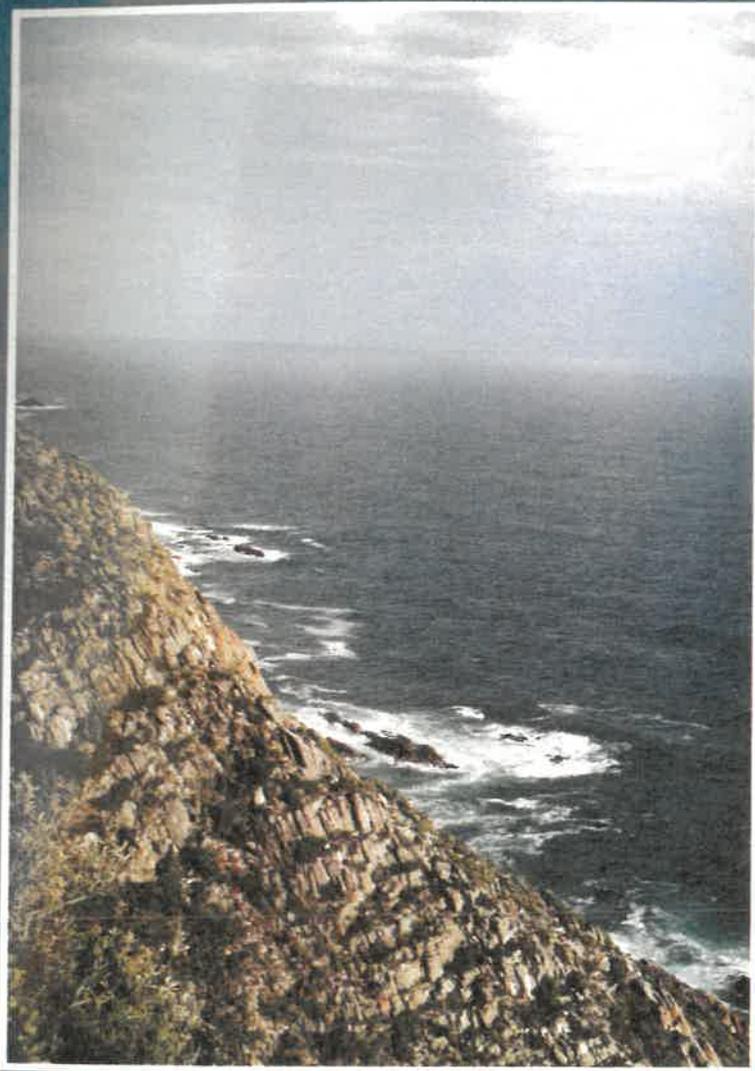


**An Explanation  
of the 1:500 000 General  
Hydrogeological Map  
Port Elizabeth 3324**



**By: P.S. MEYER  
October 1998**

# **An Explanation of the 1:500 000 General Hydrogeological Map Port Elizabeth 3324**

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October 1998**

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# FOREWORD

.....

**G**roundwater in South Africa as a whole is under-utilised, although some local over-exploitation does occur. Groundwater schemes can be implemented quickly and cheaply, and are particularly effective in conjunctive use and dispersed scenarios. With increasing pressure on scarce surface water resources, and with the priority of supplying potable water to disadvantaged rural and urban communities, it is clear that groundwater will play an increasingly important role in South Africa's economic and social prosperity.

A major obstacle to the realisation of this prosperity is that insufficient information about groundwater is reaching the planners, decision makers, users and other affected parties. In an attempt to rectify this situation groundwater information locked away in experts' minds and computer data bases is being made available on maps. The first step in this programme at the regional level is the preparation of "General Hydrogeological Maps" at the scale of 1:500 000.

The main purpose of General Hydrogeological Maps, of which the accompanying sheet is an example, is to display in an easily understood format what is known about basic geohydrological properties. These General Maps represent a synthesis of the most up-to-date data and geohydrologists' knowledge. These maps are also very useful in identifying areas where additional data need to be collected and further investigations need to be conducted.

Groundwater maps - the best available information for the best possible planning, development and management of a strategic resource - will ultimately benefit all South Africans.

**EBERHARD BRAUNE**  
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# PREFACE

.....

**W**ith the exception of air, water can, with little doubt, be defined as Man's most precious resource. It is said that to deny Man food, his body can sustain life for days, but refuse him water, and death is likely to come within hours. The availability of water to even the remotest area is thus vital to maintain this indispensable force for human existence. An estimated 3% of fluid fresh water available on Earth occurs on the surface and 97% occurs underground (Johnson Division, 1975). To tap and develop this vast amount of stored underground water, a keen knowledge of a region's environment, and above all its diversified geology, is of the utmost importance in order to comprehend how and where groundwater occurs.

The Port Elizabeth Hydrogeological Map and the accompanying explanatory brochure introduces the current state of groundwater knowledge and the basic geohydrological characteristics of the map area. It needs to be explained that within the map's confines, dissimilar and divergent conditions occur which, to various degrees may impact on groundwater. Rough mountainous terrain and undulating plains, wet rainforest vegetation to dry semi-desert shrubland, old metamorphosed rocks to recently deposited unconsolidated sands and alluvium, highly competent quartzitic sandstones containing numerous fractures in contrast to dense, incompetent, fracture-free shales and mudstones, are but a few of the diversities. Under these circumstances various groundwater distinctives and characteristics can be expected, all of which have been referred to in this brochure.

Although the primary aim of a General Hydrogeological Map is to produce a synoptic overview of the geohydrological character of an area, it is hoped that the map in question will be found useful not only by groundwater scientists for planning groundwater investigations, but also for the interested layman. The main map features borehole yields, aquifer types, groundwater quality and groundwater use. The brochure discusses these topics in more detail, as well as issues such as geological controls on borehole yields and groundwater quality, borehole siting, groundwater management, future research, etc. It is hoped, therefore, that the map together with the brochure, will be found informative by groundwater users for general planning, especially in the light of the Reconstruction and Development Programme, and can also play a role in general education and awareness-building regarding groundwater matters.

Groundwater has always been an important source of water supply to many people and localities in the map area, especially in the rural environments. Water consumers in many areas rely totally on groundwater for domestic and stock watering purposes and also for urban and irrigation purposes at a number of locations. It is hoped that this map and brochure will, among others, serve as a base for future specialised and more detailed groundwater maps and groundwater studies as suggested in this brochure.

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# ABBREVIATIONS AND UNITS

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## Abbreviations

CFB	Cape Fold Belt
DWAF	Department of Water Affairs and Forestry
CSIR	Council for Scientific and Industrial Research
EC	Electrical Conductivity
GIS	Geographic Information System
IWQS	Institute for Water Quality Studies
NGDB	National Groundwater Data Base
NWQDB	National Water Quality Data Base
SABS	South African Bureau of Standards
TAL	Total Alkalinity
TDS	Total Dissolved Solids
TMG	Table Mountain Group
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USGWCA	Uitenhage Subterranean Government Water Control Area

## Units

a	annum
km	kilometre
l	litre
l/s	litre per second
m	metre
m <sup>2</sup>	square metre
m <sup>2</sup> /day	square metre per day
m <sup>3</sup>	cubic metre
m <sup>3</sup> /a	cubic metre per annum
mg	milligram
mg/l	milligram per litre
mm	millimetre
mS/m	milliSiemens per metre
s	second

2000

1000

# 1 INTRODUCTION

## 1.1 Map Compilation

---

**E**xtensive use was made of Arc/Info for cartographic compilation, data display and manipulation. Available borehole data from the National Groundwater Data Base (NGDB) were used and supplemented by field visits to areas of sparse data coverage. The delineation of groundwater occurrence was outlined on a scale of 1:50 000, with extrapolation from hydrogeologically well defined areas into areas of data scarcity. The groundwater occurrence boundaries were then drawn by hand to final scale. Additional changes and minor boundary alterations were done within the GIS. The same methodology was used in the compilation of the 1:1 500 000 scale groundwater quality map, using data from the National Water Quality Data Base (NWQDB). The quality parameter that is expressed is the electrical conductivity (EC) of the groundwater. The EC intervals shown are taken from the Department of Water Affairs and Forestry (DWA) guidelines for human and stock water consumption.

The lithostratigraphy of the region, taken from published Geological Survey maps, was regrouped and, where necessary, simplified to lithological types. These types are displayed as greyish ornaments on the map. The geological units are provided with black codes, which, for reasons of country-wide uniformity, do not always coincide with the codes on the published geological maps, but are internal Departmental adaptations. The geological units and codes are explained on a chronostratigraphical column.

A conceptual profile has been drawn to illustrate the regional hydrogeology in terms of the geology and to evince target areas for groundwater development.

The 1:2 000 000 scale inset maps, illustrating distribution of borehole data, elevation above sea level and mean annual precipitation, are entirely computer generated.

## 1.2 Legend Explanation

The hydrogeological map utilises an adapted international hydrogeological legend (Anon/UNESCO, 1983). The main alterations to the UNESCO legend were:

- the removal of the division of aquifers between local/discontinuous or extensive, and using only local, and
- the inclusion of 'fractured and intergranular' as an additional mode of groundwater occurrence since this was considered to be appropriate for South African conditions.

The definition of the borehole productivity ranges has been left by the UNESCO authors for the local mappers to define. Consideration of local conditions resulted in the productivity ranges shown in Table 1.

The terminology adopted by the European hydrogeological map makers was used. This refers to the **occurrence of groundwater** and further subdivides according to the mode of occurrence. For this map region 'intergranular' was used for the porous mode of occurrence, 'fractured rock' for the faulted and jointed, and 'fractured and intergranular' for the intergranular and fractured mode of occurrence. These divisions are then depicted using the colour scheme in Table 1.

**TABLE 1: HYDROGEOLOGICAL CLASSIFICATION OF GROUNDWATER**

	Intergranular	Fractured	Fractured & intergranular
Description	Generally unconsolidated but occasionally semi-consolidated. Groundwater within intergranular interstices in porous medium. Moderate areal extent.	Fissured and fractured bedrock resulting from decompression and / or tectonic action. Groundwater occurs predominantly within fissures and fractures. Extensive in area.	Sandstone and shale, intruded by mainly dolerite sills of varying thicknesses. Groundwater is contained in intergranular interstices and in fissures and fractures. Very limited in areal extent.
Example	Tertiary-Quaternary coastal deposits. Alluvial deposits, along river terraces.	Sedimentary and metamorphic rocks with very limited overlying unsaturated residual weathered products.	Sedimentary and igneous rocks with significant thicknesses of overlying saturated residual products of weathering.
<b>Type Colour and Colour Shades</b>			
Yield (l/s)	<b>Blue</b>	<b>Green</b>	<b>Yellow-Brown</b>
>5,0	Dark blue	Dark green	Brown
2,0 - 5,0	Blue	Green	Light brown
0,5 - 2,0	Light blue	Light green	Pale brown
0,1 - 0,5	Pale blue	Pale green	Yellow
0,0 - 0,1	Blue tinge	Green tinge	Yellow tinge

### **1.3 Borehole Yield Distribution and Lithological Boundaries**

---

From the 1:500 000 map it would appear that yield and lithology boundaries do not always coincide. The yield boundaries were determined from the best match to the available data, which may not always be conclusive. It may be speculated that rock competency for consolidated rock units and local recharge conditions could be major factors in the overall pattern of borehole yield distributions.

## **2 PHYSICAL ENVIRONMENT**

### **2.1 Climate**

---

Divergent climatic types occur in the map area. The narrow Tsitsikamma Coastal Strip has a mild climate with average maximum winter and summer temperatures ranging between 19° and 23°C. This is the only area, apart from a few mountain terrains, where average annual precipitation exceeds 1 000 mm.

The Steytleville - Kirkwood region and the area north of the Klein Winterhoek Mountains has a semi-desert climate of hot summers and cold winters and an average annual precipitation of less than 300 mm.

The rest of the map area has a largely temperate coastal to peri-coastal climate. The average annual precipitation range between 383 mm at Patensie, 692 mm at Grahamstown and 881 mm at East London.

Precipitation is orographically influenced and rainfall occurs year-round with peaks in spring and autumn.

### **2.2 Physiography**

---

The topography of the map area is, to a large extent, characterised by a number of northwest-southeast striking mountain ranges and ridges such as the Tsitsikamma-Kareedouw, Kouga, Elands, Groot and Klein Winterhoek and the Kap River. These mountain ranges are often separated by valleys and plains such as Lang Kloof, Baviaanskloof and Steytleville-Kirkwood.

## **2.3 Surface Hydrology**

---

The map area is drained by a number of large, mainly southeast to south flowing river systems such as (drainage numbers in brackets) Krom (K1090), Baviaanskloof (L1181), Groot (L1160, L1170), Gamtoos (I190), Sundays (N1340), Bushmans (P1410), Great Fish (Q1591, Q1593) and Keiskamma (R1610).

# **3 GEOLOGY**

## **3.1 Brief Description of the Geological Units**

---

The map area is mainly underlain by sedimentary rocks of the Cape Supergroup and towards the north and northeast the Karoo Supergroup. Pre-Cape and post-Karoo rocks cover smaller areas (Fig. 1).

The pre-Cape Gamtoos Group (Ng) is confined to a few erosional windows northeast of the Gamtoos River Valley and in the Baviaanskloof. It consists of phyllites, quartzites, limestones and conglomerates.

The entire Cape Supergroup, comprising the lowermost Table Mountain, the Bokkeveld and the uppermost Witteberg Groups, is present and occupies about 50% of the map area. The predominantly arenaceous Table Mountain Group (TMG)(O-St) unconformably overlies the pre-Cape Gamtoos Group, and is followed conformably by the largely argillaceous beds of the Bokkeveld Group (Db) and the alternating shales and sandstones of the Witteberg Group (Dw).

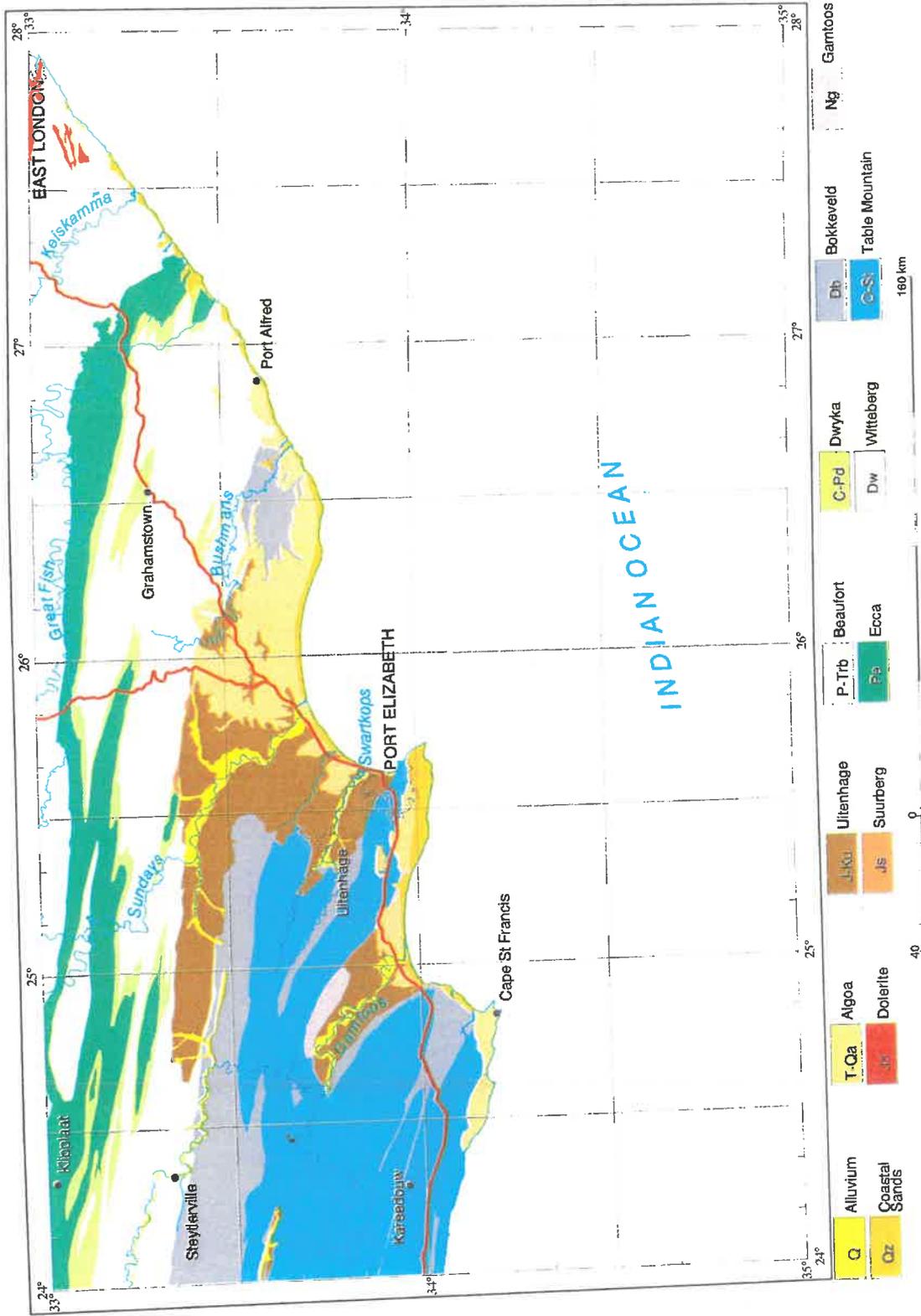
The Karoo Supergroup, which occurs in the northern and northeastern surrounds of the map, is represented by the basal glacial diamictite of the Dwyka Group (C-Pd), followed by the predominantly argillaceous Ecca Group (Pe) and shales and interbedded sandstones of the Beaufort Group (P-Trb).

