THE RESULTS OF THE HYDROGEOLOGICAL INVESTIGATIONS IN THE MHALA DISTRICT, GAZANKULU

VOLUME I

Groundwater Consulting Services
Consultants in Water Resources

Groundwater Consulting Services cc
Consultants in Water Resources
Reg. No.: 90/00984/23

Your ref:
94.1-015
Our ref:

THE RESULTS OF THE HYDROGEOLOGICAL INVESTIGATIONS IN THE MHALA DISTRICT, GAZANKULU

VOLUME I

M STEWART
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JUNE, 1994

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17 June 1994

Gazankulu Government
Department of Works
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ATTENTION : MR STEVEN HERHOLDT

Dear Sir

THE RESULTS OF THE HYDROGEOLOGICAL INVESTIGATION IN THE MHALA DISTRICT, GAZANKULU.

Please find enclosed three copies of our report detailing the results of the hydrogeological investigations in the Mhala District. These investigations involved a hydrocensus of the existing water supplies and the siting, drilling and pump testing of additional water boreholes.

Please contact us should you require additional information.

Yours faithfully

MARK STEWART
Staff Hydrogeologist

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SUMMARY

This report forms part of the ongoing Rural Water Supply Project initiated by the Gazankulu Government. This study concerns the use of groundwater resources to provide additional potable water to rural communities in the Mhala Block, Gazankulu. The aim was to identify, establish and provide potable groundwater to supplement the existing supplies.

The integration of geological, hydrogeological and geophysical information facilitated the identification of 48 target drilling sites throughout the Mhala Block. The final location of the boreholes was dictated by terrain accessibility with regard to the drilling rig.

The contract drilling programme, realised the establishment of 16 successful boreholes. The yield potential of these boreholes were determined during the course of a contract test pumping programme.

Existing groundwater abstraction in the Mhala North - East study area was at approximately 27,72m^3/hr (7,7ℓ/s). The results of this study established a further 59,04m^3/hr (16,4ℓ/s). Giving a total potential abstraction of 86,76m^3/hr (24.1ℓ/s).

Existing groundwater abstraction in Dwarsloop, Mhala Central was calculated to be approximately 22,54m^3/hr (6,26ℓ/s). The results of this study established a further 15,48m^3/hr (4,3ℓ/s). Giving a total potential abstraction of 38,02m^3/hr (10,56ℓ/s).

Included are recommendations for safe pumping rates, abstraction schedules and pump settings. Optimal utilisation of the groundwater is assured provided that abstraction is maintained to these recommendations.

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1. INTRODUCTION

The Department of Works, identified the need for the utilisation of groundwater resources in the provision of potable water for the rural communities by upgrading the existing water supplies. The settlements in the north - east portion of the Mhala Block were identified as suffering severe potable water shortages, after a hydrocensus and a test pumping programme of existing boreholes was performed. The settlements in this study area where : Phungwe, Utha, Manyeleti, Thorndale, Seville and Sevillė'A'.

Two additional study areas were identified for further groundwater supply development namely; Acornhoek and Dwårsloop, during this project. These areas were identified by the consulting engineering firm Eksteen, Van Der Walt & Nissan (EVN) of Pietersburg, who were appointed to identify and address deficiencies in this regard. Locality **Figure 1** indicates the three main study areas.

2. TERMS OF REFERENCE

Groundwater Consulting Services (GCS), having completed several hydrogeological investigations in the Mhala Block for the Department of Works, Gazankulu, were awarded a further project (Ref 102/4) by Mr Steven Herholdt (Department of Works, Gazankulu). This hydrogeological investigation in the Mhala Block, was to form part of the plan to upgrade the rural water supplies in that area.

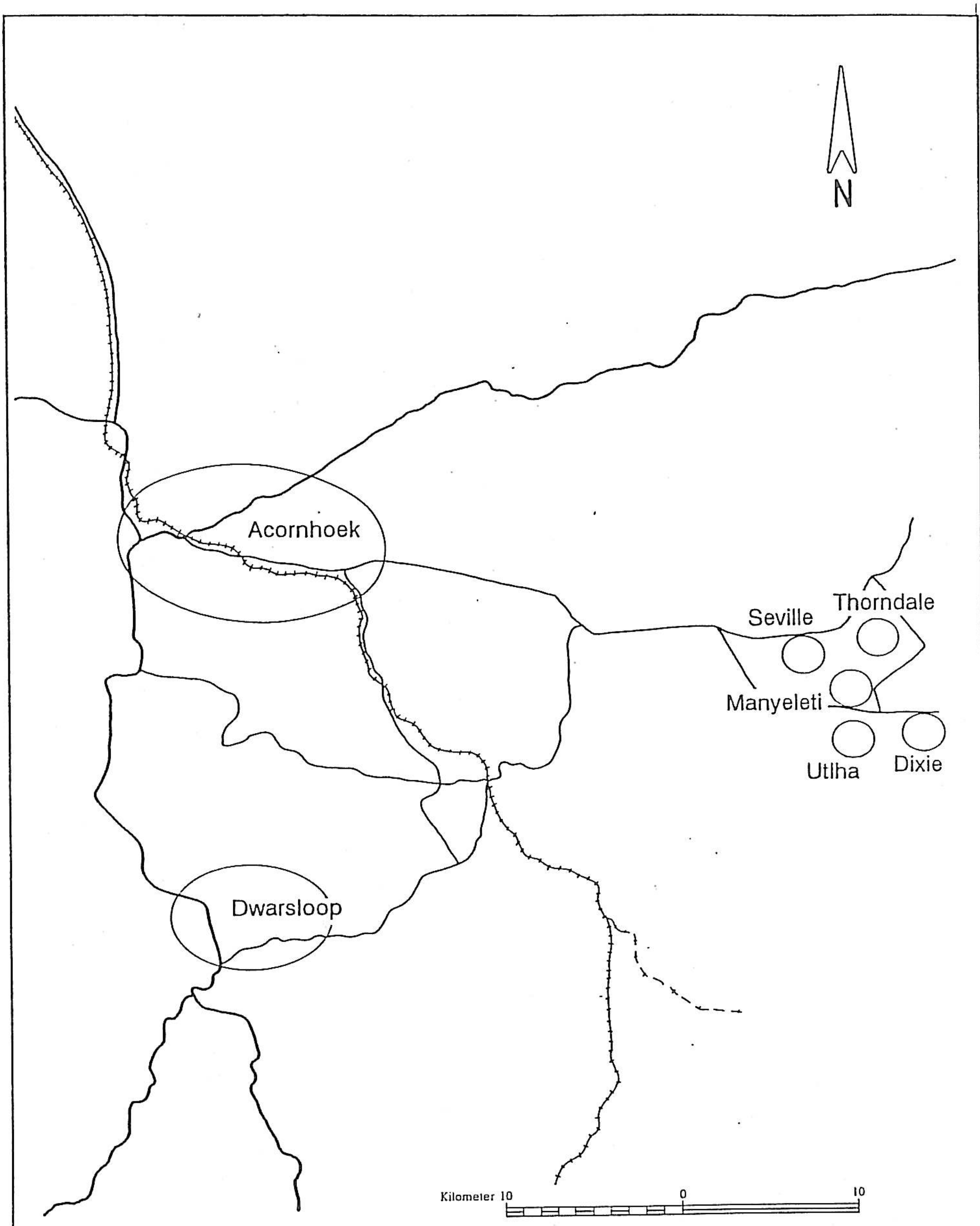
This report details the hydrogeological investigation that was completed at these villages on 31 March 1994.

3. APPROACH

The study was undertaken in four phases, as follows:

PHASE 1	:	Hydrocensus and Hydrogeological Investigation into yields of existing boreholes.
PHASE 2	:	Field Work - Geophysics
PHASE 3	:	Drilling and Test Pumping
PHASE 4	:	Final Report

Phase 1 of the study was completed in December 1993. It provided an assessment of the existing water supply situation, including unequipped boreholes in the study areas. The hydrocencus highlighted communities that were deficient in potable water supplies. The results of the investigation are discussed in Section 5.



Project

GAZANKULU - DROUGHT RELIEF PROGRAMME
MHALA AREA - LOCALITY PLAN

Groundwater Consulting Services

Consultants in Water Resources

P.O. Box 2587 Rivonia 2128 Tel (011) 803-5726

Project No 94-1.015

Scale AS ABOVE

Figure 1

Phase 2 commenced in January 1994. It entailed the execution of geophysical surveys to identify suitable drilling targets for the establishment of potential water supply boreholes. It was completed in February 1994.

Phase 3 consisted of the drilling and yield testing of boreholes. It commenced in February 1994 and was completed in April 1994.

Phase 4 of the investigation is embodied in this document.

4. GEOLOGY/HYDROGEOLOGY

4.1 Regional Geology

The oldest basement rocks in the study area are the Makhutswi Gneiss of Swazian Age. The Makhutswi Gneiss cover approximately one third of the Mhala Block, and consist essentially of a biotite-rich gneiss.

Unnamed basement lithologies comprised of migmatites and gneisses outcrop in the north and eastern portions of the Mhala block. An age of 2774 Ma has been assigned to these lithologies.

It is thought that remobilisation of these older rocks has resulted in the formation of the Cunning Moor Tonalite, which occupies much of the southern section of the study area although, its boundaries are irregular and diffuse. This formation consists of coarse-grained, granitic material containing large crystals of sphene.

Intruded into the basement lithologies are younger basic rocks. The dominant intrusion is the Timbavati Gabbro (± 1000 Ma). These gabbros are characterised by irregular shaped outcrop patterns in the north-east. The Rykoppies Gabbro forms a linear range of hills to the south of the study area, forming the border between Gazankulu and Lebowa. The occurrence of these plagioclase and pyroxene rich rocks are associated with a distinct vegetation change which is easily recognisable.

Younger (150 - 190 Ma) intrusives of dolerite and diabase have intruded into the older formations as sills and dykes.

4.2 Hydrogeology

The groundwater potential of granites and gneisses in the pristine state is negligible as they are largely impermeable and have little or no groundwater storage capacity. As a result aquifers are limited to structural features produced by tectonic processes and lithological contact zones. Deep weathering, fracturing and faulting have been recognised as the most important factor in the hydrogeology of such crystallising basement lithologies.

The Makhutswi Gneiss and the other basement rocks are generally weathered and are therefore covered by a fairly deep layer of decomposed material. They are generally homogeneous rocks but can sometimes contain pegmatite veins, and are invariably transgressed by intrusive dykes. These dykes play an important role in the hydrogeological properties of the study area. Areas of deeper weathering in these older gneiss can produce good groundwater supplies due to the local increase in transmissivities of the groundwater.

The areas targeted for drilling in the Mhala Block include contact zones between younger intrusive bodies and the surrounding country rocks, zones of deeper weathering within the basement rocks and zones of faulting and fracturing within the granites and gneisses.

5. RESULTS OF THE HYDROCENSUS AND TEST PUMPING PROGRAMME

A hydrocensus was performed at seven (7) settlements in the north-east portion of the Mhala Block.

The settlements are as follows : Gottenburg, Thorndale, Seville, Seville 'A', Manyeleti, Utha and Phungwe. The results are tabled in **Table 1**.

During this hydrogeological investigation only five existing production boreholes were identified. These holes were pumped for 24 hours while monitoring the water levels within the boreholes. The pumps were then stopped and the recovery water levels were recorded. The detailed methodology concerning these tests are explained in our previous report (Ref : 93-9-085 A&B/rp1).

A hydrocensus for Dwarsloop was performed and detailed in our previous report (Ref: 93-9-085 A&B/rp1). There was no hydrocensus data compiled for Acornhoek in this investigation due to the urgency of the project.

