

GH 3878

GROUNDWATER CHARACTERIZATION OF THE
NORTHERN SECTION OF THE 1: 250 000 VRYHEID (2730)
HYDROGEOLOGICAL MAPSHEET

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General

1. INTRODUCTION

1.1. Objectives

The Directorate: Geohydrology of the Department of Water Affairs is currently involved in the production of geohydrological mapsheets at the scale of 1 : 500 000 covering the whole of the Republic of South Africa.

The province of KwaZulu - Natal, which is broadly covered by two 1 : 500 000 maps, namely 2730 Vryheid and 2928 Durban, was recently mapped and characterized by a number of groundwater consultants. A small portion of the Vryheid sheet does not fall into the province of KwaZulu - Natal, but lies in Mpumalanga and was therefore not covered by the work of consultants. It was hence necessary to characterize this part at a scale of 1 : 250 000 as well in order to complete the 2730 Vryheid hydrogeological map.

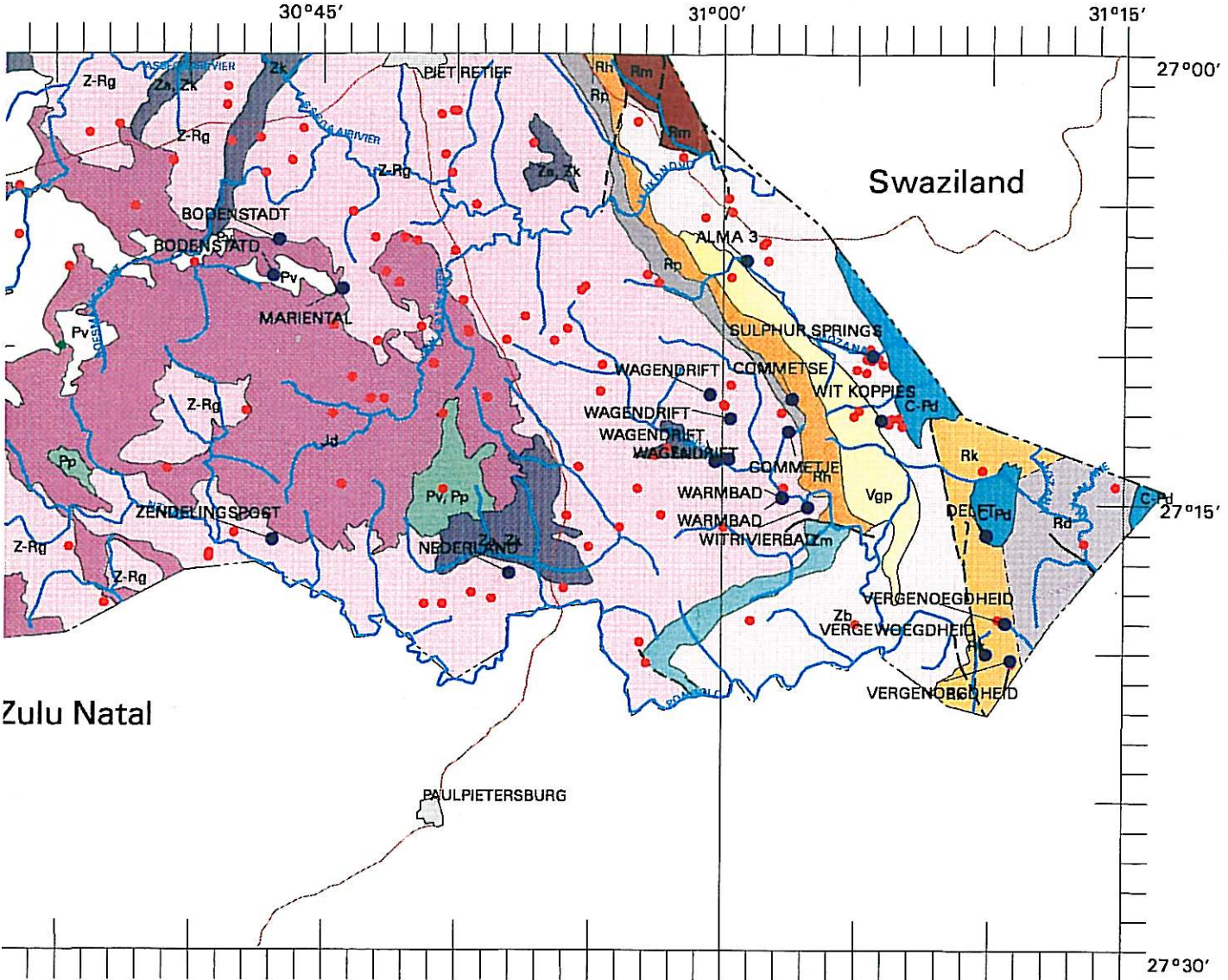
2. METHODOLOGY

A paucity of groundwater data on the National Groundwater ^{D B} data bank (NGDB) for this area necessitated a borehole survey to collect data on boreholes, springs, abstraction from boreholes and other information pertaining to groundwater. Groundwater consultants were appointed to carry out the survey, which, due to financial and time constraints, was restricted to predefined farms covering the study area in a regular network.

The area is characterized by a scarcity of boreholes, as many farms rely solely on springs and streams for their water supply and do not utilize any boreholes (see map 1). By only visiting a predetermined selection of farms boreholes which may well occur in the vicinity were not recorded and large areas appear to be without boreholes. The resulting paucity of groundwater data on the one hand and irregular spacing on the other has made data evaluation difficult and to a certain extent biased.

Table 1 shows the number of boreholes/fountains existing on the NGDB (includes the data collected during the field survey).

MOUNTAINS



<p>ORMATION andesitic lava</p> <p>IGA FORMATION thin lava flows</p> <p>coarse-grained ite</p> <p>ON SEQUENCE hart, iron formation</p> <p>ON SEQUENCE a, talc-carbonate schist</p>	<p> Geological boundary</p> <p> Inferred geological boundary</p> <p> Dyke</p> <p> Fault</p> <p> Inferred fault</p>	<p> Fountain</p> <p> Borehole</p> <p> Artesian borehole</p> <p><i>Unusual springs?</i></p>	<p>Reference</p> <p> International boundary</p> <p> Provincial boundary</p> <p> Main road</p>
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	Boreholes	Fountains
Accurate to within 10 metres	0	0
Accurate to within 100 metres	221	30
Accurate to within 1000 metres	3	0
Accurate to within 10 000 metres	108	0
No information	4	0
Total	336	30

Table 1: Available borehole information

3. DESCRIPTION OF STUDY AREA

The study area is bounded in the west by the 30° longitude, in the north by the 27° latitude. The eastern and southern boundaries coincide with the borders of Swaziland and KwaZulu - Natal respectively. The total area of the study area is 4100 km².

3.1. Terrain morphology

After Kruger (1983) the area is divided into the following terrain morphological units:

