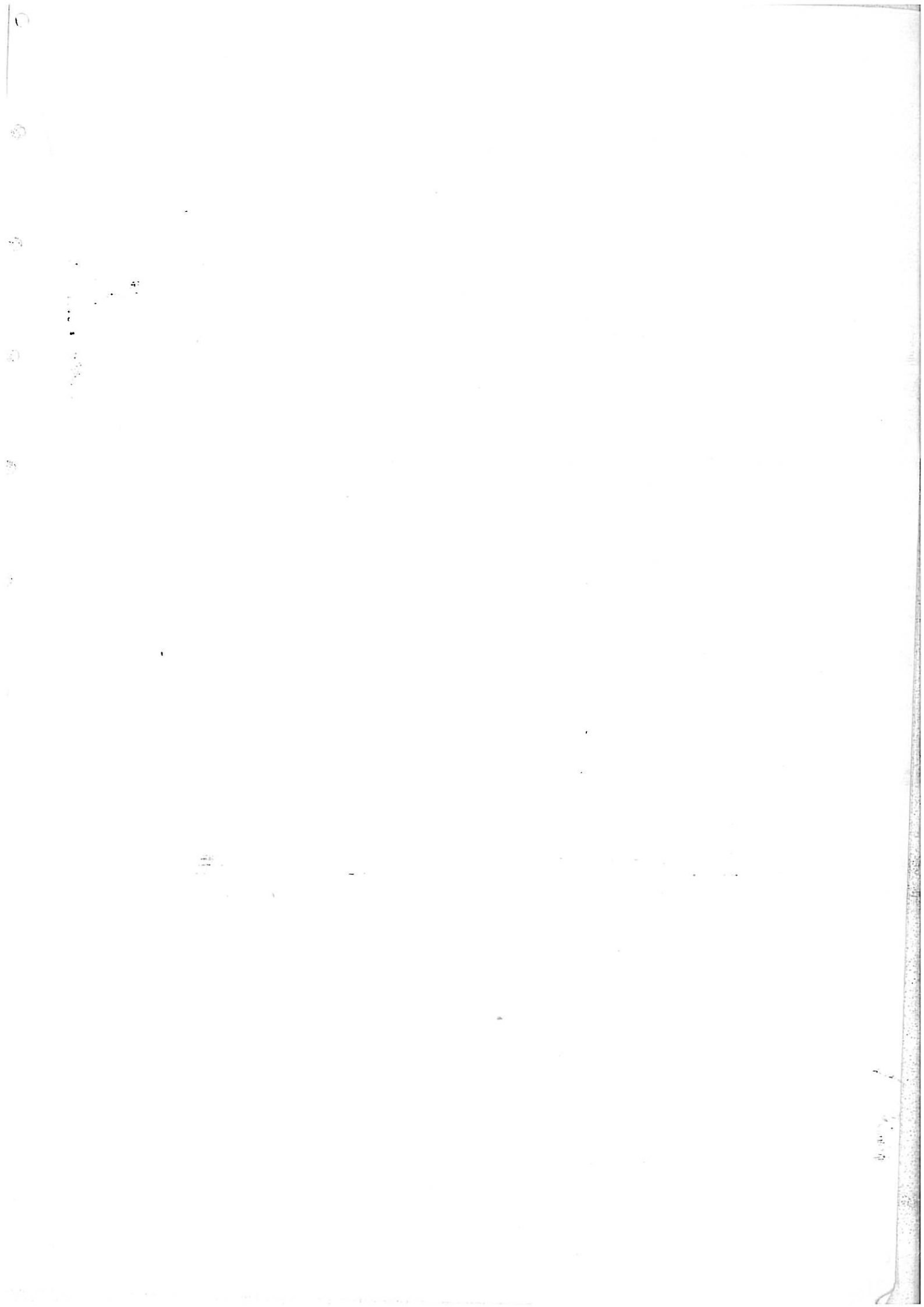


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PRELIMINARY REPORT ON THE GEOHYDROLOGY
OF THE CENOZOIC SEDIMENTS OF PART OF THE
COASTAL PLAIN BETWEEN THE BERG RIVER AND
ELAND'S BAY (SOUTHERN SECTION)

K M G TIMMERMAN
DIVISION GEOHYDROLOGY
CAPE TOWN

15 March 1985



ABSTRACT

This report deals with the results of a geohydrological investigation of part of the coastal plain between the Berg River and Eland's Bay and is a partial fulfilment of a request by the Division of Planning to report on the groundwater potential of the Lower Berg River region.

Preliminary calculations show that as much as $2500 \times 10^6 \text{ m}^3$ of groundwater is stored in two aquifers and an extensive intermediate aquitard situated in unconsolidated sediments between the Berg River and an imaginary boundary about 10 km north of and parallel with the Papkuils River. Most groundwater is brackish to saline. Groundwater with a TDS content of less than 2000 mg/l is found in the Papkuils River area and in the south-eastern portion of the study area. The combined exploitation potential of these two zones is estimated at $23 \times 10^6 \text{ m}^3$ per annum. Borehole yields of 30 l/s can be obtained in the lower aquifer, while exploitation of the upper aquifer can probably best be achieved by way of leakage to the lower aquifer.

There are indications that the freshwater aquifers of the Papkuils River area extend towards the north and north-east. Continuation of the regional geohydrological investigation is therefore strongly recommended.

SAMEVATTING

Op versoek van die Afdeling Beplanning is ondersoek ingestel na die grondwaterpotensiaal van die Benede-Bergriviergebied. Hierdie verslag behandel die resultate van geohidrologiese eksplorasiewerk in die kusvlakte tussen die Bergrivier en 'n denkbeeldige grens 10 km noord van en parallel met die Papkuilsrivier.

Voorlopige berekenings toon aan dat soveel as $2500 \times 10^6 \text{ m}^3$ grondwater voorkom in hierdie gebied. Die water is geberg in twee waterdraers en 'n tussenliggende waterhoudende kleilaag in ongekonsolideerde Senosoïese sedimente. Die grondwater is op die meeste plekke egter brak tot sout. Grondwater met 'n TOS-inhoud van minder as 2000 mg/l kom voor in die omgewing van die Papkuilsrivier en in die suidoostelike gedeelte van die ondersoekgebied. Die gesamentlike ontginningspotensiaal van hierdie twee areas word tans op sowat $23 \times 10^6 \text{ m}^3$ per jaar geskat. Boorgatlewering van 30 l/s kan in die onderste waterdraer ontwikkel word. Die ontginning van die boonste waterdraer sal moontlik mees ekonomies kan geskied by wyse van lekkasie na die onderste meer deurlaatbare waterdraer.

Daar word aanbeveel dat die regionale geohidrologiese ondersoek voortgeset word in noordelike en noordoostelike rigtings aangesien daar sterk aanduidings is dat die varswater voorkoms in die omgewing van die Papkuilsrivier belangrike voortsettings het in daardie rigtings.

* * * * *

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II	Abbreviated geological logs
III	Hydrochemical data

1. INTRODUCTION

The Division of Geohydrology has in the past ten years almost continually been engaged in the exploration, description and quantitative assessment of primary aquifer units along the West Coast. At the request of the Division of Planning efforts were lately concentrated on the unconsolidated deposits in the Lower Berg River region.

This report gives the results of groundwater exploration work in part of the coastal plain between the Berg River and Eland's Bay. The objective of the project was to identify and describe any primary aquifer units in the given area. Although the availability of drilling funds early in 1984 moved forward the exploration schedule for this particular area, insufficient funds, especially the lack of funds in the 1984 - 85 financial year, restricted work to a zone roughly bounded by the lower courses of the Berg and Papkuils Rivers.

Fieldwork took place in the period February - July 1984 and comprised the following routine investigation components : Geo-electrical exploration, exploratory drilling, short pumping tests, hydrochemical sampling, leveling and water level monitoring. Drilling work was done by the Drilling Services Subdivision (Worcester), while the following Cape Town staff members contributed to the field investigation : L. Timmerman, P. Havenga, E. Roman, J. Goliath and E. Jooste.

The regional location of the study area in the Western Cape is shown below on figure 1.

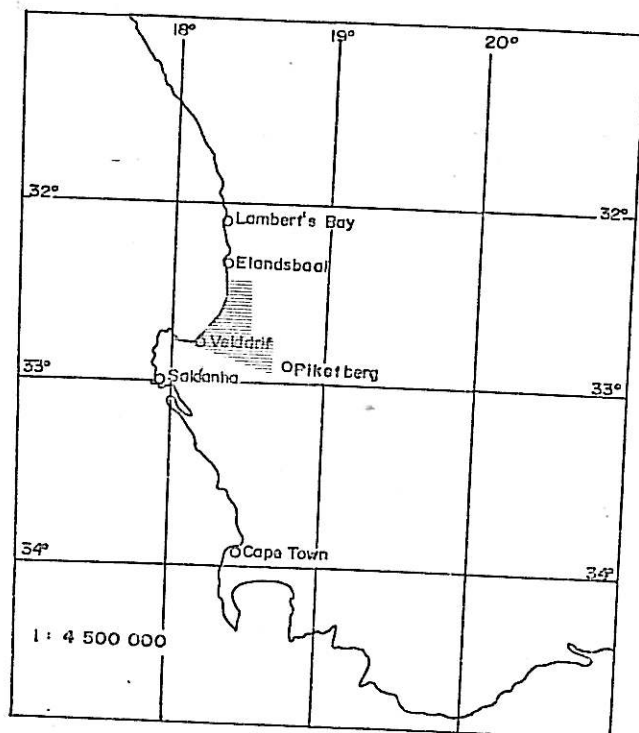


Figure 1 : Location of investigation area

The investigated area extends over approximately 1160 km² and is covered by the following 1:50 000 topographic maps : 3218 CA + CB Aurora, 3218 CD Berg River, 3218 AD Elandsbaai, 3218 DC Moravia and 3218 CC Velddrif.

Finally, geological descriptions and granulometric data of stratigraphic boreholes (S-boreholes) drilled by the Geological Survey in the area, were used extensively in this study. The Geological Survey is thanked for making the data available.

2. BACKGROUND DATA

2.1 PREVIOUS WORK

A hydrocensus, covering the area between the Berg River and the Olifants River, was undertaken during the period 1978 - 79. The report of this survey (Schreuder, 1979) contains a list of information on borehole depth, borehole equipment, water usage, borehole and well yields, a set of maps with the positions of the water points and the results of the hydrochemical analysis of a large number of water samples.

Geohydrological data are rather unreliable and limited. Two areas with high yielding boreholes (6 l/s) and with fresh water (TDS < 1000 mg/l) situated within the present study area were delineated and recommended for further investigation:

1. The area north of Aurora on the cadastral units Papekuilsfontein and Klipfontein with an extension towards the north.
2. The area in the south-eastern section, including the farm Harde Valley.

Ninety percent of all waterpoints are shallow sandpits with yields of approximately 0,5 to 1 l/s which seem to have been satisfactory for domestic use and stock watering purposes. The few private boreholes in the area were drilled to a depth of 20 m but are not sandfree due to unsatisfactory borehole construction. The dominance of shallow pits can be ascribed to a lack of knowledge in establishing production boreholes in unconsolidated sediments.

A number of boreholes and wells suitable for watersampling and waterlevel monitoring were selected from the survey's data list.

2.2 HYDROCLIMATOLOGICAL DATA

The climate in the area is mediterranean with maximum rainfall during the winter months (May to August). Rainfall figures for two stations are available : 0061/7361 Drommelvlei and 0061/2563 Laaiplek. Precipitation data for the period 1972 - 84 at Drommelvlei and for the period 1960 - 84 at Laaiplek are given in appendix I. The data are also shown graphically (figs. 2 and 3).

MONTHLY PRECIPITATION 1972-1984

Station Number: 0061 / 736 I

Drommelvlei

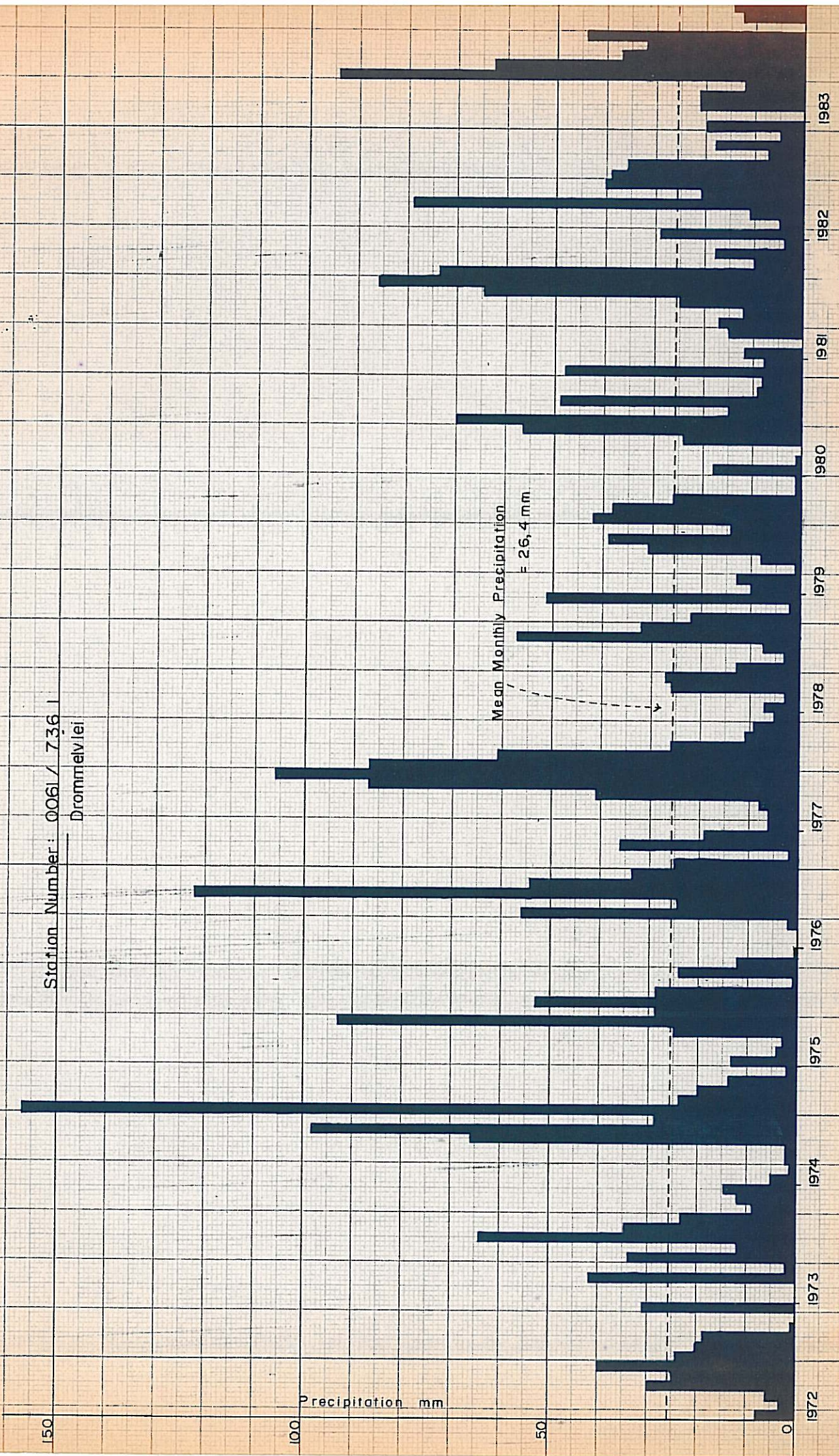


Fig. 2

The average annual rainfall at Drommelvlei is 316,8 mm, the maximum and minimum annual rainfall on record being 457 mm (1977) and 211 mm (1972) respectively. The average annual precipitation at Laaiplek is 201,6 mm with a maximum of 378 mm (1962) and a minimum of 104 mm (1973). On a monthly basis precipitation is highest during June. The relatively high figures for Drommelvlei are most probably related to orographic conditions.

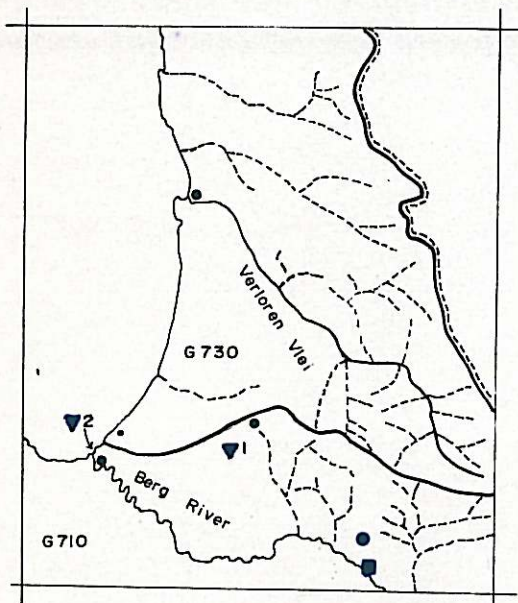
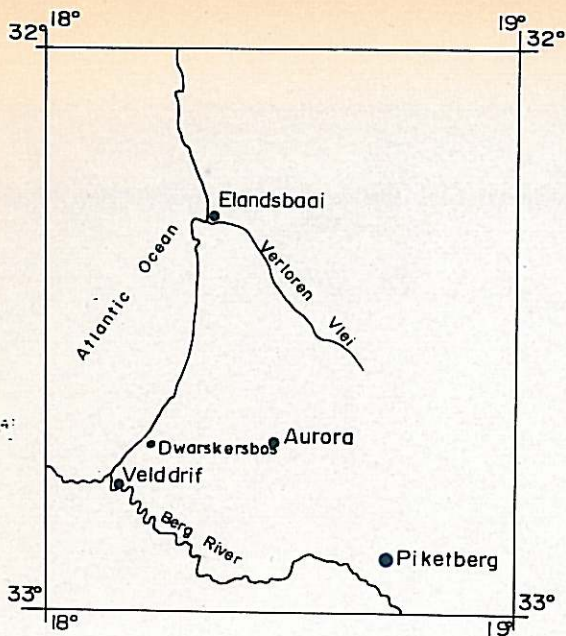
From comparison with stations outside the survey area - Drommelvlei with Hopefield which has an annual average rainfall of 286 mm and Laaiplek with Lambert's Bay which has an annual average of 121 mm, it is clear that precipitation decreases from south to north and from east to west.

Figure 4 is a schematic representation of the drainage pattern, the river system and the vegetation cover of the area. The northern part of the area belongs to the Papkuils drainage region (G730) while the southern section is part of the Berg River region (G710). The surface watershed is situated north of Aurora and stretches in a south-westerly direction towards Dwarskersbos. The Berg River is the only perennial river, while the Papkuils River and Verlore Vlei have periodical flow. The annual flow in the Berg River at station G1M31 for the period May 1974 to December 1983 is plotted on histogram (fig. 5). Before the New Misverstand dam became operational in 1978 the average yearly runoff was $1033 \times 10^6 \text{ m}^3$, afterwards the average yearly runoff was $267,7 \times 10^6 \text{ m}^3$. Peak runoff obviously occurs during the winter rainfall months (May to September).



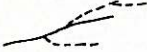
The landscape has hardly any relief features except for some vegetated stabilized dunes and saltpans. These saltpans are concentrated in the southern section and seem to be situated on top of paleoridges (see chapter 4 section 4.2 and fig. 9). The plain slopes gently upwards from sea level to approximately 100 m at the foot of the quartzitic hills which form the eastern and north-eastern boundaries of the study area.

