GEO-HYDRO TECHNOLOGIES

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GEOHYDROLOGICAL SERVICES IN KWAZULU/NATAL - LADYSMITH DISTRICT

Prepared for

Department of Water Affairs & Forestry - Natal Region

by

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JULY 1996 **Report no.: RVN38/05/92**

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OFS

Our Ref.: RVN38/05/92

24 July 1996
Department Water Affairs and Forestry
Regional Director, KwaZulu/Natal
PO Box 1018
Durban
4000

FOR ATTENTION: Mr. SW Gillham

Dear Sir

GEOHYDROLOGICAL SERVICES IN KWAZULU / NATAL - LADYSMITH DISTRICT

It is our pleasure to submit the following copy of the report RVN38/05/92 entitled **"GEOHYDROLOGICAL SERVICES IN KWAZULU / NATAL - LADYSMITH DISTRICT"** to the Department Water Affairs and Forestry.

We trust that the report will fullfil the expectations of the Department Water Affairs & Forestry. We will supply any additional information if needed and look forward to being of further service in the future.

Yours sincerely

Mr. DC Rudolph Pr.Sci.Nat.
DIRECTOR
GEO HYDRO TECHNOLOGIES

Copies :
2) Department of Water Affairs & Forestry, Natal Region.
1) Thukela Joint Services Board.

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1. INTRODUCTION

1.1. BACKGROUND

Geo-Hydro Technologies (GHT) was commissioned by the Department of Water Affairs and Forestry, KwaZulu/Natal, Durban, to undertake geohydrological services in Central KwaZulu/Natal Region - Emnambithi (Ladysmith) district. The geohydrological services included geophysical surveying for the siting of boreholes in needy areas, as identified by Thukela Joint Services Board, the drilling supervision of a possible three boreholes per identified area and pump test supervision of the successful boreholes. During the course of the project, GHT was to submit progress reports on the siting, drilling and pump testing activities. At the conclusion of the project, GHT was to submit a report, detailing all work done, analyses of the data gathered and management recommendations to Department of Water Affairs & Forestry, KwaZulu/Natal, Durban.

2. GEOPHYSICAL EXPLORATION

The geophysical survey was done during January - February 1996 to detect and delineate secondary structures for groundwater exploration. The geophysical exploration included the siting of boreholes for 28 identified areas.

The purpose of the geophysical investigations were therefore to;

- evaluate the electromagnetic "Geonics EM34-3", magnetic and direct current sounding techniques under the specific geological conditions, and
- to detect and delineate the aquifers as present in the area of interest.

Favourable conditions for the geophysical work, which prevail in the area, are;

- *geological* conditions, like;
  - the exploration target (dykes) which is conductive, and therefore it is an ideal electromagnetic target and
  - the dykes are normally magnetic, because of the presence of magnetite. The magnetic method which measure the magnetic field intensity of the earth can be used to map magnetic structures.

Unfavourable conditions for groundwater exploration were;

- cultural interference effects due to power lines, fences, etc. Close record were kept during the survey of the distance between the geophysical equipment and power lines and fences. The position of these interference objects was noted during the field survey for use during the processing of the data.
- The extreme rainfall conditions that occurred during February made some of the terrains inaccessible after they had been sited. In some cases the sites could not be reached at all due to the fact that rivers were in flood, cutting off all access. The rain furthermore worsened the problems encountered with road conditions and topography. Dirt roads were turned into mudpiles and roads that had recently been graded became too slippery

for the drill rigs to pass. Therefore, additional sites were sited where the geophysical work was limited to the vicinity of the gravel roads.

Tables 1.1 and 1.2 give a summary of the geophysical surveys that were carried out at the different communities for borehole placements. A short description of the geophysical methods which were used during the survey can be found in Appendix A. The electromagnetic and magnetic results printed out as profiles are listed in Appendix B.

2.1. CONCLUSIONS

Electromagnetic and magnetic profiling are too valuable of an investigation tool not to be used to their full benefit. They allow the thorough coverage necessary to take an objective look at the entire area under investigation. The geophysical data if collected, analysed and interpreted correctly provide an insight into the conceptual geological model, rarely obtained through other means. Borehole placement without the use of geophysics and a knowledge of the geology is a primitive and risky investigative procedure.

From the work done on site, the following conclusions can be made;

- the inaccessibility of the terrain, after the extreme rainfall conditions, has limited the applicability of the geophysical techniques only to certain areas where the drilling rig can get in. The effect of this is that some of the drilling sites were selected alongside roads.
- Due to the limitations that were given for borehole placement at some of the areas, the geophysical techniques could not be used not for siting. Therefore, borehole placement was done on the geology.

At 23 identified areas from the 28, borehole placements were done using geophysical methods. The rest of the borehole placements were sited on geological features such as outcrops from dolerite dykes and faults in the area.

3. DRILLING

The drilling programme commenced at mid February 1996 until the beginning of March by the firms J.D. Nel Drilling Contractors, Grobbies and DFPL Beleggings. During this period a total of 28 boreholes were drilled under extreme rainfall conditions that prevailed in the area. From the 28 boreholes drilled, 17 yielded successful groundwater occurrence.

All the boreholes drilled in the area are identified by the KwaZulu/Natal numbers from B303327 to B303354. The logistics of the drilling programme are summarised in Tables 2.1 and 2.2. A complete geological and construction record for each borehole is presented in Appendix C. The positions of the new boreholes drilled can be seen in Figures 1 to 5.

All the boreholes were drilled using conventional direct air rotary percussion. The boreholes were completed to a diameter of 165 mm, and in some cases 215 mm and 254 mm. Plain (solid) casing was installed through loose and potentially unstable overburden and weathered near-surface formations. In some boreholes the nature of the water-bearing horizons indicated that perforated casings needed to be used to secure these zones against collapse.

TABLE 1.1 BOREHOLE SITING REPORT - LADYSMITH

Ward	Sub Ward	Topo Map Reference	Profile No	Survey Date	Geophysical Method: Mag	Geonics EM 34: Coil seperation 10 m (Traverse Length (m))	Geonics EM 34: Coil seperation 20 m (Traverse Length (m))	Geonics EM 34: Coil seperation 40 m (Traverse Length (m))	DC Sounding	Borehole Site: Station Number	Drill Site Number	Coordinates: S	Coordinates: E	Geophysical Anomaly	Geological Drilling Target: Geology	Geological Drilling Target: Deep Weathering	Geological Drilling Target: Fracturing/ Faulting	KwaZulu/ Natal Number
Driefontein	Baldaskraal 1	2829BC	T4	27-Feb			260		No	110	LB2a	28° 17' 55"	29° 42' 55"	EM	DLRT/SHLE			B303327
			"	27-Feb			260		No	140	LB2b	28° 17' 54"	29° 42' 56"	EM	"			
Driefontein	Watersmeet	2829BC		30-Jan					No		LC3a	28° 23' 53"	29° 42' 56"	Geology	DLRT			B303328
				30-Jan					No		LC3b	28° 23' 58"	29° 42' 53"	Geology	"			
Wasbank	Uitvligt	2830AC	T11	02-Feb	300				No	20	LO15a	28° 28' 20"	30° 07' 44"	Mag	SNDS			B303329a
			"	02-Feb	300				No	105	LO15b	28° 28' 18"	30° 07' 42"	Mag	SNDS/DLRT			B303329b
			"	29-Feb					No		LO15c	28° 28' 21"	30° 07' 41"	Geology	DLRT			
Emnambithi	Esikoko	2830AC	T12	02-Feb	250		250		No	230	LX24a	28° 29' 49"	30° 10' 48"	EM/Mag	DLRT			
			"	02-Feb	250		250		No	65	LX24b	28° 29' 48"	30° 10' 52"	EM/Mag	"			B303330
Emnambithi	Wembley	2830CA	T9	04-Feb	200				No	70	LQ17a	28° 33' 13"	30° 01' 08"	Mag	DLRT/SNDS			
			"	04-Feb	220				No	60	LQ17b	28° 33' 10"	30° 01' 11"	Mag	"			
			"	27-Feb					No		LQ17c	28° 33' 12"	30° 01' 08"	Geology	"			B303331
Emnambithi	Qinisa	2829DB	T10	04-Feb	300				No	160	LP16a	28° 40' 04"	29° 54' 41"	Mag	DLRT/SNDS			
			"	04-Feb	280				No	70	LP16b	28° 40' 13"	29° 54' 53"	Mag	"			
Emnambithi	Mbango	2830CA	T13	06-Feb	150				No	60	LN14a	28° 44' 30"	30° 11' 28"	Mag	DLRT/SNDS			
			"	06-Feb	100				No	30	LN14b	28° 44' 26"	30° 11' 24"	Mag	"			
Dundee	Dival	2830AD	T14	07-Feb	260		260		No	200	LI9a	28° 27' 10"	30° 17' 34"	EM/Mag	SNDS			B303334a
			"	07-Feb	260		260		No	120	LI9b	28° 27' 08"	30° 17' 38"	EM/Mag	"			B303334b
Emnambithi	Limehill 1	2830AC	T15	08-Feb	80		80		No	30	LK1a	28° 26' 11"	30° 14' 59"	EM/Mag	DLRT/SHLE			B303335
				08-Feb					No		LK1b	28° 26' 03"	30° 14' 53"	Geology	"			
Emnambithi	Limehill 2	2830AC		08-Feb					No		LK2a	28° 26' 04"	30° 14' 28"	Geology	SNDS/DLRT			B303336
				08-Feb					No		LK2b	28° 26' 01"	30° 14' 30"	Geology	"			
Emnambithi	Emhlabathini	2830CA		08-Feb					No		LT20a	28° 34' 15"	30° 04' 53"	Geology	DLRT/SNDS			
				08-Feb					No		LT20b	28° 34' 20"	30° 04' 50"	Geology	DLRT/SNDS			
Dundee	Tholeni Rural	2830AC	T16	08-Feb	260				No	180	LY25a	28° 26' 39"	30° 13' 26"	Mag	DLRT/SNDS			B303338a
				08-Feb	260				No	130	LY25b	28° 26' 37"	30° 13' 25"	Mag	DLRT/SNDS			B303338b
Emnambhiti	S'hoek Rural	2830CA	T17	09-Feb	260		260		No	80	LU21a	28° 33' 36"	30° 11' 14"	EM/Mag	SNDS/DLRT			
			"	09-Feb	260		260		No	175	LU21b	28° 33' 40"	30° 11' 15"	EM/Mag	SNDS/DLRT			
Dundee	Namakazi	2830AC	T18	12-Feb	210		210		No	100	LH8a	28° 29' 30"	30° 12' 39"	EM/Mag	SNDS/DLRT			B303340
			"	12-Feb	210		210		No	130	LH8b	28° 29' 28"	30° 12' 38"	EM/Mag	SNDS/DLRT			

TABLE 1.2 BOREHOLE SITING REPORT - LADYSMITH

Ward	Sub Ward	Topo Map Reference	Profile No	Survey Date	Geophysical Method					Borehole Site								
					Mag	Geonics EM 34			DC Sounding	Station Number	Drill Site Number	Coordinates		Geophysical Anomaly	Geological Drilling Target			KwaZulu/ Natal Number
						Coil seperation						S	E		Geology	Deep Weathering	Fracturing/ Faulting	
						10 m	20 m	40 m										
					Traverse Length (m)													
Dundee	Kliprivier	2830AD	T20	13-Feb	170		170		No	40	LV22a	28° 31' 53"	30° 17' 33"	EM/Mag	SNDS/DLRT			
				13-Feb	170		170		No	80	LV22b	28° 31' 45"	30° 17' 47"	EM/Mag	SNDS/DLRT			
Dundee	Vaalkop	2830AC	T21	14-Feb	230		50		No	20	LS19a	28° 28' 18"	30° 13' 29"	Mag	SNDS/DLRT			B303342a
				14-Feb	230		50		No	110	LS19b	28° 28' 21"	30° 13' 28"	Mag	SNDS/DLRT			B303342b
Dundee	Tholeni Town	2830AC	T22	14-Feb			190		No	40	LW23a	28° 25' 41"	30° 12' 47"	EM	SNDS/DLRT			B303343a
				14-Feb			190		No	120	LW23b	28° 25' 41"	30° 12' 46"	EM	SNDS/DLRT			B303343b
Emnambhiti	St Chads	2829BD	T1	08-Feb	130				No	100	LR18a	28° 34' 35"	29° 53' 36"	Mag	DLRT/SNDS			B303354
				08-Feb	100				No	70	LR18b	Destroyed by floods		Mag	DLRT/SNDS			
Emnambhiti	Greylock	2830CA		13-Feb					No	40	LL12a	28° 34' 42"	30° 05' 21"	Geology	DLRT			B303351a
				13-Feb					No	90	LL12b	28° 34' 49"	30° 05' 16"	"	DLRT			B303351b
Driefontein	Godi	2829BD	T23	20-Feb	300		300		No	190	LD4a	28° 25' 12"	29° 47' 32"	EM/Mag	DLRT/SNDS			B303344
				20-Feb	300		300		No	45	LD4b	28° 25' 11"	29° 47' 35"	EM/Mag	DLRT/SNDS			
Driefontein	Gcabane	2829BD	T24	20-Feb			200		No	100	LZ27a	28° 23' 25"	29° 45' 00"	EM	DLRT/SNDS			B303347a
				20-Feb			200		No	130	LZ27b	28° 23' 25"	29° 45' 00"	EM	DLRT/SNDS			B303347b
Driefontein	Riverside	2829BD		23-Feb					No	120	LE5a	28° 22' 39"	29° 37' 07"	Geology	SHLE/DLRT			B303345
				23-Feb					No	20	LE5b	28° 22' 46"	29° 37' 12"	"	SHLE/DLRT			
Kliprivier	Hobsland	2829BD	T25	21-Feb			140		No	70	LF6a	28° 27' 44"	29° 46' 24"	EM	DLRT/SNDS			
				21-Feb			140		No	20	LF6b	28° 27' 42"	29° 46' 20"	EM	DLRT/SNDS			
Emnambhiti	Pieters 2 School	2829BD	T26	23-Feb			150		No	50	LG7a	28° 40' 08"	29° 51' 38"	EM	DLRT			B303349
				23-Feb			150		No	80	LG7b	28° 40' 09"	29° 51' 41"	EM	DLRT			
Driefontein	Inkuthu	2829BD	T8	02-Mar			150		No	50	LA26a	28° 22' 11"	29° 38' 26"	EM	DLRT			
				02-Mar			210		No	70	LA26b	28° 22' 13"	29° 38' 21"	EM	DLRT			
Driefontein	Baldaskraal 2	2829BC	T7	01-Mar			200		No	75	LJ10a	28° 18' 16"	29° 43' 09"	EM	SHLE/DLRT			B303350
				01-Mar			200		No	90	LJ10b	28° 18' 17"	29° 43' 06"	EM	SHLE/DLRT			
Emnambithi	Pieters 2 Rural	2829BD	T19	23-Feb	80		80		No	40	LM13a	28° 39' 39"	29° 52' 08"	EM/Mag	DLRT/SNDS			
				23-Feb	80		80		No	70	LM13b	28° 39' 46"	29° 51' 48"	EM/Mag	DLRT/SNDS			
Emnambithi	Emanseleni	2830CA	T5	28-Feb	100		100		No	90	LB28a	28° 43' 24"	30° 11' 45"	EM/Mag	DLRT/SNDS			
				28-Feb	100		100		No	40	LB28b	28° 43' 28"	30° 11' 42"	EM/Mag	DLRT/SNDS			

TABLE 2.1 GEOHYDROLOGICAL PROGRESS REPORT - LADYSMITH

SITE INFORMATION							BOREHOLE CONSTRUCTION								AQUIFER INFORMATION			
		Borehole number			Coordinates		Drilling			Casing					Yield		Aquifer	Water
Ward / Sub Ward	Topo Map Reference	KwaZulu / Natal	DWA &F	GHT - Hydrocom	S	E	Depth (m)	Diam (mm)	Method	Length (m)	Diam (mm)	Type	Height (mbgl)	Date Drilled	Air-lift (l/s)	Depth (m)	Type / Code	level (mbgl)
Baldaskraal 1	2829BC	B303327	LB2a	2829BC00001	28° 17' 55"	29° 42' 55"	0-12 12-120	254 165	Air-P "	12	215	S	0.28	01-Mar	0.21	80	DLRT	4.02
Watersmeet	2829BC	B303328	LC3a	2829BC00002	28° 23' 53"	29° 42' 56"	0-16 16-81	205 165	Air-P "	16	165	S	0.41	06-Feb	0.56	65	SNDS	2.8
Uitvligt	*2830AC*	*B303329a*	*LO15a*	*2830AC00003*	*28° 28' 20"*	*30° 07' 44"*	*0-33* *33-121*	*205* *165*	*Air-P* "	*Stone plugged*				*06-Feb*	*Dry*			
		B303329b	*LO15b*	*2830AC00004*	*28° 28' 18"*	*30° 07' 42"*	*0-57* *57-149*	*205* *165*	*Air-P*	*Stone plugged*				*12-Feb*	*Dry*			
Esikoko	2830AC	B303330	LX24b	2830AC00005	28° 29' 48"	30° 10' 52"	0-17 17-97	215 165	Air-P "	17	205	S	0.32	14-Feb	0.2	80	DLRT	1.4
Wembley	*2830CA*	*B303331a*	*LQ17a*	*2830AC00006*	*28° 33' 13"*	*30° 01' 08"*	*0-20* *20-120*	*165*	*Air-P*	*Stone plugged*				*25-Feb*	*Dry*			
		B303331b	*LQ17b*	*2830AC00007*	*28° 33' 10"*	*30° 01' 11"*	*0-152*	*165*	*Air-P*	*Stone plugged*				*26-Feb*	*Dry*			
		B303331	LQ17c	2830AC00008	28° 33' 12"	30° 01' 08"	0-20 20-150	215 165	Air-P "	20	205	S		27-Feb	0.13	110	SHLE	14.4
Dival	*2830AD*	*B303334a*	*LI9a*	*2830AD00009*	*28° 27' 10"*	*30° 17' 34"*	*0-18* *18-126*	*215* *165*	*Air-P* "	*Stone plugged*				*12-Feb*	*Dry*			
		B303334b	LI9b	2930AD00010	28° 27' 08"	30° 17' 38"	0-12 12-120	215 165	Air-P "	12	165	S	0.28	13-Feb	4.2	96	SHLE	6.6
Limehill 1	2830AC	B303335	LK1a	2830AC00011	28° 26' 11"	30° 14' 59"	0-21 21-150	215 165	Air-P "	21	165	S	0.29	16-Feb	0.6	60	F/DLRT	3.3
Limehill 2	2830AC	B303336	LK2a	2830AC00012	28° 26' 04"	30° 14' 28"	0-18 18-150	215 165	Air-P "	18	165	S	0.32	19-Feb	0.8	144	SHLE	4.6
Tholeni Rural	*2830AC*	*B303338a*	*LY25a*	*2830AC00013*	*28° 26' 39"*	*30° 13' 26"*	*150*	*165*	*Air-P*	*Stone plugged*				*18-Feb*	*Dry*			
		B303338b	LY25b	2830AC00014	28° 26' 37"	30° 13' 25"	0-8 8-150	215 165	Air-P "	8	165	S	0.3	22-Feb	0.08	70	DLRT	2.3
Namakazi	2830AC	B303340	LH8a	2830AC00015	28° 29' 30"	30° 12' 39"	0-29 29-97	205	Air-P "	8 8-29	165 165	S P	0.32	18-Feb	1.4	30	DLRT	(+0.0)

TABLE 2.2 GEOHYDROLOGICAL PROGRESS REPORT - LADYSMITH

SITE INFORMATION							BOREHOLE CONSTRUCTION								AQUIFER INFORMATION			
		Borehole number			Coordinates		Drilling			Casing					Yield		Aquifer	Water
Ward / Sub Ward	Topo Map Reference	KwaZulu / Natal	DWA &F	GHT - Hydrocom	S	E	Depth (m)	Diam (mm)	Method	Length (m)	Diam (mm)	Type	Height (mbgl)	Date Drilled	Air-lift (l/s)	Depth (m)	Type / Code	level (mbgl)
Vaalkop	*2830AC*	*B303342a*	*LS19a*	*2830AC00016*	*28° 28' 18"*	*30° 13' 29"*	*150*	*165*	*Air-P*	*Stone plugged*				*21-Feb*	*Dry*			
		B303342b	LS19b	2830AC00017	28° 28' 21"	30° 13' 28"	0-42	215	Air-P	20	165	S	0.31	22-Feb	0.2	40	DLRT	1.0
							42-101	165	"	20-42	165	P						
Tholeni Town	*2830AC*	*B303343a*	*LW23a*	*2830AC00018*	*28° 25' 41"*	*30° 12' 47"*	*0-24*	*215*	*Air-P*	*Stone plugged*				*20-Feb*	*Dry*			
							24-150	*165*	"									
		B303343b	LW23b	2830AC00019	28° 25' 41"	30° 12' 46"	0-22	215	Air-P	22	165	S	0.25	21-Feb	0.2	96	SHLE	13.9
							22-150	165	"									
St Chads	2829BD	B303354	LR18a	2829BD00020	28° 34' 35"	29° 53' 36"	0-6	254	Air-P	6	215	S	0.21	05-Mar	0.3	107	DLRT	6.76
							6-138	165	"									
Greylock	*2830CA*	*B303351a*	*LL12a*	*2830CA00021*	*28° 34' 42"*	*30° 05' 21"*	*0-16*	*215*	*Air-P*	*Stone plugged*				*03-Mar*	*Dry*			
							16-127	*165*	"									
		B303351b	*LL12b*	*2830CA00022*	*28° 34' 49"*	*30° 05' 16"*	*0-6*	*215*	*Air-P*	*Stone plugged*				*04-Mar*	*Dry*			
							6-121	*165*	"									
Godi	2829BD	B303344	LD4a	2829BD00023	28° 25' 12"	29° 47' 32"	0-42	215	Air-P	30	165	S	0.33	24-Feb	0.7	65	DLRT	9.4
							42-138	165	"	30-42	165	P						
Gcabane	2829BD	B303347a	LZ27a	2829BD00024	28° 23' 25"	29° 45' 00"	0-150	*165*	*Air-P*	*Stone plugged*				27-Feb	Dry			
		B303347b	LZ27b	2829BD00025	28° 23' 25"	29° 45' 00"	0-18	215	Air-P	18	165	S	0.32	28-Feb	0.08	110	DLRT	9.48
							18-150	165	"									
Riverside	2829BD	B303345	LE5a	2829BD00026	28° 22' 39"	29° 37' 07"	0-6	254	Air-P	6	215	S	0.32	29-Feb	0.5	86	DLRT	(+0.0)
							6-54	215	"	38	165	S						
							54-120	165	"	38-54	165	P						
Pieters 2	2829BD	B303349	LG7a	2829BD00027	28° 40' 08"	29° 51' 38"	0-12	254	Air-P	12	215	S	0.23	04-Mar	0.44	24	DLRT	11.16
							12-132	165	"									
Baldaskraal 2	2829BC	B303350	LJ10a	2829BC00028	28° 18' 16"	29° 43' 09"	0-6	254	Air-P	6	215	S	0.31	02-Mar	0.12	80	DLRT	5.9
							6-13	215	"	10	165	S						
							13-102	165	"	10-13	165	P						

GEO-HYDRO TECHNOLOGIES

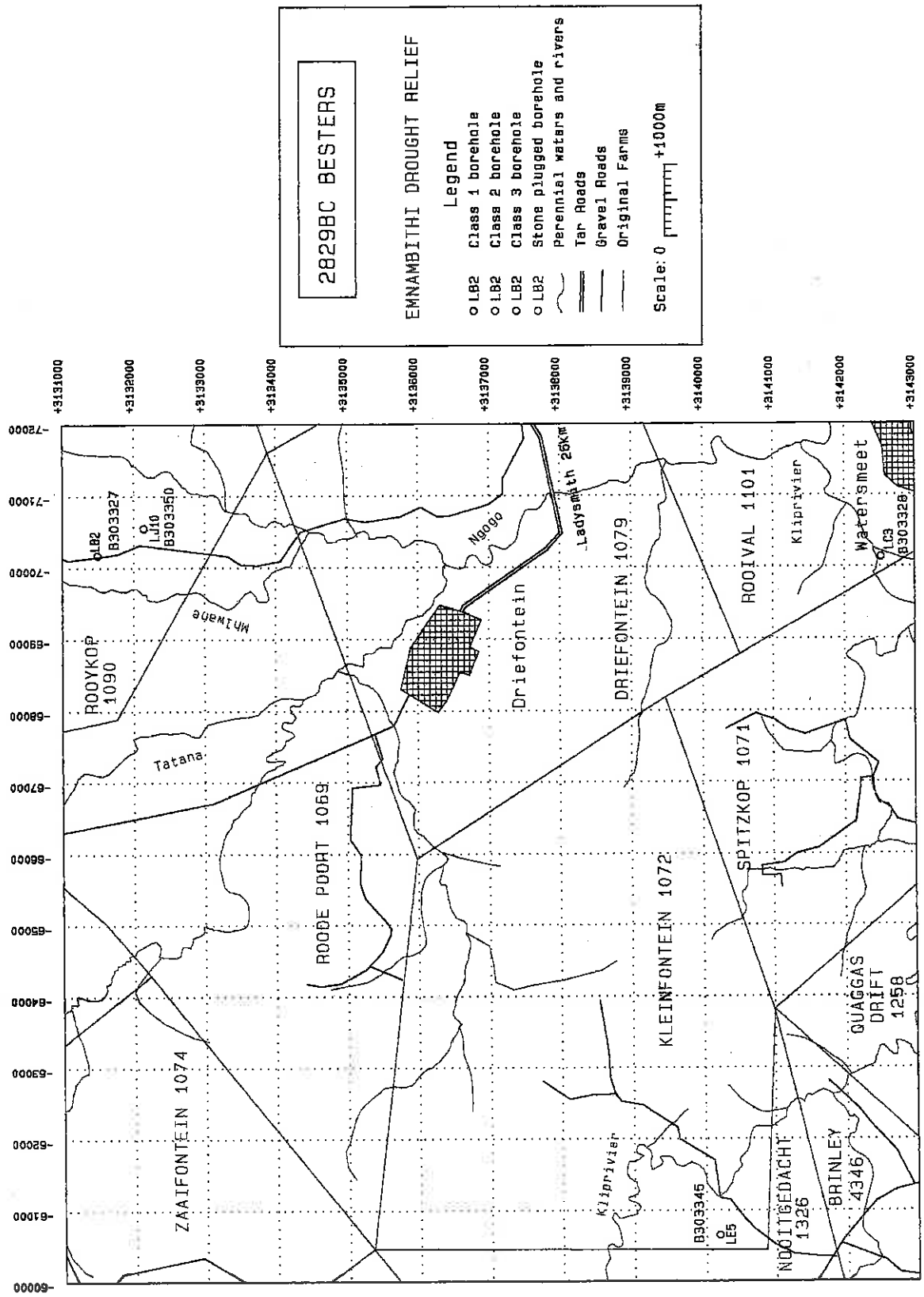

Figure 1. Locality plan of the new boreholes.

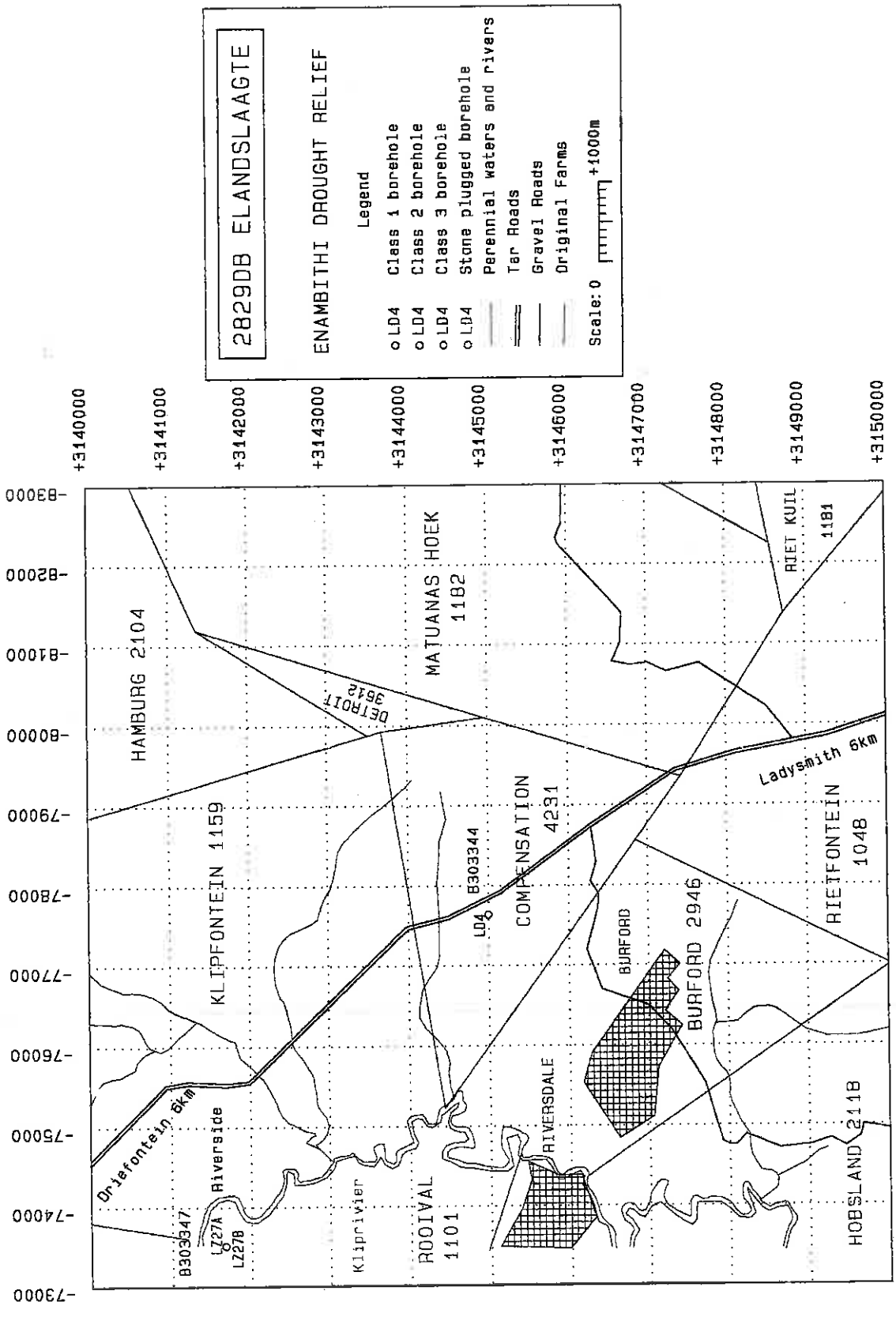

Figure 2. Locality plan of the new boreholes.

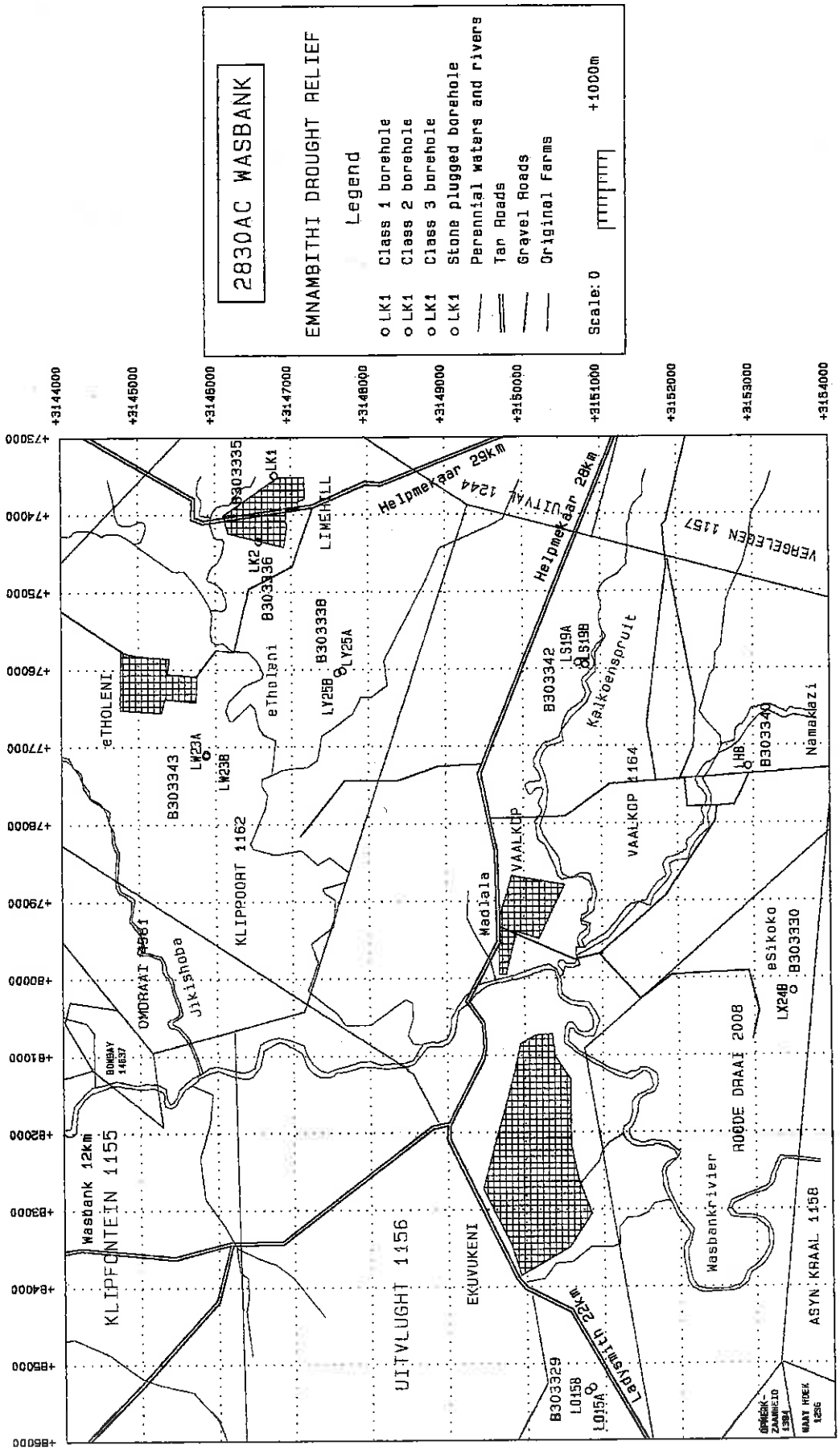

Figure 3. Locality plan of the new boreholes.

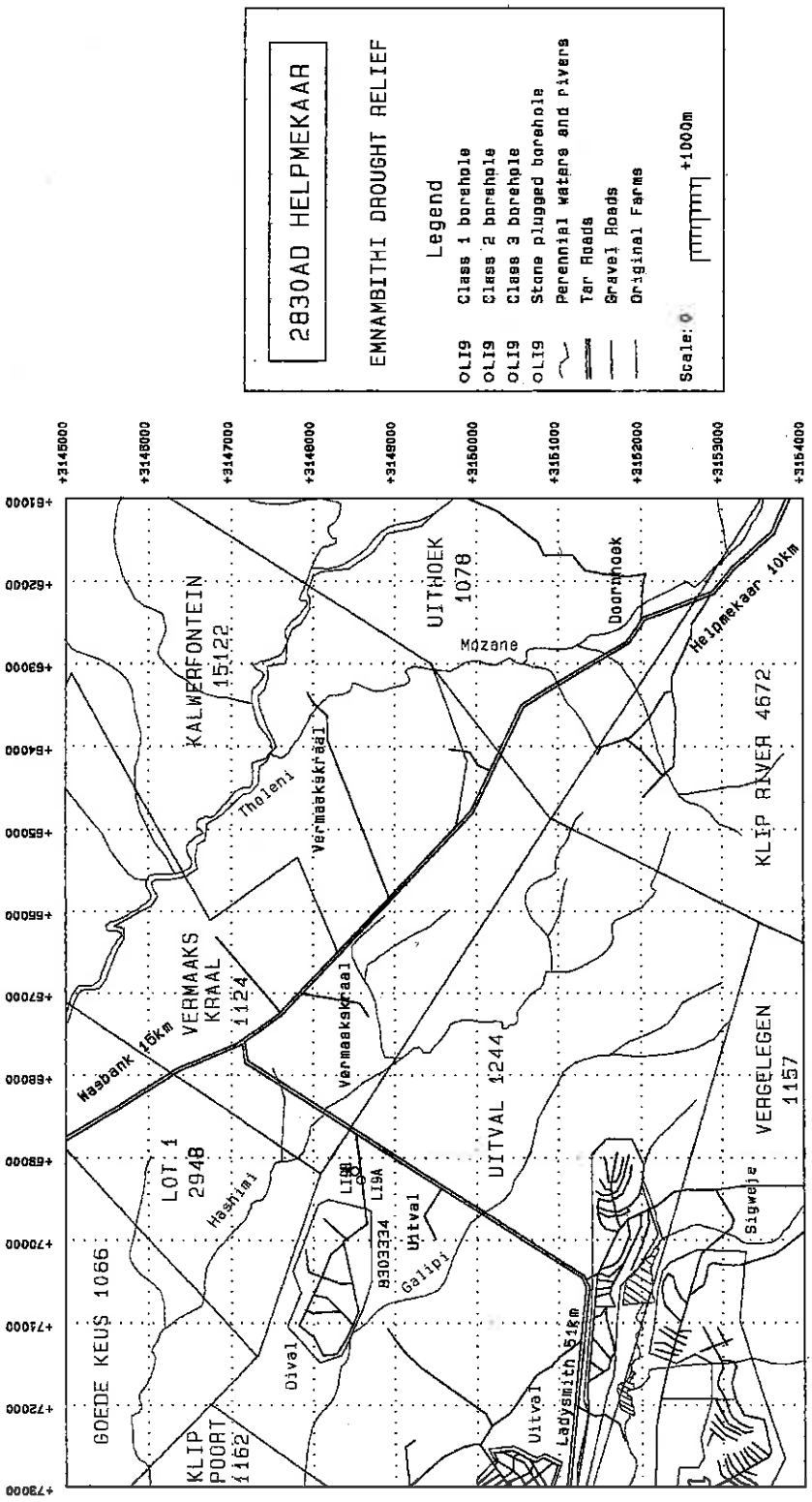

Figure 4. Locality plan of the new boreholes.

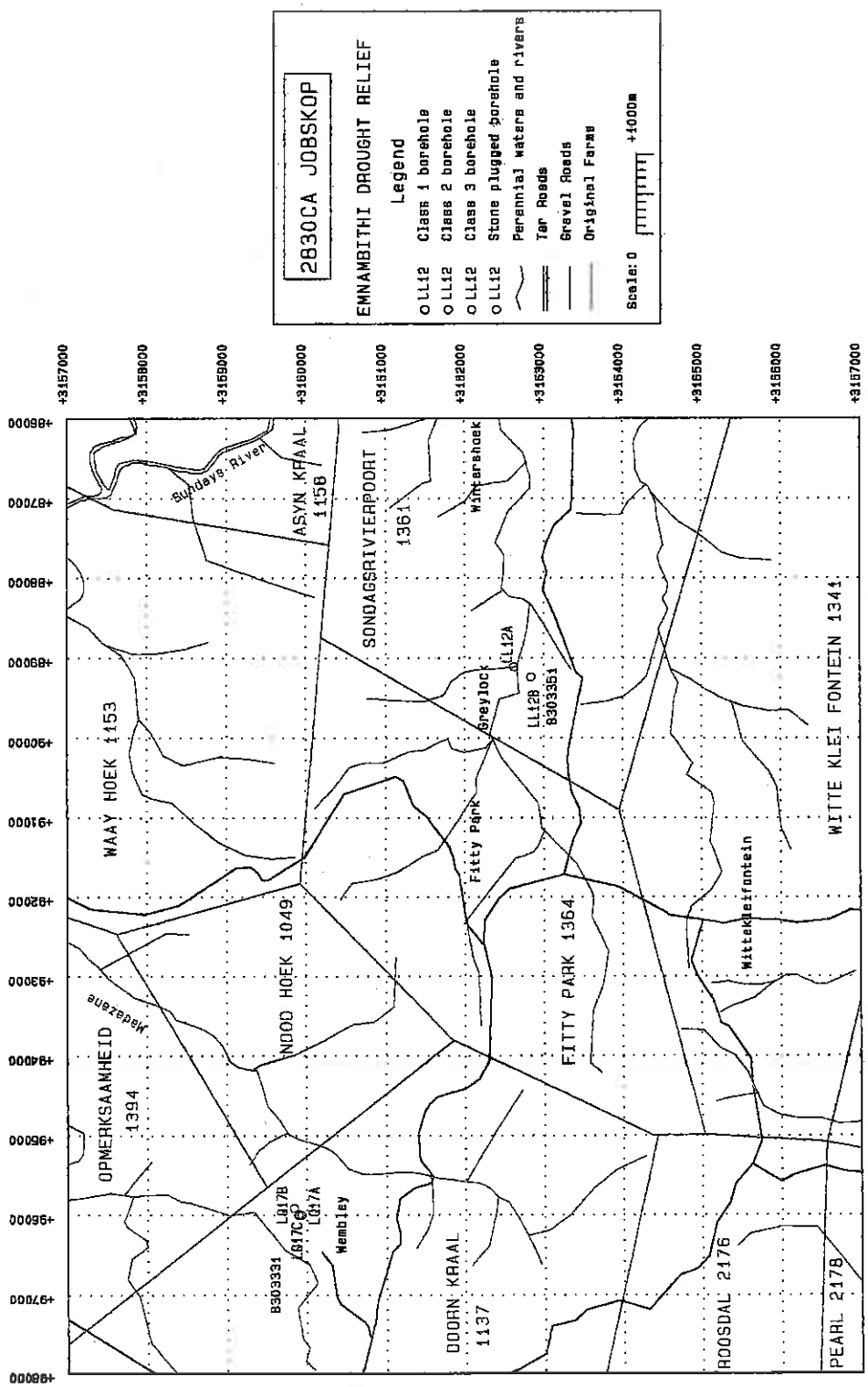

Figure 5. Locality plan of the new boreholes.

4. GEOHYDROLOGY

Only a brief overview of the geology, as relevant to the geophysical and geohydrological work will be given.

The lithostratigraphy of the water-bearing formations in the area of interest is namely;

- the Vryheid and Volkrust Formation from the Ecca Group of the Karoo Sequence.

The Volkrust Formation mainly consists of dark grey shale. The Vryheid Formation consists of medium- to coarse- grained sandstone with thin grit beds and grey micaceous shale. Karoo dolerites, in the form of dykes and sills (sheets) are common throughout the Beaufort Group.

4.1. GROUNDWATER OCCURRENCE

A borehole is deemed successful if upon completion it yields more than 0.08 l/s. On the basis of the drilling results, three modes of groundwater occurrence in the area are identified. These are the following;

- groundwater in sedimentary rocks. Groundwater that is held in the undisturbed sandstone and shale. These constitute poor to moderate aquifers for handpump installations that support low yielding (< 1 l/s) boreholes. Boreholes LZ27 (B303347), LS19b (B303342), LQ17c (B303331) and LX24b (B303330) penetrate such aquifers.
- Groundwater that occurs in subvertical contact zones between the sediments and the dolerite dykes that intrude them. These constitute moderate to good aquifers. Boreholes LC3 (B303328), LB2 (B303327), LE5(B303345), LK1 (B303335) BG3 penetrate such aquifers.
- Groundwater that occurs within harder, fractured and jointed sediments that owe these properties to moderate alteration by nearby dolerite intrusions or faults. These constitute good aquifers. Borehole LI9b (B303334) penetrates such an aquifer.

All the rocks in the area are inherently impervious and are low yielding. The storage, movement and occurrence of groundwater in these rocks are controlled by their secondary geohydrological properties.

The nature of the water-bearing rocks from the Ecca Group lack significant primary porosity and are dominantly arenaceous strata. The secondary hydrological properties developed as a result of openings produced by jointing, faulting, the intrusion by dolerite and physical weathering.

On the basis of the above observations it is clear that the siting of a high yielding borehole in the area requires the scientific identification of a suitable drilling target.

The water table in the area is limited to joints, fissures and other permeable zones. It is reasonable to assume that the aquifers in the Ecca Group are of a semi-confined to confined nature. This is supported by the observation that the static groundwater level in all the boreholes that were drilled is shallower than the first water strike. Further, the existence of artesian boreholes (B303340 and B303345) in the area also supports this assumption.

5. TEST PUMPING

The testing programme entailed a 6 hour constant discharge test followed by a recovery test on boreholes with blow yields below 2 l/s. For boreholes above 2 l/s blow yield a 12 hour constant discharge test followed by a recovery test were carried out.

The methods of Theis, Theis Recovery and Cooper-Jacob were used in the analyses of the data obtained from the constant discharge tests. The determined parameters were used in the Theis equation for the prediction of the drawdown obtained under a given discharge rate. The analysed pumping test data of the potential production boreholes are presented in Appendix D.

The exploitation potential of groundwater depends not only on the given borehole prospects, but also on storage, recharge and quality of groundwater. A summary of the boreholes tested and its hydrogeological properties are given in the management recommendation and water quality spreadsheets.

6. MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

For all the successful boreholes management recommendation and water quality spreadsheets have been prepared and are listed in Appendix E. The spreadsheets contain all the necessary information regarding the site logistics, water quality, the pump test results, pump installation specifics and recommendations.

6.1. HYDROCHEMISTRY

Water samples were taken during the drilling phase and at the end of the pumping tests. These samples have been analysed by the Institute for Groundwater Studies, UOFS, for pH, electrical conductivity (EC), ammonia (NH_4 as N), calcium (Ca), chloride (Cl), Fluoride (F), magnesium (Mg), nitrate (NO_3 as N), phosphate (P), potassium (K), silicon (Si), sodium (Na), sulphide (SO_4), total alkalinity (as $CaCO_3$) and total dissolved solids. The results are listed in Appendix F and are evaluated according to the guidelines set in "South African Water Guidelines - Volume 1, Domestic Use, 1993".

BOXPLOTS

The basic constituents that occur in groundwater in health endangering concentrations are sodium, magnesium, chloride and sulphate. To these nitrate and fluoride must be added as they often occur at dangerous levels in groundwater and the parameters pH and electrical conductivity. Boxplots of these basic constituents have been prepared and evaluated according to the SA Drinking Water Standards for humans. The graphical representations of the boxplots are illustrated in Figures 6 to 13. The last sample value on the boxplots represents the pumptest sample. Although only two sample values per borehole exists, the following meaningful interpretations and conclusions can be drawn from the boxplots :

- The obvious difference in the boxplots is the variation in the concentrations of sodium, magnesium, chloride, fluoride and nitrate values and the parameter values of pH and EC.

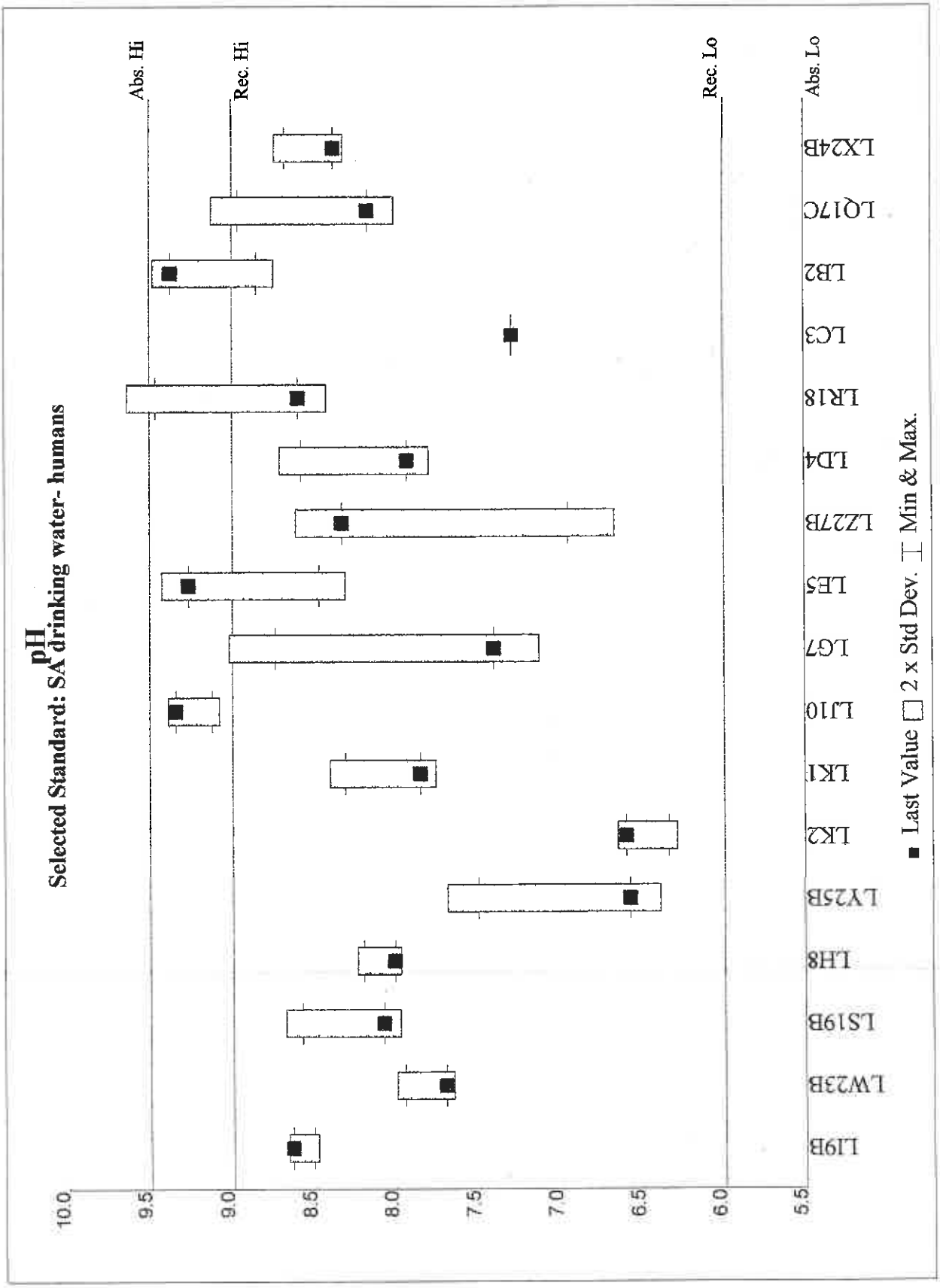

Figure 6. Boxplots of the pH parameter.

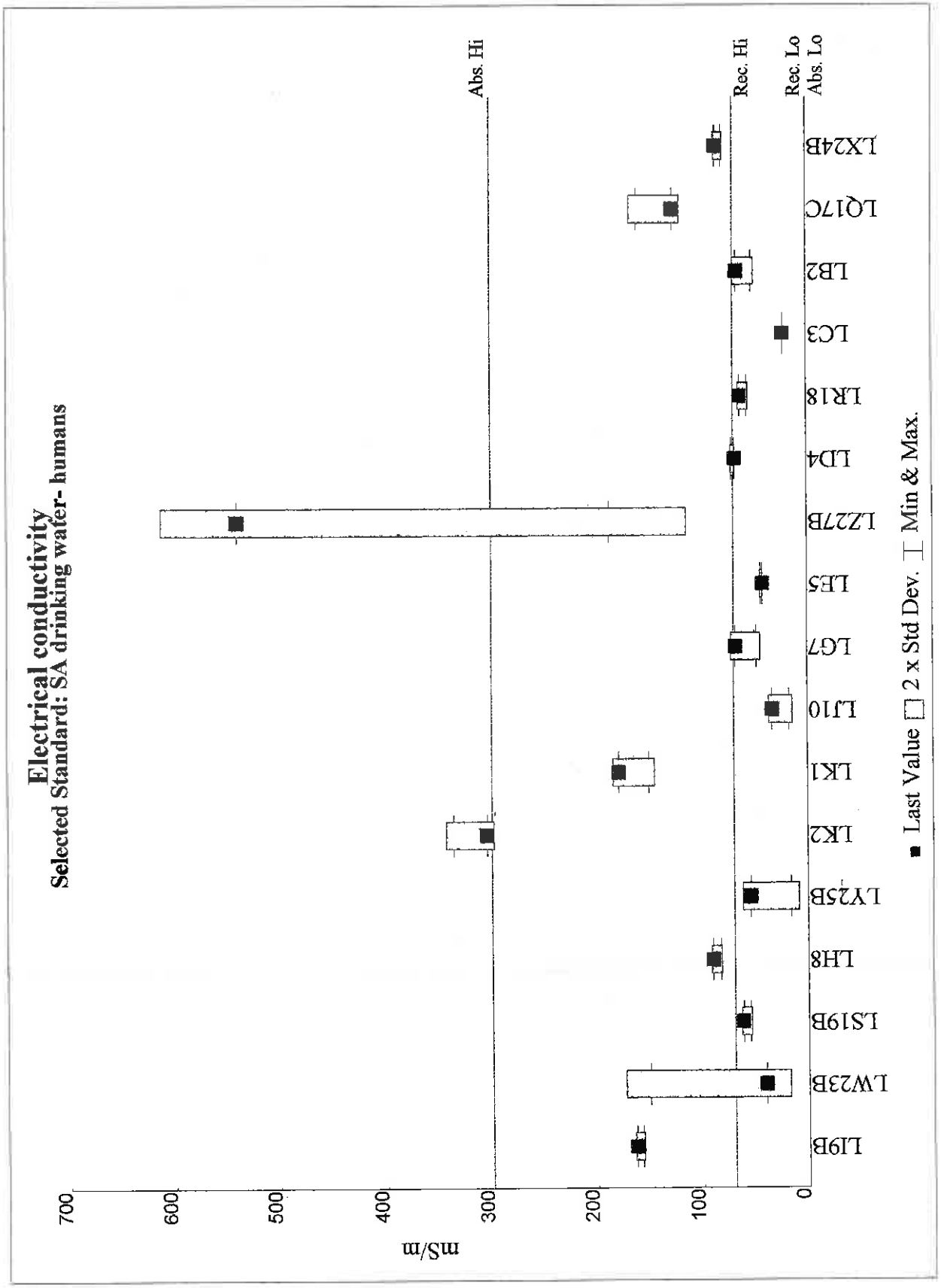

Figure 7. Boxplots of the EC parameter.

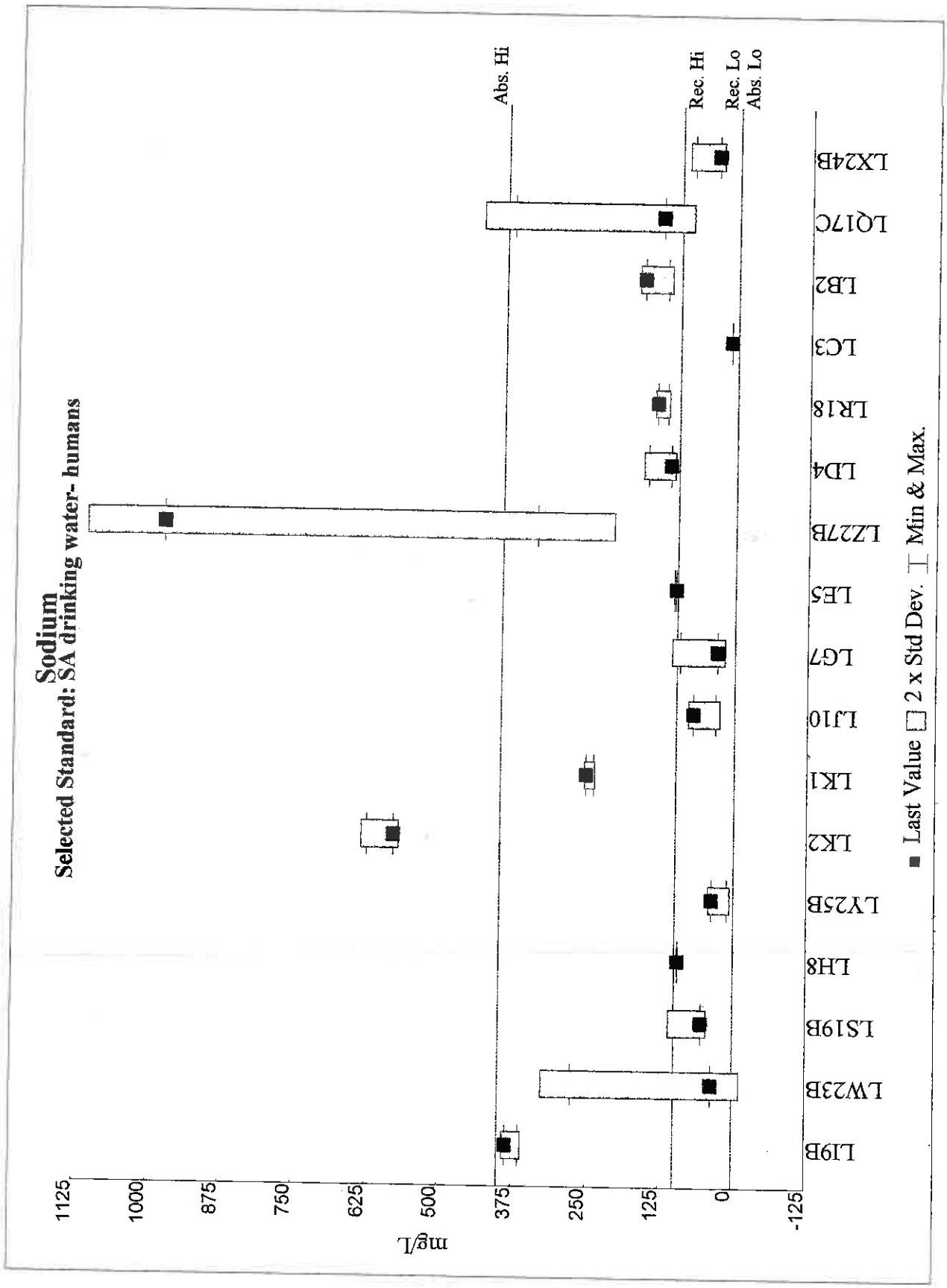

Figure 8. Boxplots of the sodium constituent.

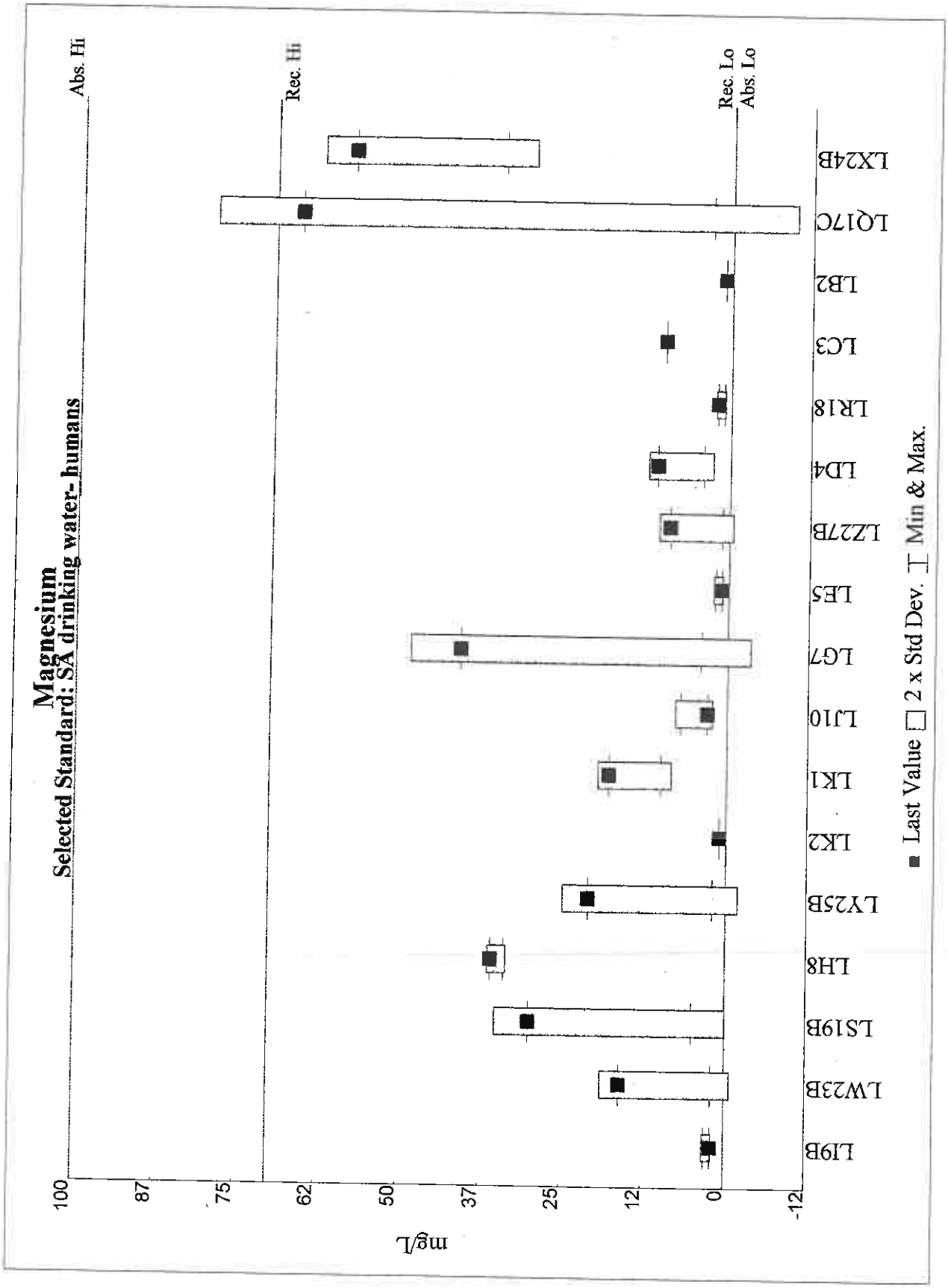

Figure 9. Boxplots of the magnesium constituent.

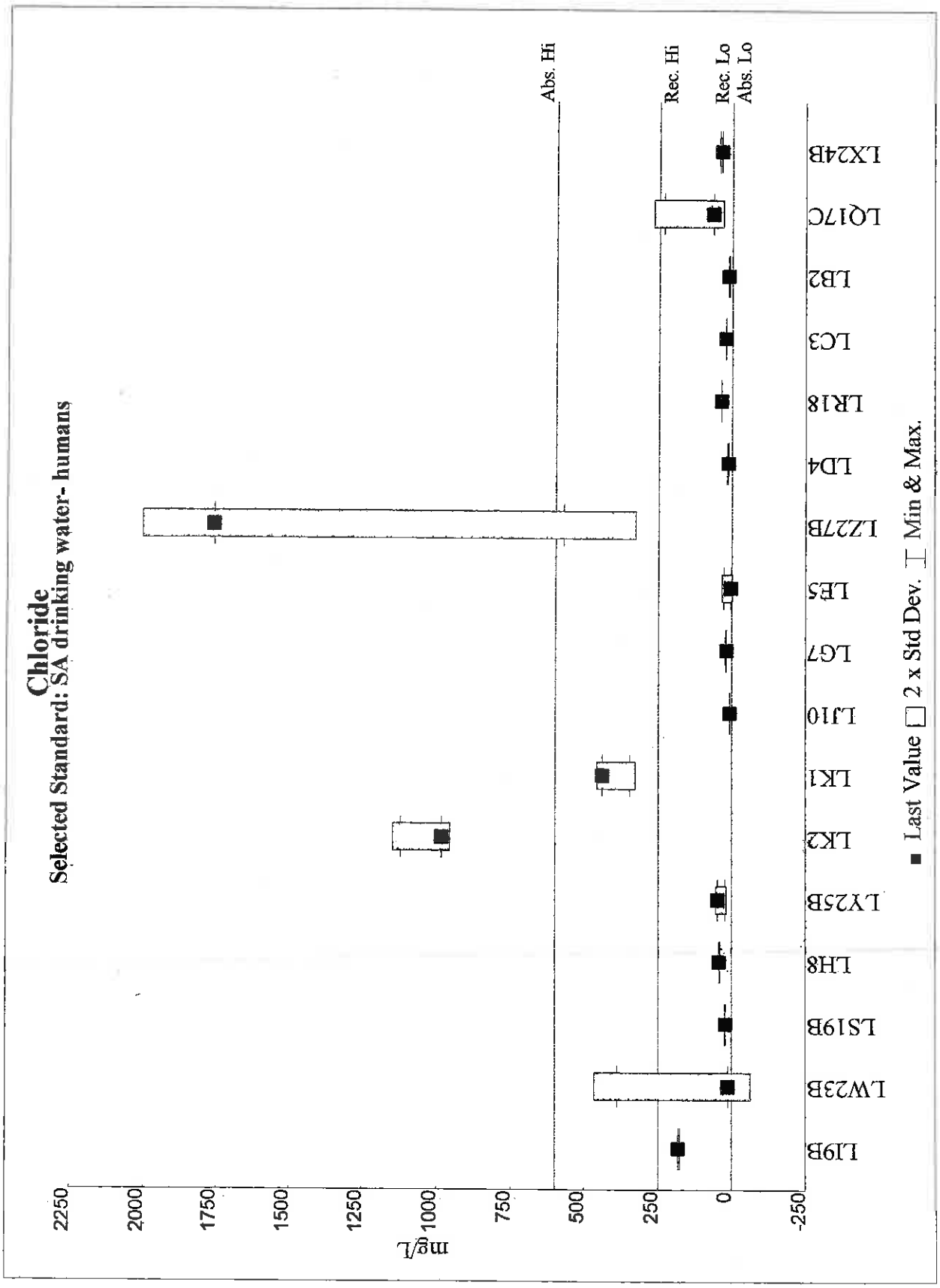

Figure 10. Boxplots of the chloride constituent.

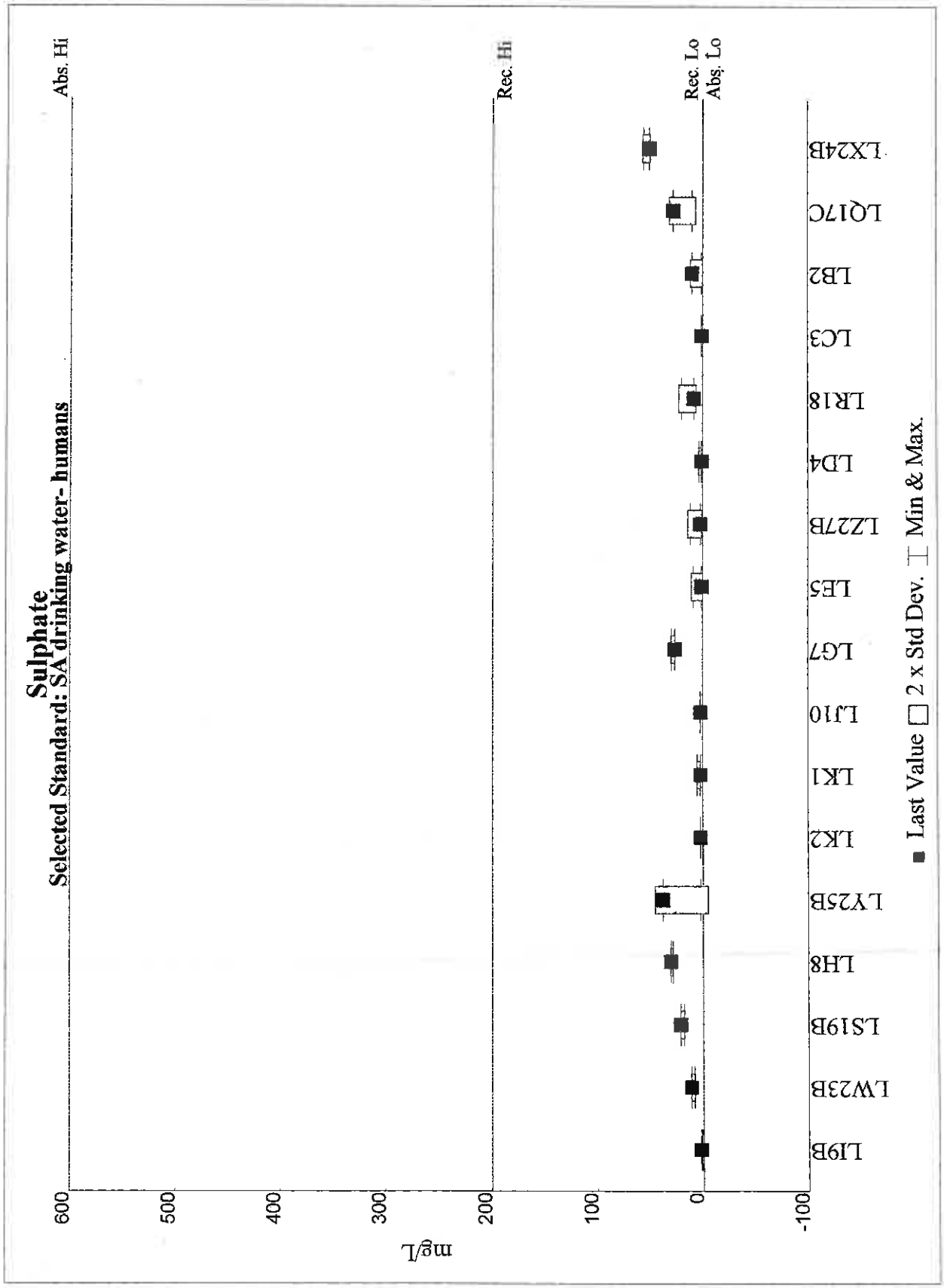

Figure 11. Boxplots of the sulphate constituent.