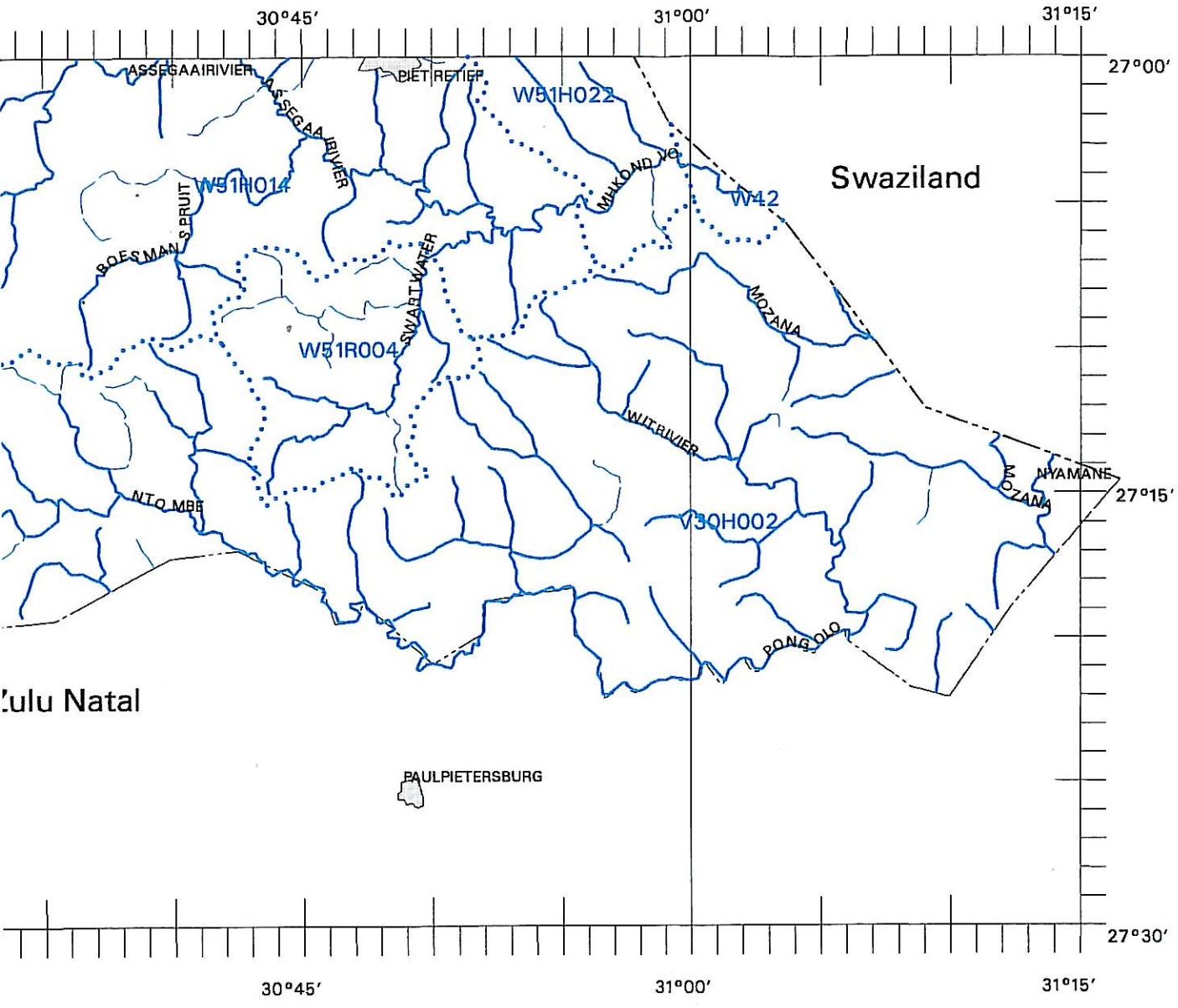
- strongly undulating plains in the northwest of the study area
- moderately undulating plains in the north
- the north east of the area is classified as undulating hills and lowlands
- low mountains and
- strongly undulating irregular land occurs in the south

*give elevations
a. w. s. l.*

The low mountains are separated from the undulating plains and irregular land by a distinct escarpment, which crosses the area in a north - south direction, turning east - west near Wakkerstroom.

Figure to portray terrain morphology will be added to the report later.

ONS AND DAMS



3.2. Surface Water Hydrology:

The major drainage systems draining the study area are the Pongola System towards the south and south east, the Vaal System towards the north and north west and the Tugela catchment towards the south (see map 2). No large rivers dissect the area, except the Pongola River which, in its ^{lower} later course forms the provincial boundary between Mpumalanga and KwaZulu - Natal. Although the Pongola river is perennial, flow might be reduced considerably during periods of drought. The river rises in the escarpment described before.

Apart from the Pongola River the Assegai River is relatively important. It is dammed up in the Heyshope dam near Driefontein (storage capacity 465 266 mill m³). The second dam, in this case a municipal dam, is the Martins dam near Wakkerstroom. *Not on Map 2*

In addition to the larger rivers, numerous streams and rivulets occur in the area, very often fed by perennial springs, which provide an adequate and reliable water source.

4. GEOLOGY

Geologically, the study area may be divided into two sections approximately along the 30° 30' longitude (see map 3):

- an eastern semicircular band in which Pre - Karoo rocks crop out and
- the western portion, which is dominated by Karoo sediments and dolerite intrusions.

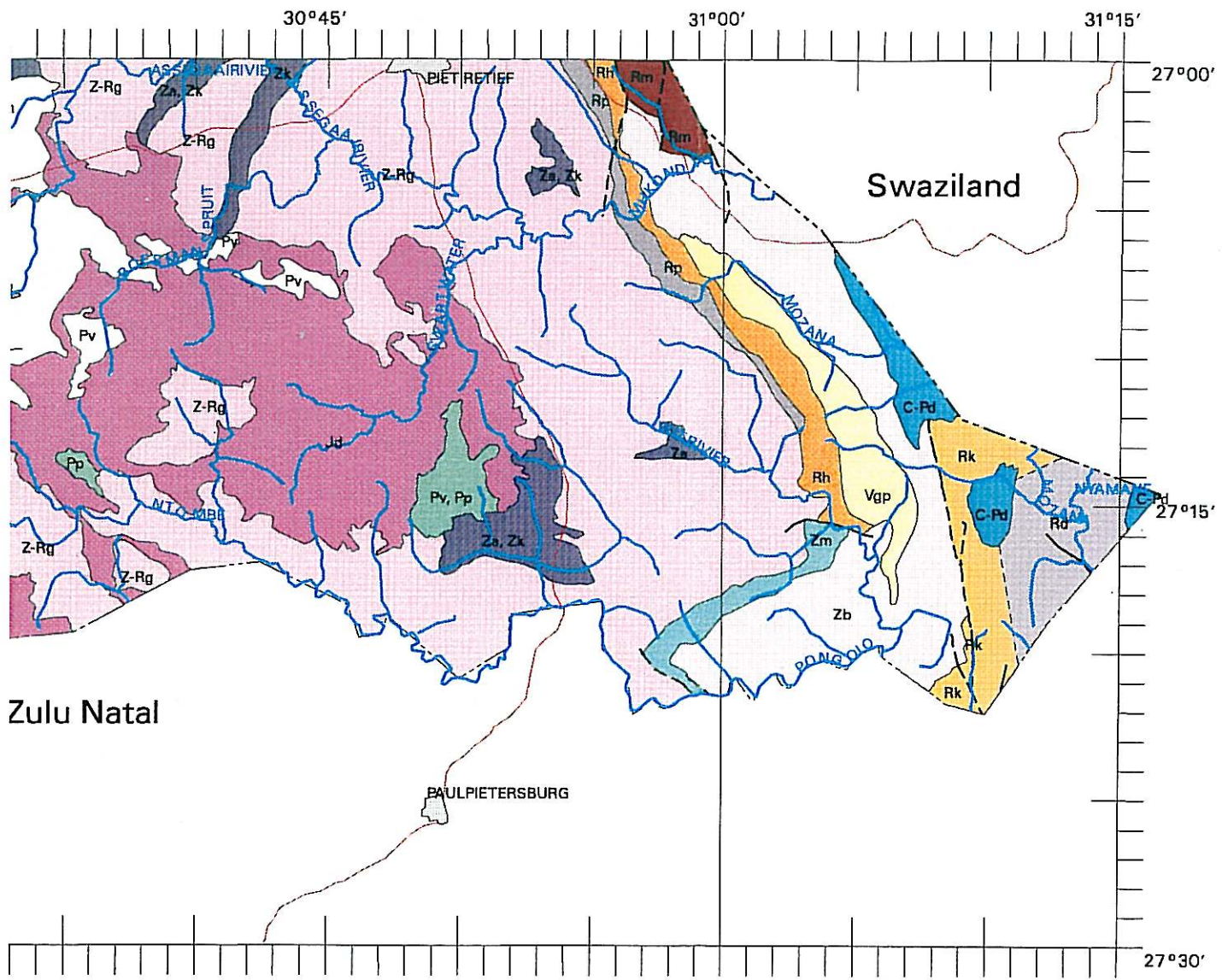
The oldest rocks in the area are the metasedimentary and ultrabasic - basic igneous rocks of the Barberton Sequence. They occur as xenoliths in the Archaean basement granite and consist of amphibolite (Za) and quartzitic chert (Zk).