Table 1 RESULTS OF THE HYDROCENSUS AT 7 SETTLEMENTS. MHALA NORTH-EAST GAZANKULU

SETTLEMENT NAME	BOREHOLE CO-ORDINATES	BOREHOLE NUMBER	DATE	SWL (mbgl)	YIELD (l/s)	DEPTH (m)	PUMP TYPE	POWER	COMMENTS
Phungwe	24 41,97"S 31 28,66"E	DIXI01	09/11/93	-	0.25	-	HAND	HAND	SALTY TASTE
Phungwe	24 41,86"S 31 28,91"E	DIXI02	09/11/93	19.44	1.5	45	MONO	DIESEL	NEEDS MORE STORAGE
Phungwe	24 41,53"S 31 28,97"E	DIXI03	09/11/93	23.15	ND	71	NONE	NONE	NEEDS TESTING & EQUIP.
Utha	24 42,67"S 31 23,26"E	UTHA01	16/11/93	-	ND	-	NONE	NONE	HOLE BLOCKED WITH CEMENT
Utha	24 43,11"S 31 24,01"E	UTHA02	16/11/93	-	ND	-	NONE	NONE	DISUSED HOLE
Utha	24 43,14"S 31 14,37"E	UTHA03	16/11/93	-	NONE	-	NONE	NONE	COLLAPSED HOLE
Utha	24 43,22"S 31 24,50"E	UTHA04	10/11/93	8.34	0.5	46.84	MONO	DIESEL	ENGINE BREAKS FREE
Utha	24 42,47"S 31 26,56"E	UTHA05	17/11/93	15.2	ND	-	NONE	NONE	NEEDS TESTING & EQUIP.
Utha	24 42,42"S 31 26,52"E	UTHA06	17/11/93	-	ND	-	NONE	NONE	NEEDS TESTING & EQUIP.
Utha	24 42,47"S 31 26,63"E	UTHA07	17/11/93	-	ND	-	NONE	NONE	NEEDS TESTING & EQUIP.
Utha	24 41,69"S 31 26,89"E	UTHA08	17/11/93	-	0.25	-	HAND	HAND	VERY SALTY WATER
Utha	24 41,98'S 31 26,81"E	UTHA09	18/11/93	-	ND	-	NONE	NONE	DISUSED HOLE
Utha	24 41,98'S 31 26,96"E	UTHA10	18/11/93	-	0.25	-	HAND	HAND	STRONG HOLE
Utha	24 41,92"S 31 26,92"E	UTHA11	17/11/93	-	0.25	-	HAND	HAND	RELIABLE HOLE
Manyeleti	24 40,13"S 31 26,57"E	MNL01	16/11/93	47.11	ND	66.45	NONE	NONE	NEEDS TESTING & EQUIP.
Manyeleti	24 40,10"S 31 26,57"E	MNL02	16/11/93	-	NONE	-	NONE	NONE	BLOCKED HOLE
Manyeleti	24 40,74"S 31 26,37"E	MNL03	16/11/93	-	0.25	-	HAND	HAND	RELIABLE HOLE
Manyeleti	24 40,24"S 31 26,54"E	MNL04	16/11/93	-	ND	-	NONE	NONE	NEEDS TESTING & REPAIRS
Manyeleti	24 40,47"S 31 26,88"E	MNL05	18/11/93	-	0.25	-	HAND	HAND	RELIABLE HOLE
Manyeleti	24 40,60"S 31 26,21"E	MNL06	16/11/93	26.65	ND	-	NONE	NONE	NEEDS TESTING & EQUIP.
Seville'A'	24 40,43"S 31 24,87"E	SVLLA01	15/11/93	21.3	1	-	MONO	DIESEL	PUMPS 10 HOURS/DAY
Seville'A'	24 40,59"S 31 25,47"E	SVLLA04	18/11/93	23.4	ND	-	NONE	NONE	NEEDS TESTING & EQUIP.
Seville'A'	24 40,58"S 31 25,49"E	SVLLA05	18/11/93	23.5	ND	-	NONE	NONE	NEEDS TESTING & EQUIP.
Seville	24 39,15"S 31 25,03"E	SVLL01	11/11/93	8.89	0.7	73.5	MONO	DIESEL	PUMPS 8 HOURS/DAY
Gottenburg	24 37,04"S 31 25,28"E	GTBG01	12/11/93	46.84	4	-	MONO	DIESEL	VERY STRONG HOLE
Gottenburg	24 37,02"S 31 26,00"E	GTBG02	15/11/93	-	NONE	-	HAND	HAND	BROKEN SHAFT
Gottenburg	24 36,78"S 31 25,81"E	GTBG03	15/11/93	22.31	ND	46.81	NONE	NONE	NEEDS TESTING & EQUIP.
Gottenburg	24 36,90"S 31 24,84"E	NONE	15/11/93	-	0.1	-	HAND	HAND	WEAK HOLE

ND - NO DATA AVAILABLE

5.1 Testing Pumping Results of Existing Supplies, Mhala North-East

5.1.1 Yields

All five yields of the existing production boreholes could be established, using the volumetric method. These varied from 1.8 m^3/hr to 14.4 m^3/hr. The average yield is 5.4 m^3/hr.

The transmissivities (**Table 2**) varied from 15 to 264m^2/day during pumping (average 105m^2/day) and between 10 and 333m^2/day during recovery (average 125m^2/day).

5.1.2 Recovery

A study of the recovery data from the boreholes indicates that 70% of the boreholes exhibit good recovery rates. The boreholes recovered to an average 91,8% of static water level within three hours.

5.1.3 Abstraction Schedules

Information obtained from the pump operations indicated that the holes are pumped, on average, for periods of 8 - 10 hours per day.

5.2 Water Balance Equations

Based on the recorded pumping rates and verbal information as to the number of hours the boreholes are pumped per day, it is estimated that the following volumes of groundwater are utilised in each village.

5.2.1 Phungwe

1 borehole tested	=	5,4m^3/hr
Pumping Period	=	10 hours/day
Weekly Consumption	=	378m^3/week
Yearly Consumption	=	19656m^3/year

Table 2 RESULTS OF TESTS PREFORMED ON PRODUCTION BOREHOLES, MHALA NORTH-EAST GAZANKULU

SETTLEMENT NAME	BOREHOLE CO-ORDINATES	BOREHOLE NUMBER	DATE	SWL (mbgl)	YIELD (l/s)	DRAWDOWN (m)	SPECIFIC CAPACITY (l/s/m)	TEST DURATION (min)	RECOVERY (%)	RECOVERY DURATION (min)	T DURING TEST (m^2/day)	T DURING RECOVERY (m^2/day)
Phungwe	24 41,86"S 31 28,91"E	DIXI02	09/11/93	19.44	1.5	14.435	0.10	1440	90%	180	30	10
Utha	24 43,22"S 31 24,50"E	UTHA04	11/11/93	8.34	0.5	2.23	0.22	1440	94%	120	132	100
Sevile'A'	24 40,43"S 31 24,87"E	SVLLA01	15/11/93	21.3	1	46.9	0.02	1440	-	-	15	-
Seville	24 39,15"S 31 25,03"E	SVLL01	11/11/93	8.89	0.7	5.195	0.13	1440	97%	180	85	55
Gottenburg	24 37,04"S 31 25,28"E	GTBG01	13/11/93	46.84	4	1.97	2.03	1440	86%	180	264	333

5.2.2 Utha

1 borehole tested	=	1,8m^3/hr
Pumping Period	=	10 hours/day
Weekly Consumption	=	126m^3/week
Yearly Consumption	=	6552m^3/year

5.2.3 Seville 'A'

1 borehole tested	=	3,6m^3/hr
Pumping Period	=	10 hours/day
Weekly Consumption	=	252m^3/week
Yearly Consumption	=	13104m^3/year

5.2.4 Seville

1 borehole tested	=	2,52m^3/hr
Pumping Period	=	8 hours/day
Weekly Consumption	=	141,12m^3/week
Yearly Consumption	=	7338,24m^3/year

5.2.5 Gottenburg

1 borehole tested	=	14,4m^3/hr
Pumping Period	=	10 hours/day
Weekly Consumption	=	1008m^3/week
Yearly Consumption	=	52416m^3/year

All the test pumping results are presented in **Appendix A.**

5.3 Discussion of the Pumping Test Results for each Village

Using the population data supplied by the Department of Works, Gazankulu, and a figure for water consumption of 30 litres per head per day, the water demand for each village could be estimated.

5.3.1 Phungwe/Dixie

Borehole DIXI2 delivered a constant yield of 1,5 ℓ/s for 24 hours. The static water level is 19,44 metres below ground level (mbgl) and the drawdown measured at the end of the test was 14,435m (33,875 mbgl). Recovery was slow, to 90% after 180 minutes, this can be attributed to poor efficiency of the borehole.

In Phungwe, the population has been calculated to be 400 for 1993, this gives a water demand of $12m^3$ per day ($4380m^3$ per annum). The annual abstraction of groundwater is $19656m^3$. Resulting in an excess supply of $15726m^3$/year.

However, this water is very salty, due to high sodium values, and an alternative water source should be located (chemistry results are presented in **Appendix B** and discussed under section 9.2.a). An existing unused borehole DIXI3† was tested but was found to be very weak, therefore it was decided to investigate the possibility for further, less saline boreholes to supplement the existing supply.

Note : † The results of the test pumping is detailed in **Appendix A.**

5.3.2 Utha

Borehole UTHA4 delivered a constant yield of 0,5 ℓ/s for 24 hours. The initial water level was 8,34 mbgl and a drawdown of 2,32m was measured at the end of the test. The borehole revealed an excellent recovery to 94% of the static water level within 20 minutes.

In Utha, the population is estimated at 702 for 1993. The water demand calculates to $7686{,}9m^3$/year. The abstraction of groundwater calculates to $6552m^3$/year. Resulting in a shortfall of $1134.9m^3$/year.

These calculations are assuming the borehole UTHA4 pumped to a reservoir which was used for domestic use, at present this is not the case as the settlement is quite a distance from the borehole UTHA4, which provides water for an agricultural scheme.

The remaining unused boreholes were tested (results in **Appendix A.2**). Boreholes UTHA6, UTHA7, and UTHA9 were capped, dry holes. UTHA5 is a weak hole and it is recommended that it not be equipped.

UTHA8, a handpump, is used only in emergencies, as the water is very salty. The high sodium and chloride content causing this can be attributed to the breakdown of plagioclase within the granitic terrain.

Both UTHA10 and UTHA11 were equipped with handpumps these were removed and the holes were tested. The yield of borehole UTHA10 is sufficient to support a pumping rate of 0,5 ℓ/s for 12 hours per day ($7862{,}4m^3$/year). This is sufficient for the daily requirements but it was decided to target and drill further boreholes to supplement this supply. UTHA11 can only support a handpump.

5.3.3 <u>Seville 'A'</u>

Borehole SVLLA1 delivered a constant yield of 1 ℓ/s for the duration of the test. The initial water level was measured at 21,3 mbgl, and the drawdown at the end of the test was 68,2 mbgl a drawdown of 46,82m.

Seville'A' has an estimated 720 people for 1993. The water demand is calculated at 9198m^3/year.

The abstraction of groundwater is calculated at 13104m^3/year.

Borehole SVLLA1 is a weak hole, so two unused boreholes, SVLLA4 and SVLLA5, were tested to determine their safe yields and abstraction schedules. Boreholes SVLLA2 and SVLLA3 were capped dry holes.

It is recommended that SVLLA4 be equipped to pump at a rate of 1ℓ/s for 10 hours per day, and SVLLA5 to pump at 2 ℓ/s for 8 hours per day. This allows for an additional yearly abstraction of 34070m^3/year. All pump test data for Seville'A' is presented in **Appendix A.3**.

Further siting and drilling was undertaken in this area as the results of previous drilling indicated good groundwater potential.

5.3.4 <u>Seville</u>

Borehole SVLL1 delivered a constant yield of 0,7 ℓ/s for the duration of the test. The original static water level was 8,89 mbgl and the water level measured at the end of the test was 14,085 mbgl, a drawdown of 5,195m. The borehole recovered to 97% within 180 minutes.

Thorndale receives its water from the borehole SVLL1 situated at the outskirts of Seville. The population of Thorndale is calculated at 400 for 1993. The water demand is calculated at 12m^3/day (4380m3/year). borehole SVLL1 provides 7338,24m^3/year, thus giving an excess of 2958,24m^3/year. Results are presented in **Appendix A.4**.

As borehole SVLL1 supplies water to both Seville and to Thorndale and is the only supply to Thorndale, it was decided that drilling targets be scientifically sited and that these sites be drilled in this area.

5.3.5 Manyeleti

Manyeleti is solely reliant on two handpumps as there are no diesel driven pumps in this settlement. There are no facilities for water trucks to deliver water to this settlement. The population is Manyeleti is estimated at 705 for 1993. This indicates a water demand of 21,14m³/day (7719,75m³/year), which is equivalent to a pumping rate of 0,6 ℓ/s for 10 hours per day.

As there is little potable water available to this settlement, it was decided that the four unused boreholes (MNL1, MNL2, MNL4 and MNL6) be tested. Borehole MNL1 has a very weak yield and it was recommended that it be equipped with a handpump. Borehole MNL2 was dry. MNL4 was determined to have a safe yield of 0,6 ℓ/s for an abstraction period of 12 hours per day. Borehole MNL6 recommendations were, a safe yield of 0,5 ℓ/s for 10 hours per day. This would provide 16030,8 m³/year which would result in an excess of 8311,05 m³/year.

