AN INVESTIGATION INTO RAINFALL RECHARGE TO GROUND WATER

APPENDIX REPORT

by

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RAINFALL RECHARGE TO GROUND WATER

APPENDIX REPORT

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A P P E N D I X A

EVALUATION AND SELECTION OF GROUND WATER CATCHMENTS

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REPORT CI.3760/2

February 1984

WATER RESEARCH COMMISSION

EVALUATION AND SELECTION OF GROUNDWATER CATCHMENTS FOR A DETAILED RECHARGE INVESTIGATION

1 INTRODUCTION

Historically the study of rainfall recharge to groundwater in southern Africa has been neglected due to the lack of human and technical resources. Low estimates (less than 10 per cent) of recharge by rainfall have been generally used. However, recent work using numerical computer models has shown that recharge from rainfall in some areas may be as high as 30 per cent. In view of the increasing dependence on groundwater in many areas of South Africa, the consequences become very important and it may be possible to significantly upgrade the potential groundwater resource in certain areas.

In January 1983, Steffen Robertson and Kirsten (Civil) Inc (SRK), submitted to the Water Research Commission (WRC) a research proposal, Report CI.3346/1, entitled "An investigation into rainfall infiltration and recharge to groundwater". The study was to use several different approaches to examine potential recharge in areas which were hydrogeologically dissimilar and contained a number of different but commonly-found surface soil-types. The objective was to identify the best cost-effective method of estimating aquifer recharge with greater confidence.

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At a meeting on 17 March 1983, the proposal was accepted in principle with a number of suggested modifications. However, the Chief Geohydrologist, Department of Environment Affairs, indicated that there were a number of hydrogeological catchments that might be more suitable for the research study than those given in the proposal. Consequently, Steffen Robertson and Kirsten (Civil) Inc were requested to submit a proposal, Report CI.3760/1, for the evaluation and selection of groundwater catchments for the recharge study. This proposal was submitted and accepted in June 1983.

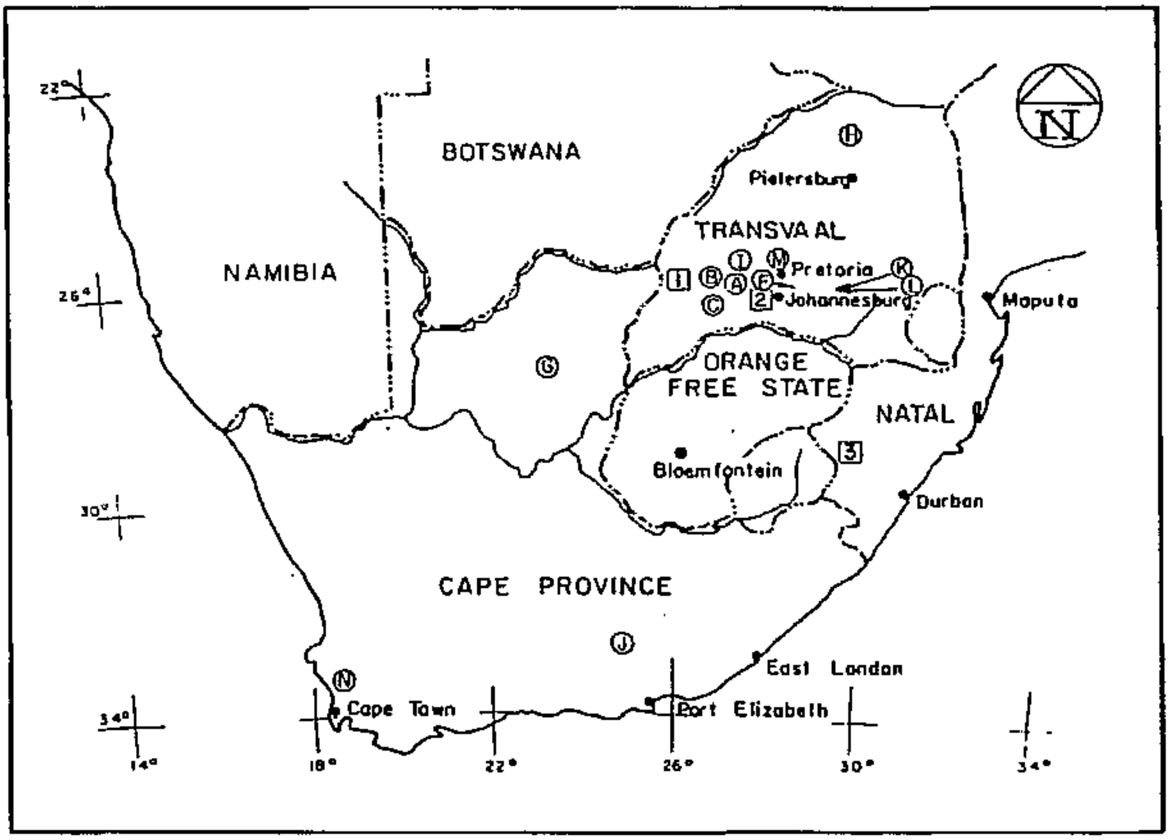
This report describes the evaluation of the sixteen suggested catchments using a semi-quantitative rating developed for the study, and their reduction down to seven possible sites (Fig 1.1). Further filtering, together with field visits to four of the sites, led to the final selection of three catchments recommended for the recharge study.

LEGEND

CATCHMENTS EVALUATED

Ⓐ STEENKOPPIES
Ⓑ UPPER EYE, MOOI R
Ⓒ SKOONSPRUIT
Ⓕ RIETVLEIDAM
Ⓖ MOTHIBISTADT
Ⓗ DENDRON
Ⓘ RIETVALLEY RESERVE
Ⓙ MIDDELBURG, KP
Ⓚ HARTBEESTFONTEIN
Ⓛ PHOENIX
Ⓜ RIETONDALE
Ⓝ ATLANTIS

[1] MOLOPO / GROOTFONTEIN COMPARTMENTS
[2] ZUURBEKOM / GEMSBOKFONTEIN COMPARTMENTS
[3] CATCHMENT 14, NTABAMHLOPE



0 100 200 300 400 500 Km

SCALE

LOCALITY PLAN

CATCHMENT AREAS

JOB Nº		FIG Nº
CI 3760	RECHARGE STUDY FEASIBILITY INVESTIGATION	1.

Ozalid 81/5746

2 TERMS OF REFERENCE

The research proposal, Report CI.3760/1, entitled "Feasibility study on the selection of groundwater catchments for a detailed recharge investigation", was submitted in June 1983. This proposal was accepted in a letter dated 23 June 1983, by the Water Research Commission.

The resulting Consulting Agreement (Ref K 18/63/1) between the WRC and SRK formed the terms of reference for the feasibility study. The pertinent conditions were:

1 The study should concentrate on the twelve potential research catchments as identified by the Division of Geohydrology of the Department of Environment Affairs, and the three additional sites proposed by SRK. All arrangements in connection with access to the data on the proposed areas should be made in collaboration with the Head of the Division of Geohydrology.

2 In addition to those areas mentioned in (1), a number of those surface water catchments forming part of other investigations funded by the Commission may also be included in this study. Selection of and visits to these catchments should take place in collaboration with Dr Roberts of our staff.

3 The investigation should be executed in the three phases proposed in paragraph 4 of your submission. The final phase, ie the report on the study, should give an evaluation of the various sites investigated and should make recommendations on the most suitable sites for the recharge study envisaged in the proposal entitled "An investigation into rainfall infiltration and recharge to groundwater.

3 METHOD OF APPROACH

3.1 Introduction

The feasibility study was divided into three phases:

- Phase I - Desk study

  A review of all the available information on the catchments was carried out and the data scored according to evaluation matrices, which are discussed in more detail below.

  The objectivity of the matrix approach was considered to be important in the assessment of each catchment and the formation of a short-list of potential sites.

- Phase II - Site visit

  A ground visit was then made to four potential catchments by personnel from the Division of Geohydrology and SRK. The objective was to confirm, if possible, the suitability of each site as defined by the Phase I study.

- Phase III - Report

  On completion of the first two phases, a report was to be generated. It would include the evaluation of the various sites and detail our recommendations of one or more areas for the recharge research.

3.2 Literature search and initial catchment evaluation

In the desk study most of the available literature and unpublished data on the proposed catchments were derived from the records of the Division of Geohydrology, the Pretoria Municipality and SRK files. The information for each site was evaluated and recorded using particular parameters (Table 3.1) identified as important criteria (Appendix A) for the recharge study and assigned to reflect the quality of this information.

The information and evaluation for each site was discussed with Mr J R Vegter, Head of the Geohydrology Division and, if possible, with the relevant authors. This ensured that all the available pertinent documentation had been examined and any additional factors or shortcomings were highlighted.

The Initial Catchment Evaluation Matrix (ICEM) was completed for each site using these criteria and scores. Total scores were determined and compared, allowing a short-list of the most-promising catchments to be prepared.

3.3 Short-list catchment evaluation

Having identified the most-promising catchments, more specific criteria (Appendix B) were used with differential weighting to more accurately compare the merits of each site. A Short-list Catchment Evaluation Matrix (SLCEM, Table 3.2) was drawn up allowing:

- a comparison of the amount of relevant hydrological and hydrogeological information for each site

- estimation of the additional work required to attain an adequate confidence level for the above

- comparison of the potential benefits of a recharge study for the catchment

Description of parameters

The first set of parameters, R1, was used to determine how well the surface hydrology of each catchment had been defined. The

TABLE 3.1 INITIAL CATCHMENT EVALUATION MATRIX

Study area	Aquifer-type & geological environment	Available information												Physiography						Hydrology											Geology					Geophysics				Hydrogeology												Long-term monitoring: Records					Long-term monitoring: Stations				User-benefit (recharge study)									
		Topographical maps	Geological maps	Geophysical maps	Soils-survey maps	Other maps	Air-photographs	Ortho-photographs	Thermal infra-red	Reports-published	Reports-unpublished	File documentation	Sub-total	Topography	Climate	Vegetation	Land-use	Accessibility	Sub-total	Catchment area	Surface drainage	Wind	Rainfall	Evaporation	Evapotranspiration	Runoff	Soil hydraulic characteristics	Interflow	Baseflow	Sub-total	Stratigraphy	Lithology	Structure	Secondary features	Sub-total	Aerial	Surface	Borehole	Sub-total	Aquifer definition	Aquifer boundaries	Piezometric surface	Hydraulic parameters	Hydrogeochemistry	Inflows	Throughflow	Outflows	Recharge	Groundwater balance	Aquifer computer model	Sub-total	Springflow	Groundwater levels	Groundwater quality	Environmental isotopes	Abstraction	Gauging station	Piezometers	Climatic station	Sub-total	General (natural)	Government	Mining	Industrial	Agricultural	Municipal	Research	Academic	Sub-total	Total score
STEENKOPPIES (MALONEY) (FAR WEST RAND)	DOLOMITE																																																																					
UPPER EYE, MOOI RIVER (EAST OF DERBY)	DOLOMITE																																																																					
SCHOONSPRUIT EYE (FAR WEST RAND)	DOLOMITE																																																																					
GROOTFONTEIN (WEST OF LICHTENBURG)	DOLOMITE																																																																					
MOLOPO COMPARTMENT (NW OF LICHTENBURG)	DOLOMITE																																																																					
RIETVLEIDAM (SE OF PRETORIA)	DOLOMITE																																																																					
MOTHIBISTADT (NE OF KURUMAN)	DOLOMITE																																																																					
ZUURBEKOM/GEMSBOKFONTEIN (FAR WEST RAND)	DOLOMITE																																																																					
DENDRON (NORTH OF PIETERSBURG)	GRANITE																																																																					
RIETVALLEY NATURE RESERVE (RUSTENBURG)	QUARTZITE																																																																					
MIDDELBURG (CAPE)	KAROO/DOLERITE																																																																					
HARTEBEESFONTEIN (EAST RAND)	KAROO																																																																					
PHOENIX (EAST RAND)	KAROO																																																																					
RIETONDALE RESEARCH STATION (PRETORIA)	SHALE & DIABASE																																																																					
ATLANTIS (CAPE)	RECENT SANDS																																																																					
DE HOEK H.R.C. (ESTCOURT)	KAROO																																																																					

SCORE CATEGORY

- 5 EXCELLENT
- 4 VERY GOOD
- 3 GOOD
- 2 FAIR
- 1 POOR
- 0 NON-EXISTENT

TABLE 3.2

SHORT-LIST CATCHMENT EVALUATION MATRIX

R1 – HYDROLOGY

CATCHMENT	Maps and historical: Topography, land-use, soils and vegetation maps	Maps and historical: Climate	Maps and historical: Rainfall and runoff	Maps and historical: Baseflow and interflow	Maps and historical:	Instrument: Climate	Instrument: Rainfall and runoff	Instrument: Baseflow and interflow	Total R1
MAX. SCORE	10	10	20	10	10	10	20	10	100
GROOTFONTEIN									
RIETVLEIDAM									
MOTHIBISTADT									
ZUURBEKOM-GEMSBOKFONTEIN									
MIDDELBURG									
ATLANTIS									
DE HOEK H.R.C.									

R2 – HYDROGEOLOGY

CATCHMENT	Maps and historical: Geological maps: stratigraphy, structure, lithology & sedimentary features	Geophysical maps	Aquifer boundaries	Piezometric surface & water levels	Hydraulic parameters	Groundwater balance: inflows, outflows & abstraction	Aquifer computer model	Environmental isotopes	Water quality	Instrument: Piezometers	Water level recorders	Flow meters	Total R2
MAX. SCORE	10	5	10	15	5	15	5	5	5	10	10	5	100
GROOTFONTEIN													
RIETVLEIDAM													
MOTHIBISTADT													
ZUURBEKOM-GEMSBOKFONTEIN													
MIDDELBURG													
ATLANTIS													
DE HOEK H.R.C.													

R3 – SUITABILITY FOR STUDY

CATCHMENT	Distance from Johannesburg	Access from participating institution	Availability of long term, local technical staff	On-going projects	Abstraction – agricultural, industrial control	Definition of catchment: surface & groundwater	Uniformity of hydrology	Uniformity of hydrogeology	Uniformity of soil types	Uniformity of land use	Size	Absence of interference	Capital cost	Total R3
MAX. SCORE	5	5	10	5	5	10	5	5	5	5	10	5	25	100
GROOTFONTEIN														
RIETVLEIDAM														
MOTHIBISTADT														
ZUURBEKOM-GEMSBOKFONTEIN														
MIDDELBURG														
ATLANTIS														
DE HOEK H.R.C.														

R4 – BENEFIT

CATCHMENT	Local: Mining	Local: Industrial	Local: Agricultural	Local: Municipal	National: [illegible]	National: [illegible]	Areal influence	General applicability	Total R4	
MAX. SCORE	10	10	10	10	10	10	10	30	100	400
GROOTFONTEIN										
RIETVLEIDAM										
MOTHIBISTADT										
ZUURBEKOM-GEMSBOKFONTEIN										
MIDDELBURG										
ATLANTIS										
DE HOEK H.R.C.										

NOTES/AANTEKENINGE

STEFFEN, ROBERTSON & KIRSTEN

CONSULTING ENGINEERS RAADGEWENDE INGENIEURS

TITLE/TITEL: GROUNDWATER CATCHMENT SELECTION FOR RECHARGE STUDY SHORT-LIST CATCHMENT EVALUATION MATRIX

CLIENT/KLIENT: WATER RESEARCH COMMISSION

	BY/DEUR	DATE/DAT	CHK/KON
DESIGNED ONTWERP	J P T DAVIS	JAN 84	
DRAWN GETEKEN			
TRACED NAGETREK			
A3	SCALE SKAAL		
DRG NO / TEK NR	3760	REVISION	ISSUED

score for existing instrumentation, because of its importance, accounts for 40% of the total R1 score.

The second set of parameters, R2, was used to see how well the hydrogeology had been defined. The relative significance of each aspect is shown by its maximum score. It can be seen that the importance of historical data, required for the calibration of numerical recharge models, is emphasized more in R2 than in R1.

The third set of parameters, R3, gives a semi-quantitative assessment of the relative suitability of each site for a detailed recharge study. This included assessments of staffing requirements, site location and order-of-magnitude of capital cost, as well as assessments of the degree of definition and uniformity of the hydrological and hydrogeological regimes.

The last set of parameters, R4, gives an assessment of the potential benefits to be gained by studying a particular catchment. The sectors which stand to benefit from the proposed research are identified.

Two extra factors, not addressed in the initial ICEM, have been added to the R4 section:

. Areal influence: this reflects the proportion of South Africa covered by that geological sequence

. General applicability: this is the areal influence score multiplied by a score reflecting the value of additional water to the major users

4 CATCHMENT EVALUATION

4.1 Initial catchment evaluation

The amount and nature of information available varied considerably from site to site. The completed Initial Catchment Evaluation Matrix (Table 4.1) shows several sites, such as Steenkoppies, for which very good springflow records exist for Maloney's Eye but hydrogeological records are lacking, and others such as Atlantis, where considerable effort has already gone into hydrogeological modelling.

Total scores ranged from 54 (Upper Eye, Mooi Rivier) to 210 (Atlantis).

The selection of study areas for more detailed consideration was based partly on the total scores and partly on the scores for the long-term monitoring records. This is because any recharge model will have to be calibrated against long-term rainfall, springflow, and water level records. Therefore, the quality of these records is critical to the success of the recharge project. Catchments without such records were excluded from further study due to the excessive potential cost and delay associated with accumulating these records. The catchments excluded were:

- Steenkoppies/Maloney's Eye (no groundwater level records)
- Upper Eye, Mooi River (no springflow or groundwater level records).
- Skoonspruit Eye (no abstraction records)
- Molopo Compartment (no continuous groundwater level records)
- Dendron (no adequate definition of groundwater catchment)
- Rietvalley Nature Reserve (no springflow, water level or adquate abstraction records)
- Rietondale Research Station (no springflow or abstraction records)

TABLE 4.1 INITIAL CATCHMENT EVALUATION MATRIX

STUDY AREA	AQUIFER-TYPE & GEOLOGICAL ENVIRONMENT	AVAILABLE INFORMATION												PHYSIOGRAPHY						HYDROLOGY											GEOLOGY					GEOPHYSICS				HYDROGEOLOGY												LONG-TERM MONITORING: RECORDS					LONG-TERM MONITORING: STATIONS				USER-BENEFIT (RECHARGE STUDY)									
		TOPOGRAPHICAL MAPS	GEOLOGICAL MAPS	GEOPHYSICAL MAPS	SOILS SURVEY MAPS	OTHER MAPS	AIR-PHOTOGRAPHS	ORTHO-PHOTOGRAPHS	THERMAL INFRA-RED	REPORTS-PUBLISHED	REPORTS-UNPUBLISHED	FILE DOCUMENTATION	SUB-TOTAL	TOPOGRAPHY	CLIMATE	VEGETATION	LAND-USE	ACCESSIBILITY	SUB-TOTAL	CATCHMENT AREA	SURFACE DRAINAGE	WIND	RAINFALL	EVAPORATION	EVAPOTRANSPIRATION	RUNOFF	SOIL HYDRAULIC CHARACTERISTICS	INTERFLOW	BASEFLOW	SUB-TOTAL	STRATIGRAPHY	LITHOLOGY	STRUCTURE	SECONDARY FEATURES	SUB-TOTAL	AERIAL	SURFACE	BOREHOLE	SUB-TOTAL	AQUIFER DEFINITION	AQUIFER BOUNDARIES	PIEZOMETRIC SURFACE	HYDRAULIC PARAMETERS	HYDROGEOCHEMISTRY	INFLOWS	THROUGHFLOW	OUTFLOWS	RECHARGE	GROUNDWATER BALANCE	AQUIFER COMPUTER MODEL	SUB-TOTAL	SPRINGFLOW	GROUNDWATER LEVELS	GROUNDWATER QUALITY	ENVIRONMENTAL ISOTOPES	ABSTRACTION	GAUGING STATION	PIEZOMETERS	CLIMATIC STATION	SUB-TOTAL	GENERAL (NATIONAL)	GOVERNMENT	MINING	INDUSTRIAL	AGRICULTURAL	MUNICIPAL	RESEARCH	ACADEMIC	SUB-TOTAL	TOTAL SCORE
STEENKOPPIES (MALONEY) (FAR WEST RAND)	DOLOMITE	4	1	3	2	0	3	3	1	0	1	2	20	3	1	0	0	3	7	1	0	0	3	0	0	0	0	0	0	4	1	1	1	1	4	2	0	0	2	1	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	3	2	0	1	10	2	4	2	3	3	3	1	1	19	67
UPPER EYE, MOOI RIVER (EAST OF DERBY)	DOLOMITE	4	2	3	2	0	2	3	4	0	0	1	21	2	1	1	1	2	7	0	0	0	2	2	0	2	0	0	0	6	2	1	1	0	4	2	0	0	2	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	3	1	1	1	1	1	3	1	1	10	54
SCHOONSPRUIT EYE (FAR WEST RAND)	DOLOMITE	3	2	3	2	1	3	0	4	1	2	2	23	2	1	2	2	2	9	1	1	0	2	0	0	2	0	0	0	6	2	2	1	1	6	2	0	0	2	2	1	1	1	2	0	0	1	1	0	0	9	2	1	1	0	0	2	0	2	8	2	3	2	2	3	3	3	3	21	84
GROOTFONTEIN (WEST OF LICHTENBURG)	DOLOMITE	3	2	4	2	2	3	0	1	2	4	2	24	3	3	2	2	2	12	3	2	1	2	2	2	2	0	0	[illegible]	14	2	3	2	3	10	3	1	1	5	3	3	3	3	0	2	2	2	2	2	3	25	3	3	0	2	2	3	4	2	19	3	4	2	2	4	2	2	2	21	130
MOLOPO COMPARTMENT (NW OF LICHTENBURG)	DOLOMITE	3	1	4	2	1	3	0	1	0	1	1	17	2	2	2	2	2	10	1	1	1	2	2	2	2	0	0	0	11	2	3	2	3	10	2	0	0	2	2	2	1	0	0	0	0	2	0	0	0	7	2	0	0	0	1	2	3	2	7	1	2	2	1	1	1	2	2	12	80
RIETVLEIDAM (SE OF PRETORIA)	DOLOMITE	4	3	3	2	1	3	2	1	0	3	4	24	4	3	0	2	4	13	3	3	3	3	3	0	4	1	0	3	23	2	2	2	1	7	2	0	0	2	3	2	3	1	1	1	1	2	2	1	1	18	3	2	3	0	3	4	1	3	19	3	4	1	3	3	4	3	3	24	120
MOTHIBISTADT (NE OF KURUMAN)	DOLOMITE	4	1	3	2	3	5	3	2	3	3	3	31	4	3	3	3	2	15	4	3	1	2	2	2	2	2	1	1	20	3	3	3	3	12	3	3	3	12	3	4	3	3	2	2	2	2	1	2	2	26	2	2	1	0	2	1	3	2	12	2	3	3	2	2	4	3	3	22	159
ZUURBEKOM/GEMSBOKFONTEIN (FAR WEST RAND)	DOLOMITE	4	4	4	0	4	4	3	3	3	4	4	37	4	4	4	4	4	20	4	4	0	3	3	0	3	1	0	0	18	4	4	4	4	16	4	4	0	8	3	4	4	3	3	3	3	3	2	3	0	31	4	4	3	0	4	3	3	3	24	3	4	4	0	3	4	4	2	24	125
DENDRON (NORTH OF PIETERSBURG)	GRANITE	3	1	3	2	2	3	2	0	0	3	2	22	2	2	1	1	1	7	3	2	0	2	1	0	1	0	0	3	12	2	1	2	2	7	3	2	2	7	1	2	2	1	2	1	1	1	2	1	0	14	0	2	1	0	2	0	2	2	9	2	3	1	1	4	2	3	3	19	97
RIETVALLEY NATURE RESERVE (RUSTENBURG)	QUARTZITE	3	2	3	2	0	3	3	0	2	2	2	22	3	1	0	2	2	8	1	2	0	1	0	0	1	0	0	0	5	2	2	2	1	7	2	0	0	2	2	1	0	1	0	0	0	0	0	0	0	4	0	0	0	0	1	2	0	1	4	1	2	3	3	2	3	2	2	18	70
MIDDELBURG (CAPE)	KAROO/DOLERITE	4	4	0	1	2	4	3	0	0	2	3	23	3	4	2	3	2	14	3	1	2	3	3	1	0	1	0	0	14	3	3	3	3	12	1	2	2	5	3	3	3	2	2	1	1	1	1	1	0	18	1	4	1	0	2	0	3	4	15	2	3	0	2	4	3	4	3	21	122
HARTEBEESFONTEIN (EAST RAND)	KAROO	4	1	3	2	2	2	3	0	0	2	2	21	3	2	1	1	3	10	3	1	0	3	2	0	1	1	0	0	11	3	3	2	2	10	3	1	3	7	3	1	3	2	2	1	1	1	0	0	0	14	0	1	1	0	0	2	3	2	9	1	2	3	2	2	1	2	3	16	98
PHOENIX (EAST RAND)	KAROO	4	2	3	2	3	3	3	1	0	2	3	26	4	2	1	1	3	11	3	3	1	2	2	0	2	1	0	1	15	3	2	2	3	10	3	1	3	7	3	2	3	2	3	2	2	2	2	2	0	23	1	1	1	0	1	2	3	2	11	1	2	3	1	1	1	3	4	16	119
RIETONDALE RESEARCH STATION (PRETORIA)	SHALE & DIABASE	4	3	2	1	1	3	3	0	0	2	2	18	3	2	3	1	4	13	3	1	2	4	2	0	0	0	0	0	12	3	2	3	2	10	2	1	1	4	3	2	2	3	0	1	1	1	1	1	0	15	0	2	0	0	0	0	3	3	8	1	2	0	0	2	1	3	3	12	92
ATLANTIS (CAPE)	RECENT SANDS	4	4	4	3	3	2	3	3	0	4	4	34	4	4	4	5	2	20	4	5	1	4	4	3	3	0	2	5	31	5	5	4	4	18	2	4	0	6	4	4	4	4	4	3	3	4	3	4	3	40	4	4	4	3	5	4	5	4	33	3	4	0	4	0	4	3	3	21	234
DE HOEK H.R.C. (ESTCOURT)	KAROO	3	2	2	3	3	3	0	0	4	4	4	28	4	4	3	3	2	16	4	4	3	5	4	3	5	2	1	4	35	2	2	2	2	8	2	0	0	2	2	2	2	0	1	2	1	1	1	1	0	13	2	2	0	0	0	4	4	5	17	2	3	0	0	3	4	5	3	20	139

SCORE CATEGORY

5 EXCELLENT
4 VERY GOOD
3 GOOD
2 FAIR
1 POOR
0 NON-EXISTENT

In addition, the Phoenix and Hartebeesfontein study areas were excluded because, although there were some records of spring-flow, groundwater levels and abstraction, these were still inadequate for calibration of any numerical recharge models.

4.2 Short-list catchment evaluation

The Short-list Catchment Evaluation Matrix (SLCEM) (Table 4.2) shows the strengths and weaknesses of each of the short-listed study area in terms of suitability for the proposed recharge investigation.

For example, Grootfontein catchment scored low as regards hydrology due to the relatively low level of data, in particular baseflow and infiltration and soil moisture characteristics, even though considerable instrumentation has recently been installed. The rather higher standing for hydrogeology reflects the effort put in by the Geohydrology Division over the years. The catchment score for suitability for study was the lowest due in part to the lack of uniformity of hydrological regimes and soil cover, but also due to such factors as the lack of easy access from the participating institutions, which whould tend to increase operating costs on the recharge study. In terms of potential benefit, Grootfontein achieved the modal score, suggesting that as much or more overall benefit could be derived if the study were performed on most other sites.

A synopsis of the characteristics of any of the other sites can similarly be made by inspection of the SLCEM.

A list of the reports available for each of the short-listed catchments is given in Appendix C.

TABLE 4.2

SHORT-LIST CATCHMENT EVALUATION MATRIX

CATCHMENT	R1 – HYDROLOGY: Maps and historical – Topography, land-use, soils and vegetation maps	Climate	Rainfall and runoff	Baseflow and interflow	Soil moisture characteristics	R1 Instrument – Climate	Rainfall and runoff	Baseflow and interflow	Total R1	R2 – HYDROGEOLOGY: Maps and historical – Geological maps: stratigraphy, structure, lithology & secondary fea.	Geophysical maps	Aquifer boundaries	Piezometric surface & water levels	Hydraulic parameters	Groundwater balance: inflows, outflows & abstraction	Aquifer computer model	Environmental isotopes	Water quality	R2 Instrument – Piezometers	Water level recorders	Flow meters	Total R2
MAX. SCORE	10	10	20	10	10	10	20	10	100	10	5	10	15	5	15	5	5	5	10	10	5	100
GROOTFONTEIN	4,5	4	8	0	0	4	12	6	38,5	5	4	3	9	3	6	3	2	0	4	8	1	48
RIETVLEIDAM	4,5	4,5	14	3	2	6	14	8	56	3,5	3	2	7	1	5,2	1	0	3	1	2	5	33,7
MOTHIBISTADT	6,5	4	8	2	4	4	6	2	36,5	6	3	4	7	3	6	0	0	1	3	2	3	30
ZUURBEKOM–GEMSBOKFONTEIN	6	3,5	12	0	2	6	12	6	47,5	8	4	4	12	3	9,8	0	0	3	3	2	5	53,6
MIDDELBURG	5	5	6	0	2	8	8	0	34	6	0	3	11	2	3,8	0	0	1	3	2	2	33,8
ATLANTIS	6,5	6	18	7	0	8	16	8	69,5	9	4	4	12	4	12	4	3	4	5	8	5	74
DE HOEK H.R.C.	6	7	20	5	4	10	18	8	78	4	2	2	6	0	3	1	0	0	4	4	5	31

CATCHMENT	R3 – SUITABILITY FOR STUDY: Distance from Johannesburg	Access from participating institution	Availability of long term, local technical staff	On-going projects	Abstraction – artificial recharge control	Definition of catchment: surface & groundwater	Uniformity of hydrology	Uniformity of hydrogeology	Uniformity of soil types	Uniformity of land use	Size	Absence of interference	Capital cost	Total R3	R4 – BENEFIT: Local – Mining	Industrial	Agriculture	Municipal	National – Government	Research	Areal influence	General applicability	Total R4	Grand total
MAX. SCORE	5	5	10	5	5	10	5	5	5	5	10	5	25	100	10	10	10	10	10	10	10	30	100	400
GROOTFONTEIN	2	2	2	2	3	6	1	3	1	4	2	3	10	41	4	4	8	6	8	6	2	4	42	169,5
RIETVLEIDAM	4	4	10	2	2	5	1	3	1	3	3	2	10	50	2	6	6	8	8	6	2	6	44	183,7
MOTHIBISTADT	2	3	4	3	3	8	2	3	2	4	2	2	15	53	4	6	4	8	6	6	2	6	42	169,5
ZUURBEKOM–GEMSBOKFONTEIN	4	4	10	3	1	8	2	3	1	4	2	2	16	59	8	0	2	8	8	8	2	6	42	202,[illegible]
MIDDELBURG	2	4	10	3	3	6	2	2	2	4	4	2	20	61	0	4	8	6	6	8	10	10	52	183,8
ATLANTIS	1	3	10	4	5	8	4	5	4	5	3	3	25	80	0	8	0	8	8	6	1	3	34	257,5
DE HOEK H.R.C.	2	3	10	5	5	6	4	3	4	5	3	5	15	70	0	0	6	8	6	10	10	10	50	229

STEFFEN, ROBERTSON & KIRSTEN

CONSULTING ENGINEERS — RAADGEWENDE INGENIEURS

GROUNDWATER CATCHMENT SELECTION FOR RECHARGE STUDY
SHORT-LIST CATCHMENT EVALUATION MATRIX

WATER RESEARCH COMMISSION

Designed: JPT DAVIS — JAN 84

A3

3760

A.13

4.3 Progress meeting

On 15 August 1983, a progress meeting was held between Dr P Roberts of the WRC, Mr J R Vegter and Drs M P Mulder and D B Bredenkamp of The Division of Geohydrology and Messrs A S Harley, J P Davis and Dr A D Ward of SRK.

At this meeting the results of the Phase I study were presented and considered in light of other factors, beyond the scope of the desk study, to decide which catchments were the most suitable for the proposed recharge study.

The concensus on each short-listed catchment is given below:

. Grootfontein

The Division of Geohydrology has numerous internal reports on the area, most recently by Drs Mulder, Bredenkamp and Cogho. A computer model is available. The heterogeneity of soil cover was identified as a complicating factor for the recharge study.

It was suggested that a study area combining both the Grootfontein and Molopo dolomite compartments might be simpler to analyse in terms of the hydrogeology.

A visit to the area by Drs Mulder and Ward and Mr Harley was proposed to further evaluate the catchments.

. Rietvleidam

The Municipality of Pretoria has commissioned several studies on the area and its hydrology is well documented.

The hydrogeological information has been summarised in an internal report by Dr B N Temperley of The Division of Geohydrolgy. That report identified that a considerable amount of further work would be required to define the hydrogeology of the dolomitic catchment.

This site was therefore assigned a low priority in terms of the proposed recharge study.

- Mothibistadt

This dolomite catchment is in Bophuthatswana and is outside the jurisdiction of the Division of Geohydrology. SRK performed a groundwater resource investigation on the area in 1982. This included an overview of the surface hydrology, an assessment of potential recharge, two hydrocensuses, drilling and aquifer testing. The report identified a lack of long-term monitoring of most of the parameters needed for calibration of the recharge model, although springflows and the water level in one borehole had been monitored for over 10 years.

Due to access and jurisdiction problems, this site was given a low priority for the proposed recharge study.

- Zuurbekom/Gemsbokfontein

These dolomite catchments have been examined in detail by the Division of Geohydrology and SRK as a result of dewatering activities by the mines in the area. The surface hydrology has been studied in moderate detail and streamflows have been monitored for years. The geology and hydrogeology have been well defined and considerable groundwater monitoring data have been accumulated.

Concern was expressed by Dr Bredenkamp over the possible complications due to inflows across dykes and to dewatering activities in the Gemsbokfontein Compartment. Certainly the consultants felt that Zuurbekom should be studied in preference to Gemsbokfontein because of the possibility of the mine dewatering in the Gemsbokfontein Compartment, which could wipe out all groundwater observation of recharge events and the fact that Gemsbokfontein is not as well instrumented as Zuurbekom.

The area was selected for detailed consideration and a site visit was proposed.

- Middelburg, Cape

Since 1945 the Division of Geohydrology has supported much investigation in the area, most recently by M A C van Dooleaghe. The hydrology of the Middelburg area has not been studied in detail, however. As a result, it has the lowest R1 (hydrology) score of the short-listed catchments.

In terms of hydrogeology the area is complex and the interaction of the Beaufort sediments, weathered material and alluvium is not well understood. Groundwater level records from 1951 are available for three stations in the area and abstraction and water quality are monitored intermittently.

The Grootfontein Agricultural College is nearby and some technical support might be available for the study but, as Middelburg is not close to any of the participating institutions, access will generally be difficult.

Due to poor access and lack of long-term hydrological monitoring, this area was assigned a low priority for the proposed recharge study.

- Atlantis

Considerable industrial development is planned for this area and a large water supply must be implemented. The

Division of Geohydrology has supported considerable research on the area and the hydrogeology and hydrology are well understood and documented by Van Dooleaghe, Bertram, Bredenkamp and others.

In view of the work already done, it was suggested that the methodologies and techniques identified in the proposed recharge study might be applied to the Atlantis area data for further calibration.

- De Hoek/Ntabamhlope hydrological research catchments

The WRC has supported a great deal of hydrological research in this area under the direction of Professor R Schulze, at the University of Natal, and further is already planned.

Surface water studies have been carried out on the catchments since 1936 and so there is a wealth of hydrological monitoring data; this is reflected in the very high R1 score.

Groundwater studies by the Geological Survey (van Wyk and du Preez, 1968) included core drilling in 55 boreholes, pumping tests, staged falling-head permeability tests, chemical sampling, springflow analysis and tracer tests. Water-level monitoring has been carried out sporadically since 1958. The Division of Geohydrology has given little attention to the area recently, but recognises the merit of further hydrogeological investigation.

More work is required before the hydrogeology of the site can be well defined. The short-list matrix suggests that the area is suitable for a recharge study and that the benefits would be significant since rocks of the Group cover a large part of the country.

A visit to the area by Mr Harley of SRK, Mr Vegter and Dr Bredenkamp of the Division of Geohydrology and Professor Schulze of the University of Natal was proposed.

4.4 Site visit and final evaluation

A schedule of site visits is presented in Appendix D.

The following observations and conclusions were made or confirmed on the site visits.

4.4.1 Grootfontein Compartment

Due to pinnacle formation in the dolomites in the Grootfontein Compartment, the soil cover varies tremendously. Hence the soil moisture and recharge characteristics are likely to be complex and there is a strong possibility that the results of a recharge investigation here may be indeterminate. As a result a recharge investigation at Grootfontein is not recommended at this stage.

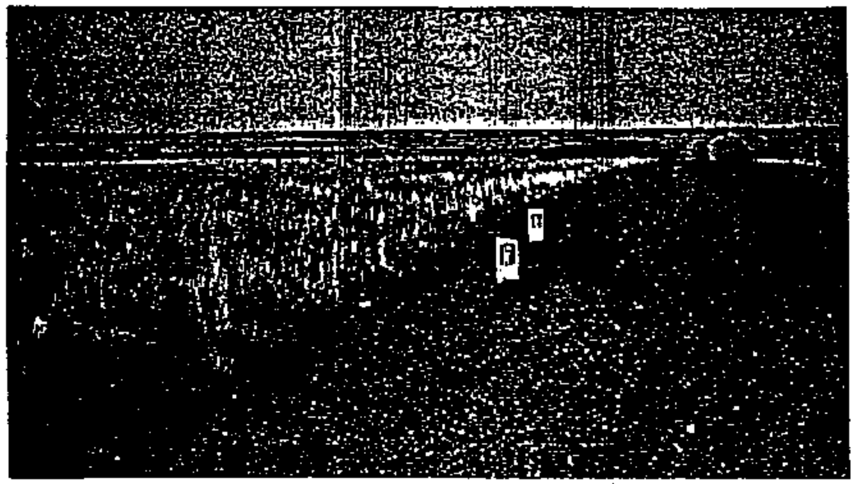
4.4.2 Molopo Compartment

Like the Grootfontein Compartment, this relatively flat area is also underlain by dolomite but with a non-existent to thin soil cover (Fig 4.1). It is bounded by dolerite dykes on all four sides to form a groundwater compartment of some 169 km^2 (Fig 4.2).

The Molopo area is covered by a few large farms, which primarily utilise the land for grazing. Hence there are few boreholes and no irrigation. The only area of habitation is the holiday village at Molopo Eye.

Surface runoff is negligible, the rainfall is either evapotranspired or goes to recharge.

OVERVIEW OF MOLOPO DOLOMITE COMPARTMENT. LOOKING S.E. ACROSS AREA



PARSHALL FLUME MONITORING RIGHT-HAND CANAL(EAST) OF DISCHARGE FROM MOLOPO EYE ($\pm 0,7\ m^3/S$)

(Dr. MP Mulder)
(Dr. AD Ward)

MOLOPO EYE

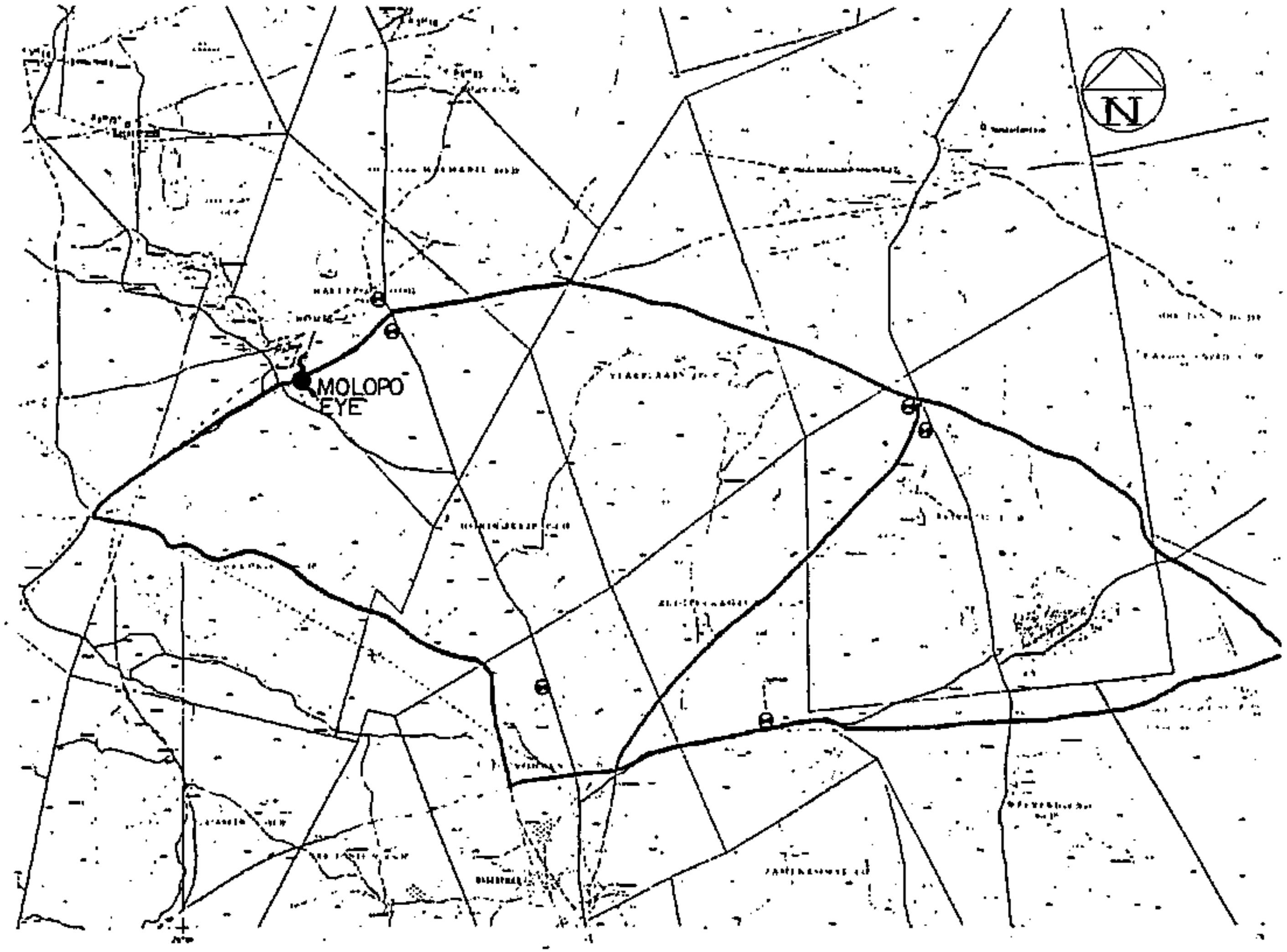
AT N-W EDGE OF MOLOPO COMPARTMENT

JOB Nº		FIG Nº
CI3760	RECHARGE STUDY FEASIBILITY INVESTIGATION .	4·1

JOB No
CI 3760

RECHARGE STUDY
FEASIBILITY INVESTIGATION

FIG No
4·2



MOLOPO COMPARTMENT

0 5Km
SCALE

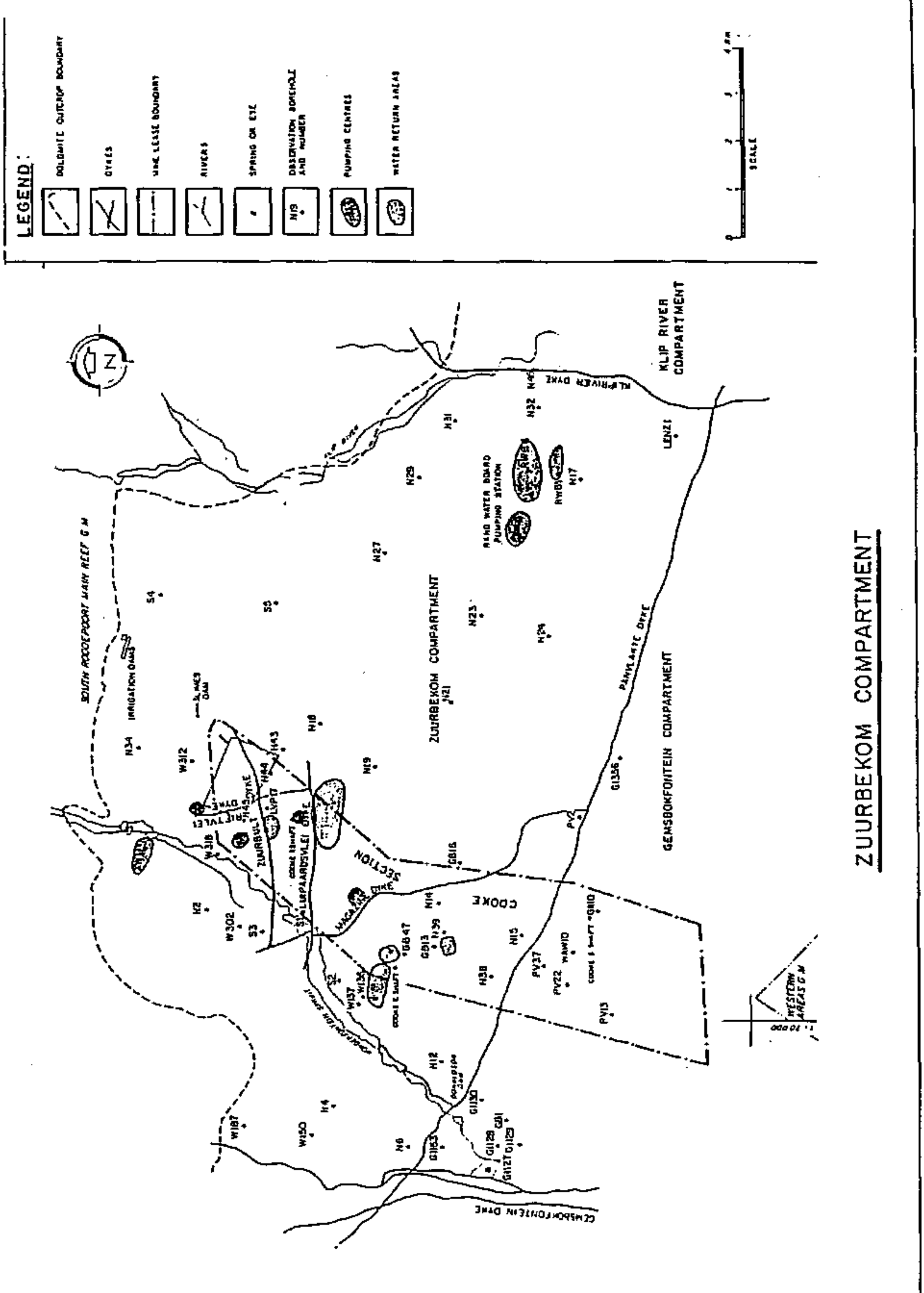
MOLOPO EYE
OBS. BOREHOLE POSITION
COMPARTMENT BOUNDARY

The groundwater flows in a northwesterly direction across the catchment to surface at the Molopo Eye (Fig 4.1) against the northwest boundary dyke. Whilst it is accepted that the dolerite dykes form the compartment boundaries, it is recognised that there may be some leakage through them, especially along the southern boundary. Since the hydraulic gradient is very flat and water levels have only fallen 1,5 m in the last 6 years, it is thought that the most significant part of the groundwater budget is discharge from the Molopo Eye. (Fig 4.1). The six observation boreholes shown on the locality plan (Fig 4.2) have been monitored on a monthly basis for the last seven or eight years by the Division of Geohydrology.

Although originally eliminated by our initial catchment evaluation, the general area is important with respect to present and future groundwater supplies, and the Department of Environment Affairs are interested in further work with regard to recharge estimates to the dolomite. It is therefore recommended that this catchment be included in the recharge study. However, due to its distance from Johannesburg and the fact of the thin or absent soil cover, this would be mainly a groundwater monitoring exercise, and hence a relatively low-key involvement.

4.4.3 Zuurbekom Compartment

The Zuurbekom Compartment is a dolomite aquifer with a relatively deep (5 m) soil cover, and is bounded on three sides by dolerite/syenite dykes with the fourth northern boundary formed by the dolomite wedging out onto the underlying relatively impermeable Black Reef Formation (Fig 4.3). The compartment covers an area of 150 km^2. The ground slopes gently to the south in the general dip direction of the bedrock.



	JOB Nº		FIG Nº
	CI 3760	RECHARGE STUDY FEASIBILITY INVESTIGATION	4·3

Two water courses cross the area from north to south, the Wonderfontein Spruit in the west which feeds into Donaldson Dam, and the Klip River, which flows along the eastern boundary. The groundwater flows from the north and then bifurcates, to flow southwest to the area of the Donaldson Dam and to the southeast to the Rand Water Board Pumping Station. It appears that the southern boundary Panvlakte Dyke is a significant groundwater barrier.

Much of the land is owned by the mining company Randfontein Estates, and the general land use is that of both arable and pasture farming, with some irrigation in the vicinity of the Wonderfontein Spruit. Some eucalyptus plantations also occur in the southeastern part of the area.

Although the compartment is complex in terms of deriving a groundwater budget, it felt that the problem is not insurmountable as the Department of Environment Affairs have carried out a lot of work in the area (Fleisher, 1981) and Steffen, Robertson and Kirsten have recently completed a hydrogeological study for Randfontein Estates (Steffen, Robertson and Kirsten, 1983). Furthermore, Steffen, Robertson and Kirsten are currently investigating the water budget of the slimes and return water dams, and have just been commissioned to carry out Phase I of a surface and groundwater pollution investigation for JCI.

From the monitoring point of view there are 23 boreholes equipped with autographic water level recorders located in the compartment. A further 13 boreholes are dipped on a monthly basis. These will provide a good data bank and it is felt that no further boreholes or instrumentation will be required.

There are river gauging stations (Fig 4.4) on the Wonderfontein Spruit near the northern and southern compartment boundaries. Two stations are also suitably located on the Klip River, but are currently closed and will have to be reactivated.

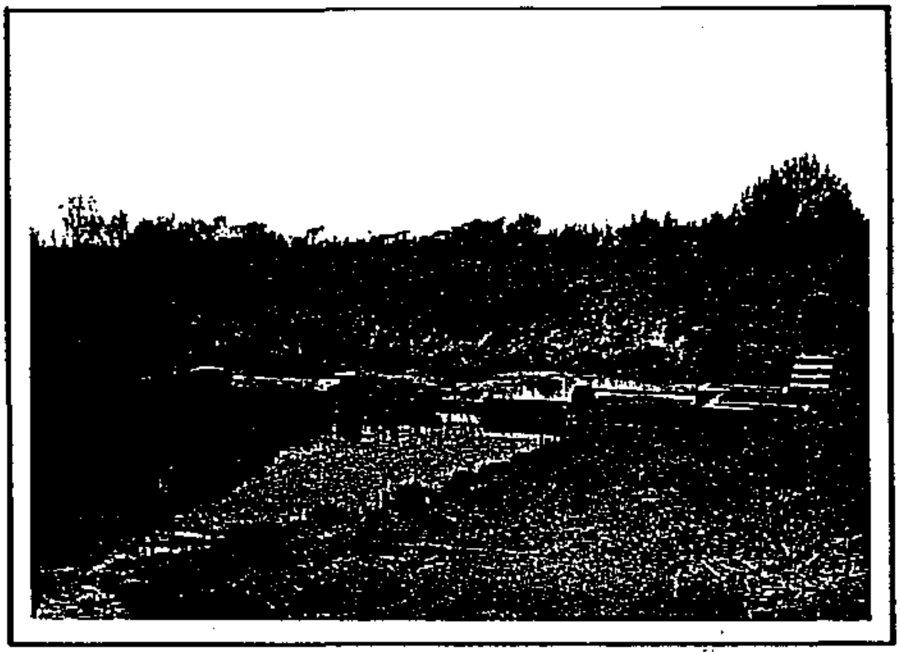
The proximity of the compartment to Johannesburg is a significant advantage from the aspects of monitoring and the infiltration studies. It will therefore be easy to observe the infiltration of sudden storm events as they occur and hence increase our confidence level in this part of the investigation.

4.4.4 Ntabamhlope Catchment 14

Catchment 14 (including sub-catchment 14A) is one of a number of Hydrological Research Catchments in the De Hoek/Ntabamhlope area that have been studied over the last few decades (Fig 4.5). A considerable amount of time and money has been spent on research on these catchments, which included geohydrological investigations carried out between 1958 and 1960 and groundwater-level monitoring on a number of boreholes in the 1960's.

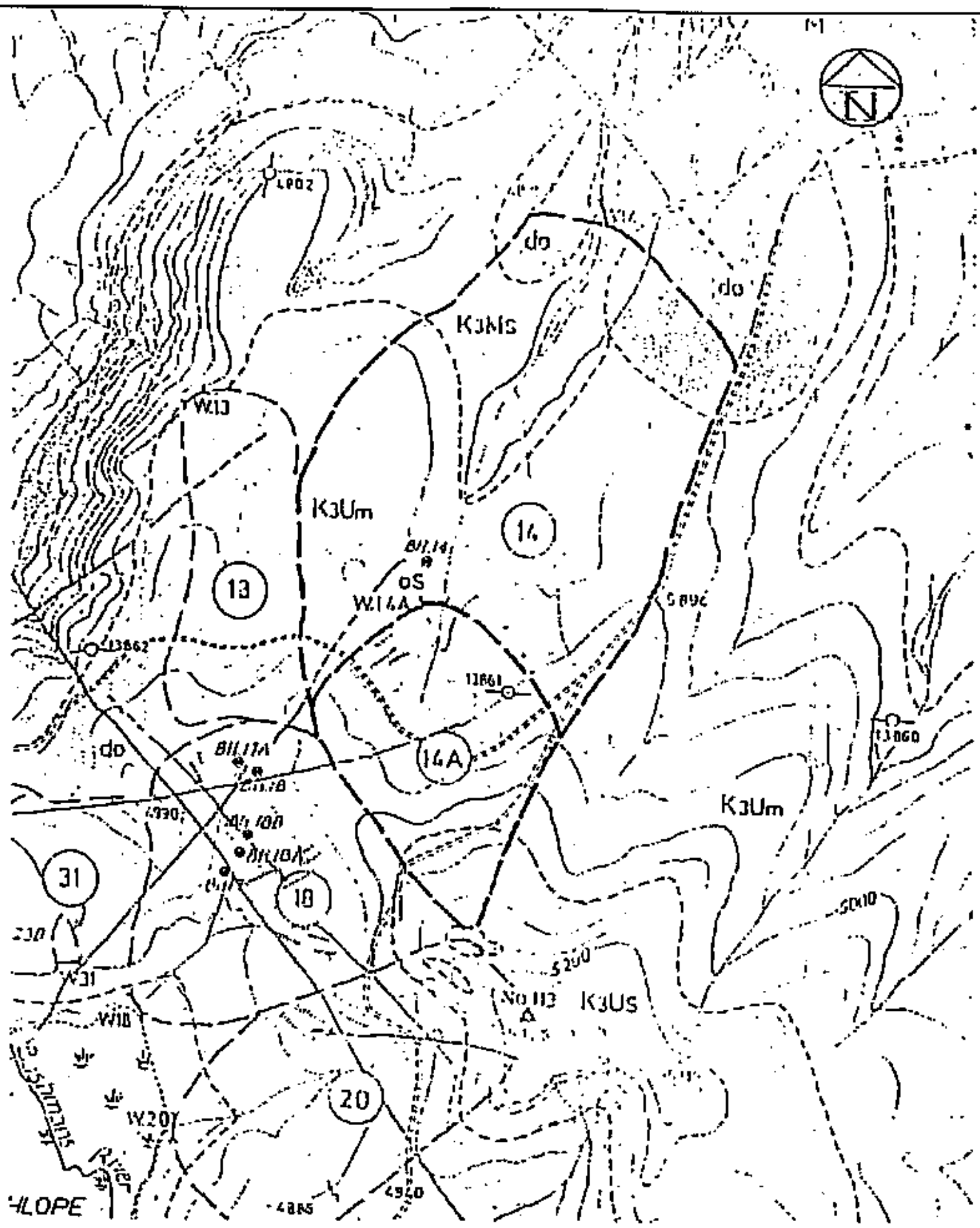
From the unpublished work of the Geological Survey it appears that the area is underlain by sandstone and mudstone of the Beaufort Group, which are intruded by a number of dolerite dykes and sills (van Wyk and du Preez, 1968). Primary permeability of the sediments is very low and secondary permeability, which is also low, depends on the development of erratically distributed joints and fissures. The only zones of significant permeability are associated with the dykes and their contact margins.