Tuff, breccia and basalt of the Suurberg Group (Js), occurring as a thin east-west striking band south of the Kirkwood Panhandle and south of the Suurberg range between Enon and Paterson, is too limited in extent to feature on the map.

Conglomerate, mudstone and sandstone of the Uitenhage Group (J-Ku) covers a relatively large area north of Port Elizabeth and south of the Suurberg and Klein Winterhoek Mountains.

The Uitenhage Group and other older rocks are overlain by semi-consolidated calcareous sands and conglomerates of the Algoa Group (T-Qa) from Cannonvale towards Alexandria.

FIG 1: PRINCIPAL GEOLOGICAL UNITS



Limited occurrences of Coastal Sands (Qz) were deposited mainly along the coast between Cape St. Francis and Port Alfred.

Alluvial Deposits (Q) occur along the valleys of the Gamtoos River, Swartkops River and Sunday's River.

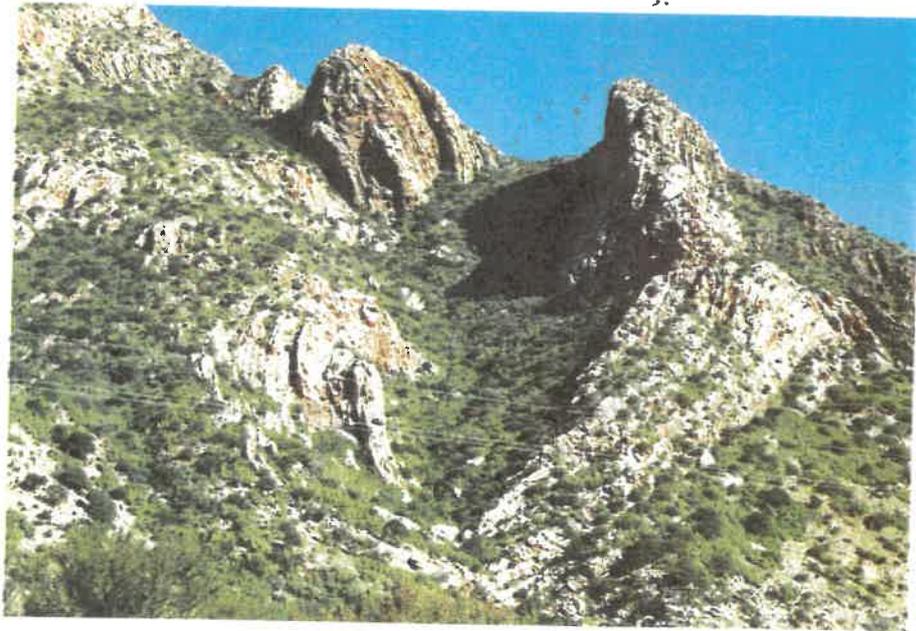
### 3.2 Structural Geology

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The Cape Fold Belt (CFB) is roughly located south of latitude 33°. It consists predominantly of sedimentary rocks which were subjected to great pressure from the south, resulting in a variety of structural features.

**The main structural characteristics of the CFB in the map area can be summarized as follows:**

- The pre-Cape rocks have been deformed into a series of recumbent isoclinal folds sliced by a number of southward dipping imbricate thrusts. Subsequent Cape folding has further affected the pre-Cape rocks, but the pre-Cape and Cape folds are different in style and orientation (Shone *et al*, 1990).
- The outcrop pattern (of the CFB rocks) and corresponding topography disclose a dominant regional structure of east-southeast trending folds and mountain chains (Toerien and Hill, 1989). The more competent quartzitic sandstones of the TMG and Witteberg Group (Plate 1) constitute the core of major anticlines, forming mountain chains due to resistance to weathering (Toerien and Hill, 1989).



**Plate 1:** *Intricate fold structures in the Witpoort sandstone Formation (Witteberg Group northeast of Willowmore). Such competent quartzitic sandstones were responsible for the formation of mountain chains due to their resistance to weathering. Owing to their competent nature some fracture structures were able to develop following the various deformation episodes. (Photo: P.S. Meyer)*

- The Cape Supergroup strata, as well as the Dwyka and Eccca strata south of Peddie, have been strongly folded into a series of parallel anticlines and synclines along east-southeast-trending fold axes. Over-folding to the north is common (Johnson and Le Roux, 1994). The upper Eccca and Beaufort strata display much gentler folding (Johnson and Le Roux, 1994).
- Over-folding and ultimately recumbent isoclinal folds, sometimes accompanied by thrusts on the northern limbs of anticlines (Toerien and Hill, 1989), are distinct characteristics of the structural geology of many areas of the CFB. Thrust faulting in the Kareedouw region is considerably more common than previously thought, and may constitute one of the most important structural features of the CFB in that area (Sephton, 1997).
- Most of the larger faults trend roughly east-west.
- Brittle failure is often evident in the competent, arenaceous units of the TMG, but to a lesser degree in the arenaceous units of the Bokkeveld and Witteberg Groups. The relatively thin interbedded sandstones of the Eccca and Beaufort Groups show the least amount of brittle failure. Minor fold structures abound in the incompetent strata of the Bokkeveld, Witteberg, Eccca and Beaufort Groups (Plate 2).



**Plate 2:** *Fold structures in shale of the Weltevrede Formation (Witteberg Group) northeast of Willowmore. Due to their incompetent, flexible nature, few fracture structures could develop following the various deformation episodes. (Photo: P.S. Meyer)*

### 3.3 Intrusives

Several large dolerite bodies (Jd) intrude the Beaufort strata between Kaysers Beach and East London, and a west-northwest striking dolerite dyke outcrops in the vicinity of Breakfast Vlei.

Two small outcrops of fine-grained granite, presumably pre-Cape in age and associated with the Gamtoos Group, occur in the Baviaanskloof (Toerien and Hill, 1989).

Five linear intrusions of diabase, between 4 and 10 m thick are known to cut into rocks of the Gamtoos Group east-northeast of Patensie, near Van Stadens River Mouth and north-northeast of the Maitland River Mouth (Toerien and Hill, 1989).

## 4 HYDROGEOLOGY OF THE DIFFERENT GEOLOGICAL UNITS

### 4.1 Fractured Aquifers

Consolidated hard rocks cover approximately 90% of the map area. This rock mass was formed over a period of about 800 million years, experiencing intrusion episodes in an early stage and subsequently endured several deformation phases. The deformation processes and succeeding orogenesis, continental uplift, weathering and erosion, all aided in the development of the present groundwater environment. Competent rocks underwent brittle failure, resulting in numerous fracture structures in formations containing significant arenaceous material, thus furthering the formation of fracture porosity. In contrast the incompetent rocks were more flexible and less inclined to break, thereby inhibiting fracture porosity formation (Table 2).

**TABLE 2: DETAILS OF CONSOLIDATED ROCKS WITHIN THE CAPE FOLD BELT**

Geological Unit	1	2	3	4
Gamtoos (Ng)	0,9	800 - 700	Meta-Sedimentary	30:70
Table Mountain (O-St)	18,7	495 - 417	Sedimentary	85:15
Bokkeveld (Db)	9,5	417 - 365	Sedimentary	20:80
Witteberg (Dw)	22,1	365 - 345	Sedimentary	45:55
Dwyka (C-Pd)	4,5	320-285	Sedimentary (glacial)	20:80
Ecca (Pe)	11,8	285 - 240	Sedimentary	20:80
Beaufort (P-Trb)	14,0	240 - 230	Sedimentary	30:70
Suurberg (Js)	0,3	190 - 170	Extrusive	*
Uitenhage (J-Ku)	7,9	150 - 100	Sedimentary	20:80

\* = Not applicable

1 = Percentage of map area covered by individual geological unit.

2 = Approximate age in million years.

3 = Geological origin.

4 = Approximate ratio of arenaceous: argillaceous material.

The existence or absence of fracture structures and prevailing groundwater recharge conditions thus play a decisive role in the occurrence and characteristics of groundwater in the consolidated rocks of the CFB.

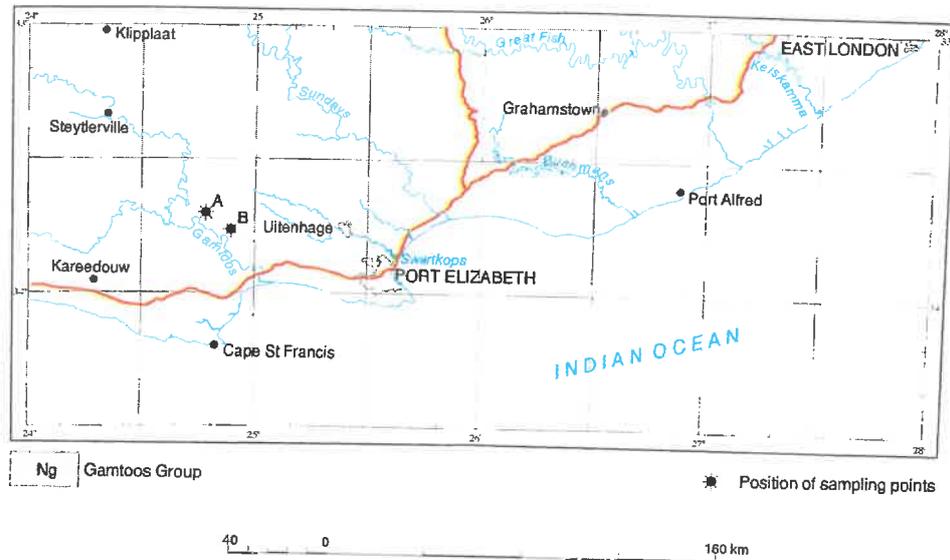
#### 4.1.1 Gamtoos Group

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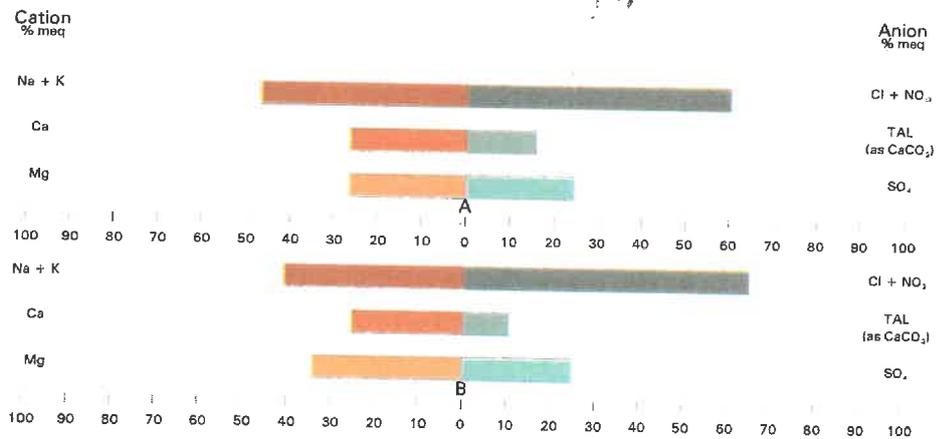
The more important geological and groundwater characteristics are as follows:

- ❑ The area underlain by the Gamtoos rocks (Fig. 2) is topographically so dissected, rugged, mountainous and generally inaccessible that it is often difficult to develop groundwater sources in localities where it can be utilized beneficially.
- ❑ The meta-sedimentary rocks of the Gamtoos Group can be divided into three units, separated by at least two major thrust zones (Shone *et al.*, 1990). The basal Kaan unit consists of limestones and phyllites with minor schist, grit and conglomerate beds. The Kleinrivier unit and the uppermost Van Stadens unit consist of conglomerate, greywacke, subarkose, quartzite and phyllite.
- ❑ Despite the evidence that the rocks have undergone several deformational episodes, the Gamtoos Group shows relatively little fracturing, and the Group is generally not known for its advantageous groundwater potential. Due to scanty borehole information, a borehole yield analysis was not justified.
- ❑ Although no significant karst development has to date been reported, it is assumed that groundwater prospects might be better in the limestones of the Kaan unit than in the other units.
- ❑ Groundwater quality seems to vary from less than 100 mS/m to more than 300 mS/m (Table 3), which may be related to divergent lithologies. Sodium, magnesium, chloride and sulphate seem to often exceed maximum recommended limits (Table 3) and may occasionally exceed maximum allowable limits. Groundwater appears to be of a sodium-chloride nature (Fig. 3).

**FIG 2: AREAL LOCATION OF THE GAMTOOS GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 3**



**FIG 3: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 3 (GAMTOOS GROUP)**



**TABLE 3: CHEMICAL ANALYSES FROM DIFFERENT  
BOREHOLES IN THE GAMTOOS GROUP  
(ANALYSED BY THE CSIR)**

		A	B	C	D
EC	(mS/m)	96,0	300,0	70,0	300,0
TDS	(mg/l)	614,0	1 920,0	1 200,0	2 000,0
pH		8,6	7,1	6 - 9	5,5 - 9,5
Na	(mg/l)	96,0	285,0	100,0	400,0
K	(mg/l)	4,6	5,3	200,0	400,0
Ca	(mg/l)	48,4	157,0	150,0	200,0
Mg	(mg/l)	29,5	128,0	70,0	100,0
Cl	(mg/l)	189,0	685,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	108,0	354,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	83,0	188,0	20 - 300	650,0
F	(mg/l)	*	*	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	*	*	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	*	*	-	-
Si	(mg/l)	*	*	-	-
NH <sub>4</sub> (as N)	(mg/l)	*	*	6,0	10,0
Fe	(mg/l)	0,21	0,08	0,1	1,0

\* = Not determined

**Please note :**

In this table, and throughout chapter 4, chemical analyses have been selected that are deemed representative of the aquifers under discussion

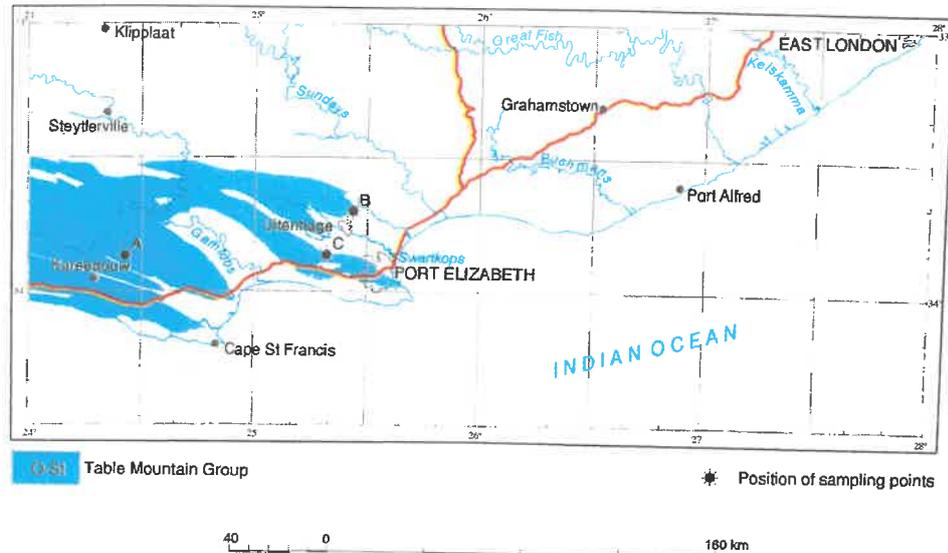
- A = Borehole; van Stadens Formation; farm Stuurmanskop north of Patensie; yield 0,5 l/s.  
 B = Borehole; Kaan Formation; farm Island Bush east of Patensie; yield 0,3 l/s.

**C = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**D = Drinking Water Quality Criteria: Maximum Allowable limit.**

### 4.1.2 Table Mountain Group

The TMG (Fig. 4) consists of four units in the map area, namely (thickness in brackets) the basal Sardinia Bay Formation (180 m), the Peninsula Formation (1500 m), the Cedarberg Formation (50 m) and the topmost Nardouw Subgroup (850 m) (Geological Survey Handbook 8, 1980).