However, it was decided that further drilling was to take place to supplement these two weak holes. Results are presented in **Appendix A.6.**

5.3.6 Gottenburg

Borehole GTBG1 delivered a constant yield of 4 ℓ/s for the duration of the test. The initial static water level was measured to be 46,84 mbgl and the drawdown measured after continuous pumping for 24 hours was 48,81 mbgl. The borehole recovered slowly to 86% of its initial water level after 180 minutes.

In Gottenburg, the population has been calculated to be 840 for 1993. The water demand is calculate at 9198m³/year. This gives an excess of 2958,24m³/year.

An unused borehole GTBG3 was tested to determine the safe yield and abstraction schedule. This hole can deliver 1,5 ℓ/s for 12 hours per day.

It was decided that there would not be any further drilling in Gottenburg at this time. Results are presented in **Appendix A.6.**

5.4 SUMMARY OF HYDROCENSUS RESULTS

The test pumping undertaken by GCS was aimed at gaining information as to the existing groundwater supplies to the villages. The information gathered allowed GCS to determine problems, deficits in water demand and excess water.

A crude water balance study indicates that the aquifer in Mhala North-East, enveloping Dixie, Utha, Manyeleti, Seville 'A', Seville, Thorndale and Gottenburg is being utilised to 33,4% of its storage and 4,1% of its potential recharge. Based on this information additional groundwater can be utilised in Mhala North-East. Our previous report (Ref: 93.9.085 A&B/rp1) details the calculations for the water balance equations.

Water samples were taken of the end of each constant discharge test, these were then analyzed for major anions and cations, pH and electric conductivity. The results were compared to the "SABS 241-1984 Standard for Drinking Water in South Africa." (All the hydrochemistry is discussed in Section 9, and the results are tabled in **Appendix B**).

6. GROUNDWATER EXPLORATION

In addition to the 7 villages identified by GCS, Acornhoek and Dwarsloop where recognised by the consulting engineering firm, Eksteen, Van Der Walt and Nissan, as areas for further groundwater development.

Each of these study areas will be discussed separately, as follows :

1) Mhala North-East, which comprises of Utha, Dixie, Seville 'A', Manyeleti, Seville and Thorndale.

2) Mhala North, which comprises of Acornhoek and Cottondale.

3) Mhala Central, which comprises, solely, of Dwarsloop.

6.1 Desk Study

In all three areas, a study of the relevant aerial photographs (Scale 1:1500) and all relevant geological maps was undertaken to aid in the selection of target drilling sites. This reconnaissance photogeological interpretation and study helped to identify lithological outcrops and lineaments such as joints, intrusions, shear zones, faults and fractures. These were then selected for detail field geophysical investigations.

6.2 Geophysical Investigation

The geophysical methods employed in these study areas were the ground magnetic and electromagnetic techniques. The object of the geophysical investigations was to locate geological structures of hydrogeological significance. The interpretation and analysis of the geophysical data facilitated the selection and identification of target drilling sites.

The geophysical instruments used were the Chemtron model G4 proton magnetometer and the Geonics EM34-3 terrain conductivity meter. These instruments met with varying success in identifying successful borehole sites. It was found that a combination of the magnetic and EM34-3 instrument enjoyed the greater success.

The location of all the geophysical traverses carried out are shown on the relevant locality plans (**Figures 2-4**, pages 14 to 20). The corresponding data collected along these traverses are graphically presented in **Appendix C: 1-8**. The station interval used for each of the methods was 10m.

The siting of boreholes on field geological observations and aerial photographic interpretations also enjoyed a fair measure of success.

7. DRILLING

7.1 Introduction

The contract drilling programme was awarded to Drill Strata (Pty) Ltd from Pretoria after the contract had gone to tender.

The first phase of drilling at Dwarsloop, Mhala Central was started and completed in January 1994. Six (6) holes were drilled, 4 of which were successful.

The second phase of drilling in both Mhala North and Mhala North-East began in February 1994 and was completed in March 1994. In total, forty two boreholes were drilled, 12 of which were successful.

The direct circulation air-rotary-percussion drilling method was employed. The use of a stabilizer ensured the verticality and straightness of the boreholes. Drill-chip returns were collected every metre and logged on site by a GCS hydrogeologist, who supervised the drilling programme. Water intersections were recorded and airlift yields measured by means of a V-notch weir during drilling.

Project
GAZANKULU - DROUGHT RELIEF PROGRAMME
DWARSLOOP AREA - MHALA CENTRAL

Groundwater Consulting Services
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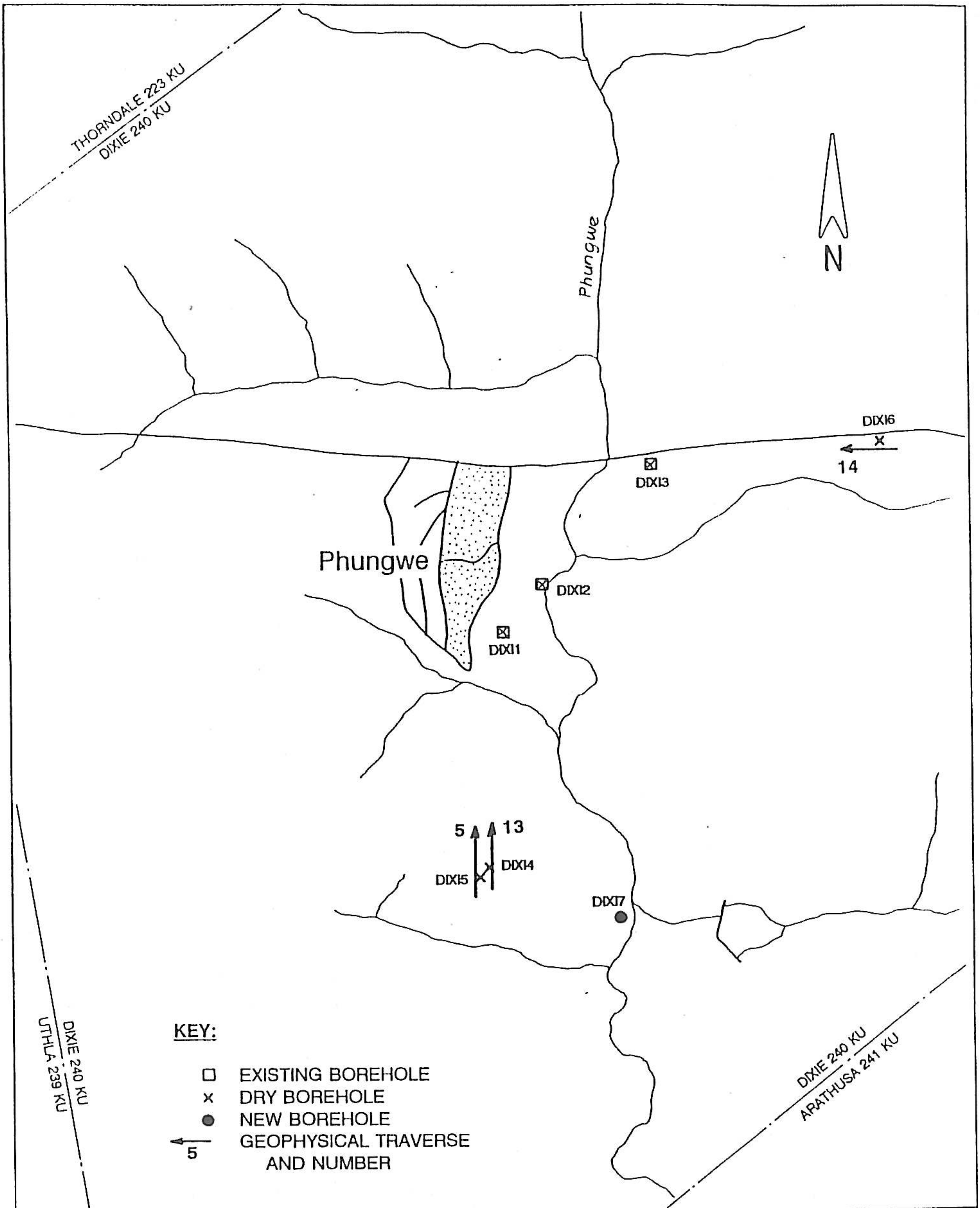
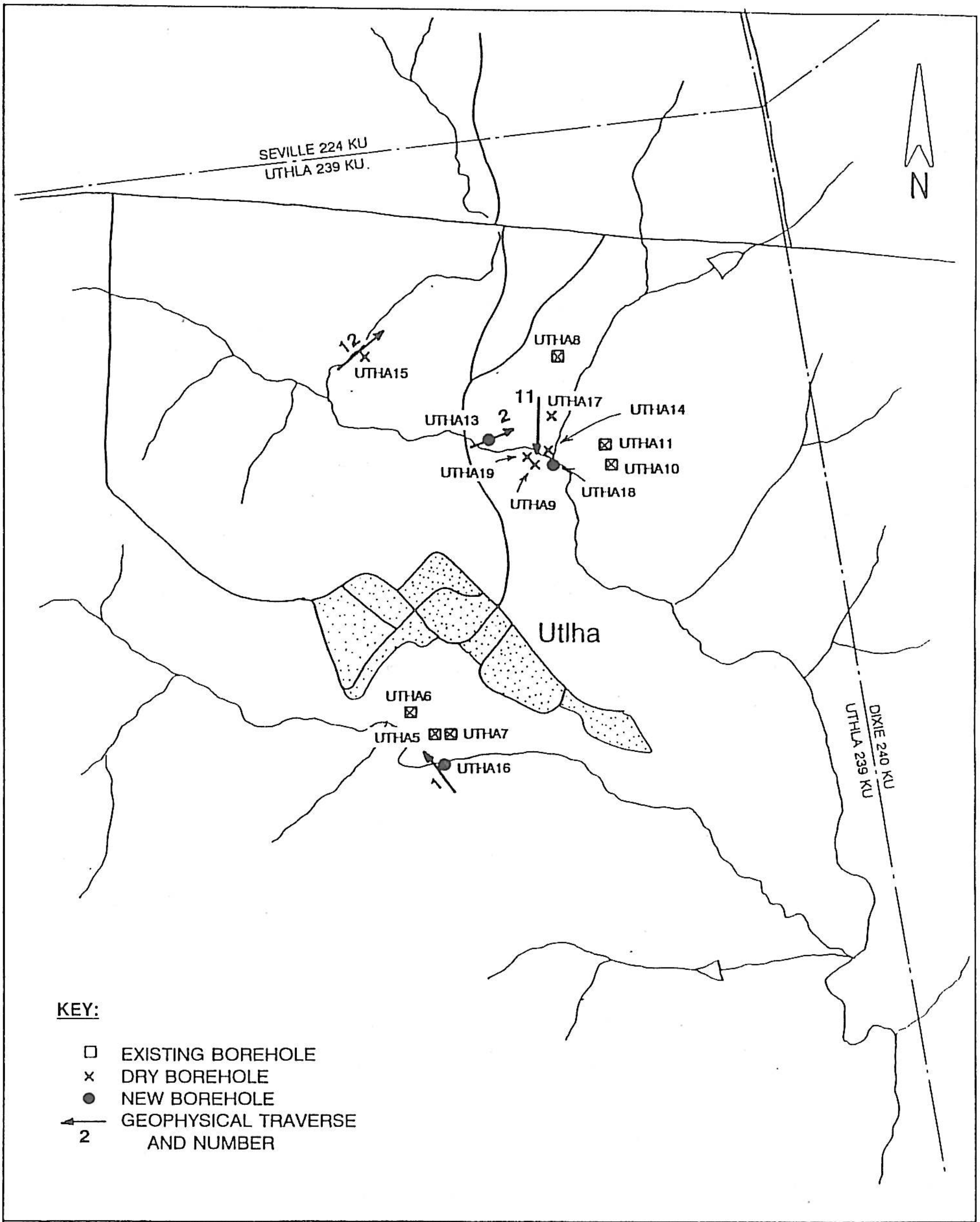
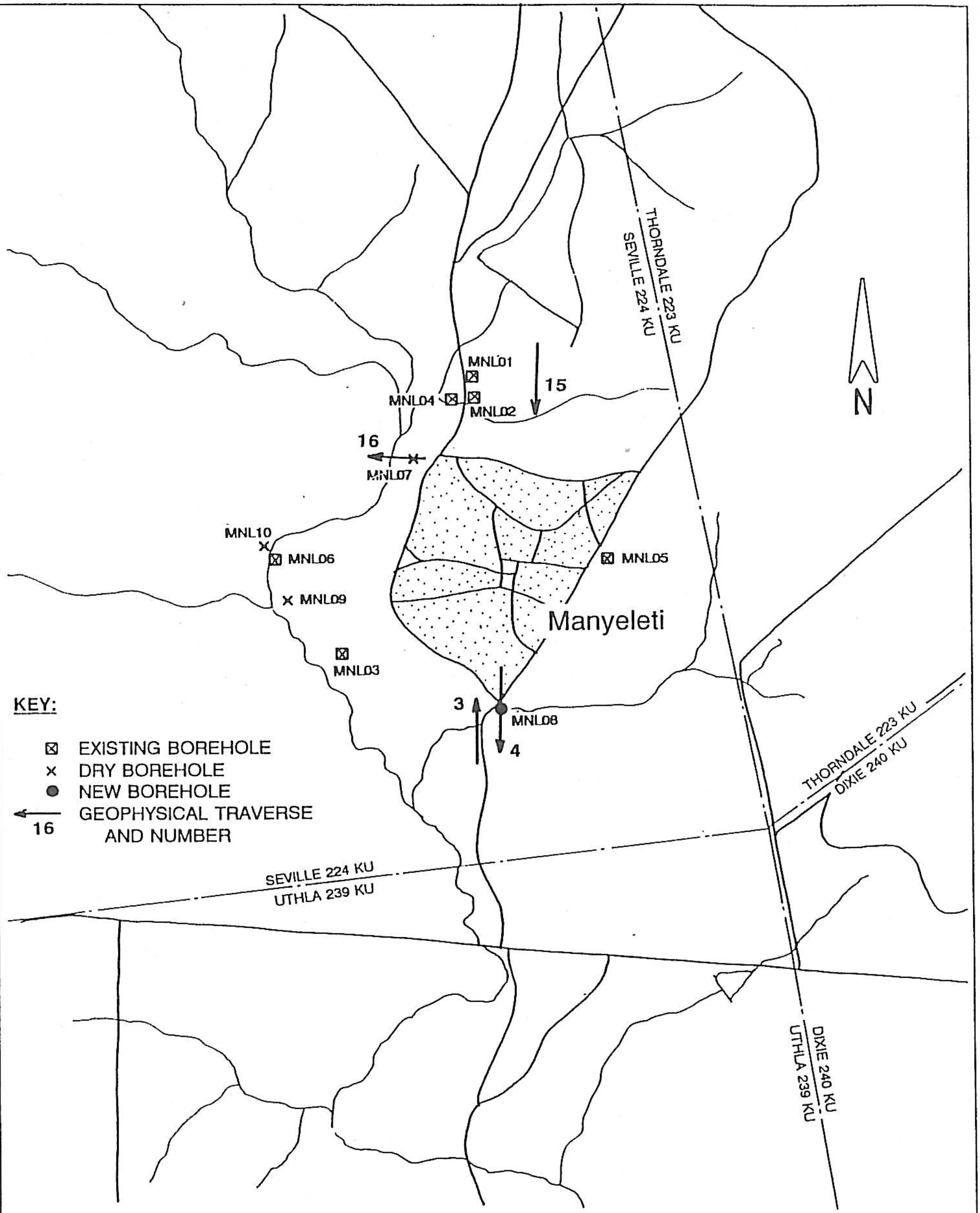
Project No	94-1.015
Scale	1:20 000
Figure	2