Although the Survey's work indicates that groundwater recharge is in the order of one per cent of the mean



DONALDSON WEIR
C2 M24
± 200m BELOW DONALDSON DAM WALL
GEMSBOKFONTEIN/ ZUURBEKOM COMPARTMENT WEST RAND

	JOB Nº		FIG Nº
	CI 3760	RECHARGE STUDY FEASIBILITY INVESTIGATION	4·4



KEY:

(14) SURFACE CATCHMENT WITH NUMBER

BH 14 BOREHOLE NUMBER AND POSITION

W14A WEIR NUMBER AND POSITION

SCALE 1:18000

0 200 400 600 800 1000 m

NTABAMHLOPE CATCHMENT 14

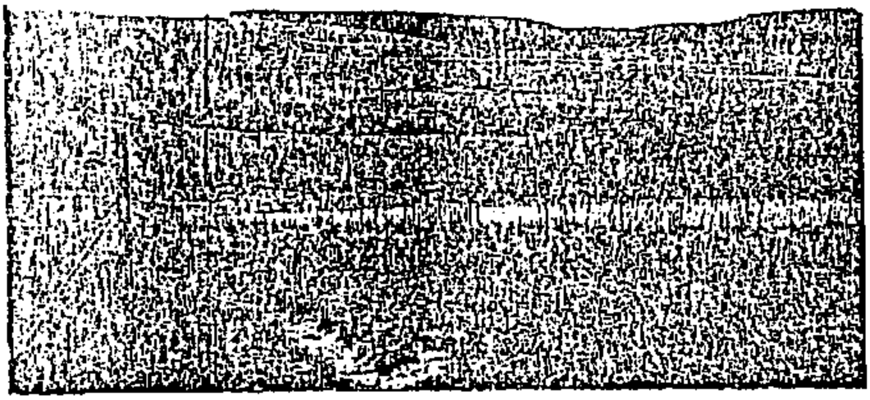
	JOB Nº		FIG Nº
	CI 3760	RECHARGE STUDY FEASIBILITY INVESTIGATION	4·5

annual rainfall, it is recommended that further recharge investigations should be carried out for the following reasons:

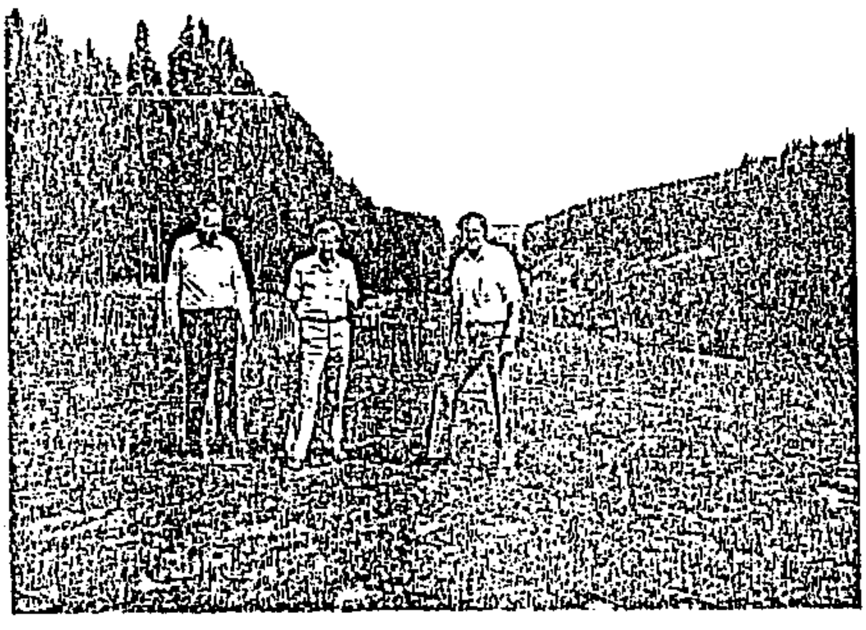
- A vast amount of historical hydrological and hydrogeological information is available as a data base
- On-going hydrological work is being funded by the Water Research Commission, some of which can be integrated into the recharge study
- The sediments of the Beaufort Group constitute an important groundwater source, since they cover a significant portion of South Africa
- If the true quantity of recharge is as low as present results suggest, this type of aquifer requires a very accurate data base in order to realistically determine the recharge

Ntabamhlope Catchment 14 has been identified as the best site for the investigation, since it is one of the least complicated hydrogeological catchments (as it does not appear to be cross-cut by major dykes) and Professor Schulze is carrying on work in the catchment under the auspices of the Water Research Commission.

The catchment (Fig 4.6) lies on top of the De Hoek escarpment southeast of the amphitheatre. It is 1,5 km^2 in area and forms the major part of a relatively-gentle north-sloping valley, which is underlain by both mudstone and sandstone and has a remnant dolerite sill cropping out at the bottom of the catchment. The main part of the catchment is under pasture, but at the lower end is a black wattle plantation, which is of hydrological and hydrogeological interest (Fig 4.6).



LOOKING NNE DOWN CATCHMENT 14 AND 14A FROM NEAR THE TOP
NB W14A GAUGING STATION (OPEN)



BOTTOM END OF CATCHMENT 14, SHOWING BLACK WATTLE PLANTATION,
W14 GAUGING WEIR (CLOSED) AND SEDIMENT PONDS
(Mr. J Vegter, Prof. Schulze and Dr. D Bredenkamp)

	JOB Nº		FIG Nº
	CI3760	RECHARGE STUDY FEASIBILITY INVESTIGATION	4·6

From the hydrological aspect of the recharge study the catchment is eminently suitable. There is an operating gauging station at 14a; 14 has a weir which is closed currently, and will need cleaning up and instrumentation. There is a rainfall station at the southern end of the catchment and a full weather station at the Ntambamhlope Research Station. Professor Schulze is also keen to model the energy process as part of this study. The site looks suitable for the infiltration studies and we are satisfied that close control can be maintained on this aspect.

5 CONCLUSIONS

- Evaluation matrices were constructed in an attempt to compare objectively the groundwater catchments. In these matrices data were scored according to a number of parameters and then totalled for each catchment.

- Sixteen different catchments throughout the country were researched and assessed using the ICEM matrix.

  From this evaluation a short-list of seven catchments was compiled.

- The short-list was further evaluated using a SLCEM matrix and then discussed at a progress meeting.

  Three catchment areas were identified as potential sites and visits to them were arranged. They were:

  - Grootfontein/Molopo Compartments (dolomite)
  - Zuurbekom Compartment (dolomite)
  - De Hoek/Ntabamhlope Catchments (sandstone-mudstone)

- Final conclusions were:

  - Grootfontein Compartment

    A considerable amount of work has been done by the Division of Geohydrology in this compartment. Consequently, the hydrology is relatively well understood, the system has been modelled, and there is a good groundwater monitoring network in position.

    However, the soil cover is very heterogeneous and it was felt that infiltration studies, considered to be an important part of the recharge project, would be meaningless in a compartment of this size and diversity in soil types and thickness. Furthermore, its distance from Johannesburg would be a real practical problem in the monitoring of individual storm water events for the infiltration study.

- Molopo Compartment

Although adjacent to the Grootfontein Compartment, its hydrogeology is not as well known. However, there are four boreholes and no irrigation in the compartment and the only known groundwater outflow is at the Eye, which is being monitored. In addition, some six downstream boreholes have been monitored by the Division of Geohydrology for about eight years.

The soil cover is thin to absent so no infiltration studies could be carried out. However, because the general area is potentially important on a groundwater resource, a limited but useful recharge study could be carried out based mainly on groundwater monitoring.

- Zuurbekom Compartment

The hydrology and hydrogeology of the area are well understood in general, although inflows across compartment boundaries may complicate recharge calculations, especially those based on a groundwater balance.

Good records of rainfall, streamflow and groundwater levels have been collected by the Division of Geohydrology and by the mines concerned. These should be suitable for calibration purposes and will provide a good data bank.

The area is easily accessible from Johannesburg, which makes the monitoring of individual storm events a practical proposition.

- Ntabamhlope, Catchment 14

The hydrology of the catchment has been studied in detail for many years. Good historical data are available, and the density of stations to monitor streamflow and climatic parameters is good. However, a better hydrogeological understanding of the catchment is required.

The existing WRC research projects in the area and the proposed recharge investigation will serve to complement each other and produce a greater confidence in the results.

Since the area is under active investigation, good control will be maintained by technical personnel from the Department of Agricultural Engineering, University of Natal.

6 RECOMMENDATIONS

It is recommended that the following three catchment areas be used in the proposed investigation into rainfall recharge to groundwater, for the following reasons:

- Molopo Compartment

  This is situated in an area which has considerable potential for groundwater supply and hence recharge is significant parameter.

- Zuurbekom Compartment

  Owing to the extensive monitoring system in the area data control is thought to be very good. This is extremely important in the development, calibration and verification of any recharge model.

  In addition the Compartment has been identified as a potential groundwater supply area for the PWV and a resource study has been initiated as an immediate priority by the Government.

- Ntabamhlope, Catchment 14

  The Ntabamhlope Catchments are geohydrologically representative of the aquifer system that covers much of South Africa and is therefore important.

  Excellent historical hydrological data have been collected in the area and the WRC are currently funding several research projects. It is considered that the recharge investigation will complement this other work both academically and practically.

It is also recommended that the Atlantis Catchment, which is now well understood through investigations leading to numerical aquifer modelling, is used as a verification test once the best methodology for recharge determination has been selected.

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A S HARLEY Sci Nat
Senior Hydrogeologist

Steffen Robertson & Kirsten (Civil) Inc

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8 ACKNOWLEDGEMENTS

The assistance of the Division of Geohydrology, Department of Environment Affairs, is gratefully acknowledged with respect to access to their unpublished records, and the many useful discussions held both in Pretoria and on site.

Our sincere thanks are also recorded for the help given by the Department of Agricultural Engineering, University of Natal.

A P P E N D I X   A   O F   M A I N   A P P E N D I X   A

INITIAL CATCHMENT EVALUATION MATRIX CRITERIA FOR ASSINGNING SCORES

APPENDIX A : CRITERIA FOR ASSIGNING SCORES IN THE INITIAL CATCHMENT EVALUATION MATRIX

Parameter	Criteria for assigning scores in the initial catchment evaluation matrix					
Score	0	1	2	3	4	5
Topographical maps	None	1:250 000 +	1:125 000 +	1:50 000 +	1:10 000 +	1:10 000 -
Geological maps	None	1:250 000 +	1:125 000 +	1:50 000 +	1:50 000 with some detailed maps	Extensive detailed mapping
Geophysical maps	None			1:50 000 Aeromag	Some detailed maps	Extensive detailed maps
Other maps (eg Hydrogeology)	None relevant to recharge	Peripheral	Of minor relevance to recharge	Relevant to recharge	Pertinent	Gives good definition of recharge
Accessibility (Jhb or other centre with research facility)	-	400 km + (Jhb) or 200 km + (other)	200 km + (Jhb) 100 km + (other)	100 km + (Jhb) 50 km + (other)	50 km + (Jhb) 50 km + (other)	Within 50 km from Johannesburg
Long-term monitoring : records	No records	Single survey	Two surveys	Annual monitoring or 10 + records	Monthly monitoring or 100 + records	Daily monitoring or 1 000 + records
Gauging stations	0	1 Weir	2 Weirs or 1 weir + 1 AR	4 Weirs or 2 weirs + 2 AR	6 Weirs or 4 weirs + 4 AR	12 Weirs or 8 weirs + 8 AR
Piezometers	0	0 - 20 No AR	20 - 50 No AR	50 - 100 or 1 - 5 AR	100 - 200 or 5 - 15 AR	200 + or 15 + AR
Climatic stations	0	1 R	2 R or 1 R + E + T	3 - 4 R or 2 R + E + T or bureau nearby	1st Order on site or 5 - 10 R or 3 - 5 R + E + T	1st Order on site or 10+ R or 5 + R + E + T
All other parameters*	Non-existent	Poor	Fair	Good	Very good	Excellent

* The adjectives apply to the level of records, or quality of data as required for the recharge study

AR = Autographic recorder R = rain gauge E = evaporation pan T = max and min thermometers

APPENDIX B OF MAIN APPENDIX A

SHORT-LIST CATCHMENT EVALUATION MATRIX

FORMULAE USED FOR SCORING

FORMULAE FOR SCORING IN THE SHORT-LIST CATCHMENT EVALUATION MATRIX

GENERAL

Grand Total (400) = R7 (Hydrology, max 100) + R2 (Hydrology, max 100) + R3 (Suitability, max 100) + R4 (Benefit, max 100)

The maximum score for each component is given in parentheses.
The assignation of scores is largely based on that shown in the Appendix A table.

R.1 : Hydrology

Topography, soils, vegetation and land-use data (10)	=	Topographic maps (5)/2 + Soils maps (5)/2 + Vegetation maps (5)/2 + Land use maps (5)/2
Climatic data (10)	=	Wind (5)/2 + Rainfall (5)/2 + Evaporation (5)/2 + Evapotranspiration (5)/2
Rainfall and runoff data (20)	=	Rainfall (5)x2 + Runoff data (5)x2
Interflow and baseflow data (10)	=	Interflow (5) + Baseflow (5)
Soil moisture characteristics (10)	=	Soil hydraulic characteristics (5)x2
Climatic stations (10)	=	Climatic stations (5)x2
Rainfall and runoff instrumentation (20)	=	Gauging stations (5)x2 + Climatic stations (5)x2
Baseflow and interflow instrumentation (10)	=	Gauging stations (5)x2
TOTAL R1 (100)		

R.2 : Hydrogeology

Geological maps (10)	=	Stratigraphy (5)/2 + Lithology (5)/2 + Structure (5)/2 + Secondary features (5)/2
Geophysical maps (5)	=	Aerial geophys (5)/3 + Surface geophys (5)/3 + Borehole geophs (5)/3
Aquifer boundaries (10)	=	Aquifer boundaries (5)x2
Piezometric surface (15)	=	Groundwater levels (5) + Piezometric surface (5)x2
Hydraulic parameters (5)	=	Hydraulic parameters (5)
Groundwater balance (15)	=	Inflows (5)x¾ + Outflows (5)x¾ + Abstraction (5)x¾ + Change in storage (groundwater levels + hydraulic parameters) (5+5)x3/8
Aquifer computer model (5)	=	Aquifer computer model (5)
Environmental isotopes (5)	=	Environmental isotopes (5)
Water quality (5)	=	Water quality (5)
Piezometers (10)	=	Piezometers (5)x2
Water level recorders (10)	=	Water level recorders (5)x2
Flow meters (5)	=	1 if 20% of abstraction points metered 2 if 50% of abstraction points metered 3 if 80% of abstraction points metered 4 if 90% of abstraction points metered 5 if 95% of abstraction points metered
TOTAL R2 (100)		

R.3 : Suitability for study

Distance from Jhb (5)	=	Accessibility (5)
Access from participating institution (5)	=	1 for distance = 200 + km
		2 " " = 100 - 200 km
		3 " " = 50 - 100 km
		4 " " = 25 - 50 km
		5 " " = 0 - 25 km
Availability of staff (10)	=	0 (none available) to 10 (on-site permanently)
On-going projects (5)	=	0 (none) to 5 (similar project in progress)
Abstraction, artificial recharge control (5)	=	0 (no control) to 5 (complete control)
Definition of catchment: Surface and groundwater (10)	=	Catchment area (5) + aquifer definition (5)
Uniformity of hydrology (5)	=	5 for 1 - 5 hydrological zones*
		4 " 6 - 10 " "
		3 " 11 - 15 " "
		2 " 16 - 20 " "
		1 " 21 - 25 " "

* Number of hydrological zones = Estimated number of permutations of soil cover-type and land-use

Uniformity of hydrogeology (5)	=	0 (very complex) to 5 (single aquifer)
Uniformity of soil types (5)	=	5 for single soil cover type 3 for 2 soil types 2 for 3 soil types 1 for 4 or more soil types
Uniformity of land-use (5)	=	5 for no land-user 4 for single user 3 for 2 users 2 for 3 users 1 for 4 or more users
Size (10)	=	2 for 200 + km^2 4 for 100 - 200 km^2 6 for 50 - 100 km^2 8 for 25 - 50 km^2 10 for less than 25 km^2
Absence of interference (5)	=	5 if totally natural 4 if domestic or stock boreholes only 3 if irrigation from boreholes, or recycled mine drainage, but net abstraction or artificial recharge to compartment is negligible 2 if net abstraction or artificial recharge to compartment is significant but metered 1 if not metered
Capital cost (25)	=	25 for cost* 0 - R 5 000 20 " " R 5 000 - R 10 000 15 " " R 10 000 - R 50 000 10 " " R 50 000 - R100 000 5 " " R100 000 +
TOTAL R3		(100)

* Based on rough estimate of capital cost of construction and instumentation only

R4 : Benefit

Mining (10)	=	Mining (5) x 2
Industrial (10)	=	Industrial (5) x 2
Agricultural (10)	=	Agricultural (5) x 2
Municipal (10)	=	Municipal (5) x 2
Government (10)	=	Government (5) x 2
Research (10)	=	Research (5) x 2
Areal influence (10)	=	1/3 x % area of SA covered by geological (lithological) formation
General applicability (30)	=	Areal influence (10) x value of additional water to major users (1 = low, 3 = very high)

TOTAL R.4 (100)

APPENDIX C OF MAIN APPENDIX A

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BIBLIOGRAPHY FOR THE SHORT-LISTED CATCHMENTS

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APPENDIX D OF MAIN APPENDIX A

SCHEDULE OF SITE VISITS

SCHEDULE OF SITE VISITS

Date	Catchment	Personnel
22 - 23.8.83	Molopo Grootfontein	Dr Mulder (Div Geohydrol) Dr Ward, Mr Harley (SRK)
5.9.83	Zuurbekom Gemsbokfontein	Dr Ward, Mr Harley, Mr Rosewarne (SRK)
12.9.93	De Hoek, Ntabamhlope	Mr Vegter, Dr Bredenkamp (Div Geohydrol) Professor Schulze (University Natal) Mr Harley (SRK)

A P P E N D I X   B

EVALUATION, SELECTION, PRICING AND ORDERING OF INSTRUMENTS

CONTENTS

TABLES

B. EVALUATION, SELECTION, PRICING AND ORDERING OF INSTRUMENTS

B.1 Introduction

While planning the project it was recognised that the ordering of instruments was of high priority in the first three months of the investigation. Delivery of certain of the instruments might take as long as six months, and that to avoid hold ups the placing of orders should be done as soon as possible.

As both Dr Ward and Mr Harley had done their work in soil moisture and recharge overseas and some time ago it was thought necessary to first review the existing techniques and systems in use and available in South Africa.

B.2 Identification of available instruments

SRK interviewed as many people as possible who were involved or had been involved in similar studies, thus collecting a comprehensive list of the instrumentation available, their short-comings or advantages and the possible improvements that could be made. A list of the persons contacted is given in Table B.1. Results of the discussions are summarised in Table B.2, and the relevant information carried over to each section.

Those items regarded as useful for the project were some price comparisons to be made. A list of the instruments discussed and those finally selected are presented in Tables B.3 and B.4 respectively giving some idea of the range of equipment and prices available in South Africa, although the prices are subject to significant change.

From the experiences of the Department of Agriculture at Cedara and the Soil and Irrigation Research Institute at Roodeplaat Dam, it was decided not to construct lysimeters for this project.

TABLE B.1

LIST OF PERSONS, INSTITUTIONS AND ORGANISATION VISITED

Person	Institution	Topic of Discussion
Prof R Schulze Prof Meiring Dr A Lass	) Univ of Natal) Pietermaritzburg))	. Project assistance in De Hoek . Neutron probe Pressure cookers, temple cells, tensionmeter, hygrometer, water retention curves, precision scales, ovens, vacuum filter, soil classification.
Dr J Mellett R Mottram	Cedara, Agric training college	Moisture probes, tensionmeters, pressure-membrane apparatus, pressure cooker, infilremeter, evapotranspiration, lysimeters, soil contents
Bill Reynolds	Instrument Station, Cedara	Wind speed, direction, sun, evaporation, rel humidity, barometric readings, evapotrans-piration soil temp.
Mr C James	Univ of Wits	Instrumentation
Dr von Vuuren, Dr Gerber	NIWR	Instrumentation
Waterlit	CSIE	Literature search
Dr P Berliner	Soil and Irri-gation Research Institute	Discussion on soil conductivity and evapotranspiration and instrumentation

It was agreed that the expense and difficulties involved in their use were not worth the low standard of results obtained.

B.3 Criteria in the Selection of Instruments

General criteria for the selection of instruments to be ordered was agreed on from the experience of A S Harley and A D Ward and the various external persons visited, as listed in Table B.1. Briefly :

. it was decided that each instrument should be a separate unit capable of giving data independently of other instruments. We accepted that instruments in general do misfunction, and that the temporary loss of one system should not affect other systems. Thus central data storage systems were avoided.

. data logging systems were avoided as it was felt that time and effort would have to be spent in the calibration and initial "running-in" period. Although it is generally accepted that data logging systems are likely to replace mechanical recording systems in the future, South African suppliers do not have proven long term systems presently in operation, not could they guarantee acceptable replacement/repairtimes.

. instruments were ordered which are compatible with systems presently in use wherever possible. For example A. Ott Water Level Recorders were ordered, despite their higher price, as the Division of Geohydrology has standardised on this make. Thus in the Molopo compartment their technician will be able to change charts and service the instruments without additional problems. It is also expected that some of the instruments will remain in use after the completion of the project and will be handed over to other organisations.

These criteria for selection were agreed to by the Steering Committee.

B.4 Instruments ordered

A complete list of the instruments ordered is given in Table 7.1. Instruments are arranged as follows:

. Meteorological
. Laboratory
. Soil Moisture
. Hydrological
. Ground water monitoring

The allocation of the instruments to the three catchments is discussed in the individual sections for each catchment.

B.5 Filing and distribution of instrumentation information collected

At the Steering Committee Meeting in Septembeer 1984, SRK were requested to circulate the information collected on the various instruments to interested parties.

A full index and referencing system was adopted and circulated to interested parties and internally (SRK). The indexes and listed references are given in Table B.5. The information collected on the various instruments is in the SRK library for reference by any interested peson.

TABLE B.2

SUMMARY OF USEFUL DISCUSSIONS

VISIT: UNIVERSITY OF NATAL, DEPARTMENT OF AGRICULTURAL ENGINEERING, PIETERMARITZBURG

CONTACT: PROF. R SCHULTZE

SRK REPRESENTATIVE: A D WARD, A S HARLEY, M J ROBINSON

DATE: 13.02.84 and 14.02.84

SALIENT POINTS OF DISCUSSION WITH HEAD OF DEPARTMENT: Prof. Meiring

Involvement by University

- Technician to be appointed by University
- Control and administration of project technician (R Schultze).
- Professional and logistical assistance as required
- additional work (budget available) by external personnel (i.e. University Students)
- technician to be appointed by University

Benefits to University:

- technician available to Department in slack periods (during winter dry period for e.g.) (equals out time spent by R Schultze)
- publications
  (Requested to note that recognition should be given to Department of Agricultural Engineering, Natal University and not only to individual)

Logistics of Financing:

- technician to be employed by University of Natal, under their standard conditions, and paid for by SRK
- Capital expenditure borne by SRK, although some intrumentation (additional weather station) budgeted for by University of Natal
- additional work at cost

Transport:

- Need for scrambler bike queried by Prof Meiring

- (After discussion) transport of technician to be paid for as follows:

  - normal UN trip (weekly) : no charge
  - special/additional trips at UN rates of hire (estimated as 20 trips x 250 km x 50 c/km = R2 500/annum)
  - accepted 1st year will be over budget
  - accepted as adequate compensation to the Department of Agriculture

Steering Committee - WRC

- UN requested to delegate a nominee
- noted that R Schultze can always be asked to attend meetings anyway. Therefore suggest that Prof. Meiring be nominee.

<u>DEPARTMENT OF SOIL SCIENCE</u>: Prof A Cass

- Noted size of catchments - from soils aspect spatial variability in soils must be accommodated
- has had extensive use of tensiometers

  - mercury manometers preferable, but require daily maintenance and readings
  - automated systems not as successful to date, although new literature available on "plug-on" gas pressure semi automated systems (Ref: McRinger, University of Arizona)
  - Thought that problem would be the modification of the soil near to the tensiometer cup by the necessary priming (or pre wetting) required (either by wetting soil, or causing the boundary to separate from the cup)

- noted methods to eliminate tensiometers

  - Ref: Don Labardy, University of California
    Prepared infiltration rings equipped with neutron probes
    Monitored soil moisture changes as soil was wetted up
    Assumed hydraulic gradient = 1
    Performed 100 tests in situ without maintenance

- suggested examine Geostatistical methods

  - modelling of soil characteristics
  - Campells methods - simple
  - Maulin might be better - review

- Neutron Gama probes

  - Department has used 3 different types (single probes) to ± 5m depths
  - Campells have not yet had problems
  - Roy Motram (Cedara) not successful with Swedish model
  - beware of chloride rich soils or salinity
  - use standard 1-1/2" irrigation tubes
  - recommended steel pipes driven into ground (or aluminium)
  - problem of calibration

    - either sand tanks
    - or in situ - problem destroy area

  - sensitive to organic matter - thermalizes readings
  - Jeff Bamber at Sugar Research has used dual probes

- Department of Soil Science has truck auger, capable of drilling to 3 m depth (would be made available for our use)
- queried whether we would do grammetrical sampling and testing
- Referred us to Pedro Belino, Soil and Irrigation Research Institute (soil physicist with experience in soil moisture) Tel: (021) 28-4048
- recommended contact with Chris Roper, Anglo American, who has done work on water movement in spoils (to be done tactfully)
- recommended references:

  - Hillel, Krentos & Stylianon, procedure and test of an internal drainage method for measuring soil hydraulic characteristics

in situ, 1972, Soil Science Soc Ame J
(The Hebrew University, Faculty of Agriculture, Rehovot, Israel and Agricultural Research Institute, Athalassa, Nicosia, Cyprus)

. Libardi, P L, Richardt T C, Nidian D R, Biggas J W,
Simple Field Methods for Estimating Soil Hydraulic Conductivity
Soil Science Soc Ame J 44 : 3 - 7 (1980)

- A D W to send copy of thesis plus two or three papers of interest

<u>LAB VISIT</u>: Dr A Cass

Pressure Cookers

- Ø ±30 cm, measurements at 2,5,7,10 bars
- recommends high flow plates

Temple Cells (Ceramic)

- larger than off shelf, self made to specifications
- permeability, leeching and swelling tests
- refer to thesis by Dane, Colorado State University.
  also paper by Dane, Kloof : Soil Sci. Soc. Am. J. V41 p1043 to p1049

Switches for tensiometer

- refer to Maringer, Soil Science Soc Am J - solid state transducers (self made)

Hygrometer and Digital multimeter

- measure soil moisture
- good results so far (-5 bar to - 45 bar)
- for small <u>disturbed</u> samples - sample charger

Water retention curves (Wilting point and field capacity)

- possibility of UN carrying out tests

    - for 3 to 4 points on curve ± R75
    - recommend that for batch of samples, a student be paid at cost (± R30/day)
    - involve WRC technician, although noted that special skills are required, or constant supervision
    - excess costs to be covered by donations to Department of Agricultural Engineering

Precision Scales

- Satarius (Optical Instruments & Co)

    - to 4 decimals, fairly accurate
    - R3000 -> R4000

- dual range electronic reading balance preferred

    - Shimadzu, Libror Ael 160 (Supplied by Ilsa (Pty) Ltd)
    - 2 balance for ± R3000
    - recommended by U N - after 1 years use calibration was exact
    - supply top loading balances with 2 ranges

- Mettler top loading balances

    - supplied by Protea Lab Holdings
    - expensive

Ovens

- recommend microwave oven
    - no setting required

- time x 50 watts
- uses much less energy
- refer to papers

1 Miller R J, Smith R B, Biggas T W, Soil Water Content: Microwave Oven Method - Soil Science Society Amer. Proc., Vol 38, 1974

2 Hankin L, Sawhney Brij L, Note on Soil Moisture Determination using microwave radiation. Soil Science, Vol 126 No 5, 1978 (Connecticut Agricultural Experiment Station, Box 1106, New Harei, Connecticut 06504

3 Gee G W, Dodson M E, Soil Water Content by microwave drying: A routine Procedure Soil Science Society Am. J45 : 1234-1237

Vacuum Filter (Batch test or Saturation Extract)

- Kartell Apparatus (Made in Italy)

  - screw into funnel
  - container holds soil
  - apply vacuum on bottom of container

- Soil Moisture Equipment Company

  - better equipment
  - more expensive

Shaker/Mixer

- self made
- Talber & Corsar

Soil Classification of De Hoek

- suggest that use UN students prac as cost effective means of classifying De Hoek

- compared to Tutuka Power Station, cost R9000
  (10 Km^2, intensive 100 m grid survey, soil depths, 40 well documented profiles, 10 sets of chemical analyses, 3 students for 15->20 days (field) + 1 student for 15 days (lab))
- pay only student wages
- estimate for De Hoek R1500
- students usually available in July although Dec possible

- For previous work refer to :

  Martin Fey : Pathologist
  John De Villiers : Soil Scientist

  - Pioneering book in 1969 on classification System
  - as part of Tugela basin, catchment 14 has been classified before (copy with R Schultze)
  - check to see how much work to be done

- estimated work

  - possibly to be done on grid basis
  - estimated depth 1 m, a few down to maximum 3 m
  - 2 transects
  - recommended Geostatistical Models - creeding facilities on UN computer (?)

Aerial Photographs

- recommended use
  - Department of Surveying, Natal University, Durban, Prof. Scoggins (non-profit, use students)
  - for 10 Km^2 ± R600 (1966 prices)
  - go through Department of Agricultural Engineering, Pietermaritzburg - cheaper
  - produce
    - 1 : 4000
    - 1 : 10000
    - 2 m Contour maps

- Government Survey Office

    . 1 : 36000 then blown up
    . Bad resolution

- check original survey (± 1962)
- also possible to use

    . infra-red (different colouration for soil moisture regimes)
    . microwave photography

Survey Point

- overlooking De Hoek Catchment 14 ± 1 Km away
- full meterological station at Agricultural Research

VISIT TO CEDARA, AGRICULTURAL TRAINING COLLEGE: Dr John Mallet, Roy Mottram

- Moisture measurement probes
  - Campell moisture probe
    - correlation problems especially for actual results
    - for differences in moisture good results
    - service good
  - Nea (Denmark)
    - badly affected by temperature
  - for sandy soils results OK, for heavier soils not so good
  - Tensiometers
    - require daily servicing
    - not liked
    - only in wet soils - when dry soil breaks up around cup creating some sort of artificial compaction or change to soil
    - queried whether representative results could be obtained
    - dual moisture/density apparatus thought more dangerous
- Refer to Soil and Irrigation Institute in Pretoria
  Pedro Belino (or Tony Proffit (?))
  - has done excellent work in soil moisture
  - leaving in October after 10 year period
  - seconded to WRC
- Pressure Membrane Apparatus
  - not used, prefer ceramic plates (set up but not in use)
  - sampling problem

refer to : John Hudson (Soils Research) difference of 300% between disturbed and undisturbed samples

- 1-1/2" "tins"
- obtain suction curves
- equipment (small) is available for undisturbed samples
- no testing on commercial basis - either A Cass or Sugar Asssociation

Pressure Cooker Apparatus

- used for disturbed cores, 2" or 3"
- 15 bar -> 0,05 bar
- make: Soil Moisture Equipment

Infiltrometers

- refer to studies by Dave Turner on ring infiltrometers
- scattered results
- rainfall simulator not good

Vegetation effects

- leaf area index (week to 10 days)
- Dave Bramsley (overseas ?) has done work
- require discrete sunshine hour by hour + geometrical loading to give some estimation of total radiation
- recommended method : wind, sunshine and radiation by Priestley, Taylor and Richey
- measure leaf area (direct & visual measurements)
  - destructive tests
  - belt driven machine light meter register

Soil Constants

- for wilting points etc., John Hudson has done work for RSA producing constants for soil, silt, clay

- gravimetric methods?
- electrical resistance box?

Lysimeter Work

- Refer to Daan Opperman, Sugar Association
    - hydraulic lysimeters
    - batteries
- queried merit of work as:
    - disturb area by putting in lysimeter, create artificial layers
    - weighing lysimeter (to measure moisture bearing soil) - R20 000
    - suggest non weighing studies - sample water coming out
        - seal all the way down
        - pump water for soil suction
    - problem : is representative?
    - drying of soil and cracking a problem
    - require 3 m depth (at least below root depth)

Rooting Depths (Vegetation component)

- information on natural vegetation very sparse
- for crops, should not be a problem to get rooting depths
    - Pasture Sciences - Dave Bramsley
      - Peter Bartholemew
    - Botanical Research Institute
    - Sugar Research Institute
    - British Commonwealth Research Institute (Trouter) (1967)

- Information not likely to be in published form
- trees are large "users" of water in Winter at different levels
  - refer to Douglas Fir experiment (tree lysimeter)

- Forests do not produce groundwater - look at turbulence, albedo, anticedant moisture conditions

DISCUSSION WITH BILL REYNOLDS, Instrument Station

Wind, Speed and Direction

- recommends total wind run to separate speed and direction readings (which are never analysed)
- . read at 08h00, 12h00, 18h00
- cost ± R2000

Sun

- record daily changes
- prefer measurement of nett radiation
    - . costs R1800
    - . relate to salary of tech to analyse sunshine hours
    - . battery operated i.e. maintenance NB
- automatic Weather Station at Cathedral Peak
    - . cost R5000 - R7000
    - . monitoring at 5 minute intervals
    - . remote station
    - . run since November without problem
    - . Department of Forestry
    - . supplied by Cape Town Firm (?)

Evaporation

- use non automatic A pan
- refer to : Water S A ± October 83 Van Wyk

. Stellenbosch - continuous recording of evaporation from type A pan
(Forest Research Station
Department of Environmental Affairs
Private Bag X5011
Stellenbosch 7600)

Relative Humidity etc.

- uses thermohydrograph
- sent in once per week, take off highest and lowest daily measurements

Barometric Information for Boreholes

- not very important, not used
- water level recorders custom built and expensive
- of interest :

  groundwater fluctuations with tides (?)

  at De Hoek

Soil temperatures

- hand read twice daily
- in remote area's problem with thermometers being broken

Evapotranspiration

- Penman type equation; Thornthwaite doesn't work as well here
- refer paper by Limanacker (Australia)

VISIT: WITWATERSRAND UNIVERSITY CIVIL ENGINEERING DEPARTMENT
CONTACT: MR C JAMES (Lecturer/Researcher in Hydraulics Department)
SRK REPRESENTATIVE: M J ROBINSON
DATE: 09.02.84

WATER SYSTEMS RESEARCH UNIT : John Abbot (MSc Student)

- Hydrological Research Unit has disbanded and was replaced by the WSRU.
- Dr Pitman and assistant (?) now working at Stewart, Sviridov and Oliver (783-5393)
- Hydrological instrumentation not at Wits. Only data records (mainly rainfall)
- 1 MSc Student employed full time punching in data
- Raingauges :
  - Cheaper Japanese (OSK 764) more reliable compared to German (Lambrecht KG)
  - S A Supplier : ECO Pretoria, Tel: (012) 46-9251

TRANSPORTATION SYSTEMS DEPT: Prof. (?) (Lecturer)

- Recording System to collect and store data Electromatic (Pty) Limited,Pietermaritzburg Tel: (0331) 53339
- For remote areas (i.e. no electrical supply)
  - batteries R5 000 p.a. (10 traffic counting instruments)
  - Consider solar cells if not in public access position (problem of tampering)
  - tape recording system saves much time
  - require interface with computer system
  - beware dust and sun for tape system

ARTIFICIAL RECHARGE TO DOLOMITES: MSc Student Mr Pahling

- Dutch MSc Student

- Project to examine the artificial recharge to the Dolomites
- Particularly interested in Water and Wastewater Treatment Plants Effluent
- No instrumentation as yet - uses results of plant and Rand Water Board
- he is interested in our Dolomite Project

<u>OTHER CONTACTS</u>

- Work on water and groundwater budgeting and on recharge to groundwater was done by Prof. W James of Mc Master University, Canada, sabbatical while at Witwatersrand University (?)

VISIT: NUCLEAR PHYSICS RESEARCH UNIT
CONTACT: PROF. F SELLSCHOP (Head NPRU)
SRK REPRESENTATIVE: M J ROBINSON
DATE: 09.02.84

SALIENT NOTES ON DISCUSSION with Prof. Sellschop

- Not previously aware of project
- showed interest in project, especially for work to be done by Prof Verhagen
- NPRU has done a lot of work on groundwater age and movement (not normally associated with Nuclear Physics)

    - promised a list ot topics and reprints
    - Vanhagen should come back to us as soon as possible

- Prof Sellschop was seeing Prof. Verhagen the next morning. To be properly prepared he requested a copy of the recharge report, which was reluctantly given.

- Equipment for our "environmental" labs is fairly standard - most is used by the NPRU. Vanhagen to arrange visit for us.

VISIT : NATIONAL INSTITUTE FOR WATER RESEARCH, C S I R.
CONTACT: DR VAN VUUREN, Dr Gerber
SRK REPRESENTATIVE: M J Robinson, D P Harpley
DATE: 15.02.84

DISCUSSION WITH DR VAN VUUREN AND 4 MEMBERS OF HIS STAFF

- NIWR more involved in Water Quality Research, although some groundwater work has been done.

- Recommend most strongly literature review

  overseas ± 5 years ahead

  - Thames Water Authority has some good automated monitoring equipment
  - Dutch in encroachment of salt water table and ways of preventing
  - Americans for instrumentation
  - Israeli's - Irrigation
    ref Idelowich (?)

  work has been done in "unrelated fields"

  - sand infiltration in S W A - Dr Harwich
    - Dr Hellwick
  - Lysimeter studies in S W A
    and Cape - Stellenbosch - Hannes Nel
    - Windhoek - Dr Harvey

  recommend contact:

  - Department of Agricultural Technical Services
  - Hydrological Research Institute
  - Department of Geophysics
  - Universities Department of Agriculture, Soil Science, etc.

VISIT THROUGH LABS

- not very relevant except for tumbler apparatus (self made)

VISIT TO WATER LIT

Suid Afrikaanse Inligtingsentrum vir Water
Posbus 395
PRETORIA 0001

Tel: 86-9211 Ext 3083 or 2048

Contact: Mr Steyn

When one of documents required from this search, quote this
Search No : 840240
Cost : R2,00 handling charge
10c per page

Keywords for search:

Groundwater
Piezometers
Soil Water movement
Infiltration
Recharge

TELEPHONE CALL	:	ECO PRETORIA (Suppliers of Hydrological Equipment)
Tel	:	(012) 46-9254
Contact	:	Mr Evans (Sales Manager)
Date	:	16.02.84

For an automatic recording system, recommended

Webb & Partners
Atmospheric Systems.

Automatic Digital Recording Systems have been used by

Dr Denis Hughes
Rhodes University
Hydrological Research Unit

System has been running for 11 months without problem

TELEPHONE CALL TO: Electromatic (Pty) Limited, Pietermaritzburg
Tel: (0331) 5339
Contact : Mr Grahamn Liebetrau (Marketing Manager)
Date : 14.02.84

Not possible for them to supply digitising/data storage/recording systems, but suggested:

H Le Roux & Associates Information Systems
Computer Business Systems
Le Roux House
Kelvin Drive
Morningside Manor
P O Box 742 Gallo Manor

Tel: 802-4251
[Telemetry Div.]

VISIT: SOIL AND IRRIGATION RESEARCH INSTITUTE, PRETORIA

CONTACT: DR PEDRO BERLINER

FROM SRK: A D WARD, M J ROBINSON

DATE: THURSDAY 23.02.84

NOTES ON DISCUSSION WITH PEDRO BERLINER

- MSc in Soil Physics and infiltration

  Involved in Agro hydrology - soil/plant/atmosphere relations
  Prefers "in depth" studies

- Latest Study : Spatial variability in soil conductivity

- Sees recharge study as 2 separate problems

  - micro aspect - recharge in homogeneous material
  - integration of micro aspects to give macro aspect

- Most important factor expected to be the evaluation of evapotranspiration

  - largest percentage loss of water
  - dependant on soil cover - can thus change drastically in short time periods
  - most complicated to measure
  - is usual to use formula's and "fudge" factor

    - don't understand errors
    - Penman equation (approximate energy balance equation developed for S of England) not relevant to South Africa as assumes equal surface and soil water temperatures
    - estimate 20% error, up to 50% on cloudy days
    - problem in measuring temperature as prediction - correlation to energy regime difficult
    - Other models better

      - Priestly Taylor
      - Penman approximate formula (+ thatch factor)

EP/ measured

EP max actual found by Berliner

70%
PAN

- Overestimate by 50%

- problem using pans

- depends also on evapotranspirational demand in the atmosphere
- Refer to paper :
  "Morton (1983) Operational Estimates of Areal Evapotranspiration and their significance to the science and practice of hydrology, J. of Hydrology V66 P1'76"

  - suspiciously good results

- How to measure?
  - Bowen ratio
    - radiation
    - wet and dry bulbs
    - synchrometers
  - are sophisticated instruments, but station needs to be properly situated (N B), and in each area (i.e. each crop/land use area) can be highly different.

- Roodeplaat Experimental Farm

  - Lycosensor
  - Temperature of soil
  - Wind Speed
  - Rainfall
  - Data logger, 8 channels. R6000
  - require instrument that measures representative radiation
    - Gyronometers ± R2000
    - Lycosensors

- Data logger, ECO Dave Evans ((012/46 9251)
  - not reliable supplier

- Thomson, Capetown (021/53.7400)
  direct importer and sells a local product

- To measure changes in soil measure

  - Neutron probe - long term changes
  - in calibration, standard error + 1% water content
    which could be 15 to 30 ml possible loss in 30 cm depth
    (compare to 6 ml/day evapotranspiration)
  - realistic measuring time 1 week.

- or treat problem as black box

  - 10 yrs ago in Israel, Hebrew University (Author ?)
  - measure beneath roots

- Moisture density calibration not easy
  - large errors
  - 15 cm depth resolution
  - " 5 day intervals
  - Campell used - cheapest
  - not possible to follow wetting front accurately - will get results, but what is confidence?
  - need to wait at least 2 days after irrigation to be able to compare with actual quantities of rain
  - sharp differentials of water content not measured because of integrating nature of instrument counts

- Tensiometers
  - 3 to 4 days after wetting, results are very suspect
  - mercury manometers better
  - switching never works on pressure transducers
  - problematic to operate

- Infiltrometers

  - used by Topp
  - some problems with use - see literature
  - disturb surface area

- Undisturbed core
  - difficult to take
  - requires large amount of time - lab organisation etc.
  - e.g. 3 months, 2 graduates full time + Pedro 40% + technician at Roodeplaat to do hydraulic conductivity tests.
  - practical knowledge of lab technicians very N.B.

- Data loggers vs Strip charts

  - Have to digitize results anyway
  - Problem not able to see results
  - trade off in time vs expense/reliability

- Step from microsystem to macrosystem very large
  - groundwater table need not be the "absolute"
  - is microsystem really necessary - is interesting but cannot integrate micro without introducing a fudge factor!
  - might be possible to arrive at model without going to such detailed measurements
  - Is it not preferable, because of spatial variability, to attempt to simply take factor for clay, factor for sand etc.

- His approach would be :

  - attempt some approximate results in assumed model
  - look for simplest method - what comes out, using assumptions
  - identify important parameters and their sensitivity
  - relate to recharge, does this parameter affect model
  - if good answer, do you need better model?
  - if no absolute datum, then are even cross checks valid?
  - other ways much more time and money, and at end don't know how to integrate micro (cf accuracy of calibration of Neutron probe)
  - for different areas, different problems

- Agreed that would probably need:

  - Hydraulic conductivity
  - Soil type
  - Evapotranspiration
  - Air temp
  - Precipitation
  - Run off estimate/erodability

- Refer to Namaqualand Study - movement of groundwater
    - John Hudson (Cape)
    - ? Hydrologist O F S
    - Con Russel Soil Physicist
    - using finite element methods

- Evapotranspiration from forests very difficult/impossible
    - large disagreements
    - + 50% accuracy
    - Churchill, Ellyett & Holmes. A study of regional evapotranspiration using remotely sensed and meterological data - contrasts between forests and grasslands.
      Department of National Development and Energy, Australia Water Resources Council, Research project No. 77/93,94

- lysimeters
    - refer to paper comparing lysimeters with other methods
    - won't miss much by leaving out
    - only gives you one point in graph
    - spatial variability large problem
    - expensive
    - existing lysimeter) Monitored by Pedro for three years
    - developed one)

- Journals
    - Publishers overseas only - Agronomy Journal and Journal of Hydrology
    - New publication in R S A coming out - S A Journal of Soil and Plant Science
        - International referees
        - George Green Editor

- Agment data bare at S I R I
    - Johan Erasmus

- Instrumentation - Hydrology Congress 1981

- Rainfall simulator; Marin, Goldbert.
    - work on crusting

- Mr Bob Gaynor
  Leeds & Northrup (Pty) Limited
  106 Harry Street
  Robertsham 2091
  Johannesburg

TABLE B.3

LIST OF INSTRUMENTS DISCUSSED

	Make	Model No.	Unit Cost (R)	No	Total Cost (R)	Budget No	Budget (R)	SA Supplier	Delivery Time	Ref No	Remarks *
METEOROLOGICAL											
1 Wind						1	1 000,00				(Combined Wind + temperature)
Combined Wind speed & direction indicator	Casella	W 1404	4 800,00		4 800,00			Wild + Leitz	6-8 wks	W1	
Electrical Charge Recorder (additional)	Casella	W1762/1									
Mechanical Wind Recorder (continuous) Woelfle Type	Lambrecht	1482	2 888,00	1	2 888,00			Optical Instruments	Stock	W2	
Electrical Wind (Direction + Run) Recorder	Lambrecht	1464	8 085,00	1	8 085,00			Zeiss S.A	6-8 wks	W3	
Wind speed sensor Wind direction sensor Recorder	Met One Met One	014 024	410,00 510,00 500,00	1	1 420,00			ECO Pty Ltd	8 wks	W4	Link to Envirologger
Cup Counter Anemometer Cup Contact Anemometer Wind Vane EMO Pattern	Casella Casella Casella	W1208/2 W1254/2 W1000	300,00 1 000,00 50,00	1	1 350,00			Wild + Leitz	Stock	W5	Cumulative Counters only (1982 prices)
2 Temperature											(Included in budget for Wind)
Temperature Probe	Campbell Sciennetic	101 Thermitor	50,00					ECO	8 wks	T1	
Stevenson Screen + Stand Thermometers Wet + Dry Max/Min			210,00 16,00 80,00	1	308,00			H + S Timbers Rand Medical Suppliers	4 wks	T2	
Thermograph	Casella	T6554	300,00					Wild + Leitz	4 wks	T3	
Thermohydrograph Accessories	Lambrecht	252 Va	625,00 135,00					Zeiss	12 wks	T4	
3 Pressure											Not budget for
Aneroid Barograph	Lambrecht	290	710,00					Zeiss	6-8 wks	P1	
Small pattern barograph	Casella	W2450/1	650,00					Wild + Leitz	12 wks	P2	
Barograph	Ogani Seiki	OSK7130						ECO		P3	
4 Relative Humidity (Hygrometers)											
Humidity Sensor + Interface	Hygrometrix	XNAM10205	490,00					ECO		H1	
5 Rainfall											
Natural syphon rainfall recorder	Casella	W 5396	1 200,00					Wild + Leitz	12 wks	R1	
Recording Hellmann Type Rain gauge	Lambrecht	1507	1 050,00					Zeiss	6-8 wks	R2	
0,2 mm Tipping bucket Recorder	Ogani Seiki	OSK 764 OSK 754	400,00 440,00		940,00			ECO	6 wks	R3	Recommended by Water Systems Research Unit
Tipping bucket precipitation recorder	Letratek	TP 8206	1 518,00					Ritnic	Stock	R4	Made in RSA. Prices 1983
Long-term recording rain gauge	Ogani Seiki	OSK7179a	2 947,00					ECO	60-70 days		
6 Sun/Radiation											
Sunshine Recorder – Campbell Stokes Pattern	Lambrecht	1603	815,00					Zeiss	6-8 wks	S1	
Solar Energy Measurement – Pyranometer Sensor	Li-Cor	LI200SB	420,00					ECO	6 wks	S2	
7 Evaporation											
Symons S Tank	Made to Specification		900,00					SA Instrumentation	4 weks	E1	

	Make	Model No.	Unit Cost (R)	No	Total Cost (R)	Budget No	Budget (R)	SA Supplier	Delivery Time	Ref No	Remarks
METEOROLOGICAL (Cont)											
8 Meteorological Stat ("Weather Stations")											
Wind speed sensor	Met One	Model 014	410,00					)			
Wind direction sensor	Met One	Model 024	510,00					)			
Temperature probe	Campbell	101 Ther	50,00					)			
Humidity sensor + interface	) Hygro-) metrix	XCAM10205	410,00 80,00					)			For individual instruments see information above.
Solar Energy Measurement, Pyranometer Sensor + Levelling device + Attachment	Li-Cor	LI-2005B	265,00 75,00 80,00					) ECO	4-6 wks	C1	Limited additional information can also be collected : - Moisture blocks - Evaporation data (local equip to be ready in Sept)
Tipping Bucket Rain Gauge	Ogani Seiki	OSK 764	400,00					)			
+ Datalogger :								)			
Envirologger			2 250,00					)			
Enclosure + Radiation Shield			360,00					)			
Cassette Recorder + Cable			310,00					)			
Tripod			350,00					)			
Wind cross arm			80,00	1	5 630,00			)			
Meteorograph - Temperature, Pressure Humidity	Lambrecht	253 C	1 040,00					Zeiss	12wks	C2	Monthly reading
GROUNDWATER											
1 Water Level Recorders											
Vertical water level recorder (Options : Digital display Tilting casing)	A.Ott	R16	1 920,00 480,00 228,00					) Zeiss	12wks	A1	
Combined Water Level Recorder + Barograph	A.Ott	Made to order	±5 100,00					)	12 wks	A1A	
Water Level Sensing Device Recorder	Johnson A.Ott	SD-62-B	1 100,00 ±1 200,00					Dril-Chem	Stock	A2	
Water Level Recorders	Alpina-Werk	P-10	3 187,00 12 1650,00					Basic Mineral Engineering	4 mnths	A3	
2 Water Level Indicator						1	400,00				
Water Level Indicator	Made-up		± 260,00					GI	4 wks	B1	
Electric Contact Gauge	A.Ott	KL 50	390,00					)			
Gauge with temperature (0°C to 20°C)	A.Ott	KLT 50	900,00					) Zeiss	Stock	B2	
Gauge with temperature (-5°C to 45°C) + digital display	A.Ott	KLTD 50	1 140,00					)			
Water Level Tester	Johnsons	(Tape = 250')	400,00					Dril-Chem	Stock	B3	
Portable Level Indicator	Alpina-Werk	(Tape = 200 m)	671,00					Basic Mineral Engineering	Stock	B4	
Borehole Dipper	ELE	ELE514-390/50 m	828,00					Soil Lab Supplies	Stock	B5	
3 WATER SAMPLERS		NOT TO BE ORDERED YET									
4 PIEZOMETERS						3	1 500,00				Twin Piezometers
63 mm I.D tubing + 15 m each Twin Piezometers	GI	-	1 524,00					GI	4 wks	C1	

	Make	Model No.	Unit Cost (R)	No	Total Cost (R)	Budget No	Budget (R)	SA Supplier	Delivery Time	Ref No	Remarks
SOIL MOISTURE EQUIPMENT											
1 Vacuum Extraction Equipment											
Filter Funnel Stand	Soil Moisture Equipment (USA)	No 1300	396,00	1	396,00			Civiquip	12 wks	See File	Order placed 29/03/84
100 ml Richards Funnel		NO 1390	24,60	6	147,60						
500 ml Richards Funnel		No 1391	39,50	4	158,00						
2 Ceramic Plate Extractors						1	4 000,00				
15 Bar extractor		No 1500	3 200,00	1	3 200,00						
1 Bar Pressure Plate Cells		No 1290	222,00	2	444,00						
3 Bar Pressure Plate Cells		No 1690	271,00	2	542,00						
3 Tensiometer Equipment						60	12 000,00				
Cup Tube Kits 12"		No 2325	37,50	12	450,00						
24"		"	41,60	24	998,00						
36"		"	43,40	24	1 041,60						
48"		"	47,50	24	1 140,00						
60"		"	52,00	12	624,00						
Soil Moisture Meter		No 5910-1	725,00	1	725,00						
Soil Moisture Blocks		No 5201. L 1,5	22,00	50	1 100,00						
					10 939,60						
				+GST	765,77						
					11 705,37		16 000,00				
LABORATORY EQUIPMENT											
1 Ovens											
2401 Bulk sampler oven	Gallenhaup	OT 160	1 500,00	1	1 500,00			Gemlab	Received		
Microwave oven + rotating base	Sanyo	2410	490,00	1	490,00			Dions	Stock		Ordered 08/03/84
					1 990,00	1	2 000,00				
2 Balances											
Precision Scale to 160 g acc 0,1 mg	Shimadzu	AEL 160	3 000,00	1	3 000,00				6 wks		
Top loading balance 0,01 – 200 g	Precisa	1518MPS	1 300,00	1	1 300,00						Ordered 08/03/84
					4 300,00	1	2 000,00	Gemlab	Received		

	Make	Model No.	Unit Cost (R)	No	Total Cost (R)	Budget No	Budget (R)	SA Supplier	Delivery Time	Ref No	Remarks
MATERIALS AND INSTALLATION							12 500,00				Non recurring Expenses
1 Auger											
To drill: 45 mm Ø hole to max 5 m (60 holes)	Equipment to be made up specially		R10/m	300 m	3 000,00			Dump and Dune drillers	1 month notice		Minimum charge R500. Prices for Jhb Area Hand drilled Sampling facility possible
20 mm Ø holes to ± 1,5 m (146 holes)			R10/m	220 m	2 200,00						
Hire of Auger)	Specially made		R850/mnth	1	850,00			Gemlab	1 month		Additional flights reqd Not sure if auger will be able to do job
Add Flights) 42 mm			R220/mnth	2	200,00						
1 Operator) OD only			R 16/day	20	320,00						
3 Labourers)			R 6/day	20	360,00						
For 20 mm Ø holes (3/4") to be hand drilled	Special flights reqd		Estimated					Gemlab			
2 Access Tubes											
44,5 mm O.D, 1,62 mm thick @ 0,591 kg/m	Extended pipe	Grade: 5 OSTS	R2,494/m	300	748,20			Hullett Aluminum	3-4 wks		To SIRI specification

TABLE B.4

LIST OF INSTRUMENTS PURCHASED

LIST OF INSTRUMENTATION

Instrument	Budget		Type of Instrument Chosen	Make	Supplier (S.African)	Delivery Time	Cost/ Unit (R)	No to be Bought	Total Cost (R)
	No.	Amount (R)							
Meteorological									
Wind	1	1 000	Continuous mechanical wind recorder (Direction + Run)	Lambrecht 1482	Optical Instruments	Stock	2 888		
Pressure/Temperature } Relative humidity }	1	-1 000	Meteorograph No. 253	Lambrecht 253	Wild + Leitz	6-8 wks	1 040		
Sun (Daily)			Campbell Stockes Pattern No. 1603	Lambrecht	"	"	815		
Rain Gauge	3	6 000	Natural Syphon Recorder	Casella W 5488	"	12 wks	1 200		
Laboratory Equipment									
Oven }	1	2 000	To be supplied by Gemlab			Stock			
Microwave Oven }			Sanyo std microwave	Sanyo	Dions	Stock	490		
Precision Scale	1	2 000	160 g to 0,1 mg	Shimadzu	Lasa Pty	6-12 wks	3 000		
Top loading balance			To be supplied by Gemlab						
Soil Moisture Equip									
Pressure Cooker apparatus	1	4 000	Tempe Pressure Cells (+ extras)	Soil Moisture	Soil Lab Supplies	12 wks	±1 000		
			Pressure Plate Extractor	"	"	"	2 500		
Tensiometers	60	12 000							
Density probes	1	5 000	} DR 501 B Scaler	Campbell	King Nuclear Instr	4-14 mths	8 200		
Moisture probes	1	6 000	}				6 800		
Hydrological									
Evaporation pan	1	1 500	Made to specification	A-Pan W.Bureau					
Lysimeters	6	15 000	-	NOT TO BE INSTALLED					
Ground Water Monitoring									
Water level recorder	12	24 000							
Water level Indicators	1	400							
In Situ Water Samples	1	1 600	NOT TO BE ORDERED						
Piezometers	3 (twin)	1 500	TO BE INSTALLED BY GEMLAB						
TOTAL		85 000							

TABLE B.5

INSTRUMENTATION INDEX AND CONTENTS

INSTRUMENTS

General INDEX

Information collected for Water Research Commission projects has been collated into various files which are stored in the library. Indexed words include:

INSTRUMENTS plus

METEOROLOGICAL, WEATHER, SOIL MOISTURE, INFILTRATION, GROUNDWATER, GEO-TECHNICAL, LABORATORY.