**FIG 4: AREAL LOCATION OF THE TABLE MOUNTAIN GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 4**



**The more important geological and groundwater characteristics are as follows:**

- Only the Cedarberg Formation is primarily an argillaceous unit, while the remaining three units are predominantly arenaceous. The arenaceous content of the sandstone units varies between 75 and 90%.
- The arenaceous : argillaceous ratio of approximately 80 : 20 has an important bearing on both borehole yield and groundwater quality. Groundwater sources in predominantly sandstone units tend to have higher yields than those in shaly material. Water from boreholes in sandstone has, almost without exception, a better quality than those in shale (A and C in Table 4).
- A network of joints and fractures (Plate 3) control the infiltration, recharge, storage and movement of groundwater in the competent, and often brittle-natured, arenaceous units of the TMG. Fracturing may extend down to several hundred metres in many areas and deep groundwater circulation is one of the notable groundwater characteristics of the TMG. Despite the often highly fractured nature of the TMG sandstones, secondary groundwater storage is often limited, which could result in the rapid depletion of an aquifer under significant groundwater abstraction.
- The TMG rocks generally constitute the mountainous areas, which in turn control the occurrence of precipitation to a considerable extent. Due to the fractured nature of the sandstones in generally high rainfall regions,



**Plate 3:** *A well developed joint structure in Table Mountain sandstone near Kareedouw. (Photo: P.S. Meyer)*

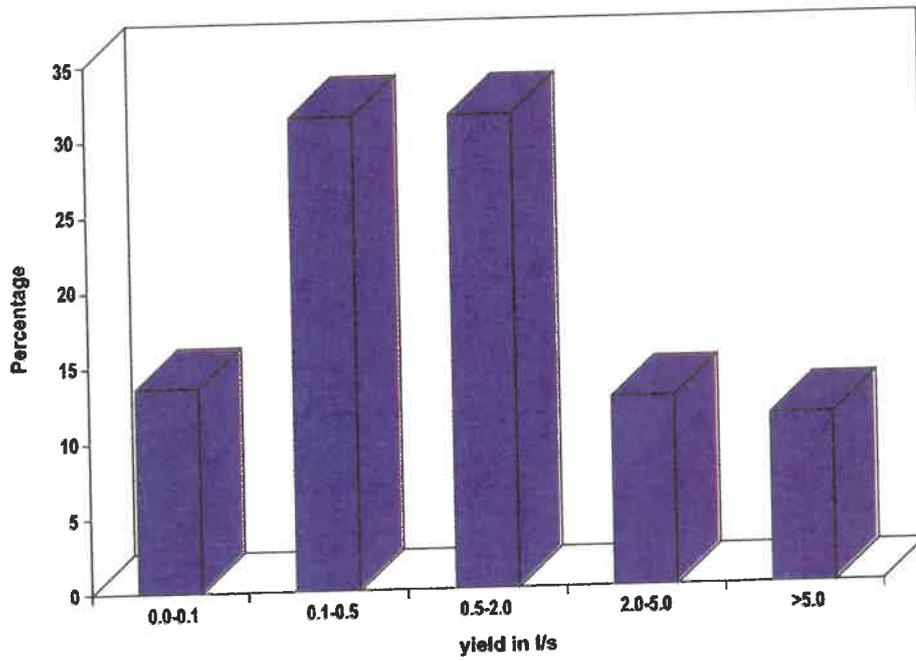


**Plate 4:** *Micro brecciation in a fracture structure in Table Mountain sandstone near Kareedouw. Micro brecciation and mylonitization often impede permeability in the Table Mountain sandstones. (Photo: P.S. Meyer)*

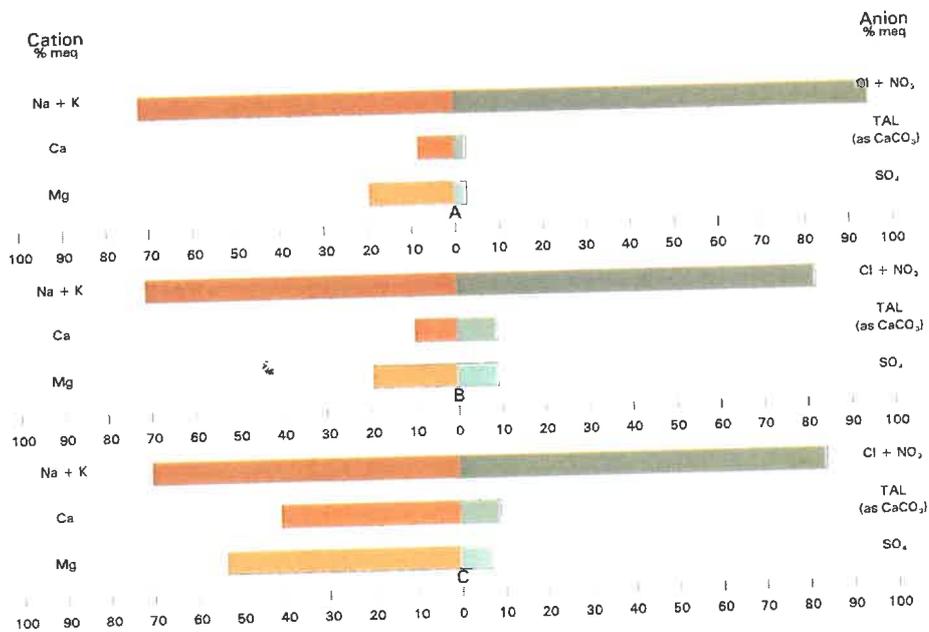
recharge is favourable. The general perception that infiltration rates of up to 15% and more of precipitation are possible in certain areas is not unrealistic.

- An abundance of springs issue from the TMG sandstones. Three kinds of springs can be distinguished:
  - ◆ Fracture and major structure controlled, relatively deep circulating springs with often large constant supplies. The Uitenhage Spring is an example : its average flow rate is 44,7 l/s, and the yield fluctuation varies between 44, 4 and 45,2 l/s.
  - ◆ Lithologically controlled, relatively shallow circulating springs. These springs issue due to the presence of impeding layers such as the Cedarberg shale. The Humansdorp Spring is an example. Yields from these springs are less constant and seasonal yield fluctuations are a distinctive feature. The average flow rate of the Humansdorp Spring is 28 l/s but seasonal yield fluctuations vary between 16 and 40 l/s. The bulk of the perennial springs issuing from the TMG sandstones are likely to be lithologically controlled.
  - ◆ Springs seeping from numerous small fractures and joints. They are very evident during and shortly following rainy spells. They are however highly seasonable and cease to exist with the onset of dry weather conditions.
  
- High yielding boreholes, like the seven production boreholes of the Jeffreys Bay Municipality (all with yields exceeding 5 l/s), can be developed in the TMG (Fig. 5), provided scientific methods for borehole siting are applied. Low borehole yields can often be attributed to incorrect borehole positioning and/or too shallow drilling.
  
- Quality of groundwater in the TMG is generally between 10 and 100 mS/m (A in Table 4). Less potable groundwater is however occasionally procured from boreholes drilled into interbedded shaly layers (C in Table 4). Groundwater from the TMG generally displays a sodium-chloride-magnesium nature (Fig. 6).
  
- Despite the relatively favourable groundwater potential in the TMG, both quantitatively and qualitatively, and provided proper scientific methods of siting are applied, some adverse exploitation aspects of groundwater from the TMG need to be mentioned:
  - ◆ Permeability inhibiting material (Plate 4) derived from micro-breccia, mylonite, iron and manganese oxides and silica formed and deposited in many of the fracture and joint structures, renders some of these structures less effective as groundwater conduits.
  - ◆ Due to the rough, mountainous terrain, large areas of the TMG are almost inaccessible. Groundwater development is thus generally limited to the foothills.

**FIG 5: YIELD FREQUENCIES OF BOREHOLES IN THE TABLE MOUNTAIN GROUP  
(287 BOREHOLES ANALYSED)**



**FIG 6: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 4  
(TABLE MOUNTAIN GROUP)**



- ◆ The TMG sandstones are hard, brittle and cross-jointed and are difficult to drill into. Due to the abrasiveness of these rocks, drilling bits tend to lose gauge, resulting in a gradual narrowing of the borehole diameter with depth. If this is not heeded, considerable problems of delivering a borehole of uniform diameter can result.
- ◆ Owing to the fractured and somewhat unstable nature of structures that are often drilled into, loose rock fragments are inclined to slip into boreholes not equipped with casing, causing obstructions. As numerous boreholes were lost this way, it became customary to fully equip boreholes with casing, adding considerably to the cost. Effective groundwater exploitation of the TMG is costly. Deep groundwater circulation is a reality and borehole depths in excess of 200 m, drilled in a difficult and complex medium and cased off to great depths, are required for optimum results. The cost of a single borehole can thus amount to tens of thousands of Rand.
- ◆ Once a borehole is functional, the action of iron bacteria can set in under certain circumstances. Iron bacteria often occur when substantial levels of iron and manganese are present in the groundwater, as is often the case with groundwater in the TMG. Slimy material is created which may plug screen pores and perforated slotting, and may even retard fracture permeability, rendering a once productive borehole much less effective. Borehole rehabilitation is possible with chemical treatment.
- ◆ The low pH of the groundwater and consequent corrosive action makes relatively inexpensive steel unsuitable for well screens and casing. PVC can be used to overcome these problems.

**TABLE 4: CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE TABLE MOUNTAIN GROUP (ANALYSED BY THE IWQS)**

		A	B	C	D	E
EC	(mS/m)	45,8	14,5	241,0	70,0	300,0
TDS	(mg/l)	230,0	63,0	1 319,0	1 200,0	2 000,0
pH		5,0	6,0	7,6	6 - 9	5,5 - 9,5
Na	(mg/l)	60,0	17,0	355,0	100,0	400,0
K	(mg/l)	<0,3	5,6	200,0	400,0	0,3
Ca	(mg/l)	7,0	2,0	59,0	150,0	200,0
Mg	(mg/l)	9,0	2,0	46,0	70,0	100,0
Cl	(mg/l)	135,0	33,0	641,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	4,2	7,0	73,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	<4,0	<4,0	114,0	20 - 300	650,0
F	(mg/l)	0,1	0,1	0,4	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	0,72	0,04	<0,04	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	0,006	0,03	0,008	-	-
Si	(mg/l)	4,2	5,3	13,7	-	-
NH <sub>4</sub> (as N)	(mg/l)	<0,04	<0,04	0,06	6,0	10,0
Fe	(mg/l)	1,48	0,025	2,15	0,1	1,0

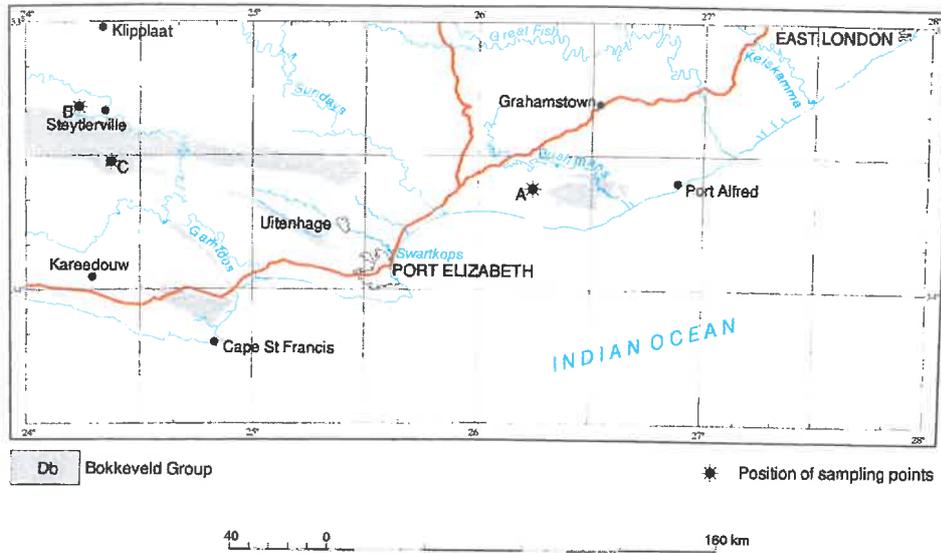
- A = Borehole drilled in relatively massive sandstone of the Nardouw Subgroup; farm Laagte northeast of Kareedouw; yield 0,5 l/s.
- B = Uitenhage Spring; fracture related; sandstone of the Peninsula Formation; possibly relatively deep circulating groundwater; yield >40 l/s.
- C = Borehole drilled in sandstone and interbedded shale of the Nardouw Subgroup; farm Brakkefontein west of Port Elizabeth; yield < 1 l/s.

**D = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**E = Drinking Water Quality Criteria: Maximum Allowable limit.**

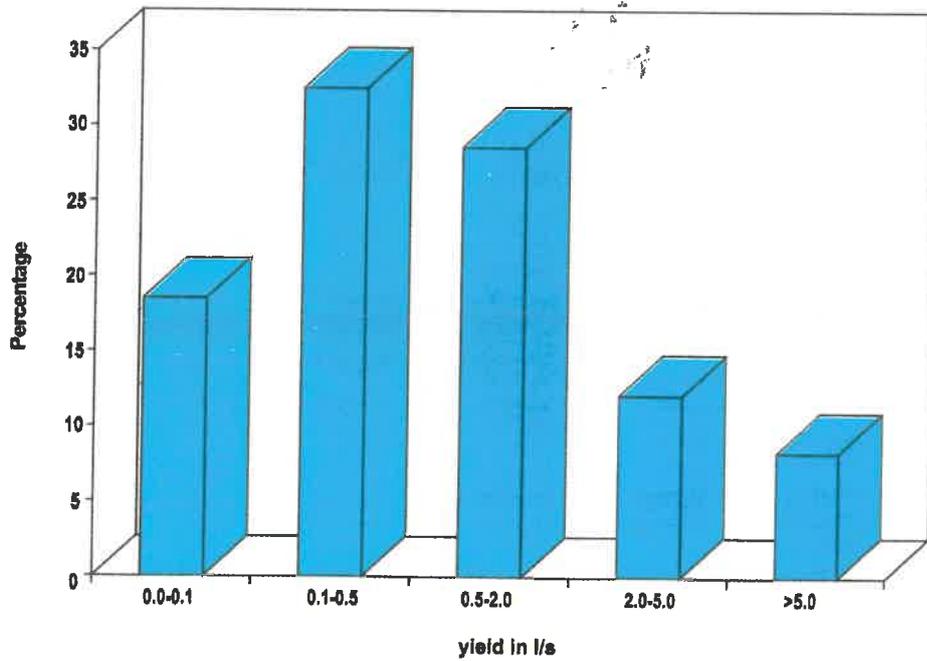
### 4.1.3 Bokkeveld Group

The Bokkeveld Group (Fig. 7) is composed of two Subgroups in the map area, namely the basal Ceres Subgroup and the uppermost Traka Subgroup. The Ceres Subgroup consists of the following Formations (thickness in brackets): Gydo Shale (600 m), Gamka Sandstone (200 m), Voorstehoek

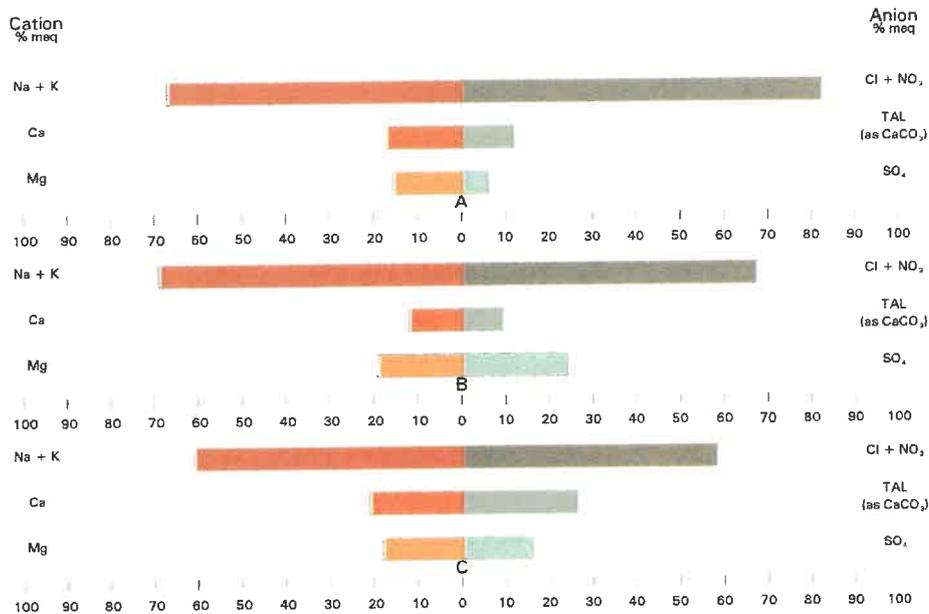
**FIG 7: AREAL LOCATION OF THE BOKKEVELD GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 5**



**FIG 8: YIELD FREQUENCIES OF BOREHOLES IN THE BOKKEVELD GROUP (206 BOREHOLES ANALYSED)**



**FIG 9: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 5  
(BOKKEVELD GROUP)**



Shale (300 m), Hex River Sandstone (70 m), Tra-tra Shale (350 m), and the Boplaas Sandstone (100 m). The Traka Subgroup consists of the following Formations : Karies Shale (1200 m), Adolphspoot Siltstone (72 m) and the topmost Sandpoort Shale (400 m) (Geological Survey Handbook 8, 1980).

**The more important geological and groundwater characteristics are as follows:**

- ❑ The Ceres Subgroup consists of alternating dark grey mudrock lithozones and dark, very fine-grained muddy sandstone, plus subordinate paler grey, fine to medium-grained feldspathic sandstone lithozones. The Traka Subgroup consists primarily of mudrock and rhythmite and very subordinate sandstone. It is a thick, largely sandstone-free unit (Johnson, 1976).
- ❑ The arenaceous : argillaceous ratio of the Ceres Subgroup is on average 30 : 70, and that of the Traka Subgroup 5 : 95 (Johnson, 1976).
- ❑ The arenaceous : argillaceous ratio plays a noticeable groundwater role, both quantitatively and qualitatively. Borehole yields and groundwater quality vary widely (Table 5 and Figs. 8 and 9). Yields of more than 5 l/s are not uncommon in the sandstone-rich Ceres Subgroup, but are generally substantially less than 5 l/s. Borehole yields in the sandstone-poor Traka Subgroup seldom exceed 5 l/s, and are usually well below 1 l/s.
- ❑ ECs in the Ceres Subgroup commonly exceed 200 mS/m and that of the Traka Subgroup usually exceed 300 mS/m (Table 5). Sodium, and chloride often exceed maximum recommended limits in the Ceres

Subgroup and may even exceed maximum allowable limits. Sodium, chloride and sulphate usually exceed maximum allowable limits in the Traka Subgroup and in the undifferentiated Bokkeveld rocks. Groundwater in the Bokkeveld Group is generally of a sodium-chloride nature.

