & \rightarrow & BC & \rightarrow & B & \rightarrow & BA & \rightarrow & AB & \rightarrow & A \\ & \searrow & \downarrow & & & & & & & & \uparrow & \nearrow & \\ & & CA & & & & \longrightarrow & & & & AC & & \end{array}$$

The series is a continuum between the two end members (dominant bicarbonate and dominant chloride) rather than an abrupt change from one type to another, and this is shown by the contours on the ionic ratios involving the anions. On the other hand the changes may be rapid because of aquifer composition or change in hydraulic gradients, and some types in the geochemical sequence may appear to be absent. In areas or belts of rapid change, the presence of a particular geochemical type may be concealed because there are too few bores or samples. These points should be borne in mind in the examination of Figure 23, which illustrates the distribution of the geochemical types.

If the geochemical type reflects the position of groundwater in the hydrodynamic environment, the change from bicarbonate waters to chloride waters should be in the direction of groundwater flow, and bicarbonate waters should be near recharge areas.

The distribution of geochemical type shown in Figure 23 conforms to the regional pattern of groundwater flow as evidenced by the contours on the piezometric surface (Fig. 8) and the isosalinity contours (Fig. 10). The slight anomalies are probably due to changes in the geochemistry of the aquifers and the intermingling of waters which have progressed through different phases of the geochemical evolution.

In the north-east, the piezometric contours indicate a south-westward direction of movement of groundwater, which is also the direction of increasing salinity: the geochemical trend here is C → CA → AB → A. The regional direction of movement in the south-west is northwards, and the increase in salinity is accompanied by the geochemical trend C → CA → AC → A. The northward flow about Anthony Lagoon homestead has the chemical change C → AC → AB on the west and B → BA → AB on the east. A recharge area of low salinity which contains a closed high-value piezometric contour west of Brunette Downs homestead produces bicarbonate-type waters (Fig. 23). In the direction of flow towards Frewena the change in chemical type is C → BC → BA → AB.

In the east, the regional direction of groundwater flow as evidenced by the piezometric surface is from the Alexandria-Gallipoli area southwards towards Soudan and Lake Nash homesteads. This is also the direction of increasing salinity, and the geochemical trend is C → CB → AB → A towards Ranken store, and C → CA → AC → A towards Austral Downs homestead.

The areas of low piezometric surface and low gradients near Ranken store produce water of high salinity and chloride type; similarly a small area of high gradients about Avon Downs homestead produces bicarbonate types with marginal chloro-bicarbonate types.

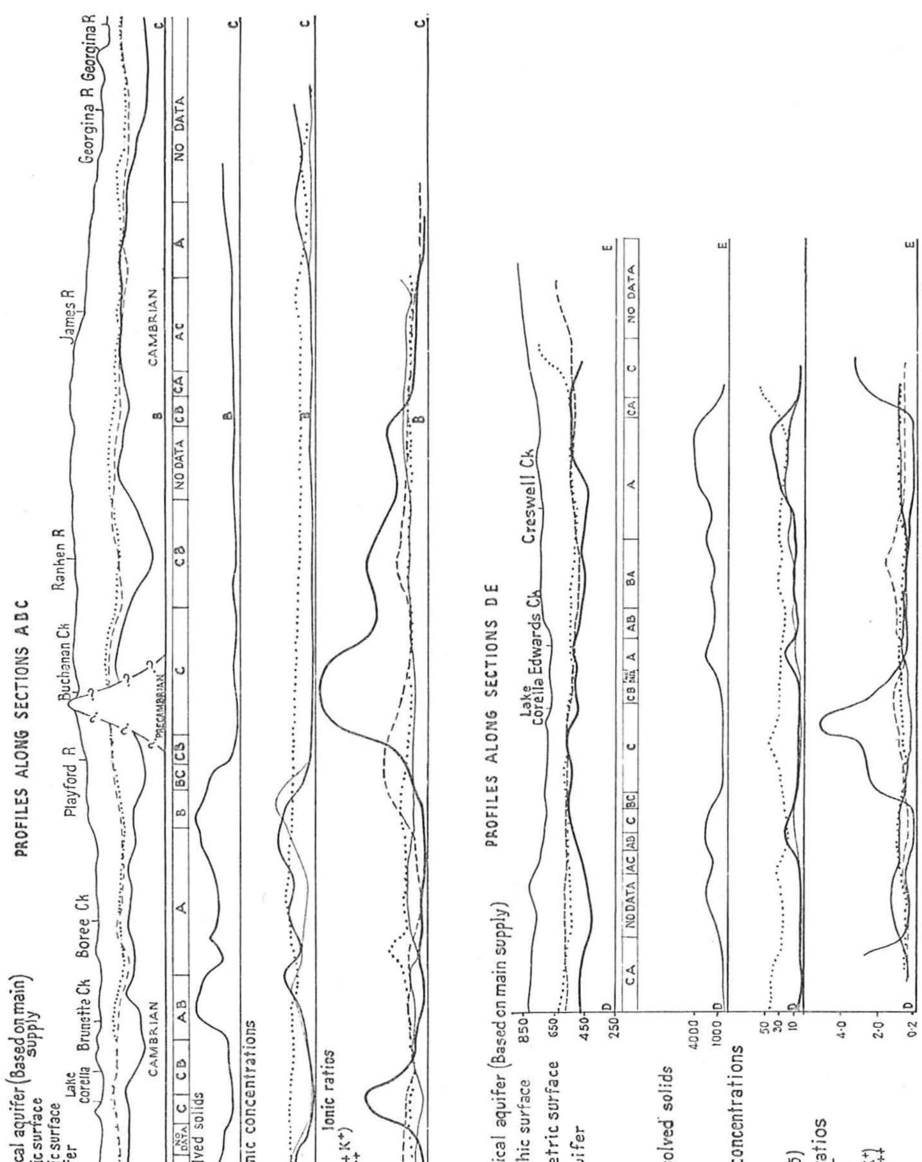

Fig. 25: Profiles of hydraulic and chemical parameters.

Both Schoeller (op. cit.) and Chebotarev (op. cit.) indicate that geochemical type may be controlled by geological structure, in particular the depth of the aquifer. The contours on a hypothetical aquifer (Fig. 7) indicate that the aquifer is frequently deepest in the area of highest progressive salinity (see Fig. 25) and vice versa. The relationship is not exact, probably because of the limitations on the validity of the aquifer map (see p. 25), and because of probable variations in aquifer composition and hydraulic gradients.

The main geochemical types of groundwater in the Barkly Tableland cannot be related to individual Cambrian units because the entire Cambrian sequence consists mainly of carbonate rocks. The main geochemical control has been the hydraulic environment—the physical properties of the rocks and their structural position in relation to recharge areas. That the aquifer composition has some effect on the geochemistry of the groundwater is indicated by the anomalous variations in absolute values and ionic ratios as discussed on pages 41-59. The problem cannot be solved until more data are available on speed and direction of groundwater movement, and the subsurface geology of the area, particularly composition of the aquifers. It appears that the main influence will be on the cations rather than the anions, but if the sequence of anionic variation caused by the groundwater flow can be established, the anomalies caused by a change of aquifer composition may become more apparent, and of greater value for subsurface geological interpretation.

CONCLUSIONS

In the central and eastern parts of the Barkly Tableland considerable quantities of groundwater are stored in aquifers in the Cambrian marine sequence composed mainly of carbonate rocks, with subordinate siltstone and sandstone. Although correlation of aquifers from bore to bore is impossible at present, it is apparent that water is stored in several aquifers with some vertical interconnexion through cavities, joints, and fissures in the carbonate rocks. There is no evidence of depletion of the aquifers and the comparison between the probable annual recharge and the maximum annual withdrawal indicates considerable reserves for further development of the pastoral industry.

The water is subartesian; a large area in the central part of the region contains groundwater in simulated unconfined conditions, but this water occurs in the shallower aquifers with restricted supplies. It appears to be confined groundwater that has leaked upward through cavities and other openings from deeper aquifers, and has adjusted itself to the regional piezometric surface.

The groundwater system is divided into two areas by a ridge in the piezometric surface generally directed south-westwards from near Alexandria homestead to Wonarah telegraph station and Dalmore Downs homestead. To the east of the ridge the hydraulic gradient is generally coincident with the drainage directions of the Georgina River Basin, and to the west the gradient is directed towards the Barkly Internal Drainage Basin; but some restricted flow occurs to the north-west and west.

The chemical evolution of the groundwater in the two areas is similar, but in the western area the salinity (up to 11,000 ppm) is much higher than in the eastern area (up to 2500 ppm). There is a distinct connexion between the groundwater flow, as indicated by the piezometric surface, and the salinity in terms of total dissolved solids. The salinity contours clearly reflect the division of the groundwater system into two areas, and parallel the general trends of the piezometric surface. The same divisions are indicated to varying degrees by the distribution of the individual ions and the ionic ratios. The chemical type of the groundwater, based on the anionic content, conforms to the normal pattern of groundwater flow and distribution: bicarbonate waters in recharge or near recharge areas and areas of low salinity; chloride waters in areas of semistagnation and low hydraulic gradients, and areas of high salinity; and intermediate chemical types in areas of intermediate hydraulic gradients.

The quality of the groundwater is extremely variable: the salinity ranges from 31 to about 11,000 ppm; over much of the area it is unfit for human consumption, mainly because of the high salinity, or the high content of sulphate or fluoride. In this respect, the groundwater in the Barkly Internal Drainage Basin is the most unsuitable, particularly in the crescentic belt from Creswell Downs homestead to Alroy Downs homestead and westward to near Rockhampton Downs homestead, and in the irregular arcuate and discontinuous belt from Anthony Lagoon homestead to Rockhampton Downs homestead. Very few of the borewaters are unsuitable for stock. The waters from many of the bores are of doubtful value for agriculture on the clayey black soils, as they are generally high in sodium relative to magnesium and calcium, and the risk of soil deterioration is high. Should future development require water for agriculture, the shallow aquifers should be investigated, as they may contain better-quality water.

The chemistry of the groundwater appears to be controlled mainly by the hydraulic environment, but some control by aquifer composition is apparent, particularly from the variations of the ionic ratios. The influence of aquifer composition may mainly affect the cation content of the groundwater, but should a sequence of anion variation caused by hydraulics be established, the anion anomalies caused by aquifer composition may become apparent and may provide a basis for subsurface interpretation.

Since the chemistry of the groundwater reflects its hydraulic environment, which is partly a function of the position of the water in the geological structure, there is some connexion between the geochemistry and the geological structure of the Barkly Tableland. The sets of profiles (Fig. 25) show a close connexion between the surface topography, standing water level, depth of first aquifer, and geochemistry; and a partial connexion between surface topography and depth to the main supply. The structural and lithological factors which have combined to produce the present physiography have presumably affected the disposition of the intake (recharge) areas relative to the present configuration of the rock sequence —and of the aquifers contained in it; this in turn has controlled the hydraulic environment and consequently the geochemistry. The groundwater is essentially a bicarbonate type on the margins of the basin, progressing towards chloride types both in the centre of the region and downstream in the Georgina River Basin; also there is a pronounced constriction in the area of the chloride types along a zone between Dalmore Downs and Alexandria homesteads. The distribution over the Barkly Tableland of Mesozoic rocks, Tertiary limestone deposits, and laterite indicates some warping during the Tertiary or late Mesozoic (Randal & Nichols, 1963), and the present groundwater system probably attained its present configuration at about that time. However, the groundwater system may have been already in existence, as discussed earlier in connexion with the invasion into the system of water rich in chloride from the Mesozoic transgression.

A. J. Flavelle (BMR, pers. comm.) reports an elongated gravity minimum from south-west of Wonarah towards Alexandria homestead with an associated gravity maximum to the west, which trends diagonally across the Alroy Sheet area from south-west to north-east. The significance of the gravity minimum in relation to the subsurface sequence is not clear, but the trend parallels anomalies in the hydraulic and geochemical parameters. R. Wells (BMR, pers. comm.) reports a similar trend in the magnetic basement. A series of closed contours indicates magnetic basement at about sea level along a line from the Barkly Highway, about 20 miles north-west of Dalmore Downs homestead, north-eastwards towards Alexandria homestead.

Recommendations for future work. This study has shown that a great deal of useful information has been lost because of inadequate recording of data from waterbores both during and after drilling. The situation has vastly improved since the establishment of the Water Resources Branch of the Northern Territory Administration. It is essential that accurate and detailed borelogs are kept and copies forwarded to the appropriate authority, and rock chips made available for geological examination. In the course of drilling some attention should be paid to the reputedly good water of the shallower aquifers, even though supplies are at present not considered adequate, and some waters should be analysed. Chemical analyses of rock chips from the aquifers may give some help in the understanding of the chemical evolution, and subsequently in aquifer correlation, which will also be assisted by gamma ray logging. Accurate levelling of bore sites is required for the detailed study of groundwater flow. Tritium determinations and radioactive tracer studies may provide useful tools in the study of rate and direction of groundwater flow. A great deal of useful data could be obtained on pressure variations and aquifer characteristics by a series of observation wells: these will certainly be needed if the shallower aquifers are investigated.

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APPENDIX 1 — WATERBORES — BARKLY TABLELAND

(Giving main hydrological parameters)

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
			BRUNETTE DOWNS 1:250,000 SHEET AREA								
112	Brunette 22	6 miles south-west of Coolibah Waterhole and 11 miles north of Mittiebah Creek.	765	258	Cambrian dolomite	211, 218 and 258*	191	230	3000	4600	
115	Brunette 25	9 miles from Rockhampton Downs boundary on Brunette-Rockhampton track.	710	175	Anthony Lagoon Beds	137, 150*	135	135	2500	540	
116	Brunette 26	8 miles south of Bore No. 25.	695	155	Anthony Lagoon Beds	130	125	138	2400	2869	
117	Brunette 27	On western side of Lake De Burgh, 8 miles south-east of Bore 26.	680	187	Anthony Lagoon Beds	124	110	123	2000	Good 3012	
118	Brunette 28	23 miles south of Brunette Downs homestead, on track to Alroy homestead.	685	145	Anthony Lagoon Beds	116*, 140	116 (?)	125	3000+	2340	
119	Brunette 29	11 miles east by north of No. 28 and 3 miles south of Boree Creek.	690	167	Cambrian dolomite	145 (?)	141	149	3600	Good 2672	
120	Brunette 30	East of Corella Creek and 1.5 miles north of Barkly Stock Route.	740	213	Anthony Lagoon Beds	184	176	197	3000+	Good	
121	Brunette 31	15 miles south of Brunette Downs homestead.	710	180	Anthony Lagoon Beds	—	—	—	—	—	Was originally equipped but now abandoned
122	Brunette 32	Half way between Nos 15 and 23 (Not located).	680 (?)	120	Anthony Lagoon Beds	115	110	—	unlimited	Very poor	Never equipped — abandoned
123	Brunette 33	12 miles west by north of Brunette Creek, on Brunette-Rockhampton Road.	680	229	Anthony Lagoon Beds	120 (1st supply)	—	207	1800	Fresh 1018	
243	Brunette 23	Lake Sylvester; 15 miles west by north of No. 28.	725	224	Anthony Lagoon Beds	148, 195	165 (?)	185	1500		Bad water, now abandoned
299	Brunette 35	14 miles east-south-east of homestead. Position uncertain as not located	725 (?)	185	Cambrian dolomite	160	—	—	—	Not fit for stock	Never equipped — abandoned
317	Rockhampton 13	21 miles north-north-west of Rockhampton Downs homestead	710	217	Cambrian dolomite	—	169	—	Good	Good 1851	
336	Brunette 36	Brunette homestead	718	387	Anthony Lagoon Beds	147	—	250	1600	Unfit for humans	Abandoned 11-8-61
354	Brunette 21	East of Brunette Creek, 5 miles north of Coolibah Waterhole	795	304	Cambrian dolomite	251, 261, 285*	213	275	2000	—	Not working in 1962
360	Brunette 18	14 miles west-south-west of Boundary Bore, Barkly Stock Route	670	240	Anthony Lagoon Beds	151, 191, 202*	133	161	2000	3240	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
394	Rock-hampton 11	11 miles north-west of Rockhampton Downs homestead	717	150	Cambrian	—	114	—	Good	Good 1819	
398	Rock-hampton 10	14 miles north-north-west of Rockhampton Downs homestead	725	175	Cambrian	—	130	—	Good	Fair 2582	
405	Rock-hampton 12	4 miles west-south-west of Rockhampton Downs homestead on Brunchilly road	700	518	Cambrian	—	150	—	Good	Good 3148	
413	Rock-hampton 9	5 miles north-north-east of Rockhampton Downs homestead on Anthony Lagoon road	738	227	Cambrian	—	153	—	Good	Good 1688	
415/1920	Rock-hampton 5	Rockhampton Downs homestead	729	298/671	Cambrian	—	156/150	—	—	Brackish 2746	No. 1920 drilled in 1948 to improve supply
526	B.S.R.*-Desert	4 miles south of Creswell Creek	705	290	Anthony Lagoon Beds	167, 287*	140	230	1500	Fair	
527	B.S.R. Boundary	On Edwards Creek	725	208	Anthony Lagoon Beds	—	160	181	1400	Good for stock 2858	
528	B.S.R. Mittiebah	Mittiebah Creek	750	219	Cambrian dolomite	185	185	209	1600	Fair 858	
530	B.S.R. Brunette Creek	1 mile west of Brunette Creek	750	256	Cambrian dolomite	210	165	214	1500	Good for stock 3500	
538	Anthony Lagoon Old Dip	6 miles south of Anthony Lagoon aerodrome	748	240	Anthony Lagoon Beds	175	160	190	1800	Good for stock	
546	B.S.R. Wendy	9 miles south of Anthony Lagoon aerodrome	740	252	Anthony Lagoon Beds	195, 252*	162	208	1200	Fair 1738	
602	Anthony Lagoon 7	5 miles south of Barkly Stock Route, on Anthony Lagoon — Rockhampton Downs Road	717	418	Anthony Lagoon Beds	245, 380	240	—	2250	2410	
603	Anthony Lagoon 9	2 miles east of Tarrabool Lake	690	197	Anthony Lagoon Beds	170	—	180	2000	850	
604	Anthony Lagoon 1 (Bluebush)	Off Barkly Stock Route, 22 miles south of Anthony Lagoon homestead	736	260	Anthony Lagoon Beds	172, 260*	192	—	3000	504	
760	Brunette 7	Not located	—	—	—	—	—	—	—	—	Abandoned
761	Brunette 8	15 miles east of homestead and 7 miles south of Long Waterhole	730	281	Cambrian dolomite	—	172	179	2000	1491	

* Barkly Stock Route

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
762	Brunette 9	8 miles north-north-west of homestead	715	245	Anthony Lagoon Beds	—	169	180	2000	3779	
763	Brunette 10	9 miles north-west of homestead on tributary of Corella Creek	670	289	Anthony Lagoon Beds	289	154	—	2000	—	Abandoned — Casing collapsed.
764	Brunette 11	On Brunette Creek 7 miles south-west of Brunette Downs homestead	685	161	Anthony Lagoon Beds	—	115	—	—	—	Casing collapsed Abandoned
765	Brunette 12	11 miles west of Brunette Downs homestead	715	700	Anthony Lagoon Beds	267, 520, 700	157	240	2000	—	Caved in — abandoned
766	Brunette 13	12 miles east by north of Brunette Downs homestead	710	381	Cambrian dolomite	124, 373	120	—	2250	—	Not equipped Abandoned
767*	Brunette 14	6 miles south of Mittiebah Creek, and one mile north of Boree Creek	730	283	Cambrian dolomite	—	173	—	3000	—	Abandoned; new bore on site*
768	Brunette 15	15 miles south of Brunette Downs homestead	710	—	—	—	—	—	—	—	Abandoned
795	Brunette 6	5 miles east of Edwards Creek	712	393	Anthony Lagoon Beds	195, 275, 297, 378*	160	231	2500	3220	
933	Brunette 1	Corella Creek on Barkly Stock Route	705	255	Anthony Lagoon Beds	180	—	—	—	—	Casing collapsed Abandoned
934	Brunette Corella 2	Corella Creek near Edwards Creek	710	212	Anthony Lagoon Beds	160, 200*	—	165	2000	1718	
935	Brunette 3	4 miles north of Brunette Downs homestead	715	357	Anthony Lagoon Beds	—	165	180	2000	4480	
936	Brunette 4	13 miles north-east of homestead	745	252	Cambrian dolomite	180	160	—	2000	—	Casing collapsed Abandoned
937	Brunette 5	Southern Branch of Brunette Creek, 8 miles east of Dingo Waterhole	725	180 (?)	Cambrian dolomite	180(?)	180	—	2000	—	Casing collapsed Abandoned
938	Brunette 6	5 miles east of Edwards Creek	712	267	Anthony Lagoon Beds	240	—	—	2000	—	Abandoned; see Reg. No. 795
1180	Anthony Lagoon 10	10 miles south by east of Anthony Lagoon homestead	725	231	Anthony Lagoon Beds	189	—	—	1600	Unfit for humans 2010	
1181	Anthony Lagoon 11	5 miles south-south-west of Anthony Lagoon aerodrome	720	309	Anthony Lagoon Beds	175, 265, 299*	150	—	1800	Unfit for humans 3880	
1182	Anthony Lagoon 12	On Rocky Creek, east of Tarrabool Lake	700	150	Anthony Lagoon Beds	114	107	132	—	Good 670	
1183	Anthony Lagoon 13	7 miles east of Adder Waterhole on Creswell Creek	695	275	Anthony Lagoon Beds	150, 262*	136	250	—	Unfit for humans 3360	

* see No. 1211

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
1211	Brunette 14	6 miles south of Mittiebah Creek and one mile north of Boree Creek	730	202	Cambrian dolomite	—	173 (?)	186	2000	2964	
1213	Brunette 37	14 miles north-north-east of Brunette Downs homestead on Creswell road	740	356	Anthony Lagoon Beds	185	—	240	Small	3566	Main aquifer below 185
1214	Brunette 38	On Mittiebah Creek, 7 miles north of Boree Creek	730	229	Cambrian dolomite	220	—	212/ 227	2000	2901	
1215	Brunette 39	9 miles south by east of No. 14 (R1211)	735	301	Cambrian dolomite	—	—	249	2000	4217	
1216	Brunette 40	4 miles east of White Waterhole and 7 miles north of Boree Creek	710	187	Cambrian dolomite	—	—	175	2000	3019	
1217	Brunette 41	6 miles south of Boree Creek and 19 miles east of No. 28	710	353	Cambrian dolomite	—	—	170	1400	3726	
1218	Brunette 42	Lake Sylvester, 21 miles south by west of Brunette homestead	685	242	Anthony Lagoon Beds	—	—	126/ 138	2400	Good 2163	
1219	Brunette 43	Lake Sylvester, 20 miles south-south-west of Brunette Downs homestead	700	127	Anthony Lagoon Beds	120	109	115	2500	5720	
1220	Brunette 44	11 miles south of Brunette Downs homestead, on Alroy Downs Road	700	225	Anthony Lagoon Beds	220	133	160	2500	4870	
1221	Brunette 45	On Mittiebah Creek 3.5 miles north of Barkly Stock Route	745	249	Cambrian dolomite	—	—	200	2800	840	Rose 4 ft
1222	Brunette 46	7 miles north of Dingo Waterhole on Brunette Creek	755	232	Cambrian dolomite	—	178	210	2400	3843	
1223	Brunette 47	9 miles south-east of Brunette Downs homestead, near Anthony Lagoon Beef Road	720	227	Cambrian dolomite	—	176	199	2200	5079	
1225	Brunette 17	12 miles north by east of Dingo Waterhole on Brunette Creek	785	250	Cambrian dolomite	—	—	235	—	4078	
1226	Brunette 17	12 miles north by east of Dingo Waterhole on Brunette Creek	785	259	Cambrian dolomite	—	—	—	—	—	Abandoned
1227	Brunette 19	Headwaters of Brunette Creek	755	292	Cambrian dolomite	196, 268*	191	216	2400	5274	
1228	Brunette 48	On Boree Creek	710	185	Cambrian dolomite	—	—	170	2400	2620	
1229	Brunette 49	North branch of Brunette Creek	760	230	Cambrian dolomite	—	—	215	2400	7212	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
1230	Brunette 50	Junction Fish Hole and Brunette Creeks	730	256	Cambrian dolomite	—	—	232	1400	6589	
1250	Creswell 5	9 miles north-north-west of Creswell Creek on Brunette Downs-Creswell Road	765	298	Anthony Lagoon Beds	210, 275	—	257	—	4090	
1757	Brunette Schoolhouse	Homestead	718	200	Anthony Lagoon Beds	142	137	190	1400	Poor 4290	Abandoned
1990	**Brunette D2**	14 miles south-east of Wire Yard Waterhole on Creswell Creek	770	325	Cambrian dolomite	234, 298*	234	260	2000	4010	
1991	Brunette D3	11 miles north of Coolibah Waterhole on Fish Hole Creek	790	345	Cambrian dolomite	215, 315*	215	—	1600	—	
1992	Brunette D4	16 miles north of Coolibah Waterhole on Fish Hole Creek	785	345	Cambrian dolomite	235, 310*	240	270 (a)	1800	Fair	
1993	Brunette D5	8 miles south-east of Bowgan Waterhole on Creswell Creek	790	304	Cambrian dolomite	277	232	251	1800	Fair 1250	
1994	Brunette D6	3 miles south-south-west of Long Waterhole on Creswell Creek	800	402	Cambrian dolomite	252, 297, 347*	240	—	1500	Bad	Not equipped in 1962
1995	Brunette D8	4 miles south by east of Bowgan Waterhole on Creswell Creek	790	291	Cambrian dolomite	235, 272*	210	270	1800	Fair 3710	
1996	Brunette D9	8 miles south by east of Bowgan Waterhole on Creswell Creek	780	284	Cambrian dolomite	232, 262*	220	270	1650	Fair 3530	
1998	Brunette D14	Lake Sylvester, 8 miles south of Brunette Creek	645	196	Anthony Lagoon Beds	105, 110, 185*	105	156 (a)	2000	Fair 6708	
2157	Anthony Lagoon 14	21 miles south-south-west of Anthony Lagoon aerodrome	735	400	Anthony Lagoon Beds	185, 350*	—	375	1800	Unfit for humans 3990	
2159	Anthony Lagoon 16	11 miles north-west of Adder Waterhole on Creswell Creek	695	150	Anthony Lagoon Beds	130, 137	—	—	1800	Unfit for humans 1170	
2160	Anthony Lagoon 17	3 miles north-west of Tarrabool Lake	690	134	Anthony Lagoon Beds	123	113	134	1800	Fit for humans 630	
2161	Anthony Lagoon 18	North-western margin of Tarrabool Lake	700	230	Anthony Lagoon Beds	—	—	190	—	Fit for humans 602	
2162	Anthony Lagoon 19	6 miles north-north-east of Adder Waterhole on Creswell Creek	685	170	Anthony Lagoon Beds	158	130	—	2000	Unfit for humans 2340	
2163	Anthony Lagoon 20	2 miles north of Tarrabool Lake	670	160	Anthony Lagoon Beds	120, 146*	—	—	1920	1060	
2164	Anthony Lagoon 21	7 miles east of Tarrabool Lake	735	238	Anthony Lagoon Beds	213, 228	—	232	1440	—	
2222	Rockhampton 1	5 miles east-south-east of Rockhampton Downs homestead	740	272	Cambrian	—	169	—	1500	1376	

(a) Position of pump during test.