SUPPLIERS, TRADE CATALOGUES, REFERENCES, USEFULL INFORMATION

There are eight files containing trade catalogues, prices (where obtained), instrument suppliers, and relevant information (references, instruction manuals, standard proceedures etc) for the various instruments. Generally the information is seperated initially into sections and then under individual instruments. Hence all types of instruments for similar purposes should be in the same section.

The sections are:

File 1 General information (addresses of suppliers, coordinating bodies,- usefull contacts etc)

File 2 Data loggers and information storage and retrieval systems

File 3 Meteorological instruments

File 4 Soil moisture and infiltration instruments

File 5 Groundwater measuring instrumentation

File 6 Hydrological instrumentation

File 7 Laboratory equipment

File 8 Miscellaneous geotechnical instruments

To keep the information up to date, please add copies of any additional information received.

If you take out any information, please leave a record in the file for further users reference.

INSTRUMENTS

CONTENTS

Cont.

CONTENTS

Cont.

CONTENTS

TABLE B.6

INSTRUMENTATION REFERENCES

REFERENCES - INSTRUMENTATION

CARRINGTON T.J., and WATSON D.A. 1981. Preliminary evaluation of an alternate electrode array for use in shallow subsurface electrical resistivity studies. GROUND WATER Vol 19 (1) 48 - 57.

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APPENDIX C

ACRUWAT

USER GUIDELINES

1. INTRODUCTION

This appendix is presented as an aid to users who wish to run the ACRUWAT model. Since ACRUWAT is essentially a combination of two models:

- ACRU (Schulze, 1984) and
- WATFLO (Hutson, 1983),

this document serves only to augment the descriptions of the authors of these models in so far as the combination of these models is concerned

ACRUWAT is a conceptual-physical model which integrates the components of the ACRU and WATFLO models into a one dimensional (vertical), deterministic, site specific, multi-and two-layered, finite-difference and moisture accounting Fortran program.

The model can be regarded as a modified version of ACRU which optionally uses WATFLO as a subroutine for soil moisture redistribution. ACRU uses two soil layers and daily time steps while the WATFLO component uses multiple soil layers and smaller time steps for improved accuracy.

The main interactions between the two models are summarised in figure 1 and involve the transfer of:

- Actual transpiration from the A and B horizon,
- Effective rainfall,
- Surface evaporation,

from ACRU to WATFLO in daily time steps, the use of these data in WATFLO redistributions of soil moisture over finer time intervals and multiple soil layers. Soil moisture amounts for the A and B horizons are transferred from WATFLO to ACRU at the end of each day.

ACRUWAT has been structured with as little changes to the ACRU program as possible so that it can be easily incorporated into the ongoing development of ACRU at the University of Natal. Current versions of

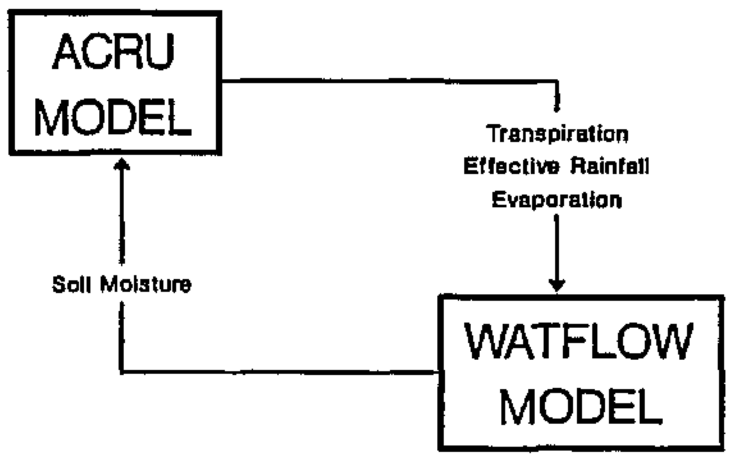

FIGURE C.1 TRANSFER OF VARIABLES BETWEEN ACRU AND WATFLOW COMPONENTS OF ACRUWAT

ACRU contain greater sophistication and more facilities (eg interbasin transfers than the version presented in this document, but these should not preclude ACRUWAT-type modifications.

ACRU inputs

ACRU inputs and their formats are described in detail in Schulze (1984). The inputs consist of two main files containing:

. site data, parameters and menu,
. sequential daily data.

The contents of the first file include:-

** locational input
** output options
** potential evaporation control variables
* mean maximum and minimum temperatures
* monthly day length factors for Thornthwaite potential evaporation option
* monthly day length factors for Blaney - Criddle potential evaporation options
** soil information and control variables
** vegetation information and control variables
** monthly leaf area index
** monthly A-horizon root fraction
** monthly interception loss
** runoff simulation control variables
** monthly coefficient of initial abstraction
* sediment yield data
* irrigation water demand/supply
* crop yield data
* reservoir modelling data

When daily rainfall and pan evaporation data are available and the model is being run for the prime purpose of recharge estimation under dryland conditions, only data for those items marked ** above are required.

Data required in the second file for potential recharge estimates as conducted in this project included:

- site identification,
- daily rainfall,
- daily A-pan evaporation

ACRU outputs

ACRU outputs include various options for daily or summary reports described in detail in Schulze (1984).

WATFLO inputs

WATFLO inputs consist of four groups of information :-

- general data
- soil profile data
- daily input data
  - effective rainfall
  - surface evaporation
  - potential evapotranspiration
- monthly rooting distribution

The first two are input at the beginning of the program while the last two are provided by ACRU during the execution of the ACRUWAT program.

The input menu for general data is according to alphabetical codes (A - G) and comprises:-

A minimum number of time intervals/day

B bottom boundary conditions

C minimum permissible soil matric potential (kPa)

D* depth of profiles (mm)

E number of soil layers (max 18)

F print format

G maximum change in θ per time interval (m/m)

Similarly the inputs for the soil profile data comprise:

H* depth to top of soil layer

I initial soil potential (providing initial soil moisture) (mm)

J* root fraction

K Campbell's 'a' coefficient (mm)

L Campbell's 'b' coefficient

M saturated moisture content (m/m)

N saturated hydraulic conductivity (mm/day)

Items marked * are dependant upon the ACRU input and are overwritten by ACRU. A model input file is given in figure 2.

```
         INPUT TO THE WATFLOW SUBROUTINE
     (see below for details on inputs A to N)
                A         B      C    D    E     F     G
XXXXXXXXXXIIIIIXXXXXIIIIFFFFFF.IIIIIIIIIIFFF.FFFF.FFF
                :         :      :    :    :     :     :
               15         2 -1500. 1400    9   1.0   .010
         SITE : DE HOEK, No. 18
         ======================
    H         I    J             K      L      M          N
FFFFFFFFFFFF.FFF.FFFFFFFFFF.FFFFFF.FFFFF.FFFFFFFFFFF
    :         :    :             :      :      :          :
  000.    -10.0 0.000    -373.00    4.47  0.443      1440.  ORTHIC A
  128.    -10.0 0.000    -373.00    4.47  0.443      1440.
  256.    -10.0 0.000    -543.00    4.67  0.432      1440.  APEDAL B
  384.    -10.0 0.000    -543.00    4.67  0.432      1440.
  512.    -10.0 0.000    -543.00    4.67  0.432      1440.
  640.    -10.0 0.000    -543.00    4.67  0.432      1440.
  768.    -10.0 0.000    -543.00    4.67  0.432      1440.  APEDAL B (RED)
  896.    -10.0 0.000    -543.00    4.67  0.432      1440.
 1024.    -10.0 0.000    -543.00    4.67  0.432      1440.
 1152.    -10.0 0.000    -543.00    4.67  0.432      1440.
........... insert further soils data here if required ...............


A: minimum number of time intervals/day  B: bottom boundry conditions 2 = free flow
C: minimum permissable tension           D: approx depth of profile, ammended by ACRU.
E: number of watflo soil layers (20 max) F: print 1, 2 or 3
G: time interval  (frac of day)          H: approx depth, ammended by ACRU
I: initial potential (kPa)               J: root fraction, ammended monthly by ACRU.
K: Camble,s 'a' coefficient (mm water)   L: Camble,s 'b' coefficient
M: saturated moisture content (m/m)      N: saturated hydrolic conductivity Ks. (mm/day)
```

FIGURE C.2 : A TYPICAL WATFLOW INPUT FILE

ACRUWAT program

The ACRUWAT modification of ACRU involved the addition of a common block of transfer variables to the ACRU model and two subroutine calls - one to WATFL2, where WATFLO initialization occurs and the other to WATFL3, which is the daily moisture redistribution subroutine. This means that the WATFLO model can be added to late developments of ACRU with relative ease, provided ACRU is operating on only two soil horizons. More complex modifications are needed for a multisoil layer version of ACRU.

The WATFLO subroutines are called if the IUNSAT input variable in the ACRU input menu is set to 2. When this is done the ACRU input of Field Capacity (FC) and Wilting Point (WP) for the A and B horizons are over-written by the average values calculated from the WATFLO soil moisture characteristics.

The program is designed to operate on IBM compatible PC computers with hard disk storage facilities and has been developed and compiled on an IBM AT with a 8087 MATH co-processor. The program is entirely file input driven from the menu files described above. The source code consists of a main program and numerous subroutines:-

ACRWAT	.FOR	-	MAIN PROGRAM CONTAINING ACRU
OBJFUN	.FOR		
ANSL	.FOR		
PRNTMO	.FOR		
HAR1	.FOR		
INI1	.FOR		
INM1	.FOR		
PLO1	.FOR		
IND1	.FOR		
LDV1	.FOR		
PET1	.FOR		
PRE1	.FOR		

PRT1	.FOR		
PRT1	.FOR	-	ACRU SUBROUTINGS
RIC1	.FOR		
STA1	.FOR		
UNSL	.FOR		
CNCALC3	.FOR		
CNPREP3	.FOR		
IRRIG3	.FOR		
MZCAL3	.FOR		
WATFL2	.FOR	-	WATFLO initialisation
WATFL3	.FOR	-	WATFLO Main program
WATFL4	.FOR	-	WATFLO functions

The code is written in Microsoft Fortran 1985.

The program is most conveniently run from a batch file containing the following information:

1)	ACRWAT3,	-	main program call
2)	(ACRU MENU).DAT	-	the ACRU input file menu
3)	(ACRU PRINTOUT).PRN	-	the ACRU output file
4)	(WATFLO INPUT).DAT	-	WATFLO input data file
5)	(DAILY INPUT).DAT	-	WATFLO input data file
6)	(WATFLO OUTPUT A).PRN	-	Full WATFLO output file name
7)	(WATFLO OUTPUT B).PRN	-	Summarised WATFLO output file name
8)	(WATFLO OUTPUT C).PRN	-	Moisture profile WATFLO output file name

(Files must be named in this order and must be separated by commas)

A supplementary program called AWATBAT.COM has been written to assist the user in preparing and running the batch file. It produces a batchfile called WRUN.BAT. The source is AWATBAT.PAS written and compiled in Turbo Pascal. A simple procedure control batch file called RUN.BAT is included which runs AWATBAT.COM and then runs WRUN.BAT. The relevant source code is presented in Appendix D.

WATFLO outputs

WATFLO has facilities to produce three separate output files:

- full output,
- soil moisture output,
- summary printout

The full output contains:-

- Date
- Daily actual evapotranspiration (mm)
- Daily effective Rainfall (mm)
- Infiltration (mm)
- Watflo evapotranspiration (mm)
- A - horizon, moisture store (mm)
- B - horizon, moisture store (mm)
- Recharge (mm)
- Cumulative effective rain (mm)
- Cumulative Infiltration (mm)
- Cumulative evapotranspiration (mm)
- Cumulative Recharge (mm)
- Accumulative check balance (mm)

The soil moisture output contains:-

- Date
- moisture content (mm) for each WATFLO soil layer

The summary output gives :-

- A - horizon moisture store (mm)
- B - horizon moisture store (mm)
- Surface infiltration (mm)
- Recharge (mm)

Figure 3 contains examples of the WATFLO output files

DATE	TRANSin	PEVAPin	RAINin	INFILTR.	TRANSPIR	EVAP	STORE-A	STORE-B	RECHARGE	C.RAIN	C.INFIL	C.EVAP	C.TRANS	C.RECHRG	BALANCE
1/ 3/85	2.969	.563	.600	.840	2.969	.130	56.145	104.366	.289	51.791	55.573	9.126	53.564	139.555	.723
2/ 3/85	3.923	.744	.000	.000	3.923	.693	53.814	102.231	.244	51.791	55.573	9.820	57.487	139.799	.733
3/ 3/85	2.367	.444	.000	.000	2.367	.422	52.950	100.525	.200	51.791	55.573	10.242	59.854	139.999	.736
4/ 3/85	2.105	.395	.000	.000	2.105	.376	52.163	99.048	.165	51.791	55.573	10.618	61.959	140.164	.739
5/ 3/85	2.614	.491	.000	.000	2.614	.457	50.927	97.443	.138	51.791	55.573	11.074	64.573	140.302	.743
6/ 3/85	1.402	.262	.000	.000	1.402	.251	50.625	96.300	.116	51.791	55.573	11.326	65.975	140.418	.745
7/ 3/85	1.760	.330	.000	.000	1.760	.312	49.907	95.143	.100	51.791	55.573	11.638	67.735	140.518	.747
8/ 3/85	1.244	.233	1.900	2.400	1.244	.076	51.584	94.693	.087	53.691	57.973	11.713	68.979	140.605	.777
9/ 3/85	1.131	.217	29.422	28.878	1.130	.250	65.929	107.486	.078	83.114	86.851	11.964	70.109	140.683	1.050
10/ 3/85	2.543	.514	23.460	23.460	2.543	.306	69.587	120.029	.203	106.574	110.311	12.270	72.652	140.885	1.208
11/ 3/85	2.191	.417	8.300	8.480	2.191	.328	68.322	123.306	1.118	114.874	118.791	12.598	74.844	142.004	1.274
12/ 3/85	2.957	.563	3.900	4.800	2.957	.228	67.619	123.444	1.804	118.774	123.591	12.826	77.801	143.808	1.319
13/ 3/85	1.575	.300	8.800	9.600	1.575	.226	69.824	126.450	1.957	127.574	133.191	13.052	79.376	145.764	1.375
14/ 3/85	1.744	.332	.000	.000	1.744	.332	67.750	124.334	2.351	127.574	133.191	13.384	81.120	148.116	1.379
15/ 3/85	2.588	.493	.000	.000	2.588	.491	66.060	121.650	1.933	127.574	133.191	13.875	83.707	150.048	1.384
16/ 3/85	4.972	.947	.100	.000	4.972	.920	63.322	117.862	1.463	127.674	133.191	14.795	88.679	151.511	1.399
17/ 3/85	1.612	.304	.000	.000	1.612	.305	62.886	115.947	1.053	127.674	133.191	15.100	90.292	152.564	1.401
18/ 3/85	3.173	.602	.000	.000	3.173	.590	61.170	113.584	.845	127.674	133.191	15.690	93.464	153.409	1.407
19/ 3/85	2.385	.451	.000	.000	2.385	.445	60.146	111.620	.672	127.674	133.191	16.134	95.849	154.081	1.410
20/ 3/85	2.093	.397	.200	.000	2.093	.391	59.240	109.935	.547	127.874	133.191	16.525	97.942	154.628	1.413
21/ 3/85	2.059	.390	.000	.000	2.059	.384	58.315	108.358	.456	127.874	133.191	16.909	100.002	155.085	1.416
22/ 3/85	2.668	.506	.000	.000	2.668	.490	56.990	106.550	.383	127.874	133.191	17.399	102.669	155.467	1.420
23/ 3/85	2.525	.477	.000	.000	2.525	.461	55.861	104.794	.317	127.874	133.191	17.859	105.195	155.784	1.424
24/ 3/85	.600	.113	.000	.000	.600	.114	56.058	103.941	.266	127.874	133.191	17.973	105.795	156.050	1.424
25/ 3/85	.359	.068	.700	.980	.359	.104	56.708	103.761	.235	128.574	134.171	18.077	106.154	156.286	1.433
26/ 3/85	1.476	.283	3.700	3.680	1.476	.208	57.949	104.323	.221	132.274	137.851	18.285	107.630	156.507	1.484
27/ 3/85	1.447	.279	.000	.000	1.447	.275	56.494	103.785	.222	132.274	137.851	18.560	109.076	156.729	1.486
28/ 3/85	2.168	.414	.000	.000	2.168	.400	55.077	102.559	.218	132.274	137.851	18.960	111.244	156.946	1.489
29/ 3/85	2.065	.392	.000	.000	2.065	.377	54.018	101.237	.197	132.274	137.851	19.338	113.309	157.143	1.491
30/ 3/85	1.966	.372	.000	.000	1.966	.357	53.116	99.937	.173	132.274	137.851	19.695	115.275	157.316	1.494
31/ 3/85	1.196	.226	.000	.000	1.196	.221	52.793	98.965	.150	132.274	137.851	19.915	116.471	157.466	1.495

FIGURE C.3 EXAMPLES OF ACRUWAT OUTPUT FILES: a) FULL OUTPUT

Date

moisture content (mm) for each WATFLO soil layer

1	3 85						
.18939	.18972	.20938	.21089	.21242	.21369	.21459	.21507
2	3 85						
.17980	.18005	.20192	.20511	.20783	.20983	.21115	.21182
3	3 85						
.17708	.17731	.19856	.20159	.20429	.20636	.20775	.20847
4	3 85						
.17443	.17463	.19565	.19864	.20129	.20332	.20470	.20541
5	3 85						
.16971	.16989	.19142	.19496	.19797	.20018	.20167	.20245
6	3 85						
.16917	.16935	.18997	.19298	.19567	.19773	.19913	.19987
7	3 85						
.16655	.16671	.18745	.19060	.19333	.19537	.19676	.19750
8	3 85						
.17525	.17547	.19161	.19161	.19253	.19376	.19483	.19545
9	3 85						
.22656	.22744	.24315	.23727	.22753	.21419	.20152	.19624
10	3 85						
.23755	.23869	.25725	.25446	.24961	.24274	.23465	.22813
11	3 85						
.23209	.23310	.25323	.25298	.25225	.25126	.25031	.24971
12	3 85						
.22929	.23023	.25090	.25147	.25186	.25209	.25221	.25226
13	3 85						
.23707	.23820	.25878	.25881	.25845	.25785	.25726	.25688
14	3 85						
.22946	.23039	.25165	.25256	.25344	.25414	.25463	.25489
15	3 85						
.22351	.22432	.24551	.24673	.24785	.24878	.24944	.24978

FIGURE C.3
EXAMPLES OF ACRUWAT OUTPUT FILES:
b) SOIL MOISTURE OUTPUT

STORE-A	STORE-B	INFILTR.	RECHARGE
53.814,	102.231,	.000,	.244
52.950,	100.525,	.000,	.200
52.163,	99.048,	.000,	.165
50.927,	97.443,	.000,	.138
50.625,	96.300,	.000,	.116
49.907,	95.143,	.000,	.100
51.584,	94.693,	2.400,	.087
65.929,	107.486,	28.878,	.078
69.587,	120.029,	23.460,	.203
68.322,	123.306,	8.480,	1.118
67.619,	123.444,	4.800,	1.804
69.824,	126.450,	9.600,	1.957
67.750,	124.334,	.000,	2.351
66.060,	121.650,	.000,	1.933
63.322,	117.862,	.000,	1.463
62.886,	115.947,	.000,	1.053
61.170,	113.584,	.000,	.845
60.146,	111.620,	.000,	.672
59.240,	109.935,	.000,	.547
58.315,	108.358,	.000,	.456
56.990,	106.550,	.000,	.383
55.861,	104.794,	.000,	.317
56.058,	103.941,	.000,	.266
56.708,	103.761,	.980,	.235
57.949,	104.323,	3.680,	.221
56,494,	103.785,	.000,	

FIGURE C.3 EXAMPLES OF ACRUWAT OUTPUT FILES: c) SUMMARY OUTPUT

A P P E N D I X D

ACRUWAT COMPUTER PROGRAM

APPENDIX D.1

ACRUWAT

MAIN PROGRAM

(file ACRUWAT 3)

```
$STORAGE:2
C.......................................................................
C           VARIABLES USED FOR THE WATFLO SUBROUTINES
C

      REAL AETWAT,LWAT,N,IWAT,KWAT,M,MAXDT,IRATE,IRRBEG,IRRIG,NDEPTH,
     *MINPOT,NPOT,MOISTW,Ks,ERAIN
      INTEGER FDAY,LDAY,MININT,NIRR,BOTBOUND,PDEPTH,R47,NODES,R45,R14,
     1W,R30,R46,R9,R49,R50,R51,R52,R55,MON,DAYY,AHOFRAC,BHOFRAC,ZZ

C
C.......................................................................
C
C


C
      DIMENSION AET(32),AETIR(32),AET1(32),AET2(32),ALAID(32),
     *APAN(12,32),APANA(12,32),APLIRR(32),APPIRR(32),ASOEV(32),
     *ATRAN1(32),ATRAN2(32),ATRANS(32),CAY(12),CAYD(12,32),CAYIRR(12),
     *CFACD(32),CFACTD(32),COIAN(12),CONSTA(32),CORPAN(12),CORPPT(12),
     *COVER(12),D(12),DAMDAT(70,13),DAMET(32),DAMPER(32),DAMSTO(32),
     *DAYS(12),DEF1(32),DEF2(32),DIRRIG(70,13),DL(12),DNO(32),DPE(32),
     *DPEIR(32),E(12),ELAID(12,32),ELAIM(12),ERFL(32),ERFLIR(32),
     *ETINT(32),ETLY(32),ETLYS(32),HAIRR(12),IDAY(32),IRRMON(12),
     *MNPLV(480),MOSTAT(12),OBSQMX(480),OBSTO1(32),                    SJD
     *OBSTO2(32),ODATA(70,13),OVER(5),OVERFL(37),PAN(32),
     *PANRES(32),PARAM(12,32),PDATA(70,13),PK(32),PERC(32),PLINT(32),
     *PLSTRS(32),POSOEV(32),POTRAN(32),POTR1(32),POTR2(32),PP1(32)
      DIMENSION PP2(32),QPEAK(32),QPKOB(32),QPKOBS(32),QRNK(5),
     *QUICKF(32),RAIN(32),REQIR(32),RFL(37),RFLC(5),RFLIR(32),         SJD
     *RFLNET(32),ROOTA(12),ROOTB(12),RQ(5),RUN(32),RUNCO(32),
     *SDATA(70,13),SEDYLD(32),SIMQMY(480),SIMSQ(32),
     *SMD(32),SMDIR(32),SMOBS1(32),SMOBS2(32),STMQOB(32),STQOBS(32),
     *STRFL(32),STOIR(32),STOIRO(32),STORM(32),STORMQ(32),STO1(32),
     *STO2(32),STQIR(32),STRMCO(32),STRMFL(32),SUPPIR(32),SURIR(32),
     *SUR1(32),SUR2(32),SWTRRA(11),T(12),TAET(12),TAETIR(12),TAET1(12)
      DIMENSION TAET2(12),TAPAN(12),TASOEV(12),TDAY(32),TDISCH(32),
     *TDPE(12),TDPEIR(12),TERAIN(12),TET(12),TETLYS(12),TE1(12),TE2(12),
     *TIRRFL(12),TMAX(12),TMAXD(32),TMAXID(32),TMIN(12),TMIND(32),
     *TMINID(32),TMITDD(32),TMLIND(32),TOVERF(12),TPLINT(12),TPOSEV(12),
     *TPOTR1(12),TPOTR2(12),TPTRAN(12),TRAIN(12),TREQIR(12),TRQIR(12),
     *TRUN(12),TQUICK(12),TSEDYD(12),TSTORM(12),TSTQIR(12),TSTREM(12),
     *TSUPIR(12),TSUR(12),TSURIR(12),TTRANS(12),TTRAN1(12),TTRAN2(12),
     *VEGINT(12),WPFCPO(3,11),XDRAFT(12),XXX(12),OVERAC(32),DREQIR(32)
C...........DIMENSIONS COMMENTED OUT - USED FOR STATS PACK.................
C           - removed - lja 26/9/86
C.......................................................................
C           DIMENSIONS USED FOR THE WATFLO SUBROUTINES

      DIMENSION b(20),aWAT(20),G(20),LWAT(20),EWAT(20),H(20),KWAT(20),
     *M(20),P(20),S(20),IRRIG(20),TWAT(20),U(20),V(20),OPOT(20),Z(20),
     *Y(11,2),ROOTF(20),Y1(20,2),Y2(20,2),Y3(20,2),Y4(20,2),ER(20),
     *IRATE(20),DEPTH(20),IRRBEG(20),NPOT(20),MOISTW(20),Ks(20),
     *MON(2),DAYY(2)
C
C.......................................................................
      CHARACTER EQTN(7)*19,HEAD*34,HEMIS(2)*5,ISTID*8,LAGEQ(2)*7       SJD
      CHARACTER QUAD(2)*4                                               SJD
C.......................................................................
C.......................................................................
C           COMMON BLOCK USED FOR THE WATFLO SUBROUTINES
C
$INCLUDE:'WATCOM.FOR'
C
C.......................................................................
```

```
C*       COMMON/ANSUM/SUMRA,SUAPAN,SUMPE,SUMPE1,SUMPE2,SUMERA,SUMAE,
C*      *SUMAE1,SUMAE2,SUMET,SUMPSE,SUMASE,SUPTR1,SUPTR2,SUATR1,SUATR2,
C*      *SUMPTR,SUMATR,SUMIR,SUMSU,SUMRU,SUMQU,SUMINT,SFLOW,SDATA,DIRRIG,
C*      *SUMST,SUMSEO,LMN,TET,TPLINT,SUMPEI,SUMAEI,SUMIRA,SUSUIR,SUQIR,
C*      *SUETLY,ODATA,PDATA
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      COMMON/HDGMTH/HEAD
      COMMON/IRRIGA/AETIR,SMDIR,STQIR,ERFLIR,STOIRO,SURIR,TAETIR,TSTQIR,
     *TIRRFL,TSURIR,TREQIR,DPEIR,TDPEIR,APPIRR,ICYCLE,ISTART           WG30/5
      COMMON/LDVAL/STOIR,PLINT,RUNCO,STRMCO,RFL,E,ERFL,DAMSTO,DAMPER,
     *OVERFL,SUPPIR                                                    WG15/1
      COMMON/MAIZE/PLDATE,LENGTH
      COMMON/PTEMP/TEMP,TMAX,TMIN,EQPET,DL,D,LINWIN,ELEV,ALAT,WNDSPD
      COMMON/PRVDAY/SOIL1,SOIL2,PLINTC,RFLC,RCO,STCO,SOILI,EFPPT,STODAM,
     *PERDAM,OVER,SUPP,DEFCT1                                          SJD
      COMMON/PRINT/DEF1,DEF2,STO1,STO2
      COMMON/PRTMO/TRAIN,TERAIN,TDPE,TAET,TPOSEV,TASOEV,TPOTR1,
     *TPOTR2,TTRAN1,TTRAN2,TPTRAN,TTRANS,TSUR,TRUN,TQUICK,TDISCH,TSTREM,
     *TRQIR
      COMMON/PRNTDY/MOIST,DNO,PP1,PP2,DPE,AET1,AET2,OBSTO1,OBSTO2,RUN,
     *QUICKF,SIMSQ,STRMFL,REQIR,CONSTA,APAN,SUR2,PERC,PRIRR,EVTR,CAYO,  WG4/11
     *POSOEV,ASOEV,POTR1,POTR2,ATRAN1,ATRAN2,ETLYS,QPEAK,SEDYLD,QPKOBS  WG15/8
      COMMON/RESAN/WIDTH,TANB,AREA,HAIRR,DAMCAP,QNORM,SEEP,RESCON,      WG2111
     *RESEXP,ARCAP
      COMMON/RITCHI/SUESW,SUESD,DYSIRA,UPLISO,ALFASO,LAIND              WG15/7
      COMMON/RNKING/IVENT,EVENT,IRANK,NOYRS,ISCS                        SJD
      COMMON/SOIL/PAW1,PAW2,SMWP1,SMWP2,SMFC1,SMFC2,SMWPIR,PAWIR,SMFCIR
      COMMON/TOTALS/TE1,TE2,TAET1,TAET2,TAPAN,TETLYS,TSEDYD
      CONTINUE
C   C     ----------------------------------------------------------------
C
C     DATA STATEMENTS
C
      DATA DAYS/31.,28.,31.,30.,31.,30.,31.,31.,30.,31.,30.,31./
      DATA EQTN/'LINACRE MONTHLY','BLANEY CRIDDLE','THORNTHWAI
     *TE','DAILY A-PAN DATA','MONTHLY A-PAN DATA','LINACRE MONTHLY','LIN
     *ACRE DAILY'/
      DATA LAGEQ/'SCS','SCHMIDT'/
      DATA WPFCPO/.272,.385,.396,  .177,.270,.434,  .033,.091,.417,
     *.055,.125,.401,  .095,.207,.412,  .133,.330,.486,  .148,.255,.330,
     *.197,.318,.390,  .208,.366,.432,  .239,.321,.339,  .250,.387,
     *.423/
      DATA SWTRRA/3.5,4.5,3.3,3.8,4.2,4.2,4.5,5.0,4.0,3.4,3.7/
      DATA HEMIS/'NORTH','SOUTH'/                                       SJD
      DATA QUAD/'EAST','WEST'/                                          SJD
C
C     ----------------------------------------------------------------
C
C     INPUT VARIABLES
C
C      LOCATIONAL INPUT
      READ(5,20)HEAD,AREA,ELEV,ALAT,ALONG,IHEMI,IQUAD
   20 FORMAT(4(/),1X,A34,1X,F5.2,1X,F6.1,2(1X,F5.2),2(5X,I1))           SJD
C
C     OUTPUT OPTIONS
C
      READ(5,30)WRIDY,WRIMO,PRIRR,SUMMRY,WRTYLD,IPLOT,ICOMPR,LOGVAL,    WG 3/2
     *MUSLE,RESYLD,IRRAPL                                               WG 3/2
   30 FORMAT(5(/),3(5X,F1.0),2(6X,F1.0),3(6X,I1),5X,I1,6X,F1.0,6X,I1)  WG 3/2
      READ(5,40)ICOMPV,IUNSAT                                           WG 3/2
   40 FORMAT(5(/),2(6X,I1))                                             WG 3/2
      IF(IRRAPL.EQ.1.AND.RESYLD.EQ.1.)THEN                              WG4/11
        WRITE(6,*)'OPTION ERROR - NO DAM, I.E. IRRIGATION WATER SUPPLIED  .
     * FROM OUTSIDE CATCHMENT'                                           .
        STOP                                                             .
      ENDIF                                                              .
      IF(IRRAPL.EQ.2.AND.RESYLD.EQ.0.)THEN                               .
```

```
        WRITE(6,*)'OPTION ERROR - DAM REQUIRED WHEN IRRAPL = 2'       .
        STOP                                                          .
      ENDIF                                                           .
      IF(IRRAPL.EQ.3.AND.RESYLD.EQ.1.)THEN                            .
        WRITE(6,*)'OPTION ERROR - CANNOT HAVE DAM WHEN IRRAPL = 3'    .
        STOP                                                          .
      ENDIF                                                           WG4/11

C      RAINFALL CONTROL OPTIONS
      READ(5,50)PPTCOR                                                WG4/11
   50 FORMAT(5(/),6X,F1.0)                                            WG4/11
      IF(PPTCOR.NE.0.)THEN                                            WG4/11
        READ(5,55)(CORPPT(I),I=1,12)
   55 FORMAT(5(/),12(1X,F5.2))                                        .
      ELSE                                                            .
        READ(5,80)A                                                   .
      ENDIF                                                           WG4/11
C      EVAP CONTROL OPTIONS
      READ(5,61)PANDAY,PANMON,PANCOR,EQPET,TEMP,LINWIN,WNDSPD,EVTR,
     *LAIND,LYSIM
   61 FORMAT(5(/),5(6X,F1.0),4X,I3,3X,F4.1,6X,F1.0,2(5X,I1))
      IF(EQPET.EQ.7.AND.TEMP.NE.2.)WRITE(6,*)'OPTION ERROR - DAILY LINACRE
     *REQUESTED WITH NO DAILY TEMPERATURES AVAILABLE'
      IF(PANCOR.EQ.1)THEN
        READ(5,70)(CORPAN(I),I=1,12)
   70   FORMAT(5(/),12(1X,F4.2))
      ELSE
        READ(5,80)A
   80   FORMAT(5(/),F1.0)
      ENDIF
C      READ IN 12 VALUES OF MEAN MAX & MIN TEMPS (IF TEMP = 1)
      IF(TEMP.EQ.1)THEN
        READ(5,90)(TMAX(I),I=1,12),(TMIN(I),I=1,12)
   90   FORMAT(5(/),12(1X,F5.1),/12(1X,F5.1))
      ELSE
        READ(5,100)A
  100   FORMAT(6(/),F1.0)
      ENDIF
C     FOR THORNTHWAITE PE OPTION, READ IN DAYLENGTH FACTOR, DL(I) FOR EACH
C     MONTH ACCORDING TO LATITUDE
      READ(5,70)(DL(I),I=1,12)
C     FOR BLANEY CRIDDLE PE OPTION, READ IN DAYLIGHT FRACTION ACCORDING TO
C     LATITUDE
      READ(5,110)(D(I),I=1,12)
  110 FORMAT(5(/),12(1X,F4.3))
C      SOILS OPTIONS & INFORMATION
      READ(5,120)PEDINF,PEDDEP,ITEXT,MOIST,DEPAHO,DEPBHO,FC1,FC2,WP1,
     *WP2,PO1,PO2
  120 FORMAT(5(/),2(6X,F1.0),5X,I2,6X,I1,2(2X,F5.2),6(1X,F4.3))
C      VEGETATION OPTIONS & INFORMATION
      READ(5,130)CONST,CRLEPO
  130 FORMAT(5(/),1X,F5.0,2X,F5.2)
C      READ IN CROP FACTORS FOR ET EQUATIONS
      READ(5,70)(CAY(I),I=1,12)
C     READ MONTHLY LEAF AREA INDICES
      IF(LAIND.EQ.1)THEN
        READ(5,70)(ELAIM(I),I=1,12)
      ELSE
        READ(5,80)A
      ENDIF
C      READ IN 12 VALUES OF PROPORTION OF ROOTS IN 'A' HORIZON
      READ(5,70)(ROOTA(I),I=1,12)
      DO 140 I=1,12
  140 ROOTB(I)=1.0-ROOTA(I)
C      READ IN 12 MONTHLY VALUES OF INTERCEPTION LOSS
      READ(5,70)(VEGINT(I),I=1,12)
C      READ IN RUNOFF CONTROL VARIABLES
```

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      READ(5,150)IOBSQ,IOBSUN,SMODEP,COFRU,QFRESP,ABRESP,BFRESP,PEAK,      SJD
     *IOBSTQ,IOBSPK,IRUN                                                   SJD
  150 FORMAT(5(/),2(6X,I1),1X,F6.2,2X,F4.2,3(2X,F5.2),5X,F1.0,2(6X,I1),   WG18/6
     *4X,I1)                                                               SJD
      READ(5,155)IRANK,CNII                                                SJD
  155 FORMAT(5(/),5X,I1,2X,F3.0)                                           SJD
      IF(MUSLE.EQ.1.AND.PEAK.EQ.0.)WRITE(6,*)'OPTION ERROR - MUSLE = 1 &
     * PEAK = 0'
C     MONTHLY COEFFICIENT OF INITIAL ABSTRACTION
      READ(5,70)(COIAM(I),I=1,12)                                          SJD
C     MONTHS TO BE INCLUDED IN RANKING STATISTICS
      READ(5,210)(MOSTAT(I),I=1,12)                                        SJD
      IF(PEAK.EQ.1.)THEN
C     PEAK DISCHARGE VARIABLES
        READ(5,160)SLOPE,HYLEN,XI30,XMAP,LAG                               WG 3/2
  160   FORMAT(5(/),F5.1,1X,F6.1,1X,F6.2,1X,F7.2,3X,I1)                    WG 3/2
      ELSE
        READ(5,80)A
      ENDIF
      IF(MUSLE.EQ.1)THEN
C     SEDIMENT YIELD VARIABLES
        READ(5,170)SOIFAC,ELFACT,PFACT,ICOVRD
  170   FORMAT(5(/),2(F6.2,1X),F5.2,6X,I1)
C     COVER FACTORS FOR M.U.S.L.E.
        READ(5,70)(COVER(I),I=1,12)
      ELSE
        READ(5,180)A
  180   FORMAT(11(/),F1.0)
      ENDIF
C      IRRIGATION REQUIREMENTS
      READ(5,190)WRIRR,SCHED,EFFIRR,CONSTI,PLADEF,AMTIR,ICYCLE,CONLOS,     WG30/5
     *FAMLOS,IRUNIT,PPTIRR,UPSTIR
  190 FORMAT(5(/),2(5X,F1.0),2(3X,F4.2),2(2X,F5.2),5X,I2,2(3X,F4.2),6X,   WG30/5
     *I1,1X,F6.2,6(/),6X,F1.0)
      IF(WRIRR.EQ.1.)THEN
        READ(5,201)(HAIRR(I),I=1,12)
  201   FORMAT(5(/),12(1X,F4.0))
        READ(5,70)(CAYIRR(I),I=1,12)
C     READ DATA FOR SOILS OF IRRIGATED AREA
        READ(5,205)IRRPED,IRRDEP,IRTEXT,XMXIRR,FCIR,WPIR,POIR              WG7/11
  205   FORMAT(5(/),2(6X,I1),5X,I2,1X,F6.2,3(1X,F4.3))                     WG7/11
      ELSE
        READ(5,206)A                                                       WG7/11
  206   FORMAT(17(/),F1.0)                                                   WG7/11
      ENDIF
      READ(5,210)(IRRMON(I),I=1,12)
  210 FORMAT(5(/),12(4X,I1))
C      CROP YIELD VARIABLES
      READ(5,220)CROP,PLDATE,ISTDAY,ISTMO,LENGTH
  220 FORMAT(5(/),2(6X,F1.0),2(5X,I2),4X,I3)
C     RESERVOIR YIELD ANALYSIS OPTION
      IF(RESYLD.EQ.1.)THEN
        READ(5,230)DAMCAP,ARCAP,SURFAR,PANDAM,WIDTH,QNORM,SEEP,RESCON,
     *  RESEXP
  230   FORMAT(5(/),F10.0,6X,F1.0,3(2X,F5.2),2(1X,F6.1),2(2X,F5.2))
        READ(5,70)(XDRAFT(I),I=1,12)                                       WG23/1
      ELSE
        READ(5,180)A
      ENDIF
C     DEPTH-DURATION-FREQUENCY OPTIONS
      READ(5,235)SERIES,EVO,IVENT,EVENT,ISCS,ISTAT                         SJD
  235 FORMAT(5(/),6X,F1.0,3X,F1.0,5X,I1,1X,F6.1,4X,I1,5X,I1)               SJD
      DO 236 I=1,12                                                        WG23/1
  236 XDRAFT(I)=XDRAFT(I)/DAYS(I)                                          WG23/1
C     CHECK FOR ERRORS IN SELECTION OF FLOW OPTIONS.
      IF((IOBSQ.EQ.0).AND.(ICOMPV.EQ.1))THEN                               WG11/6
      WRITE(6,*)'OPTION ERROR, ICOMPR REQUESTED WITHOUT FLOW DATA'
```

```
      STOP
      ENDIF
C
C     ------------------------------------------------------------------
C
C     PREPARE FOR AND CALL SUBROUTINE WHICH DOES HARMONIC ANALYSIS
C     12 MONTHLY VALUES ARE ENTERED AND THE SUBROUTINE RETURNS 365 DAILY VALUES
C
      DO 240 I=1,12
      XXX(I)=CAY(I)
  240 CONTINUE
      WRITE(*,*)'CALL HARMON'
      CALL HARMON(XXX,PARAM)
      WRITE(*,*)'RETURN FROM HARMON'
      DO 260 I=1,12
      DAYS(2)=29.
      NDYM=IFIX(DAYS(I))
      DO 250 J=1,NDYM
      CAYD(I,J)=PARAM(I,J)
C     LIMITS ARE IMPOSED ON THE CROPPING FACTORS (.2 < CAYD < 1.1)
      IF(CAYD(I,J).LT.0.2)CAYD(I,J)=0.2
      IF(CAYD(I,J).GT.1.1)CAYD(I,J)=1.1
  250 CONTINUE
  260 CONTINUE
C
C     ------------------------------------------------------------------
C
C     CONVERT MONTHLY LEAF AREA INDEX VALUES TO DAILY ONES USING HARMONIC
C     ANALYSIS
C
      IF(LAIND.EQ.1)THEN                                               WG15/7
        DO 261 I=1,12                                                    .
  261   XXX(I)=ELAIM(I)                                                  .
        CALL HARMON(XXX,PARAM)                                           .
        DO 263 I=1,12                                                    .
        DAYS(2)=29.                                                      .
        NDYM=IFIX(DAYS(I))                                               .
        DO 262 J=1,NDYM                                                  .
        ELAID(I,J)=PARAM(I,J)                                            .
  262   CONTINUE
  263   CONTINUE                                                         .
      ENDIF                                                            WG15/7
C
C     ------------------------------------------------------------------
C
C     DEFINE AMOUNT OF STORAGES IN A AND B HORIZONS
C
      IF(PEDINF.EQ.1.)GO TO 310
      IF(PEDDEP-2.)270,280,290
C     TYPICAL VALUES FOR INADEQUATE SOILS DATA
  270 DEPAHO=0.3
      DEPBHO=0.8
      GO TO 300
  280 DEPAHO=0.2
      DEPBHO=0.2
      GO TO 300
  290 DEPAHO=0.3
      DEPBHO=0.5
  300 WP1=WPFCPO(1,ITEXT)
      WP2=WP1
      FC1=WPFCPO(2,ITEXT)
      FC2=FC1
      PO1=WPFCPO(3,ITEXT)
      PO2=PO1
C     CALCULATIONS OF SOIL MOISTURE RETENTION CONSTANTS
  310 SMWP1=WP1*DEPAHO*1000.
      SMWP2=WP2*DEPBHO*1000.
```

```
      SMFC1=FC1*DEPAHO*1000.
      SMFC2=FC2*DEPBHO*1000.
      SMPO1=0.0                                                         WG17/1
      XXXXX=PO1*DEPAHO*1000.
      SMPO2=PO2*DEPBHO*1000.
      PAW1=SMFC1-SMWP1
      PAW2=SMFC2-SMWP2
      TPAW=PAW1+PAW2
      SMPAW=SMFC1+SMFC2
      SMWPT=SMWP1+SMWP2
      SMPOT=XXXXX+SMPO2
      ALFASO=SWTRRA(ITEXT)
      UPLISO=9.*((ALFASO-3.)**0.42)
      IF(SMDDEP.EQ.0.)SMDDEP=DEPAHO                                     WG18/6
C
C
C     DEFINE SOIL STORAGES FOR IRRIGATED SOILS
C
      IF(WRIRR.EQ.1.)THEN                                               WG21/1
        IF(IRRPED.EQ.1)GO TO 315                                        WG7/11
        IF(XMXIRR.EQ.0.)THEN                                              .
          IF(IRRDEP-2.)311,312,313                                        .
  311     XMXIRR=1.1                                                      .
          GO TO 314                                                       .
  312     XMXIRR=0.4                                                      .
          GO TO 314                                                       .
  313     XMXIRR=0.8                                                      .
        ENDIF                                                             .
  314   WPIR=WPFCPO(1,IRTEXT)                                             .
        FCIR=WPFCPO(2,IRTEXT)                                             .
        POIR=WPFCPO(3,IRTEXT)                                             .
  315   SMWPIR=WPIR*XMXIRR*1000.                                          .
        SMFCIR=FCIR*XMXIRR*1000.                                          .
        SMPOIR=POIR*XMXIRR*1000.                                          .
        PAWIR=SMFCIR-SMWPIR                                             WG7/11
      ENDIF
C

C     ------------------------------------------------------------------
C
C     INITIALIZATIONS
C
C     CHECK FOR MONTH IN WHICH DATA STARTS
      MOSTRT=0                                                          WG18/7
C
C     CROP YIELD MODELS
      IYEAR=0
      LMN=0
      LM=0
C
C     COUNTERS FOR OBJECTIVE FUNCTION PACKAGE
      NDYTAL = 0
      MNTALY = 0
      NOYRS=0                                                           SJD
      NTAL=0                                                            SJD
C
C     STORAGES OF SOIL MOISTURE AND INTERCEPTION
      IF(ALAT.GE.40.)THEN                                               SJD
        SOILI=SMPAW                                                       .
        SOIL1=SMFC1                                                       .
        SOIL2=SMFC2                                                       .
      ELSE                                                              SJD
        SOILI=PAWIR*0.5+SMWPIR                                          WG2911
        SOIL1=PAW1*0.5+SMWP1
        SOIL2=PAW2*0.5+SMWP2
      ENDIF
      DEFCT1=SMFC1-SOIL1                                                SJD
```

```
      PLINTC=0.0
      DO 316 I=1,5                                                      WG15/1
      OVER(I)=0.0                                                       WG15/1
  316 RFLC(I)=0.0                                                       SJD
      EFPPT=0.0
      DYSIRA=0.0
      SUESW=0.0
      SUESD=0.0
      RCO=0.0
      STCO=0.0
C
C     PE FOR DECEMBER OF PREVIOUS YEAR
      ETDE=150.
C
C     -----------------------------------------------------------------
C
C     ESTIMATE CATCHMENT LAG (BY SCS METHOD IF LAG = 1, BY SCHMIDT
C                             EQUATION IF LAG = 2)
      IF(PEAK.EQ.1.AND.HYLEN.EQ.0.)HYLEN=173B.*AREA**0.6
      IF(PEAK.EQ.1.AND.LAG.EQ.1)CLAG=(HYLEN**0.8*((25400./CNII-254.)+
     *25.4)**0.7)/(7069.*SLOPE**0.5)
      IF(PEAK.EQ.1.AND.LAG.EQ.2)CLAG=(XMAP**1.1*AREA**0.35)/(41.67*SLOPE
     ***0.3*XI30**.87)
C
      IF(MUSLE.EQ.1)THEN
C     ESTIMATE 'LS' FACTOR FOR M.U.S.L.E.
        IF(ELFACT.EQ.0.)THEN
          IF(SLOPE.GT.25.)ELFACT=25.
          IF(SLOPE.LE.25.)ELFACT=-3.0*SLOPE+100.
        ENDIF
        IF(SLOPE.GT.3.)MFACT=0.5                                        WG 6/9
        IF(SLOPE.LE.3.)MFACT=0.3                                        WG 6/9
        ELES=(ELFACT/22.1)**MFACT*(0.065+(0.0454*SLOPE)+(0.0065*SLOPE*  WG 6/9
     *  SLOPE))                                                         WG 6/9
      ENDIF
C
C     -----------------------------------------------------------------
C
C     CALCULATE STORAGES AND CONSTANTS FOR USE IN RESERVOIR YIELD ANALYSIS
      IF(RESYLD.EQ.1.)THEN
C     CALCULATE DAM STORAGES
        PERDAM=50.
        STODAM=0.5*DAMCAP
C     CALCULATE DAM DIMENSIONS I.E. LENGTH OF THROWBACK AND MAXIMUM HEIGHT OF
C     WALL
        IF(ARCAP.EQ.0.)THEN
          ALEN=(2.0E4*SURFAR)/WIDTH
          DEPTHI=(4.0E4*DAMCAP)/(WIDTH*ALEN)
C     CALCULATE TRIG. CONSTANTS FOR DEPTH AND LENGTH RELATIONSHIPS
          TANA=(2.*DEPTHI)/WIDTH
          TANB=(2.*ALEN)/WIDTH
        ENDIF
      ENDIF
      IF(IRRAPL.EQ.1)THEN
        XB=FAMLOS*100.
        XC=CONLOS*100.
        XD=EFFIRR*100.
      ENDIF
C
C     -----------------------------------------------------------------
C
C     WRITE GENERAL HEADING
C
      WRITE(6,320) HEAD
  320 FORMAT(1H1,39X,A34,/40X,40('-')/)
      IEQPET = EQPET
      WRITE(6,330)AREA,ALAT,HEMIS(IHEMI),ALONG,QUAD(IQUAD),ELEV,        SJD
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```
     *EQIN(IEQPET)
  330 FORMAT(5X,'AREA OF CATCHMENT  (KM SQ)',11X,'=',F7.2,/5X,'LATITUDE'
     *,29X,'=',F7.2,A5,/5X,'LONGITUDE',28X,'=',F7.2,A5,/5X,'ELEVATION (M
     *)',24X,'=',F7.2,/5X,'POTENTIAL EVAPORATION BY ',A19)
      IF(PEAK.EQ.1.)WRITE(6,340)LAGEQ(LAG)
  340 FORMAT(5X,'LAG EQUATION BY ',A7)
      WRITE(6,350)COFRU,QFRESP,BFRESP,ABRESP,SMDDEP,DEPAHO,DEPBHO,WP1,  WG 3/2
     *SMWP1,WP2,SMWP2,FC1,SMFC1,FC2,SMFC2,PO1,PO2
  350 FORMAT(5X,'COEFFICIENT OF DRAINAGE RELEASE',6X,'=',F7.2,/5X,'COEFF
     *ICIENT OF QUICKFLOW RESPONSE',4X,'=',F7.2,/5X,'COEFFICIENT OF BASE
     *FLOW RESPONSE',5X,'=',F7.2,/5X,'COEFFICIENT OF "A TO B" RESPONSE',
     *5X,'=',F7.2,/5X,'EFFECTIVE DEPTH FOR RUNOFF RESPONSE  =',F7.2,/5X,WG18/6
     *'DEPTH OF SOIL IN A-HORIZON (M)',7X,'=',F7.2,/5X,'DEPTH OF SOIL IN
     * B-HORIZON (M)',7X,'=',F7.2,/5X,'WILTING POINT OF A-HORIZON (M/M)'
     *,5X,'=',F8.3,2X,'(=',F6.1,'MM)',/5X,'WILTING POINT OF B-HORIZON (M
     */M)',5X,'=',F8.3,2X,'(=',F6.1,'MM)',/5X,'FIELD CAPACITY OF A-HORIZ
     *ON (M/M)',4X,'=',F8.3,2X,'(=',F6.1,'MM)',/5X,'FIELD CAPACITY OF B-
     *HORIZON (M/M)',4X,'=',F8.3,2X,'(=',F6.1,'MM)',/5X,'POROSITY OF SOI
     *L IN A-HORIZON (M/M)',2X,'=',F8.3,/5X,'POROSITY OF SOIL IN B-HORIZ
     *ON (M/M)',2X,'=',F8.3)
      IF(WRTYLD.EQ.1.)WRITE(6,355)LENGTH                               WG 1/8
  355 FORMAT(5X,'LENGTH OF GROWING SEASON',13X,'=',I5)                 WG 1/8
      IF(RESYLD.EQ.1.)WRITE(6,360)DAMCAP,SURFAR
  360 FORMAT(5X,'DAM CAPACITY (M**3)',18X,'=',F10.0,/,5X,'SURFACE AREA (
     *HA)',20X,'=',F9.3)
      IF(PEAK.EQ.1.OR.ISCS.EQ.1)WRITE(6,375)CNII                       WG 3/2
  375 FORMAT(5X,'CURVE NUMBER II',22X,'=',F4.0)                        WG 3/2
      WRITE(6,380)
  380 FORMAT(//,30X,'JAN',3X,'FEB',3X,'MAR',3X,'APR',3X,'MAY',3X,
     *'JUN',3X,'JUL',3X,'AUG',3X,'SEP',3X,'OCT',3X,'NOV',3X,'DEC')
      WRITE(6,385)(COIAM(I),I=1,12)                                    SJD
  385 FORMAT(/1X,'COEFF OF INITL ABSTRACTION',12(2X,F4.2))             SJD
      WRITE(6,390) (CAY(I),I=1,12)
  390 FORMAT(1X,'CROPPING FACTOR',11X,12(2X,F4.2))
      IF(WRIRR.EQ.1.)THEN
        WRITE(6,400)(HAIRR(I),I=1,12)
  400   FORMAT(1X,'AREA IRRIGATED (HA) ',6X,12(1X,F5.0))
        WRITE(6,410)(CAYIRR(I),I=1,12)
  410   FORMAT(1X,'IRRIGATION CROPPING FACTOR',12(2X,F4.2))
      ENDIF
      WRITE(6,420) (ROOTA(I),I=1,12)
  420 FORMAT(1X,'PROP OF ROOTS IN A HORIZON',12(2X,F4.2))
      WRITE(6,430)(VEGINT(I),I=1,12)
  430 FORMAT(1X,'INTERCEPTION LOSS (MM)',4X,12(1X,F5.2))
      IF(PANCOR.EQ.1.)WRITE(6,440)(CORPAN(I),I=1,12)
  440 FORMAT(1X,'PAN CORRECTION FACTOR',5X,12F6.2)
      IF(TEMP.EQ.1.)THEN
        WRITE(6,450)(TMAX(I),I=1,12)
  450   FORMAT(1X,'TEMP: MEAN MAXIMUM (C)',4X,12(2X,F4.1))
        WRITE(6,460)(TMIN(I),I=1,12)
  460   FORMAT(1X,6X,'MEAN MINIMUM (C)',4X,12(2X,F4.1))
      ENDIF
C
C     ----------------------------------------------------------------------
C
C     PE ROUTINE USING TEMPERATURE-BASED EQUATIONS
C
      IF(EQPET.LE.3.0.OR.EQPET.GE.6.0)CALL PETEMP(T,E)
C
C     USE HARMONIC ANALYSIS TO CONVERT THESE DERIVED MONTHLY PE VALUES INTO
C     DAILY ONES
C
      IF(EQPET.LE.3.OR.EQPET.EQ.6.)THEN
        DO 470 I=1,12
  470   XXX(I)=E(I)/IFIX(DAYS(I))
        CALL HARMON(XXX,PARAM)
        DO 490 I=1,12
```