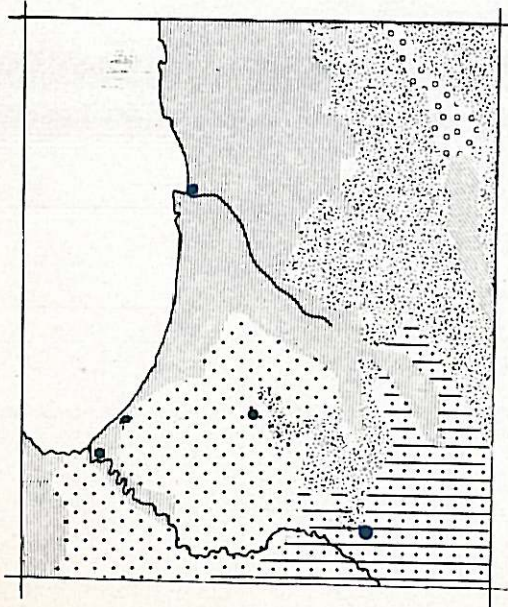
The Berg River which forms the southern boundary, meanders in a broad valley which gradually becomes a 2 to 3 km wide tidal floodplain. Tidal action is noticeable up to 25 km inland at the farms Zoute Kloof and Kersefontein.

According to Acocks (1975) two veldtypes dominate the investigation area:



Drainage Regions and River System

-  Region boundary
-  Sub-Region boundary
-  Rivers
- G 730 Drainage-region number
- ▼ 1 Rainfall station 0061/7361
- ▼ 2 Rainfall station 0061/2565
- River gauging station GIM31



Veld -Types (J. Acocks 1951)







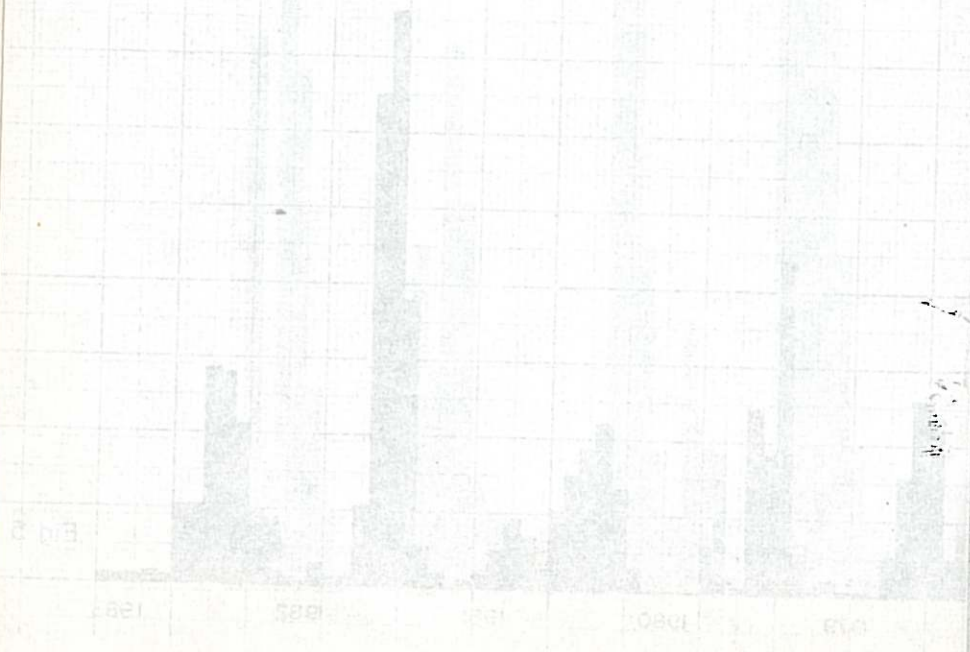
-  Coastal Macchia
-  Strandveld of West Coast
-  Coastal Renosterbosveld
-  Macchia
-  Karroid Broken Veld
-  Succulent Karoo

Fig. 4

4-2

MONTHLY RUN OFF May 1954 - April 1955

Station Number 6131



1. Coastal Macchia in the southern and south-eastern parts.
2. Strandveld of the West Coast in the northern part, along the coast and in the tidal floodplain of the Berg River.

Approximately 40% of the area is usually under cultivation. Wheat is grown during the winter months while vegetables and fruit are cultivated on a small scale during the summer months. No crop irrigation takes place.

2.3 GEOLOGY

The coastal plain is underlain by Malmesbury metasediments between the Berg River and the Papkuils River.

Arenaceous sediments of the Table Mountain Group underlie the area north of the Papkuils River. Very few outcrops of the Malmesbury Group occur except in the south-eastern section along the Berg River and about the intersection of the Sishen - Saldanha railway line and the Berg River.

The Malmesbury Group exists of a wide variety of rock types : shales, greywackes, quartzitic shists, conglomerates and limestone beds with phyllitic lenses. Shales and greywackes weather to an off-white or greyish-white clay.

The fine to coarse sandstones of the Table Mountain Group are discordant in relation to the underlying Malmesbury sediments. The Table Mountain sandstones form the Aurora-Piketberg hills along the eastern and north-eastern boundary of the study area.

The geology of the region is shown on figure 6.

The unconsolidated deposits which originate from Tertiary to Recent times can superficially only be differentiated into soil types. The soils are generally sandy, often brackish and calcareous. Clayey deposits are restricted to the floodplain of the Berg River. On the farms Velddrift and Dwarskersbos consolidated to unconsolidated marine shells, sand and gravel (QB1) are found which often are phosphatic.

The current lithostratigraphical classification of the Cenozoic sediments in the area between Velddrif and Eland's Bay is given in table 1.

Epoch	Age in Myr.	Lithostratigraphic Unit		Sediments
		Formation	Member	
Holocene and Pleistocene	1,7	Bredasdorp	Yzerfontein Velddrif Papkuils	Calcareous sand (Aeolian) Shelly sand (marine) Silica and muddy sand (aeolian)
Pliocene	5,2	Varswater (Marine)	Bookram	Pelletal Phosphorite sand Shelly gravel
Miocene	22	Elandsfontyn		Coarse sand and gravel interbed- ded with silty clayey layers. (Fluviatile)




TABLE 1 : Provisional Lithostratigraphy of the Cenozoic sediments between The Berg River and Eland's Bay (Rogers, 1982).

GEOLOGY

from the Geological Series 1: 250 000
(1973) 3218 Clanwilliam

- ~ Alluvium
- Q1 Sandy soil
- Q2 Sand, sandy loam
- Q4 Brackish calcareous soil
- Q5 Dune sand
- QB1 Marine shells, sand, gravel

Tertiary to Recent.

-  Table Mountain Group
-  Klipheuvel Formation
-  Malmesbury Group

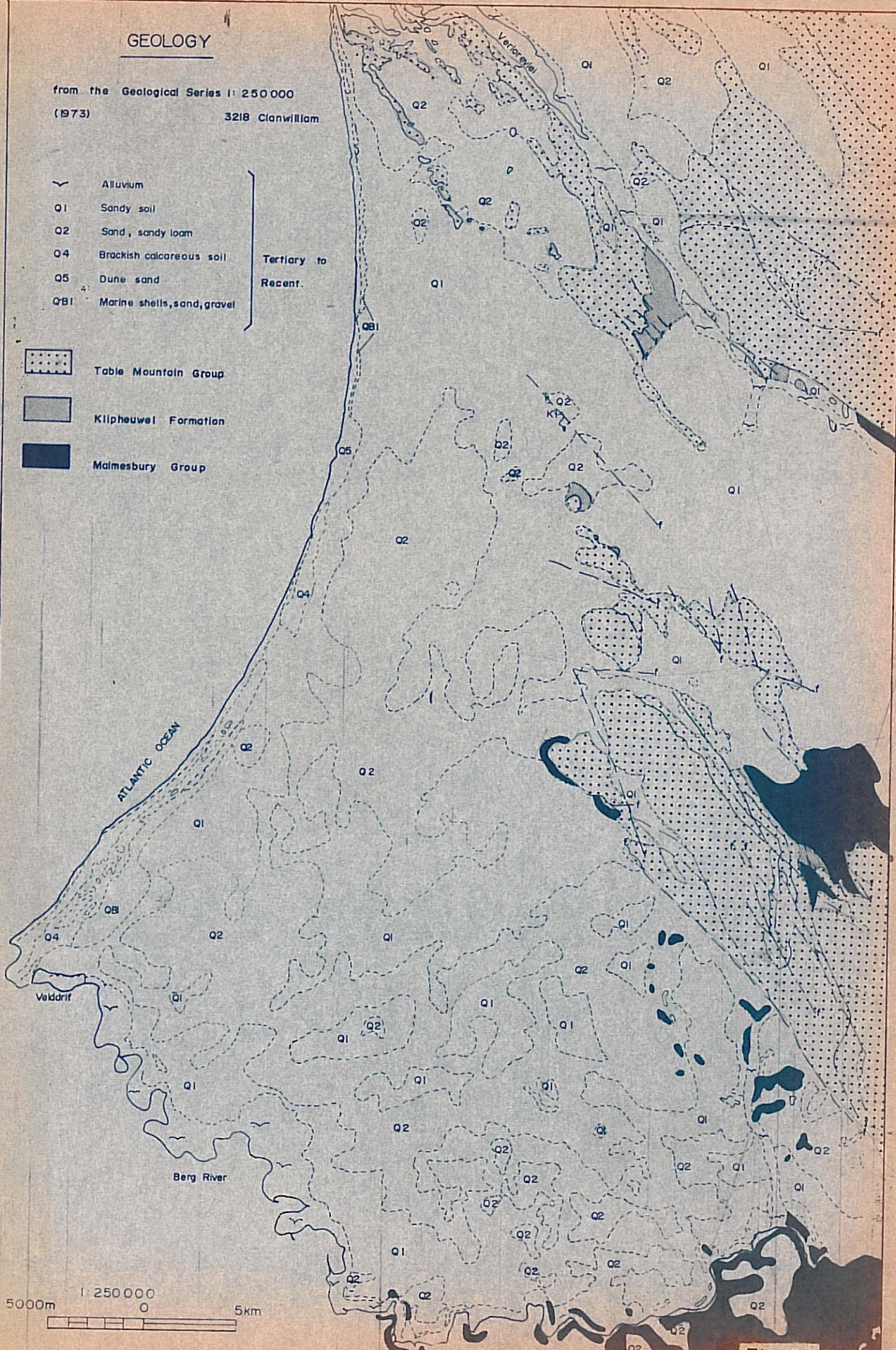


Fig. 6

3. EXPLORATION PROGRAMME

3.1 DRILLING PROGRAMME

During the period 01-02/28-03-1984, 17 exploration boreholes and 1 test borehole were drilled by the Drilling Services Subdivision, using a rotary unit with organic mud circulation.

Relevant drilling and borehole data are given in table 2. The borehole positions are plotted on the geophysical survey map (fig. 7).

The specific aims of the exploratory drilling programme were :

- (i) Calibration of resistivity work.
- (ii) Determination of the geohydrological characteristics of the water-bearing formations.

Borehole sites were chosen on the following criteria :

- (i) accessibility
- (ii) proximity to the 6 major resistivity lines
- (iii) optimal coverage of the study area.

Although all boreholes were to be drilled to solid bedrock, this was not always achieved mainly because of misinterpretation of the sediment samples and communication problems. Five boreholes (G33244 - G33253 - G33256 - G33254 - G33257) did not reach weathered or solid bedrock. Borehole G33242 was abandoned because of construction problems.

The total accumulated drilling depth was 846,5m. The exploration boreholes were equipped with 160 mm OD PVC casing. The test borehole was equipped with 200 mm OD PVC casing. The perforated sections were covered with two layers of bidim U34. The perforation details are given below :

160 mm OD PVC

Type 1 : Length = 6m

14 rows of slots

16 slots per row

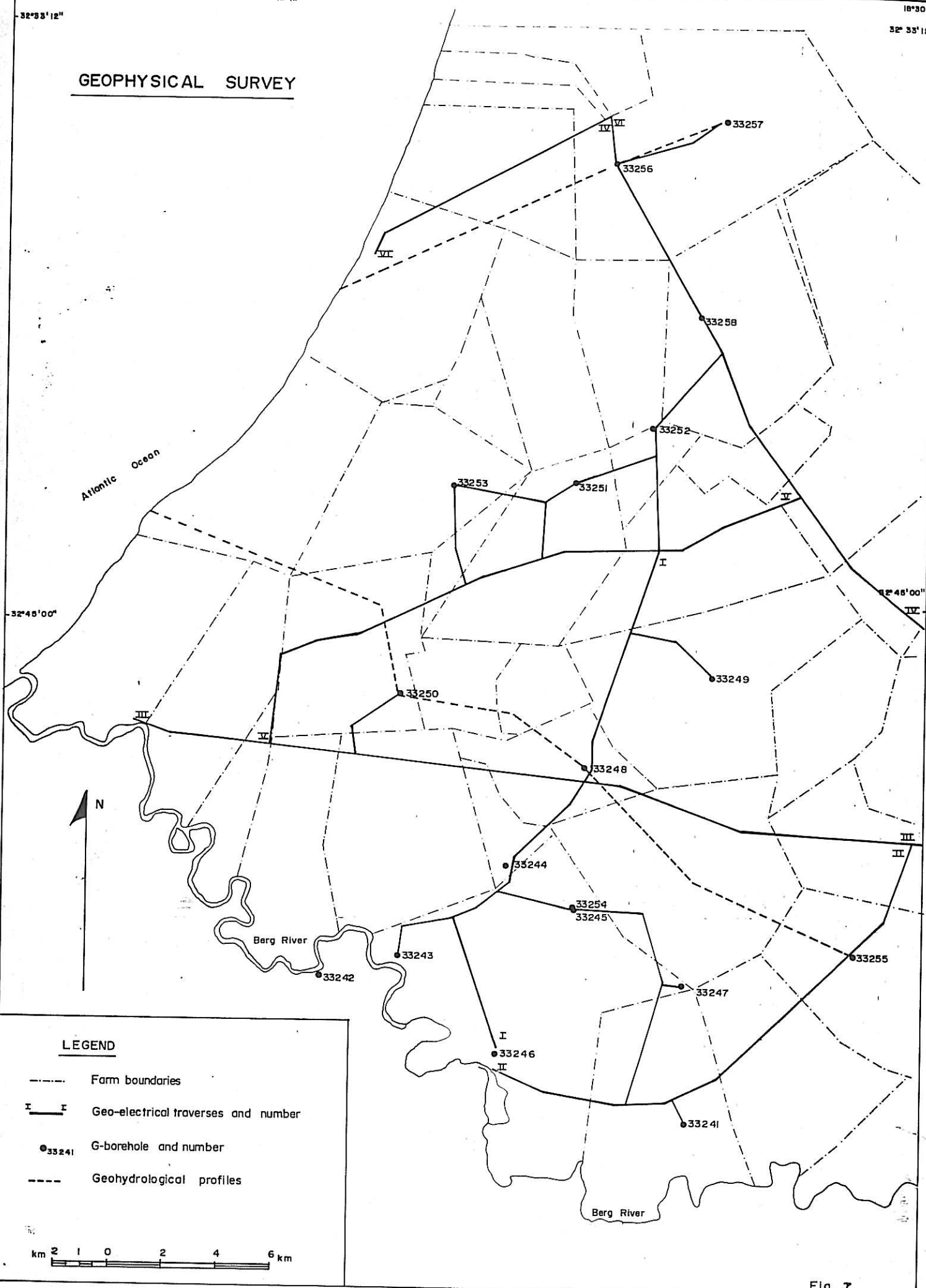
slot width : between 2 and 2,5 mm

slot opening = \pm 2,82 %

32°33'12"

18°30'
32°33'12"

GEOPHYSICAL SURVEY



LEGEND

- Farm boundaries
- I I Geo-electrical traverses and number
- 33241 G-borehole and number
- Geohydrological profiles



Fig. 7

Type 2 : Length = 5,78 m
 13 rows of slots
 16 slots per row
 slot width : between 2 and 2,6 mm
 slot opening = 2,72 %

200 mm OD PVC

Length = 6 m
 15 rows of slots
 21 slots per row
 slot width = 3mm
 slot opening = 4,89 %

The above equipment specifications were not as instructed to the Drilling Services Subdivision. Prior to the commencement of drilling operations perforation specifications for a total slot surface of 4,77 % for the exploration boreholes and 13,54 % for the test borehole were given. A two meter long steel casing sleeve was dug in and cemented around each borehole as a sanitary safety measure. Development of the boreholes was done by airlifting. During the development, which lasted three hours on average, blow yields were measured and after completion of the development water samples were taken.

During drilling sediment samples were taken at 1 m intervals and described after breakdown of the drilling mud. The abbreviated geological logs are given in appendix II. The accuracy of the sedimentological descriptions is influenced by the drilling method. The following particulars featured in the description : roundness, sorting, grain size and mud content. Notes were made of additional features like : shells, calcareous and organic material, heavy minerals and colour. The geological descriptions were adjusted and refined with the aid of the Mount Sopris gamma log. Generally, depth corrections were made and a better estimate of the relative silt-clay content was obtained.

Borehole Number	Drilling depth below ground level m	Depth of bottom plate below ground surface m	Collar elevation a.m.s.l. m	Equipment 160 mm OD PVC			Coordinates		Blow yield #/s
				Solid m	Solid sump m	Perforated m	Latitude	Longitude	
33241	18	18	35,083	0 - 10	16 - 18	10 - 16	32°55'43"	18°24'36"	0,008
33242	39	-	-	-	-	-	-	-	-
33243	38	36	0,820	0 - 22	34 - 36	22 - 34	32°51'53"	18°17'48"	10
33244	50	48,5	16,220	0 - 28,5	46,5 - 48,5	28,5 - 46,5	32°50'15"	18°20'33"	0,57
33245	60	56,8	44,764	0 - 37	55 - 57	37 - 55	32°51'00"	18°22'08"	0,033
33246	25	22,5	7,655	0 - 16,5	-	16,5 - 22,5	32°54'07"	18°20'15"	0,28
33247	33	33	52,585	0 - 18	30 - 33	18 - 30	32°52'43"	18°24'46"	0,011
33248	20	16,5	42,087	0 - 4,5	10,5 - 16,5	4,5 - 10,5	32°48'08"	18°22'31"	0,01
33249	30	25	56,805	0 - 11	23 - 25	11 - 23	32°46'15"	18°25'24"	0,05
33250	75	44	45,007	0 - 30	42 - 44	30 - 42	32°46'29"	18°17'48"	0,12
33251	45	44	63,548	0 - 26	38 - 44	26 - 38	32°42'26"	18°22'17"	0,005
33252	65	63	85,615	0 - 49	61 - 63	49 - 61	32°41'12"	18°24'07"	10
33253	41	38	51,498	0 - 18	36 - 38	18 - 36	32°42'21"	18°19'15"	0,095
33254	62	60	44,779	0 - 33*	57 - 60*	33 - 57*	32°52'12"	18°28'46"	0,03
33255	55	54	58,345	0 - 22	28 - 34	22 - 28	32°51'00"	18°22'08"	0,13
33256	35	34	63,310	0 - 16	52 - 54	34 - 52	32°35'48"	18°25'15"	5
33257	88,5	86	73,551	0 - 68,6	28 - 34	16 - 28	32°34'58"	18°25'58"	0,3
33258	67	66	43,844	0 - 24	51 - 57	24 - 30	32°38'59"	18°25'17"	0,005
Total	846,5			443,1	57	247,6			

* 200 mm OD PVC Casing

TABLE 2 : DRILLING AND BOREHOLE DATA

3.2 GEOPHYSICS

3.2.1 GEO-ELECTRICAL EXPLORATION

Figure 7 shows the position of the six major sounding lines and several smaller lines branching off towards the exploration boreholes. The main reason for the resistivity survey was to attempt extrapolation of geo-hydrological data obtained from exploratory drilling over the entire area.