**TABLE 5: CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE BOKKEVELD GROUP**  
(A AND B ANALYSED BY THE IWQS AND C WAS ANALYSED BY THE CSIR)

		A	B	C	D	E
EC	(mS/m)	430,0	378,8	175,0	70,0	300,0
TDS	(mg/l)	2 641,0	2362,0	1120,0	1 200,0	2 000,0
pH		7,9	7,9	7,2	6 - 9	5,5 - 9,5
Na	(mg/l)	686,0	602,0	245,0	100,0	400,0
K	(mg/l)	7,5	7,7	7,8	200,0	400,0
Ca	(mg/l)	152,0	90,0	71,7	150,0	200,0
Mg	(mg/l)	84,0	91,0	39,0	70,0	100,0
Cl	(mg/l)	135,0	878,0	348,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	118,0	420,0	132,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	299,0	212,0	265,0	20 - 300	650,0
F	(mg/l)	0,3	3,2	*	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	0,57	2,6	*	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	0,011	0,007	*	-	-
Si	(mg/l)	14,0	3,8	*	-	-
NH <sub>4</sub> (as N)	(mg/l)	0,04	0,04	*	6,0	10,0

\* = Not determined

- A = Borehole at Zuney west of Alexandria; undifferentiated Bokkeveld rocks; yield 0,5 l/s.  
 B = Borehole; farm Nashvale west of Steytlerville; Sandpoort Formation; Traka Subgroup; yield 0,25 l/s.  
 C = Borehole; farm Wolwekraal south of Steytlerville; Voorstehoek Formation; Ceres Subgroup; yield 5l/s.

**D = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**E = Drinking Water Quality Criteria: Maximum Allowable limit.**

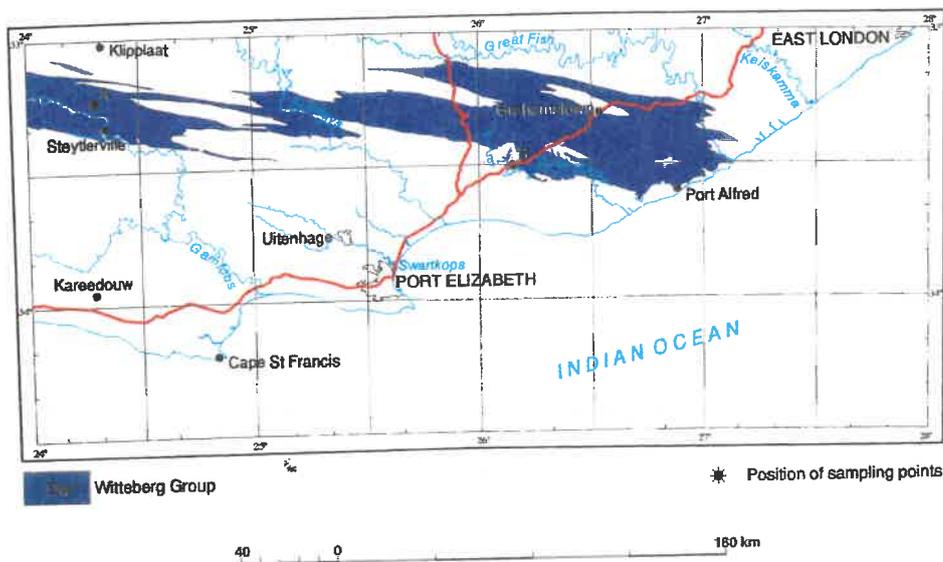
#### 4.1.4 Witteberg Group

The Witteberg Group (Fig. 10) is divided into four units in the map area, namely (thickness in brackets) the basal Weltevrede Formation (800 m), the Witpoort Formation (850 m), the Lake Mentz Subgroup (620 m) and the topmost Kommadagga Subgroup (380 m) (Geological Survey Handbook 8, 1980).

The more important geological and groundwater characteristics are as follows:

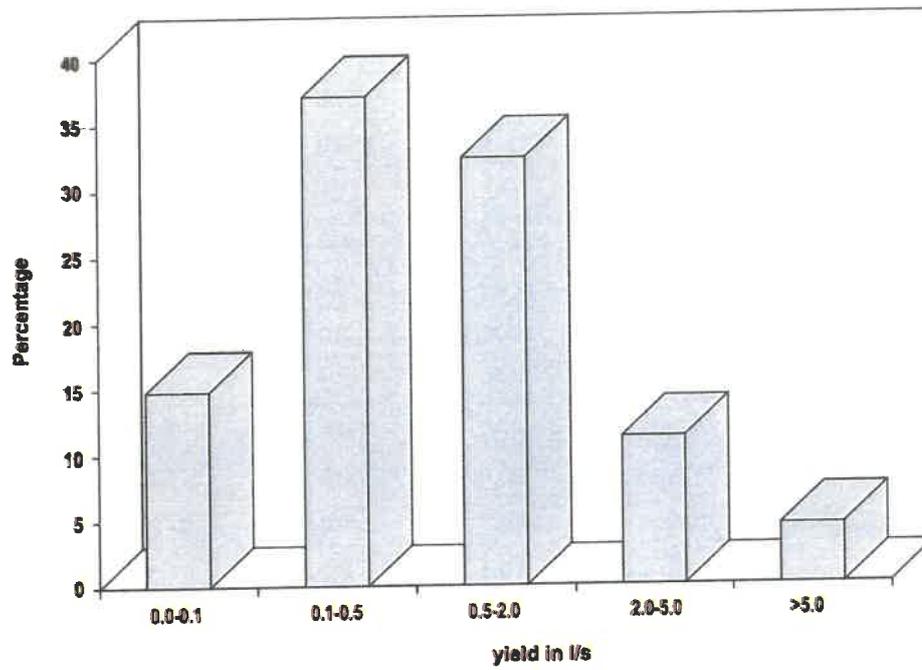
- The approximately 800 m thick Weltevrede Formation consists of grey, streaky mudrock lithozones with subordinate fine-grained, pale grey sandstone lithozones. Two sandstone horizons occur within the Weltevrede Formation, viz. the 50 m thick Driekuilen Sandstone Member and the 120 m thick Blinkberg Sandstone Member. The arenaceous : argillaceous ratio for the unit as a whole is approximately 30 : 70.
- The approximately 850 m thick Witpoort Formation is essentially an arenaceous unit and consists of siliceous ultra-quartzose sandstone with subordinate mudrock. The arenaceous : argillaceous ratio for the unit is about 94 : 6.

**FIG 10: AREAL LOCATION OF THE WITTEBERG GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 6**

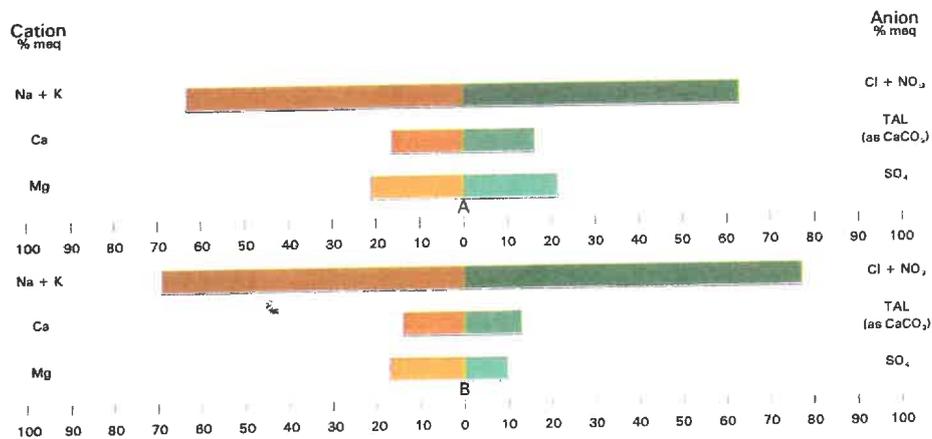


- ❑ The Lake Mentz Subgroup consists of three Formations. The basal Kweekvlei Formation is a 200 m thick shale unit. The 80 m thick Floriskraal Formation is composed of shale and quartzitic sandstone. The topmost 340 m thick Waaiport Formation is also a shale unit.
- ❑ The Kommadagga Subgroup is composed of the 10 m thick basal Miller Diamictite Formation, the 8 m thick Swartwaterspoort Sandstone Formation, which has an intertongued relationship with the Miller Formation, the 170 m thick Southkloof Shale Formation and the topmost 110 m thick Dirkskraal Sandstone Formation.
- ❑ The largely argillaceous components of the Witteberg Group seldom yield more than 2 l/s in boreholes. The yield potential of the arenaceous components are noticeably better, especially in the Witpoort Formation, with borehole yields exceeding 2 l/s not uncommon (Fig. 11).
- ❑ ECs ranging between 200 to 700 mS/m can be expected in the shale components. Sodium, magnesium, chloride and sulphate often exceed maximum allowable limits in the shales (A in Table 6), and the water is generally of a sodium-chloride nature (A in Fig. 12).
- ❑ ECs of groundwater from the sandstone units are generally less than 100 mS/m (B in Fig. 12). Determinants seldom exceed maximum recommended limits.
- ❑ Positioning of boreholes on fractures in the sandstone units close to shale units often poses the danger of poor quality groundwater being drawn in from the shale units.

**FIG 11: YIELD FREQUENCIES OF BOREHOLES IN THE WITTEBERG GROUP  
(776 BOREHOLES ANALYSED)**



**FIG 12: STIFF DIAGRAM OF THE CHEMICAL ANALYSES IN TABLE 6  
(WITTEBERG GROUP)**



**TABLE 6: CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE WITTEBERG GROUP**  
(ANALYSED BY THE IWQS)

		A	B	C	D
EC	(mS/m)	385,0	70,8	70,0	300,0
TDS	(mg/l)	2 717,0	394,0	1 200,0	2 000,0
pH		8,2	7,1	6 - 9	5,5 - 9,5
Na	(mg/l)	621,0	100,0	100,0	400,0
K	(mg/l)	4,9	3,0	200,0	400,0
Ca	(mg/l)	140,0	18,0	150,0	200,0
Mg	(mg/l)	111,0	13,0	70,0	100,0
Cl	(mg/l)	917,0	171,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	425,0	29,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	408,0	49,0	20 - 300	650,0
F	(mg/l)	0,8	0,2	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	0,04	0,07	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	0,01	0,012	-	-
Si	(mg/l)	9,7	6,1	-	-
NH <sub>4</sub> (as N)	(mg/l)	0,06	0,04	6,0	10,0
Fe	(mg/l)	*	*	0,1	1,0

\* = Not determined

A = Borehole in a shale component of the Lake Mentz Subgroup (Witteberg Group); farm Allemanskraal northwest of Steyterville; yield 0,2 l/s.

B = Borehole in the Witpoort Sandstone Formation of the Witteberg Group; farm Woodbury southeast of Paterson; yield 0,4 l/s.

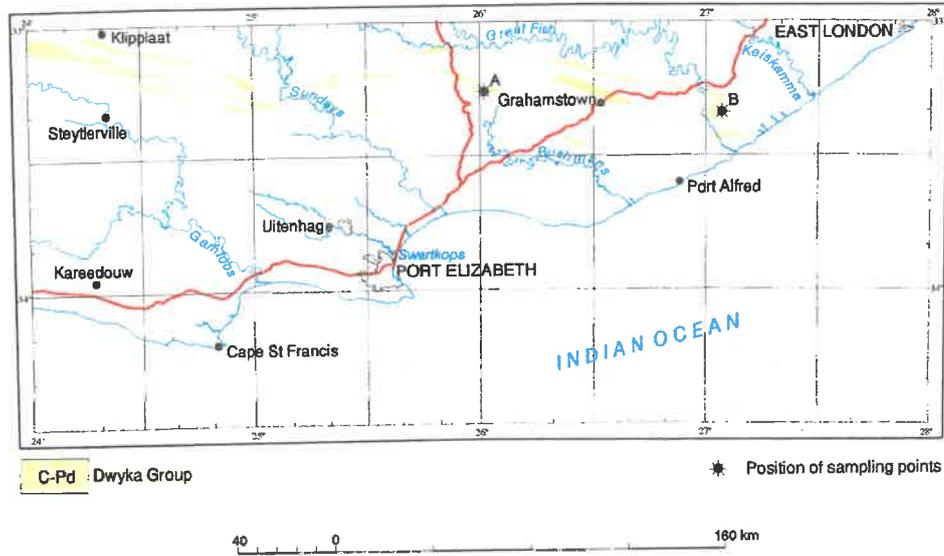
<p>C = Drinking Water Quality Criteria: Maximum Recommended limit. D = Drinking Water Quality Criteria: Maximum Allowable limit.</p>
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#### 4.1.5 Dwyka Group

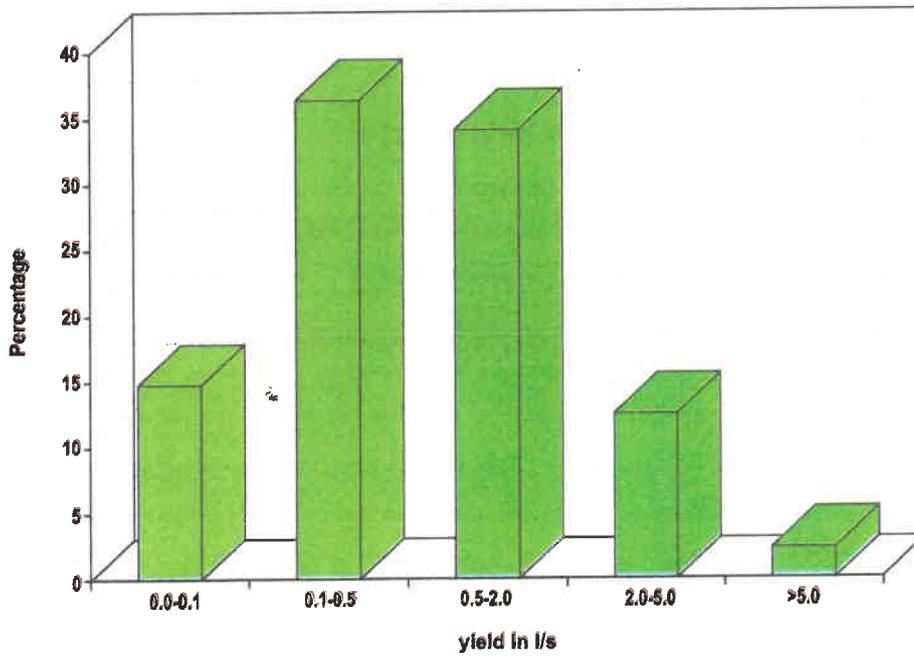
The more important geological and groundwater characteristics are as follows:

- The Dwyka Group (Fig. 13) is an approximately 600 m thick mass of diamictite which contains a dark grey to greenish argillaceous matrix. Subordinate lenses of shale and sandstone occur sporadically.

**FIG 13: AREAL LOCATION OF THE DWYKA GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 7**

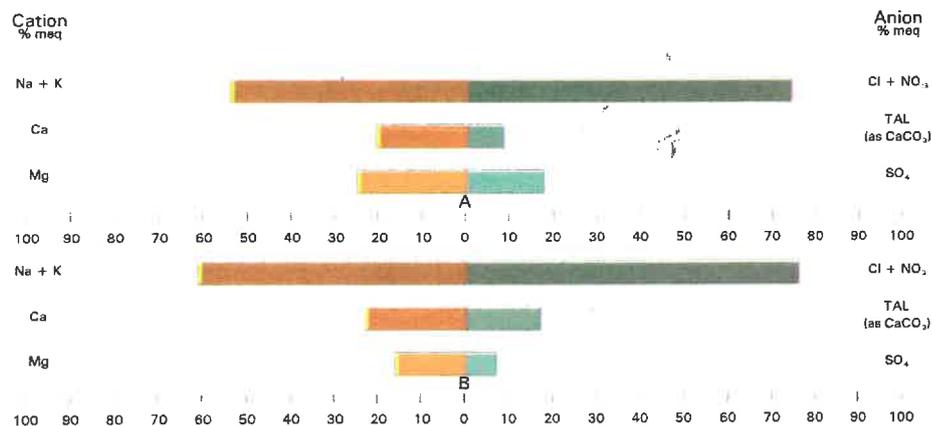


**FIG 14: YIELD FREQUENCIES OF BOREHOLES IN THE DWYKA GROUP (88 BOREHOLES ANALYSED)**



- ❑ Due to their dense, impervious nature, the rocks of the Dwyka Group generally offer limited groundwater potential.
- ❑ A borehole yield analysis (Fig. 14) indicates that 45% of boreholes drilled, yield less than 0,5 l/s. Borehole yields exceed 2 l/s only where occasional fault or joint structures, backed by favourable recharge conditions, occur.
- ❑ ECs of groundwater from the Dwyka rocks often exceed 300 mS/m (A in Table 7). The following determinants often exceed maximum recommended or even maximum allowable limits: sodium, calcium, magnesium, chloride and sulphate (A and B in Table 7 and Fig. 15). Groundwater obtained in relatively massive Dwyka rocks generally portrays a sodium-chloride-sulphate nature (A in Fig. 15).
- ❑ In boreholes drilled in fracture and joint structures where significant groundwater movement and recharge takes place, ECs of less than 200 mS/m can be expected (B in Table 7).