```
      DAYS(2)=29.
      NDYM=IFIX(DAYS(I))
      DO 480 J=1,NDYM
  480 APANA(I,J+1)=PARAM(I,J)                                          WG4/11
  490 CONTINUE
     ENDIF
C     ---------------------------------------------------------------
C            CALL INPUT DATA FOR RICHARD'S EQUATION (WATFLO MODEL)
C     ---------------------------------------------------------------
     IF (IUNSAT.EQ.2)CALL WATFL2(DEPAHO,DEPBHO)
C
C            NOTE: initial soil moisture is set in WATFLO input.
C

C
C     -----------------------------------------------------------------
C
C     INITIALIZE ANNUAL TOTALS TO ZERO
C
  200 CALL INITAN(SUMRA,SUMERA,SUMIRA,SUAPAN,SUMPE,SUMPEI,SUMPE1,SUMPE2,
     *SUMAE,SUMAEI,SUMAE1,SUMAE2,SUMET,SUMPSE,SUMASE,SUPTR1,SUPTR2,
     *SUATR1,SUATR2,SUMPTR,SUMATR,SUMINT,SUMSU,SUSUIR,SUMIR,SUMRU,SUMQU,WG15/1
     *SUQIR,SFLOW,SUMST,STAET,STPET,STCAN,TOTAET,TOTPET,TOTCAN,SUMSED,
     *SUETLY,SUMSQ,QRNK,AMC,RQ)                                        SJD
      LMN=LMN+1
      IYEAR=IYEAR+1
C
C     -----------------------------------------------------------------
C
C     CHECK WHETHER MONTHLY A-PAN VALUES TO BE READ IN. THESE ARE READ IN FOR
C     12 MONTHS OF THE YEAR IN JANUARY
      IF(EQPET.EQ.5.AND.I.EQ.1)READ(5,500)KYR,(E(I),I=1,12)            WG4/11
  500 FORMAT(I2,1X,12F4.1)
C
C ***********************************************************************
C
C     START OF MAIN DO LOOP - AT MONTHLY LEVEL WITH DAILY CALCS WITHIN EACH
C     LOOP
C
      DO 2 I=1,12
C
C     -----------------------------------------------------------------
C
C     INITIALIZE DAILY ARRAYS
C
      IF(MOSTRT.EQ.1)GO TO 505                                         WG22/7
      CALL INITDY(SMD,STORMQ,ERFL,ERFLIR,PLINT,STQIR,RAIN,RFL,STRFL,
     *STRMFL,TMIND,TMAXD,APAN,PAN,PANRES,DPE,SMOBS1,SMOBS2,OBSTO1,
     *OBSTO2,ETLYS,ETLY,QPEAK,SEDYLD,IDAY,I,ETINT,APLIRR,APPIRR,DPEIR,
     *DAMET,STOIRO,SMDIR,REQIR,SURIR,STMQOB,STQOBS,QPKOB,QPKOBS,CFACD,
     *CFACTD,TDAY,TMLIND,TMITDD,EQPET,ELAID,LAIND,TMAXID,THINID,SUPPIR, WG2111
     *QUICKF)                                                          WG 4/2
C
C     *****************************************************************
C
C     READ IN DAILY DATA ONE MONTH AT A TIME (FROM FILE 21)
C
C     *****************************************************************
C
  505 E(I)=0.0                                                         WG22/7
      DO 520 L=1,31
      IF(MOSTRT.EQ.1)GO TO 515                                         WG18/7
      READ(21,510,END=99)ISTID,IYR,MO,IDAY(L),RAIN(L),TMAXID(L),       WG15/1
     *TMINID(L),PAN(L),STRFL(L),SMOBS1(L),SMOBS2(L),ETLY(L),APLIRR(L), WG15/1
     *STMQOB(L),QPKOB(L),CFACD(L),ALAID(L)                             WG15/7
  510 FORMAT(A8,3I2,4(F5.1,1X),F7.3,1X,4(F5.1,1X),F7.3,F5.2,1X,F5.3,1X,
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```
     *F4.2)                                                          WG15/7
C     CHECK WHETHER DATA STARTS IN MONTH 1 OR NOT. IF NOT SKIP THROUGH LOOPS
C     UNTIL I = MO
  515 IF(MO.NE.I)THEN                                                WG18/7
        MOSTRT=1                                                     WG18/7
        GO TO 2                                                      WG18/7
      ELSE                                                           WG18/7
        MOSTRT=0                                                     WG18/7
      ENDIF
      K=IDAY(L)+1
      RFL(K+5)=RAIN(L)
      STRMFL(K)=STRFL(L)
      IF(EOPET.EQ.4.)APAN(I,K)=PAN(L)
      IF(EOPET.LE.3.OR.EOPET.EQ.6.)THEN                              WG4/11
        IF(RFL(K+5).GE.5.)APAN(I,K)=APANA(I,K)*0.8                    WG4/11
        IF(RFL(K+5).LT.5.)APAN(I,K)=APANA(I,K)                        WG21/1
        IF(RFL(K+5).EQ.0.)APAN(I,K)=APANA(I,K)*1.05                   WG4/11
      ENDIF                                                          WG27/6
      E(I)=E(I)+APAN(I,K)
      IF(TEMP.EQ.2.)THEN                                             WG16/7
        TMAXD(K)=TMAXID(L)                                           WG16/7
        TMIND(K)=TMINID(L)                                           WG16/7
      ENDIF
      OBSTO1(K)=SMOBS1(L)
      OBSTO2(K)=SMOBS2(L)
      ETLYS(K)=ETLY(L)
      STQOBS(K)=STMQOB(L)
      QPKOBS(K)=QPKOB(L)
      CFACTO(K)=CFACD(L)
      IF(LAIND.EQ.2)ELAID(I,K)=ALAID(L)                              WG15/7
      APPIRR(K)=APLIRR(L)
C     CONVERT UNITS OF IRRIGATION APPLICATION IF NECESSARY
      IF(IRUNIT.EQ.1.AND.IRRAPL.EQ.1)APPIRR(K)=APPIRR(K)*8640/HAIRR(I)
      DAYS(2)=28.
      IF(MOD(IYR,4).EQ.0)DAYS(2)=29.
      IF(IFIX(DAYS(MO)).EQ.IDAY(L))GO TO 530
  520 CONTINUE
  530 NDYM=IFIX(DAYS(MO))
C
C     ---------------------------------------------------------------------
C
C     DAILY LINACRE CALCULATIONS (USED WHEN DAILY TEMPS AVAILABLE)
C
      IF(EOPET.EQ.7.)THEN
        DO 540 K=2,(NDYM+1)
        TDAY(K)=(TMAXD(K)+TMIND(K))/2.
        TMLIND(K)=TDAY(K)+0.006*ELEV
        TMITDD(K)=0.0023*ELEV+0.37*TDAY(K)+0.53*(TMAXD(K)-TMIND(K))+0.35
     *  *(T(1)-T(7))-10.9
        IF(TMITDD(K).LT.4.)TMITDD(K)=4.
        APAN(I,K)=(650.*TMLIND(K)/(85.-ALAT)-56.+(5.+4.*WNDSPD)*
     *  TMITDD(K))/(80.-TDAY(K))
C     CONVERT THESE VALUES FROM LAKE TO PAN EVAPORATION WITH FACTOR OF 1.00
        APAN(I,K)=APAN(I,K)*1.00
        IF(RFL(K+5).EQ.0.)APAN(I,K)=APAN(I,K)*1.05                   WG4/11
        IF(RFL(K+5).GE.5.)APAN(I,K)=APAN(I,K)*0.8                    WG28/6
  540   CONTINUE
      ENDIF
C
C     ---------------------------------------------------------------------
C
C     SET STORAGES FROM PREVIOUS DAYS' READINGS
C
      CALL PREVDY(STO1,STO2,PLINT,RFL,ERFL,DEF1,DEF2,RUNCO,STRMCO,STOIR,
     *DAMSTO,DAMPER,OVERFL,SUPPIR,IRRAPL)                            WG15/1
C
C     ---------------------------------------------------------------------
```

```
C
C     INITIALIZE MONTHLY TOTALS
C
      CALL INITMO(TSUR,TE1,TE2,TDPE,TAET,TAET1,TAET2,TET,TRQIR,TRUN,
     *TERAIN,TRAIN,TSTORM,TQUICK,TDISCH,TSTREM,TPLINT,TAETIR,TSTQIR,
     *TIRRFL,TSURIR,TREQIR,TAPAN,TPOSEV,TASOEV,TPOTR1,TPOTR2,TTRAN1,
     *TTRAN2,TPTRAN,TTRANS,TETLYS,TSEDYD,TDPEIR,TOVERF,I,IEMPTY,ICONSC, WG15/1
     *TSUPIR)                                                          WG2811
C     -----------------------------------------------------------------
C
C
C     CALCULATION OF DAILY WATER BALANCE; NDYM=NO DAYS IN MONTH
C
      DO 60 K=2,(NDYM+1)
C
C
C
C     CHECK WHETHER DAILY PE AND RAINFALL HAVE TO BE CORRECTED FOR A
C     SYSTEMATIC ERROR
C
      IF(PANCOR.EQ.1)APAN(I,K)=APAN(I,K)*CORPAN(I)
      IF(PPTCOR.EQ.1.)RFL(K+5)=RFL(K+5)*CORPPT(I)                        WG4/11
      IF(PPTCOR.EQ.2.)RFL(K+5)=RFL(K+5)+CORPPT(I)                        WG4/11
      IF(WRIRR.EQ.1.AND.PPTIRR.NE.0.)RFLIR(K)=RFL(K+5)*PPTIRR
      IF(WRIRR.EQ.1.AND.PPTIRR.EQ.0.)RFLIR(K)=RFL(K+5)
C     CONVERT PAN EVAPORATION TO CROP POTENTIAL EVAPOTRANSPIRATION
C
C     .................................................................
C                 Write a-pan eveporation to file 14 for comparison
C     write(14,999)i,k-1,apan(i,k)
C999  format(2x,2i6,f10.2)
C     .................................................................
      DPE(K)=APAN(I,K)*CAYD(I,K-1)
      DPEIR(K)=APAN(I,K)*CAYIRR(I)
      DAMET(K)=APAN(I,K)*PANDAM
C     CALCULATION OF CONST, THE FRACTION OF P.A.M. AT WHICH STRESS SETS IN.
C     IF CRITICAL LEAF WATER POTENTIAL IS NOT USED, A FIXED VALUE OF 'CONST' IS
C     USED. IF IT IS NOT USED IN THE CALCULATION, 'CONST' IS A VARIABLE FOR THE
C     DAY AND IT IS CALCULATED HERE
C
      IF(CRLEPO.NE.0.)CONST=0.94+0.26*CRLEPO/(APAN(I,K))
      IF(CONST.LT.0.1)CONST=0.1
C     APPORTION POTENTIAL EVAPOTRANSPIRATION TO A AND B HORIZONS.
C     BEFORE THIS IS DONE, THE INTERCEPTED WATER OF THE PREVIOUS DAY FIRST HAS
C     TO BE EVAPORATED AT POTENTIAL RATE FROM THE INTERCEPTION STORAGE I.E.
C     AT 0.5 INTERCEPTION LOSS
C
      IF(RFL(K-1+5).GT.0.)THEN
        IF(APAN(I,K).GE.0.5*PLINT(K-1))THEN
          ETINT(K)=0.5*PLINT(K-1)
          DPE(K)=(APAN(I,K)-ETINT(K))*CAYD(I,K-1)
          PANRES(K)=APAN(I,K)-ETINT(K)
          PLINT(K)=0.0
        ELSE
          ETINT(K)=APAN(I,K)
          DPE(K)=0.001
          PANRES(K)=0.001
          PLINT(K)=0.5*PLINT(K-1)-APAN(I,K)
        ENDIF
      ELSE
        PANRES(K)=APAN(I,K)                                            WG 6/8
      ENDIF
      PP1(K)=DPE(K)*ROOTA(I)
      PP2(K)=DPE(K)*ROOTB(I)
C
C     -----------------------------------------------------------------
C
```

```
C      CALCULATE ACTUAL EVAPOTRANSPIRATION (AET)
C
C      CHECK WHETHER EVAPORATION AND TRANSPIRATION TO BE ESTIMATED SEPARATELY
C      (EVTR = 2) OR TOGETHER (EVTR = 1)
C
       IF(EVTR.EQ.1.)THEN
C
C      AET CAN EQUAL PE, BUT IS LESS IF AVAILABLE SOIL MOISTURE < FRACTION, I.E.
C      IF STRESS HAS SET IN
C
C      CALCULATION OF AET FOR A HORIZON
C
       IF(STO1(K-1).GE.(PAW1*CONST+SMWP1))THEN
C      NO STRESS SITUATION, THEREFORE AE=PE FOR DAY
         AET1(K)=PP1(K)
       ELSE
C      STRESS SITUATION, THEREFORE AE < PE
         AET1(K)=PP1(K)*(STO1(K-1)-SMWP1)/(PAW1*CONST)
       ENDIF
C
C      CALCULATION OF AET FOR B HORIZON
C
       IF(STO2(K-1).GE.(PAW2*CONST+SMWP2))THEN
         AET2(K)=PP2(K)
C      B-HORIZON IS NOT UNDER STRESS BUT IF A-HORIZON IS, B-HORIZON WILL
C      CONTRIBUTE MORE THAN EXPECTED FROM ITS PROPORTION OF ROOTS IF THE
C      VEGETATION IS ACTIVELY GROWING (I.E. IF ROOTB > 0.1)
         IF(ROOTB(I).GT.0.1.AND.PP1(K).GT.AET1(K))AET2(K)=AET2(K)+0.5*   WG12/7
     *  (PP1(K)-AET1(K))                                                 WG12/7
       ELSE
         AET2(K)=PP2(K)*(STO2(K-1)-SMWP2)/(PAW2*CONST)
C      B-HORIZON IS UNDER STRESS AND IF A-HORIZON IS NOT, A-HORIZON WILL
C      CONTRIBUTE MORE THAN EXPECTED FROM ITS PROPORTION OF ROOTS:
         IF(PP1(K).EQ.AET1(K))AET1(K)=AET1(K)+0.5*(PP2(K)-AET2(K))       WG18/6
       ENDIF
       AET(K)=AET1(K)+AET2(K)+ETINT(K)
C      SET NEW STORAGES
       STO1(K)=STO1(K-1)-AET1(K)
       STO2(K)=STO2(K-1)-AET2(K)
C
C      CHECK FOR OVERALL STRESS
       IF(AET(K).GE.(0.5*DPE(K)))THEN
         PLSTRS(K)=0.0
       ELSE
         PLSTRS(K)=1.0
       ENDIF
       ENDIF
C
C      CALCULATE TRANSPIRATION AND SOIL EVAPORATION SEPARATELY BY THE RITCHIE
C      (1972) APPROACH
C
       IF(EVTR.EQ.2.)CALL RICHIE(CAYD,POSOEV,PANRES,ERFL,ASOEV,STO1,
     *POTRAN,POTR1,POTR2,ROOTA,ROOTB,CONST,ATRAN1,ATRAN2,AET1,AET2,AET,
     *STO2,ETINT,ATRANS,PLSTRS,ELAID)                                    WG15/7
C
C      ------------------------------------------------------------------
C
C      CALCULATE SOIL STORAGE. START WITH TOP SOIL LAYER.
C
C      FOR DRYLAND CONDITIONS, FIRST ABSTRACT STORMFLOW BY SCS-SMB MODEL IF
C      RAINFALL IS GREATER THAN OR EQUAL TO 1 MM FOR THE DAY.
C      THIS ABSTRACTION INCLUDES INTERCEPTION.
C*       IF(LYSIM.EQ.1)GO TO 555                                         WG15/7
       IF(RFL(K-5).GT.1.)THEN
C      DETERMINE THE DEPTH OF HORIZON TO BE USED IN CALCULATING DEFICITS
         IF(SMDDEP.LE.DEPAHO)THEN                                        ES24/6
           SMD(K)=(XXXXX-STO1(K))*(SMDDEP/DEPAHO)                        ES24/6
```

```
        ELSE
          SMD(K)=(XXXXX-STO1(K))+(SMPO2-STO2(K))*((SMDDEP-DEPAHO)/      ES24/6
     *    DEPBHD)                                                       ES24/6
        ENDIF
        IF(SMD(K).LT.0.)SMD(K)=0.01
        RFLNET(K)=RFL(K+5)-(VEGINT(I)-PLINT(K))
        IF(RFLNET(K).LE.COIAM(I)*SMD(K))GO TO 550
C     CALCULATE STORMFLOW
        STORMQ(K)=(RFLNET(K)-COIAM(I)*SMD(K))**2/(RFLNET(K)-COIAM(I)
     *  *SMD(K)+SMD(K))
C     CALCULATE PEAK DISCHARGE
        IF(PEAK.EQ.1.)QPEAK(K)=0.2083*STORMQ(K)*AREA/(1.83*CLAG)
C     CALCULATE SEDIMENT YIELD BY WILLIAMS & BERNDT M.U.S.L.E.
        IF(MUSLE.EQ.1)THEN
          IF(IOBSTQ.EQ.0)STORM(K)=STORMQ(K)
          IF(IOBSTQ.EQ.1)STORM(K)=STQOBS(K)
          IF(IOBSPK.EQ.0)PK(K)=QPEAK(K)
          IF(IOBSPK.EQ.1)PK(K)=QPKOBS(K)
          IF(ICOVRD.EQ.0)SEDYLD(K)=11.8*(STORM(K)*AREA*1000.*PK(K))**
     *    0.56*ELES*COVER(I)*SOIFAC*PFACT
          IF(ICOVRD.EQ.1)SEDYLD(K)=11.8*(STORM(K)*AREA*1000.*PK(K))**
     *    0.56*ELES*CFACTD(K)*SOIFAC*PFACT
        ENDIF
        ERFL(K)=RFLNET(K)-STORMQ(K)
        QUICKF(K)=QFRESP*(STORMQ(K)+STRMCO(K-1))
        STRMCO(K)=(1.-QFRESP)*(STORMQ(K)+STRMCO(K-1))
        PLINT(K)=VEGINT(I)
      ENDIF
C
  550 IF(RFL(K+5).LE.1.OR.RFLNET(K).LE.COIAM(I)*SMD(K))THEN
C
C     ABSTRACT "INTERFLOW" FROM PREVIOUS DAY
        QUICKF(K)=STRMCO(K-1)*QFRESP
        STRMCO(K)=STRMCO(K-1)-QUICKF(K)
 555    IF(RFL(K+5).GT.0.AND.RFL(K+5).GE.VEGINT(I))THEN
C     ABSTRACT INTERCEPTED RAINFALL TO OBTAIN DAILY EFFECTIVE RAINFALL AND
C     INTERCEPTION LOSS
          ERFL(K)=RFL(K+5)-VEGINT(I)
          PLINT(K)=VEGINT(I)
        ELSE
          PLINT(K)=RFL(K+5)
        ENDIF
      ENDIF
C
C     CONTINUE WITH SOIL STORAGE CALCULATIONS
      STO1(K)=STO1(K)+ERFL(K)
C
C     CHECK STATE OF SOIL STORAGES
      IF(STO1(K).LE.SMWP1)THEN
C     STORAGE IS NOW BELOW WILTING POINT
C     IF STORAGE IS BELOW WILTING POINT, IT IS SET TO SOIL MOISTURE STORAGE AT
C     WILTING POINT
        SUR1(K)=0.0
        DEF1(K)=PAW1
        STO1(K)=SMWP1
      ELSE
C     IF STORAGE IS NOW POSITIVE, CONTINUE CALCULATION OF SOIL MOISTURE
        IF(STO1(K).GT.SMFC1)THEN
C     STORAGE IS NOW IN EXCESS OF PLANT AVAILABLE MOISTURE
          SUR1(K)=STO1(K)-SMFC1
C     A FRACTION OF THIS SURPLUS WATER NOW REMAINS IN STORAGE, THE REMAINDER
C     DRAINS TO THE NEXT HORIZON
          DEF1(K)=SMFC1-STO1(K)                                         WG18/6
          STO1(K)=SMFC1+(1.-ABRESP)*SUR1(K)
          SUR1(K)=ABRESP*SUR1(K)
        ELSE
C     STORAGE IS NOW BETWEEN CAPACITY AND WILTING POINT
```

```
          SUR1(K)=0.0
          DEF1(K)=SMFC1-STO1(K)
        ENDIF
      ENDIF
C
C     CALCULATE SOIL MOISTURE BALANCE FOR LOWER SOIL LAYER
C
      STO2(K)=STO2(K)+SUR1(K)
      IF(STO2(K).LE.SMWP2)THEN
        SUR2(K)=0.0
        DEF2(K)=PAW2
        STO2(K)=SMWP2
        RUN(K)=RUNCO(K-1)*COFRU
        RUNCO(K)=RUNCO(K-1)-RUN(K)
      ELSE
C     CHECK WHETHER STORAGE IN LAYER 2 EXCEEDS PAW OF LAYER 2. IF SO,
C     SATURATED DEEP PERCOLATION OCCURS
        IF(STO2(K).GT.SMFC2)THEN
          SUR2(K)=STO2(K)-SMFC2*BFRESP                            WG19/6
C     AGAIN A FRACTION OF SURPLUS WATER PERCOLATES OUT AND A FRACTION REMAINS
          STO2(K)=STO2(K)-SUR2(K)                                 WG 1/4
          DEF2(K)=SMFC2-STO2(K)                                   WG 1/4
          RUNCO(K)=RUNCO(K-1)+SUR2(K)                             WG 1/4
          RUN(K)=RUNCO(K)*COFRU
          RUNCO(K)=RUNCO(K)-RUN(K)
          PERC(K)=0.0                                             WG 1/4
        ELSE
C     STORAGE IN LAYER 2 NOW BETWEEN CAPACITY AND ZERO
          SUR2(K)=0.0
          RUN(K)=RUNCO(K-1)*COFRU
          RUNCO(K)=RUNCO(K-1)-RUN(K)
          DEF2(K)=SMFC2-STO2(K)
        ENDIF
      ENDIF
C
C     ----------------------------------------------------------------
C
C     UNSATURATED SOIL MOISTURE REDISTRIBUTION
C
      IF(IUNSAT.EQ.1)CALL UNSAT(PERC,RUNCO)                       WG4/11

      IF(IUNSAT.EQ.2) THEN
                    AETWAT=AET1(K)+AET2(K)
                    ERAIN =ERFL(K)
                    SEVAP =DPE(K)
        CALL WATFL3(AETWAT,SEVAP,ERAIN,I,K,STO1,STO2,ROOTA,ROOTB,DEPAHO,
     *DEPBHO)
      ENDIF

C
C     ----------------------------------------------------------------
C
C     IRRIGATION REQUIREMENTS ARE NOW CALCULATED
C
      IF(WRIRR.EQ.1.)THEN                                         WG2011
        IF(IRRAPL.EQ.2)THEN                                       WG2011
          OVERAC(K)=OVERFL(K-1+5)+OVERFL(K-2+5)+OVERFL(K-3+5)+
     *    OVERFL(K-4+5)+OVERFL(K-5+5)
          OVERAC(K)=OVERAC(K)*(1.-CONLOS)
        ENDIF
C
        CALL IRRIGW(STOIR,REQIR,EFFIRR,IRRAPL,CONLOS,FAMLOS,IRRMON,     WG4/11
     *  BFRESP,CONSTI,SCHED,PLADEF,AMTIR,RESYLD,HAIRR,DAMSTO,SMPOIR,
     *  RFLIR,COIAM,VEGINT,SUPPIR,OVERFL,OVR,OVERAC)                    WG2811
C       PRINT OUT NEW VALUES OF OVERFLOW FOR END OF PREVIOUS MONTH IF THEY HAVE
C       BEEN CHANGED
        IF(IRRAPL.EQ.2.AND.OVR.EQ.1.)THEN                            WG15/1
```

```
        IF(K.EQ.5)WRITE(6,560)OVERFL(0+5)                                    .
        IF(K.EQ.4)WRITE(6,560)(OVERFL(L+5),L=0,-1,-1)                        .
        IF(K.EQ.3)WRITE(6,560)(OVERFL(L+5),L=0,-2,-1)                        .
        IF(K.EQ.2)WRITE(6,560)(OVERFL(L+5),L=0,-3,-1)                        .
  560   FORMAT(1X,'RE-ADJUSTED VALUES OF OVERFLOW FOR END OF PREVIOUS        .
     *MONTH:',4F6.2)                                                         .
        ENDIF                                                           WG2711
      ENDIF
C
C     ------------------------------------------------------------------
C
C     CHECK WHETHER IRRIGATION APPLIED UP- OR DOWNSTREAM OF RESERVOIR
      IF(UPSTIR.EQ.1.AND.SURIR(K).GT.0.)THEN                            WG2711
        IF(IRRAPL.EQ.0.AND.RESYLD.EQ.1.OR.IRRAPL.EQ.2)RUN(K)=RUN(K)+         .
     *  SURIR(K)                                                             .
      ENDIF                                                             WG2711
C
C     CALCULATE RUNOFF FOR DAY
      IF(IRUN.EQ.1)SIMSQ(K)=QUICKF(K)+RUN(K)                            SJD
      IF(IRUN.EQ.0)SIMSQ(K)=QUICKF(K)                                   SJD
C     ------------------------------------------------------------------
C
C     RESERVOIR YIELD ANALYSIS
C
      IF(RESYLD.EQ.1.)CALL RESANL(DAMPER,DAMSTO,SIMSQ,SUPPIR,DAMET,     WG2011
     *OVERFL,K,RFL,I,IEMPTY,ICONSC,SURFAR,XDRAFT,WRIRR,PUMPIN)          WG19/6
C
C     ------------------------------------------------------------------
C
C     DAILY VALUES ARE STORED IN ARRAYS FOR LATER USE IN THE STATISTICAL
C     PACKAGE   removed - lja 26/9/86
C
C     ------------------------------------------------------------------
C
C     MONTHLY VALUES OF THE WATER BALANCE ARE NOW TOTALLED PER DAY
C
      CONSTA(K)=CONST
      TRAIN(I)=TRAIN(I)+RFL(K+5)
      TERAIN(I)=TERAIN(I)+ERFL(K)
      TE1(I)=TE1(I)+PP1(K)
      TE2(I)=TE2(I)+PP2(K)
      TDPE(I)=TDPE(I)+DPE(K)
      TDPEIR(I)=TDPEIR(I)+DPEIR(K)
      TAPAN(I)=TAPAN(I)+APAN(I,K)
      TSUR(I)=TSUR(I)+SUR2(K)
      TRUN(I)=TRUN(I)+RUN(K)
C
      TSTORM(I)=TSTORM(I)+STORMQ(K)
      TQUICK(I)=TQUICK(I)+QUICKF(K)
      TAET2(I)=TAET2(I)+AET2(K)
      TAET1(I)=TAET1(I)+AET1(K)
      TAET(I)=TAET(I)+AET(K)
      TET(I)=TET(I)+ATRANS(K)
C
      TPOSEV(I)=TPOSEV(I)+POSOEV(K)
      TASOEV(I)=TASOEV(I)+ASOEV(K)
      TPOTR1(I)=TPOTR1(I)+POTR1(K)
      TPOTR2(I)=TPOTR2(I)+POTR2(K)
      TTRAN1(I)=TTRAN1(I)+ATRAN1(K)
      TTRAN2(I)=TTRAN2(I)+ATRAN2(K)
C
      TPTRAN(I)=TPTRAN(I)+POTRAN(K)
      TTRANS(I)=TTRANS(I)+ATRANS(K)
      TRQIR(I)=TRQIR(I)+REQIR(K)
      TSUPIR(I)=TSUPIR(I)+SUPPIR(K)                                     WG2811
      TSTREM(I)=TSTREM(I)+STRMFL(K)
      TDISCH(I)=TDISCH(I)+SIMSQ(K)                                      WG24/7
```

```
      TPLINT(I)=TPLINT(I)+PLINT(K)
C
      TAETIR(I)=TAETIR(I)+AETIR(K)
      TSTOIR(I)=TSTOIR(I)+STOIR(K)
      TIRRFL(I)=TIRRFL(I)+ERFLIR(K)
      TSURIR(I)=TSURIR(I)+SURIR(K)
      TREQIR(I)=TREQIR(I)+REQIR(K)
      TETLYS(I)=TETLYS(I)+ETLYS(K)
      TOVERF(I)=TOVERF(I)+OVERFL(K+5)
      TSEDYD(I)=TSEDYD(I)+SEDYLD(K)
C     DNO = PENTAD NUMBERS, 1 - 6
      DNO(K)=K-1
C
C
C     ------------------------------------------------------------------
C
C     CROP YIELD ROUTINES
C
      IF(WRTYLD.EQ.0.)GO TO 60
C
      IF(CROP.EQ.1.)CALL MZPREP(PRAIN,TPRAIN,LSTART,LDAY,ISTMO,ISTDAY,
     *NSTRES,MSDAYS,TOTAET,TOTPET,LGROW,STAET,STPET,ATRANS,RFL,WRIRR,
     *AETIR,DPEIR)
C
      IF(CROP.EQ.2.)CALL CNPREP(I,K,STCAN,TOTCAN,AET1,AET2,WRIRR,AETIR)
C
C     ------------------------------------------------------------------
C
   60 CONTINUE
C
C     THIS IS END OF DAILY MOISTURE BUDGET LOOP
C
C     ------------------------------------------------------------------
C
C     ROUTINE FOR COMPUTING IRRIGATION REQUIREMENTS AND ABSTRACTING THE WATER
C     FROM THE RIVER, HENCE REDUCING DAILY STREAMFLOW. DAILY IRRIGATION
C     REQUIREMENT AND STREAMFLOW REDUCTIONS ARE CALCULATED FROM THE MONTHLY
C     TOTAL
C
      IF(WRIRR.EQ.1.AND.IRRAPL.EQ.3.AND.IRRMON(I).EQ.1)THEN           WG25/7
        TDISCH(I)=0.0                                                     .
        DAYIRR=TREQIR(I)/NDYM                                             .
C     CALCULATE MEAN DAILY IRRIGATION REQUIREMENT IN M**3 FOR AREA UNDER
C     IRRIGATION
        DO 571 K=2,(NDYM+1)                                               .
        DREQIR(K)=DAYIRR*HAIRR(I)*10.                                     .
  571   SUPPIR(K)=DREQIR(K)/(1.-CONLOS)/(1.-FAMLOS)/EFFIRR            WG2011
C       ADD VALUE FROM END OF PREVIOUS MONTH
        SUPPIR(2)=SUPPIR(2)+SUPPIR(1)                                 WG2011
        DO 572 K=2,(NDYM+1)                                               .
        SIMSQ(K)=SIMSQ(K)*AREA*1000.                                      .
C
        IF(SIMSQ(K).GE.SUPPIR(K))THEN                                     .
          SIMSQ(K)=SIMSQ(K)-SUPPIR(K                                      .
        ELSE                                                              .
          SUPPIR(K+1)=SUPPIR(K+1)+SUPPIR(K)-SIMSQ(K)                  WG2011
          SUPPIR(K)=SIMSQ(K)                                          WG2011
          SIMSQ(K)=0.0                                                    .
        ENDIF                                                             .
C
        SIMSQ(K)=SIMSQ(K)/(AREA*1000.)                                    .
        TDISCH(I)=TDISCH(I)+SIMSQ(K)                                      .
        STOIR(K)=STOIR(K)+SUPPIR(K)*(1.-CONLOS)*(1.-FAMLOS)*EFFIRR    WG2011
  572   CONTINUE                                                          .
      ENDIF                                                           WG25/7
C
C
```

```
C     -----------------------------------------------------------------
C
C     MONTHLY VALUES ARE STORED IN ARRAYS FOR LATER USE IN THE STATISTICAL
C     PACKAGE.  removed - lja 26/9/86
C


C     -----------------------------------------------------------------
C
C     OPTION FOR PRINTING DAILY MOISTURE BUDGET WITH MONTHLY SUB-TOTALS
C
      IF(WRIDY.EQ.1.)CALL PRTDLY(RESYLD,TOVERF,AET,TSUPIR)             WG15/1
C
C     -----------------------------------------------------------------
C
C     OPTION FOR PRINTING MONTHLY MOISTURE BUDGET WHEN DAILY VALUES NOT
C     REQUESTED
C
      IF(WRIMO.EQ.1.AND.WRIDY.EQ.0.)CALL PRNTMO(EVTR,TAPAN,TOVERF,
     *TIRRFL,TDPEIR,TAETIR,STOIR,DAMPER,SMDIR,TSTQIR,TSURIR,RESYLD,     WG15/1
     *IRRAPL,IEMPTY,ICONSC,TREQIR)
C
C     -----------------------------------------------------------------
C
C     SUMMATION OF ANNUAL TOTALS
C
C     SUMMATION OF ANNUAL TOTALS
C
      SUMRA=SUMRA+TRAIN(I)
      SUMPE=SUMPE+TDPE(I)
      SUMPEI=SUMPEI+TDPEIR(I)
      SUMPE1=SUMPE1+TE1(I)
      SUMPE2=SUMPE2+TE2(I)
      SUMERA=SUMERA+TERAIN(I)
      SUMAE=SUMAE+TAET(I)
C
      SUMAEI=SUMAEI+TAETIR(I)
      SUMAE1=SUMAE1+TAET1(I)
      SUMAE2=SUMAE2+TAET2(I)
      SUMET=SUMET+TET(I)
      SUETLY=SUETLY+TETLYS(I)
      SUMPSE=SUMPSE+TPOSEV(I)
      SUMASE=SUMASE+TASOEV(I)
      SUPTR1=SUPTR1+TPOTR1(I)
      SUPTR2=SUPTR2+TPOTR2(I)
      SUATR1=SUATR1+TTRAN1(I)
C
      SUATR2=SUATR2+TTRAN2(I)
      SUAPAN=SUAPAN+TAPAN(I)
      SUMPTR=SUPTR1+SUPTR2
      SUMATR=SUATR1+SUATR2
      SUMIR=SUMIR+TRQIR(I)
      SUMSU=SUMSU+TSUR(I)
      SUMRU=SUMRU+TRUN(I)
      SUMQU=SUMQU+TQUICK(I)
      SUMINT=SUMINT+TPLINT(I)
C
      SUMIRA=SUMIRA+TIRRFL(I)
      SUSUIR=SUSUIR+TSURIR(I)
      SUDIR=SUDIR+TSTQIR(I)
      SFLOW=SFLOW+TDISCH(I)
      SDATA(LMN,I)=TDISCH(I)
      ODATA(LMN,I)=TSTREM(I)                                         SJD
      PDATA(LMN,I)=TRAIN(I)                                          SJD
      DIRRIG(LMN,I)=TRQIR(I)
      SUMST=SUMST+TSTREM(I)
      SUMSED=SUMSED+TSEDYD(I)
```

```
C*      CALL ANSUMS
C
C     ----------------------------------------------------------------
C
C     STORE VALUES OF DAM LEVELS AT END OF EACH MONTH FOR PROBABILITY ANALYSIS
C     OF DAM STORAGE
C
      DAMDAT(LMN,I)=DAMPER(NDYM+1)
C
C     ----------------------------------------------------------------
C
C     VALUES OF LAST DAY OF MONTH ARE STORED FOR USE ON FIRST DAY OF NEXT
C     MONTH OR YEAR
C
      CALL LDVALS(SOIL1,SOIL2,SOILI,PLINTC,RCO,STCO,RFLC,EFPPT,STODAM,
     *PERDAM,ETDE,OVER,SUPP,IRRAPL,DEFCT1)                          SJD
C
C     ----------------------------------------------------------------
C
C     END OF MAIN LOOP
C
    2 CONTINUE
C
C     ----------------------------------------------------------------
C
      SDATA(LMN,13)=SFLOW
      ODATA(LMN,13)=SUMST                                           SJD
      PDATA(LMN,13)=SUMRA                                           SJD
      DIRRIG(LMN,13)=SUMIR
C
C     ----------------------------------------------------------------
C
C     THE MONTHLY MOISTURE BUDGET HAS NOW BEEN ESTABLISHED - GIVE ANNUAL TOTALS
C
      IF(WRTYLD.EQ.1.)GO TO 620
      IF(WRIMO.EQ.1.)WRITE(6,570)
  570 FORMAT(1X,120('-'))
C
      IF(WRIMO.EQ.1.AND.EVTR.EQ.1.AND.IRRAPL.EQ.0)WRITE(6,580)SUMRA,
     *SUMERA,SUMPE,SUMAE,SUMSU,SUMRU,SUMQU,SFLOW,SUMST,SUMIR
  580 FORMAT(1X,'TOTALS',4X,F8.1,F9.1,2F7.1,29X,F7.3,F8.3,4F7.1)
C
      IF(WRIMO.EQ.1.AND.EVTR.EQ.1.AND.IRRAPL.EQ.1)WRITE(6,590)SUMRA,
     *SUMIRA,SUMPEI,SUMAEI,SUQIR,SUSUIR                             WG15/1
  590 FORMAT(1X,'TOTALS',5X,F7.1,2X,3F7.1,17X,F5.1,18X,F7.1)        WG15/1
C
      IF(WRIMO.EQ.1.AND.EVTR.EQ.1.AND.IRRAPL.EQ.2)WRITE(6,600)SUMRA,
     *SUMERA,SUMPE,SUMAE,SUMSU,SUMRU,SUMQU,SFLOW,SUMST,SUMIR
  600 FORMAT(1X,'TOTALS',5X,F7.1,2X,3F7.1,28X,2(1X,F7.3),4F7.1)
C
      IF(WRIMO.EQ.1.AND.EVTR.EQ.2.)WRITE(6,610)SUMRA,SUMERA,SUAPAN,
     *SUMPSE,SUMASE,SUMPTR,SUMATR,SUMSU,SUMRU,SUMQU,SFLOW,SUMST,SUMIR
  610 FORMAT(1X,'TOTALS',3X,7F6.1,24X,2F6.2,F7.1,F8.1,F7.1,F6.1)
C
C     ----------------------------------------------------------------
C
C     CROP YIELD MODELS
C
  620 IF(WRTYLD.EQ.1.)THEN
        IF(CROP.EQ.1.)CALL MZCALC(TOTAET,TOTPET,NSTRES,LSTART,LDAY,
     *  ISTMO,ISTDAY,STAET,STPET,LM,CDATA,XMDP,PLDATE,ENDAET,ENDPET)
        IF(CROP.EQ.2.)CALL CNCALC(TOTCAN,STCAN,LM,CDATA)
      ENDIF
      GO TO 200
   99 CONTINUE
C
C     ----------------------------------------------------------------
```

```
C
C     AT THIS STAGE THE PROGRAM HAS GONE THROUGH THE ENTIRE DATA SET.
C     STATISTICAL ROUTINES/OPTIONS FOLLOW
C            - removed -  Lja 26/9/86
C     ---------------------------------------------------------------------
C
C     ---------------------------------------------------------------------
C     STOP
      END
C
C     ---------------------------------------------------------------------
```

SUBROUTINE OBJFUN

(FILE : OBJFUN)

```
      SUBROUTINE OBJFUN(XX,YY,N,L,IOPTN)
C
C     PACKAGE FOR MEASURES OF MODEL PERFORMANCE BASED ON WORK OF P.J.T. ROBERTS
C     (1978) AND ADAPTED FOR USE IN THE ACRU MODEL BY C.B. SCHULTZ WITH EXTRA
C     ADDITIONS AS RECOMMENDED BY PROF. R.E. SCHULZE, NOV. 1983.
C     THE MEAN, STANDARD DEVIATION, VARIANCE, CORRELATION COEFFICIENT,
C     COEFFICIENT OF DETERMINATION, COEFFICIENT OF MODEL EFFICIENCY, STUDENTS
C     T VALUE, REGRESSION COEFFICIENT AND BASE CONSTANT OF REGRESSION EQUATION
C     ARE PROVIDED FOR SIMULATED AND OBSERVED FLOW VALUES. THE PRESENCE OF
C     SYSTEMATIC ERRORS IS ALSO INDICATED. THE PACKAGE CAN BE USED FOR MONTHLY
C     OR DAILY EVALUATIONS DEPENDING ON OPTIONS CHOSEN IN THE MAIN PROGRAM.
C        IF ICOMPR = 0  THIS PACKAGE IS OMITTED.
C        IF ICOMPR = 1  AN ANALYSIS IS DONE FOR DAILY FLOWS
C        IF ICOMPR = 2  AN ANALYSIS IS DONE FOR MONTHLY FLOWS
C        IF ICOMPR = 3  ANALYSES ARE DONE FOR DAILY AND MONTHLY FLOWS
C     AN OPTION ALSO EXISTS FOR THE USE OF LOG VALUES SHOULD THE USER WISH TO
C     PREVENT GIVING TOO MUCH WEIGHT TO HIGH FLOWS
C        IF LOGVAL = 0 ACTUAL VALUES ARE USED
C        IF LOGVAL = 1 LOGARITHMIC FLOW VALUES ARE USED
C
      DIMENSION XX(4000),YY(4000)
C     INITIALIZATIONS
      SPXY=0.
      SYSQ=0.
      SXSQ=0.
      SUMY=0.
      SUMX=0.
      SUMMX=0.
      SXMY=0.
      DO 30 I=1,N
      IF (L.NE.1) GO TO 10
C     --------------------------------
C     CONVERT TO LOG VALUES IF REQUESTED
C     --------------------------------
      XX(I)=XX(I)*1000.
      YY(I)=YY(I)*1000.
      IF (XX(I).LT.1.0)XX(I)=1.0
      IF (YY(I).LT.1.0) YY(I)=1.0
      XVAL=ALOG10(XX(I))
      YVAL=ALOG10(YY(I))
      GO TO 20
   10 XVAL=XX(I)
      YVAL=YY(I)
C     ----------------------------------------------------------
C     CALCULATE ARRAY TOTALS,SUM OF SQUARES AND SUM OF CROSS PRODUCTS
C     ----------------------------------------------------------
   20 SUMX=SUMX+XVAL
      SUMY=SUMY+YVAL
      XSQ=XVAL**2.0
      YSQ=YVAL**2.0
      SXSQ=SXSQ+XSQ
      SYSQ=SYSQ+YSQ
      PXY=XVAL*YVAL
   30 SPXY=SPXY+PXY
C     --------------------
C     CHECK FOR ZERO ARRAYS
C     --------------------
      IF ((SUMX.GT.0.).AND.(SUMY.GT.0.)) GO TO 40
      AMENX=0.
      AMENY=0.
      CCOF=0.
      TTEST=0.
      RECO=0.
      BASE=0.
      SDEVY=0.
      VARY=0.
```

```
      SDY=0.
      VARX=0.
      SDX=0.
      EVAL=0.
      SDIF=0.
      GO TO 150
C     ----------------------------------------------------------------
C     CALCULATE MEAN,STD.DEVIATION,VARIANCE,CORRELATION COEFFICIENT STUDENT'S
C     T VALUE,REGRESSION COEFFICIENT AND BASE CONSTANT OF REGRESSION EQUATION
C     ----------------------------------------------------------------
   40 AMENX=SUMX/FLOAT(N)
      AMENY=SUMY/FLOAT(N)
      AX=SXSQ-((SUMX**2.0)/FLOAT(N))
      AY=SYSQ-((SUMY**2.0)/FLOAT(N))
      TOP=SPXY-((SUMX*SUMY)/FLOAT(N))
      CCOF=TOP/((AX*AY)**0.5)
      NCC=N-2
      BNC=FLOAT(NCC)
      TTEST=CCOF*(BNC**0.5)/((1.0-(CCOF*CCOF))**0.5)
      RECO=TOP/AX
      BASE=AMENY-(RECO*AMENX)
      SDEVY=(AY**0.5)*((1.0-(CCOF*CCOF))**0.50)
      VARY=(SYSQ/NCC)-(AMENY*AMENY)
      VARX=(SXSQ/NCC)-(AMENX*AMENX)
      SDX=VARX**0.5
      SDY=VARY**0.5
      DO 50 J=1,N
      XMMX=(XX(J)-AMENX)*(XX(J)-AMENX)
      XMY=(XX(J)-YY(J))*(XX(J)-YY(J))
      SXMMX=SXMMX+XMMX
   50 SXMY=SXMY+XMY
C     ----------------------------------------------------------
C     CALCULATE COEFFICIENT OF DETERMINATION AND COEFFICIENT OF MODEL
C     EFFICIENCY
C     ----------------------------------------------------------
      CODETR = CCOF*CCOF
      EVAL = (SXMMX - SXMY)/SXMMX
      SDIF = ((SDX-SDY)/SDX)*100.0
C     -------------------------
C     CHECK FOR SYSTEMATIC ERRORS
C     -------------------------
      ISYSER = 1
      IF(EVAL.LT.CODETR)ISYSER = -1
C     ---------------------------------------
C     OUTPUT OF STATISTICS OF MODEL PERFORMANCE
C     ---------------------------------------
      WRITE(6,60)
   60 FORMAT (1H0,42X,'STATISTICS OF PERFORMANCE OF ACRU MODEL'
     *,/,42X,39('-'),//,40X,'A COMPARISON OF SIMULATED AND OBSERVED FLOW
     *S',/)
      IF(IOPTN.EQ.1) WRITE(6,70)
   70 FORMAT(1X,52X,'FOR DAILY VALUES',//)
      IF(IOPTN.EQ.2) WRITE(6,80)
   80 FORMAT(1X,52X,'FOR MONTHLY VALUES',//)
      IF(L.EQ.1)WRITE(6,90)
   90 FORMAT(1X,12X,'LOG VALUES ARE USED THROUGHOUT',//)
      WRITE(6,100)SUMX,SUMY
  100 FORMAT(1X,14X,'TOTAL OBSERVED FLOWS ',23X,'=',F10.3,
     *//,1X,14X,'TOTAL SIMULATED FLOWS',23X,'=',F10.3,/)
      WRITE(6,110) AMENX,AMENY,CCOF,TTEST,RECO,BASE,SDEVY,VARX,VARY
  110 FORMAT (1X,14X,'MEAN OF OBSERVED FLOWS',22X,'=',F10.3,//
     *,1X,14X,'MEAN OF SIMULATED FLOWS                  =',F10.3,//
     *,1X,14X,'CORRELATION COEFFICIENT                  =',F10.3,//
     *,1X,14X,'STUDENTS T VALUE                         =',F10.3,//
     *,1X,14X,'REGRESSION COEFFICIENT                   =',F10.3,//
     *,1X,14X,'BASE CONSTANT FOR REGRN. EQN.            =',F10.3,//
     *,1X,14X,'STANDARD ERROR OF SIMULATED FLOW         =',F10.3,//
```

```
     *,1X,14X,'VARIANCE OF OBSERVED FLOW                    =',F10.3,//
     *,1X,14X,'VARIANCE OF SIMULATED VALUES                 =',F10.3,/)
      WRITE(6,120)SDX,SDY,SDIF,CODETR,EVAL
  120 FORMAT (1X,14X,'STANDARD DEVIATION OF X VALUES',13X,' =',F10.3,//
     *,1X,14X,'STANDARD DEVIATION OF Y VALUES                 =',F10.3,//
     *,1X,14X,'PERCENTAGE DIFFERENCE IN STANDARD DEVIATION =',F10.3,//
     *,1X,14X,'COEFFICIENT OF DETERMINATION                =',F10.3,//
     *,1X,14X,'COEFFICIENT OF EFFICIENCY                   =',F10.3,//)
      IF(ISYSER.EQ.1)WRITE(6,130)
  130 FORMAT(1X,14X,'NO SYSTEMATIC ERRORS DETECTED',//)
      IF(ISYSER.EQ.-1)WRITE(6,140)
  140 FORMAT(1X,14X,'###CAUTION### SYSTEMATIC ERROR DETECTED ###')
  150 RETURN
      END
```

APPENDIX D.3

SUBROUTINE ANSUMS

(FILE ANS1)

```
C     SUMMATION OF ANNUAL TOTALS
C
      SUBROUTINE ANSUMS
C
      DIMENSION TRAIN(12),TDPE(12),TE1(12),TE2(12),TERAIN(12),TAET(12),
     *TAET1(12),TAET2(12),TET(12),TPOSEV(12),TASOEV(12),TPOTR1(12),
     *TPOTR2(12),TTRAN1(12),TTRAN2(12),TRQIR(12),TSUR(12),TRUN(12),
     *TQUICK(12),TPLINT(12),TDISCH(12),TSTREM(12),SDATA(70,13),
     *ODATA(70,13),PDATA(70,13),DIRRIG(70,13),TAPAN(12),TSEDYD(12),      SJD
     *TDPEIR(12),TAETIR(12),TIRRFL(12),TSURIR(12),TSTQIR(12),TETLYS(12)
C
      COMMON/ANSUM/SUMRA,SUAPAN,SUMPE,SUMPE1,SUMPE2,SUMERA,SUMAE,
     *SUMAE1,SUMAE2,SUMET,SUMPSE,SUMASE,SUPTR1,SUPTR2,SUATR1,SUATR2,
     *SUMPTR,SUMATR,SUMIR,SUMSU,SUMRU,SUMQU,SUMINT,SFLOW,SDATA,DIRRIG,
     *SUMST,SUMSED,LMN,TET,TPLINT,SUMPEI,SUMAEI,SUMIRA,SUSUIR,SUQIR,
     *SUETLY,ODATA,PDATA
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      COMMON/IRRIGA/AETIR,SMDIR,STQIR,ERFLIR,STQIRO,SURIR,TAETIR,TSTQIR,
     *TIRRFL,TSURIR,TREQIR,DPEIR,TDPEIR,APPIRR,ICYCLE,ISTART           WG30/5
      COMMON/PRTMO/TRAIN,TERAIN,TDPE,TAET,TPOSEV,TASOEV,TPOTR1,
     *TPOTR2,TTRAN1,TTRAN2,TPTRAN,TTRANS,TSUR,TRUN,TQUICK,TDISCH,TSTREM,
     *TRQIR
      COMMON/TOTALS/TE1,TE2,TAET1,TAET2,TAPAN,TETLYS,TSEDYD
C
      CONTINUE
C
C     ///////////////TRACE/////////////////////////
      WRITE(*,*)'SUBROUTINE ANSUMS'
C     /////////////////////////////////////////////
C
      SUMRA=SUMRA+TRAIN(I)
      SUMPE=SUMPE+TDPE(I)
      SUMPEI=SUMPEI+TDPEIR(I)
      SUMPE1=SUMPE1+TE1(I)
      SUMPE2=SUMPE2+TE2(I)
      SUMERA=SUMERA+TERAIN(I)
      SUMAE=SUMAE+TAET(I)
      SUMAEI=SUMAEI+TAETIR(I)
      SUMAE1=SUMAE1+TAET1(I)
      SUMAE2=SUMAE2+TAET2(I)
      SUMET=SUMET+TET(I)
      SUETLY=SUETLY+TETLYS(I)
      SUMPSE=SUMPSE+TPOSEV(I)
      SUMASE=SUMASE+TASOEV(I)
      SUPTR1=SUPTR1+TPOTR1(I)
      SUPTR2=SUPTR2+TPOTR2(I)
      SUATR1=SUATR1+TTRAN1(I)
      SUATR2=SUATR2+TTRAN2(I)
      SUAPAN=SUAPAN+TAPAN(I)
      SUMPTR=SUPTR1+SUPTR2
      SUMATR=SUATR1+SUATR2
      SUMIR=SUMIR+TRQIR(I)
      SUMSU=SUMSU+TSUR(I)
      SUMRU=SUMRU+TRUN(I)
      SUMQU=SUMQU+TQUICK(I)
      SUMINT=SUMINT+TPLINT(I)
      SUMIRA=SUMIRA+TIRRFL(I)
      SUSUIR=SUSUIR+TSURIR(I)
      SUQIR=SUQIR+TSTQIR(I)
      SFLOW=SFLOW+TDISCH(I)
      SDATA(LMN,I)=TDISCH(I)
      ODATA(LMN,I)=TSTREM(I)                                             SJD
      PDATA(LMN,I)=TRAIN(I)                                              SJD
      DIRRIG(LMN,I)=TRQIR(I)
      SUMST=SUMST+TSTREM(I)
      SUMSED=SUMSED+TSEDYD(I)
      END
```

APPENDIX D.4

SUBROUTINE PRNTMO

(FILE : PRNTMO)