Three types of Archaean granite (Z - Rg), namely a medium to coarse - grained biotite granite, a porphyritic biotite granite and a coarse - grained hornblende granite, have been identified (Linström, 1987).

The Archaean granite is unconformably overlain by the Pongola Supergroup represented in this area by the Nsuzé and the Mozaan Groups.

The lowermost Mantonga Formation (Zm) of the Nsuzé Group comprises mainly quartzite with thin intercalated lava and pyroclastic beds. The next unit of the Nsuzé Group, the Bivane Formation (Zb) consists of basaltic and andesitic lava.

GEOLOGY



30°45' 31°00' 31°15' 27°00' 27°15' 27°30'

31VANE FORMATION
basaltic to andesitic lava






Group N500




MANTONGA FORMATION
sartzite, thin lava flows

edium- to coarse-grained stite granite

JARBERTON SEQUENCE
sartzitic chert, bordinate iron formation

JARBERTON SEQUENCE
nphibolite, talc-carbonate shist

-  Geological boundary
-  Inferred geological boundary
-  Dyke
-  Fault
-  Inferred fault

- Reference**
-  International boundary
 -  Provincial boundary
 -  Main road

map 3

Overlying the Nsuze Group is the Mozaan Group (Rm), which consists of a thick succession of quartzite and shale. It outcrops in the top eastern corner of the study area and is bounded by north - south striking faults.

Further in the south of the study area an outcrop of the Mozaan Group has been classified as belonging to the Subgroup Klipwal (Rk) (name not yet approved by SACS, 1980), also comprising a thick succession of quartzite and shale with thin beds of banded iron formation.

The rocks of the Pongola Supergroup have probably only experienced low - grade metamorphism, although they appear to have been exposed to at least two folding phases.

The Pongola Supergroup is intruded by various rocks of which the Usushwana Complex is the most important. Middle to coarse grained diabase sheets (Rd) most likely represent an early phase of the Usushwana magmatism, although they do not form part of the complex itself (Hammerbeck, 1977). The Usushwana Complex is made up of the Piet Retief (Rp) and the Hlelo Suite (Rh). The former represents a phase of primarily basic magmatism, with rocks ranging from gabbroic to dioritic in composition (Hammerbeck, 1977). Rocks belonging to the more acidic phase, like granophyres and microgranites, have been grouped into the Hlelo Suite.

Of the three separate granites which postdate the Pongola Supergroup only a porphyritic biotite granite (Vgp) occurs as a semicircular band in the northeastern and southeastern map area.

The larger part of the study area is covered by lithologies belonging to the Karoo Supergroup. The basal Dwyka Formation (C - Pd) is found only in isolated outcrops in the eastern study area. It consists of tillite with subordinate shales and sandstones. The Dwyka Formation is followed by the Eccca Group.

The Pietermaritzburg Formation (Pp) which conformably overlies the Dwyka Formation consists predominantly of shale. The succeeding Vryheid Formation (Pv) comprises medium to coarse grained sandstone. The uppermost succession in the Eccca Group is the Volksrust Formation (Pvo). It again, like the Pietermaritzburg Formation consists of shale and siltstone.

The Eccca Group is followed conformably by the Estcourt Formation (Pe) containing sandstone as well as carbonaceous shale.

The ubiquitous Karoo dolerite (Jd) consists of a complex network of sills and dykes. The dolerite is the youngest rock formation apart from insignificant alluvial deposits along the greater rivers and streams.

Lithologies belonging to the Karoo Supergroup are relatively undisturbed and lie near horizontally in the map area. Occasional small faults striking roughly NW / SE have been mapped.

5. HYDROGEOLOGY OF THE STUDY AREA

5.1. Groundwater Occurrence

The recommended map legend and mapping methodology for the compilation of regional hydrogeological maps of the Republic of South Africa at a scale 1 : 500 000 classifies the occurrence of groundwater according to the saturated interstitial properties of the rock types under consideration, either as

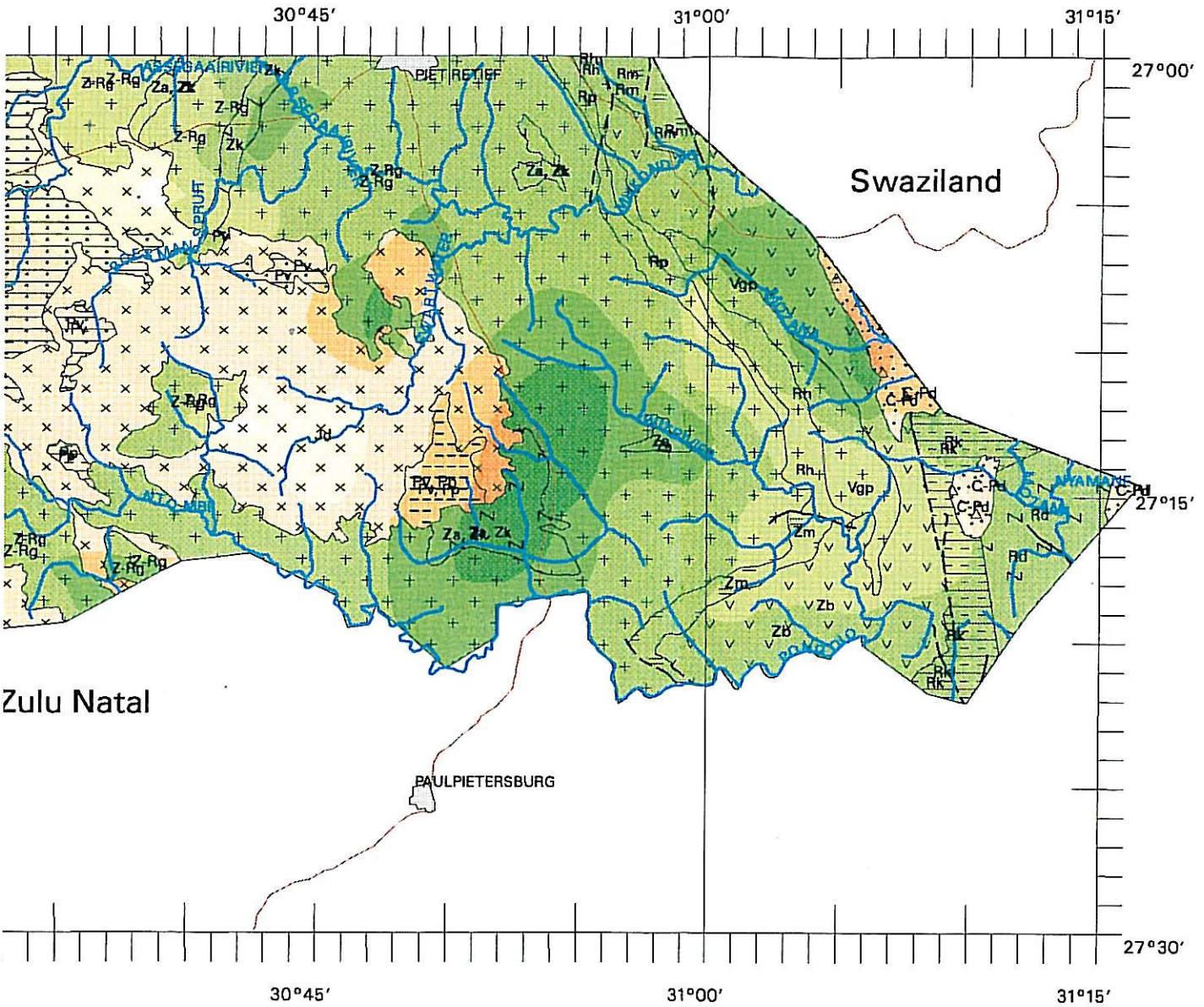
- i) intergranular (primary aquifers)
- ii) karst
- iii) fissured and fractured
- iv) fissured and fractured and weathered (secondary aquifers).