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
2223	Rockhampton 2	11 miles north-north-east of Rockhampton Downs homestead on Anthony Lagoon Road	710	206	Anthony Lagoon Beds	—	139	—	1500	1506	
2224	Rockhampton 17	19 miles north by east of Rockhampton Downs homestead	705	194	Anthony Lagoon Beds	—	145	—	—	1263	
2225	Rockhampton 18	27 miles north by east of Rockhampton Downs homestead	670	180	Anthony Lagoon Beds	—	—	—	—	4230	
2226	Rockhampton 19	34 miles north by east of Rockhampton Downs homestead on Anthony Lagoon Road	703	210	Anthony Lagoon Beds	—	—	—	—	3814	
2227	Rockhampton 20	31 miles north of Rockhampton Downs homestead	730	210	Anthony Lagoon Beds	—	—	—	—	1353	
2228	Rockhampton 21	21 miles north-west of Rockhampton Downs homestead	680	187	Anthony Lagoon Beds	—	150	—	—	5093	
2232	Rockhampton 25	30 miles north-north-west of Rockhampton Downs homestead	720	196	Anthony Lagoon Beds	—	140	—	—	2762	
2233	Rockhampton 26	33 miles north by west of Rockhampton Downs homestead	725	210	Anthony Lagoon Beds	—	129	—	—	4250	
2234	Rockhampton 27	6 miles north-west of Rockhampton Downs homestead	740	262	Anthony Lagoon Beds	—	150	—	—	3078	
2235	Rockhampton 28	10 miles west of Rockhampton Downs homestead on Brunchilly Road	730	288	Anthony Lagoon Beds	—	155	—	—	3532	
2279	Brunette D10	Lake Sylvester, 19 miles south of Brunette Creek	710	286	Anthony Lagoon Beds	115, 235*	115	197/ 225 (a)	360	—	Abandoned — Site moved
2280	Brunette D10	Lake Sylvester, 15 miles south of Brunette Creek	710	195	Anthony Lagoon Beds	130, 160, 176*	130	164	1800	Poor 10850	Abandoned in 1962
2282	Brunette D12	North-eastern corner of Lake De Burgh	655	193	Anthony Lagoon Beds	105, 173*	120	—	1500	Fair 5362	
2283	Brunette D13	5 miles north-east of D12	633	209	Anthony Lagoon Beds	105, 181*	105	155	1800	Fair 5794	
2287	Brunette D19	East of Lake Corella and 7 miles north of Brunette Creek	665	412	Anthony Lagoon Beds	103, 280, 390*	95	365 (a)	1200	Good 1806	
2288	Brunette D20	6 miles south by west of Brunette homestead	715	234	Anthony Lagoon Beds	175, 215*	175	—	1400	Fair 10,546	
2289	Brunette D21	North-eastern Lake Sylvester, 5 miles east of Joe Waterhole	670	276	Anthony Lagoon Beds	123, 190, 255*	120	194 (a)	1500	Fair 4815	
2412	Creswell 9	18 miles north-west of Wire Yard Waterhole on Creswell Creek	740	265	Anthony Lagoon Beds	191, 241*	176	225	1500	3787	

(a) Position of pump during test.

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
2498	Brunette D22	6 miles north of Buffalo Waterhole on Corella Creek	760	322	Cambrian dolomite	230, 302*	230	—	2000	Fair 3490	
2499	Brunette D23	5 miles south of Wire Yard Waterhole on Creswell Creek	760	326	Cambrian dolomite	220, 260, 305*	220	257	1600	Fair 4242	
2500	Brunette D24	6 miles south-west of Wire Yard Waterhole on Creswell Creek	755	350	Anthony Lagoon Beds	239, 330*	239	278	1600	Good 3201	
2501	Brunette D25	1 mile north of Creswell Creek and 2 miles west of Brunette Downs-Creswell Road	750	352	Anthony Lagoon Beds	214, 334*	214	—	1500	Good 4129	
2502	Brunette D26	24 miles west by north of Wire Yard Waterhole on Creswell Creek	755	355	Anthony Lagoon Beds	200, 325*	110	339 (a)	1000	Fair 2208	Not equipped in 1962
2503	Brunette D27	11 miles north by west of Lignum Waterhole on Corella Creek	730	320	Anthony Lagoon Beds	203, 300*	200	—	3600	Fair 2803	
2504	Brunette D28	Headwaters of Edwards Creek	720	343	Anthony Lagoon Beds	200, 328*	189	—	2800	Good 1660	
2505	Brunette D29	6 miles north of Lignum Waterhole on Corella Creek	725	281	Anthony Lagoon Beds	187, 265*	180	—	3600	Fair 1231	
2506	Brunette D30	19 miles north-north-east of Brunette Downs homestead	755	280	Anthony Lagoon Beds	230, 260*	230	—	1800	Fair 4190	
2507	Brunette D31	6 miles north-west of Corella Lagoon	706	235	Anthony Lagoon Beds	165, 215*	160	—	3600	Good 1010	
2508	Brunette D32	18 miles west-north-west of Corella Lagoon	680	200	Anthony Lagoon Beds	153, 181*	150	—	2400	Fair	
2577	Brunette D36	Immediately south of Corella Lake	685	304	Anthony Lagoon Beds	108, 290*	108	—	3000	Fair 483	
2578	Brunette D37	2 miles north-west of Lake De Burgh	700	220	Anthony Lagoon Beds	160, 220*	140	—	2600	Fair 1245	
2580	Brunette D39	North-eastern corner of Lake Sylvester	690	302	Anthony Lagoon Beds	202, 280*	180	—	2000	Good 972	
2581	Brunette D40	On Anthony Lagoon Beef Road, 5 miles west of Racecourse	730	266	Anthony Lagoon Beds	130, 240*	130	—	3600	Fair 2875	
2582	Brunette D41	3 miles south-west of Brunette Downs homestead	675	436	Anthony Lagoon Beds	140, 296*	120	370 (a)	2050	5508	
2583	Brunette D38	North of Lake Sylvester and 2.5 miles south of Brunette Creek	692	252	Anthony Lagoon Beds	140, 240*	120	—	2600	Good 829	
2584	Brunette D33	24 miles west by north of Corella Lagoon	695	565	Anthony Lagoon Beds	—	—	—	—	—	Dry Hole
2585	Brunette D34	On Edwards Creek and 4 miles north of Corella Creek	698	208	Anthony Lagoon Beds	140, 188*	140	—	2400	Fair 3099	
2586	Brunette D35	1.5 miles north-west of Lake Corella	700	182	Anthony Lagoon Beds	130, 155*	130	—	3000	Fair 711	

(a) Position of pump during test.

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
2744	Creswell (not named)	5 miles north by west of Bowgan Waterhole on Creswell Creek	760	200	Anthony Lagoon Beds	—	—	—	—	—	Dry Hole
2745	Creswell 13	5 miles north-north-east of Bowgan Waterhole on Creswell Creek	745	355	Anthony Lagoon Beds	325	140	—	2050	Fair 471	
2757	Brunette-racecourse	Racecourse	720	251	Cambrian dolomite	196, 223	196	—	4880	Fair	
2758	Brunette D7	14 miles north-west of Brunette homestead and 3 miles east of Corella Creek	732	252	Anthony Lagoon Beds	190	140	—	2000	Fair 2110	
2901	B.S.R. Bishops	6 miles south-east of Corella Creek	735	259	Anthony Lagoon Beds	205	170	—	2000	Fair 2522	
2914	Nemo Bore	9 miles north of Lignum Waterhole on Corella Creek	735	302	Anthony Lagoon Beds	230, 250-280*	203	—	1200	Fair	Not equipped in 1962
2958	Rockhampton 33	24 miles north of Rockhampton Downs homestead	695	174	Anthony Lagoon Beds	145, 165	125	—	—	—	
3100	Brunette K1	On Creswell Creek, 10 miles west of Brunette Downs Creswell Road	735	258	Anthony Lagoon Beds	—	—	258	—	1976	
3101	Brunette K2	4 miles south by west of Buffalo Waterhole on Corella Creek	750	493	Anthony Lagoon Beds	—	—	258	—	2097	
3102	Brunette K3	On Fish-Hole Creek, six miles east of Brunette Creek	740	251	Cambrian dolomite	210, 240*	—	212	1800	Good 4702	
3103	Brunette K4	17 miles west by north of Wire Yard Waterhole on Creswell Creek	740	288	Anthony Lagoon Beds	190, 243*	—	223	—	3544	
3104	Brunette K5	5 miles north-west of Brunette Downs homestead	720	705	Anthony Lagoon Beds	172, 500, 687*	167	200	—	2224	
3105	Brunette K6	5 miles south of Brunette Downs homestead, on Alroy Downs Road	725	377	Anthony Lagoon Beds	100, 220, 357*	195	240	2000	3924	
3107	Brunette K8	20 miles east-south-east of Brunette Downs homestead	725	220	Cambrian dolomite	200, 210	194	207	—	1306	
3109	Brunette 60	25 miles east of Brunette Downs homestead	770	274	Cambrian dolomite	229, 265*	198	225	1800	1980	
3110	Brunette 59	On Anthony Lagoon Beef Road, 7 miles north-west of Lignum Waterhole on Corella Creek	740	335	Anthony Lagoon Beds	330	195	250	3600	1920	
3111	Brunette 58	8 miles south-east of Wire Yard Waterhole on Creswell Creek	775	271	Cambrian dolomite	217, 255*	247	247	3300	4237	
3112	Brunette 57	Headwaters of Brunette Creek	755	272	Cambrian dolomite	250	200	237	2400	4162	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
3113	Brunette 56	On Boree Creek, on eastern margin of Lake Sylvester	690	256	Cambrian dolomite	—	—	193	2200	2935	
3114	Brunette 55	2.5 miles east of Edwards Creek and 4 miles south of Barkly Stock Route	666	234	Anthony Lagoon Beds	—	—	230	2400	1518	
3115	Brunette 54	22 miles north-north-east of Rockhampton Downs homestead	685	150	Anthony Lagoon Beds	—	—	120/ 147	2000	590	
3116	Brunette 53	16 miles north-north-east of Rockhampton Downs homestead	705	175	Anthony Lagoon Beds	—	—	158	2800	760	
3117	Brunette 52	11 miles east by south of Rockhampton Downs homestead	720	174	Anthony Lagoon Beds	140	—	158	2800	—	
3118	Brunette 51	Wire Yard Waterhole on Creswell Creek, on Brunette Downs-Creswell Road	755	333	Anthony Lagoon Beds	—	—	240	1800	4367	
3119	Brunette D15	19 miles south of Brunette Downs homestead on Alroy Downs Road	678	176	Anthony Lagoon Beds	95, 125, 154*	95	175	1200	Fair 3560	
3121	Brunette D18	14 miles east-south-east of Brunette Downs homestead	725	270	Cambrian dolomite	180, 250*	180	234 (a)	1400	Fair	
3122	Brunette D17	23 miles east of No. 28	700	294	Cambrian dolomite	172, 272*	170	280	1500	Fair 3970	
3146	Anthony Lagoon 27	On Rocky Creek, near Tarrabool Lake	695	200	Anthony Lagoon Beds	—	—	180	—	—	
3147	Anthony Lagoon 26	10 miles east of Anthony Lagoon aerodrome	690	255	Anthony Lagoon Beds	—	—	230	—	2308	
3149	Brunette 16	Headwaters of Corella Creek	755	425	Anthony Lagoon Beds	—	—	260	14,000 (?)	2000	
3163	B.S.R. Bishops (old)	6 miles south-east of Corella Creek	735	261	Anthony Lagoon Beds	205	172	210	1600	Fair	Now abandoned, see No. 2901
3568	Brunette D46	20 miles east-south-east of Brunette Downs homestead	725	225	Cambrian dolomite	192, 210*	186	—	—	2945	
3654	Brunette D43	North-western margin of Lake Sylvester	650	—	Anthony Lagoon Beds	—	—	—	—	—	
3655	Brunette D44	Near White Waterhole seven miles north of Boree Creek	685	210	Cambrian dolomite	150	137	—	—	5350	
3656	Brunette D45	2 miles north of Boree Creek	695	206	Cambrian dolomite	157	146	—	—	3104	
3657	B.S.R. Quarantine	3 miles south of Mittiebah Creek	—	—	—	—	—	—	—	—	Not located; see 3658 Mt Drummond sheet
4052	Brunette D42	4 miles north of Lake De Burgh	687	—	Anthony Lagoon Beds	—	—	—	—	3102	
	Brunette Downs X 1	12 miles south-west of homestead	—	320	Anthony Lagoon Beds	130, 210-310	103	220	3000	—	Drilled after maps prepared
	Brunette Downs X 2	18 miles south-west of homestead	—	220	Anthony Lagoon Beds	120, 180-200	106	170	2400	—	Drilled after maps prepared

(a) Position of pump during test.

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
	Brunette Downs X 3	33 miles south-west of homestead	—	180	Anthony Lagoon Beds	80, 165-180	104	130	2000	—	Drilled after maps prepared
	Brunette Downs X 4	36 miles south-west of homestead	—	150	Anthony Lagoon Beds	125	114	—	3250	—	Drilled after maps prepared
	Brunette Downs X 5	24 miles west of homestead	—	420	Anthony Lagoon Beds	160, 260	105	—	1050	—	Drilled after maps prepared
	Brunette Downs X 6	39 miles west of homestead	—	170	Anthony Lagoon Beds	35, 150-165	106	—	3000	—	Drilled after maps prepared
	Brunette Downs X 7	36 miles west-north-west of homestead	—	135	Anthony Lagoon Beds	120-135	111	—	3000	—	Drilled after maps prepared
	Brunette Downs X 8	36 miles north-west of homestead	—	150	Anthony Lagoon Beds	130-150	123	—	3000	3083	Drilled after maps prepared
	Brunette Downs X 9	30 miles west-north-west of homestead	—	165	Anthony Lagoon Beds	150-165	114	—	1500	1275	Drilled after maps prepared
	Brunette Downs X 10	30 miles north-west of homestead	—	245	Anthony Lagoon Beds	160, 230-245	152	—	2000	3125	Drilled after maps prepared
	Brunette Downs X 11	23 miles north-west of homestead	—	210	Anthony Lagoon Beds	168, 200	150	—	3000	2505	Drilled after maps prepared
	Brunette Downs X 12	22 miles north-north-west of homestead	—	200	Anthony Lagoon Beds	160, 187-200	161	—	3000	—	Drilled after maps prepared
	Brunette Downs X 13	34 miles north-north-west of homestead	—	300	Anthony Lagoon Beds	220, 280-300	187	—	2700	2381	Drilled after maps prepared
	Brunette Downs X 14	20 miles north-north-east of homestead	—	305	Anthony Lagoon Beds	230, 275, 305	212	—	3000	2871	Drilled after maps prepared
	Brunette Downs X 15	27 miles north-east of homestead	—	270	Anthony Lagoon Beds	215, 257-270	215	—	2700	4804	Drilled after maps prepared
	Brunette Downs X 16	8 miles south-south-west of homestead	—	450	Anthony Lagoon Beds	145, 350-450	145	—	2000	6356	Drilled after maps prepared
	Brunette Downs X 17	20 miles south-west of homestead	—	150	Anthony Lagoon Beds	103, 143-150	104	—	3600	4825	Drilled after maps prepared
	Brunette Downs X 18	30 miles south-south-east of homestead	—	195	Anthony Lagoon Beds	132-140, 187-195	133	—	3600	2776	Drilled after maps prepared
					ALROY 1:250,000 SHEET AREA						
29	Dalmore 9 (Barkly Highway 14A)	Barkly Highway, 9 miles south by east of Dalmore Downs homestead	785	251	Wonarah Beds	—	172	—	—	1420	
31	Barkly Highway 4A	Barkly Highway, ½ mile east of Wonarah	800	305	Wonarah Beds	—	227	—	300	—	Not equipped
32	Barkly Highway 17A	Barkly Highway 15 miles west-north-west of Frewena	770	172	Wonarah Beds	—	156	—	1140	—	Not equipped
41	Frewena (Barkly Highway 6A)	Barkly Highway	711	188	Wonarah Beds	—	133	—	3600	586	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
43	Dalmore 10 (Barkly Highway 9A)	2 miles north-west of Barkly Highway-Anthony Lagoon Beef Road Junction	748	254	Wonarah Beds	—	152	—	300	Poor	Not equipped
124	Brunette 34	On southern margin of Lake Sylvester, 11 miles west of Playford River	655	186	Wonarah Beds (?)	110, 154*	100	150	2000	Good 2488	
231	Barkly Highway 21A	On Barkly Highway, 25 miles west-north-west of Frewena	815	251	Wonarah Beds	—	217	—	530	—	
285	Rockhampton 7	18 miles north-north-west of Frewena	765	244	Wonarah Beds	—	139/158	—	Good	Good 1899	
353	Dalmore 8 (Barkly Highway 18A)	On Barkly Highway, 5 miles south-south-west of Dalmore Downs homestead	750	232	Wonarah Beds	—	—	170	800	860	
358	Rockhampton 3	8 miles north-west of Frewena	730	196	Wonarah Beds	—	147	—	Good	Good 442	
364	Barkly Highway 16A	Barkly Highway 9 miles west-north-west of Wonarah	785	231	Wonarah Beds	—	190	—	500	—	Not equipped
379	Barkly Highway 11A	Barkly Highway 13 miles south-west of Frewena	740	199	Wonarah Beds	—	172	—	500	—	Not equipped
395	Rockhampton 4	25 miles north by west of Frewena	775	269	Wonarah Beds	—	147	—	Good	Brackish 3301	
396	Rockhampton 6	3 miles north of Frewena	700	186	Wonarah Beds	—	141	—	Good	Good 989	
403	Brunette 24	Near Lake Sylvester, 5 miles west of Playford River	660	245	Wonarah Beds (?)	102, 228*	101	131	2500	Fit for stock 4880	
414	Rockhampton 14	19 miles north of Frewena	733	149	Wonarah Beds	—	124	132	Good	Brackish 3144	
496	†S.B.S.R. 2	9 miles north of Kerringnew swamp	820	456	Wonarah Beds (?)	208	208	233	2800	Good	
498	S.B.S.R. 4	8 miles south by east of Alroy Downs homestead	780	221	Wonarah Beds (?)	132, 205*	132	154	2400	Good	
499	S.B.S.R. 5	13 miles west by south of Alroy Downs homestead	720	230	Wonarah Beds (?)	160, 210*	160	189	2400	Good	
500	S.B.S.R. 6	19 miles north-east of Frewena	690	220	Wonarah Beds (?)	126	126	—	2000	980	
501	S.B.S.R. 7	10 miles north of Frewena	710	198	Wonarah Beds (?)	141, 180*	141	171	1000	Good	Apparently clogged with clay in 1961. Replaced by No. 2800
503	S.B.S.R. 8	17 miles north-west of Frewena	730	328	Wonarah Beds (?)	153, 315*	153	220	2000	Good 1071	
504	S.B.S.R. 9	31 miles west-north-west of Frewena	735	314	Wonarah Beds (?)	167, 305	167	210	2400	Good 1052	

† South Barkly Stock Route.

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
719	Alroy 1	11 miles east of Alroy Downs homestead	770	190	Cambrian limestone	150 (?)	150	165	1500	Salty 2526	
720	Alroy 2	14 miles north-west of Alroy Downs homestead	750	180	Cambrian limestone	—	148	163	2000	Fair 1888	
721	Alroy 3	14 miles west of Alroy Downs homestead	720	190	Wonarah Beds	—	150	165	2000	—	
722	Alroy 4	16 miles south-east of Alroy Downs Homestead	810	600	Wonarah Beds	—	180	217	1000	Good 1415	
723	Alroy 5	Alroy Downs homestead	745	180	Wonarah Beds (?)	—	150	162	2000	Not fit for humans 2317	
724	Alroy 6	13 miles north of Alroy Downs homestead, on Brunette Downs Road	740	170	Cambrian limestone	—	140	157	2000	Not fit for humans 2538	
725	Alroy 7	12 miles south of Alroy Downs homestead, on Dalmore Downs Road	770	180	Wonarah Beds	—	150	163	2000	Good 1375	
726	Alroy 8	5 miles south by west of Alroy Downs homestead, on Dalmore Downs Road	770	198	Wonarah Beds	148	143	164	2000	—	Abandoned; Replaced by Reg No. 3142
727	Alroy 9	24 miles west of Alroy Downs homestead on Frewena Road	670	147	Wonarah Beds (?)	—	115	123	2000	Good 1336	
728	Alroy 10	Desert Creek confluence with Playford River	765	177	Cambrian limestone	140	142	165	2000	Unfit for humans 4018	
729	Alroy 11	13 miles south of Buchanan Dam	800	260	Wonarah Beds	180	130	204	2000	Unfit for humans 1831	
730	Alroy 12	17 miles east of Frewena	704	267	Wonarah Beds	—	150	240	2000	Unfit for humans 1274	
731	Dalmore 13	4 miles south of Mt Lamb	800	208	Wonarah Beds	—	170	190	2000	1472	Originally Alroy Downs No. 13†
732	Alroy 14	11 miles north-east of Frewena on Alroy Downs Road	700	160	Wonarah Beds	—	125	130	—	Fair 992	
733	Alroy 15	19 miles north-north-east of Frewena	680	144	Wonarah Beds	125	125	135	2000	Unfit for humans 2801	
734	S.B.S.R. 3	8 miles west of Desert Creek	800	250	Wonarah Beds	—	180	200	1700	918	Originally Alroy Downs No. 16†
1212	Brunette Rocky 2	20 miles north by east of Frewena	690	198	Wonarah Beds (?)	—	138	150	—	1417	

† Since the transfer of these bores, Alroy Downs station has drilled replacement bores at other localities viz registered Nos 3143 (No. 13) and 3144 (No. 16).