**FIG 15: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 7 (DWYKA GROUP)**



**TABLE 7: CHEMICAL ANALYSES FROM DIFFERENT  
BOREHOLES IN THE DWYKA GROUP**  
(A WAS ANALYSED BY THE IWQS AND B WAS ANALYSED BY THE CSIR)

		A	B	C	D
EC	(mS/m)	419,0	255,0	70,0	300,0
TDS	(mg/l)	2 477,0	1632,0	1 200,0	2 000,0
pH		7,9	7,8	6 - 9	5,5 - 9,5
Na	(mg/l)	520,0	352,0	100,0	400,0
K	(mg/l)	3,7	3,8	200,0	400,0
Ca	(mg/l)	173,0	79,0	150,0	200,0
Mg	(mg/l)	127,0	69,0	70,0	100,0
Cl	(mg/l)	1 057,0	638,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	343,0	77,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	207,0	254,0	20 - 300	650,0
F	(mg/l)	0,5	1,0	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	0,06	0,1	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	0,026	*	-	-
Si	(mg/l)	8,8	*	-	-
NH <sub>4</sub> (as N)	(mg/l)	0,04	*	6,0	10,0
Fe	(mg/l)	*	1,10	0,1	1,0

\* = Not determined

A = Borehole; farm Wilger Fontein south of Riebeeck East; relatively massive tillite; yield 1 l/s.

B = Borehole; farm Salisbury Plain near Great Fish River Mouth; fractured rock related; yield 5 l/s (courtesy of Toens and Partners).

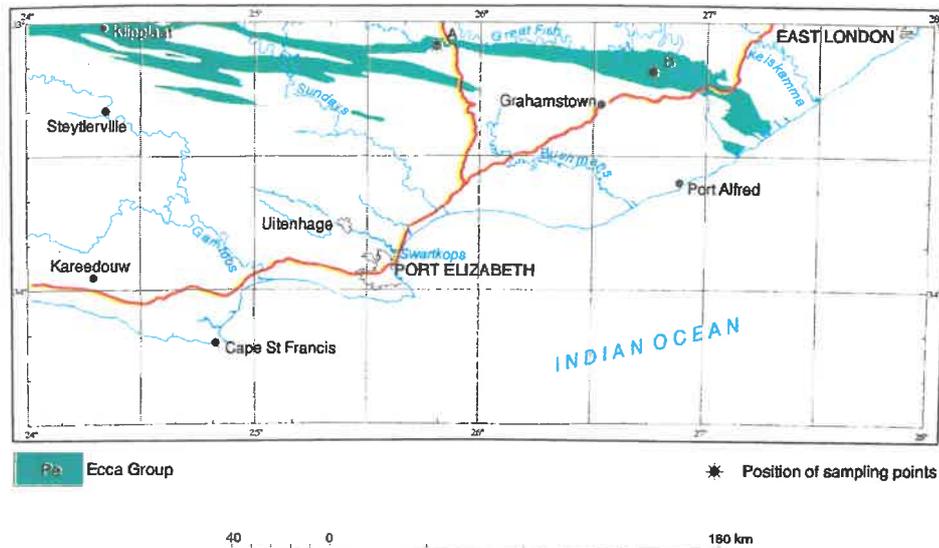
<p><b>C = Drinking Water Quality Criteria: Maximum Recommended limit.</b>  <b>D = Drinking Water Quality Criteria: Maximum Allowable limit.</b></p>
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#### 4.1.6 Ecça Group

The more important geological and groundwater characteristics are as follows:

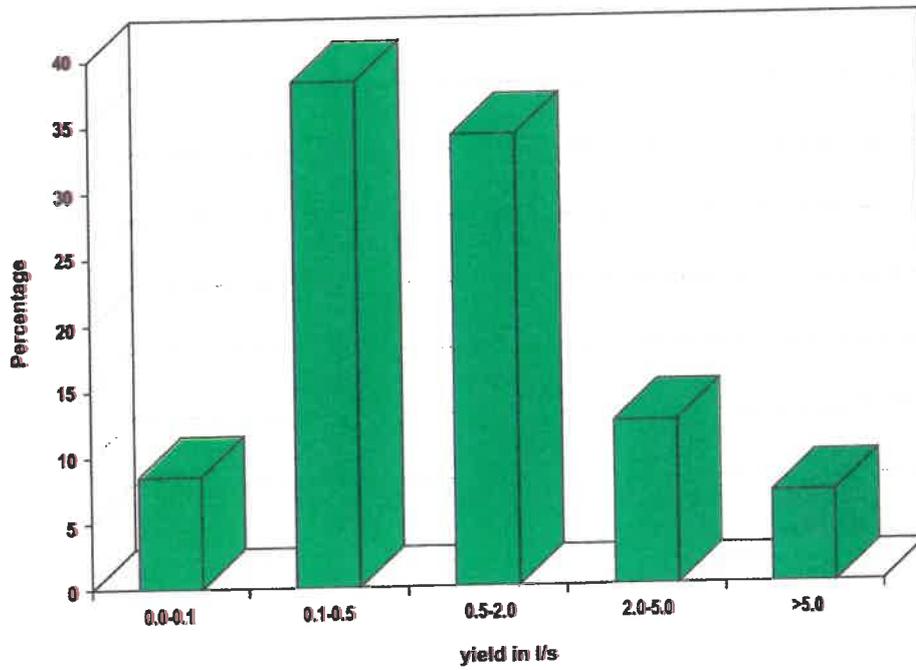
- The Ecça Group (Fig. 16) consists predominantly of laminated and platy argillaceous rocks and subordinate interbedded sandstones. The following Formations occur in the map area (average thickness in brackets) : Prince Albert (110 m), Whitehill (30 m), Collingham (30 m), Ripon (600 m), Fort Brown (1000 m), Waterfort (300 m) (Johnson, 1976).

**FIG 16: AREAL LOCATION OF THE ECCA GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 8**

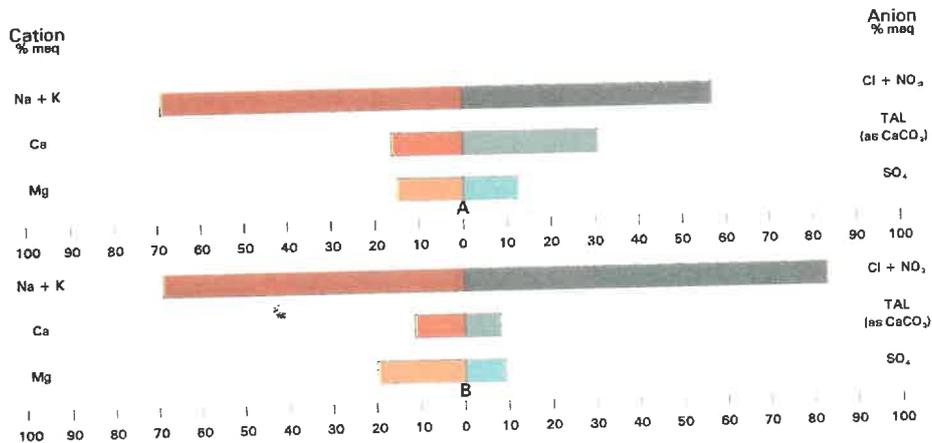


- A borehole yield analysis indicates that about 41% of boreholes yield less than 2 l/s (Fig. 17). Borehole yields of more than 5 l/s can, however, be obtained in fold, joint and fault structures where favourable recharge conditions exist.
- Groundwater quality varies considerably, with ECs ranging between 100 and 1 200 mS/m. About 16% of boreholes registered ECs of less than 200 mS/m and 18% of boreholes have ECs in excess of 500 mS/m which means that 66% of boreholes have ECs ranging between 200 and 500 mS/m. The following determinants often exceed maximum recommended and occasionally even maximum allowable limits: sodium, magnesium, chloride, total alkalinity, sulphate and fluoride (Table 8). Groundwater generally has a sodium-chloride nature (Fig. 18).

**FIG 17: YIELD FREQUENCIES OF BOREHOLES IN THE ECCA GROUP  
(193 BOREHOLES ANALYSED)**



**FIG 18: STIFF DIAGRAMS OF CHEMICAL ANALYSES IN TABLE 8  
(ECCA GROUP)**



**TABLE 8: CHEMICAL ANALYSES OF DIFFERENT  
BOREHOLES IN THE ECCA GROUP  
(ANALYSED BY THE IWQS)**

		A	B	C	D
EC	(mS/m)	201,0	552,0	70,0	300,0
TDS	(mg/l)	1 480,0	3 252,0	1 200,0	2 000,0
pH		8,2	7,7	6 - 9	5,5 - 9,5
Na	(mg/l)	347,0	867,0	100,0	400,0
K	(mg/l)	8,5	9,9	200,0	400,0
Ca	(mg/l)	72,0	125,0	150,0	200,0
Mg	(mg/l)	40,0	70,0	70,0	100,0
Cl	(mg/l)	410,0	1 550,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	123,0	236,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	386,0	262,0	20 - 300	650,0
F	(mg/l)	1,8	0,8	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	1,57	2,12	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	0,014	0,026	-	-
Si	(mg/l)	7,6	3,6	-	-
NH <sub>4</sub> (as N)	(mg/l)	<0,04	0,13	6,0	10,0

A = Borehole drilled in shale and interbedded sandstone of the Ripon Formation; farm Grasfontein north of Paterson; yield 2,5 l/s.

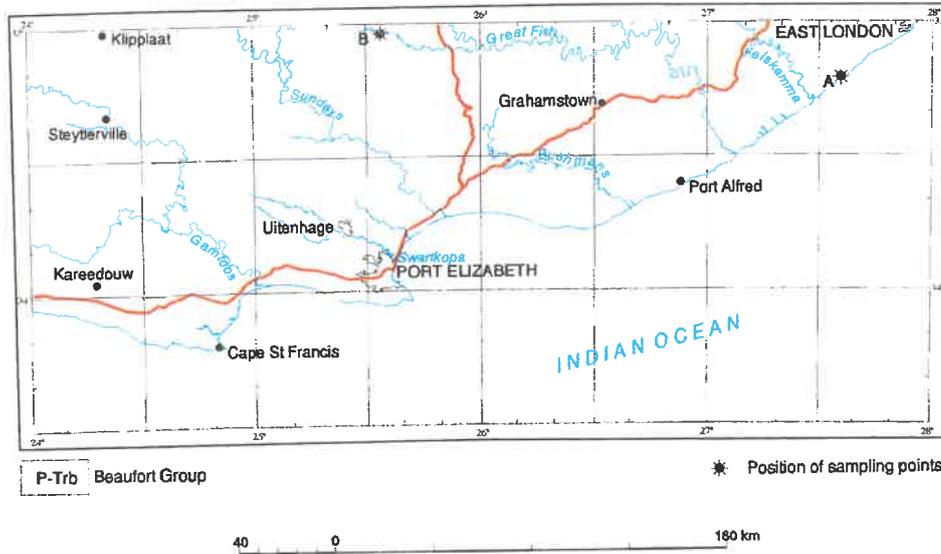
B = Borehole drilled in shale of the Fort Brown Formation; farm Lakeside northeast of Grahamstown; yield 0,25 l/s.

<p><b>C = Drinking Water Quality Criteria: Maximum Recommended limit.</b>  <b>D = Drinking Water Quality Criteria: Maximum Allowable limit.</b></p>
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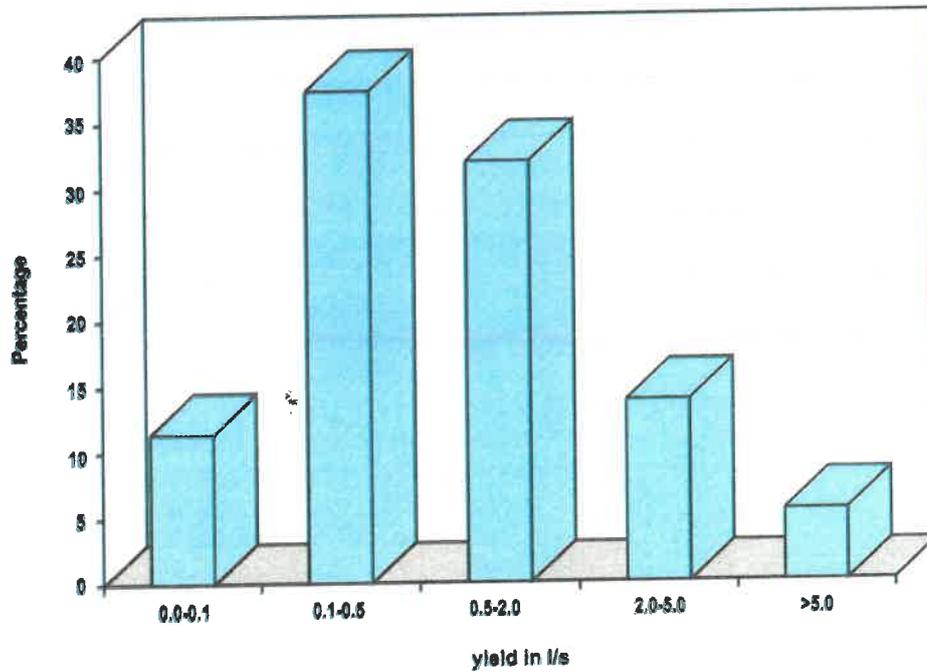
#### **4.1.7 Beaufort Group**

Four Formations of the Beaufort Group (Fig. 19) occur in the map area, namely (maximum thickness in brackets) the basal Koonap (1300 m), Middleton (1500 m), Balfour (2000 m) and Katberg (1000 m) (Johnson, 1976).

**FIG 19: AREAL LOCATION OF THE BEAUFORT GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 9**



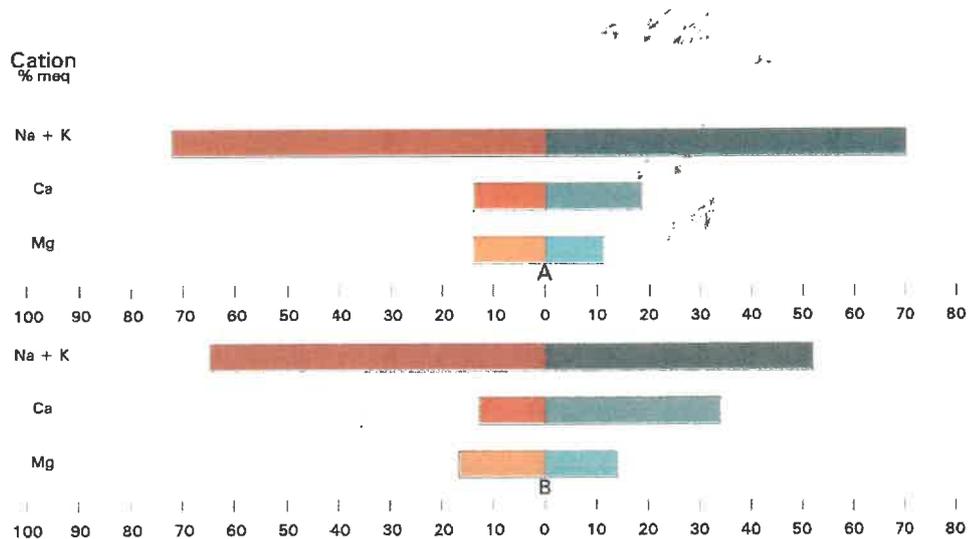
**FIG 20: YIELD FREQUENCIES OF BOREHOLES IN THE BEAUFORT GROUP (369 BOREHOLES ANALYSED)**



The more important geological and groundwater characteristics are as follows:

- The Koonap, Middleton and Balfour Formations consists of between 70 - 80% of greenish-grey to red mudrock, and between 20 - 30% sandstone (Johnson, 1976). The Katberg Formation is largely a sandstone unit (90% sandstone).
- A borehole yield analysis indicates that about 42% of boreholes yield less than 0,5 l/s (Fig. 20). Borehole yields in excess of 3 l/s can however be obtained in joint, fault and fold structures, provided favourable recharge conditions exist.
- Groundwater quality varies between 70 and 1 200 mS/m. About 30% of boreholes recorded ECs of less than 200 mS/m and 5% of boreholes have ECs in excess of 500 mS/m. Sodium, chloride, total alkalinity and fluoride may exceed maximum recommended limits (Table 9), and may occasionally even exceed maximum allowable limits. Groundwater from the Beaufort rocks generally displays a sodium-chloride-bicarbonate nature (Fig. 21).