All mode of groundwater occurrences in the investigated area were classed as secondary aquifers, thereunder as fissured and fractured or fissured and fractured and weathered. Alluvium has been mapped along major rivers on the 2730 Vryheid 1 : 250 000 geological map. It is not considered to be important hydrogeologically as it does not attain great thicknesses and often has a high clay content (Linström, 1987). In view of the fact that no rocks of carbonate or ~~or~~ carbonate composition are found in the northern part of the map sheet karstic aquifers are not developed.

*-dit is
in o'plassing*

The Archaean granites, the quartzites, lithologies belonging to the Natal Metamorphic province as well as the Karoo dolerite sills and dykes are all classified as weathered and fractured and fissured. All sedimentary lithologies belonging to the Karoo Formation are only weathered to a very shallow depth, the main aquifer being the contact zones between dolerite sills and dykes and surrounding sediments and faults and fractures and are therefore considered as belonging to the class fissured and fracture only (see map 4).

GEOLOGICAL MAP



- Sandstone, shale
- Quartzite
- Undifferentiated metamorphic rocks
- Basaltic lavas
- Granite intrusives
- Diorite intrusives

- ### Reference
- International boundary
 - Provincial boundary
 - Main road

- Geological boundary
- Inferred geological boundary
- Dyke
- Fault
- Inferred fault

5.1.1. Fractured Aquifers

5.1.1.1. Volksrust shale and associated Karoo dolerite (Pvo and Jd)

As all of the lithologies belonging to the Karoo Group in the area of investigation, the Volksrust shale shows a near horizontal layering. There is no evidence of post - Karoo folding apart from that associated with the intrusion of dolerite and according to the 1 : 250 000 geological map 2730 Vryheid, very few structures or faults have been mapped in the Wakkerstroom/Volksrust area. It has been reported that primary structures in sediments such as bedding planes and contacts between layers of sandstone and shale are less successful groundwater targets (van Wyk, 1963). The shales are also characterized by a low primary porosity as well as low permeabilities (van Wyk, 1963).

Groundwater is therefore primarily found along the contact zones of dolerite intrusions and the surrounding host rocks, to a lesser extent also in existing faults and fractures, although it has been reported, that if these are not associated with dolerite sills or dykes they are usually lower yielding (van Wyk, 1963). The Karoo sedimentary lithologies do not yield meaningful supplies unless they are highly fractured and fissured. Further, if weathering has proceeded too far, the sandstones and shales may be converted to sandy clays and subsequently low permeability. As the contact zone between dolerite sills/dykes and underlying sediments (Volksrust shale, Estcourt and Vryheid sandstones) are important aquifers, the ubiquitous dolerites were not considered a class of their own, but grouped together with the surrounding sediments.

The improved water bearing characteristics of the otherwise poor yielding shale in contact with dolerite intrusions is attributed to alterations in the sediments in the contact zone: due to the heat generation associated with the dolerite intrusions the shale hardens and in consequence becomes more susceptible to jointing and fracturing and hence also to weathering. These 'baked' zones are usually intensely jointed with higher permeabilities than unaffected sediments, thus forming an aquifer.

It has also been noted, that boreholes intersecting the contact zone where dolerite sills or dykes overlie the sediment are generally higher yielding than those traversing the sediment/dolerite contact zone, so that it seems that the dolerite is the preferred groundwater target (Hofmeyr, 1995).

Weathering in the shales and dolerites is shallow (Hofmeyr, 1995) and no basins of weathering have been reported (van Wyk, 1963). Additional factors complicating the geophysical siting of boreholes in this area include

- scarcity of dykes

and overlying

Not clear

- very massive dolerite plates normally render the siting of boreholes as unsuccessful. Away from the edges of dolerite sheets the weathering is usually shallow. Feasible borehole target areas are more towards the edges of the sheets where dolerite thins out.

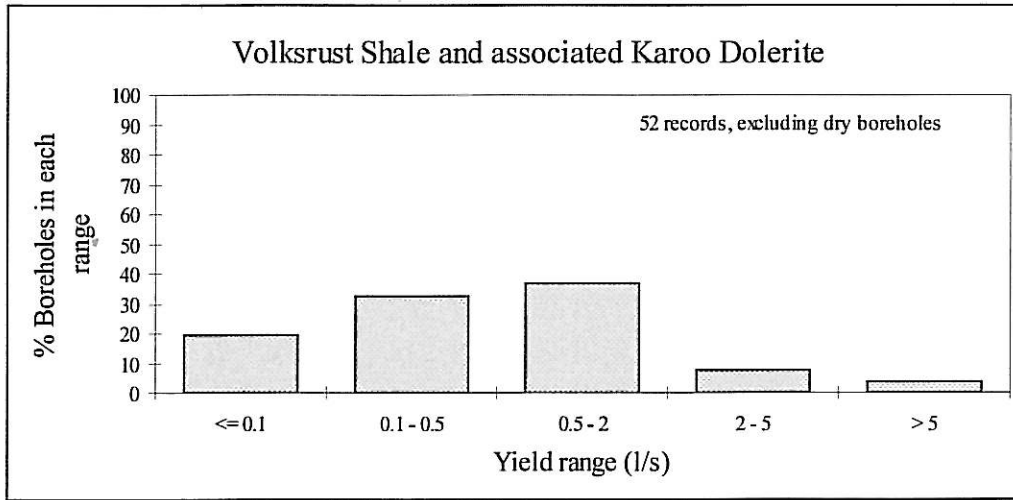


Figure 1: Borehole yield distribution (Pvo, Jd)

Evaluation of a total of fifty two records, excluding dry boreholes, which after the NGDB fall into the class Volksrust shale and associated Karoo dolerite (it needs to be stressed at this point, that the majority of the available records have coordinates accurate only to within 10 000 metres) shows that most borehole yields lie in the range of > 0.5 - 2 l/s (see Figure 1). More than 70% of all boreholes yield less than 1 l/s, the median yield is 0.5 l/s, the reported maximum 6.67 l/s (see Figure 2). Areas with high yielding boreholes are very localized and limited in extent.

The NGDB also has record of eleven dry boreholes apparently sited on the contact zone of shale and dolerite. According to their borehole logs most of the holes (seven records) penetrated the shale and were stopped in dolerite, which would confirm the above mentioned suggestion that siting on the contact dolerite/shale is potentially more successful than on shale/dolerite.

accommodative frequency graphs must be added to the data set.

better say lower or upper contact of a sill.

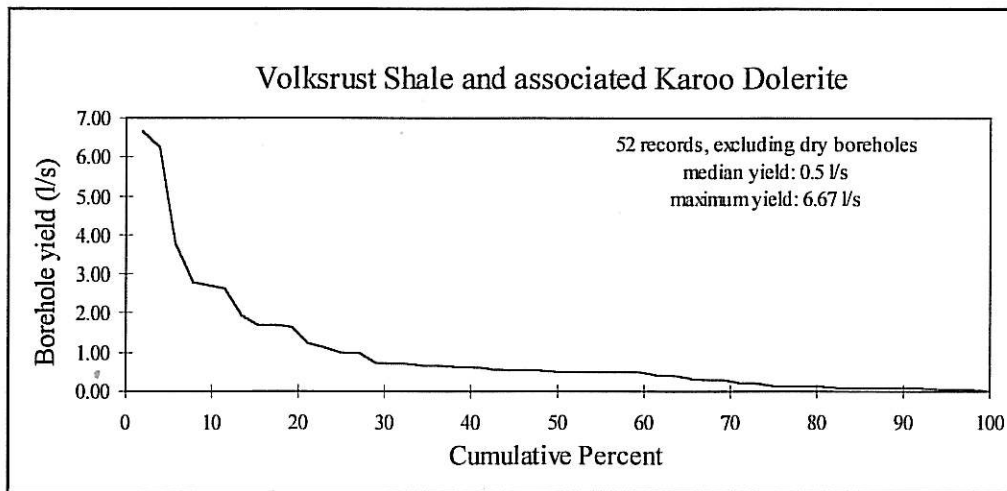


Figure 2: Yield probability (Pvo, Jd)

It has also been implied, that

- the contact zone has a higher permeability under a decomposed or fractured rock cover, but is impermeable under a cover of impermeable rock due to limited weathering.
- inclined intrusions such as dykes appear to yield higher productive boreholes than horizontally laying dolerite sheets *lack of or silts*.
- the yield of borehole decreases with distance away from dyke (van Wyk, 1963).