The ERMA MK 1 instrument was used for the majority of the electrical resistivity soundings. Use of the CSIR instrument was reserved to very dry spots where poor electrode contacts occurred.

The Schlumberger electrode configuration was employed throughout. The maximum AB/2 spacing varied from 100 to 400 m. The average distance between sounding stations was one kilometre. In total 182 soundings were made.

Accessibility was the prime reason for positioning the sounding stations. The secondary and tertiary road network gave at the same time an optimal distribution over the survey area. As sounding data became available, a preliminary interpretation was made using a set of master curves (Joubert, 1977). Afterwards, this interpretation was verified and corrected by means of a computer program (Johnson, 1975).

Correlation between the individual soundings of a resistivity traverse was extremely difficult. Resistivity fluctuations were caused by salt-pans and by lateral variations in lithology and water quality. All possible geohydrological sources had to be used to construct geo-electrical profiles. Distinction was made between silty sand, gravel, weathered Malmesbury and bedrock. The resistivity for these specific layers varied significantly :

silty sand	1 - 14 Ω m
gravel	9 - 26 Ω m
weathered Malmesbury shale	1 - 50 Ω m
fresh Malmesbury	45 - 500 Ω m

A combination of geo-electrical data and geological information enabled

the construction of the following maps :

1. isopachs of the Cenozoic sediments (fig. 8)
2. bedrock elevation a.m.s.l. (fig. 9)

3.2.2. GEOPHYSICAL BOREHOLE LOGGING

Immediately after drilling the Widco gamma log was run in each borehole. The log was generally relied upon to decide on the construction of the borehole.

When the Mount Sopris instrument became available in the course of the Saldanha exploratory drilling programme, the opportunity was taken to run the following set of logs: gamma, gamma - gamma, neutron - neutron, caliper, temperature and waterresistivity. The first three logs were usefully applied to make depth corrections caused by slow mud circulation, and to determine the relative clay content.

3.3 PUMPING TESTS

Although blow-yields were generally very low and no observation boreholes were available, short pumping tests were performed in an attempt to obtain some hydraulic characteristics of the aquifer(s).

An electrically-driven submersible pump (maximum yield = 3 l/s) was used. Each test consisted of :

1. 30 to 120 minutes of pumping to establish the approximate yield of the borehole.
2. 50 to 160 minutes of recovery.

The tests were only successful in the high-yielding boreholes, in casu G33252 and G33256. The residual drawdown for these boreholes was plotted against t/t'' (figs. 10 and 11). Borehole G33252 was pumped for 75 minutes at an average rate of 1,99 l/s giving a maximum drawdown of 3m. Borehole G33256 was pumped for 120 minutes at an average rate of 1,82 l/s resulting in a final drawdown of 2 m.

Because of the limited test results Hazen's empirical method was used to obtain transmissivity and hydraulic conductivity values from granulometric data of the Geological Survey's S-boreholes in the area.

ISOPACHS of the CENOZOIC SEDIMENTS

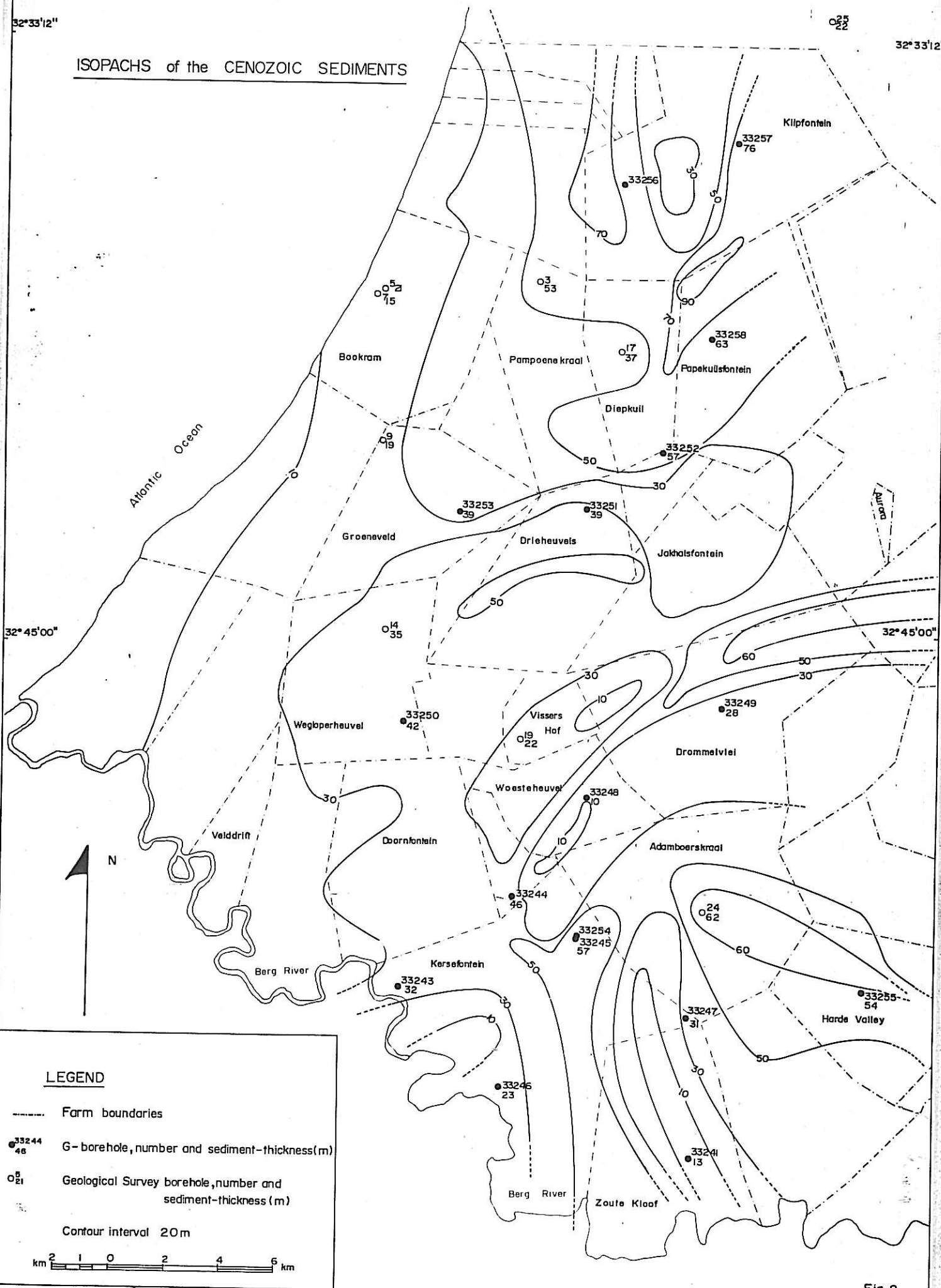


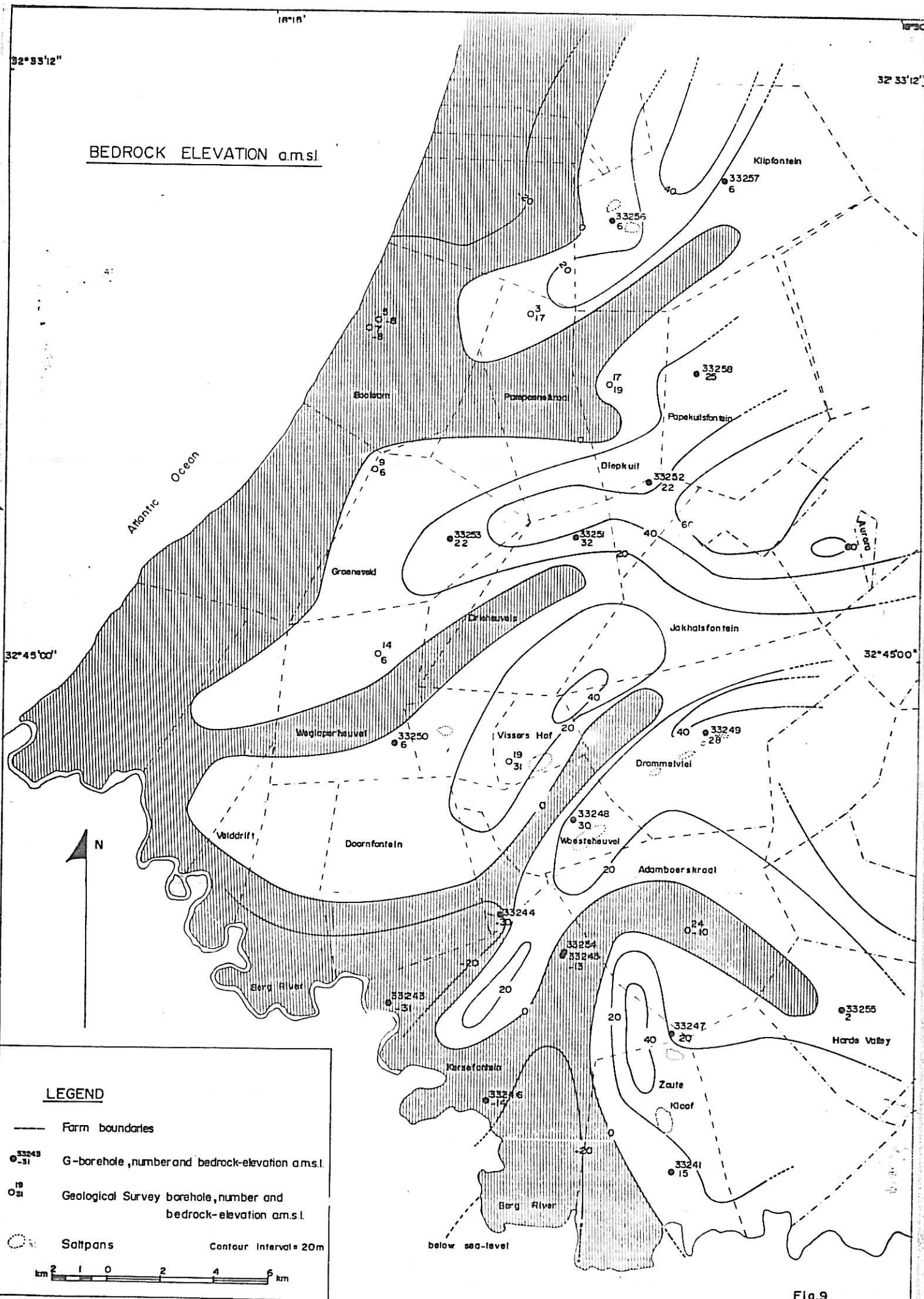
Fig. 8

18°18'

32°33'12"

32°33'12"

BEDROCK ELEVATION a.m.s.l.



LEGEND

- Farm boundaries
 - ³³²⁴⁵/₃₁ G-borehole, number and bedrock-elevation a.m.s.l.
 - ¹⁸/₃₁ Geological Survey borehole, number and bedrock-elevation a.m.s.l.
 - Salt pans
- Contour Interval = 20m



Fig.9

Short Pump Test G33252

$$Q = 1,991 / s$$

$$T = 308 \text{ m}^2 / \text{day}$$

$$k = 18,2 \text{ m day}^{-1}$$

m

0,4

0,3

residual
drawdown

0,2

0,1

0

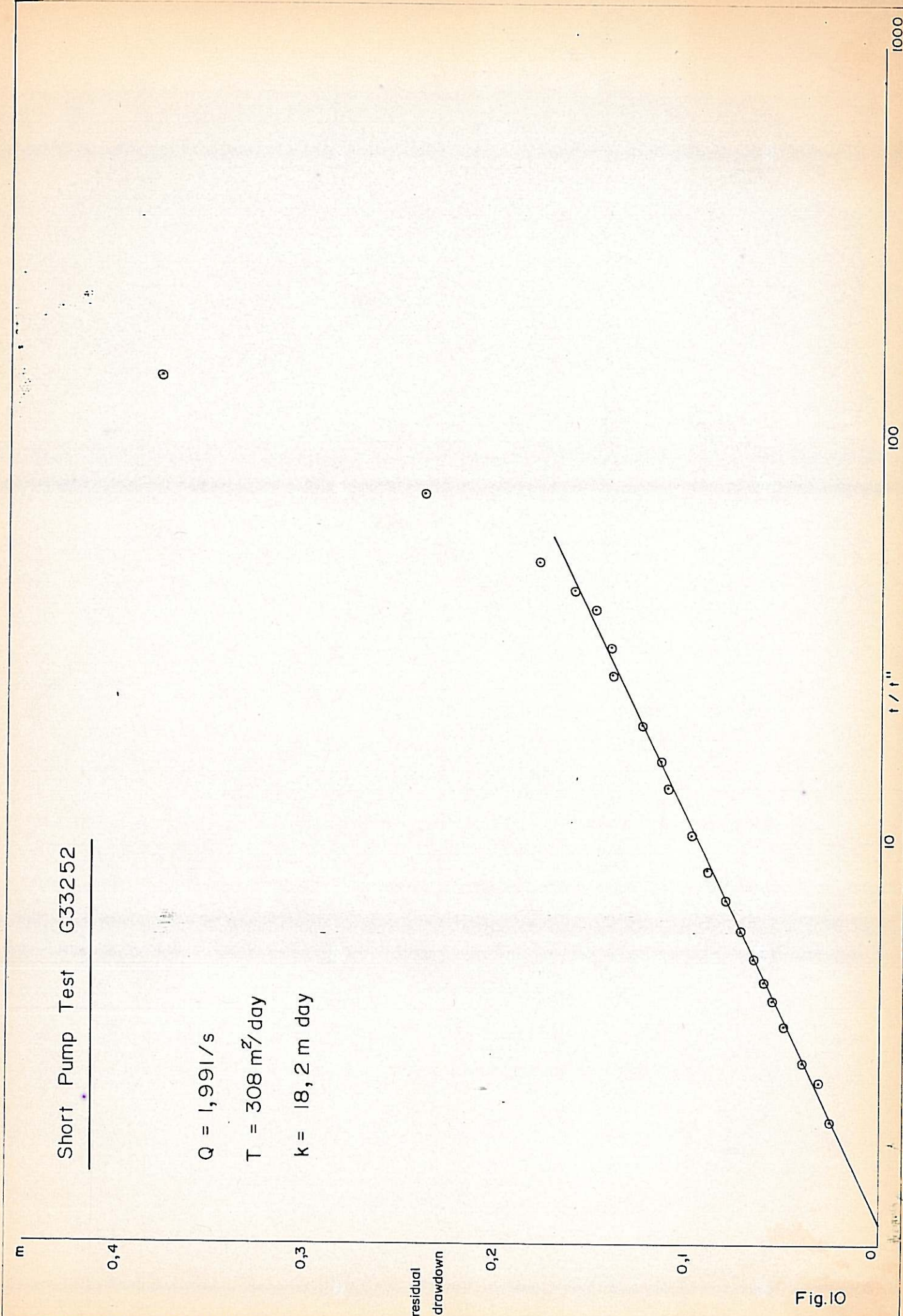
t / t''

10

100

1000

Fig.10



Hazen's formula is given below:

$$k = Cd_{10}^2 (0,7 + 0,03 t)$$

k = hydraulic conductivity (cm/sec)
 C = constant (cm⁻¹.sec⁻¹)
 d_{10} = effective grain size (cm)
 t = temperature (°C - 20°C)

3.4 WATERQUALITY SURVEY

A large number of watersamples was collected with the view of determining watertypes, groundwater quality, chemical composition and change in groundwater quality with time. Therefore samples were not only taken during development and testing of the G-boreholes, but also from a number of selected private boreholes. The hydrochemical data were analysed graphically by means of both Piper and Durov diagrams (figs. 12 and 13). The results of the chemical analysis of watersamples collected during the development of G-boreholes are given in appendix III.

The electrical conductivity of samples was routinely measured in the field or in the office. The values were converted to mS/m at 25°C using the following formula :

$$EC_{25^{\circ}C} = EC_t \times f_t$$

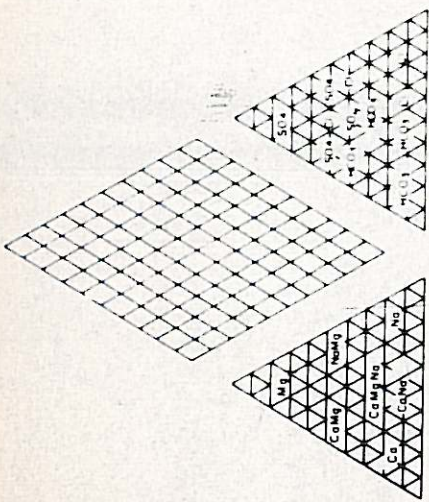
Where f_t is the temperature factor.

An approximate conversion to Total Dissolved Solids (TDS) was obtained by multiplying the converted electrical conductivities with the factor 6,5. A waterquality map (fig. 14) was constructed with field TDS values and laboratory data.

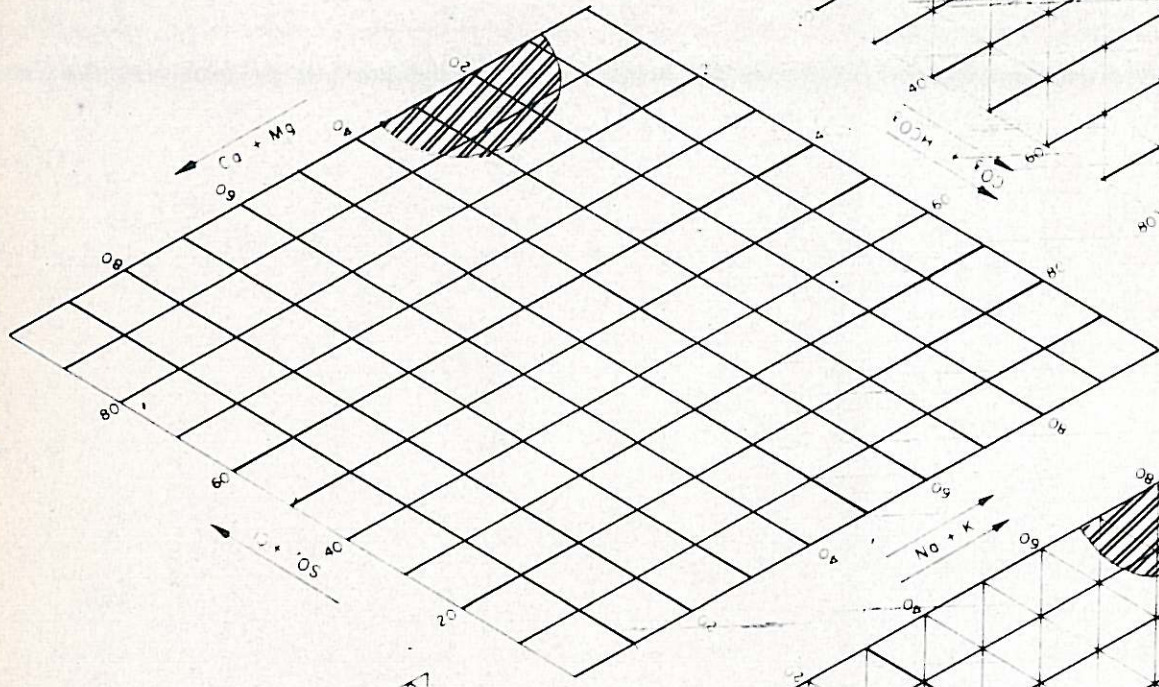
3.5 WATERLEVEL MEASUREMENTS

Waterlevels were measured during a one-day campaign in 15 G-boreholes and 12 suitable private waterpoints. The accuracy on the piezometric map (fig. 15) is definitely affected by the limited number of data points. The majority of the private boreholes and all new departmental boreholes were levelled from bench marks and trigonometric beacons. Collar elevations, with the PVC casing as reference point, are given in table 2.