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
1236	Dalmore 1	21 miles north of Wonarah	825	550	Wonarah Beds	—	170 (?)	200	—	1505	
1237	Dalmore 2	12 miles north of Wonarah	760	—	Wonarah Beds	—	—	—	—	1698	
1238	Dalmore 3	20 miles east of Dalmore Downs homestead	750	272	Wonarah Beds	—	—	—	—	—	
1239	Dalmore 4	9 miles east of Dalmore Downs homestead	745	—	Wonarah Beds	—	—	—	—	659	
1240	Dalmore 5	Dalmore Downs homestead	765	—	Wonarah Beds	—	—	—	—	1305	
1241	Dalmore 6	18 miles east-north-east of Dalmore Downs homestead	775	246 (?)	Wonarah Beds	—	—	—	—	923	
1242	Dalmore 7	14 miles north-north-east of Dalmore Downs homestead	755	230	Wonarah Beds	—	—	—	—	944	
1749	Dalmore 11	16 miles east by north of Dalmore Downs homestead	785	230	Wonarah Beds	—	—	—	2500	—	
2190	Alroy 17	16 miles north-north-east of Alroy Downs homestead	775	235	Cambrian limestone	—	170	187	2000	Unfit for humans 4574	
2191	Alroy 18	23 miles north-east of Alroy Downs homestead	745	212	Cambrian limestone	—	—	—	—	Poor 6785	Abandoned in 1962
2192	Alroy 19	13 miles south-south-west of Alroy Downs homestead	750	—	Wonarah Beds	—	140	—	—	2056	
2193	Alroy 20	15 miles west-south-west of Alroy Downs homestead	725	235	Wonarah Beds	—	—	—	—	Good 1496	
2194	Alroy 21	3 miles east by north from Dookamunda Waterhole on Playford River	690	182	Cambrian limestone	—	—	—	—	Fair 1458	
2195	Alroy 22	8 miles south by east of Buchanan Dam	785	270	Wonarah Beds	—	175	—	—	Unfit for humans 2224	
2229	Rockhampton 22	37 miles north-west of Frewena	722	477	Wonarah Beds	—	—	—	—	3369	
2236	Rockhampton 29	13 miles north by west of Frewena	730	186	Wonarah Beds	—	160	—	—	1857	
2281	Brunette D11	In Lake Sylvester, 2 miles north of Lignum Waterhole	670	206	Wonarah Beds (?)	100, 130, 183*	100	—	1800	4506	
2579	Brunette D1	24 miles north of Frewena	685	220	Wonarah Beds (?)	161, 200	140	—	3200	Fair 1372	
2800	S.B.S.R. 7	10 miles north of Frewena	710	190	Wonarah Beds (?)	140	141	—	1500	1276	
2940	Rockhampton 30	15 miles west-north-west of Frewena	715	245	Wonarah Beds	142, 217-241*	142	—	2200	437	
2941	Rockhampton 31	8 miles north by west of Frewena	740	182	Wonarah Beds	140, 178-182*	140	—	2800	Fair	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
2942	Rockhampton 32	25 miles north of Frewena	700	380	Wonarah Beds	135, 349-363*	135	—	1200	Fair 2920	
3106	Brunette K7	22 miles north-north-west of Alroy Downs homestead	690	307	Wonarah Beds (?)	130, 200, 270*	—	200	2800	—	
3108	Brunette K9	26 miles north-west of Alroy Downs homestead	642	166	Wonarah Beds	105, 157*	—	121	2000	2248	
3120	Brunette D1	24 miles north of Frewena	685	187	Wonarah Beds (?)	152, 182*	—	—	—	—	Abandoned (see Reg. No. 2579)
3123	Brunette D16	22 miles north-north-east of Alroy Downs homestead	690	281	Cambrian dolomite	150, 165, 265*	150	—	1500	Fair 4288	
3138	Alroy 26	9 miles north by east of Alroy Downs homestead	750	265	Cambrian dolomite	—	—	190	—	Fair 2660	
3139	Alroy 25	15 miles east of Alroy Downs homestead	785	233	Wonarah Beds	—	165	203	—	3003	
3140	Alroy 24	11 miles south-east of Alroy Downs homestead	785	196	Wonarah Beds	185	178	—	1440	850	
3141	Alroy 23	20 miles west-north-west of Alroy Downs homestead	690	176	Cambrian limestone	—	129	150	—	1507	
3142	Alroy 8A	7 miles south of Alroy Downs homestead	770	448	Wonarah Beds	172,420-448*	142	—	2500	Good	
3143	Alroy 13	19 miles west by south of Alroy Downs homestead	725	167	Cambrian limestone	147, 166*	—	155	—	1060	
3144	Alroy 16	18 miles north-north-west of Alroy Downs homestead	730	193	Cambrian limestone	155, 178*	—	165	—	5130	
3145	Alroy 18A	26 miles north-east of Alroy Downs homestead	—	350	Cambrian limestone	—	—	—	—	Poor 6774	Never equipped
3659	Dalmore 12	11 miles east-north-east of Dalmore Downs homestead	765	330	Wonarah Beds	280	180	200 (?)	Good	—	
3660	Dalmore 14	6 miles north by east of Dalmore Downs homestead	765	—	Wonarah Beds	—	—	—	—	—	
3661	Dalmore 15	9 miles north-west of Dalmore Downs homestead	—	289	Wonarah Beds	—	—	—	—	—	
—	Wonarah	Wonarah repeater station	800	366	Wonarah Beds	311	177	321	520	Fit for humans 1097	
					WALLHALLOW 1:250,000 SHEET AREA						
524	B.S.R. 2	4½ miles west of Turkey Creek	754	208	Anthony Lagoon Beds	180	157	195	1300	Fair for domestic use 471	
525	B.S.R. 1	16 miles west of Anthony Lagoon homestead	759	242	Anthony Lagoon Beds	215	156	—	1400	2170	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
598	Anthony Lagoon 3	6 miles west by south of Anthony Lagoon homestead on Six-mile Creek	730	225	Anthony Lagoon Beds	145-225	178	—	2700	3640	
599	Anthony Lagoon 4	Headwaters of Lignum Creek	700	398	Anthony Lagoon Beds	208, 381	200	200	1500	3296	
600	Anthony Lagoon 5	7 miles north-north-west of Anthony Lagoon homestead	700	331	Anthony Lagoon Beds	170, 289	171	202	1800	Unfit for humans 3702	
601	Anthony Lagoon 6	9 miles north-east of Anthony Lagoon homestead	710	274	Anthony Lagoon Beds	171, 270	—	194	1700	2361	
605	Anthony Lagoon 2	Anthony Lagoon homestead	716	225	Anthony Lagoon Beds	162, 200-220	145 (?)	—	2500	2702	
606	Anthony Lagoon 8	25 miles west by north of Anthony Lagoon homestead	691	309	Anthony Lagoon Beds	190, 297	170	—	2400	Unfit for humans 3044	
607	Police Bore-Anthony Lagoon	Anthony Lagoon police station	720	212	Anthony Lagoon Beds	168	—	190	1000	Fit for stock	
952	Wallhallow 1	Old Wallhallow ruins on Cattle Creek	840	363	Cambrian?	—	270	—	2800	—	
960	Wallhallow 2 (Collabirrian Creswell Downs)	Headwaters of Cattle Creek	820	412	Cambrian?	327	304	—	3000	Good 525	
961	Wallhallow 3	Eight Mile Creek	870	320	Cambrian?	240, 286-312	240	—	3200	Excellent	
1067	Mallapunyah	Bullock Creek	860	—	Cambrian?	—	250	—	—	827	
1070	Creswell-Coolibah	6 miles south of Collabirrian, on Anthony Lagoon-Mallapunyah Road	805	—	Cambrian?	—	—	—	—	905	
1246	Creswell 1	Creswell Downs homestead	745	206	Anthony Lagoon Beds	—	—	—	—	3670	
1247	Creswell 2	11.5 miles east by north of Creswell Downs homestead	765	238	Anthony Lagoon Beds	210	205	227	1400	4765	
1248	Creswell 3	11 miles west by south of Creswell Downs homestead	720	271	Anthony Lagoon Beds	—	—	—	—	4670	
1249	Creswell 4	6 miles north-west of Creswell Downs homestead	725	279	Anthony Lagoon Beds	187, 257*	—	—	2200	Fair 3335	
1251	Creswell 6	14 miles west-north-west of Creswell Downs	750	241	Anthony Lagoon Beds	185, 220*	184	—	1450	1251	
1252	Creswell 7	18.5 miles east of Creswell Downs homestead	775	242	Anthony Lagoon Beds	211	—	—	—	5042	
2158	Anthony Lagoon 15	31 miles west of Anthony Lagoon homestead	725	194	Anthony Lagoon Beds	180, 194	—	184	1800	Suitable for humans 1273	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
2409	Creswell 12	27 miles east by north of Creswell Downs homestead	800	333	Anthony Lagoon Beds	298, 305	210	326	—	545	
2410	Creswell 11	19.5 miles east-north-east of Creswell Downs homestead	790	260	Anthony Lagoon Beds	232	225	—	1460	888	
2411	Creswell 10	17.5 miles north-east of Creswell Downs homestead	800	302	Anthony Lagoon Beds	235	223	—	1440	906	
2413	Creswell 8	11 miles east-south-east of Creswell Downs homestead	775	265	Anthony Lagoon Beds	—	206	—	1200	4083	
2746	Creswell 14	38 miles east of Creswell Downs homestead	810	325	Cambrian or Upper Proterozoic	72, 134-325*	52	—	1300	Fair 304	
2749	Creswell 16	37 miles east of Creswell Downs homestead	820	179	Cambrian (?)	70, 105-176	70	—	4000	Good	
2750	Creswell 17	24 miles north-east of Creswell Downs homestead	845	392	Cambrian	298, 370	140	—	—	Fair	
2751	Creswell 18	6.5 miles north of Creswell Downs homestead	765	288	Cambrian	203, 270	120	—	1000	Fair 3824	
2752	Creswell Kelly Bore	13 miles north of Creswell Downs homestead	780	369	Cambrian	201, 328, 369	140	—	1500	Fair 1356	
3148	Anthony Lagoon 25	36 miles west by north of Anthony Lagoon homestead	756	270	Anthony Lagoon Beds	198	—	270	1800	—	
				RANKEN 1:250,000 SHEET AREA							
33	Barkly Highway 15A	110 miles west of Camooweal	—	428	Wonarah Beds	—	300	—	360	Fair	Not located (a)
83	Avon Downs 5	20 miles north of Avon Downs homestead	850	334	Camooweal Dolomite	275	—	—	3000	Good 733	
84	Avon Downs 6	Between 6-mile Creek and Bull Creek	860	304	Camooweal Dolomite	290	—	—	300	494	
96	Avon Downs 20	Headwaters of Lingaree Creek	880	374	Camooweal Dolomite	—	297	—	—	598	
97	Avon Downs 21	South-west of Avon Downs No. 20	850	—	Camooweal Dolomite	—	—	—	—	—	Abandoned
215	Barkly Highway 22A	On Six-mile Creek	833	300	Camooweal Dolomite	—	288	—	500	—	Abandoned
347	Avon Downs 8	7 miles north of Lignum Waterhole	840	325	Camooweal Dolomite	—	290	315	3000	—	
352	Avon Downs 9	On Six-mile Creek	885	370	Camooweal Dolomite	—	315	—	3000	—	
359	Avon Downs 12 (old)	6 miles north of Avon Downs homestead	820	290	Camooweal Dolomite	—	263	—	6000	Good	Abandoned; see Reg. No. 3159
392	Avon Downs 10	James River	875	380	Camooweal Dolomite	—	300	—	6000	940	
495	S.B.S.R. 1	16 miles west by north of Ranken store	785	336	Camooweal Dolomite	180, 276, 336	180	224	960	Good 1988	

(a) Subsequently found near Barry Caves Roadhouse, 1965.

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
532	B.S.R.-Alexandria	2 miles south of Alexandria homestead	795	284	Camooweal Dolomite	175, 278	175	225	1500	Good	
533	B.S.R. Buchanan	2.5 miles south of Buchanan Creek	840	273	Camooweal Dolomite	226, 255, 272	213	239	1330	Good 374	
534	B.S.R. Ranken Plain	14 miles north of Ranken store	860	344	Camooweal Dolomite	225, 258	225	286	1000	Good	
536	B.S.R. Avon	On Bull Creek	815	290	Camooweal Dolomite	—	258	—	1020	Good 682	
537	B.S.R. Rocklands West	Blue-bush Creek	810	372	Camooweal Dolomite	—	240	297	1550	Fair 1289	
542	B.S.R. O'Reillys	1.5 miles north of Barkly Highway	825	—	Camooweal Dolomite	—	—	270	1200	Fair 1259	
545	B.S.R. Rocklands East	Cattle Creek	860	323	Camooweal Dolomite	—	270	—	1500	Good 1227	
623	Drought Relief	On Alexandria station	—	340	—	—	160	—	2400	—	Not located
735	Alexandria 1	16 miles south-east of Alexandria homestead	815	1760	Burton Beds, Camooweal Dolomite; Mittiebah Sandstone	238	233	232/275	3500	Useable 342	
736	Alexandria 2	South-west of Alexandria homestead. Not located	—	450	—	166	166	253	400	Useable	Abandoned
737	Alexandria 3	4 miles north of Buchanan Creek	850	344	Burton Beds	—	241	284	3000	Useable 636	
738	Alexandria 4	Playford River	795	360	Burton Beds	—	202	267	3000	Useable 517	
740	Gallipoli 6	8 miles east by south of Gallipoli homestead	879	402	Camooweal Dolomite	—	346	367	—	—	
742	Alexandria 7	4 miles south of junction of Barkly Highway and main access road to B.S.R.	805	313	Camooweal Dolomite	250, 313	223	239	3000	—	
743	Alexandria 8	On Lorne Creek; not located	—	408	—	—	—	—	—	—	No supply
744	Alexandria 9	Near Ranken store	805	306	Camooweal Dolomite	243	233	243	3000	Good 1100	
745	Alexandria 10	10 miles north-east of Ranken store	815	366	Camooweal Dolomite	255, 320, 345*	254	254	3000	Good	
746	Alexandria 11	Borodo Creek	835	308	Camooweal Dolomite	255	237	258	3000	Good	
747	Alexandria 12	Alexandria homestead	815	451	Burton Beds	445	255	249	3000	Good 370	
750	Alexandria 15	Near Alexandria homestead	—	130	Burton Beds	—	—	—	—	—	Not completed

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
751	Alexandria 16	South-west of Alexandria homestead	805	278	Burton Beds	205, 240, 260*	205	225	3000	Useable 294	
752	Alexandria 17	On Ranken River, 12 miles downstream from Ranken store	805	841	Ranken Limestone	745, 835*	—	395/ 700	3000	Useable 2520	
753	Alexandria 18	3.5 miles south-west of Junction of Ranken River and Lorne Creek	780	437	Ranken Limestone	260-435	225	273	3000	Good	
754	Alexandria 19	East of Six-mile Creek	815	263	Camooweal Dolomite	243?	243	—	3000	Good	Abandoned. See Reg. No. 2487
755	Alexandria 20	9 miles east of Lulu Water-hole on Gallipoli Road	890	305/325	Camooweal Dolomite	285/296	285/ 296	300/ 320	2000	Good	Redrilled in 1961
756	Alexandria 21	4 miles west of D'Arcy grave on Gallipoli Road	908	358	Camooweal Dolomite	290, 320*	280	300	2400	Good 875	
757	Alexandria 22	12.5 miles east by north of Ranken store	830	501	Camooweal Dolomite	278, 379*	268	—	1200	Good	Abandoned
758	Alexandria 23	14.5 miles east by north of Ranken store	845	603	Camooweal Dolomite	100, 500, 600*	280	—	2250	460	
932	B.S.R.-Ranken Dip	Ranken dip	797	309	Camooweal Dolomite	—	256	280	—	Good 2094	
940	Rocklands 6	Cattle Creek	855	526	Camooweal Dolomite	278, 285*	—	—	1600	—	Abandoned
941	Rocklands 10	Georgina River	830	300	Camooweal Dolomite	255	245	—	1600	Fair 534	
942	Rocklands 11	Kiama Creek	825	353	Camooweal Dolomite	260, 286, 314, 343*	240	—	1600	Good	
944	Rocklands 13	Happy Creek	835	355	Camooweal Dolomite	265, 355	—	—	Good	Good 548	
945	Rocklands 14	Georgina River	850	400	Camooweal Dolomite	—	—	—	700	—	Abandoned
946	Rocklands 15	Middle Branch	845	339	Camooweal Dolomite	—	270	—	1600	—	Abandoned
947	Rocklands 16	McKay Creek	870	338	Camooweal Dolomite	—	280	—	1600	—	Abandoned
948	Rocklands 17	Scrubby Creek	855	308	Camooweal Dolomite	—	280	300	1600	Good	
949	Rocklands 19	Mikado Creek	875	420	Camooweal Dolomite	280	—	318	1600	558	
950	Rocklands 23	7 miles south-west of Dariel Gate on border fence	810	360	Camooweal Dolomite	305, 325*	280	—	1800	—	
951	Avon Downs 11	6.5 miles north of Avon Downs No. 10 (Reg. No. 392)	870	344	Camooweal Dolomite	—	292	318	Poor	Fair 595	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
999	Rocklands 24	Middle Branch	880	350	Camooweal Dolomite	—	315	—	—	—	
1000	Rocklands 25	West of Rocklands No. 24	870	229	Camooweal Dolomite	—	—	—	—	—	Not completed
1142	Alexandria 32	Homestead	815	446	Burton Beds	223, 253	185	280	—	Good	
1143	Alexandria 29	On South Barkly stock route	805	389	Camooweal Dolomite	227, 250-280, 350-385	200	301	2100	Good	
1144	Alexandria 28	Not located	—	—	—	—	—	—	—	—	Probably 1st attempt at Alexandria No. 41
1148	Alexandria 41	4.5 miles south of Bell Waterhole on Lorne Creek	775	389	Ranken Limestone or Camooweal Dolomite	—	221	247	2700	Good 1238	
1149	Alexandria 27	Playford River	770	419	Burton Beds	178, 250, 410*	150	370	Good	Good	
1150	Alexandria 24	Cigarette Hole Creek	840	382	Camooweal Dolomite	275, 352, 382*	268	366	—	482	
1151	Alexandria 25	White Waterhole	830	411	Burton Beds or Camooweal Dolomite	340, 393*	258	393	—	384	
1152	Alexandria 26	2.5 miles west of Lulu Waterhole, on Gallipoli Road	880	402	Camooweal Dolomite	291, 334, 382, 480	275	365	Good	Useable 427	
1153	Gallipoli 1	Homestead	900	367	Camooweal Dolomite	—	346	367	2400	Good 520	
1154	Gallipoli 7	8 miles north of Gallipoli homestead	885	400	Camooweal Dolomite	—	240	—	Good	Good 364	Put down as Herbert Vale No. 7
1155	Gallipoli 5	7 miles south-east of Gallipoli homestead	885	402	Camooweal Dolomite	—	260	—	Good	Good 570	Put down as Herbert Vale No. 5
1156	Alexandria 31	10.5 miles south-west of Gallipoli homestead	920	930	Camooweal Dolomite	315, 326	305	317	Good	Good 401	
2486	Alexandria 49	10 miles west by north of Alexandria homestead	765	246	Burton Beds	200	185	—	2000	—	
2487	Alexandria 19 (New)	East of Six-Mile Creek	815	268	Camooweal Dolomite	232	210	—	—	Fair	
2769	Alexandria 51	25 miles south by west of Alexandria homestead	775	242	Burton Beds (?)	180	170	—	2000	2090	
3124	Alexandria 30	10 miles south-west of Gallipoli homestead	920	149	Camooweal Dolomite	—	—	—	—	—	1st attempt at No. 31 (Reg. No. 1156)
3125	Alexandria 50	19 miles south-south-west of Alexandria homestead	785	204	Burton Beds (?)	165	160	—	2000	Good 620	
3126	Alexandria 36	7 miles north of Cigarette Hole Creek	880	388	Camooweal Dolomite	310, 380*	285	325	Good	Good 455	
3131	Alexandria 42	Oolgoolgarri Swamp	820	220	Camooweal Dolomite (?)	197, 210*	190	—	2040	Good	
3133	Alexandria 44	Buchanan Creek	855	310	Burton Beds	300	—	267	1800	Good 409	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
3135	Alexandria 46	North by west of Weaner Waterhole	885	350	Camooweal Dolomite	330	—	—	1800	Good 472	
3136	Alexandria 47	3.5 miles north-west of homestead	825	323	Burton Beds	222, 304*	—	285	2040	Good 31	
3137	Alexandria 48	16 miles south by east of homestead	840	260	Burton Beds (?)	222-250	212	250	2700	Good 333	
3156	Rocklands 27	Cattle Creek	880	381	Camooweal Dolomite	290, 335, 370	281	—	2400	Good 568	
3157	Rocklands 28	Georgina River	845	415	Camooweal Dolomite	347, 360, 397	—	—	1800	406	
3158	Herbert Vale 4	10 miles north-west of Gallipoli homestead	849	395	Camooweal Dolomite	—	—	—	—	—	
3159	Avon Downs 12 (new)	Between James River and Bull Creek	820	336	Camooweal Dolomite	—	263	270	—	528	
3162	Avon Downs 26	Six-mile Creek	835	375	Camooweal Dolomite	—	250	—	—	1132	
3163	B.S.R.-Wilfred	Twelve-Mile Creek	785	338	Camooweal Dolomite	—	221	250	1220	Fair 1408	
	Alexandria 20A	On Gallipoli Road	—	—	—	—	—	—	—	—	Abandoned
	Rocklands 25	—	—	350	—	300, 335-350	292	—	2000	—	Successful redrilling of R.N. 1000
	Rocklands 31	—	—	—	—	—	—	—	—	—	
	Rocklands 34	—	—	435	—	316, 415	292	—	2000	—	
	Alexandria 33	—	—	—	—	—	—	—	—	—	Crooked Hole. Abandoned
	Alexandria 52	—	—	—	—	—	—	—	—	—	
	Alexandria 53	Near Alexandria No. 27	—	270		215, 235, 240	—	—	2400	—	
	Alexandria 54	Near Alexandria No. 4	—	280	—	200, 210-280	186	—	3000	—	
	Alexandria 55	12 miles south-west of Alexandria No. 20	—	432	—	305, 410	282	—	2400	—	
				MOUNT	**DRUMMOND**	**1:250,000 SHEET**	**AREA**				
531	B.S.R.-Connells	Connells Lagoon	776	288	Burton Beds	225, 258	225	256	1800	Good 343	
748	Alexandria 13	On Eastern Creek	860	383	Burton Beds	264	234	272	3000	452	
749	Alexandria 14	3.5 miles north of Tobacco Waterhole on Playford River	895	665	Burton Beds/ Camooweal Dolomite	632	250	268/ 403	3500	415	
3127	Alexandria 37	3 miles north-north-east of Iris Waterhole on Playford River	855	340	Burton Beds	160, 320	—	285	—	—	
3128	Alexandria 38	3 miles north-east of Bull Waterhole on Corporal Ck.	908	495	Camooweal Dolomite	280, 490-495	—	380	2400	441	
3129	Alexandria 39	5.5 miles west of Bull Waterhole on Corporal Creek	908	400	Camooweal Dolomite	268, 395	268	387	2500	373	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
3130	Alexandria 40	14 miles north of Connells	770	268	Burton Beds (?)	213-268	213	255	—	—	Not working in 1962
3134	Alexandria 45	5 miles south of Connells	760	253	Burton Beds	233	—	—	1800	—	
3658	B.S.R. New Quarantine Bore	8 miles north of Connells	755	400	Burton Beds (?)	215	210	—	Poor	—	Abandoned
—	B.S.R. New Quarantine Bore 2nd try	1½ miles south-west of No. 3658	—	250	Burton Beds (?)	220, 235-250	213	—	1200	—	
AVON DOWNS 1:250,000 SHEET AREA											
75	Lake Nash 22	Lake Nash homestead	578	216	Camooweal Dolomite (?)	—	63	190	Good	Good	
91	Avon Downs Old 15	7 miles south of Avon Downs homestead	740	203	Camooweal Dolomite (?)	—	183	—	—	—	Abandoned; see Reg. No. 3160
92	Avon Downs 17	On eastern side of Blue-bush swamp, 5 miles south of Ranken River	668	160	Camooweal Dolomite (?)	—	120	—	1700	1218	New Austral Downs No. 17 on Burramurra Block
93	Avon Downs 16	29 miles south of Avon Downs homestead	685	218	Camooweal Dolomite (?)	—	130	—	1700	—	
94	Avon Downs 18	17 miles west-south-west of Austral Downs homestead	690	325	Camooweal Dolomite (?)	—	130/ 150	—	1250	—	Now Austral Downs No. 18 on Burramurra Block
95	Avon Downs 19	At Burramurra homestead	685	350	Camooweal Dolomite (?)	—	150	—	1750	—	Now Austral Downs No. 19 on Burramurra Block
98	Avon Downs 22	6 miles south-east of Avon Downs homestead	790	276	Camooweal Dolomite	—	238	—	1750	878	Abandoned
205	Chinaman Well Lake Nash	Lake Nash station	—	—	—	—	—	—	—	—	Not located
206	Barkly Highway 7A	9 miles west by south of Soudan homestead	822	196	Wonarah Beds	—	156	—	1600	—	Not working
214	Avon Downs 17-mile well	15 miles south by east of Avon Downs homestead	743	207	Camooweal Dolomite	—	200	—	Good	—	Abandoned
318	Avon Downs 13	3 miles south-east of Avon Downs homestead	765	230	Camooweal Dolomite	—	218	—	Poor	—	Abandoned
331	Avon Downs 14	20 miles south by east of Avon Downs homestead	741	221	Camooweal Dolomite	—	176	—	1300	1490	
340	Avon Downs 3	12 miles south-east of Avon Downs homestead	750	228	Camooweal Dolomite	—	202	218	—	1490	
346	Avon Downs 2	Not located	770 (?)	246	—	—	230	—	—	—	Abandoned
366	Avon Downs 1	8 miles east of Avon Downs homestead	765	259	Camooweal Dolomite	—	235	—	1750	712	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
369	Avon Downs 4	2 miles north-west of homestead	—	226	Camooweal Dolomite	—	211	—	1720	—	Abandoned
384	Avon Downs 23	Avon Downs homestead	679	228	Camooweal Dolomite (?)	—	216	—	1750	587	
739	Alexandria 5	5 miles east of Soudan homestead	775	317	Camooweal Dolomite (?)	—	215	227	3000	—	
741	Alexandria 6	Ranken River 16 miles downstream from Soudan homestead	710	608	Camooweal Dolomite (?)	—	—	—	—	—	No supply
769	Austral Downs 4-mile Bore	5 miles west-north-west of Austral Downs homestead	666	168	Camooweal Dolomite	—	146	—	—	—	
770	Austral Downs Goat Hole	Near confluence of Western Creek and Georgina River	796	246	Camooweal Dolomite	—	—	180	2000	—	
771	Austral Downs Shakespeare 1	14 miles north by west of Austral Downs homestead	688	254	Camooweal Dolomite	140	—	—	500	—	Never equipped
772	Austral Downs Shakespeare 2	14 miles north by west of Austral Downs homestead	688	184	Camooweal Dolomite	143-156; 179-184	141	—	2000	—	
773	Austral Downs New Year	10 miles north-north-east of Austral Downs homestead	790	220	Camooweal Dolomite	—	—	200	3000	—	
775	Austral Downs Yellow Hole 1	Yellow Waterhole on Bluebush Creek	680	219	Camooweal Dolomite	142, 161-210	145	—	2000	—	Abandoned, silted up
776	Austral Downs Yellow Hole 2	Yellow Waterhole on Bluebush Creek	680	173	Camooweal Dolomite	137, 173*	143	—	2000	—	
777	Austral Downs Bluebush	12 miles east-south-east of Austral Downs homestead on Bluebush Creek	640	179	Camooweal Dolomite	131, 167	124	124	2000	—	
778	Austral Downs Coolibah	12 miles south of Austral Downs homestead	660	380	Camooweal Dolomite	116-147, 332	147	185	2000	—	
779/996	Austral Downs Poison Bore	19 miles south-east of Austral Downs homestead	630	278	Camooweal Dolomite	—	113	141	—	—	Bore was redrilled. Not equipped
939	Rocklands 5	Western Creek	845	266	Camooweal Dolomite	238	—	238	1300	—	
943	Rocklands 12	Between Happy Creek and Shakespeare Creek	763	298	Camooweal Dolomite	254	—	245	1600	Good	