5.1.1.2. Vryheid and Estcourt sandstones and associated Karoo dolerites (Pv, Pe and Jd)

In principle the same characteristics as described above under the chapter Volksrust shale and associated Karoo dolerite also apply to the sandstones of the Vryheid and Estcourt Formations with dolerite. Groundwater is also primarily found in the altered contact zone around dolerite intrusions where the sandstone has become more quartzitic, more brittle and therefore more susceptible to jointing and weathering.

The Vryheid/Estcourt Formations are treated separately from the shale because of their less favourable water quality, which can be attributed to the carbonaceous content in the sandstone. On the other hand the hydrogeological properties of the Vryheid Formation and Estcourt Formations are considered to be similar and no distinction has been made between these two.

As was the case with the Volksrust shale, the majority of yields of analyzed boreholes falls into the yield range $> 0.5 - 2$ l/s (see Figure 3) The median and maximum borehole yields are

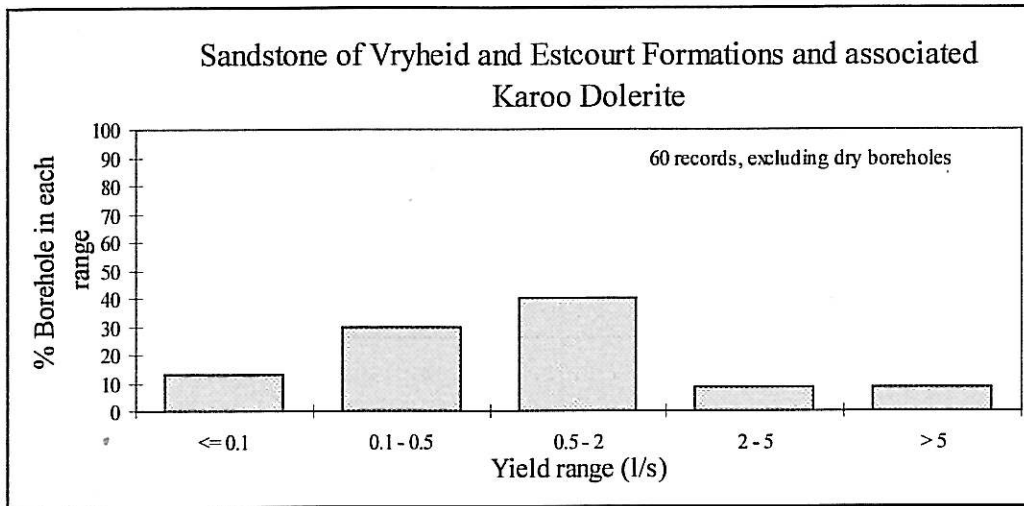


Figure 3: Borehole yield distribution (Pv, Pe, Jd)

slightly better at 0.67 l/s and 9.7 l/s respectively. More than 50% of the boreholes yield less than 1 l/s (see Figure 4). Again it would seem that boreholes with higher discharges are only ~~occur~~ as localized features. ✓ occur

Twenty reported dry boreholes which, according to their coordinates (again it needs to be emphasized, that except for one single borehole, all are accurate only within the nearest 10 000 metres) lie in sandstone/dolerite geology are listed on the NGDB. Their logs show that they

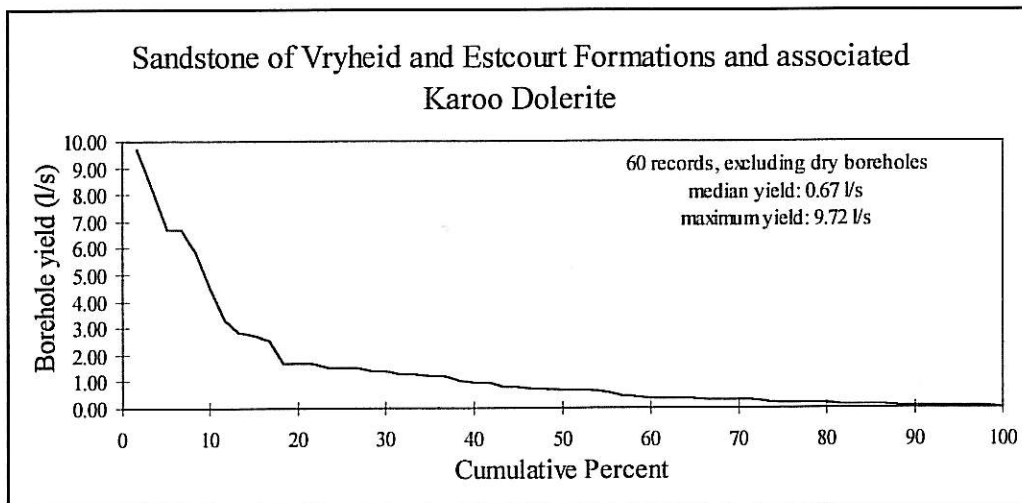


Figure 4: Yield probability (Pv, Pe, Jd)

either only penetrate sandstone or dolerite and do not intersect a contact zone or they intersect the contact dolerite/sandstone.

5.1.2. Weathered and fissured and fractured aquifers

5.1.2.1. Archaean Granite (Z-Rg), Hlelo Suite (Rh), Biotite Granite (Vgp)

All the acid to intermediate intrusives have been grouped together into one class. No yield records of boreholes falling into the Piet Retief Suite (Rp), only one penetrating the granophyres and microgranites of the Hlelo Suite (Rh) and two of the porphyritic biotite granite (Vgp) have been ^{drilled} recorded. This scarcity of data does not allow any separate characterization. It was assumed that all mentioned rock types have similar hydrogeological properties, on the basis that their petrography and petrology is comparable, although they may be of different ages.

The granites, granophyres and microgranites are intensely folded and faulted, leading to areas highly fractured with deep basins of decomposition. In many cases however, the granitic rocks have weathered to a sour clay, which reduces the permeability in these otherwise high potential groundwater target basins.

In many cases the ^{rugged} inaccessible topography renders promising borehole sites ^{but} impassable for drilling machines.

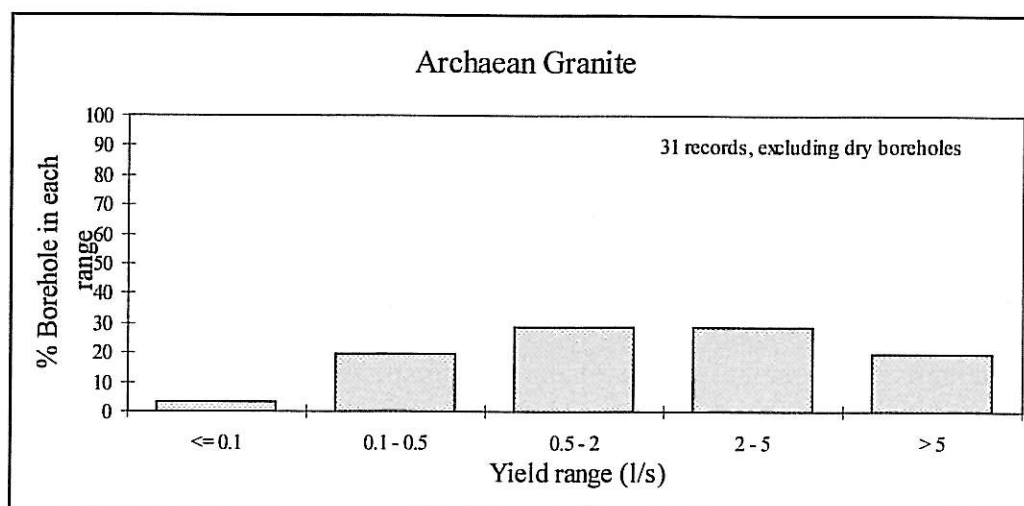


Figure 5: Borehole yield distribution (Z-Rg)

Of the 31 records, excluding dry boreholes, linked to the Archaean granites (Z-Rg), the classes $> 0.5 - 2$ l/s and $> 2 - 5$ l/s both hold the same number of yield records, followed closely on either side by the ranges $> 0.1 - 0.5$ l/s and > 5 l/s (see Figure 5). The median yield is 1.66 l/s, the maximum 13.5 l/s (see Figure 6). It would appear, that borehole prospects are better in the Z-Rg than they are in the rock types belonging to the Karoo Supergroup.