CLASSIFICATION OF WATER



PIPER - DIAGRAM



TOTAL DISSOLVED SOLIDS

NAME	ppm
Fresh water	0 - 1000
Brackish water	1000 - 10000
Salty water	10000 - 100000
Brine	More than 100000

GROUND WATER QUALITY : SCHEMATIC

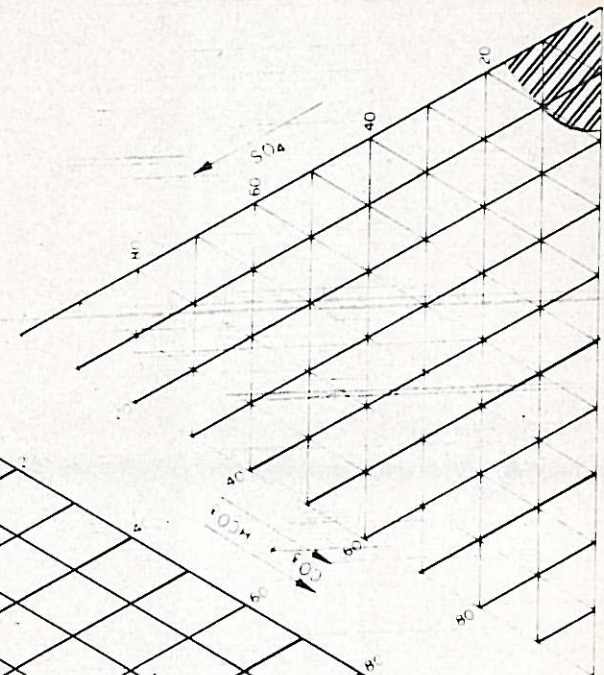


Fig. 12

Ca
Cations

Cl
Anions

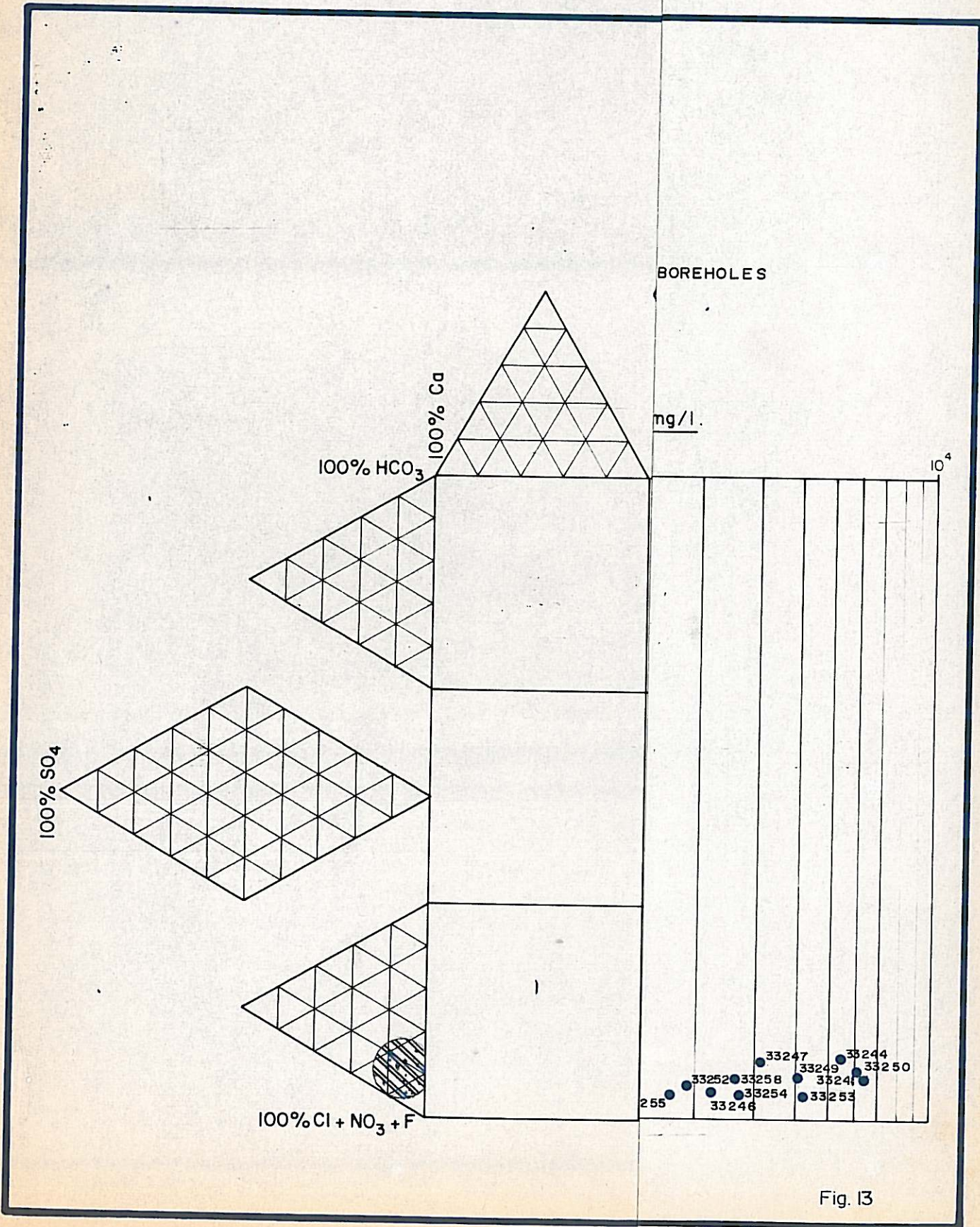


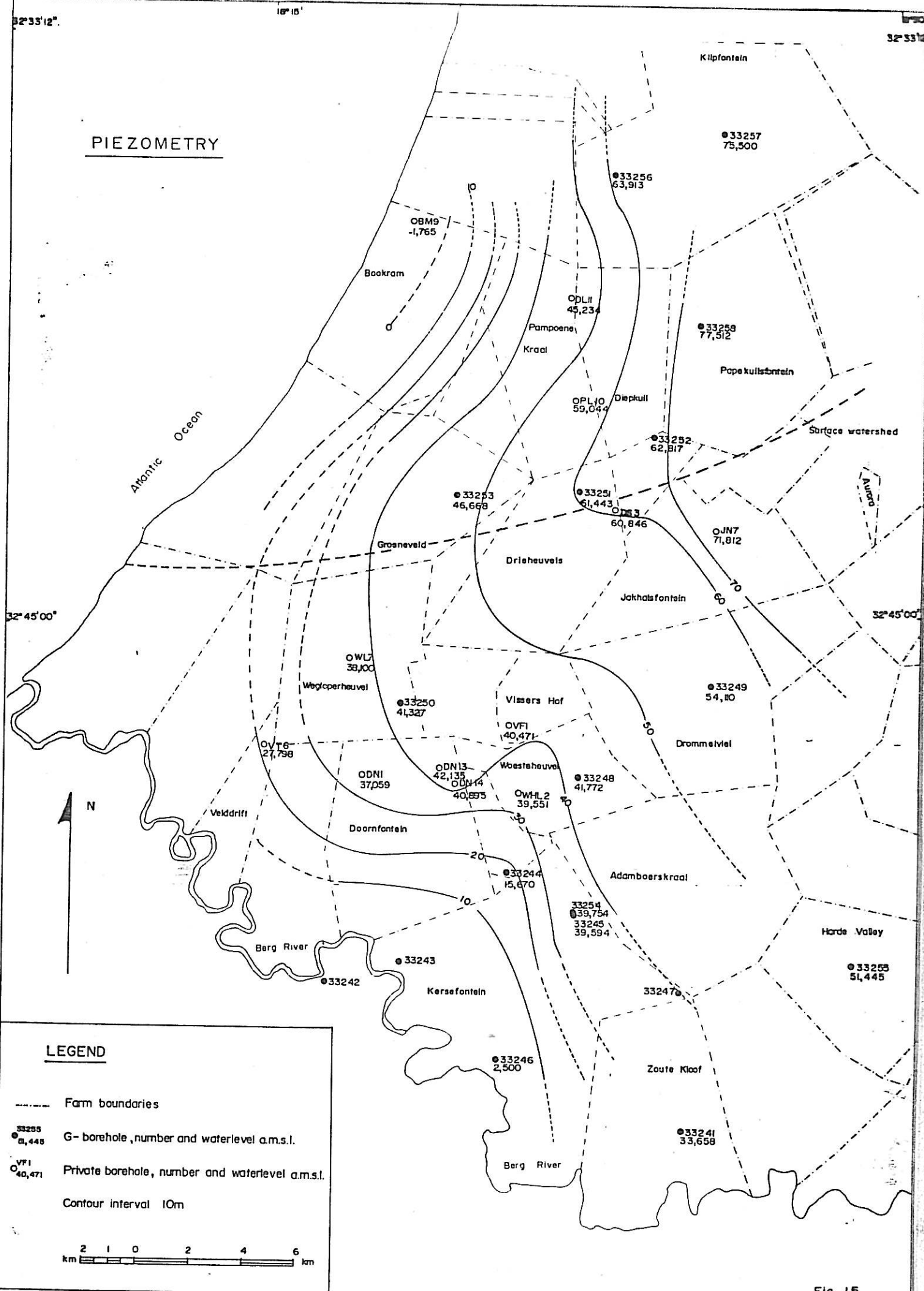
Fig. 13

32° 33' 12"

16° 15'

32° 33'

PIEZOMETRY



LEGEND

- Farm boundaries
- 33255
51,445 G- borehole, number and waterlevel a.m.s.l.
- VFI
40,471 Private borehole, number and waterlevel a.m.s.l.
- Contour interval 10m

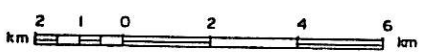


Fig. 15

4. GEOHYDROLOGY OF THE STUDY AREA

4.1 GEOLOGY AND GEOMETRY

The bedrock elevation map (fig. 9) together with the isopachs of the Cenozoic sediments (fig. 8) and the geohydrological profiles (fig. 16) illustrate the relief of the bedrock topography and the significant variations in sediment thickness.

The most striking feature is a paleoridge, covered with a thin layer of sediments, which starts north of Aurora and stretches across Drieheuvels and Groeneveld down to Dwarskersbos thus coinciding with the surface watershed between the two drainage regions. Large parts of the paleo-surface are situated below sea level.

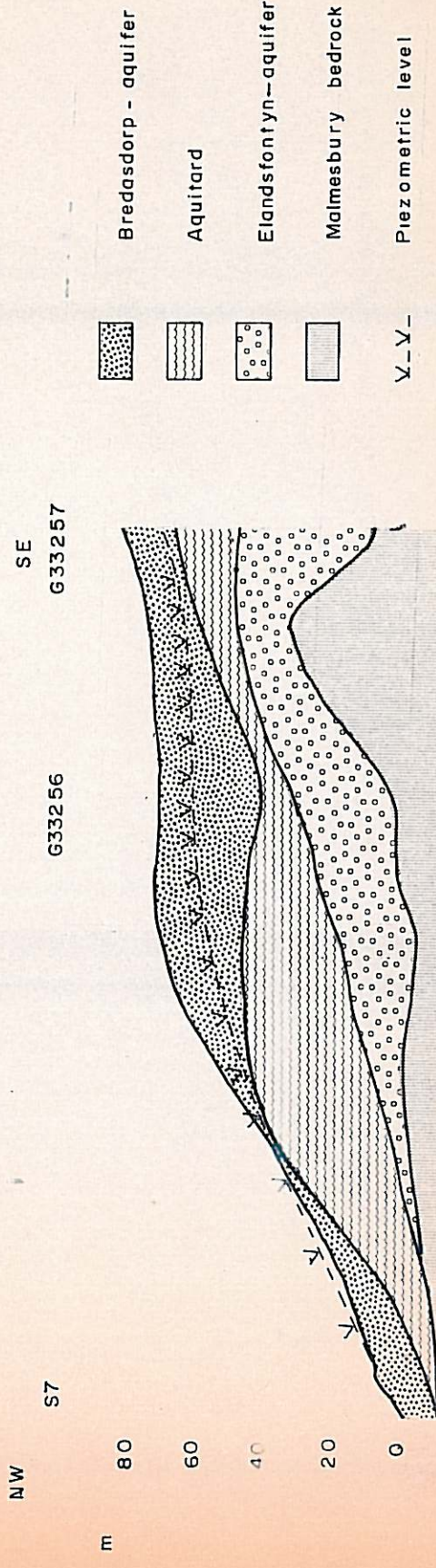
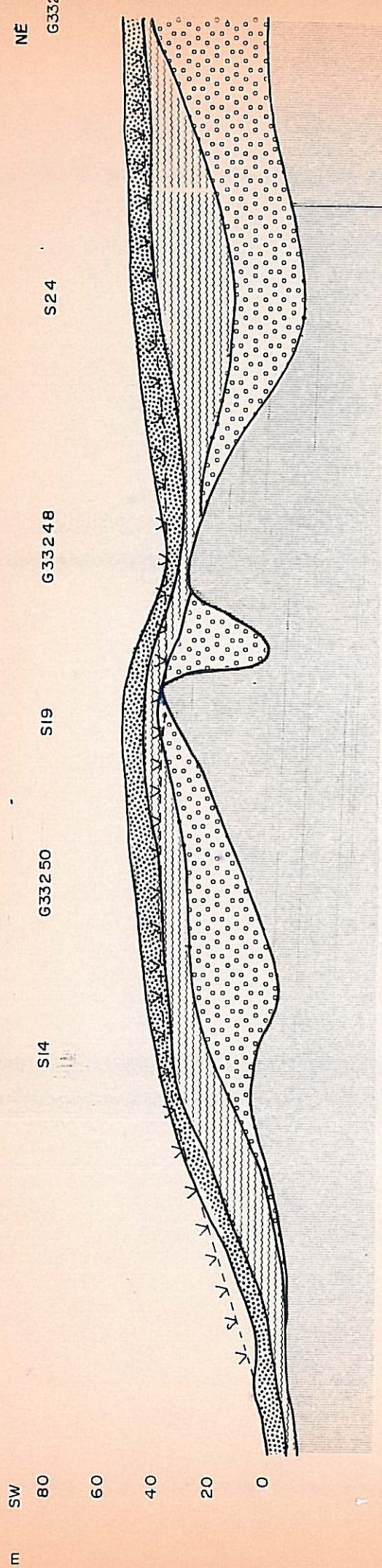
Figure 9 shows the existence of four distinct channels :






1. The most southern channel is situated on Harde Valley, Adamboerskraal and Kersefontein, and can probably be seen as a paleomeander of the Berg River.
2. A second channel starts on the farm Drommelvlei and forks into two channels on Jakhalsfontein. Both channels are probably paleocourses of the Kuilders River, one of which stretches in a south-westerly direction across Woesteheuwel and Doornfontein, while the other channel goes in a more westerly direction across Drieheuvels and Wegloperheuwel.
3. The channel on Klipfontein, Pampoenekraal and Bookram is probably related to a paleochannel of the Papkuils River.

Fluviatile sediments (J. Rogers, 1980) were deposited in these channels. The three most southern channels are filled with sand and gravel interbedded with silty fine sands and clay. The sand is predominantly coarse and the mean size of the gravel is 7 mm. The sand and gravel beds produce gamma log readings in the range of 20 - 25 cps against readings of 35 to 40 cps for the silty-clayey layers.

The fluviatile sediments in the Papkuils channel are medium-grained sands with a 2 m thick basal gravel. The mean size of the gravel is 5 mm. The gamma range average here for sand is 15 to 20 cps and 30 to 40 cps for the silty-clayey beds.

GEOHYDROLOGICAL PROFILES



-  Bredasdorp - aquifer
-  Aquitard
-  Elandsfontyn - aquifer
-  Malmesbury bedrock
-  Piezometric level

horizontal scale : 1 cm = 1250 m

Fig 16

Fluviatile sediments do not occur in a 3 - 4 km zone along the entire coast. The Elandsfontyn fluviatile deposits are covered by sands of aeolian and marine origin. The sands are predominantly fine. Combining the provisional lithostatigraphic classification (J. Rogers, 1982) and the sedimentological descriptions, the following stratigraphic units can be recognized :

Bredasdorp Formation

Yzerfontein - Velddrif Members : fine sands
 Papkuils Member : silty, clayey layer

Varswater Formation

Bookram Member : marine sands

Elandsfontyn Formation

Elandsfontyn : top layer = clay layer
 coarse sand and gravel layers or medium to coarse sand
 and basal gravel

It should be noted that the sands of the Varswater Formation were found to be restricted to the farms Bookram, Sint Helenasfontein and Pampoenkraal. These fine marine sands were deposited on an eroded surface of Elandsfontyn sediments.

The Bredasdorp sediments, excluding those of the Papkuils, form an unconfined aquifer which is present over the entire study area.

Generally the aquifer thickness varies between 0 - 10 m. The greatest thickness of 25 to 30 m is found on the farms Kersefontein and Woesteheuveld in the vicinity of G 33244 and in a zone connecting G 33256 with G 33258 on the farms Klipfontein and Diepkuil

The coarse sand and gravel layers of the Elandsfontyn Formation together with the locally distributed Varswater sediments form a semi-confined aquifer.

The isopach map of the Elandsfontyn aquifer (fig. 17) learns us the following:

1. The aquifer is located in four major channels.
2. The aquifer(s) in the Adamboerskraal channel and the Woesteheuveld channel are either connected directly to the Berg River or continue underneath the river and are connected to the aquifer system south

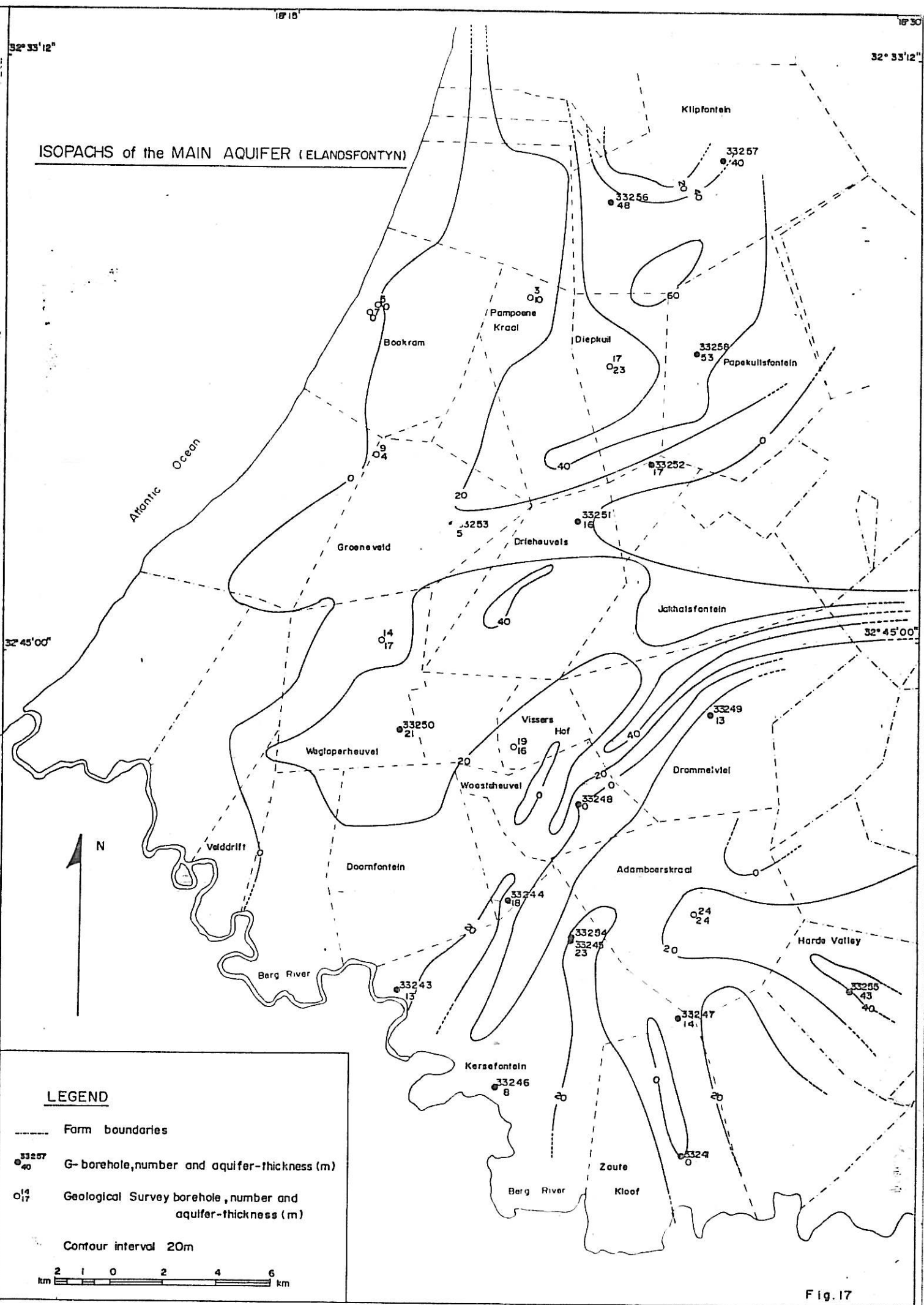


Fig. 17

of the Berg River. More information on this will probably be available after evaluation of the Saldanha project data.