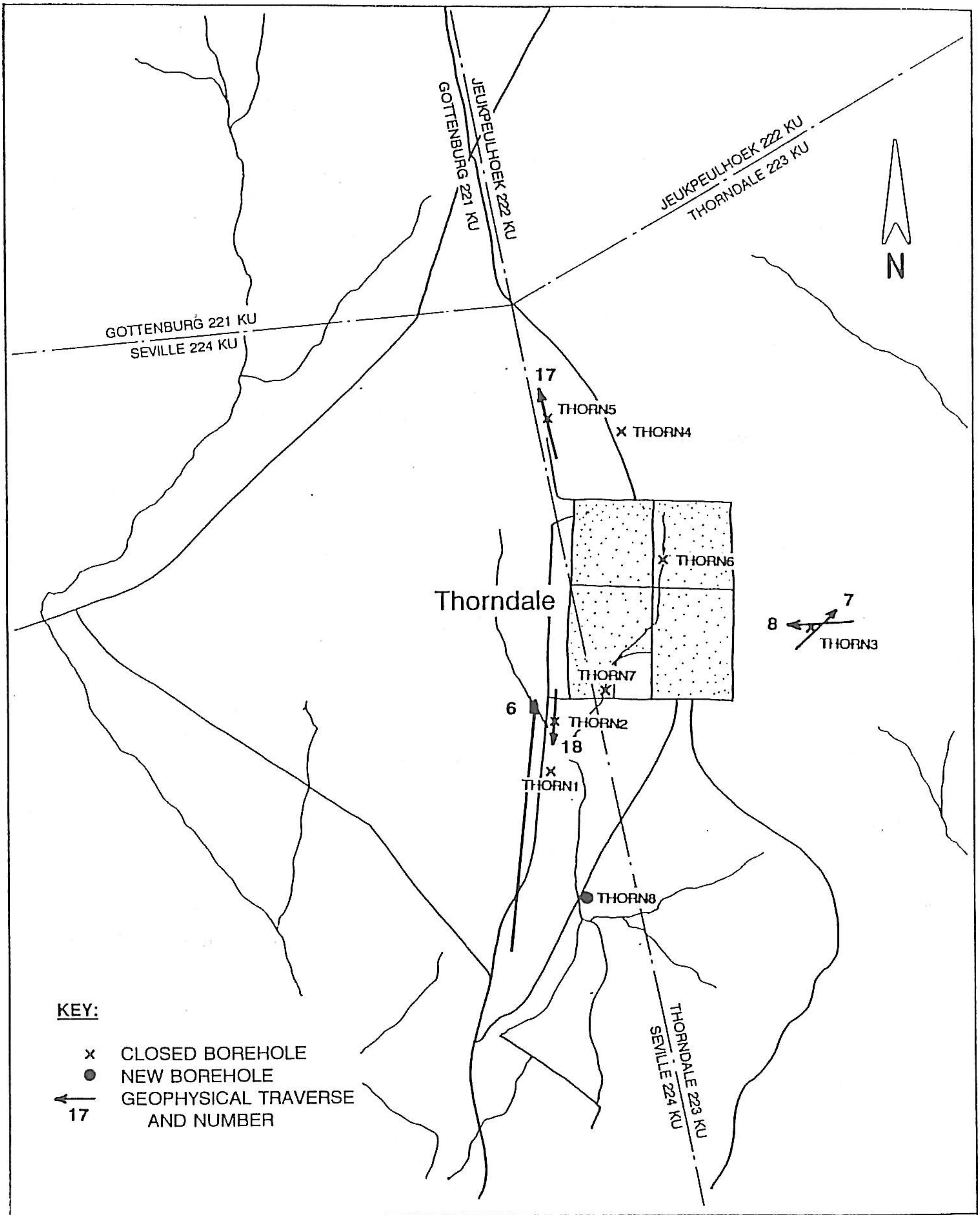
Project	Groundwater Consulting Services	Project No 94-1.015
GAZANKULU - DROUGHT RELIEF PROGRAMME DIXIE - MHALA NORTH EAST	Consultants In Water Resources	Scale 1:20 000
	P O Box 2507 Rivonia 2128 Tel (011) 803-5726	Figure 3a



Project		Project No
GAZANKULU - DROUGHT RELIEF PROGRAMME UTHLA - MHALA NORTH EAST	**Groundwater Consulting Services** Consultants in Water Resources P O Box 2597 Rivonia 2128 Tel (011) 803-5726	94-1.015 Scale 1:20 000 Figure **3b**



Project	Groundwater Consulting Services	Project No 94-1.015
GAZANKULU - DROUGHT RELIEF PROGRAMME MANYELETI - MHALA NORTH EAST	Consultants In Water Resources P O Box 2597 Rivonia 2128 Tel (011) 803-5726	Scale 1:20 000 Figure 3c



Project

GAZANKULU - DROUGHT RELIEF PROGRAMME
THORNDALE - MHALA NORTH EAST

Groundwater Consulting Services

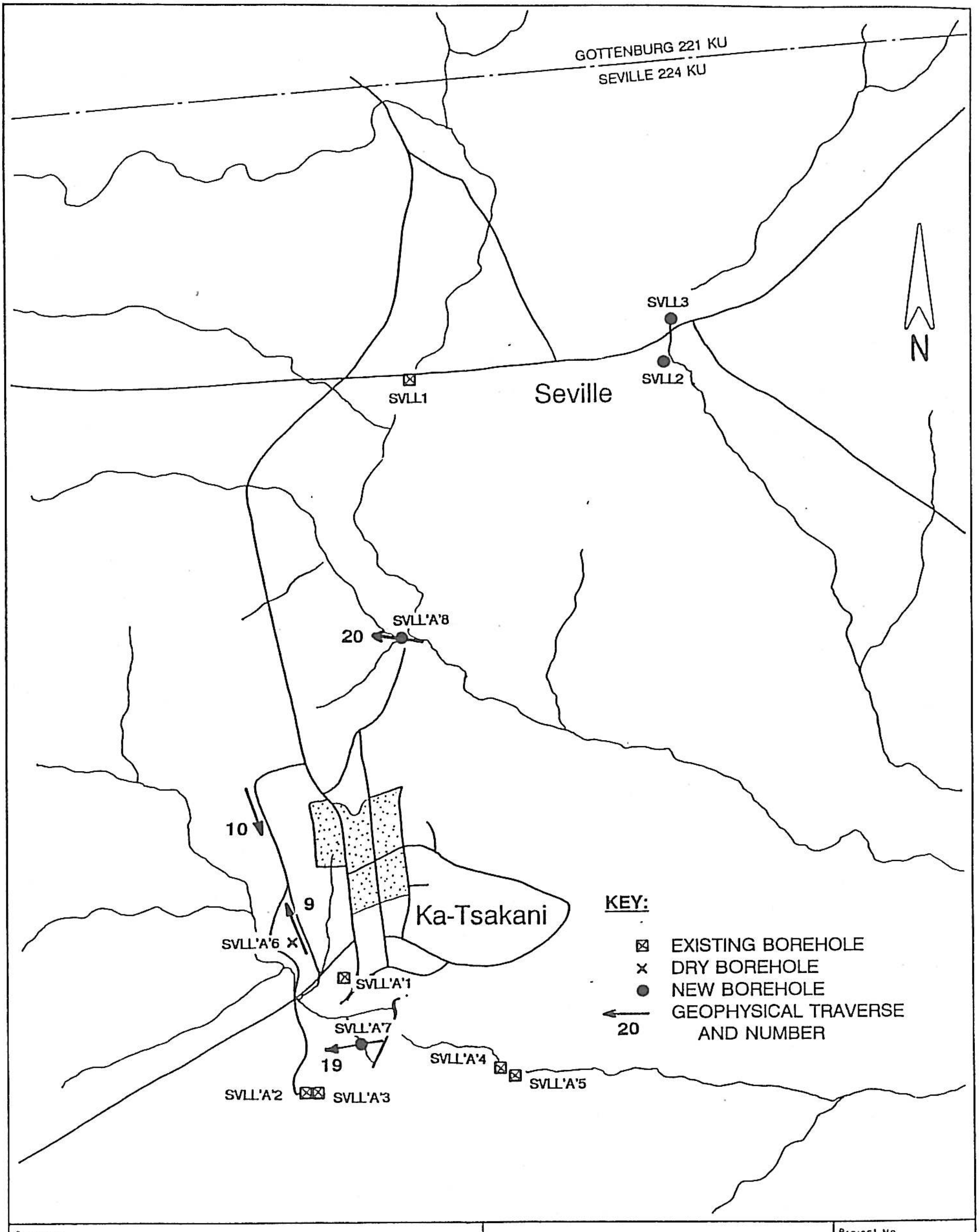
Consultants in Water Resources

P O Box 2597 Rivonia 2128 Tel (011) 803-5726

Project No 94-1.015

Scale 1:20 000

Figure **3d**



Project	Groundwater Consulting Services	Project No 94-1.015
GAZANKULU - DROUGHT RELIEF PROGRAMME SEVILLE - MHALA NORTH EAST	Consultants in Water Resources P O Box 2597 Rivonia 2128 Tel (011) 803-5726	Scale 1:20 000 Figure 3e

Project	Groundwater Consulting Services	Project No 94-1.015
GAZANKULU - DROUGHT RELIEF PROGRAMME ACORNHOEK AREA - MHALA NORTH	Consultants in Water Resources	Scale AS ABOVE
	P.O. Box 2597 Rivonia 2128 Tel: (011) 803-5726	Figure 4

Details of individual borehole construction and the respective geological logs are presented in **Appendix D : 1-7.**

7.2 Results

The position of all existing boreholes plus the new boreholes are indicated on the locality **Figures 2-4.** The geophysical traverses are presented in **Appendix C.**

7.2.1 Mhala Central - Dwarsloop

The underlying geological formation in this study area is the Cunning Moor Tonalite.