Reg. No.	Station No. or Name	Position	Elevation (ft)	Total Depth (ft)	Rock Units	Depth of Aquifers (*Main Supply) (ft)	Depth of Standing Water Level (ft)	Pump Depth (ft)	Supply (gph)	Quality (ppm)	Remarks
994	Avon Downs 24	27 miles south-south-east of Avon Downs homestead	703	315	Camooweal Dolomite	—	145	—	—	1604	
995	Austral Downs Top Bore 1	23 miles north of Austral Downs homestead	722	227	Camooweal Dolomite	193	—	—	—	—	Abandoned, tools jammed
1146	Alexandria 34	On Six-mile Creek	760	295	Camooweal Dolomite (?)	—	210	250	2500	—	Abandoned (?)
1147	Alexandria 35	23 miles south-south-east of Soudan homestead	720	397	Wonarah Beds (?)	300, 325	190	317	—	—	
1185	Austral Downs Goose Hole	9 miles north by west of Austral Downs homestead	685	190	Camooweal Dolomite	—	—	150	—	—	
1871	Soudan homestead	Soudan homestead	738	—	Ranken Limestone (?)	—	208	—	—	1150	
1906	Avon Downs Police Bore	James River on Barkly Highway	780	231	Camooweal Dolomite	203	193	—	900	Good 1230	
2139	Austral Downs 16	22 miles south-south-west of Austral Downs homestead	670	—	Camooweal Dolomite	—	—	—	—	—	On Burramurra Block
2140	Austral Downs Mathieson 15	South side of Bluebush Swamp	680	154	Camooweal Dolomite (?)	—	—	—	—	—	On Burramurra Block
2141	Austral Downs Eldershaw 20	6 miles west-north-west of Burramurra homestead	—	168	Wonarah Beds (?)	—	—	—	—	—	On Burramurra Block
2488	Alexandria 34	On Six-mile Creek	760	—	Camooweal Dolomite (?)	—	—	—	—	—	1st attempt at Reg. No. 1146 (?)
2489	Alexandria 7B	9 miles west by north of Soudan homestead	820	335	Wonarah Beds (?)	240	—	—	Poor	—	Abandoned
3132	Alexandria 43	—	—	—	—	—	—	—	—	—	May be identical to Reg. No. 1871
3160	Avon Downs New 15	9 miles south of Avon Downs homestead	745	306	Camooweal Dolomite	—	191	—	—	—	
3161	Avon Downs 25	—	—	623	—	—	—	—	—	720	Abandoned (?)
3178	Austral Downs 21	5 miles north of Burramurra homestead	700	—	Wonarah Beds (?)	—	—	—	—	—	
3662	Austral Downs New Top	22 miles north of Austral Downs homestead	700	212	Camooweal Dolomite	—	173	208	—	800	
3663	Austral Downs 10 New	10 miles south-east of Austral Downs homestead	640	—	Camooweal Dolomite	—	—	—	—	—	
3664	Austral Downs 22	17 miles north-east of Austral Downs homestead	795	—	Camooweal Dolomite	—	—	—	—	—	

Appendix 2—Borewater Analyses
(In Parts Per Million)

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	NO_2	PO_4	Mn	Fe	Al	B	Pb	Sr	Li	S.C.	pH	TDS	Year	Laboratory
									BRUNETTE DOWNS 1:250,000 SHEET AREA																
112	292	197	1030	50	1510	1330	370	x	0.8	20	2.2	..	..	..	x0.1	x0.2	1.5	..	3	..	6480	7.0	4600	1962	BMR
115	77.5	25.5	56.5	22	69.7	52.3	361	x	1.3	55.3	11.2	0.025	x0.01	x0.03	0.02	x0.02	0.25	x0.01	2.0	x0.05	817	7.45	540	1962	AMDL
116	244	142	533	88.5	1027	701	265	x	2.75	42.7	42.4	0.025	x0.01	x0.03	x0.01	x0.02	0.93	x0.01	6.5	0.08	4424	7.45	2869	1962	AMDL
117	230	128	561	24.0	690	1160	222	x	3.55	21	17.5	x0.001	x0.01	x0.02	x0.01	x0.02	0.91	x0.01	8.9	0.17	4253	7.75	3012	1962	AMDL
118	164	109	500	57	850	387	474	x	1	15	7.5	..	..	..	x.01	x0.2	x0.5	..	2.4	..	3400	6.8	2340	1962	BMR
119	173	132	576	31.5	998	461	504	x	2.8	18.6	2.4	0.008	x0.01	x0.03	x0.01	0.05	0.79	x0.01	3.0	0.09	4245	7.45	2672	1962	AMDL
123	59.5	26.0	251	36	160	199	497	x	4.45	48.4	9.2	0.07	0.01	x0.03	0.015	0.04	2.55	x0.01	2.6	x0.05	1604	7.6	1018	1962	AMDL
317	52.5	25.5	555	40.5	427.5	493.5	431	x	4.3	38.5	..	..	..	..	..	..	..	..	..	..	2950	7.55	1851	1962	AMDL
360	140	80	885	46	870	1160	314	x	3	10	13.3	..	..	..	x0.1	x0.2	1.5	..	2.9	..	4500	7.1	3240	1962	BMR
394	43	61	412	38	510	494	229	24	0.86	..	7	..	..	..	..	..	..	..	..	..	..	..	1819	1956	AIB
398	139.5	64.0	630	29.5	686.5	791	288	x	3.2	40.0	..	..	..	..	..	..	..	..	..	..	3920	7.45	2582	1962	AMDL
405	528	132.2	220	21	289.5	1757	159.1	x	4.9	22.4	..	..	..	..	..	..	..	..	..	..	3639	7.3	3148	1962	AMDL
413	166.4	80.5	298	23	458.5	397.5	342.8	x	1.7	49.3	..	..	..	..	..	..	..	..	..	..	2644	7.3	1688	1962	AMDL
415	439.8	103.2	267	21	364.5	1434.9	153	x	4.6	23.0	..	..	..	..	..	..	..	..	..	..	3442	7.15	2746	1962	AMDL
527	175.7	101.4	676	78	884.8	800.4	306	x	3.8	21.2	..	..	..	..	..	..	..	..	..	..	4402	7.25	2858	1962	AMDL
528	74.7	45.1	157	13.5	266	174	213	x	2.0	16.5	0.75	x0.001	x0.01	x0.03	x0.01	0.04	0.23	x0.01	0.9	x0.05	1491	7.6	858	1962	AMDL
530	216	146	760	44	1246	834	312	x	2.85	20.5	..	..	..	..	..	..	..	..	..	..	5310	7.25	3500	1962	AMDL
546	194	86.2	260	14.5	448	539	307	x	3.8	17.3	0.25	x0.001	x0.01	x0.02	x0.01	0.06	0.44	x0.01	9.9	0.25	2639	7.85	1738	1962	AMDL
602	375	127	206	15.0	621	914	197	x	3.65	18.3	0.5	x0.001	x0.01	0.02	0.02	x0.02	0.52	x0.01	7.3	0.40	3406	7.7	2410	1962	AMDL
603	56	34	184	32	80	235	447	x	2	10	8.9	..	..	..	x0.1	x0.2	0.5	..	1.7	..	1170	7.1	850	1962	BMR
604	76.6	51.5	27.5	11.5	18.3	16.5	539	x	0.5	54.5	0.6	0.003	x0.01	x0.02	0.15	0.02	0.12	x0.01	0.6	x0.05	812	7.6	504	1962	AMDL
761	106.5	68.5	311	23.5	494	333	254	x	2.9	19	..	..	..	..	..	..	..	..	..	..	2510	7.5	1491	1962	AMDL
762	274.2	152.4	769	69	1243.2	1046	266.2	x	4.1	22.4	..	..	..	..	..	..	..	..	..	..	5594	7.2	3779	1962	AMDL
795	156	90	830	52	800	1120	421	x	3	25	8.9	..	..	..	x0.1	x0.2	2	..	4.1	..	4200	7.0	3220	1962	BMR
934	126	67.1	370	35	480.8	417.7	388.7	x	3.4	22.2	..	..	..	..	..	..	..	..	..	..	2790	7.35	1718	1962	AMDL
935	317.1	221.5	884	81	1544.9	1275.2	238.7	x	4.6	21.5	..	..	..	..	..	..	..	..	..	..	6643	7.25	4480	1962	AMDL
1180	192	104	308	10	580	547	260	x	3	10	8.9	..	..	..	x0.1	x0.2	x0.5	..	5	..	2910	7.1	2010	1962	BMR
1181	469	148	515	20	760	1660	160	x	3	20	x2.0	..	..	..	x0.1	x0.2	1	..	8	..	4200	7.0	3880	1962	BMR
1182	71.5	33.6	94.5	31.5	71.8	120	421	x	1.9	56.1	9.8	0.01	x0.01	x0.02	x0.01	x0.02	0.48	x0.01	1.6	x0.05	961	7.8	670	1962	AMDL
1183	252	126	780	23	1120	1010	240	x	1	25	13.3	..	..	..	x0.1	x0.2	1	..	1.8	..	4500	6.9	3360	1962	BMR
1183	156	82	398	26	553	441	393	x	2.5	..	11	..	..	..	..	..	..	..	..	..	..	..	2062	1957	AIB
1211	198.9	131.4	646	45	1093.4	637.8	342.7	x	2.9	17	..	..	..	..	..	..	..	..	..	..	4679	7.3	2964	1962	AMDL
1213	236	139	786	41.3	1200	977.5	284.5	x	2.9	20.2	..	..	..	..	..	..	..	..	..	..	5410	7.2	3566	1962	AMDL
1214	266	167	486	30.5	934	730	443	x	2.55	30.1	2.3	x0.001	0.01	x0.03	0.01	x0.02	0.63	x0.01	2.8	0.08	4303	7.4	2901	1962	AMDL
1215	252.6	178.9	926	59	1575.3	938.2	348.8	x	3.65	15.8	..	..	..	..	..	..	..	..	..	..	6423	7.25	4217	1962	AMDL
1216	170.2	144.3	676	62.5	1177.6	546.1	425.3	x	4.74	23.6	..	..	..	..	..	..	..	..	..	..	4882	7.35	3019	1962	AMDL
1217	226	166	812	67.5	1387	773.0	410	x	3.4	16.5	..	..	...	..	..	..	..	..	..	..	5709	7.2	3726	1962	AMDL
1218	135.7	110	471	49	759.5	391.7	459	x	2.8	18.5	..	..	..	..	..	..	..	..	..	..	3583	7.25	2163	1962	AMDL
1219	224	156	1230	60	1720	1160	325	x	4	10	x2.0	..	..	..	x0.1	x0.2	2	..	3.5	..	5490	7.0	5720	1962	BMR
1220	255	197	1260	63	2030	1095	266	x	4	15	2.2	..	..	..	x0.1	x0.2	1.5	..	6	..	6440	6.9	4870	1962	BMR
1221	96.5	55.6	128.0	11.1	230.6	144.8	324.4	x	2.49	22.1	..	..	..	..	..	..	..	..	..	..	1475	7.3	840	1962	AMDL
1222	254.4	161.8	846	47.5	1352.8	1019.3	315.2	x	6.80	20.1	..	..	..	..	..	..	..	..	..	..	5825	7.2	3843	1962	AMDL
1223	267.5	200.8	1193	71	1941.8	1070.3	376.4	x	4.3	18.1	..	..	..	..	..	..	..	..	..	..	7799	7.15	5079	1962	AMDL
1225	276.6	162	865	47	1349.4	1142.3	281.6	x	2.9	19.3	..	..	..	..	..	..	..	..	..	..	5982	7.2	4078	1962	AMDL
1227	458.4	241.9	951	58	1583.7	1752.6	272.4	x	2.8	27.1	..	..	..	..	..	..	..	..	..	..	7203	7.15	5274	1962	AMDL
1228	173.4	124.4	562	55	967.9	467.9	471.2	x	2.7	17.4	..	..	..	..	..	..	..	..	..	..	4310	7.1	2620	1962	AMDL

.. not determined x not detected x0.1 not detected at limit for method used S.C. Specific Conductivity

APPENDIX 2—BOREWATER ANALYSES—*continued*

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	NO_2	PO_4	Mn	Fe	Al	B	Pb	Sr	Li	S.C.	pH	TDS	YEAR	LABORATORY
1229	528.6	356.7	1410	55.5	2300	2428.3	260.1	x	12.1	20.4	..	..	..	..	..	..	..	..	..	..	9903	6.95	7212	1962	AMDL
1230	455.2	315.5	1352	66.5	2118	2028.3	483.5	x	7.51	21.5	..	..	..	..	..	..	..	..	..	..	9003	6.95	6589	1962	AMDL
1250	295.1	163.6	856	46	1319.1	1192.5	275.4	x	3.3	21.7	..	..	..	..	..	..	..	..	..	..	6033	7.35	4090	1962	AMDL
1757	372	208	840	37	1345	1305	178	x	3.0	..	2	..	..	..	..	..	..	..	..	..	..	..	4290	1958	AIB
1900	334.4	173	765	36	1174.4	1311.9	275.4	x	2.55	20	..	..	..	..	..	..	..	..	..	..	5599	7.2	4010	1962	AMDL
1903	156	78	155	10	265	353	405	x	0.4	65	x2.0	..	..	..	x0.1	x0.2	x0.5	..	1	..	1930	6.9	1250	1962	BMR
1905	361	175	580	20	1020	1270	210	x	0.2	40	x2.0	..	..	..	x0.1	x0.2	x0.5	..	1	..	4760	6.9	3710	1962	BMR
1906	308	160	640	20	1010	1225	213	x	0.2	40	x2.0	..	..	..	x0.1	x0.2	0.5	..	2	..	4460	7.0	3530	1962	BMR
1908	382	209	1550	62.5	2058	2139	243	x	4.15	15.9	1.4	0.001	x0.01	x0.02	x0.01	0.06	2.77	x0.01	9.3	0.18	9215	7.7	6708	1962	AMDL
2157	437	131	644	10	830	1670	190	x	2.0	20	x2.0	..	..	..	x0.1	x0.2	1.5	..	5	..	4760	7.0	3990	1962	BMR
2159	52	29	294	20	250	220	389	x	2.0	20	8.9	..	..	..	x0.1	x0.2	1.5	..	x1.0	..	1780	7.4	1170	1962	BMR
2160	68	22	133	15	75	152	373	x	1.0	10	13.3	..	..	..	x0.1	x0.2	x0.5	..	1.1	..	850	7.1	630	1962	BMR
2161	34.7	21.7	146	14.3	71.7	118.1	342.7	x	2.63	21.7	..	..	..	..	..	..	..	..	..	..	981.9	7.6	602	1962	AMDL
2162	204	106	398	20	620	720	240	x	3.0	20	8.9	..	..	..	x0.1	x0.2	0.5	..	4	..	3400	7.1	2340	1962	BMR
2163	54	37	224	30	160	165	527	x	2.0	25	13.3	..	..	..	x0.1	x0.2	1.0	..	x1.0	..	1490	7.2	1060	1962	BMR
2222	137.8	75.9	226.5	22.2	333.1	283.9	468	x	1.97	40.7	..	..	..	..	..	..	..	..	..	..	2180	7.1	1376	1962	AMDL
2223	151.9	63.7	260	24	337.3	418.5	345.8	x	2.3	48.5	..	..	..	..	..	..	..	..	..	..	2322	7.3	1506	1962	AMDL
2224	64	30	327	23	220	366	392	x	3.1	41	..	..	..	..	..	..	..	..	..	..	2010	7.4	1263	1962	AMDL
2225	294.2	118.8	979	70	993.8	1573.6	351.9	x	5.2	32.9	..	..	..	..	..	..	..	..	..	..	5834	7.05	4230	1962	AMDL
2226	220.9	90.8	937	52	783.8	1527.1	330.5	x	5.2	23.9	..	..	..	..	..	..	..	..	..	..	5229	7.35	3814	1962	AMDL
2227	61.5	28	328	51.5	178	459	398	x	4.3	29.5	..	..	..	..	..	..	..	..	..	..	2100	7.45	1353	1962	AMDL
2228	282.5	159.5	1160	36.0	1156	2058	217	x	5.55	15.0	..	..	..	..	..	..	..	..	..	..	6850	7.35	5093	1962	AMDL
2232	181.5	77	569	64.5	339.5	1324	294	x	4.75	26.5	..	..	..	..	..	..	..	..	..	..	3700	7.25	2762	1962	AMDL
2233	297	122	885	55.5	780.5	1944	190	x	5.29	14.5	..	..	..	..	..	..	..	..	..	..	5520	7.35	4250	1962	AMDL
2234	563	165.5	89.5	15	164	1856	119	x	4.75	22.2	..	..	..	..	..	..	..	..	..	..	3254	7.2	3078	1962	AMDL
2235	623	162.5	217	18.5	337.8	2027	129	x	5.7	15.8	..	..	..	..	..	..	..	..	..	..	3960	7.1	3532	1962	AMDL
2280	535	325	2790	70	3350	3485	285	x	4.5	..	11	..	..	..	..	..	..	..	..	..	..	8.0	10850	1960	AIB
2282	399	196	1088	34	1448	1942	200	x	4.0	23.3	10.4	0.003	x0.01	0.02	0.01	0.03	1.49	x0.01	10.2	0.21	7240	7.65	5362	1962	AMDL
2283	358	184	1331	48	1745	1909	222	x	4.35	15	4.7	0.025	x0.01	0.02	0.04	0.06	2.11	x0.01	8.5	0.15	8067	7.65	5794	1962	AMDL
2287	107	53.6	447	40.0	585	393	319	x	3.95	26.6	6.3	x0.001	x0.01	x0.02	0.01	0.04	1.25	0.01	8.9	0.1	2926	7.95	1806	1962	AMDL
2288	486	424	2500	68	3860	2848	351	x	3.2	..	6	..	..	..	..	..	..	..	..	..	..	7.5	10546	1961	AIB
2289	207	131	1263	44	1584	1375	280	x	5.0	13.3	0.2	0.001	x0.01	x0.02	0.01	0.08	1.11	x0.01	7.6	0.24	7134	7.8	4815	1962	AMDL
2412	268	152	800	34	1210	1091	227	x	3.6	..	2.0	..	..	..	..	..	..	..	..	..	..	..	3787	1957	AIB
2498	256	142	680	40	1060	971	309	x	2	10	x2.0	..	..	..	x0.1	x0.2	x0.5	..	3.5	..	4200	7.1	3490	1962	BMR
2499	287.8	172.5	900	47	1407.2	1170.3	309.1	x	3.75	20.0	..	..	..	..	..	..	..	..	..	..	6122	7.2	4242	1962	AMDL
2500	238	128	652	34.3	944	978	318	x	3.45	22.6	0.3	x0.001	x0.01	x0.03	0.01	0.22	1.1	x0.01	7.5	0.10	4558	7.55	3201	1962	AMDL
2501	300	165	848	42.3	1287	1218	336	x	3.0	24.5	x0.1	x0.001	x0.01	x0.03	0.02	0.26	1.28	x0.01	7.5	0.10	5731	7.5	4129	1962	AMDL
2502	330	119	144	15	52	1362	178	x	3.6	..	4	..	..	..	..	..	..	..	..	..	..	7.2	2208	1961	AIB
2503	361.7	107.9	353	22	255.1	1483.5	257	x	5.0	49.8	..	..	..	..	..	..	..	..	..	..	3412	7.4	2803	1962	AMDL
2504	93	52	345	24	310	437	391	x	4.0	..	4	..	..	..	..	..	..	..	..	..	..	7.6	1660	1961	AIB
2505	88	47.5	288	19	260.2	353.1	394.7	x	4.05	19.1	..	..	..	..	..	..	..	..	..	..	2047	7.55	1231	1962	AMDL
2506	278	174	950	50	1410	1300	298	x	2.0	15	x2.0	..	..	..	x0.1	x0.2	0.5	..	3.0	..	5100	7.0	4190	1962	BMR
2507	66	34.2	224	43	166	279	407	x	3.8	31.4	9.7	0.003	x0.01	x0.05	x0.01	x0.02	0.97	x0.01	3.3	0.06	1660	8.05	1010	1962	AMDL
2577	54.6	20.0	83.5	20	27.5	37.4	401	x	3.7	51.8	12.8	0.01	0.01	x0.03	0.01	0.04	0.52	x0.01	2.0	x0.05	770	7.55	483	1962	AMDL
2578	124	55.7	196	31	139	538	313	x	3.95	23.2	3.3	0.003	x0.01	x0.05	x0.01	0.04	0.91	x0.01	9.4	0.11	1857	8.0	1245	1962	AMDL
2580	31	35	..	..	165	294	316	x	..	..	..	..	..	..	..	..	..	..	..	..	..	8.0	972	1961	AIB