3. The aquifers in the Wegloperheuvél and Papkuils channels do not extend underneath the sea.
4. In the three southernmost channels a thickness of 40 m is found while the aquifer is up to 60 m thick on the farm Klipfontein (Papkuils channel).

The silty clayey sediments of the Papkuils Member together with the clay layer of the Elandsfontyn Formation form a semi-previous or aquitard layer between the two aquifers. The aquitard is present over the entire area and reaches the considerable thickness of 30 m in the following places :

1. Along the foot of the TMS hills.
2. In a zone from Wegloperheuvél to Pampoenekraal, up to 8 - 9 km inland parallel to the coast.
3. On the farm Adamboerskraal.

4.2 HYDRAULIC CHARACTERISTICS

The hydraulic parameters (table 3) were obtained from only two pumping tests and from granulometric data using Hazen's formula. It should be kept in mind that the figures are more important as an indication of the range of magnitude than for their actual values.

Unconfined aquifer (Bredasdorp)

The transmissivity and hydraulic conductivity values calculated from the pumping test data of borehole G 33256 are $90,1 \text{ m}^2/\text{day}$ and $3,0 \text{ m/day}$ respectively. The application of Hazen's formula on the granulometric data of S12 gave T and k values of $228,4 \text{ m}^2/\text{day}$ and $11,4 \text{ m/day}$.

These limited values can not be considered representative for the aquifer in the study area. The saturated sand volume for the unconfined aquifer is estimated at $2600 \times 10^6 \text{ m}^3$ which means that assuming a figure of 8% for effective porosity the aquifer contains $200 \times 10^6 \text{ m}^3$ of groundwater. Since no figures were obtained from tests, the 8% value was extrapolated from data of a similar area, in this case Atlantis (Bredenkamp - Vandoolaeghe, 1982). Taking into account the aquifer thickness and the hydraulic characteristics then it should be possible to establish boreholes yielding between 10 and 15 l/s.

	Borehole Number	Hydraulic Conductivity m/day	Transmissivity m ² /day	Aquifer thickness m
Bredasdorp aquifer	G 33256	3,0	90,1	30
	S12	11,4	228,4	20
North	G 33252	18,2	308,4	17
	S3	21,1	528,0	25
	S9	20,9	83,7	4
	S17	19,7	453,0	23
	S18	5,8	75,8	13
South	S14	40,0	720,0	18
	S19	31,2	502,0	16
	S24	26,6	451,8	17
Elandsfontyn aquifer				

TABLE 3 : HYDRAULIC CHARACTERISTICS

Semi-confined aquifer (Elandsfontyn)

T and k values were obtained from pumping test data of G 33252 and granulometric analysis of six S-boreholes using Hazen's formula. The average transmissivity and hydraulic conductivity values are $509 \text{ m}^2/\text{day}$ and 25 m/day respectively. The saturated sand volume is estimated at $14,6 \times 10^9 \text{ m}^3$. Assuming an effective porosity of 15% this means a groundwater storage of $2,2 \times 10^9 \text{ m}^3$. In view of the semi-confined character of the aquifer this volume would only become available through groundwater mining.

Given a storativity value of 10^{-3} , only $14,6 \times 10^6 \text{ m}^3$ could be exploited if the semi-confined character of the aquifer is to be maintained.

Considering the blow yield of G 33252 and the hydraulic and aquifer characteristics then it should be possible to establish boreholes with a yield of 30 l/s .

Because of the superior hydraulic characteristics of the semi-confined aquifer large-scale groundwater exploitation of the unconfined aquifer will preferably take place indirectly by way of leakage to the deeper aquifer.

4.3 PIEZOMETRY

The piezometric map (fig. 15) gives a rather unreliable picture of the upper boundary of the aquifer, because both atmospheric and pressure levels had to be used to construct the map. Generally the private boreholes used for waterlevel measurements are often very shallow. Nevertheless, the following features can be deduced from the piezometric map:

1. The waterlosses occur towards the sea in the northern part of the study area, towards the Berg River in the southernmost part and in both these directions in the central part.
2. On the farms Papkuilsfontein, Pampoenekraal and Bookram a steady flow of water towards the sea occurs at a gradient of 0,012.
3. The flow on Jakhalsfontein and Drieheuveld is sluggish against a gradient of 0,001. The flow seems to radiate towards the sea and the Berg River on the farms Groeneveld, Wegloperheuvel and Doornfontein.

4. A recurve of the equipotential lines occurs on the farms Drommelvlei and Woesteheuvel, where the gradient is about 0,005; this feature may be the reflection of the relatively high permeability of the sediments in this zone.
5. Piezometric data in the south-eastern section of the survey area are very limited. Groundwater flow seems to be rather sluggish in a south-westerly direction.

4.4 GROUNDWATER QUALITY

All groundwater in the investigated area is of the sodium-chloride type. However there is a great variety in the absolute concentrations of the different determinants :

Cations	Ca	7	-	1586	mg/l
	Mg	21	-	3499	mg/l
	Na	110	-	28975	mg/l
	K	2,1-		724	mg/l
Anions	Cl	187	-	51484	mg/l
	SO ₄	15	-	12681	mg/l

In the majority of samples the concentrations of Mg, Ca, Na and Cl exceed the SABS (1984) limits for human consumption.

Groundwater that can be used for direct human consumption is restricted to the area about boreholes G 33256 and G 33257. The total hardness and acidity are within acceptable limits.

The waterquality map (fig. 14) also shows that:

1. Relatively good water (TDS < 2000 mg/l) is found.
 - (a) in a zone at the foot of the TMS-hills with one extension from Klipfontein to Sint Helenasfontein and another from Harde Valley towards Steenboksfontein.
 - (b) on Vissers Hof and Woesteheuvel, which coincides with the zone where the piezometric map shows a groundwater movement towards the paleovalley and ultimately towards the Berg River.

From the piezometric map and the knowledge of the aquifer characteristics it is deduced that the low TDS waters are associated with high permeability zones in the aquifers.

2. Generally waterquality deteriorates towards the sea.
3. Very bad quality water is also found in the saltpan area in the vicinity of boreholes G 33249, G 33250 and G33251.

4.5 GROUNDWATER LOSSES AND RECHARGE

As can be deduced from the waterquality (fig. 14) and the piezometric (fig. 15) maps, two modes of recharge seem to occur in the study area:

1. Recharge from direct infiltration of precipitation.
2. Recharge from runoff (i) in the Papkuils River and
(ii) on the TMS - mountain slopes.

No data are available to calculate the recharge from runoff.

The recharge from direct infiltration is probably in the order of 15% of the average rainfall. This means for the most promising area - the Papkuils area and Adamboerskraal areas - a recharge of $13,6 \times 10^6 \text{ m}^3$ and $9,6 \times 10^6 \text{ m}^3$ per annum respectively, against a volume of $55 \times 10^6 \text{ m}^3$ per annum for the entire study area.

Recharge compensates for losses which may be attributed to :

1. seepage to the sea and the Berg River
2. evapotranspiration
3. artificial abstraction

The latter factor is negligible in view of the limited abstraction from pits and boreholes for domestic and stock watering purposes.

* * * * *

5. SUMMARY

A rather limited exploration effort in the coastal plain between the Berg and Papkuils Rivers has led to a fairly accurate delineation and description of groundwater occurrences in the unconsolidated sediments of Cenozoic age.

Two aquifer units, separated by an aquitard, were recognized. The unconfined unit in sediments of the Bredasdorp Formation stores about $200 \times 10^6 \text{ m}^3$ of groundwater. This shallow unit occurs throughout the area but contains a groundwater divide along a line between Aurora and Dwarskersbos. The semi-confined aquifer in the permeable section of the Elandsfontyn Formation can yield about $15 \times 10^6 \text{ m}^3$ without changing the semi-confined character of the aquifer. However, if mining were to be practised a volume of about $2200 \times 10^6 \text{ m}^3$ would be available. This aquifer is not continuous, but indeed consists of a number of subunits which coincide with buried river channels.

The hydraulic description of the aquifer units is so far only tentative. Transmissivity and hydraulic conductivity values for the semi-confined unit are of the order of $500 \text{ m}^2/\text{day}$ and $25 \text{ m}/\text{day}$ respectively. Borehole yields of up to 30 l/s are therefore possible. The hydraulic properties of the unconfined aquifer unit would seem to be less favourable, which means that optimal exploitation of this unit will preferably take place by way of leakage to the semi-confined unit.

The quality of the groundwater in the area is generally brackish or saline and shows a deterioration in the direction of groundwater movement. About $500 \times 10^6 \text{ m}^3$ or 20 % of the total volume of groundwater stored in the area has a TDS content of less than 2000 mg/l . Water of this quality range is restricted to two areas; one centred on the farm Adamboerskraal, the other on the lower reaches of the Papkuils River.

Recharge from precipitation on the aquifer sections containing fresh water is estimated at $23 \times 10^6 \text{ m}^3$ per annum. This figure is then approximately the exploitation potential of these aquifer sections on a yearly basis.

* * * * *

6. RECOMMENDATIONS

The geohydrological investigation reported upon here carried time and budget restraints that determined both its content and extent. As it happened the northern and eastern boundaries of the investigation area (fig. 18) cut right across aquifer units. Very little data on the hydraulic properties of the waterbearing sediments could be collected.

The prime recommendation is thus to extend exploration to the south-east, towards the north (Eland's Bay) and towards the north-east (Redelinghuys). Groundwater units should be covered in their entirety. Apparent boundary areas, whether recharge or discharge, and intrabasin divides should in contrast with past exploration approaches be studied with the same scrupulousness as prospective production areas.





This investigation again underscored the hydraulic complexity of the Cenozoic aquifer system of the South-western Cape. It is time to account for this complexity in the planning of future exploration programmes, thereby precluding additional exploration efforts specifically aimed at gathering information for analytical and numerical waterbalance calculations. In the end, total drilling and testing expenditure will also be reduced especially if the following adjustments to the current routine exploration procedures are made :

- (1) reduction of drilling diameter to 150 mm or even 125 mm for exploratory boreholes, which, after installation of 75 mm or 63 mm OD plastic PVC screen sections of no more than 3 m length, can be used as piezometers for permeability tests. The tests can be carried out by Geohydrology staff.
- (2) combination of sediment sampling with tube or core barrel and rotary mud drilling in one procedure;
- (3) development of large diameter boreholes (= 160 or 200 mm ID cased boreholes) is restricted to test aquifer productivity only;
- (4) establishment of small diameter piezometers down to depths of 20 m by waterjetting for test and observation purposes. This work can also be done by the Division of Geohydrology.

The electrical resistivity method is a very useful tool to extrapolate point information over the entire study area. However, under the given complex geohydrological conditions it is of the utmost importance to have access to sufficient and accurate calibration data. It is felt that short and long normal resistivity borehole logs are essential in this respect.

SUGGESTED LAY - OUT of
DATA POINTS for FUTURE
INVESTIGATIONS

LEGEND

- limit of the 1984 investigation area
-  Table Mountain sandstone and Matmesbury shale
-  Jetted boreholes = shallow piezometers
-  small diameter rotary boreholes
-  large diameter rotary boreholes
- electrical resistivity lines

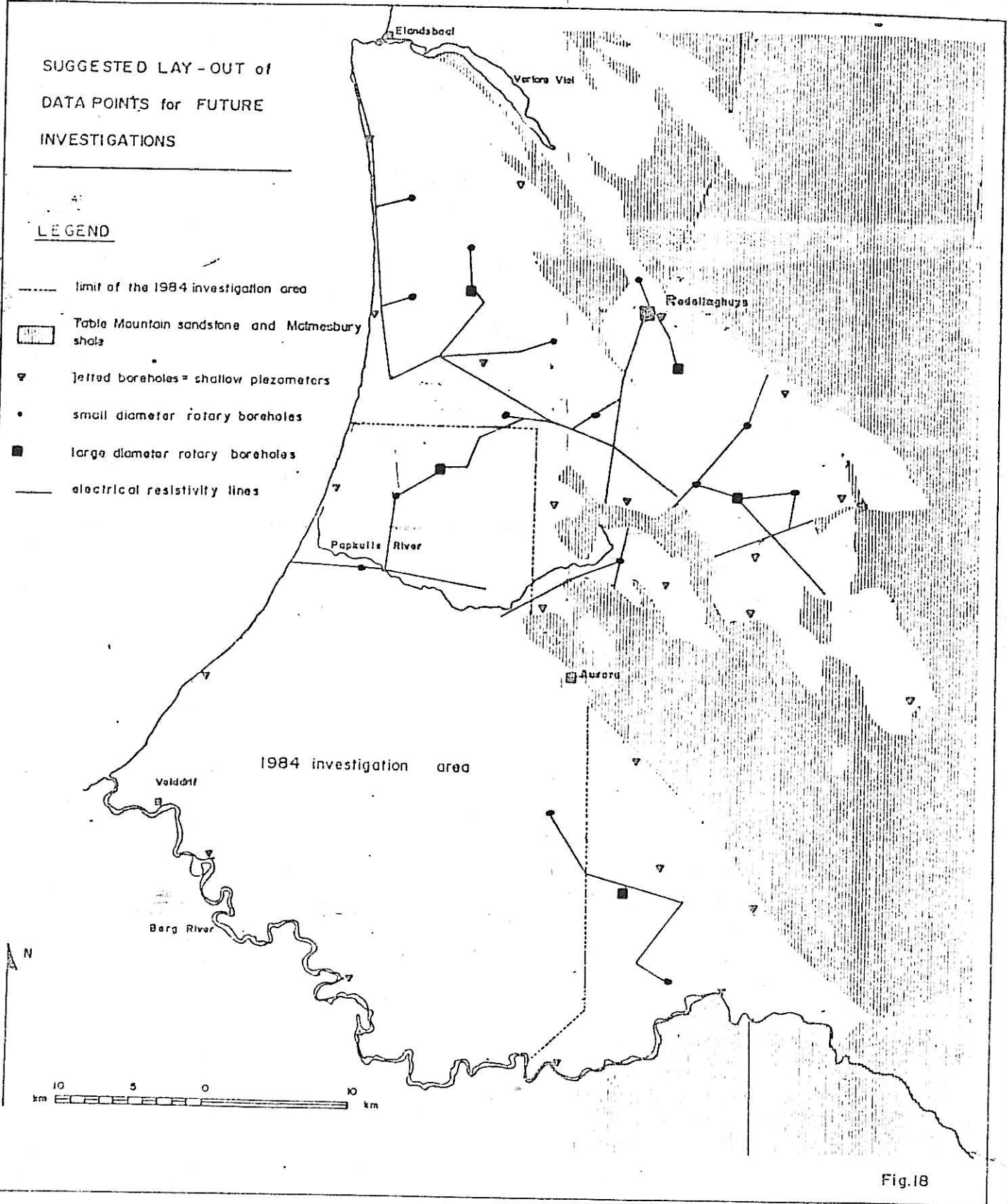


Fig.18

This investigation has once again shown that using perforated PVC casing wrapped with bidim synthetic in boreholes for observation, production or test purposes as a cost saving measure cannot be done without losing on borehole performance and data reliability. This type of borehole construction should not be considered anymore.

Figure 18 is a layout of suggested data collection points for future investigations between the Berg River and Eland's Bay. The spread and density of data points are more pertinent than the actual positions. No additional work is anticipated in the area south of the Papkuils River, except east of Aurora, until the exploitation of saline and brackish groundwater is considered, or, until all unexplored portions of the coastal plain have been investigated.