```
C     OPTION FOR PRINTING MONTHLY MOISTURE BUDGET WHEN DAILY VALUES NOT
C     REQUESTED.
C
      SUBROUTINE PRNTMO(EVTR,TAPAN,TOVERF,TIRRFL,TDPEIR,TAETIR,STOIR,
     *DAMPER,SMDIR,TSTQIR,TSURIR,RESYLD,IRRAPL,IEMPTY,ICONSC,TREQIR)
C
      DIMENSION TRAIN(12),TERAIN(12),TAPAN(12),TDPE(12),TAET(12),
     *STO1(32),STO2(32),DEF1(32),DEF2(32),TSUR(12),TRUN(12),TQUICK(12),
     *TDISCH(32),TSTREM(12),TROIR(12),TPOSEV(12),TASOEV(12),TPOTR1(12),
     *TPOTR2(12),TTRAN1(12),TTRAN2(12),TPTRAN(12),TTRANS(12),TOVERF(12),
     *TIRRFL(12),TDPEIR(12),TAETIR(12),STOIR(32),DAMPER(32),SMDIR(32),
     *TSTQIR(12),TSURIR(12),TREQIR(12)
      CHARACTER HEAD*34
      COMMON/HDGMTH/HEAD
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      COMMON/PRINT/DEF1,DEF2,STO1,STO2
      COMMON/PRTMO/TRAIN,TERAIN,TDPE,TAET,TPOSEV,TASOEV,TPOTR1,
     *TPOTR2,TTRAN1,TTRAN2,TPTRAN,TTRANS,TSUR,TRUN,TQUICK,TDISCH,TSTREM,
     *TRQIR
      CONTINUE
C       ////////////////////////////////////////////////////////////////
        WRITE(*,*)'SUBROUTINE PRNTMO'
C       ////////////////////////////////////////////////////////////////
C
      IF(RESYLD.EQ.0.AND.IRRAPL.EQ.1)GO TO 110
      IF(I.EQ.1.AND.EVTR.EQ.1.OR.I.EQ.1.AND.RESYLD.EQ.1.)THEN
C     WRITE HEADING
C
      WRITE(14,10)HEAD
   10 FORMAT(//5X, 'MONTHLY SUMMARY OF MOISTURE BUDGET',5X,A34)
      WRITE(14,20)
   20 FORMAT(5X,80('-'))
      WRITE(14,30)
   30 FORMAT(20X,'EFFECTIVE',13X,2(1X,'S.M.C.'),3X,'DEF.   DEF.   DRAIN
     *  BASE   STORM   EST.   OBS.  SUPP.  OVER   DAM',/1X,'YEAR MONTH R
     *AINFALL RAINFALL    PET     AET  A-HOR  B-HOR  A-HOR  B-HOR    AGE
     *   FLOW   FLOW  RUNOFF RUNOFF IRRIGN  FLOW   (%)'/)
      ENDIF
C
      IF(EVTR.EQ.1.OR.RESYLD.EQ.1.)THEN
C     WRITE RESULTS FOR 'EVAPOTRANSPIRATION-COMBINED' METHOD
      WRITE(14,50)IYR,I,TRAIN(I),TERAIN(I),TDPE(I),TAET(I),STO1(NDYM+1),
     *STO2(NDYM+1),DEF1(NDYM+1),DEF2(NDYM+1),TSUR(I),TRUN(I),TQUICK(I),
     *TDISCH(I),TSTREM(I),TREQIR(I),TOVERF(I),DAMPER(NDYM+1),IEMPTY,
     *ICONSC
   50 FORMAT(1X,I3,3X,I3,2X,F7.1,F9.1,6F7.1,2F8.3,4F7.1,2F6.1,'(',I2,',
     *,I2,')')
      ENDIF
C
  110 IF(I.EQ.1.AND.IRRAPL.EQ.1)THEN
C     WRITE HEADING FOR IRRIGATION APPLICATION
      WRITE(14,10)HEAD
      WRITE(14,20)
      WRITE(14,80)
   80 FORMAT(20X,'EFFECTIVE',15X,'S.M.C.   DEF.   STORM   EFF. IRRIG.  PER
     *COLATION/',/1X,'YEAR MONTH',2(1X,'RAINFALL'),'   PET    AET ',2('(M
     *ID-HO)'),'  FLOW  APPLICATION    RECHARGE',/)
      ENDIF
C
      IF(IRRAPL.EQ.1)WRITE(14,100)IYR,I,TRAIN(I),TIRRFL(I),TDPEIR(I),
     *TAETIR(I),STOIR(16),SMDIR(16),TSTQIR(I),TSURIR(I)
  100 FORMAT(1X,I3,3X,I3,2X,F7.1,F9.1,3F7.1,1X,2F7.1,19X,F6.1)
C
      IF(I.EQ.1.AND.EVTR.EQ.2.)THEN
C     WRITE HEADING
      WRITE(14,10)HEAD
      WRITE(14,20)
```

```
      WRITE(14,60)                                                      PRN00680
   60 FORMAT(17X,'EFFEC',8X,'SOIL EVAP  TRANPIRATION S.M.C S.M.C  DEF  DPRN00690
     *EF  DRAIN  BASE  STORM   ESTD   OBSD  SUPP.',/1X,'YEAR MONTH RAIN PRN00700
     * RAIN  APAN  POT   ACT   POT   ACT   A-HOR B-HOR  "A"  "B"   AGE  PRN00710
     * FLOW  FLOW   RUNOFF RUNOFF IRRIGN'/)                             PRN00720
      ENDIF                                                             PRN00730
C                                                                       PRN00740
      IF(EVTR.EQ.2.)THEN                                                PRN00750
C     WRITE RESULTS FOR 'EVAPORATION AND TRANSPIRATION' SEPARATED       PRN00760
      WRITE(14,70)IYR,I,TRAIN(I),TERAIN(I),TAPAN(I),TPOSEV(I),TASOEV(I),PRN00770
     *TPTRAN(I),TTRANS(I),STO1(NDYM+1),STO2(NDYM+1),DEF1(NDYM+1),       PRN00780
     *DEF2(NDYM+1),TSUR(I),TRUN(I),TQUICK(I),TDISCH(I),TSTREM(I),       PRN00790
     *TRQIR(I)                                                          PRN00800
   70 FORMAT(2X,I2,3X,I2,1X,3F6.1,4F6.1,F7.1,F6.1,2F5.1,1X,2F6.2,F7.1,  PRN00810
     *1X,2F7.1,F6.1)                                                    PRN00820
      ENDIF                                                             PRN00830
      END                                                               PRN00840
```

APPENDIX D.5

SUBROUTINE : HARMON

(FILE : HAR1)

```
C     366 DAILY VALUES ARE CALCULATED FROM 12 MONTHLY VALUES USING HARMONIC
C     ANALYSIS
C
      SUBROUTINE HARMON(XXX,PARAM)
C
      DIMENSION XXX(12),A(6),B(6),IDA(12),PARAM(12,32),XA(6),XB(6)
      DATA  IDA/31,29,31,30,31,30,31,31,30,31,30,31/
C
C     ////////////////TRACE//////////////////////////
C     WRITE(*,*)'SUBROUTINE HARMON'
C     ///////////////////////////////////////////////
C
      AM=0.0
      DO 5 K=1,6                                                    WG12/8
      XA(K)=0.0
    5 XB(K)=0.0                                                     WG12/8
      DO 10 J=1,6
      A(J)=0.0
      B(J)=0.0
   10 CONTINUE
C     CORRECT MONTHLY VALUES TO EQUALIZE TIME INTERVALS (MONTHS)
      XXX(1)=XXX(1)*0.981
      XXX(2)=XXX(2)*1.086
      XXX(3)=XXX(3)*0.981
      XXX(4)=XXX(4)*1.014
      XXX(5)=XXX(5)*0.981
      XXX(6)=XXX(6)*1.014
      XXX(7)=XXX(7)*0.981
      XXX(8)=XXX(8)*0.981
      XXX(9)=XXX(9)*1.014
      XXX(10)=XXX(10)*0.981
      XXX(11)=XXX(11)*1.014
      XXX(12)=XXX(12)*0.981
C     CALCULATE AVERAGE MONTHLY VALUE
      DO 20 I=1,12
   20 AM=AM+XXX(I)
      AM=AM/12.0
C     DETERMINE FOURIER COEFFICIENTS
      DO 40 J=1,6
      DO 30 I=1,12
      XA(J)=XA(J)+XXX(I)*COS(30*I*J*.01744)
      XB(J)=XB(J)+XXX(I)*SIN(30*I*J*.01744)
   30 CONTINUE
      XA(J)=XA(J)/6.
      XB(J)=XB(J)/6.
   40 CONTINUE
      XA(6)=XA(6)/2.
      XB(6)=0.0
C     MANIPULATE SIGNS TO AVOID NEGATIVES
      DO 667 J=1,6
      IF(XA(J))54,55,55
   54 IF(XB(J))57,58,59
   55 IF(XB(J))57,58,58
   57 AWI=180.0
      GO TO 9999
   58 AWI=0.0
      GO TO 9999
   59 AWI=360.0
 9999 CONTINUE
C     DETERMINE THE PHASE AND AMPLITUTDE
      A(J)=SQRT((XA(J))**2+(XB(J)**2))
      IF(XB(J).EQ.0.)THEN
        IF(XA(J).LT.0.)XB(J)=270.0
        IF(XA(J).EQ.0.)XB(J)=0.0
        IF(XA(J).GT.0.)XB(J)=90.0
      ELSE
```

```
C      CONVERSION TO RADIANS (57.3 = 360/(2*PI))
         B(J)=57.3*ATAN(XA(J)/XB(J))
       ENDIF
       B(J)=AWI+B(J)
   667 CONTINUE
       N=-1
       DO 60 IMO=1,12
       DO 50 IDAY=1,IDA(IMO)
       N=N+1
C      'R' VARIES FOR EACH DAY OF THE YEAR (30.42 = AVERAGE LENGTH OF MONTH)
       R=.5+N/30.42
       PARAM(IMO,IDAY)=FOURIE(R,A,B,AM)
    50 CONTINUE
    60 CONTINUE
       END
C
C
C
       REAL FUNCTION FOURIE(R,A,B,AM)
       DIMENSION A(6),B(6)
       REAL R
       FOURIE=AM+A(1)*SIN((30*R+B(1))*.01744)+A(2)*SIN((60*R+B(2))*.0174
      *4)+A(3)*SIN((90*R+B(3))*.01744)+A(4)*SIN((120*R+B(4))*.01744)+A(5
      *)*SIN((150*R+B(5))*.01744)+A(6)*SIN((180*R+B(6))*.01744)
       RETURN
       END
```

APPENDIX D.6

SUBROUTINE : INITAN

(FILE : INT1)

```
C     INITIALIZE ANNUAL TOTALS TO ZERO
C
      SUBROUTINE INITAN(SUMRA,SUMERA,SUMIRA,SUAPAN,SUMPE,SUMPEI,SUMPE1,
     *SUMPE2,SUMAE,SUMAEI,SUMAE1,SUMAE2,SUMET,SUMPSE,SUMASE,SUPTR1,
     *SUPTR2,SUATR1,SUATR2,SUMPTR,SUMATR,SUMINT,SUMSU,SUSUIR,SUMIR,
     *SUMRU,SUMQU,SUQIR,SFLOW,SUMST,STAET,STPET,STCAN,TOTAET,TOTPET,    WG15/1
     *TOTCAN,SUMSED,SUETLY,SUMSQ,QRNK,AMC,RQ)                           SJD
      DIMENSION QRNK(5),AMC(5),RQ(5)                                    SJD
C
C     ////////////////TRACE///////////////////////////
C     ////////////////////////////////////////////////
C
      SUMRA=0.0
      SUMERA=0.0
      SUMIRA=0.0
      SUAPAN=0.0
      SUMPE=0.0
      SUMPEI=0.0
      SUMPE1=0.0
      SUMPE2=0.0
      SUMAE=0.0
      SUMAEI=0.0
      SUMAE1=0.0
      SUMAE2=0.0
      SUMET=0.0
      SUETLY=0.0
      SUMPSE=0.0
      SUMASE=0.0
      SUPTR1=0.0
      SUPTR2=0.0
      SUATR1=0.0
      SUATR2=0.0
      SUMPTR=0.0
      SUMATR=0.0
      SUMINT=0.0
      SUMSU=0.0
      SUSUIR=0.0
      SUMIR=0.0
      SUMRU=0.0
      SUMQU=0.0
      SUQIR=0.0
      SUMSED=0.0
      SFLOW=0.0
      SUMST=0.0
      SUMSQ=0.0                                                         SJD
      STAET=0.0
      STPET=0.
      STCAN=0.
      TOTAET=0.0
      TOTPET=0.0
      TOTCAN=0.
      DO 10 N=1,5                                                       SJD
      QRNK(N)=0.0
      RQ(N)=0.0
   10 AMC(N)=0.0                                                        SJD
      END
```

SUBROUTINE : INITMO

```
$STORAGE:2
$DEBUG
C     INITIALIZE MONTHLY TOTALS
C
      SUBROUTINE INITMO(TSUR,TE1,TE2,TDPE,TAET,TAET1,TAET2,TET,TRQIR,
     *TRUN,TERAIN,TRAIN,TSTORM,TQUICK,TDISCH,TSTREM,TPLINT,TAETIR,
     *TSTQIR,TIRRFL,TSURIR,TREQIR,TAPAN,TPOSEV,TASOEV,TPOTR1,TPOTR2,
     *TTRAN1,TTRAN2,TPTRAN,TTRANS,TETLYS,TSEDYD,TDPEIR,TOVERF,I,IEMPTY,
     *ICONSC,TSUPIR)                                                    WG2811
C
      DIMENSION TSUR(12),TE1(12),TE2(12),TDPE(12),TAET(12),TAET1(12),
     *TAET2(12),TET(12),TRQIR(12),TRUN(12),TERAIN(12),TRAIN(12),
     *TSTORM(12),TQUICK(12),TDISCH(12),TSTREM(12),TPLINT(12),TAETIR(12),
     *TSTQIR(12),TIRRFL(12),TSURIR(12),TREQIR(12),TAPAN(12),TPOSEV(12),
     *TASOEV(12),TPOTR1(12),TPOTR2(12),TTRAN1(12),TTRAN2(12),TPTRAN(12),
     *TTRANS(12),TETLYS(12),TSEDYD(12),TDPEIR(12),TOVERF(12),TSUPIR(12) WG15/1
C
C     ///////////////TRACE/////////////////////////
      WRITE(*,*)'SUBROUTINE INITMO'
C     ////////////////////////////////////////////
C
      TSUR(I)=0.0
      TE1(I)=0.0
      TE2(I)=0.0
      TDPE(I)=0.0
      TDPEIR(I)=0.0
      TAET(I)=0.0
      TAET1(I)=0.0
      TAET2(I)=0.0
      TET(I)=0.0
      TRQIR(I)=0.0
      TSUPIR(I)=0.0                                                     WG2811
      TRUN(I)=0.0
      TERAIN(I)=0.0
      TRAIN(I)=0.0
      TSTORM(I)=0.0
      TQUICK(I)=0.0
      TDISCH(I)=0.0
      TSTREM(I)=0.0
      TPLINT(I)=0.0
      TSEDYD(I)=0.0
      TAETIR(I)=0.0
      TSTQIR(I)=0.0
      TIRRFL(I)=0.0
      TSURIR(I)=0.0
      TREQIR(I)=0.0
      TAPAN(I)=0.0
      TPOSEV(I)=0.0
      TASOEV(I)=0.0
      TPOTR1(I)=0.0
      TPOTR2(I)=0.0
      TTRAN1(I)=0.0
      TTRAN2(I)=0.0
      TPTRAN(I)=0.0
      TTRANS(I)=0.0
      TETLYS(I)=0.0
      TOVERF(I)=0.0
      IEMPTY=0
      ICONSC=0
      END
```

APPENDIX D.8

SUBROUTINE PLOTOP

(FILE : PL01)

```
C     OPTION FOR OUTPUT OF DAILY GRAPHICAL PLOT
C
      SUBROUTINE PLOTOP(IPLOT,STRMFL,SIMSQ,STO1,STO2,OBSTO1,OBSTO2,FFS,
     *ETLYS,AET,MNTALY,MNPLV,OBSQMX,SIMQMY)
C
      DIMENSION FF(6),FFS(4),OBSTO1(32),OBSTO2(32),SIMSQ(32),STO1(32),
     *STO2(32),STRMFL(32),ETLYS(32),AET(32),OBSQMX(480),SIMQMY(480)
      CHARACTER SYBL(4)*1,FMT(6)*4,HEAD*34,SYBLQ(2)*1
      COMMON/HDGMTH/HEAD
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      DATA SYBLQ/'1','2'/
      DATA SYBL/'1','2','3','4'/
      DATA FMT/'(12X','F9.','0,2X','    ','    ','    '/
C
C     PLOTTING SECTION WHICH USES THE STAT-PACK OF THE UNIVERSITY OF NAT
C     TO PRESENT THE PLOT OF SIMULATED AND OBSERVED VALUES
C     IF IPLOT = 0  NO PLOT
C              = 1  PLOT OF OBSERVED AND SIMULATED DAILY STREAMFLOWS
C              = 2  PLOT OF OBSERVED AND SIMULATED SOIL MOISTURE STORAGE
C              = 3  PLOT OF OBSERVED AND SIMULATED ET
C              = 4  PLOT OF OBSERVED AND SIMULATED MONTHLY FLOWS
C
      WRITE(14,10)HEAD
   10 FORMAT('1',1X,1H1,//,50X,A34,//)
      IND=0
      IS=0
      IF(IPLOT.EQ.1)WRITE(14,20)I,IYR
   20 FORMAT(1X,34X,' HYDROGRAPH OF OBSERVED(M) AND SIMULATED(S) DAILY
     *FLOWS',//,50X,'MONTH = ',I2,'  YEAR = ',I2,//,50X,'2 = SIMULATED F
     *LOW IN MM',//,50X,'1 = MEASURED FLOW IN MM'//)
      IF(IPLOT.EQ.2)WRITE(14,60)I,IYR
   60 FORMAT(1X,34X,'PLOT OF OBSERVED(M) AND SIMULATED(S) SOIL MOISTURE
     *STORAGE',//,50X,'MONTH = ',I2,'   YEAR = ',I2
     *,//,50X,'1=SIMULATED MOISTURE IN STORAGE 1',/
     *,50X,'2=SIMULATED MOISTURE IN STORAGE 2'/
     *50X,'3=OBSERVED MOISTURE IN A HORIZON'/
     *50X,'4=OBSERVED MOISTURE IN B HORIZON'/
     *50X,'0=VARIABLES OCCUPY THE SAME POSITION',//)
      IF(IPLOT.EQ.3)WRITE(14,80)I,IYR
   80 FORMAT(1X,34X,'PLOT OF OBSERVED (M) AND SIMULATED (S) ET',//,50X,
     *'MONTH = ',I2,'   YEAR = ',I2,//50X,'2 = SIMULATED ET',/50X,'1 = O
     *BSERVED ET',/50X,'0 = VARIABLES OCCUPY THE SAME POSITION',//)
      IF(IPLOT.EQ.4)WRITE(14,100)
  100 FORMAT(1X,34X,'PLOT OF OBSERVED (M) AND SIMULATED (S) MONTHLY FLOW
     *S',//50X,'2 = SIMULATED MONTHLY FLOW (MM)',/50X,'1 = MEASURED MONT
     *HLY FLOW (MM)',/50X,'0 = VARIABLES OCCUPY THE SAME POSITION',//)
C     WRITE HEADINGS FOR Y-AXIS
      WRITE(14,30)
   30 FORMAT(1X,'                         0         10         20         30
     *     40         50         60         70         80         90         1
     *00')
      WRITE(14,40)
   40 FORMAT(24X,10('---------+'))
C     PLOT ACCORDING TO SELECTED OPTION
      IF(IPLOT.EQ.1)THEN
        DO 50 IPL=2,NDYM+1
        Y=FLOAT(IPL-1)
        FF(1)=STRMFL(IPL)
        FF(2)=SIMSQ(IPL)
C********************************           CALL PLOT1(IND,IS,Y,SYBLQ,FF,2,F
   50   CONTINUE
      ENDIF
      IF(IPLOT.EQ.2)THEN
        DO 70 IPL=2,NDYM+1
        Y=FLOAT(IPL-1)
        FFS(1)=STO1(IPL)
        FFS(2)=STO2(IPL)
```

```
      FFS(3)=OBSTO1(IPL)
      FFS(4)=OBSTO2(IPL)
C*******************************         CALL PLOT1(IND,IS,Y,SYBL,FFS,4,F
   70   CONTINUE
      ENDIF
      IF(IPLOT.EQ.3)THEN
        DO 90 IPL=2,NDYM+1
        Y=FLOAT(IPL-1)
        FF(1)=ETLYS(IPL)*10.
        FF(2)=AET(IPL)*10.
C     "10" IS A SCALE-RELATED FACTOR
C*******************************         CALL PLOT1(IND,IS,Y,SYBLO,FF,2,F
   90   CONTINUE
      ENDIF
      IF(IPLOT.EQ.4)THEN
        DO 110 IPL=1,MNTALY
        Y=(FLOAT(MNPLV(IPL)))/100
        FF(1)=OBSOMX(IPL)
        FF(2)=SIMOMY(IPL)
C*******************************         CALL PLOT1(IND,IS,Y,SYBL,FF,2,FM
  110   CONTINUE
      ENDIF
C
      WRITE(14,40)
      WRITE(14,30)
      END
```

APPENDIX D.9

SUBROUTINE : PROBAB

(FILE : PRO1)

```
C     OPTION FOR SUMMARIES OF SIMULATED RUNOFF OR IRRIGATION REQUIREMENT
C     PROBABILITY ANALYSIS OF THE RESULTS
C
      SUBROUTINE PROBAB(FLAG,LMN,SCHED,EFFIRR,CONSTI)
C
      DIMENSION X(70),SDATA(70,13),VALUE(9),XMEAN(13),STD(13),CV(13),
     *PCTILE(9,13),PCENT(9),DIRRIG(70,13),DAMDAT(70,13),PDATA(70,13),
     *ODATA(70,13)
      CHARACTER IRRTYP(4)*18
      COMMON/PROB/SDATA,DIRRIG,DAMDAT,PDATA,ODATA
      DATA IRRTYP/'TO PLANNED DEFICIT','TO FIELD CAPACITY',
     *'BY FIXED AMOUNT','IN A CYCLE'/
      DATA PCENT/5.,10.,20.,33.,50.,67.,80.,90.,95./
C
C     ///////////////TRACE/////////////////////////
      WRITE(*,*)'SUBROUTINE PROBAB'
C     /////////////////////////////////////////////
C
      DO 30 I=1,13
      DO 10 J=1,LMN
      IF(FLAG.EQ.1.)X(J)=SDATA(J,I)
      IF(FLAG.EQ.2.)X(J)=DIRRIG(J,I)
      IF(FLAG.EQ.3.)X(J)=DAMDAT(J,I)
      IF(FLAG.EQ.4.)X(J)=PDATA(J,I)
   10 IF(FLAG.EQ.5.)X(J)=ODATA(J,I)
      N=LMN

      CALL STAT(X,N,AVE,SDEV,CVAR,VALUE)
 2001 WRITE(*,*)'RETURN FROM STAT!'
      XMEAN(I)=AVE
      STD(I)=SDEV
      CV(I)=CVAR
      DO 20 J=1,9
   20 PCTILE(J,I)=VALUE(J)
   30 CONTINUE
      IF(FLAG.EQ.1.)WRITE(14,40)
   40 FORMAT(1H1,//52X,'SIMULATED RUNOFF (MM)'/52X,21('-')/)
      IF(FLAG.EQ.2.)THEN
        WRITE(14,60)
   60   FORMAT(1H1,//49X,'IRRIGATION REQUIREMENTS (MM)'/49X,28('-')/)
      ISCHED=SCHED
        WRITE(14,50)IRRTYP(ISCHED),EFFIRR,CONSTI
   50   FORMAT(/5X,'IRRIGATION ',A18,/5X,'FIELD EFFICIENCY',36X,'=',
     *  F7.2,/5X,'AVAILABLE SOIL MOISTURE CONTENT AT STRESS THRESHOLD ='
     *  ,F7.2,//)
      ENDIF
      IF(FLAG.EQ.3.)WRITE(14,140)
  140 FORMAT(1H1,52X,'RESERVOIR STORAGE (%)',/53X,21('-')/)
      IF(FLAG.EQ.4.)WRITE(14,61)
   61 FORMAT(1H1,//50X,'MEASURED RAINFALL (MM)',/50X,22('-')/)
      IF(FLAG.EQ.5.)WRITE(14,62)
   62 FORMAT(1H1,//52X,'OBSERVED RUNOFF (MM)',/52X,20('-')/)
      WRITE(14,70)
   70 FORMAT(24X,'JAN',5X,'FEB',5X,'MAR',5X,'APR',5X,'MAY',5X,'JUN',
     *5X,'JUL',5X,'AUG',5X,'SEP',5X,'OCT',5X,'NOV',5X,'DEC',5X,'ANN'/)
      WRITE(14,80)(XMEAN(I),I=1,13)
   80 FORMAT(/16X,'MEAN',12F8.2,F9.2)
      WRITE(14,90)(STD(I),I=1,13)
   90 FORMAT(/2X,'STANDARD DEVIATION',12F8.2,F9.2)
      WRITE(14,100)(CV(I),I=1,13)
  100 FORMAT(/2X,'COEFF OF VARIATION',12F8.2,F9.2)
      WRITE(14,110)
  110 FORMAT(//52X,'PROBABILITY ANALYSIS'/52X,20('-')/)
      DO 130 J=1,9
      WRITE(14,120)PCENT(J),(PCTILE(J,I),I=1,13)
  120 FORMAT(/16X,F3.0,'%',12F8.2,F9.2)
  130 CONTINUE
```

APPENDIX D.10

SUBROUTINE : INITDY

(FILE : INDI1)

```
C     INITIALIZE DAILY ARRAYS
C
      SUBROUTINE INITDY(SMD,STORMQ,ERFL,ERFLIR,PLINT,STQIR,RAIN,RFL,
     *STRFL,STRMFL,TMIND,TMAXD,APAN,PAN,PANRES,DPE,SMOBS1,SMOBS2,
     *OBSTO1,
     *OBSTO2,ETLYS,ETLY,QPEAK,SEDYLD,IDAY,I,ETINT,APLIRR,APPIRR,DPEIR,
     *DAMET,STOIRO,SMDIR,REQIR,SURIR,STMQOB,STQOBS,QPKOB,QPKOBS,CFACD,
     *CFACTD,TDAY,TMLIND,TMITDD,EQPET,ELAID,LAIND,TMAXID,TMINID,SUPPIR, WG16/7
     *QUICKF)                                                           SJD
C
C     NOTE:  32 DAYS PER MONTH USED TO ENABLE CALCULATIONS TO
C     INCLUDE VALUES OF LAST DAY OF PREVIOUS MONTH
C
      DIMENSION APAN(12,32),APLIRR(32),APPIRR(32),CFACD(32),CFACTD(32),
     *DAMET(32),DPE(32),DPEIR(32),ELAID(12,32),ERFL(32),ERFLIR(32),     WG16/7
     *ETINT(32),ETLY(32),ETLYS(32),IDAY(32),OBSTO1(32),OBSTO2(32),
     *PAN(32),PANRES(32),PLINT(32),QPEAK(32),QPKOB(32),
     *QPKOBS(32),QUICKF(32),RAIN(32),REQIR(32),RFL(37),SEDYLD(32),      SJD
     *SMDIR(32),SMOBS1(32),SMOBS2(32),STMQOB(32),STOIRO(32),STORMQ(32),
     *STQIR(32),STQOBS(32),STRFL(32),STRMFL(32),SUPPIR(33),SURIR(32),   WG2811
     *TDAY(32),TMAXD(32),TMAXID(32),TMIND(32),TMINID(32),TMITDD(32),
     *TMLIND(32),SMD(32)
C
C     ///////////////TRACE//////////////////////////
C     ///////////////////////////////////////////////
C
      DO 10 K=1,32
      SMD(K)=0.0
      STORMQ(K)=0.0
      ERFL(K)=0.0
      ERFLIR(K)=0.0
      PLINT(K)=0.0
      STQIR(K)=0.0
      RAIN(K)=0.0
      RFL(K+5)=0.0
      STRFL(K)=0.0
      STRMFL(K)=0.0
      QUICKF(K)=0.0                                                     SJD
      TMAXID(K)=0.0                                                     WG16/7
      TMINID(K)=0.0                                                     WG16/7
      TMIND(K)=0.0
      TMAXD(K)=0.0
      IF(EQPET.EQ.4.)APAN(I,K)=0.0
      PAN(K)=0.0
      PANRES(K)=0.0
      DPE(K)=0.0
      DPEIR(K)=0.0
      ETINT(K)=0.0
      SMOBS1(K)=0.0
      SMOBS2(K)=0.0
      OBSTO1(K)=0.0
      OBSTO2(K)=0.0
      ETLYS(K)=0.0
      ETLY(K)=0.0
      QPEAK(K)=0.0
      SEDYLD(K)=0.0
      APLIRR(K)=0.0
      APPIRR(K)=0.0
      DAMET(K)=0.0
      STOIRO(K)=0.0
      SMDIR(K)=0.0
      REQIR(K)=0.0
      SURIR(K)=0.0
      SUPPIR(K)=0.0                                                     WG2111
      SUPPIR(33)=0.0                                                    WG15/1
      TDAY(I)=0.0
```

```
      TMLIND(I)=0.0
      TMITDD(I)=0.0
      STMOOB(K)=0.0
      STQOBS(K)=0.0
      QPKOBS(K)=0.0
      QPKOB(K)=0.0
      CFACD(K)=0.0
      CFACTD(K)=0.0
      IF(LAIND.EQ.2)ELAID(I,K)=0.0                                  WG16/7
   10 IDAY(K)=0
      END
```

APPENDIX D.11

SUBROUTINE : LDVIALS

(FILE : LDV1)

```
C      SOIL MOISTURE VALUES OF LAST DAY OF MONTH OR YEAR ARE STORED FOR USE ON
C      FIRST DAY OF NEXT MONTH OR YEAR
C
       SUBROUTINE LDVALS(SOIL1,SOIL2,SOILI,PLINTC,RCO,STCO,RFLC,EFPPT,
      *STODAM,PERDAM,ETDE,OVER,SUPP,IRRAPL,DEFCT1)                      SJD
C
       DIMENSION STO1(32),STO2(32),STOIR(32),PLINT(32),RUNCO(32),
      *STRMCO(32),RFL(37),ERFL(32),E(12),DEF1(32),DEF2(32),DAMSTO(32),
      *DAMPER(32),OVERFL(37),OVER(5),SUPPIR(33),RFLC(5)                 SJD
       COMMON/LDVAL/STOIR,PLINT,RUNCO,STRMCO,RFL,E,ERFL,DAMSTO,DAMPER,
      *OVERFL,SUPPIR                                                    WG15/1
       COMMON/PRINT/DEF1,DEF2,STO1,STO2
       COMMON/COUNT/I,IYR,NDYM,IYEAR,K
C
C      ///////////////TRACE//////////////////////////
C      WRITE(*,*)'SUBROUTINE LDVALS'
C      //////////////////////////////////////////////
C
       SOIL1=STO1(NDYM+1)
       SOIL2=STO2(NDYM+1)
       SOILI=STOIR(NDYM+1)
       PLINTC=PLINT(NDYM+1)
       RCO=RUNCO(NDYM+1)
       STCO=STRMCO(NDYM+1)
       EFPPT=ERFL(NDYM+1)
       DEFCT1=DEF1(NDYM+1)                                              SJD
       STODAM=DAMSTO(NDYM+1)
       PERDAM=DAMPER(NDYM+1)
       ETDE=E(12)
       DO 10 N=1,5                                                      WG2111
       RFLC(N)=RFL(NDYM+2-N+5)                                            SJD
    10 OVER(N)=OVERFL(NDYM+2-N+5)                                          .
       IF(IRRAPL.EQ.3)SUPP=SUPPIR(NDYM+2)                               WG15/1
       END
```

APPENDIX D.12

SUBROUTINE : PETEMP

(FILE : PET1)

```
                                                                        PET00010
C     PE ROUTINE                                                        PET00020
C                                                                       PET00030
      SUBROUTINE PETEMP(T,E)                                            PET00040
C                                                                       PET00050
      DIMENSION T(12),TMAX(12),TMIN(12),TI(12),E(12),DL(12),D(12),      PET00060
     *FACTOR(12),TMLIN(12),TMITD(12),WINDFA(12,3),DAYS(12)              PET00070
      COMMON/PTEMP/TEMP,TMAX,TMIN,EQPET,DL,D,LINWIN,ELEV,ALAT,WNDSPD    PET00080
      DATA DAYS/31.,28.,31.,30.,31.,30.,31.,31.,30.,31.,30.,31./        PET00090
      DATA WINDFA/19.,18.8,18.7,17.,14.8,14.6,15.4,18.7,20.4,20.7,      PET00100
     *20.,20.,  14.,13.,12.5,11.8,12.3,11.8,12.6,15.5,15.7,17.,16.,     PET00110
     *15.,  12.,12.,12.,10.2,10.6,10.7,11.,12.3,13.,13.,12.,12./        PET00120
C                                                                       PET00130
C     ////////////////TRACE//////////////////////////                   PET00140
      WRITE(*,*)'SUBROUTINE PETEMP'                                     PET00150
C     ///////////////////////////////////////////////                   PET00160
C                                                                       PET00170
    2 FORMAT(4X,'TEMP = ',F5.2)                                         PET00180
      IF(TEMP.EQ.0.)THEN                                                PET00190
        WRITE(14,10)                                                    PET00200
   10   FORMAT(//1X,'YOU HAVE MADE AN ERROR - YOU CANNOT REQUEST A TEMPEPET00210
     *RATURE BASED P.E. METHOD WITHOUT TEMPERATURE')                    PET00220
        STOP                                                            PET00230
      ENDIF                                                             PET00240
C                                                                       PET00250
C     CALCULATE MEAN TEMPERATURES                                       PET00260
C                                                                       PET00270
      DO 20 I=1,12                                                      PET00280
   20 T(I)=(TMAX(I)+TMIN(I))/2.                                         PET00290
C     SELECTION PE EQUATION (BY EQPET)                                  PET00300
      IF(EQPET.EQ.3.)THEN                                               PET00310
C     THORNTHWAITE METHOD                                               PET00320
C     CALCULATE ANNUAL HEAT INDEX (ANHEI) AND MONTHLY TEMPERATURE INDEX PET00330
        ANHEI=0.0                                                       PET00340
        DO 30 I=1,12                                                    PET00350
        TI(I)=(T(I)/5.0)**1.514                                         PET00360
   30   ANHEI=ANHEI+TI(I)                                               PET00370
C     CALCULATE THE INDEX A                                             PET00380
        A=0.49+0.0179*ANHEI-0.000077*ANHEI**2.0+0.000000675*ANHEI**3.0  PET00390
C     CALCULATE MONTHLY VALUES OF POTENTIAL EVAP. E(I) IN MM            PET00400
        DO 40 I=1,12                                                    PET00410
   40   E(I)=16.0*((10.0*T(I)/ANHEI)**A)*DL(I)                          PET00420
      ENDIF                                                             PET00430
      IF(EQPET.EQ.2.)THEN                                               PET00440
C     BLANEY CRIDDLE METHOD                                             PET00450
        DO 50 I=1,12                                                    PET00460
        E(I)=(0.142*T(I)+1.095)*(T(I)+17.8)*D(I)*10.0                   PET00470
        IF(T(I).LE.3.)E(I)=1.38*(T(I)+17.8)*D(I)*10.0                   PET00480
   50   CONTINUE                                                        PET00490
      ENDIF                                                             PET00500
      IF(EQPET.EQ.1.OR.EQPET.EQ.6.)THEN                                 PET00510
C     LINACRE MONTHLY METHOD                                            PET00520
C     SELECT WIND FACTOR FOR LINACRE EQUATION. IF NO REGIONAL FACTOR    PET00530
C     IS KNOWN, THE LINACRE VALUE OF 15 IS ASSUMED.                     PET00540
        DO 60 I=1,12                                                    PET00550
        IF(LINWIN.EQ.0)FACTOR(I)=15.                                    PET00560
        IF(LINWIN.EQ.1)FACTOR(I)=WINDFA(I,1)                            PET00570
        IF(LINWIN.EQ.2)FACTOR(I)=WINDFA(I,2)                            PET00580
        IF(LINWIN.EQ.3)FACTOR(I)=WINDFA(I,3)                            PET00590
        TMLIN(I)=T(I)+0.006*ELEV                                        PET00600
        TMITD(I)=0.0023*ELEV+0.37*T(I)+0.53*(TMAX(I)-TMIN(I))+0.35*     PET00610
     *  (T(1)-T(7))-10.9                                                PET00620
        IF(TMITD(I).LT.4.)TMITD(I)=4.                                   PET00630
C     OLD EQUATION                                                      PET00640
        IF(EQPET.EQ.1.)E(I)=(700.*TMLIN(I)/(100.-ALAT)+FACTOR(I)*       PET00650
     *  TMITD(I))/(80.-T(I))*DAYS(I)                                    PET00660
C     NEW EQUATION                                                      PET00670
```

```
      IF(EQPET.EQ.6.)E(I)=(650.*TMLIN(I)/(85.-ALAT)-56.+(5.+4.*       PET00680
     * WNDSPD)*TMITD(I))/(80.-T(I))*DAYS(I)                            PET00690
C     CONVERT VALUES FROM LAKE EVAPORATION TO PAN EVAPORATION WITH FACTOPET00700
C     1.00                                                             PET00710
      E(I)=E(I)*1.00                                                   PET00720
   60 CONTINUE                                                         PET00730
      ENDIF                                                            PET00740
      END                                                              PET00750
```

APPENDIX D.13

SUBROUTINE : PREVDY

(FILE : PRE1)

```
C     SET STORAGES FROM PREVIOUS DAYS' READINGS
C
      SUBROUTINE PREVDY(STO1,STO2,PLINT,RFL,ERFL,DEF1,DEF2,RUNCO,
     *STRMCO,STOIR,DAMSTO,DAMPER,OVERFL,SUPPIR,IRRAPL)               WG15/1
C
      DIMENSION STO1(32),STO2(32),PLINT(32),RFL(37),ERFL(32),        SJD
     *DEF1(32),DEF2(32),RUNCO(32),STRMCO(32),STOIR(32),DAMSTO(32),
     *OVERFL(37),OVER(5),SUPPIR(33),DAMPER(32),RFLC(5)               SJD
      COMMON/PRVDAY/SOIL1,SOIL2,PLINTC,RFLC,RCO,STCO,SOILI,EFPPT,STODAM,
     *PERDAM,OVER,SUPP,DEFCT1                                        SJD
C
C     ///////////////TRACE/////////////////////////
C     WRITE(*,*)'SUBROUTINE PREVDY'
C     /////////////////////////////////////////////
C
      K=2
      STO1(K-1)=SOIL1
      STO2(K-1)=SOIL2
      PLINT(K-1)=PLINTC
      ERFL(K-1)=EFPPT
      DEF1(K-1)=DEFCT1                                               SJD
      DEF2(K-1)=0.0
      RUNCO(K-1)=RCO
      STRMCO(K-1)=STCO
      STOIR(K-1)=SOILI
      DAMSTO(K-1)=STODAM
      DAMPER(K-1)=PERDAM
      DO 10 N=1,5                                                    WG2111
      RFL(K-N+5)=RFLC(N)                                                SJD
   10 OVERFL(K-N+5)=OVER(N)                                                .
      IF(IRRAPL.EQ.3)SUPPIR(K-1)=SUPP                                WG15/1
      END
```

APPENDIX D.14

SUBROUTINE : PRTDLY

(FILE : PRT1)

```
$STORAGE:2
$DEBUG

C     OPTION FOR PRINTING DAILY MOISTURE BUDGET WITH MONTHLY SUB-TOTALS
C
      SUBROUTINE PRTDLY(RESYLD,TOVERF,AET,TSUPIR)                       WG15/1
C
      DIMENSION AET(32),AETIR(32),AET1(32),AET2(32),APAN(12,32),
     *APPIRR(32),ASOEV(32),ATRAN1(32),ATRAN2(32),CAYD(12,32),CONSTA(32),
     *DAMPER(32),DAMSTO(32),DEF1(32),DEF2(32),DNO(32),DPE(32),DPEIR(32),
     *E(12),ERFL(32),ERFLIR(32),ETLYS(32),OBSTO1(32),OBSTO2(32),
     *OVERFL(37),PERC(32),PLINT(32),POSOEV(32),POTR1(32),POTR2(32),     WG5/11
     *PP1(32),PP2(32),QPEAK(32),QPKOBS(32),QUICKF(32),REQIR(32),        WG 1/8
     *RFL(37),RUN(32),RUNCO(32),SEDYLD(32),SIMSQ(32),SMDIR(32),         SJD
     *STOIR(32),STOIRO(32),STO1(32),STO2(32),STQIR(32),STRMCO(32),
     *STRMFL(32),SUPPIR(33),SURIR(32),SUR2(32),TAET(12),TAETIR(12),
     *TAET1(12),TAET2(12),TAPAN(12),TASOEV(12),TDISCH(12),TDPE(12),
     *TDPEIR(12),TERAIN(12),TETLYS(12),TE1(12),TE2(12),TIRRFL(12),
     *TOVERF(12),TPOSEV(12),TPOTR1(12),TPOTR2(12),TPTRAN(12),TQUICK(12),
     *TRAIN(12),TREQIR(12),TRQIR(12),TRUN(12),TSEDYD(12),TSTQIR(12),
     *TSTREM(12),TSUPIR(12),TSUR(12),TSURIR(12),TTRANS(12),TTRAN1(12),
     *TTRAN2(12)
      COMMON/LDVAL/STOIR,PLINT,RUNCO,STRMCO,RFL,E,ERFL,DAMSTO,DAMPER,
     *OVERFL,SUPPIR                                                     WG15/1
      COMMON/PRINT/DEF1,DEF2,STO1,STO2
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      COMMON/PRTMO/TRAIN,TERAIN,TDPE,TAET,TPOSEV,TASOEV,TPOTR1,
     *TPOTR2,TTRAN1,TTRAN2,TPTRAN,TTRANS,TSUR,TRUN,TQUICK,TDISCH,TSTREM,
     *TRQIR
      COMMON/PRNTDY/MOIST,DNO,PP1,PP2,DPE,AET1,AET2,OBSTO1,OBSTO2,RUN,
     *QUICKF,SIMSQ,STRMFL,REQIR,CONSTA,APAN,SUR2,PERC,PRIRR,EVTR,CAYD,  WG5/11
     *POSOEV,ASOEV,POTR1,POTR2,ATRAN1,ATRAN2,ETLYS,QPEAK,SEDYLD,QPKOBS  WG 1/8
      COMMON/TOTALS/TE1,TE2,TAET1,TAET2,TAPAN,TETLYS,TSEDYD
      COMMON/IRRIGA/AETIR,SMDIR,STQIR,ERFLIR,STOIRO,SURIR,TAETIR,TSTQIR,
     *TIRRFL,TSURIR,TREQIR,DPEIR,TDPEIR,APPIRR,ICYCLE,ISTART             WG30/5
      COMMON/RNKING/IVENT,EVENT,IRANK,NOYRS,ISCS                         SJD
C
C      ///////////////////////////////////////////////////////////////////
       WRITE(*,*)'SUBROUTINE PRTDLY'
C      ///////////////////////////////\\\\\\\\\\\\\\\\\\\/////////////////////
C      CHECK IF DAILY OUTPUT TO INCLUDE OBSERVED SOIL-MOISTURE DATA
       IF(MOIST.EQ.1.AND.PRIRR.EQ.0.)THEN
       WRITE(6,10)I,IYR
   10 FORMAT(1H1,1X,'DAILY MOISTURE BUDGET OF MONTH ',I2,', YEAR ',I2,//
     *1X,'DAY RAIN ERAIN APAN CAYD PET1 PET2 AE1 AE2 ETLYS STO1 OST1 STOWG19/7
     *2 OST2 DEF1 DEF2 BSFLO RUNCO  STORM SIMSQ OBSERQ   IRR CONST'/)   WG5/11
       DO 30 K=2,(NDYM+1)
       WRITE(6,20)DNO(K),RFL(K+5),ERFL(K),APAN(I,K),CAYD(I,K-1),PP1(K),
     *PP2(K),AET1(K),AET2(K),ETLYS(K),STO1(K),OBSTO1(K),STO2(K),
     *OBSTO2(K),DEF1(K),DEF2(K),RUN(K),RUNCO(K),QUICKF(K),SIMSQ(K),
     *STRMFL(K),REQIR(K),CONSTA(K)                                      WG5/11
   20 FORMAT(1X,F3.0,F5.1,F6.1,F5.1,F5.3,2F5.1,2F4.1,F6.2,6F5.1,2F6.2,
     *F7.2,F6.2,F7.2,2F6.2)
   30 CONTINUE
       WRITE(6,230)
       WRITE(6,40)TRAIN(I),TERAIN(I),TAPAN(I),TE1(I),TE2(I),TAET1(I),
     *TAET2(I),TETLYS(I),TRUN(I),TQUICK(I),TDISCH(I),TSTREM(I),TRQIR(I)
   40 FORMAT(1X,2X,2F6.1,F5.1,4X,2F5.0,2F4.0,F7.2,29X,F7.2,5X,F7.1,F6.1,
     *F7.1,F7.2)
       ENDIF
C      - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
       IF(MOIST.EQ.0.AND.PRIRR.EQ.0.AND.EVTR.EQ.1.AND.RESYLD.EQ.0.)THEN
       WRITE(6,50)I,IYR
   50 FORMAT(/1X,'DAILY MOISTURE BUDGET OF MONTH ',I2,', YEAR 19',I2,/,
     *45('-')/)
       WRITE(6,60)
   60 FORMAT(9X,'EFFEC-  A-',22X,2(' SOIL '),'DEF- DEF-',7X,'UNSAT BASE'WG1112
```

```
     *,14X,'RUNOFF   STRESS    PEAK',/5X,'RAIN TIVE  PAN CROP PET PET AEWG 2/8
     *T AET STORE STORE ICIT ICIT DRAIN DRAIN FLOW BASE STORM SIMU- OBSEWG1112
     *R FRAC-  DISCHARGE  SED',/1X,'DAY FALL RAIN EQIV FACT "A" "B" "A" WG 2/8
     *"B" "A"  "B" "A" "B" -AGE -AGE STORE FLOW FLOW  LATED -VED  WG1112
     *TION  ESTD  OBSD  YLD'/)                                    WG 2/8
C     IF(IVENT.EQ.1)THEN                                          SJD
C       WRITE(15,50)I,IYR                                           .
C       WRITE(15,60)                                                .
C     ENDIF                                                       SJD
      DO 100 K=2,(NDYM+1)
C     IF(IVENT.EQ.1)THEN                                          SJD
C       IF(RFL(K+5).GT.EVENT)THEN                                     .
C         NOCNT=7                                                   .
C         WRITE(15,70)DNO(K-1),RFL(K-1+5),STO1(K-1),STO2(K-1),DEF1(K-1),  .
C    *    DEF2(K-1)                                                 .
C 70      FORMAT(1X,F3.0,F5.1,2F6.1,2F5.1)                          .
C         WRITE(14,80)IYR,I,RFL(K+5),DEF1(K-1),SIMSQ(K),STRMFL(K)       .
C 80      FORMAT(1X,2(1X,I2),2(1X,F5.1),2(1X,F5.2))                 .
C       ENDIF                                                       .
C       WRITE(15,230)                                               .
C       WRITE(15,110)TRAIN(I),TERAIN(I),TAPAN(I),TE1(I),TE2(I),TAET1(I), .
C    *  TAET2(I),TSUR(I),TRUN(I),TQUICK(I),TDISCH(I),TSTREM(I),TSEDYD(I) .
C     ENDIF                                                         .
C     IF(IVENT.EQ.2)THEN                                            .
C       IF(STRMFL(K).GT.EVENT)WRITE(14,80)IYR,I,RFL(K+5),DEF1(K-1),     .
C    *  SIMSQ(K),STRMFL(K)                                          .
C     ENDIF                                                         .
C     IF(NOCNT.GT.0)WRITE(15,90)DNO(K),RFL(K+5),ERFL(K),APAN(I,K),    .
C    *CAYD(I,K-1),PP1(K),PP2(K),AET1(K),AET2(K),STO1(K),STO2(K),DEF1(K),  .
C    *DEF2(K),SUR2(K),PERC(K),RUNCO(K),RUN(K),QUICKF(K),SIMSQ(K),     .
C    *STRMFL(K),CONSTA(K),QPEAK(K),QPKOBS(K),SEDYLD(K)              .
C     NOCNT=NOCNT-1                                               SJD
      WRITE(6,90)DNO(K),RFL(K+5),ERFL(K),APAN(I,K),CAYD(I,K-1),PP1(K),
     *PP2(K),AET1(K),AET2(K),STO1(K),STO2(K),DEF1(K),DEF2(K),SUR2(K),   WG1112
     *PERC(K),RUNCO(K),RUN(K),QUICKF(K),SIMSQ(K),STRMFL(K),CONSTA(K),   WG 1/8
     *QPEAK(K),QPKOBS(K),SEDYLD(K)
   90 FORMAT(1X,F3.0,3F5.1,F5.2,4F4.1,2F6.1,2F5.1,1X,2F5.2,F6.2,F5.2,   WG1112
     *3F6.2,F5.2,2F6.2,F5.1)                                        WG 1/8
  100 CONTINUE
      WRITE(6,230)
      WRITE(6,110)TRAIN(I),TERAIN(I),TAPAN(I),TE1(I),TE2(I),TAET1(I),
     *TAET2(I),TSUR(I),TRUN(I),TQUICK(I),TDISCH(I),TSTREM(I),TSEDYD(I)
  110 FORMAT(4X,3F5.1,4X,F5.1,3F4.1,22X,F6.2,10X,4F6.2,15X,F7.1)      WG1112
      ENDIF
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      IF(RESYLD.EQ.1.AND.PRIRR.EQ.0.)THEN                         WG2811
      WRITE(6,50)I,IYR
      WRITE(6,260)
  260 FORMAT(13X,'EFFECTIVE',13X,2(1X,'S.M.C.'),3X,'DEF.   DEF.   DRAIN
     *  BASE   STORM   EST.   OBS.  REQD.  SUPP.  OVER   DAM',/1X,'DAY',WG2811
     *2(1X,'RAINFALL'),3X,'PET    AET',2(2X,'A-HOR  B-HOR'),4X,'AGE ',2(
     *3X,'FLOW'),2X,2('RUNOFF',1X),2('IRRIGN',1X),' FLOW   (%)'/)    WG2811
      DO 280 K=2,(NDYM+1)
      WRITE(6,270)DNO(K),RFL(K+5),ERFL(K),DPE(K),AET(K),STO1(K),STO2(K),
     *DEF1(K),DEF2(K),SUR2(K),RUN(K),QUICKF(K),SIMSQ(K),STRMFL(K),
     *REQIR(K),SUPPIR(K),OVERFL(K+5),DAMPER(K)                       WG2811
  270 FORMAT(1X,F3.0,F8.1,F9.1,6F7.1,2F8.3,5F7.1,2F6.1)              WG2811
  280 CONTINUE
      WRITE(6,230)
      WRITE(6,290)TRAIN(I),TERAIN(I),TDPE(I),TAET(I),TSUR(I),TRUN(I),
     *TQUICK(I),TDISCH(I),TSTREM(I),TRQIR(I),TSUPIR(I),TOVERF(I)      WG2811
  290 FORMAT(4X,F8.1,F9.1,2F7.1,28X,2F8.3,5F7.1,F6.1)                WG2811
      ENDIF
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      IF(MOIST.EQ.0.AND.PRIRR.EQ.0.AND.EVTR.EQ.2.)THEN
      WRITE(6,50)I,IYR
      WRITE(6,120)
```

```
120 FORMAT(9X,'EFFEC-',12X,'SOIL EVAP   TRANSPIRATION    SOIL  SOIL  D
   *EF- DEF-',8X,'UNSAT  BASE',14X,'SIMU-  OBSER- STRESS',/5X,'RAIN TI
   *VE A-PAN  CROP',11X,'POT  POT  ACT  ACT MOIST MOIST ICIT ICIT  DRA
   *IN DRAIN  FLOW  BASE  STORM LATED   VED   FRAC-',/1X,'DAY FALL RAI
   *N EQUIV  FACT POT  ACT  "A"  "B"  "A"  "B" A-HOR B-HOR "A" "B"   -
   *AGE  -AGE  STORE  FLOW  FLOW  RUNOFF RUNOFF TION'/)
    DO 160 K=2,(NDYM+1)
    WRITE(6,150)DNO(K),RFL(K+5),ERFL(K),APAN(I,K),CAYD(I,K-1),
   *POSOEV(K),ASOEV(K),POTR1(K),POTR2(K),ATRAN1(K),ATRAN2(K),STO1(K),
   *STO2(K),DEF1(K),DEF2(K),SUR2(K),PERC(K),RUNCO(K),RUN(K),QUICKF(K),
   *SIMSQ(K),STRMFL(K),CONSTA(K)
150 FORMAT(1X,F3.0,2F5.1,1X,F5.1,1X,F5.3,F4.1,5F5.1,2F6.1,2F5.1,1X,
   *3F6.2,F6.3,3F7.3,F4.1)
160 CONTINUE
    WRITE(6,230)
    WRITE(6,170)TRAIN(I),TERAIN(I),TAPAN(I),TPOSEV(I),TASOEV(I),
   *TPOTR1(I),TPOTR2(I),TTRAN1(I),TTRAN2(I),TSUR(I),TRUN(I),TQUICK(I),
   *TDISCH(I),TSTREM(I)
170 FORMAT(4X,2F5.1,F6.1,5X,6F5.1,23X,F6.2,12X,F6.2,3F7.3)
    ENDIF
C   - - - - - - - - - - - - - - - - - - - - - - - - - - - -
    IF(PRIRR.EQ.1.)THEN
    WRITE(6,180)I,IYR
180 FORMAT(/1X,'DAILY MOISTURE BUDGET FOR IRRIGATION ROUTINE FOR MONTH
   * ',I2,' YEAR 19',I2,/)
    WRITE(6,190)
190 FORMAT(34X,'IRRIGN',10X,'FINAL',17X,'EFFEC.',/7X,'RAIN  EFFEC',16XWG2811
   *,'SOIL    PERC/   SOIL    STORM  IRRIGN  IRRIGN',/1X,'DAY    FALL     .
   *RAIN PET-IR AET-IR DEFICIT RECHRGE STORAGE  FLOW REQMENT APPLICN')    .
    DO 220 K=2,(NDYM+1)
    WRITE(6,210)DNO(K),RFL(K+5),ERFLIR(K),DPEIR(K),AETIR(K),SMDIR(K),
   *SURIR(K),STOIR(K),STQIR(K),REQIR(K),SUPPIR(K)                        .
210 FORMAT(1X,F3.0,4(2X,F5.1),3(2X,F6.1),F6.1,2(2X,F6.1))                .
220 CONTINUE
    WRITE(6,230)
230 FORMAT(1X,130('-'))
    WRITE(6,240)TRAIN(I),TIRRFL(I),TDPEIR(I),TAETIR(I),TSURIR(I),         .
   *TSTQIR(I),TREQIR(I),TSUPIR(I)                                         .
240 FORMAT(4X,4(F7.1),10X,F6.1,6X,3(F8.1))                          WG4/12
    ENDIF
    END
```

APPENDIX D.15

SUBROUTINE : RICHIE

(FILE : RIC1)