APPENDIX 2—BOREWATER ANALYSES—*continued*

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	NO_2	PO_4	Mn	Fe	Al	B	Pb	Sr	Li	S.C.	pH	TDS	YEAR	LABOR-ATORY
2581	185	121	639	38	1030	679	307	x	2.6	17.7	0.1	x0.001	x0.01	x0.02	x0.01	0.12	0.84	x0.01	2.8	0.1	4502	7.9	2875	1962	AMDL
2582	212	270	..	..	1685	1751	126	x	..	..	..	..	..	..	..	..	..	..	..	..	..	6.8	5508	1961	AIB
2583	66.3	32.5	188	30	139.4	202.5	385.6	x	2.6	23	..	..	..	..	..	..	..	..	..	..	1417	7.45	829	1962	AMDL
2585	177	106	723	53	1013	818	340	x	4.2	33.1	7.0	x0.001	x0.01	x0.05	x0.01	x0.02	1.65	x0.01	10.1	0.09	4731	7.9	3099	1962	AMDL
2586	60.4	30.5	139	39.5	79.4	149	426	x	3.45	27	6.4	0.01	x0.01	x0.03	0.015	0.06	0.7	x0.01	3.6	0.05	1149	7.55	711	1962	AMDL
2745	48.7	45.5	66	10	80.4	34.6	390	x	0.3	27	0.9	0.025	x0.01	x0.03	0.01	0.08	0.26	x0.01	0.3	x0.05	795	7.7	471	1962	AMDL
2758	172	80	500	36	570	806	303	x	3	10	4.5	..	..	..	x0.1	x0.2	1	..	8.9	..	2860	7.0	2110	1962	BMR
2901	235.7	116	430	45	690.5	807	269.3	x	3.7	23.3	..	..	..	..	..	..	..	..	..	..	3796	7.15	2522	1962	AMDL
3100	121.5	62	477	23.5	443.5	602.5	407	x	4.3	19.8	..	..	..	..	..	..	..	..	..	..	3040	7.3	1976	1962	AMDL
3101	159.4	81.1	416	33	510.2	692.1	281.5	x	3.7	23.3	..	..	..	..	..	..	..	..	..	..	3207	7.3	2097	1962	AMDL
3102	340	217.6	942	48	1467.2	1491.3	315.2	x	5.73	28.2	..	..	..	..	..	..	..	..	..	..	6665	7.15	4702	1962	AMDL
3103	287	134	685	28.5	878	1309	283	x	4.3	36.5	1.0	x0.001	0.01	x0.05	x0.01	0.05	1.16	x0.01	17.9	0.22	4896	7.6	3544	1962	AMDL
3104	143	84.2	474	37	643	579	332	x	3.35	20.1	6.9	0.001	x0.01	x0.02	0.01	0.11	1.13	x0.01	6.6	0.07	3456	7.85	2224	1962	AMDL
3105	215.5	141.5	937	50	136.5	983.5	297	x	4.75	16.5	..	..	..	..	..	..	..	..	..	..	5916	7.35	3924	1962	AMDL
3107	95.5	59.5	284	20.5	439.5	296.5	214	x	2.45	20.5	..	..	..	..	..	..	..	..	..	..	2260	7.6	1306	1962	AMDL
3109	172	97	370	25	460	623	490	x	0.8	15	x2.0	..	..	..	x0.1	x0.2	0.5	..	1	..	2690	7.0	1980	1962	BMR
3110	113	53	456	22	405	602	417	x	4.5	21.3	4.3	0.001	x0.01	x0.05	0.01	0.035	1.15	x0.01	16.3	0.08	2891	7.45	1920	1962	AMDL
3111	293	168	875	46	1383	1181	312	x	3.8	22.4	x0.1	0.001	x0.01	x0.05	0.01	0.05	1.25	x0.01	6.5	0.1	6099	7.35	4237	1962	AMDL
3112	384	190	680	25	1119	1456	247	x	2.3	31.8	x0.1	0.002	0.01	x0.05	0.013	0.055	0.62	x0.01	2.3	0.1	5545	7.25	4162	1962	AMDL
3113	166.7	115.5	690	45.5	1081.6	620.5	373.3	x	5.58	15.8	..	..	..	..	..	..	..	..	..	..	4652	7.45	2935	1962	AMDL
3114	108.9	54.9	320	47	331.3	444.4	351.9	x	3.5	21.4	..	..	..	..	..	..	..	..	..	..	2409	7.4	1518	1962	AMDL
3115	77.5	33	94.5	24.2	68.4	81.9	425	x	2.75	34.8	..	..	..	..	..	..	..	..	..	..	1030	7.35	590	1962	AMDL
3116	101.5	33.5	102.5	17.3	132.9	113.5	334	x	0.65	57.2	..	..	..	..	..	..	..	..	..	..	1220	7.15	760	1962	AMDL
3118	312.8	177.3	926	66	1389	1232	361.1	x	3.2	23.3	..	..	..	..	..	..	..	..	..	..	6305	7.00	4367	1962	AMDL
3119	188	155	834	60	1290	765	378	x	3	10	x2.0	..	..	..	x0.1	x0.2	1	..	3.0	..	5100	6.9	3560	1962	BMR
3122	232	176	884	31.5	1520	819	401	x	3.3	14.3	x0.1	x0.001	0.01	x0.03	x0.01	0.45	1.04	x0.01	4.2	0.12	5954	7.6	3970	1962	AMDL
3147	254	116	329	13.5	572	818	234	x	3.55	17.6	1.6	0.025	0.02	x0.02	x0.01	0.04	0.63	x0.01	7.8	0.2	3285	7.85	2308	1962	AMDL
3149	161.1	85.5	388	28	523.2	629.2	281.6	x	3.6	16.4	..	..	..	..	..	..	..	..	..	..	3056	7.45	2000	1962	AMDL
3568	176	126	665	52	1146	587	342	x	2.85	16.3	0.9	0.015	x0.01	x0.02	0.01	0.07	0.99	x0.01	3.4	0.1	4665	7.8	2945	1962	AMDL
3655	264	202	1240	160	2060	1200	283	x	3	10	x2.0	..	..	..	x0.1	x0.2	2	..	5	..	7140	7.0	5350	1962	BMR
3656	180	151	673	70	1211	558	466	x	3.2	18.4	0.4	0.017	x0.01	x0.05	0.01	0.14	0.95	x0.01	3.7	0.11	4975	7.8	3104	1962	AMDL
4052	237.5	95.5	557	63.5	161.5	1819	208	x	4.95	23.5	..	..	..	..	..	..	..	..	..	..	3900	7.45	3102	1962	AMDL
													ALROY 1:250,000 SHEET AREA												
29	108.5	94.5	258	48.5	368.5	199	658	x	2.0	43	..	..	..	..	..	..	..	..	..	..	2393	6.95	1420	1962	AMDL
41	59.1	35.4	100	41	33.4	28.0	563.1	x	2.8	50.9	..	..	..	..	..	..	..	..	..	..	1005	7.15	586	1962	AMDL
41	60	39	102	40	33	24	610	x	2.9	..	7.0	..	..	..	..	..	..	..	..	..	..	..	918	1960	AIB*
124	193	127	463	36.5	787	639	339	x	2.65	31.2	14.3	0.005	x0.01	x0.02	x0.01	x0.02	0.92	x0.01	5.9	0.15	3791	7.7	2488	1962	AMDL
285	202.7	108.6	293.0	22	579.1	430	422.3	x	1.45	45.1	..	..	..	..	..	..	..	..	..	..	3012	7.00	1899	1962	AMDL
353	93.4	69.7	116	44	131.6	65.4	627.4	x	1.5	64.5	..	..	..	..	..	..	..	..	..	..	1461	7.00	860	1962	AMDL
358	51.1	32.1	56	31	28.3	18.5	410	x	1.8	56	..	..	..	..	..	..	..	..	..	..	761	7.35	442	1962	AMDL
395	484.8	210.3	298	19.8	813.2	1334.5	217.5	x	3.99	34.1	..	..	..	..	..	..	..	..	..	..	4510	7.65	3301	1962	AMDL
396	136.9	51.9	115	25	112.4	332.5	382.5	x	2.9	35.6	..	..	..	..	..	..	..	..	..	..	1503	7.1	989	1962	AMDL

*Sampled from household tap, not borehead.

APPENDIX 2—BOREWATER ANALYSES—*continued*

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	NO_2	PO_4	Mn	Fe	Al	B	Pb	Sr	Li	S.C.	pH	TDS	YEAR	LABOR-ATORY
403	348	264	998	57.5	2032	1029	345	x	2.55	21.2	15.7	x0.001	x0.001	x0.02	0.02	x0.02	1.01	x0.01	9.1	0.19	7715	7.6	4886	1962	AMDL
414	293.1	167.2	540	30	1008.4	897.1	292.2	x	2.3	60.1	..	..	..	..	..	..	..	..	..	..	4694	7.15	3144	1962	AMDL
500	104	61	140	30	225	115	540	x	0.4	40	22.2	..	..	..	x0.1	x0.2	x0.5	..	1	..	1620	6.9	980	1962	BMR
503	105	54.3	179	18.0	213	279	351	x	1.95	44.0	21.3	0.005	x0.01	x0.02	x0.01	0.02	0.46	x0.01	3.6	0.14	1740	7.7	1071	1962	AMDL
504	110	69.3	168	20.0	250	174	505	x	1.0	52.4	15.0	0.01	x0.01	x0.02	0.06	0.03	0.42	x0.01	1.6	0.07	1737	7.55	1052	1962	AMDL
719	150.5	137	507	55.5	838.5	524.5	425	x	2.55	39.6	..	..	..	..	..	..	..	..	..	..	3874	7.25	2526	1962	AMDL
720	124	97	300	47	533	216	561	x	0.8	..	10	..	..	..	..	..	..	..	..	..	..	..	1888	1957	AIB
722	129.9	81.5	230	34.3	322.8	324.7	501.8	x	1.81	33.3	..	..	..	..	..	..	..	..	..	..	2236	7.2	1415	1962	AMDL
723	118	113	420	67	600	318	676	x	2.6	..	3	..	..	..	..	..	..	..	..	..	..	..	2317	1957	AIB
724	125	120	490	74	765	334	625	x	2.2	..	3	..	..	..	..	..	..	..	..	..	..	..	2538	1957	AIB
725	100	81	140	44	165	106	732	x	2.0	..	5.0	..	..	..	..	..	..	..	..	..	..	..	1375	1957	AIB
727	116.7	80.4	240	44	396.9	170.4	543.2	x	1.5	45.7	..	..	..	..	..	..	..	..	..	..	2317	7.05	1336	1962	AMDL
728	170	197	840	105	1310	667	725	x	3.0	..	1.0	..	..	..	..	..	..	..	..	..	..	..	4018	1957	AIB
729	115.5	97	358	59.5	530.5	404	456	x	2.0	34.9	..	..	..	..	..	..	..	..	..	..	2958	7.2	1831	1962	AMDL
730	112.7	68.9	218	38	300.7	211.5	538.6	x	1.45	35.6	..	..	..	..	..	..	..	..	..	..	2048	7.1	1274	1962	AMDL
731	137.1	89.4	267	48	423.2	265.4	526.4	x	1.1	20.4	..	..	..	..	..	..	..	..	..	..	2513	7.1	1472	1962	AMDL
732	112.3	62.3	151	32	217.7	113.6	569.2	x	1.2	46.4	..	..	..	..	..	..	..	..	..	..	1693	7.1	992	1962	AMDL
733	206.2	147.7	563	42	1115.7	495.4	403.9	x	3.45	23.7	..	..	..	..	..	..	..	..	..	..	4546	6.95	2801	1962	AMDL
733	198	157	605	41	1120	482	412	x	2.1	..	4.0	..	..	..	..	..	..	..	..	..	..	..	3021	1957	AIB
734	90.8	62.4	148	33	182.2	173.2	514.1	x	1.2	33.1	..	..	..	..	..	..	..	..	..	..	1559	7.2	918	1962	AMDL
1212	169.3	77.2	196	22	384.7	382.3	319.8	x	2.8	29.8	..	..	..	..	..	..	..	..	..	..	2252	7.25	1417	1962	AMDL
1236	133	77	217	32	408	193	444	x	1.7	..	x	..	..	..	..	..	..	..	..	..	..	..	1505	1957	AIB
1237	141	92	250	42	458	275	437	x	1.3	..	x	..	..	..	..	..	..	..	..	..	..	..	1698	1957	AIB
1239	63	48	78.5	62.5	75	68.5	511	x	1.6	30.8	..	..	..	..	..	..	..	..	..	..	1146	7.05	659	1962	AMDL
1240	84	74	160	43	185	95	646	x	1.1	..	17.0	..	..	..	..	..	..	..	..	..	..	..	1305	1958	AIB
1241	99	53	70	20	95	55	527	x	0.2	..	4.0	..	..	..	..	..	..	..	..	..	..	..	923	1957	AIB
1242	92	67.5	146	42.5	168	126	606	x	2.3	30.8	..	..	..	..	..	..	..	..	..	..	1648	7.00	944	1962	AMDL
2190	227.2	200.7	1061.3	123	1883.2	817.7	468.2	x	3.72	24	..	..	..	..	..	..	..	..	..	..	7221	7.1	4574	1962	AMDL
2190	222	204	1110	124	1968	820	478	x	3.0	..	14	..	..	..	..	..	..	..	..	..	..	..	4943	1957	AIB
2191	482	418	1120	22	1225	3140	370	x	4.0	..	4.0	..	..	..	..	..	..	..	..	..	..	7.2	6785	1961	AIB
2192	107	74	187	322	391	200	769	x	2.6	..	..	..	..	..	..	..	..	..	..	..	..	..	2056	1953	AIB
2193	103	79	230	43	330	139	566	x	2.0	..	4.0	..	..	..	..	..	..	..	..	..	..	..	1496	1957	AIB
2194	128.1	79.3	284	37.3	469	230.9	477.4	x	2.5	30.7	..	..	..	..	..	..	..	..	..	..	2548	7.1	1458	1962	AMDL
2194	124	83	290	39	465	233	493	x	1.8	..	4.0	..	..	..	..	..	..	..	..	..	..	..	1732	1957	AIB
2195	126.5	118.0	463	64.5	704.5	466.5	496	x	2.6	32.8	..	..	..	..	..	..	..	..	..	..	3576	7.2	2224	1962	AMDL
2195	116	118	447	61	670	442	478	x	1.6	..	x	..	..	..	..	..	..	..	..	..	..	..	2333	1957	AIB
2229	634	166.5	154	17.4	273.2	2016	116	x	5.6	15.8	..	..	..	..	..	..	..	..	..	..	3730	7.15	3369	1962	AMDL
2236	170.2	91.6	333.3	26.3	552.4	477.3	339.5	x	2.69	32.1	..	..	..	..	..	..	..	..	..	..	2880	7.2	1857	1962	AMDL
2281	507	179	640	23.0	847	2052	160	x	3.65	15.9	5.4	x0.001	x0.01	0.02	x0.01	0.14	1.06	x0.01	9.3	0.31	5576	7.8	4506	1962	AMDL
2579	163	73.3	164	19.6	320	418	225	x	2.15	36.3	33.1	0.001	x0.01	x0.02	x0.01	0.05	0.4	x0.01	4.7	0.09	2113	7.75	1372	1962	AMDL
2800	130	65.8	208	29.0	336	242	403	x	2.0	48.2	20.8	0.005	x0.01	x0.02	0.02	0.03	0.44	0.01	5.3	0.09	2067	7.65	1276	1962	AMDL
2940	49.4	29.2	51.3	32.7	31.1	20.2	354	x	1.2	35.3	46.8	0.015	x0.01	x0.02	x0.01	0.06	0.32	x0.01	1.1	x0.05	751	7.8	437	1962	AMDL
2942	323	185	..	..	590	1069	196	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2920	1956	AIB
3108	130	108	494	48.0	785	391	495	x	2.8	21.8	13.8	0.005	x0.001	x0.02	0.08	x0.02	0.92	x0.01	2.6	0.09	3686	7.7	2248	1962	AMDL
3123	246	193	948	78	1644	931	397	x	3.65	15.4	2.6	0.025	x0.01	x0.03	0.015	0.39	1.14	x0.01	4.3	0.14	6462	7.5	4288	1962	AMDL
3138	139	136	..	..	905	413	577	x	..	..	..	..	..	..	..	..	..	..	..	..	..	7.5	2660	1961	AIB

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	NO_2	PO_4	Mn	Fe	Al	B	Pb	Sr	Li	S.C.	pH	TDS	YEAR	LABORATORY
3139	100	159	630	63	955	658	434	x	2.4	..	2.0	..	..	..	..	..	..	..	..	..	..	6.9	3003	1961	AIB
3140	84	63	145	30	155	125	580	x	0.4	50	4.5	..	..	..	x0.1	x0.2	x0.5	..	x1.0	..	1520	6.9	850	1962	BMR
3141	123.3	83.3	293.3	44.5	512.8	204.9	477.4	x	2.32	31.8	..	..	..	..	..	..	..	..	..	..	2521	7.1	1507	1962	AMDL
3143	116	78	149	30	260	138	570	x	0.4	50	13.3	..	..	..	x0.1	x0.2	0.5	..	1	..	1650	6.9	1060	1962	BMR
3144	240	221	1220	130	2080	850	650	x	2.0	20	x2.0	..	..	..	x0.1	x0.2	1.5	..	5	..	6490	6.8	5130	1962	BMR
3145	473	411	1080	18	1250	3157	377	x	3.3	..	5.0	..	..	..	..	..	..	..	..	..	..	7.3	6774	1961	AIB
1778	116.6	75.4	184	30	368.5	125.1	446.8	x	0.7	17.3	..	..	..	..	..	..	..	..	..	..	2016	7.25	1097	1962	AMDL
1778	50	..	201	65	378	89	200	x	0.4	..	5.0	..	..	..	..	..	..	..	..	..	..	..	988	1958	AIB
											WALLHALLOW 1:250,000 SHEET AREA														
524	54.1	26.3	86.5	14.5	44.3	65.8	376	x	1.65	43.7	12.8	0.003	0.01	x0.05	x0.01	x0.02	0.47	x0.01	1.1	0.05	833	7.8	471	1962	AMDL
525	218	109	346	12.5	581.5	705.5	248	x	3.1	25.0	..	..	..	..	..	..	..	..	..	..	3240	7.25	2176	1962	AMDL
598	414	193	520	17.5	992	1346	216	x	3.35	25.0	1.8	x0.001	x0.01	x0.02	0.01	x0.02	0.55	x0.01	9.7	0.25	4950	7.9	3640	1962	AMDL
599	328	168	520	21.0	935	1150	205	x	3.25	20.8	2.2	x0.001	x0.01	0.04	0.10	0.03	0.68	x0.01	12.9	0.25	4599	7.9	3296	1962	AMDL
600	355	199	600	22	1070	1222	232	x	2.7	..	x	..	..	..	..	..	..	..	..	..	..	..	3702	1957	AIB
601	209	101	417	24.5	615	772	203	x	3.8	22.3	0.25	x0.001	x0.01	x0.02	0.02	x0.02	0.59	x0.01	16.3	0.3	3361	7.8	2361	1962	AMDL
605	309	159	385	17.5	842	874	246	x	3.6	19.0	2.7	0.009	x0.01	0.02	0.06	0.02	0.47	x0.01	18.8	0.3	3999	7.9	2702	1962	AMDL
606	296	176	468	16.0	888	962	311	x	1.2	35.7	2.9	x0.001	x0.01	x0.02	0.01	x0.02	0.8	x0.01	4.6	0.1	4321	7.7	3044	1962	AMDL
960	110	46.0	24.0	5.1	33.4	50.2	512	x	0.35	28.4	x0.1	x0.001	x0.01	x0.03	0.01	0.08	0.11	x0.01	0.3	x0.05	876	7.35	525	1962	AMDL
1067	152.5	62	41.5	7.3	65.5	223.5	471	x	0.95	23	..	..	..	..	..	..	..	..	..	..	1250	6.95	827	1962	AMDL
1070	145	65	90	8.3	132.9	160.5	545	x	0.5	30.6	..	..	..	..	..	..	..	..	..	..	1480	6.85	905	1962	AMDL
1246	276.5	143	786	37.8	1164	1079	272	x	3.7	21.6	..	..	..	..	..	..	..	..	..	..	5370	7.15	3670	1962	AMDL
1247	340	190	959	47	1499	1416	296	x	3.6	25.8	0.7	0.004	x0.01	x0.05	x0.01	0.035	1.35	x0.01	7.8	0.1	6702	7.3	4765	1962	AMDL
1248	578.6	202.9	621	30	1012.4	2011	165.2	x	5.05	45.8	..	..	..	..	..	..	..	..	..	..	5902	7.25	4670	1962	AMDL
1249	259.6	128.7	680	30	1030.6	992.1	247.9	x	4.45	19.1	..	..	..	..	..	..	..	..	..	..	4853	7.2	3335	1962	AMDL
1251	135.5	60.6	173	17	235.9	327.6	364.1	x	4.4	47.0	..	..	..	..	..	..	..	..	..	..	1825	7.2	1251	1962	AMDL
1252	373	218.5	1033	49.0	1514	1592	327	x	3.1	34.6	..	..	..	..	..	..	..	..	..	..	6960	6.95	5042	1962	AMDL
2158	92.3	53.9	267	13.5	309	336	325	x	1.65	28.5	8.9	x0.001	0.01	0.02	0.01	0.04	0.78	x0.01	1.7	0.06	2010	7.85	1273	1962	AMDL
2409	56.2	35.8	89.6	8.2	139	79.8	259	x	0.35	17.8	2.9	x0.001	x0.01	x0.03	0.2	0.02	0.45	x0.01	0.4	0.05	955	7.7	545	1962	AMDL
2410	129	69.2	94.7	9.3	131	119	623	x	0.50	54.4	0.5	x0.005	x0.01	x0.03	0.03	0.06	0.24	x0.01	0.6	0.05	1440	7.2	888	1962	AMDL
2411	129	62.6	98.2	9.8	145	149	565	x	0.55	42.5	0.2	0.005	x0.01	x0.03	0.01	x0.02	0.23	x0.01	0.9	0.05	1402	7.3	906	1962	AMDL
2413	283	167.5	880	44.8	1322	1178	294	x	4.0	20.2	..	..	..	..	..	..	..	..	..	..	5980	6.95	4083	1962	AMDL
2746	36.8	25.8	35.0	6.2	38.7	13.6	268	x	0.1	38.1	x0.1	x0.001	0.02	x0.03	0.01	0.17	0.12	x0.01	x0.2	0.05	524	7.2	304	1962	AMDL
2751	286	150	760	38	1168	1121	333	x	3.35	19.5	0.1	0.004	x0.01	x0.05	x0.01	0.11	1.05	x0.01	6.3	0.1	6249	7.4	3824	1962	AMDL
2752	161	82	178	13	270	309	543	x	1.0	28.7	x0.1	0.001	0.018	x0.05	0.02	0.13	0.32	x0.01	1.4	0.05	2033	7.25	1356	1962	AMDL
											RANKEN 1:250,000 SHEET AREA														
83	80.3	41.3	113	6.4	190	158	222	x	1.25	17.7	1.2	x0.001	x0.01	x0.02	0.02	x0.02	0.26	x0.01	0.9	x0.05	1252	7.9	733	1962	AMDL
84	69.8	35.6	43.1	6.1	82.2	127	209	x	1.10	19.1	x0.1	x0.001	x0.01	0.02	0.03	x0.02	0.14	x0.01	0.9	x0.05	829	7.9	494	1962	AMDL
96	93	51.4	62.1	7.2	135.9	188.1	238.5	x	1.24	19.7	..	..	..	..	..	..	..	..	..	..	1090	7.5	598	1962	AMDL
392	118.9	53.5	124	6.65	220.6	267.5	241.5	x	1.36	18.6	..	..	..	..	..	..	..	..	..	..	1510	7.5	940	1962	AMDL
495	150	94.5	385	24	580.1	592.1	260.1	x	2.9	22	..	..	..	..	..	..	..	..	..	..	3130	7.75	1988	1962	AMDL
533	68	32.5	23.6	4.9	29.9	42.4	324.4	x	0.35	20.2	..	..	..	..	..	..	..	..	..	..	641	7.35	374	1962	AMDL
536	92	47	80	17.1	170	171	221	x	1.19	19.8	..	..	..	..	..	..	..	..	..	..	1200	7.3	682	1962	AMDL
537	132	74	233	7.7	488	214.5	269	x	1.38	20.6	..	..	..	..	..	..	..	..	..	..	2320	7.25	1289	1962	AMDL
542	144.5	83	199	5.2	429	217	381	x	0.95	22.6	..	..	..	..	..	..	..	..	..	..	2250	7.15	1259	1962	AMDL