CAPE TOWN

15-03-1985

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APPENDIX I

PRECIPITATION DATA

APPENDIX II

ABBREVIATED GEOLOGICAL LOGS

Project Coastal Plain Velddrif - Elands Bay

3218 CD11

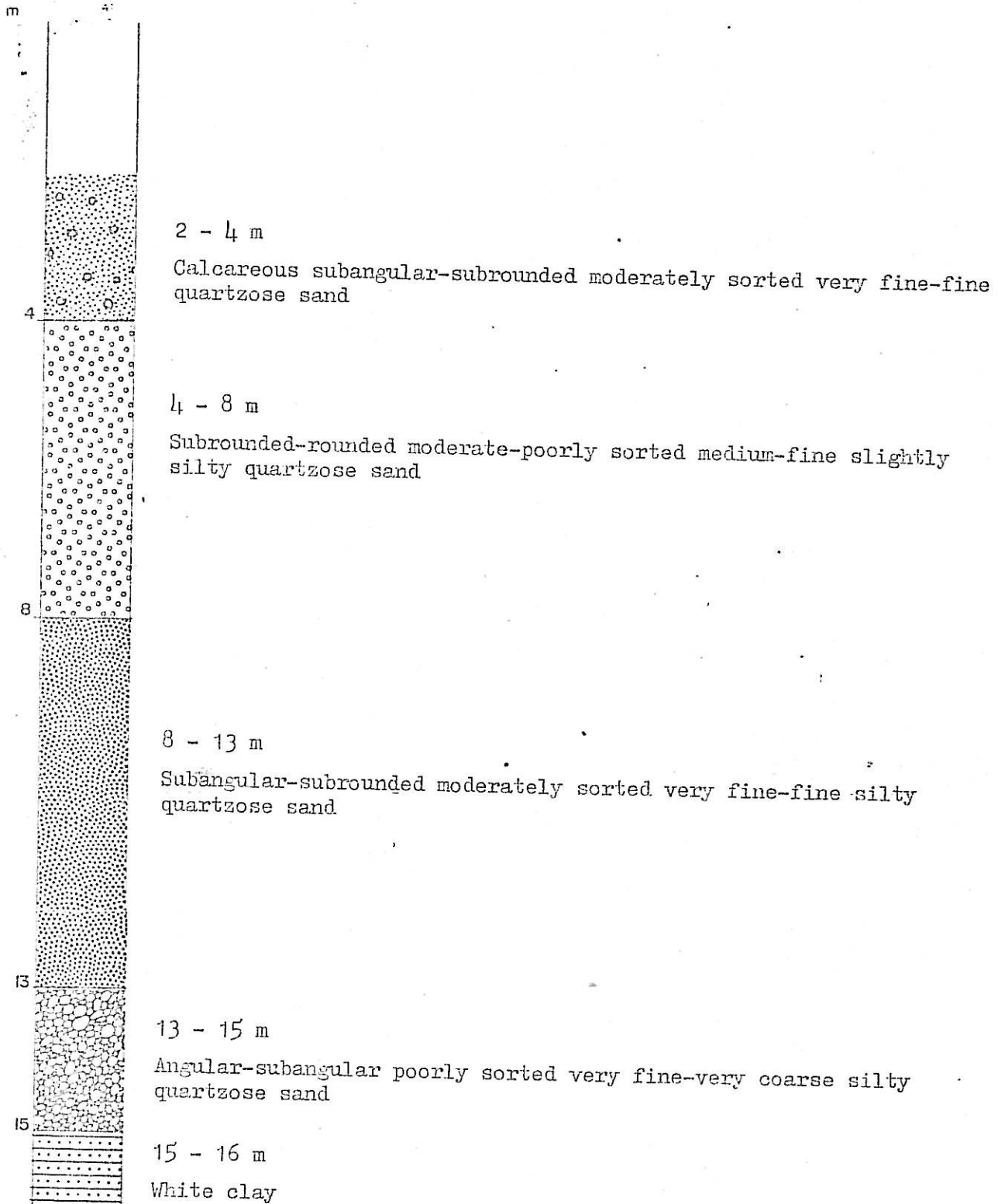
Borehole number: G33241

Coordinates: Lat 32°55'43"

Long. 18°24'36"

Farm: Zoute Kloof

Elevation a m s l 35,083 m



Project: Coastal Plain Velddrif - Elands Bay

3218 CD10

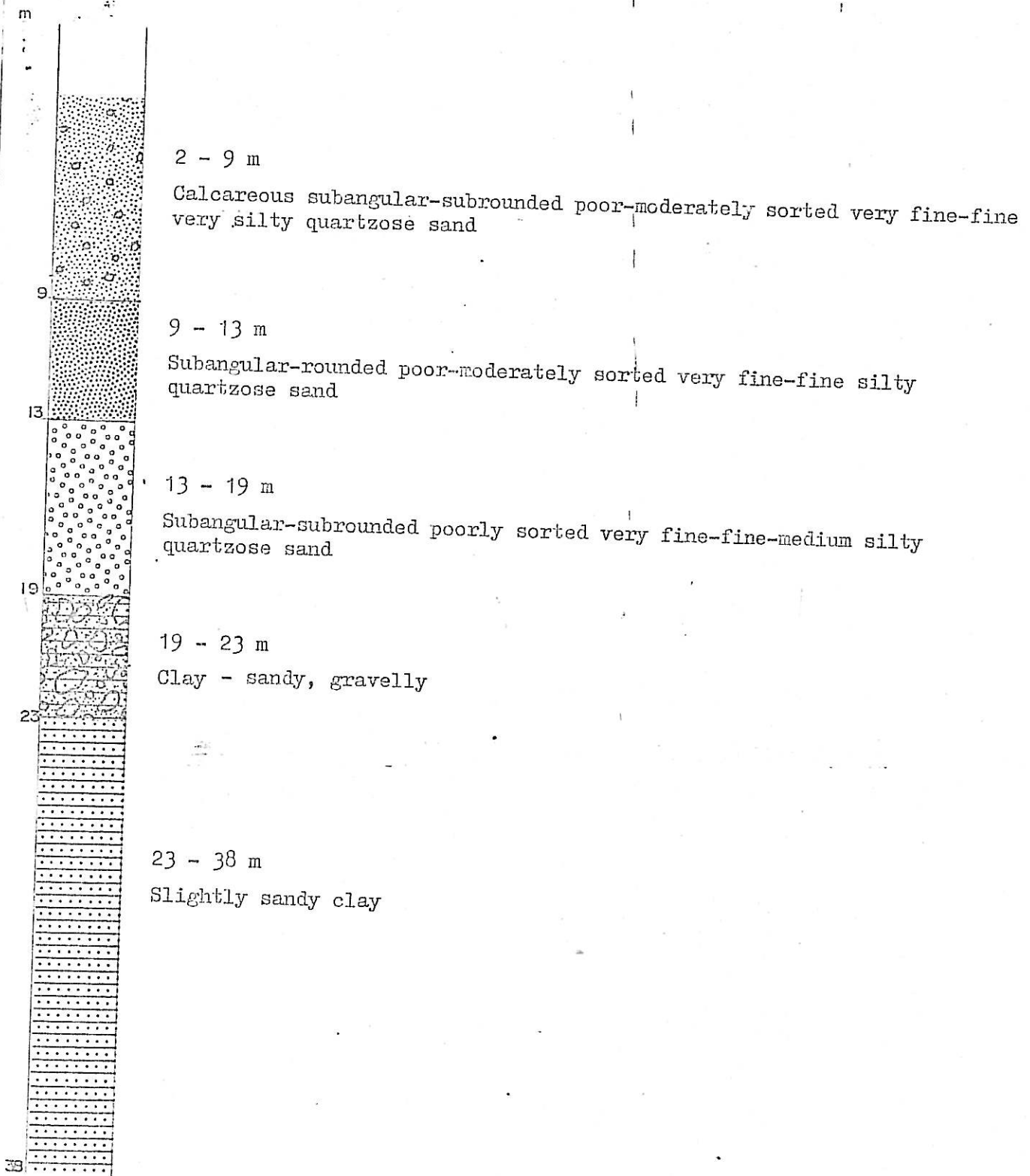
Borehole number: G33242

Coordinates: Lat. 32° 52' 43"

Farm: Lange Riet Vlei

Long. 18° 16' 00"

Elevation a.m.s.l. m



Project: Coastal Plain Velddrif - Elands Bay

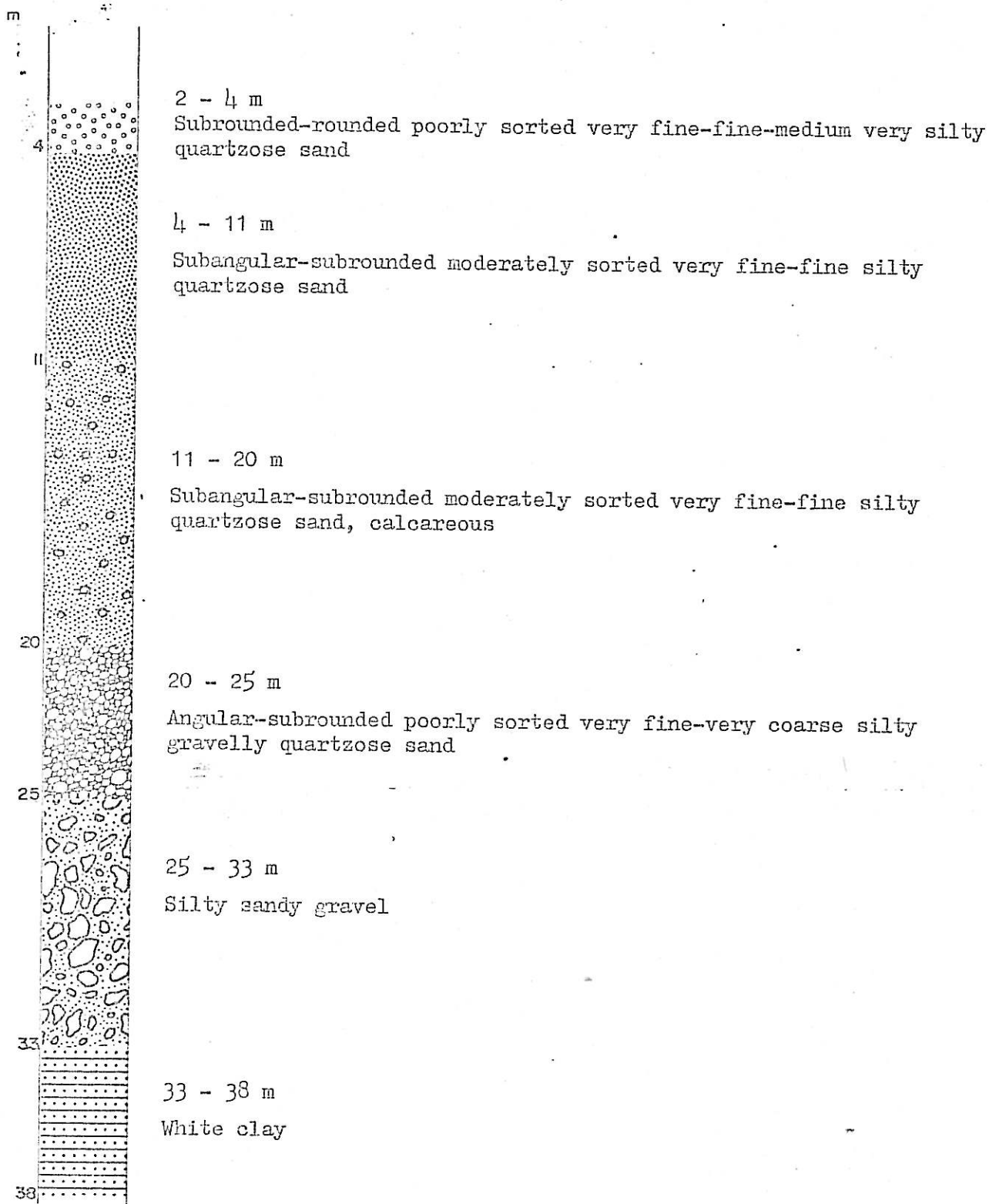
Borehole number: 033243

Coordinates: Lat 32° 51' 53"

Long 18° 17' 48"

Farm: Kersefontein

Elevation a.m.s.l. 0,820 m



Project: Coastal Plain Velddrif - Elands Bay

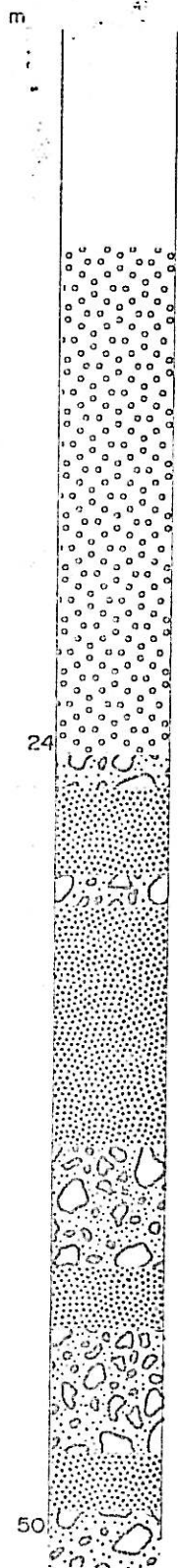
Borehole number: G33244

Coordinates: Lat 32°50'15"

Long 18°20'33"

Farm: Woestehouel A

Elevation a.m.s.l. 16,220 m



2 - 24 m

Angular-subangular-subrounded moderately sorted very fine-fine-MEDIUM quartzose sand, fluctuating peat content

24 - m

Angular-subangular-subrounded poor-moderately sorted very fine-FINE-medium quartzose sand - slightly to very silty, gravelly

- Interbedded with gravel :
- 24-25 m
 - 28-29 m
 - 37-41 m
 - 43-47 m
 - 49-50 m

BEDROCK NOT REACHED

Project Coastal Plain Velddrif - Elands Bay

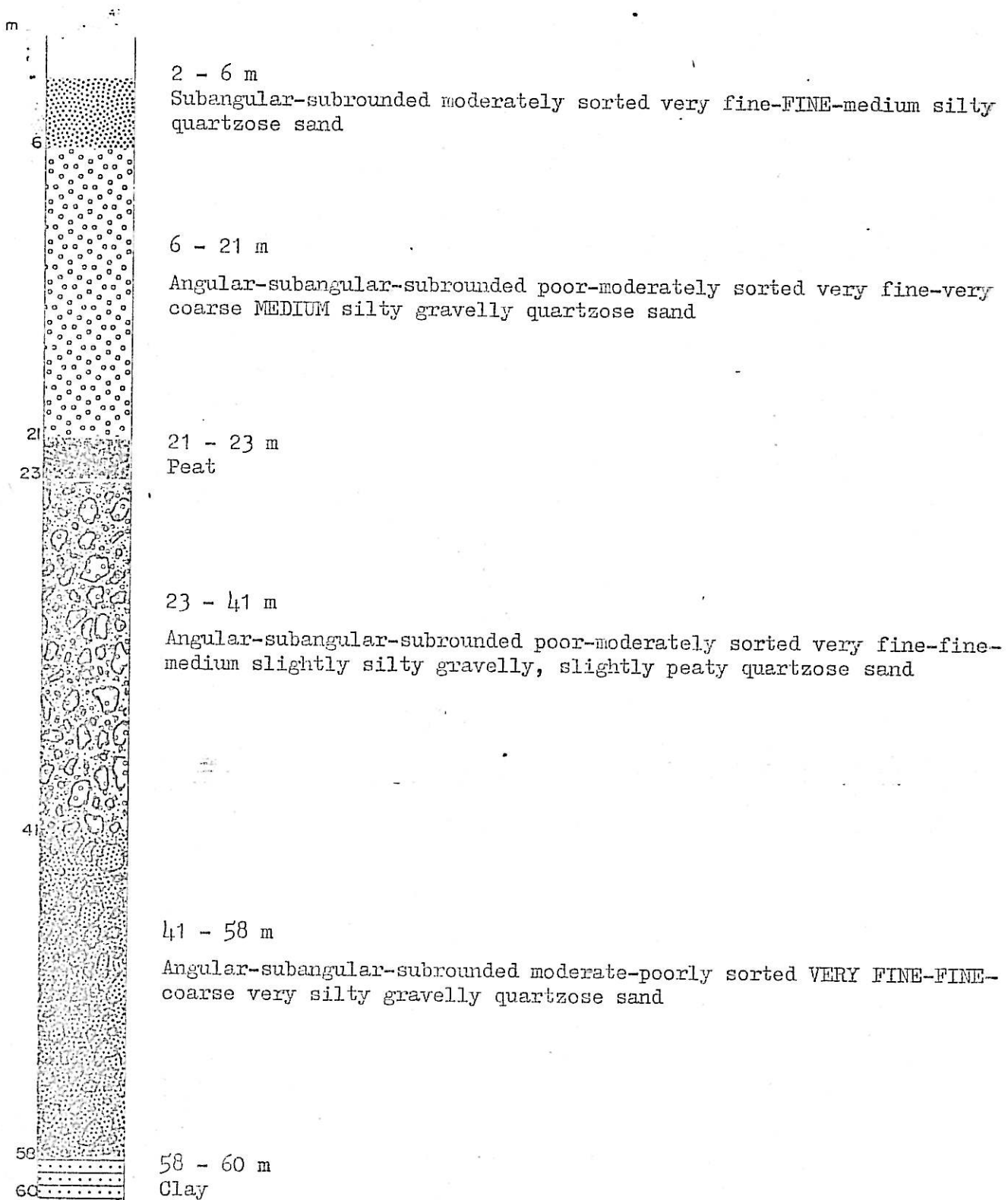
Borehole number: G33245

Coordinates: Lat. 32° 51' 00"

Long. 18° 22' 08"

Farm: Kersefontein

Elevation a.m.s.l. 44,746 m



Project: Coastal Plain Velddrif - Elands Bay

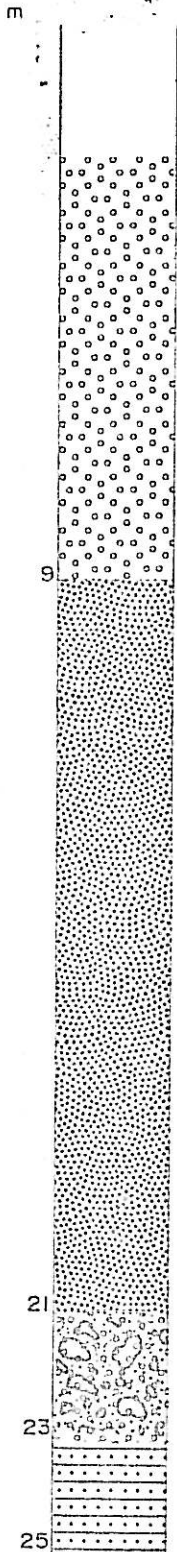
Borehole number: G33246

Coordinates: Lat. 32°54'07"

Long. 18°20'15"

Farm: Kersefontein

Elevation a.m.s.l. 7,655 m



2 - 9 m

Subangular-subrounded-rounded moderately sorted medium clean quartzose sand

9 - 21 m

Subangular-subrounded poorly sorted very fine-fine-medium silty quartzose sand

21 - 23 m

Angular-subangular poorly sorted fine-medium silty gravelly quartzose sand

23 - 25 m

Clay

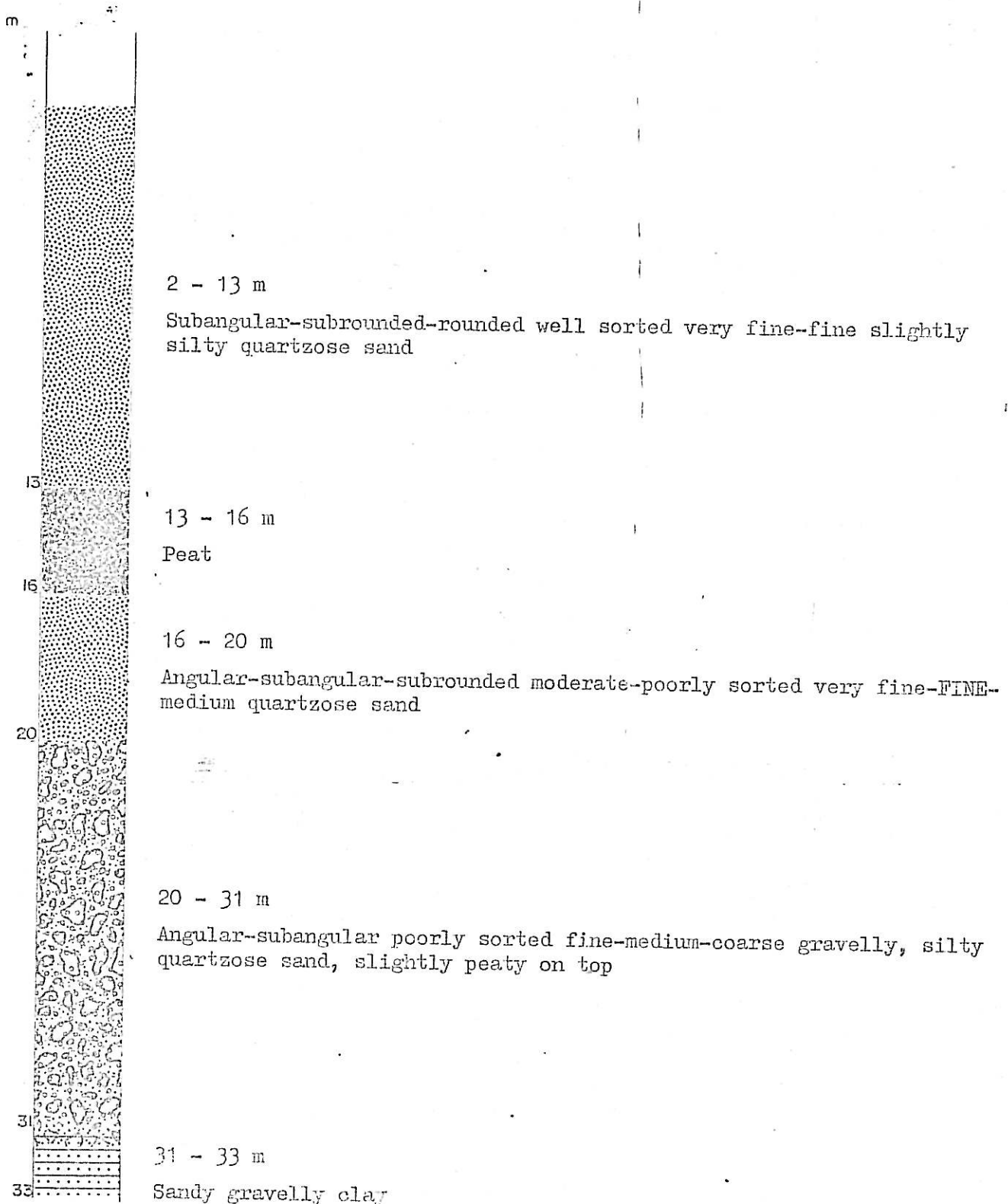
Project: Coastal Plain Velddrif - Elands Bay