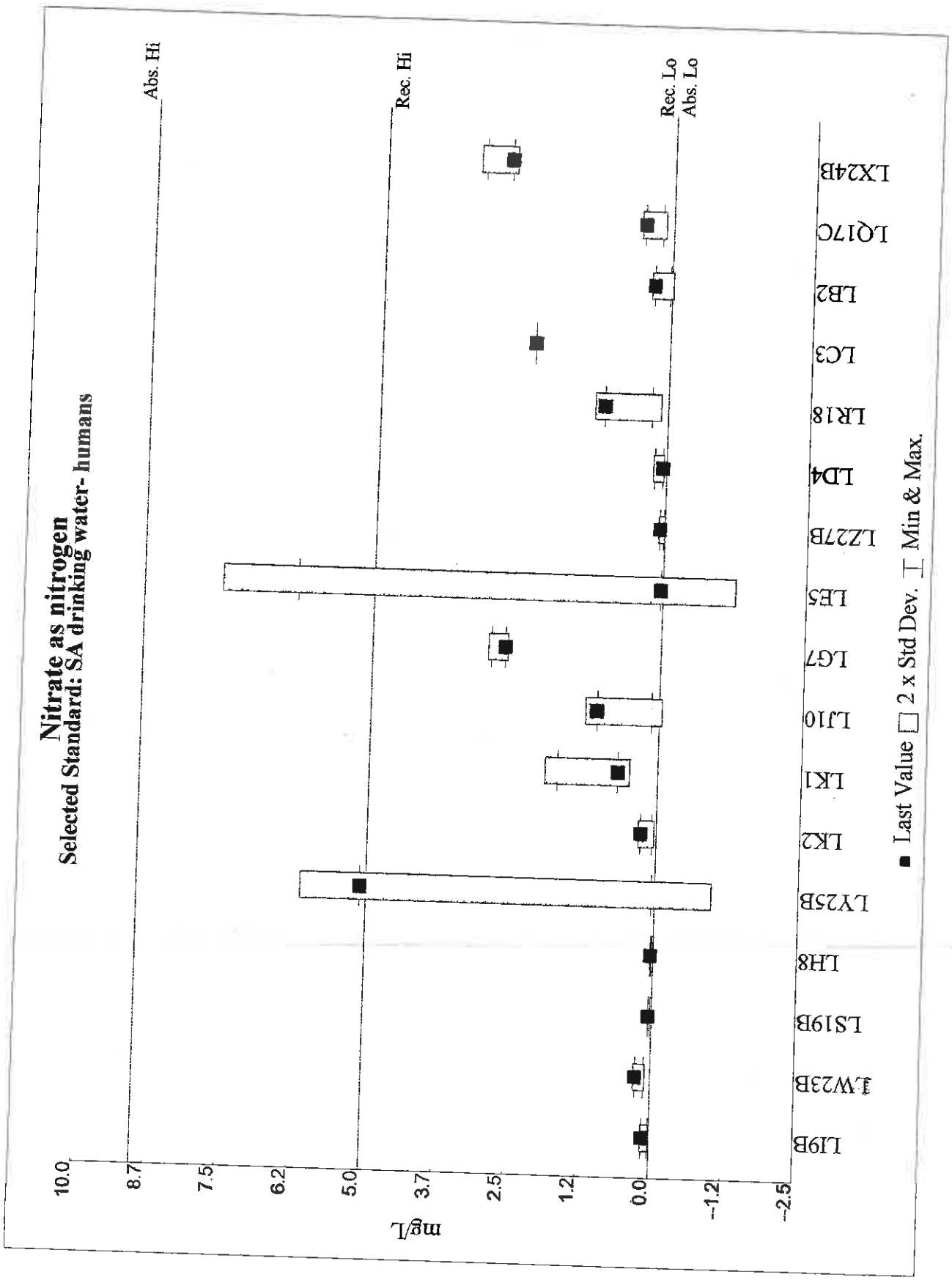

Figure 12. Boxplots of the nitrate constituent.

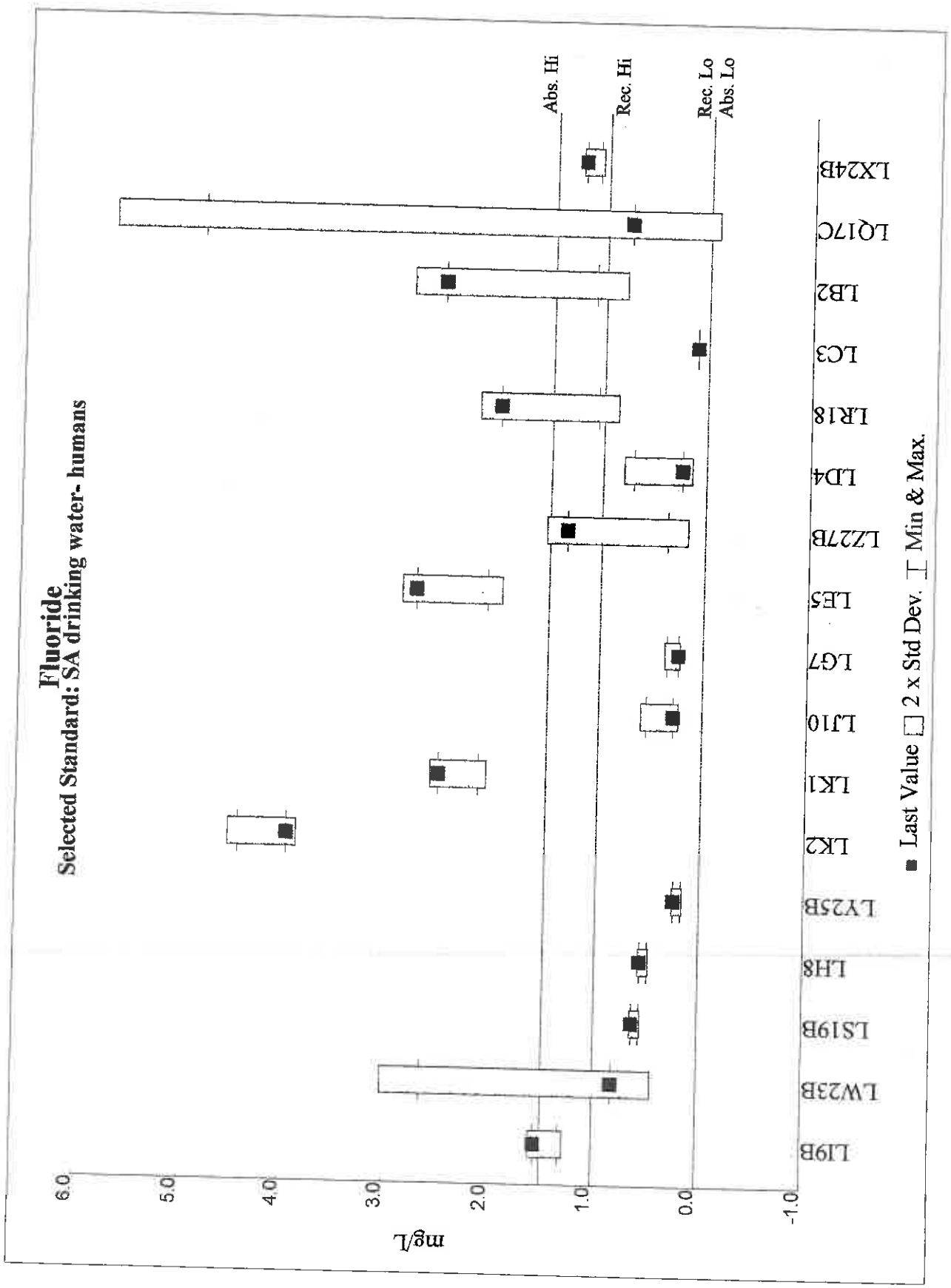

Figure 13. Boxplots of the fluoride constituent.

- A close investigation of the constituent values in the boxplots indicates that a variety of water types are present.
- The boxplot of the pH parameter (Figure 6) indicates that all the samples fall within the maximum recommended guideline range (Class 2).
- The boxplots of the EC parameter, the sodium and chloride constituents (Figures 7, 8 and 10) indicate that samples LK2 (B303336) and LZ27b (B303347) exceed the maximum recommended guideline value. Sample LK2 (B303336) has a small standard deviation above and below the mean value which is indicative of tightly clustered values around a central value. Sample LZ27b (B303347) has a large standard deviation above and below the mean value which is indicative of largely spread amongst the central value.
- The magnesium, sulphate, nitrate and fluoride boxplots (Figures 9, 11, 12 and 13) indicate that all the latest sample values fall within the maximum guideline value (Class 2). There is some concern in the standard deviation of the fluoride constituent of sample LQ17c (B303331). The first sample (drilling phase) plotted above the maximum recommended guideline value, while the second sample (pumptest phase) plots below the acceptable value (Class 1).

TRILINEAR DIAGRAM

Apart from the boxplots, the chemical compositions of ground water may be effectively represented on a trilinear diagram developed by Piper. He proposed that ground water be treated as though it contains three cation constituents i.e. sodium, calcium and magnesium and three anion constituents i.e. bicarbonate, sulphate and chloride only. As can be seen in Figure 14, the Piper trilinear diagram combines three plotting fields, i.e. two triangular fields and a intervening diamond-shaped field, all having scales of 0 to 100 representing percentages of total equivalents per million. The proportion of each cation constituent is plotted as a single-point in the left-hand triangular field and each anion constituent is plotted as a single-point in the right-hand triangular field. The central diamond-shaped field is used to show the overall chemical character of the ground water by a third single-point which lies at the intersection of the projections from the cation and anion points.

The ground water sequence of chemical evolution currently in use, can be explained by the following :

(i) Ground water directly after being recharged towards the ground-water regime and within the uppermost zone of facies of development, has a $Ca/MgHCO_3$ character which can be ascribed to dissolved CO_2 normally present within rain-water. Recharged or infiltrating rain-water reacts with calcium and magnesium within the aerated and unsaturated zone resulting in a unique bicarbonate chemical character representing recent ground water. As the ground water moves further, calcium and magnesium are adsorbed on particles present within the soil and rock with a simultaneous release of Na^+-ions; a reaction which results in the water having a dominantly $NaHCO_3$ character. The ground water maintains this $NaHCO_3$ character as long as the rate of movement remains constant.

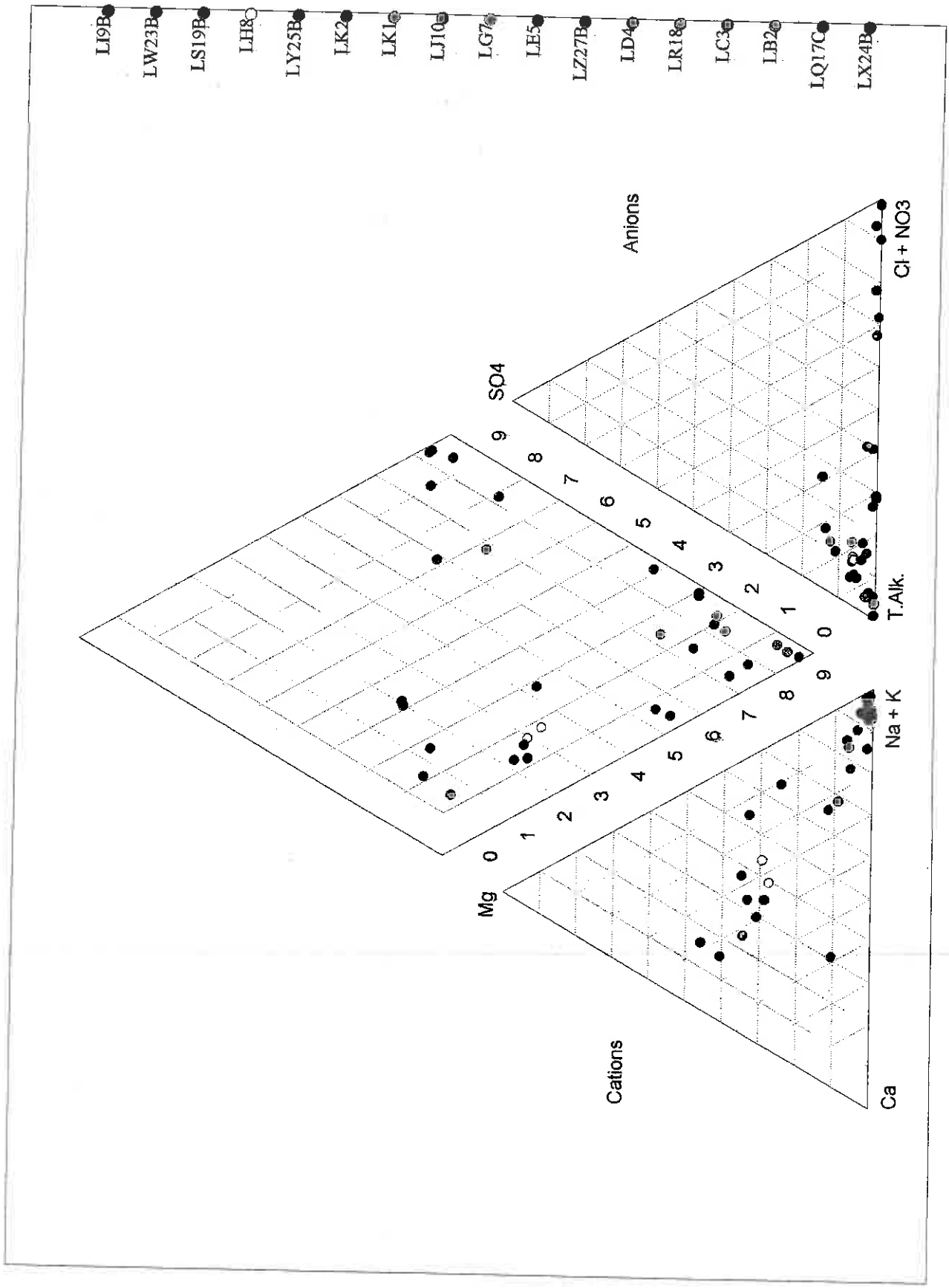

Figure 14. A plot of the Piper trilinear diagram.

(i) However, within the intermediate zone of facies development with less intensive circulation , the rate of ground water movement slow down resulting in precipitation of remaining $CaCO_3$, with a resultant drastic increase in Cl^- percentage and higher total mineralisation of the ground water.

(ii) As long as the rate of movement remains sufficient, the ground water maintains its $SO_4^{2-} + Cl^-$ character. If the rate of movement decreases further, the SO_4^{2-} precipitates which results in a ground water enriched in chloride. In terms of facies development this represents the lowermost zone in a near stagnant condition with highly mineralised water.

However, one must keep in mind that this chemical evolutionary processes is only valid under relatively shallow conditions of ground-water flow. If ground water therefore is entrapped within deeper zones of the ground-water regime, the above-described processes and sequences will change. However, the use of the Piper trilinear diagram will still be of help in distinguishing between recent shallow flowing ground water and entrapped older deep seated ground water. In the light of the above discussion, the following classification may be introduced which permits ground water being placed within one of the four major categories, represented on the central diamond-shaped diagram in Figure 15, namely :

(i) recent ground water having a high $Ca/MgHCO_3$ content,

(ii) a dynamic regime containing $NaHCO_3$ ground water,

(iii) stagnant ground-water conditions characterised by $Ca/MgCl_2$ and $Ca/MgSO_4$ ground waters, and

(iv) old or mature ground water enriched in Na^+ and Cl^-.

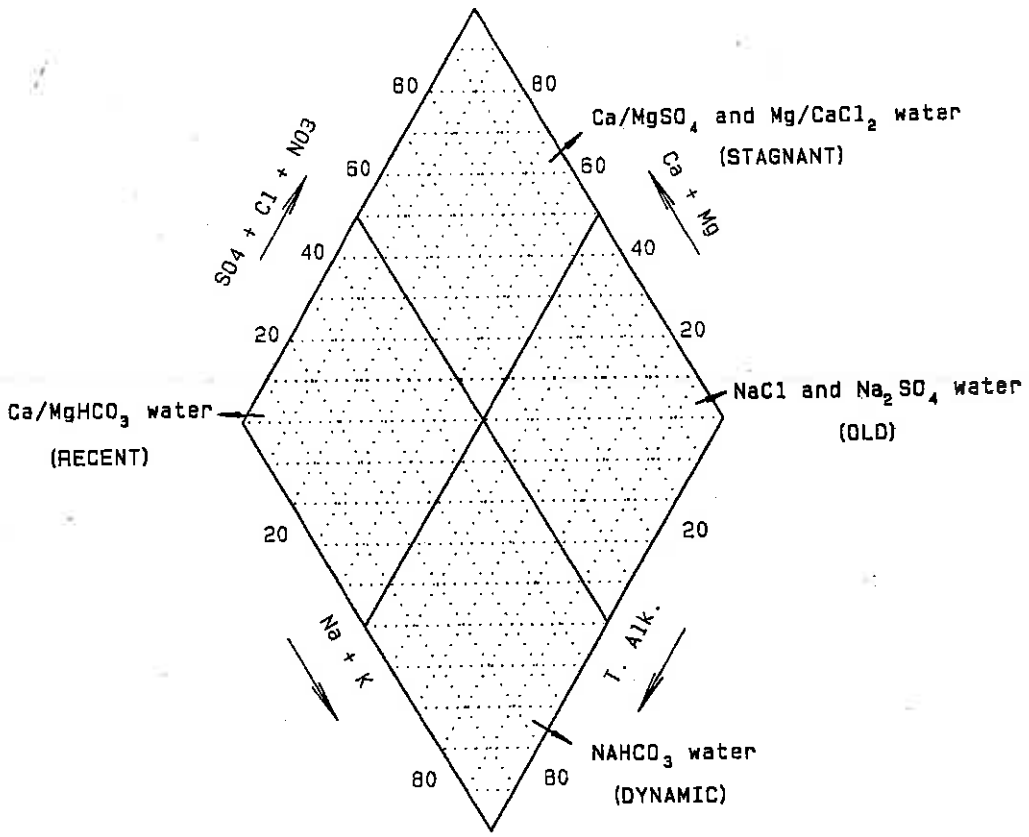

Figure 15. Subdivision of the central diamond-shaped field into 4 categories.

Based on the Piper diagrams in Figures 14 and 15 the water samples can be classified into the following categories, namely :

Recent water : LW23b (B303343), LS19b (B303342), LH8 (B303340), LY25b (B303338), LC3 (B303328) and LX24b (B303330).

Dynamic water : LI9b (B303334), LJ10 (B303350), LG7 (B303349), LE5 (B303345), LD4 (B303344), LR18 (B303354), LB2 (B303327) and LQ17c (B303331).

Old water : LK2 (B303336), LK1 (B303335) and LZ27b (B303347)

The decision whether or not to equip boreholes was based on the fitness for emergency potable use according to the following three categories as indicated in Table 3 by the Institute for Water Quality Studies.

From the 17 successful boreholes, two failed for equipping namely, LK2 (B303336) and LZ27b (B303347). Boreholes LK2 (B303336) and LZ27b (B303347) failed due to the high sodium and chloride content. The high sodium and chloride content holds the danger of deaths in infants due to salt overload. Therefore, without suitable treatment of the salt content (desalination - reverse osmosis) the borehole is not fit for emergency potable use.

Table 3. Provisional class guideline categories for the assessment of the fitness for use of borehole water for emergency potable use.

CONSTITUENT	CLASS 1	CLASS 2	CLASS 3
Total dissolved solids (mg/l)	<1000	1000 - 2450	>2450
Electrical conductivity (mS/m)	<150	150 - 370	>370
Nitrate plus nitrite as N (mg/l)	<10	10 - 20	>20
Fluoride (mg/l)	<1,5	1,5 - 4,0	>4,0
Sulphate (mg/l)	<400	400 - 600	>600
Magnesium (mg/l)	<100	100 - 200	>200
Sodium (mg/l)	<200	200 - 400	>400
Chloride (mg/l)	<200	200 - 600	>600
pH	5-9	4 - 5 or 9 - 10	<4 or >10

- CLASS I : Water suitable for emergency potable supply on a lifetime basis and the boreholes can be equipped immediately.

The borehole water is of such physical and chemical quality that consumption of the water on a long term basis will have no health effects on the users. Slight aesthetic effects (for example taste) may however occur in the upper range of this group.

- CLASS II : Without suitable treatment, water only suitable for emergency potable supply on short term basis and the boreholes can be equipped when no other water source of better quality are present.

The borehole water is of such physical and chemical quality that consumption of the water, without prior suitable treatment, on short term basis will have no health effects of the users. Aesthetic effects may occur and health effects when water is consumed on a long term basis.

- CLASS III : Without suitable treatment, water not suitable for even emergency potable supply and borehole not to be equipped.

The borehole water is of such physical and chemical quality that consumption of the water, without prior suitable treatment, even on short-term basis will have health effects of the users.

6.1.1. CONCLUSIONS

Based on the hydrochemical results and the interpretation from the boxplots and Piper diagrams the following boreholes fall in the Class 3 guideline value and can thus not be equipped, namely

- LK2 (B303336). High NaCl content (Na = 1121 mg/l & Cl = 627 mg.l).
- LZ27b (B303347). High NaCl content (Na = 1121 mg/l & Cl = 627 mg.l).

On the Piper diagram, both these samples plot in the NaCl and Na_2SO_4 category (old water enriched in Na^+ and Cl^-). The high sodium and chloride content holds the danger of death in infants due to salt overload. Therefore, without the suitable treatment (desalination - reverse osmosis) of the borehole water, the water is not fit for human consumption.

Water samples must be taken on a regularly basis at all the production boreholes and analysed for the constituents to determine the fitness of the borehole water for future emergency potable use.

6.2. GROUNDWATER MANAGEMENT

Overpumping occurs when water is abstracted from aquifers at a rate which exceeds the rate of recharge to the aquifer. This situation manifests itself in the lowering of water levels, pump suction and eventually the drying up of the boreholes. The adverse effects of overpumping include increasing energy costs for pumping as the water level declines, added maintenance costs for lowering pumps and deepening boreholes. Overpumping can endanger both the borehole itself as well as the pump installation. All the boreholes will be equipped with handpumps and it is therefore unlikely that overpumping might occur from the aquifers.

6.2.1. Proposed abstraction

Since all the successful boreholes will be equipped with handpumps, its discharge is directly proportional to the speed at which their handles are turned. Therefore the abstraction rates for all the boreholes will be more or less the same depending the depth of pump intake installation. The performance of a typical handpump that can be obtained by the average person is approximately between 0.09 - 0.2 l/s. In Table 4 all the relevant information regarding the pump installation specifics are given.

TABLE 4. LADYSMITH HAND PUMP INSTALLATION SPECIFICS

Borehole Number			Coordinates		Borehole Details				Recommendations							
DWA &F	KwaZulu / Natal	Topo map reference	S	E	Depth (m)	Blow yield (l/s)	Water Quality (Blow test)	Water Quality (Pump test)	Design yield (l/s)	Handpump Type	Pump intake (m)	Pump Yield (l/s)	Static water level (m)	Available drawdown (m)	Discharge volume 24h (l)	Comments
LC3a	B303328	2829BC	28° 23' 53"	29° 42' 56"	81	0.56	1	1	0.30	Cemo HDP 9M	60	0.11	2.8	57.2	5184000	Complies
LX24b	B303330	2830AC	28° 29' 48"	30° 10' 52"	97	0.17	1	1	0.10	Cemo HDP 9M	80	0.09	1.4	78.6	6912000	Complies
LQ17c	B303331	2830CA	28° 33' 12"	30° 01' 08"	152	0.13	3	1	0.10	Cemo HDP 9M	70	0.10	14.4	55.6	6048000	Complies
LI9b	B303334	2830AD	28° 27' 08"	30° 17' 38"	120	4.2	2	2	2.20	Cemo HDP 9M	60	0.11	6.6	53.4	5184000	Complies
LK1a	B303335	2830AC	28° 26' 11"	30° 14' 59"	150	0.60	2	2	0.40	Cemo HDP 9M	80	0.09	3.3	76.7	6912000	Complies
LK2a	B303336	2829CB	28° 26' 04"	30° 14' 28"	150	0.80	3	3	Water not fit for human consumption. High NaCl content (Na = 1121 mg/l & Cl = 627 mg/l)							
LY25b	B303338	2830AC	28° 26' 37"	30° 13' 25"	150	0.08	1	1	0.10	Cemo HDP 9M	80	0.09	2.3	77.7	6912000	Complies
LH8a	B303340	"	28° 29' 30"	30° 12' 39"	97	1.4	1	1	1.00	Cemo HDP 9M	60	0.11	Artesian	60.0	5184000	Complies
LS19b	B303342	"	28° 28' 21"	30° 13' 28"	101	0.2	1	1	0.15	Cemo HDP 9M	60	0.11	1.0	59.0	5184000	Complies
LW23b	B303343	"	28° 25' 41"	30° 12' 46"	150	0.2	2	1	0.10	Cemo HDP 9M	80	0.09	13.9	66.1	6912000	Complies
LD4a	B303344	2829BD	28° 25' 12"	29° 47' 32"	138	0.7	1	1	0.40	Cemo HDP 9M	60	0.11	9.4	50.6	5184000	Complies
LZ27b	B303347	"	28° 23' 30"	29° 45' 02"	150	0.08	2	3	Borehole has no sustainable yield for hand pump installation. High NaCl (Na = 979 mg/l & Cl = 1761 mg/l)							
LE5a	B303345	"	28° 22' 39"	29° 37' 07"	120	0.5	2	2	0.30	Cemo HDP 9M	80	0.09	Artesian	80.0	6912000	Complies
LJ10a	B303350	2829BC	28° 18' 16"	29° 43' 09"	102	0.12	2	2	0.20	Cemo HDP 9M	80	0.09	5.9	74.1	6912000	Complies
LB2	B303327	2830CA	28° 43' 24"	30° 11' 45"	120	0.23	1	2	0.15	Cemo HDP 9M	80	0.09	4.0	76.0	6912000	Complies
LG7	B303349	2829BD	28° 40' 08"	29° 51' 38"	132	0.44	1	1	0.30	Cemo HDP 12L	80	0.09	11.16	68.8	6912000	Complies
LR18	B303354	"	28° 34' 35"	29° 53' 36"	138	0.3	2	2	0.15	Cemo HDP 9M	80	0.09	6.76	73.2	6912000	Complies

GEO-HYDRO TECHNOLOGIES

6.2.2. Maintaining safe water supplies

The boreholes will not always continue to have the same yield. The water yield vary depending on the time of year, the number of new boreholes in the vicinity and the yearly changes in the annual rainfall.

If some of the high yielding boreholes are going to be equipped with a motorised unit in the future, it is recommended at least a 24 h constant discharge test must be carried out to determine the optimal operation properties under the specific geohydrological conditions.

To ensure a continuos supply from the production boreholes, a proper management plan is needed so that the aquifer is used optimally. To do this, firstly, the pump test results have been used to determine the aquifer and borehole characteristics, which were used to decide on the optimum rates and times.

It is further recommended that members of the communities must be trained to take water level measurements to ensure the proper management of the aquifer.

7. CONCLUSIONS

The following conclusions are drawn from the results and findings of the geohydrological services:

- Electromagnetic and magnetic profiling are too valuable of an investigation tool not to be used to their full benefit. They allow the thorough coverage necessary to take an objective look at the entire area under investigation. The geophysical data if collected, analysed and interpreted correctly provide an insight into the conceptual geological model, rarely obtained through other means. Borehole placement without the use of geophysics and a knowledge of the geology is a primitive and risky investigative procedure.

  From the work done on site, the following conclusions can be made;

  - the inaccessibility of the terrain, after the extreme rainfall conditions, has limited the applicability of the geophysical techniques only to certain areas where the drilling rig can get in. The effect of this is that some of the drilling sites were selected alongside roads.
  - Due to the limitations that were given for borehole placement at some of the areas, the geophysical techniques could not be used not for siting. Therefore, borehole placement was done on the geology.
  - At 23 identified areas from the 28, borehole placements were done using geophysical methods. The rest of the borehole placements were sited on geological features such as outcrops from dolerite dykes and faults in the area.

- On the basis of the drilling results, three modes of groundwater occurrence in the area are identified. These are the following;

  - groundwater in sedimentary rocks. Groundwater that is held in the undisturbed sandstone and shale. These constitute poor to moderate aquifers for handpump

installations that support low yielding (< 1 l/s) boreholes. Boreholes LZ27 (B303347), LS19b (B303342), LQ17c (B303331) and LX24b (B303330) penetrate such aquifers.

- Groundwater that occurs in subvertical contact zones between the sediments and the dolerite dykes that intrude them. These constitute moderate to good aquifers. Boreholes LC3 (B303328), LB2 (B303327), LE5(B303345), LK1 (B303335) BG3 penetrate such aquifers.
- Groundwater that occurs within harder, fractured and jointed sediments that owe these properties to moderate alteration by nearby dolerite intrusions or faults. These constitute good aquifers. Borehole LI9b (B303334) penetrates such an aquifer.

- The water table in the area is limited to joints, fissures and other permeable zones. It is reasonable to assume that the aquifers in the Ecca Group are of a semi-confined to confined nature. This is supported by the observation that the static groundwater level in all the boreholes that were drilled is shallower than the first water strike. Further, the existence of artesian boreholes (B303340 and B303345) in the area also supports this assumption.
- If some of the high yielding boreholes are going to be equipped with a motorised unit in the future, it is recommended at least a 24 h constant discharge test must be carried out to determine the optimal operation properties under the specific geohydrological conditions.
- Based on the hydrochemical results and the interpretation from the boxplots and Piper diagrams the following conclusions are made:
  - The obvious difference in the boxplots is the variation in the concentrations of sodium, magnesium, chloride, fluoride and nitrate values and the parameter values of pH and EC.
  - A close investigation of the constituent values in the boxplots indicates that a variety of water types are present.
  - The boxplot of the pH parameter indicates that all the samples fall within the maximum recommended guideline range.
  - The boxplots of the EC parameter, the sodium and chloride constituents indicate that samples LK2 (B303336) and LZ27b (B303347) exceed the maximum recommended guideline value.
  - The magnesium, sulphate, nitrate and fluoride boxplots indicate that all the latest sample values fall within the maximum guideline value. There is some concern in the standard deviation of the fluoride constituent of sample LQ17c (B303331). The first sample (drilling phase) plotted above the maximum recommended guideline value, while the second sample (pumptest phase) plots below the acceptable value.
  - Boreholes LW23b (B303343), LS19b (B303342), LH8 (B303340), LY25b (B303338), LC3 (B303328) and LX24b (B303330) are classified from **recent water** origin.
  - Boreholes LI9b (B303334), LJ10 (B303350), LG7 (B303349), LE5 (B303345), LD4 (B303344), LR18 (B303354), LB2 (B303327) and LQ17c (B303331) are classified as from **dynamic water** origin.

- Boreholes LK2 (B303336), LK1 (B303335) and LZ27b (B303347) are classified as from **old water** origin.

- The following boreholes fall in the **Class 3** guideline value and can thus not be equipped, namely

  - **LK2 (B303336)**. High NaCl content (Na = 1121 mg/l & Cl = 627 mg.l).
  - **LZ27b (B303347)**. High NaCl content (Na = 1121 mg/l & Cl = 627 mg.l).

  On the Piper diagram, both these samples plot in the NaCl and Na_2SO_4 category (old water enriched in Na^+ and Cl^-). The high sodium and chloride content holds the danger of death in infants due to salt overload. Therefore, without the suitable treatment (desalination - reverse osmosis) of the borehole water, the water is not fit for human consumption.

- Water samples should at least be taken twice a year and analysed to determine their fitness.

- The successful boreholes will be equipped with handpumps therefore, its discharge is directly proportional to the speed at which their handles are turned. The abstraction rates for all the boreholes will be more or less the same depending the depth of pump intake installation.

- The performance of a typical handpump that can be obtained by the average person is approximately between 0.1 - 0.2 l/s. Its unlikely that overpumping will occur with handpump installations.

- The exploitation potential of groundwater depends not only on the given borehole prospects, but also on storage, recharge and quality of groundwater.

APPENDIX A

Theoretical background for the geophysical methods

1. INTRODUCTION

The purpose of this section is not to provide a comprehensive description of the physical principles by which the various methods operate, but only to provide an introduction for a better understanding of the resolution limits of the different techniques.

2. GEOPHYSICAL METHODS

2.1. THE MAGNETIC METHOD

The normal magnetic field of the earth can be visualised as if a bar magnet is placed at the centre of the earth. Any changes in this "normal" magnetic field superimposed by dykes, for example, can be measured by a magnetometer. These measurements (changes) can then, through the process of modelling, be interpreted in terms of the dip, strike, depth and width of the body that causes the anomaly. Since these geological magnetic features might well be remnant (i.e. "permanently") magnetised, a feature which is normally not known to the modeller, no unique solution of the model exists. By making certain reasonable assumptions about the geology, restrictions can be placed on some of the geological features of the body. The magnetic method is an extremely useful method to map the presence of dykes which are, in the present case, good groundwater exploration targets.

2.2. DIRECT CURRENT (DC) METHOD

The configuration used during this study was the Schlumberger method for vertical electrical soundings (VES) by which changes in resistivity and layer thickness can be detected. From Archies Law the porosity of a rock matrix is inversely proportional to the formation factor (ρ_r / ρ_w),

This means that for an aquifer with "constant" ρ_w, which is common for certain rock types, the resistivity of the rock material can be related to the porosity thereof. This method lends itself to the quantification of the geohydrological characteristics of the aquifer. It is therefore important to carry out soundings at boreholes for calibration purposes to define the reason why some of the boreholes can be regarded as high yielding and others not.

Fig. A1 is a representation of how a Schlumberger sounding is normally carried out. By increasing the current electrode spacing (AB), symmetrically around the centre point (0), an increase in exploration depth is achieved. A potential difference between electrodes M and N (ΔV) is measured and these results can then be substituted in to the formula

$$\rho_a = K\frac{\Delta V}{I} \qquad 1$$

to calculate the apparent resistivity of the underlying rock material for the AB and MN distances used.

The apparent resistivity (ρ_a) is plotted on a double logarithmic scale (62.5 mm/logcycle) by which it is possible to visualise the changes of ρ_a with depth.

As with all geophysical methods no unique solution of layer resistivities and thickness is possible. The deeper and thinner the layers become the less possible it is to detect them. The only parameters which can be determined uniquely are the so called Dar Zarrouk parameters, namely:

longitudinal conductance, $S_i = \frac{h_i}{\rho_i}$ and

transverse resistance $T_i = h_i \rho_i$ which

are functions of both layer thickness (h_i) and resistivity (ρ_i). This non-unique problem as referred to in geophysics is called the "*problem of equivalence*".

Knowledge about geology must be used to limit the number of possible models which will result in a equally good fit between the field data and the theoretical data.

2.3. ELECTROMAGNETIC (EM) INDUCTION METHOD

The Geonics EM34-3 is a moving source/moving receiver electromagnetic system. The system is designed to operate at small induction numbers and measures the ration of the quadrature component of the secondary magnetic field to the free space primary magnetic field.

Transmitter and receiver coils can be held in a horizontal or vertical coplanar configuration. The intercoil spacing can be 10, 20 or 40 m and the system operates at fixed frequencies of 6400, 1600 and 400 Hz, respectively for each coil separation. The intercoil spacing is measured electronically and the receiver operator reads a meter to accurately set the coils to the correct spacing. The receiver of the EM34-3 is calibrated to indicate the apparent conductivity (1 to 300 mS/m). At low values of terrain conductivity the (less than 100 mS/m) the apparent conductivity is linearly proportional to the actual conductivity. This is however not true at high values of terrain conductivity.

According to Mc Neil (1980) the following depth's of investigation is possible:

"For resistive terrains the effective depths of exploration over a homogeneous or horizontally stratified earth for the coil separations 10, 20 and 40 m are: 15, 30 and 60 m (horizontal coils), respectively."

Limitations of the EM34-3 system are:

- At low values of terrain conductivity it becomes difficult to magnetically induce sufficient current in the ground to produce a detectable magnetic field at the receiver coil.
- At high levels of conductivity (> 100 mS/m) the quadrature component of the received magnetic field is no longer linearly proportional to terrain conductivity.

- The maximum coil separation of 40 m limits the exploration depth to a maximum of 60 m for certain geological environments.

Advantages of the EM34-3 system are:

- Easy and rapid measurements.
- The lateral extent of the volume of earth whose conductivity is sensed by the inductive technique is approximately the same as the vertical depth. Small changes in conductivity, for example of the order of 5 or 10 percent, are easily and accurately measured.
- Simple multi-layered earth calculations is possible. An interpretation program for layered earth interpretations exists (program EMIX34 from Interprex Limited).

As with the DC method this method also detects changes in resistivity/conductivity of rock material. A few differences between the two techniques are highlighted below:

- the depth of exploration is a function of frequency and not AB distance;
- the EM method is more sensitive to changes in the conductivity of the material, whilst the DC method is more sensitive to the changes in the resistivity of the material.

3. REFERENCES

McNeil, J.D.,(1980). Electromagnetic terrain conductivity measurements at low induction numbers: Geonics Ltd., Toronto, TN7.

APPENDIX B

Electromagnetic and magnetic profiles

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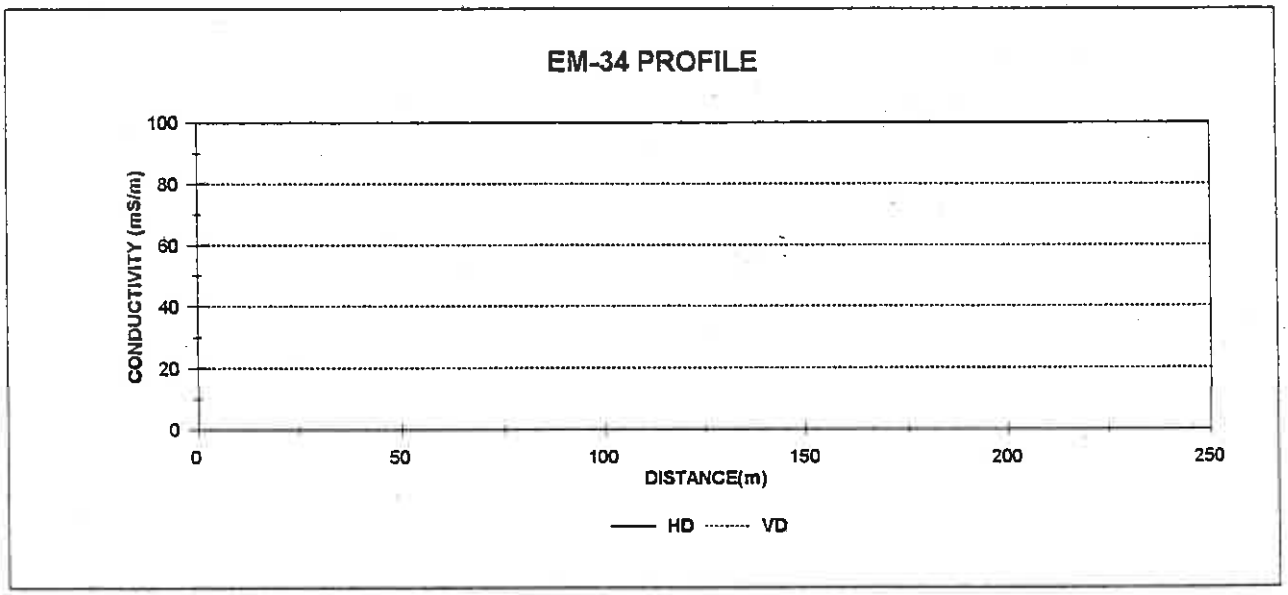

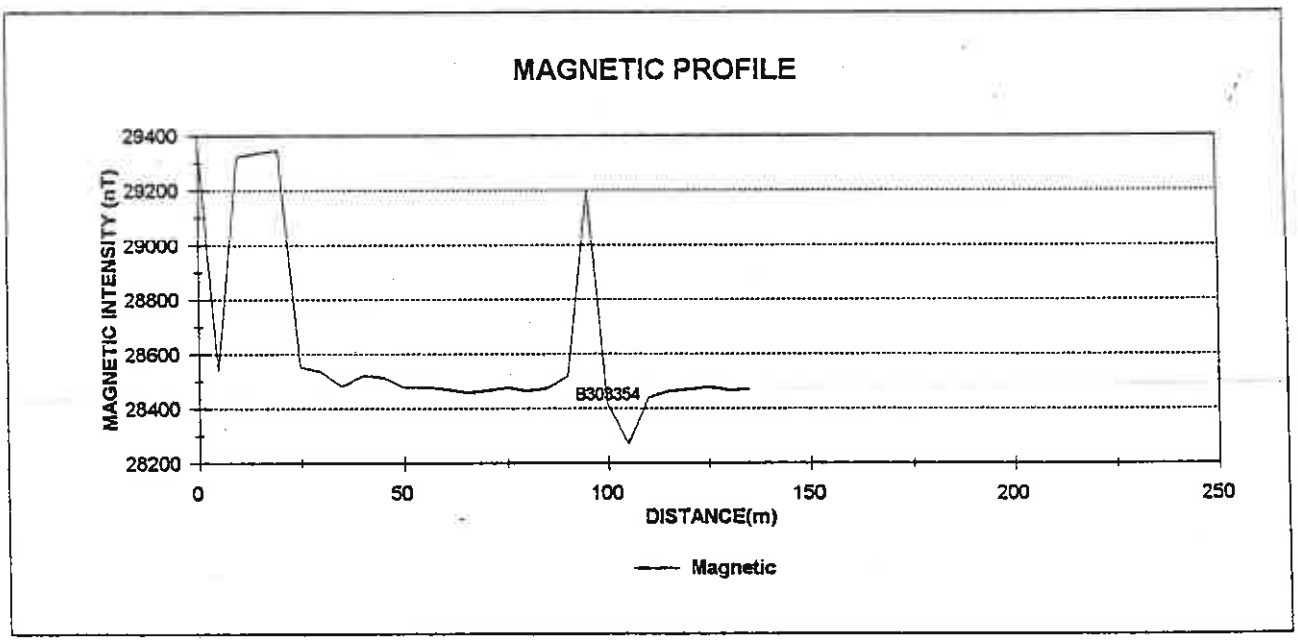

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Survey Area:	Ladysmith	**Station Spacing:**	5		
ate of Survey:	05 Mar 1996	**Operator:**	GW Schaaf		

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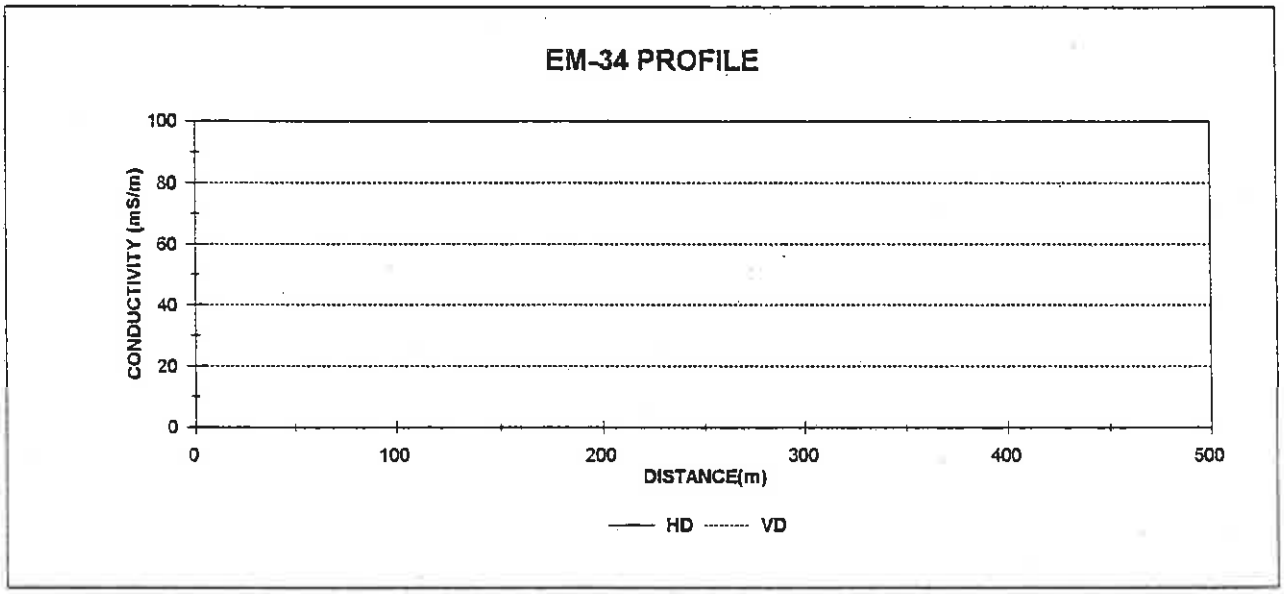

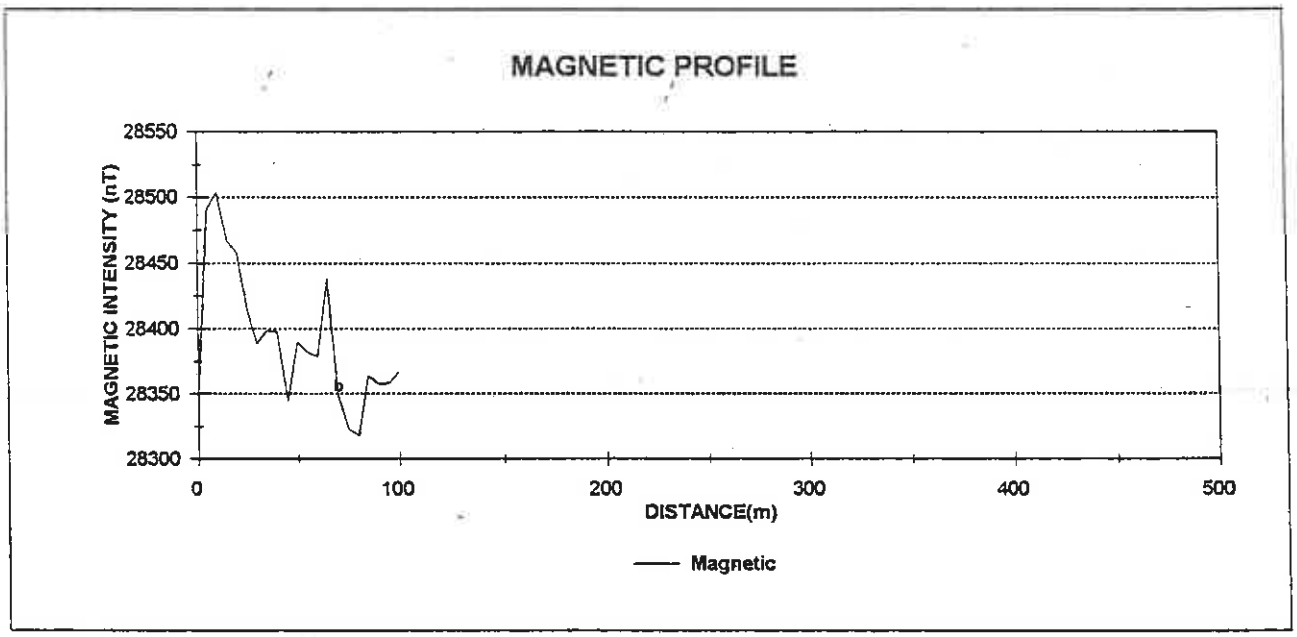

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Date of Survey:	05 Mar 1996	Operator:	GW Schaaf		

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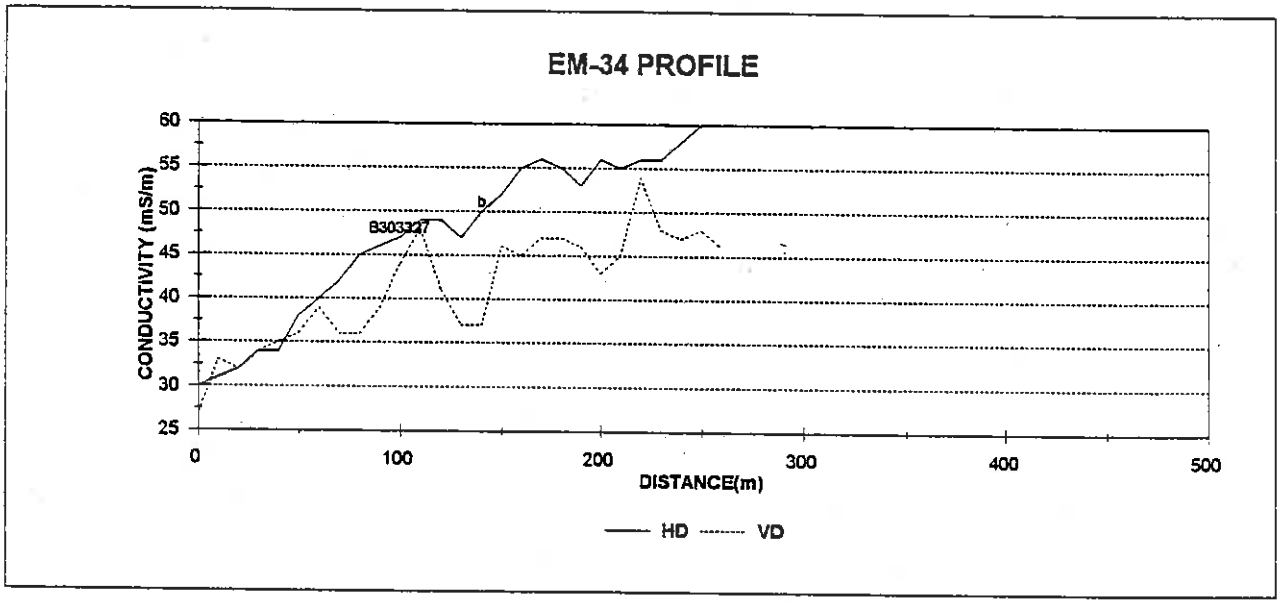

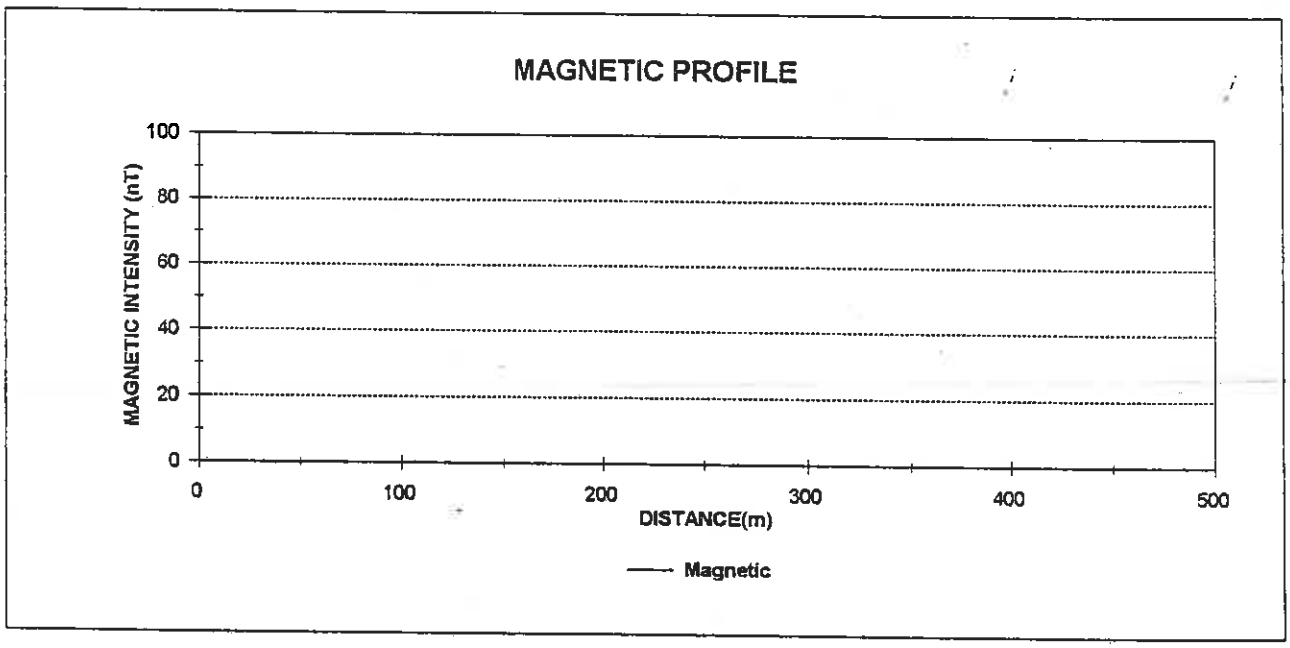

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Date of Survey:	27 Feb 1996	Operator:	GW Schaaf		

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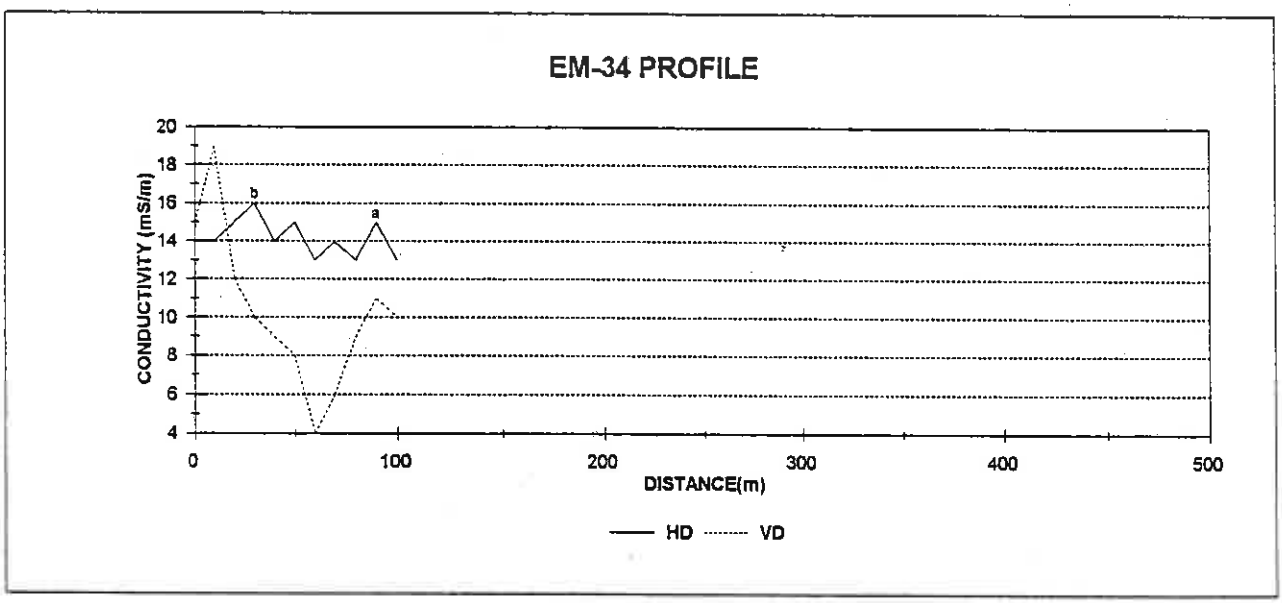

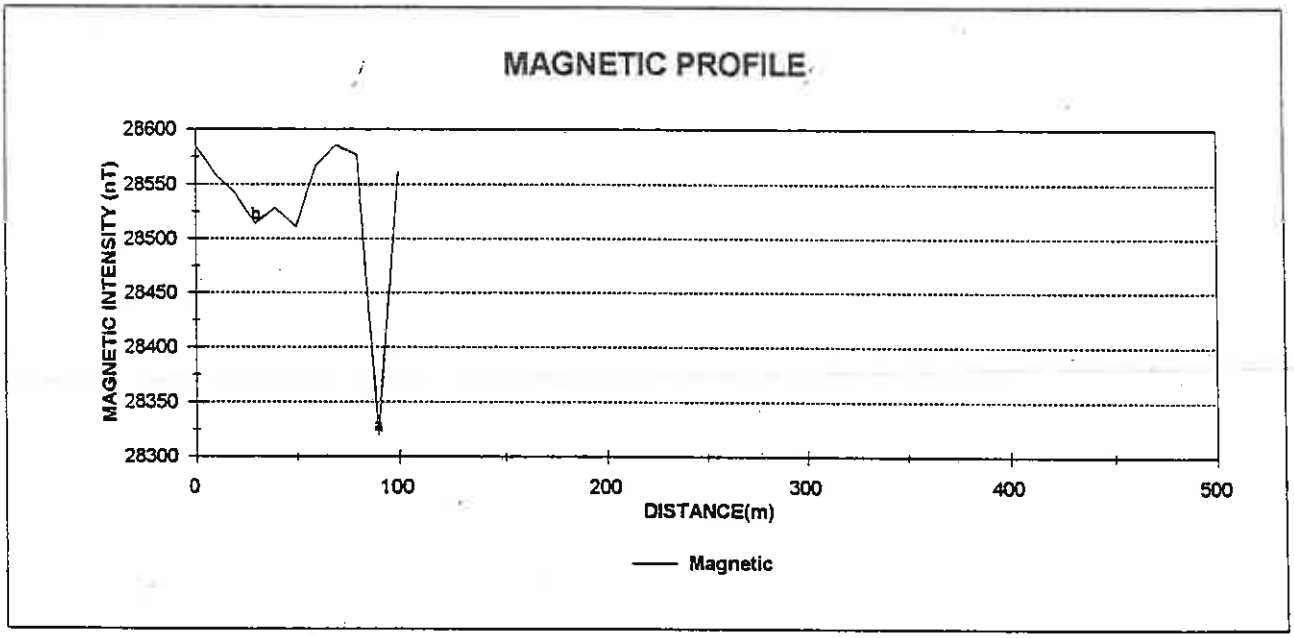

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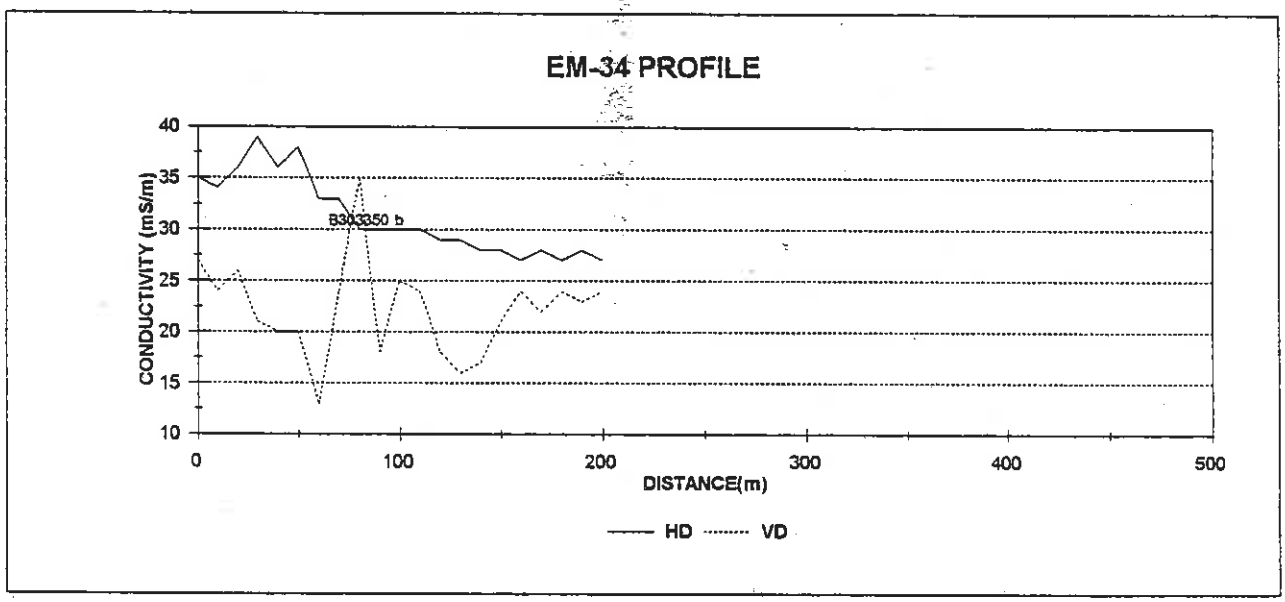

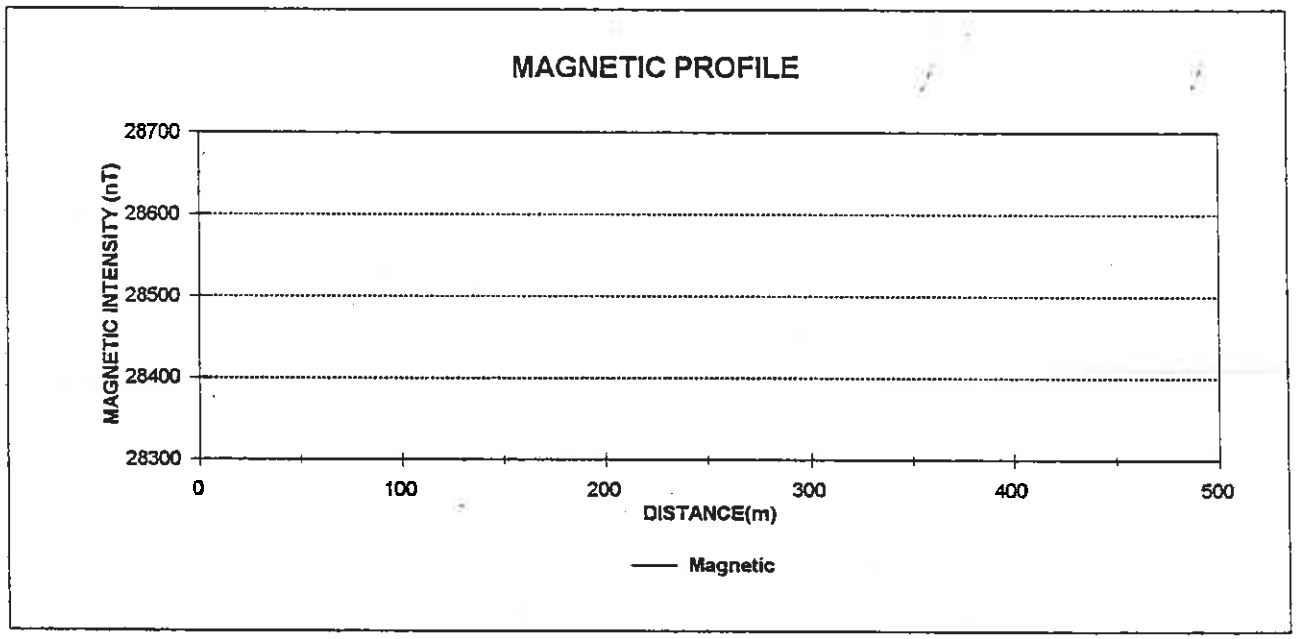

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Date of Survey:	01 Mar 1996	Operator:	GW Schaaf	

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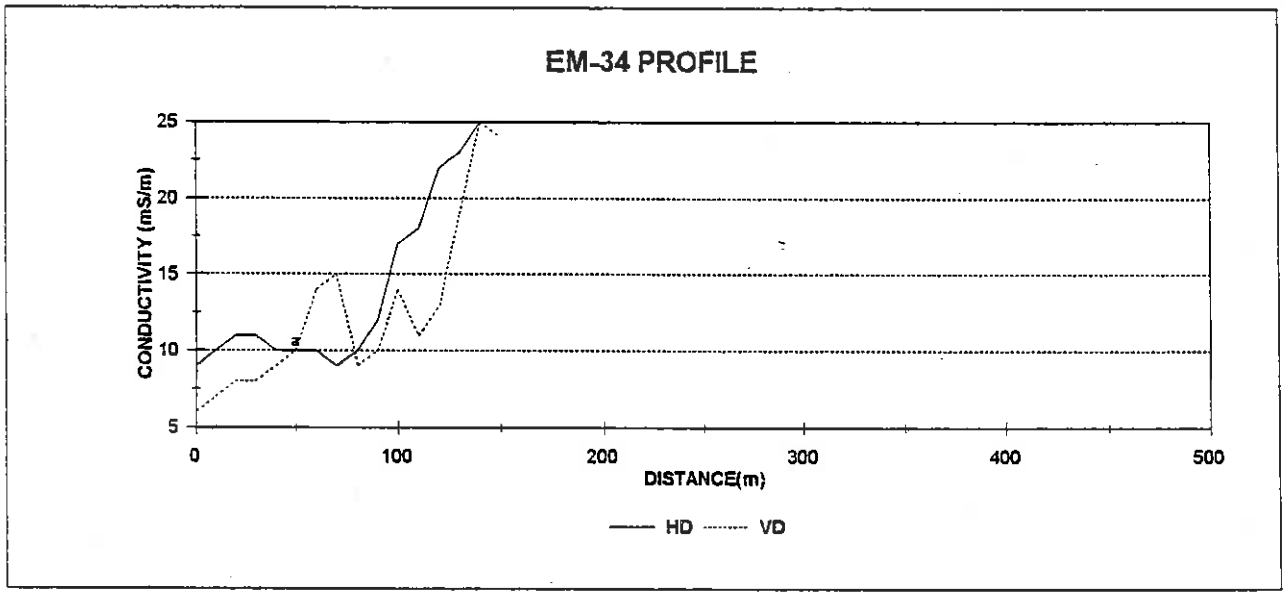

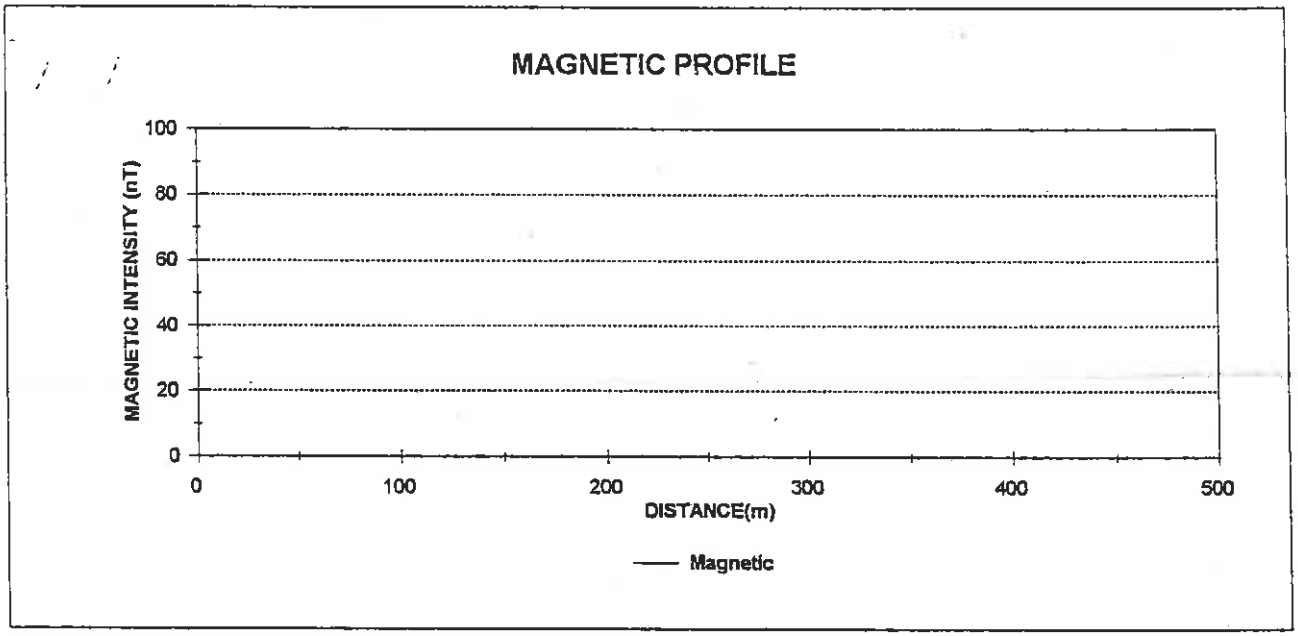

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Date of Survey:	2 Mar 1996	Operator:	GW Schaaf		