DRLP20: This hole was targeted on an electromagnetic anomaly adjacent to a dry river bed (station 120 Traverse 1). This hole was drilled to 64,8m and had water seepage at 47m. This hole was unsuccessful.

DRLP21: This borehole was drilled in a dry river to intersect the contact zone of the Rykoppies Gabbro and Cunning Moor Tonalite. This was achieved at 17mbgl. The borehole was then cased and cleaned. Due to the nature of the surrounding material, there has been an ingress of fine silts and clays which has caused the hole to have to be cased and cleaned again.

DRLP22: This borehole was drilled to intersect the Gabbro and Tonalite contact zone, but at a higher elevation. This resulted in drilling to 82,5m without reaching the contact zone.

DRLP23: The target was a zone of deeper weathering identified using the EM34-3 (station 110 Traverse 4). Here the water strike was at 41m and a blow yield of 2 ℓ/s was measured on the V-notch weir.

DRLP24: The target site (station 125 Traverse 7) was identified using the EM34-3 across pegmatite veins within the tonalite. Although the drill intersected several fracture zones and quartz-veins, the blow yield was measured to be 0,5 ℓ/s.

<u>DRLP25:</u> This borehole was drilled to intersect the contact zone of an intrusive dolerite dyke, this occurred at 33mbgl (station 30 Traverse 8). The blow yield was measured to be 0,5 ℓ/s.

7.22 <u>Mhala North-East</u>

7.2.2a <u>PHUNGWE/DIXIE</u>

<u>DIXI4:</u> The target for this hole was an electromagnetic anomaly corresponding to a linear feature recognised from the aerial photographic interpretation (station 70 Traverse 13). Two attempts to intersect water were tried on this site but to no avail.

<u>DIXI5:</u> This hole was drilled to intersect the contact zone between the gneissic terrain and a younger intrusive dolerite dyke (station 40 Traverse 5). The contact was dry.

<u>DIXI6:</u> The drilling target was sited on both a magnetic and an electromagnetic anomaly (station 130 traverse 4). The hole was terminated at 70,55m without any hydrogeological significant changes in the geology.

<u>DIXI7:</u> Observation of local geological conditions of the area determined this borehole site. Water was intersected in a fracture zone within the gneiss. The resultant blow-yield was measured to be 2,5 ℓ/s.

7.22.b <u>UTHA</u>

<u>UTHA13:</u> The target was a contact zone between an intrusive dolerite dyke and the surrounding country rock (station 100 Traverse 2). The hole had to be moved along the dip of the dolerite dyke to enable the contact zone to be intersected at depth. Water was intersected at

16mbgl. The blow yield was measured at 0,5 ℓ/s.

UTHA14: This drilling site was targeted on both a magnetic and an electromagnetic anomaly (station 90 Traverse 11). The hole was drilled to 60,42 m but was unsuccessful.

UTHA15: This hole was drilled to intersect the contact zone of a dolerite dyke and the surrounding gneiss (station 10 Traverse 12). The hole was unsuccessful.

UTHA16: This hole is situated adjacent to borehole UTHA7, which has been closed. The target is the contact zone between an intrusive dolerite dyke and the gneiss terrain (station 50 Traverse 1). The blow yield measured on the V-notch weir was 1 ℓ/s.

UTHA17: The target for this hole was both a magnetic and an electromagnetic anomaly in the gneiss (station 50 Traverse 17). The borehole was drilled to 81,45m without intersecting water.

UTHA18: This target was select from observations in the field and interpretation of the aerial photograph of this area. Two water strikes were intersected at 21mbgl and 32mbgl. The final blow yield was measured at 1 ℓ/s.

UTHA19: This was drilled at a site determined by the surrounding topographic and geomorphological features. No major fractures were intersected. The borehole was unsuccessful.

7.2.2.c **MANYELETI**

MNL7: This hole was sited on a relatively minor EM34 anomaly (station 10 Traverse 6). This borehole was drilled into weathered granite and gneiss. The hole was unsuccessful.

MNL8: This hole was drilled on the intersection of two dolerite dykes which were identified from aerial photography. The geophysical traverse 3 and traverse 4 indicate the presence of two steeply dipping dykes. The site was chosen to intersect the intersection of the two dykes and the contact zone of these dykes and the surrounding gneiss (station 150 Traverse 4). Water was intersected at 33mbgl, resulting in a blow yield of 1,5 ℓ/s.

MNL9: Using field observations, this hole was drilled adjacent to a dry river bed. The hole was drilled to 60,95m. This hole was unsuccessful.

MNL10: This was hole was targeted using aerial photograph interpretation. Fracture zones were intersected while drilling, however, these fractures produced only seepage water.

7.2.2.d **THORNDALE**

THORN1: A geophysical traverse (Traverse No. 6) was performed from Manyeleti to Thorndale adjacent to the dam. A magnetic anomaly was detected and a site was drilled to intersect the contact zone of an intrusion dolerite dyke (station 800 Traverse 6). This contact was dry.

<u>THORN2:</u>	Pegmatite veins were observed in the surrounding gneiss. The EM34-3 reveal a minor anomaly (station 90 Traverse 18). The hole was drilled to 60,65m without success.
<u>THORN3:</u>	The hole was drilled on the intersection of two dolerite dykes (station 70 Traverse 7 and station 60 Traverse 8) Both dykes were intersected, both without success.
<u>THORN4:</u>	The hole was targeted using aerial photograph interpretation. The hole intersected a dolerite dyke at 25mbgl. Both the top and bottom contact zones were dry.
<u>THORN5:</u>	The target was chosen on both a magnetic and electromagnetic anomaly (station 170 Traverse 17). The hole intersected dolerite at 27mbgl and again at 48mbgl both contact zones were dry.
<u>THORN6:</u>	This site was drilled using field observations and surrounding geological features. This hole intersected dolerite at 21mbgl. The hole was unsuccessful.
<u>THORN7:</u>	This site was drilled using observations of local geological conditions. The hole was drilled to 60,55m and was unsuccessful.
<u>THORN8:</u>	Using the aerial photography of this area, and the information obtained from drilling THORN1. The hole was drilled near the end of the dam. A water strike was intersected at 34m, giving a final blow yield of 0,5 ℓ/s.

7.2.2.e SEVILLE

SVLL2: This hole was drilled at a site determined by surrounding topographic and geomorphological features. Fractured and weathered gneiss was intersected at 29mbgl. The final blow yield was measured at 3 ℓ/s.

SVLL3: This hole was sited using the interpretation of aerial photography of this area. Fractured and weathered gneiss was intersected at 27 mbgl, resulting in a final blow yield of 5 ℓ/s.

7.2.2.f SEVILLE 'A'

SVLLA6: This hole was drilled on a magnetic anomaly (station 90 Traverse 9). The hole was drilled to 60,65m. The hole was unsuccessful.

SVLLA7: A minor electromagnetic anomaly was revealed near the dam to the south of Seville 'A' (station 110 Traverse 19). The borehole intersects a zone of altered granite at 36mbgl coinciding with a water strike. The resultant blow yield was 0,5 ℓ/s.

SVLLA8: A geophysical traverse was performed parallel to a dry river, across a lineation recognised from the aerial photography. This lineation gave rise to a large electromagnetic anomaly (station 50 Traverse 20). A zone of fracturing was intersected at 27mgbl. A water strike was recorded at 32mbgl resulting in a blow yield of 5 ℓ/s.

7.2.3 Mhala North

The underlying geology in this study area is the unnamed migmatites and gneiss of the basement complex.

7.2.3a. **ACORNHOEK**

ACNH20: This hole was drilled on an EM34-3 anomaly, using both the 20m and 40m cables (station 40 Traverse 21). Two zones of fracturing were intersected, both were dry.

ACNH21: A geophysical traverse was conducted near an existing borehole to establish the geophysical signature (Traverse 23). This site was selected on an EM34-3 anomaly in the vicinity of this borehole (station 420 Traverse 23). This hole was unsuccessful.

ACNH22: This drilling target was an electromagnetic anomaly that suggested the existence of a fracture (station 160 Traverse 24). The hole did not intersect any fractures and the hole was terminated at 60,45m.

ACNH23: A marked EM34-3 anomaly corresponding with a magnetic anomaly led to the selection of this site (station 150 Traverse 25). The hole was drilled to 61,55m, a fracture zone was intersected at 11mbgl. This fracture zone was dry.

ACNH24: Pegmatite veins within the gneiss terrain led to the selection of this borehole, as did a minor EM 34-3 anomaly, (station 90 Traverse 26). A quartz-rich granite was intersected at 9m, the hole was moved to intersect this quartz vein at a greater depth. The quartz-rich granite was then intersected at 15m. Both attempts were dry.

ACHN25: This hole was drilled on an electromagnetic anomaly (station 80 Traverse 27). The hole intersected two zones of fracturing, both were dry. This site was then moved to intersect these fractures at a greater depth. Using the EM34-3, the site was drilled on an electromagnetic anomaly (station 500 Traverse 29). This site intersected a dry fracture zone.

7.2.3.b COTTONDALE

<u>GCS1:</u> Using the surrounding topographic and geomorphological features, this site was drilled to intersect a dolerite dyke. A water strike was intersected at 16mbgl with a initial blow yield of 1 ℓ/s, this blow yield decreased with depth. This suggests that the reservoirs of groundwater that was initially intersected is being recharged by weak micro fractures.

<u>GCS2:</u> This hole was drilled after interpretation of the aerial photography of this area. This hole was drilled to 63,65m without success.

<u>GCS3:</u> This site was selected at the confluence of two rivers, near the school. The hole was drilled to 63,75m without success.

<u>GCS4:</u> This hole was drilled on a lineation recognised from the aerial photograph which indicated the presence of a dolerite dyke. Water was intersected within the dolerite at 11mbgl. Drilling was terminated within the dolerite. The blow yield was measured to be 1,5 ℓ/s.

<u>GCS5:</u> Using the field observations and a relatively minor electromagnetic anomaly (station 90 Traverse 32), this hole was drilled into a dolerite sill. The hole was terminated within the dolerite at 60,65m.

<u>GCS6:</u> The drilling target was a magnetic anomaly that suggested the existence of a dyke (station 70 Traverse 35). Water seepage was recorded at 34mbgl. The hole was terminated within dolerite at 52,45m.

8. TEST PUMPING

8.1 Introduction

Test pumping was carried out to determine the yield potential of each of the study areas. In Mhala north-east, all the existing boreholes had been tested to determine their potential for abstraction. This was taken into account before deciding on where to continue the hydrogeological investigation.

In the Mhala North, the drilling of new boreholes was considered urgent, thus the test pumping of existing boreholes was not considered necessary, prior to the establishment of new boreholes.

Each of the existing unused boreholes in each of the settlements were test pumped to evaluate their yields as there was no information available. The stronger holes were then tested to determine safe pumping rates, abstraction schedules and suitable equipment.

The new holes were tested after the completion of the drilling contract.

Following the evaluation of tenders for the testing of boreholes, Borehole Testing Services were contracted to perform the tests. The first phase in Mhala Central and in Mhala North-East was completed in January 1994. This first phase consisted of testing all the unused/unequipped boreholes in these areas. This enabled GCS to determine the groundwater abstraction potential in each area. The second phase was to test all the new successful boreholes drilled during this investigation.

GCS tested and evaluated all the existing equipped holes in Dwarsloop, Dixie, Utha, Manyeleti, Seville, Seville 'A' and Gottenburg. The methodology has been discussed in our previous report (Ref : 93-9.085 A&B/rp1).

8.2 Results

The logistics and results of all the pumping tests are summarised along with their time/drawdown and recovery data graphs in **Appendix A**. Each settlement has been evaluated and their groundwater potential has been calculated according to the recommendations concerning safe yields and abstraction schedules.

8.2.1 Dwarsloop

As illustrated in **Table 3**, Dwarsloop has a conservative estimate of groundwater abstraction of 344,3m^3/day.