**FIG 21: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 9 (BEAUFORT GROUP)**



**TABLE 9: CHEMICAL ANALYSES FROM DIFFERENT  
BOREHOLES IN THE BEAUFORT GROUP  
(ANALYSED BY THE IWQS)**

		A	B	C	D
EC	(mS/m)	111,0	219,0	70,0	300,0
TDS	(mg/l)	992,0	1 610,0	1 200,0	2 000,0
pH		8,2	8,0	6 - 9	5,5 - 9,5
Na	(mg/l)	174,0	346,0	100,0	400,0
K	(mg/l)	3,7	21,3	200,0	400,0
Ca	(mg/l)	70,0	75,0	150,0	200,0
Mg	(mg/l)	43,0	58,0	70,0	100,0
Cl	(mg/l)	269,0	394,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	51,0	143,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	311,0	446,0	20 - 300	650,0
F	(mg/l)	1,2	2,4	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	0,28	6,07	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	0,011	0,011	-	-
Si	(mg/l)	8,3	11,7	-	-
NH <sub>4</sub> (as N)	(mg/l)	0,07	0,07	6,0	10,0

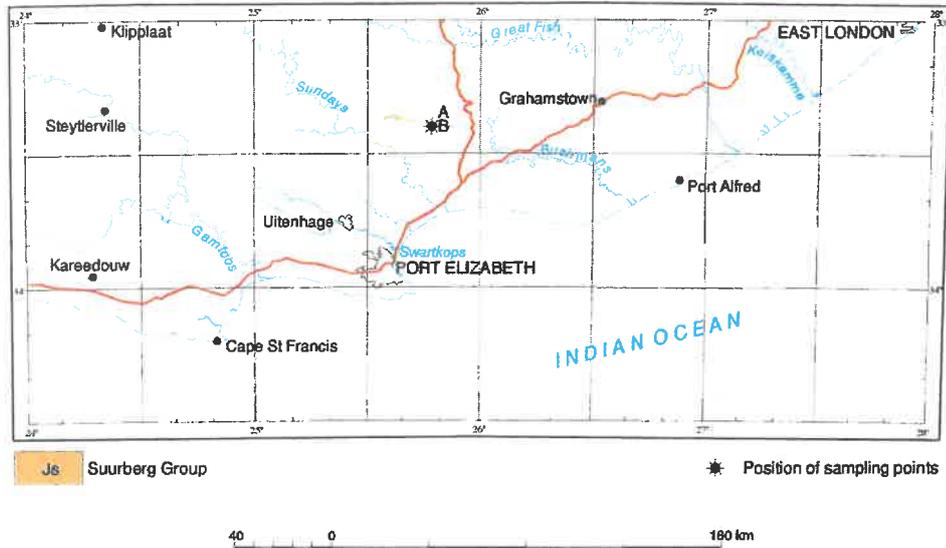
- A = Borehole; farm Kayserworth west of Kaysers Beach; Katberg Formation; yield 1,3 l/s.  
 B = Borehole; farm Bassonskraal south of Somerset East; Koonap Formation; yield 2,5 l/s.

**C = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**D = Drinking Water Quality Criteria: Maximum Allowable limit.**

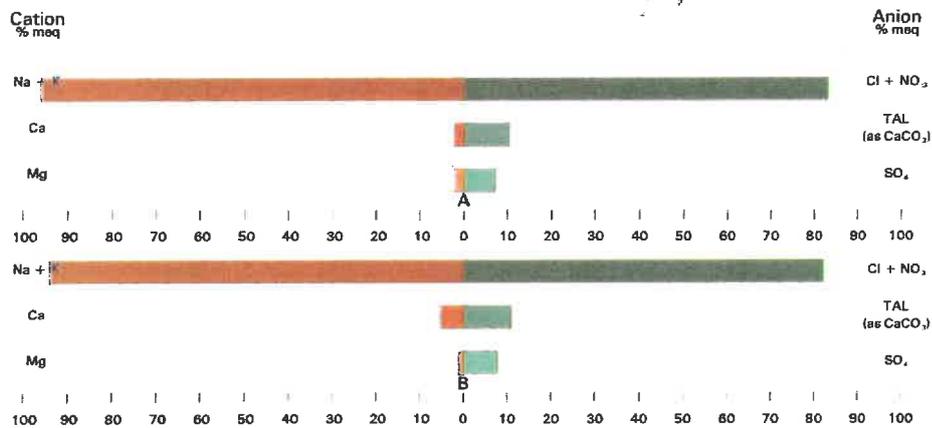
#### 4.1.8 Suurberg Group

The Suurberg Group (Fig. 22) consists of breccia and conglomerate of the (thickness in brackets) Slagboom Formation (60 m), acidic tuffs and tuffaceous rocks of the Coerney Formation (80 m), and basalt and subordinate interbedded tuffs of the Mimosa Formation (140 m) (Toerien and Hill, 1989). The Suurberg Group covers only 0,3% of the map area. Topographically the area is dissected and rugged and somewhat inaccessible.

**FIG 22: AREAL LOCATION OF THE SUURBERG GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 10**



**FIG 23: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 10 (SUURBERG GROUP)**



The more important geological and groundwater characteristics are as follows:

- Very few boreholes were recorded from the Suurberg rocks. Borehole yields seem to be limited (generally less than 0,5 l/s) and groundwater quality appears to be rather brackish with ECs in excess of 300 mS/m (Table 10 and Fig. 23).
- In view of the scanty information available on groundwater in the Suurberg Group, a conclusive opinion of its groundwater characteristics cannot be given.

**TABLE 10: CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE SUURBERG GROUP (ANALYSED BY THE CSIR)**

		A	B	C	D
EC	(mS/m)	330,0	325,0	70,0	300,0
TDS	(mg/l)	2 112,0	2 080,0	1 200,0	2 000,0
pH		8,8	8,5	6 - 9	5,5 - 9,5
Na	(mg/l)	669,0	654,0	100,0	400,0
K	(mg/l)	1,8	1,2	200,0	400,0
Ca	(mg/l)	15,0	32,1	150,0	200,0
Mg	(mg/l)	7,0	3,7	70,0	100,0
Cl	(mg/l)	864,0	829,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	102,0	107,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	182,0	188,0	20 - 300	650,0
F	(mg/l)	*	*	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	*	*	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	*	*	-	-
Si	(mg/l)	*	*	-	-
NH <sub>4</sub> (as N)	(mg/l)	*	*	6,0	10,0
Fe	(mg/l)	0,29	0,26	0,1	1,0

\* = Not determined

A = Borehole; farm Coerney west of Paterson; breccia of the Slagboom Formation; yield 0,38 l/s.

B = Borehole; farm Buffelskuil west of Paterson; basalt and interbedded tuff of the Mimosa Formation; yield 0,22 l/s.

**C = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**D = Drinking Water Quality Criteria: Maximum Allowable limit.**

### 4.1.9 Uitenhage Group

The Uitenhage Group (Fig. 24) is represented by three Formations in the map area, namely (maximum thickness in brackets) the basal Enon (3000 m), the Kirkwood (2200 m) and the topmost Sundays River (1600 m) Formations. (Information on thicknesses obtained from the Council for Geoscience).

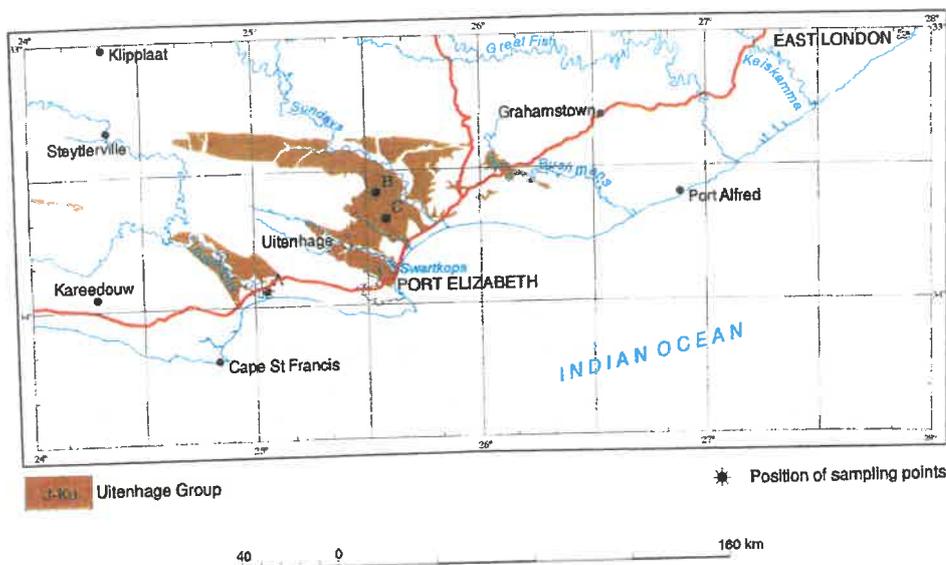
**The more important geological and groundwater characteristics are as follows:**

- The basal Enon Formation (Plate 5) is a largely conglomerate unit with mostly lenticular interbedded sandstone and mudstone. The Kirkwood Formation consists mainly of reddish to greenish-grey mudstone and pale-grey sandstone. The Sundays River Formation consists of grey to bluish-grey mudstone, siltstone and sandstone.
- Large outcrops of Uitenhage rocks occur from west of Alexandria to west of Kirkwood, east of Uitenhage, north of Port Elizabeth and in the Gamtoos River Valley. Minor outcrops of mainly Enon conglomerate occur in the Baviaanskloof.
- The Uitenhage beds are a dense mass of rocks of low permeability. Its groundwater potential is thus limited. A borehole yield analysis indicates that close to 40% of boreholes yield less than 0,5 l/s. (Fig. 25) The groundwater potential of the Uitenhage rocks is in reality much worse. Information of numerous boreholes which were drilled unsuccessfully and which have subsequently been destroyed, could not be obtained and used in the assessment.
- ECs in excess of 300 mS/m are common. Sodium, calcium, magnesium, chloride and, occasionally sulphate often exceed maximum allowable limits (Table 11 and Fig. 26).

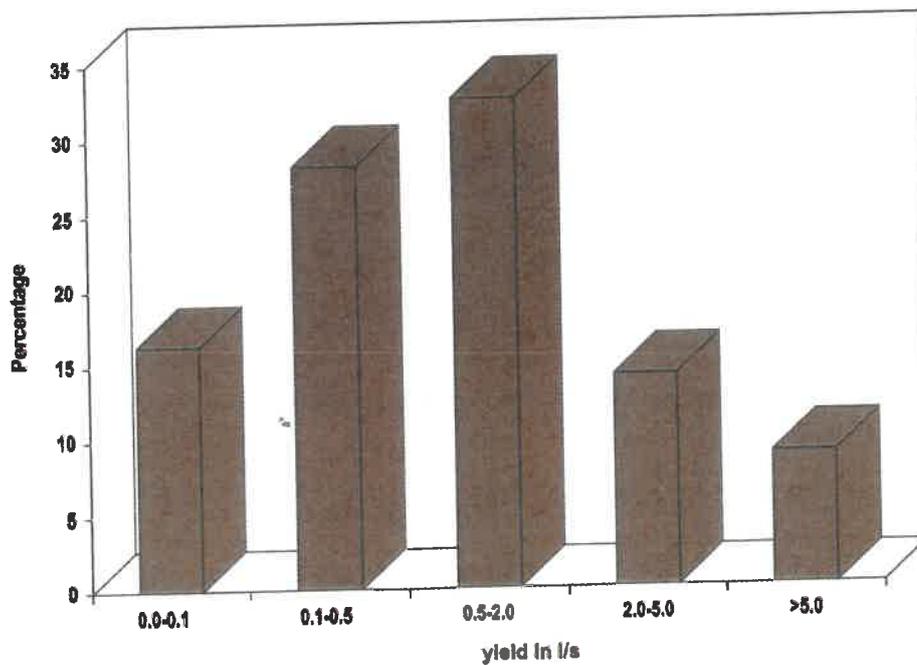


**Plate 5:** A sandstone lense in conglomerate of the Enon Formation in the Gamtoos River Valley. Such sandstone lenses can be targeted for groundwater development in the Enon conglomerate. (Photo: P.S. Meyer)

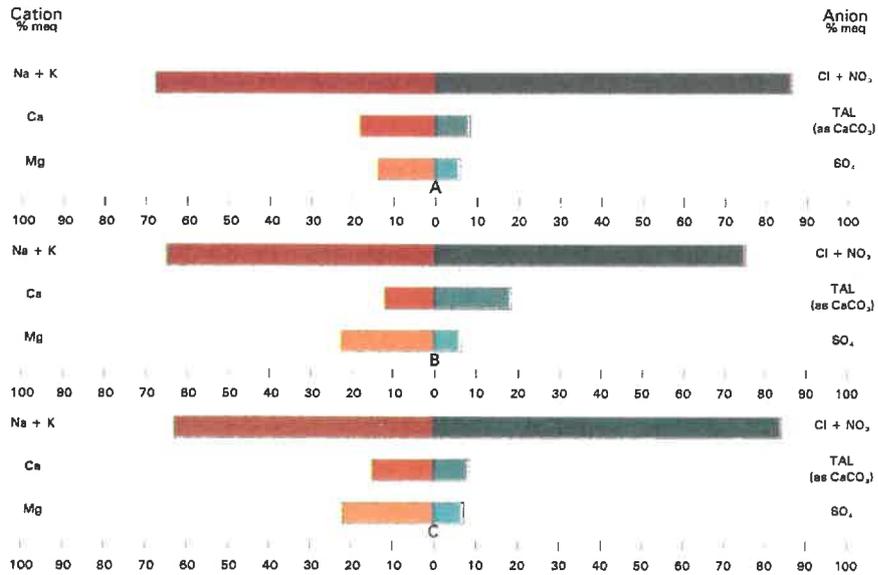
**FIG 24: AREAL LOCATION OF THE UITENHAGE GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 11**



**FIG 25: YIELD FREQUENCIES OF BOREHOLES IN UITENHAGE GROUP (227 BOREHOLES ANALYSED)**



**FIG 26: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 11  
(UITENHAGE GROUP)**



**TABLE 11: CHEMICAL ANALYSES FROM DIFFERENT  
BOREHOLES IN THE UITENHAGE GROUP  
(ANALYSED BY THE IWQS)**

	A	B	C	D	E
EC (mS/m)	458,0	151,0	788,0	70,0	300,0
TDS (mg/l)	2 735,0	825,0	5 116,0	1 200,0	2 000,0
pH	7,9	8,1	8,1	6 - 9	5,5 - 9,5
Na (mg/l)	698,0	189,0	1 240,0	100,0	400,0
K (mg/l)	4,7	16,8	22,2	200,0	400,0
Ca (mg/l)	167,0	33,0	259,0	150,0	200,0
Mg (mg/l)	77,0	37,0	232,0	70,0	100,0
Cl (mg/l)	1 357,0	336,0	2 535,0	250,0	600,0
SO <sub>4</sub> (mg/l)	127,0	40,0	292,0	200,0	600,0
TAL (as CaCO <sub>3</sub> ) (mg/l)	220,0	142,0	437,0	20 - 300	650,0
F (mg/l)	0,3	0,5	0,6	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N) (mg/l)	8,2	0,04	0,54	6,0	10,0
PO <sub>4</sub> (as P) (mg/l)	0,005	0,009	0,014	-	-
Si (mg/l)	10,5	5,7	12,5	-	-
NH <sub>4</sub> (as N) (mg/l)	0,07	0,05	0,09	6,0	10,0
Fe (mg/l)	*	*	*	0,1	1,0

\* = Not determined

A = Borehole; farm Mouritzkraal north-east of the Gamtoos River Mouth; shale of the Kirkwood Formation; yield 1,26 l/s.

- B = Borehole; farm Blauw Baadjies Vley north of Port Elizabeth; water presumably intercepted in a sandstone lense in the Kirkwood rocks; yield 0,25 l/s.
- C = Borehole; farm Grassridge north of Port Elizabeth; shale and silty sandstone of the Sundays River Formation; yield 0,4 l/s.

**D = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**E = Drinking Water Quality Criteria: Maximum Allowable limit.**

## **4.2 Fractured and Intergranular Aquifers**

The only formation in the map area which contains intruded material, classifying it as a fractured and intergranular aquifer, occurs in a limited area southwest of East London. Grey mudstone and sandstone of the Balfour Formation and medium-grained sandstone of the Katberg Formation (both Formations belonging to the Beaufort Group) have been intruded by dolerite sills. Many prominent, largely NE-SW striking faults also feature in this area.

The region is heavily dissected topographically, with many of the dolerite sills capping high ground, rendering many of the intrusion contact zones as well as the intergranular properties ineffective in terms of groundwater potential. The many faults could probably be used advantageously for groundwater development.

## **4.3 Intergranular Aquifers**

Intergranular aquifers cover approximately 10% of the map area. Three intergranular aquifer types can be distinguished of which the Algoa Group and the Coastal Sands can be considered coastal aquifers. The third type is the Alluvial Deposits which occur mainly along the flood plains of the Gamtoos, Sundays and Swartkops Rivers.

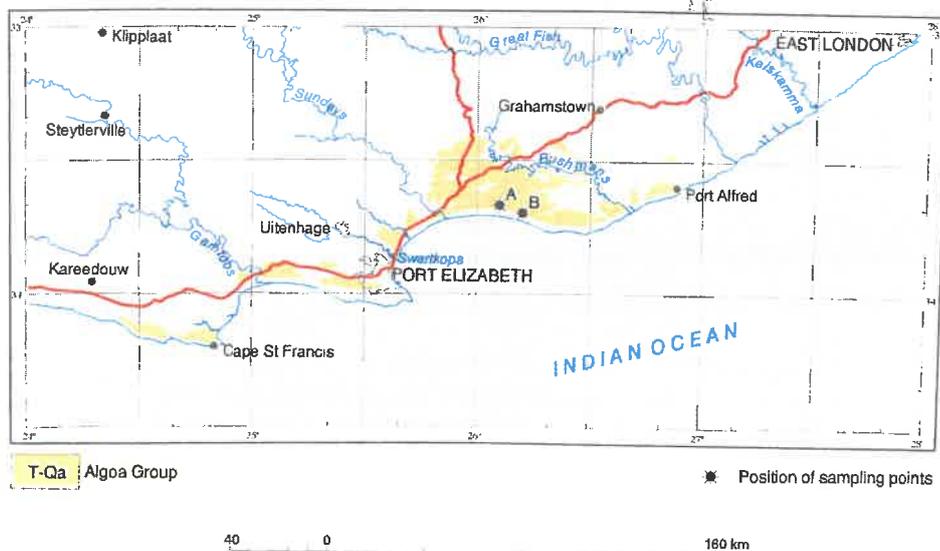
### **4.3.1 Algoa Group**

The Algoa Group (Fig. 27) consists of three Formations, namely (maximum thickness in brackets) the basal Alexandria Formation (10 m), the Kinkelbos Formation (20 m), and the topmost Nanaga Formation (250 m). (Information on thicknesses obtained from the Council for Geoscience).