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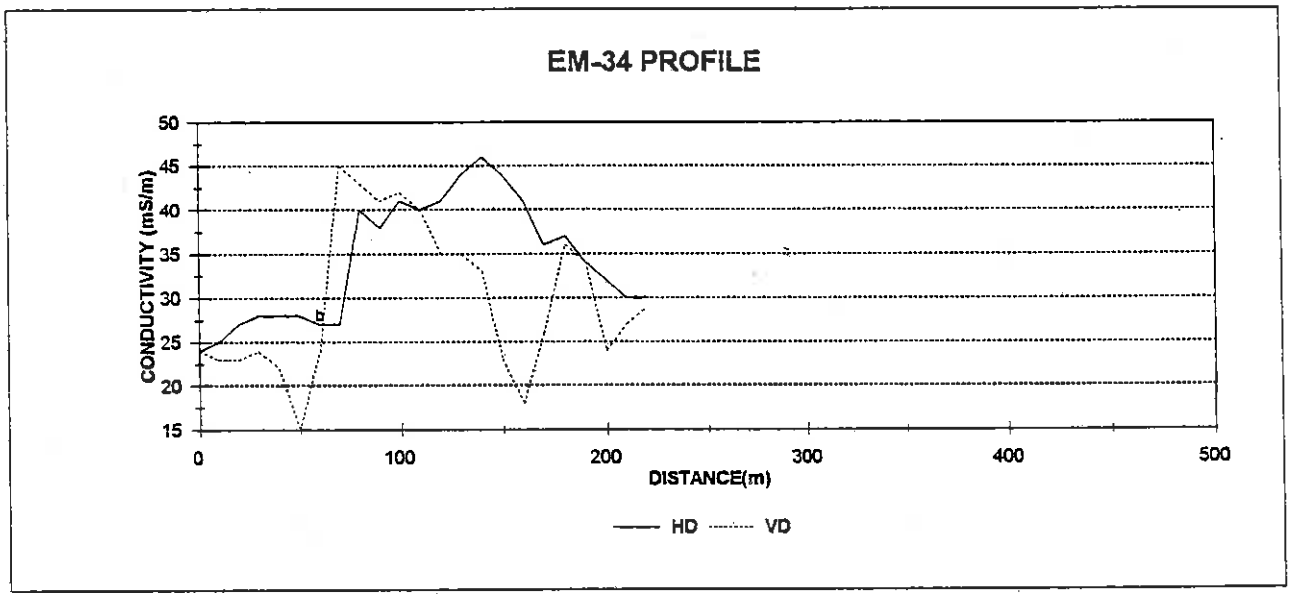

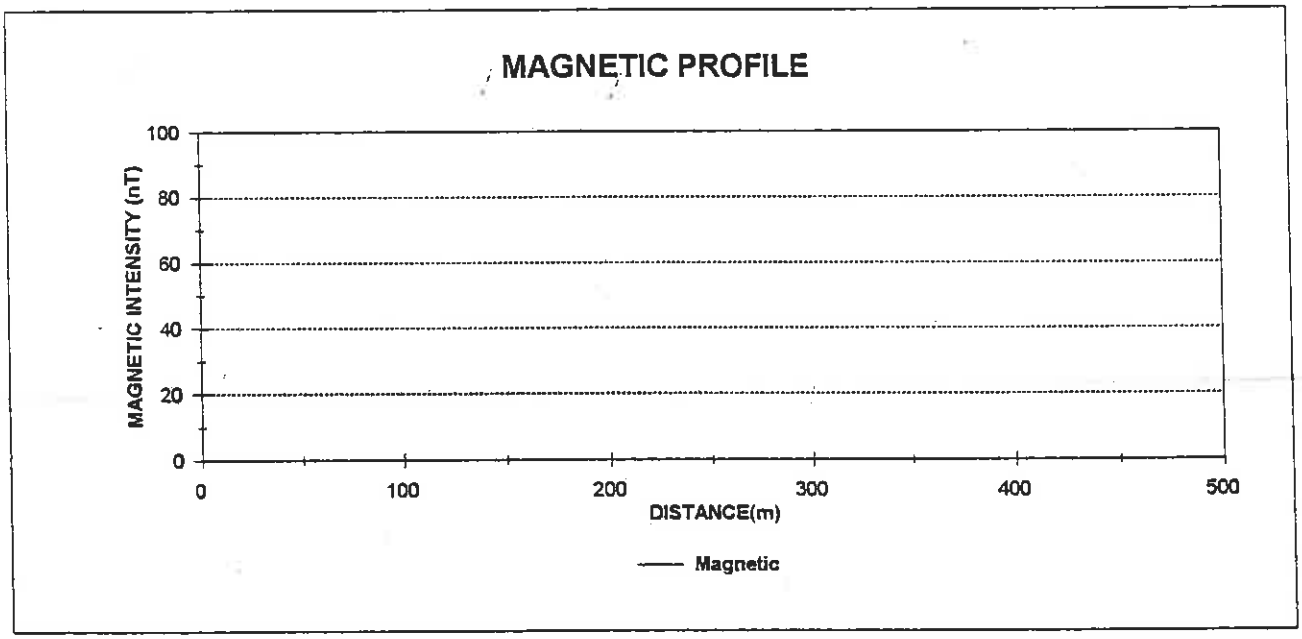

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Date of Survey:	2 Mar 1996	Operator:	GW Schaaf		

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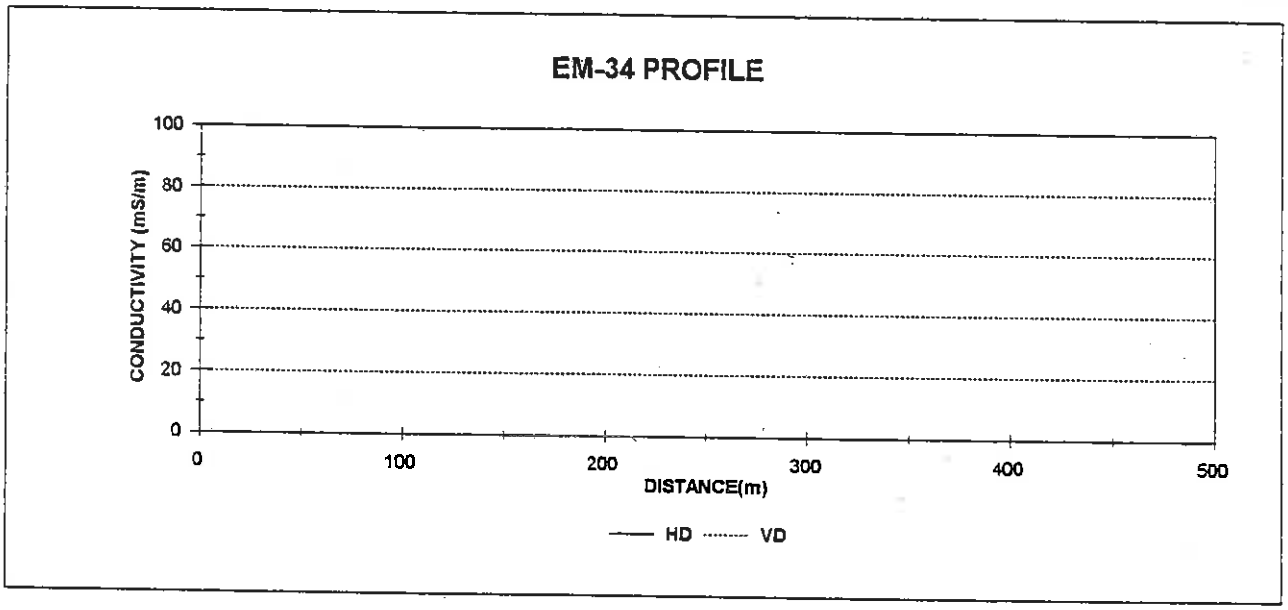

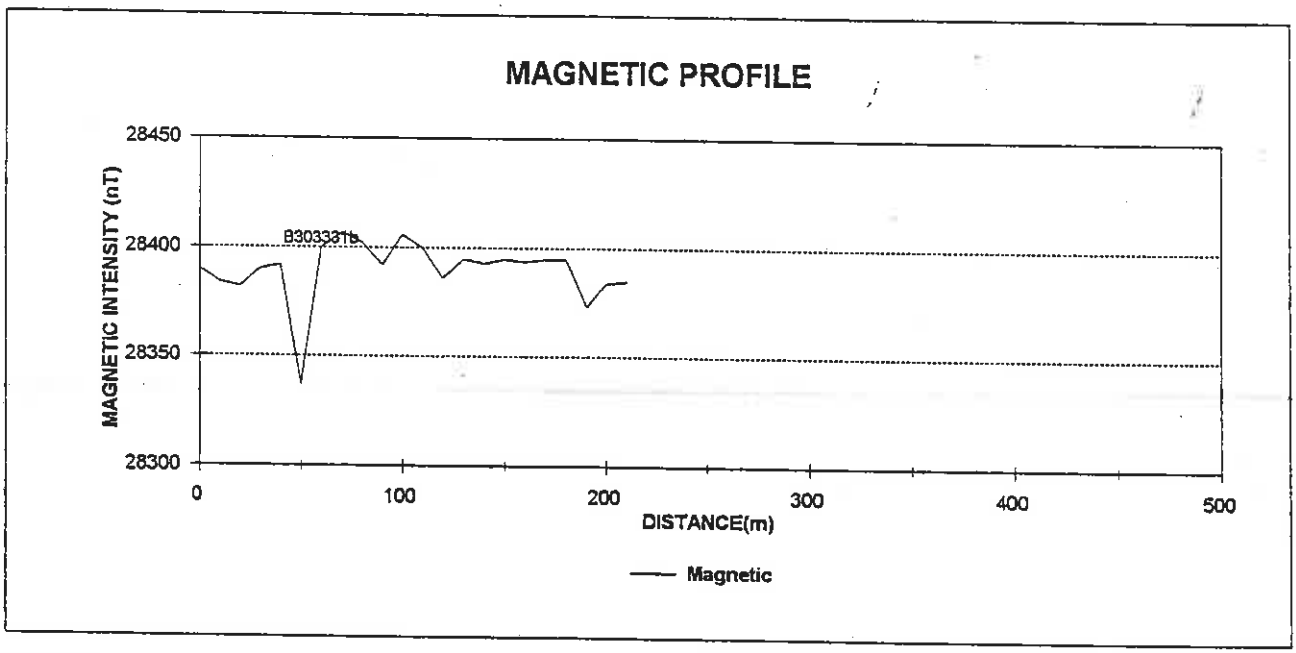

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ate of Survey:	04 Feb 1996	Operator:	GW Schaaf		

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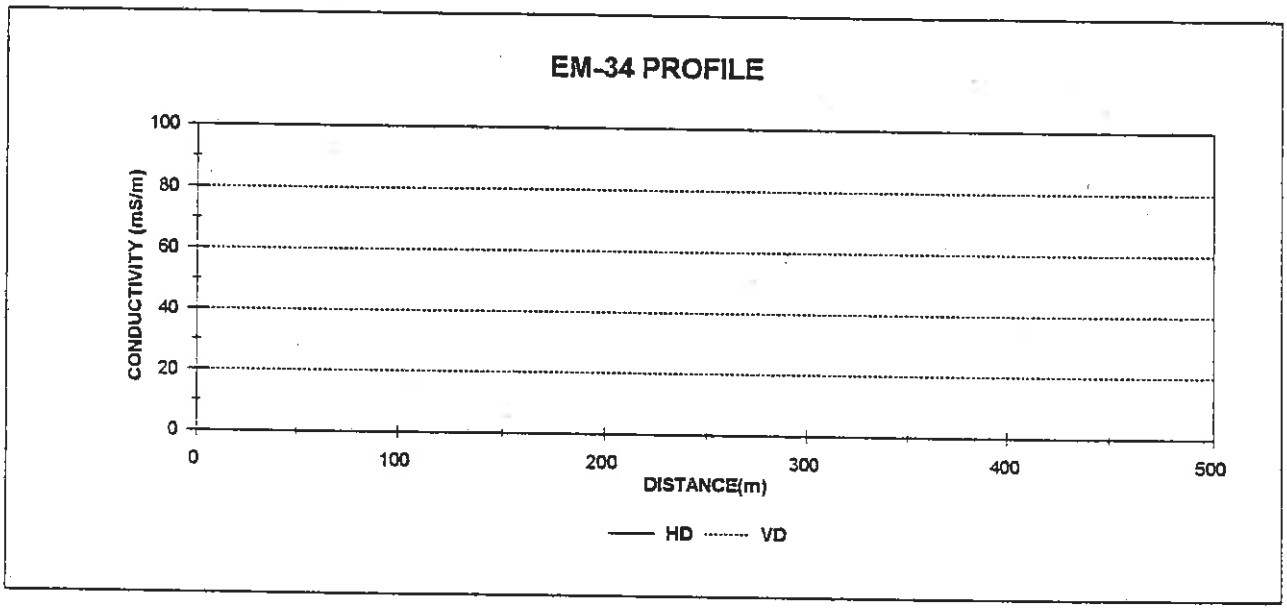

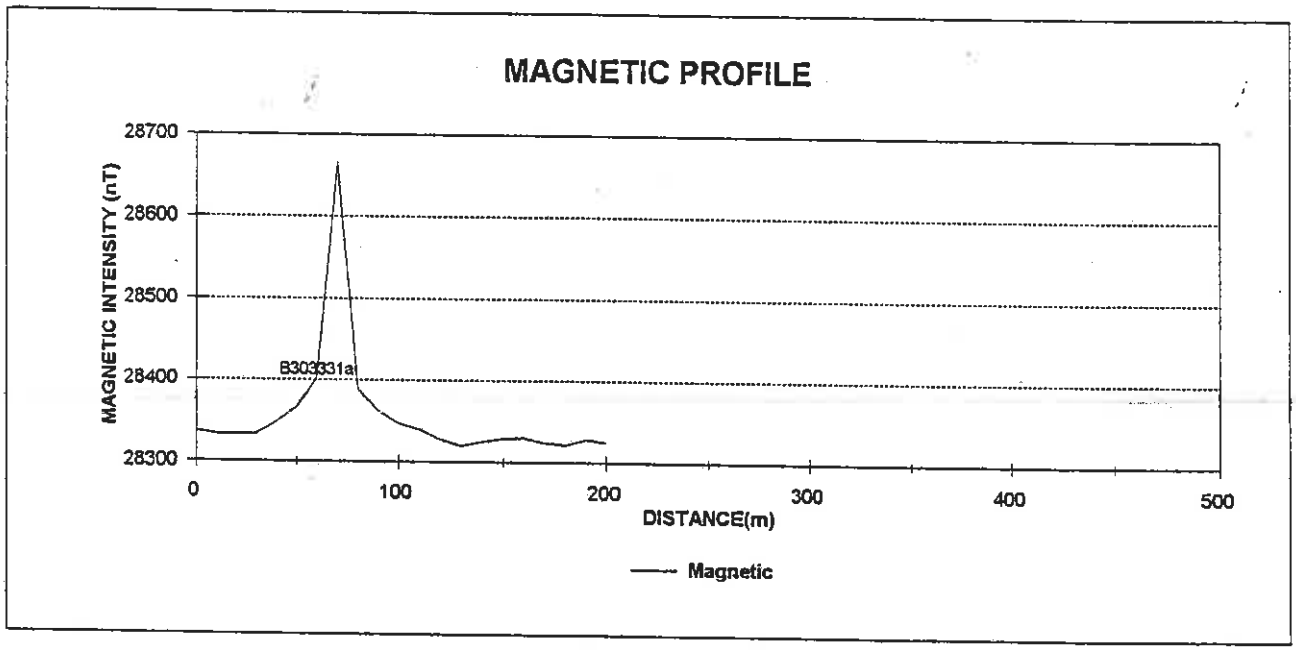

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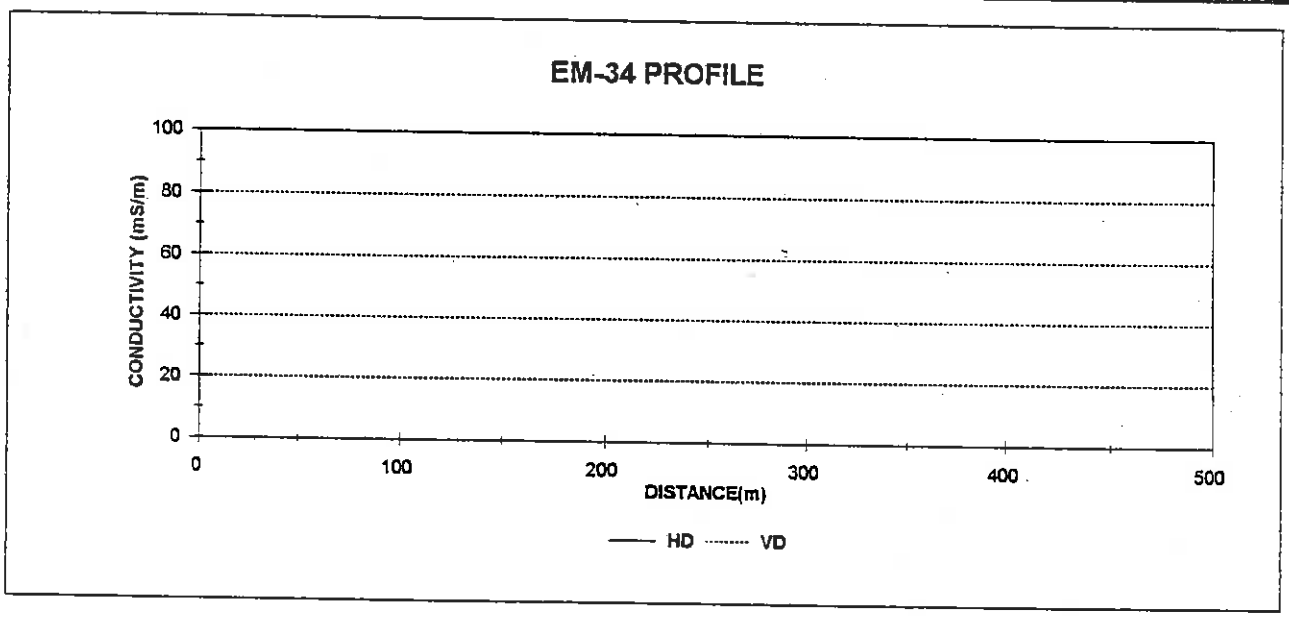

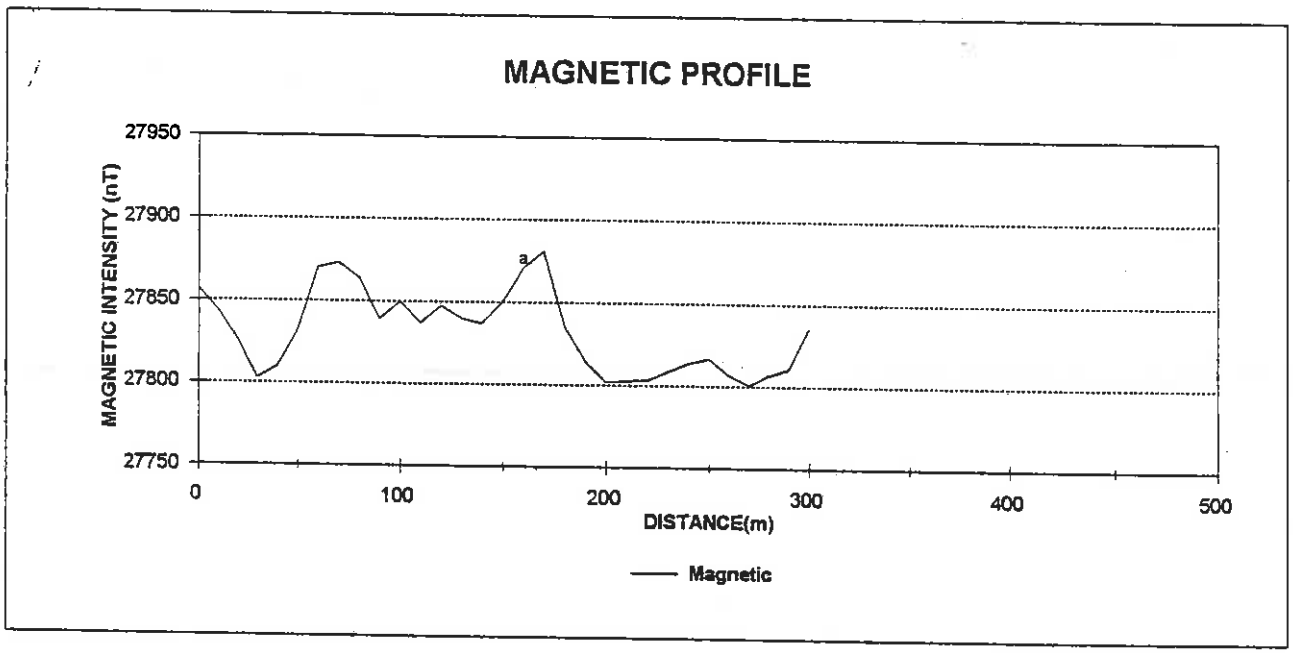

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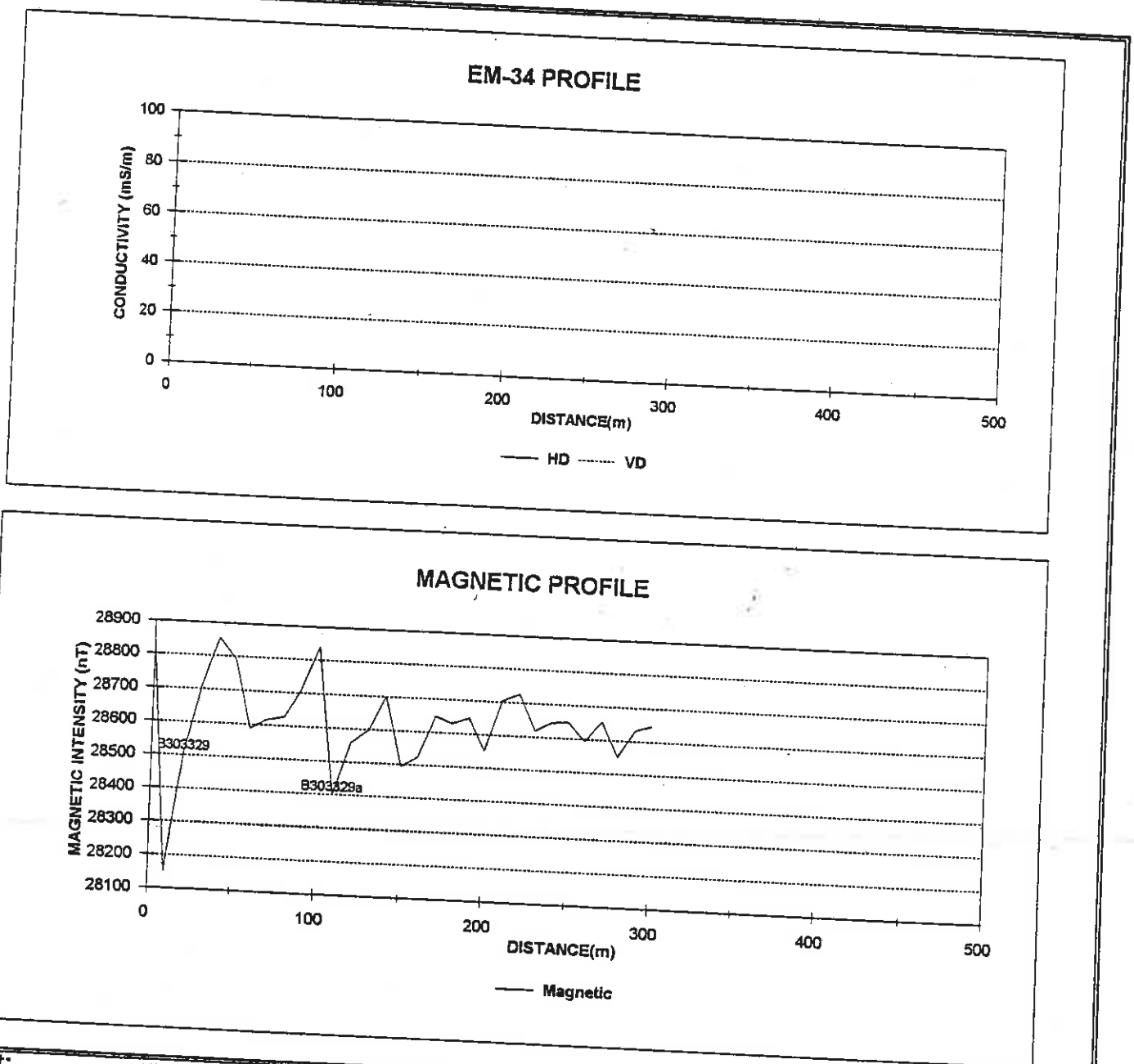

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Date of Survey:	02 Feb 1996	Operator:	GW Schaaf	

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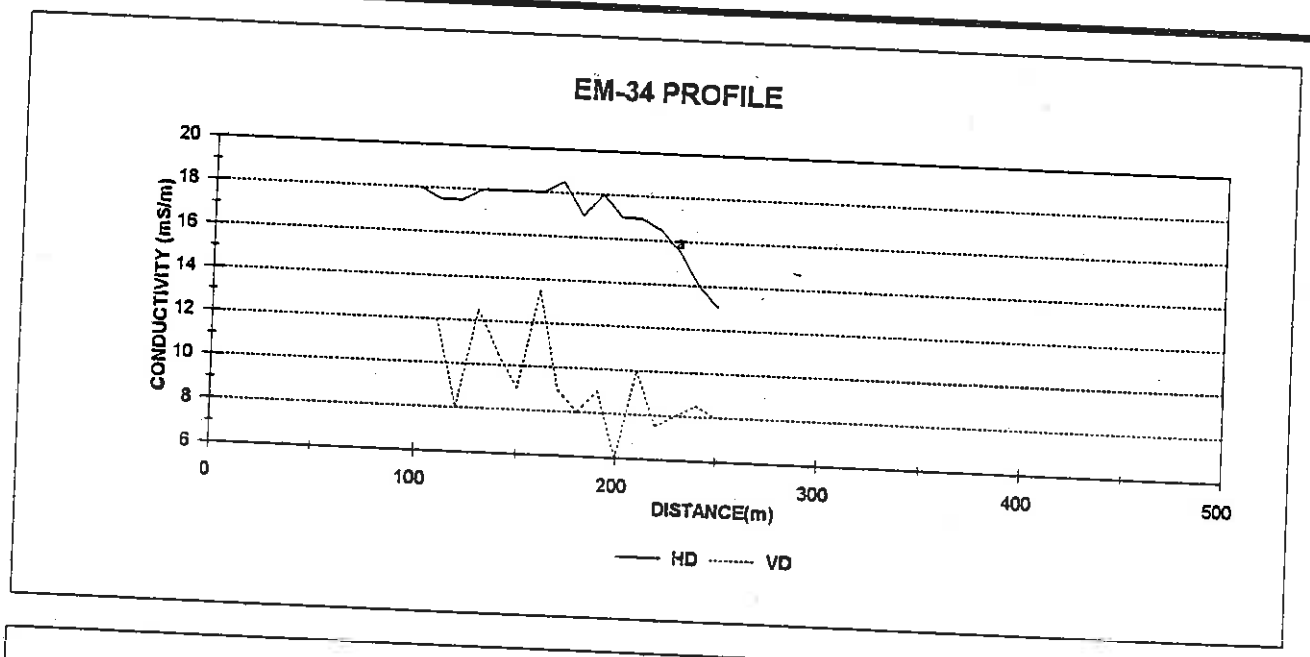

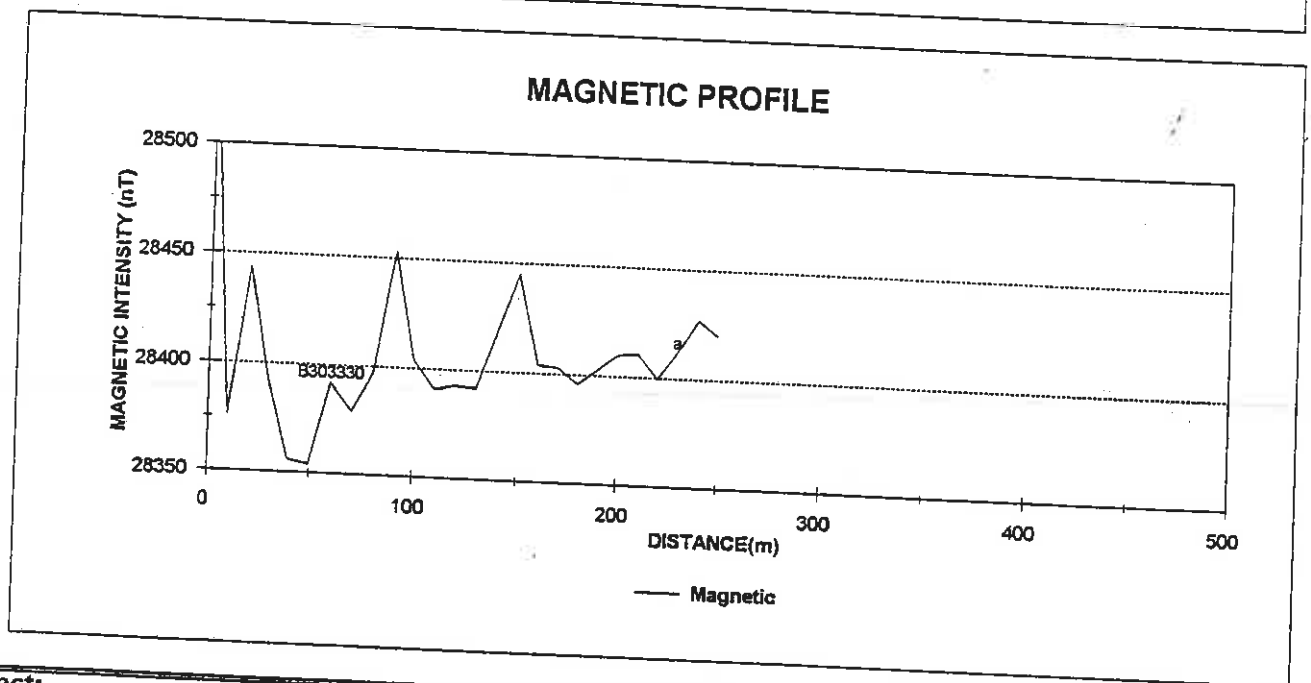

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Date of Survey:	02 Feb 1996	Operator:	GW Schaaf		

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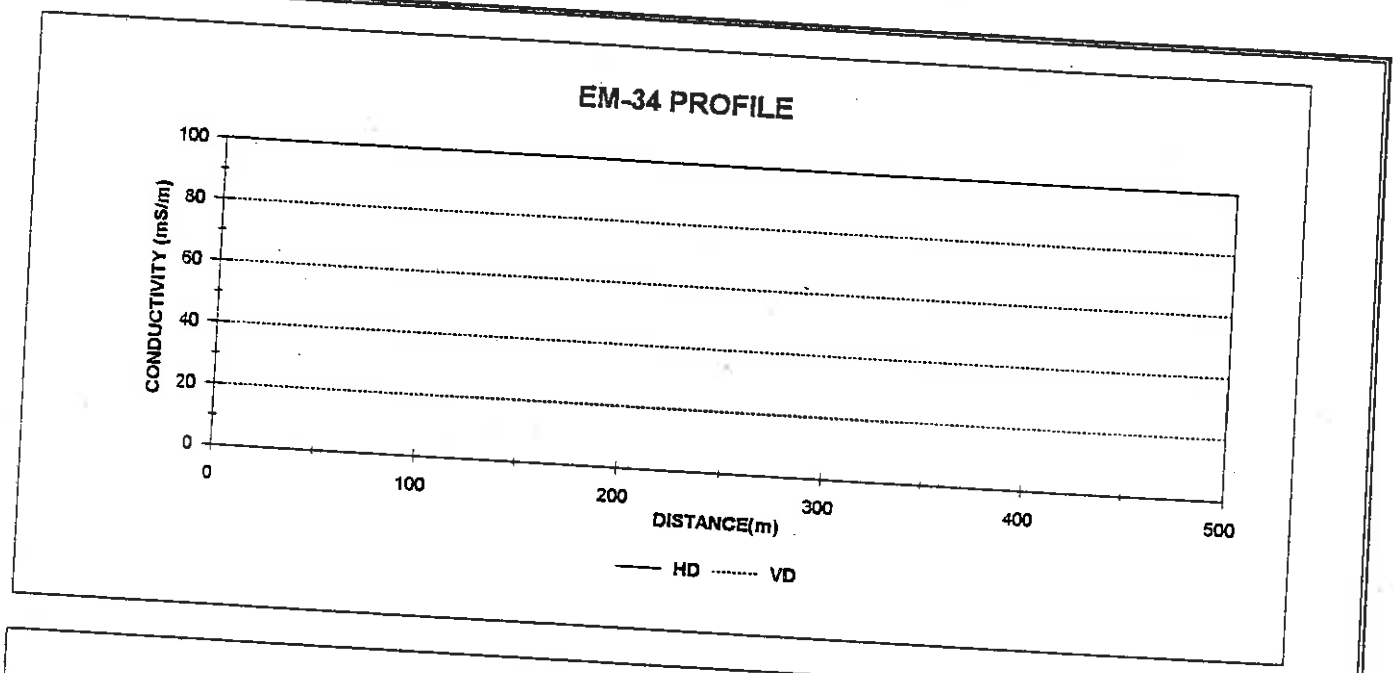

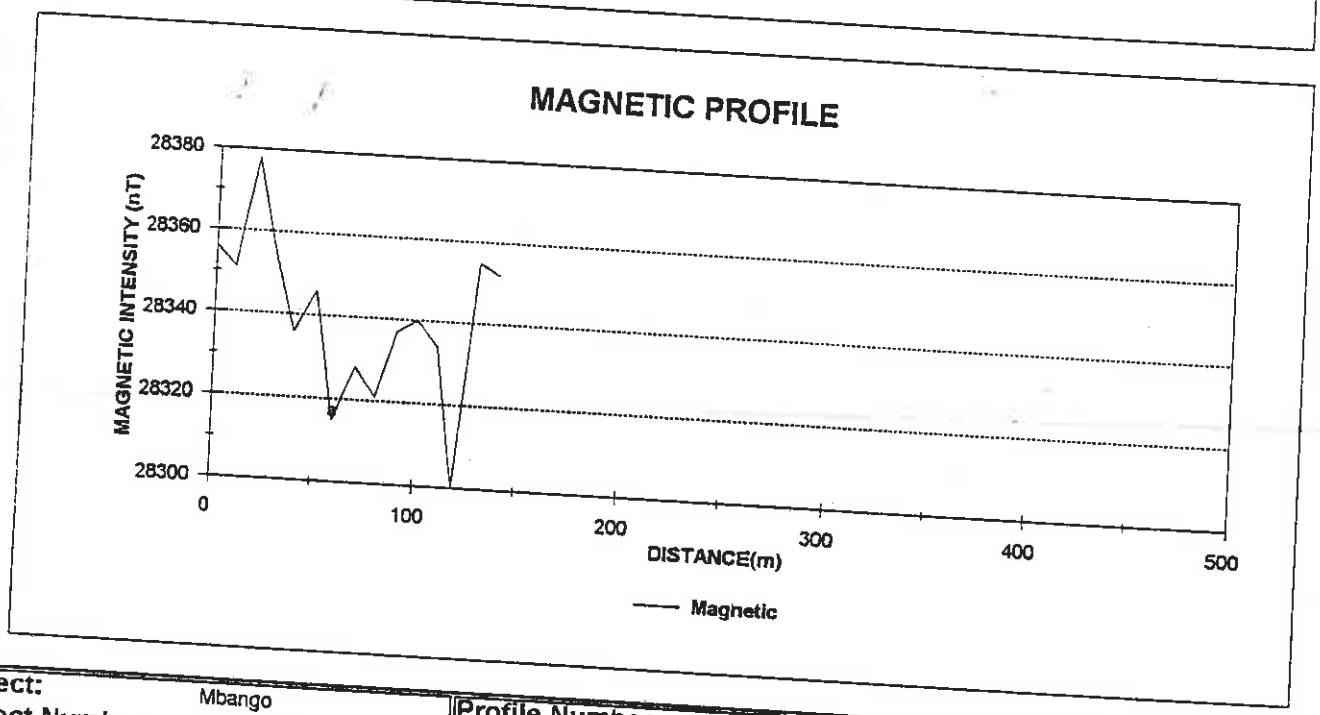

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Date of Survey:	06 Feb 1996	Operator:	GW Schaaf		

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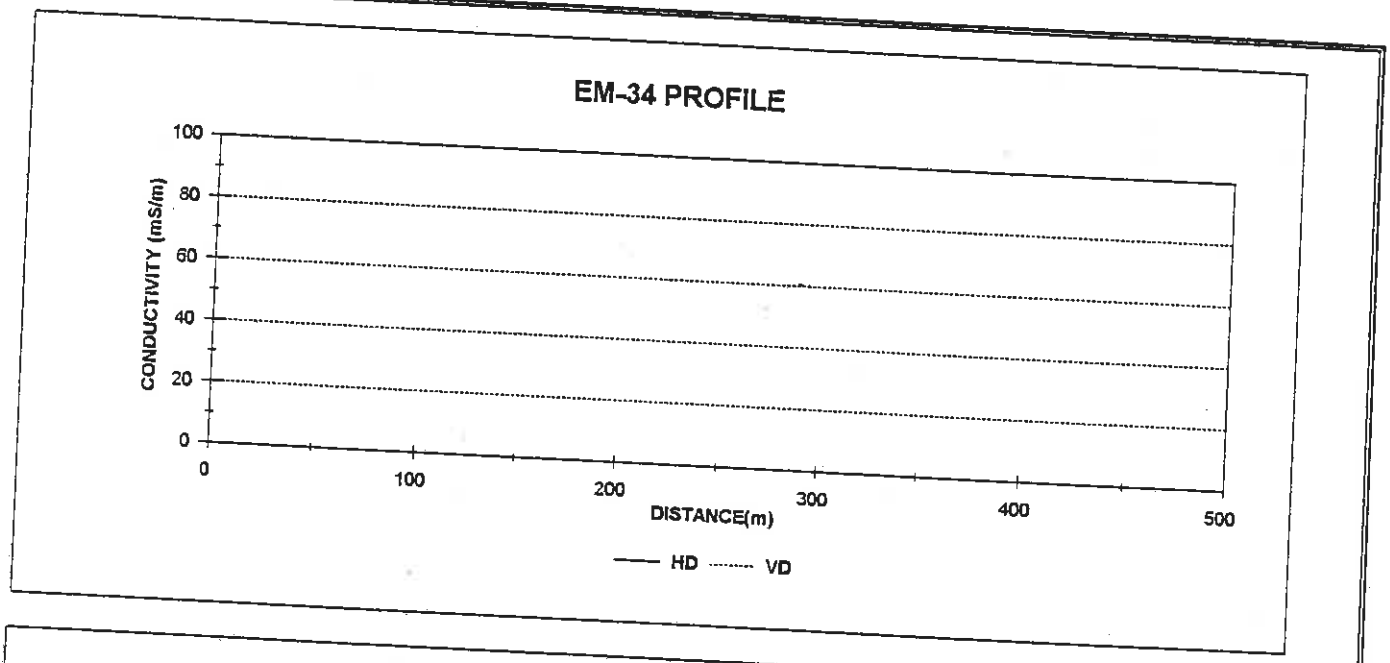

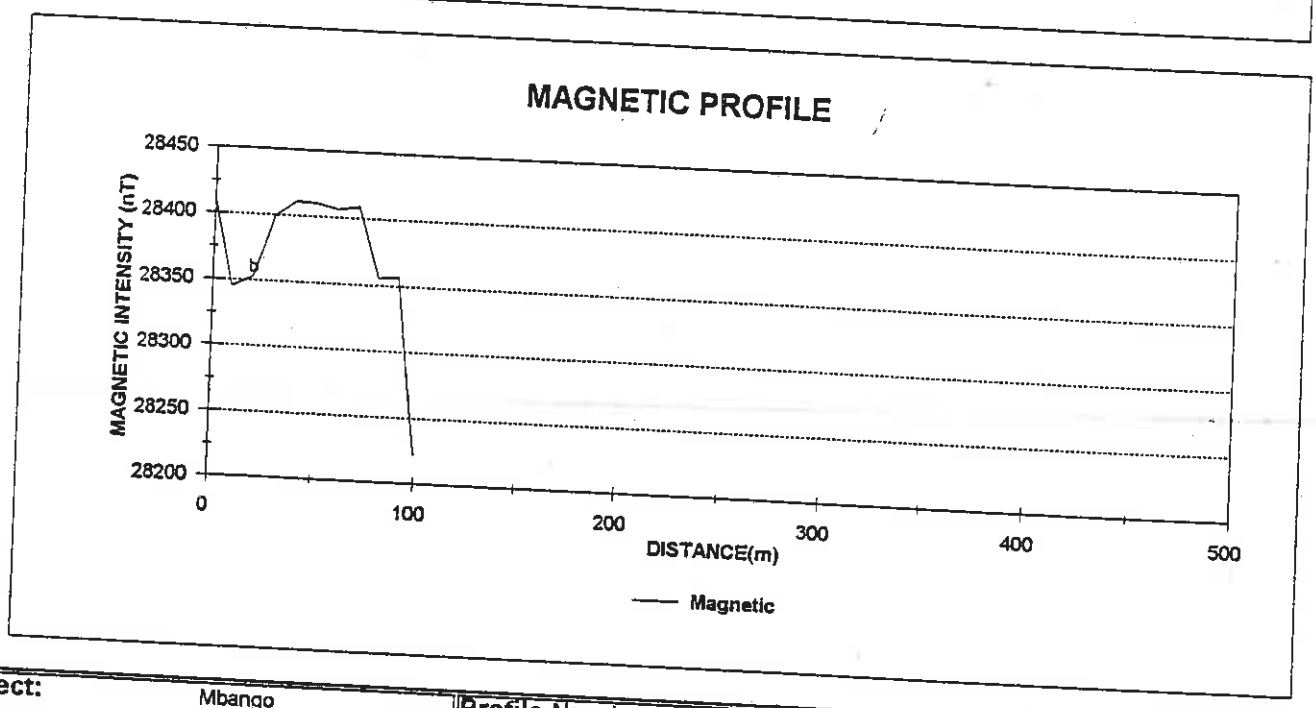

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te of Survey:	06 Feb 1996	Operator:	GW Schaaf		

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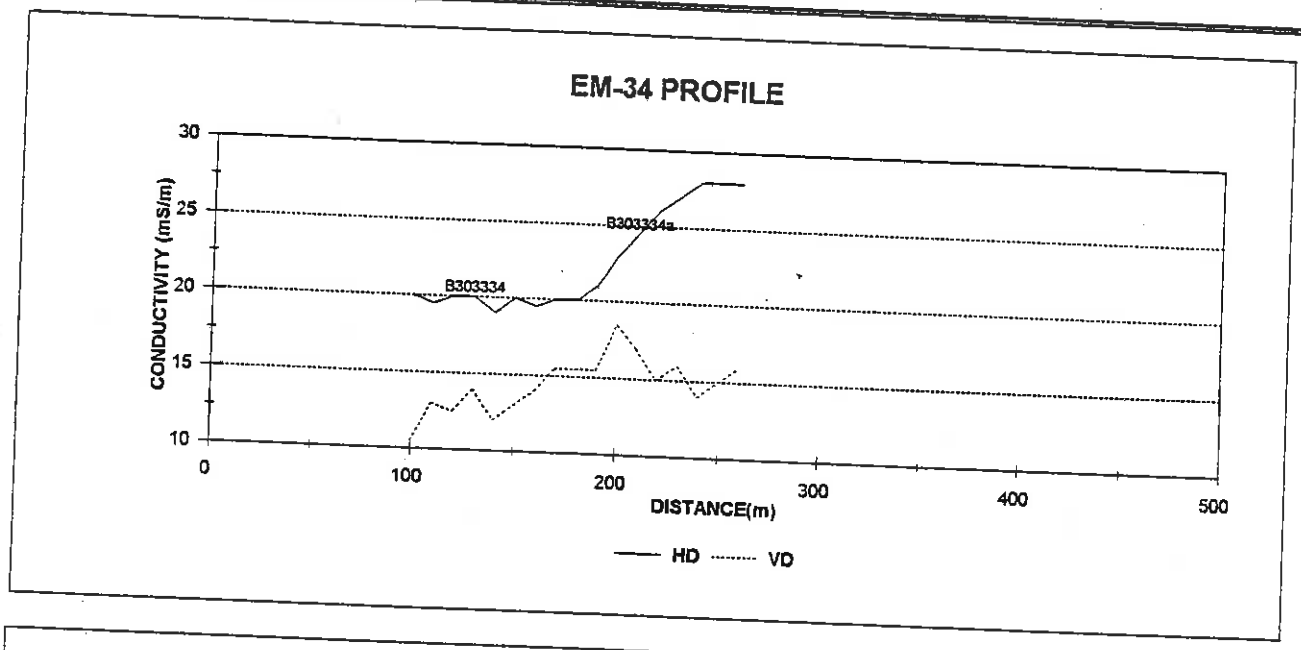
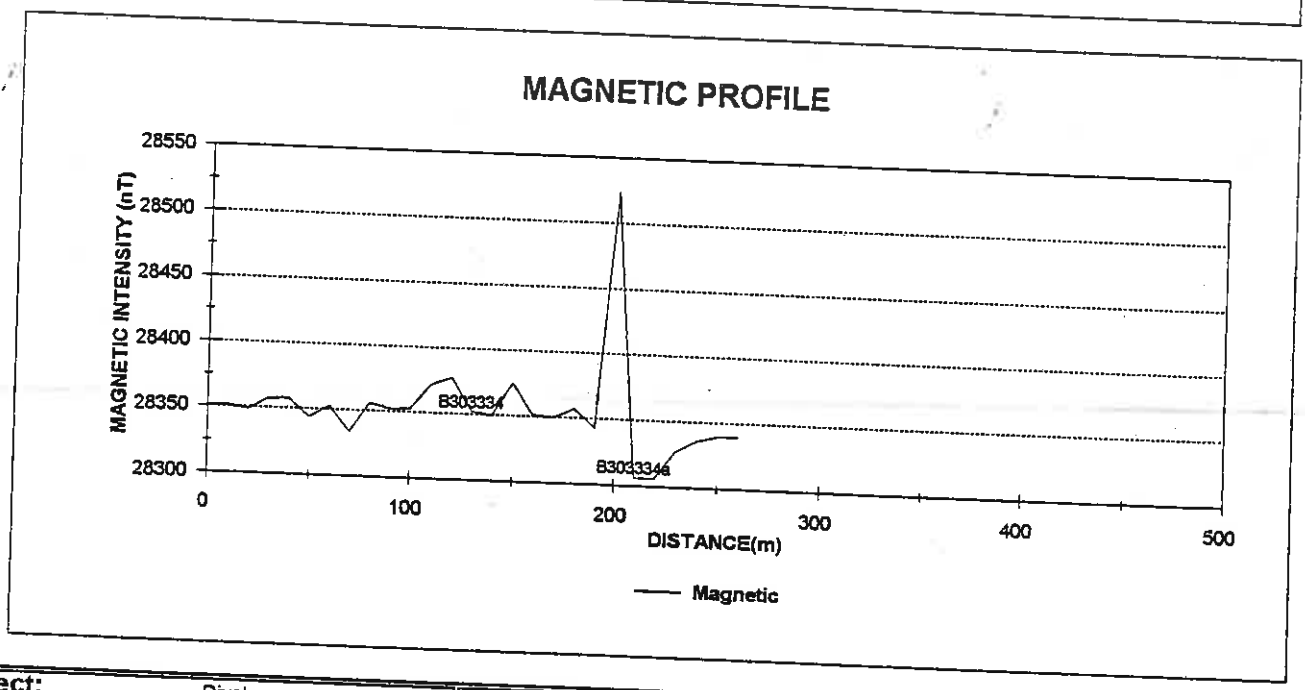
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m





oject:	Dival	Profile Number:	T14	Remarks:	
Project Number:	GH95WHD	Profile Direction:	East to West	B303334	
Survey Area:	Ladysmith	Station Spacing:	10		
te of Survey:	12 Feb 1996	Operator:	GW Schaaf		

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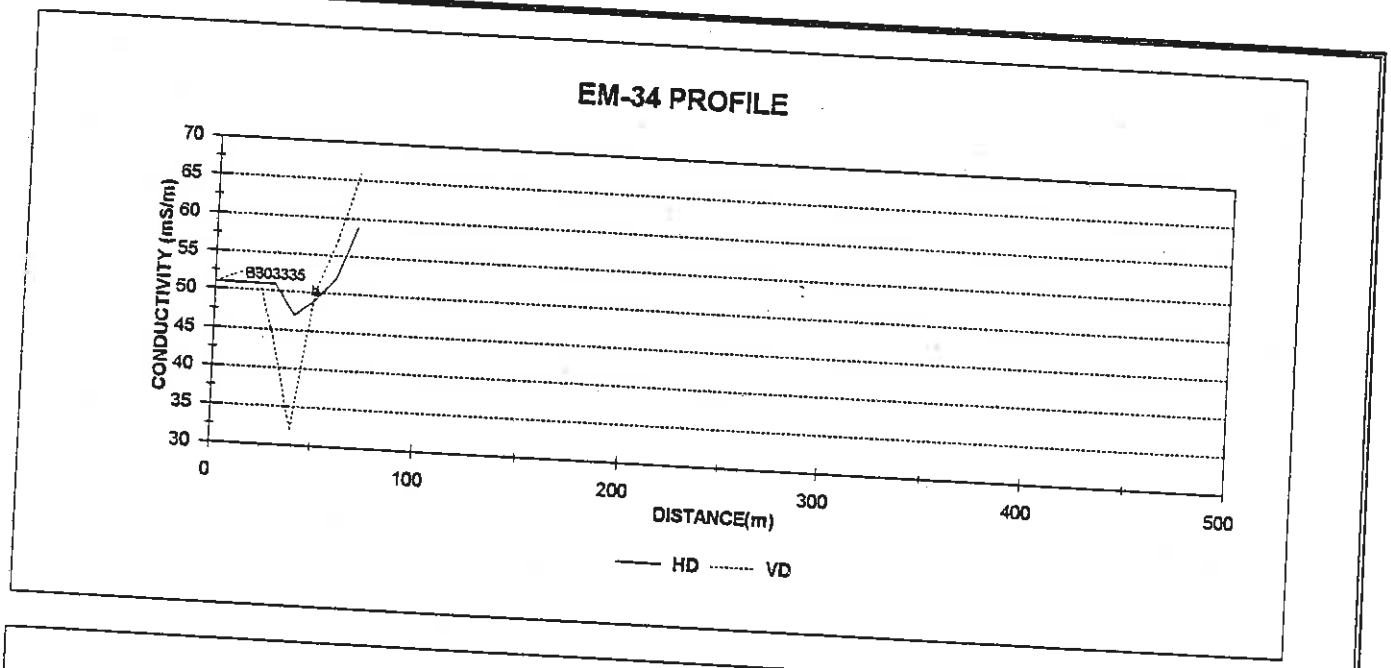
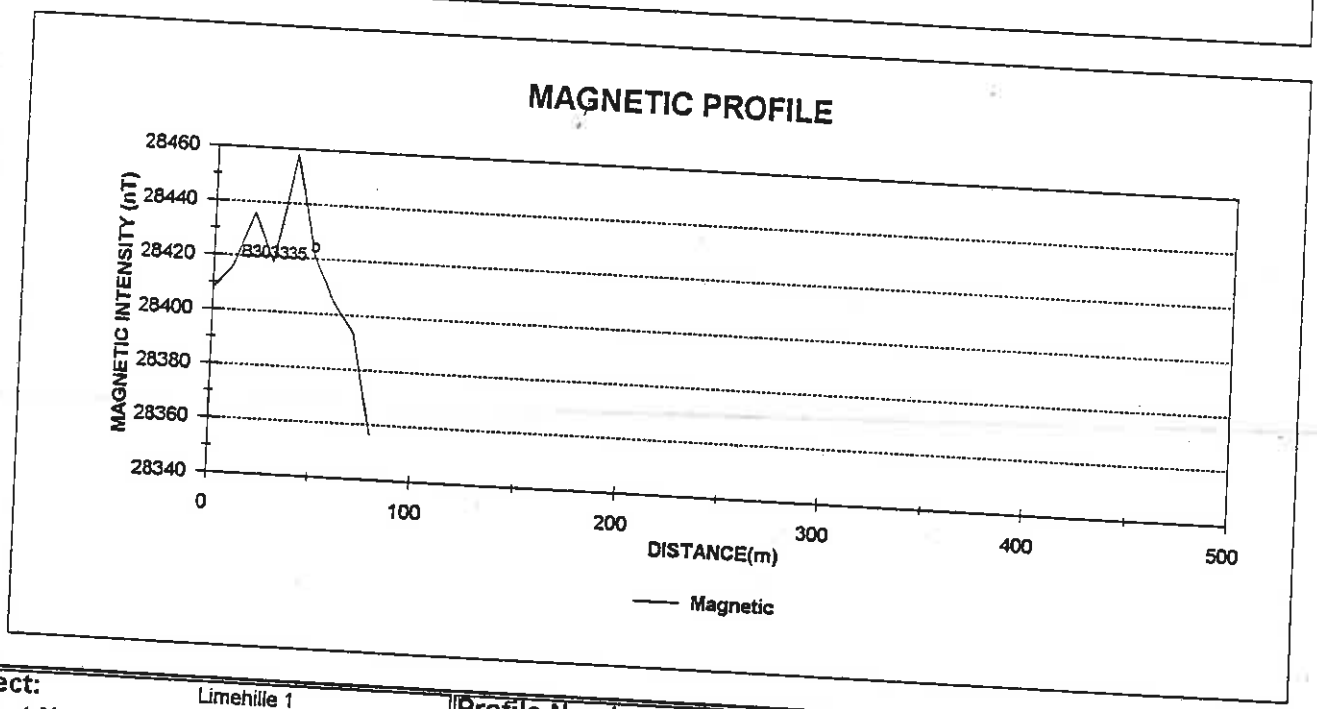
P.O.Box 38384 Garsfontein 0042

Tel : (051) 227185 Fax: (051) 224205
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m





Project:	Limehille 1	Profile Number:	T15	Remarks:	
Project Number:	GH95WHD	Profile Direction:	South to North	B303335	
Survey Area:	Ladysmith	Station Spacing:	10		
Date of Survey:	16 Feb 1996	Operator:	GW Schaaf		

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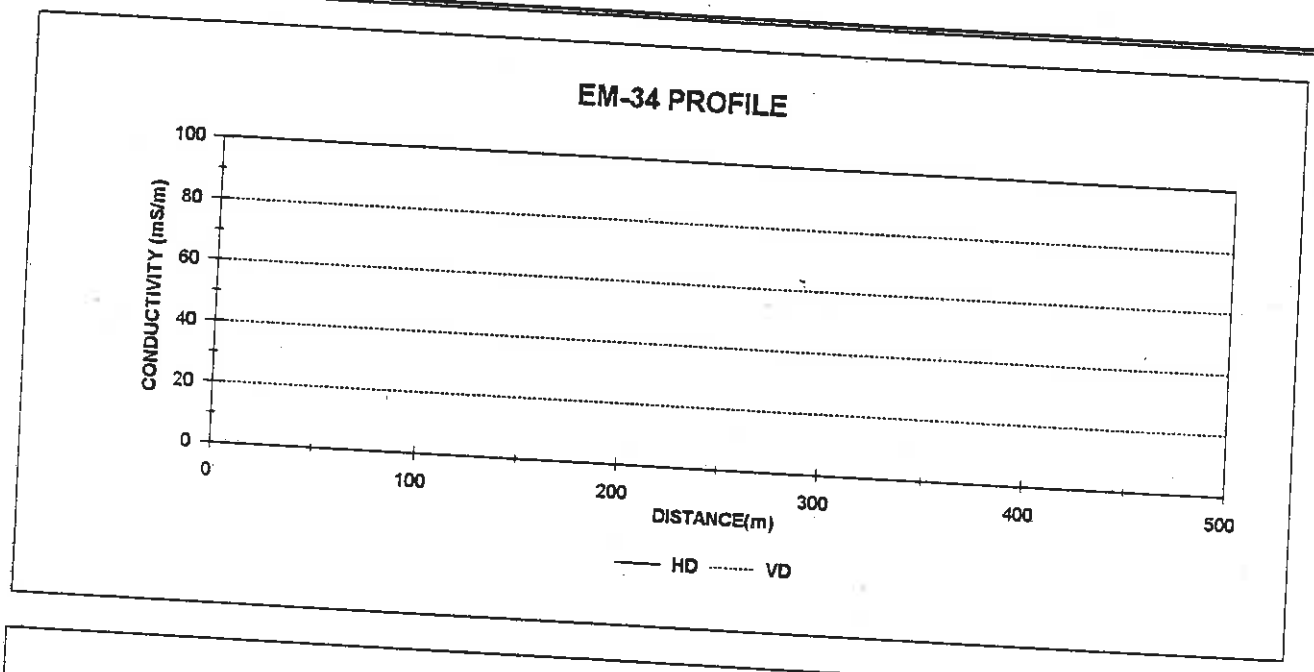
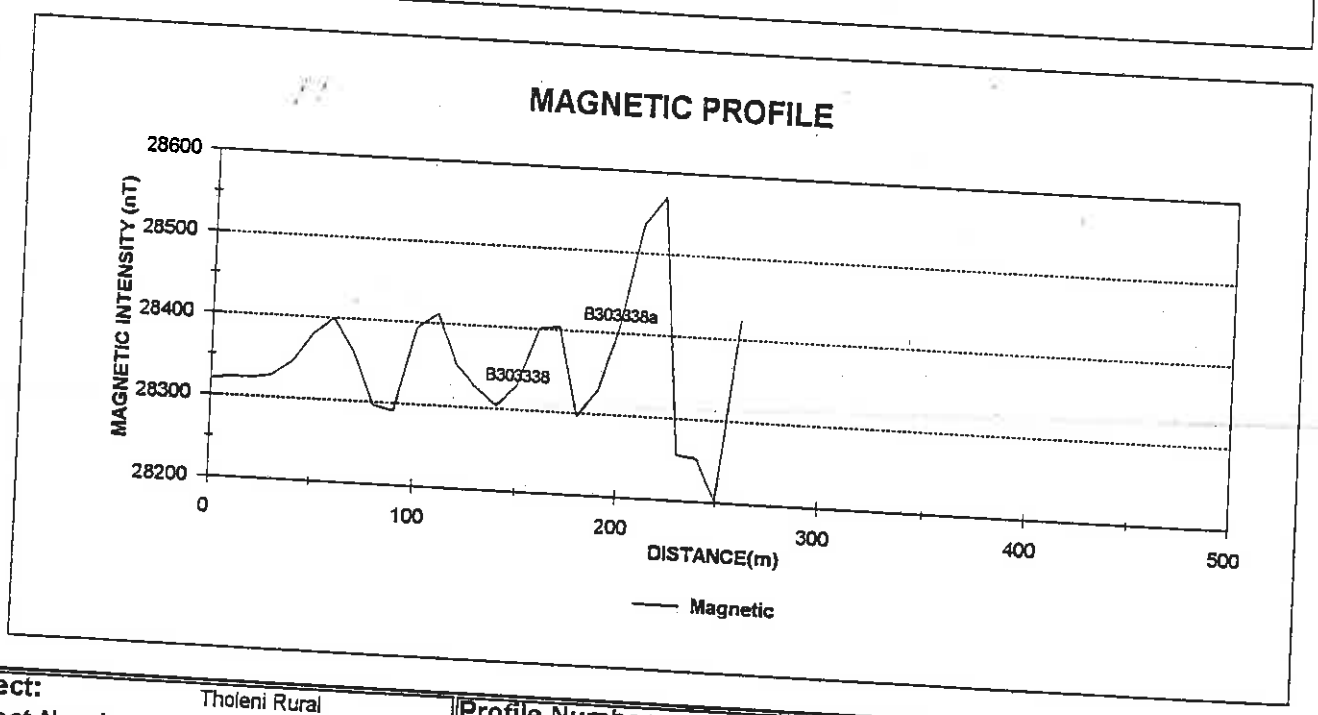
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m





Project:	Tholeni Rural	Profile Number:	T16	Remarks:	
Project Number:	GH95WHD	Profile Direction:	East to West	B303338	
Survey Area:	Ladysmith	Station Spacing:	10		
Date of Survey:	18 Feb 1996	Operator:	GW Schaaf		

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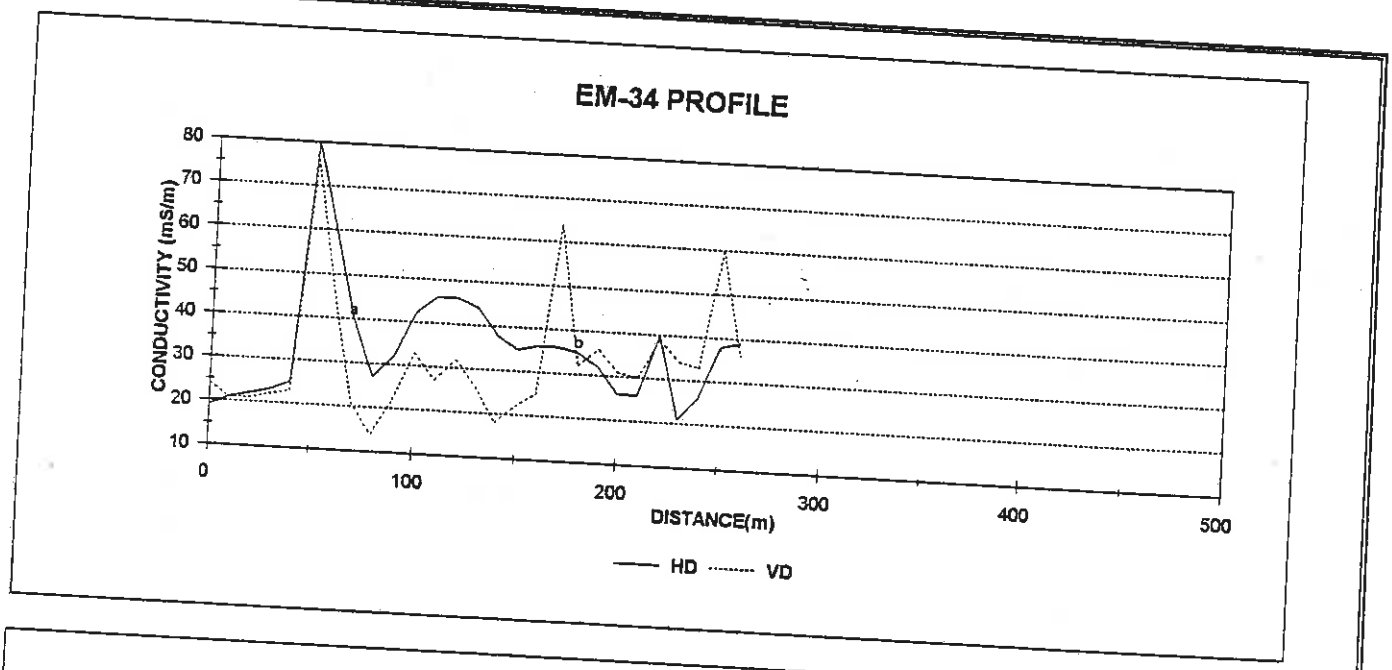
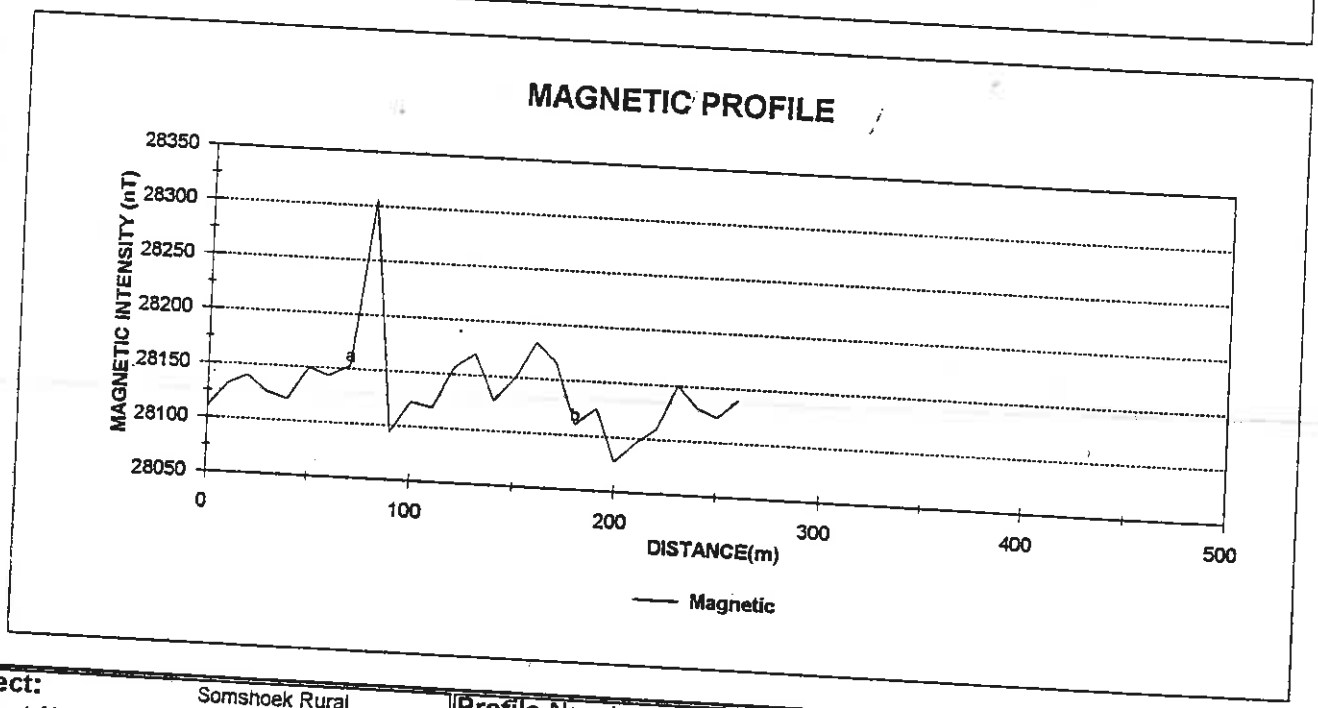
Tel : (051) 227185 Fax: (051) 224205
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m





Project:	Somshoek Rural	**Profile Number:**	T17	**Remarks:**
Project Number:	GH95WHD	**Profile Direction:**	North to South	0
Survey Area:	Ladysmith	**Station Spacing:**	10	
Date of Survey:	9 Feb 1996	**Operator:**	GW Schaaf	