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	NO_2	PO_4	Mn	Fe	Al	B	Pb	Sr	Li	S.C.	pH	TDS	Year	Laboratory
545	139	74	190	6.6	387	309	235	x	1.13	21.4	..	..	..	..	..	..	..	..	..	..	2100	7.35	1227	1962	AMDL
735	60	32	30	1	35	66	280	x	1.0	20	x2.0	..	..	..	x0.1	x0.2	x0.5	..	1	..	595	7.3	342	1962	BMR
737	79.5	41.5	94.5	4.9	124.0	133.5	304	x	0.47	20.6	..	..	..	..	..	..	..	..	..	..	1100	7.35	636	1962	AMDL
738	103.1	44.5	47.1	3.1	102.8	37.4	425.3	x	0.10	19.4	..	..	..	..	..	..	..	..	..	..	1003	6.95	517	1962	AMDL
744	90	50	245	15	300	340	240	x	2	15	4.5	..	..	..	x0.1	x0.2	x0.5	..	0.5	..	1660	7.3	1160	1962	BMR
747	72	34	32	1	50	45	330	x	0.1	20	11.7	..	..	..	x0.1	x0.2	x0.5	..	x0.5	..	595	7.2	370	1962	BMR
751	53.2	33.7	20.3	3.9	18.8	29.6	319	x	0.45	22.5	0.25	0.014	0.03	x0.02	0.03	x0.02	0.10	x0.01	x0.2	x0.05	523	7.8	294	1962	AMDL
752	172	69	600	36	820	650	280	x	2.0	20	x2.0	..	..	..	x0.1	x0.2	x0.5	..	0.5	..	3570	7.2	2520	1962	BMR
756	129	71.8	86.2	6.4	217	163	422	x	0.55	21.5	1.9	0.011	x0.01	x0.02	x0.01	x0.02	0.20	x0.01	0.8	x0.05	1388	7.4	875	1962	AMDL
758	60	35	36	1	40	130	220	x	1.0	20	x2.0	..	..	..	x0.1	x0.2	x0.5	..	1	..	600	7.5	460	1962	BMR
932	152.7	77.7	446	21	585.2	628.8	278.5	x	2.95	17.3	..	..	..	..	..	..	..	..	..	..	3263	7.3	2094	1962	AMDL
941	79.6	42.5	49.3	5.0	132	94.2	255	x	0.8	19.2	x0.1	0.003	x0.01	x0.02	0.01	0.02	0.19	x0.01	0.7	x0.05	935	7.8	534	1962	AMDL
944	72.8	40.5	81.5	4.6	160	95.1	234	x	0.9	17.8	x0.1	x0.001	x0.01	x0.02	0.02	x0.02	0.21	x0.01	0.7	x0.05	1024	7.8	548	1962	AMDL
949	73.1	40.1	61.7	4.8	123	123	228	x	1.0	18.9	x0.1	x0.001	x0.01	x0.02	0.02	0.02	0.18	x0.01	0.8	x0.05	951	7.75	558	1962	AMDL
951	75	42.1	73.6	6.3	144.8	114.8	232.5	x	1.23	18.3	..	..	..	..	..	..	..	..	..	..	1030	7.5	595	1962	AMDL
1148	129	80.1	182	22	356.3	202.9	431.5	x	0.75	21.5	..	..	..	..	..	..	..	..	..	..	2084	7.05	1238	1962	AMDL
1150	70	39	47	2	70	134	250	x	1.0	30	x2.0	..	..	..	x0.1	x0.2	x0.5	..	4	..	1000	7.3	482	1962	BMR
1151	63.6	31.1	28.5	6.2	45.1	68.3	260.1	x	1.35	19.2	..	..	..	..	..	..	..	..	..	..	643	7.3	384	1962	AMDL
1152	67.8	35.8	29.4	5.6	42.4	86.4	283	x	0.65	20.7	0.1	x0.001	x0.01	x0.02	0.03	0.02	0.18	x0.01	0.4	x0.05	670	7.8	427	1962	AMDL
1153	85.1	52.7	44.0	4.8	85.9	76.5	379.5	x	1.01	20.4	..	..	..	..	..	..	..	..	..	..	960	7.2	520	1962	AMDL
1154	64.7	36.6	31.7	3.6	46.3	44.0	321.3	x	1.25	18	..	..	..	..	..	..	..	..	..	..	706	7.25	364	1962	AMDL
1155	82.5	58.6	60.0	4.1	149.5	51.8	370	x	0.41	20.3	..	..	..	..	..	..	..	..	..	..	1090	7.25	570	1962	AMDL
1156	71.7	40.4	23.2	5.8	25.7	40.3	391	x	0.75	21.1	x0.1	x0.001	x0.01	x0.02	0.02	x0.02	0.14	x0.01	0.7	x0.05	614	7.7	401	1962	AMDL
2769	180	119	375	15	800	410	250	x	0.7	20	x2.0	..	..	..	x0.1	x0.2	x0.5	..	1	..	2860	7.2	2090	1962	BMR
3125	72	62	64	1	95	140	360	x	0.5	20	x2.0	..	..	..	x0.1	x0.2	x0.5	..	x0.5	..	970	7.3	620	1962	BMR
3126	72	44	25	2	60	140	230	x	0.7	20	x2.0	..	..	..	x0.1	x0.2	x0.5	..	0.5	..	600	7.4	455	1962	BMR
3133	79.8	37.0	28.3	5	48.1	85.2	302.9	x	0.3	18.2	..	..	..	..	..	..	..	..	..	..	777	7.25	409	1962	AMDL
3135	70	36	40	2	70	130	220	x	0.7	20	x2.0	..	..	..	x0.1	x0.1	x0.5	..	0.5	..	710	7.2	472	1962	BMR
3136	2.9	2.3	6.1	1.7	7.1	1.6	21.4	x	0.05	14.7	..	..	..	..	..	..	..	..	..	..	74.4	5.6	31	1962	AMDL
3137	65.1	33.1	22.9	4.7	24	38.3	330.5	x	0.3	21.3	..	..	..	..	..	..	..	..	..	..	629	7.3	333	1962	AMDL
3156	76.8	40.6	67.5	5.5	162	95.9	225	x	0.7	18.6	x0.1	x0.001	x0.01	0.02	0.07	0.03	0.15	x0.01	0.5	x0.05	1029	7.9	568	1962	AMDL
3157	61.9	37.1	38.0	4.6	98.5	79.8	206	x	0.85	17.3	x0.1	x0.001	x0.01	x0.02	0.04	0.02	0.18	x0.01	0.5	x0.05	774	7.85	406	1962	AMDL
3159	76.3	38.6	54.8	6.25	105.9	123	235.5	x	1.36	17.9	..	..	..	..	..	..	..	..	..	..	900	7.45	528	1962	AMDL
3162	125.5	71.1	170.5	15	324.4	215.2	385.5	x	1.26	22	..	..	..	..	..	..	..	..	..	..	1890	7.1	1132	1962	AMDL
3163	92	55.5	318	18.4	428	348	223	x	3.08	22.2	..	..	..	..	..	..	..	..	..	..	2340	7.45	1408	1962	AMDL
											MT. DRUMMOND 1:250,000 SHEET AREA														
531	68.9	34.6	15.8	3.5	19.2	33.3	342.7	x	0.25	22.9	..	..	..	..	..	..	..	..	..	..	623	7.3	343	1962	AMDL
748	86	41	34.3	6.2	36.5	36.5	439	x	0.41	20.4	..	..	..	..	..	..	..	..	..	..	823	7.15	452	1962	AMDL
749	82.5	44.5	19.5	6.5	19.3	20.5	464	x	0.38	26.2	..	..	..	..	..	..	..	..	..	..	729	7.15	415	1962	AMDL
3128	95.6	55.1	16.2	3.3	19.2	20.6	541.6	x	0.35	20.8	..	..	..	..	..	..	..	..	..	..	866	7.00	441	1962	AMDL
3129	79.8	40.4	11.9	5.5	13.4	26.3	422	x	0.6	19.2	x0.1	x0.001	x0.01	x0.02	0.04	0.04	0.11	x0.01	0.4	x0.05	567	7.75	373	1962	AMDL

Reg. No.	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	F	SiO_2	NO_3	NO_2	PO_4	Mn	Fe	Al	B	Pb	Sr	Li	S.C.	pH	TDS	YEAR	LABORATORY
											AVON DOWNS 1:250,000 SHEET AREA														
92	85	..	348	..	497	166	116	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1218	1952	AIB
98	65	..	239	1	319	142	..	104	..	..	..	..	..	..	..	..	..	..	..	..	..	..	878	1952	AIB
331	110	..	430	278*	958	129	98	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1490	1952	AIB
340	161	..	369	..	674	128	146	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1490	1952	AIB
366	85.1	47.1	101.3	8.2	202.3	138.7	229.5	x	1.47	19.6	..	..	..	..	..	..	..	..	..	..	1240	7.7	712	1962	AMDL
384	81.2	44.2	72.0	7.6	55.7	50.6	492.5	x	1.46	59.3	..	..	..	..	..	..	..	..	..	..	960	7.05	587	1962	AMDL
994	103	..	286	..	550	203	213	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1604	1952	AIB
1871	114	67	138	17	280	129	400	x	0.6	..	4.0	..	..	..	..	..	..	..	..	..	..	7.6	1150	1959	AIB
1906	108	84	137	13	235	196	453	x	1.2	..	3.0	..	..	..	..	..	..	..	..	..	..	7.4	1230	1960	AIB

*Doubtful value: may be typographical error on original.

APPENDIX 3—BOREWATER ANALYSES
(IN EQUIVALENTS PER MILLION)

Reg. No.	Na (epm)	K (epm)	$Na+K$ (epm)	(%)	Ca (epm)	(%)	Mg (epm)	(%)	Total Cations (epm)	Cl (epm)	(%)	SO_4 (epm)	(%)	HCO_3 (epm)	(%)	Total Anions (epm)	$\frac{Cl}{Na+K}$	$\frac{Mg}{Ca}$	$\frac{SO_4}{Cl}$	$\frac{HCO_3}{Cl}$	$\frac{TDS}{S.C.}$	$Ca+Mg$ (epm)	$\frac{Ca+Mg}{Na+K}$	Type
BRUNETTE DOWNS 1:250,000 SHEET AREA																								
112	44.78	1.28	46.06	60	14.6	19	16.2	21	76.86	42.54	56	27.71	36	6.07	8	76.32	0.92	1.11	0.65	0.14	0.71	30.8	0.669	Anm
115	2.46	0.56	3.02	34	3.87	43	2.10	23	8.99	1.96	22	1.09	12	5.92	66	8.97	0.65	0.54	0.56	3.02	0.661	5.97	1.977	Cc
116	23.17	2.27	25.44	51	12.20	25	11.68	24	49.32	28.92	61	14.6	30	4.34	9	47.86	1.14	0.96	0.50	0.15	0.648	23.88	0.939	Anc
117	24.39	0.62	25.01	53	11.5	25	10.53	22	47.04	19.44	41	24.17	51	3.64	8	47.25	0.78	0.92	1.24	0.19	0.708	22.03	0.881	BAnc
118	21.74	1.46	23.2	58	8.20	20	8.96	22	40.36	23.94	60	8.06	20	7.77	20	39.77	1.03	1.09	0.34	0.32	0.688	17.16	0.740	Anm
119	25.04	0.81	25.85	57	8.65	19	10.86	24	45.36	28.11	61	9.60	21	8.26	18	45.97	1.09	1.26	0.34	0.29	0.629	19.51	0.755	Anm
123	10.91	0.92	11.83	70	2.97	17	2.14	13	16.94	4.51	27	4.15	25	8.15	48	16.81	0.38	0.72	0.92	1.81	0.635	5.11	0.432	Cnc
317	24.13	1.04	25.17	84	2.62	9	2.1	7	29.89	12.04	41	10.28	35	7.07	24	29.39	0.48	0.80	0.85	0.59	0.627	4.72	0.188	ABnc
360	38.48	1.18	39.96	75	7.00	13	6.58	12	53.24	24.51	46	24.17	46	5.15	9	53.83	0.61	0.94	0.99	0.21	0.720	13.58	0.340	ABnc
394	17.91	0.97	18.88	73	2.15	8	5.02	19	26.05	14.36	49	10.29	35	4.6*	16	29.25	0.76	2.33	0.72	0.32	..	7.17	0.380	ABnm
398	27.39	0.76	28.15	70	6.97	17	5.26	13	40.38	19.34	48	16.48	40	4.72	12	40.54	0.69	0.75	0.85	0.24	0.659	12.23	0.434	ABnc
405	9.57	0.54	10.11	21	26.4	56	10.87	23	47.38	8.16	17	36.61	77	2.61	6	47.38	0.81	0.41	4.49	0.32	0.865	37.27	3.686	Bc
413	12.96	0.59	13.55	48	8.32	29	6.62	23	28.49	12.92	48	8.28	31	5.62	21	26.82	0.95	0.8	0.64	0.43	0.638	14.94	1.102	ABnc
415	11.61	0.54	12.15	29	21.99	51	8.49	20	42.63	10.27	24	29.89	70	2.51	6	42.67	0.85	0.39	2.91	0.24	0.798	30.48	2.509	Bcn
527	29.39	2.0	31.39	65	8.78	18	8.34	17	48.51	24.92	53	16.67	36	5.02	11	46.61	0.79	0.95	0.67	0.20	0.649	17.12	0.545	ABnc
528	6.83	0.35	7.18	49	3.73	26	3.71	25	14.62	7.49	51	3.63	25	3.49	24	14.61	1.04	0.88	0.48	0.47	0.575	7.44	1.036	Anc
530	38.04	1.13	34.17	60	10.8	19	12.01	21	56.98	35.1	61	17.38	30	5.11	9	57.59	1.03	1.11	0.50	0.15	0.659	22.81	0.667	Anm
546	11.3	0.37	11.67	41	9.7	34	7.09	25	28.46	12.62	44	11.23	39	5.03	17	28.88	1.08	0.73	0.89	0.40	0.658	16.79	1.439	ABnc
602	10.26	0.38	10.64	27	18.75	47	10.44	26	39.83	17.49	44	19.04	48	3.23	8	39.76	1.64	0.56	1.09	0.18	0.707	29.19	2.743	BAc
603	8.00	0.82	8.82	62	2.8	19	2.8	19	14.42	2.25	16	4.9	34	7.33	50	14.48	0.26	1.0	2.18	3.26	0.726	5.6	0.635	CBnc
604	1.2	0.29	1.49	16	3.83	40	4.24	44	9.56	0.52	5	0.34	4	8.84	91	9.70	0.35	1.11	0.65	17.0	0.621	8.07	5.416	Cm
761	13.52	0.6	14.12	56	5.32	21	5.63	23	25.07	13.92	56	6.94	28	4.16	16	25.02	0.99	1.06	0.50	0.30	0.594	10.95	0.775	Anm
762	33.43	1.77	35.2	57	13.71	22	12.53	21	61.44	35.02	57	21.79	36	4.36	7	61.17	0.99	0.91	0.62	0.12	0.675	26.24	0.745	Anc
795	36.09	1.33	37.42	71	7.8	15	7.4	14	52.62	22.54	43	23.33	44	6.9	13	52.77	0.60	0.95	1.04	0.31	0.767	15.2	0.406	BAnc
934	16.09	0.9	16.99	59	6.3	22	5.52	19	28.81	13.54	47	8.7	31	6.37	22	28.61	0.80	0.88	0.64	0.47	0.616	11.82	0.696	ABnc
935	38.43	2.07	40.5	55	15.86	21	18.22	24	74.58	43.52	59	26.57	36	3.91	5	74.00	1.07	1.15	0.61	0.09	0.674	34.08	0.841	Anm
1180	13.39	0.26	13.65	43	9.60	30	8.56	27	31.81	16.34	51	11.4	36	4.26	13	32.0	1.20	0.89	0.70	0.26	0.690	18.16	1.330	ABnc
1181	22.39	0.51	22.9	39	23.4	40	12.17	21	58.47	21.41	36	34.58	59	2.62	5	58.61	0.93	0.52	1.62	0.12	0.924	35.57	1.553	Bcn
1182	4.11	0.81	4.92	44	3.57	32	2.76	24	11.25	2.02	18	2.50	22	6.90	60	11.42	0.41	0.77	1.24	3.42	0.697	6.33	1.286	Cnc
1183	33.91	0.59	34.50	60	12.6	22	10.36	18	57.46	31.55	57	21.04	36	3.93	7	56.52	0.91	0.82	0.67	0.12	0.747	22.96	0.665	Anc
1183	17.3	0.67	17.96	55	7.8	24	6.74	21	32.51	15.58	50	9.19	29	6.44	21	31.21	0.87	0.86	0.59	0.41	..	14.54	0.809	Anc
1211	28.09	1.15	29.24	58	9.94	20	10.81	22	49.99	30.8	62	13.29	27	5.62	11	49.71	1.05	1.09	0.43	0.18	0.633	20.75	0.710	Anm
1213	34.17	1.06	35.23	60	11.8	20	11.43	20	58.46	33.8	57	20.36	35	4.66	8	58.82	0.96	0.97	0.60	0.14	0.659	23.23	0.659	Anc
1214	21.13	0.78	21.91	45	13.3	27	13.73	28	48.94	26.31	54	15.21	31	7.26	15	48.78	1.20	1.03	0.58	0.28	0.674	27.03	1.234	Anm
1215	40.26	1.51	41.77	61	12.63	18	14.71	21	69.11	44.37	64	19.55	28	5.72	8	69.64	1.06	1.16	0.44	0.13	0.656	27.34	0.654	Anm
1216	29.39	1.6	30.99	60	8.51	17	11.87	23	51.37	33.17	64	11.38	22	6.97	14	51.52	1.07	1.39	0.34	0.21	0.618	20.38	0.658	Anm
1217	35.3	1.73	37.03	60	11.3	18	13.65	22	61.98	39.07	63	16.1	26	6.72	11	61.89	1.06	1.21	0.41	0.17	0.653	24.95	0.674	Anm
1218	20.48	1.26	21.74	58	6.78	18	9.05	24	37.57	21.39	58	8.16	22	7.52	20	37.07	0.98	1.33	0.38	0.35	0.604	15.83	0.728	Anm
1219	53.48	1.54	55.02	70	11.2	14	12.83	16	79.05	48.45	62	24.17	31	5.33	7	77.95	0.88	1.15	0.5	0.11	1.042	24.03	0.437	Anm
1220	54.78	1.62	56.4	66	12.75	15	16.2	19	85.35	57.18	68	22.81	27	4.36	5	84.35	1.01	1.27	0.40	0.08	0.756	28.95	0.513	Anm
1221	5.57	0.28	5.85	38	4.82	32	4.57	30	15.24	6.5	44	3.02	20	5.32	36	14.84	1.11	0.95	0.46	0.82	0.569	9.39	1.605	AcnC
1222	36.78	1.22	38.00	59	12.72	20	13.31	21	64.03	38.11	59	21.24	33	5.17	8	64.52	1.0	1.05	0.56	0.14	0.660	26.03	0.685	Anm
1223	51.87	1.82	53.69	64	13.37	16	16.51	20	83.57	54.70	66	22.3	27	6.17	7	83.17	1.02	1.23	0.41	0.11	0.651	29.88	0.556	Anm