```
C     CALCULATE TRANSPIRATION AND SOIL EVAPORATION SEPARATELY BY THE RITCHIE
C     (1972) APPROACH
C
      SUBROUTINE RICHIE(CAYD,POSOEV,PANRES,ERFL,ASOEV,STO1,POTRAN,POTR1,
     *POTR2,ROOTA,ROOTB,CONST,ATRAN1,ATRAN2,AET1,AET2,AET,STO2,ETINT,
     *ATRANS,PLSTRS,ELAID)                                              WG16/7
C
      DIMENSION CAYD(12,32),EXX(32),ELAID(12,32),POSOEV(32),PANRES(32), WG16/7
     *ERFL(32),ESRFL(32),ASOEV(32),ASOEVD(32),STO1(32),POTRAN(32),
     *POTR1(32),POTR2(32),ROOTA(12),ROOTB(12),ATRAN1(32),AET1(32),
     *STO2(32),ATRAN2(32),AET2(32),ETINT(32),AET(32),ATRANS(32),
     *PLSTRS(32)
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      COMMON/RITCHI/SUESW,SUESD,DYSIRA,UPLISO,ALFASO,LAIND              WG16/7
      COMMON/SOIL/PAW1,PAW2,SMWP1,SMWP2,SMFC1,SMFC2,SMWPIR,PAWIR,SMFCIR WG8/11
C
C     ///////////////TRACE/////////////////////////
      WRITE(*,*)'SUBROUTINE RICHIE'
C     ///////////////////////////////////////////////
C
      IF(LAIND.EQ.0)THEN                                                WG16/7
C     FIRST CALCULATE LEAF AREA INDEX FOR THE DAY FROM CROPPING FACTOR
C     (WITH 0.3 < CAYD < 1.06)
      IF(CAYD(I,K-1).LT.0.3)CAYD(I,K-1)=0.3
      IF(CAYD(I,K-1).GT.1.06)CAYD(I,K-1)=1.06
      EXX(K)=1.+(CAYD(I,K-1)-0.3)*11./0.76
      ELAID(I,K)=1.32+1.29*SIN(30*EXX(K)+137.3)+0.78*SIN(60*EXX(K)+     WG16/7
     *133.6)                                                            WG16/7
      ENDIF
C     ASSUME THAT INTERCEPTED WATER FROM THE PREVIOUS DAY HAS BEEN EVAPORATED
C     I.E. APAN(I,K) IS REFERRED TO AS PANRES(K), THE APAN RESIDUAL
C     CALCULATE POTENTIAL SOIL EVAPORATION
      POSOEV(K)=PANRES(K)*EXP(ELAID(I,K)*(-0.4))
      IF(POSOEV(K).GT.PANRES(K))POSOEV(K)=PANRES(K)
C     CALCULATE ACTUAL SOIL EVAPORATION BY THE RITCHIE ROUTINE
      IF(SUESW.LT.UPLISO)THEN
        IF(ERFL(K-1).GE.SUESW)THEN
          SUESW=0.0
        ELSE
          SUESW=SUESW-ERFL(K-1)
        ENDIF
      ELSE
        IF(ERFL(K-1).GE.SUESD)THEN
          ESRFL(K-1)=ERFL(K-1)-SUESD
          SUESW=UPLISO-ESRFL(K-1)
          IF(ESRFL(K-1).GT.UPLISO)SUESW=0.0
        ELSE
          GO TO 10
        ENDIF
      ENDIF
      SUESW=SUESW+POSOEV(K)
      IF(SUESW.GT.UPLISO)THEN
        ASOEV(K)=POSOEV(K)-0.4*(SUESW-UPLISO)
        SUESD=0.6*(SUESW-UPLISO)
        DYSIRA=(SUESD/ALFASO)**2
      ELSE
        ASOEV(K)=POSOEV(K)
      ENDIF
      GO TO 20
   10 DYSIRA=DYSIRA+1
      ASOEV(K)=ALFASO*SQRT(DYSIRA)-ALFASO*SQRT(DYSIRA-1)
      IF(ERFL(K-1).GT.0.0)THEN
        ASOEVD(K)=0.8*ERFL(K-1)
        IF(ASOEVD(K).LE.ASOEV(K))ASOEVD(K)=ASOEV(K)+ERFL(K-1)
        IF(ASOEVD(K).GT.POSOEV(K))ASOEVD(K)=ASOEV(K)
        ASOEV(K)=ASOEVD(K)
      ELSE
```

```
        IF(ASOEV(K).GT.POSOEV(K))ASOEV(K)=POSOEV(K)
      ENDIF
      SUESD=SUESD+ASOEV(K)-ERFL(K-1)
      DYSIRA=(SUESD/ALFASO)**2
C     CALCULATE SOIL STORAGE AFTER SOIL EVAPORATION ALONE
   20 STO1(K)=STO1(K-1)-ASOEV(K)
C     CALCULATE TOTAL POTENTIAL TRANSPIRATION
      IF(ELAID(I,K).GE.0.1)THEN                                  WG16/7
        IF(ELAID(I,K).GE.2.7)THEN                                WG16/7
          POTRAN(K)=PANRES(K)-ASOEV(K)
        ELSE
          POTRAN(K)=PANRES(K)*(0.7*SQRT(ELAID(I,K))-0.21)        WG16/7
          IF(POTRAN(K).GT.PANRES(K)-ASOEV(K))POTRAN(K)=PANRES(K)-
     *    ASOEV(K)
        ENDIF
      ELSE
        POTRAN(K)=0.0
      ENDIF
C     APPORTION TOTAL POTENTIAL TRANSPIRATION TO A- AND B-HORIZONS
      POTR1(K)=POTRAN(K)*ROOTA(I)
      POTR2(K)=POTRAN(K)*ROOTB(I)
C     CALCULATE AET (ASOEV + ATRANS) FOR A-HORIZON
C
C     CHECK FOR WATER STRESS IN A-HORIZON
      IF(STO1(K).GE.(PAW1*CONST+SMWP1))THEN
C     NO STRESS, THEREFORE ACTUAL = POTENTIAL TRANSPIRATION
        ATRAN1(K)=POTR1(K)
      ELSE
C     STRESS SITUATION, THEREFORE ACTUAL < POTENTIAL TRANSPIRATION
        ATRAN1(K)=POTR1(K)*(STO1(K)-SMWP1)/(PAW1*CONST)
      ENDIF
      AET1(K)=ATRAN1(K)+ASOEV(K)
      STO1(K)=STO1(K-1)-AET1(K)
C     CALCULATE AET FOR B-HORIZON
      IF(STO2(K-1).GE.(PAW2*CONST+SMWP2))THEN
        ATRAN2(K)=POTR2(K)
      ELSE
        ATRAN2(K)=POTR2(K)*(STO2(K-1)-SMWP2)/(PAW2*CONST)
      ENDIF
      AET2(K)=ATRAN2(K)
      STO2(K)=STO2(K-1)-AET2(K)
      AET(K)=AET1(K)+AET2(K)+ETINT(K)
      ATRANS(K)=ATRAN1(K)+ATRAN2(K)
C     CHECK FOR STRESS
      IF(ATRANS(K).GE.(0.5*POTRAN(K)))THEN
        PLSTRS(K)=0.0
      ELSE
        PLSTRS(K)=1.0
      ENDIF
      END
```

APPENDIX D.16

SUBROUTINE : STAT

(FILE : STA1)

```
C     SUBROUTINE TO PERFORM STATISTICAL CALCULATIONS ON DATA
C
      SUBROUTINE STAT(X,N,AVE,SDEV,CVAR,VALUE)
C
      DIMENSION X(70),VALUE(9),PCPT(9)
      DATA PCPT/5.,10.,20.,33.,50.,67.,80.,90.,95./
C
C     THIS SUBROUTINE CALCULATES THE MEAN, STANDARD DEVIATION AND
C     COEFFICIENT OF VARIATION.
C     ///////////////TRACE/////////////////////////
      WRITE(*,*)'SUBROUTINE STAT'
C     ////////////////////////////////////////////
C
      XTOT=0.
      SSX=0.
      DO 10 J=1,N
      XTOT=XTOT+X(J)
   10 SSX=SSX+X(J)**2.
      XL=FLOAT(N)
      SDEV=SQRT((SSX-(XTOT**2./XL))/(XL-1.))
      AVE=XTOT/XL
      IF (AVE.EQ.0.0)THEN
        CVAR=99.9
      ELSE
          CVAR=(SDEV/AVE)*100.
      ENDIF
C
C     SORT VALUES IN ASCENDING ORDER
      NK=N-1
      DO 20 J=1,NK
      LEAST=J
      NB=J+1
      DO 15 K=NB,N
   15 IF(X(K).LE.X(LEAST))LEAST=K
      XTEMP=X(LEAST)
      X(LEAST)=X(J)
   20 X(J)=XTEMP
C
C     CALCULATE MEDIAN AND PERCENTAGE POINTS
      DO 30 J=1,9
      EVENT=XL/100.*PCPT(J)
      IF(EVENT.LT.1)EVENT=1.05
      JK=IFIX(EVENT)
      DECPL=EVENT-FLOAT(JK)
   30 VALUE(J)=X(JK)+(X(JK+1)-X(JK))*DECPL
      END
```

APPENDIX D.17

SUBROUTINE : UNSAT

(FILE : UNS1)

```
C      UNSATURATED SOIL MOISTURE REDISTRIBUTION.
C
       SUBROUTINE UNSAT(PERC,RUNCO)                                    WG5/11
C
       DIMENSION STO1(32),STO2(32),REDAB(32),REDBA(32),DEF1(32),DEF2(32),
      *PERC(32),RUNCO(32)                                              WG5/11
       COMMON/COUNT/I,IYR,NDYM,IYEAR,K
       COMMON/PRINT/DEF1,DEF2,STO1,STO2
       COMMON/SOIL/PAW1,PAW2,SMWP1,SMWP2,SMFC1,SMFC2,SMWPIR,PAWIR,SMFCIR
C
C      SOIL MOISTURE REDISTRIBUTION IS A FUNCTION OF SOIL MOISTURE GRADIENT
C      WHICH IS EXPRESSED AS A PROPORTION OF SOIL MOISTURE CONTENT TO PLANT
C      AVAILABLE WATER.
C      FRSMA = FRACTION OF SOIL MOISTURE IN A HORIZON
C
C      ///////////////TRACE//////////////////////////
       WRITE(*,*)'SUBROUTINE UNSAT'
C      //////////////////////////////////////////////
C
       FRSMA=STO1(K)/SMFC1
       FRSMB=STO2(K)/SMFC2
       FRSMC=((SMFC2-SMWP2)/2.+SMWP2)/SMFC2
C      DOWNWARD UNSATURATED REDISTRIBUTION - ONLY IF ALL HORIZONS ARE BELOW
C      FIELD CAPACITY
       IF(SMFC1.GT.STO1(K).AND.SMFC2.GT.STO2(K))THEN
C      CHECK WHETHER  A HORIZON IS MORE MOIST THAN B HORIZON
         IF(FRSMA.GE.FRSMB)THEN
C      REDISTRIBUTION FACTOR A TO B IS AT 2% PER DAY (REFAB)
           REFAB=0.02
           REDAB(K)=STO1(K)*REFAB*(FRSMA-FRSMB)
C      RESET SOIL MOISTURE FOR A AND B HORIZONS
           STO1(K)=STO1(K)-REDAB(K)
           STO2(K)=STO2(K)+REDAB(K)
           REDBA(K)=0.0
           DEF1(K)=SMFC1-STO1(K)
           DEF2(K)=SMFC2-STO2(K)
         ELSE
C      UPWARD REDISTRIBUTION IF B HORIZON MORE MOIST THAN A HORIZON
           REFBA=0.01
           REDBA(K)=REFBA*STO2(K)*(FRSMB-FRSMA)
           STO1(K)=STO1(K)+REDBA(K)
           STO2(K)=STO2(K)-REDBA(K)
           REDAB(K)=0.0
           DEF1(K)=SMFC1-STO1(K)
           DEF2(K)=SMFC2-STO2(K)
         ENDIF
       ENDIF
C      IF B HORIZON IS MOISTER THAN 50% PAW, UNSATURATED PERCOLATION TAKES
C      PLACE OUT OF 'B' INTO GROUNDWATER ZONE
       PERCFC=0.0001
       IF(FRSMB.GT.FRSMC)THEN
         UNSDRN=STO2(K)*PERCFC*(FRSMB-FRSMC)                           WG5/11
         PERC(K)=PERC(K)+UNSDRN                                        WG5/11
         STO2(K)=STO2(K)-UNSDRN                                        WG5/11
         DEF2(K)=SMFC2-STO2(K)
C      ADJUST BASEFLOW STORE
         RUNCO(K)=RUNCO(K)+UNSDRN                                      WG5/11
       ELSE
         UNSDRN=0.0                                                    WG5/11
       ENDIF
       END
```

APPENDIX D.18

SUBROUTINE : IRRIGW

(FILE : IRRIG3)

```
$STORAGE:2
$DEBUG

C     CALCULATE IRRIGATION REQUIREMENTS
C
      SUBROUTINE IRRIGW(STOIR,REQIR,EFFIRR,IRRAPL,CONLOS,FAMLOS,IRRMON,  WG4/11
     *BFRESP,CONSTI,SCHED,PLADEF,AMTIR,RESYLD,HAIRR,DAMSTO,SMPOIR,      WG8/11
     *RFLIR,COIAM,VEGINT,SUPPIR,OVERFL,OVR,OVERAC)                      WG2811
C
      DIMENSION AETIR(32),APPIRR(32),DAMSTO(32),DPEIR(32),ERFLIR(32),   WG4/11
     *HAIRR(12),IRRMON(12),OVERAC(32),OVERFL(37),REQIR(32),RFLIR(32),   WG1112
     *SMDIR(32),STOIR(32),STOIRO(32),STOIR(32),SUPPIR(33),SURIR(32),    WG15/1
     *TAETIR(12),TDPEIR(12),TIRRFL(12),TREQIR(12),TSTOIR(12),TSURIR(12),WG4/11
     *VEGINT(12),COIAM(12)
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      COMMON/SOIL/PAW1,PAW2,SMWP1,SMWP2,SMFC1,SMFC2,SMWPIR,PAWIR,SMFCIR WG8/11
      COMMON/IRRIGA/AETIR,SMDIR,STOIR,ERFLIR,STOIRO,SURIR,TAETIR,TSTOIR,
     *TIRRFL,TSURIR,TREQIR,DPEIR,TDPEIR,APPIRR,ICYCLE,ISTART            WG30/5
C     'OVR' IS A CHECK FOR WHETHER OVERFLOW HAS BEEN READJUSTED OR NOT
C     IF OVR = 0  UNCHANGED
C            = 1  CHANGED
      OVR=0.                                                            WG2711
      OVRREM=0.                                                         WG2711
C
C     CALCULATE AET FOR IRRIGATION
C
      IF(STOIR(K-1).GE.(PAWIR*CONSTI+SMWPIR))THEN                       WG8/11
        AETIR(K)=DPEIR(K)
      ELSE
        AETIR(K)=DPEIR(K)*(STOIR(K-1)-SMWPIR)/(PAWIR*CONSTI)            WG8/11
      ENDIF
      STOIR(K)=STOIR(K-1)-AETIR(K)
      IF(STOIR(K).LT.SMWPIR)STOIR(K)=SMWPIR                             WG2111
C
C     ABSTRACT STORMFLOW BY SCS-SMB MODEL FOR ANY AMOUNT OF RAINFALL AND THEN
C     CALCULATE SOIL STORAGE
C
C     SOIL MOISTURE DEFICIT OF A-HORIZON CONSIDERED FOR STORMFLOW CALCULATIONS
      SMDIR(K)=(SMPOIR-STOIR(K))*0.3                                    WG8/11
      IF(SMDIR(K).LT.0.)SMDIR(K)=0.0
C
C     CHECK THAT RAINFALL > INITIAL ABSTRACTION
      IF(RFLIR(K).GT.COIAM(I)*SMDIR(K))THEN
        STOIR(K)=(RFLIR(K)-COIAM(I)*SMDIR(K))**2/(RFLIR(K)-COIAM(I)*
     *  SMDIR(K)+SMDIR(K))
        ERFLIR(K)=RFLIR(K)-STOIR(K)
      ELSE
        IF(RFLIR(K).GT.0.AND.RFLIR(K).GE.VEGINT(I))ERFLIR(K)=RFLIR(K)-
     *  VEGINT(I)
      ENDIF
      STOIR(K)=STOIR(K)+ERFLIR(K)
      STOIRO(K)=STOIR(K)
C
C     CALCULATE HOW MUCH IRRIGATION WATER HAS BEEN APPLIED
      IF(IRRAPL.EQ.1)THEN
        SUPPIR(K)=APPIRR(K)*(1.0-CONLOS)*(1.0-FAMLOS)*EFFIRR            WG2111
        STOIR(K)=STOIR(K)+SUPPIR(K)                                     WG2111
      ENDIF
C
C     CHECK WHETHER SOIL STORAGE IS ABOVE FIELD CAPACITY
      IF(STOIR(K).GT.SMFCIR.AND.SCHED.NE.4.)THEN                        WG17/7
        SURIR(K)=BFRESP*(STOIR(K)-SMFCIR)                               WG8/11
        STOIR(K)=SMFCIR+(1.-BFRESP)*(STOIR(K)-SMFCIR)                   WG8/11
        GO TO 50
      ENDIF
C     IF NO CROP GROWING (IRRMON(I)=0), NO IRRIGATON REQUIREMENT NEEDS TO BE
C     CALCULATED, THEREFORE SKIP THIS SECTION
```

```
      IF(IRRMON(I).EQ.0)GO TO 50
C
C     IRRIGATION APPLICATION IN SET CYCLE
      IF(SCHED.EQ.4.)THEN                                                PF30/5
C       IF RAINFALL > CYCLE APPLICATION, RESTART CYCLE
        IF(RFLIR(K).GE.AMTIR)ISTART=-1                                   PF30/5
        ISTART=ISTART+1                                                  PF30/5
        IF(ISTART.EQ.ICYCLE)THEN                                         PF30/5
          REQIR(K)=AMTIR                                                 PF30/5
          ISTART=0                                                       PF30/5
          GO TO 41                                                       WG12/8
        ENDIF                                                            PF30/5
        GO TO 50                                                         PF30/5
      ENDIF
C
      IF(STOIR(K).GT.(PAWIR*CONST(+SMWPIR))GO TO 50                      WG12/8
C     STORAGE IS NOW BETWEEN FIELD CAPACITY AND WILTING POINT, THEREFORE
C     IRRIGATION IS REQUIRED
C     CHECK WHAT TYPE OF IRRIGATION SCHEDULING IS TO BE USED
      IF(SCHED-2)20,30,40
C     SCHEDULE IS A PLANNED DEFICIT TO E.G. 0.8 FIELD CAPACITY
   20 REQIR(K)=PAWIR*PLADEF+SMWPIR-STOIR(K)                              WG8/11
      GO TO 41                                                           WG2/12
C     SCHEDULE IS TO IRRIGATE TO FIELD CAPACITY
   30 REQIR(K)=PAWIR+SMWPIR-STOIR(K)                                     WG8/11
      GO TO 41                                                           WG2/12
C     SCHEDULE IS TO IRRIGATE A FIXED AMOUNT, AMTIR (EG 25MM)
   40 REQIR(K)=AMTIR
   41 IF(IRRAPL.EQ.1.OR.IRRAPL.EQ.3)GO TO 50                            WG3/12
C     CALCULATE ACTUAL AMOUNT REQUIRED AS ABSTRACTION TO SUPPLY REQIR(K)
      XREQIR=REQIR(K)/(1.-CONLOS)/(1.-FAMLOS)/EFFIRR                     WG2111
C     SELECT THE CORRECT IRRIGATION OPTION (IRRAPL) FOR ESTIMATING
C     SUPPLEMENTARY IRRIGATION REQUIREMENTS
      IF(IRRAPL.EQ.0)THEN                                                WG2111
        IF(RESYLD.EQ.0.)THEN                                                  .
C     ..................................................................
C          logic change lja 10/11/86 the following line changed from
C         SUPPIR(K)=XREQIR to :-
C     ..................................................................
          SUPPIR(K)=REQIR(K)                                                  .
C     ..................................................................
        ELSE                                                                  .
C       CONVERT IRRIGATION REQUIREMENT TO M**3
          REQIRM=XREQIR*HAIRR(I)*10.                                     WG2111
C         CHECK IF DAM STORAGE SUFFICIENT TO MEET IRRIGATION REQUIREMENT
          IF(REQIRM.GT.DAMSTO(K-1))THEN
            SUPPIR(K)=DAMSTO(K-1)/HAIRR(I)*0.1                           WG2111
          ELSE
            SUPPIR(K)=XREQIR                                             WG2111
          ENDIF
        ENDIF
      ENDIF
      IF(IRRAPL.EQ.2)THEN                                                WG2111
        IF(OVERAC(K).GE.XREQIR)THEN                                           .
          SUPPIR(K)=XREQIR                                                    .
          OVRREM=OVERAC(K)-XREQIR                                             .
C         ADJUST OVERFLOW FOR PREVIOUS 5 DAYS DEPENDING ON HOW MUCH OF THE
C         ACCUMULATED OVERFLOW HAS BEEN USED FOR IRRIGATION
          DO 10 N=5,1,-1                                                      .
          IF(OVRREM.GT.OVERFL(K-N+5))THEN                                     .
            OVRREM=OVRREM-OVERFL(K-N+5)                                       .
            OVERFL(K-N+5)=0.0                                                 .
          ELSE                                                                .
            OVERFL(K-N+5)=OVERFL(K-N+5)-OVRREM
            OVRREM=0.0                                                        .
          ENDIF                                                               .
   10     CONTINUE                                                            .
```

```
        ELSE                                                        .
          DAMIRR=XREQIR-OVERAC(K)                                   .
          DAMIRM=DAMIRR*HAIRR(I)*10.                                .
          IF(DAMIRM.GT.DAMSTO(K-1))THEN                             .
            SUPPIR(K)=DAMSTO(K-1)/HAIRR(I)*0.1+OVERAC(K)            .
          ELSE                                                      .
            SUPPIR(K)=XREQIR                                        .
          ENDIF
          DO 45 N=1,5                                               .
   45     OVERFL(K-N+5)=0.0                                          .
        ENDIF                                                       .
        IF(K.LE.5)OVR=1.                                       WG15/1
      ENDIF                                                         .
C     INCREASE STORAGE BY THE AMOUNT OF WATER ACTUALLY GIVEN TO THE PLANT
C     ....................................................................
C                  logic change lja 10/11/
C     ....................................................................
      IF (IRRAPL.EQ.0)THEN
      STOIR(K)=STOIR(K)+SUPPIR(K)
      ELSE
      STOIR(K)=STOIR(K)+SUPPIR(K)*(1.-CONLOS)*(1.-FAMLOS)*EFFIRR        WG2111
      ENDIF
C     ....................................................................
   50 CONTINUE
      END
```

APPENDIX D.19

SUBROUTINE : MZCALC

(FILE : MZCAL3)

```
C     MAIZE YIELD MODEL
C
      SUBROUTINE MZCALC(TOTAET,TOTPET,NSTRES,LSTART,LDAY,ISTMO,ISTDAY,
     *STAET,STPET,LM,CDATA,XMDP,PLDATE,ENDAET,ENDPET)
C
      DIMENSION CDATA(70,4)
      CHARACTER SMONTH(12)*9
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      DATA SMONTH/'JANUARY','FEBRUARY','MARCH','APRIL','MAY','JUNE',
     *'JULY','AUGUST','SEPTEMBER','OCTOBER','NOVEMBER','DECEMBER'/
C
      IF(IYEAR.EQ.1)GO TO 30
      IF(IYEAR.EQ.2)WRITE(14,10)
   10 FORMAT(///45X,'MAIZE YIELD ESTIMATION (T/HA/SEASON)'/45X,36('-'),
     *//16X,'YEAR    DU PISANI 77    DU PISANI 78',7X,'DE JAGER',5X,'USA
     *-STEWART',8X,'PLANTING DATE',4X,'STRESS DAYS'//)
      TOTAET=TOTAET+ENDAET
      TOTPET=TOTPET+ENDPET
      YLDDP=TOTAET/92.
      YLDUSA=0.01845*TOTAET-3.0825
      YLDP78=0.88**NSTRES*4575.0*TOTPET/424.4/1000.
      YLDDJ=30.*(TOTAET-100.)*.45/1000.
      IYRA=IYR-1
      IF(PLDATE.EQ.0.)WRITE(14,20)IYRA,IYR,YLDDP,YLDP78,YLDDJ,YLDUSA,
     *SMONTH(LSTART),LDAY,NSTRES
   20 FORMAT(13X,'19',I2,'/',I2,3X,3(F10.3,6X),F10.3,11X,A9,I3,7X,I3)
      IF(PLDATE.EQ.1.)WRITE(14,20)IYRA,IYR,YLDDP,YLDP78,YLDDJ,YLDUSA,
     *SMONTH(ISTMO),ISTDAY,NSTRES
   30 ENDAET=STAET
      ENDPET=STPET
      IF(IYEAR.EQ.1)GO TO 40
      LM=LM+1
      XMDP=XMDP+YLDDP
      CDATA(LM,1)=YLDDP
      CDATA(LM,2)=YLDP78
      CDATA(LM,3)=YLDDJ
      CDATA(LM,4)=YLDUSA
   40 CONTINUE
      END
```

APPENDIX D.20

SUBROUTINE : MZPREP

(FILE : MZPREP)

```
C     MAIZE YIELD MODEL
C
      SUBROUTINE MZPREP(PRAIN,TPRAIN,LSTART,LDAY,ISTMO,ISTDAY,NSTRES,
     *MSDAYS,TOTAET,TOTPET,LGROW,STAET,STPET,ATRANS,RFL,WRIRR,AETIR,
     *DPEIR)
C
      DIMENSION AETIR(32),AET1(32),AET2(32),APAN(12,32),ASOEV(32),
     *ATRANS(32),ATRAN1(32),ATRAN2(32),CAYD(12,32),CONSTA(32),DEF1(32),
     *DEF2(32),DNO(32),DPE(32),DPEIR(32),ETLYS(32),OBSTO1(32),
     *OBSTO2(32),PERC(32),POSOEV(32),POTR1(32),POTR2(32),PP1(32),        WG5/11
     *PP2(32),PRAIN(6),QPEAK(32),QPKOBS(32),QUICKF(32),REQIR(32),        WG 1/8
     *RFL(32),RUN(32),SEDYLD(32),SIMSQ(32),STO1(32),STO2(32),STRMFL(32),
     *SUR2(32)
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
      COMMON/PRNTDY/MOIST,DNO,PP1,PP2,DPE,AET1,AET2,OBSTO1,OBSTO2,RUN,
     *QUICKF,SIMSQ,STRMFL,REQIR,CONSTA,APAN,SUR2,PERC,PRIRR,EVTR,CAYD,  WG5/11
     *POSOEV,ASOEV,POTR1,POTR2,ATRAN1,ATRAN2,ETLYS,QPEAK,SEDYLD,QPKOBS  WG 1/8
      COMMON/MAIZE/PLDATE,LENGTH
      COMMON/PRINT/DEF1,DEF2,STO1,STO2
C
C     CALCULATE PLANTING DATE IF IT IS NOT SPECIFIED
      IF(PLDATE.EQ.0.AND.ISTMO.EQ.0)THEN
        IF(I.LT.10)THEN
          GO TO 60
        ELSE
          IF(I.GE.12.AND.K.GE.24)THEN
            ISTMO=12
            ISTDAY=24
            GO TO 30
          ENDIF
          DO 10 J=2,6
   10     IF(K.EQ.J)PRAIN(J)=RFL(K)
          IF(K.GT.J.OR.K.LT.J.AND.I.GT.10)THEN
            DO 20 J=2,5
   20       PRAIN(J)=PRAIN(J+1)
            PRAIN(6)=RFL(K)
          ENDIF
C     TOTAL PLANTING RAIN HAS TO BE 25MM ACCUMULATED OVER 5 DAYS
          TPRAIN=PRAIN(2)+PRAIN(3)+PRAIN(4)+PRAIN(5)+PRAIN(6)
          IF(TPRAIN.LE.25.)THEN
            GO TO 60
          ELSE
            ISTMO=I
            ISTDAY=K-1
          ENDIF
        ENDIF
      ENDIF
C     CALCULATE AET FOR GRAIN YIELD EQUATIONS
   30 IF(I.LT.ISTMO)THEN
        IF(IYEAR.EQ.1)THEN
          GO TO 60
        ELSE
C       IF END OF GROWING SEASON HAS BEEN REACHED, REINITIALIZE VALUES
          IF(LGROW.GE.LENGTH)THEN
            IF(PLDATE.EQ.0)THEN
              LSTART=ISTMO
              LDAY=ISTDAY
              ISTMO=0
              ISTDAY=0
              NSTRES=MSDAYS
              MSDAYS=0
              DO 40 J=1,6
   40         PRAIN(J)=0.0
            ELSE
              IF(MSDAYS.GT.0)THEN
                NSTRES=MSDAYS
```