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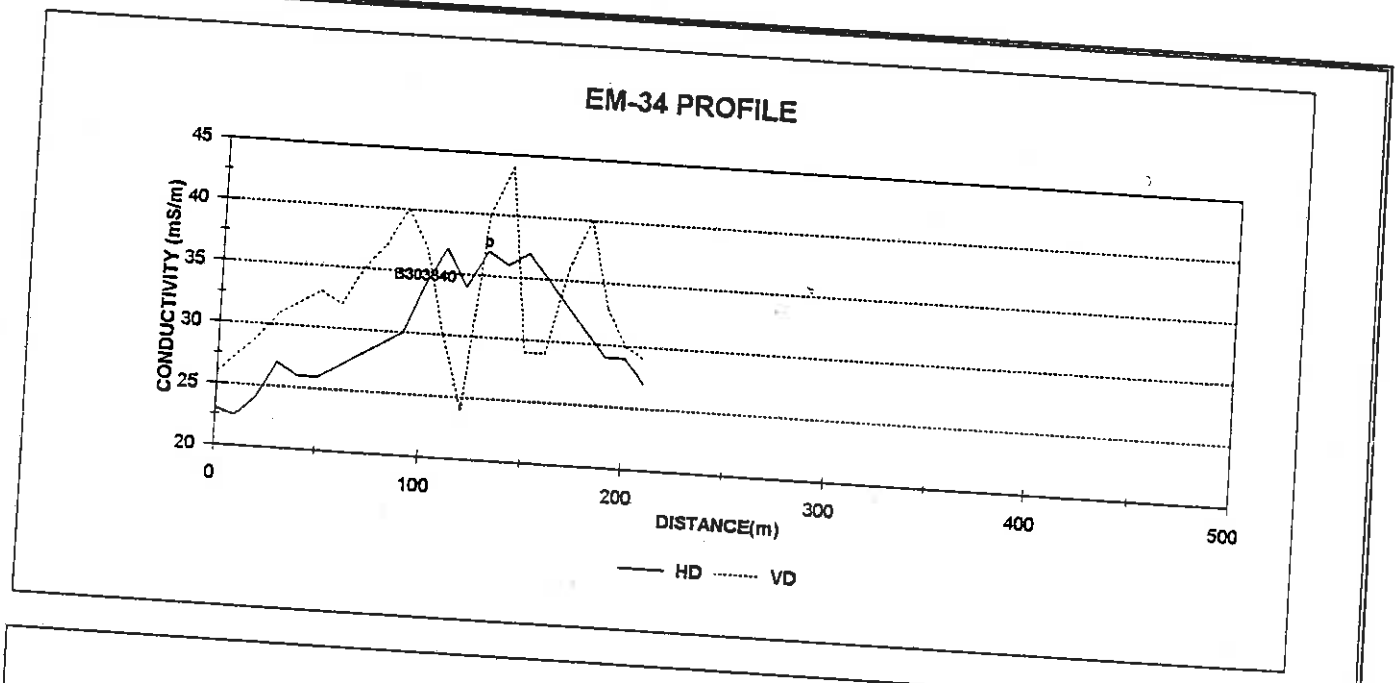
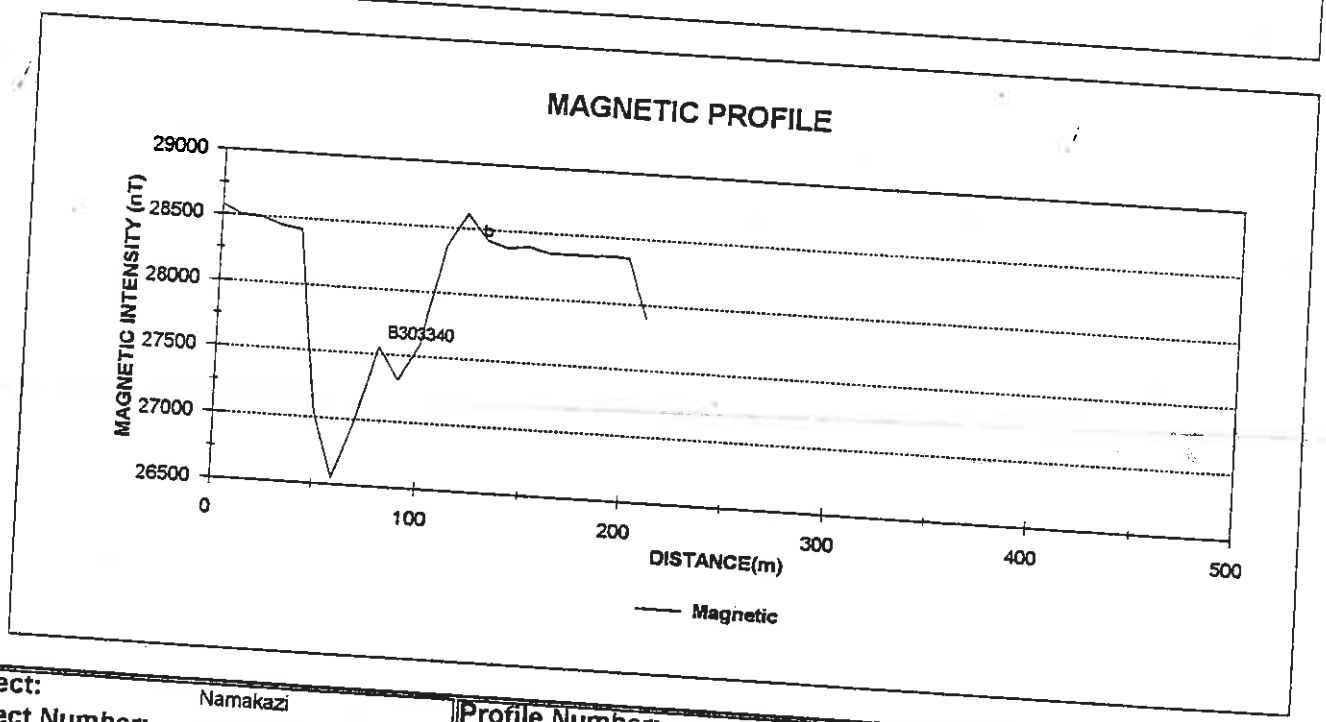
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m





oject:	Namakazi	Profile Number:	T18	Remarks:	
Project Number:	GH95WHD	Profile Direction:	South to North	B303340	
rvey Area:	Ladysmith	Station Spacing:	10		
te of Survey:	12 Feb 1996	Operator:	GW Schaaf		

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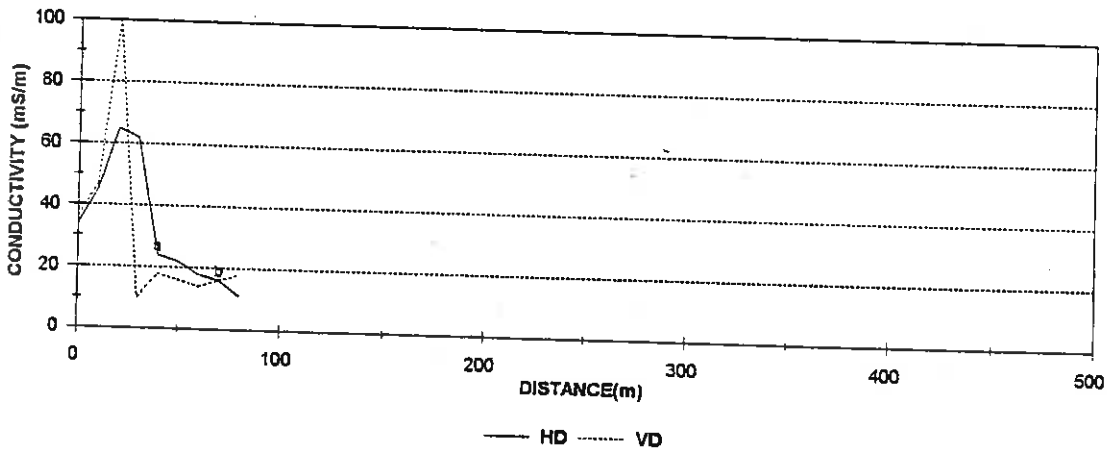
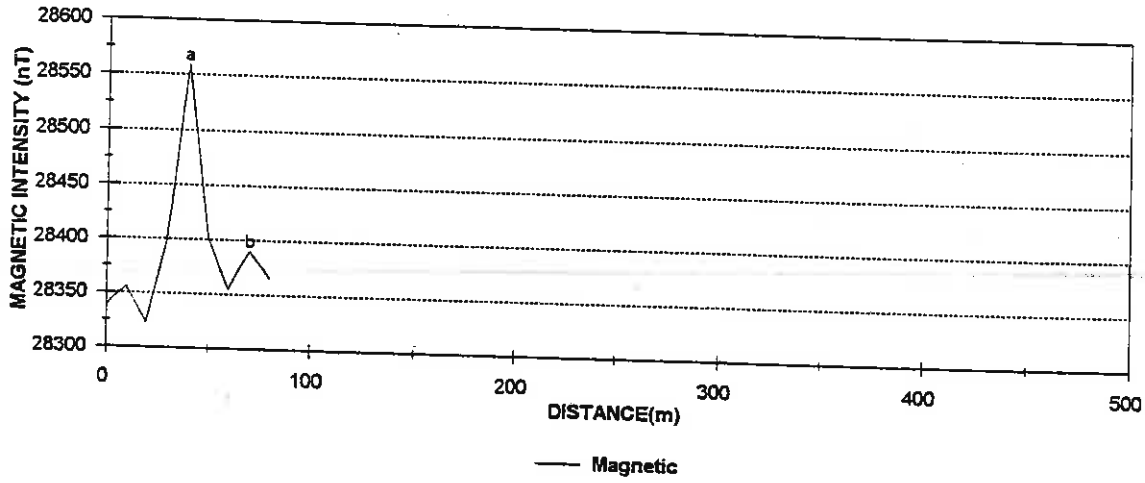
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m

EM-34 PROFILE



MAGNETIC PROFILE



oject:	Pieters 2	**Profile Number:**	T19	**Remarks:**
Project Number:	GH95WHD	**Profile Direction:**	West to East	0
Survey Area:	Ladysmith	**Station Spacing:**	10	
te of Survey:	23 Feb 1996	**Operator:**	GW Schaaf	

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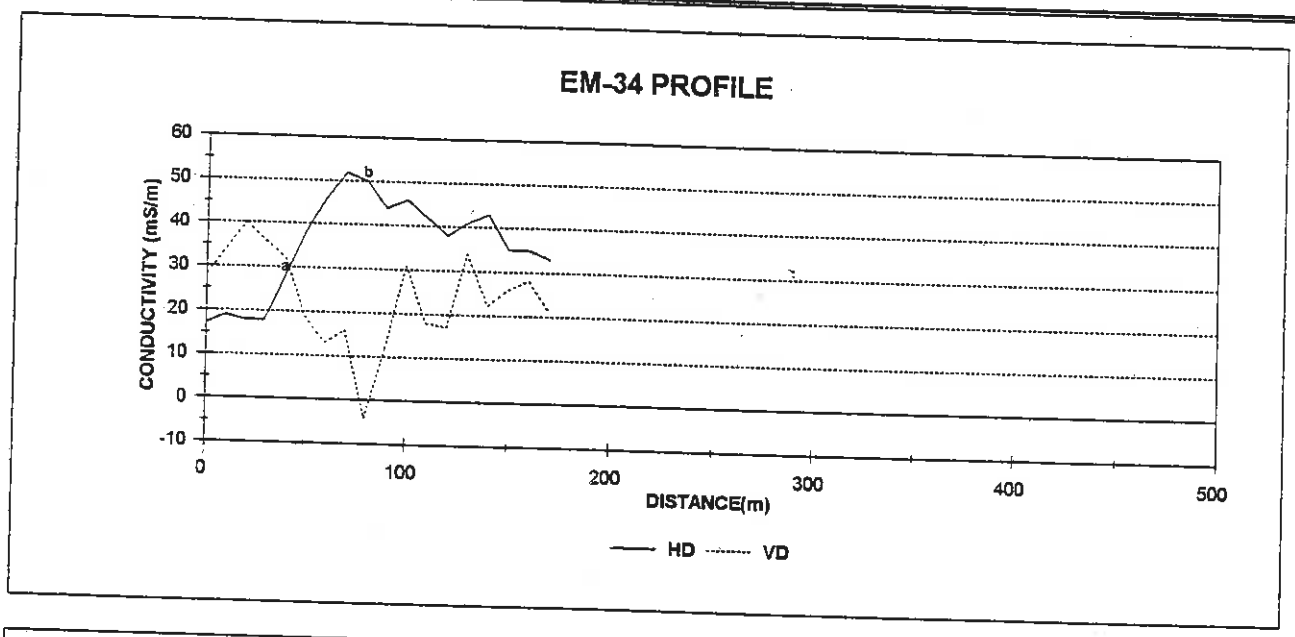
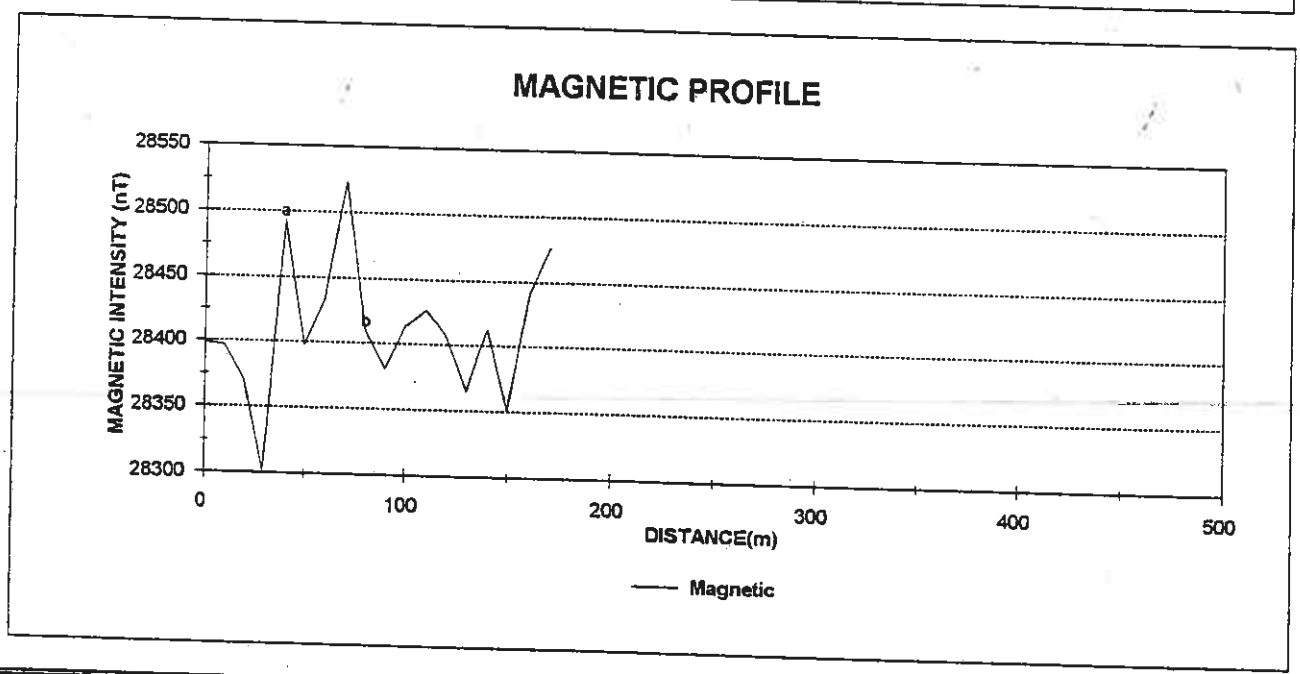
Tel : (051) 227185 Fax: (051) 224205
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m





oject:	Kliprivier	Profile Number:	T20	Remarks:
Project Number:	GH95WHD	Profile Direction:	South to North	0
urvey Area:	Ladysmith	Station Spacing:	10	
ate of Survey:	13 Feb 1996	Operator:	GW Schaaf	

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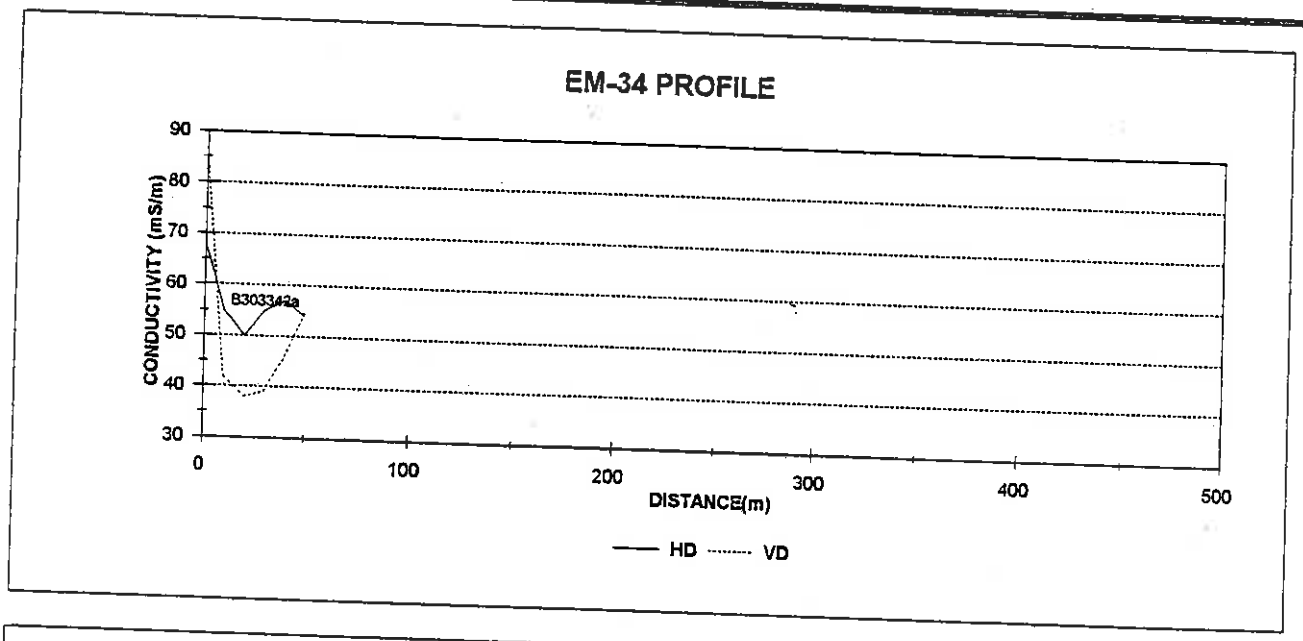
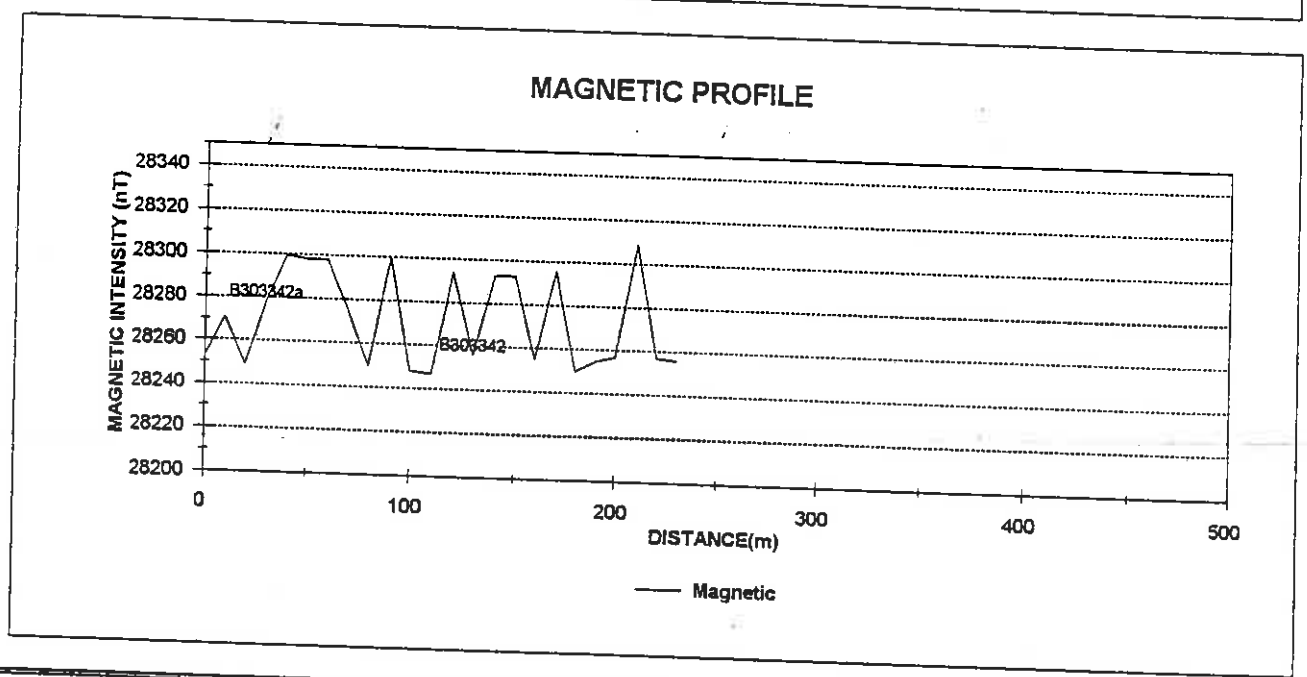
L = 20 m





Project:	Vaalkop	**Profile Number:**	T21	**Remarks:**	
Project Number:	GH95WHD	**Profile Direction:**	North to South	B303342	
Survey Area:	Ladysmith	**Station Spacing:**	10		
Date of Survey:	21 Feb 1996	**Operator:**	GW Schaaf		

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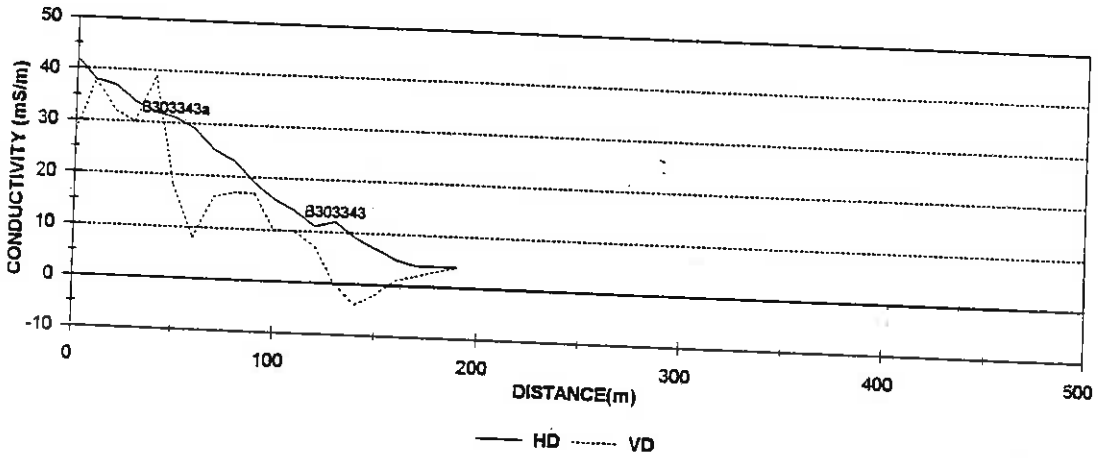
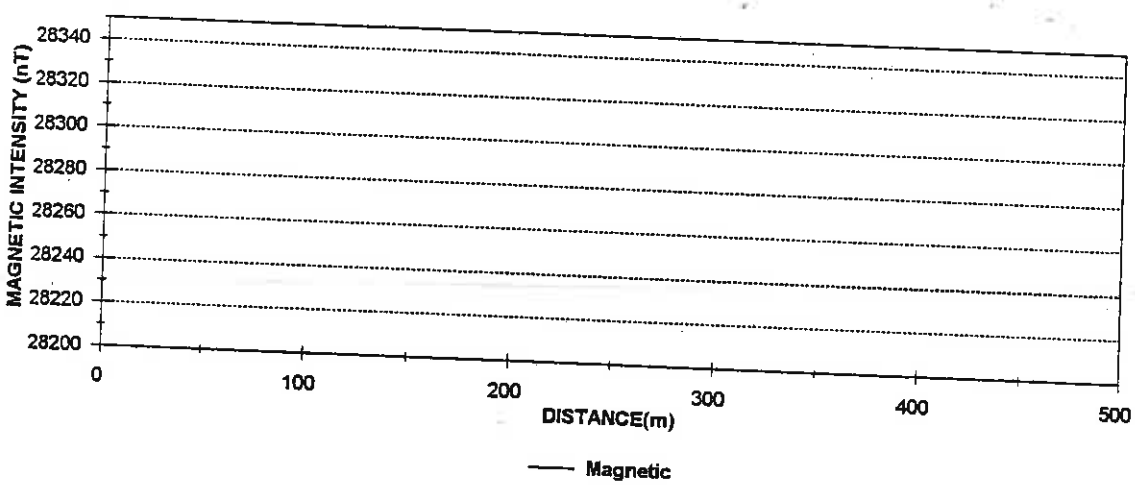
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m

EM-34 PROFILE



MAGNETIC PROFILE



Project:	Tholeni Town	**Profile Number:**	T22	**Remarks:**
Project Number:	GH95WHD	**Profile Direction:**	South to North	B303343
Survey Area:	Ladysmith	**Station Spacing:**	10	
Date of Survey:	14 Feb 1996	**Operator:**	GW Schaaf	

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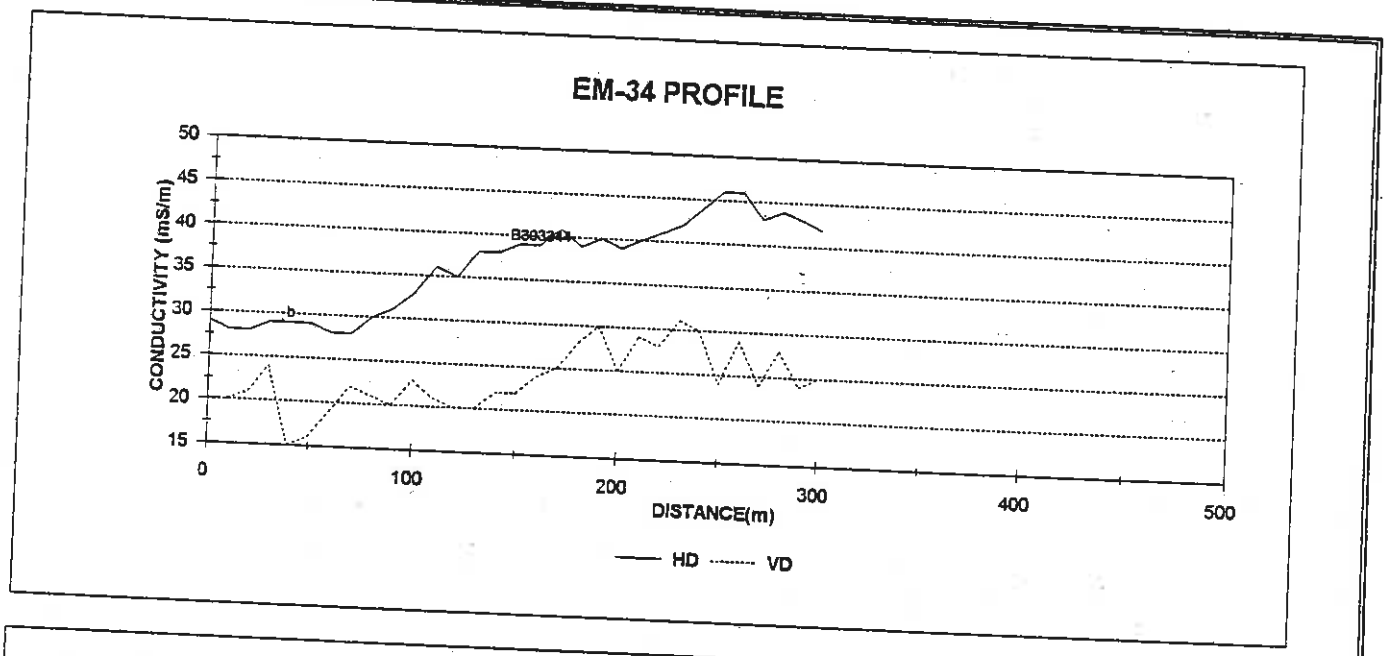
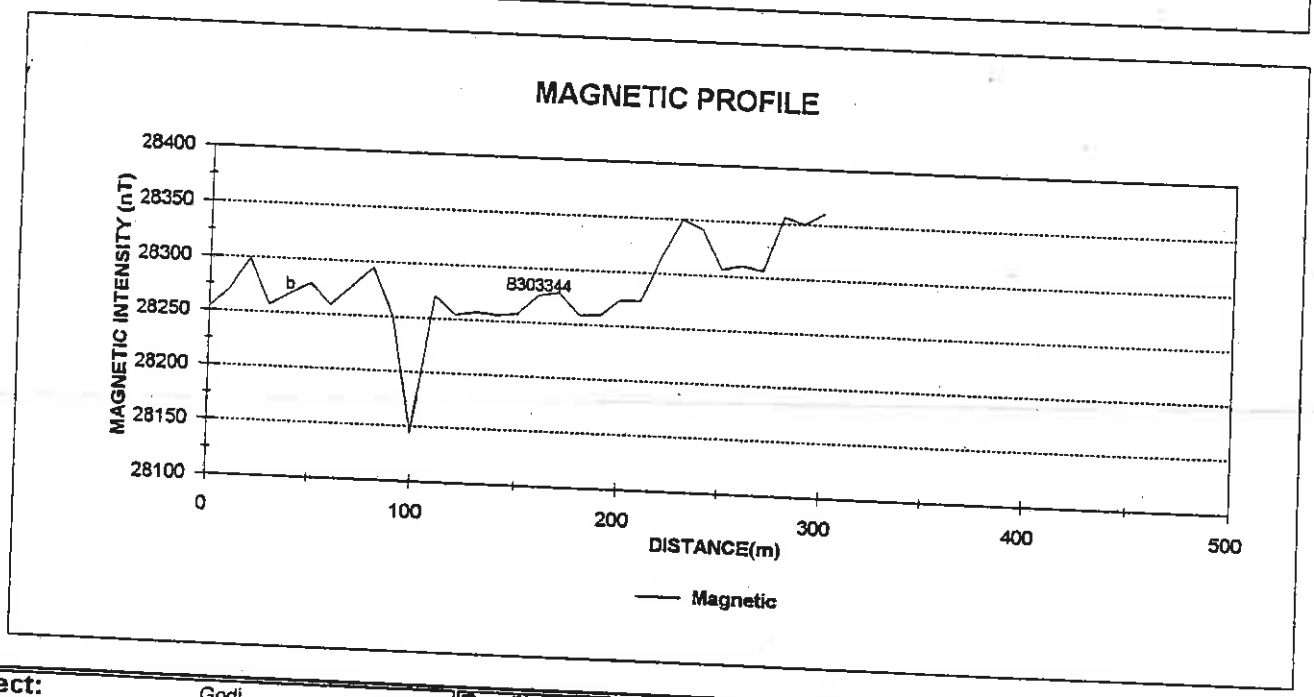
Tel : (012) 98-5231 Fax: (012) 998-6519

L = 20 m





Project:	Godi	Profile Number:	T23	Remarks:	
Project Number:	GH95WHD	Profile Direction:	East to West	B303344	
Survey Area:	Ladysmith	Station Spacing:	10		
Date of Survey:	24 Feb 1996	Operator:	GW Schaaf		

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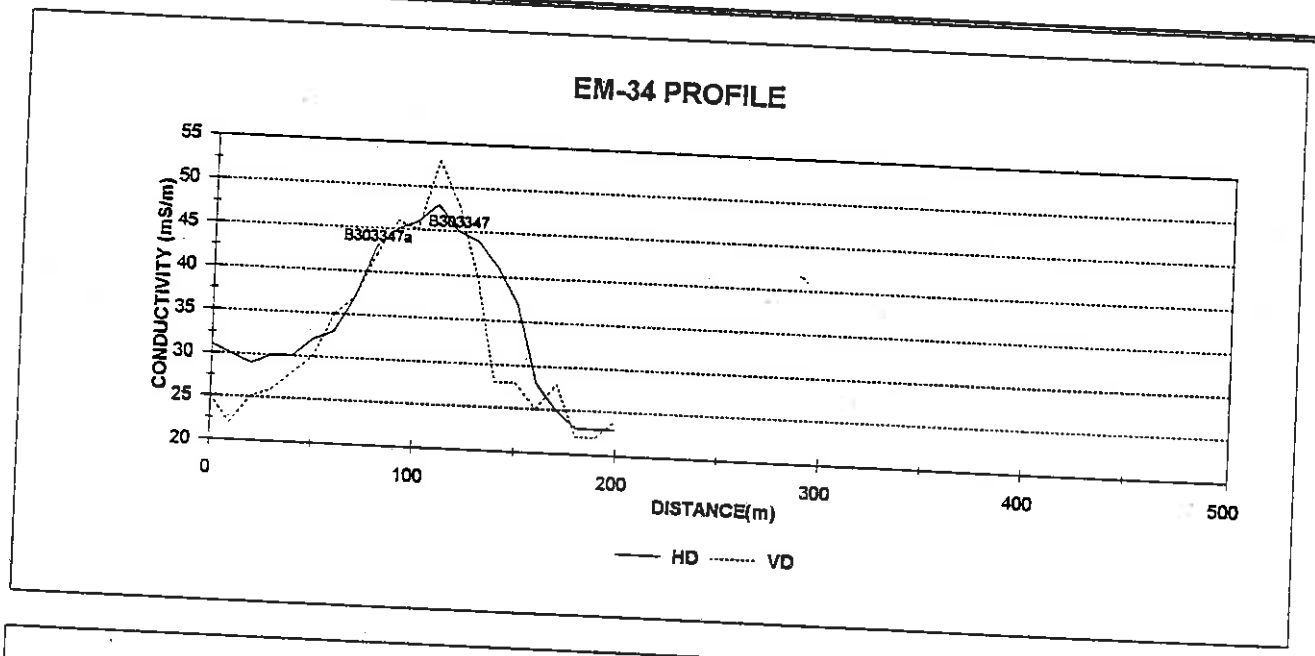
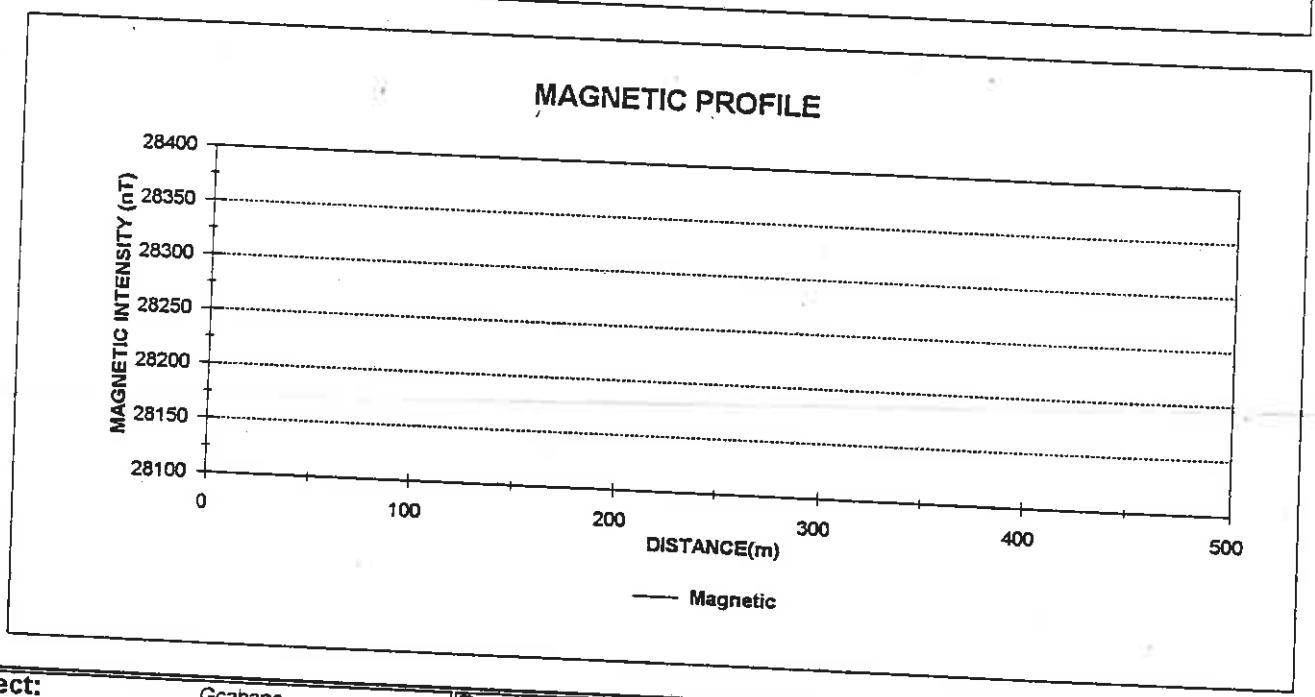
L = 20 m





Project:	Gcabane	Profile Number:	T24	Remarks:
Project Number:	GH95WHD	Profile Direction:	East to West	B303347
Survey Area:	Ladysmith	Station Spacing:	10	
Date of Survey:	27 Feb 1996	Operator:	GW Schaaf	

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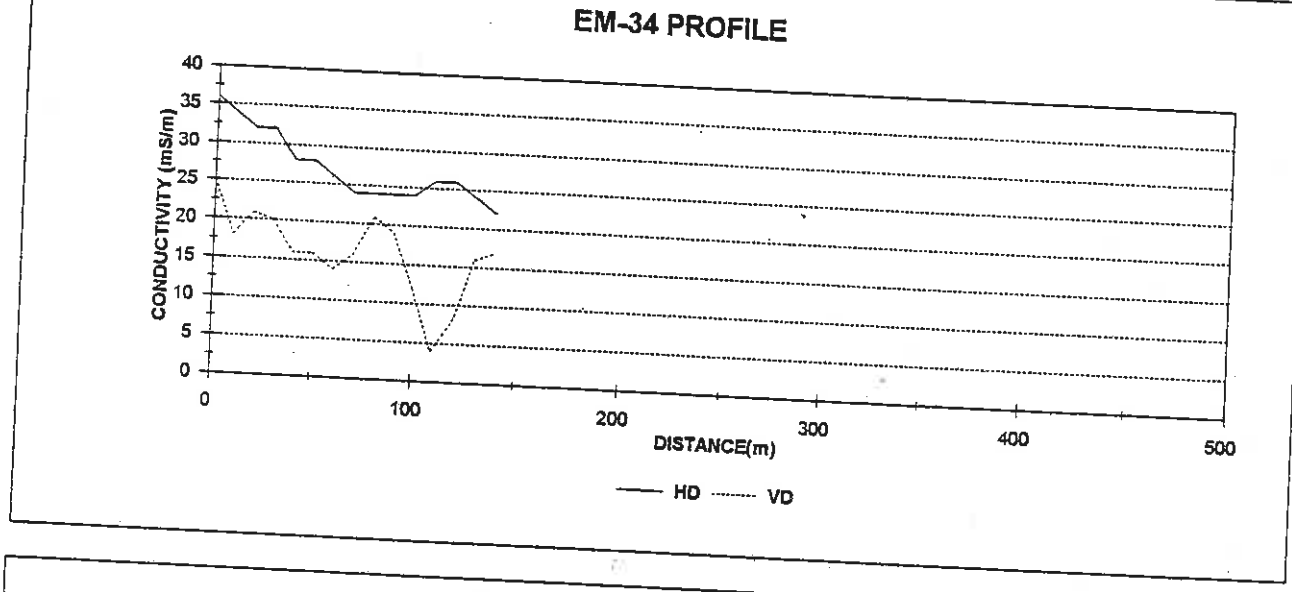
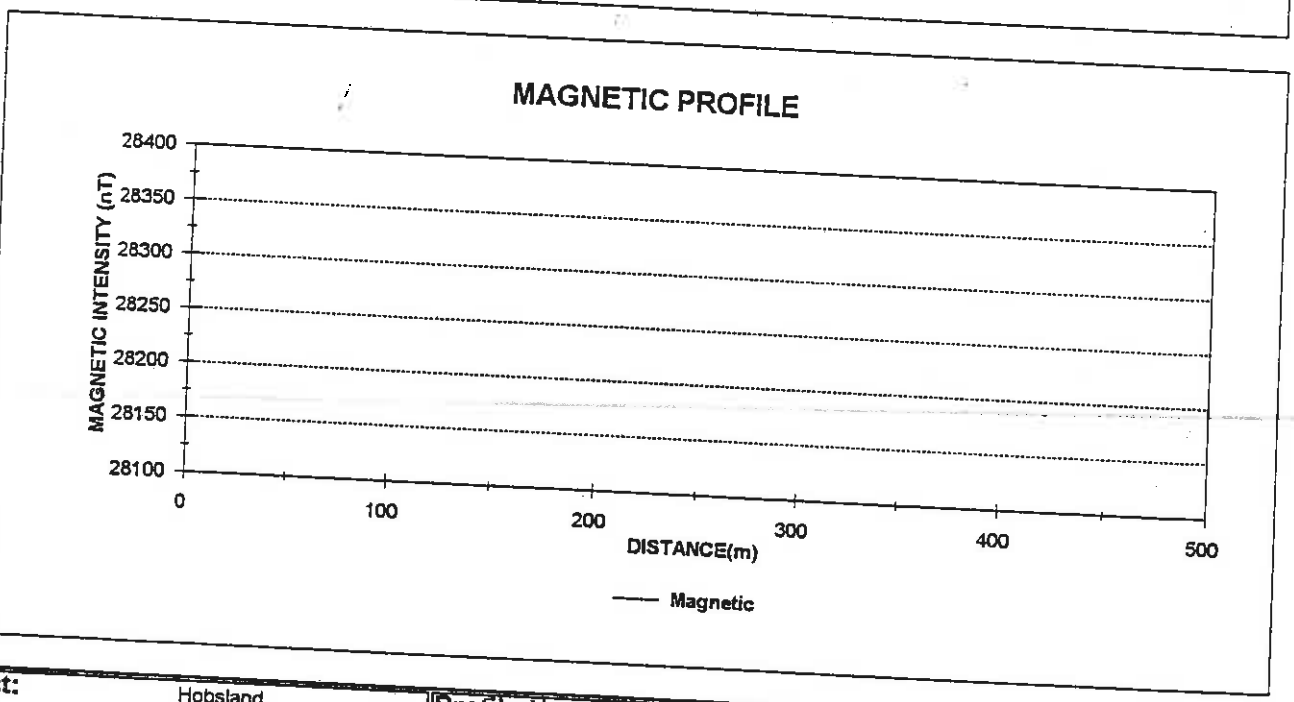
L = 20 m





Project:	Hobsland	Profile Number:	T2S	Remarks:	
Project Number:	GH95WHD	Profile Direction:	South to North	0	
Survey Area:	Ladysmith	Station Spacing:	10		
Date of Survey:	21 Feb 1996	Operator:	GW Schaaf		

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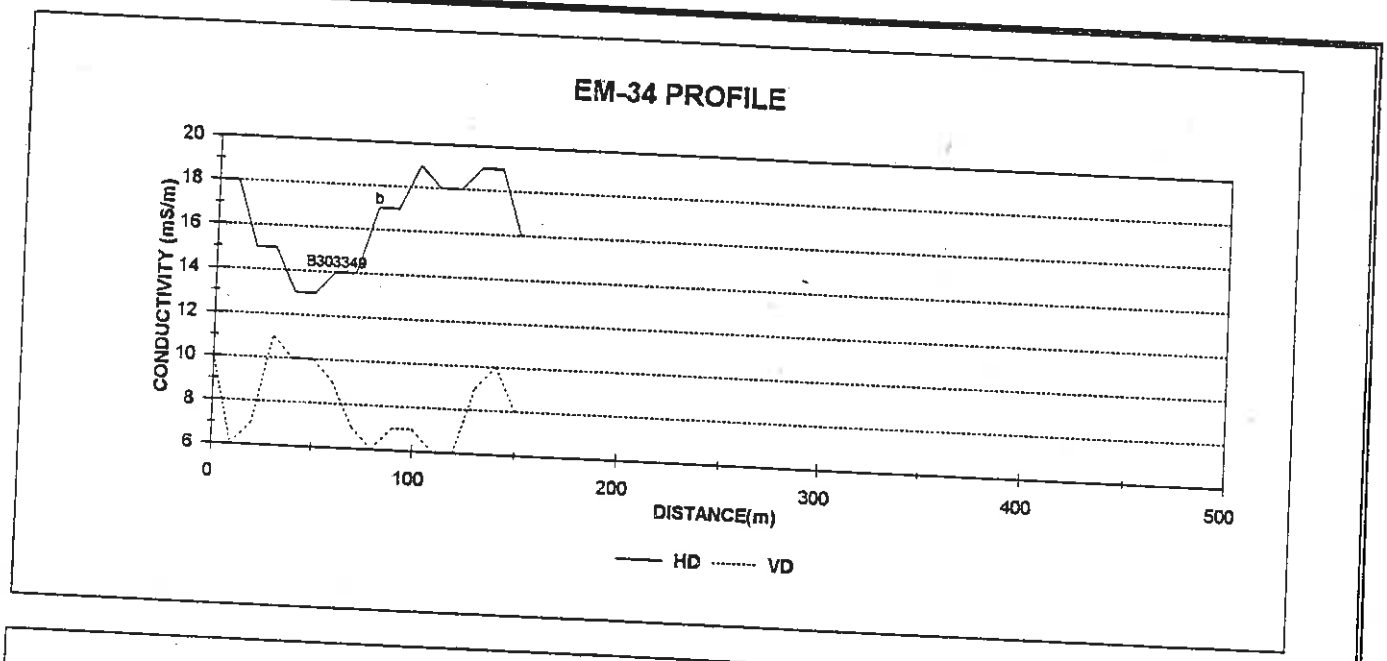
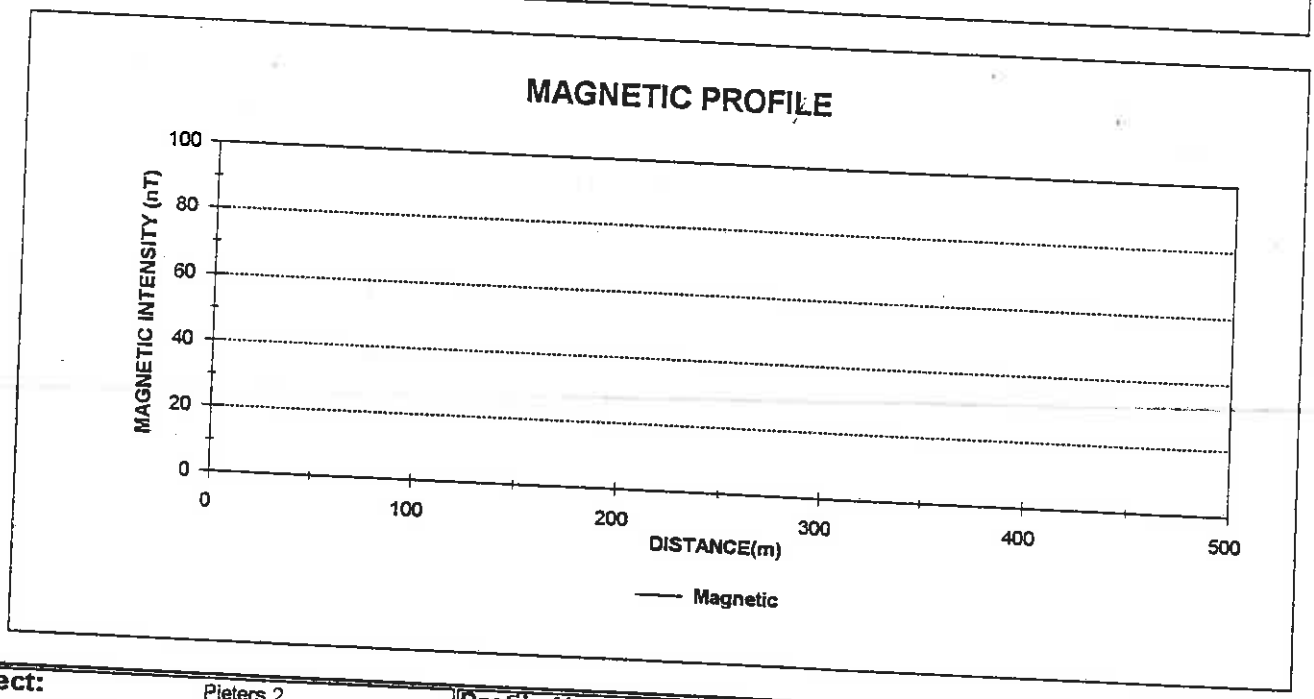
L = 20 m





Project:	Pieters 2	**Profile Number:**	T26	**Remarks:**	
Project Number:	GH95WHD	**Profile Direction:**	Southwest to Northeast	0	
Survey Area:	Ladysmith	**Station Spacing:**	10	B303349	
Date of Survey:	23 Feb 1996	**Operator:**	GW Schaaf		

APPENDIX C

Geological and Geohydrological profiles

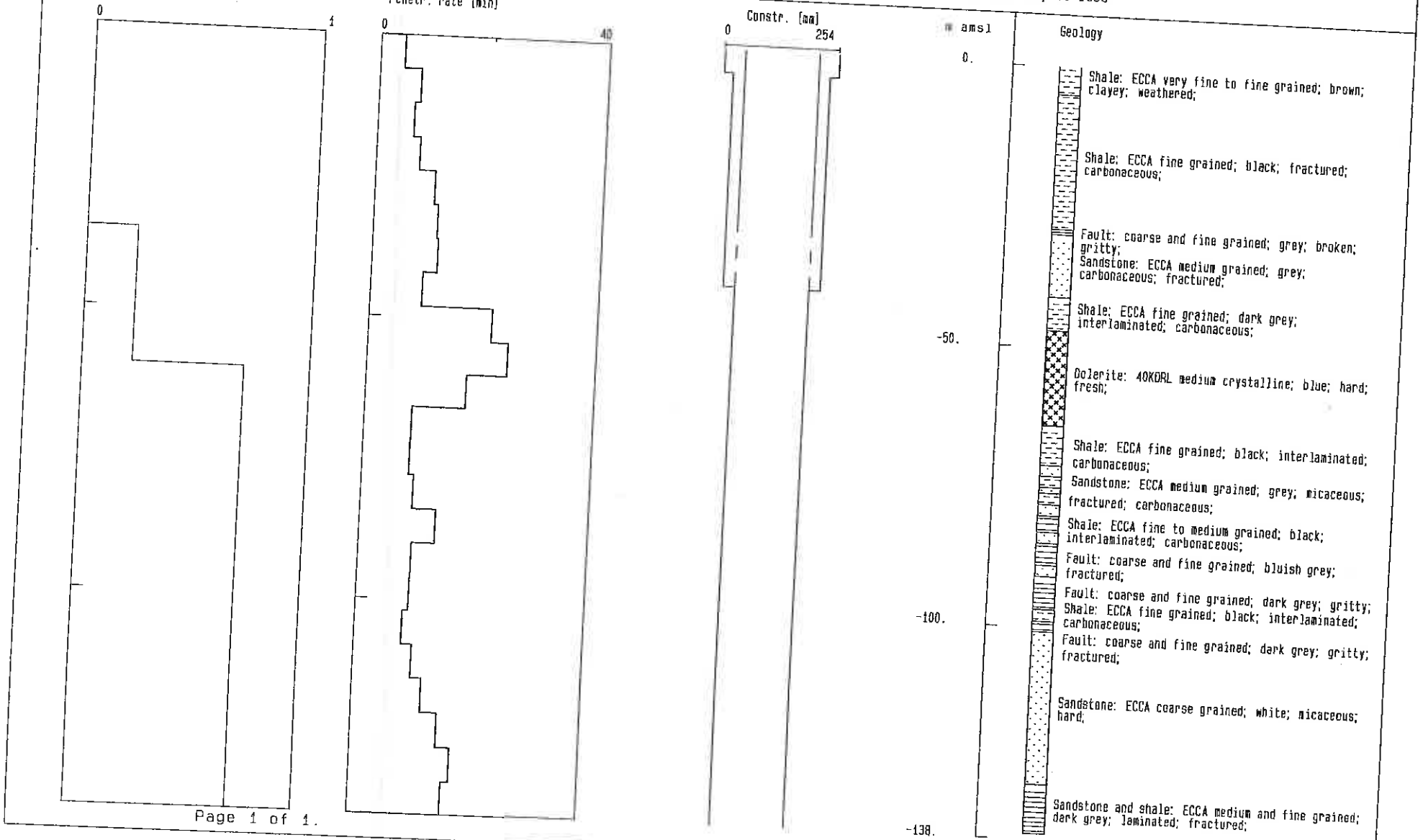
Site-ID : 2829BD00023

Nr on Map : LD4

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -77624.11 (E-W) 3144992.86 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site ID: 2829BD00023 Number on map: LD4

91.00	97.00	6.00	FAULT : coarse and fine grained; dark grey; gritty; fractured. SAME MATERIAL AS ABOVE.
97.00	99.00	2.00	SHALE : ECCA fine grained; black; interlaminated; carbonaceous.
99.00	101.00	2.00	FAULT : coarse and fine grained; dark grey; gritty; fractured. SAME MATERIAL AS 80-83M (DOLRT,QRTZT,CB SHLE) IN SAMPLES.
101.00	128.00	27.00	SANDSTONE : ECCA coarse grained; white; micaceous; hard.
128.00	137.00	9.00	SANDSTONE AND SHALE : ECCA medium and fine grained; dark grey; laminated; fractured.

Geohydrology

36.00	38.00	2.00	0.22 L/sec measured by volumetric measurement (container + stop-watch method).
60.00	62.00	2.00	0.71 L/sec measured by volumetric measurement (container + stop-watch method).

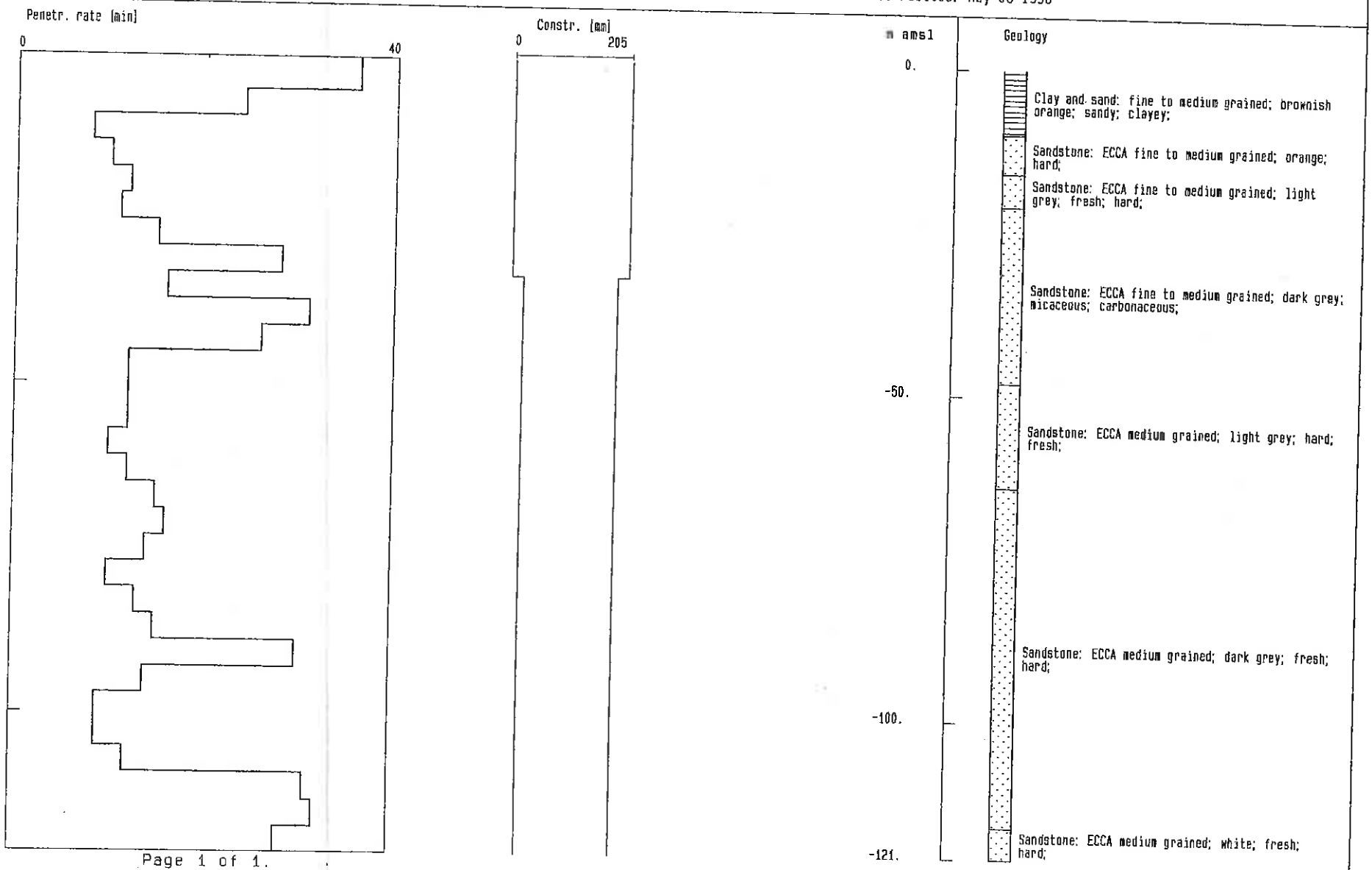
Site-ID : 2829AC00003

Nr on Map : L015A

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -110559.33 (E-W) 3151043.78 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Uitvligt
Notes : Dry borehole. Stone plugged.

Site ID: 2829AC00003
Number on map: LO15A

Longitude : 30.12889
Latitude : 28.47222
Ground Elevation: 0.00 mamsl
Collar Height: 0.00 m
Depth of Casing: 0.00 m
Diameter of Hole: 165 mm
Logged by:
Date Drilled: 19960202

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	10.00	10.00	CLAY AND SAND : fine to medium grained; brownish orange; sandy; clayey.
10.00	16.00	6.00	SANDSTONE : ECCA fine to medium grained; orange; hard.
16.00	21.00	5.00	SANDSTONE : ECCA fine to medium grained; light grey; fresh; hard.
21.00	48.00	27.00	SANDSTONE : ECCA fine to medium grained; dark grey; micaceous; carbonaceous.
48.00	64.00	16.00	SANDSTONE : ECCA medium grained; light grey; hard; fresh.
64.00	116.00	52.00	SANDSTONE : ECCA medium grained; dark grey; fresh; hard.
116.00	121.00	5.00	SANDSTONE : ECCA medium grained; white; fresh; hard.
Geohydrology			
(no information.)			

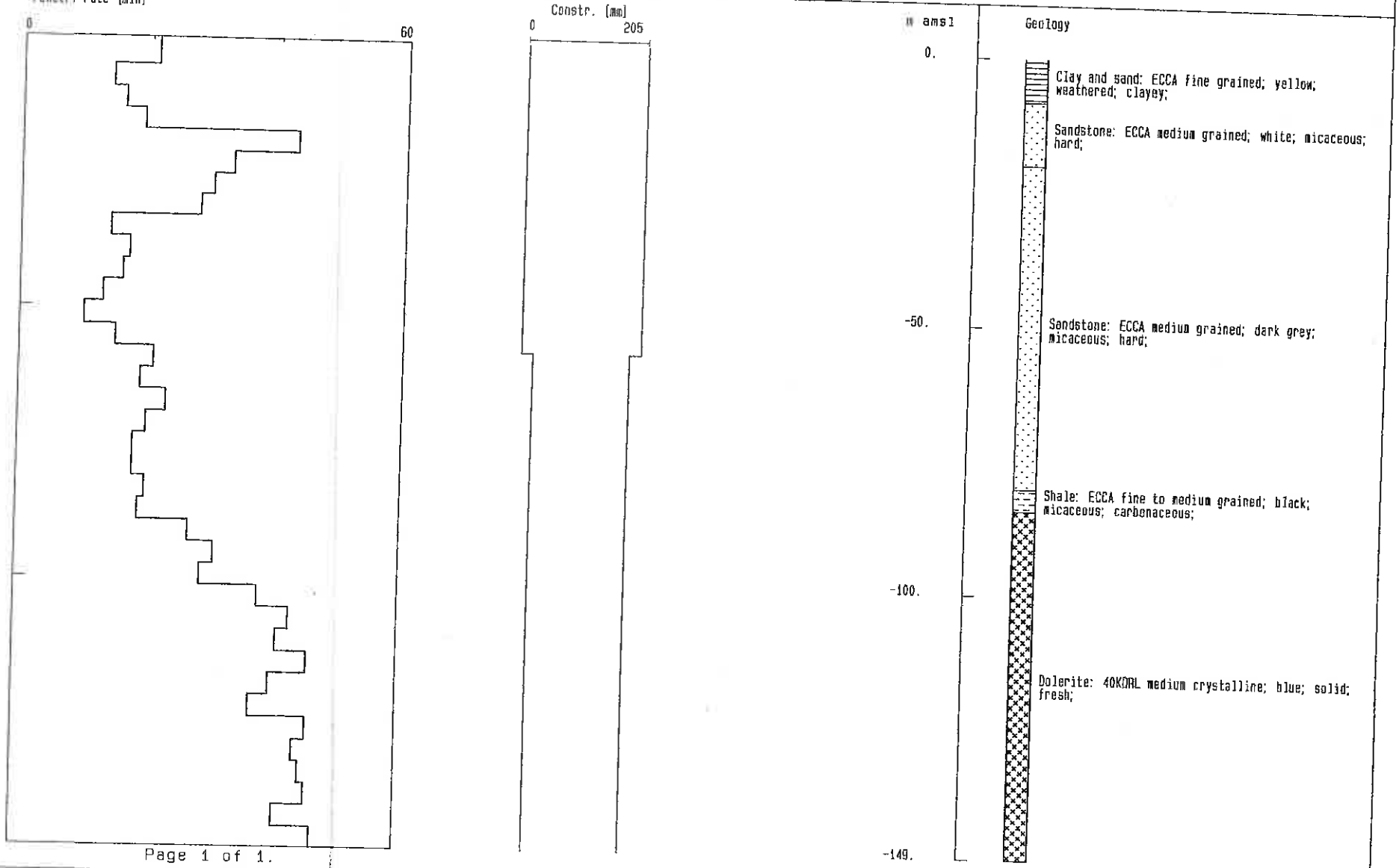
Site-ID : 2829AC00004

Nr on Map : L0158

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -110507.01 (E-W) 3150982.32 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Uitvligt
Notes : Dry borehole. Stone plugged.

Site ID: 2829AC00004 Number on map: LO15B

Longitude : 30.12835 Latitude : 28.47167
Ground Elevation: 0.00 mamsl Collar Height: 0.00 m
Depth of Casing: 0.00 m Diameter of Hole: 165 mm
Logged by: Date Drilled: 19960202

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	8.00	8.00	CLAY AND SAND : ECCA fine grained; yellow; weathered; clayey.
8.00	20.00	12.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
20.00	80.00	60.00	SANDSTONE : ECCA medium grained; dark grey; micaceous; hard.
80.00	84.00	4.00	SHALE : ECCA fine to medium grained; black; micaceous; carbonaceous.
84.00	149.00	65.00	DOLERITE : 40KDRL medium crystalline; blue; solid; fresh.

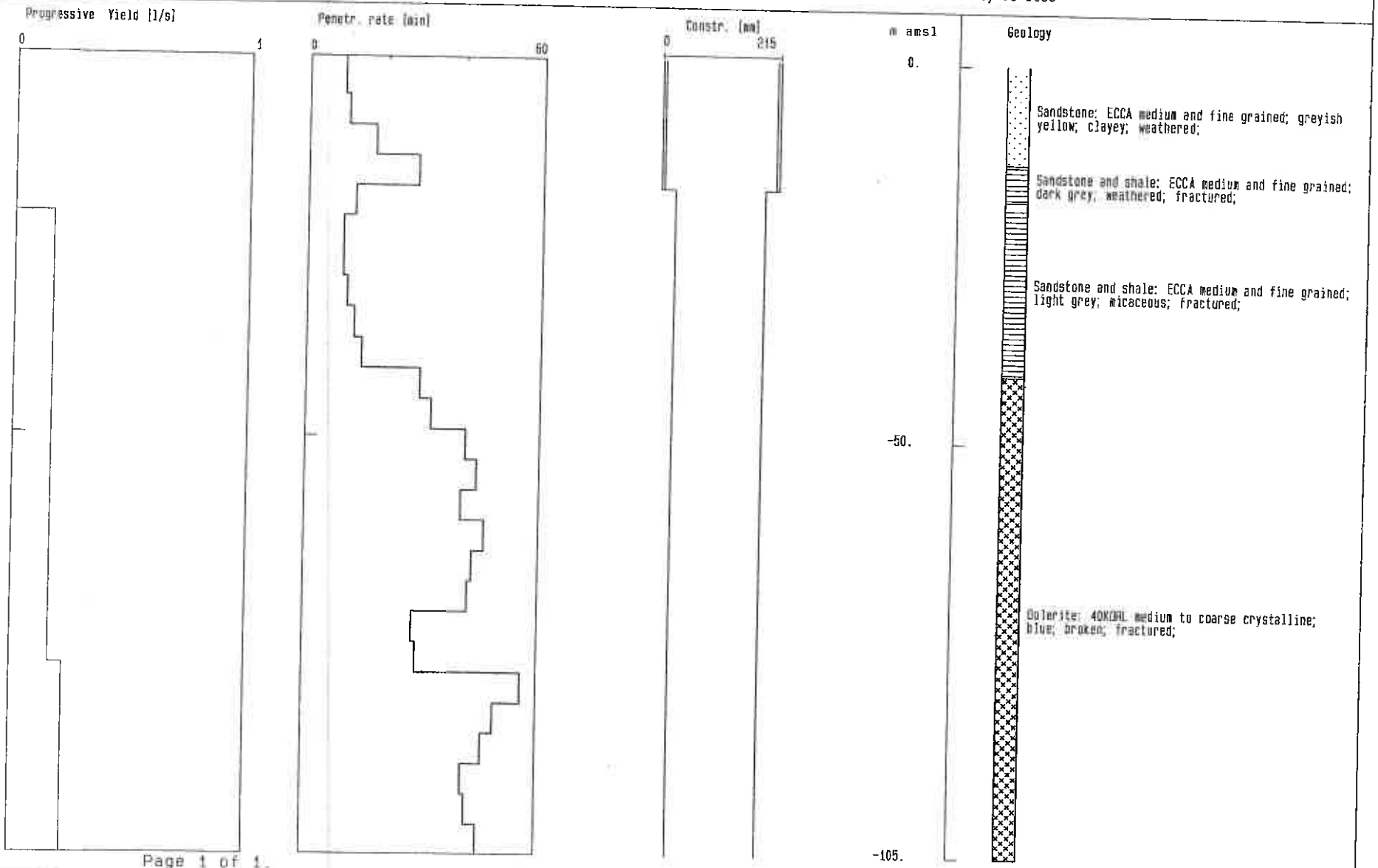
Geohydrology

(no information.)

Site-ID : 2829AC00005 Nr on Map : LX24B

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -115649.43 (E-W) 3153802.85 (N-S) 0.00 (Ground elevation) Date Plotted: May 06 1998



Site name : EMNAMBITHI - Esikoko
Notes :

Site ID: 2829AC00005
Number on map: LX24B

Longitude : 30.18113
Latitude : 28.49667
Ground Elevation: 0.00 mamsl
Collar Height: 0.42 m
Depth of Casing: 17.00 m
Diameter of Hole: 165 mm
Logged by: GHT
Date Drilled: 19960214

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	13.00	13.00	SANDSTONE : ECCA medium and fine grained; greyish yellow; clayey; weathered.
13.00	18.00	5.00	SANDSTONE AND SHALE : ECCA medium and fine grained; dark grey; weathered; fractured.
18.00	41.00	23.00	SANDSTONE AND SHALE : ECCA medium and fine grained; light grey; micaceous; fractured.
41.00	105.00	64.00	DOLERITE : 40KDRL medium to coarse crystalline; blue; broken; fractured.

Geohydrology

21.00	22.00	1.00	0.16 L/sec measured by volumetric measurement (container + stop-watch method).
80.00	81.00	1.00	0.22 L/sec measured by volumetric measurement (container + stop-watch method).