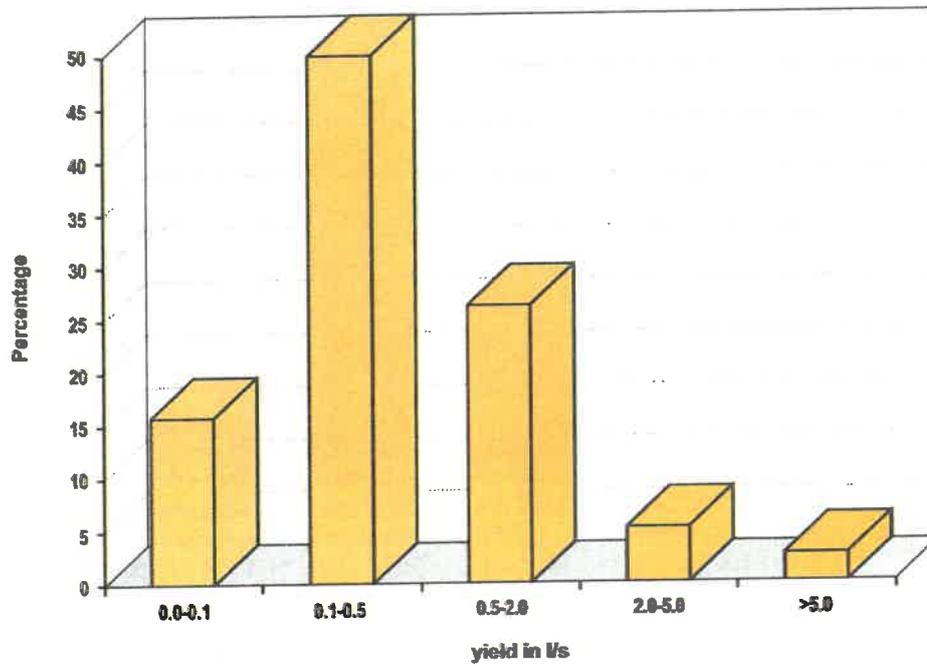
The more important geological and groundwater characteristics are as follows:

- The Alexandria Formation is composed of calcareous sandstone, shelly limestone and conglomerate, the Kinkelbos Formation of silt and fine-grained sand, and the Nanaga Formation of aeolianite.
- The Alexandria conglomerate (Plate 6) which occurs at the base of the Algoa beds is not laterally persistent (Johnson and Le Roux, 1994). The conglomerate is, from a groundwater point of view, the most important formation because groundwater is found in the conglomerate only.
- The Algoa Group aquifer is a unique intergranular aquifer. Water seeps relatively rapidly through the highly porous, sandy calcareous material to the contact with underlying, usually impervious pre-Algoa rocks, from where it moves in the conglomerate seawards, frequently emerging as springs near sea-level (the spring at Cape Padrone which provides Alexandria's water needs, is an example). Unlike conventional intergranular aquifers, hardly any build-up in groundwater level takes place and a water interception in the conglomerate, because of its high permeability, is likely to be the true piezometric level.
- A borehole yield analysis reveals that 60% of boreholes yield less than 0,5 l/s (Fig. 28).
- Groundwater quality is generally potable, provided drilling does not extend into underlying formations where brack groundwater can be encountered. ECs are generally less than 300 mS/m. Sodium, calcium and chloride often exceed maximum recommended limits (Table 12). Groundwater from the Algoa Group generally displays a sodium-chloride-calcium nature (Fig. 29).

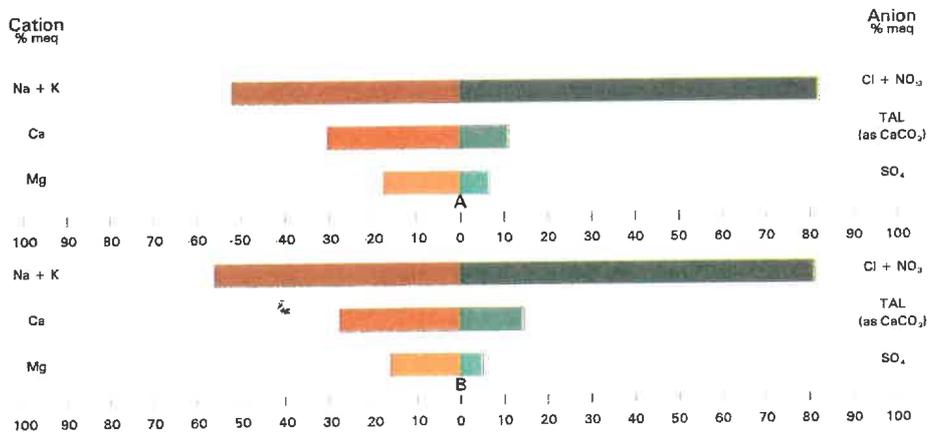
**FIG 27: AREAL LOCATION OF THE ALGOA GROUP AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 12**



**FIG 28: YIELD FREQUENCIES OF BOREHOLES IN THE ALGOA GROUP  
(38 BOREHOLES ANALYSED)**



**FIG 29: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 12  
(ALGOA GROUP)**





**Plate 6:** A remnant of the basal Alexandria conglomerate (Algoa Group) at Van Stadens Bridge west of Port Elizabeth. The Alexandria conglomerate offers virtually the only hope of obtaining groundwater in the Algoa Group. (Photo: Johan Hattingh, Council for Geoscience, Port Elizabeth)

**TABLE 12: CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE ALGOA GROUP**  
(ANALYSED BY THE IWQS)

		A	B	C	D
EC	(mS/m)	288,0	212,0*	70,0	300,0
TDS	(mg/l)	1 834,0	1 356,0	1 200,0	2 000,0
pH		7,9	8,0	6 - 9	5,5 - 9,5
Na	(mg/l)	366,0	280,0	100,0	400,0
K	(mg/l)	3,4	2,9	200,0	400,0
Ca	(mg/l)	187,0	120,0	150,0	200,0
Mg	(mg/l)	66,0	42,0	70,0	100,0
Cl	(mg/l)	856,0	615,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	97,0	55,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	202,0	191,0	20 - 300	650,0
F	(mg/l)	0,2	0,2	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	2,45	1,49	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	0,012	0,011	-	-
Si	(mg/l)	12,6	10,2	-	-
NH <sub>4</sub> (as N)	(mg/l)	0,05	0,07	6,0	10,0
Fe	(mg/l)	*	*	0,1	1,0

\* = Not determined

A = Borehole; farm Sea View southwest of Alexandria; water interception in basal Alexandria conglomerate; yield 2,6 l/s.

B = Borehole; farm Paarden Valley southwest of Alexandria; water interception in basal Alexandria conglomerate, and possibly polluted by water from the underlying formation; yield 0,7 *l/s*.

**C = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**D = Drinking Water Quality Criteria: Maximum Allowable limit.**

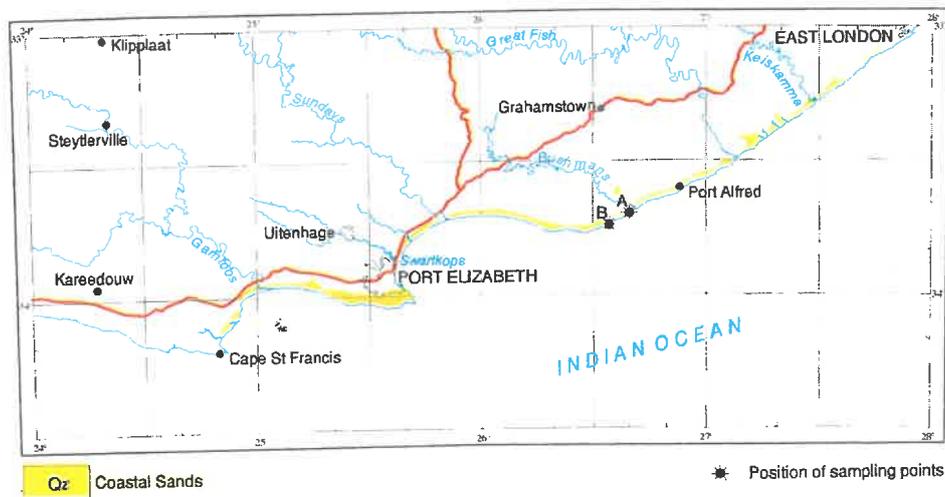
### 4.3.2 Coastal Sands

The Coastal Sand aquifer type occurs sporadically along the coast from Cape St. Francis to northeast of Port Alfred (Fig. 30). It consists of wind-blown sand, overlying beach deposits such as beach sand, pebbles and shell fragments (Reynders, 1984).

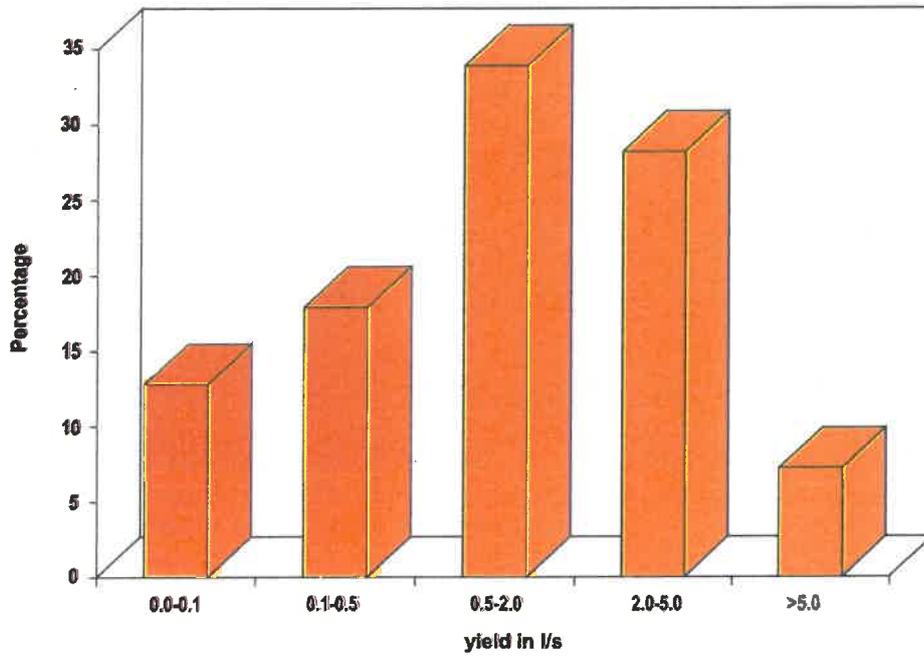
The more important geological and groundwater characteristics are as follows:

- Borehole yields vary between 0,10 and 15 *l/s*. A borehole yield analysis indicates that 26% of boreholes yield less than 0,5 *l/s*, and 4% yield more than 5 *l/s* (Fig. 31).
- Groundwater quality is potable, providing boreholes do not extend into underlying formations such as the Bokkeveld and Uitenhage beds where inferior groundwater quality might be obtained. ECs are generally less than 300 mS/m (Table 13). Sodium, total alkalinity and chloride often exceed maximum recommended and even maximum allowable limits (Table 13 and Fig. 32).

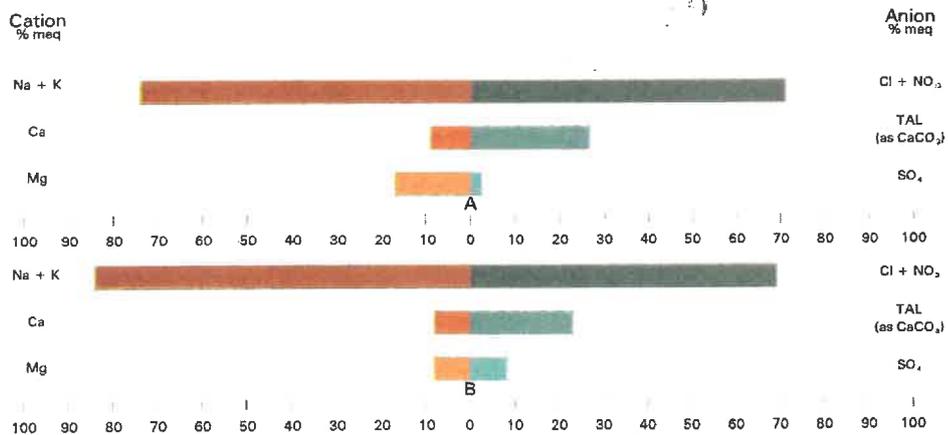
**FIG 30: AREAL LOCATION OF THE COASTAL SANDS AND POSITION OF SAMPLING POINTS FOR CHEMICAL ANALYSES SHOWN IN TABLE 13**



**FIG 31: YIELD FREQUENCIES OF BOREHOLES IN THE COASTAL SANDS  
(39 BOREHOLES ANALYSED)**



**FIG 32: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 13  
(COASTAL SANDS)**



**TABLE 13: CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE COASTAL SANDS**

(A WAS ANALYSED BY THE IWQS AND B WAS ANALYSED BY THE DEPARTMENT OF AGRICULTURAL TECHNICAL SERVICES)

		A	B	C	D
EC	(mS/m)	233,0	270,0	70,0	300,0
TDS	(mg/l)	1 374,0	1 775,0	1 200,0	2 000,0
pH		7,4	9,6	6 - 9	5,5 - 9,5
Na	(mg/l)	260,0	598,0	100,0	400,0
K	(mg/l)	8,0	-	200,0	400,0
Ca	(mg/l)	28,0	50,0	150,0	200,0
Mg	(mg/l)	37,0	30,0	70,0	100,0
Cl	(mg/l)	614,0	745,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	29,0	120,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	398,0	427,0	20 - 300	650,0
F	(mg/l)	*	1,0	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	*	*	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	*	*	-	-
Si	(mg/l)	*	*	-	-
NH <sub>4</sub> (as N)	(mg/l)	*	*	6,0	10,0

\* = Not determined

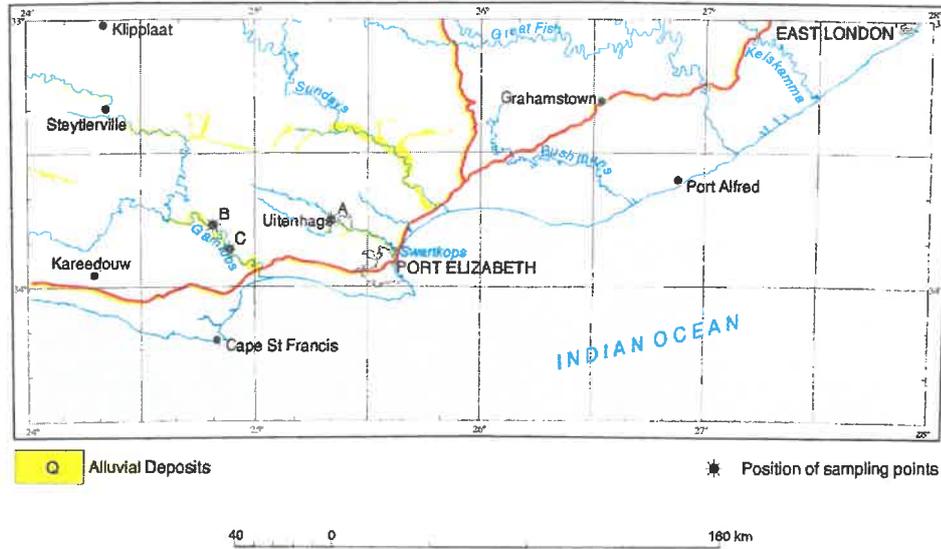
A = Borehole; Boesmansriviermond, southeast of Alexandria.  
 B = Borehole; Boknes, southeast of Alexandria.