```
               MSDAYS=0
             ENDIF
           ENDIF
           GO TO 60
         ELSE
C        SUMMATE PE AND AE FOR BOTH SOIL LAYERS
           IF(WRIRR.EQ.0.)THEN
C        YIELD IS CALCULATED ASSUMING DRYLAND CONDITIONS
             IF(EVTR.EQ.1.)TOTAET=TOTAET+AET1(K)+AET2(K)
             IF(EVTR.EQ.2.)TOTAET=TOTAET+ATRANS(K)
             TOTPET=TOTPET+PP1(K)+PP2(K)
           ELSE
C        YIELD IS CALCULATED ASSUMING IRRIGATED CONDITIONS
             TOTAET=TOTAET+AETIR(K)
             TOTPET=TOTPET+DPEIR(K)
           ENDIF
           LGROW=LGROW+1
           GO TO 50
         ENDIF
       ENDIF
     ENDIF
C    SPECIAL CASE FOR FIRST YEAR
     IF(I.EQ.ISTMO)THEN
       IF(K.LT.(ISTDAY+1))GO TO 60
       IF(K.EQ.(ISTDAY+1))LGROW=0
     ENDIF
     IF(WRIRR.EQ.0.)THEN
C    YIELD IS CALCULATED ASSUMING DRYLAND CONDITIONS
       IF(EVTR.EQ.1.)STAET=STAET+AET1(K)+AET2(K)
       IF(EVTR.EQ.2.)STAET=STAET+ATRANS(K)
       STPET=STPET+PP1(K)+PP2(K)
     ELSE
C    YIELD IS CALCULATED ASSUMING IRRIGATED CONDITIONS
       STAET=STAET+AETIR(K)
       STPET=STPET+DPEIR(K)
     ENDIF
     LGROW=LGROW+1
  50 IF(LGROW.GE.70.AND.LGROW.LE.100)THEN
C    CHECK FOR STRESS DAY
       IF(WRIRR.EQ.0.)THEN
         IF(AET1(K).LT.(0.5*PP1(K)).AND.AET2(K).LT.(0.5*PP2(K)))MSDAYS=
    *    MSDAYS+1
       ELSE
         IF(AETIR(K).LT.(0.5*DPEIR(K)))MSDAYS=MSDAYS+1
       ENDIF
     ENDIF
  60 CONTINUE
     END
```

WATER RESEARCH COMMISSION

A P P E N D I X   E

DE HOEK CATCHMENT

C O N T E N T S

FIGURES

TABLES

APPENDIX E

LIST OF APPENDICES

APPENDIX E

DE HOEK CATCHMENT *

1. REASONS FOR SELECTING THE DE HOEK CATCHMENT FOR RECHARGE STUDY

The De Hoek catchment was selected as being suitable for study into rainfall recharge for a number of reasons.

- there was a wealth of pre-existing hydrological and hydrogeological data which was available as a data base for this project;

- ongoing hydrological work in the area was being funded by the WRC; it was hoped that data generated by such work could be integrated into the recharge study;

- the lithologies encountered in the De Hoek catchment are typical of the whole karoo sequence, which is widespread over South Africa; thus, it was hoped that results generated by study of the De Hoek catchment could be extrapolated widely;

- the local geology of the De Hoek catchment is relatively uncomplicated, since it does not appear to be crosscut by major post-Karoo dykes which might compartmentalise flow;

- there were no pumping boreholes or wells in and around the catchment, so interference effects did not have to be taken into consideration when interpreting the local ground water conditions;

* The correct title for the catchment is : Catchment V1M20, De Hoek/ Ntabamhlope. For convenience, all reference in the text will be given as 'De Hoek'.

- the Beaufort Group and other Karoo sediments constitute a significant source of ground water, primarily because of their large areal extent. It was suspected that the value of recharge to these units was very low, thus necessitating the establishment of a reliable and extensive data base from which accurate determinations of recharge could be made. Such information is of particular importance in ensuring that water resources planning and development in areas of similar geology is responsibly carried out in the future.

2. GEOGRAPHICAL SETTING

The De Hoek valley lies 21 km due east of Estcourt, Natal (See Figure E 1) on the fringes of the Drakensberg escarpment.

3. REVIEW OF AVAILABLE HISTORICAL RECORDS

A history of the previous research carried out in this area was detailed in an excursion guide compiled by Schulze (1983). This guide has been extensively used as a reference text in this study.

Ground water studies were carried out in the district prior to 1964 (Van Wyk and Du Preez, 1968). Data from this report has been analysed and is discussed in detail in the following sections.

The Department of Agriculture Historical records on this region were saved from destruction by R Schulze, and are presently stored at the University of Natal. B Mappeldoorn, of the Department of Agriculture, Estcourt, was a technician during the original experiments at De Hoek and was able to provide further information to supplement the existing records.

STEFFEN ROBERTSON AND KIRSTEN

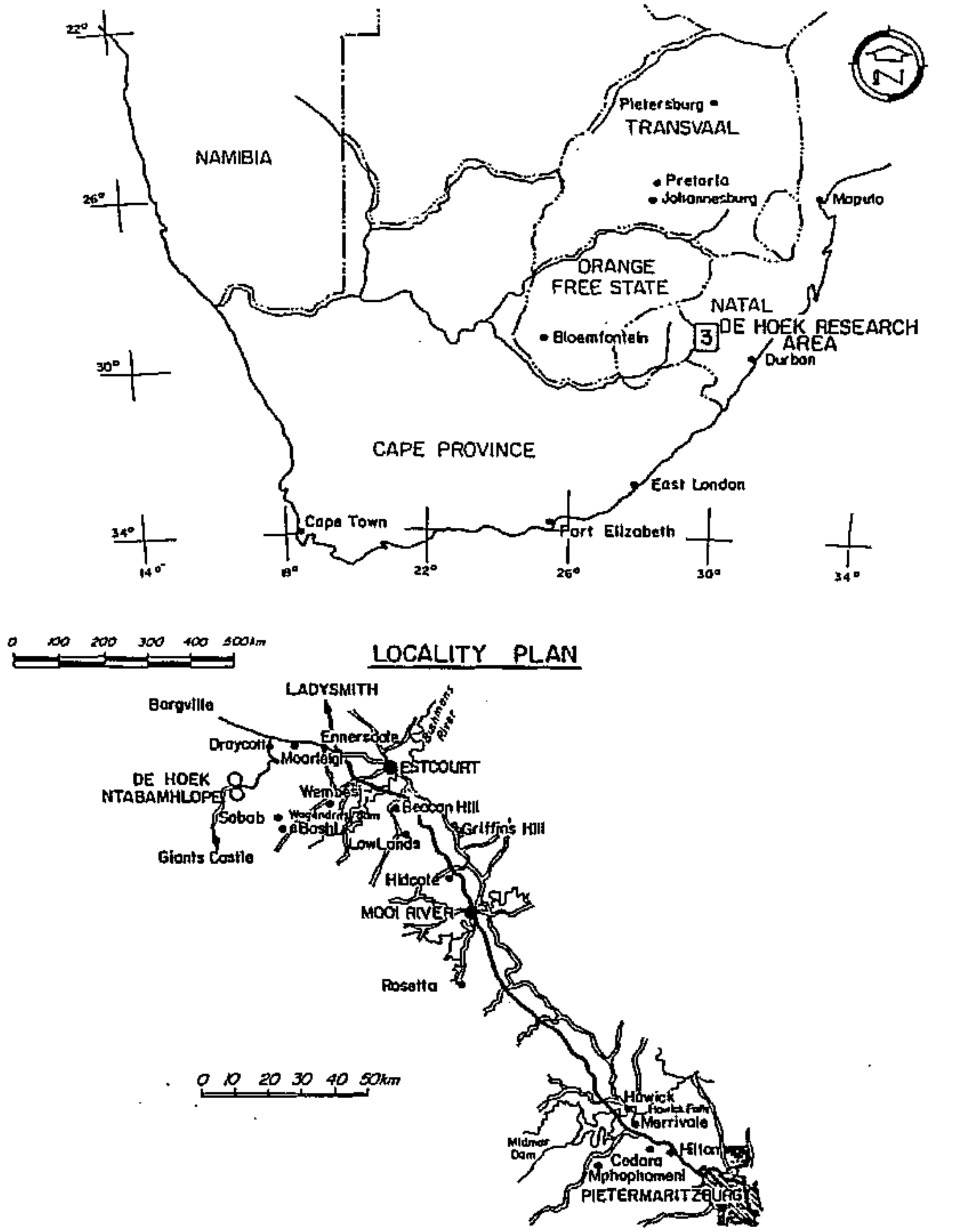


FIGURE E.1 GENERAL LOCATION

DE HOEK / NTABAMHLOPE HYDROLOGICAL RESEARCH STATIONS

R Pallett systematically searched through this historical information to extract useable data for catchments 20 and 28. This includes the following information:

- soil mapping details (work done by De Villiers in 1964);
- borehole drilling logs;
- previous borehole water quality analysis;
- previous plans, geological profiles and botanical studies of the De Hoek district.

R Schulze has established information storage and retrieval systems for meteorological and hydrological data for the recharge project. The relevant data from this source was regularly accessed, and the following information was made available in a processed form:

- daily rainfall records representative of the catchment;
- daily weir flow records from gauging stations V1M20 and V1M28.

4. CATCHMENT DESCRIPTION

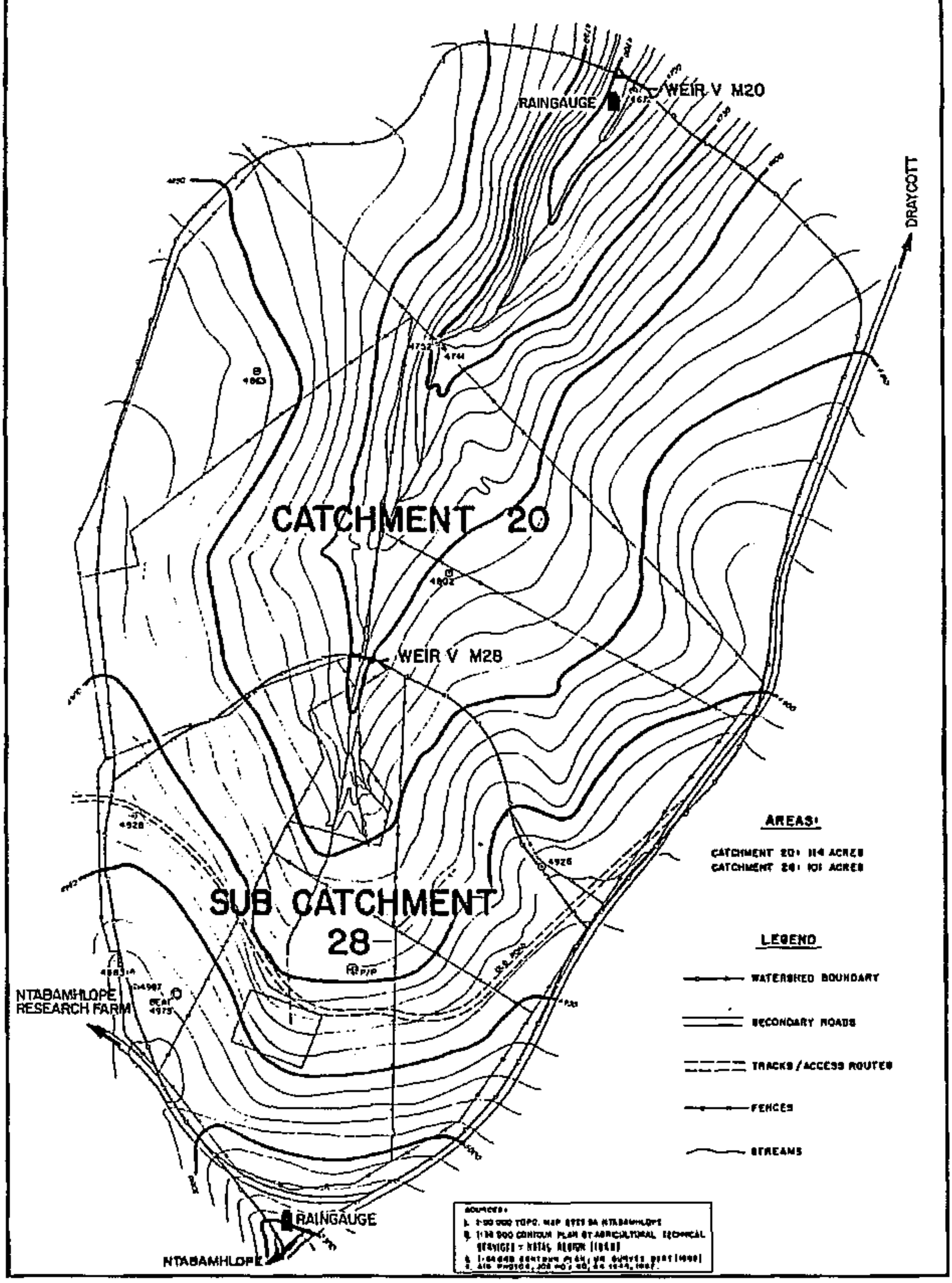
4.1 Topography

A general impression of the area may be obtained from the 1:50 000 topographic sheet (2929BA NTABAMHLOPE). The relevant portion of this map has been extracted and enlarged, and is presented as Figure E 2.

Schulze (1982) divides the study area into three distinct physiographic regions:

- the De Hoek valley (1220 - 1280m);
- an escarpment rising about 180m, which represents the watershed;
- the Ntabamhlope plateau area (1460 - 1525m).

FIGURE E.2 TOPOGRAPHY



Catchment 20 (including subcatchment 28) lies in the plateau area, which is part of the spurs and foothills of the high Drakensberg and borders the Winterton-Estcourt-Muden plain.

The stream in the catchment flows approximately northwards down the gently sloping valley, over the escarpment and into the main De Hoek valley.

Topographic information was obtained from four sources:

- 1:3 600 scale contour map produced by the University of Natal Survey Department, 1968;
- 1:3 600 scale contour map produced by the Agricultural Technical Services Department, Natal region, drawn by MM 27.05.1968;
- 1:50 000 topographic map 2929 BA NTABAMHLOPE;
- 1:3 600 geological map, produced by the Geological Survey of South Africa.

4.2 Available photography

4.2.1 Aerial photography

Aerial photographs flown in 1944 were on a scale of 1:6 600. Subsequent aerial photographs from Professor De Villiers, soil survey, were also received.

The Survey Department of the UN was requested to fly colour and black and white thermal infrared surveys of the research catchment in the early spring of 1984 in order that the catchment could be examined in its driest state before the area was burnt.

4.2.2 Normal photography

Photographs were taken regularly on visits to the area, and have been used for correlation as well as a visual record of the area for reporting purposes.

4.3 Geology

4.3.1 The Middle and Upper Beaufort sediments

The De Hoek catchment is mostly underlain by fine to medium grained sandstones and maroon, khaki and blue mudstones of the Tarkastad formation of the Beaufort Group. These Karoo sediments are crosscut by post Karoo dolerite dykes and sills, although these appear to be less extensive in catchments 20 and 28 than in the surrounding catchments.

The sandstones of the Middle and Upper Beaufort stages are medium to fine grained, well cemented and grey-blue in colour when fresh, weathering to yellow and fawn. The Beaufort sandstones in this catchment are generally fairly massive. The contact between the Middle and Upper Beaufort successions is poorly defined, due to the presence of mudstone intercalations at the top of the middle Beaufort, which are difficult to distinguish from the predominantly argillaceous Upper Beaufort.

The Beaufort mudstones are variegated and maroon, khaki and fawn in colour, and occur predominantly in the Upper Beaufort sequence.

4.3.2 The Karoo Dolerites

The Beaufort sediments in this area are crosscut by a number of dolerite intrusions, which take the form of both sills and dykes. The De Hoek catchment was initially chosen for study because it was anticipated that this area was relatively free of dykes which might complicate the ground water flow pattern. During the course of drilling in catchments 20 and 28, doleritic layers (interpreted as being sills) were encountered.

4.3.3 Structure

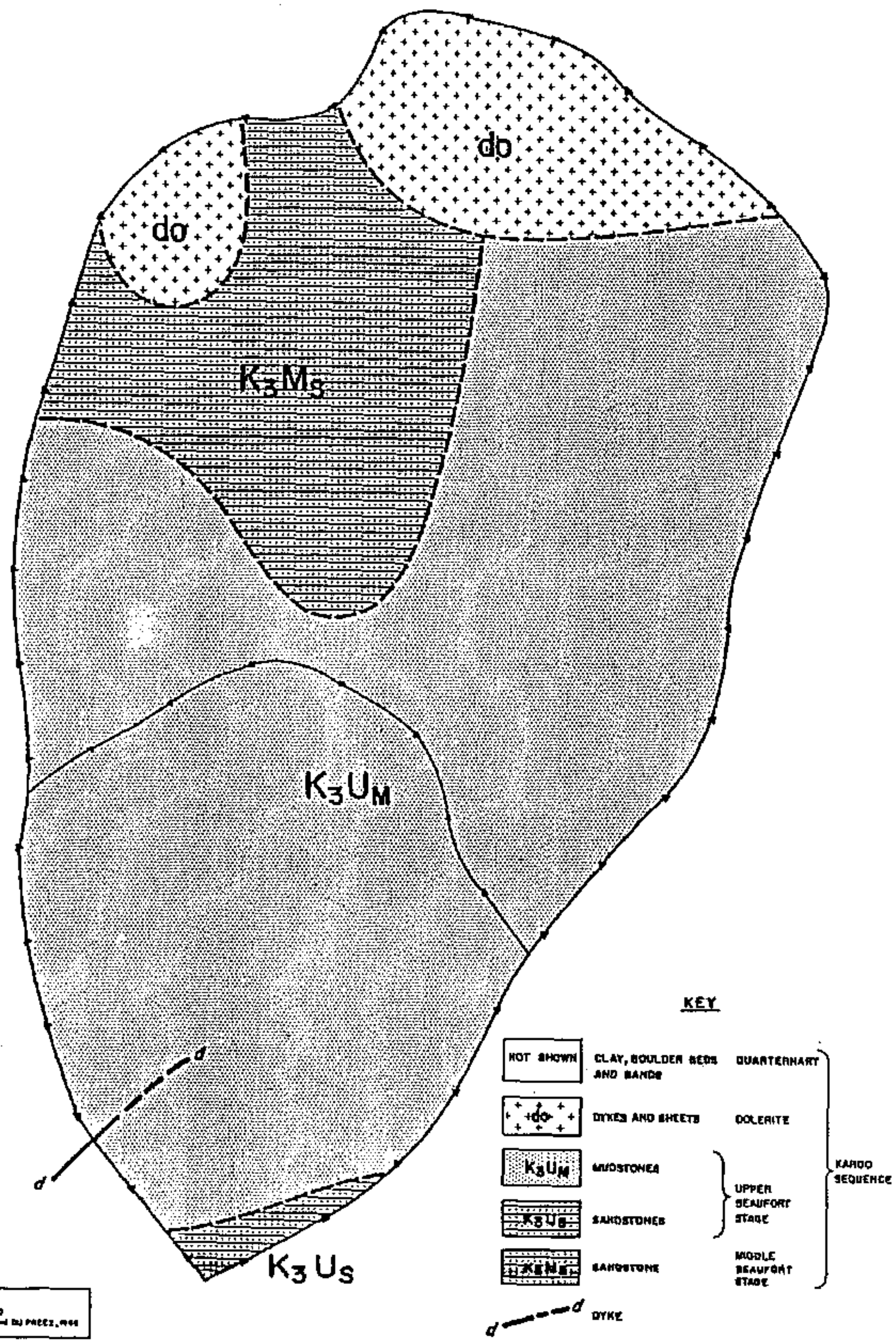
There is little apparent structure in this area. Both the sediments of the Beaufort and those of the Quaternary are essentially flatlying. There are no apparent faults within the catchment, although it is possible that dyke emplacement in the vicinity has taken place along lines of previous weakness such as joints and faults.

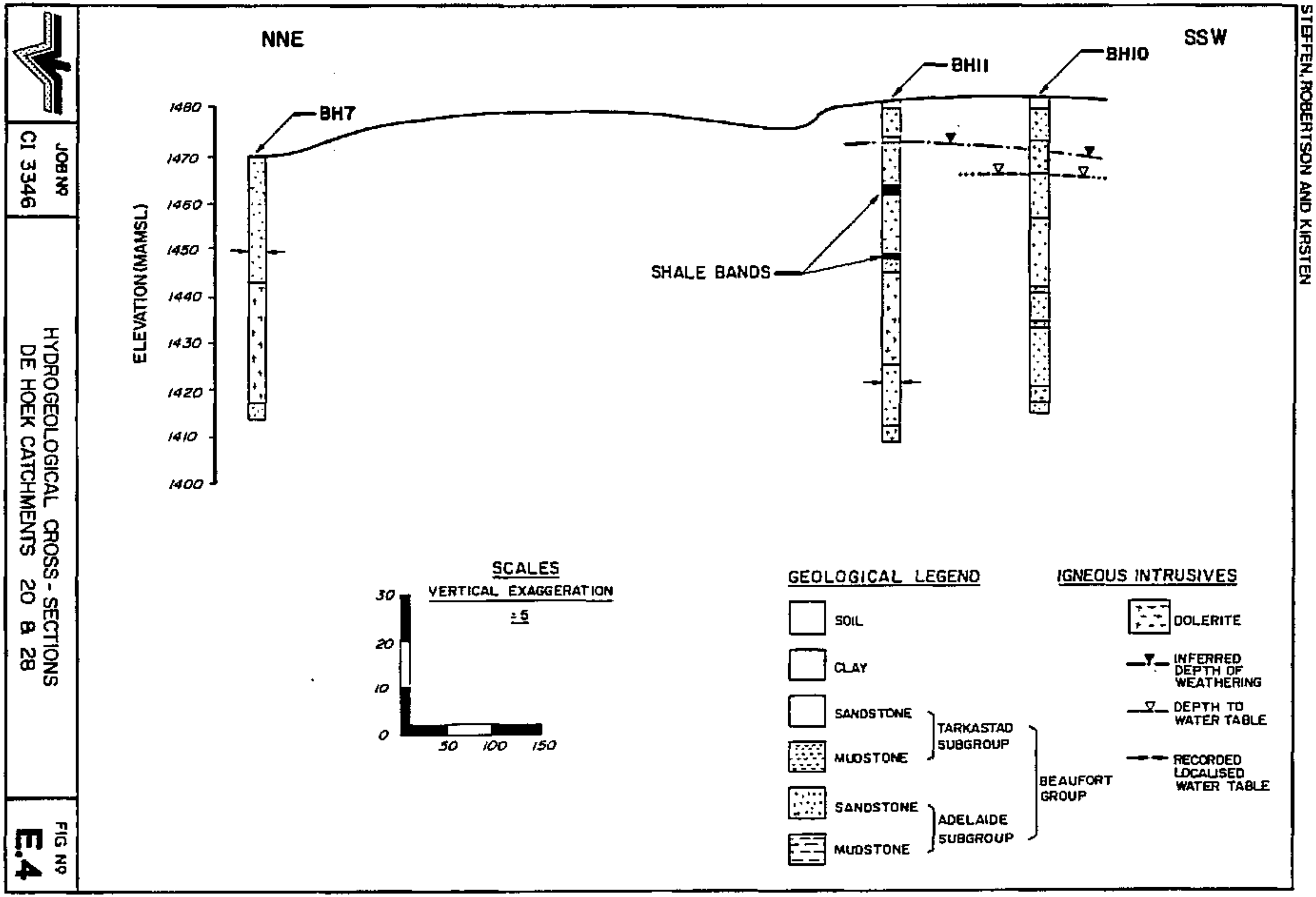
4.3.4 Quarternary sediments

A sharp unconformity exists between the sandstones of the Middle Beaufort and the basal boulder beds of the Quaternary sequence. These are overlain by an alternation of poorly stratified clays, gravels, laterites and black vlei soils.

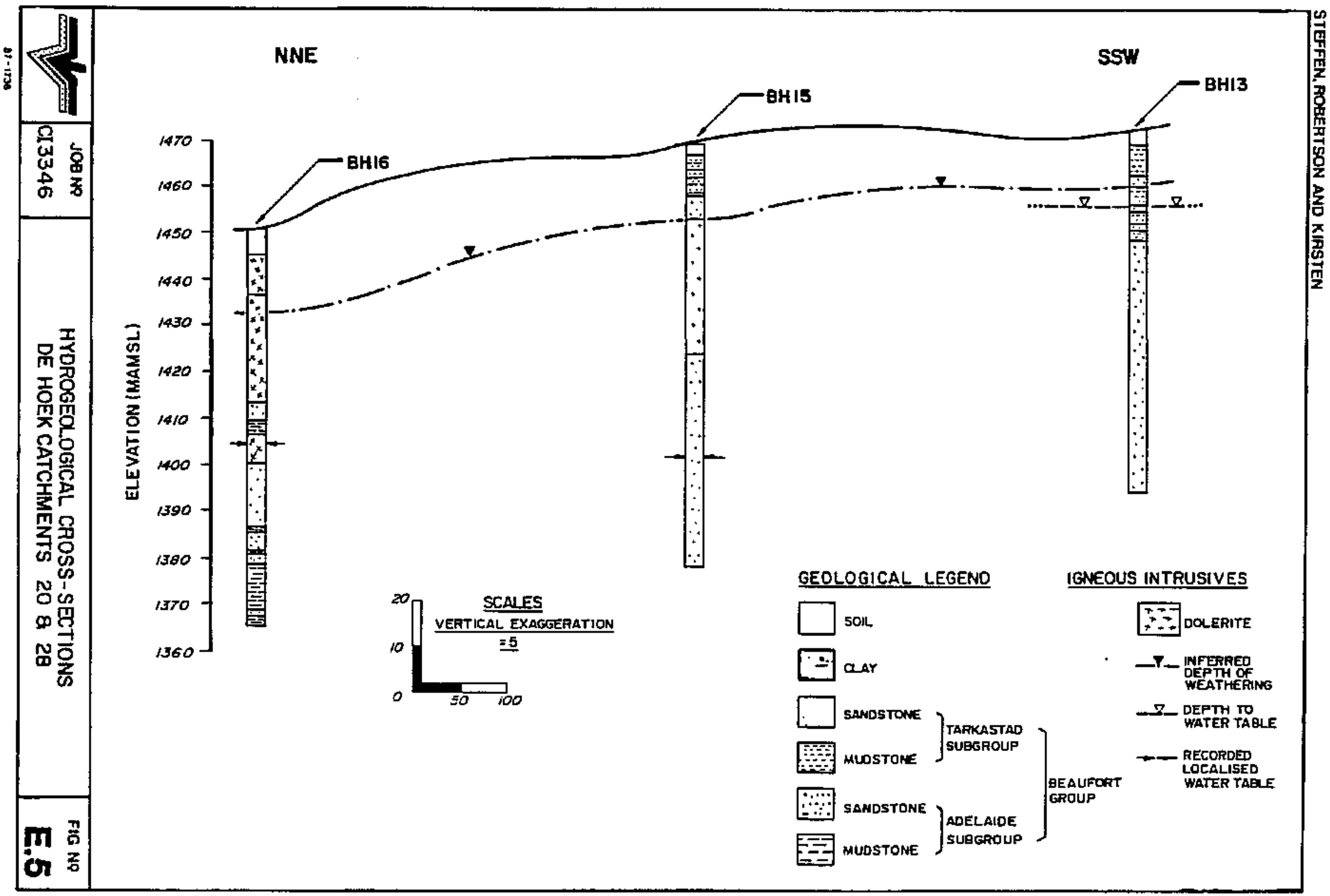
A geological map of this area is presented as figure E 3 and a series of sketch cross-sections across this catchment, constructed using the drilling data from boreholes put down as part of this project are presented in Figures E 4 to E 10.

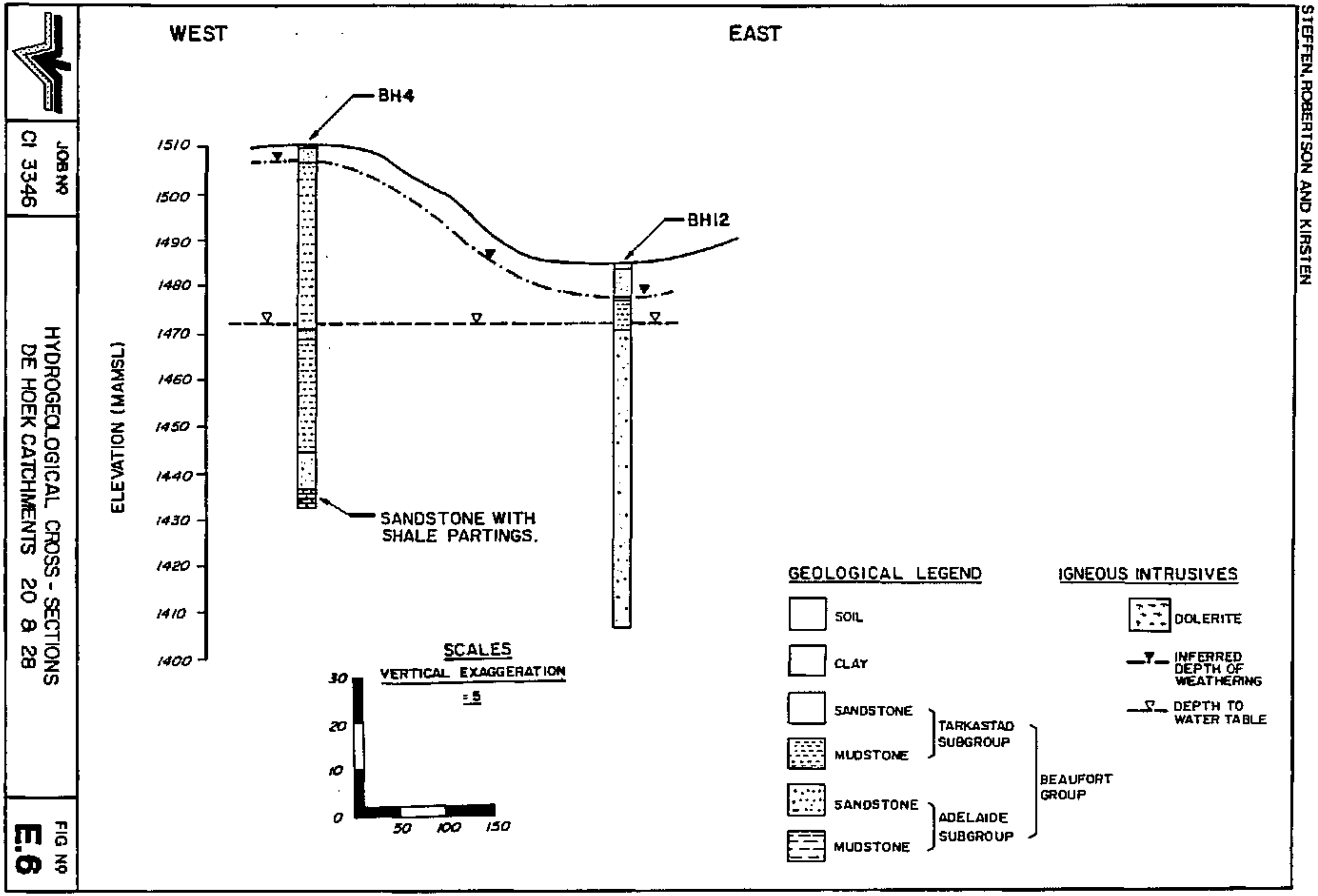
FIGURE E.3 GEOLOGY

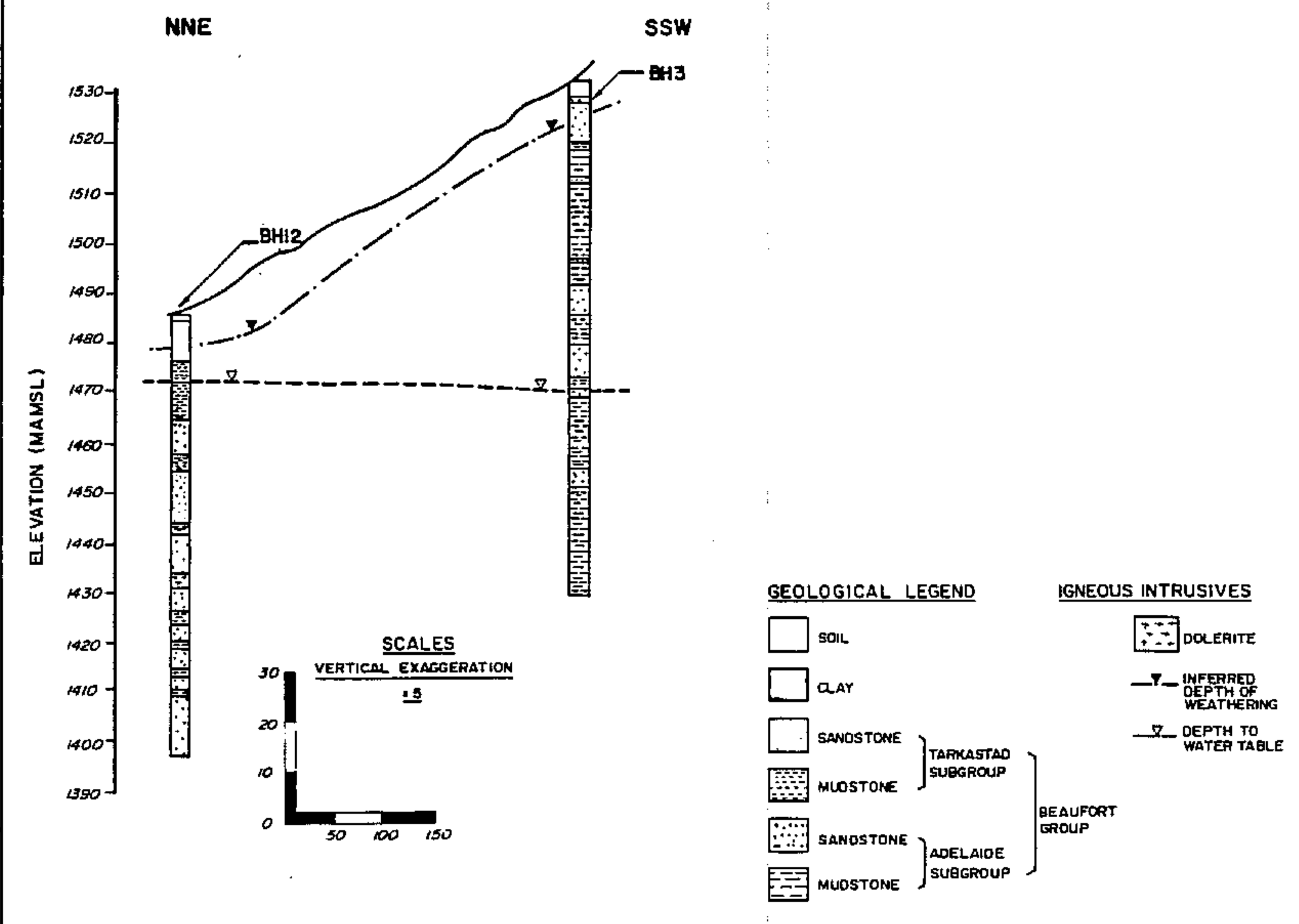




NNE
SSW
BH7
BH11
BH10
ELEVATION (MAMSL)
1480
1470
1460
1450
1440
1430
1420
1410
1400
SHALE BANDS
SCALES
VERTICAL EXAGGERATION
≈5
30
20
10
0
50
100
150
GEOLOGICAL LEGEND
SOIL
CLAY
SANDSTONE
MUDSTONE
TARKASTAD SUBGROUP
SANDSTONE
MUDSTONE
ADELAIDE SUBGROUP
BEAUFORT GROUP
IGNEOUS INTRUSIVES
DOLERITE
INFERRED DEPTH OF WEATHERING
DEPTH TO WATER TABLE
RECORDED LOCALISED WATER TABLE
JOB No
CI 3346
HYDROGEOLOGICAL CROSS-SECTIONS
DE HOEK CATCHMENTS 20 & 28
FIG No
E.4
STEFFEN, ROBERTSON AND KIRSTEN


NNE
SSW
BH16
BH15
BH13
ELEVATION (MAMSL)
1470
1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
1360
SCALES
VERTICAL EXAGGERATION
=5
20
10
0
50
100
GEOLOGICAL LEGEND
SOIL
CLAY
SANDSTONE
MUDSTONE
TARKASTAD SUBGROUP
SANDSTONE
MUDSTONE
ADELAIDE SUBGROUP
BEAUFORT GROUP
IGNEOUS INTRUSIVES
DOLERITE
INFERRED DEPTH OF WEATHERING
DEPTH TO WATER TABLE
RECORDED LOCALISED WATER TABLE
STEFFEN, ROBERTSON AND KIRSTEN
JOB No
CI3346
HYDROGEOLOGICAL CROSS-SECTIONS
DE HOEK CATCHMENTS 20 & 28
FIG No
E.5


JOB No
CI 3346
HYDROGEOLOGICAL CROSS - SECTIONS
DE HOEK CATCHMENTS 20 & 28
FIG No
E.6
STEFFEN, ROBERTSON AND KIRSTEN
WEST
EAST
BH4
BH12
ELEVATION (MAMSL)
1510
1500
1490
1480
1470
1460
1450
1440
1430
1420
1410
1400
SANDSTONE WITH SHALE PARTINGS.
SCALES
VERTICAL EXAGGERATION
= 5
30
20
10
0
50
100
150
GEOLOGICAL LEGEND
SOIL
CLAY
SANDSTONE
MUDSTONE
TARKASTAD SUBGROUP
SANDSTONE
MUDSTONE
ADELAIDE SUBGROUP
BEAUFORT GROUP
IGNEOUS INTRUSIVES
DOLERITE
INFERRED DEPTH OF WEATHERING
DEPTH TO WATER TABLE

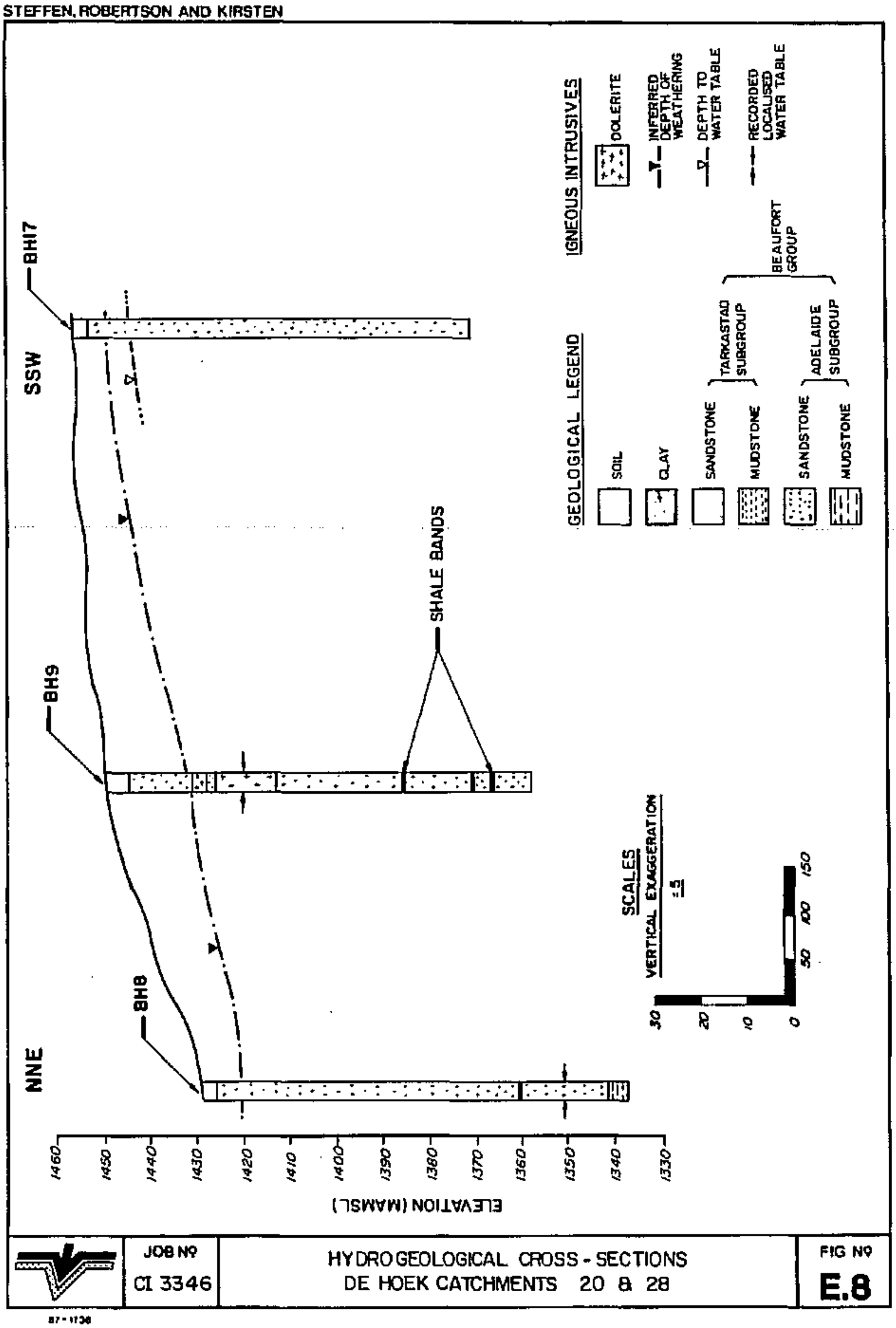


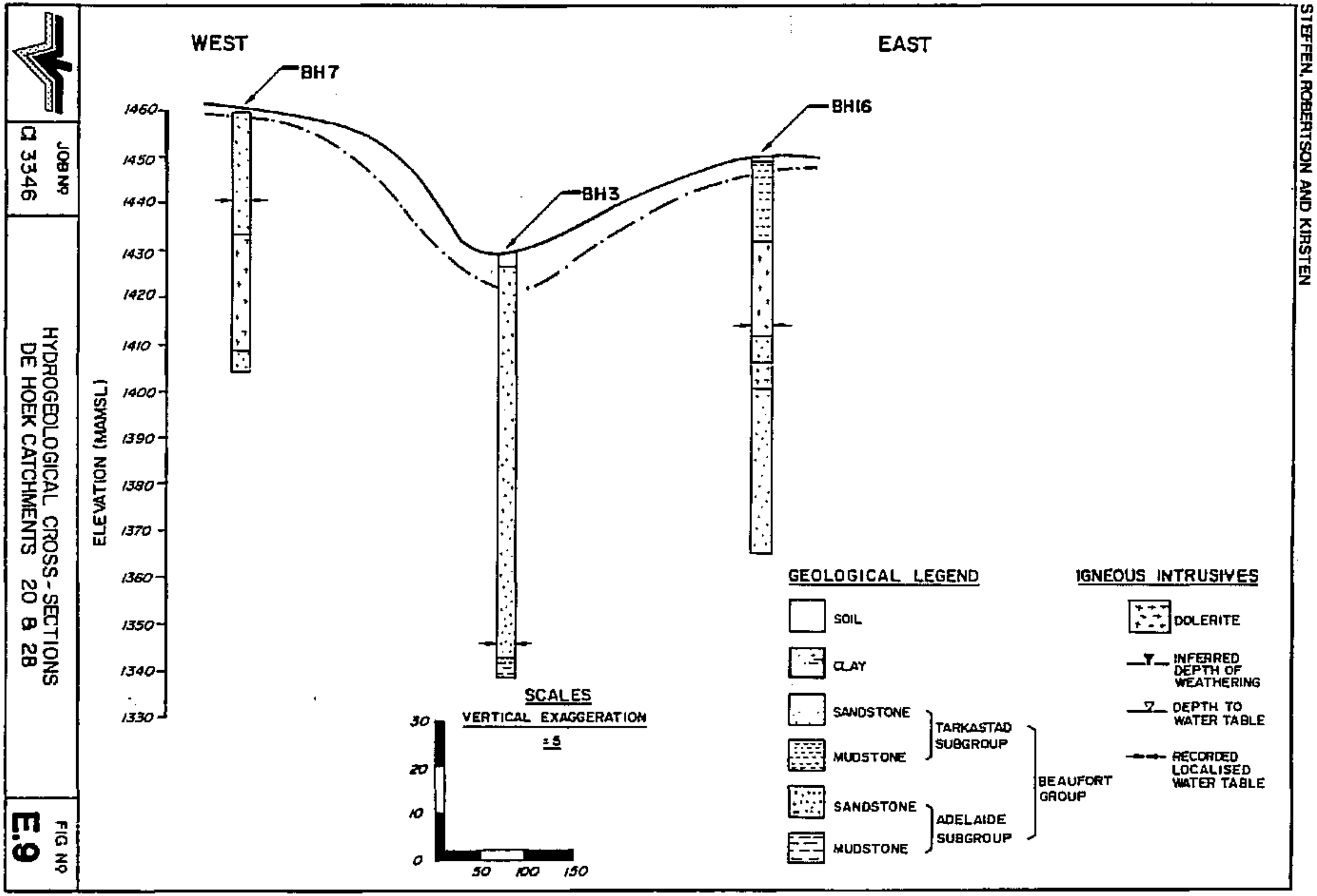
STEFFEN, ROBERTSON AND KIRSTEN

JOB Nº CI 3346

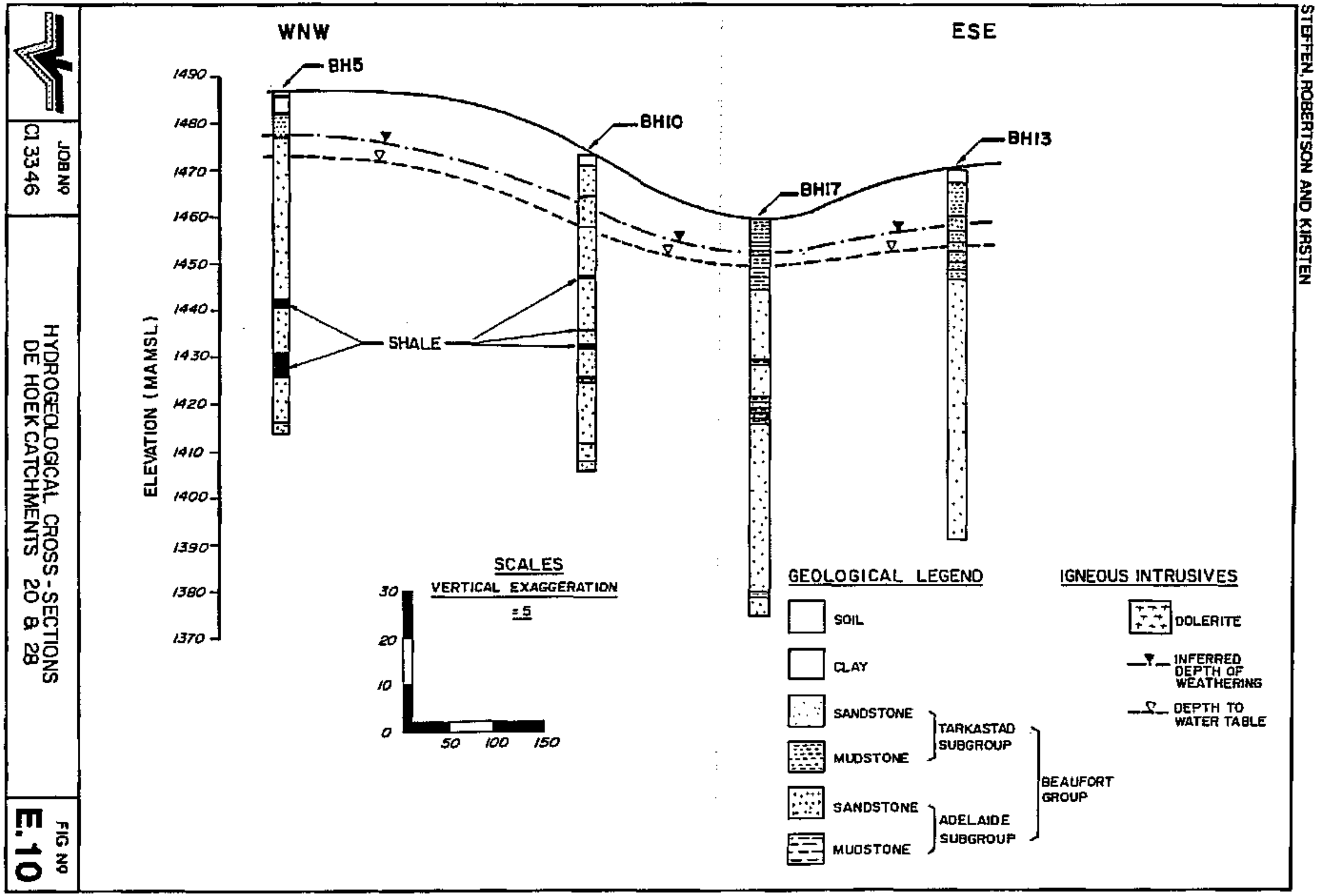
HYDROGEOLOGICAL CROSS - SECTIONS
DE HOEK CATCHMENTS 20 & 28

FIG Nº E.7


STEFFEN, ROBERTSON AND KIRSTEN
NNE
SSW
BH8
BH9
BH17
SHALE BANDS
ELEVATION (MAMSL)
1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
1360
1350
1340
1330
GEOLOGICAL LEGEND
SOIL
CLAY
SANDSTONE
MUDSTONE
TARKASTAD SUBGROUP
SANDSTONE
MUDSTONE
ADELAIDE SUBGROUP
BEAUFORT GROUP
IGNEOUS INTRUSIVES
DOLERITE
INFERRED DEPTH OF WEATHERING
DEPTH TO WATER TABLE
RECORDED LOCALISED WATER TABLE
SCALES
VERTICAL EXAGGERATION
±5
0
10
20
30
50
100
150
JOB Nº
CI 3346
HYDROGEOLOGICAL CROSS-SECTIONS
DE HOEK CATCHMENTS 20 & 28
FIG Nº
E.8
87-1138



WEST
EAST
BH7
BH3
BH16
ELEVATION (MAMSL)
1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
1360
1350
1340
1330
SCALES
VERTICAL EXAGGERATION
x5
30
20
10
0
50
100
150
GEOLOGICAL LEGEND
SOIL
CLAY
SANDSTONE
MUDSTONE
TARKASTAD SUBGROUP
SANDSTONE
MUDSTONE
ADELAIDE SUBGROUP
BEAUFORT GROUP
IGNEOUS INTRUSIVES
DOLERITE
INFERRED DEPTH OF WEATHERING
DEPTH TO WATER TABLE
RECORDED LOCALISED WATER TABLE
STEFFEN, ROBERTSON AND KIRSTEN
JOB No
CI 3346
HYDROGEOLOGICAL CROSS-SECTIONS
DE HOEK CATCHMENTS 20 & 28
FIG No
E.9



WNW
ESE
BH5
BH10
BH17
BH13
ELEVATION (MAMSL)
1490
1480
1470
1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
SHALE
SCALES
VERTICAL EXAGGERATION
=5
30
20
10
0
50
100
150
GEOLOGICAL LEGEND
SOIL
CLAY
SANDSTONE
MUDSTONE
TARKASTAD SUBGROUP
SANDSTONE
MUDSTONE
ADELAIDE SUBGROUP
BEAUFORT GROUP
IGNEOUS INTRUSIVES
DOLERITE
INFERRED DEPTH OF WEATHERING
DEPTH TO WATER TABLE
STEFFEN, ROBERTSON AND KIRSTEN
JOB Nº
CI 3346
HYDROGEOLOGICAL CROSS-SECTIONS
DE HOEK CATCHMENTS 20 & 28
FIG Nº
E.10

4.4 Soil type

4.4.1 Description of the soils

The soils of the catchment were classified according to the South African binomial system for soil classification (MacVicar et al., 1977). This is a standard system used throughout South Africa. In 1963, De Villiers conducted a soil survey of the area. This was slightly modified during the duration of the project after observations made whilst soil sampling and during access tube installation.

Characteristics of the catchment soils (after De Villiers, 1963) are detailed below. Figure E 11 illustrates their distribution.

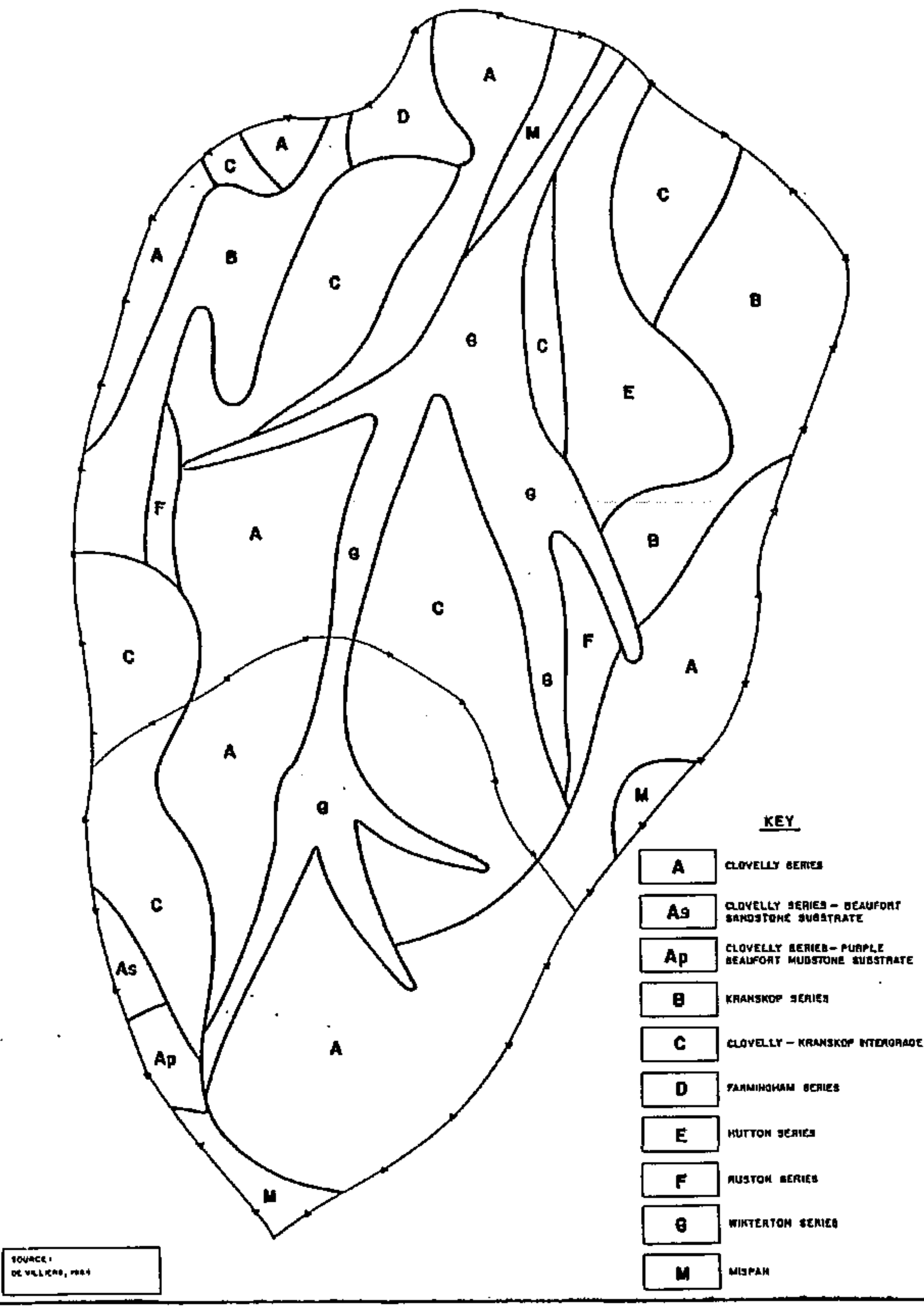
Griffin/Griffin

Moderately deep (1.0 - 1.2m), well drained, acid soils with sandy clay texture, lacking macro-structure. The topsoil is dark brown, diffusing to a yellow brown apedal B horizon at 0.28 - 0.32 m. This diffuses to a dark red horizon at 0.75 - 0.85 m. Clay content within the subsoil is 45-55%.

Kranskop/Kranskop

Deep (1.2 - 2.5 m), well drained acid soil with clay loam to fine sandy clay loam texture and granular, grading to weak sub-angular blocky structure. The topsoil is dark grey brown and contains 2-3% organic carbon. This grades to a yellow brown B horizon at 0.45-0.55 m and a dark red horizon at 0.9-1.0 m. Clay content within the subsoil is 45-55%.

FIGURE E.11 SOILS



Clovelly/Clovelly

Moderately shallow (0.25-0.75 m), well drained acid soil with clay loam to find sandy clay loam texture and granular, grading to weak sub-angular blocky structure. The topsoil is dark grey brown and grades to a yellow brown apedal B horizon at 0.2-0.3 m. Clay content within the subsoil is 45-55%.

Clovelly-Kranskop intergrade

A soil intermediate in depth between the Clovelly and Kranskop series.

Longlands/Winterton

Moderately shallow soils (0.25-0.75 m), poorly drained, occupying bottomland positions and subject to a fluctuating water table. The topsoil is grey to dark grey and hard when dry. This overlies a pale brown or grey brown bleached E horizon at 0.28-0.32 m, fairly high in silt due to eluviation of clay. At 0.5-0.7 m this changes to a mottled hydromorphic clay. Clay content within the E horizon is 35-45%. These soils are subject to erosion and are frequently gullied. Erosion also takes the form of sinkholes and subterranean channels which are subject to collapse.

Hutton/Farningham

Moderately deep (1.0-1.3 m), well drained acid soil lacking macro-structure and with 40-50% clay. The topsoil is dark reddish brown diffusing to a redder subsoil between 0.45 and 0.60 m. Organic carbon content of the topsoil is approximately 2%. These soils are derived from colluvial material probably of mixed dolerite-shale origin.

Hutton/Hutton

A coarse sandy clay loam, containing 20-30% clay, derived from colluvial dolerite and sandstone, otherwise analogous with the Farningham series.

Avalon/Normandien

Moderately shallow soils (0.30-0.75 m), sandy clay to clay texture (40-50% clay), subject to a fluctuating water table at depth 0.6-8 m. Above this mottled grey lies a yellow brown apedal B horizon. The topsoil is a dark yellowish brown.

Mispah/Mispah

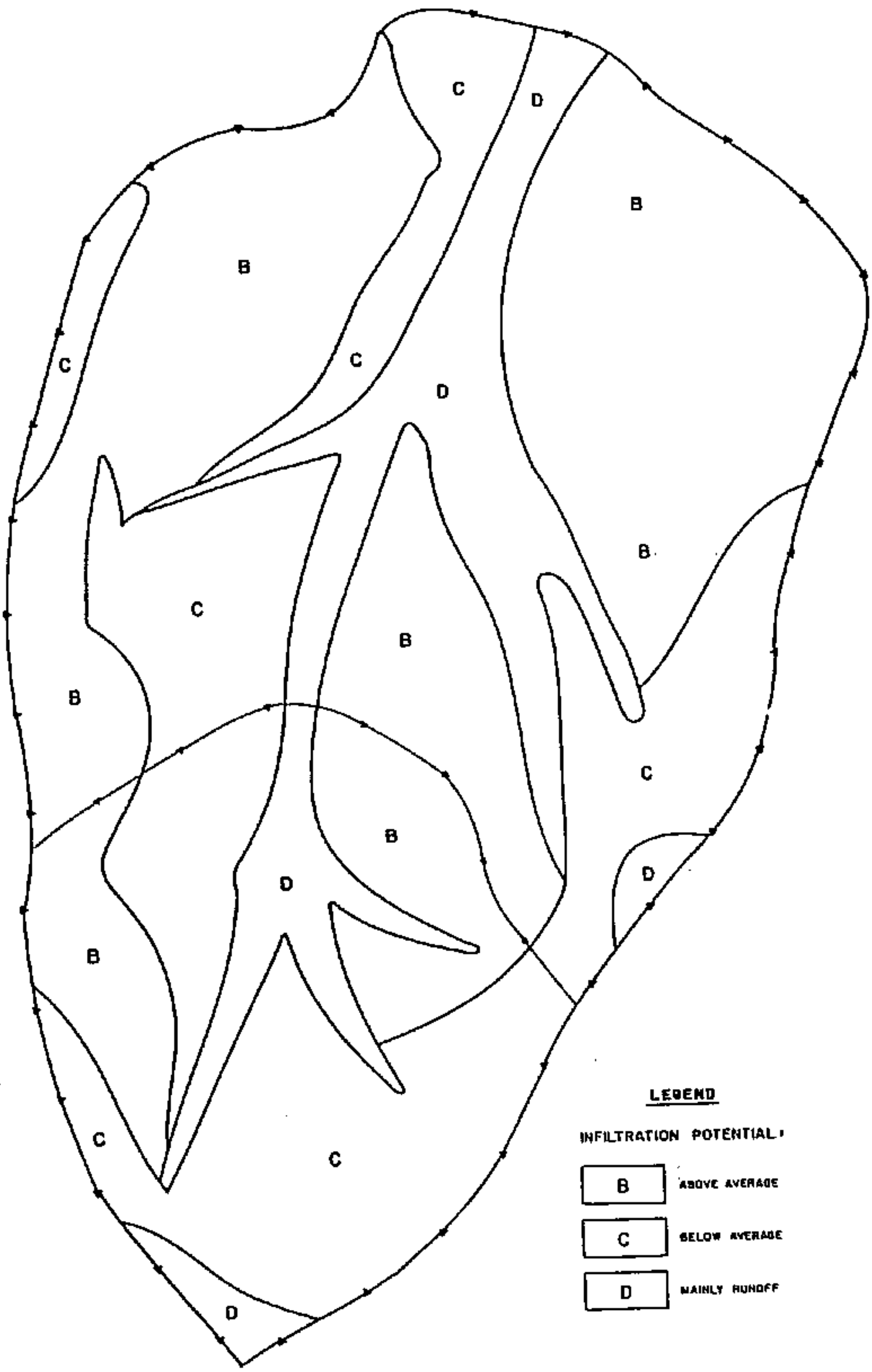
Very shallow soils (0.05-0.3 m), fine to medium sandy clay loam texture (25-35% clay) overlying hard rock, usually sandstone.

Clovelly/Clovelly

Beaufort sandstone/mudstone substrates analogous with the Clovelly series, but shallow and lying directly on sandstone or mudstone.

Information on the physical characteristics of these soils has been used to divide the area into zones of below average and about average infiltration potential, and zones where runoff rather than infiltration is dominant. This information is presented in figure E 12.

FIGURE E.12 INFILTRATION POTENTIAL



4.5 Hydrology

Catchments 20 and 28 lie in the plateau area rising above the main De Hoek valley. The stream within the catchment rises in the south at the elevation of approximatly 1495m and flows northwards towards the main valley, leaving the catchment at weir V1M20, which is at an elevation of 1425m.

The catchments have a combined area of 137 hectares and contain two weirs, numbered V1M28 and V1M20, which are used to gauge flow in the stream. Surface water studies have been carried out in this region since 1936, so a large amount of hydrological information is available for appraisal.

4.6 Hydrogeology

The hydrogeology of the De Hoek and Ntabamhlope regions was first investigated during the period 1958 - 1968, when a ground water study was undertaken by Van Wyk and Du Preez of the Geological Survey. This included the core drilling of 55 boreholes, although none of these were put down within catchments 20 or 28. Both pumping and bailing tests were carried out on these holes where possible, and falling head permeability tests were conducted on selected boreholes. Porosity tests were also carried out on fragments of bedrock retrieved by coring. The summarised results of this study are outlined in the following sections:

4.6.1 Drilling in the De Hoek region

This study included the core drilling of 55 boreholes between July 1958 and June 1960, with a total core length of 1484m. Auger drilling was conducted on the watersheds of several of the catchments to determine whether or not there was linkage of smaller catchments via a network of subterranean tunnels and sinkholes.

4.6.2 Porosity and permeability determinations

Porosity determinations were carried out on some 200 samples obtained from core drilling. The results of this investigation are tabulated below in table E 1.

TABLE E 1: POROSITY DETERMINATIONS ON CORE SAMPLES FROM THE DE HOEK REGION

Lithology	Number of determination	Average porosity (%)	Range of porosities (%)
Sandstone	69	6.38	3.95 - 10.95
Mudstone	26	41.9	20.3 - 62.1
Weathered sandstone	11	14.19	8.05 - 24.1
Indurated sandstone	9	3.25	1.86 - 4.08
Indurated mudstone	11	8.53	3.54 - 14.7
Fresh dolerite	3	2.91	1.14 - 4.73
Sandstone above water table	2	10.37	10.1 - 10.63
Sandstone below water table	8	7.26	3.46 - 9.32

243 permeability tests were also conducted on 43 boreholes by testing the boreholes at between 1.5m and 3m, and thereafter, at a variety of depths until completion. A known amount of clean water was added to each borehole, and the drop in water level per unit of time was recorded. Only qualitative rather than quantitative conclusions were drawn from these studies, but a number of general comments about the field permeability may be made :

. at shallow depths, the field permeability was generally of a low order, irrespective of lithology.

- field permeability increased with depth, but not in a readily predictable fashion, as the permeability of units in this catchment appears to be primarily a function of fissure distribution.

- the field permeability of boreholes which cross cut dolerite dykes was considerably higher than that of those which did not. This feature may be attributed to induration along dyke margins and the increased incidence of jointing due to cooling of the rock mass.

4.6.3 Water level monitoring

Of the 55 boreholes put down by the Department of Water Affairs, eighteen were completed by the end of 1958 with an additional twenty one being sunk in 1959 and the final sixteen being added to the network in 1960.

All of these sites were regularly monitored throughout 1960 and 1961. In addition, Stevens water stage recorders were installed at six selected sites to provide a continuous record of ground water level fluctuations, with additional recorders being installed on a short term basis for ad hoc level readings and monitoring of pumping tests.

Responsibility for the monitoring of these observation boreholes passed from the Geological Survey to the Department of Agricultural Technical Services in December 1961, when the number of monitoring points was reduced from 55 to 41. In February 1962, this number was increased to 50, and then reduced again in October 1962 to 39. In the period July 1964 to March 1968, only nineteen of the original 55 boreholes were still being monitored on a regular basis.

4.6.4 Water table fluctuations

Data from monitoring of water levels in the De Hoek and Ntabamhlope districts demonstrated a number of relationships:

- patterns and scales of water level fluctuation in boreholes which intersected the same dolerite dykes showed striking similarity, thus indicating a high degree of interconnection via fissure networks;

- annual hydrographs in the vast majority of boreholes showed a seasonal variation comparable with the pattern of precipitation over these catchments. However peaks in ground water level tend to lag several weeks behind peaks in rainfall, thus indicating that there is a delay between rainfall and aquifer recharge;

- semi-diurnal water level fluctuations attributable to earth tides were also identified in a number of boreholes equiped with autographic recorders, with new and full moons causing fluctuations of the maximum amplitude.
  These effects were only discernable in boreholes which intersected dolerite dykes.

4.6.5 Pumping tests

An estimate of borehole yield was obtained by conducting a series of bailing tests on 11 boreholes. Yields ranged from "very small" to a maximum of 480 gph (2.2m^3/h).

A series of five pumping tests were carried out. However, the data obtained from these tests was not suitable for analysis using standard graphical analytical techniques, as the pumping rate was altered at several points during each test, and tests commenced when recovery from previous phases of pumping was still incomplete. However, broad conclusions may be drawn from the results of these experiments:

- boreholes in this area generally have low yields (less than 500 gph ($2.3m^3/h$)). The maximum yield seen was at borehole 15P, where an abstraction rate of 1600gph (7.3 m^3/h) was sustained for 60 hours. However, such a yield is recognised as being exceptional for the region;

- boreholes which lie on the same dyke appear to have good hydraulic connectivity and show drawdown effects as the result of interference from pumping wells up to 1850' (564 m) away;

- boreholes in the sediments show little response to pumping of adjacent boreholes due to the relative impermeability of the sandstones and mudstones;

- recovery of abstraction and observation wells after pumping was generally very slow (on average, after 98 hours pumping at 1600gph ($7.3m^3/h$), the majority of boreholes took nearly 200 days to recover to pre-test water levels). This indicates that recharge rates within the aquifer are slow.

4.6.6 SRK ground water investigation

Eighteen boreholes were sunk in and around catchments 20 and 28 (previously labelled 14 and 14A respectively). This drilling was undertaken by Mr Pretorius of the Department of Water Affairs, Ladysmith between September and November 1984, under the supervision of M Sacchi of SRK. Chip samples were logged, retained and then re-examined by R Pallett, University of Natal, technician seconded to SRK in June 1985. The positions of these boreholes are shown on Figure E 13.

These boreholes range between 27.1m and 103m in depth. (See Table E 2). The majority of these boreholes were dry, with the highest air lift yield being encountered in borehole 18. This yielded 0.375l/sec (1.35 m^3/h), which is still extremely low. Lithologies encountered were essentially sandstones and mudstones of the Beaufort Group, intruded by later dolerite dykes and sills. Sediments adjacent to intrusions showed a tendancy to become indurated due to baking, and may have considerably higher permeabilities than the unbaked country rock due to the development of cooling joints and fissures.

Although it was originally intended that some of these holes should be pump tested, the extremely low air lift yields indicated that no meaningful results could be obtained from such testing, as the boreholes would dewater rapidly, even at a very low pumping rate. Instead, it was decided that packer testing of a pair of selected boreholes would be a more reliable method of determining transmissivity and hydraulic conductivity values for the aquifers encountered.

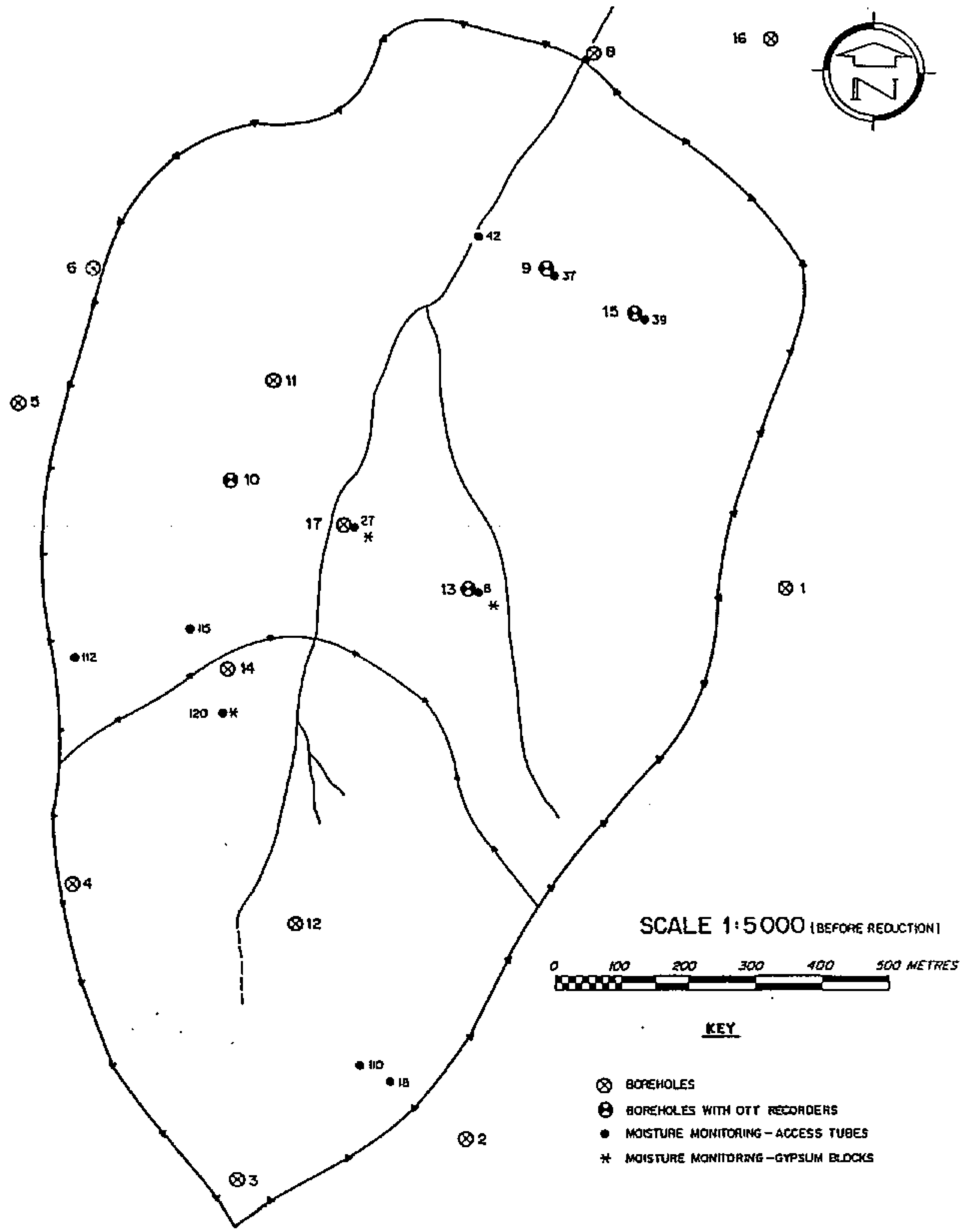

16
8
9
37
15
39
42
6
11
5
10
17
27
13
8
1
115
112
14
120
4
12
110
18
2
3
SCALE 1:5000 (BEFORE REDUCTION)
0
100
200
300
400
500 METRES
KEY
BOREHOLES
BOREHOLES WITH OTT RECORDERS
MOISTURE MONITORING – ACCESS TUBES
MOISTURE MONITORING – GYPSUM BLOCKS

TABLE E 2

GROUND WATER MONITORING

BOREHOLE NUMBER	TOPO ELV H A M S L (m)	AVERAGE REST WATER LEVEL	AVERAGE REST WATER LEVEL (mamsl)	BOREHOLE	DEPTH (m)	AIR LIFT YIELD (1/sec)
1	1490	- 25.70	1464.30	1	91	-
2	1521	- 60.37	1460.63	2	93	3
3	1535	- 63.84	1471.16	3	103	0.23
4	1514	- 39.48	1474.52	4	78	0.27
5	1487	- 14.23	1472.77	5	73	0.11
6	1485	- 60.83	1424.17	6	69	-
7	1460	- 19.05	1440.95	7	55	-
8	1430	- 84.18	*1345.82	8	91	-
9	1452	- 27.85	1424.15	9	91	-
10	1474	- 19.35	1454.65	10	67	-
11	1473	- 69.96	1403.04	11	73	-
12	1489	- 14.72	1474.28	12	79	0.32
13	1471	- 16.03	1454.97	13	79	-
14	1474	- 6.94	1467.06	14	27.1	-
15	1470	- 79.49	1390.51	15	91	-
16	1450	- 43.73	1406.27	16	85	-
17	1458	- 3.50	1454.50	17	85	-
18	1489	- 17.24	1471.76	18	67	0.375

* Ground water levels calculated from 1:50 000 topo reference height to determine correct conversion factor (1m = 3.28 ft).

4.6.7 Packer testing

Two boreholes, boreholes 4 and 17 were selected for packer testing in June 1987 in order to determine the variation of permeability with depth within these boreholes.

The results of these tests are tabulated below:

TABLE E 3: BOREHOLE 14 PACKER TESTING

TEST NUMBER	INTERVAL TOP (m)	(mbgl) BASE (m)	TEST SECTION LENGTH (m)	HYDRAULIC CONDUCTIVITY (m/sec)	TRANSMISSIVITY, T INTERVAL (m^2/d)	CUMULATIVE (m^2/d)
1	66.5	76.2	9.7	IMPERMEABLE	0	0
2	60.5	67.0	6.5	IMPERMEABLE	0	0
3	53.45	59.95	6.5	IMPERMEABLE	0	0
4	47.1	53.6	6.5	2.8×10^{-7}	0.16	0.04
5	40.4	46.9	6.5	2.8×10^{-6}	1.57	0.344

Thus, for the section of borehole 4 between 40.4 mbgl and 76.2 m the cumulative transmissivity is 0.344 m^2/d, which is extremely Of this interval, the section between 53.45 mbgl and 76.2 mbg effectively impermeable. This corresponds to alternating grey-sandstone and purple mudstone beds on the lithological log for hole. However, there appears to be little difference in term lithology between this and the more permeable section between 40.4 and 53.6 mbgl.

TABLE E 4 BOREHOLE 17, PACKER TESTING

TEST NUMBER	INTERVAL TOP (mbgl)	INTERVAL BASE (mbgl)	TEST SECTION LENGTH (m)	HYDRAULIC CONDUCTIVITY (m/sec)	TRANSMISSIVITY, T INTERVAL (m^2/d)	TRANSMISSIVITY, T CUMULATIVE (m^2/d)
1	13.65	84	70.35	8.7×10^{-8}		
2	13.65	20.25	6.60	6.6×10^{-7}	0.4	
3	20.35	84	63.65	IMPERMEABLE		

Thus, for the section of borehole between 13.65mbgl and 84 mbgl, the cumulative transmissivity is effectivly zero Only the top 6.6m of this interval shows any permeability. This corresponds to light brown weathered sandstone on the lithological logs. The impermeable section below this can be correlated to the lower section of this weathered brown sandstone and the underlying grey sandstone.

4.6.8 Borehole hydrographs from the De Hoek Catchments

A monitoring programme was set up in March 1985 to observe the fluctuations in water levels seen in the eighteen boreholes put down in late 1984. This data was used to plot up hydrographs which are presented in Figures E 14, E 15 and E 16.

It should be noted that the scale along the horizontal axis is not directly proportional to time, as each division simply represents a single reading. Initially readings were taken on approximately a weekly basis, but, as time progressed, the interval between readings grew progressively longer. In all, data was collected between March 1985 and October 1986, a period of 19 months.

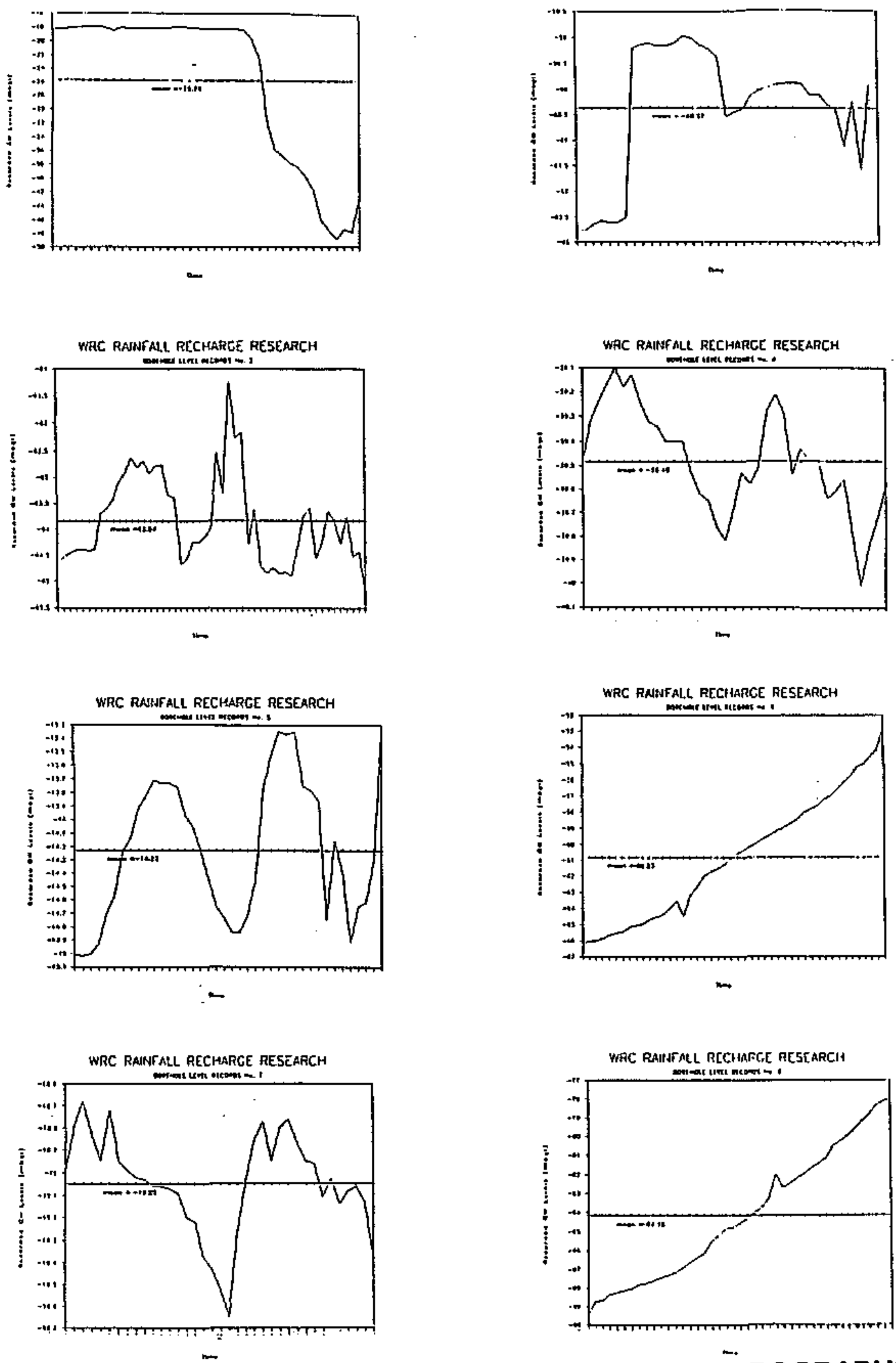


FIGURE E.14 GROUND WATER HYDROGRAPHS

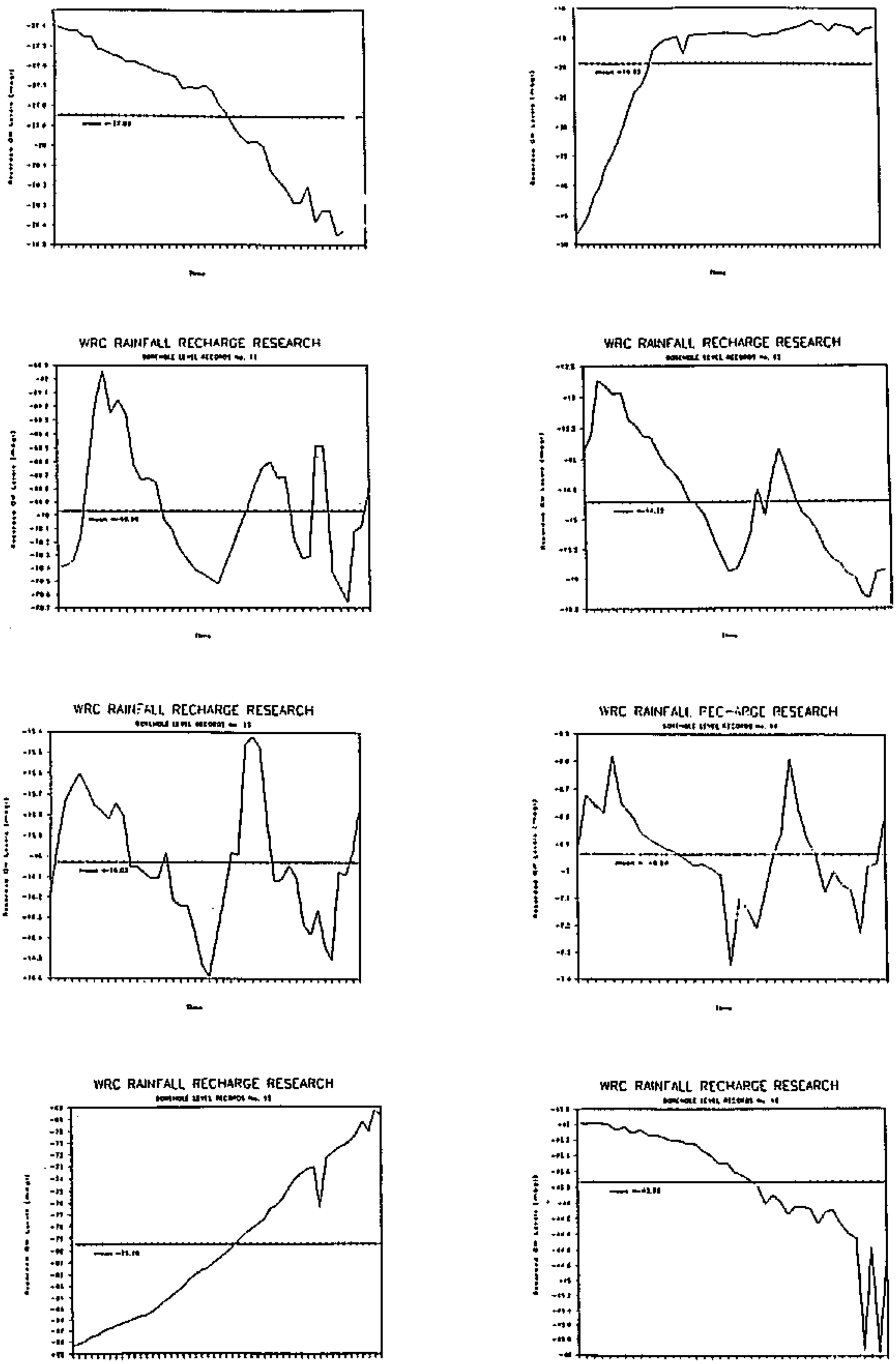
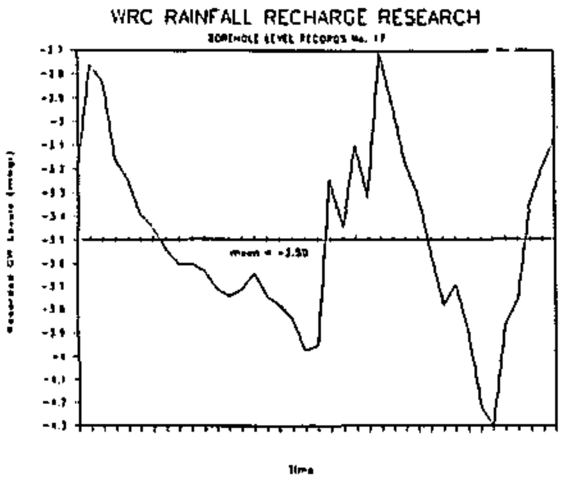


FIGURE E.15 GROUND WATER HYDROGRAPHS



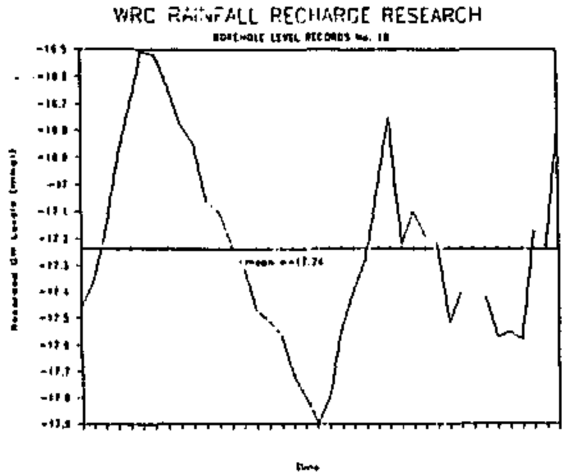


FIGURE E.16 GROUND WATER HYDROGRAPHS

Despite the distortion of this timescale, these hydrographs can still be used to determine valuable information about the ground water conditions within the De Hoek Catchment.

In general, these eighteen hydrographs may be subdivided into five categories;

- those which show 'seasonal' fluctuation in levels (seen in boreholes 3, 4, 5, 7, 11, 12, 13, 14, 17, 18);

- those which show a dominantly 'upward' trend in water levels, that is, there appears to be a consistant rise in ground water levels with time. Boreholes 6, 8 and 15 fall into this category;