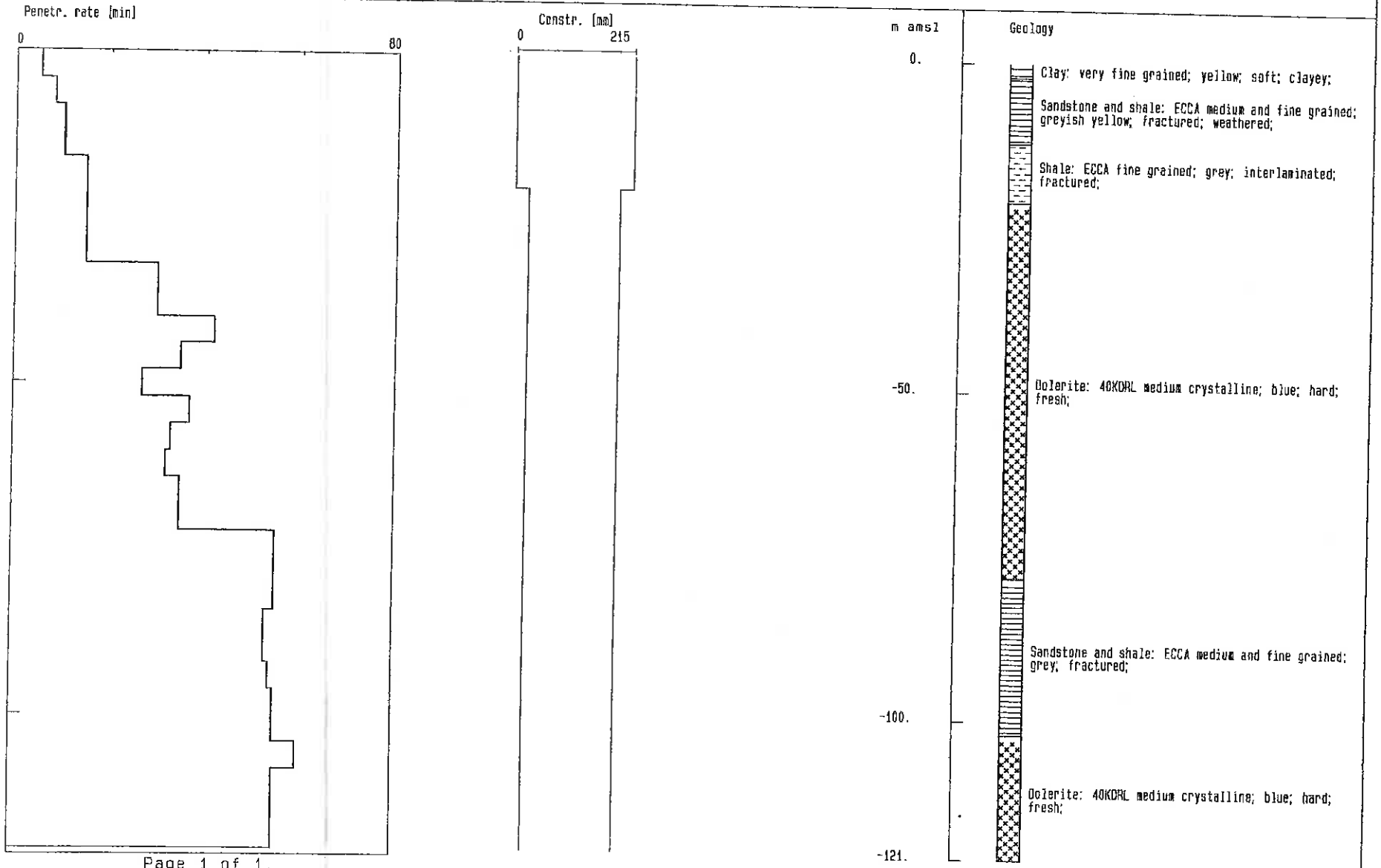
Site-ID : 2829AC00006

Nr on Map : LQ17A

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -99709.79 (E-W) 3159968.06 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Wembley
Notes : Dry borehole. Stone plugged.

Site ID: 2829AC00006 Number on map: LQ17A

Longitude : 30.01890 Latitude : 28.55361
Ground Elevation: 0.00 mamsl Collar Height: 0.00 m
Depth of Casing: 0.00 m Diameter of Hole: 165 mm
Logged by: Date Drilled: 19960225

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	2.00	2.00	CLAY : very fine grained; yellow; soft; clayey.
2.00	12.00	10.00	SANDSTONE AND SHALE : ECCA medium and fine grained; greyish yellow; fractured; weathered.
12.00	21.00	9.00	SHALE : ECCA fine grained; grey; interlaminated; fractured.
21.00	78.00	57.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
78.00	102.00	24.00	SANDSTONE AND SHALE : ECCA medium and fine grained; grey; fractured.
102.00	121.00	19.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.

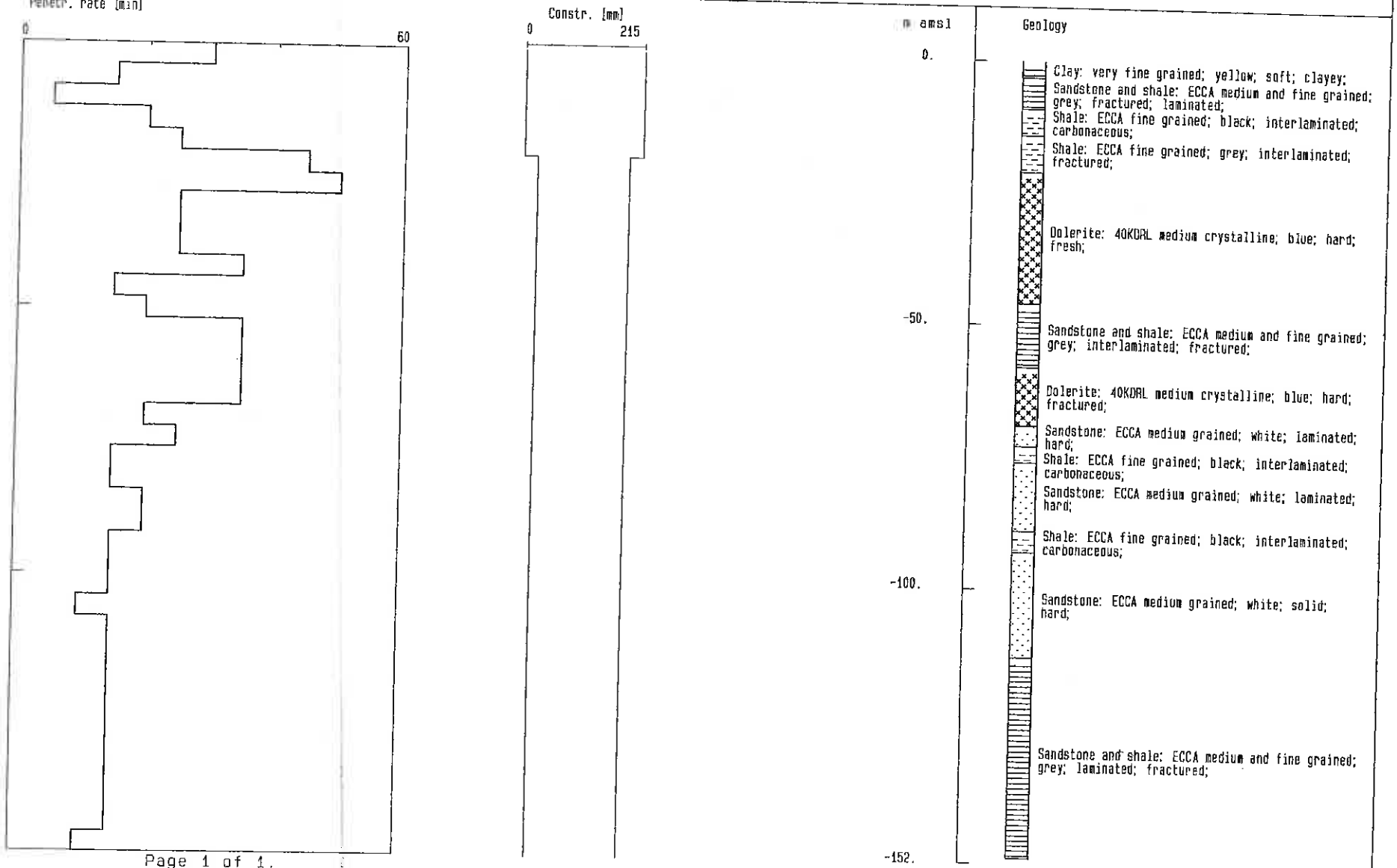
Geohydrology

(no information.)

Site-ID : 2829AC00007 Nr on Map : LQ17B

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -99791.81 (E-W) 3159875.65 (N-S) 0.00 (Ground elevation) Date Plotted: May 06 1996



Site name : EMNAMBITHI - Wembley
Notes : Dry borehole. Stone plugged.

Site ID: 2829AC00007
Number on map: LQ17B

Longitude : 30.01973
Latitude : 28.55277
Ground Elevation: 0.00 mamsl
Collar Height: 0.00 m
Depth of Casing: 0.00 m
Diameter of Hole: 165 mm
Logged by:
Date Drilled: 19960226

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	3.00	3.00	CLAY : very fine grained; yellow; soft; clayey.
3.00	9.00	6.00	SANDSTONE AND SHALE : ECCA medium and fine grained; grey; fractured; laminated.
9.00	14.00	5.00	SHALE : ECCA fine grained; black; interlaminated; carbonaceous.
14.00	21.00	7.00	SHALE : ECCA fine grained; grey; interlaminated; fractured.
21.00	46.00	25.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
46.00	58.00	12.00	SANDSTONE AND SHALE : ECCA medium and fine grained; grey; interlaminated; fractured.
58.00	69.00	11.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fractured.
69.00	73.00	4.00	SANDSTONE : ECCA medium grained; white; laminated; hard.
73.00	76.00	3.00	SHALE : ECCA fine grained; black; interlaminated; carbonaceous.
76.00	89.00	13.00	SANDSTONE : ECCA medium grained; white; laminated; hard.
89.00	93.00	4.00	SHALE : ECCA fine grained; black; interlaminated; carbonaceous.
93.00	113.00	20.00	SANDSTONE : ECCA medium grained; white; solid; hard.
113.00	151.00	38.00	SANDSTONE AND SHALE : ECCA medium and fine grained; grey; laminated; fractured.

Geohydrology

(no information.)

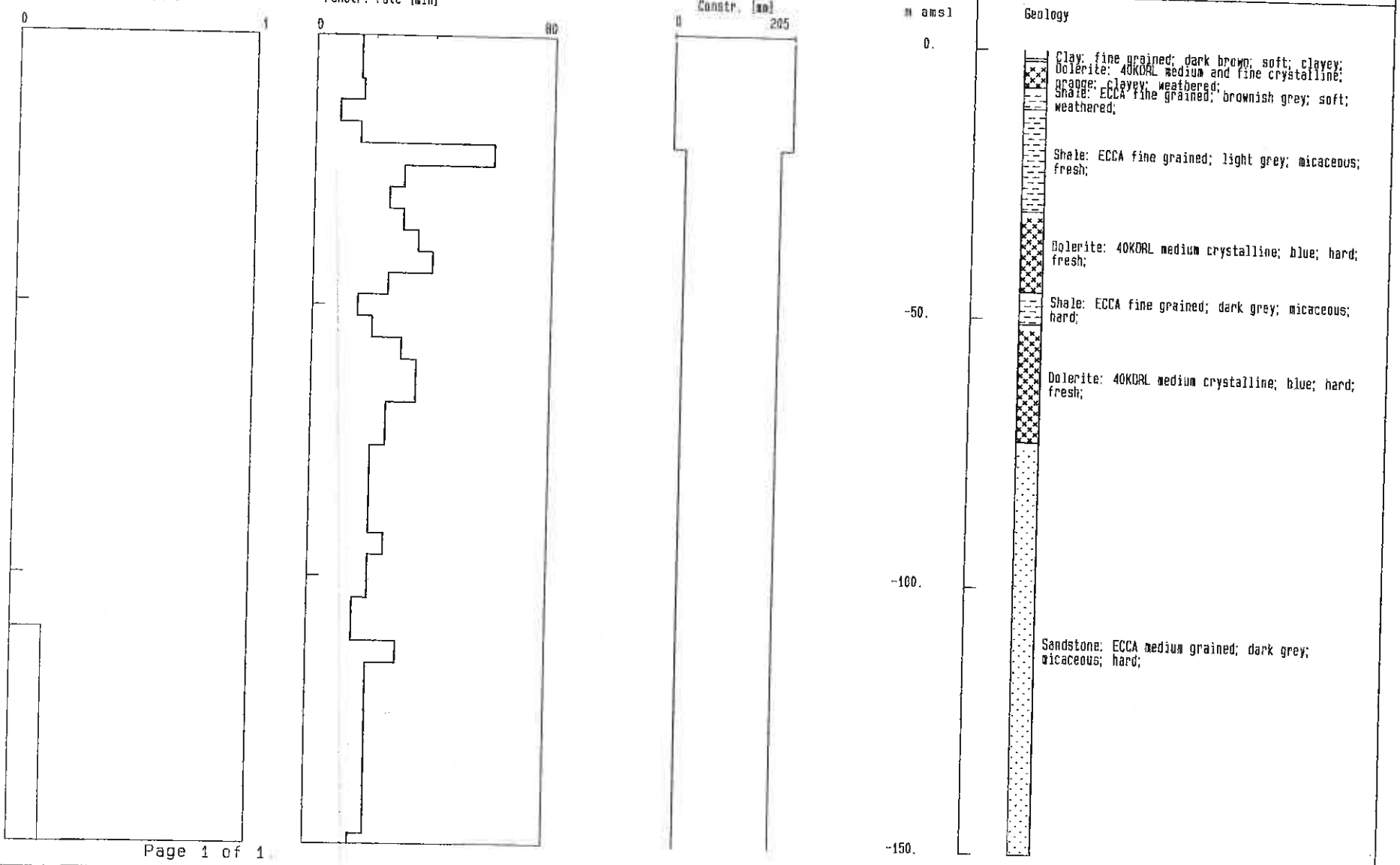
Site-ID : 2829AC00008

Nr on Map : LQ17C

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -99710.05 (E-W) 3159937.03 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Wembley
Notes :

Site ID: 2829AC00008
Number on map: LQ17C

Longitude : 30.01890
Ground Elevation: 0.00 mamsl
Depth of Casing: 20.00 m
Logged by: GHT

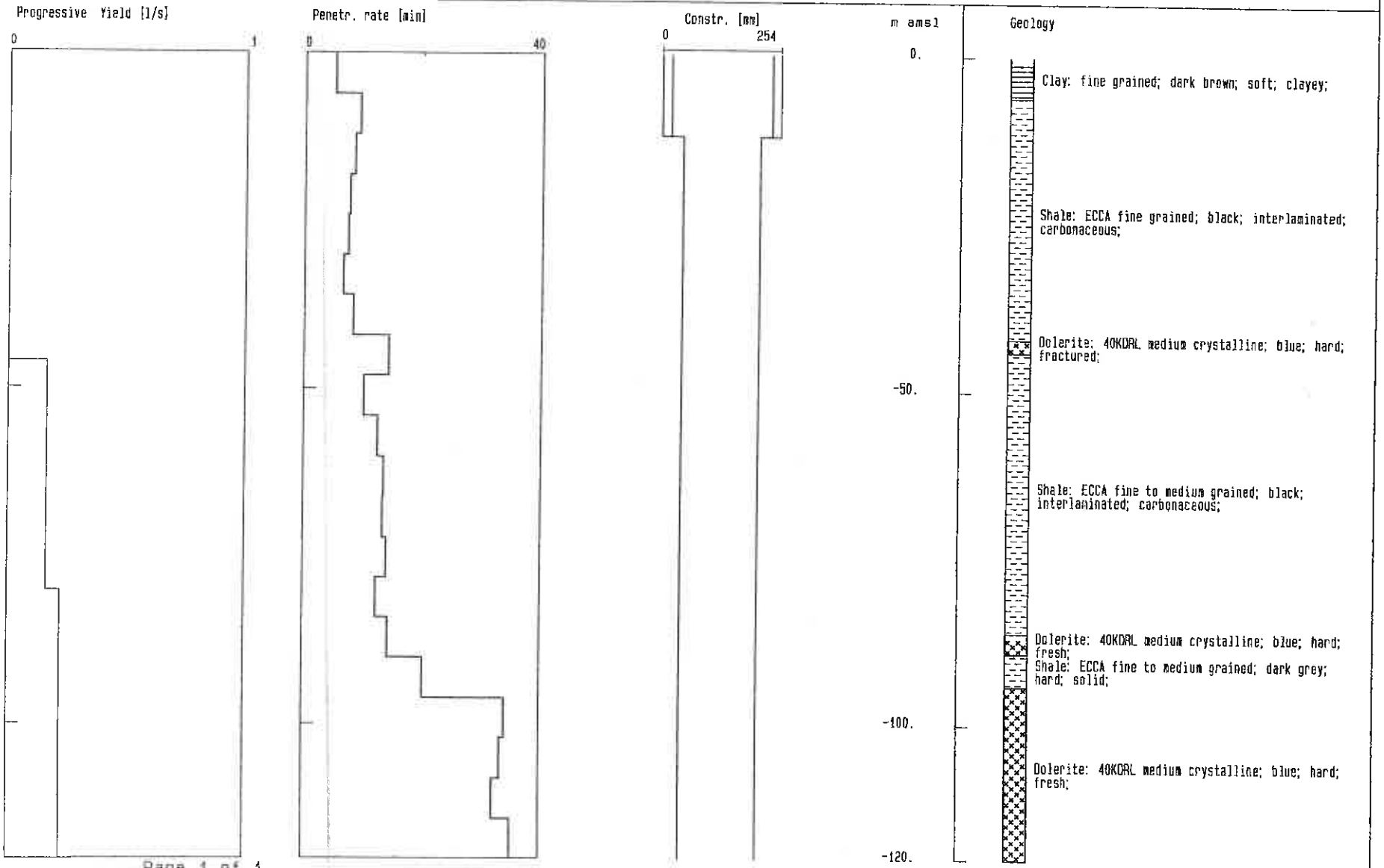
Latitude : 28.55333
Collar Height: 0.43 m
Diameter of Hole: 165 mm
Date Drilled: 19960227

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	2.00	2.00	CLAY : fine grained; dark brown; soft; clayey.
2.00	7.00	5.00	DOLERITE : 40KDRL medium and fine crystalline; orange; clayey; weathered.
7.00	11.00	4.00	SHALE : ECCA fine grained; brownish grey; soft; weathered.
11.00	30.00	19.00	SHALE : ECCA fine grained; light grey; micaceous; fresh.
30.00	45.00	15.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
45.00	51.00	6.00	SHALE : ECCA fine grained; dark grey; micaceous; hard.
51.00	73.00	22.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
73.00	150.00	77.00	SANDSTONE : ECCA medium grained; dark grey; micaceous; hard.
Geohydrology			
110.00	111.00	1.00	0.13 L/sec measured by volumetric measurement (container + stop-watch method).

Site-ID : 2829BC00001 Nr on Map : LB2

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -70164.77 (E-W) 3131492.74 (N-S) 0.00 (Ground elevation) Date Plotted: May 06 1996



Site name : EMNAMBITHI - Baldaskraal
Notes :

Site ID: 28298C00001 Number on map: LB2

Longitude : 29.71528 Latitude : 28.29861
Ground Elevation: 0.00 mamsl Collar Height: 0.45 m
Depth of Casing: 12.00 m Diameter of Hole: 165 mm
Logged by: GHT Date Drilled: 19960301

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	6.00	6.00	CLAY : fine grained; dark brown; soft; clayey.
6.00	42.00	36.00	SHALE : ECCA fine grained; black; interlaminated; carbonaceous.
42.00	44.00	2.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fractured.
44.00	86.00	42.00	SHALE : ECCA fine to medium grained; black; interlaminated; carbonaceous.
86.00	89.00	3.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
89.00	94.00	5.00	SHALE : ECCA fine to medium grained; dark grey; hard; solid.
94.00	120.00	26.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.

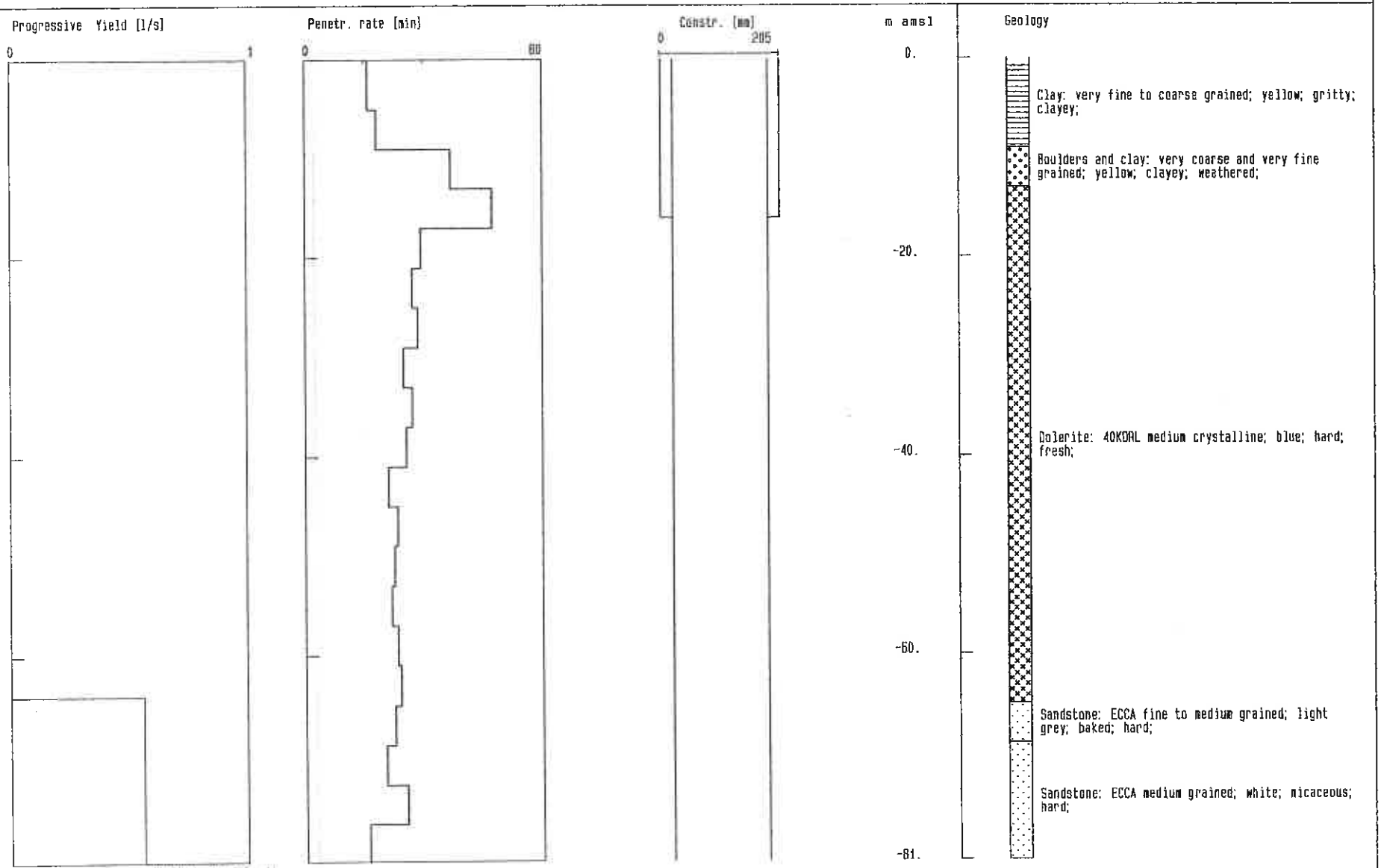
Geohydrology

46.00	47.00	1.00	0.16 L/sec measured by volumetric measurement (container + stop-watch method).
80.00	81.00	1.00	0.22 L/sec measured by volumetric measurement (container + stop-watch method).

Site-ID : 2829BC00002 Nr on Map : LC3

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -70125.90 (E-W) 3142514.32 (N-S) 0.00 (Ground elevation) Date Plotted: May 06 1996



Site name : EMNAMBITHI - Watersmeet
Notes :

Site ID: 2829BC00002 Number on map: LC3

Longitude : 29.71555 Latitude : 28.39806
Ground Elevation: 0.00 mamsl Collar Height: 0.42 m
Depth of Casing: 16.00 m Diameter of Hole: 165 mm
Logged by: GHT Date Drilled: 19960130

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	9.00	9.00	CLAY : very fine to coarse grained; yellow; gritty; clayey.
9.00	13.00	4.00	BOULDERS AND CLAY : very coarse and very fine grained; yellow; clayey; weathered.
13.00	65.00	52.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
65.00	69.00	4.00	SANDSTONE : ECCA fine to medium grained; light grey; baked; hard.
69.00	81.00	12.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
Geohydrology			
64.00	65.00	1.00	0.56 L/sec measured by volumetric measurement (container + stop-watch method).

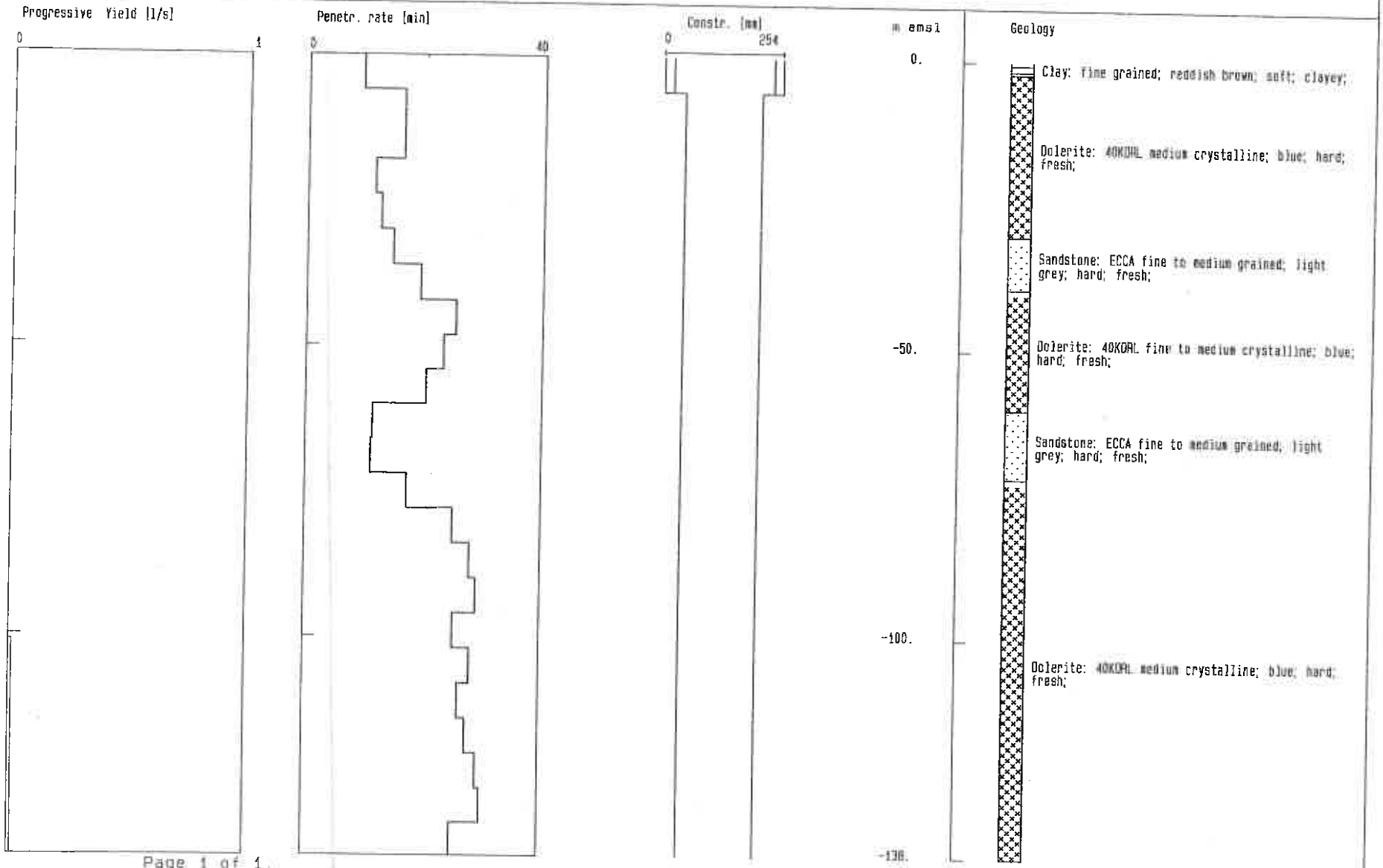
Site-ID : 2829BD00020

Nr on Map : LR18

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -87402.77 (E-W) 3162393.64 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - St Chads
Notes :

Site ID: 2829BD00020 Number on map: LR18

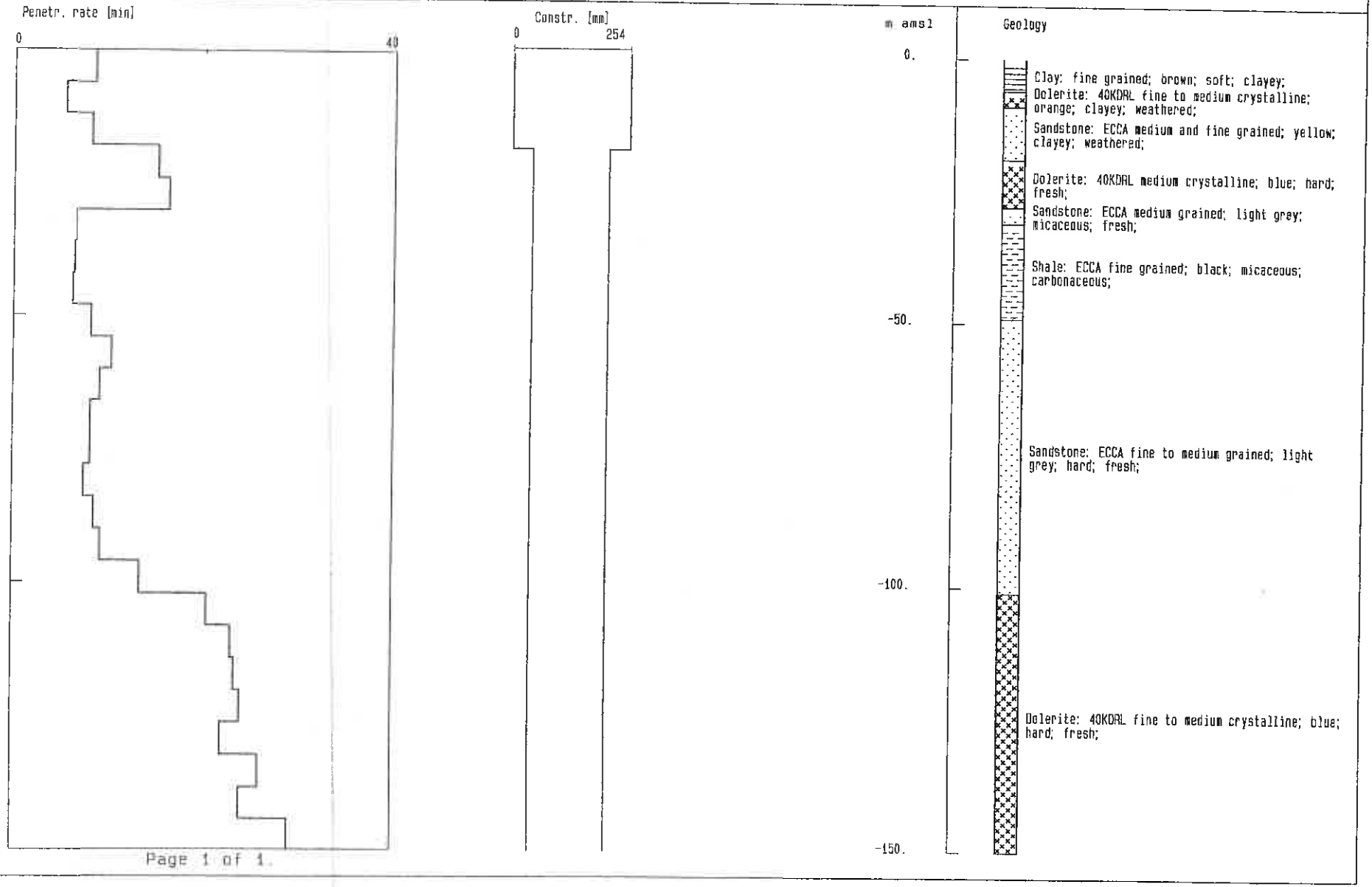
Longitude : 29.89334 Latitude : 28.57638
Ground Elevation: 0.00 mamsl Collar Height: 0.42 m
Depth of Casing: 6.00 m Diameter of Hole: 165 mm
Logged by: GHT Date Drilled: 19960305

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	2.00	2.00	CLAY : fine grained; reddish brown; soft; clayey.
2.00	30.00	28.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
30.00	39.00	9.00	SANDSTONE : ECCA fine to medium grained; light grey; hard; fresh.
39.00	60.00	21.00	DOLERITE : 40KDRL fine to medium crystalline; blue; hard; fresh.
60.00	72.00	12.00	SANDSTONE : ECCA fine to medium grained; light grey; hard; fresh.
72.00	138.00	66.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
Geohydrology			
101.00	102.00	1.00	0.01 L/sec measured by volumetric measurement (container + stop-watch method).

Site-ID : 28298000024 Nr on Map : LZ27A

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -73507.61 (E-W) 3141671.53 (N-S) 0.00 (Ground elevation) Date Plotted: May 06 1996



Site name : DRIEFONTEIN - Gcabane
Notes : Dry borehole. Stone plugged.

Site ID: 2829BD00024 Number on map: LZ27A

Longitude : 29.75000 Latitude : 28.39027
Ground Elevation: 0.00 mamsl Collar Height: 0.00 m
Depth of Casing: 0.00 m Diameter of Hole: 165 mm
Logged by: Date Drilled: 19960227

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	6.00	6.00	CLAY : fine grained; brown; soft; clayey.
6.00	9.00	3.00	DOLERITE : 40KDRL fine to medium crystalline; orange; clayey; weathered.
9.00	19.00	10.00	SANDSTONE : ECCA medium and fine grained; yellow; clayey; weathered.
19.00	28.00	9.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
28.00	31.00	3.00	SANDSTONE : ECCA medium grained; light grey; micaceous; fresh.
31.00	49.00	18.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
49.00	101.00	52.00	SANDSTONE : ECCA fine to medium grained; light grey; hard; fresh.
101.00	150.00	49.00	DOLERITE : 40KDRL fine to medium crystalline; blue; hard; fresh.

Geohydrology

(no information.)

Site name : DRIEFONTEIN - Gcabane
Notes :

Site ID: 2829BD00025
Number on map: LZ27B

Longitude : 29.75000
Latitude : 28.39030
Ground Elevation: 0.00 mamsl
Collar Height: 0.42 m
Depth of Casing: 18.00 m
Diameter of Hole: 165 mm
Logged by: GHT
Date Drilled: 19960228

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	15.00	15.00	CLAY : fine grained; reddish brown; soft; clayey.
15.00	23.00	8.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
23.00	151.00	128.00	SANDSTONE : ECCA fine to medium grained; grey; hard; fresh.

Geohydrology

0.00	0.00	0.00	0.00 L/sec.
100.00	102.00	2.00	0.02 L/sec measured by volumetric measurement (container + stop-watch method).

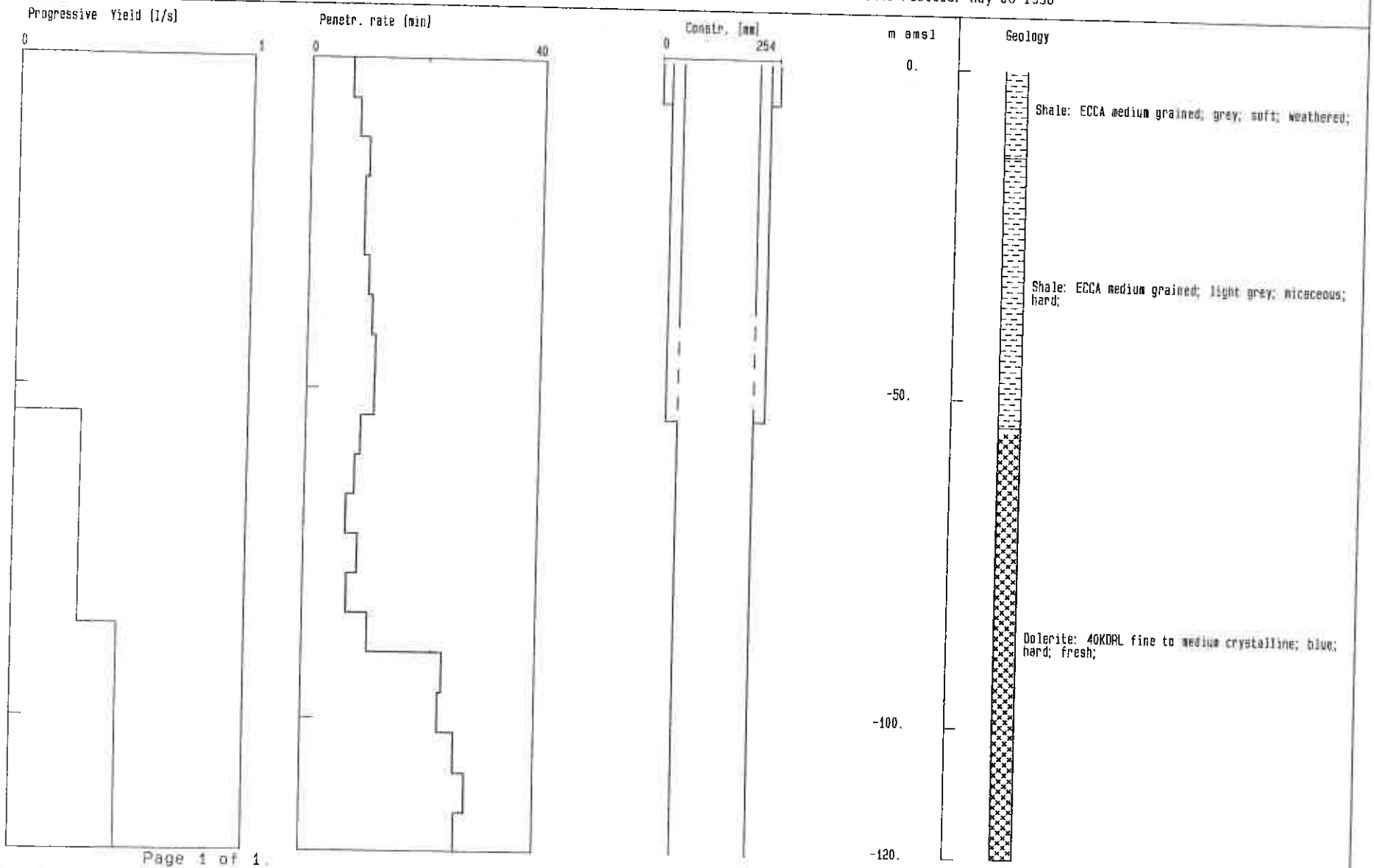
Site-ID : 2829BD00026

Nr on Map : LE5

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -60636.92 (E-W) 3140183.18 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : DRIEFONTEIN - Riverside
Notes :

Site ID: 2829BD00026

Number on map: LE5

Longitude : 29.61861
Ground Elevation: 0.00 mamsl
Depth of Casing: 54.00 m
Logged by: GHT

Latitude : 28.37750
Collar Height: 0.44 m
Diameter of Hole: 165 mm
Date Drilled: 19960229

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	13.00	13.00	SHALE : ECCA medium grained; grey; soft; weathered.
13.00	54.00	41.00	SHALE : ECCA medium grained; light grey; micaceous; hard.
54.00	120.00	66.00	DOLERITE : 40KDRL fine to medium crystalline; blue; hard; fresh.
Geohydrology			
54.00	56.00	2.00	0.28 L/sec measured by volumetric measurement (container + stop-watch method).
86.00	88.00	2.00	0.45 L/sec measured by volumetric measurement (container + stop-watch method).

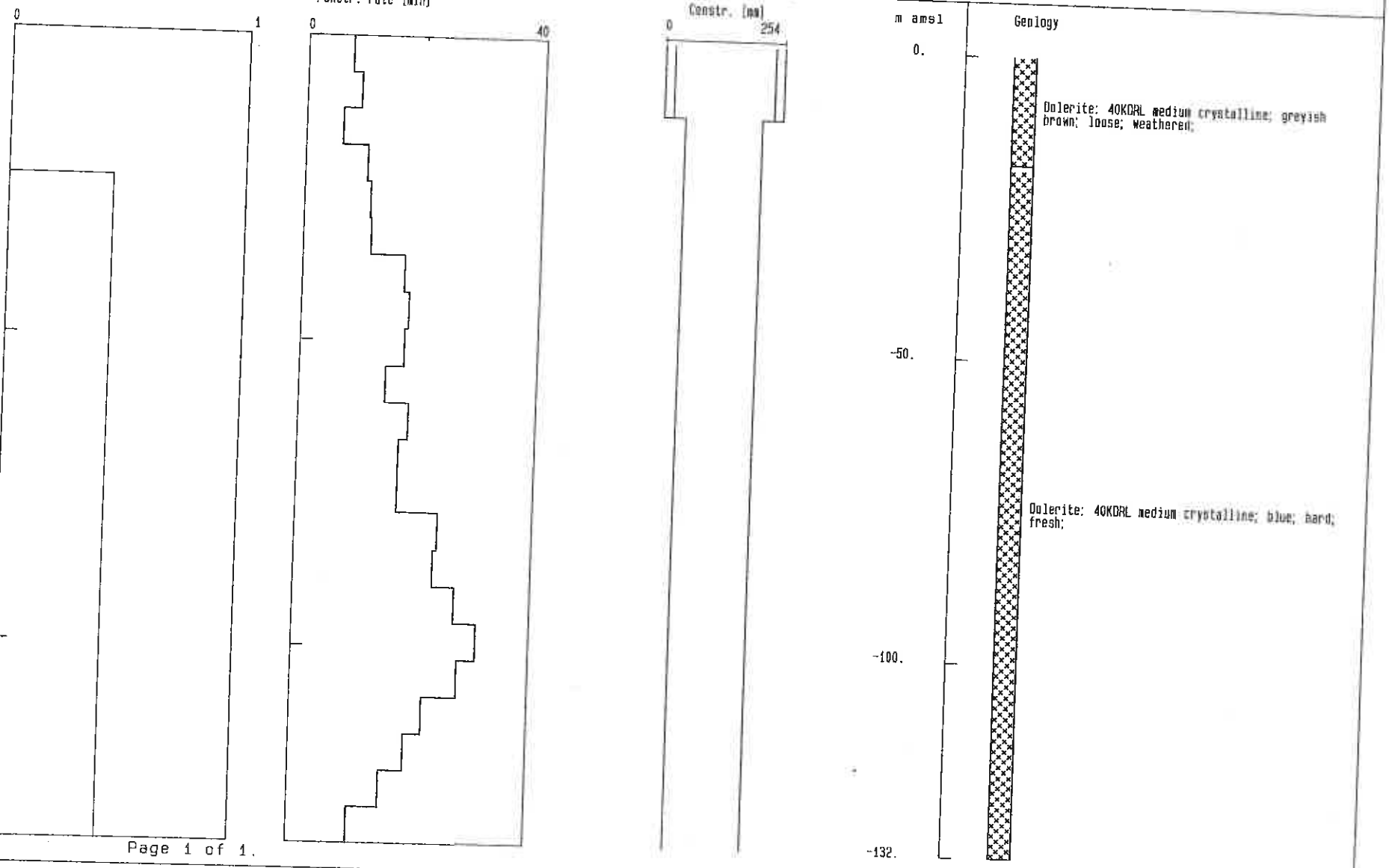
Site-ID : 2829BD00027

Nr on Map : LG7

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -84121.66 (E-W) 3172621.96 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Peters 2 School
Notes :

Site ID: 2829BD00027
Number on map: LG7

Longitude : 29.86056
Latitude : 28.66888
Ground Elevation: 0.00 mamsl
Collar Height: 0.41 m
Depth of Casing: 12.00 m
Diameter of Hole: 165 mm
Logged by: GHT
Date Drilled: 19960304

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	18.00	18.00	DOLERITE : 40KDRL medium crystalline; greyish brown; loose; weathered.
18.00	132.00	114.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
Geohydrology			
24.00	26.00	2.00	0.44 L/sec measured by volumetric measurement (container + stop-watch method).

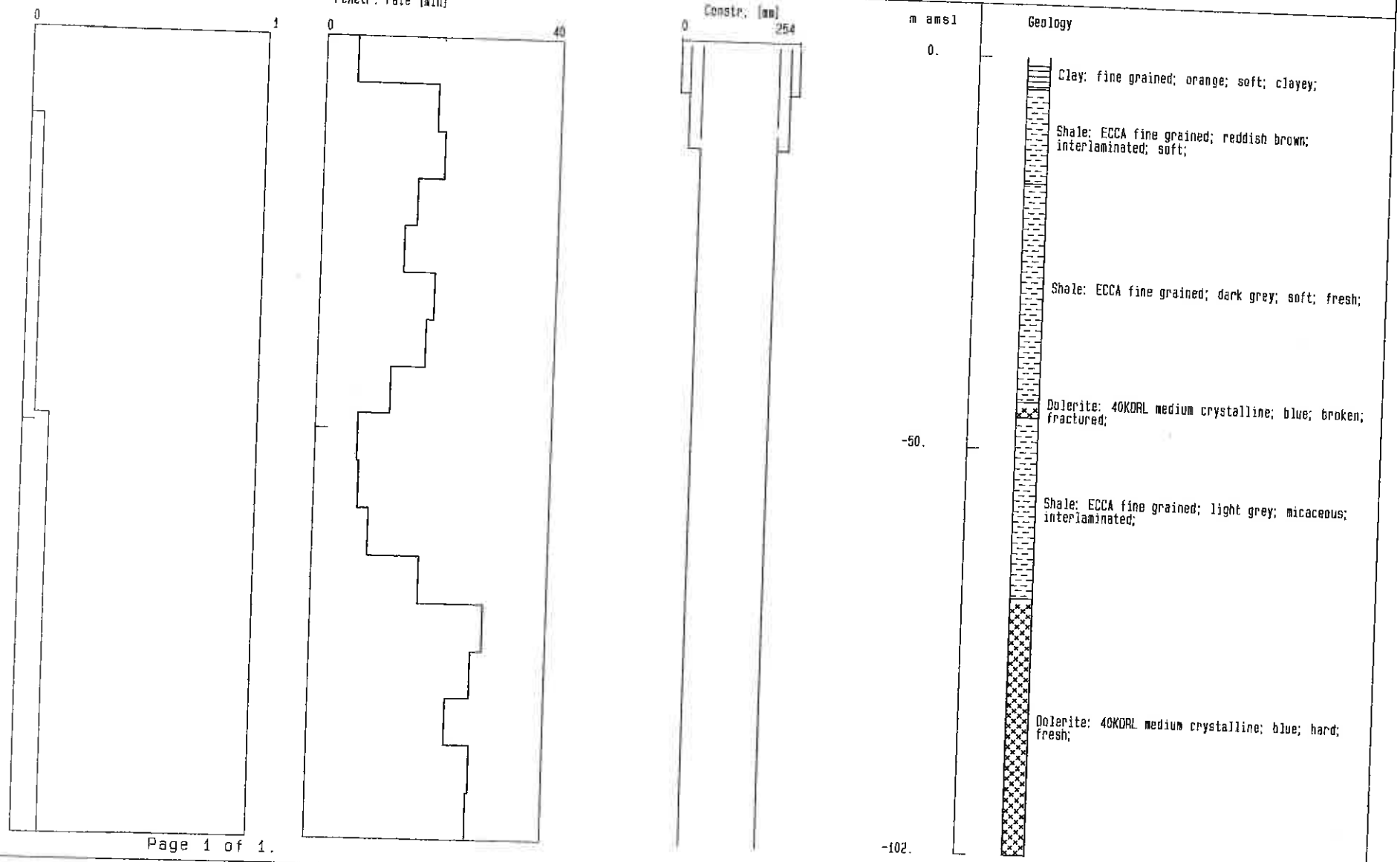
Site-ID : 2829BD00028

Nr on Map : LJ10

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : -70541.55 (E-W) 3132141.10 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : DRIEFONTEIN - Baldaskraal 2
Notes :

Site ID: 2829BD00028

Number on map: LJ10

Longitude : 29.71916
Ground Elevation: 0.00 mamsl
Depth of Casing: 13.00 m
Logged by: GHT

Latitude : 28.30444
Collar Height: 0.43 m
Diameter of Hole: 165 mm
Date Drilled: 19960302

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	4.00	4.00	CLAY : fine grained; orange; soft; clayey.
4.00	16.00	12.00	SHALE : ECCA fine grained; reddish brown; interlaminated; soft.
16.00	44.00	28.00	SHALE : ECCA fine grained; dark grey; soft; fresh.
44.00	46.00	2.00	DOLERITE : 40KDRL medium crystalline; blue; broken; fractured.
46.00	69.00	23.00	SHALE : ECCA fine grained; light grey; micaceous; interlaminated.
69.00	102.00	33.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
Geohydrology			
11.00	13.00	2.00	0.05 L/sec measured by volumetric measurement (container + stop-watch method).
49.00	51.00	2.00	0.11 L/sec measured by volumetric measurement (container + stop-watch method).

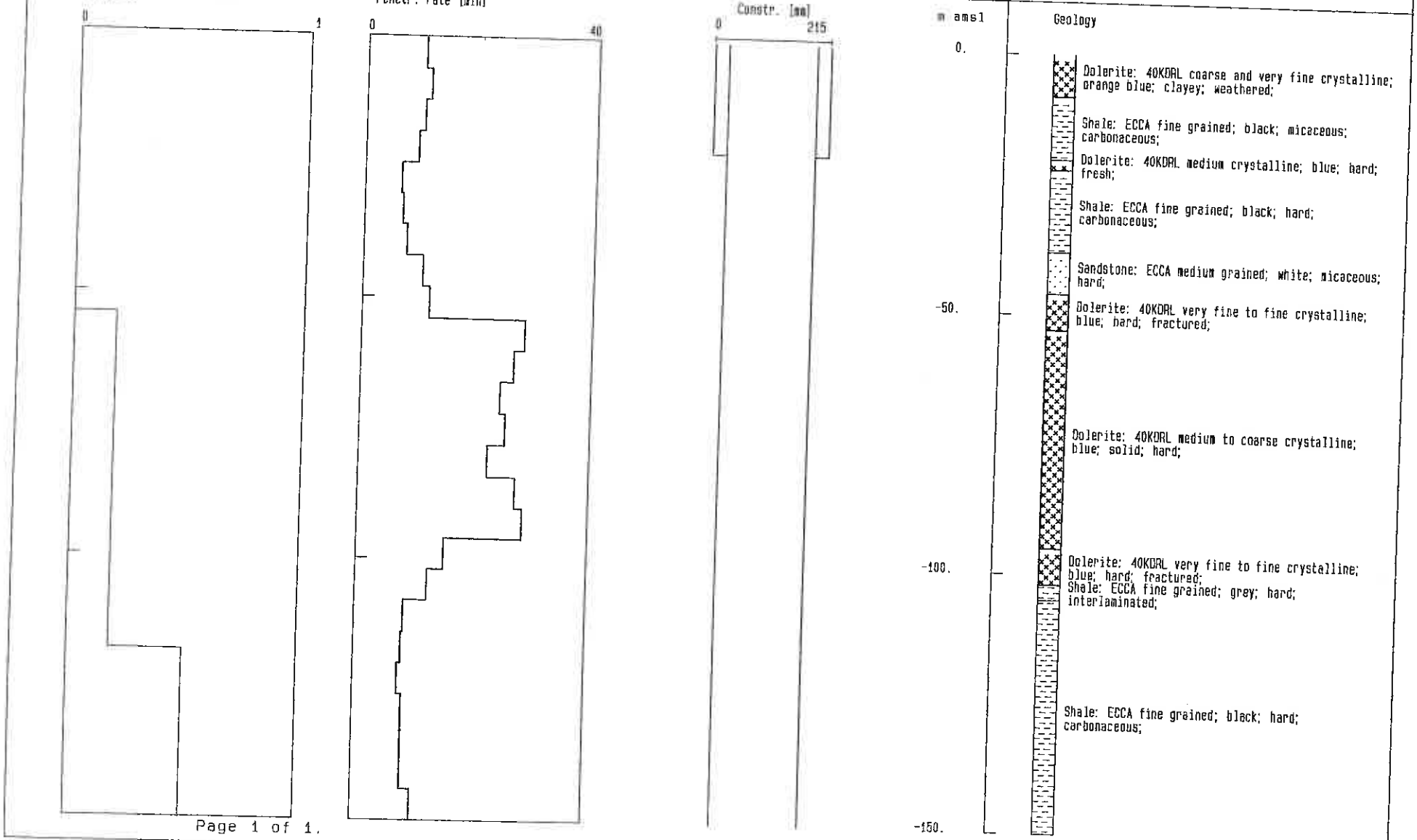
Site-ID : 2830AC00011

Nr on Map : LK1

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 73503.21 (E-W) 3146781.85 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Limehill 1
Notes :

Site ID: 2830AC00011

Number on map: LK1

Longitude : 30.24972
Ground Elevation: 0.00 mamsl
Depth of Casing: 21.00 m
Logged by: GHT

Latitude : 28.43638
Collar Height: 0.40 m
Diameter of Hole: 165 mm
Date Drilled: 19960208

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	8.00	8.00	DOLERITE : 40KDRL coarse and very fine crystalline; orange blue; clayey; weathered.
8.00	20.00	12.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
20.00	22.00	2.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
22.00	38.00	16.00	SHALE : ECCA fine grained; black; hard; carbonaceous.
38.00	46.00	8.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
46.00	53.00	7.00	DOLERITE : 40KDRL very fine to fine crystalline; blue; hard; fractured.
53.00	95.00	42.00	DOLERITE : 40KDRL medium to coarse crystalline; blue; solid; hard.
95.00	102.00	7.00	DOLERITE : 40KDRL very fine to fine crystalline; blue; hard; fractured.
102.00	105.00	3.00	SHALE : ECCA fine grained; grey; hard; interlaminated.
105.00	150.00	45.00	SHALE : ECCA fine grained; black; hard; carbonaceous.

Geohydrology

54.00	60.00	6.00	0.18 L/sec measured by volumetric measurement (container + stop-watch method).
118.00	120.00	2.00	0.50 L/sec measured by volumetric measurement (container + stop-watch method).

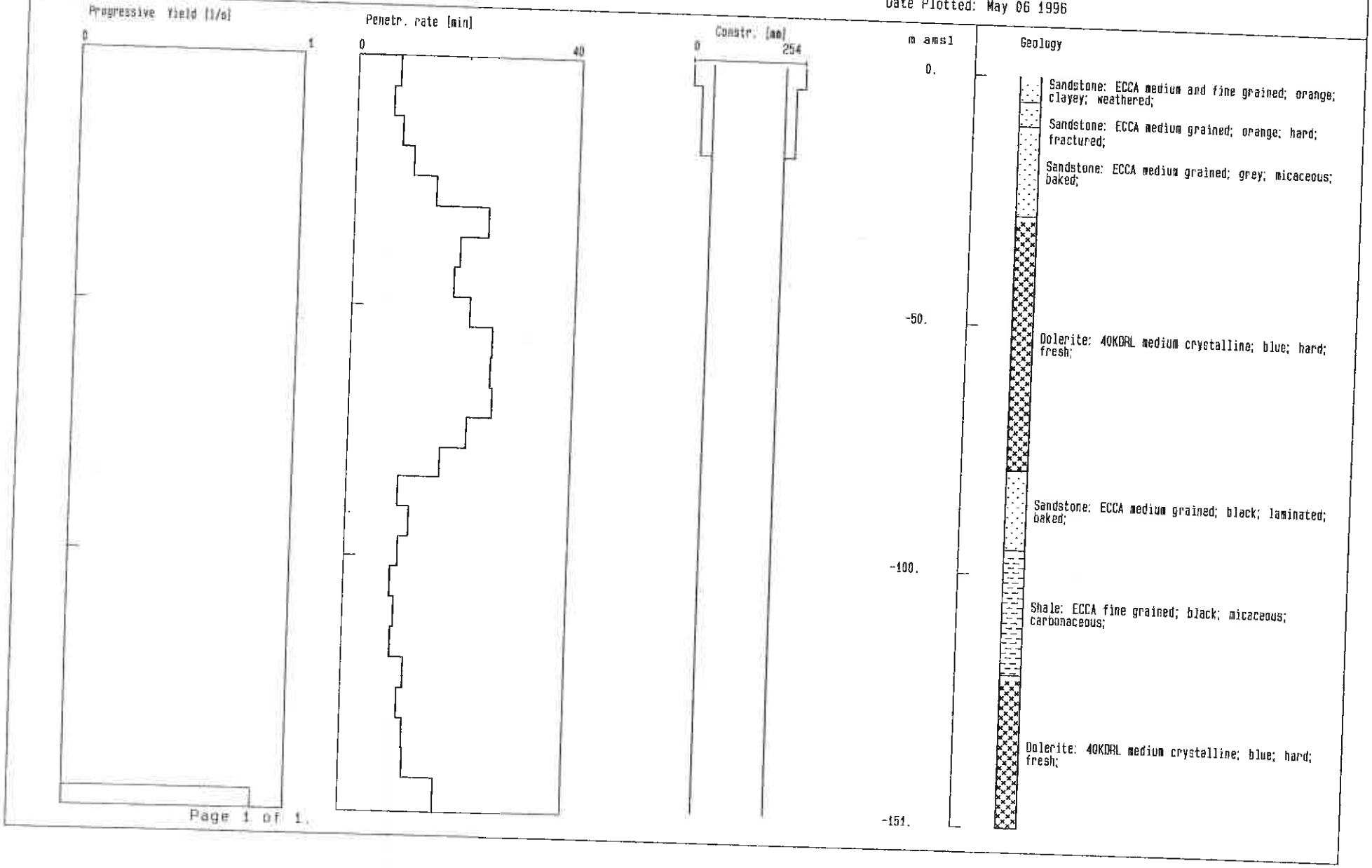
Site-ID : 2830AC00012

Nr on Map : LK2

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 74348.10 (E-W) 3146572.14 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Limehill 2
Notes :

Site ID: 2830AC00012 | Number on map: LK2

Longitude : 30.24111 | Latitude : 28.43444
Ground Elevation: 0.00 mamsl | Collar Height: 0.42 m
Depth of Casing: 18.00 m | Diameter of Hole: 165 mm
Logged by: GHT | Date Drilled: 19960208

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	5.00	5.00	SANDSTONE : ECCA medium and fine grained; orange; clayey; weathered.
5.00	10.00	5.00	SANDSTONE : ECCA medium grained; orange; hard; fractured.
10.00	28.00	18.00	SANDSTONE : ECCA medium grained; grey; micaceous; baked.
28.00	79.00	51.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
79.00	95.00	16.00	SANDSTONE : ECCA medium grained; black; laminated; baked.
95.00	120.00	25.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
120.00	151.00	31.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
Geohydrology			
147.00	149.00	2.00	0.85 L/sec measured by volumetric measurement (container + stop-watch method).

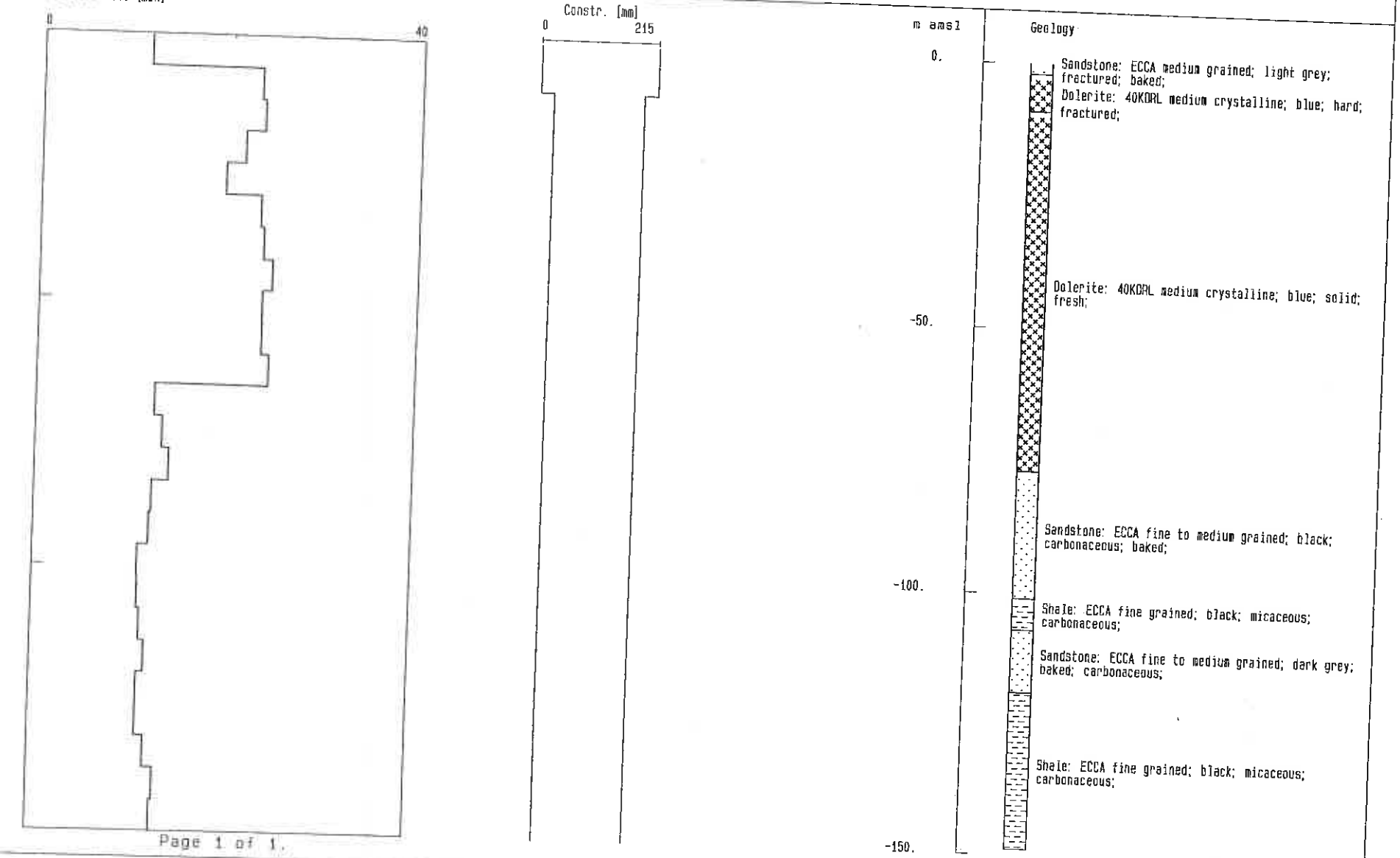
Site-ID : 2830AC00013

Nr on Map : LY25A

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 76029.24 (E-W) 3147660.14 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Tholeni Rural
Notes : Dry borehole. Stone plugged.

Site ID: 2830AC00013

Number on map: LY25A

Longitude : 30.22388
Latitude : 28.44416
Ground Elevation: 0.00 mamsl
Collar Height: 0.00 m
Depth of Casing: 0.00 m
Diameter of Hole: 165 mm
Logged by:
Date Drilled: 19960218

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	2.00	2.00	SANDSTONE : ECCA medium grained; light grey; fractured; baked.
2.00	9.00	7.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fractured.
9.00	77.00	68.00	DOLERITE : 40KDRL medium crystalline; blue; solid; fresh.
77.00	101.00	24.00	SANDSTONE : ECCA fine to medium grained; black; carbonaceous; baked.
101.00	107.00	6.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
107.00	119.00	12.00	SANDSTONE : ECCA fine to medium grained; dark grey; baked; carbonaceous.
119.00	149.00	30.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.

Geohydrology

(no information.)

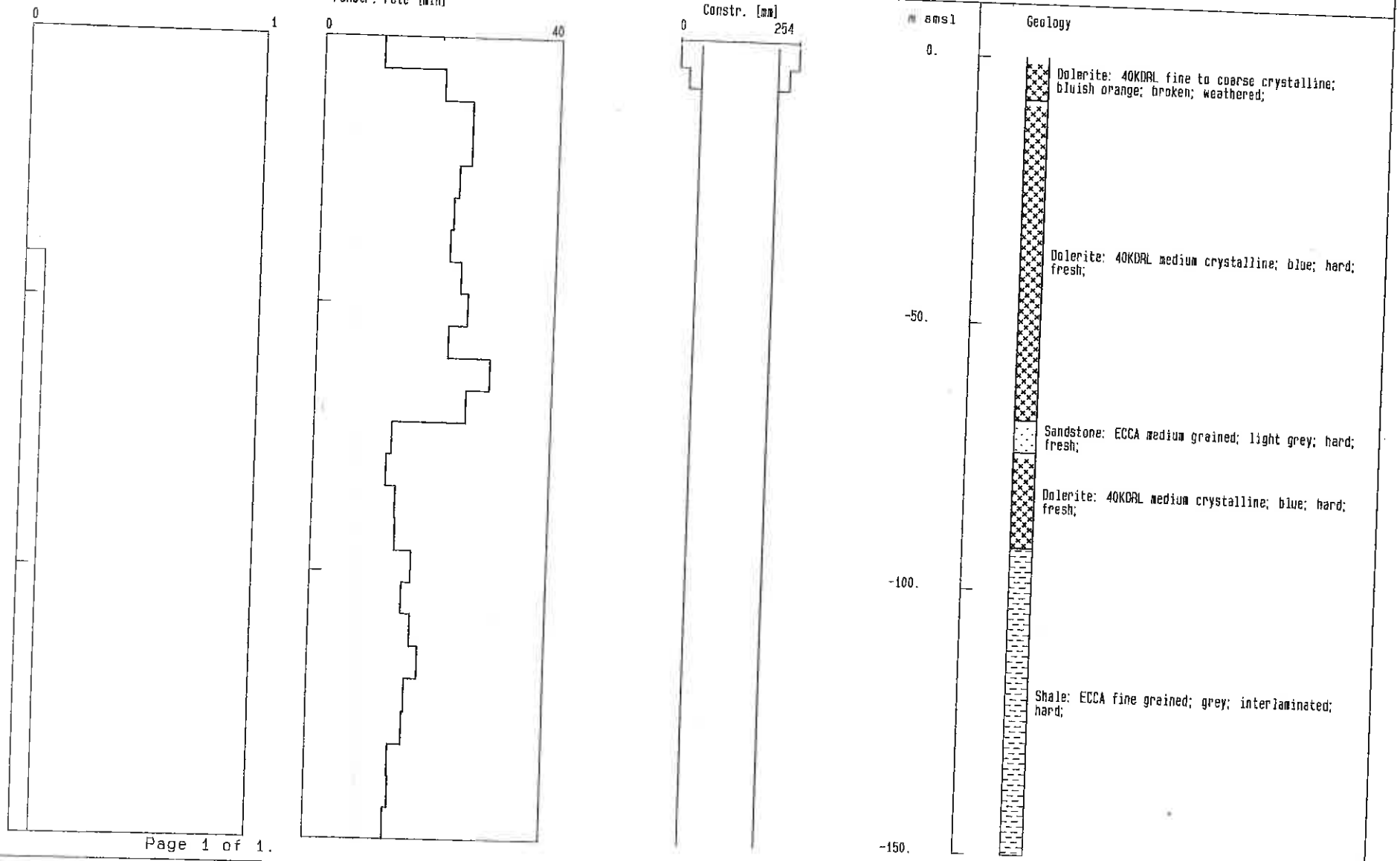
Site-ID : 2830AC00014

Nr on Map : LY25B

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 76056.08 (E-W) 3147599.35 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Tholeni Rural
Notes :

Site ID: 2830AC00014
Number on map: LY25B

Longitude : 30.22361
Latitude : 28.44361
Ground Elevation: 0.00 mamsl
Collar Height: 0.44 m
Depth of Casing: 8.00 m
Diameter of Hole: 165 mm
Logged by: GHT
Date Drilled: 19960222

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	8.00	8.00	DOLERITE : 40KDRL fine to coarse crystalline; bluish orange; broken; weathered.
8.00	68.00	60.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
68.00	74.00	6.00	SANDSTONE : ECCA medium grained; light grey; hard; fresh.
74.00	92.00	18.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
92.00	150.00	58.00	SHALE : ECCA fine grained; grey; interlaminated; hard.