This figure is conservative because the following boreholes could not be tested due to various technical problems:

DRLP4	:	has a broken shaft,
DRLP7	:	has an electrical problem,
DRLP9	:	needs a new engine,
DRLP10	:	needs new electrical cable,
DRLP15	:	has an electrical problem.

Further groundwater can be abstracted from the weaker holes by means of handpumps, in times of emergency.

8.2.2 Dixie/Phungwe

Table 4 provides an accurate estimate of the groundwater abstraction in Dixie, as all the boreholes have been assessed.

The groundwater abstraction potential is $54m^3$/day. Dixie has a water demand of $12m^3$ per day.

8.2.3 Utha

The potential for groundwater abstraction has been calculated at $39,6m^3$/day in **Table 5** this excludes Utha 18 which had collapsed. This borehole has been cleaned on 6/6/94 and needs to be tested before recommendations can be made.

The water demand for Utha is $21,06m^3$/day for a population of 702 calculated for 1993.

8.2.4 Manyeleti

At present, Manyeleti relies on two handpumps for its water supplies. According to **Table 6**, Manyeleti will be capable of abstracting $61,92m^3$/day when all the boreholes are equipped.

The water demand for Manyeleti is calculated to be $21.15m^3$/day. This means Manyeleti now has an excess of groundwater $40,77m^3$/day.

TABLE 3 : RESULTS OF PUMPING TESTS AT DWARSLOOP - MHALA CENTRAL

BH·No.	BH Co-ord.	Date	SWL (mbgl)	Yield (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Duration of Test (min)	Duration of Recovery (min)	Recovery (%)	T During Test (m^2/day)	T During Recovery (m^2/day)	Recommended Pumping Rate (l/s)	Abstraction Schedule (hr/day)	Daily Yield (m^3/day)
DRLP 01	24°46.99'S 31° 06.19'E	18/10/93	12.01	0.6	3.96	0.15	1440	60	94	95	31	0.6	14	30.24
DRLP 02	24°46.95'S 31° 06.22'E	19/10/93	14.01	2.1	1.03	2.04	1440	60	99	415	151	2.1	10	75.6
DRLP 03	24°46.91'S 31°06.23'E	20/10/93	18.1	0.15	3.83	0.04	1440	180	90	5.9	6.6	0.15	14	7.56
DRLP 05	24°40.90'S 31°06.22'E	18/10/93	6.24	0.2	46.005	0.004	1440	60	92	3.01	0.21	0.2	14	10.08
DRLP 06	24°46.88'S 31°06.23'E	19/10/93	12.93	0.09	45.28	0.002	1440	90	97	1.28	0.05	0.09	10	3.24
DRLP 08	24°47.73'S 31°05.66'E	21/10/93	11.64	1	15.43	0.06	1440	60	65	26.35	1.54	1	10	36,0
DRLP 12	24°47,18'S 31°04.98'E	24/11/93	2	0.4	19.35	0.02	1440	210	65	0.9	0.8	Hand pump	-	-
DRLP 13	24°47,19'S 31°04.98'E	19/10/93	2.98	0.4	Dry	-	25	300	99	-	0.9	None	-	-
DRLP 14	24°47.04'S 31°05.16'E	16/10/93	27,9	1.25	Dry	-	545	360	99	-	0.4	1.25	-	-
DRLP 16	24°47.02'S 31°05.38'E	17/10/93	9,13	0,87	0.9	0.97	1440	120	98	138	34	0.87	12	37.58
DRLP 17	24°47.03'S 31°05.67'E	17/11/93	8.38	0.5	28.75	0.018	1440	150	98	4.9	6.1	0.7	10	25.2
DRLP 18	24°46.93'S 31°05.95'E	23/11/93	10,7	0.5	Dry	-	2	210	99	-	1.9	None	-	-
DRLP 19	24°46.96'S 31°06.02'E	18/11/93	7,29	0.5	Dry	-	3	210	91	-	1	None	-	-

TABLE 3 : RESULTS OF PUMPING TESTS AT DWARSLOOP - MHALA CENTRAL (cont'd)

BH No.	BH Co-ord	Date	SWL (mbgl)	Yield (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Duration of Test (min)	Duration of Recovery (min)	Recovery (%)	T During Test (m^2/day)	T During Recovery (m^2/day)	Recommended Pumping Rate (l/s)	Abstraction Schedule (hr/day)	Daily Yield (m^3/day)
DRLP 21	24°48.63'S 31°05.31'E	30/3/93	1.19	2.25	Dry	-	270	300	99	-	80	1.5	10	54
DRLP 23	24°47.63'S 31°06.46'E	20/1/94	26	1	7.83	0.13	1440	140	95	34	26	1	12	43.2
DRLP 24	24°46.99'S 31°06.12'E	25/1/94	10	0.5	Dry	-	1000	30	100	-	0.4	0.5	12	21.6
DRLP 25	24°47.32'S 31°05.10'E	22/1/94	15	0.32	Dry	-	1340	480	94	-	2	Hand pump	-	-

TABLE 4 : RESULTS OF PUMPING TESTS AT DIXIE - MHALA NORTH-EAST

BH No.	BH Co-ords	Date	SWL (mbgl)	Yield (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Duration of Test (min)	Duration of Recovery (min)	Recovery (%)	T During Test (m^2/day)	T During Recovery (m^2/day)	Recommended Pumping Rate (l/s)	Abstraction Schedule (hr/day)	Daily Yield (m^3/day)
DIXI 02	24°41.86'S 31°28.91'E	9/11/93	19.44	1.5	35.095	0.04	1440	180	90	30	10	1.5	10	54
DIXI 03	24°41.53'S 31°28.97'E	17/1/94	23.6	0.4	Dry	-	360	360	96	-	2.3	Handpump	-	-
DIXI 07	24°42.48'S 31°28.83'E	28/3/94	21.95	1	Dry	-	100	80	99	-	10.5	Handpump	-	-

TABLE 5 : RESULTS OF PUMPING TESTS AT UTHA - MHALA NORTH EAST

BH No.	BH Co-ord.	Date	SWL (mbgl)	Yield (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Duration of Test (min)	Duration of Recovery (min)	Recovery (%)	T During Test (m^2/day)	T During Recovery (m^2/day)	Recommended Pumping Rate (l/s)	Abstraction Schedule (hr/day)	Daily Yield (m^3/day)
UTHA 04	24°43.22'S 31°24.50'E	11/11/93	8.34	0.5	2.23	0.22	1440	120	94	132	100	0.5	10	18.0
UTHA 05	24°42.47'S 31°26.56'E	7/12/93	15.3	0.4	Dry	-	5	225	98	-	2.5	-	-	-
UTHA 10	24°41.98'S 31°26.96'E	20/1/94	13	0.42	5.55	0.07	1440	720	92	24.6	5.4	0.5	12	21.6
UTHA 11	24°41.92'S 31°26.92'E	19/1/94	16.8	0.42	Dry	-	12	20	99	-	-	Hand pump	-	-
UTHA 13	24°41.79'S 31°26.68'E	18/3/93	11.39	0.46	Dry	-	30	120	99	-	0.43	Hand pump	-	-
UTHA 16	24°42.47'S 31°26.65'E	20/3/94	13.85	0.8	Dry	-	5	-	-	-	-	Hand pump	-	-
UTHA 18	24°41.96'S 31°26.86'E	-	-	-	-	-	-	-	-	-	-	-	-	-

UTHA 18 has collapsed and needs redrilling and casing, the hole will then have to be tested.

TABLE 6 : RESULTS OF PUMPING TESTS AT MANYELETI, MHALA NORTH-EAST

BH No.	BH Co-ord	Date	SWL (mbgl)	Yield (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Duration of Test (min)	Duration of Recovery (min)	Recovery (%)	T During Test (m^2/day)	T During Recovery (m^2/day)	Recommended Pumping Rate (l/s)	Abstraction Schedule (hr/day)	Daily Yield (m^3/day)
MNL 01	24°40.13'S 31°26.57'E	13/1/94	14.46	0.4	Dry	-	15	15	8	-	-	Hand pump	-	-
MNL 04	24°41,53'S 31°28.97'E	13/1/94	12	0.5	12.3	0.04	1440	240	93	4.3	2.1	0.6	12	25.92
MNL 06	24°40.60'S 31°26.21'E	14/1/94	17.45	1	Dry	-	720	360	94	-	7	0.5	10	18
MNL 08	24°40.91'S 31°26.71'E	25/3/94	19.25	1	Dry	-	180	140	99	-	10,4	0.5	10	18

8.2.5 Thorndale

During the drilling programme, only one borehole drilled in Thorndale intersected water. This hole is a very weak hole and it is recommended that this hole can only be equipped with a handpump. The results are in **Appendix A5.**

As Thorndale receives groundwater from Seville, a pipeline already exists, several strong boreholes were found at Seville, one of these holes should be equipped to supply Thorndale with an additional supply.

8.2.6 Seville

Table 7 indicates that the safe groundwater abstraction from three boreholes equals 408,96m^3/day. The combined water demand for Seville and Thorndale is 32,79m^3/day (population figures of 693 and 400 respectively for 1993). This gives an excess of 376,17m^3/day.

8.2.7 Seville 'A'

Seville 'A' has a calculated water demand of 21,6m^3/day. **Table 8** indicates a calculated groundwater abstraction potential from boreholes of 129,6m^3/day.

8.2.8 Gottenburg

In Gottenburg, the population has been calculated to be 840 for 1993. The water demand is calculated to be 25,2m^3/day. The abstraction potential of groundwater has been calculated at 237,6m^3/day (See **Table 9**). This gives an excess of 212,4m^3/day.

This water supply was deemed sufficient at this time for Gottenburg.

8.2.9 Acornhoek - Cottondale Area

Only two of the 14 boreholes drilled in this study area had water strikes. The test pumping of these holes were performed by the test pumping crew of the Department of Works, Gazankulu.

TABLE 7 : RESULTS OF PUMPING TESTS AT SEVILLE, MHALA NORTH-EAST

BH No.	BH Co-ord	Date	SWL (mbgl)	Yield (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Duration of Test (min)	Duration of Recovery (min)	Recovery (%)	T During Test (m^2/day)	T During Recovery (m^2/day)	Recommended Pumping Rate (l/s)	Abstraction Schedule (hr/day)	Daily Yield (m^3/day)
SVLL 01	24°39.45'S 31°25.03'E	11/11/93	8.89	0.7	15.085	0.13	1440	180	97	85	55	0.07	8	20.16
SVLL 02	24°39.08'S 31°25.66'E	29/3/94	20.75	4	14.95	0.27	1440	480	99	15	90	4	12	172.8
SVLL 03	24°39.02'S 31°25.66'E	24/3/94	19.0	3,1	2.69	1.15	1440	660	100	94	55	5	12	216

TABLE 8 : RESULTS OF PUMPING TESTS AT SEVILLE 'A', MHALA NORTH-EAST

BH No.	BH Co-ord	Date	SWL (mbgl)	Yield (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Duration of Test (min)	Duration of Recovery (min)	Recovery (%)	T During Test (m^2/day)	T During Recovery (m^2/day)	Recommended Pumping Rate (l/s)	Abstraction Schedule (hr/day)	Daily Yield (m^3/day)
SVLL'A' 1	24°40.43'S 31°24.87'E	15/11/94	21.3	1	68.28	0.02	900	-	-	15	-	1	10	36
SVLL'A' 4	24°40.59'S 31°25.47'E	18/1/94	23.5	1	9.48	0.1	1440	1440	92	8.9	4.4	1	10	36
SVLL'A' 5	24°40.58'S 31°25.49'E	17/1/94	24.7	6.6	Dry	-	720	720	78	-	3.3	2	8	57.6
SVLL'A' 7	24°40.50'S 31°24.85'E	25/3/94	9.7	1	Dry	-	3	-	-	-	-	Hand pump	-	-
SVLL'A' 8	24°39.67'S 31°25.03'E	29/3/94	10.33	1	Dry	-	33	120	99	-	1.84	Hand pump	-	-

TABLE 9: RESULTS OF PUMPING TESTS AT GOTTENBURG, MHALA NORTH-EAST

BH No.	BH Co-ord	Date	SWL (mbgl)	Yield (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Duration of Test (min)	Duration of Recovery (min)	Recovery (%)	T During Test (m^2/day)	T During Recovery (m^2/day)	Recommended Pumping Rate (l/s)	Abstraction Schedule (hr/day)	Daily Yield (m^3/day)
GTBG 01	24°36.78'S 31°25.81'E	21/1/94	23.13	1.4	11.08	0.13	1440	300	96	1.7	25	1.5	12	64.8
GTBG 03	24°37,04'S 31°25.28'E	12/11/93	46.84	4	66.97	0.06	1440	180	86	264	333	4	12	172.8

Mr Petrus Mabasa (Department of Works) informed GCS that one of the boreholes, GCS4, could not be tested as the hole has collapsed. The drillers corrected this hole on 6/6/94.