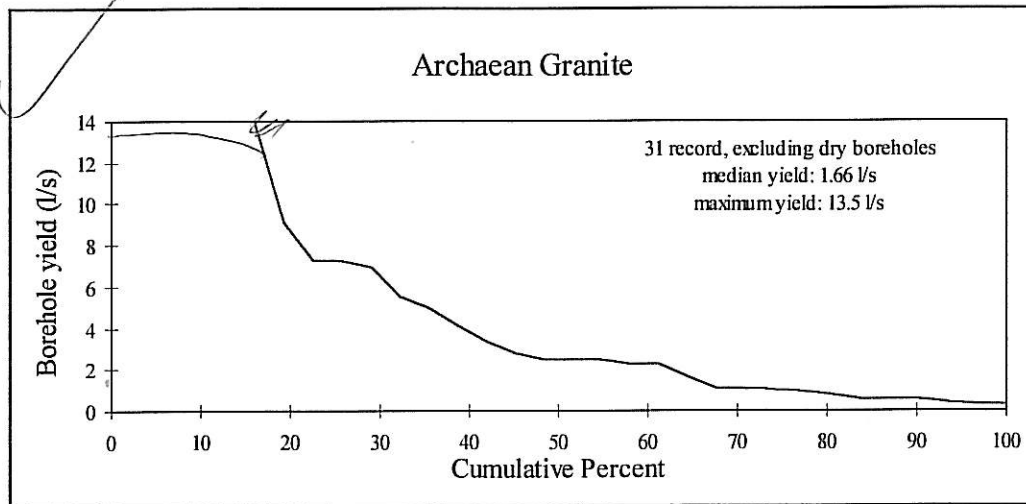


Figure 6: Yield Probability (Z-Rg)

Only two records are listed for the porphyritic biotite granite (Vgp), both falling into the class $> 0.5 - 2$ l/s. The median (in this case also the mean) yield is equal to 1.23 l/s, the higher yield of the pair being 1.9 l/s.

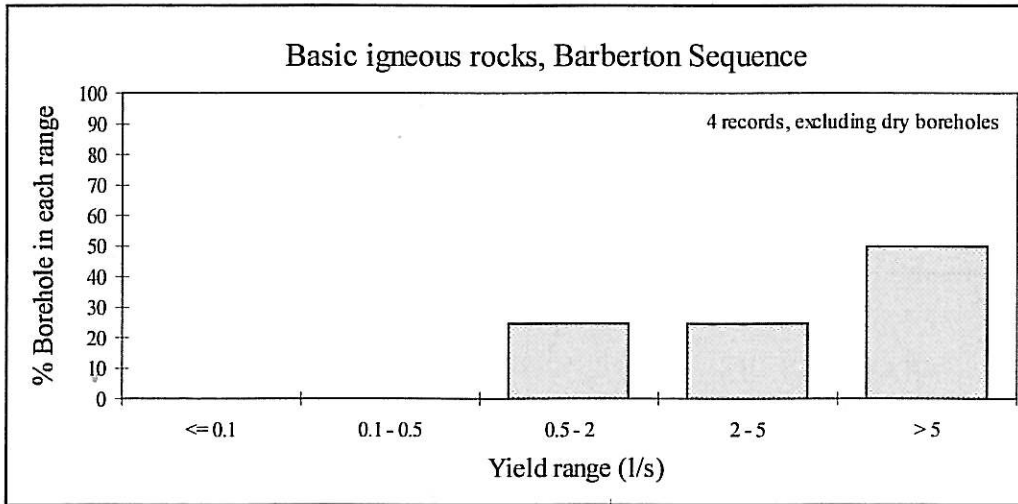
The ^{single} only discharge rate reported for the Hlelo Suite granophyres and microgranites has a value of 0.2 l/s and falls into the yield range $> 0.1 - 0.5$ l/s.

Five dry boreholes are recorded in the NGDB for the granitic type rocks, three in the Archaean granites (Z-Rg), two in the porphyritic biotite granite (Vgp).

5.1.2.2. Barberton Sequence (Za, Zk)

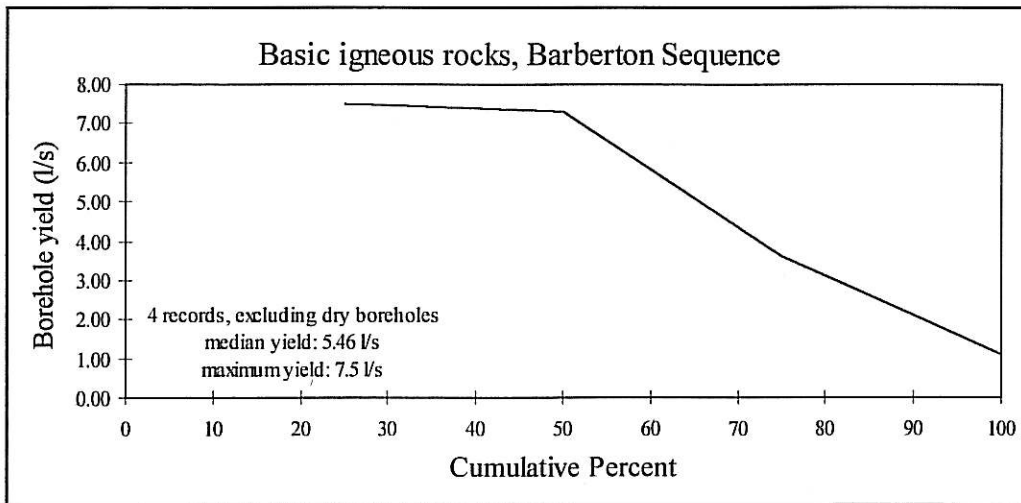
Groundwater occurs mainly in deeply weathered basins and fracture zones. The groundwater potential appears to be generally good, although data scarcity may be biased towards the results: two of the four yield records fall into the class > 5 l/s, no yields of the two lower ranges have been reported (see Figure 7). The median yield is 5.46 l/s, the maximum 7.5 l/s with 90% of the boreholes reportedly yielding more than 2 l/s (see Figure 8). One dry borehole has been recorded.

It is not needed to calculate median, and any % when there is only four records! Skip it!



No picture from four boreholes.

Figure 7: Borehole yield distribution (Za, Zk)



A
||

Figure 8: Yield probability (Za, Zk)

5.1.2.3. Bivane Group (Zb)

The basaltic to andesitic lavas of the Bivane Group are also grouped in the weathered, fractured and fissured group, with groundwater occurring in weathered basins and fracture zones. Of the eight yield records available, 40 % fall into the class > 5l/s (see Figure 9). A second peak can be seen in the class > 0.1 - 0.5 l/s. Nearly 70% of the captured records yield more than 1 l/s, the median for this group is 1.8 l/s, the maximum yield 7.5 l/s (see Figure 10). Eight dry boreholes are listed on the NGDB.