Geohydrology

42.00	43.00	1.00	0.08 L/sec measured by volumetric measurement (container + stop-watch method).

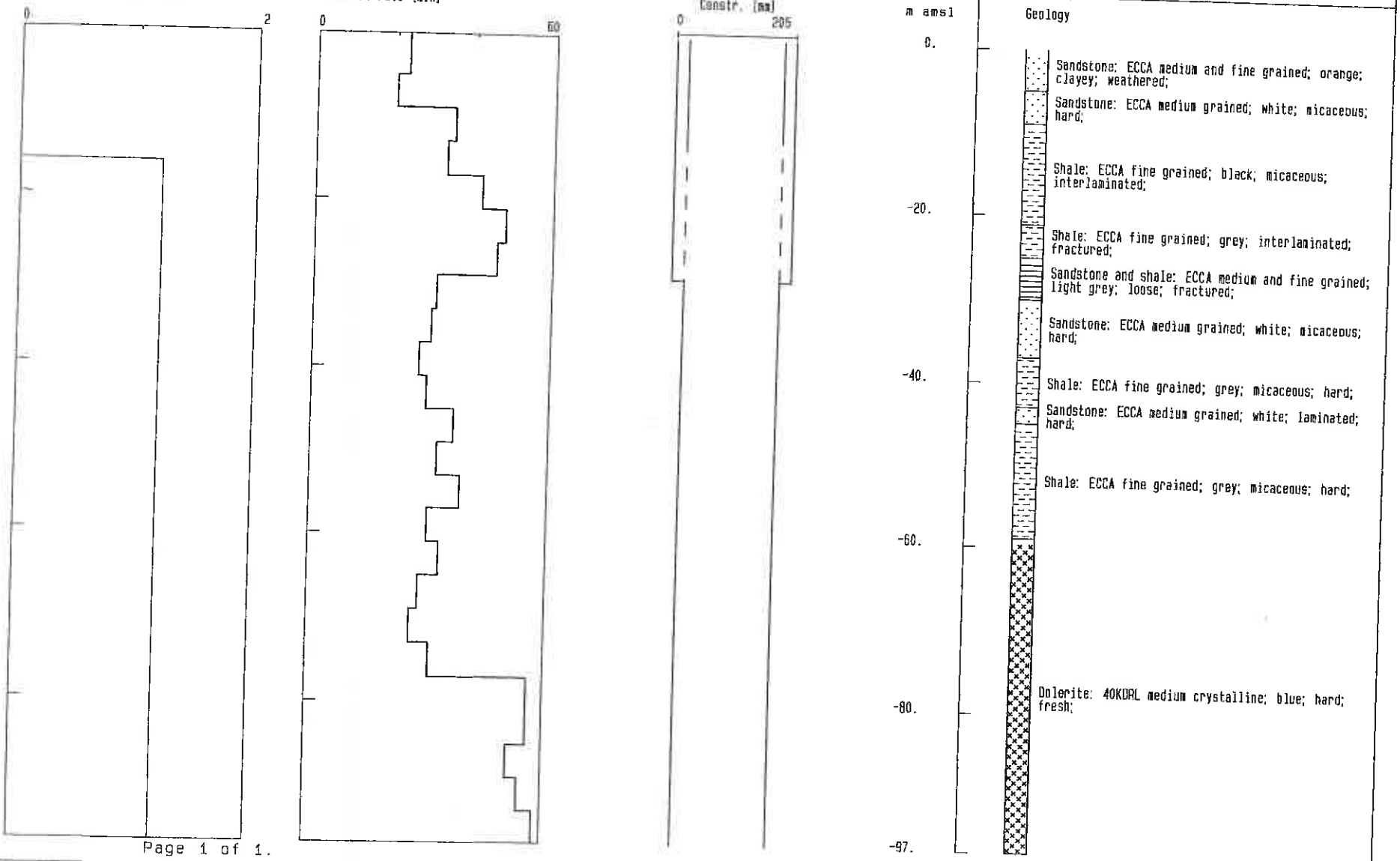
Site-ID : 2830AC00015

Nr on Map : LH8

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 77273.11(E-W) 3152933.83(N-S) 0.00(Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Namakazi
Notes :

Site ID: 2830AC00015
Number on map: LH8

Longitude : 30.21083
Latitude : 28.49167
Ground Elevation: 0.00 mamsl
Collar Height: 0.40 m
Depth of Casing: 29.00 m
Diameter of Hole: 165 mm
Logged by: GHT
Date Drilled: 19960218

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	5.00	5.00	SANDSTONE : ECCA medium and fine grained; orange; clayey; weathered.
5.00	9.00	4.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
9.00	21.00	12.00	SHALE : ECCA fine grained; black; micaceous; interlaminated.
21.00	25.00	4.00	SHALE : ECCA fine grained; grey; interlaminated; fractured.
25.00	30.00	5.00	SANDSTONE AND SHALE : ECCA medium and fine grained; light grey; loose; fractured.
30.00	37.00	7.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
37.00	43.00	6.00	SHALE : ECCA fine grained; grey; micaceous; hard.
43.00	45.00	2.00	SANDSTONE : ECCA medium grained; white; laminated; hard.
45.00	59.00	14.00	SHALE : ECCA fine grained; grey; micaceous; hard.
59.00	97.00	38.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
Geohydrology			
16.00	18.00	2.00	1.20 L/sec measured by volumetric measurement (container + stop-watch method).

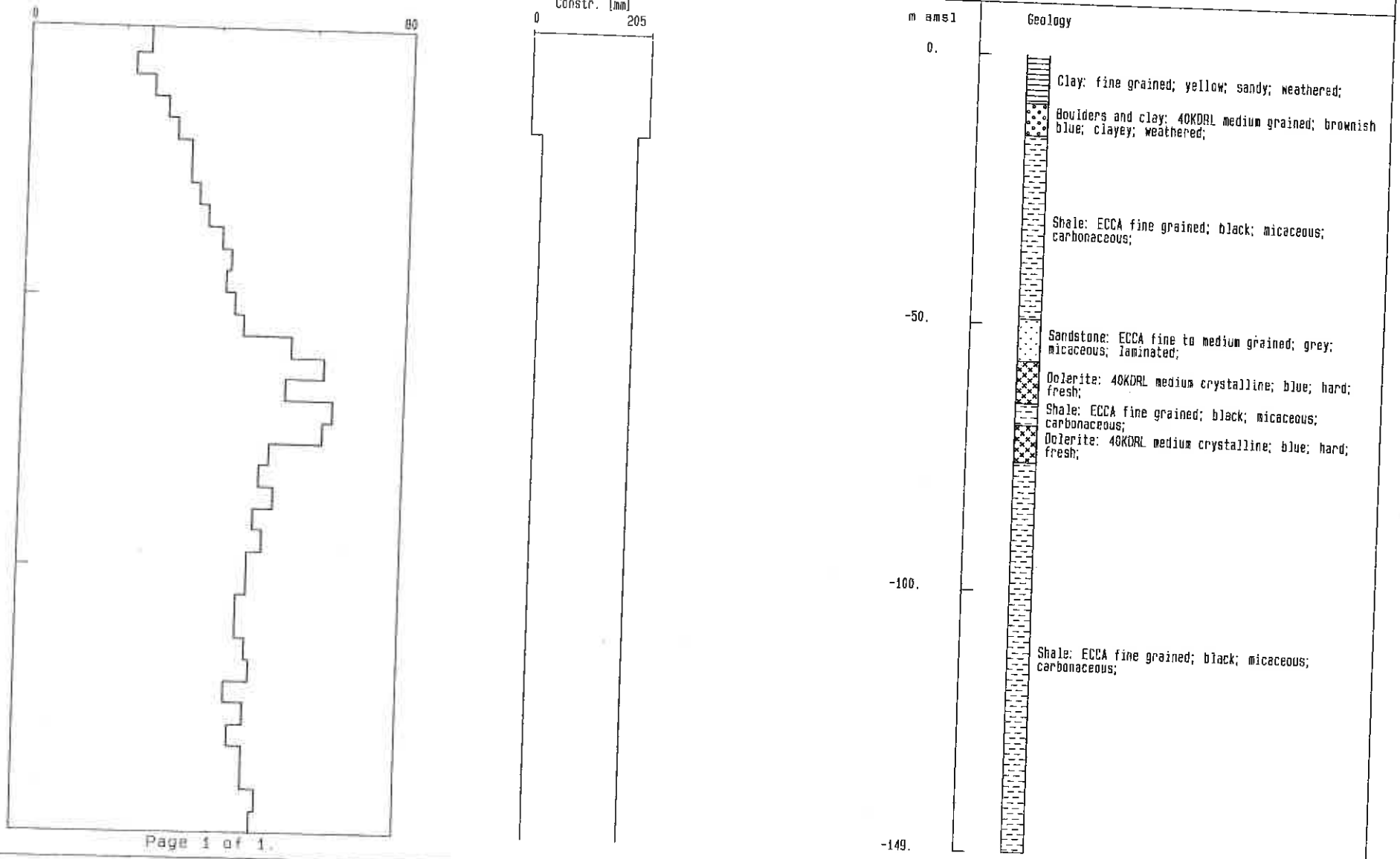
Site-ID : 2830AC00016

Nr on Map : LS19A

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 75927.30 (E-W) 3150707.33 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Vaalkop
Notes : Dry borehole. Stone plugged.

Site ID: 2830AC00016
Number on map: LS19A

Longitude : 30.22472
Latitude : 28.47166
Ground Elevation: 0.00 mamsl
Collar Height: 0.00 m
Depth of Casing: 0.00 m
Diameter of Hole: 165 mm
Logged by:
Date Drilled: 19960221

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	9.00	9.00	CLAY : fine grained; yellow; sandy; weathered.
9.00	15.00	6.00	BOULDERS AND CLAY : 40KDRL medium grained; brownish blue; clayey; weathered.
15.00	49.00	34.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
49.00	57.00	8.00	SANDSTONE : ECCA fine to medium grained; grey; micaceous; laminated.
57.00	65.00	8.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
65.00	69.00	4.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
69.00	76.00	7.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
76.00	149.00	73.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.

Geohydrology

(no information.)

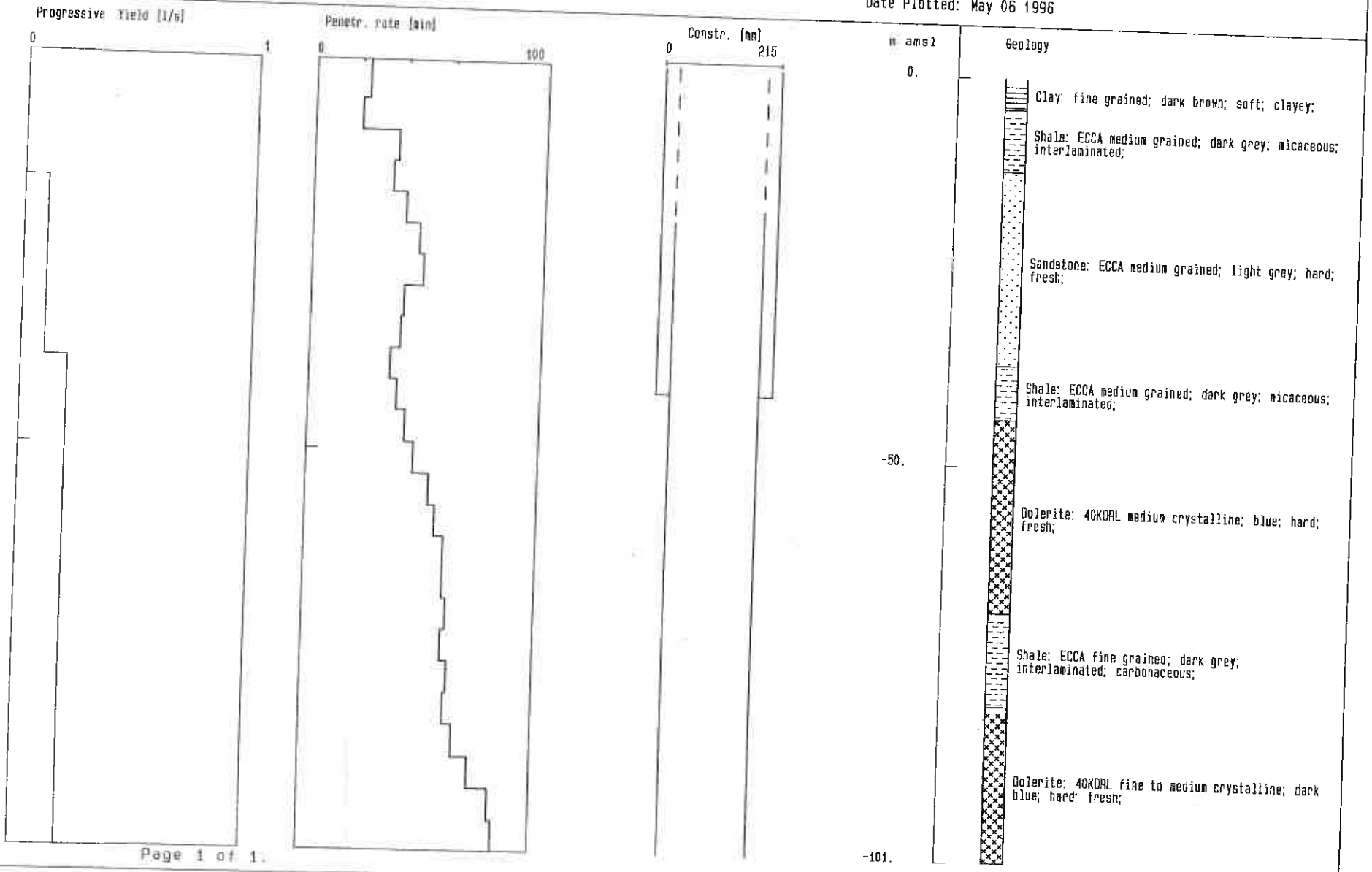
Site-ID : 2830AC00017

Nr on Map : LS19B

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 75954.12 (E-W) 3150800.60 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Vaalkop
Notes :

Site ID: 2830AC00017

Number on map: LS19B

Longitude : 30.22444
Ground Elevation: 0.00 mamsl
Depth of Casing: 42.00 m
Logged by: GHT

Latitude : 28.47250
Collar Height: 0.40 m
Diameter of Hole: 165 mm
Date Drilled: 19960221

Geology

Depth (m) from	to	Thickness (m)	Description
0.00	4.00	4.00	CLAY : fine grained; dark brown; soft; clayey.
4.00	12.00	8.00	SHALE : ECCA medium grained; dark grey; micaceous; interlaminated.
12.00	37.00	25.00	SANDSTONE : ECCA medium grained; light grey; hard; fresh.
37.00	44.00	7.00	SHALE : ECCA medium grained; dark grey; micaceous; interlaminated.
44.00	69.00	25.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
69.00	81.00	12.00	SHALE : ECCA fine grained; dark grey; interlaminated; carbonaceous.
81.00	101.00	20.00	DOLERITE : 40KDRL fine to medium crystalline; dark blue; hard; fresh.

Geohydrology

0.00	0.00	0.00	0.00 L/sec.
16.00	18.00	2.00	0.10 L/sec measured by volumetric measurement (container + stop-watch method).
39.00	40.00	1.00	0.20 L/sec measured by volumetric measurement (container + stop-watch method).

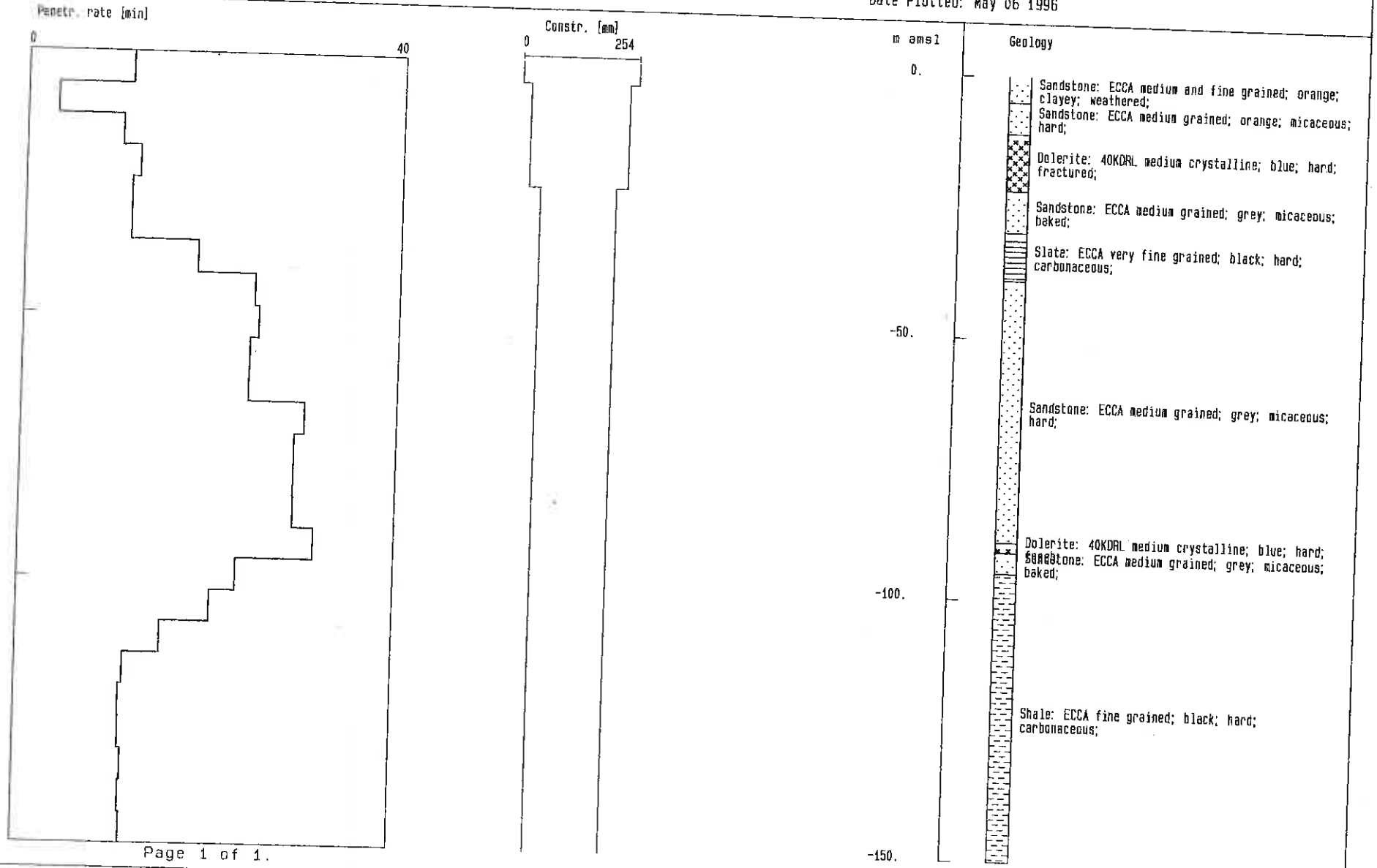
Site-ID : 2830AC00018

Nr on Map : LW23A

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 77101.88 (E-W) 3145881.62 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Tholeni Town
Notes : Dry borehole. Stone plugged.

Site ID: 2830AC00018
Number on map: LW23A

Longitude : 30.21305
Latitude : 28.42805
Ground Elevation: 0.00 mamsl
Collar Height: 0.00 m
Depth of Casing: 0.00 m
Diameter of Hole: 165 mm
Logged by:
Date Drilled: 19960220

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	5.00	5.00	SANDSTONE : ECCA medium and fine grained; orange; clayey; weathered.
5.00	11.00	6.00	SANDSTONE : ECCA medium grained; orange; micaceous; hard.
11.00	22.00	11.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fractured.
22.00	30.00	8.00	SANDSTONE : ECCA medium grained; grey; micaceous; baked.
30.00	39.00	9.00	SLATE : ECCA very fine grained; black; hard; carbonaceous.
39.00	89.00	50.00	SANDSTONE : ECCA medium grained; grey; micaceous; hard.
89.00	91.00	2.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
91.00	95.00	4.00	SANDSTONE : ECCA medium grained; grey; micaceous; baked.
95.00	150.00	55.00	SHALE : ECCA fine grained; black; hard; carbonaceous.

Geohydrology

(no information.)

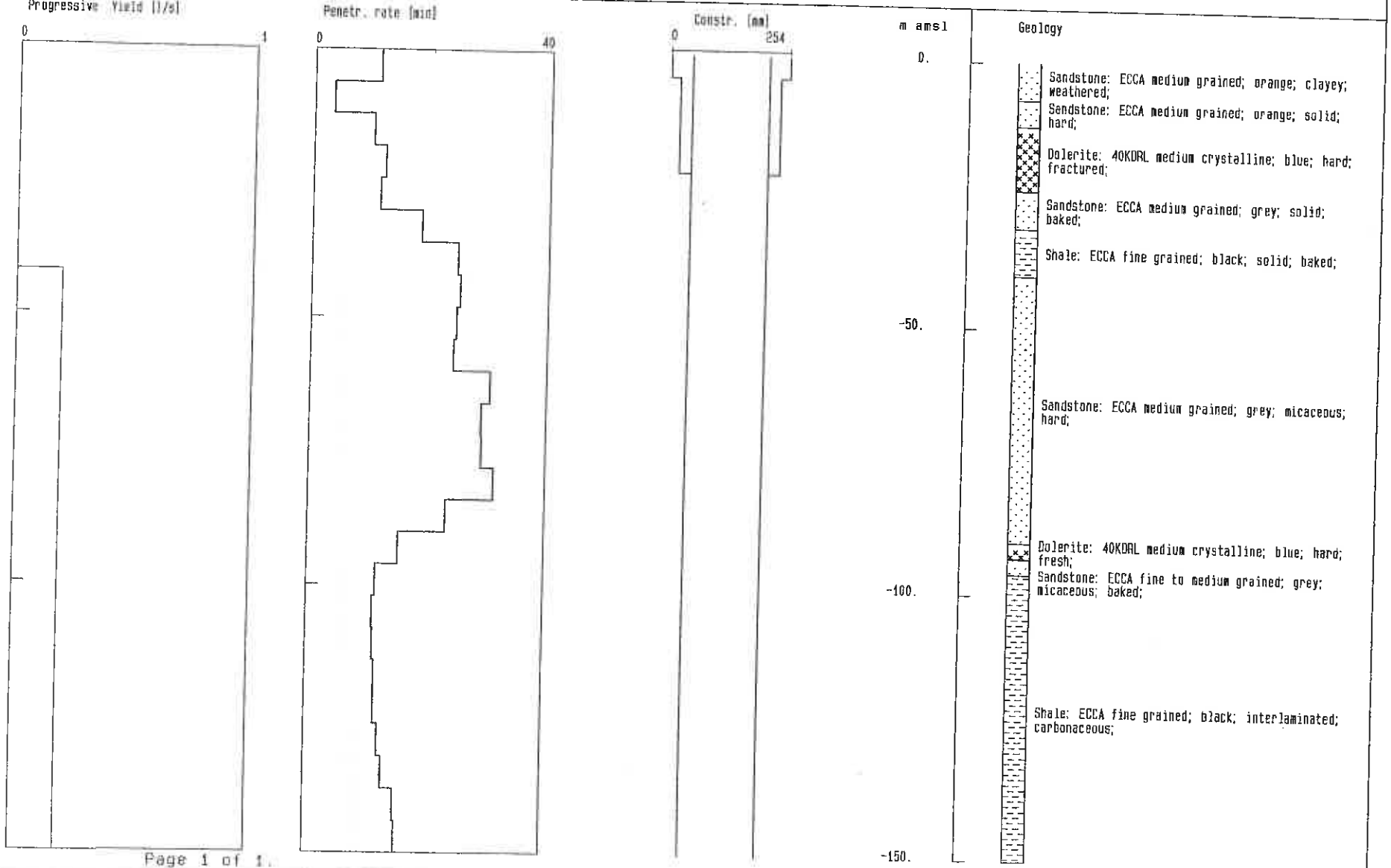
Site-ID : 2830AC00019

Nr on Map : LW23B

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 77129.31(E-W) 3145881.80(N-S) 0.00(Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Tholeni Town
Notes :

Site ID: 2830AC00019

Number on map: LW23B

Longitude : 30.21277
Ground Elevation: 0.00 mamsl
Depth of Casing: 22.00 m
Logged by: GHT

Latitude : 28.42805
Collar Height: 0.41 m
Diameter of Hole: 165 mm
Date Drilled: 19960221

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	7.00	7.00	SANDSTONE : ECCA medium grained; orange; clayey; weathered.
7.00	12.00	5.00	SANDSTONE : ECCA medium grained; orange; solid; hard.
12.00	24.00	12.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fractured.
24.00	31.00	7.00	SANDSTONE : ECCA medium grained; grey; solid; baked.
31.00	40.00	9.00	SHALE : ECCA fine grained; black; solid; baked.
40.00	90.00	50.00	SANDSTONE : ECCA medium grained; grey; micaceous; hard.
90.00	93.00	3.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
93.00	96.00	3.00	SANDSTONE : ECCA fine to medium grained; grey; micaceous; baked.
96.00	150.00	54.00	SHALE : ECCA fine grained; black; interlaminated; carbonaceous.
Geohydrology			
42.00	43.00	1.00	0.19 L/sec measured by volumetric measurement (container + stop-watch method).

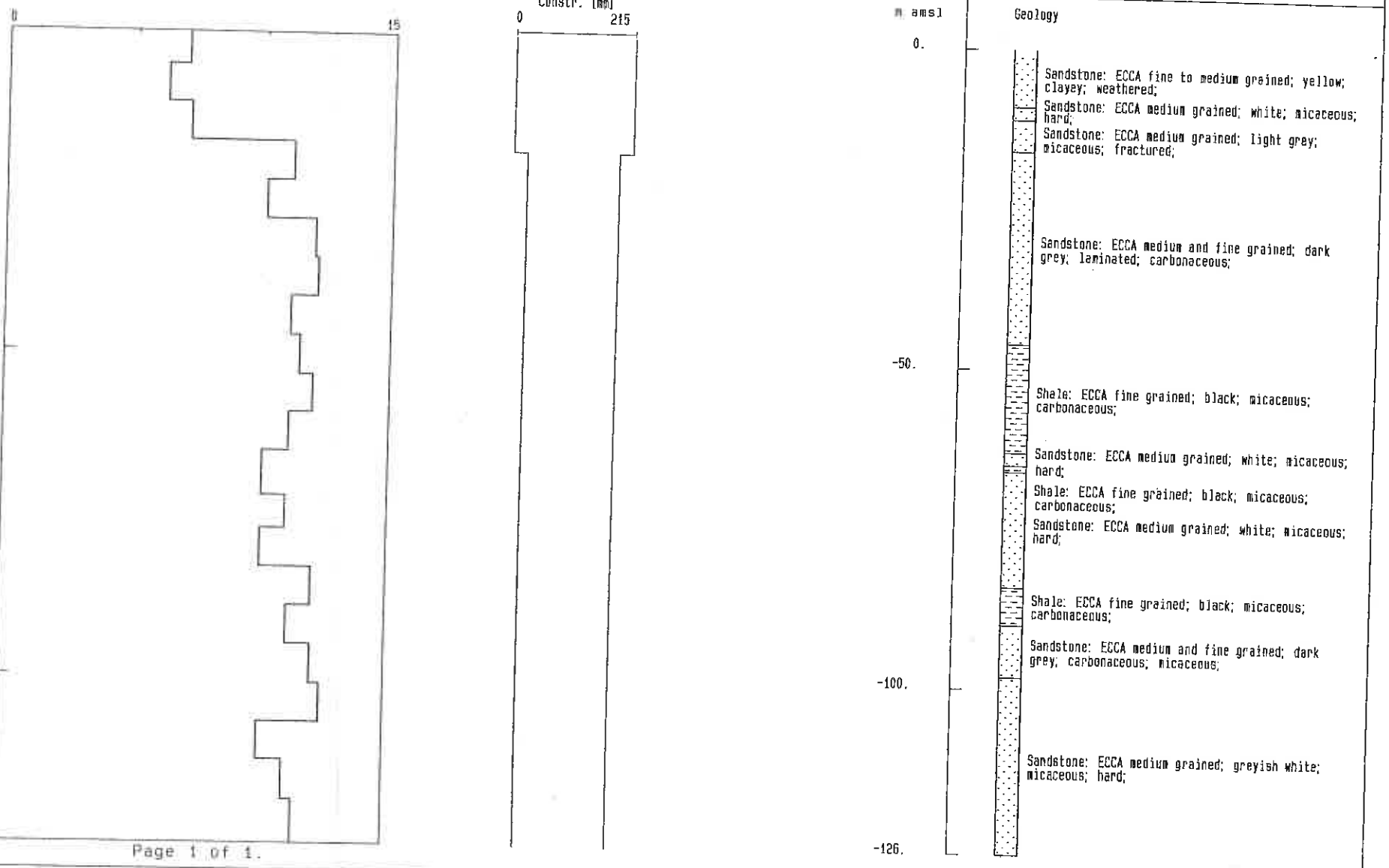
Site-ID : 2830AD00009

Nr on Map : LI9A

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 69274.86 (E-W) 3148572.73 (N-S) 0.00 (Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Dival
Notes : Dry borehole. Stone plugged.

Site ID: 2830AD00009
Number on map: LI9A

Longitude : 30.29277
Latitude : 28.45277
Ground Elevation: 0.00 mamsl
Collar Height: 0.00 m
Depth of Casing: 0.00 m
Diameter of Hole: 165 mm
Logged by:
Date Drilled: 19960212

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	9.00	9.00	SANDSTONE : ECCA fine to medium grained; yellow; clayey; weathered.
9.00	11.00	2.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
11.00	16.00	5.00	SANDSTONE : ECCA medium grained; light grey; micaceous; fractured.
16.00	46.00	30.00	SANDSTONE : ECCA medium and fine grained; dark grey; laminated; carbonaceous. SANDSTONE IS BAKED WITH FOLIATION FEATURES PRESENT CAUSED BY HIGH MICA CONTENT.
46.00	63.00	17.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
63.00	65.00	2.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
65.00	66.00	1.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
66.00	84.00	18.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
84.00	90.00	6.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
90.00	98.00	8.00	SANDSTONE : ECCA medium and fine grained; dark grey; carbonaceous; micaceous.
98.00	126.00	28.00	SANDSTONE : ECCA medium grained; greyish white; micaceous; hard.

Geohydrology

(no information.)

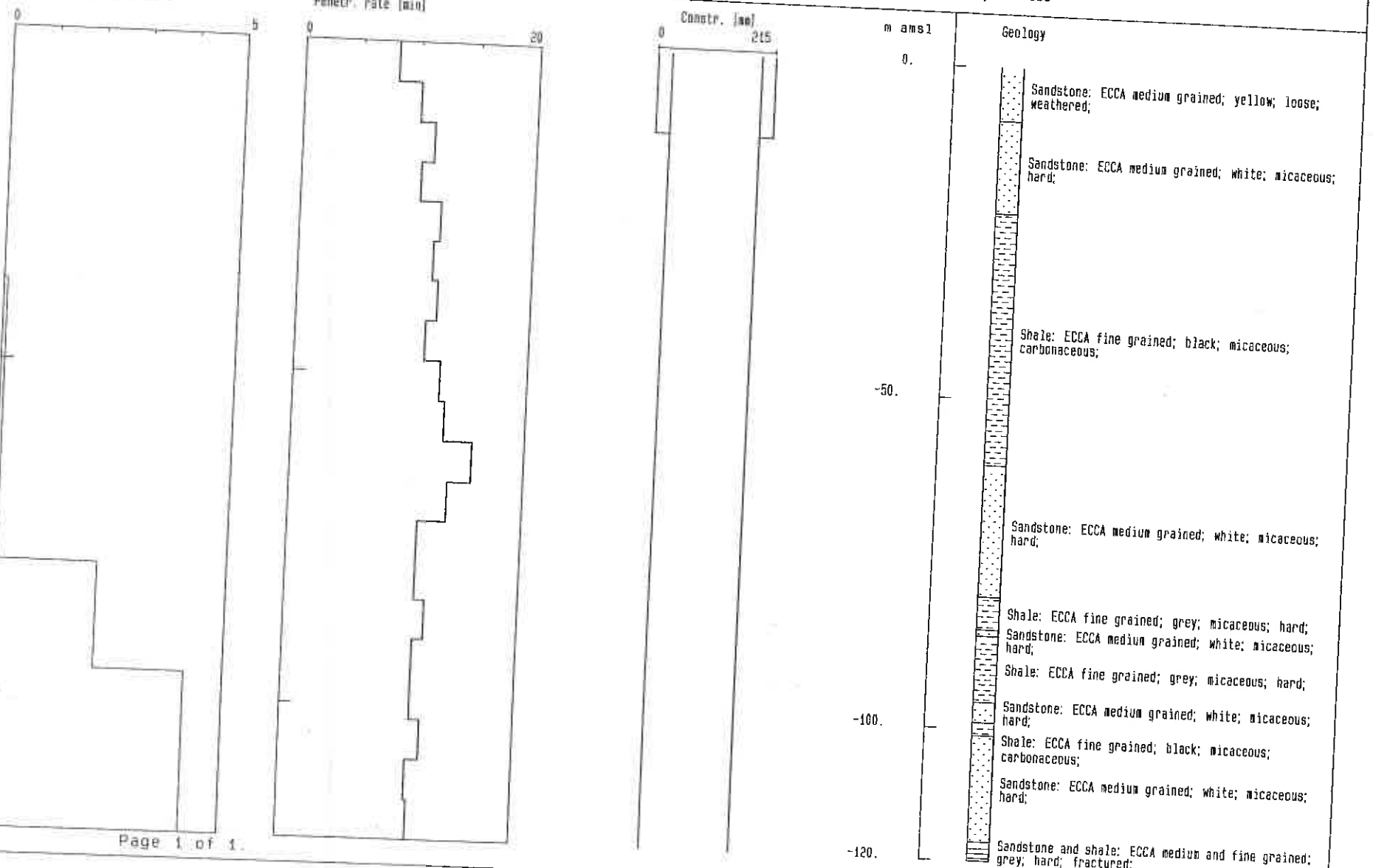
Site-ID : 2830AD00010

Nr on Map : LI9B

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 69166.49(E-W) 3148511.14(N-S) 0.00(Ground elevation)

Date Plotted: May 06 1996



Site name : DUNDEE - Dival
Notes :

Site ID: 2830AD00010
Number on map: LI9B

Longitude : 30.29388
Latitude : 28.45222
Ground Elevation: 0.00 mamsl
Collar Height: 0.44 m
Depth of Casing: 12.00 m
Diameter of Hole: 165 mm
Logged by: GHT
Date Drilled: 19960207

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	8.00	8.00	SANDSTONE : ECCA medium grained; yellow; loose; weathered.
8.00	22.00	14.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
22.00	60.00	38.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
60.00	80.00	20.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
80.00	85.00	5.00	SHALE : ECCA fine grained; grey; micaceous; hard.
85.00	86.00	1.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
86.00	96.00	10.00	SHALE : ECCA fine grained; grey; micaceous; hard.
96.00	99.00	3.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
99.00	101.00	2.00	SHALE : ECCA fine grained; black; micaceous; carbonaceous.
101.00	117.00	16.00	SANDSTONE : ECCA medium grained; white; micaceous; hard.
117.00	120.00	3.00	SANDSTONE AND SHALE : ECCA medium and fine grained; grey; hard; fractured.
Geohydrology			
38.00	40.00	2.00	0.07 L/sec measured by volumetric measurement (container + stop-watch method).
80.00	82.00	2.00	2.22 L/sec measured by volumetric measurement (container + stop-watch method).
96.00	98.00	2.00	4.16 L/sec measured by volumetric measurement (container + stop-watch method).

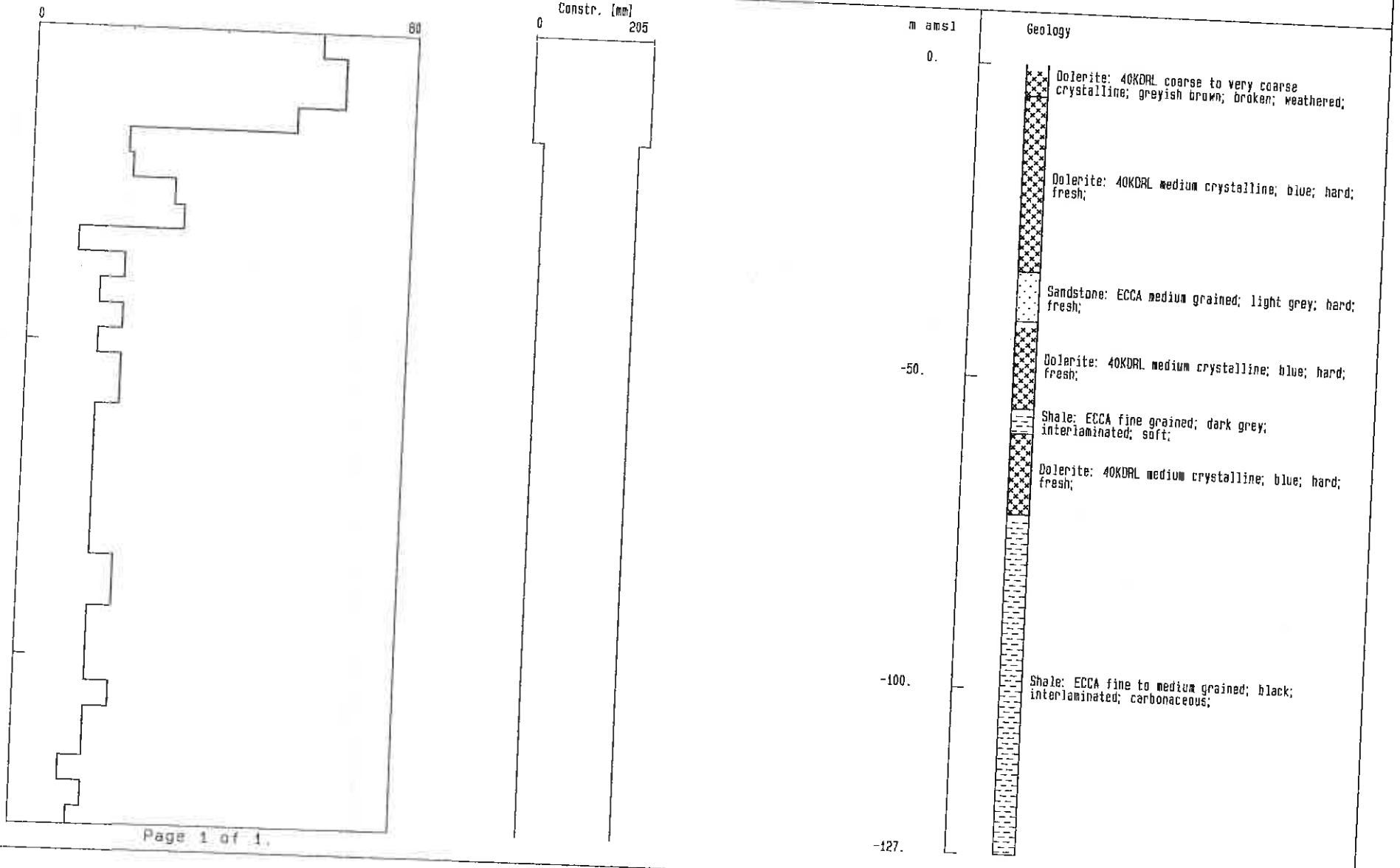
Site-ID : 2830CA00021

Nr on Map : LL12A

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 89114.39(E-W) 3162622.66(N-S) 0.00(Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Greylock
Notes : Dry Borehole. Stone plugged.

Site ID: 2830CA00021
Number on map: LL12A

Longitude : 30.08915
Ground Elevation: 0.00 mamsl
Depth of Casing: 0.00 m
Logged by:

Latitude : 28.57833
Collar Height: 0.00 m
Diameter of Hole: 165 mm
Date Drilled: 19960303

Depth (m) from	to	Thickness (m)	Description

Geology

0.00	5.00	5.00	DOLERITE : 40KDRL coarse to very coarse crystalline; greyish brown; broken; weathered.
5.00	33.00	28.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
33.00	41.00	8.00	SANDSTONE : ECCA medium grained; light grey; hard; fresh.
41.00	55.00	14.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
55.00	59.00	4.00	SHALE : ECCA fine grained; dark grey; interlaminated; soft.
59.00	72.00	13.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fresh.
72.00	127.00	55.00	SHALE : ECCA fine to medium grained; black; interlaminated; carbonaceous.

Geohydrology

(no information.)

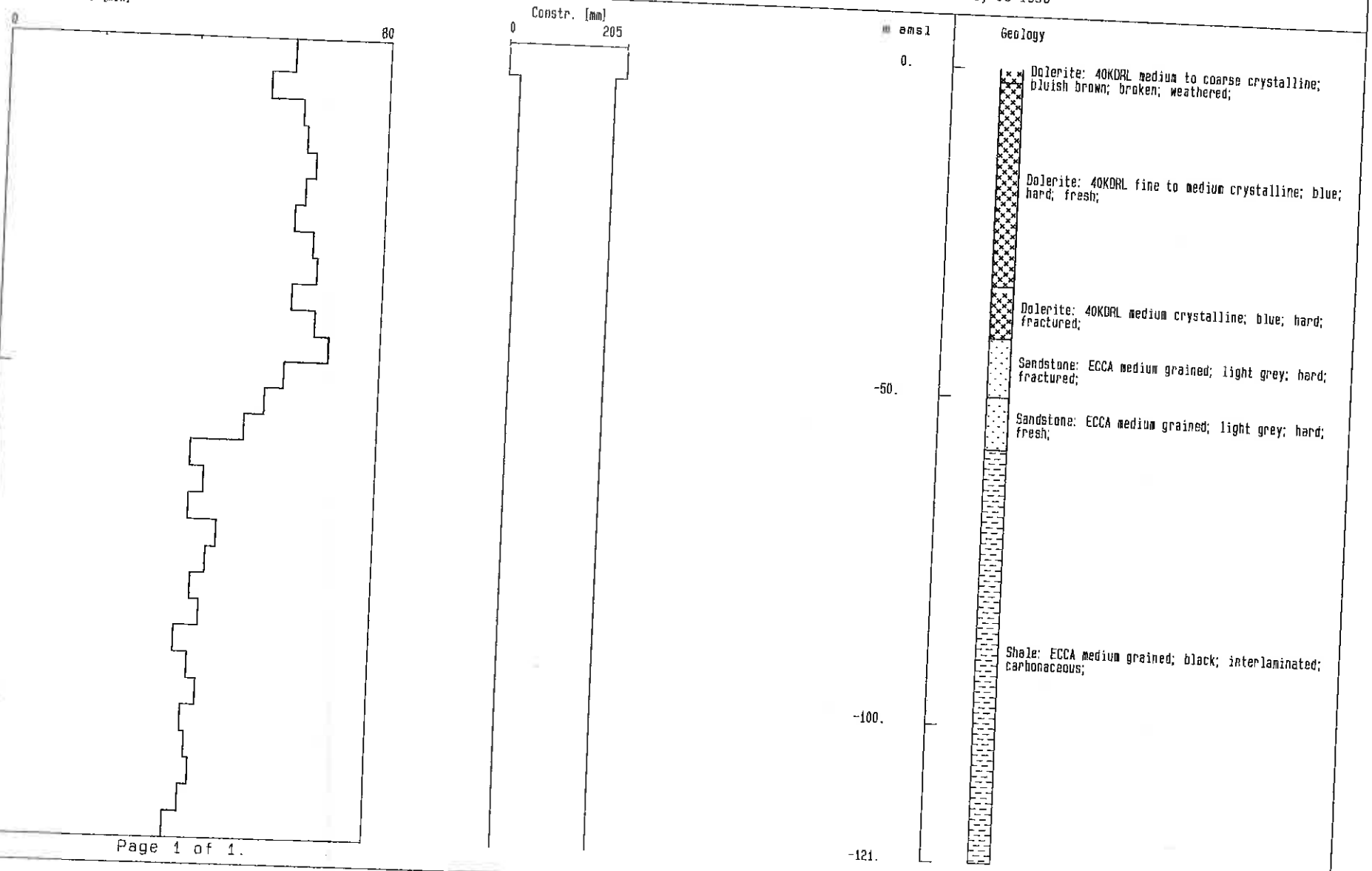
Site-ID : 2830CA00022

Nr on Map : LL128

* HydroGraph * Borehole log : Geo-Hydro Technologies

Coordinates : 89248.75(E-W) 3162838.71(N-S) 0.00(Ground elevation)

Date Plotted: May 06 1996



Site name : EMNAMBITHI - Greylock
Notes : Dry borehole. Stone plugged.

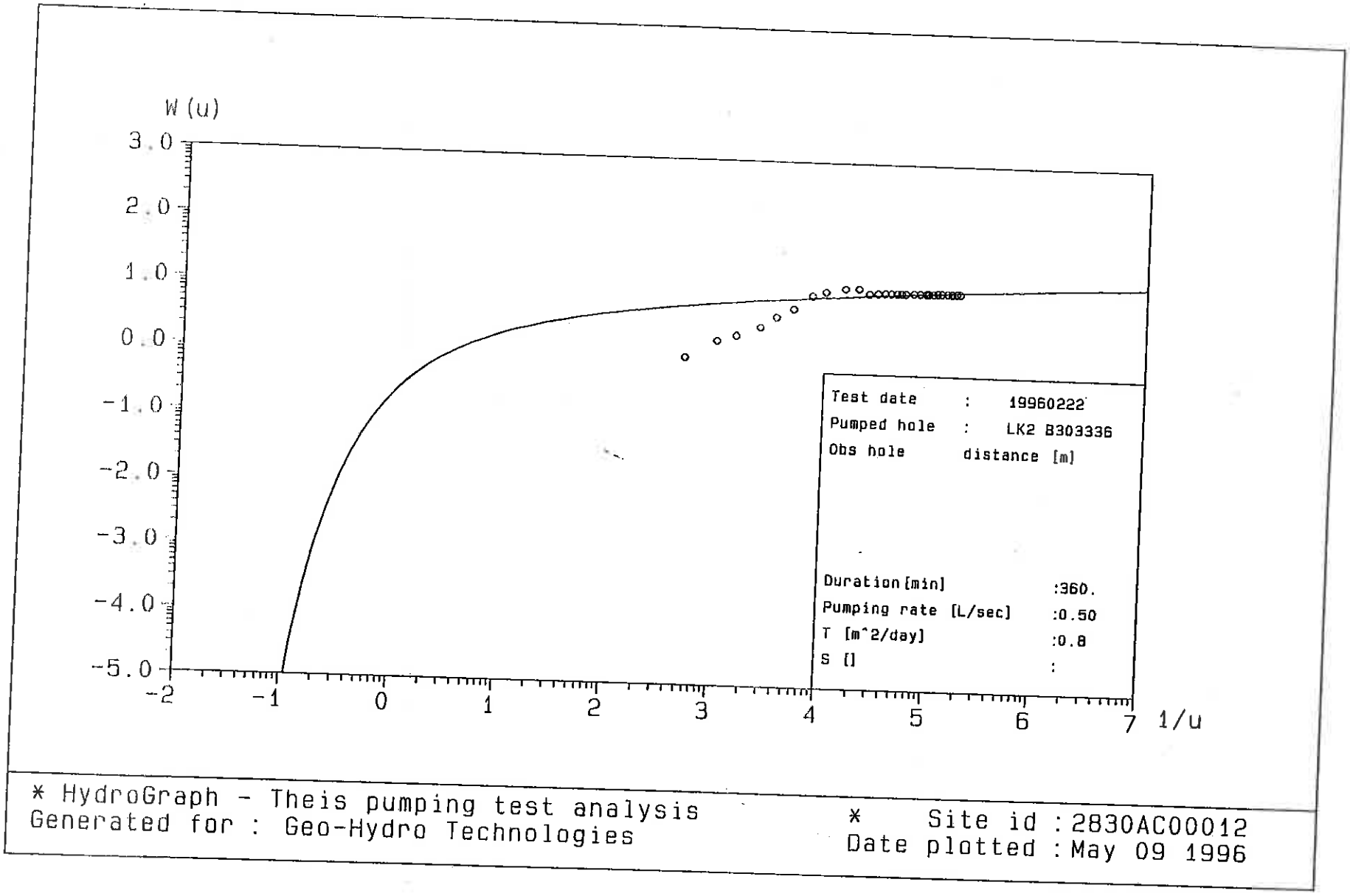
Site ID: 2830CA00022
Number on map: LL12B

Longitude : 30.08776
Latitude : 28.58027
Ground Elevation: 0.00 mamsl
Collar Height: 0.00 m
Depth of Casing: 0.00 m
Diameter of Hole: 165 mm
Logged by:
Date Drilled: 19960304

Depth (m) from	to	Thickness (m)	Description
Geology			
0.00	2.00	2.00	DOLERITE : 40KDRL medium to coarse crystalline; bluish brown; broken; weathered.
2.00	33.00	31.00	DOLERITE : 40KDRL fine to medium crystalline; blue; hard; fresh.
33.00	41.00	8.00	DOLERITE : 40KDRL medium crystalline; blue; hard; fractured.
41.00	50.00	9.00	SANDSTONE : ECCA medium grained; light grey; hard; fractured.
50.00	58.00	8.00	SANDSTONE : ECCA medium grained; light grey; hard; fresh.
58.00	121.00	63.00	SHALE : ECCA medium grained; black; interlaminated; carbonaceous.
Geohydrology			
(no information.)			

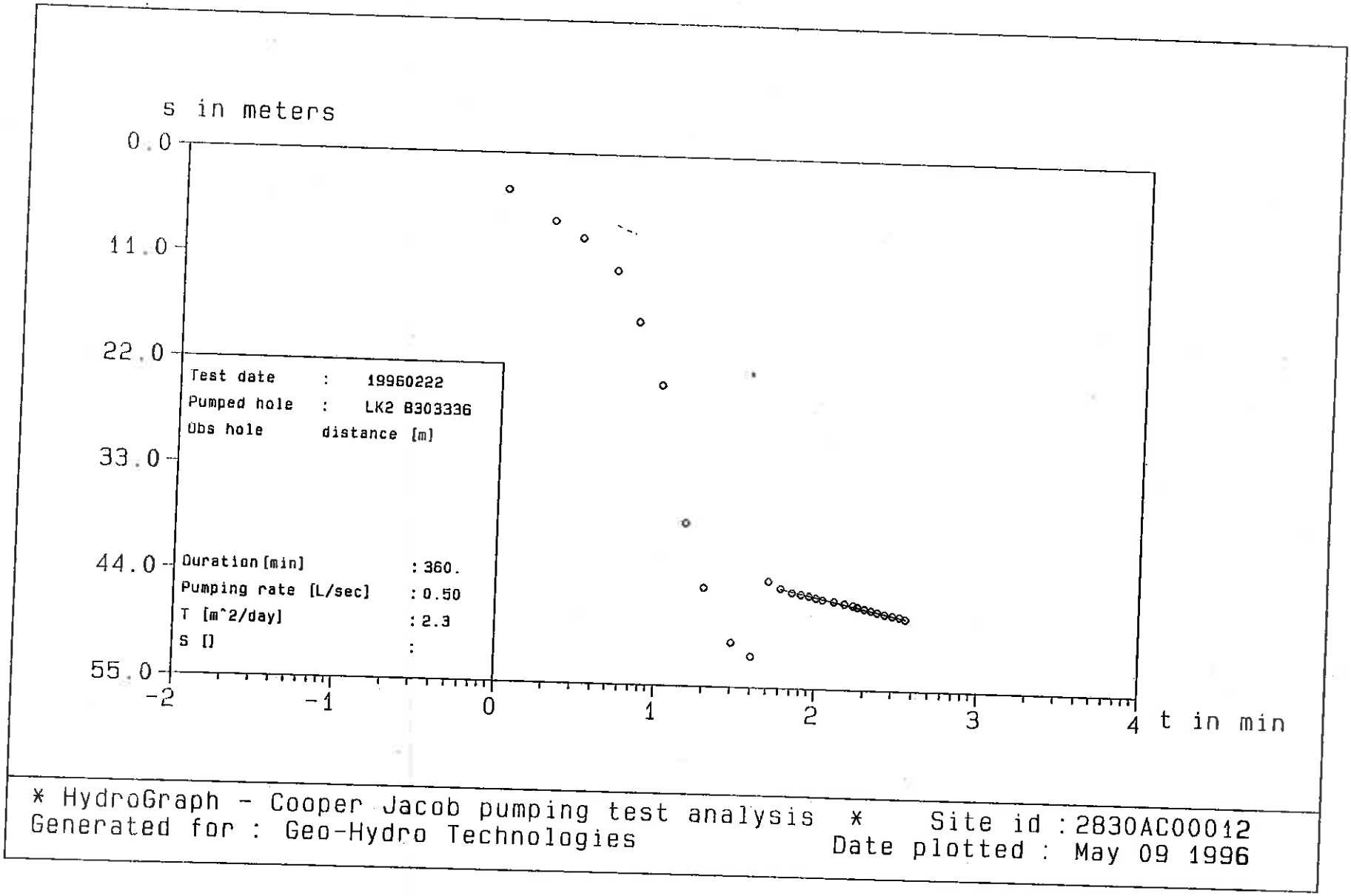
APPENDIX D

Pump Test Graphs

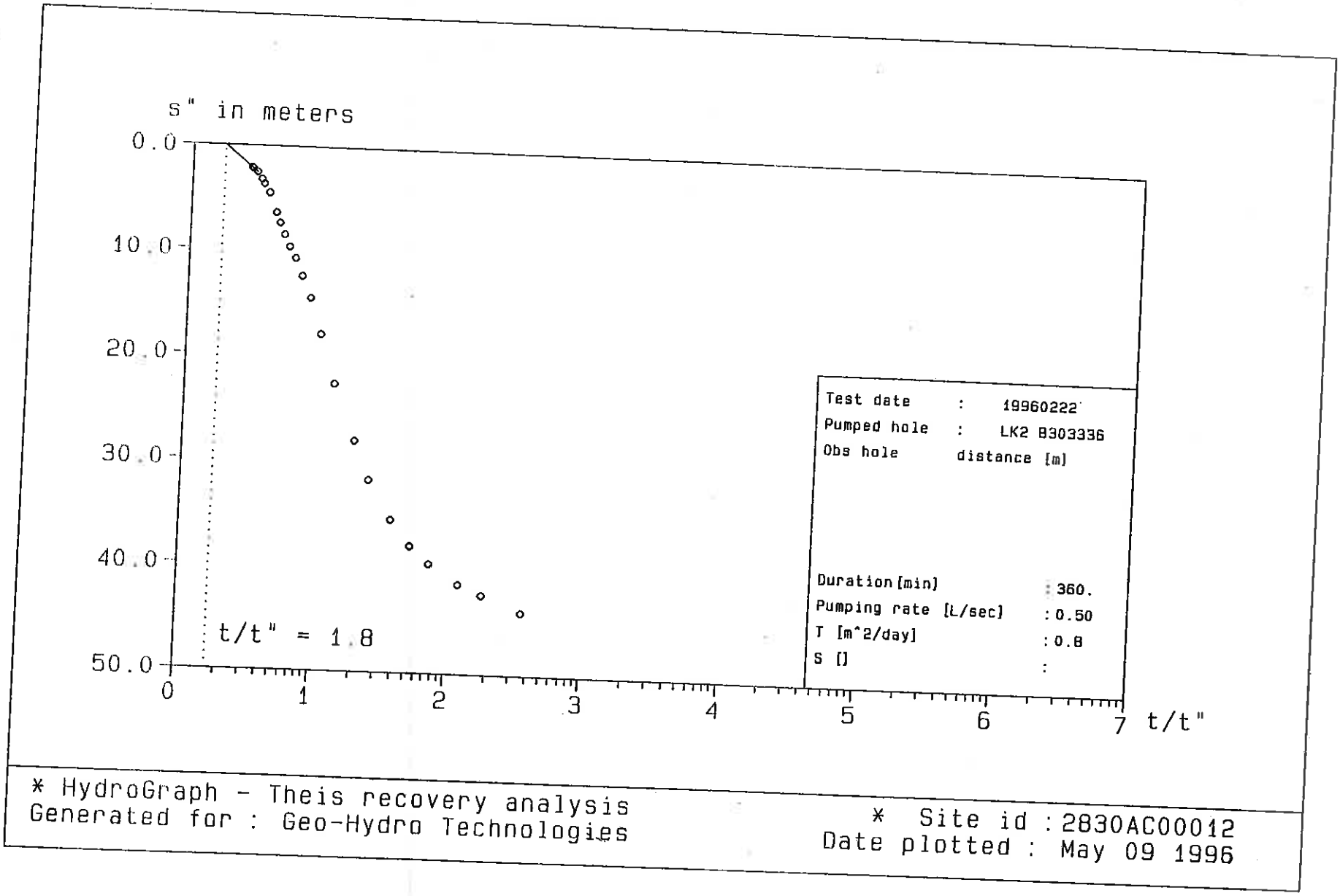


* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00012
Date plotted : May 09 1996

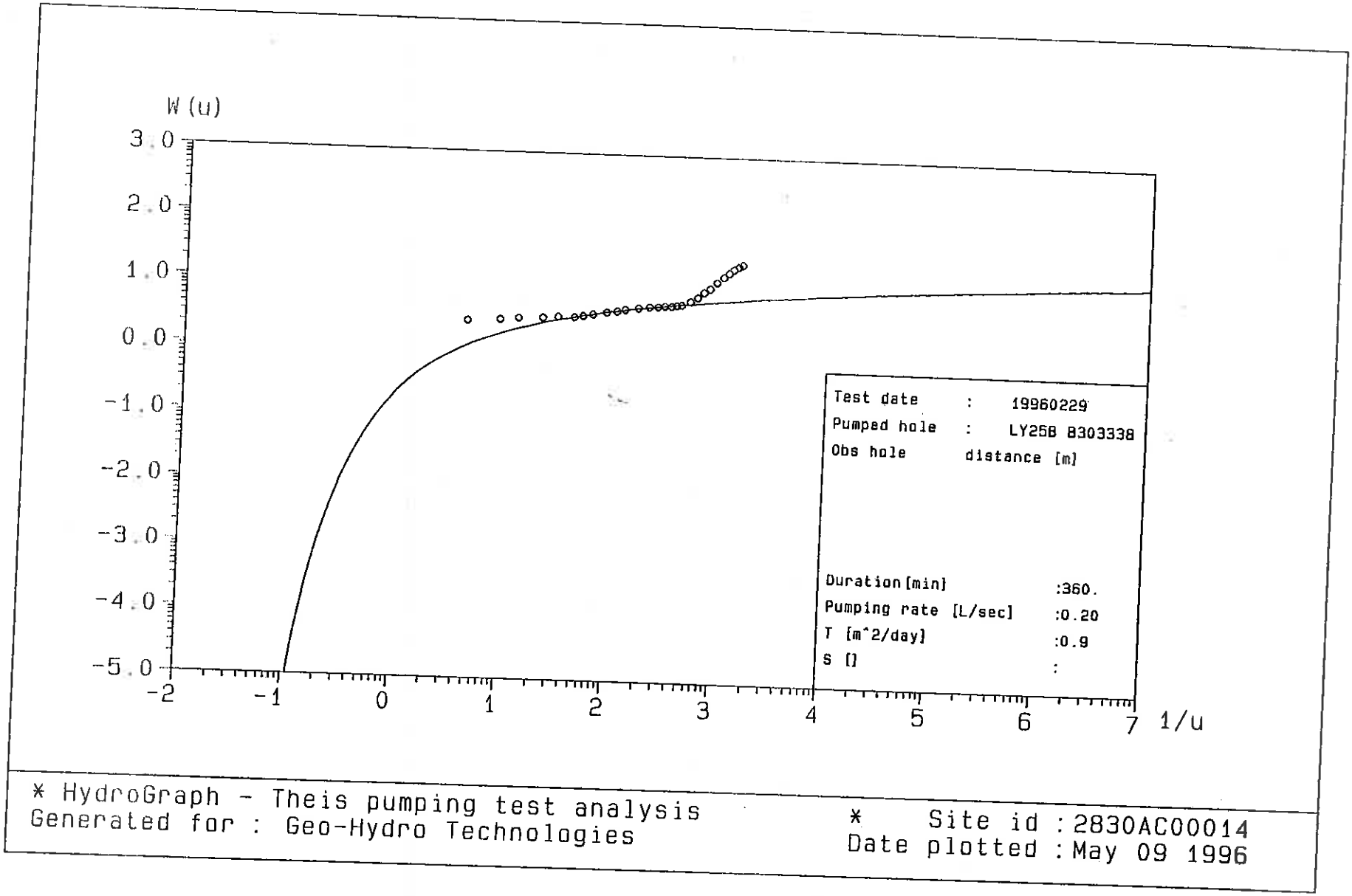


* HydroGraph - Cooper Jacob pumping test analysis * Site id : 2830AC00012
Generated for : Geo-Hydro Technologies Date plotted : May 09 1996



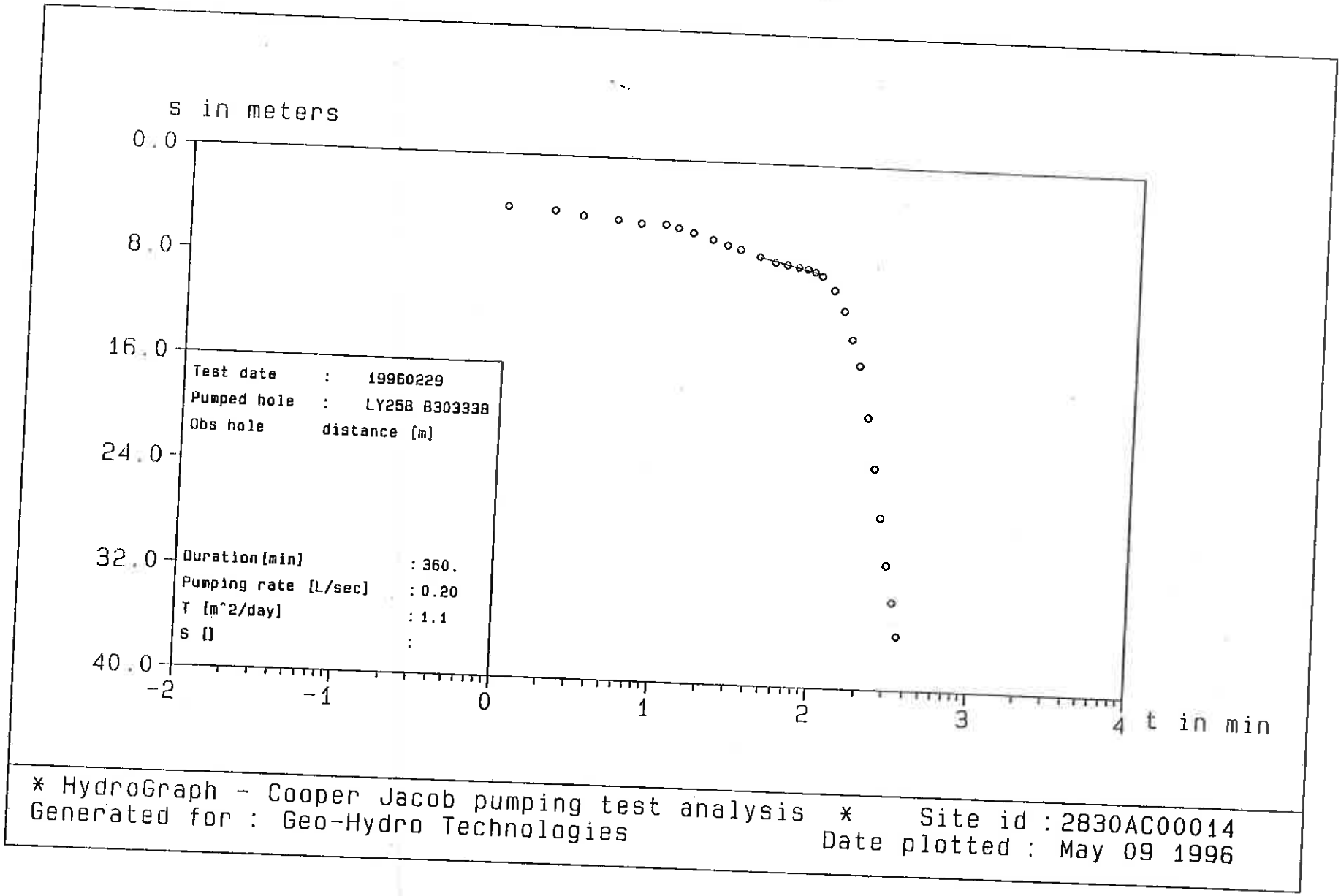
* HydroGraph - Theis recovery analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00012
Date plotted : May 09 1996



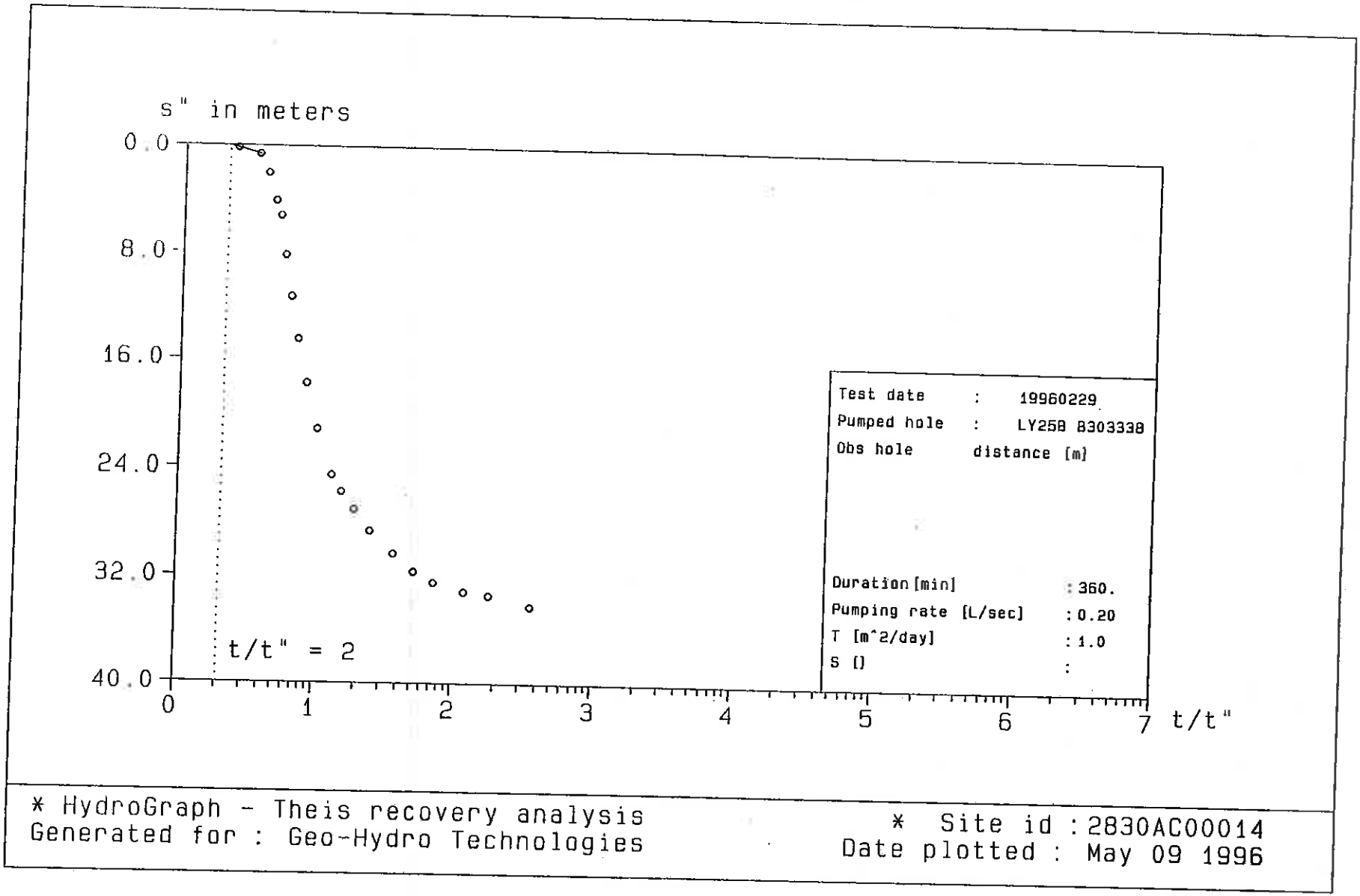
* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00014
Date plotted : May 09 1996