Borehole GCS 1 was tested by the Gazankulu testing crew. They performed a yield test and Mr A Myburgh (EVN) informed GCS that he would analyze this data and calculate the abstraction rate and schedule.

9. GROUNDWATER CHEMISTRY

During the hydrocensus, no water samples were collected and so quality was based on taste and smell alone. There were incidents of the water being too salty to drink, this occurred at DIXI1, DIXI2 and UTHA8. This can be attributed to the breakdown of the plagioclase feldspars within the country rock, leading to high Na and Cl values in the water. The Mhala Block, on a whole, appears to have good water quality and there were no cases of bad odoured water.

During the testing programme, water samples were taken during the last hour of the constant discharge test. This ensures that the well has been comprehensively purged to remove the stagnant water, the groundwater sample is then representative of the groundwater within the aquifer. The samples were collected and stored in compliance with the Water Research Commission's Guide: WRC Project No 339, entitled "Groundwater Sampling - a Comprehensive Guide for Sampling methods" by Weaver (1992).

The samples were sent to Cydna Laboratory in Johannesburg and to the Government laboratory in Pietersburg, for the following determinants: Full analysis of major cations and anions, toxic substances of interest, pH and electroconductivity. The results are tabled in **Appendix B.**

9.1 Mhala Central

9.1.a Dwarsloop:

The following boreholes were sampled at Dwarsloop; DRLP1, DRLP2, DRLP5, DRLP6, DRLP8, DRLP14, DRLP16, DRLP21, DRLP23 and DRLP24. All of these boreholes were drilled into the Cunning Moor Tonalite.

The groundwater chemistry revealed that the water at Dwarsloop is a mixture of a sodium type and a bicarbonate type water. The resultant water is potable groundwater.

The groundwater at Dwarsloop falls into two classifications of irrigation waters, namely: **C2 - S1** and **C3 - S1**

C2 - Medium-salinity, water can be used where a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

C3 - high-salinity, water cannot be used on soil that has restricted drainage. With adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

S1 - Low-sodium, water can be used with little danger on nearly all soils.

The hydrochemical data of the groundwater revealed that all the samples taken are to be derived from the same source aquifer.

9.2 Mhala North-East

9.2.a Dixie/Phungwe

The following boreholes were sampled at Dixie, DIXI2, DIXI3 and DIXI7. These boreholes were drilled into the unnamed gneissic basement complex. The results of the chemical analysis are in **Appendix B.**

The groundwater, is a mixed water of recently recharged water and water from an arid to semi-arid environment.

The groundwater is a class **C4-S2** irrigation water.

C4 - Very-high salinity, water is not suitable for irrigation under ordinary conditions. If used, the soil must be adequate, considerable excess irrigation water must be applied, and very tolerant crops should be selected.

S2 - Medium-sodium, water is hazardous for use on fine-textured soils that have high cation-exchange capacity. This water may be used on coarse-textured or organic soils with good permeability.

Samples taken at DIXI2, and DIXI3 have the same chemical signature, this implies that they are derived from the same geological environment.

9.2.b Utha

UTHA4, UTHA10, UTHA11, UTHA13 and UTHA16 were sampled during the test pumping programme. UTHA18 had collapsed and a sample could not be taken. These boreholes were drilled into the Makhutswi Gneiss.

The water is a mixed groundwater of potable quality, comprised of recently recharged groundwater and water derived from a low rainfall crystalline terrain.

The groundwater falls into two classes of irrigation water, **C2-S1** and **C3-S1**, as in the case of Dwarsloop. These two classes are as discussed in 9.1.a.

The chemical data revealed that the samples taken are derived from the same fractured gneiss terrain. Although the boreholes are associated on different fractures, the geology has not changed.

Only UTHA16 has poor groundwater quality, with the chloride value being greater than the maximum allowable limit.

9.2.c Seville

Groundwater samples were taken at SVLL1, SVLL2 and SVLL3 during the test pumping programme. The boreholes were drilled into the Makhutswi gneiss.

The groundwater at Seville is recently recharged groundwater mixed with groundwater of a low rainfall crystalline terrain.

The classification of irrigation water based on the sodium values and conductivity classes the water as **C3 - S1**.

C3 - High-salinity, water cannot be used on soils that have restricted drainage.

S1 - Low-sodium, water can be used with little danger to nearly all soils.

9.2.d Gottenburg

Samples were taken at GTBG1 and GTBG4, during testing. These holes were seen to be drilled into the contact zone of the Timbavati Gabbro and the Makhutswi Gneiss, no drilling details were available for these boreholes. The chemical results are shown in **Appendix B**.

The groundwater is seen as a mixture of two main groups of water, a Ca,Mg/CO_3 dominant and a K, Na/CO_3, HCO_3 dominant. This characterises a recently recharged groundwater and a groundwater derived from a low rainfall crystalline terrain.

The groundwater is classified as a **C3-S1** type of irrigation water.

C3 - High-salinity, water cannot be used on soils that have restricted drainage.

S1 - Low-sodium, can be used with little danger on nearly all soils.

The chemical data reveals a different signature than that of the Makhutswi Gneiss or the unnamed gneiss terrain at Dixie. This corresponds to the assumption that the drilling targets at Gottenburg were aimed at the contact zone of the gabbros and gneiss rather than fractures within the gneiss. GTBG1 has good potable quality groundwater. GTBG3 has a magnesium value greater than the maximum allowable limit. This may lead to diarrhoea in new users.

9.2.e. Seville 'A'

Groundwater samples were taken at SVLLA1, SVLLA4, SVLLA5, SVLLA7 and SVLLA8. The results of the laboratory tests are shown in **Appendix B**. The boreholes SVLLA1, SVLLA4 and SVLLA5 were drilled into the Makhutswi Gneiss; according to the geological map 2430 Pilgrim's Rest (Scale 1:250 000). This assumption was made as no information was available. SVLLA7 and SVLLA8 are new holes which were logged, details are in **Appendix D.**

The groundwater at SVLLA1, SVLLA4 and SVLLA5 is a matrix of recently recharged groundwater and groundwater from semi-arid crystalline terrains.

These three samples are classified as **C3-S2** type of irrigation water.

C3 - High-salinity, water cannot be used on soils that have restricted drainage.

S2 - Medium-sodium, water is hazardous for use on fine textured or organic soils with good permeability.

The chemistry data for SVLLA1, SVLLA4 and SVLLA5 is very similar to that of DIXI2 and DIXI3. This suggested that the geology of the two are very similar,. it can therefore be implied that these holes were drilled into the unnamed gneissic terrain.

The groundwater found at Seville 'A' is of good potable quality.

9.2.f <u>Manyeleti</u>

Samples were taken at MNL4, MNL6 and MNL8 during the last hour of the constant discharge tests. The underlying geology in this area is the Makhutswi Gneiss.

The two samples MNL4 and MNL6 represent two different types of water. MNL4 is an example of potable groundwater which is characteristic of recently recharged groundwater. MNL6 has extremely high chloride, magnesium and sodium values. This water is characteristic of evaporite dissolution environments (arid to semi-arid).

These two samples are classified as **C4-S2** irrigation water.

C4 - very-high-salinity, water is not suitable for irrigation under ordinary conditions. If use, the soils must be permeable, drainage must be adequate, considerable excess irrigation water must be applied, and very tolerant crops should be selected.

S2 - medium-sodium, water is hazardous for use on fine-textured soils that have high cation-exchange capacity. This water may be used on coarse-textured or organic soils with good permeability.

The chemical data clearly indicates that MNL4 and MNL6 are derived from different source aquifers. As MNL6 is known to have been drilled onto a contact zone, between an intrusive dolerite dyke and the surrounding gneiss. This intrusion has caused alteration to the country rock and has caused an alteration in the hydrochemistry.

MNL4 has good potable quality groundwater, whereas MNL6 has magnesium, sodium and chloride values which are greater than the maximum allowable limits.

9.3 Mhala North

9.3.a Acornhoek - Cottondale Area

Unfortunately no water samples were taken at these new holes during the pump tests by the Gazankulu pump testing crew.

It is suggested that the Department of Works, Gazankulu, have samples taken and analyzed before these holes are utilised.

10 CONCLUSIONS AND RECOMMENDATIONS

After the siting of boreholes, using geophysical methods, drilling of these sites commenced. Due to the poor performance of these geophysical instruments in some areas, additional sites were targeted using aerial photography interpretation and geological observations. The results of the drilling and the subsequent testing of the successful holes are discussed for each settlement. Recommendations have been made with regard to further hydrogeological work in these areas.

10.1 Dwarsloop

The geology underlying the Mhala Central study area, consists of the Cunning Moor Tonalite. The boreholes drilled into the Tonalite yield on average 2,8m^3/hr, with the average borehole depth being 45,6m.

Of the 6 boreholes drilled during the investigation, three holes were drilled on electromagnetic anomalies, all three had water strikes although DLRP20 was very weak. The water was intersected on average at 45 mbgl. Two holes were sited using changes in the total magnetic field, both were unsuccessful. DLRP25 was drilled into a dolerite contact zone at 33 mbgl, which is below the average static water level for Dwarsloop, 12,12 mbgl. The hole was tested and found to be very weak.

The borehole DRLP21 was sited using geological observations. The hole was drilled to intersect the Rykoppies Gabbro dyke below static water level. The contact zone was intersected at 17 mbgl resulting in a blow yield of 2 ℓ/s.

Hydrocensus and drilling data indicates that the main water strikes are intersected before 35 mbgl and that the higher yields are intersected within the zones of deeper weathering. Thus stronger yields were intersected at shallow depths and lower yields at greater depths.

Future borehole drilling sites should be sited using the electromagnetic geophysical technique, as this proved to be the most successful method of siting in the Tonalite. Borehole depths should not exceed 60m.

Due to the limited area bordering Dwarsloop and the extent of drilling within this area it is considered necessary to investigate possible future drilling targets further afield.

10.2 Phungwe/Dixie

Four boreholes were drilled at Dixie, three of these holes were targeted using geophysical methods, these three were unsuccessful. The fourth borehole, DIXI7, was drilled after an examination of the local aerial photography. This borehole was sited to intersect an area of displacement on a dyke. Water was intersected at 39m and 56m below ground level.

The average borehole depth in Dixie is 49,1 mbgl and yields average 3,5 m^3/hr. It would seem that these existing holes may have been terminated prematurely and that drilling deeper would have achieved higher yields.

It is recommended that future boreholes be drilled to at least 70m in this area. Sites should be targeted further away from the village, using aerial photography to aid in identifying possible drilling targets.

10.3 Utha

Twelve boreholes had already been drilled in and around Utha, resulting in the following: one diesel-driven pump at the Utha scheme (UTHA4) and three handpumps (UTHA8, UTHA10 and UTHA11).

An additional seven boreholes were drilled at Utha by GCS. Three of these holes yielded water. UTHA13 was drilled to intersect an intrusive dolerite dyke. The contact zone was intersected at 16 mbgl. The yield was very weak even though the average static water level in this area is 13,3 mbgl. Other holes drilled on magnetic anomalies proved unsuccessful, although UTHA16 had a weak yield.

Two electromagnetic anomalies were recorded and drilled, both of these holes were unsuccessful. Although changes in the electromagnetics were noted, there was no hydrogeological significant changes in the formations drilled.

Two holes were drilled on sites positioned after aerial photography interpretation. One was successful UTHA18 and one was not, UTHA19.

The average depth of boreholes in Utha is 37,2 m with the average water strike depth being measured at 25,4 mbgl. There is little or no changes in the borehole yields with greater depths and no yields exceed 0,5 ℓ/s.

It is recommended that future work in this area be limited to low lying areas adjacent to the river beds in the area. Drilling depths should not exceed 60m.

10.4 Manyeleti

Four boreholes were drilled in Manyeleti. The only successful borehole, MNL8, was drilled on a magnetic anomaly. A blow yield of 1,5ℓ/s was recorded during drilling. Dolerite was intersected at 35 mbgl,and the water strike was measured at 33 mbgl within the contact zone. The borehole was tested and a safe yield of 0,5 ℓ/s was established. This indicates that the drilling intersected a localised reservoir of groundwater which is fed by minor groundwater pathways. After the initial reservoir of water had been pumped the borehole ran dry. This is indicative of many of the holes drilled in the gneissic terrain in Mhala North-East.