✓

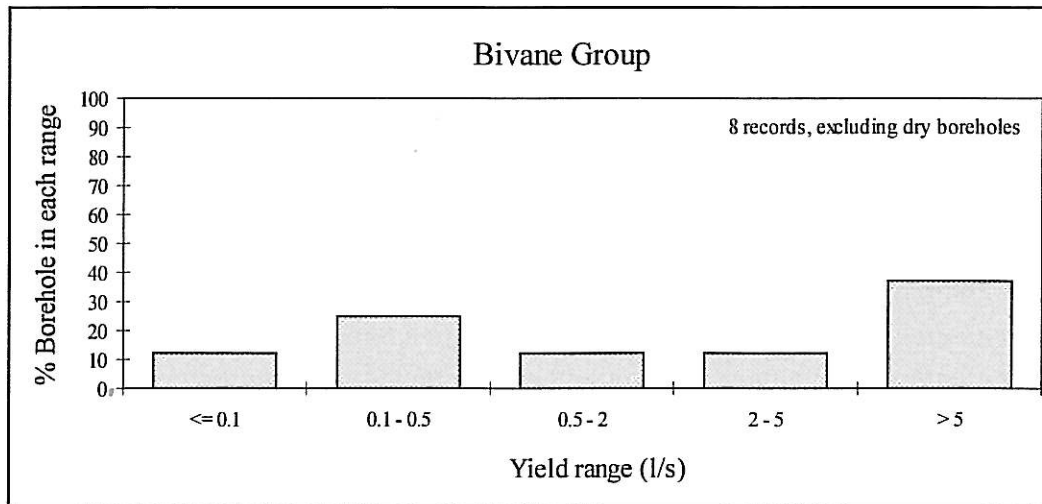


Figure 9: Borehole yield distribution (Zb)

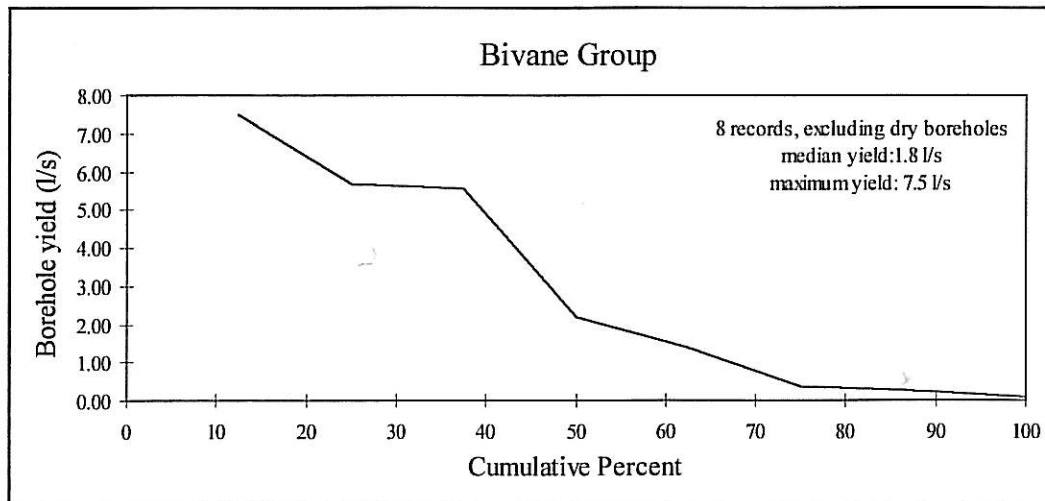


Figure 10: Yield probability (Zb)

5.1.2.4. Mantonga quartzite (Zm), Mozaan Group (Rm), Klipwal Subgroup (Rk) with Diabase (Rd), Dwyka Formation (C-Pd)

No yield records are available for the lithologies of the Mantonga quartzite (Zm), the Mozaan fissured and fractured with groundwater assumed to be occurring in weathered basins and faults and fracture zones. One discharge rate of 1.89 l/s is listed for the undifferentiated metamorphic rocks (folded succession of quartzite, shales and diabase) in the eastern most tip of the map area. Again, the contact zones between the intrusive sills and sedimentary rocks or between the quartzite and shale are the favourable water bearing target zones.

No yield records are available either for the Dwyka tillites (C-Pd), which occur in the far east of the area of investigation. The tillites are poor aquifers on their own with very few struc-

tures. Groundwater target areas are, as with all Karoo lithologies, on the contact zones to intrusive dolerites (Hofmeyr, 1995).

5.2 Recommended geophysical siting techniques

The following geophysical siting techniques are generally recommended for all hydrogeological units: magnetics, particularly to trace magnetic dolerite sills and dykes, electromagnetics and the resistivity method with constant electrode separation. *for other water bearing structures.*

6. HYDROCHEMISTRY

Approximately 150 field measurements (electrical conductivity (EC) in mS/m, pH and temperature (°C) were obtained from boreholes as well as springs in the study area. Additionally about 50 water samples were collected during the borehole survey and analyzed for macro elements by the Institute for Water Quality Studies at Roodeplaat.

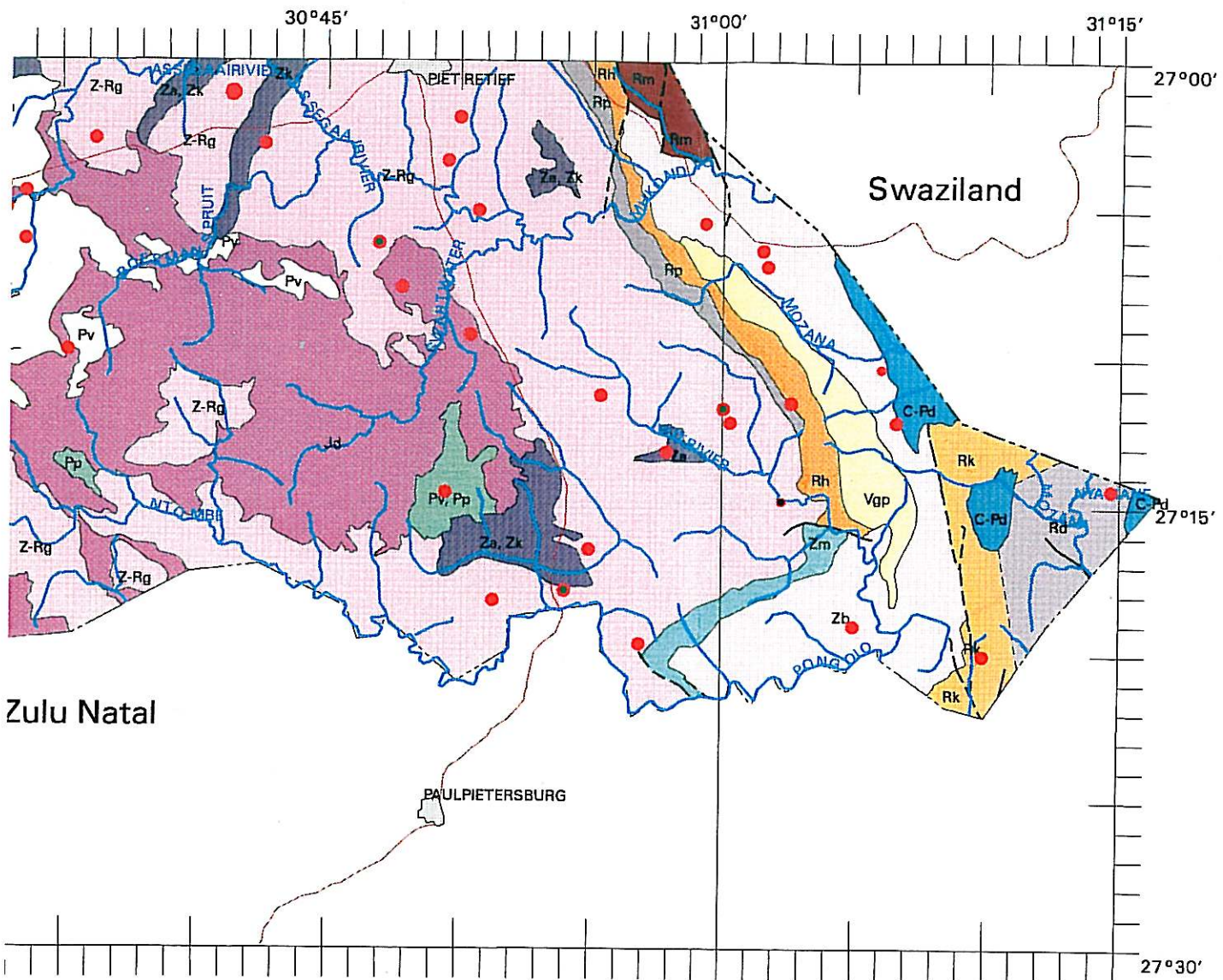
Generally the groundwater quality in the study area is ~~of a~~ very good quality. According to the guidelines for groundwater quality suitability (DWAF, 1993) an EC < 70 mS/m is suitable for domestic, stock and irrigation use. The majority of measurements taken and samples analyzed fall into this range. The average EC in mS/m for the whole study area is 24.68 at 25°C with a minimum of 4 mS/m to a maximum of 90 mS/m. The higher EC values tend to occur in the sandstones and shales of the Karoo Supergroup, although this fact needs to be verified by additional sampling.