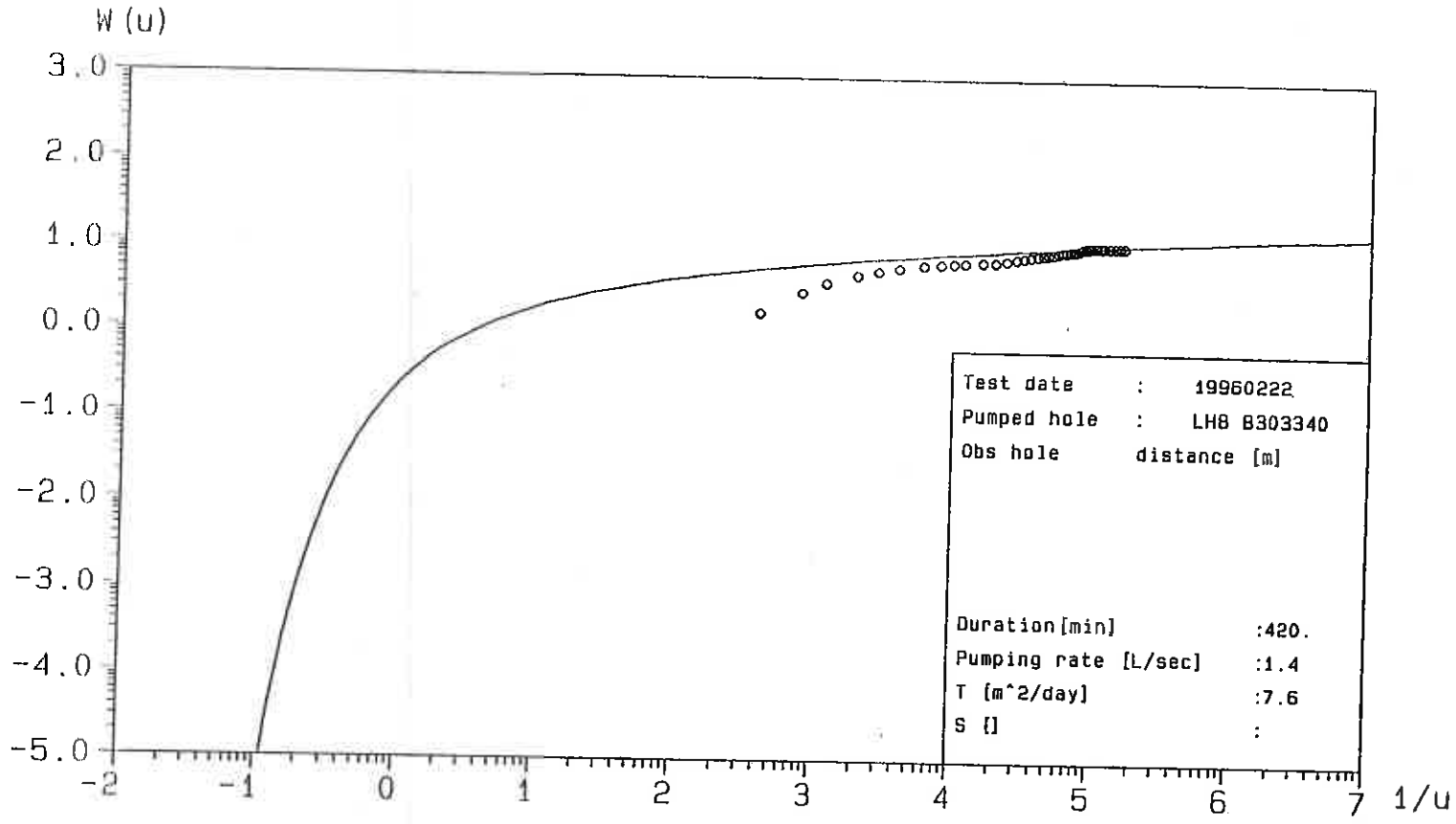
* HydroGraph - Cooper Jacob pumping test analysis *
Generated for : Geo-Hydro Technologies

Site id : 2830AC00014
Date plotted : May 09 1996



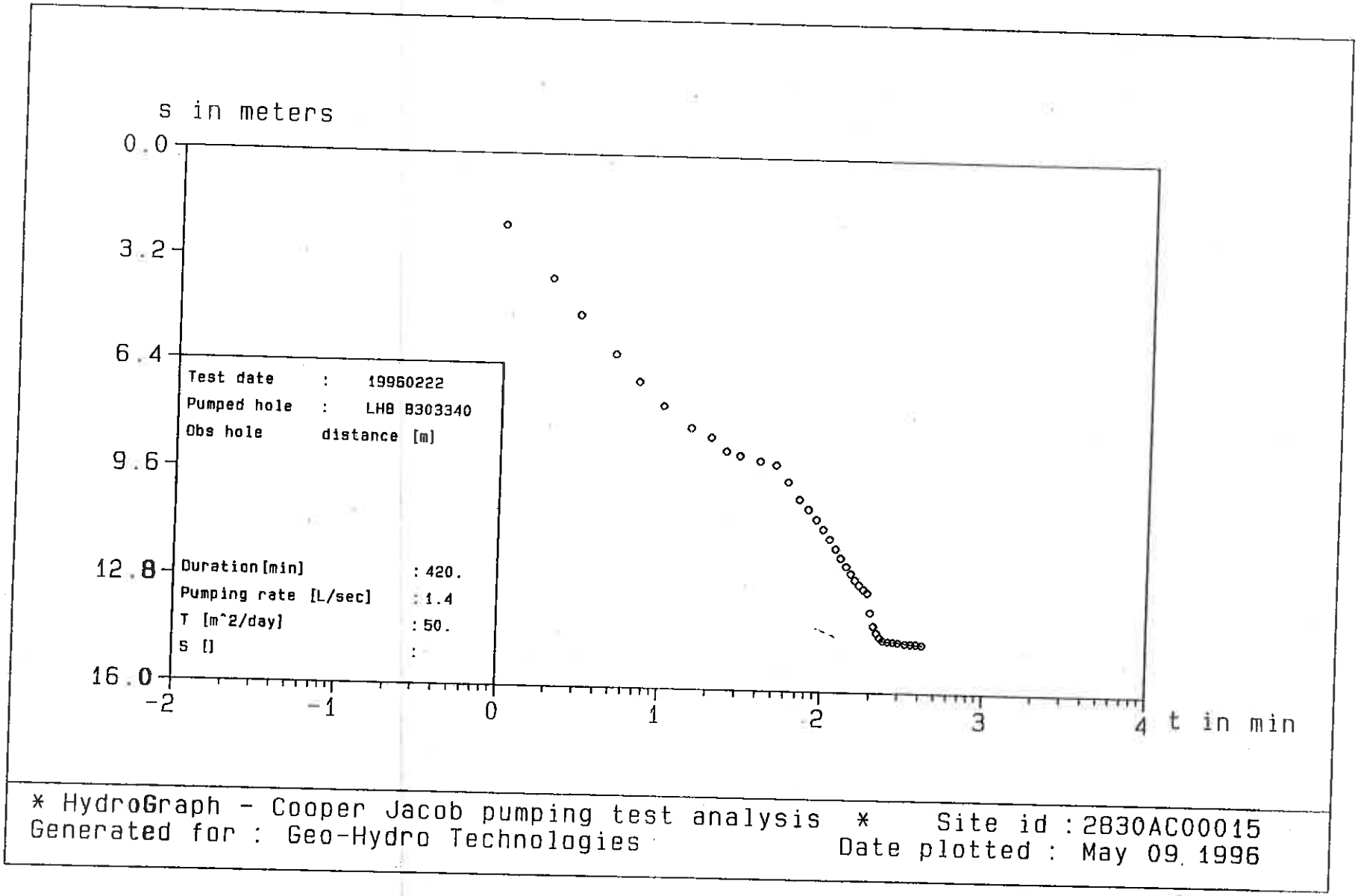
* HydroGraph - Theis recovery analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00014
Date plotted : May 09 1996

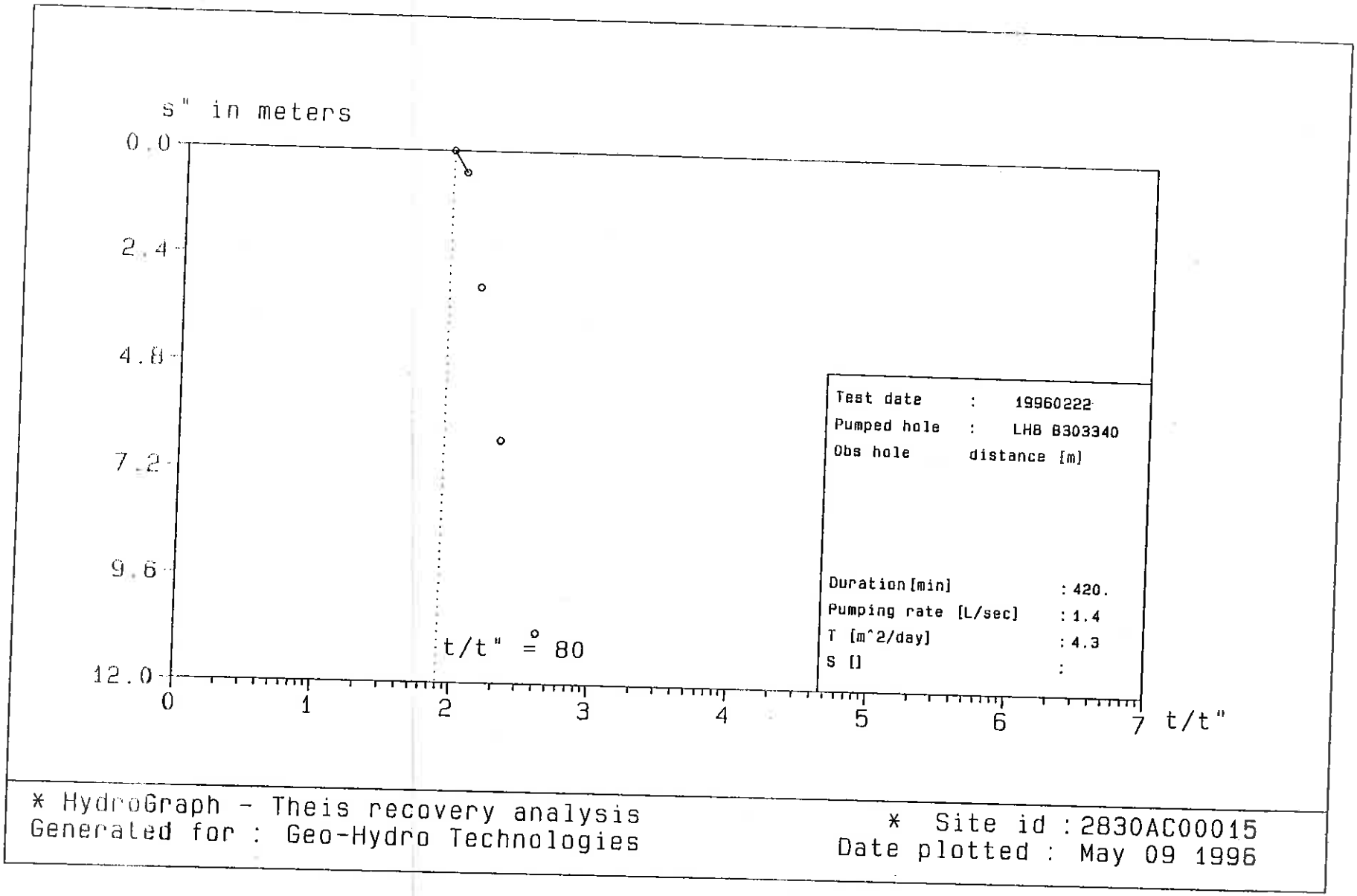


* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00015
Date plotted : May 09 1996

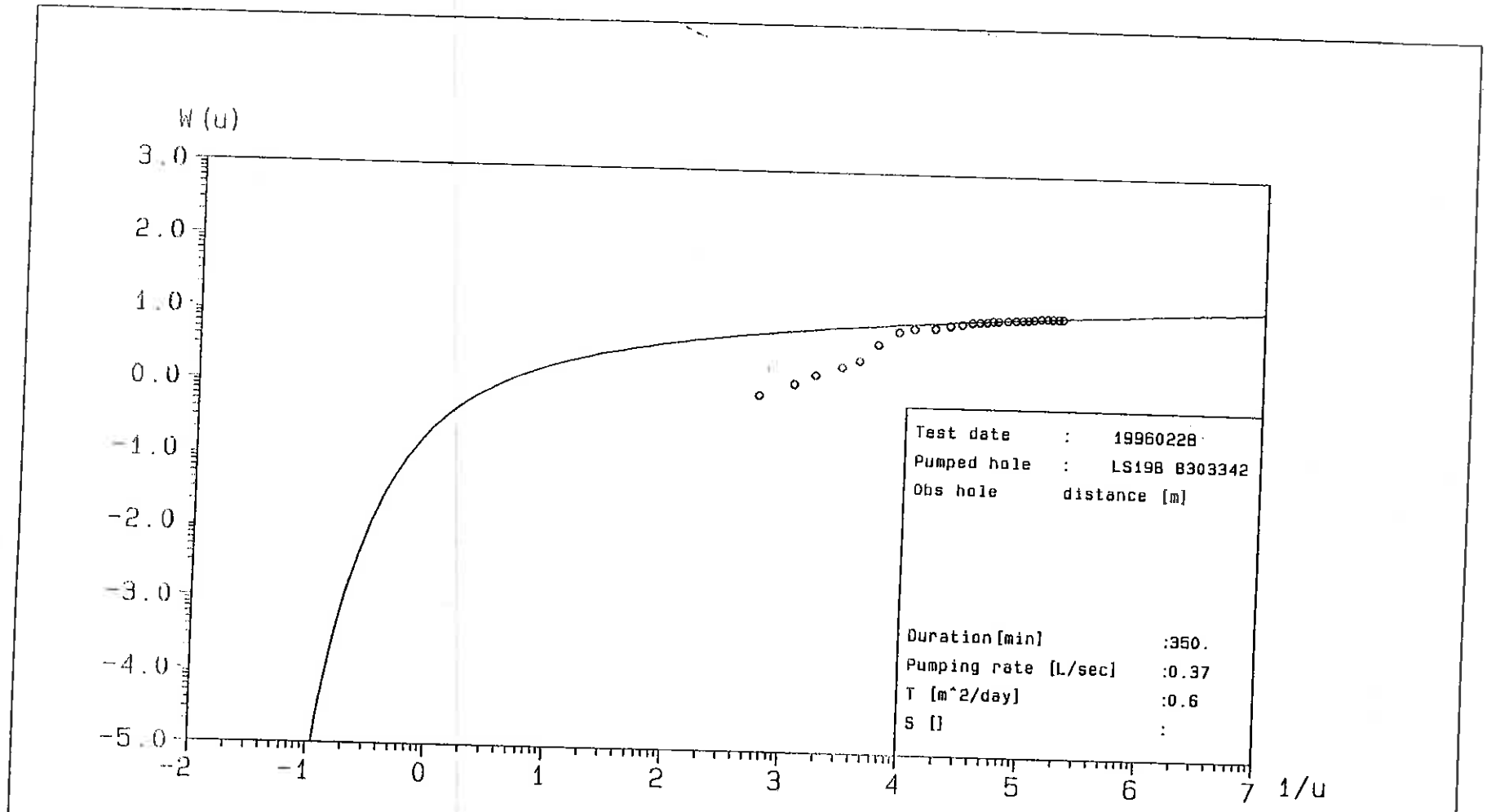


* HydroGraph - Cooper Jacob pumping test analysis * Site id : 2830AC00015
Generated for : Geo-Hydro Technologies Date plotted : May 09 1996



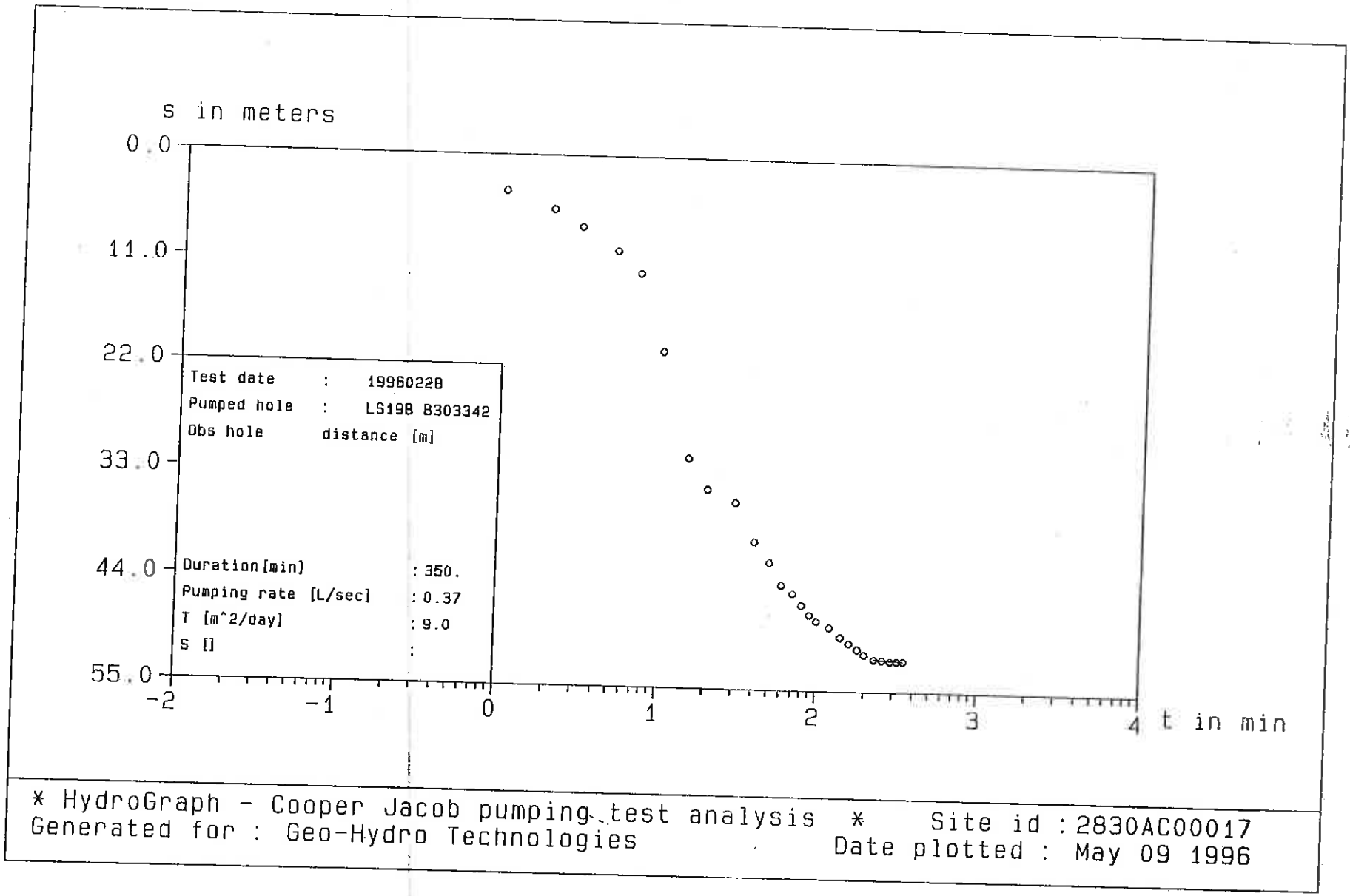
* HydroGraph - Theis recovery analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00015
Date plotted : May 09 1996

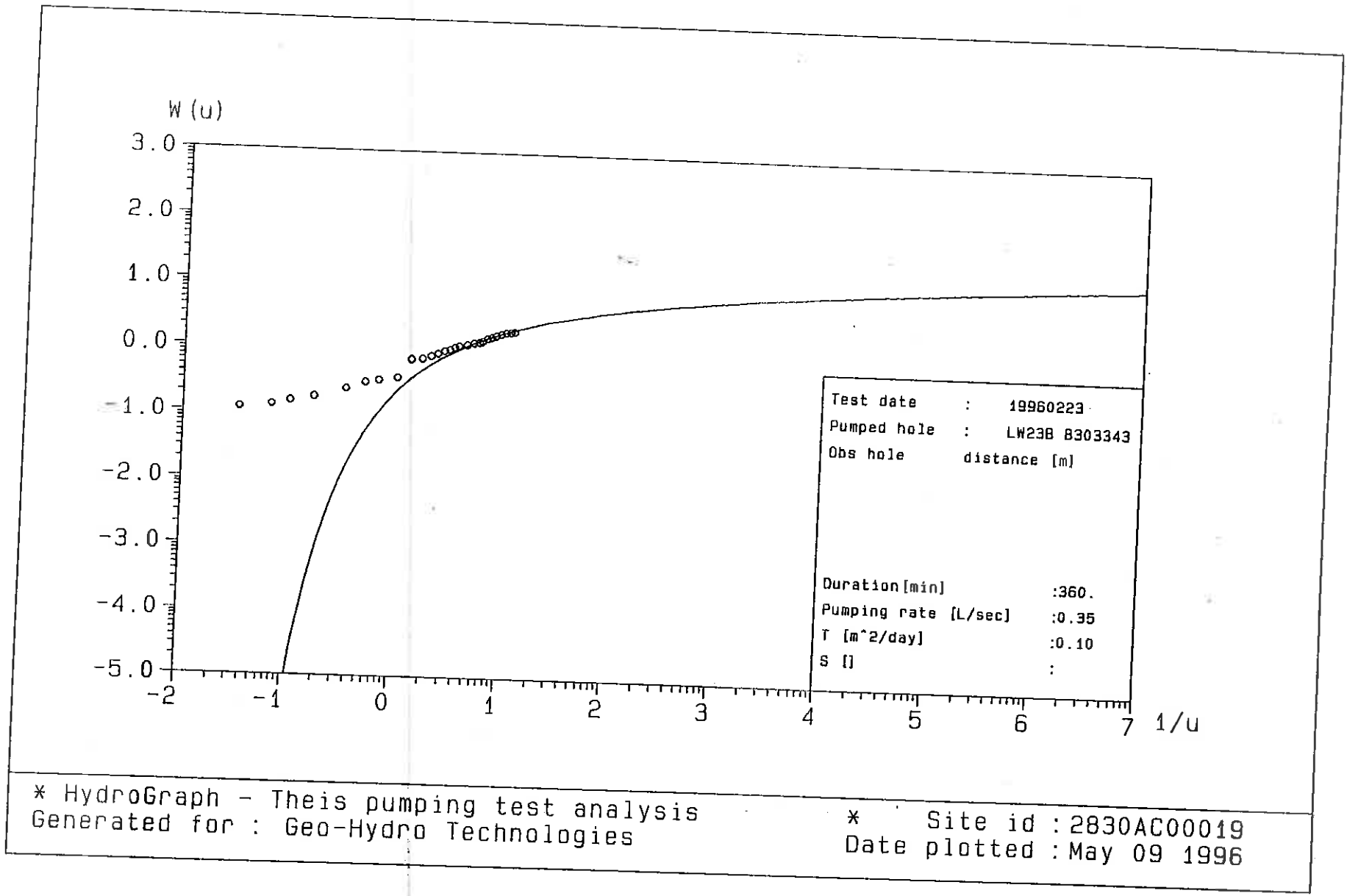


* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00017
Date plotted : May 09 1996

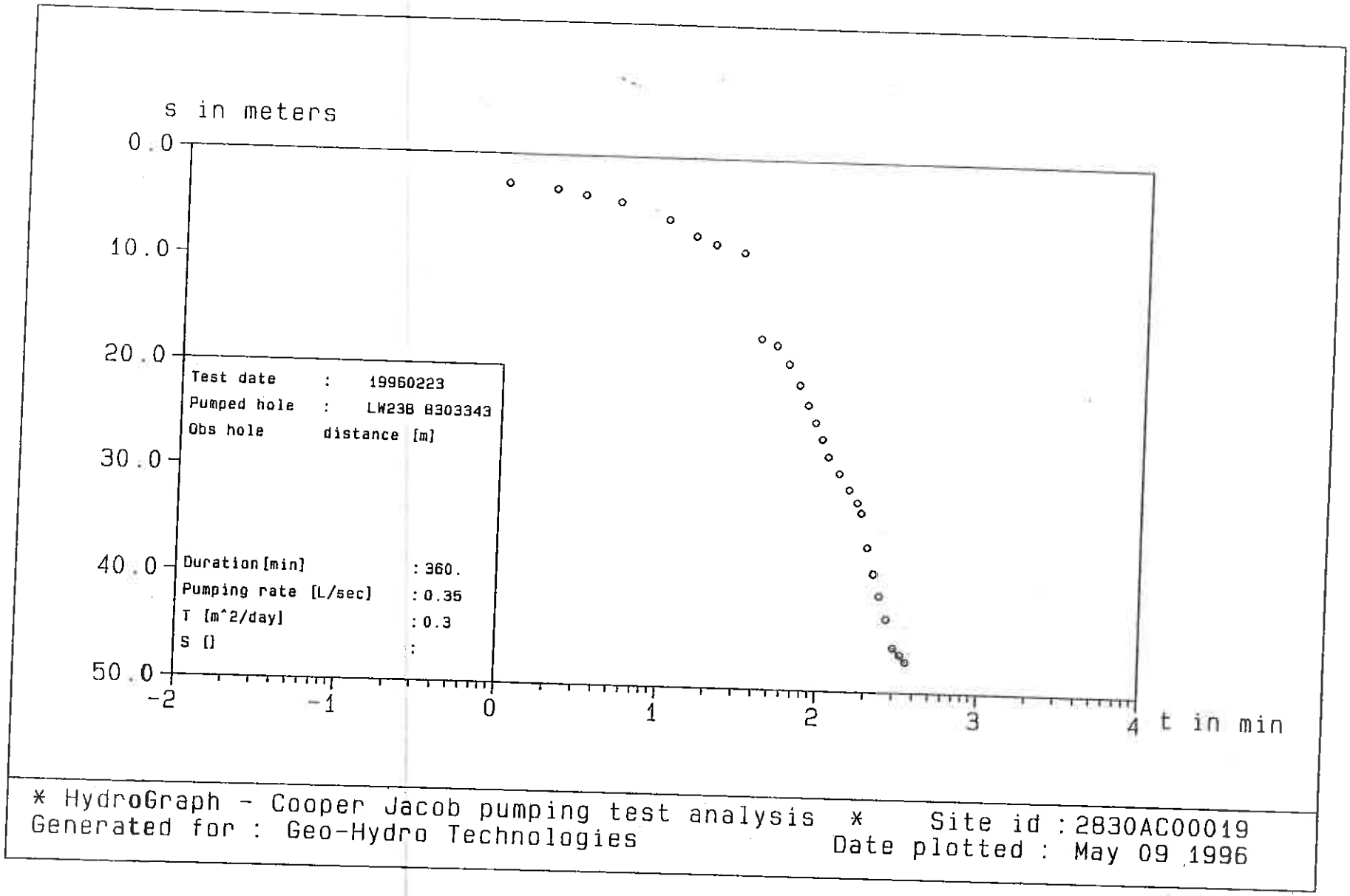


* HydroGraph - Cooper Jacob pumping test analysis * Site id : 2830AC00017
Generated for : Geo-Hydro Technologies Date plotted : May 09 1996



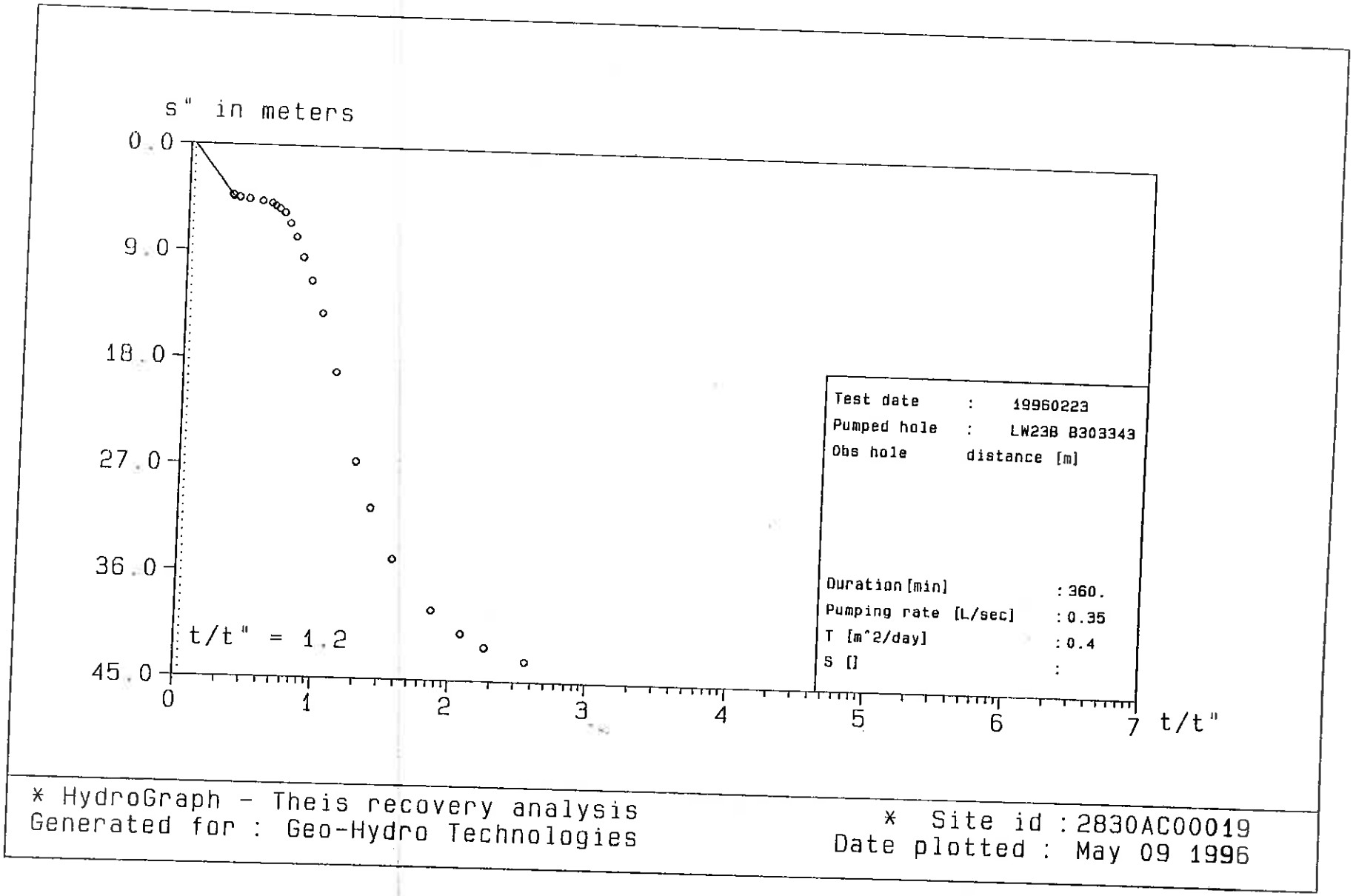
* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00019
Date plotted : May 09 1996



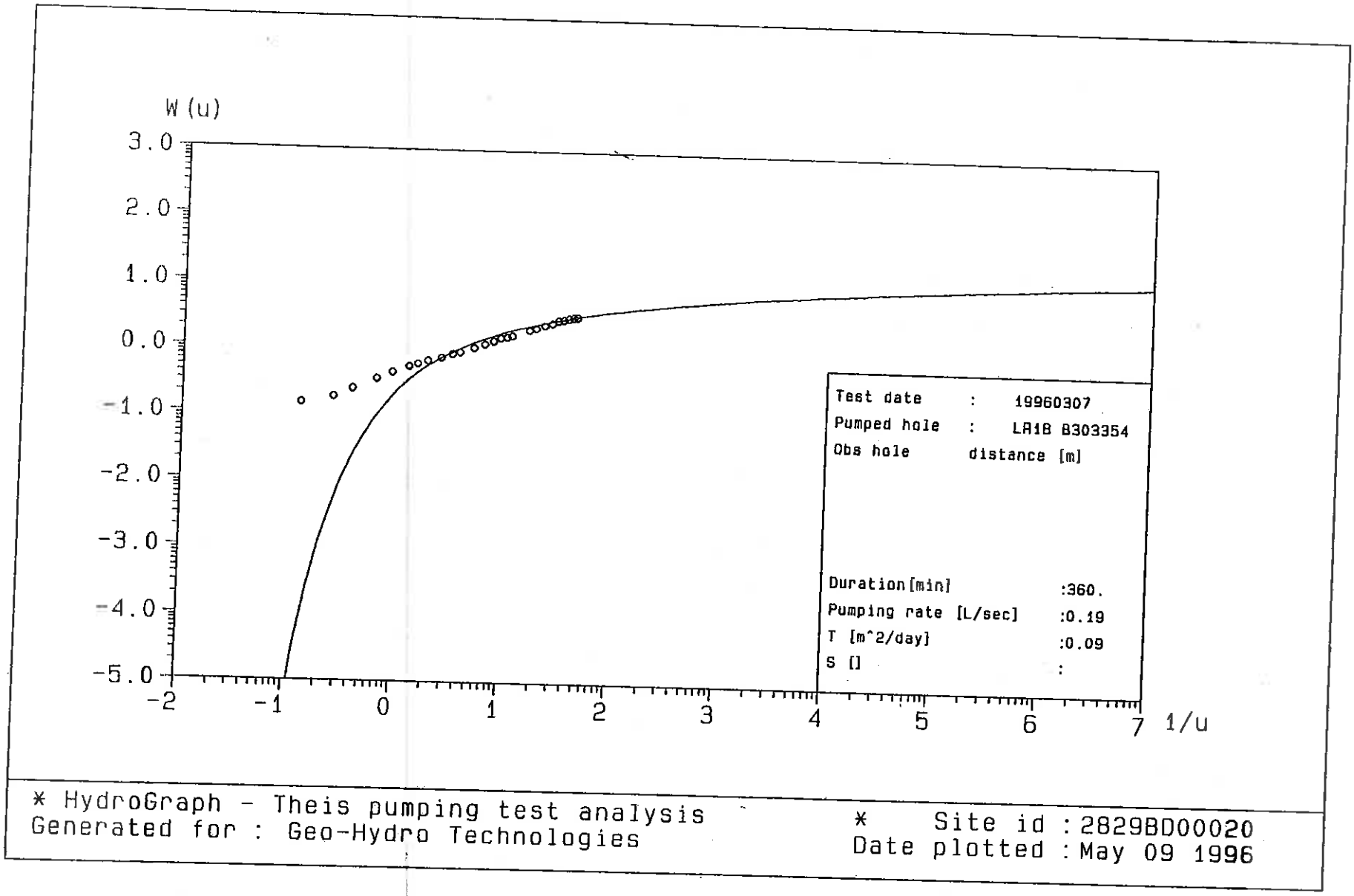
* HydroGraph - Cooper Jacob pumping test analysis *
Generated for : Geo-Hydro Technologies

Site id : 2830AC00019
Date plotted : May 09 1996



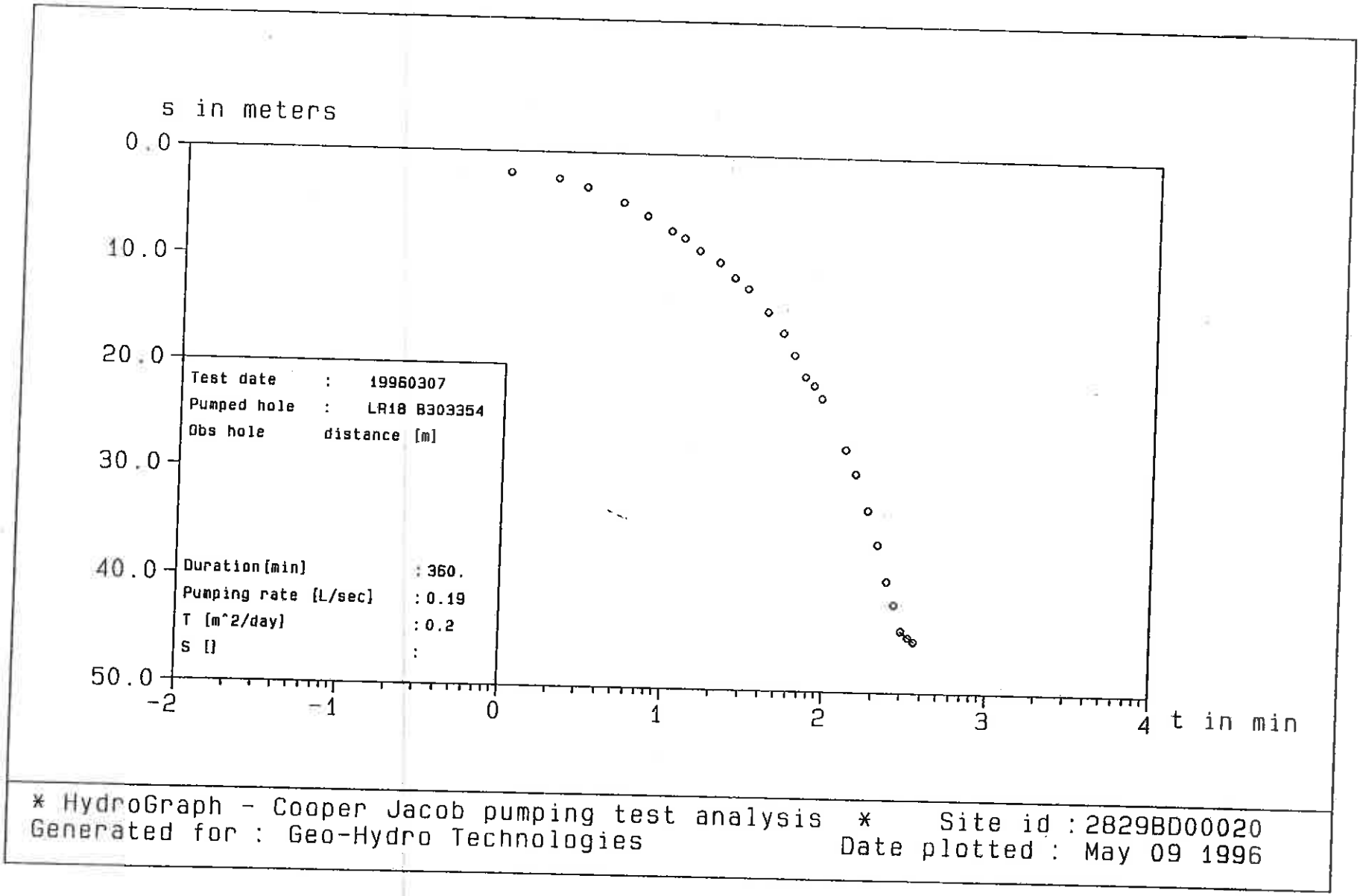
* HydroGraph - Theis recovery analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00019
Date plotted : May 09 1996

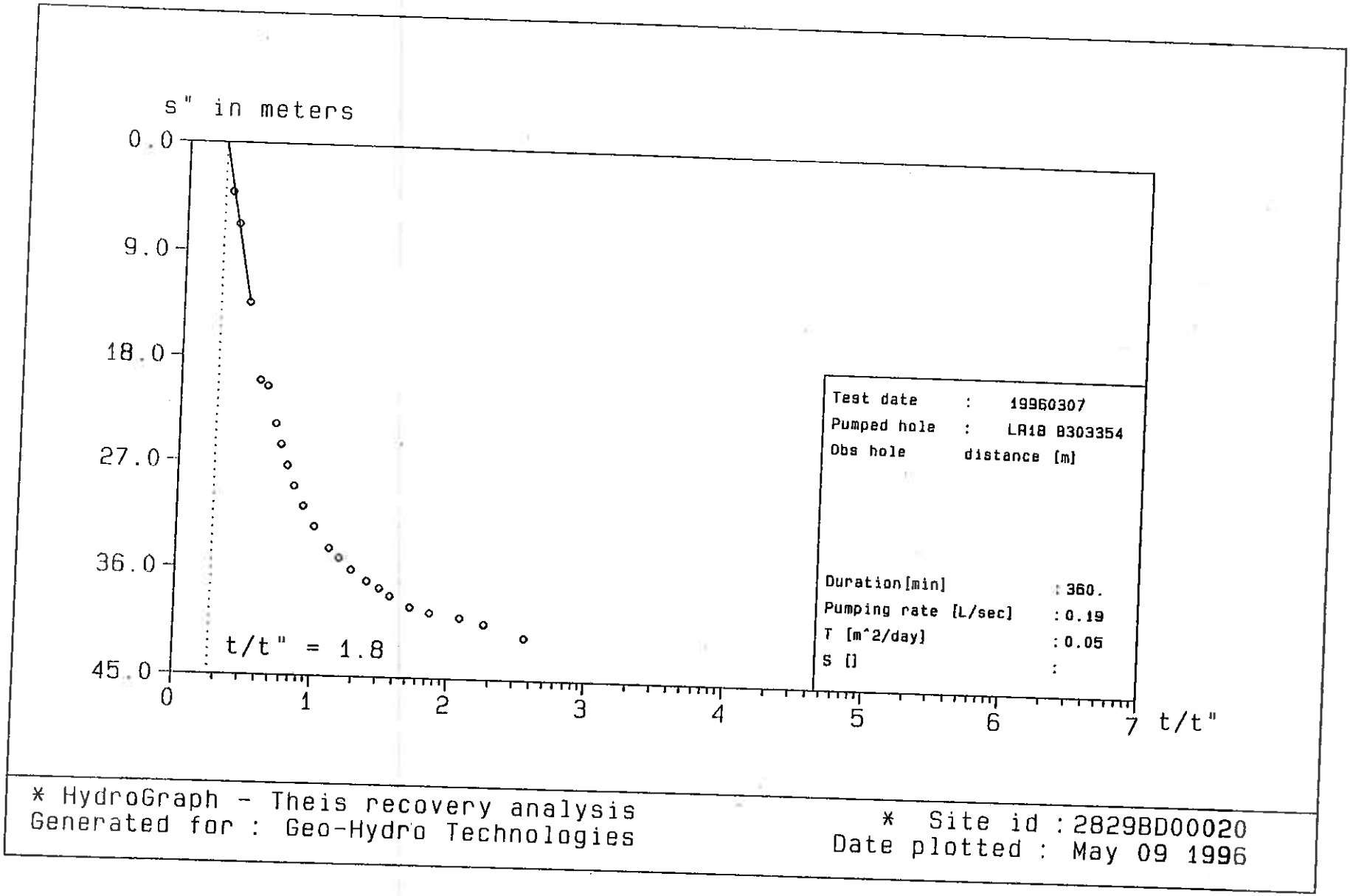


* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2829BD00020
Date plotted : May 09 1996



* HydroGraph - Cooper Jacob pumping test analysis * Site id : 2829BD00020
Generated for : Geo-Hydro Technologies Date plotted : May 09 1996



* HydroGraph - Theis recovery analysis
Generated for : Geo-Hydro Technologies

* Site id : 2829BD00020
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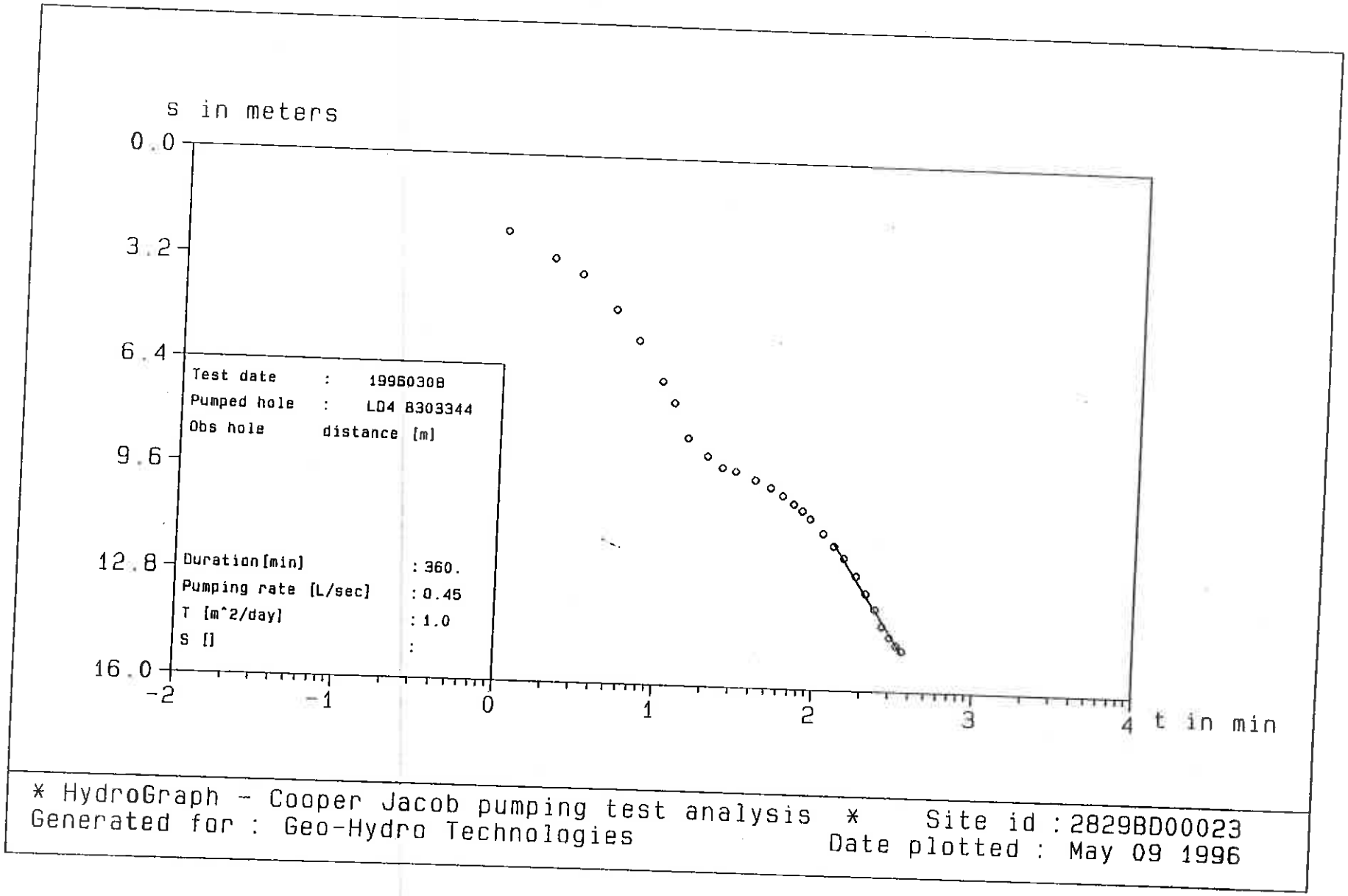

* HydroGraph - Cooper Jacob pumping test analysis * Site id : 2829BD00023
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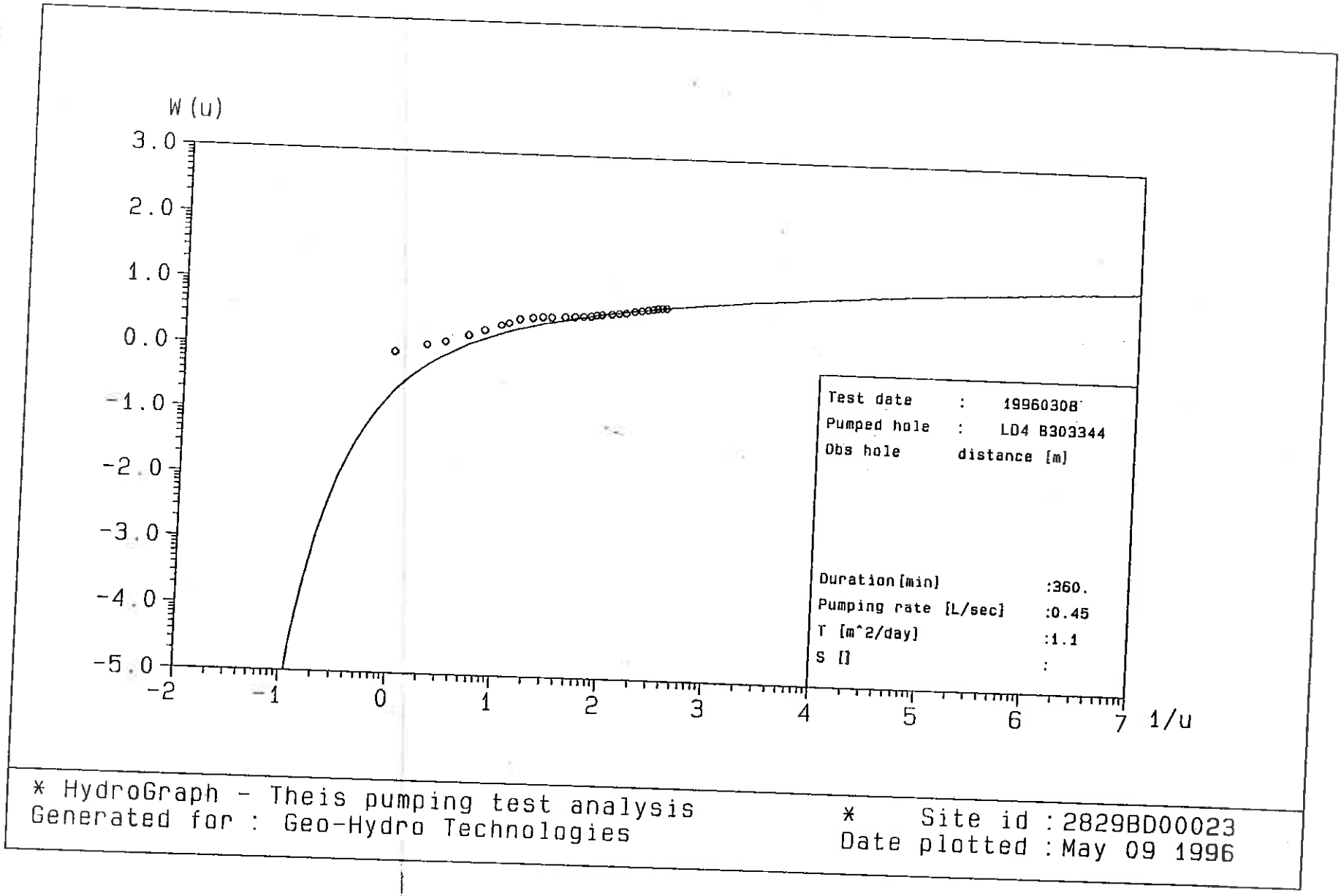
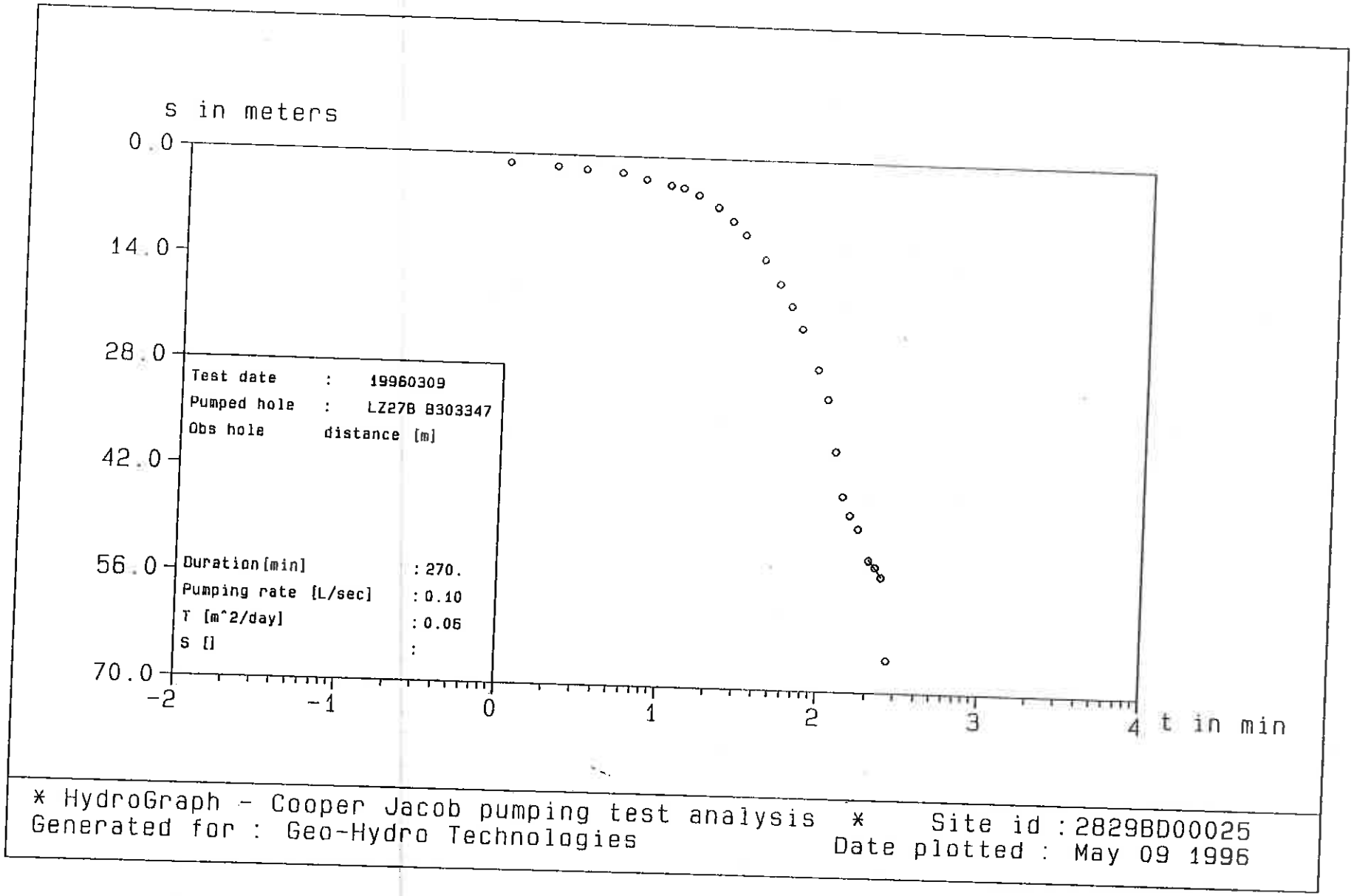
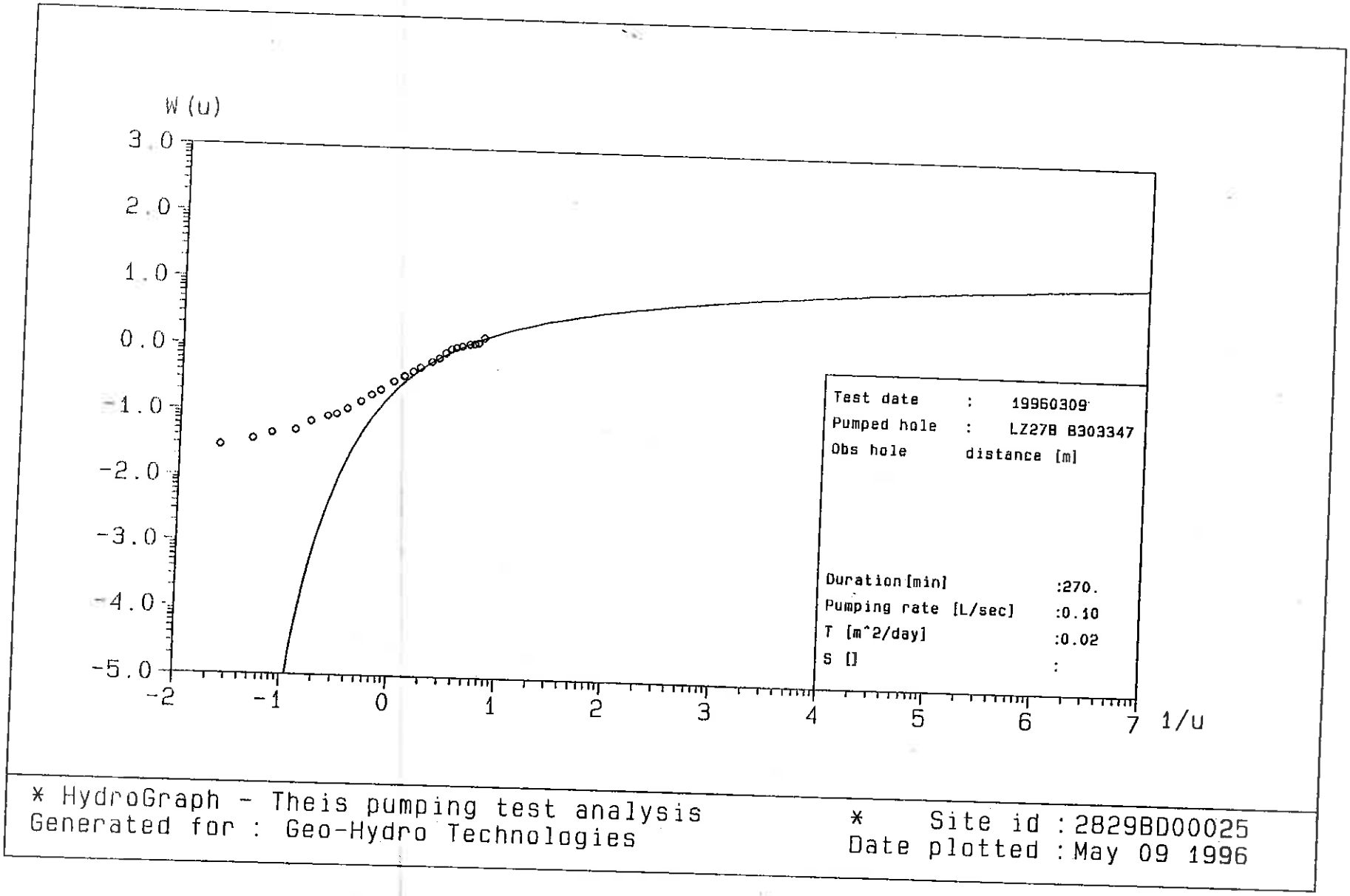


* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2829BD00023
Date plotted : May 09 1996



* HydroGraph - Cooper Jacob pumping test analysis * Site id : 2829BD00025
Generated for : Geo-Hydro Technologies Date plotted : May 09 1996



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* Site id : 2829BD00025
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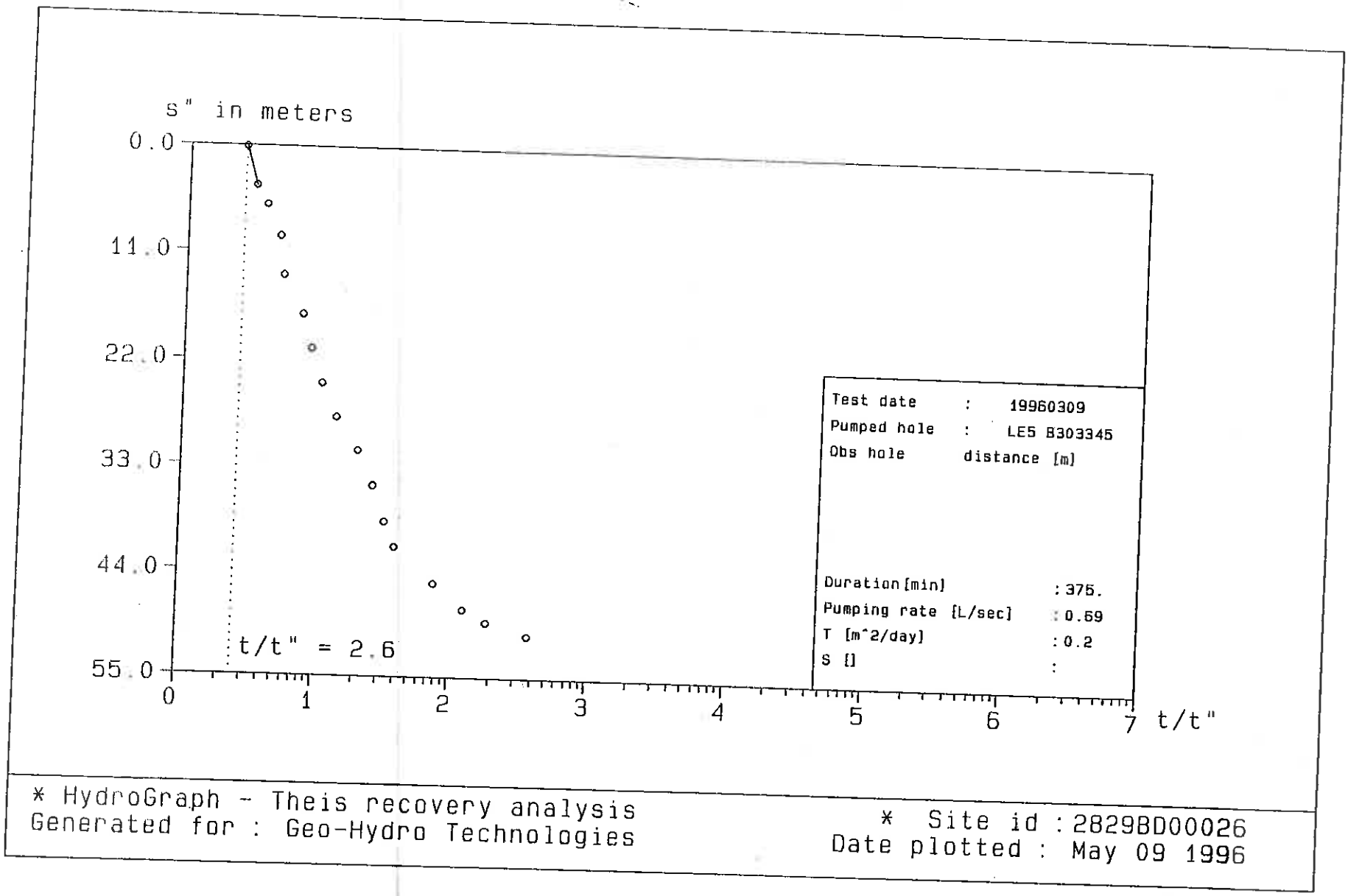
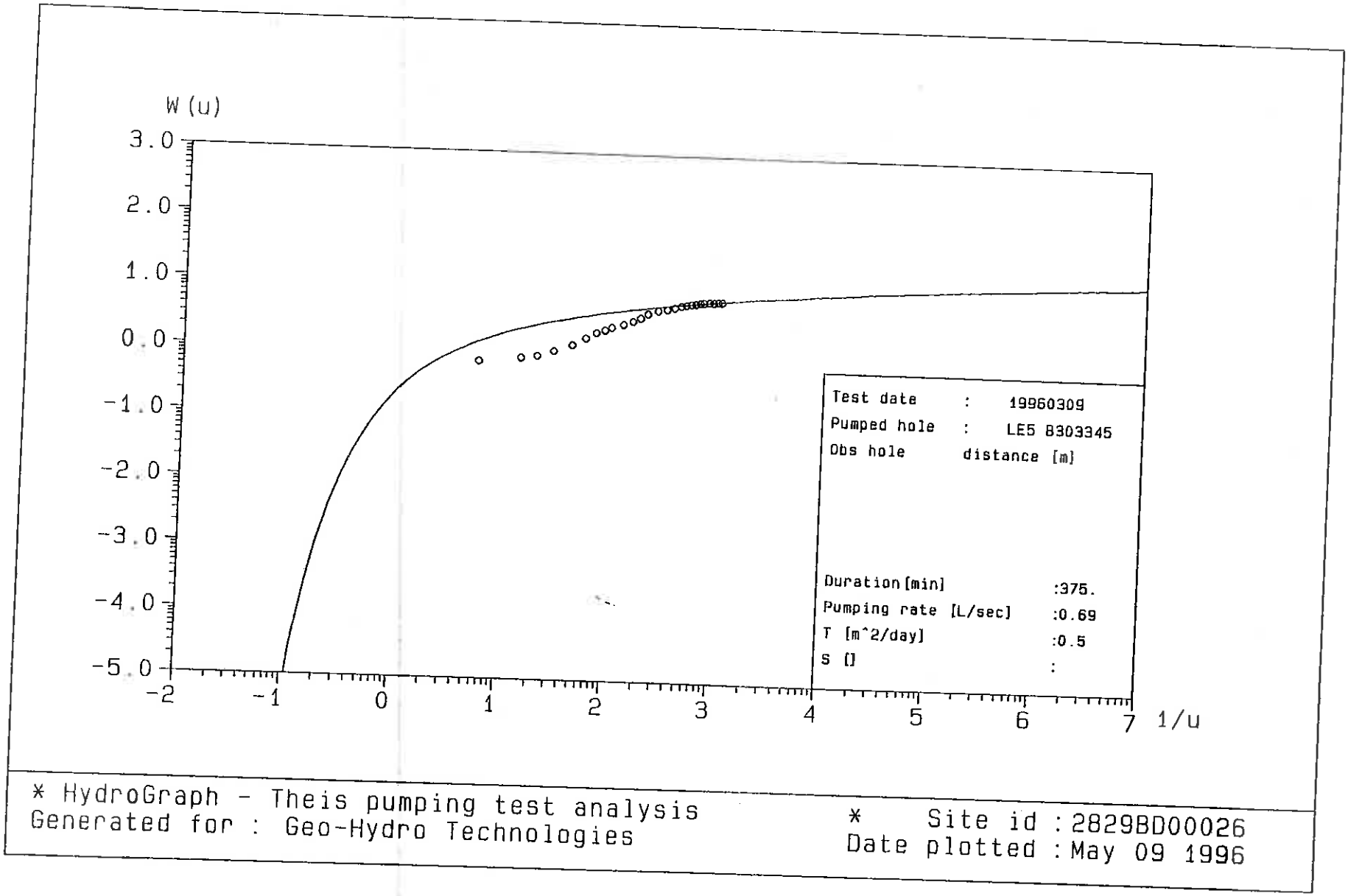


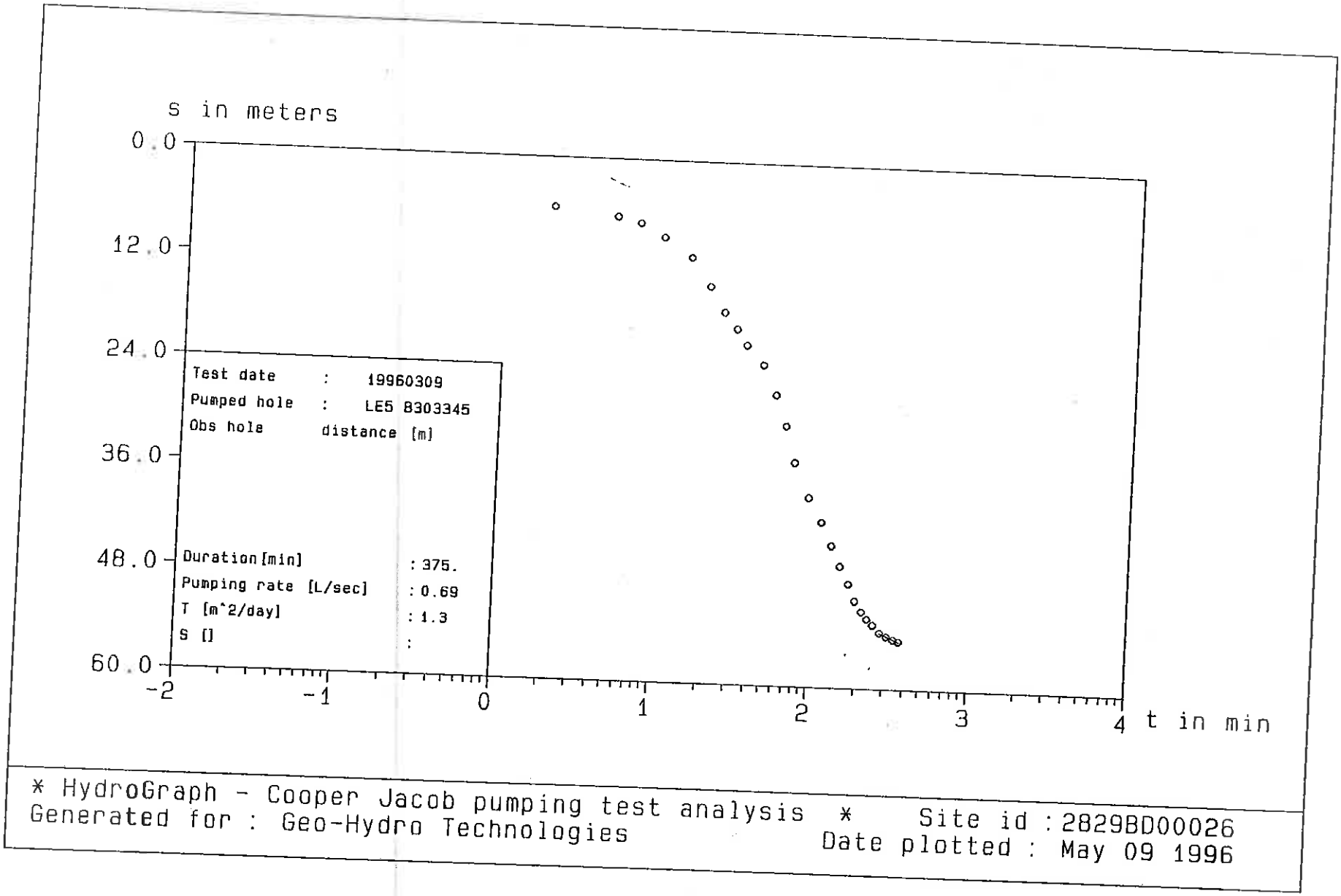
* HydroGraph - Theis recovery analysis
Generated for : Geo-Hydro Technologies