*includes 0.8 epm CO_3

APPENDIX 3—BOREWATER ANALYSES—*continued*

Reg. No.	Na (epm)	K (epm)	$Na+K$ (epm)	(%)	Ca (epm)	(%)	Mg (epm)	(%)	Total Cations (epm)	Cl (epm)	(%)	SO_4 (epm)	(%)	HCO_3 (epm)	(%)	Total Anions (epm)	$\frac{Cl}{Na+K}$	$\frac{Mg}{Ca}$	$\frac{SO_4}{Cl}$	$\frac{HCO_3}{Cl}$	$\frac{TDS}{S.C.}$	$Ca+Mg$ (epm)	$\frac{Ca+Mg}{Na+K}$	Type
1225	37.61	1.2	38.81	59	13.83	21	13.32	20	65.96	38.01	57	23.8	36	4.62	7	66.43	0.98	0.96	0.63	0.12	0.682	27.15	0.699	Anc
1227	41.35	1.49	42.84	50	22.92	27	19.89	23	85.65	44.61	52	36.51	43	4.46	5	85.58	1.04	0.87	0.82	0.10	0.732	42.81	0.999	ABnc
1228	24.43	1.41	25.84	58	8.67	19	10.23	23	44.74	27.26	61	9.75	22	7.72	17	44.73	1.05	1.18	0.36	0.28	0.608	18.9	0.731	Anm
1229	61.3	1.42	62.72	53	26.43	22	29.33	25	118.43	64.79	54	50.59	42	4.26	4	119.64	1.03	1.11	0.781	0.07	0.728	55.76	0.889	ABnm
1230	58.78	1.71	60.49	55	22.76	21	25.95	24	109.20	59.66	54	42.26	39	7.93	7	109.85	0.99	1.14	0.71	0.13	0.732	48.71	0.805	ABnm
1250	37.22	1.18	38.40	58	14.75	22	13.45	20	66.60	37.16	56	24.84	37	4.51	7	66.51	0.97	0.91	0.67	0.12	0.680	28.2	0.734	ABnm
1757	36.52	0.95	37.47	51	18.6	25	17.11	24	73.18	37.89	56	27.19	40	2.92	4	68.00*	1.01	0.92	0.72	0.08	..	35.71	0.953	ABnm
1990	33.26	0.92	34.18	52	16.72	26	14.23	22	65.13	33.08	51	27.33	42	4.51	7	64.92	0.97	0.85	0.83	0.14	0.716	30.95	0.905	ABnc
1993	6.74	0.26	7.0	33	7.8	37	6.41	30	21.21	7.46	35	7.35	34	6.64	31	21.45	1.07	0.82	0.99	0.89	0.647	14.21	2.030	ABcn
1995	25.22	0.51	25.73	44	18.05	31	14.39	25	58.19	28.73	49	26.46	45	3.44	6	58.63	1.12	0.80	0.92	0.12	0.779	32.44	1.261	ABnc
1996	27.83	0.51	28.34	50	15.4	27	13.16	23	56.9	28.45	50	25.52	44	3.49	6	58.63	1.00	0.85	0.90	0.12	0.791	28.56	1.008	ABnc
1998	67.39	1.6	68.99	66	19.1	18	17.19	16	105.28	57.97	54	44.56	42	3.98	4	106.51	0.84	0.90	0.77	0.07	0.728	36.29	0.526	ABnc
2157	28.0	0.26	28.26	46	21.85	36	10.86	18	60.97	23.38	38	34.79	57	3.11	5	61.28	0.83	0.50	1.49	0.13	0.838	32.71	1.157	BAnc
2159	12.78	0.51	13.29	73	2.6	14	2.38	13	18.27	7.04	39	4.58	26	6.38	35	18.0	0.53	0.92	0.65	0.91	0.657	4.98	0.375	ACnc
2160	5.78	0.38	6.16	54	3.40	30	1.81	16	11.37	2.11	18	3.17	28	6.11	54	11.39	0.34	0.53	1.50	2.90	0.741	5.21	0.846	Cnc
2161	6.35	0.37	6.72	66	1.73	17	1.78	17	10.23	2.02	20	2.46	24	5.62	56	10.10	0.3	1.03	1.22	2.78	0.613	3.51	0.522	Cnm
2162	17.3	0.51	17.81	48	10.2	28	8.72	24	36.73	17.46	48	15.0	41	3.93	11	36.39	0.98	0.85	0.86	0.23	0.688	18.92	1.062	ABnc
2163	9.74	0.77	10.51	65	2.7	16	3.04	19	16.25	4.51	27	3.44	21	8.64	52	16.59	0.43	1.13	0.76	1.92	0.711	5.74	0.546	Cnm
2222	9.85	0.57	10.42	44	6.89	29	6.24	27	23.55	9.38	41	5.91	26	7.67	33	22.96	0.90	0.91	0.63	0.82	0.631	13.13	1.260	ACnc
2223	11.3	0.62	11.92	48	7.59	31	5.24	21	24.75	9.5	40	8.72	36	5.67	24	23.89	0.80	0.69	0.92	0.60	0.648	12.83	1.076	ABnc
2224	14.22	0.59	14.81	72	3.20	16	2.47	12	20.48	6.20	30	7.63	38	6.43	32	20.26	0.42	0.77	1.23	1.04	0.628	5.67	0.383	BCnc
2225	42.57	1.79	44.36	65	14.71	21	9.77	14	68.84	27.99	42	32.78	49	5.77	9	66.54	0.63	0.66	1.17	0.21	0.725	24.48	0.552	BAnc
2226	40.74	1.33	42.07	70	11.04	18	7.47	12	60.58	22.08	37	31.81	54	5.42	9	59.31	0.52	0.68	1.44	0.25	0.729	18.51	0.440	BAnc
2227	14.26	1.32	15.58	74	3.07	15	2.3	11	20.95	5.01	24	9.56	45	6.52	31	21.09	0.32	0.75	1.91	1.30	0.644	5.37	0.345	BCnc
2228	50.43	0.92	51.35	65	14.12	18	13.12	17	78.59	32.56	41	42.87	54	3.56	5	78.99	0.63	0.93	1.32	0.11	0.743	27.24	0.530	BAnc
2232	24.74	1.65	26.39	63	9.07	22	6.33	15	41.79	9.56	23	27.58	66	4.82	11	41.96	0.36	0.70	2.88	0.50	0.746	15.40	0.583	Bnc
2233	38.48	1.42	39.9	62	14.85	23	10.03	15	64.78	21.99	33	40.5	62	3.11	5	65.60	0.55	0.68	1.84	0.14	0.770	24.88	0.623	Bnc
2234	3.89	0.38	4.27	9	28.15	61	13.61	30	46.03	4.62	10	38.67	86	1.95	4	45.24	1.08	0.48	8.37	0.42	0.946	41.76	9.780	Bc
2235	9.43	0.47	9.9	18	31.15	57	13.36	25	54.31	9.52	18	42.23	78	2.11	4	53.86	0.96	0.43	4.44	0.22	0.892	44.51	4.500	Bc
2280	121.3	1.79	123.09	70	26.75	15	26.73	15	176.57	94.37	55	72.6	42	4.67	3	171.64	0.77	1.0	0.77	0.05	..	53.48	0.434	ABnm
2282	47.3	0.87	48.17	57	19.95	24	16.12	19	84.24	40.79	48	40.46	48	3.28	4	84.53	0.85	0.81	0.99	0.08	0.741	36.07	0.749	ABnc
2283	57.87	1.23	59.10	64	17.9	19	15.13	17	92.13	49.15	53	39.77	43	3.64	4	92.56	0.83	0.85	0.81	0.07	0.718	33.03	0.559	ABnc
2287	19.43	1.03	20.46	68	5.35	18	4.41	14	30.22	16.48	53	8.19	27	5.23	18	29.90	0.81	0.82	0.50	0.32	0.617	9.76	0.4770	Anc
2288	108.7	1.74	110.44	65	24.3	14	34.87	21	169.61	108.87	63	59.33	34	5.75	3	173.94	0.99	1.43	0.54	0.05	..	59.17	0.536	Anm
2289	54.91	1.13	56.04	73	10.35	13	10.77	14	77.16	44.62	57	28.65	37	4.59	6	77.86	0.80	1.04	0.64	0.10	0.675	21.12	0.377	Anm
2412	34.78	0.87	35.65	58	13.4	22	12.5	20	61.55	34.08	56	22.73	37	3.72	7	60.53	0.96	0.93	0.67	0.11	..	25.9	0.726	ABnc
2498	29.57	1.03	30.60	56	12.8	23	11.68	21	55.08	29.86	54	20.23	37	5.07	9	55.16	0.98	0.91	0.68	0.17	0.831	24.48	0.800	ABnc
2499	39.13	1.21	40.34	58	14.39	21	14.19	21	68.92	39.64	58	24.38	35	5.07	7	69.09	0.98	0.99	0.62	0.13	0.693	28.58	0.708	Anm
2500	28.35	0.88	29.23	57	11.9	23	10.53	20	51.66	26.59	51	20.38	39	5.21	10	52.18	0.91	0.88	0.77	0.20	0.702	22.43	0.767	ABnc
2501	36.87	1.08	38.95	57	15	23	13.57	20	66.52	36.25	54	25.38	38	5.51	8	67.14	0.93	0.90	0.70	0.15	0.720	28.57	0.733	ABnc
2502	6.26	.038	6.64	20	16.5	50	9.79	30	32.93	1.46	4	28.38	87	2.92	9	32.76	0.22	0.59	20.18	2.00	..	26.29	3.959	Bc
2503	15.35	0.56	15.91	37	18.08	42	8.87	21	42.86	7.19	17	30.91	73	4.21	10	42.31	0.45	0.49	4.30	0.59	0.821	26.95	1.694	Bcn
2504	15.0	0.62	15.62	64	4.65	19	4.28	17	24.55	8.73	36	9.10	38	6.41	26	24.24	0.56	0.92	1.04	0.73	..	8.93	0.572	BAnc
2505	12.52	0.49	13.01	61	4.40	21	3.91	18	21.32	7.33	35	7.36	35	6.47	30	21.16	0.56	0.89	1.00	0.88	0.601	8.31	0.639	ABnc

*poor balance.

Reg. No.	Na (epm)	K (epm)	$Na+K$ (epm)	(%)	Ca (epm)	(%)	Mg (epm)	(%)	Total Cations (epm)	Cl (epm)	(%)	SO_4 (epm)	(%)	HCO_3 (epm)	(%)	Total Anions (epm)	$\frac{Cl}{Na+K}$	$\frac{Mg}{Ca}$	$\frac{SO_4}{Cl}$	$\frac{HCO_3}{Cl}$	$\frac{TDS}{S.C.}$	$Ca+Mg$ (epm)	$\frac{Ca+Mg}{Na+K}$	Type
2506	41.3	1.3	42.6	60	13.9	20	14.3	20	70.8	39.72	55	27.1	38	4.89	7	71.71	0.93	1.03	0.68	0.12	0.821	28.2	0.662	ABnm
2507	9.74	1.1	10.84	63	3.3	20	2.81	17	16.95	4.68	27	5.81	34	6.67	39	17.16	0.43	0.85	1.24	1.43	0.608	6.11	0.564	CBnc
2577	3.63	0.51	4.14	49	2.73	32	1.64	19	8.51	0.77	9	0.78	10	6.57	81	8.12	0.19	0.6	1.01	8.53	0.627	4.37	1.055	Cnc
2578	8.52	0.79	9.31	46	6.2	31	4.58	23	20.09	3.92	20	11.21	55	5.13	25	20.26	0.42	0.74	2.86	1.31	0.670	10.78	1.158	Bnc
2580	N.det.	N.det.	11.52*	72	1.55	10	2.88	18	15.95	4.64	29	6.13	38	5.18	33	15.95	0.40	1.86	1.32	1.12	. .	4.43	0.384	BCnm
2581	27.78	0.97	28.75	60	9.25	19	9.95	21	47.95	29.01	60	14.15	29	5.03	11	48.19	1.00	1.08	0.49	0.17	0.639	19.20	0.668	Anm
2582	N.det.	N.det.	53.21*	62	10.60	12	22.20	26	86.01	47.46	55	36.48	42	2.07	3	86.01	0.89	2.09	0.77	0.04	. .	32.8	0.616	ABnm
2583	8.17	0.77	8.94	60	3.31	22	2.67	18	14.92	3.93	27	4.22	29	6.32	44	14.47	0.44	0.81	1.07	1.61	0.585	5.98	0.669	CBnc
2585	31.43	1.36	32.79	65	8.85	18	8.72	17	50.36	28.54	56	17.04	33	5.57	11	51.15	0.87	0.99	0.60	0.20	0.655	17.57	0.536	Anc
2586	6.04	1.01	7.05	55	3.02	25	2.51	20	12.58	2.24	18	3.1	25	6.98	57	12.32	0.32	0.83	1.38	3.12	0.619	5.53	0.784	Cnc
2745	2.87	0.26	3.13	34	2.44	26	3.74	40	9.31	2.26	24	0.72	8	6.39	68	9.37	0.72	1.53	0.31	2.83	0.592	6.18	1.974	Cmn
2758	21.74	0.92	22.66	60	8.6	23	6.58	17	37.84	16.06	43	16.79	44	4.97	13	37.82	0.71	0.76	1.05	0.31	0.738	15.18	0.670	BAnc
2901	18.7	1.15	19.85	48	11.78	29	9.54	23	41.17	19.45	48	16.81	41	4.41	11	40.67	0.98	0.81	1.16	0.23	0.664	21.32	1.074	ABnc
3100	20.74	0.6	21.34	66	6.07	18	5.10	16	32.51	12.49	39	12.55	40	6.67	21	31.7	0.58	0.84	1.00	0.53	0.650	11.17	0.523	BAnc
3101	18.09	0.85	18.94	56	7.97	24	6.67	20	33.58	14.37	43	14.42	43	4.61	14	33.40	0.76	0.84	1.00	0.32	0.654	14.64	0.7730	BAnc
3102	40.96	1.23	42.19	55	17.00	22	17.89	23	77.08	41.33	53	31.07	40	5.17	7	77.57	0.98	1.05	0.75	0.13	0.705	38.89	0.922	ABnm
3103	29.78	0.73	30.51	54	14.35	26	11.02	20	55.88	24.73	44	27.27	48	4.64	8	56.64	0.81	0.77	1.10	0.19	0.724	35.39	1.159	BAnc
3104	20.61	0.95	21.56	61	7.15	20	6.92	19	35.63	18.11	51	12.06	34	5.44	15	35.61	0.84	0.97	0.67	0.30	0.643	14.07	0.652	ABnc
3105	40.74	1.28	42.02	65	10.77	17	11.64	18	64.43	38.45	60	20.49	32	4.87	8	63.81	0.92	1.08	0.53	0.13	0.663	22.41	0.533	Anm
3107	12.35	0.53	12.87	57	4.77	21	4.89	22	22.54	12.38	56	6.18	28	3.51	16	22.07	0.96	1.03	0.50	0.28	0.578	9.66	0.750	Anm
3109	16.09	0.64	16.73	50	8.6	26	7.98	24	33.31	12.96	38	12.98	38	8.03	24	33.97	0.77	0.93	1.00	0.62	0.736	16.58	0.991	BAnc
3110	19.83	0.56	20.39	67	5.65	19	4.36	14	30.40	11.41	37	15.24	41	6.84	22	30.79	0.56	0.77	1.34	0.60	0.664	10.01	0.491	BAnc
3111	38.04	1.18	39.22	58	14.62	22	13.82	20	67.66	38.96	57	24.6	36	5.11	7	68.69	0.99	0.95	0.63	0.13	0.695	28.44	0.725	Anc
3112	29.57	0.64	30.21	47	19.2	29	15.63	24	65.04	31.52	48	30.33	46	4.05	6	65.9	1.04	0.81	0.96	0.13	0.750	34.83	1.153	ABnc
3113	30.0	1.17	31.17	64	8.33	17	9.5	19	49.00	30.47	62	12.92	26	6.12	12	49.49	0.98	1.14	0.42	0.20	0.631	17.83	0.572	Anm
3114	13.91	1.2	15.11	60	5.44	22	4.51	18	25.06	9.33	38	9.26	38	5.77	24	24.36	0.62	0.83	0.99	0.62	0.630	9.95	0.658	ABnc
3115	4.11	0.62	4.73	42	3.87	34	2.71	24	11.31	1.93	18	1.71	16	6.97	66	10.61	0.41	0.70	0.89	3.61	0.573	6.58	1.391	Cnc
3116	4.46	0.44	4.9	38	5.07	40	2.75	22	12.72	3.74	33	2.36	20	5.48	47	11.58	0.76	0.54	0.63	1.47	0.623	7.82	1.596	CAc
3118	40.26	1.69	41.95	58	15.64	22	14.58	20	72.17	39.13	55	25.67	36	5.92	9	70.72	0.93	0.93	0.66	0.15	0.693	30.22	0.720	ABnc
3119	36.26	1.54	37.8	63	9.4	16	12.75	21	59.95	36.34	62	15.94	27	6.2	11	58.48	0.96	1.36	0.44	0.17	0.698	22.15	0.5860	Anm
3122	38.43	0.81	39.24	60	11.6	18	14.47	22	65.31	42.82	64	17.06	26	6.57	10	66.45	1.09	1.25	0.40	0.15	0.667	26.07	0.664	Anm
3147	14.3	0.35	14.65	40	12.7	34	9.54	26	36.89	16.11	44	17.04	46	3.84	10	36.99	1.10	0.75	1.06	0.24	0.702	22.24	1.518	BAnc
3149	16.87	0.72	17.59	54	8.05	25	7.03	21	32.67	14.74	46	13.11	40	4.62	14	32.47	0.84	0.87	0.89	0.31	0.654	15.08	0.857	ABnc
3568	28.91	1.33	30.24	61	8.8	18	10.36	21	49.4	32.28	64	12.23	25	5.61	11	50.12	1.07	1.18	0.38	0.17	0.631	19.16	0.633	Anm
3655	53.91	4.1	58.01	66	13.2	15	16.61	19	87.82	58.03	66	25.0	29	4.64	5	87.67	1.00	1.26	0.43	0.08	0.749	29.81	0.514	Anm
3656	29.26	1.79	31.05	38	9.0	19	12.42	23	53.47	34.11	64	11.63	22	7.64	14	53.38	1.10	1.38	0.34	0.22	0.624	21.42	0.690	Anm
4052	24.2	1.63	25.83	57	11.88	26	7.85	17	45.56	4.55	10	37.90	83	3.41	7	45.86	0.18	0.66	8.33	0.75	0.795	19.73	0.764	Bnc
ALROY 1:250,000 SHEET AREA																								
29	11.22	1.24	12.46	49	5.42	21	7.77	30	25.65	10.38	41	4.15	16	10.79	43	25.32	0.83	1.43	0.40	1.04	0.593	13.19	1.058	CAnm
41	4.35	1.05	5.40	48	2.95	26	2.91	26	11.26	0.94	9	0.58	5	9.23	86	10.75	0.17	0.99	0.62	9.82	0.583	5.86	1.085	Cnc
124	20.13	0.94	21.07	51	9.65	24	10.44	25	41.16	22.17	54	13.31	32	5.56	14	41.04	1.05	1.08	0.60	0.25	0.656	20.09	0.953	Anm
285	12.74	0.56	13.30	41	10.13	31	8.93	28	32.34	16.31	51	8.96	28	6.92	21	32.19	1.23	0.88	0.55	0.42	0.630	19.06	1.433	Anc
353	5.04	1.13	6.17	37	4.67	28	5.73	35	16.57	3.71	24	1.36	9	10.29	67	15.36	0.60	1.23	0.40	2.77	0.589	10.40	1.685	Cnm
358	2.43	0.79	3.22	38	2.55	30	2.64	32	8.41	0.80	10	0.39	5	6.72	85	7.91	0.25	1.04	0.49	8.40	0.581	5.19	1.612	Cnm

*obtained by balancing.

APPENDIX 3—BOREWATER ANALYSES—*continued*

Reg. No.	Na (epm)	K (epm)	$Na+K$ (epm)	(%)	Ca (epm)	(%)	Mg (epm)	(%)	Total Cations (epm)	Cl (epm)	(%)	SO_4 (epm)	(%)	HCO_3 (epm)	(%)	Total Anions (epm)	$\frac{Cl}{Na+K}$	$\frac{Mg}{Ca}$	$\frac{SO_4}{Cl}$	$\frac{HCO_3}{Cl}$	$\frac{TDS}{S.C.}$	$Ca+Mg$ (epm)	$\frac{Ca+Mg}{Na+K}$	Type
395	12.96	0.51	13.47	25	24.24	44	17.29	31	55.00	22.91	42	27.80	51	3.57	7	54.28	1.70	0.71	1.21	0.16	0.732	41.53	3.083	BAc
396	5.00	0.64	5.64	34	6.84	41	4.27	25	16.75	3.17	19	6.93	43	6.27	38	16.37	0.56	0.62	2.19	1.98	0.658	11.11	1.970	BCcn
403	43.39	1.47	44.86	53	17.4	21	21.71	26	83.97	57.24	68	21.44	25	5.66	7	84.34	1.28	1.25	0.37	0.10	0.633	39.11	0.872	Anm
414	23.48	0.77	24.25	46	14.65	28	13.75	26	52.65	28.41	55	18.69	36	4.79	9	51.89	1.17	0.94	0.66	0.17	0.670	28.40	1.171	ABnc
500	6.09	0.77	6.86	41	5.2	30	5.02	29	17.06	6.34	36	2.4	14	8.85	50	17.59	0.92	0.97	0.38	1.40	0.605	10.22	1.490	CAnm
503	7.78	0.46	8.24	46	5.25	29	4.47	25	17.96	6.0	34	5.81	33	5.75	33	17.56	0.73	0.85	0.97	0.96	0.615	9.72	1.180	ABnc
504	7.3	0.51	7.81	41	5.5	29	5.7	30	19.01	7.04	37	3.63	19	8.28	44	18.95	0.90	0.20	0.52	1.18	0.606	11.20	1.434	CAnm
719	22.04	1.42	23.46	55	7.52	18	11.27	27	42.25	23.62	57	10.93	26	6.97	17	41.52	1.01	1.50	0.46	0.30	0.652	18.79	0.801	Anm
720	13.04	1.21	14.25	50	6.20	22	7.98	28	28.43	15.01	52	4.50	16	9.20	32	28.71	1.05	1.29	0.30	0.01	..	14.18	0.995	ACnm
722	10.0	0.88	10.88	45	6.48	27	6.7	28	24.06	9.10	38	6.76	28	8.23	34	24.09	0.84	1.03	0.74	0.90	0.633	13.18	1.211	ACnm
723	18.26	1.72	19.98	57	5.90	17	9.29	26	35.17	16.90	49	6.63	19	11.08	32	34.61	0.85	1.57	0.40	0.66	..	15.19	0.760	ACnm
724	21.30	1.90	23.20	59	6.25	16	9.87	25	39.32	21.55	56	6.96	18	10.25	26	38.76	0.93	1.58	0.32	0.48	..	16.12	0.695	Anm
725	6.09	1.13	7.22	38	5.00	27	6.66	35	18.88	4.65	25	2.21	12	12.00	63	18.86	0.64	1.33	0.48	2.58	..	11.66	1.615	Cnm
727	10.43	1.13	11.56	48	5.83	24	6.61	28	24.00	11.18	47	3.55	15	8.90	38	23.63	0.97	1.13	0.32	0.80	0.577	12.44	1.076	ACnm
728	36.52	2.69	39.21	61	8.50	13	16.20	26	63.91	36.90	59	13.90	22	11.89	19	62.69	0.94	1.91	0.38	0.32	..	24.70	0.630	Anm
729	15.57	1.53	17.1	55	5.77	19	7.98	26	30.85	14.94	49	8.42	27	7.48	24	30.84	0.87	1.38	0.56	0.50	0.619	13.75	0.804	Anm
730	9.48	0.97	10.45	48	5.63	26	5.67	26	21.75	8.47	39	4.41	20	8.83	41	21.71	0.81	1.01	0.52	1.04	0.622	11.30	1.081	CAnm
731	11.61	1.23	12.84	48	6.86	25	7.35	27	27.05	11.92	46	5.53	21	8.63	33	26.08	0.93	1.07	0.46	0.72	0.586	14.21	1.107	ACnm
732	6.57	0.82	7.39	41	5.61	31	5.12	28	18.12	6.13	35	2.37	13	9.33	52	17.83	0.83	0.91	0.39	1.52	0.586	10.73	1.452	CAnc
733	24.48	1.08	25.56	53	10.31	22	12.15	25	48.02	31.43	65	10.32	21	6.62	14	48.37	1.24	1.18	0.33	0.21	0.616	22.46	0.879	Anm
734	6.43	0.85	7.28	43	4.54	27	5.13	30	16.95	5.13	30	3.61	21	8.43	49	17.17	0.70	1.13	0.70	1.64	0.589	9.67	1.328	CAnm
1212	8.52	0.56	9.08	38	8.46	35	6.35	27	23.89	10.84	45	7.96	33	5.24	22	24.04	1.19	0.75	0.73	0.48	0.629	14.81	1.631	ABnc
1236	9.43	0.82	10.25	44	6.65	29	6.33	27	23.23	11.49	50	4.02	18	7.28	32	22.79	1.12	0.95	0.35	0.63	..	12.98	1.266	ACnc
1237	10.87	1.08	11.95	45	7.05	27	7.57	28	26.57	12.90	50	5.73	22	7.16	28	25.79	1.08	1.07	0.44	0.56	..	14.62	1.223	ACnm
1239	3.41	1.6	5.01	41	3.15	26	3.95	33	12.11	2.11	18	1.43	12	8.38	70	11.92	0.42	1.25	0.68	3.97	0.575	7.10	1.417	Cnm
1240	6.96	1.10	8.06	44	4.20	23	6.09	33	18.35	5.21	29	1.98	11	10.59	60	17.78	0.65	1.45	0.38	2.03	..	10.29	1.277	Cnm
1241	3.04	0.51	3.55	28	4.95	38	4.36	34	12.85	2.68	21	1.15	9	8.64	70	12.47	0.75	0.88	0.43	3.22	..	9.31	2.623	Cc
1242	6.35	1.09	7.44	42	4.6	26	5.55	32	17.59	4.73	27	2.63	15	9.93	58	17.29	0.64	1.21	0.56	2.10	0.573	10.15	1.364	Cnm
2190	46.14	3.15	49.29	64	11.36	15	16.50	21	77.15	53.05	68	17.03	22	7.68	10	77.76	1.08	1.45	0.32	0.14	0.633	27.86	0.565	Anm
2191	48.7	0.56	49.26	46	24.1	22	34.38	32	107.74	34.51	32	65.42	62	6.07	6	106.00	0.70	1.43	1.47	0.18	..	58.48	1.187	Bnm
2192	8.13	8.26	16.39	59	5.35	19	6.09	22	27.83	11.01	40	4.17	15	12.61	45	27.79	0.67	1.14	0.38	1.15	..	11.44	0.6980	CAnm
2193	10.00	1.10	11.10	49	5.15	23	6.50	28	22.75	9.30	43	2.90	14	9.28	43	21.48	0.84	1.26	0.31	1.00	..	11.65	1.050	ACnm
2194	12.35	0.96	13.31	51	6.4	24	6.52	25	26.23	13.21	51	4.81	19	7.83	30	25.85	0.99	1.02	0.36	0.59	0.572	12.92	0.971	Anm
2195	20.13	1.65	21.78	57	6.32	17	9.7	26	37.80	19.84	53	9.72	26	8.13	21	37.69	0.91	1.53	0.49	0.41	0.622	16.02	0.736	Anm
2229	6.7	0.45	7.15	14	31.7	60	13.09	26	52.54	7.70	15	42.00	81	1.90	4	51.6	1.08	0.43	5.45	0.25	0.903	45.39	6.348	Bc
2236	14.49	0.67	15.16	49	8.51	27	7.53	24	31.2	15.56	50	9.94	32	5.57	18	31.07	1.03	0.88	0.64	0.36	0.645	16.04	1.058	ABnc
2281	27.83	0.59	28.42	42	25.35	37	14.72	21	68.49	23.86	34	42.75	62	2.62	4	69.23	0.84	0.58	1.79	0.11	0.808	40.07	1.410	Bnc
2579	7.13	0.5	7.63	35	8.15	37	6.03	28	21.81	9.01	42	8.71	41	3.69	17	21.41	1.18	0.74	0.97	0.41	0.649	14.48	1.898	ABcn
2800	9.04	0.74	9.78	45	6.5	30	5.41	25	21.69	9.46	45	5.04	24	6.61	31	21.11	0.97	0.83	0.53	0.70	0.617	11.91	1.218	ACnc
2940	2.23	0.84	3.07	39	2.47	31	2.4	30	7.94	0.88	11	0.42	5	5.8	74	7.85*	0.29	0.97	0.48	6.59	0.582	4.87	1.586	Cnc
2942	N.det.	N.det.	10.74*a*	26	16.15	38	15.21	36	42.1	16.62	39	22.27	53	3.21	8	42.10	1.55	0.94	1.34	0.19	..	31.36	2.920	BAc
3108	21.48	1.23	22.71	60	6.5	17	8.88	23	38.09	22.11	58	8.15	21	8.11	21	38.37	0.97	1.37	0.37	0.37	0.610	15.38	0.677	Anm
3123	41.22	2.0	43.22	61	12.3	17	15.87	22	71.39	46.31	64	19.4	27	6.51	9	72.22	1.07	1.29	0.42	0.14	0.663	28.17	0.652	Anm
3138	N.det.	N.det.	25.43*a*	58	6.95	16	11.18	26	43.55	25.49	58	8.6	20	9.46	22	43.55	1.00	1.61	0.34	0.37	..	18.13	0.713	Anm
3139	27.39	1.62	29.01	62	5.00	10	13.08	28	47.09	26.9	56	13.71	29	7.11	15	47.72	0.93	2.62	0.51	0.26	..	18.08	0.623	Anm