MNL7 was drilled on an electromagnetic anomaly and the results were similar as with those drilled at Utha. It would seem as though the electromagnetic technique gives an indication that there is a zone of increased conductivity within the gneiss. Normally, this would indicate a fracture or a zone of deeper weathering within the gneiss. The EM 34-3, using the 40m cable, can penetrate a gneissic terrain to not more than 60m. The borehole was drilled to 60,75m and the gneiss was fresh. Thick bands of biotite were intersected during drilling, these could perhaps have resulted in the variations in the conductivity beneath the surface, and implied the presence of anomalous features. It is, therefore, recommended that other geophysical techniques, such as, resistivity be applied instead of electromagnetics.

MNL9 was drilled adjacent to a dry river, using geological observations. Sand, which has high transmissivities, was drilled to 13 mbgl, but the regional static water is on average 15,97 mbgl. Thus the borehole was dry. In future, zones of deep saturated sand should be identified and drilled. Correct construction will enable strong yields.

Using aerial photograph interpretation, MNL10 was sited and drilled. Although fractures were intersected below the regional static water level, these fractures yielded weak groundwater seepage. This yield was too weak to utilize.

10.5 Thorndale

Prior to the investigation, no boreholes had been drilled at Thorndale, which meant that no hydrogeological data was available for this area. Boreholes were drilled on electromagnetic anomalies, magnetic anomalies, geological observations and aerial photograph interpretation. None of these holes were successful.

The average height of Thorndale is 410 metres above mean sea level (mamsl) which is higher than the surrounding areas, such as Manyeleti (385 mamsl) and Seville (395 mamsl). GCS then decided to use the information obtained from drilling THORN1, an intrusive dyke contact, to position the site for THORN8.

The target was moved down the strike of dolerite dyke towards the low lying area adjacent to the dam. Water seepage was measured at 31m and a water strike was intersected at 34 mbgl. Although the borehole tested to be very weak, it gave the indication that future drilling should be concentrated in the low lying areas surrounding Thorndale and not in the settlement itself.

10.6 Seville

This area produced the most successful new boreholes. Two sites were selected using aerial photograph interpretation. SVLL2 yielded 4 ℓ/s after testing and SVLL3 yielded 5 ℓ/s after testing. Both of these holes intersected fracture zones within the gneiss at approximately 30 mbgl. These fractures proved to have strong yields through the 24 hour constant discharge pumping tests indicating good groundwater transmissivities.

These boreholes were drilled in low lying areas adjacent to dry stream beds.

The other borehole in this area, SVLL1, was drilled to 73,5 m and has a yield of 0,7 ℓ/s. The two new holes were drilled to 51 m (SVLL2) and 40m (SVLL3). This indicates that in this area deeper holes do not necessarily mean stronger yields.

Further investigations should be confined to low lying areas adjacent to lineations recognised from aerial photographs.

10.7 Seville 'A'

Boreholes SVLLA4 and SVLLA5 were sited by GCS during a previous hydrogeological investigation in October 1992. These holes had been drilled but not utilised. They were drilled into the limb of a shallow dipping dyke.

The initial yields were high, SVLLA5 was 6.6 ℓ/s, but the groundwater reservoir was depleted with time during the 24 hour constant discharge pumping test and safe yields of 1 ℓ/s (SVLLA4) and 2 ℓ/s (SVLLA5) were recommended. This is the first incident of boreholes drilled into dolerite dykes in this area where the yields are greater than 1 ℓ/s.

Borehole SVLLA6 was drilled to intersect a fracture at depth. This borehole was unsuccessful even though the hole intersected a fracture zone at 24 to 27 mbgl. This indicates that these are minor or micro fractures which contribute very little to the movement of groundwater.

A combination of magnetic and electromagnetic readings led to the siting of SVLLA8. The blow yield was measured at 5 ℓ/s on a V-notch weir. The hole was tested and was found to run dry at a pumping rate of 1 ℓ/s. This indicates a depletion of the reservoir in a short time with pumping, which implies a local zone of high storage.

A minor electromagnetic anomaly adjacent to the dam at Seville, was sited and drilled. Borehole SVLLA7 was drilled to 45,65 mbgl, intersecting water at 36mbgl. The water strike corresponds to a zone of altered and fracture gneiss, the contact zone created by an intrusive dolerite dyke. The initial blow yield was 0,5 ℓ/s. After testing the yield was very weak indicating a depletion of the groundwater in storage associated with the contact zone.

10.8 Gottenberg

The two existing boreholes in Gottenberg have an average yield of 2,7 ℓ/s and average depth of 52,97 m. No information concerning water strikes was available. The regional static water level is 25 mbgl. The groundwater chemistry implies that the boreholes may have been drilled into the contact zone between the Makhutswi gneiss and the Timbavati Gabbro. Further south in the Mhala Block strong boreholes have been associated with this contact zone, future groundwater exploration in this area is recommended.

10.9 Acornhoek

Eight boreholes were drilled at Acornhoek to an average depth of 63,25 m. The sites were chosen using a combination of magnetic and electromagnetic techniques. There were no incidents of water strikes and seepage water was too weak to record. There was no other data available regarding the existing holes in Acornhoek.

It is evident from the amount of boreholes drilled and the results of this investigation that the groundwater potential is very low. This is the case in pristine granitic terrains.

A hydrocensus should be completed in this area to establish certain hydrogeological significant data before further work is done.

10.10 Cottondale

Magnetic geophysical traverses were performed and aerial photography interpretation was used to site six boreholes. The dolerite/gneiss contact zones resulted in a weak blow yield at GCS1 and a strong blow yield of 1.5 ℓ/s at GCS4.

The average depth for water strikes was 20,3mbgl. The boreholes were drilled to an average of 54,4mbgl. Although there were several water strikes in this area, the transmissivities were low and the groundwater storage capacity was found to be limited.

Table 10 is a summary of the new boreholes, the following comments are derived from these results.

It appears that the Cunning Moor Tonalite have been remobilised and intruded into by younger formations, This coarse-grained formation is seen to have a large groundwater storage capacity and an increased transmissivity with regard to groundwater.

The Makhutswi Gneiss has a low permeability with limited groundwater storage capacity. Intrusive dyke contact zones prove to have little or no groundwater storage and do not contribute to large yielding boreholes in this environment.

Deep weathering, fracturing and faulting within the Makhutswi Gneiss have been recognised as the most important factors regarding groundwater exploration. Large zones of weathering to depths below the regional static water levels should be sought for further drilling.

The unnamed basement rock to the north of Mhala Block is seen as having negligible groundwater potential due to it being largely impermeable and has very limited groundwater storage capacity. A hydrocensus should be performed on the existing boreholes drilled into this formation to establish the regional hydrogeological parameters.

Dolerite Dyke contact zones have produced very poor yields throughout the Mhala North-East and therefore future work should concentrate on fractures and zones of deeper weathering within the gneiss in topographical low lying areas.

The thickness of the zone, the number of individual fractures or the total depth reached seems to have no bearing on the transmissivity of the groundwater.

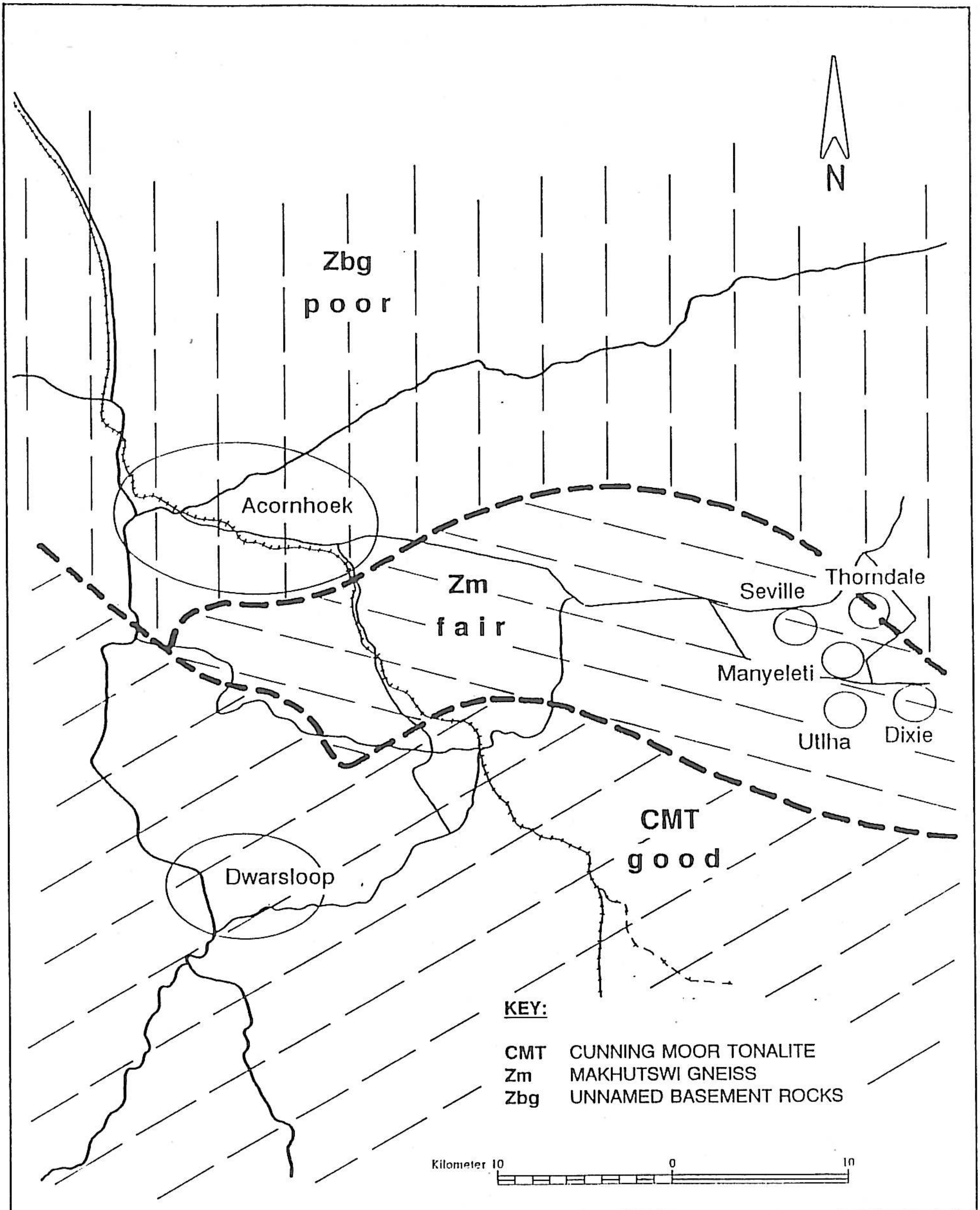
Figure 5 gives an indication of groundwater potential within the Mhala block, this will aid in future planning of groundwater development.

Table 10 Summary of New Boreholes

GEOLOGICAL UNIT	NUMBER OF NEW HOLES	TARGET SITES	TARGET METHOD	PERCENTAGE SUCCESS (%)	AVERAGE BLOW YIELD (l/s)	AVERAGE DEPTH (m)	AVERAGE STRIKES (mbgl)	GROUNDWATER QUALITY REMARKS	COMMENTS
Makhutswi Gneiss	21	5 Frac 10 Dyke 6 Weath	17 Geo 4 API 7 Obs	28	1.79	52.81	29.31	Fair with areas of high Potassium giving water an unpleasant taste	Future groundwater development should be confined to low lying areas adjacent to river beds
Unnamed Basement Gneiss	19	8 Frac 7 Dyke 4 Weath	13 Geo 2 API 4 Obs	21	2.1	55.08	32	Zones of high Salinity and Sodium	Hydrocensus data is needed before future groundwater planning
Cunning Moor Tonalites	6	2 Frac 3 Dyke 1 Weath	5 Geo 0 API 1 Obs	67	1.25	60.67	26.88	Good with incidents of high Flouride	Good potential for future groundwater development

Frac = Fractures
Dyke = Intrusive Contact Zone
Weath = Zones of Deeper Weathering

Geo = Geophysical Method
API = Aerial Photography Interpretation
Obs = Field Observation



Project		Project No 94-1.015
GAZANKULU - DROUGHT RELIEF PROGRAMME MHALA AREA AREAS OF GROUNDWATER POTENTIAL	Groundwater Consulting Services Consultants in Water Resources P O Box 2597 Rivonia 2128 Tel (011) 803 5729	Scale AS ABOVE Figure 5