**C = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**D = Drinking Water Quality Criteria: Maximum Allowable limit.**

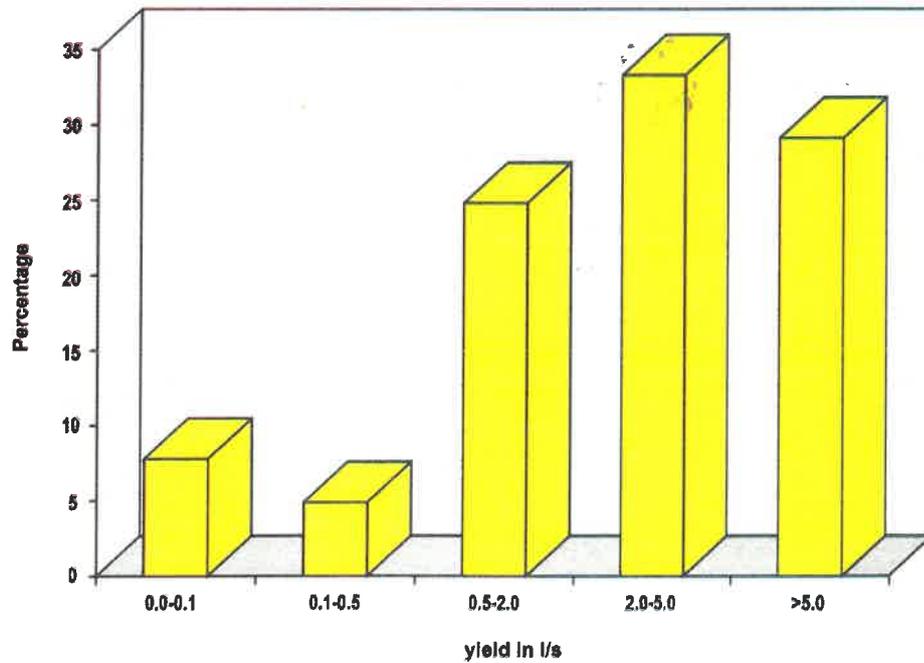
### 4.3.3 Alluvial Deposits

Alluvial deposits occur principally along the flood plains of the Sundays, Gamtoos and Swartkops Rivers (Fig 33). Minor occurrences have been reported along the Groot River southeast of Steytleville and along the Kariega and Holbak Rivers south of Glenconnor.

**FIG 33: AREAL LOCATION OF ALLUVIAL DEPOSITS AND POSITION OF SAMPLING POINT FOR CHEMICAL ANALYSES SHOWN IN TABLE 14**



**FIG 34: YIELD FREQUENCIES OF BOREHOLES IN THE ALLUVIAL DEPOSITS (306 BOREHOLES ANALYSED)**



The more important geological and groundwater characteristics are as follows:

- It consists of an assemblage of largely unsorted boulders, pebbles, sand and clay.
- Yields range between 0,1 and 15 l/s. A yield analysis indicates that 7% of boreholes yield less than 0,5 l/s and 26% yield more than 5 l/s (Fig. 34).
- Groundwater quality varies substantially between 20 and 600 mS/m (Sunday River Valley), 150 and 900 mS/m (Gamtoos River Valley), and 40 and 800 mS/m (Swartkops River Valley). Sodium, calcium, magnesium, chloride, total alkalinity and sulphate often exceed maximum recommended and maximum allowable limits (Table 14 and Fig. 35).

**TABLE 14: CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE ALLUVIAL DEPOSITS**  
(ANALYSED BY THE CSIR)

		A	B	C	D	E
EC	(mS/m)	90,0	910,0	152,0	70,0	300,0
TDS	(mg/l)	421,0	5 824,0	973,0	1 200,0	2 000,0
pH		7,1	7,8	7,6	6 - 9	5,5 - 9,5
Na	(mg/l)	119,0	1 396,0	239,0	100,0	400,0
K	(mg/l)	3,0	46,4	11,7	200,0	400,0
Ca	(mg/l)	9,4	281,0	25,1	150,0	200,0
Mg	(mg/l)	18,0	245,1	28,1	70,0	100,0
Cl	(mg/l)	202,0	2 400,0	345,0	250,0	600,0
SO <sub>4</sub>	(mg/l)	46,0	636,0	62,0	200,0	600,0
TAL (as CaCO <sub>3</sub> )	(mg/l)	20,0	535,0	144,0	20 - 300	650,0
F	(mg/l)	<0,2	*	*	1,0	1,5
NO <sub>3</sub> + NO <sub>2</sub> (as N)	(mg/l)	<0,01	*	*	6,0	10,0
PO <sub>4</sub> (as P)	(mg/l)	<0,1	*	*	-	-
Si	(mg/l)	*	*	*	-	-
NH <sub>4</sub> (as N)	(mg/l)	<0,1	*	*	6,0	10,0
Fe	(mg/l)	*	*	*	0,1	1,0

\* = Not determined

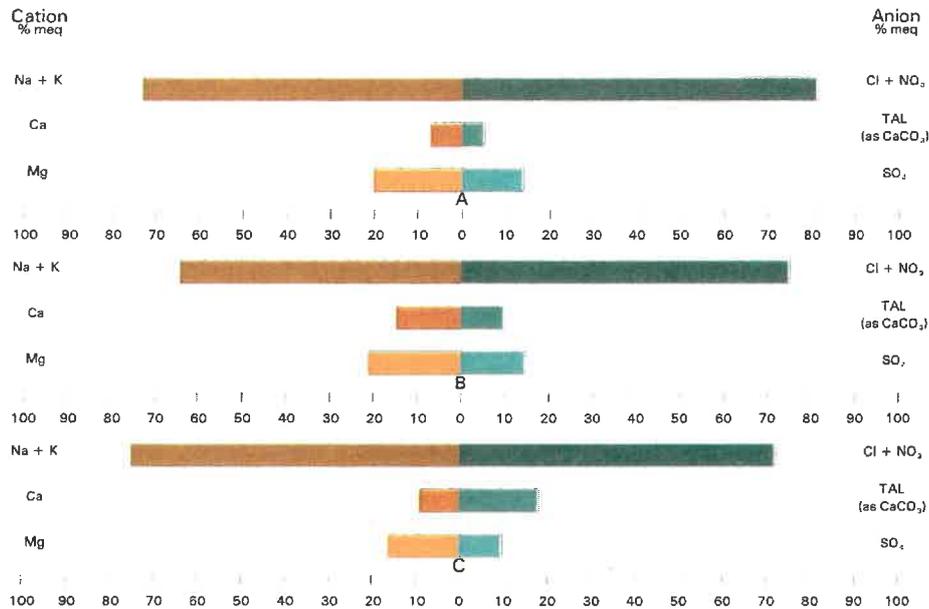
A = Borehole; Swartkops River; yield 4,6 l/s.

B = Borehole; Gamtoos River; yield 2,0 l/s.

C = Borehole; Gamtoos River; yield 6,3 l/s.

**D = Drinking Water Quality Criteria: Maximum Recommended limit.**  
**E = Drinking Water Quality Criteria: Maximum Allowable limit.**

**FIG 35: STIFF DIAGRAMS OF THE CHEMICAL ANALYSES IN TABLE 14  
(ALLUVIAL DEPOSITS)**



## 5 GROUNDWATER RELATED ISSUES

### 5.1 Previous Investigations

The Port Elizabeth Hydrogeological Map and Explanatory Brochure were compiled by utilising data obtained from various previous investigations and research projects. These investigations and research projects were executed by DWAF, various universities and a number of groundwater consultants. Investigations include among others, borehole sitings for farmers and groundwater exploration for municipal water supplies such as Humansdorp, St. Francis Bay, Jeffreys Bay, Kareedouw, Steytterville, Bushmans River Mouth, to name but a few. A fair regional spread of data was attained from numerous regional borehole surveys.

### 5.2 Groundwater Levels

Taking all the formations into account, an analysis of the available data indicates that the highest percentage of water levels shallower than 10 m occur

in the TMG and Beaufort Groups, as well as in the Coastal Sands and Alluvial Deposits (Table 15). This phenomenon can amongst others, be attributed to:

- low relief conditions in the Coastal Sands and areas of Alluvial Deposits,
- sub-artesian conditions in the TMG and Beaufort Groups, and
- favourable recharge conditions in the Coastal Sands, Alluvial Deposits and in the TMG.

The relatively high percentages of water levels deeper than 30 m in the Algoa, Witteberg, Uitenhage and Gamtoos Groups, can broadly be ascribed to:

- high relief conditions in the sandstone units of the Witteberg and the varied metamorphosed rocks of the Gamtoos Groups,
- the imperviousness of, and lack of groundwater recharge in the Uitenhage Group and in the shale units of the Witteberg Groups, and
- the lack of groundwater build-up in the Algoa Group as a result of the high permeability of the basal Alexandria conglomerate.

With the exception of the Jeffreys Bay area, where occasional excessive groundwater abstractions take place, no particularly deep water levels caused by over-abstraction are found in the area covered by the map. Excluding areas of major groundwater abstraction, seasonal fluctuations of water levels commonly vary between 1 and 5 m. In areas of large-scale withdrawal, e.g. the Jeffreys Bay area, fluctuations of up to 30 m may occur. Groundwater recharge during the rainy season is usually sufficient for water levels to recover to pre-dry seasonal levels. Exceptions can occur in the very dry areas of the Steytleville and Jansenville districts.

**TABLE 15: GROUNDWATER LEVELS BELOW SURFACE FOR THE DIFFERENT GEOLOGICAL UNITS, EXPRESSED AS PERCENTAGE**

Geological Unit	1	2	3	4	5
Gamtoos (Ng)	35,7	14,3	7,1	42,9	14
Table Mountain (O-St)	38,0	24,4	16,7	20,9	258
Bokkeveld (Db)	27,3	29,7	17,6	25,4	256
Witteberg (Dw)	21,8	23,9	17,0	37,4	813
Dwyka (C-Pd)	13,0	43,5	18,8	24,6	69
Ecca (Pe)	22,4	40,6	18,2	18,8	165
Beaufort (P-Trb)	29,4	33,7	19,5	17,3	323
Suurberg (Js)	14,3	42,9	42,9	0	7
Uitenhage (J-Ku)	26,6	28,5	14,0	30,8	214
Algoa (T-Qa)	16,2	14,4	19,8	49,6	278
Coastal Sands (Qz)	58,7	15,9	12,7	12,7	63
Alluvial deposits (Q)	27,6	20,7	27,6	24,1	29

- 1 = percentage of water levels <10 m below surface.
- 2 = percentage of water levels >10 m <20 m below surface.
- 3 = percentage of water levels >20m <30 m below surface.
- 4 = percentage of water levels >30 m below surface.
- 5 = number of water levels analysed.

### 5.3 Borehole Siting Methods

In the CFB, geophysical methods of siting boreholes are limited in their application and are used as an aid only when deeper structures are totally obscured. As fracture, joint and fold structures are generally the principal features to focus on when siting boreholes, the use of aerial photographs is crucial. A thorough field reconnaissance of the geology, topography and climate, together with the collection and interpretation of hydrocensus data is essential. Once a broad picture of conditions on the ground has taken form, obscured features can be traced geophysically, applying the electrical resistivity and electromagnetic methods, and in exceptional cases the magnetic method. The seismic and gravity methods are generally applied when more extensive regional surveys are required (refer to Table 16). The necessity of using trained personnel to site boreholes cannot be over-emphasised.

**TABLE 16: GUIDELINES FOR BOREHOLE SITING**

Geological Unit	1	2	3	4	5	6	7
Gamtoos (Ng)	••	•					
Table Mountain (O-St)	•••						
Bokkeveld (Db)	••	•	•				
Witteberg (Dw)	••	•	•				
Dwyka (C-Pd)	••		•	•			
Ecca (Pe)	••	•	•				
Beaufort (P-Trb)	••	•	•	•	•		
Suurberg (Js)	•			••			
Uitenhage (J-Ku)	•	•					
Algoa (T-Qa)							•••
Coastal Sands (Qz)						•••	
Alluvial deposits (Q)						•••	
• used on limited scale;      •• moderately used;      ••• widely used							

- 1 = Targeting fracture, joint and fold structures.
- 2 = Targeting interbedded sandstone.
- 3 = Employing alluvium as recharge medium to underlying rocks.
- 4 = Targeting weathering zones.

- 5 = Targeting intrusion contact zones.
- 6 = Targeting sand/alluvium occurrences.
- 7 = Targeting basal conglomerate.

## **5.4 Groundwater Management**

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For the optimum development of a groundwater source, sound groundwater management practices are essential in order to prevent exhaustion and/or pollution of the source.

Groundwater management by means of water level monitoring, evaluation with regard to volumes abstracted, and suitable water quality monitoring should be applied where bulk abstraction takes place or where pollution of groundwater sources is likely, or where groundwater sources are generally vulnerable.

A fairly common groundwater management approach, applied in many parts of the CFB, is the conjunctive use of groundwater and surface water. Groundwater is accordingly utilized during dry periods when little surface water is available. Surface water is utilized during wet periods, allowing recharge of groundwater sources during wet conditions. This commendable strategy should be employed wherever possible.

Sea-water intrusion in both the limited Coastal Sand aquifer and the TMG sandstone aquifer is possible in places. As far as the TMG sandstone aquifer is concerned, areas such as Port Elizabeth and St. Francis Bay are at risk.

Waste disposal and sewage sites should be selected with great care by groundwater pollution specialists in order to protect aquifers in areas where contamination from surface sources is possible.

## **5.5 Groundwater Utilization**

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Groundwater is widely utilized throughout the map area, mainly for stock watering and domestic purposes, but also to a much lesser degree for irrigation and urban purposes in a number of localities (Table 17).

An area where groundwater potential is particularly scant is the region between the Grootrivierberge and the Baviaanskloof - Winterhoekberge from west of Steytlerville to Paterson and even further east towards Kenton-on-Sea. The lack of potable groundwater seriously restricts development in this area.

Coastal towns and vacation venues like Bushmans River Mouth, Kenton-on-Sea and Port Alfred abstract some groundwater for domestic use from the Coastal Sands along the coast. Abstraction generally amounts to less than 100 000 m<sup>3</sup>/a.

The only region where surface water is relatively abundant is the largely mountainous southwestern portion of the map area where the conjunctive use of surface water and groundwater can fruitfully be practised.

In terms of groundwater utilization, the Uitenhage Subterranean Government Water Control Area (USGWCA) merits particular mention. The control area is divided into two compartments by means of the east-west striking Coega Fault. The northern compartment is known as Coega Ridge and consists of quartzitic sandstones of the TMG in the western portion of the compartment, and conglomerates, fine-grained sandstone and mudstone of the Uitenhage Group in the eastern portion of the compartment. The total abstraction from the Coega Ridge compartment is estimated at  $4,8 \times 10^6 \text{ m}^3/\text{a}$ . Transmissivity values for the quartzitic-sandstone vary between 20 and 200  $\text{m}^2/\text{day}$  and water quality is generally good, averaging about 30  $\text{mS/m}$  (Venables, 1985).

The southern compartment is known as the Uitenhage Trough and contains two artesian areas, namely the Kruisfontein and Bethelsdorp sub-compartments. The Kruisfontein aquifer is formed by fine-grained sandstone and conglomerate of the Uitenhage Group. Large abstractions have resulted in cessation of artesian flows. Abstraction is calculated at  $2,05 \times 10^6 \text{ m}^3/\text{a}$ . Highly fractured TMG quartzitic-sandstone forms the Bethelsdorp aquifer. The majority of boreholes have fallen into disuse and abstraction amounts to only 11 500  $\text{m}^3/\text{a}$ . Only four weak artesian boreholes, with a combined yield of less than 0,4  $\ell/\text{s}$ , persisted in 1985 (Bush, 1985). No artesian boreholes were listed during the 1996 hydrocensus. Groundwater quality in the Uitenhage Trough is good, averaging about 76  $\text{mS/m}$ .

A 1103 m deep artesian borehole was drilled in the Swartkops area of the USGWCA in 1908, which subsequently became known as the Swartkops Spa. The initial yield of 13,1  $\ell/\text{s}$  diminished to 4,7  $\ell/\text{s}$  in 1967. The water temperature of 40,5°C at the 1035 m interception increased to 54,5°C at the 1086m interception. Due to casing corrosion, artesian water leaked into the Uitenhage beds and the borehole had to be blocked off in 1967. It fell into disuse and has since been destroyed.

**TABLE 17: LOCALITIES WHERE LARGE-SCALE  
GROUNDWATER ABSTRACTION (>100 000 M<sup>3</sup> / A)  
TAKES PLACE**

Locality / Area	Approximate Abstraction (1996) (10 <sup>6</sup> m <sup>3</sup> /a)	
	Urban	Agriculture
Alexandria	0,24	-
Humansdorp	1,10	-
Jeffreys Bay	1,85	-
Sundays River Valley	-	2,0
Steytlerville	0,10	-
St. Francis Bay	0,55	-
St. Albans	-	0,20
Uitenhage (USGWCA)	1,10	5,70
Fish River Mouth	0,22	-
Cape St. Francis	0,10	-

## **5.6 Recommendations for Future Studies**

**Suggestions for more detailed groundwater related studies include the following:**

- Evidence exists of deep groundwater circulation mainly in the TMG sandstones. To elucidate this phenomenon, the tectonics of the CFB and associated fracturing of the deeper sections of the TMG and its groundwater exploitation potential should be studied comprehensively.
- The relative competency of rocks in the CFB plays a key role in the occurrence of groundwater. Relative rock competencies and associated brittle failure should be studied to target areas of promising groundwater potential.
- Core drilling on a variety of faults is recommended in order to establish to what extent permeability inhibiting material occurs in joints and fractures and to shed light on depth of fracture occurrence.
- Little is known about groundwater properties in rocks of the CFB such as recharge, transmissivity, storage etc. Isotope studies as well as more conventional study methods to gain further knowledge in this field should be encouraged.
- The influence of afforestation and deforestation on the groundwater regime is relatively unknown at present and needs further investigation.

- ❑ The possible development of karst features in the Kaan Formation of the Gamtoos Group, and its groundwater potential should be investigated.
- ❑ The distribution and mode of occurrence of springs in the CFB with particular emphasis on their occurrence in the TMG, needs to be examined.



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**Cover photograph**

Sandstones of the Table Mounted Group along the Tsitsikamma coast. Due to the highly fractured nature of the sandstones in many localities, the Table Mountain sandstones constitute one of the most outstanding aquifers in the map area.



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