Borehole number: 633247

Coordinates: Lat. 32°52'43"
- Long. 18°24'46"

Farm: Kersefontein

Elevation a.m.s.l. 52,585 m



Project Coastal Plain Velddrif - Elands Bay

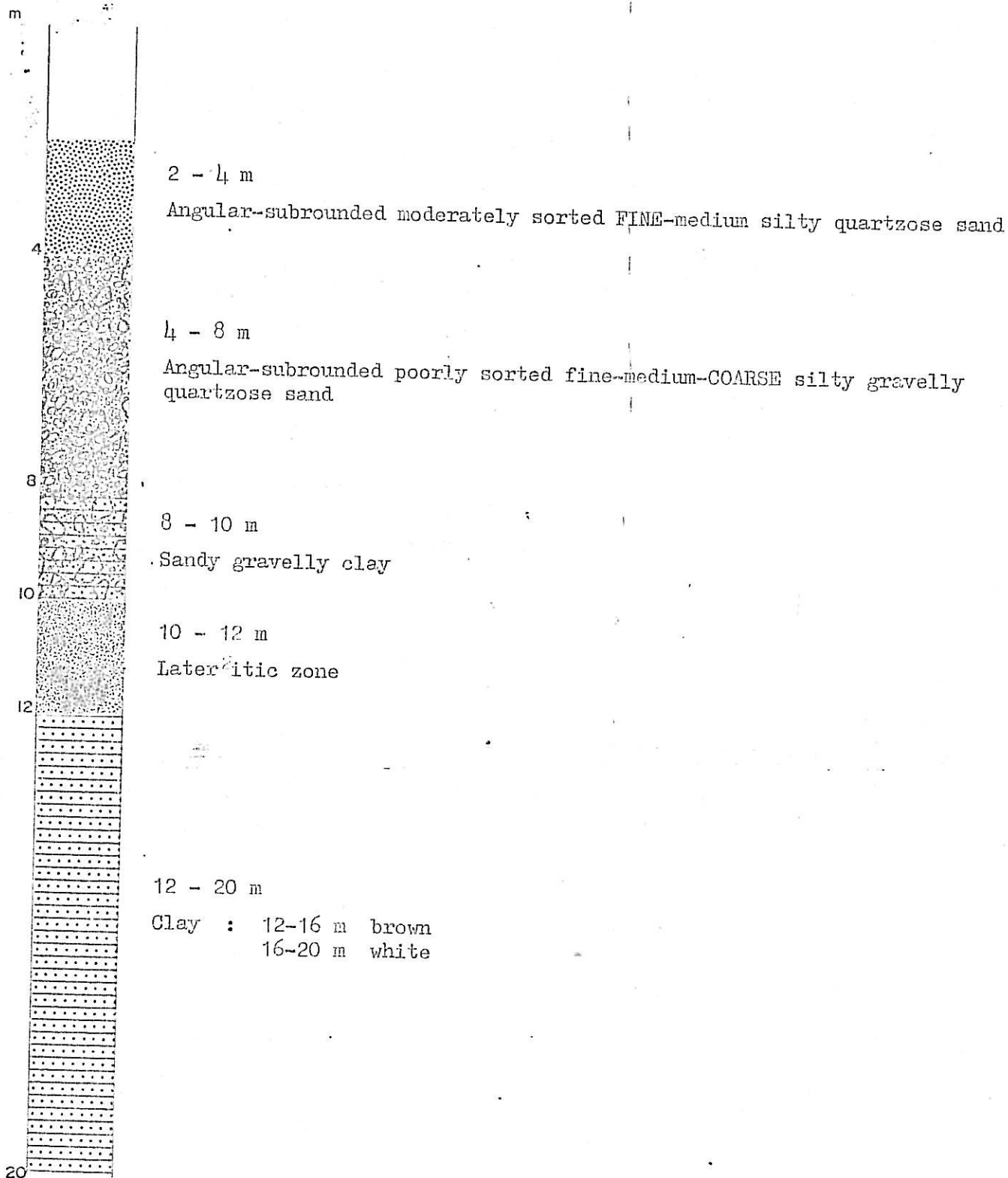
Borehole number: G33248

Coordinates: Lat 32° 48' 09"

Long. 18° 22' 31"

Farm: Woestehuvel

Elevation a.m.s.l. 42,087 m



Project Coastal Plain Velddrif - Elands Bay

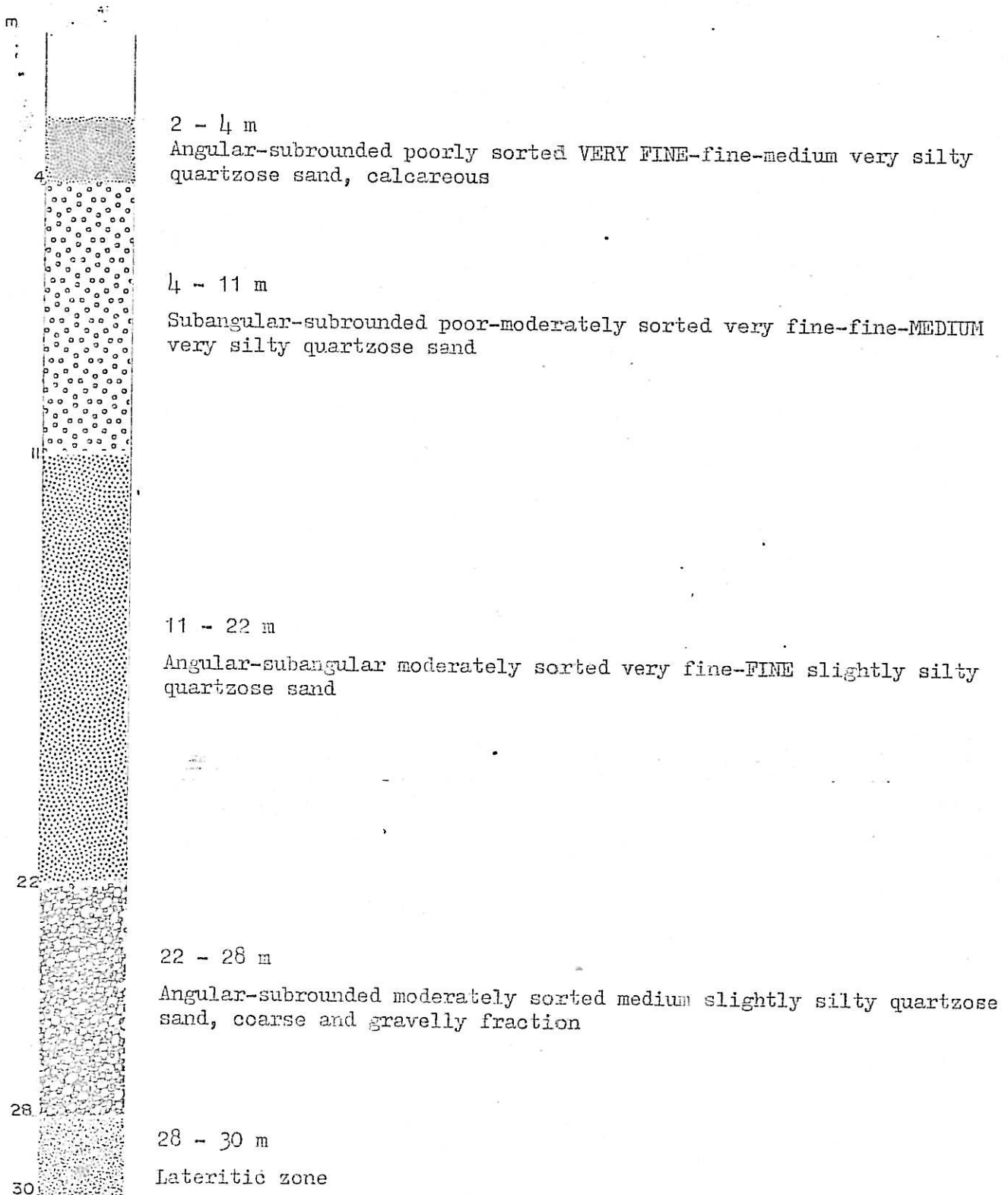
Borehole number : G33249

Coordinates : Lat 32° 46' 15"

Long 18° 25' 24"

Farm : Drommelvalley

Elevation a.m.s.l 56,805 m



Project: Coastal Plain Velddrif - Elands Bay

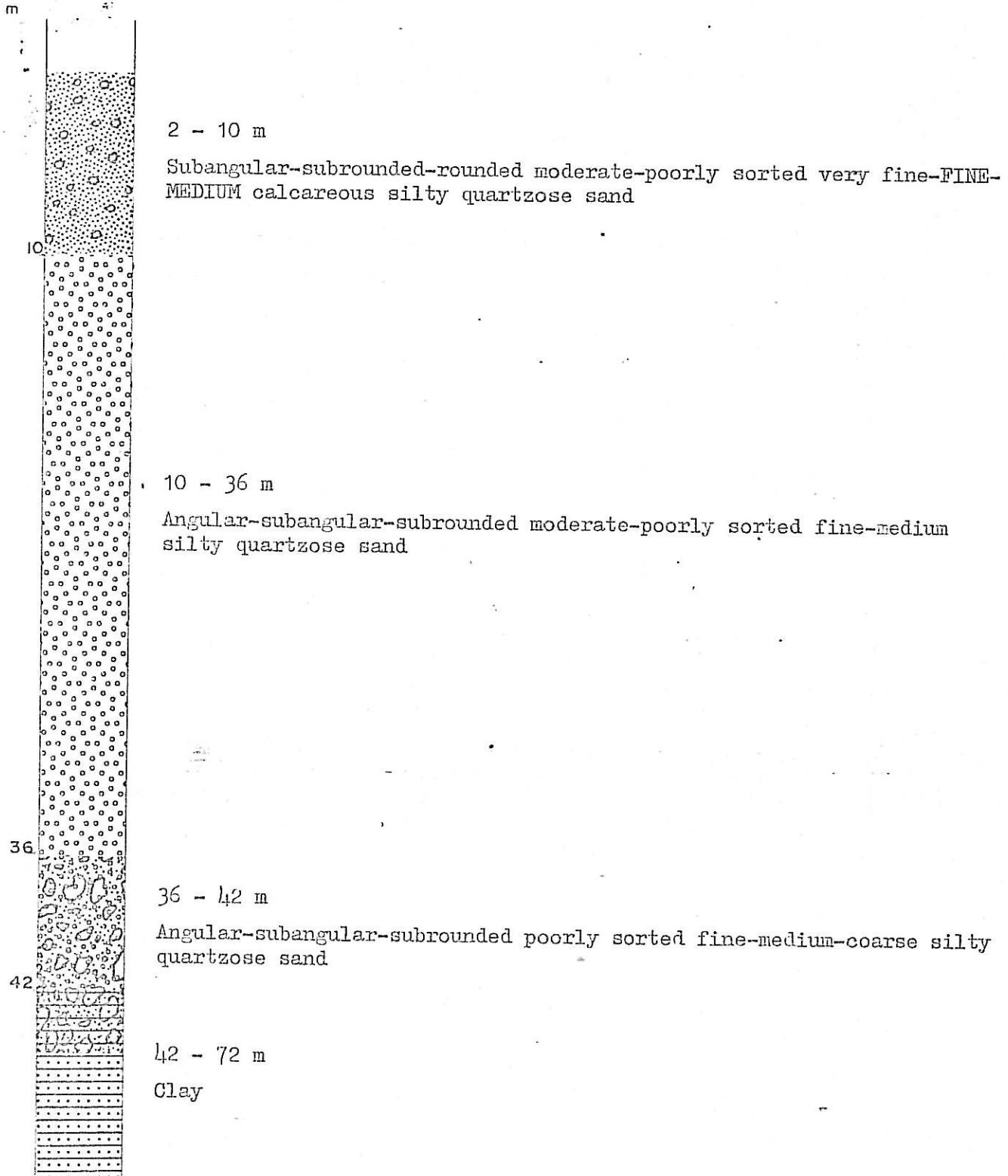
Borehole number: G33250

Coordinates: Lat 32° 46' 29"

Long. 18° 17' 48"

Farm: Wegloperheuveld

Elevation a.m.s.l. 45,007 m



Project: Coastal Plain Velddrif - Elands Bay

Borehole number: 633251 3218 CB 133

Coordinates: Lat 32° 42' 26"

Long 18° 22' 17"

Farm: Drieheuvelds

Elevation a.m.s.l 63,543 m

m

4:

No description was made due to a very high salt content
which kept the samples too damp

Project: Coastal Plain Velddrif - Elands Bay

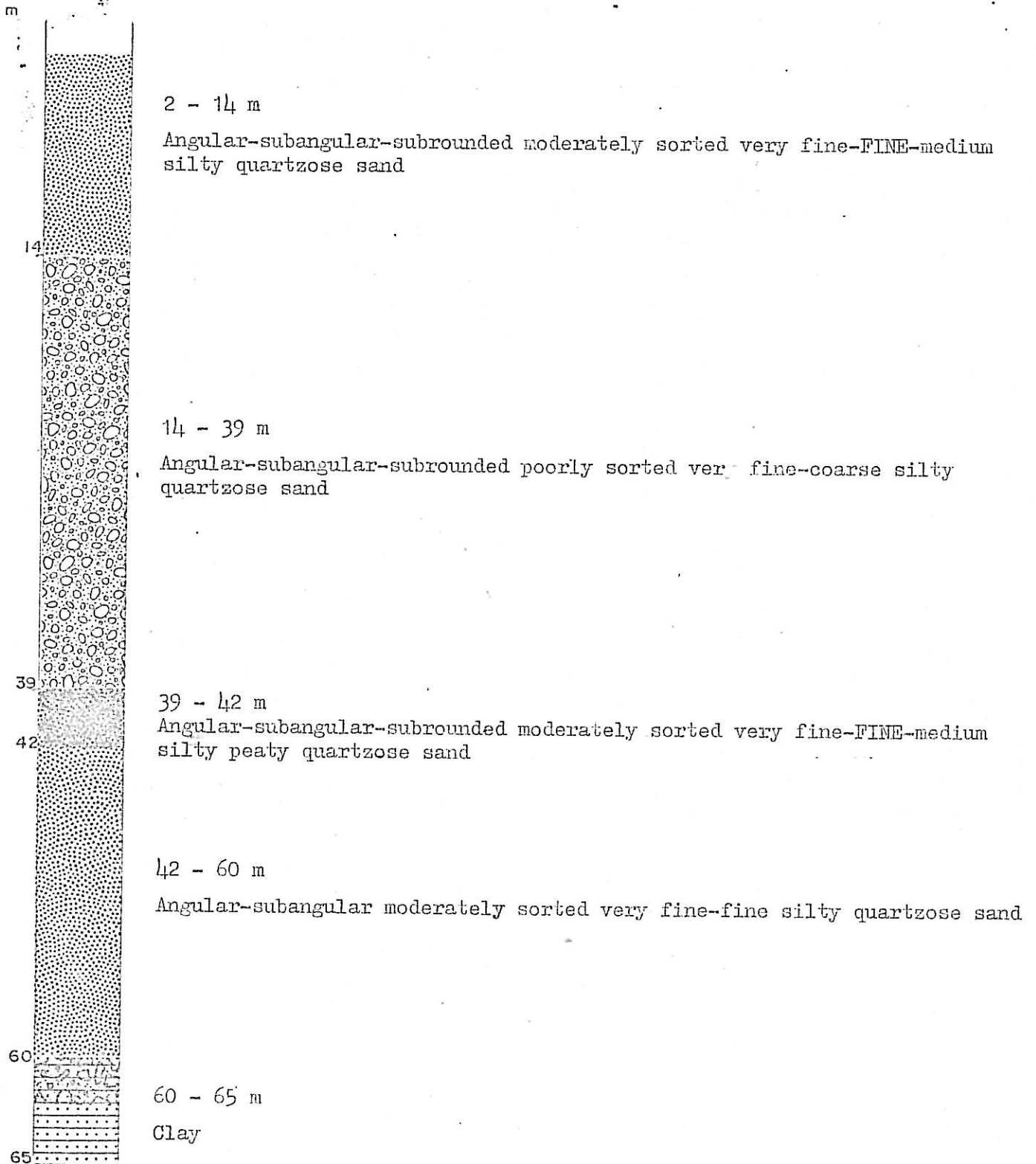
Borehole number: G33252

Coordinates: Lat. 32°41'12"

Long. 18°24'07"