The pH is very slightly basic showing an average for the whole area of 7.59. One low pH (5.1) was reported from a borehole on the farm THT 144 Goedetrouw west of Piet Retief in Archaean granites. Occasional pH values ≥ 8.5 were reported from Archaean granites (Z-Rg), basaltic to andesitic lavas of the Bivane Group (Zb) and Volksrust shale (Pvo). This might be indicative of beginning pollution, e.g. from the Assegai River which has tributaries draining the township Ethandakukhanya and the abattoir, but again, these possible trends need to be validated by ~~further~~ chemical analyses (see map 5).

more, better spread

Other hazardous chemical elements include fluoride and nitrate. Selected samples show fluoride concentrations greater than the permissible 1.5 mg/l (as may be expected occurring in Archaean granites and also in Volksrust shales). Only the occasional sample has nitrate concentrations as N greater than the permissible 10 mg/l (only reported from Archaean granites in the study area) (see map 5). No exceptionally high sulphate concentrations were measured, even

3 CHEMISTRY



<p>ORMATION andesitic lava</p> <p>IGA FORMATION thin lava flows</p> <p>coarse-grained ite</p> <p>ON SEQUENCE shert, iron formation</p> <p>ON SEQUENCE s, talc-carbonate shist</p>	<p> Geological boundary</p> <p> Inferred geological boundary</p> <p> Dyke</p> <p> Fault</p> <p> Inferred fault</p>	<p> Fluoride ≥ 1.5 mg/l</p> <p> NO₃ as N > 10 mg/l</p> <p> pH < 6.5</p> <p> pH ≥ 6.5 and < 8.5</p> <p> pH ≥ 8.5</p>	<p>Reference</p> <p> International boundary</p> <p> Provincial boundary</p> <p> Main road</p>
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Map 5

though some farmers mention that water from boreholes tends to have a sulphur smell, which is probably related to the coal bearing properties of the Estcourt Formation.

There is no significant variation in the chemical composition of groundwater from springs and wells.

6.1. Groundwater quality of lithologies belonging to the Karoo Supergroup

The piper diagrams of water samples taken from boreholes and springs in rocks of the Karoo Supergroup depict two types of water, namely Calcium - Magnesium - Bicarbonate and Sodium - Bicarbonate water. The Ca - Mg - HCO_3 water type appears to be typical of dolerite intrusives as well as sedimentary rocks of the Karoo Supergroup, while the Na - HCO_3 type is typical only of the Karoo sedimentary rocks.

still to be printed.

Figure 11, Piper Diagram, Volksrust Shale (Pvo)

still to be printed

Figure 12, Piper Diagram Vryheid and Estcourt Sandstone (Pe, Pv)

still to be printed

Figure 13: Piper Diagram, Dolerite (Jd)

6.2. Groundwater quality of Pre - Karoo lithologies

Chemical analyses of water samples taken from boreholes in pre - Karoo lithologies show a domination of the anions HCO_3^- and Cl^- , with very low concentrations of or no SO_4^{2-} . The cation content varies between Ca^{2+} and Mg^{2+} as well as Na^+ . Two samples from the Bivane Formation show particularly high sodium values.

still to be printed.

Figure 14: Piper Diagram, Pre - Karoo lithologies

7. GROUNDWATER USE

The majority of the boreholes in the study area are utilized for domestic use and stockwatering.

single ?

Irrigation is not very extensive in this area and mainly takes place from the readily available surface water. But stronger boreholes in particular are used for this purpose as on the farms Oogie THT146, Weeber THT147 (discharge 4,1 l/s), Rondekoppie NVD 70 (discharge 3,79 and 3.02 l/s) and Sulphur Springs THU 14 (discharge 5,5 l/s). No indications are given as to the size of the plantations.

No references are made to groundwater being used for mining purposes.

and municipal?

8. GROUNDWATER RECHARGE

Very few studies have so far been carried out to calculate the recharge in the area investigated and no detailed information is available.

Van Wyk (1963) undertook to determine the percentage of rainfall that infiltrates and becomes available as groundwater in an old mine near Hlobane, Vryheid District, situated in the Vryheid Formation of the Ecca Group. A mean annual recharge of 117 mm was obtained.

According to Vegters's map 'Mean Annual Groundwater Recharge, Scale 1 : 7,5 million' (1995), on which parameters such as mean annual rainfall and effective rainfall as derived by the ACRU model (Schulze, 1989) were taken into consideration, the mean annual recharge increases from 37 - 50 mm/a in the western portion of the study area to 50 - 75 mm/a in the east.

Another method used to calculate the groundwater recharge of an area is to assess the base flow component of rivers and streams. The base flow is assumed to represent the groundwater recharge for the catchment area upstream of the measuring point.

gauging

After a further map of Vegter 'Groundwater Component of River Flow (Base Flow), Scale 1 : 7,5 million' (1995) on which this method was implemented, the base flow in the study area varies from 0 - 2 % to 2 - 4 % of the mean annual precipitation. Mean annual precipitation for the study area is taken to be in the order of 700 mm/a.

9. SPRINGS AND ARTESIAN BOREHOLES

9.1. Cold Springs

Springs occur frequently throughout the study area (see map 1). They are generally associated with sub - horizontal dolerite sills, though numerous springs have also been mapped in the mostly older granites and quartzites in the eastern portion of the study area. Flow rates measured at some of the springs indicate that these are mostly less than 1l/s except for one strong

*Fluctuation of
spring flow 5*

spring on the farm Alma THU 3, where a flow rate of 7,5 l/s has been recorded. According to its coordinates this spring lies in the basaltic and andesitic lavas of the Bivane Group on the contact to interbedded tuff layers, although further information is needed to verify facts giving rise to this spring.

How strong?

Many of the farm households obtain their water from springs. The town Wakkerstroom utilized spring water in earlier years supplemented by water from the Martins dam for its water supply. Only in later years, after the pipelines from the springs needed to be repaired, all the water for the town was supplied from the Martins dam. (The water consumption of Wakkerstroom is, according to the town engineer, approximately 189 000 m³ annually).

9.2. Thermal Springs

Not on the maps!

The Geological map of the Republics of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of Lesotho and Swaziland depicts two thermal springs in the study area, namely:

- Sulphur Springs, south east of Piet Retief near the Swaziland border and
- Witrivierbad, south south east of Piet Retief.

After Kent (1968) Sulphur Springs has a flowrate of 6.3 l/s, its water temperature is 31.1°C and TDS (total dissolved solids) 130 mg/l. Its water bearing structure is described as a fault fracture in granite. Bond (1946) has classified this spring as belonging to the alkaline, sodium - carbonate water, with TDS less than 1000 mg/l, Na₂CO₃ or NaHCO₃ more than 15 % and the permanent hardness equal to zero. The spring, which is not in use today, is still flowing, although its current flow rate could not be measured on site.

on *at*
No information is available about the ~~second~~ spring Witrivierbad.

9.3. Artesian Boreholes

Three artesian boreholes were mapped during the field survey: two on the farm Spitskop THT 119, the third on the farm Rooikraal THT 173 (see map 1). All of them appear to be associated with dolerite intrusions into the Karoo sediments.

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