* Site id : 2829BD00026
Date plotted : May 09 1996



* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2829BD00026
Date plotted : May 09 1996



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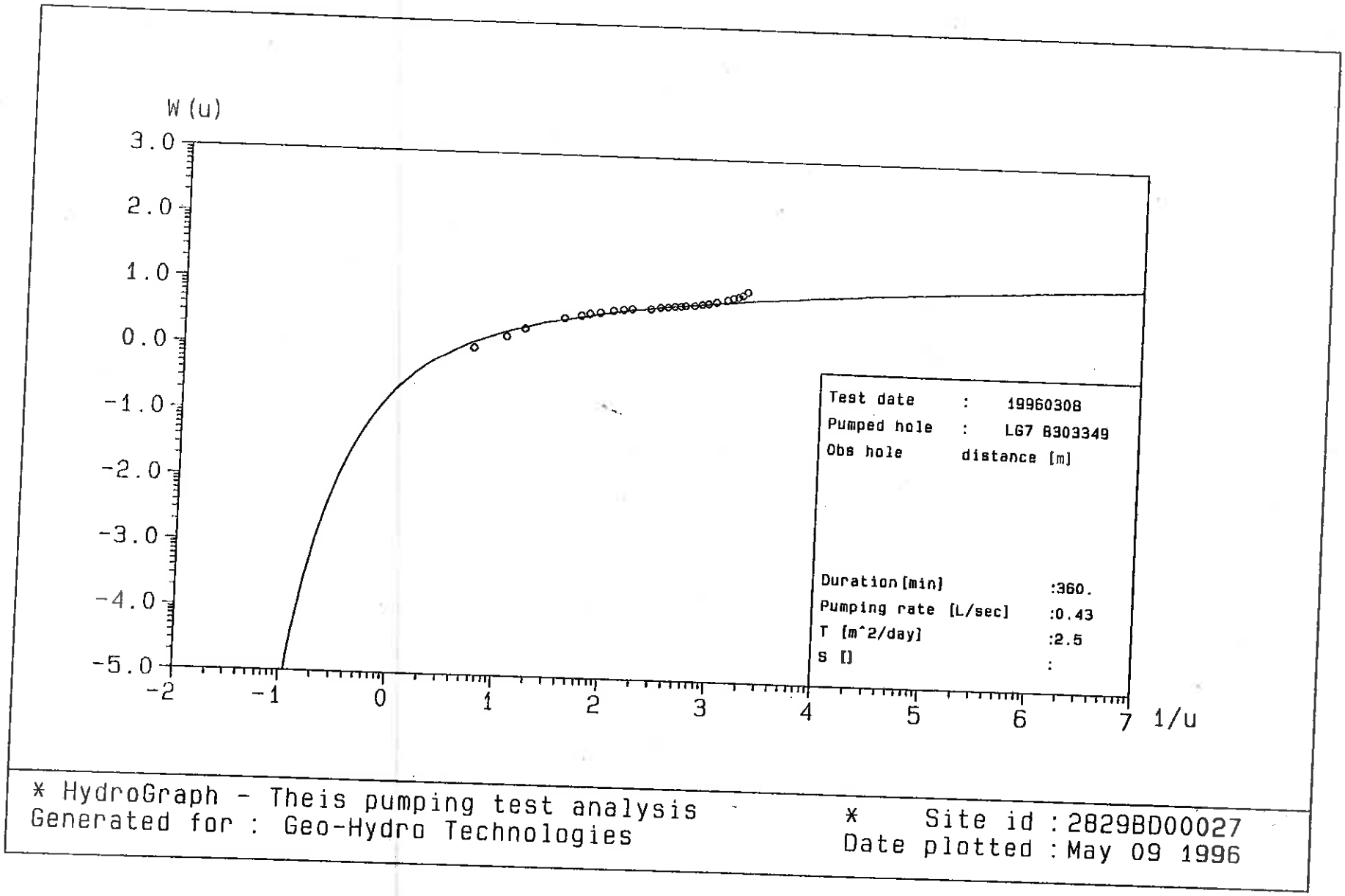
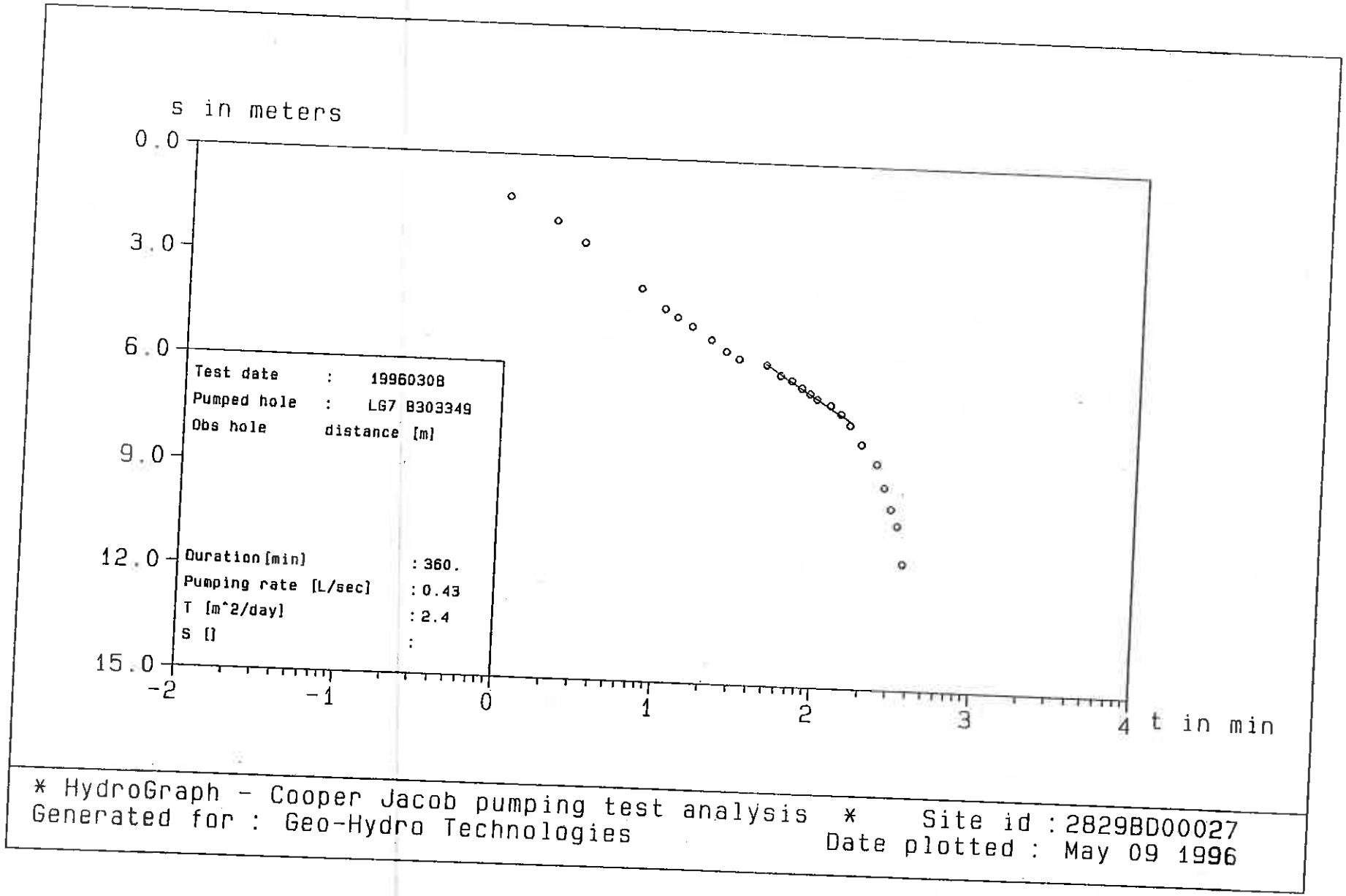
Generated for : Geo-Hydro Technologies Date plotted : May 09 1996



* HydroGraph - Theis pumping test analysis
Generated for : Geo-Hydro Technologies

* Site id : 2829BD00027
Date plotted : May 09 1996



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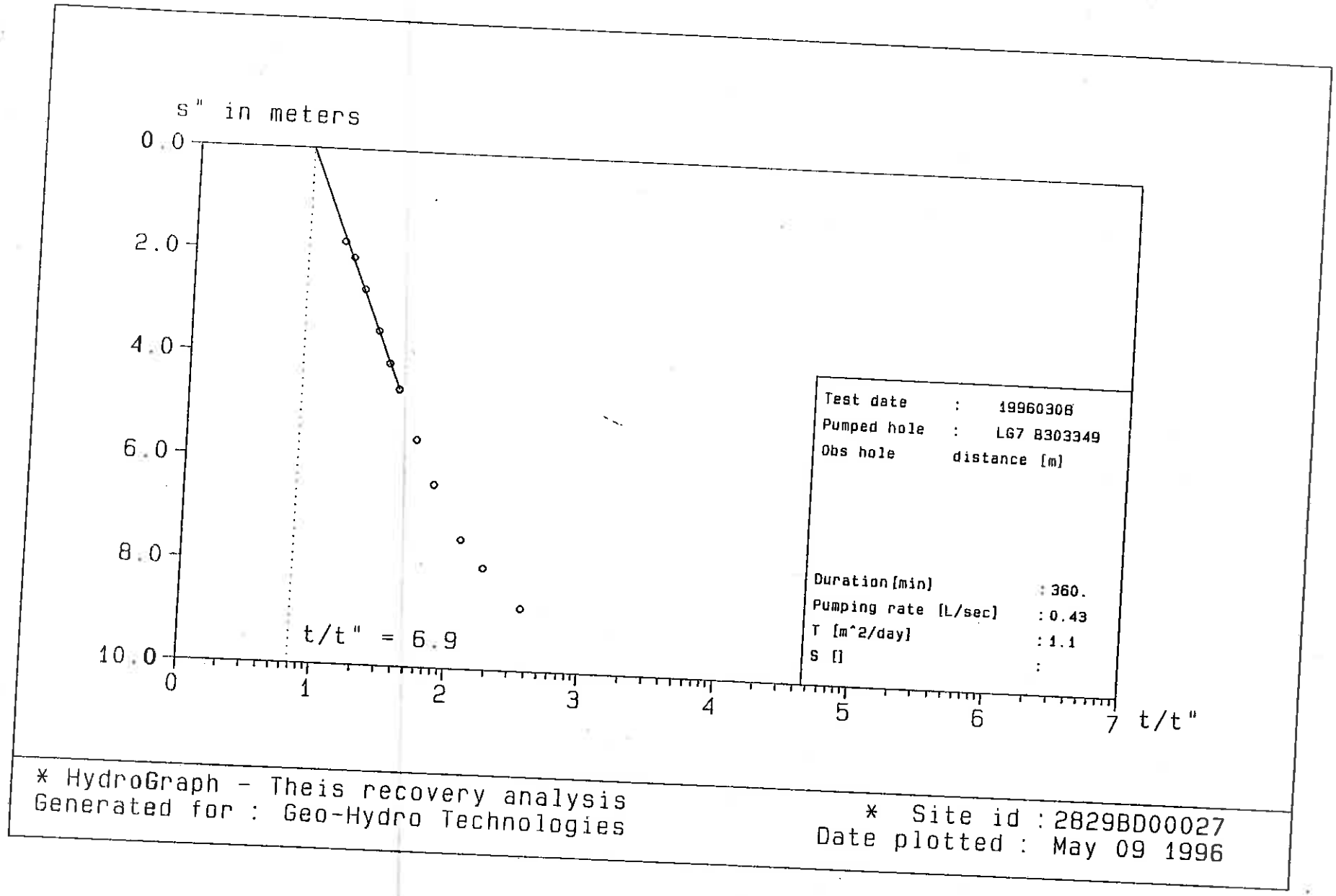
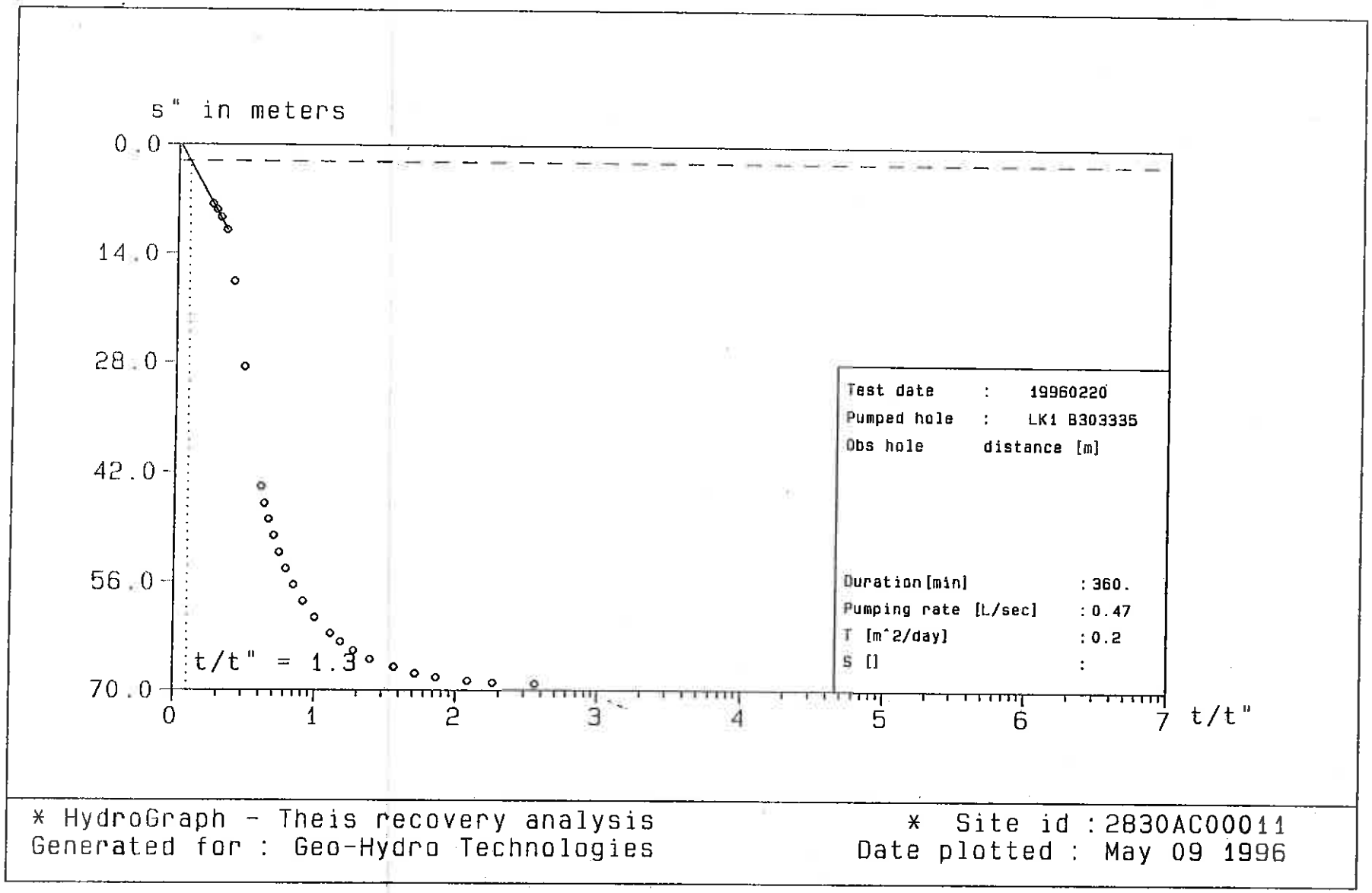
Generated for : Geo-Hydro Technologies Date plotted : May 09 1996


s" in meters
0.0
2.0
4.0
6.0
8.0
10.0
0
1
2
3
4
5
6
7
t/t"
t/t" = 6.9
Test date : 19960308
Pumped hole : LG7 B303349
Obs hole distance [m]
Duration [min] : 360.
Pumping rate [L/sec] : 0.43
T [m^2/day] : 1.1
S [] :
* HydroGraph - Theis recovery analysis
Generated for : Geo-Hydro Technologies
* Site id : 2829BD00027
Date plotted : May 09 1996



* HydroGraph - Theis recovery analysis
Generated for : Geo-Hydro Technologies

* Site id : 2830AC00011
Date plotted : May 09 1996

APPENDIX E

Management Recommendations and Water Quality Reports

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LB2
KwaZulu / Natal Number B303327
GHT Site ID 2829BC00001

Location

Map Reference 2829BC
S Coordinate 28° 17' 55"
E Coordinate 29° 42' 55"

Site New production borehole
Ward Emnambithi
Sub-Ward Baldaskraal 1

Borehole Details

Date Drilled	01-Mar-96
Depth of Borehole (m)	120
Borehole Diameter (mm)	254 (12m) ; 165 (12-120m)
Casing Length (m)	12 Type: Steel
Casing Height (m)	0.28
Depth of Water Strike (m)	80
Airlift Yield (l/s)	0.23
Aquifer Type	Fractured Dolerite
Ground-Water Level (mbgl)	4
Water above Fracture (m)	76

Existing Equipment

Pump Type	None
Pump Yield (l/s)	At Head (m)
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 At Head (m) 50
Depth of Pump Inlet (m)	80
Available Drawdown (m)	76
Contractor	Borehole Services
Date Tested	06-Mar-96

Water Quality Evaluation

	Sample Date 01-Mar-96	06-Mar-96
pH	8.85	9.37 b
Electrical Conductivity (mS/m)	52	66
Ammonia NH_4 as N (mg/l)	0.219	0.71
Calcium Ca (mg/l)	2	3
Chloride Cl (mg/l)	7	10
Fluoride F (mg/l)	1.09	2.55 b
Magnesium Mg (mg/l)	1	1
Nitrate NO_3 as N (mg/l)	0.02	0.29
Phosphate P (mg/l)	0.100<	0.100<
Potassium K (mg/l)	1	5.1
Silicon Si (mg/l)	6.4	3.3
Sodium Na (mg/l)	122 b	162 b
Sulphate SO_4 (mg/l)	1	10
Total Alkalinity as $CaCO_3$ (mg/l)	275	339
Total Dissolved Solids (mg/l)	444	573
Total Hardness as $CaCO_3$ (mg/l)	5	7
Langelier Index	0.12	0.89
Ion balance error (%)	-2.39	-0.13
CLASS	1	2
Water Usage	Domestic Household	

a = Exceeds max acceptable value
b = Exceeds max guideline value
< = Below detection limit
c = Below min guideline value
d = Below min acceptable value

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.19	16.42	360	53.45	49.45	49.45	65.1
Recovery Test	-	-	360	12.35	41.1		83.1

Comments: Although equilibrium conditions were not reached at the end of the test, the borehole has still a sustainable yield for hand pump installation. A low transmissivity in the region of 0.2 m^2/day was determined. No storage coefficient can be determined from the pumped borehole alone.

Aquifer yield l/s

Hydraulic Parameters T (m^2/day) = 0.2 S =

Recommendation

Design Yield 0.15 l/s
0.54 m^3/h

Total pumping time over 24 h 8 h
Total recovery time over 24 h 16 h

Total abstraction per day 4.32 m^3
Modeled drawdown 12.14 m

Depth of Pump Inlet 80 m

Type of pump Cemo HDP 9M

Comments: The water qualities from both the drill and pumptest samples are good. The chemical results from the drill and pump test samples fall in the Class 1 and Class 2 guideline category for the assessment of the fitness for use of borehole water for emergency potable use. It is therefore, recommended that this borehole can be equipped with a handpump. Water samples must be taken at least twice a year and analyzed to determine the fitness for emergency water supply. For handpump installation the borehole has a sustainable yield.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LC3
KwaZulu / Natal Number B303328
GHT Site ID 2829BC00002

Location

Map Reference 2829BC
S Coordinate 28° 23' 53"
E Coordinate 29° 42' 56"

Site New production borehole
Ward Emnambithi
Sub-Ward Watersmeet

Borehole Details

Date Drilled	06-Feb-96
Depth of Borehole (m)	81
Borehole Diameter (mm)	205 (16m) ; 165 (16-81m)
Casing Length (m)	16 **Type:** Steel
Casing Height (m)	0.3
Depth of Water Strike (m)	65
Airlift Yield (l/s)	0.56
Aquifer Type	Dolerite/Sandstone
Ground-Water Level (mbgl)	2.8
Water above Fracture (m)	62.2

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	60
Available Drawdown (m)	57.2
Contractor	Borehole Services
Date Tested	07-Feb-96

Water Quality Evaluation

Sample Date	06-Feb-96
pH	7.29
Electrical Conductivity (mS/m)	22
Ammonia NH_4 as N (mg/l)	0.06
Calcium Ca (mg/l)	20
Chloride Cl (mg/l)	18
Fluoride F (mg/l)	0.1
Magnesium Mg (mg/l)	10
Nitrate NO_3 as N (mg/l)	2.33
Phosphate P (mg/l)	0.100<
Potassium K (mg/l)	3.2
Silicon Si (mg/l)	10.6
Sodium Na (mg/l)	11
Sulphate SO_4 (mg/l)	1
Total Alkalinity as $CaCO_3$ (mg/l)	75
Total Dissolved Solids (mg/l)	149
Total Hardness as $CaCO_3$ (mg/l)	50
Langelier Index	-0.89
Ion balance error (%)	3.93
CLASS	1
Water Usage	Domestic Household

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.40	34.56	360	45.72	42.92	42.92	69.0
Recovery Test			360	8.35	37.37	37.37	87.1

Comments At the end of the constant discharge test, the waterlevel drawdown was approaching equilibrium conditions. It is therefore, save to make the assumption that this borehole has a sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 1.5 **S =**

Recommendation

Design Yield 0.3 l/s
1.08 m^3/h
Depth of Pump Inlet 60 m

Total pumping time over 24 h 9 h
Total recovery time over 24 h 15 h
Type of pump Cemo HDP 9M

Total abstraction per day 9.72 m^3
Modeled drawdown 23 m

Comments The borehole has a sustainable yield for handpump installation. Although only the chemical results of the water sample during the drilling phase is available, the borehole water can be regarded as fit for human consumption on a lifetime basis and can be equipped immediately.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LX24
KwaZulu / Natal Number B303330
GHT Site ID 283AC00005

Location

Map Reference 2830AC
S Coordinate 28° 29' 48"
E Coordinate 30° 10' 52"

Site New production borehole
Ward Emnambithi
Sub-Ward Esikoko

Borehole Details

Date Drilled	14-Feb-96
Depth of Borehole (m)	97
Borehole Diameter (mm)	215 (17m) ; 165 (17-97m)
Casing Length (m)	17 **Type:** Steel
Casing Height (m)	0.3
Depth of Water Strike (m)	80
Airlift Yield (l/s)	0.2
Aquifer Type	Fractured Dolerite
Ground-Water Level (mbgl)	1.4
Water above Fracture (m)	78.6

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	1.4 **At Head (m)** 50
Depth of Pump Inlet (m)	60
Available Drawdown (m)	58.6
Contractor	Borehole Services
Date Tested	17-Feb-96

Water Quality Evaluation

Sample Date	14-Feb-96	17-Feb-96
pH	8.68	8.38
Electrical Conductivity (mS/m)	**80 b**	**86 b**
Ammonia NH_4 as N (mg/l)	0.335	0.013
Calcium Ca (mg/l)	24	79
Chloride Cl (mg/l)	41	34
Fluoride F (mg/l)	**1.08 b**	**1.22 b**
Magnesium Mg (mg/l)	35	58
Nitrate NO_3 as N (mg/l)	3.28	2.83
Phosphate P (mg/l)	<0.100	<0.100
Potassium K (mg/l)	47	5.4
Silicon Si (mg/l)	7.9	19
Sodium Na (mg/l)	78	35
Sulphate SO_4 (mg/l)	56	51
Total Alkalinity as $CaCO_3$ (mg/l)	299	376
Total Dissolved Solids (mg/l)	634	694
Total Hardness as $CaCO_3$ (mg/l)	60	197
Langelier Index	1.05	1.36
Ion balance error (%)	0.46	2.82
CLASS	**1**	**1**
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Test Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.15	12.96	360	59.37	57.97	57.97	98.9
Recovery Test	-	-	360	28.48	30.89		53.3

Comments The waterlevel drawdown reached pump-intake after 320 minutes. The aquifer yield was then determined as 0.1 l/s. Although the waterlevel drawdown reached pump-intake, meaningful interpretations from the data can still be made. For handpump installation the borehole has a sustainable yield. The waterlevel recovery is poor.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 0.1 **S =**

Recommendation

Design Yield 0.1 l/s
0.36 m^3/h
Depth of Pump Inlet 80 m

Total pumping time over 24 h 9 h
Total recovery time over 24 h 15 h
Type of pump Cemo HDP 9M

Total abstraction per day 3.24 m^3
Modeled drawdown m

Comments The results of the water qualities from both the drilling and pumptest samples are good. They fall in the Class 1 guideline category for the assessment of the fitness for use of borehole water for emergency potable use. The borehole has a sustainable yield for handpump installation only. It is therefore, recommended that this borehole can be equipped with a handpump. The borehole water can be used for potable supply on a lifetime basis.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LQ17
KwaZulu / Natal Number B303331
GHT Site ID 283AC00008

Location

Map Reference 2829BC
S Coordinate 28° 33' 12"
E Coordinate 30° 01' 08"

Site New production borehole
Ward Emnambithi
Sub-Ward Wembley

Borehole Details

Date Drilled	27-Feb-96
Depth of Borehole (m)	150
Borehole Diameter (mm)	205 (20m) ; 165 (20-150m)
Casing Length (m)	20 **Type:** Steel
Casing Height (m)	0.3
Depth of Water Strike (m)	110
Airlift Yield (l/s)	0.13
Aquifer Type	Fractured Sandstone
Ground-Water Level (mbgl)	14.4
Water above Fracture (m)	95.6

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	90
Available Drawdown (m)	75.6
Contractor	Borehole Services
Date Tested	06-Mar-96

Water Quality Evaluation

	Sample Date 27-Feb-96	06-Mar-96
pH	8.96	8.17
Electrical Conductivity (mS/m)	159	126
Ammonia NH_4 as N (mg/l)	0.181	0.826
Calcium Ca (mg/l)	5	85
Chloride Cl (mg/l)	232	62
Fluoride F (mg/l)	**4.89 a**	0.76
Magnesium Mg (mg/l)	3	66
Nitrate NO_3 as N (mg/l)	0.18	0.48
Phosphate P (mg/l)	<0.100	<0.100
Potassium K (mg/l)	8.3	4.1
Silicon Si (mg/l)	6.7	6.8
Sodium Na (mg/l)	387	131
Sulphate SO_4 (mg/l)	10	28
Total Alkalinity as $CaCO_3$ (mg/l)	483	612
Total Dissolved Solids (mg/l)	1206	1031
Total Hardness as $CaCO_3$ (mg/l)	12	212
Langelier Index	0.76	1.34
Ion balance error (%)	2.51	2.75
CLASS	**3**	**1**
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δs (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.15	12.96	360	76.98	62.58	62.58	82.8
Recovery Test	-	-	370	62.65	14.33		22.9

Comments Steady state conditions were not reached during the pumptest. There was still a noticeable drawdown in the waterlevel at the end of the test. The borehole has a sustainable yield for handpump installation only. The waterlevel recovery is poor due to dewatering from fractures which contributed to the original static waterlevel.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 0.2 **S =**

Recommendation

Design Yield 0.1 l/s
0.36 m^3/h
Depth of Pump Inlet 70 m

Total pumping time over 24 h 8 h
Total recovery time over 24 h 16 h
Type of pump Cemo HDP 9 M

Total abstraction per day 2.88 m^3
Modeled drawdown 40 m

Comments The result of the chemical analyses from the drilling phase falls in a Class 3 category and from the pumptest phase in Class 1 category for the assessment of the fitness for use of borehole water for emergency potable use. The result of the chemical analyses from the pumptest is more representative from the aquifer and therefore, this borehole can be equipped with a handpump. The borehole has a sustainable yield for handpump installation only. Water samples must be taken on a regularly basis and analysed for the major constituents especially the fluoride content.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LI9b
KwaZulu / Natal Number B303334
GHT Site ID 2930AD00010

Location

Map Reference 2930AD
S Coordinate 28° 27' 08"
E Coordinate 30° 17' 38"

Site New production borehole
Ward Emnambithi
Sub-Ward Dival

Borehole Details

Date Drilled	13-Feb-96
Depth of Borehole (m)	120
Borehole Diameter (mm)	215(12m) 165(12-120m)
Casing Length (m)	12m **Type:** Steel
Casing Height (m)	0.3
Depth of Water Strike (m)	96
Airlift Yield (l/s)	4.2
Aquifer Type	Sandstone / Shale
Ground-Water Level (mbgl)	6.6
Water above Fracture (m)	89.4

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	70
Available Drawdown (m)	63.4
Contractor	Borehole Services
Date Tested	15-Feb-96

Water Quality Evaluation

	Sample Date 13-Feb-96	06-Mar-96
pH	8.64	8.51
Electrical Conductivity (mS/m)	**163 b**	**157**
Ammonia NH_4 as N (mg/l)	0.826	0.671
Calcium Ca (mg/l)	4	4
Chloride Cl (mg/l)	180	174
Fluoride F (mg/l)	**1.56 b**	1.32
Magnesium Mg (mg/l)	2	3
Nitrate NO_3 as N (mg/l)	0.12	0.02
Phosphate P (mg/l)	0.100<	<0.100
Potassium K (mg/l)	9.3	5.1
Silicon Si (mg/l)	20	5
Sodium Na (mg/l)	**386 b**	**363**
Sulphate SO_4 (mg/l)	2	1
Total Alkalinity as $CaCO_3$ (mg/l)	615	609
Total Dissolved Solids (mg/l)	**1268**	**1210**
Total Hardness as $CaCO_3$ (mg/l)	10	10
Langelier Index	0.44	0.32
Ion balance error (%)	-0.34	-2.41
CLASS	**2**	**2**
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	1.50	129.60	360	15.87	9.27	9.27	14.6
Recovery Test	-	-	160	10.01	5.86		63.2

Comments The waterlevel drawdown stabilized after 2 hours of continuous pumping, thus reaching equilibrium conditions. The waterlevel recovery is good. The borehole has a sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 14 **S =**

Recommendation

Design Yield 2.2 l/s
7.92 m^3/h
Depth of Pump Inlet 60 m

Total pumping time over 24 h 11 h
Total recovery time over 24 h 13 h
Type of pump Cemo HDP 9M

Total abstraction per day 87.12 m^3
Modeled drawdown 15.7 m

Comments The borehole has a sustainable yield for handpump installation and for a motorized unit. If a motorized unit is installed the recommended design yield and the maximum total pumping time should not be exceeded. The water qualities are good and the borehole can be equipped immediately.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LH8
KwaZulu / Natal Number B303340
GHT Site ID 2830AC00015

Location

Map Reference 2830AC
S Coordinate 28° 29' 30"
E Coordinate 30° 12' 39"

Site New production borehole
Ward Emnambithi
Sub-Ward Namakazi

Borehole Details

Date Drilled	18-Feb-96		
Depth of Borehole (m)	97		
Borehole Diameter (mm)	205(29m) 165(29-97m)		
Casing Length (m)	8(S) 8-29(P)	**Type:**	Steel
Casing Height (m)	0.32		
Depth of Water Strike (m)	30		
Airlift Yield (l/s)	1.4		
Aquifer Type	Dolerite		
Ground-Water Level (mbgl)	0		Artesian
Water above Fracture (m)	30		

Existing Equipment

Pump Type	None		
Pump Yield (l/s)		**At Head (m)**	
Depth of Pump Inlet (m)			

Test Pump

Pump Type	Submersible		
Pump Yield (l/s)	2	**At Head (m)**	50
Depth of Pump Inlet (m)	60		
Available Drawdown (m)	60		
Contractor	Borehole Services		
Date Tested	22-Feb-96		

Water Quality Evaluation

	Sample Date	18-Feb-96	22-Feb-96
	pH	8.20	8.01
	Electrical Conductivity (mS/m)	83	90
	Ammonia NH_4 as N (mg/l)	0.194	0.374
	Calcium Ca (mg/l)	50	70
	Chloride Cl (mg/l)	38	40
	Fluoride F (mg/l)	0.49	0.56
	Magnesium Mg (mg/l)	34	36
	Nitrate NO_3 as N (mg/l)	0.02	0.04
	Phosphate P (mg/l)	0.100<	0.100<
	Potassium K (mg/l)	3.3	3.8
	Silicon Si (mg/l)	15.5	18.1
	Sodium Na (mg/l)	94	95
	Sulphate SO_4 (mg/l)	28	30
	Total Alkalinity as $CaCO_3$ (mg/l)	377	423
	Total Dissolved Solids (mg/l)	659	739
	Total Hardness as $CaCO_3$ (mg/l)	125	175
	Langelier Index	0.99	0.98
	Ion balance error (%)	1.34	2.1
	CLASS	1	1
	Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	1.40	120.96	90	10.86	10.86	10.86	18,1
Recovery Test	-	-	5	0	10.86		100.0

Comments The borehole is artesian. No significant drawdown could be obtained due to the inefficiency of the test pump. The pumptest was discontinued after 90 minutes. The waterlevel recovery is good. From the results obtained it is therefore concluded that this borehole has a sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 11 **S =**

Recommendation

Design Yield 1 l/s
3.6 m^3/h
Depth of Pump Inlet 60 m
Total pumping time over 24 h 17 h
Total recovery time over 24 h 7 h
Type of pump Cemo HDP 9M
Total abstraction per day 61.2 m^3
Modeled drawdown 43.6 m

Comments The borehole has a sustainable yield for handpump installation. The water qualities are good. Both the results from the chemical analyses from the drill and pumptest phases, fall in the Class 1 category for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is suitable for emergency supply on a lifetime basis and the borehole can be equipped.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LS19b
KwaZulu / Natal Number B303342
GHT Site ID 2830AC00017

Location

Map Reference 2830AC
S Coordinate 28° 28' 21"
E Coordinate 30° 13' 28"

Site New production borehole
Ward Emnambithi
Sub-Ward Vaalkop

Borehole Details

Date Drilled	22-Feb-96
Depth of Borehole (m)	101
Borehole Diameter (mm)	215(42m) 165(42-101m)
Casing Length (m)	20(S) 20-42(P) **Type:** Steel
Casing Height (m)	0.31
Depth of Water Strike (m)	40
Airlift Yield (l/s)	0.2
Aquifer Type	Dolerite
Ground-Water Level (mbgl)	1
Water above Fracture (m)	39

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	60
Available Drawdown (m)	59
Contractor	Borehole Services
Date Tested	22-Feb-96

Water Quality Evaluation

	Sample Date 22-Feb-96	28-Feb-96
pH	8.58	8.08
Electrical Conductivity (mS/m)	55	62
Ammonia NH_4 as N (mg/l)	0.32	0.012
Calcium Ca (mg/l)	10	50
Chloride Cl (mg/l)	21	19
Fluoride F (mg/l)	0.56	0.63
Magnesium Mg (mg/l)	5	30
Nitrate NO_3 as N (mg/l)	0.02	0.05
Phosphate P (mg/l)	0.100<	0.100<
Potassium K (mg/l)	21	1.9
Silicon Si (mg/l)	3.9	7.1
Sodium Na (mg/l)	100	54
Sulphate SO_4 (mg/l)	18	21
Total Alkalinity as $CaCO_3$ (mg/l)	237	307
Total Dissolved Solids (mg/l)	448	506
Total Hardness as $CaCO_3$ (mg/l)	25	125
Langelier Index	0.5	0.81
Ion balance error (%)	0.52	1.45
CLASS	1	1
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.37	31.97	350	52.73	51.73	51.73	87.7
Recovery Test	-	-	360	10.96	41.77		80.7

Comments Equilibrium conditions were reached at the end of the pumptest. The waterlevel stabilized at a relative drawdown of 51.73 m. The waterlevel recovery is good. From the results obtained it is therefore concluded that this borehole has a sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 1 **S =**

Recommendation

Design Yield 0.15 l/s
0.54 m^3/h
Pump type Cemo HDP 9M

Total pumping time over 24 h 9 h
Total recovery time over 24 h 15 h
Inlet 60 m

Total abstraction per day 4.86 m^3
Modeled drawdown 20 m
Pump performance 0.11 l/s at head 60 m

Comments The borehole has a sustainable yield for handpump installation. The water qualities are good. Both the results from the chemical analyses from the drill and pumptest phases, fall in the Class 1 category for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is suitable for emergency supply on a lifetime basis and the borehole can be equipped.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LW23b
KwaZulu / Natal Number B303343
GHT Site ID 2830AC00019

Location

Map Reference 2830AC
S Coordinate 28° 25' 41"
E Coordinate 30° 12' 46"

Site New production borehole
Ward Emnambithi
Sub-Ward Tholeni Town

Borehole Details

Date Drilled	21-Feb-96
Depth of Borehole (m)	150
Borehole Diameter (mm)	215(22m) 165(22-150m)
Casing Length (m)	22(S) **Type:** Steel
Casing Height (m)	0.25
Depth of Water Strike (m)	96
Airlift Yield (l/s)	0.2
Aquifer Type	Shale
Ground-Water Level (mbgl)	13.9
Water above Fracture (m)	82.1

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	100
Available Drawdown (m)	86.1
Contractor	Borehole Services
Date Tested	23-Feb-96

Water Quality Evaluation

	Sample Date 21-Feb-96	23-Feb-96
pH	7.95	7.7
Electrical Conductivity (mS/m)	**150 b**	40
Ammonia NH_4 as N (mg/l)	1.367	0.065
Calcium Ca (mg/l)	18	33
Chloride Cl (mg/l)	**388 b**	11
Fluoride F (mg/l)	**2.66 b**	0.82
Magnesium Mg (mg/l)	2	16
Nitrate NO_3 as N (mg/l)	0.11	0.26
Phosphate P (mg/l)	0.100<	0.100<
Potassium K (mg/l)	14.8	0.9<
Silicon Si (mg/l)	1.6	18.9
Sodium Na (mg/l)	**276 b**	36
Sulphate SO_4 (mg/l)	8	11
Total Alkalinity as $CaCO_3$ (mg/l)	149	192
Total Dissolved Solids (mg/l)	876	328
Total Hardness as $CaCO_3$ (mg/l)	45	82
Langelier Index	-0.15	0.09
Ion balance error (%)	-2.85	0.78
CLASS	**2**	**1**
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.35	30.24	360	60.99	47.09	47.09	54.7
Recovery Test	-	-	340	18.12	42.87		91.0

Comments The waterlevel drawdown showed a trend towards equilibrium conditions at the end of the pumptest. The waterlevel recovery is good. From the results obtained it is therefore concluded that this borehole has a sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 0.4 **S =**

Recommendation

Design Yield 0.1 l/s (0.36 m^3/h) **Total pumping time over 24 h** 9 h **Total recovery time over 24 h** 15 h **Total abstraction per day** 3.24 m^3
Pump type Cemo HDP 9M **Inlet** 80 m **Modeled drawdown** 52 m
Pump performance 0.09 l/s at head 80 m

Comments The borehole has a sustainable yield for handpump installation. The water qualities are good. The chemical results from the drilling phase show high concentrations of F, Cl and Na which fall in the Class 2 guideline category. These high concentrations are absent in the pumptest sample and the chemical results fall in the Class 1 guideline category for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is suitable for emergency supply on a lifetime basis and the borehole can be equipped.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number	GH95W/HD
Region	KwaZulu/Natal
District	Ladysmith
Borehole Number	LR18
KwaZulu / Natal Number	B303354
GHT Site ID	2829BD00020

Location

Map Reference	2829BD
S Coordinate	28° 34' 35"
E Coordinate	29° 53' 36"
Site	New production borehole
Ward	Emnambithi
Sub-Ward	St Chads

Borehole Details

Date Drilled	05-Mar-96
Depth of Borehole (m)	138
Borehole Diameter (mm)	254(6m) 165(6-138m)
Casing Length (m)	6(S) Type: Steel
Casing Height (m)	0.21
Depth of Water Strike (m)	107
Airlift Yield (l/s)	0.3
Aquifer Type	Dolerite
Ground-Water Level (mbgl)	6.76
Water above Fracture (m)	100.24

Existing Equipment

Pump Type	None
Pump Yield (l/s)	At Head (m)
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 At Head (m) 50
Depth of Pump Inlet (m)	80
Available Drawdown (m)	73.24
Contractor	Borehole Services
Date Tested	07-Mar-96

Water Quality Evaluation

Sample Date	05-Mar-96	07-Mar-96
pH	9.46 b	8.6
Electrical Conductivity (mS/m)	56	63
Ammonia NH_4 as N (mg/l)	0.077	0.463
Calcium Ca (mg/l)	4	6
Chloride Cl (mg/l)	33	33
Fluoride F (mg/l)	1.05	2 b
Magnesium Mg (mg/l)	1	2
Nitrate NO_3 as N (mg/l)	28	1.1
Phosphate P (mg/l)	0.100<	0.100<
Potassium K (mg/l)	14.4	1.6
Silicon Si (mg/l)	5	4.7
Sodium Na (mg/l)	120	138
Sulphate SO_4 (mg/l)	20	8
Total Alkalinity as $CaCO_3$ (mg/l)	245	274
Total Dissolved Solids (mg/l)	498	497
Total Hardness as $CaCO_3$ (mg/l)	10	15
Langelier Index	0.98	0.35
Ion balance error (%)	-3.69	-1.88
CLASS	2	2
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.19	16.42	360	50.91	44.15	44.15	60.3
Recovery Test	-	-	320	10.86	40.05		90.7

Comments The waterlevel drawdown showed a trend towards equilibrium conditions at the end of the pumptest. The waterlevel recovery is good. From the results obtained it is therefore concluded that this borehole has a sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** T (m^2/day) = 0.3 **S =**

Recommendation

Design Yield 0.15 l/s (0.54 m^3/h) **Total pumping time over 24 h** 11 h **Total recovery time over 24 h** 13 h **Total abstraction per day** 5.94 m^3

Pump type Cemo HDP 9M **Inlet** 80 m **Modeled drawdown** 37 m **Pump performance** 0.09 l/s at head 80 m

Comments The borehole has a sustainable yield for handpump installation. The water qualities are good. The chemical results from both the drilling and pumptest phases fall in the Class 2 guideline value for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is suitable for emergency supply on a short term basis and the borehole can be equipped.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LD4
KwaZulu / Natal Number B303344
GHT Site ID 2829BD00023

Location

Map Reference 2829BD
S Coordinate 28° 25' 12"
E Coordinate 29° 47' 32"

Site New production borehole
Ward Emnambithi
Sub-Ward Godi

Borehole Details

Date Drilled	24-Feb-96
Depth of Borehole (m)	138
Borehole Diameter (mm)	215(42m) 165(42-138m)
Casing Length (m)	30(S) 12(P) **Type:** Steel
Casing Height (m)	0.33
Depth of Water Strike (m)	65
Airlift Yield (l/s)	0.7
Aquifer Type	Dolerite
Ground-Water Level (mbgl)	9.4
Water above Fracture (m)	55.6

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	64
Available Drawdown (m)	54.6
Contractor	Borehole Services
Date Tested	08-Mar-96

Water Quality Evaluation

	Sample Date	24-Feb-96	08-Mar-96
	pH	8.58	7.93
	Electrical Conductivity (mS/m)	71	68
	Ammonia NH_4 as N (mg/l)	0.8	1.290
	Calcium Ca (mg/l)	12	35
	Chloride Cl (mg/l)	14	10
	Fluoride F (mg/l)	0.7	0.23
	Magnesium Mg (mg/l)	4	11
	Nitrate NO_3 as N (mg/l)	0.2	0.06
	Phosphate P (mg/l)	0.100<	0.100<
	Potassium K (mg/l)	11.7	1.9
	Silicon Si (mg/l)	2.94	5.6
	Sodium Na (mg/l)	152	113
	Sulphate SO_4 (mg/l)	3	1
	Total Alkalinity as $CaCO_3$ (mg/l)	368	378
	Total Dissolved Solids (mg/l)	598	568
	Total Hardness as $CaCO_3$ (mg/l)	30	87
	Langelier Index	0.74	0.58
	Ion balance error (%)	-0.19	-1.68
	CLASS	1	1
	Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.45	38.88	360	24.15	14.75	14.75	27.0
Recovery Test	-	-	560	11.39	12.76		86.5

Comments The waterlevel drawdown showed a trend towards equilibrium conditions at the end of the pumptest. The waterlevel recovery is moderate. From the results obtained it is therefore concluded that this borehole has a sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 1 **S =**

Recommendation

Design Yield 0.4 l/s (1.44 m^3/h)
Total pumping time over 24 h 8 h
Total recovery time over 24 h 16 h
Total abstraction per day 11.52 m^3
Pump type Cemo HDP 9M **Inlet** 60 m
Modeled drawdown 39 m
Pump performance 0.11 l/s at head 60 m

Comments The borehole has a sustainable yield for handpump installation. The water qualities are good. The chemical results from both the drilling and pumptest phases fall in the Class 1 guideline value for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is suitable for emergency supply on a lifetime basis and the borehole can be equipped.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LZ27b
KwaZulu / Natal Number B303347
GHT Site ID 2829BD00025

Location

Map Reference 2829BD
S Coordinate 28° 23' 25"
E Coordinate 29° 45' 00"

Site New production borehole
Ward Emnambithi
Sub-Ward Gcabane

Borehole Details

Date Drilled	28-Feb-96
Depth of Borehole (m)	150
Borehole Diameter (mm)	215(18m) 165(18-150m)
Casing Length (m)	18(S) **Type:** Steel
Casing Height (m)	0.32
Depth of Water Strike (m)	110
Airlift Yield (l/s)	0.08
Aquifer Type	Dolerite
Ground-Water Level (mbgl)	9.48
Water above Fracture (m)	100.52

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	80
Available Drawdown (m)	70.52
Contractor	Borehole Services
Date Tested	08-Mar-96

Water Quality Evaluation

Sample Date	28-Feb-96	08-Mar-96
pH	6.95	8.33
Electrical Conductivity (mS/m)	**187 b**	**540 a**
Ammonia NH_4 as N (mg/l)	0.219	0.387
Calcium Ca (mg/l)	15	135
Chloride Cl (mg/l)	**572 b**	**1761 a**
Fluoride F (mg/l)	0.36	1.33
Magnesium Mg (mg/l)	1	9
Nitrate NO_3 as N (mg/l)	0.01<	0.08
Phosphate P (mg/l)	0.100<	0.100<
Potassium K (mg/l)	13.2	4.5
Silicon Si (mg/l)	0.3	3.8
Sodium Na (mg/l)	**341 b**	**979 a**
Sulphate SO_4 (mg/l)	12	2
Total Alkalinity as $CaCO_3$ (mg/l)	50	265
Total Dissolved Solids (mg/l)	**1029 b**	**3208 a**
Total Hardness as $CaCO_3$ (mg/l)	37	337
Langelier Index	-1.76	1.15
Ion balance error (%)	-4.19	-4.66
CLASS	**2**	**3**
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.10	8.64	270	77	67.52	67.52	95.7
Recovery Test	-	-	560	72.3	4.7		7.0

Comments The waterlevel drawdown reached pump intake after 270 min. The waterlevel recovery is very poor. From the results obtained it is therefore concluded that this borehole has no sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** T (m^2/day) = **S** =

Recommendation

Design Yield 0 l/s
0 m^3/h
Total pumping time over 24 h 0 h
Total recovery time over 24 h 0 h
Total abstraction per day 0 m^3
Pump type **Inlet** m **Pump performance** **Modeled drawdown** 0 m
l/s at head 0 m

Comments The borehole has no sustainable yield for handpump installation. The water qualities are bad. The chemical results from the drilling phase fall in the Class 2 guideline category and the results from the pumptest phase fall in the Class 3 guideline value for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is not suitable for emergency supply and can therefore not be equipped.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith
Borehole Number LE5
KwaZulu / Natal Number B303345
GHT Site ID 2829BD00026

Location

Map Reference 2829BD
S Coordinate 28° 22' 39"
E Coordinate 29° 37' 07"
Site New production borehole
Ward Emnambithi
Sub-Ward Riverside

Borehole Details

Date Drilled	29-Feb-96
Depth of Borehole (m)	120
Borehole Diameter (mm)	254(6m) 215(54m) 165(120m)
Casing Length (m)	6(S) 38(S) 54(P)
Casing Height (m)	0.32
Depth of Water Strike (m)	86
Airlift Yield (l/s)	0.5
Aquifer Type	Dolerite
Ground-Water Level (mbgl)	0 Artesian
Water above Fracture (m)	86

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	60
Available Drawdown (m)	60
Contractor	Borehole Services
Date Tested	09-Mar-96

Water Quality Evaluation

Sample Date	29-Feb-96	09-Mar-96
pH	8.47	**9.26 b**
Electrical Conductivity (mS/m)	44	42
Ammonia NH_4 as N (mg/l)	0.374	0.194
Calcium Ca (mg/l)	4	1
Chloride Cl (mg/l)	26	1
Fluoride F (mg/l)	**2.09 b**	**2.77 b**
Magnesium Mg (mg/l)	2	1
Nitrate NO_3 as N (mg/l)	6.32	0.03
Phosphate P (mg/l)	0.304	0.100<
Potassium K (mg/l)	5.6	0.9<
Silicon Si (mg/l)	16.7	5.1
Sodium Na (mg/l)	105	102
Sulphate SO_4 (mg/l)	9	1
Total Alkalinity as $CaCO_3$ (mg/l)	205	213
Total Dissolved Solids (mg/l)	424	359
Total Hardness as $CaCO_3$ (mg/l)	10	2
Langelier Index	-0.08	0.09
Ion balance error (%)	-4.79	1
CLASS	**2**	**2**
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.60	51.84	360	54.45	54.45	54.45	90.8
Recovery Test	-	-	240	0.09	54.36		99.8

Comments The borehole is artesian. The waterlevel recovery is good. From the results obtained it is therefore concluded that this borehole has a sustainable yield for handpump installation.

Aquifer yield l/s **Hydraulic Parameters** **T (m^2/day) =** 1 **S =**

Recommendation

Design Yield 0.3 l/s (1.08 m^3/h) **Total pumping time over 24 h** 15 h **Total recovery time over 24 h** 9 h **Total abstraction per day** 16.2 m^3
Pump type Cemo HDP 9M **Inlet** 80 m **Modeled drawdown** 25 m **Pump performance** 0.09 l/s at head 80 m

Comments The borehole is artesian. The water qualities are good. The chemical results from both the drilling and pumptest phases fall in the Class 2 guideline category for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is suitable for emergency supply on a short term basis and can be equipped.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith

Borehole Number LG7
KwaZulu / Natal Number B303349
GHT Site ID 2829BD00027

Location

Map Reference 2829BD
S Coordinate 28° 40' 08"
E Coordinate 29° 51' 38"

Site New production borehole
Ward Emnambithi
Sub-Ward Pieters 2

Borehole Details

Date Drilled	04-Mar-96
Depth of Borehole (m)	132
Borehole Diameter (mm)	254(12m) 165(12-132m)
Casing Length (m)	12(S) **Type** Steel
Casing Height (m)	0.23
Depth of Water Strike (m)	24
Airlift Yield (l/s)	0.44
Aquifer Type	Dolerite
Ground-Water Level (mbgl)	11.16
Water above Fracture (m)	12.84

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	40
Available Drawdown (m)	28.84
Contractor	Borehole Services
Date Tested	09-Mar-96

Water Quality Evaluation

	04-Mar-96	09-Mar-96
Sample Date		
pH	8.74	7.4
Electrical Conductivity (mS/m)	48	68
Ammonia NH_4 as N (mg/l)	0.851	0.026
Calcium Ca (mg/l)	11	73
Chloride Cl (mg/l)	19	16
Fluoride F (mg/l)	0.35	0.24
Magnesium Mg (mg/l)	4	41
Nitrate NO_3 as N (mg/l)	2.94	2.69
Phosphate P (mg/l)	0.100<	0.100<
Potassium K (mg/l)	7.1	1.1
Silicon Si (mg/l)	6.1	21.1
Sodium Na (mg/l)	94	29
Sulphate SO_4 (mg/l)	29	26
Total Alkalinity as $CaCO_3$ (mg/l)	181	329
Total Dissolved Solids (mg/l)	401	588
Total Hardness as $CaCO_3$ (mg/l)	27	182
Langelier Index	0.6	0.3
Ion balance error (%)	1.58	3.29
CLASS	**1**	**1**
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.40	34.56	360	22.51	11.35	11.35	39.4
Recovery Test		-	30	12.97	9.54		84.1

Comments The borehole has a sustainable yield for handpump installation. The waterlevel recovery is good.

Aquifer yield l/s **Hydraulic Parameters** T (m^2/day) = 2.5 **S** =

Recommendation

Design Yield 0.3 l/s (1.08 m^3/h)
Total pumping time over 24 h 20 h
Total recovery time over 24 h 4 h
Total abstraction per day 21.6 m^3
Modeled drawdown 11 m
Pump type Cemo HDP 9M **Inlet** 80 m
Pump performance 0.09 l/s at head 80 m

Comments The water qualities are good. The chemical results from both the drilling and pumptest phases fall in the Class 1 guideline category for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is suitable for emergency supply on a lifetime basis and can be equipped.

MANAGEMENT RECOMMENDATIONS AND WATER QUALITY

General Information

Project Number GH95WHD
Region KwaZulu/Natal
District Ladysmith
Borehole Number LJ10
KwaZulu / Natal Number B303350
GHT Site ID 2829BC00028

Location

Map Reference 2829BD
S Coordinate 28° 18' 16"
E Coordinate 29° 43' 09"
Site New production borehole
Ward Emnambithi
Sub-Ward Baldaskraal 2

Borehole Details

Date Drilled	02-Mar-96
Depth of Borehole (m)	102
Borehole Diameter (mm)	254(6m) 215(13m) 254(102m)
Casing Length (m)	6(S) 10(S) 3(P)
Casing Height (m)	0.21
Depth of Water Strike (m)	80
Airlift Yield (l/s)	0.12
Aquifer Type	Dolerite
Ground-Water Level (mbgl)	5.9
Water above Fracture (m)	74.1

Existing Equipment

Pump Type	None
Pump Yield (l/s)	**At Head (m)**
Depth of Pump Inlet (m)	

Test Pump

Pump Type	Submersible
Pump Yield (l/s)	2 **At Head (m)** 50
Depth of Pump Inlet (m)	70
Available Drawdown (m)	64.1
Contractor	Borehole Services
Date Tested	07-Mar-96

Water Quality Evaluation

	Sample Date 02-Mar-96	07-Mar-96
pH	**9.12 b**	**9.34 b**
Electrical Conductivity (mS/m)	17	33
Ammonia NH_4 as N (mg/l)	0.168	0.542
Calcium Ca (mg/l)	5	8
Chloride Cl (mg/l)	4	5
Fluoride F (mg/l)	0.54	0.28
Magnesium Mg (mg/l)	7	3
Nitrate NO_3 as N (mg/l)	0.13	1.08
Phosphate P (mg/l)	0.100<	0.100<
Potassium K (mg/l)	4.6	0.9<
Silicon Si (mg/l)	19.6	14.2
Sodium Na (mg/l)	32	71
Sulphate SO_4 (mg/l)	2	2
Total Alkalinity as $CaCO_3$ (mg/l)	99	170
Total Dissolved Solids (mg/l)	181	316
Total Hardness as $CaCO_3$ (mg/l)	12	20
Langelier Index	0.42	1.05
Ion balance error (%)	3.77	0.54
CLASS	**2**	**2**
Water Usage	Domestic Household	

a = Exceeds max acceptable value **c = Below min guideline value**
b = Exceeds max guideline value **d = Below min acceptable value**
< = Below detection limit

Borehole Pump Tests Results

Step-Drawdown Test	Discharge Rate (l/s)	Discharge Rate (m^3/day)	Duration (min)	Waterlevel Drawdown / Recovery s (m)	Δ s (m)	Σ s (m)	%
Step 1							
Step 2							
Step 3							
Step 4							
Recovery Test							
Constant Discharge Test	0.22	19.01	360	21.1	15.20	15.20	23.7
Recovery Test		-	90	7.42	13.68		90.0

Comments The borehole has a sustainable yield for handpump installation. The waterlevel recovery is good.

Aquifer yield l/s **Hydraulic Parameters** T (m^2/day) = 1 **S** =

Recommendation

Design Yield 0.2 l/s (0.72 m^3/h) **Total pumping time over 24 h** 10 h **Total recovery time over 24 h** 14 h **Total abstraction per day** 7.2 m^3 **Modeled drawdown** 24 m

Pump type Cemo HDP 9M **Inlet** 80 m **Pump performance** 0.09 l/s at head 80 m

Comments The water qualities are good. The chemical results from both the drilling and pumptest phases fall in the Class 2 guideline category for the assessment of the fitness for use of borehole water for emergency potable use. The borehole water is suitable for emergency supply on a short term basis and can be equipped.

APPENDIX F

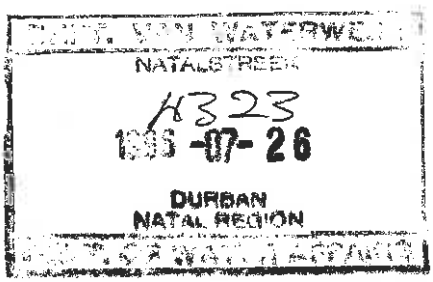
Progress Reports

LADYSMITH PROGRESS REPORT

Site Info									Geophysical Results		Drill Results				Pumptest Results			Chemical Class	
Ward	Subward	Topo Map	Site No	S	E	DWA&F	KwaZulu / Natal	HydroCom	Date	Anomaly	Date	Depth (m)	Yield (l/s)		Date	6h / 12h	Q l/s	Drill sample	Pump sample
Driefontein	Baldaskraal 1	2829BC	1	28° 17' 55"	29° 42' 55"	LB2a	B303327	2829BC00001	27-Feb	EM	01-Mar	120	0.21		06-Mar	6	0.2	1	2
				28° 17' 54"	29° 42' 56"	LB2b			27-Feb	EM									
Driefontein	Watersmeet	2829BC	2	28° 23' 53"	29° 42' 56"	LC3a	B303328	2829BC00002	30-Jan	Geology	06-Feb	81	0.56		06-Feb	6	0.36	1	1
				28° 23' 58"	29° 42' 53"	LC3b			30-Jan	Geology									
Wasbank	Uitvligt	2830AC	3a	28° 28' 20"	30° 07' 44"	LO15a	B303329a	2830AC00003	02-Feb	Mag	06-Feb	121	Dry						
			3b	28° 28' 18"	30° 07' 42"	LO15b	B303329b	2830AC00004	02-Feb	Mag	12-Feb	149	Dry						
				28° 28' 21"	30° 07' 41"	LO15c			29-Feb	EM									
Emnambithi	Esikoko	2830AC		28° 29' 49"	30° 10' 48"	LX24a			02-Feb	EM/Mag									
			4	28° 29' 48"	30° 10' 52"	LX24b	B303330	2830AC00005	02-Feb	EM/Mag	14-Feb	105	0.2		17-Feb	6	0.1	1	1
Emnambithi	Wembley	2830CA		28° 33' 13"	30° 01' 08"	LQ17a		2830AC00006	04-Feb	Mag	25-Feb	121	Dry						
				28° 33' 10"	30° 01' 11"	LQ17b		2830AC00007	04-Feb	Mag	26-Feb	151	Dry						
			5	28° 33' 12"	30° 01' 08"	LQ17c	B303331	2830AC00008	27-Feb	EM	27-Feb	150	0.13		06-Mar	6	0.1	3	1
Emnambithi	Qinisa	2829DB	6	28° 40' 04"	29° 54' 41"	LP16a			04-Feb	Mag	Site too wet to drill								
				28° 40' 13"	29° 54' 53"	LP16b			04-Feb	Mag	"								
Emnambithi	Mbango	2830CA	7	28° 44' 30"	30° 11' 28"	LN14a			06-Feb	Mag	Site too wet to drill								
				28° 44' 26"	30° 11' 24"	LN14b			06-Feb	Mag	"								
Dundee	Dival	2830AD	8a	28° 27' 10"	30° 17' 34"	Ll9a	B303334a	2830AD00009	07-Feb	EM/Mag	12-Feb	126	Dry						
			8b	28° 27' 08"	30° 17' 38"	Ll9b	B303334b	2930AD00010	07-Feb	EM/Mag	13-Feb	120	3.6		15-Feb	6	1.8	2	1
Emnambithi	Limehill 1	2830AC	9	28° 26' 11"	30° 14' 59"	LK1a	B303335	2830AC00011	08-Feb	EM/Mag	16-Feb	150	0.35		20-Feb	6	0.4	2	2
				28° 26' 03"	30° 14' 53"	LK1b			08-Feb	Geology									
Emnambithi	Limehill 2	2830AC	10	28° 26' 04"	30° 14' 28"	LK2a	B303336	2830AC00012	08-Feb	Geology	19-Feb	150	0.35		22-Feb	6	0.4	3	3
				28° 26' 01"	30° 14' 30"	LK2b			08-Feb	Geology									
Emnambithi	Emhlabathini	2830CA	11	28° 34' 15"	30° 04' 53"	LT20a			08-Feb	Geology	Site too wet to drill								
				28° 34' 20"	30° 04' 50"	LT20b			08-Feb	Geology	"								
Dundee	Tholeni Rural	2830AC	12a	28° 26' 39"	30° 13' 26"	LY25a	B303338a	2830AC00013	08-Feb	Mag	18-Feb	150	Dry						
			12b	28° 26' 37"	30° 13' 25"	LY25b	B303338b	2830AC00014	08-Feb	Geology	22-Feb	150	0.13		29-Feb	6	0.2	1	1
Emnambhiti	S'hoek Rural	2830CA	13	28° 33' 36"	30° 11' 14"	LU21a			09-Feb	EM/Mag	Site too wet to drill								
				28° 33' 40"	30° 11' 15"	LU21b			09-Feb	EM/Mag	"								
Dundee	Namakazi	2830AC	14	28° 29' 30"	30° 12' 39"	LH8a	B303340	2830AC00015	12-Feb	EM/Mag	18-Feb	97	1.2		22-Feb	6	1.43	2	1
				28° 29' 28"	30° 12' 38"	LH8b			12-Feb	EM/Mag									

LADYSMITH PROGRESS REPORT

Site Info									Geophysical Results		Drill Results			Pumptest Results			Chemical Class	
Ward	Subward	Topo Map	Site No	S	E	DWA&F	KwaZulu / Natal	HydroCom	Date	Anomaly	Date	Depth (m)	Yield (l/s)	Date	6h / 12h	Q l/s	Drill sample	Pump sample
Dundee	Kliprivier	2830AD	15	28° 31' 53"	30° 17' 33"	LV22a			13-Feb	EM/Mag	Site too wet to drill							
				28° 31' 45"	30° 17' 47"	LV22b			13-Feb	EM/Mag	"							
Dundee	Vaalkop	2830AC	16	28° 28' 18"	30° 13' 29"	LS19a	B303342a	2830AC00016	14-Feb	Mag	21-Feb	150	Dry					
				28° 28' 21"	30° 13' 28"	LS19b	B303342b	2830AC00017	14-Feb	Mag	22-Feb	101	0.56	28-Feb	6	0.38	1	1
Dundee	Tholeni Town	2830AC	17	28° 25' 41"	30° 12' 47"	LW23a	B303343a	2830AC00018	14-Feb	EM/Mag	20-Feb	150	Dry					
				28° 25' 41"	30° 12' 46"	LW23b	B303343b	2830AC00019	14-Feb	EM/Mag	21-Feb	150	0.2	23-Feb	6	0.35	2	1
Emnanbhiti	St Chads	2829BD	18	28° 34' 35"	29° 53' 36"	LR18a	B303354	2829BD00020	08-Feb	Mag	05-Mar	138	0.25	07-Mar	6	0.2	2	2
				Destroyed by floods		LR18b			08-Feb	Mag								
Emnanbhiti	Greylock	2830CA	19	28° 34' 42"	30° 05' 21"	LL12a	B303351a	2830CA00021	13-Feb	EM/Mag	03-Mar	127	Dry					
				28° 34' 49"	30° 05' 16"	LL12b	B303351b	2830CA00022	13-Feb	EM/Mag	04-Mar	121	Dry					
Driefontein	Godi	2829BD	20	28° 25' 12"	29° 47' 32"	LD4a	B303344	2829BD00023	20-Feb	EM/Mag	24-Feb	137	0.7	08-Mar	6	0.45	1	1
				28° 25' 11"	29° 47' 35"	LD4b			20-Feb	EM/Mag								
Driefontein	Gcabane	2829BD	21	28° 23' 25"	29° 45' 00"	LZ27a	B303347a	2829BD00024	20-Feb	EM	27-Feb	150	Dry					
				28° 23' 25"	29° 45' 00"	LZ27b	B303347b	2829BD00025	20-Feb	EM	28-Feb	151	0.13	09-Mar	6	0.1	2	3
Driefontein	Riverside	2829BD	22	28° 22' 39"	29° 37' 07"	LE5a	B303345	2829BD00026	23-Feb	Geology	29-Feb	120	0.45	09-Mar	6	0.6	2	2
				28° 22' 46"	29° 37' 12"	LE5b			23-Feb	Geology								
Kliprivier	Hobsland	2829BD	23	28° 27' 44"	29° 46' 24"	LF6a			21-Feb	EM	Site too wet to drill							
				28° 27' 42"	29° 46' 20"	LF6b			21-Feb	EM	"							
Emnambhiti	Pieters 2	2829BD	24	28° 40' 08"	29° 51' 38"	LG7a	B303349	2829BD00027	23-Feb	EM	04-Mar	132	0.44	08-Mar	6	0.4	1	1
	School			28° 40' 09"	29° 51' 41"	LG7b			23-Feb	EM								
Driefontein	Inkuthu	2829BD	25	28° 22' 11"	29° 38' 26"	LA26a			02-Mar	EM	Site too wet to drill							
				28° 22' 13"	29° 38' 21"	LA26b			02-Mar	EM	"							
Driefontein	Baldaskraal 2	2829BC	26	28° 18' 16"	29° 43' 09"	LJ10a	B303350	2829BC00028	01-Mar	EM	02-Mar	102	0.13	07-Mar	6	0.2	2	2
				28° 18' 17"	29° 43' 06"	LJ10b			01-Mar	EM								
Emnambithi	Pieters 2	2829BD	27	28° 39' 39"	29° 52' 08"	LM13a			23-Feb	Geology								
	Rural			28° 39' 46"	29° 51' 48"	LM13b			23-Feb	Geology								
Emnambithi	Emanseleni	2830CA	28	28° 43' 24"	30° 11' 45"	LB28a			28-Feb	EM/Mag								
				28° 43' 28"	30° 11' 42"	LB28b			28-Feb	EM/Mag								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