Farm: Jakhalsfontein

Elevation a.m.s.l. 85,615 m



Project Coastal Plain Velddrif - Elands Bay

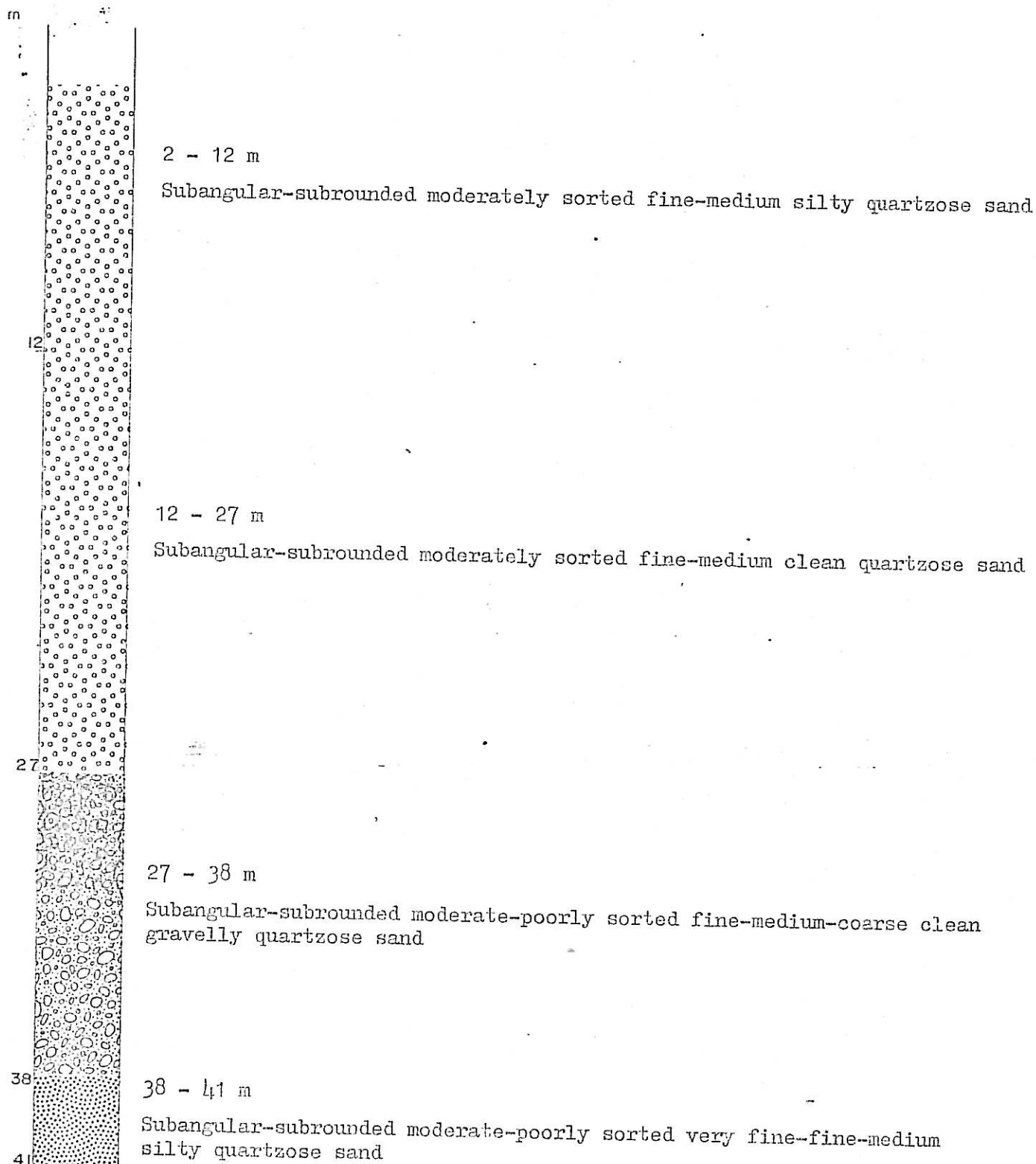
Borehole number : G33253

Coordinates : Lat. 52° 42' 21"

Long. 18° 19' 15"

Farm : Groeneveld

Elevation a.m.s.l. 51,498 m



Project Coastal Plain Velddrif - Elands Bay

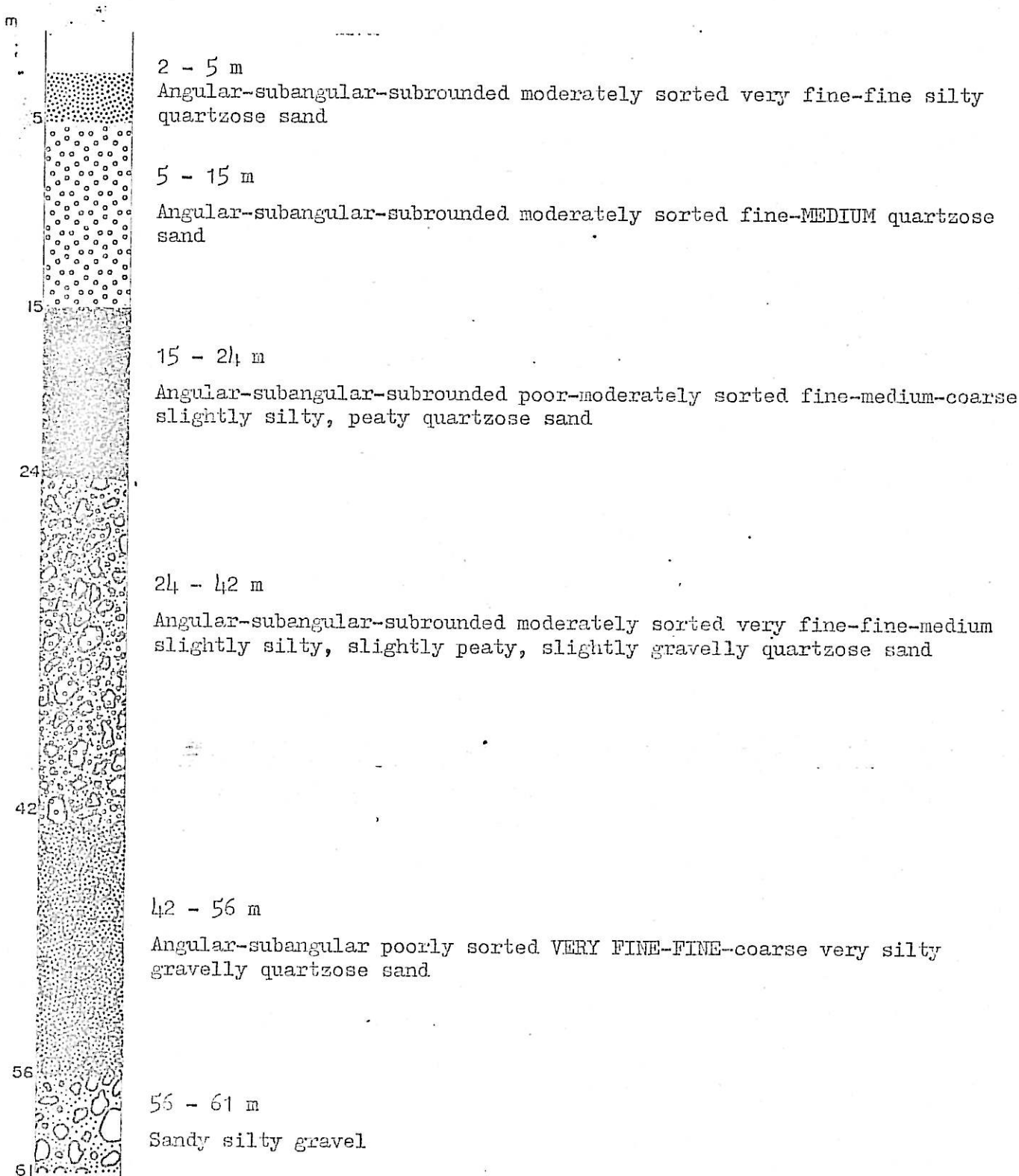
Borehole number : G33254

Coordinates : Lat 32° 51' 00"

Long 18° 22' 08"

Farm : Kersefontein

Elevation a m s l 44,779 m



Project: Coastal Plain Velddrif - Elands Bay

Borehole number: G33255

Coordinates: Lat. 32° 52' 12"

Long. 18° 28' 46"

Farm: Harde Valley

Elevation a.m.s.l. 58,345 m



2 - 6 m

Angular-subrounded poor-moderately sorted very fine-fine silty calcareous quartzose sand

6 - 9 m

Subangular-subrounded poor-moderately sorted very fine-fine silty quartzose sand

9 - 39 m

Angular-subangular-subrounded poor-moderately sorted FINE-MEDIUM-coarse very silty gravelly quartzose sand, gravel horizon 25-28 m

39 - 54 m

Silty sandy gravel

54 - 55 m

Clay

Project: Coastal Plain Velddrif - Elands Bay

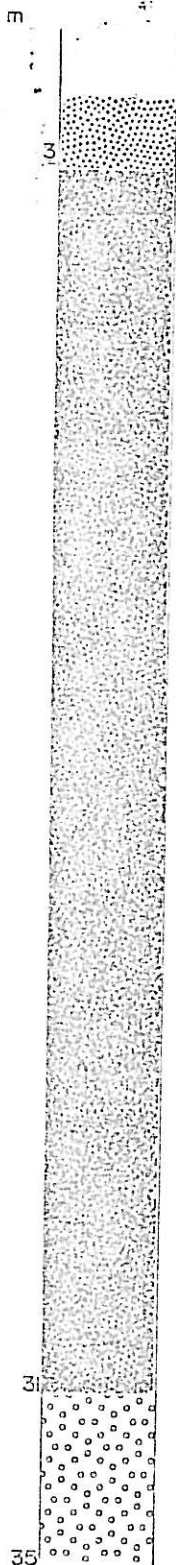
Borehole number: G33256

Coordinates: Lat. 32°35'48"

Long. 18°23'15"

Farm: Klipfontein

Elevation a.m.s.l. 63,310 m



2 - 3 m

Subangular-subrounded well sorted fine quartzose sand

3 - 31 m

Subangular-subrounded moderate-well sorted fine peaty quartzose sand

31 - 35 m

Subangular-subrounded moderately sorted fine-medium slightly silty, slightly peaty quartzose sand

BEDROCK NOT REACHED

Project: Coastal Plain Velddrif - Elands Bay

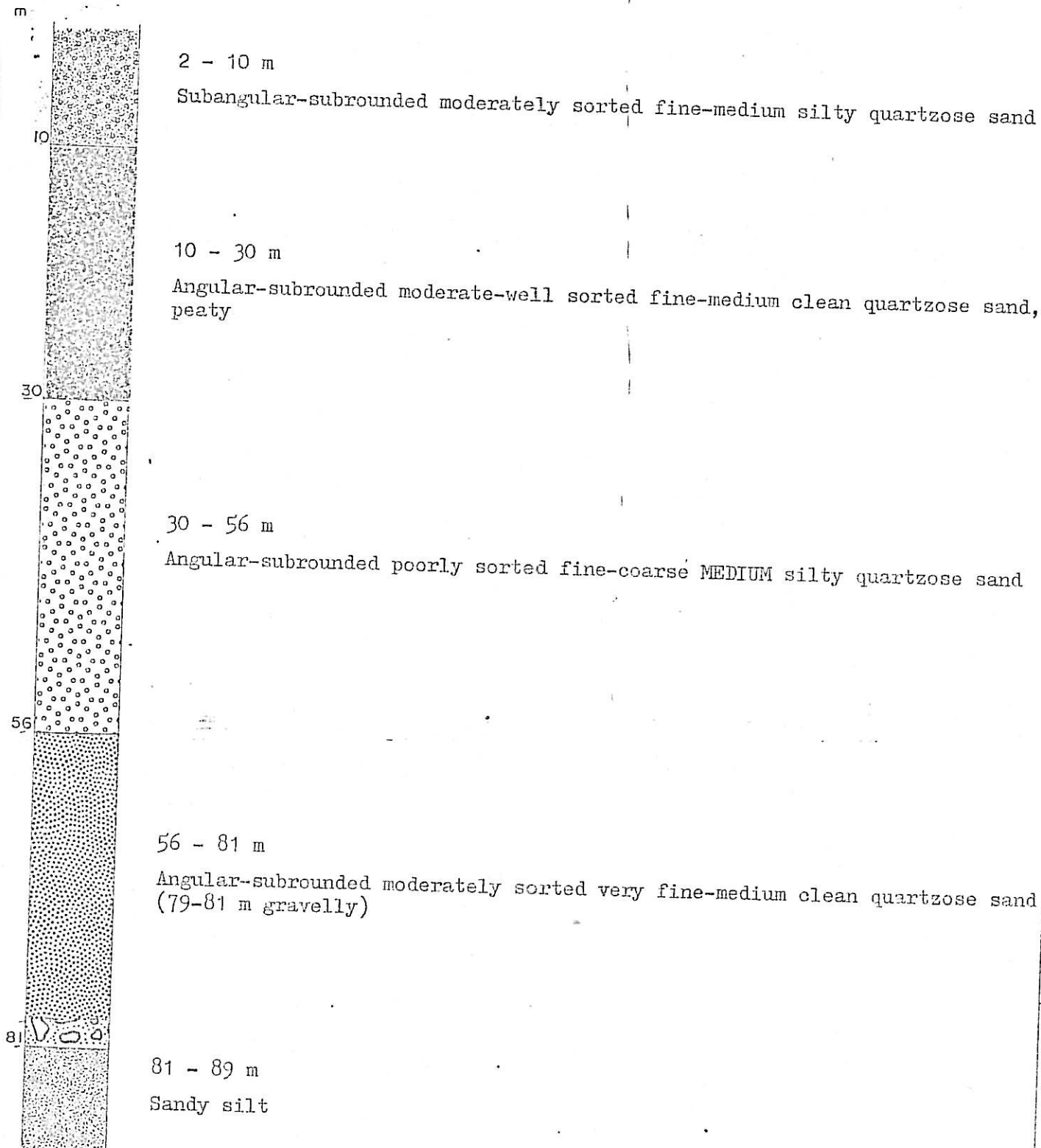
Borehole number: G 33257 3218 CB131

Coordinates: Lat 32°34'59"

Long. 18°25'58"

Farm: Klipfontein

Elevation a.m.s.l. 73,551 m



Project: Coastal Plain Velddrif - Elands Bay

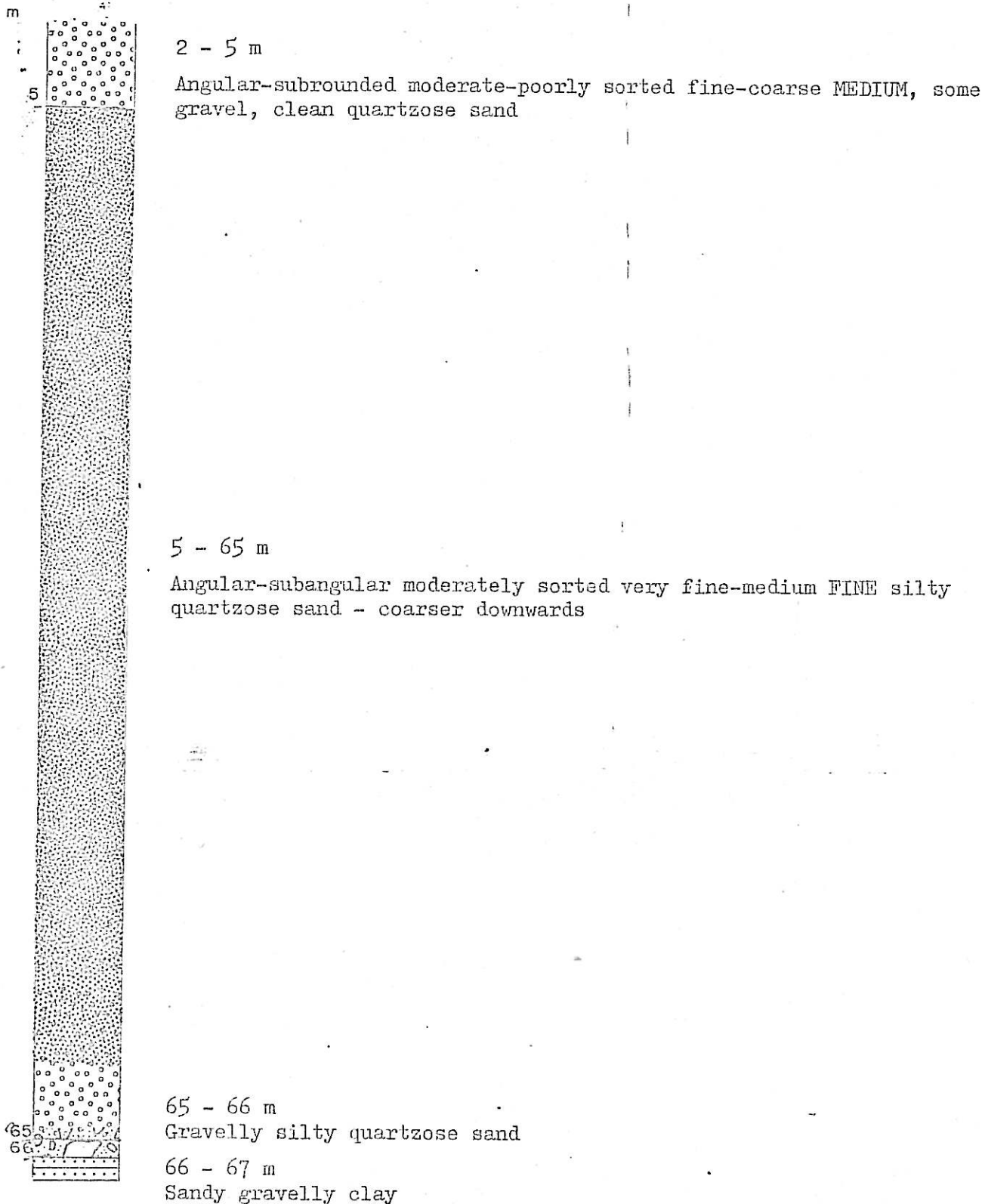
Borehole number: G 33258

Coordinates: Lat. 32° 38' 59"

Long. 18° 25' 17"

Farm: Papekuilsfontein

Elevation a.m.s.l. 43,844 m



APPENDIX III

HYDROCHEMICAL DATA

CHEMICAL ANALYSES OF GROUNDWATER SAMPLES

CONSTITUENTS IN mg/l

B.H. No.	Ca	Mg	Na	K	HCO ₃	SO ₄	Cl	Nitrate as N	P	SI	P	NH ₄	pH unit	TAL as mg/l CaCO ₃	TDS mg/l	E.C. ms/m	Nitrate as NO ₃
33241	92	178	1949	21	534	413	3165	0.14	0.2	7.2	0.108	0.05	8	438	6360	1023	0.63
33243	1586	3499	28975	724	0	12681	51484	0.02	0.5	10.1	0.052	8.82	7.3	0	98971	10444	0.09
33244	201	170	1525	17	45.2	211	3024	0.07	0.1	6.1	0.051	0.20	6.9	12.5	5308	393	0.31
33246	51	90	710	6.5	43.9	120	1331	0.03	0.3	7.6	0.017	0.10	6.9	36	2361	441	0.13
33247	85	119	849	30.5	323.1	162	1547	0.03	0.2	21.1	0.056	0.10	5.1	265	3137	534	0.13
33248	402	1039	10165	51.5	185.5	1126	19628	0.01	0.1	7.7	0.061	0.12	7.3	152	32654	4548	0.04
33249	69	136	1213	13.4	403.5	106	2204	0.03	0.3	7.8	0.036	0.04	7.7	331	4153	704	0.13
33250	272	284	1515	15.3	442.1	520	3006	0.05	0.4	8.0	0.019	0.04	7.5	338	6033	985	0.22
33251	316	14037	57348	1237	0	19944	116707	0.05	1.3	1.3	0.058	8.42	7.0	0	209653	14994	0.22
33252	42	69	575	4.1	34.1	83	1148	0.08	0.3	5.8	0.023	0.04	7.4	28	1984	404	0.35
33253	67	145	1375	10.9	81.7	169	2513	0.03	0.3	9.7	0.051	0.18	6.5	67	4368	823	0.13
33254	42	74	875	11.3	193.9	52	1510	0.10	0.3	10.0	0.243	0.19	7.0	159	2799	499	0.44
33255	32	48	518	11.3	237.8	41	825	0.05	0.5	9.0	0.072	0.05	7.0	195	1724	308	0.22
33256	7	25	151	2.1	34.1	45	246	2.10	0.2	5.6	0.090	0.16	6.7	28	526	108	9.2
33257	9	21	110	3.1	63.4	15	137	0.10	0.1	6.5	0.060	0.14	6.4	52	415	86	0.44
33258	40	132	800	3.5	145.1	17.7	1459	0.01	0.2	7.7	0.026	0.27	6.0	119	2795	534	0.04

The maximum permissible limits :
 (Hydrological Research Institute, 1984
 * as approved by SABS)

Ca = 200 mg/l
 *Mg = 100 mg/l
 *Na = 400 mg/l
 K = 400 mg/l
 *SO₄ = 600 mg/l
 *Cl = 600 mg/l

Nitrate as N = 10 mg/l
 P = 1.5 mg/l
 NH₄ = 2 mg/l
 *pH = 5.5 - 9.5
 TAL = 650 mg/l
 EC = 300 ms/m