(*a*) obtained by balancing. *includes 0.75 epm (10%) NO_3

Reg. No.	Na (epm)	K (epm)	$Na+K$ (epm)	(%)	Ca (epm)	(%)	Mg (epm)	(%)	Total Cations (epm)	Cl (epm)	(%)	SO_4 (epm)	(%)	HCO_3 (epm)	(%)	Total Anions (epm)	$\frac{Cl}{Na+K}$	$\frac{Mg}{Ca}$	$\frac{SO_4}{Cl}$	$\frac{HCO_3}{Cl}$	$\frac{TDS}{S.C.}$	$Ca+Mg$ (epm)	$\frac{Ca+Mg}{Na+K}$	Type
3140	6.30	0.77	7.07	43	4.2	25	5.18	32	16.45	4.37	26	2.6	16	9.51	58	16.48	0.62	1.23	0.59	2.18	0.559	9.38	1.327	Cnm
3141	12.75	1.14	13.89	52	6.16	23	6.85	25	26.90	14.45	55	4.27	16	7.83	29	26.55	1.04	1.11	0.30	0.54	0.598	13.01	0.937	Anm
3143	6.48	0.77	7.25	37	5.8	30	6.41	33	19.46	7.32	37	2.87	15	9.34	48	19.53	1.01	1.11	0.39	1.28	0.642	12.21	1.684	CAnm
3144	53.04	3.33	56.37	65	12.0	14	18.17	21	86.54	58.59	68	17.71	20	10.66	12	86.96	1.04	1.51	0.30	0.18	0.790	30.17	0.535	Anm
3145	46.96	0.46	47.42	45	23.65	23	33.8	32	104.87	35.21	23	65.77	61	6.18	6	107.16	0.74	1.43	1.87	0.18	. .	57.45	1.212	Bnm
1778	8.00	0.77	8.77	42	5.83	28	6.2	30	20.80	10.38	51	2.61	13	7.32	36	20.31	1.18	1.06	0.25	0.71	0.544	12.03	1.372	ACnm
WALLHALLOW 1:250,000 SHEET AREA																								
524	3.76	0.37	4.13	46	2.71	30	2.16	24	9.00	1.25	14	1.37	16	6.16	70	8.78	0.30	0.80	1.10	4.93	0.565	4.87	1.179	Cnc
525	15.04	0.32	15.36	44	10.9	31	8.96	25	35.22	16.38	47	14.7	42	4.07	11	35.15	1.07	0.82	0.90	0.25	0.672	19.86	1.293	ABnc
598	22.61	0.45	23.06	39	20.7	35	15.87	26	59.63	27.94	47	28.04	47	3.54	6	59.52	1.21	0.77	1.00	0.13	0.735	36.57	1.586	ABnc
599	22.61	0.54	23.15	43	16.4	31	13.82	26	53.37	26.34	49	23.96	45	3.36	6	53.66	1.14	0.84	0.91	0.13	0.717	30.22	1.305	ABnc
600	26.09	0.56	26.65	44	17.75	29	16.37	27	60.77	30.14	51	25.46	43	3.80	6	59.40	1.13	0.92	0.84	0.13	. .	34.12	1.280	ABnc
601	18.13	0.63	18.76	50	10.45	28	8.31	22	37.52	17.32	47	16.08	44	3.33	9	36.73	0.92	0.8	0.93	0.19	0.702	18.76	1.000	ABnc
605	16.74	0.45	17.19	38	15.45	34	13.08	28	45.72	23.72	52	18.21	40	4.03	8	45.96	1.38	0.85	0.77	0.17	0.676	28.53	1.660	ABnc
606	20.35	0.41	20.76	41	14.8	30	14.47	29	50.03	25.01	50	20.04	40	5.1	10	50.15	1.20	0.98	0.8	0.20	0.704	29.27	1.410	ABnc
960	1.04	0.13	1.17	11	5.5	53	3.78	36	10.45	0.94	9	1.05	10	8.39	81	10.38	0.80	0.69	1.12	8.93	0.599	9.28	7.931	Cc
1067	1.8	0.19	1.99	13	7.62	52	5.10	35	14.71	1.85	13	4.66	33	7.72	54	14.23	0.93	0.67	2.52	4.17	0.662	12.72	6.392	CBc
1070	3.91	0.21	4.12	25	7.25	43	5.35	32	16.72	3.74	23	3.34	21	8.93	56	16.01	0.91	0.74	0.89	2.39	0.611	12.60	3.058	Cc
1246	34.17	0.97	35.14	58	13.82	23	11.76	19	60.72	32.79	55	22.48	38	4.46	7	59.73	0.93	0.85	0.69	0.14	0.683	25.58	0.728	ABnc
1247	41.7	1.21	42.91	57	17.0	22	15.63	21	75.54	42.23	55	29.5	39	4.85	6	76.58	0.98	0.92	0.70	0.11	0.711	32.63	0.760	ABnc
1248	27.0	0.77	27.77	38	28.93	39	16.69	23	73.39	28.52	39	41.9	57	2.71	4	73.13	1.03	0.56	1.47	0.10	0.791	45.62	1.643	BAc
1249	29.57	0.77	30.34	56	12.98	24	10.58	20	53.87	29.03	54	20.67	38	4.06	8	53.79	0.96	0.82	0.71	0.14	0.687	23.56	0.777	ABnc
1251	7.52	0.44	7.96	41	6.77	34	4.98	25	19.71	6.65	34	6.82	35	5.97	31	19.44	0.84	0.74	1.03	0.90	0.685	11.75	1.476	BAnc
1252	44.91	1.26	46.16	56	18.65	22	17.97	22	82.79	42.65	52	33.17	41	5.36	7	81.18	0.92	0.96	0.78	0.13	0.724	36.62	0.793	ABnc
2158	11.61	0.35	11.96	57	4.62	22	4.43	21	21.01	8.7	41	7.00	33	5.33	26	21.03	0.73	0.96	0.80	0.61	0.633	9.05	0.757	ABnc
2409	3.9	0.21	4.11	42	2.81	28	2.94	30	9.86	3.92	40	1.66	17	4.25	43	9.83	0.95	1.05	0.42	1.08	0.571	5.75	1.399	CAnm
2410	4.12	0.24	4.36	26	6.45	39	5.69	35	16.5	3.69	23	2.48	15	10.21	62	16.38	0.85	0.88	0.65	2.77	0.617	11.14	2.555	Cc
2411	4.27	0.25	4.52	28	6.45	40	5.15	32	16.12	4.08	25	3.1	19	9.26	56	16.44	0.90	0.80	0.80	2.27	0.646	11.60	2.566	Cc
2413	38.26	1.15	39.41	59	14.15	21	13.77	20	67.33	37.24	56	24.54	37	4.82	7	66.6	0.94	0.97	0.66	0.13	0.683	27.92	0.708	ABnc
2746	1.52	0.16	1.68	30	1.84	33	2.12	37	5.64	1.09	19	0.25	5	4.39	76	5.76	0.65	1.15	0.26	4.03	0.580	3.96	2.357	Cmc
2751	33.04	0.97	34.01	56	14.3	24	12.34	20	60.65	32.9	53	23.35	38	5.46	9	61.71	0.97	0.86	0.71	0.17	0.612	26.64	0.783	ABnc
2752	7.74	0.33	8.07	35	8.05	35	6.74	30	22.86	7.61	33	6.44	28	8.9	39	22.95	0.94	0.84	0.85	1.17	0.667	14.79	1.833	CAc
RANKEN 1:250,000 SHEET AREA																								
83	4.91	0.16	5.07	41	4.02	32	3.4	27	12.49	5.35	43	3.29	27	3.64	30	12.28	1.06	0.85	0.61	0.68	0.585	7.42	1.464	ACnc
84	1.87	0.16	2.03	24	3.49	41	2.93	35	8.45	2.32	28	2.65	31	3.43	41	8.40	1.14	0.84	1.14	1.48	0.596	6.42	3.163	CBc
96	2.7	0.18	2.88	25	4.65	39	4.23	36	11.76	3.83	33	3.92	34	3.91	33	11.66	1.33	0.91	1.02	1.02	0.549	8.88	3.083	BCc
392	5.39	0.17	5.56	35	5.93	37	4.4	28	15.89	6.21	40	5.57	35	3.96	25	15.74	1.12	0.74	0.90	0.64	0.622	10.33	1.858	ABcn
495	16.74	0.62	17.36	53	7.5	23	7.77	24	32.63	16.34	50	12.33	37	4.26	13	32.93	0.94	1.04	0.75	0.26	0.635	15.27	0.880	ABnm
533	1.03	0.13	1.16	16	3.40	47	2.67	37	7.23	0.84	12	0.88	12	5.32	76	7.04	0.72	0.79	1.05	6.33	0.583	6.07	5.233	Cc
534	1.7	0.17	1.87	23	3.14	39	3.08	38	8.09	1.80	23	1.54	20	4.54	57	7.88	0.96	0.98	0.86	2.52	. .	6.22	3.326	Ccm
536	3.48	0.44	3.92	32	4.60	37	3.87	31	12.39	4.79	40	3.56	30	3.62	30	11.97	1.22	0.84	0.74	0.76	0.568	8.47	2.161	ACc
537	10.13	0.2	10.33	45	6.6	29	6.09	26	23.02	13.76	61	4.47	20	4.41	19	22.64	1.33	0.92	0.32	0.32	0.556	12.69	1.228	Anc
542	8.65	0.39	9.04	39	7.22	31	6.83	30	23.09	12.08	53	4.52	20	6.25	27	22.85	1.34	0.95	0.37	0.52	0.559	14.05	1.554	Anc
545	8.26	0.17	8.43	39	6.95	32	6.09	29	21.47	10.9	52	6.44	30	3.85	18	21.19	1.29	0.88	0.59	0.35	0.584	13.04	1.547	Anc

(*a*) obtained by balancing.   *includes 0.75 epm (10%) NO_3

APPENDIX 3—BOREWATER ANALYSES—*continued*

Reg. No.	Na (epm)	K (epm)	Na+K (epm)	(%)	Ca (epm)	(%)	Mg (epm)	(%)	Total Cations (epm)	Cl (epm)	(%)	SO_4 (epm)	(%)	HCO_3 (epm)	(%)	Total Anions (epm)	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	TDS / S.C.	Ca+Mg (epm)	Ca+Mg / Na+K	Type
735	1.3	0.02	1.32	19	3.0	43	2.63	38	6.95	0.99	14	1.37	20	4.59	66	6.95	0.75	0.88	1.38	4.64	0.575	5.63	4.265	Cc
737	4.11	0.13	4.24	37	3.97	34	3.41	29	11.62	3.49	31	2.78	25	4.98	44	11.25	0.82	0.86	0.80	1.43	0.578	7.38	1.741	CAnc
738	2.05	0.08	2.13	20	5.15	47	3.66	33	10.93	2.9	33	0.78	7	6.97	60	10.65	1.36	0.71	0.27	2.40	0.515	8.81	4.136	Cc
744	10.65	0.38	11.03	56	4.5	23	4.11	21	19.64	8.45	44	7.08	36	3.93	20	19.46	0.77	0.91	0.84	0.47	0.699	8.61	0.781	ABnc
747	1.39	0.03	1.42	18	3.6	46	2.8	36	7.82	1.41	18	0.94	12	5.41	70	7.76	1.00	0.78	0.67	3.84	0.622	6.4	4.254	Cc
751	0.88	0.1	0.98	15	2.66	42	2.77	43	6.41	0.53	8	0.62	10	5.23	82	6.38	0.54	1.04	1.17	9.87	0.562	5.43	5.541	Cm
752	26.09	0.92	27.01	65	8.6	21	5.67	14	41.28	23.1	56	13.54	33	4.59	11	41.23	0.86	0.66	0.59	0.20	0.706	14.27	0.528	Anc
756	3.75	0.16	3.91	24	6.45	40	5.9	36	16.26	6.11	37	3.4	21	6.92	42	16.43	1.56	0.91	0.56	1.13	0.630	12.35	7.841	CAc
758	1.57	0.02	1.59	21	3.0	40	2.88	39	7.47	1.13	15	2.71	37	3.61	48	7.45	0.71	0.96	2.40	3.19	0.767	5.88	3.159	CBc
932	19.39	0.54	19.93	59	7.63	22	6.39	19	33.95	16.48	48	13.10	38	4.57	14	34.15	0.83	0.84	0.79	0.28	0.642	14.02	0.703	ABnc
941	2.14	0.13	2.27	23	3.98	41	3.5	36	9.75	3.72	38	1.96	20	4.18	42	9.86	1.64	0.88	0.53	1.12	0.571	7.48	3.295	CAc
944	3.54	0.12	3.66	34	3.64	34	3.33	32	10.63	4.51	44	1.98	19	3.84	37	10.33	1.23	0.91	0.44	0.85	0.535	6.97	1.904	ACc
949	2.68	0.12	2.80	28	3.66	38	3.3	34	9.76	3.46	36	2.56	26	3.74	38	9.76	1.24	0.90	0.74	1.08	0.587	6.96	2.486	CAc
951	3.2	0.16	3.36	32	3.75	35	3.46	33	10.57	4.08	40	2.39	23	3.81	37	10.28	1.21	0.92	0.59	0.93	0.578	7.21	2.146	ACc
1148	7.91	0.56	8.47	39	6.45	30	6.59	31	21.51	10.04	47	4.23	20	7.07	33	21.34	1.19	1.02	0.42	0.70	0.594	13.04	1.540	ACnc
1150	2.04	0.04	2.08	24	3.5	40	3.21	36	8.79	1.97	22	2.79	32	4.1	46	8.86	0.95	0.92	1.42	2.08	0.482	6.71	3.226	CBc
1151	1.24	0.16	1.40	20	3.18	44	2.56	36	7.14	1.27	18	1.42	21	4.26	61	6.95	0.91	0.81	1.12	3.35	0.597	5.74	4.100	Cc
1152	1.28	0.14	1.42	18	3.39	44	2.94	38	7.75	1.19	16	1.8	23	4.64	61	7.63	0.84	0.87	1.51	3.90	0.637	6.33	4.458	Cc
1153	1.91	0.12	2.03	19	4.25	40	4.33	41	10.61	2.42	24	1.59	15	6.22	61	10.23	1.19	1.02	0.66	2.57	0.542	8.58	4.227	Cm
1154	1.38	0.09	1.47	19	3.23	42	3.01	39	7.71	1.30	18	0.92	12	5.27	70	7.49	0.88	0.93	0.71	4.05	0.516	6.24	4.245	Cc
1155	2.61	0.10	2.71	23	4.12	35	4.82	42	11.65	4.21	37	1.08	10	6.07	53	11.36	1.55	1.17	0.26	1.44	0.523	8.94	3.299	CAmc
1156	1.01	0.15	1.16	15	3.59	44	3.32	41	8.07	0.72	9	0.84	11	6.41	80	7.97	0.62	0.92	1.17	8.90	0.653	6.91	5.957	Cc
2486	3.48	0.16	3.64	21	6.2	35	7.73	44	17.57	3.58	20	8.29	47	5.67	33	17.54	0.98	1.25	2.32	1.58	..	13.93	3.827	BCm
2769	16.3	0.38	16.68	47	9.0	25	9.79	28	35.52	22.54	64	8.54	24	4.1	12	35.18	1.35	1.09	0.38	0.18	0.731	18.79	1.126	Anm
3125	2.78	0.02	2.80	24	3.6	31	5.1	45	11.5	2.68	23	2.92	25	5.9	52	11.5	0.96	1.42	1.09	2.20	0.639	8.7	3.107	Cm
3126	1.09	0.04	1.13	14	3.6	43	3.62	43	8.35	1.69	20	2.92	35	3.77	45	8.38	1.50	1.01	1.73	2.23	0.758	7.22	6.389	CBc
3133	1.23	0.13	1.36	16	3.99	48	3.04	36	8.39	1.36	17	1.78	22	4.97	61	8.11	1.00	0.76	1.31	3.65	0.526	7.03	5.169	Cc
3135	1.74	0.04	1.78	22	3.5	42	2.96	36	8.24	1.97	24	2.71	33	3.61	43	8.29	1.11	0.85	1.38	1.83	0.665	6.46	3.629	CBc
3136	0.27	0.04	0.31	48	0.14	22	0.19	30	0.64	0.20	35	0.03	5	0.35	60	0.58	0.67	1.36	0.15	1.75	0.417	0.33	1.065	Cnm
3137	1.00	0.12	1.12	16	3.25	46	2.72	38	7.09	0.68	10	0.80	12	5.42	78	6.90	0.61	0.84	1.18	7.97	0.529	5.97	5.330	Cc
3156	2.93	0.14	3.07	30	3.84	37	3.33	33	10.24	4.56	44	2.00	20	3.69	36	10.25	1.49	0.87	0.44	0.81	0.552	7.17	2.336	ACc
3157	1.65	0.12	1.77	23	3.1	39	3.05	38	7.92	2.77	36	1.66	21	3.38	43	7.81	1.56	0.98	0.60	1.22	0.524	6.15	3.475	CAc
3159	2.38	0.16	2.54	27	3.81	40	3.17	33	9.52	2.98	32	2.56	27	3.86	41	9.40	1.17	0.83	0.86	1.30	0.587	6.98	2.748	CAc
3162	7.41	0.38	7.79	39	6.27	32	5.85	29	19.91	9.14	46	4.48	22	6.32	32	19.94	1.17	0.93	0.49	0.69	0.599	12.12	1.556	ACnc
3163	13.83	0.47	14.30	61	4.6	20	4.56	19	23.45	12.06	52	7.25	32	3.66	16	22.97	0.84	0.99	0.60	0.30	0.602	9.16	0.641	Anc
										MT DRUMMOND 1:250,000 SHEET AREA														
531	0.69	0.09	0.78	11	3.44	49	2.85	40	7.07	0.54	8	0.69	10	5.62	82	6.85	0.69	0.83	1.28	10.41	0.550	6.29	8.064	Cc
748	1.49	0.16	1.65	18	4.30	46	3.37	36	9.32	1.03	12	0.76	8	7.20	80	8.99	0.62	0.78	0.74	6.99	0.549	7.67	4.648	Cc
749	0.85	0.17	1.02	12	4.12	47	3.66	41	8.80	0.54	6	0.43	5	7.61	89	8.58	0.53	0.89	0.80	14.09	0.569	7.78	7.627	Cc
3128	0.7	0.08	0.78	8	4.78	47	4.53	45	10.09	0.54	6	0.43	4	8.88	90	9.85	0.69	0.95	0.80	16.44	0.509	9.31	11.935	Cc
3129	0.52	0.14	0.66	8	3.99	50	3.32	42	7.97	0.38	5	0.55	7	6.92	88	7.85	0.56	0.83	1.45	18.21	0.658	7.31	11.076	Cc
										AVON DOWNS 1:250,000 SHEET AREA														
92	15.13	..	..	..	4.25	..	..	..	19.38	14.0	72	3.46	18	1.90	10	19.36	..	..	0.25	0.14	..	..	..	An
98	10.39	..	..	..	3.25	..	1.79	..	..	9.0	..	2.96	..	3.47	..	15.43	..	..	0.33	0.39	..	..	..	Anc
331	18.7	..	..	..	5.5	..	..	..	..	26.99	..	2.69	..	1.61	..	31.29	..	..	0.10	0.06	..	..	..	An

Reg. No.	Na (epm)	K (epm)	Na+K (epm)	(%)	Ca (epm)	(%)	Mg (epm)	(%)	Total Cations (epm)	Cl (epm)	(%)	SO_4 (epm)	(%)	HCO_3 (epm)	(%)	Total Anions (epm)	Cl / Na+K	Mg / Ca	SO_4 / Cl	HCO_3 / Cl	TDS / S.C.	Ca+Mg (epm)	Ca+Mg / Na+K	Type
340	16.04	..	..	..	8.05	..	..	..	24.07	18.99	79	2.67	11	2.39	10	24.05	..	..	0.14	0.13	..	..	..	An
366	4.4	0.21	4.61	36	4.25	33	3.87	31	12.73	5.7	46	2.89	23	3.76	31	12.35	1.24	0.91	0.51	0.66	0.574	8.12	1.761	ACnc
384	3.13	0.19	3.32	30	4.06	37	3.63	33	11.01	1.57	15	1.05	10	8.07	75	10.69	0.68	0.89	0.67	5.14	0.611	7.69	2.316	Cc
994	12.43	..	..	..	5.15	..	..	..	..	15.49	67	4.23	18	3.49	15	23.21	..	..	0.27	0.23	..	..	..	An
1871	6.00	0.44	6.44	37	5.7	32	5.51	31	17.65	7.89	46	2.69	16	6.56	38	17.14	1.23	0.97	0.34	0.83	..	11.21	1.741	ACnm
1906	5.96	0.33	6.29	34	5.40	29	6.91	37	18.60	6.62	37	4.08	22	7.43	41	18.13	1.05	1.28	0.62	1.12	..	12.31	1.957	CAmn
										DUPLICATE ANALYSES														
41	4.43	1.03	5.46	47	3.0	26	3.21	27	11.67	0.93	8	0.5	4	10.0	88	11.43	0.17	1.07	0.54	10.76	..	6.21	1.137	Cnm
733	26.3	1.05	27.35	55	9.9	20	12.9	25	50.15	31.5	65	10.0	21	6.75	14	48.25	1.15	1.30	0.32	2.14	..	22.8	0.834	Anm
2190	48.26	3.18	51.44	65	11.1	14	16.78	21	79.32	55.44	69	17.08	21	7.84	10	80.36	1.08	1.51	0.31	0.14	..	27.88	0.542	Anm
2194	12.6	1.0	13.6	51	6.2	23	6.83	26	26.63	13.1	50	4.85	19	8.08	31	25.83	0.96	1.10	0.37	0.62	..	13.03	0.958	ACnm
2195	19.43	1.56	20.99	58	5.8	16	9.70	26	36.49	18.87	52	9.21	26	7.84	22	35.92	0.90	1.67	0.49	0.42	..	15.5	0.738	Anm
1778	8.74	1.67	10.41	66	2.5	16	2.87*	18	15.78*	10.65	67	1.85	12	3.28	21	15.78	1.02	1.15	0.17	0.31	..	5.37	0.516	Anm

*obtained by balancing.

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