- those which show a dominantly 'downward' trend in water levels, that is, there appears to be a consistant decline in ground water levels with time. Boreholes 9 and 16 both show this trend;

- those which show 'seasonal' variations superimposed on an underlying downward trend, seen in boreholes 4, 11, 12 and 17;

- those which show none of the above four patterns. The hydrographs of boreholes 1, 2 and 10 fall into this category.

The average depth to water within this catchment over the period observed varied between 1474.52 mamsl (at borehole 4) and 1345.82 mamsl (at borehole 8). The maximum fluctuation in levels over the monitoring period is seen at borehole 1, where a difference of 31m between the highest and lowest readings is noted; in contrast, the minimum fluctuation is seen at borehole 14, where a variation of only 0.75m is identified over the entire period.

It should be emphasised that no pumping is taking place within the de Hoek Catchment and thus, no features on these hydrographs may be attributed to the effects of interference from adjacent pumping wells.

These trends have been interpreted to identify the ground water conditions on the basis of these hydrograph results. Each of the five identified catagories will be discussed in greater detail:

Category 1: Seasonally fluctuating hydrographs

Boreholes which show these characteristics can be seen to be responding to volumetric changes in water storage within the aquifer which may be directly correlated to seasonal trends in rainfall and infiltration patterns. Borehole water levels may be expected to attain maximum elevation in the autumn period, following the winter rainfall, and then to decline slowly throughout the winter and spring periods. The scale of these fluctuations will be dependent on the transmissivity and storage of the aquifer at a given point, which will govern the rate at which water is recharged to the aquifer under observation, both laterally as a result of ground water movement under a regional hydraulic gradient, and vertically, as a result of infiltrating precipitation. The storativity of the aquifer will also determine the scale of such fluctuations, as the lower the amount of available void space for water to occupy, the greater the size of fluctuation in ground water levels that will be seen as a result of a given amount of recharge.

Category 2 : 'Upward' trending hydrographs

A consistent rise in water levels over the period of monitoring implies that recharge is occuring to the aquifer in the vicinity of the borehole, thus leading to a gradual rise in observed water levels. Such an effect could be attributed to a number of causes. One such possible cause is a general rise in ground water levels over the entire area. However, if this were the case, then it would be expected that such an effect would be apparent over the entire catchment, and would show some seasonal fluctuation.

A consistent rise in borehole water levels could also arise as a result of leakage from the de Hoek river into the main body of the aquifer. However, it would be expected that the river and the aquifer would have reached some sort of equilibrium state, unless the drainage system has only recently been established in the present position, or has only just eroded channel down to a level where the river and the aquifer are in hydraulic continuity. Also, of the three boreholes which have been identified as showing this trend, only borehole 8 lies close enough to the river for this mechanism to be likely.

Category 3 : 'Downward' trending hydrographs

Continuous downward trends in borehole hydrographs imply a progressive draining of the aquifer in the vicinity of the boreholes. This sort of response would generally be interpreted as an interference effect from neighbouring pumping wells but, as previously mentioned, there are no pumping wells in or around this catchment.

A similar effect would also be generated as the result of a ground water recession caused by a prolonged period of drought spanning several years. However, if this were the case, then this response should be generated across the entire catchment, which is not apparent elsewhere. Similarly, if this was the case, then some sort of seasonal fluctuation would be expected, which is not seen in these boreholes.

Category 4: Seasonal fluctuations superimposed on declining hydrographs

This effect may be interpreted as being the result of a ground water recession resulting from a protracted drought period with the effects of seasonal variations in infiltration rates apparent as peaks and troughs superimposed on the underlying decline in water levels.

Category 5: Other trends

The hydrographs for boreholes 1, 2 and 10 do not fit into any of the above categories. The water level in borehole 1 is essentially static for a long period of time, and then shows a sharp drop of approximately 30m in six months. Borehole 2 shows an erratic pattern of ground water level fluctuation, with differences of up to 3.5m over a period of a fortnight.

Borehole 10 shows almost the opposite response with time to Borehole 1, with water levels coming closer and closer to the surface over a period of four months, in which time, levels rise from 48 mbgl to 15 mbgl and then level off.

It is very difficult to postulate hydrogeological conditions that would give rise to such a range of seemingly unrelated responses over such a small area. Thus, without additional investigations in this area, it is not possible to interprete the results in any useful fashion.

4.6.9 Correlation between rainfall and ground water levels

Van Wyk and du Preez noticed in their studies of the de Hoek and Ntabamhlope districts that there was a correlation between rainfall and ground water levels. This phenomenon is illustrated conclusively by plotting cumulative departure rainfall curves against ground water levels for boreholes 4, 11, 12 and 17. These graphs are presented in Figures E 17 and E 18.

From these plots it can be seen that the pattern shown by the rainfall cumulative departure curve is closely mimicked by the trend of ground water levels, showing a pronounced peak in April and May and reaching minimum levels in October and November. There appears to be very little offset of these two curves (although van Wyk and du Preez record a significant time lag between these two peaks) which suggests that "piston" displacement of water from the saturated horizons of the soil to the water table occurs following rainfall events. Alternatively, the coincidence of these two peaks may be attributed at least in part, to direct recharge of the borehole from rainfall, for example, where the boreholes have not been sealed adequately at the surface

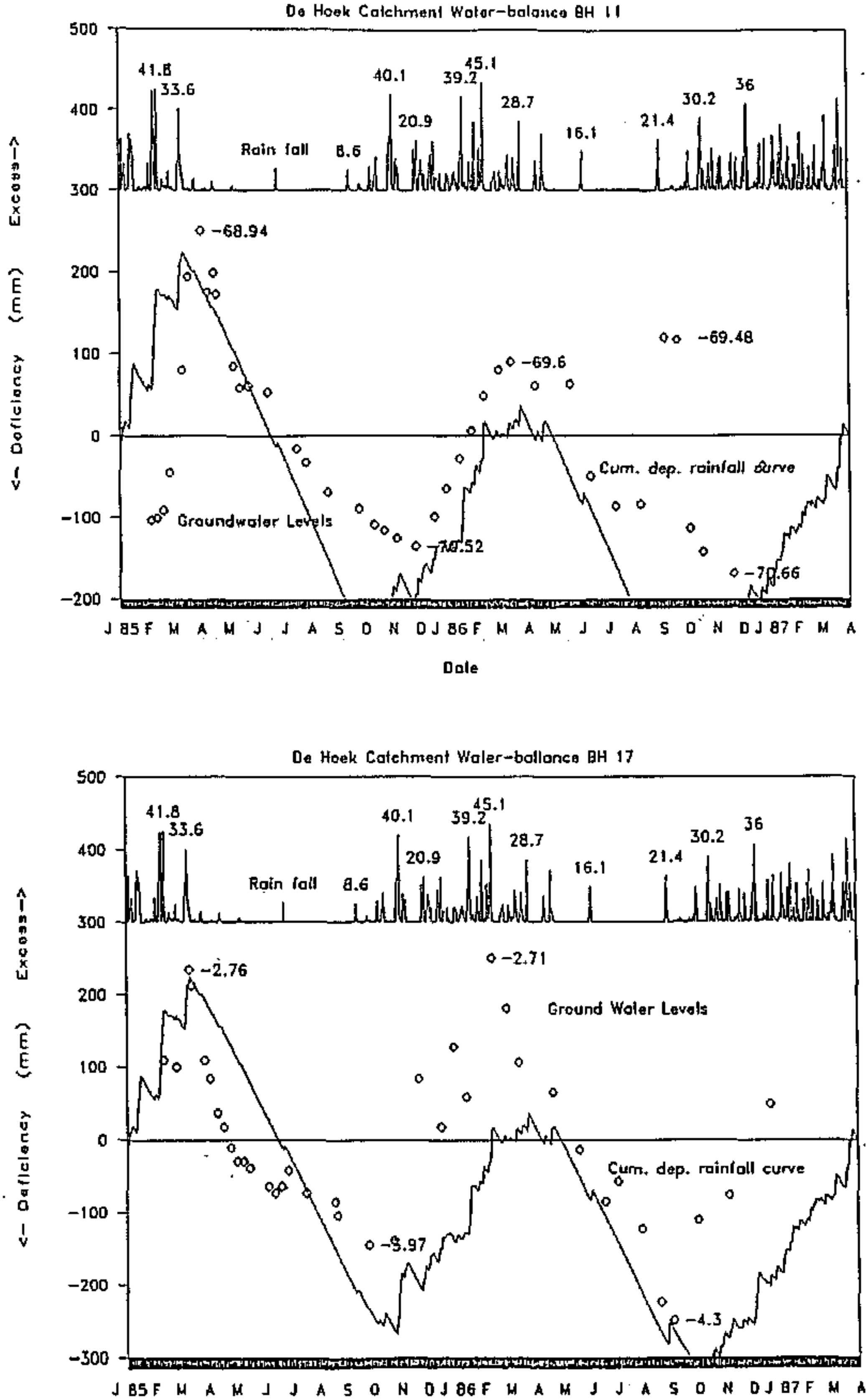
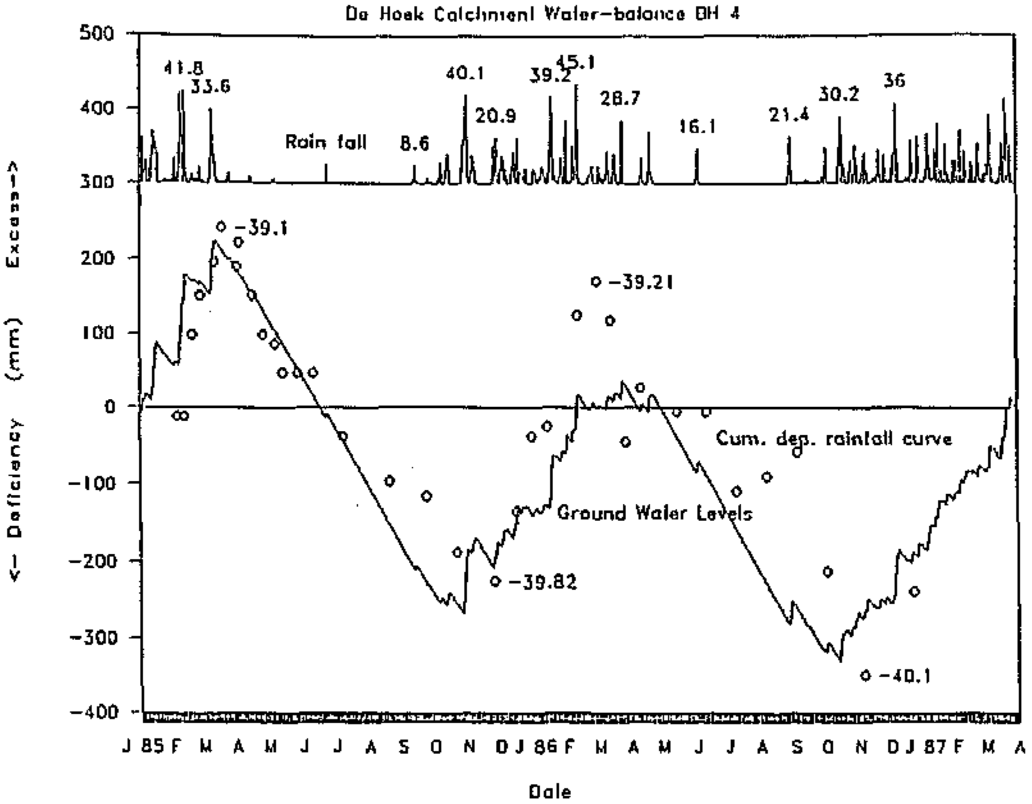


FIGURE E.17 CUMULATIVE DEPARTURE RAINFALL CURVES



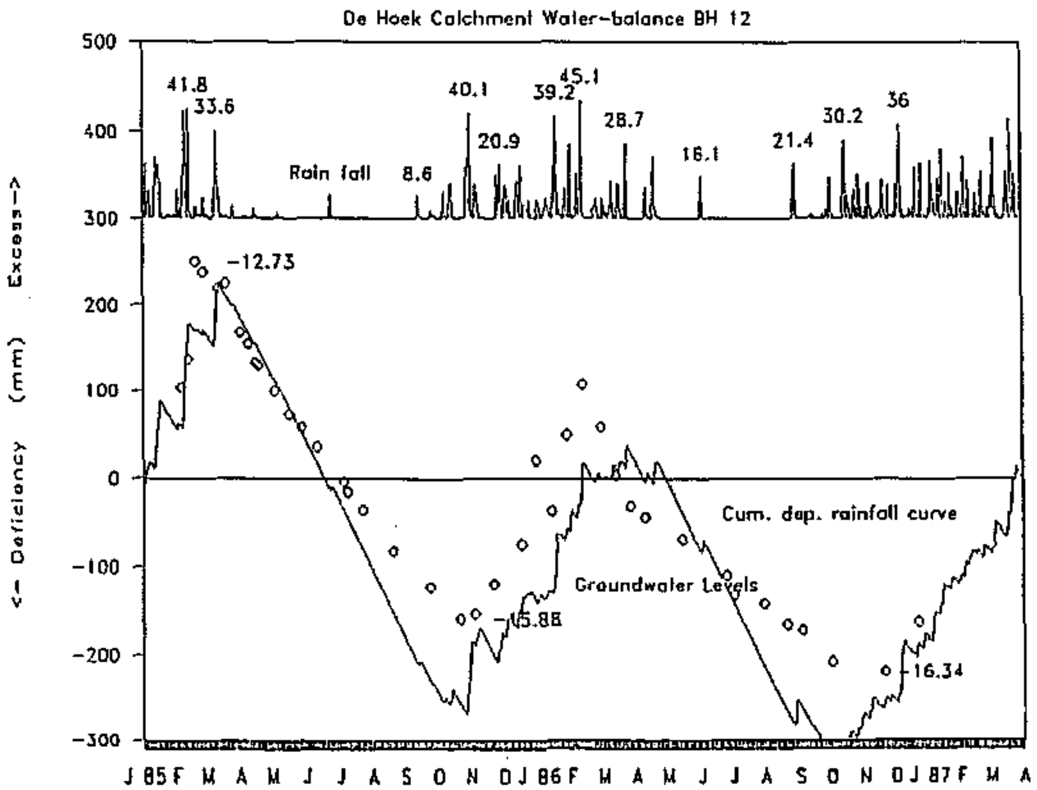


FIGURE E.18 CUMULATIVE DEPARTURE RAINFALL CURVES

4.6.10 Position of the piezometric surface

Ground water contour plans for February, April and June 1985 were drawn up using data from these boreholes, and are presented as figure E 19. These show the position of the local potentiometric surface in metres above mean sea level and indicate that ground water flow occurs in a northerly direction towards the river and the catchment outfall at weir V1M20. Flow directions do not appear to alter significantly with the season, although the elevation of the piezometric surface relative to mean sea level does show appreciable variation with time.

4.7 Climate

The climatic data for the De Hoek Catchment has been extracted from Schulze (1982).

4.7.1 Precipitation

There are two meteorological stations close to the De Hoek catchment; Monk's Cowl station 267/693 has a continuous record longer than 15 years, whilst the Ntabamhlope station 268/900 has a continuous record for 26 years.

The mean annual precipitation for the region is 1115 mm. The mean monthly precipitation over this area is tabulated in table E 5. Detailed records for station T14 are presented in Appendix E 1.

FIGURE E.19 GROUND WATER CONTOURS

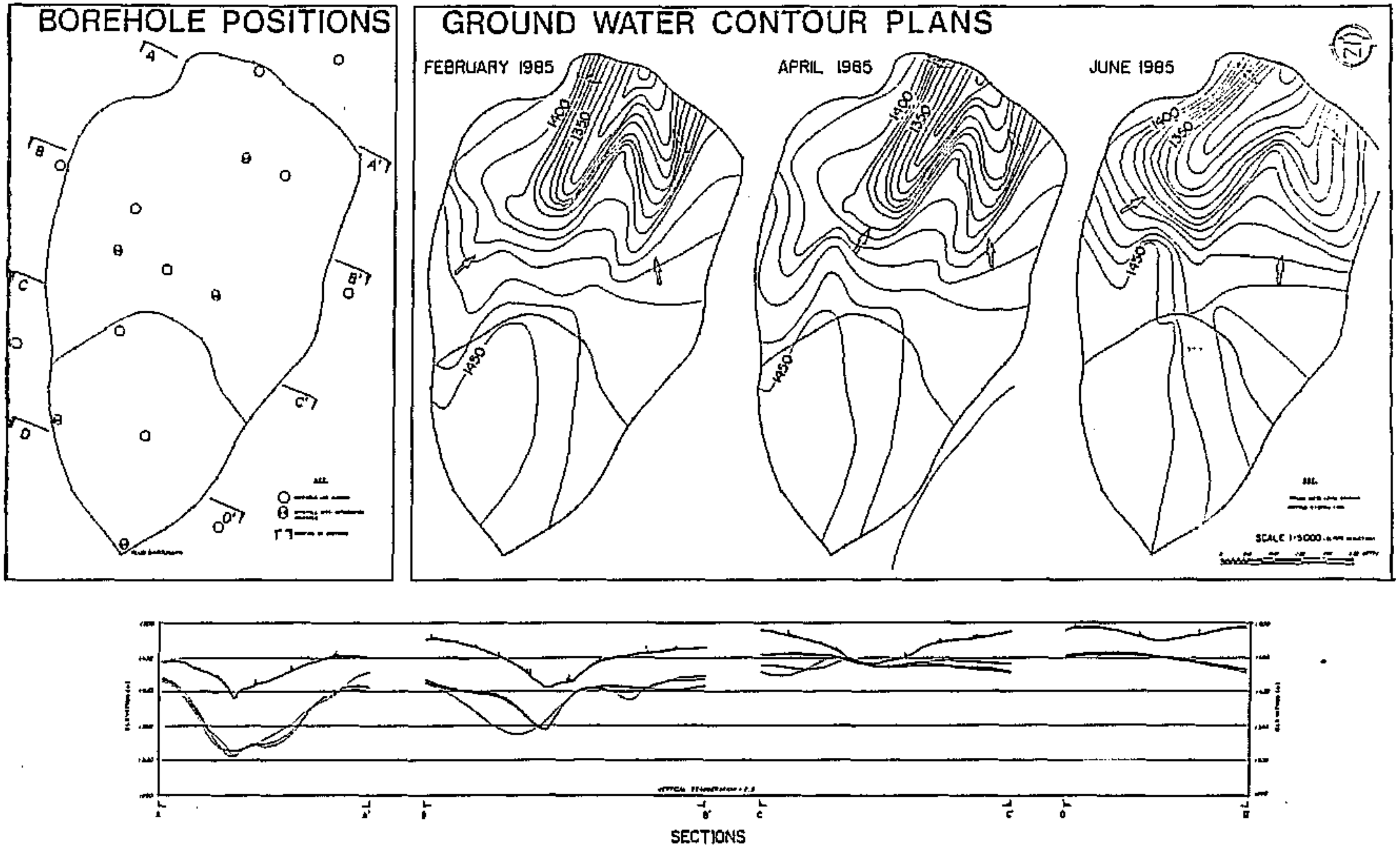


TABLE E 5
MEAN MONTHLY PRECIPITATION FALLING OVER DE HOEK CATCHMENT

MONTH	M.M.P (mm)	MONTH	M.M.P (mm)
JANUARY	235	JULY	10
FEBRUARY	200	AUGUST	25
MARCH	175	SEPTEMBER	50
APRIL	65	OCTOBER	82
MAY	30	NOVEMBER	125
JUNE	20	DECEMBER	160

Mean monthly precipitation is a particularly valuable statistic to consider when assessing the climatic regime of a region, since the time period is coarse enough to smooth over irregularities in the record which would become apparent over time steps of a shorter duration, and yet fine enough to permit major differences from one month to another. From these figures it is apparent that De Hoek experiences mainly summer rainfall with some in winter with a mean monthly maximum seen in January, and 76% of the total annual rainfall falling in the period falling in the period November - March.

Consideration of the mean monthly number of raindays provides an indication of the frequency and intensity of rainfall episodes. This may be considered in one of two ways:

. days when over 1mm of precipitation has been recorded;
. days when over 10mm of precipitation has been recorded.

The latter of these two definitions is of particular significance, as 10mm is taken as the lower limit for the production of run off.

4.7.2 TEMPERATURE

Monthly means of daily maximum temperatures range between 16.0°C in July and 24.5°C in January, whilst mean daily minima fall between 3.3°C in June and 12.9°C in January.

Figures for the mean daily temperature maxima and minimaare presented in Table E 6.

TABLE E 6
MONTHLY MAXIMUM AND MINIMUM TEMPERATURES IN
THE DE HOEK CATCHMENT

MONTH	MEAN TEMPERATURE	°C	DAILY DAILY MAXIMUMMINIMUM
JANUARY	18/19		2614
FEBRUARY	18		—
MARCH	18		2412/13
APRIL	14/15		--
MAY		11	183/4
JUNE		9/10	—
JULY		8	161
AUGUST	12		--
SEPTEMBER	15		217
OCTOBER	15/16		---
NOVEMBER	19		2410
DECEMBER	20		—

4.7.3 Evapotranspiration

An A-pan evaporation pan at the Ntabamhlope weather station records an average annual value of 1525 mm, with maxima in the months October to December (160mm in each month) and a minimum of 76 mm in June. Detailed records are presented in Appendix E 2.

Large scale maps are available which contour values for potential evapotranspiration given a full canopy coverage which give the following monthly statistics for the De Hoek catchment:

TABLE E 7

POTENTIAL EVAPOTRANSPIRATION IN THE DE HOEK CATCHMENT

MONTH	POTENTIAL MONTHLY EVAPOTRANSPIRATION (mm)	MONTH	POTENTIAL MONTHLY EVAPOTRANSPIRATION (mm)
JANUARY	178	JULY	102
FEBRUARY	155	AUGUST	132
MARCH	158	SEPTEMBER	150
APRIL	130	OCTOBER	180
MAY	115	NOVEMBER	168
JUNE	98	DECEMBER	180

Mean Annual potential evapotranspiration = 1780 mm

4.7.4 Wind

The windiest months in the De Hoek catchment are between September and November, with wind runs exceed 190 km/day.

March and April are the least windy months, whilst the most consistant winds are experienced in July.

4.7.5 Sunshine

The average daily sunshine duration is 6.9 hours; with January as the cloudiest month (6.0 hours/day of sunlight) and July as the sunniest (over 7.7 hours/day).

4.8 Landuse

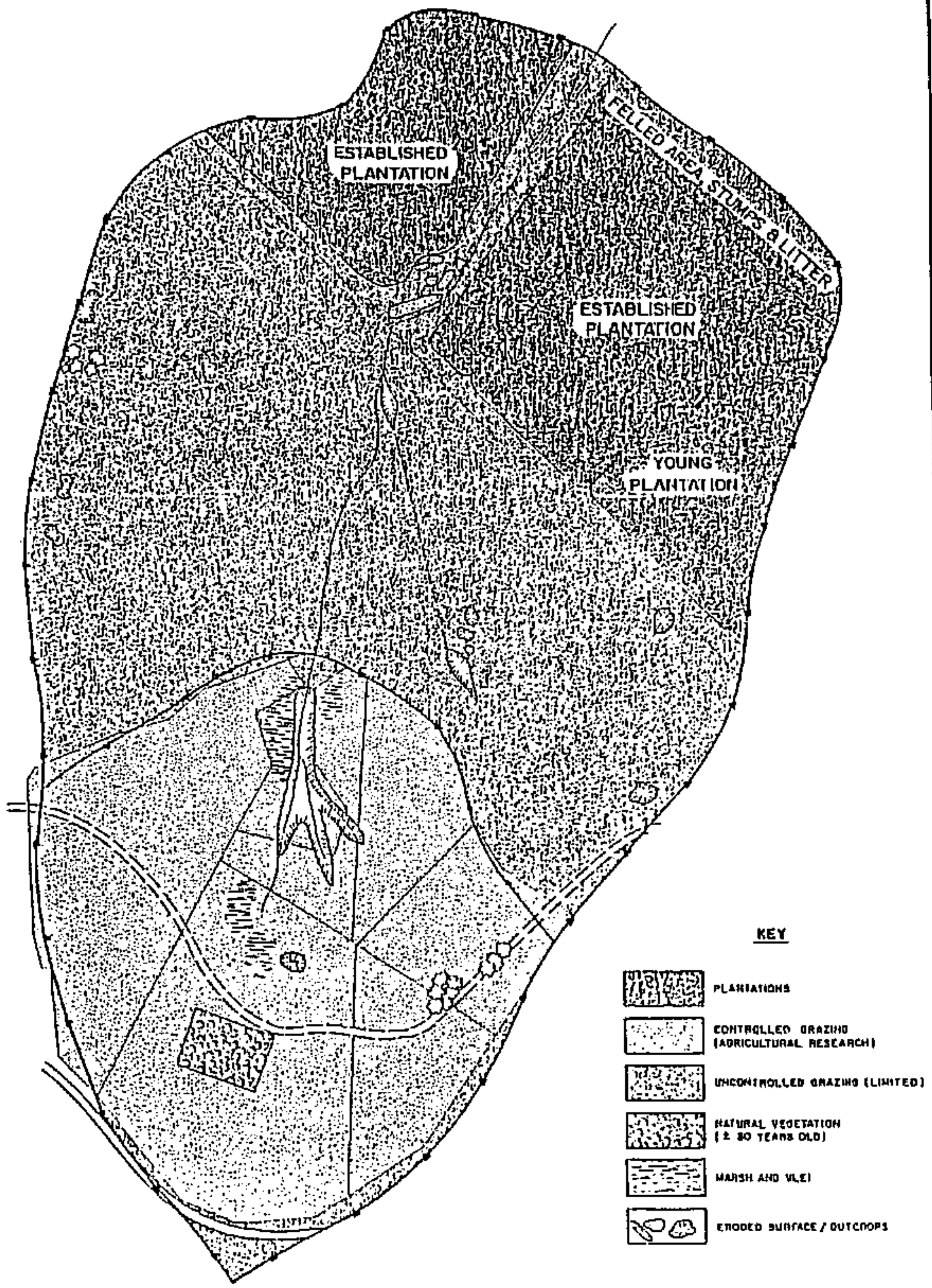
The major part of the De Hoek catchment is covered by highland sourveld, which is under controlled grazing. The northern third of the catchment is under black wattle and is given over to eucalyptus plantations which are under the juristiction of Masonite (Africa) Ltd. A map of landuse in catchments 20 and 28 is presented as figure E 20.

5 CATCHMENT INSTRUMENTATION

Monitoring of climatic and hydrological data in this region was first instigated in the late 1950's when the Department of Water Affairs in conjunction with the Department of Agricultural Technical Services initiated hydrological investigations. Data on rainfall, streamflow and borehole water levels in adjacent catchments was collected, but never processed, and the research was abandoned.

Prior to installation of any field equipment specific to the project, the catchment was already equipped with an operating stream gauging station at weir V1M28 and a closed weir, V1M20 at the mouth of the catchment. In addition, a rainfall station at the head of the catchment provided a continuous autographic rainfall record and a full weather station was operative at the Ntabamhlope Research Station.

FIGURE E.20 LANDUSE



To allow field monitoring to proceed as planned for the recharge project, it was necessary to supplement the existing hydrological infrastructure with the following equipment:

- an autographic rain gauge at the mouth of the catchment, close to weir V1M20;

- seventeen boreholes within and adjacent to the boundaries of the catchment. Four of these boreholes were subsequently equipped with autographic water level recorders;

- forty-two access tubes to allow neutron probe logging of the soil profile;

- three intensive moisture monitoring installations consisting of an access tube, moisture block and three tensionmeters;

- the clearing and rehabilitation of weir V1M20, which was also equipped with an autographic recorder.

The positions of these installations are shown in Figure E 13.

6 MONITORING AND DATA ACQUISITION

6.1 Regular monitoring

6.1.1 Climatic monitoring

The three main climatic parameters required for modelling of ground water recharge from rainfall are:

- precipitation
- evaporation
- transpiration

Precipitation was recorded using two autographic rain gauges situated at the base and head of the catchment. This yielded information on the spatial distribution and nature of rainfall falling on the catchment in terms of rainfall volume, duration, intensity and time of occurance. Rain samples were collected on an irregular basis and analysed for chloride content to provide data for the chloride mass balance determination (see Section 6.1.4).

Temperature, A-Pan evaporation, sunshine duration and windrun are monitored on a daily basis at the Ntabamhlope research station 2 km south west of the catchment.

6.1.2 Hydrological monitoring

Surface water flows in stream courses were monitored at gauging stations V1M20 and V1M28. These stations were inspected weekly to check measured streamflow and time against data recorded by the autographic recorder, and to change charts when necessary. Detailed records are presented in Appendix E 3.

Water samples were taken weekly from both stations, and subjected to a determination of conductivity for comparison with conductivities derived for ground water sampling.

6.1.3 Soil moisture status monitoring

Data on the soil moisture status of the catchment was gathered on a regular basis using the following monitoring equipment:

- neutron probe
- tensiometers
- moisture blocks

Neutron probes

A soil moisture data base for the catchment was established by monitoring moisture content at ten sites using a neutron probe. Each site was equipped with an access tube to a depth of 1.6m. Moisture readings (probe count ratios) were taken at 100mm intervals from an initial depth of 200mm.

Access tubes were sited to facilitate the monitoring of the following characteristics:

. the distribution of soil moisture with depth throughout the catchment;

. the relationship between soil moisture and depth in areas of different relief and landuse (for example, controlled grazing, plantations, upland, midslope and bottomland sizes);

. the variation of soil moisture with depth for the dominant soil types.

Monitoring was carried out twice weekly during the rainy season, and weekly during the dry season. Monitoring was intensified to take place on a daily basis during periods of significant rainfall.
A calibration curve for each moisture monitoring site was derived to convert probe count ratios to an absolute amount of moisture. To do this, soil samples were taken simultaneously with probe readings over a sixteen month period, and were analysed for moisture content. Calibration curves were then obtained by plotting moisture content against count ratio. The calibration results are presented in Appendix E 12.

Some problems were experienced during routine moisture monitoring due to vandalism of the test sites. This did not result in a significant loss of data, but additional expense was incurred in repairing and replacing access tubes. Additional data loss was caused by malfunctioning of the electronic switches and display on the neutron probe, which frequently occurred in the final months of the monitoring programme.

Moisture blocks

Gypsum blocks were installed at 500mm depth at three sites, each in association with an access tube and tensionmeter cluster, which were monitored on a weekly basis. Changes in moisture content could only be determined below field capacity because moisture contents at or above field capacity give readings of 100% moisture. After monitoring these installations for 20 months, they were destroyed by fire.

Tensiometers

Three tensiometers clusters were set up in association with access tubes. These clusters consisted of three tensiometers with porous cups set at depths of 200m, 400m and 600m, situated 1.2m from the access tube and connected by thin tubing to a mercury manometer to determine suction head.

Tensiometers proved to be unsuccessful field instruments in this area for the following reasons:

- difficulty was experienced in obtaining an airtight system, and suction heads were consistently low, thus making it difficult to take readings with accuracy;

- tensiometers are delicate instruments and not suited to installation in open areas where they have little protection. In particular cattle, rodents and fire had a destructive effect on these installations.

Tensiometer clusters were replaced twice; once to try and gain greater suction heads, with instruments modified to reduce the volume of water within the instrument itself and again after destruction by fire.

Details of results of field capacity and wilting point determinations are given in Appendices E 7 and E 8 respectively.

6.1.4 Ground water monitoring

Water levels within each borehole were measured monthly using a dip meter. Boreholes were visited weekly to change charts and cross check recorded levels with dipped levels. Problems were experienced with stepping of the pen on the chart. This was attributed to:

- cables not running freely within the borehole between float and recorder;

- the float adhering to the side of the borehole and thus not responding immediately to changes in water level;

- a swarm of bees preventing free movement of the pulley mechanism on one recorder.

These problems were overcome by:

- placing the cables centrally over the borehole by using modified mounting brackets;

- pouring soapy water into the borehole to reduce friction between the sides and float;

- removing the bees.

Difficulty was experienced in manually determining water levels in the four boreholes equipped with autographic recorders. On several occasions, the float cable was dislodged, and the float and cable had to to retrieved using a grapple hook.

Boreholes were kept locked to prevent damage, but during the monitoring programme, boreholes 7 and 8 were broken into and blocked, thus preventing further monitoring at the sites. Ground water samples were taken from the boreholes not equipped with autographic recorders on an irregular basis in the few days following a significant rainfall event. Sampling was conducted using a bailer which captured samples at a depth approximately 6m below the standing water surface. These were then subject to chloride analysis and electrical conductivity determination and the results compared with chloride content of rainfall over the catchment to obtain a mass balance determination.
Tables E 8 and E 9 present a tabular representation of the duration of the various monitoring activities in the

ACTIVITY	1985												1986												1987		
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Climate monitoring	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Groundcover Conditions																											
. Photographing						X	X								X											X	
. Veld burning										X												X					
. Tree felling	X																									X	
Soil Hydraulic Characteristics																											
. Moisture changes																											
- neutron probe	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
- moisture blocks	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
. Soil sampling																											
- particle size																X					X						
- retention const																					X						
- sat. conductivity																					X						
- bulk density																					X						
- probe calib.					X	X					X		X	X	X	X	X	X	X	X							
- Soil suction tens		X	X	X			X	X	X	X	X																
. Infiltration tests							X	X	X				X														
Ground water monitoring																											
. Manual monitoring	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
. Autographic mon.		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
. G/water sampling						X				X															X		
. Rainfall sampling							X			X	X	X	X	X	X	X	X				X	X	X	X	X	X	X
Surface water																											
. Autographic monitoring	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
. sampling												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

TABLE E.8 FIELD MONITORING PROGRAMME CARRIED OUT IN THE DE HOEK CATCHMENT

BORE-HOLE NUMBER	MONITORING PERIOD 1985												1986												1987		
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3		X	X	X	X	X	X	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
4		A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8		A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9		A	A	A	A	A	A	A	A	A	A	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10		X	X	X	A	A	A	A	A	A	A	A	X	A	A	A	A	A	A	A	A	A	A	A	A	A	A
11		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13		A	A	A	A	A	A	A	A	A	A	A	X	X	X	A	A	A	A	A	A	A	A	A	A	A	A
14		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
16		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
17		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
18		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

TABLE E.9 SUMMARY OF BOREHOLE MONITORING PROGRAMME CARRIED OUT IN THE DE HOEK CATCHMENT

A = AUTOGRAPHIC MONITORING X = MANUAL MONITORING

De Hoek catchment during the period 1985-1987. Themonitoring results are presented in Appendix E 4.

6.2 Specific testing

Double ring infiltrometer tests were undertaken at five sites distributed evenly throughout the catchment to determine the hydraulic conductivity of soils in the De Hoek region. The falling head procedure described by Klute (1965) was employed, with slight modifications to compensate for field conditions. The rings used initially were judged to test too small a cross-sectional area to be representative of the regional soils, and were replaced by rings approximately 500mm in diameter. Rings were driven into the soil to a depth of 100mm with as little disturbance to the soil as possible, and a layer of cloth was placed within the rings to prevent soil surface disturbance during water application.

6.2.1 Field determination of saturated hydraulic conductivity

Prior to making a determination of saturated hydraulic conductivity, the soil was well saturated. A head of water was maintained in the outer ring throughout the test to prevent lateral flow from the inside ring in order that the vertical hydraulic conductivity might be determined. A measured amount of water was then added to the inner ring, and the fall in head as a function of time was monitored. Detailed results are presented in Appendix E 10.

6.2.2 Field determination of unsaturated hydraulic conductivity

The progress of the wetting front through the soil profile was monitored at five sites using double ring infiltrometers. The outer ring was filled with water to prevent lateral flow, and a measured amount of water was added to the inner ring.

At a given time interval after water application, an undisturbed core sample of the soil profile was taken to a depth of 1600mm to determine moisture content. Control samples were taken nearby at the same depth and time for comparison.

Tracing the wetting front down the profile using the neutron probe was often unsuccessful. This was carried out at access tubes other than those used for routine moisture determination. Infiltration rings were placed around access tubes, and the water was added to the inner and outer rings as described above. After a given time, the neutron probe was run down the access tube. However, it proved extremely difficult to prevent lateral flow and also water travelling down the outside of the access tube, thus unacceptably exaggerating the measured unsaturated hydraulic conductivity values.

6.2.3 Soil sampling

Laboratory analysis to determine bulk density, hydraulic conductivity and water retention constants required undistrubed core samples. These were obtained using a motorised soil auger. The procedure followed was that outlined by Blake (1965). Samples were taken from moisture monitoring sites, as close as possible to the access tube without disrupting the soil within the neutron probe's sphere of influence. In addition, nine profile pits were dug to a depth of 1.6m to identify soil horizon boundaries. Each horizon was sampled from a shelf excavated into the pit wall. Characteristics of all profiles were described in detail and photographed (Appendix E5). On occasion, difficulties in obtaining undisturbed cores at sites 32 and 115 were experienced due to dry soil conditions. Laboratory determination of moisture content for neutron probe calibration and particle size distribution analysis used disturbed samples taken by hand auger. Calibration samples were taken as each moisture site and at 100mm intervals down the profile to a depth of 1600mm. Samples from each soil horizon at each moisture site were sent for particle size analysis (Appendix E 6).

6.3 LABORATORY INVESTIGATIONS

6.3.1 Determination of physical soil characteristics

Particle size distributions

The distribution of particle sizes for each horizon of the soil profile occurring at each moisture monitoring site was conducted using the hydrometer method documented by Day (1965).

Bulk density

Field samples of known volume were oven dried at 100°C to a constant mass. The bulk density was then calculated using the following equation:

$$\text{Bulk density} = \frac{\text{Mass of oven dried soil (kg)}}{\text{Volume (m}^3\text{)}}$$

Detailed results are given in Appendix E 9.

6.3.2 Determination of hydraulic soil characteristics

Moisture retention constants

Moisture retention constants for undisturbed core samples were determined at pressure of 5kPa to 10kPa, which approximate to field capacity. Retention tests on disturbed samples were conducted at 1500kPa, which was assumed to be the wilting point. The method that was used is described by Richards (1965) and involves the use of a pressure cooker and a ceramic plate.

The saturated moisture content of the soil samples was determined by soaking undisturbed cores which were analysed using the method outlined by Klute (1965). To overcome the adverse effects of sampling disturbance at the core perimeter, the volume of percolate measured during the determination was taken from the centre of the core only.

Neutron probe calibration

Samples taken for neutron probe calibration were oven dried at 100°C to constant mass in order to determine their moistur content.

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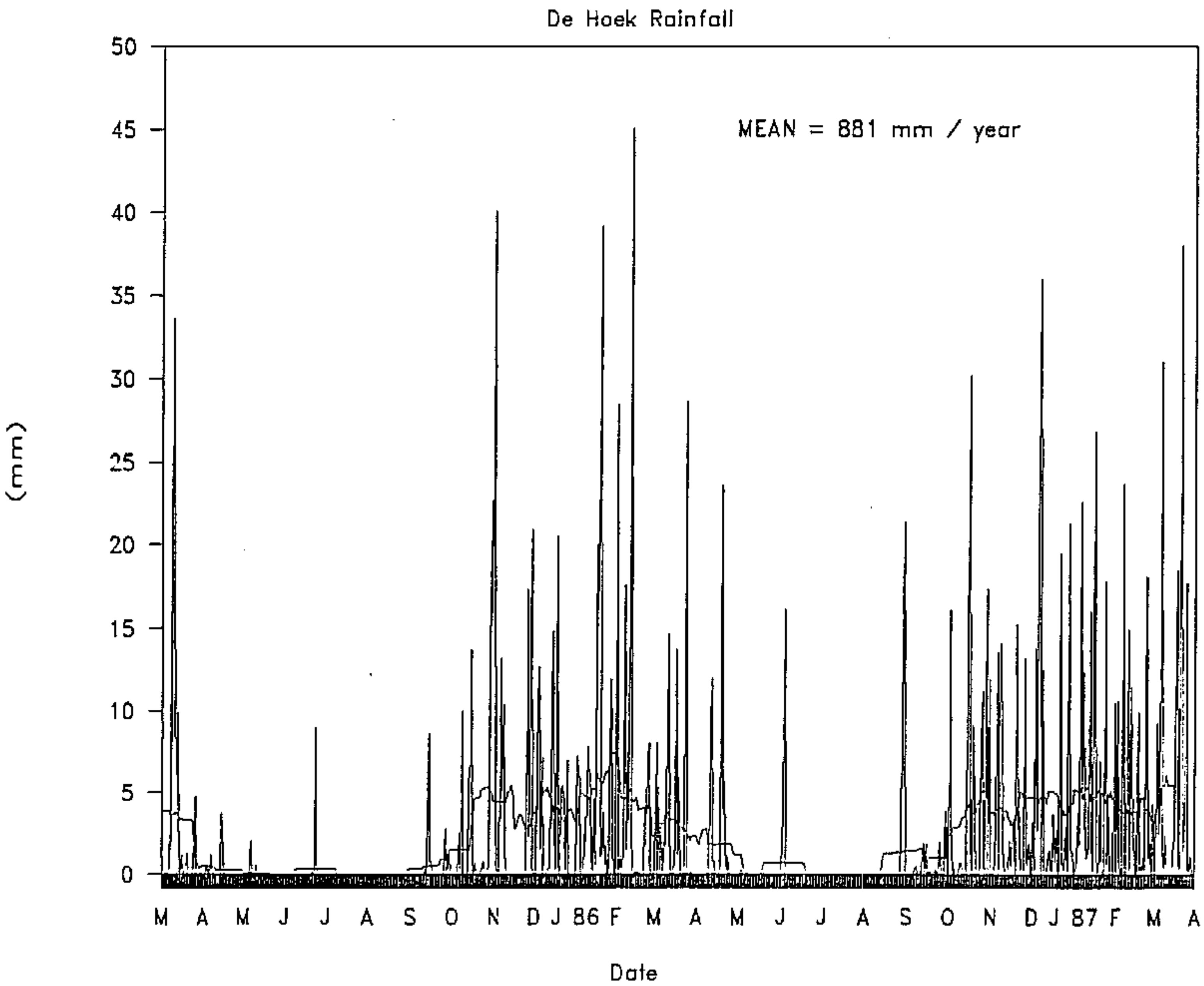
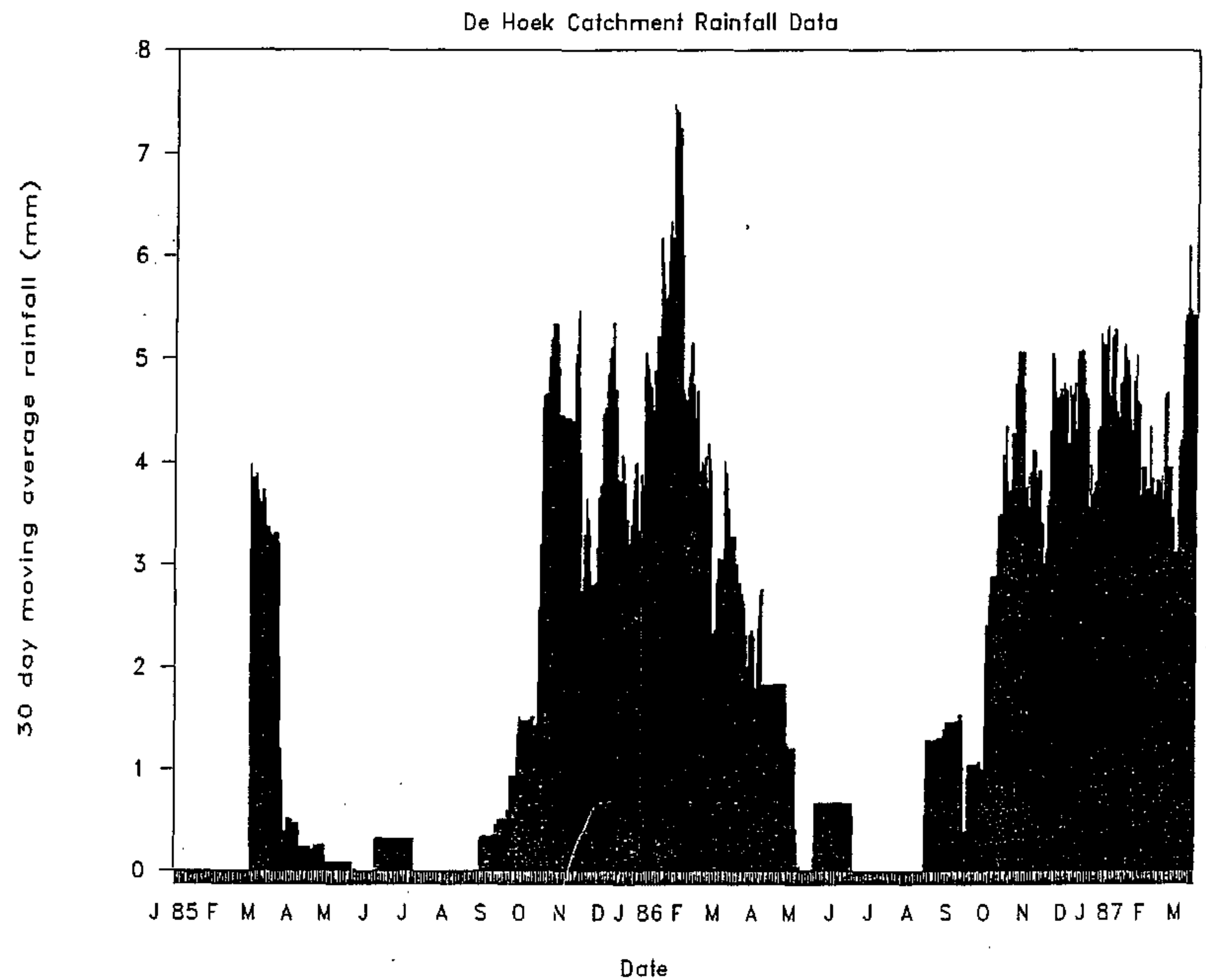
APPENDIX E 1

DIGITIZED RAINFALL DATA : RAINGAUGE T14


De Hoek Rainfall
MEAN = 881 mm / year
(mm)
50
45
40
35
30
25
20
15
10
5
0
M A M J J A S O N D J 86 F M A M J J A S O N D J 87 F M A
Date

E.1.1.



De Hoek Catchment Rainfall Data
30 day moving average rainfall (mm)
0
1
2
3
4
5
6
7
8
J 85 F M A M J J A S O N D J 86 F M A M J J A S O N D J 87 F M
Date

E.1.2.

RAINGAUGE T14 DENDEK : DIGITIZED DATA

FORMAT : STN,YEAR,MONTH,DAY,HOUR,MINUTE,RAINFALL(MM)
A8, I2, I2, I2, I2, I2, F5.2

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STN   YYMMDDHHMMRRRRDDHHMMRRRRDDHHMMRRRRDDHHMMRRRRDDHHMMRRRRDDHHMMRRRR,ETC
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T14	8610291247	364291254	364291329	366291336	367291342	369291346	370291350	372
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T14	8610301301	1301403	2310400	2310401	2310402	2310620	3310622	5

T14	8610310626	8310629	12310635	16310640	20310645	24310653	29310659	33
T14	8610310702	35310704	37310708	38310709	40310713	42310718	43310803	43
T14	8610311334	45311335	121311336	-977311336	121311318	121311338	-977311339	121
T14	8611010019	122010020	-977010020	122011919	123041749	122041830	125042006	125
T14	8611042036	126042241	127042313	129050014	130050039	133050104	134050623	136
T14	8611052002	138052038	140052113	140052159	140052229	144052329	157060049	176
T14	8611060134	193060214	202060239	203060325	212060400	217060440	225060510	230
T14	8611060535	239060605	243060620	244060656	247060726	256060731	0060741	15
T14	8611060826	24060906	35060936	40060951	44061047	44061532	44061533	0
T14	8611061534	0081132	-3081142	-1081157	0081456	1081520	23081550	24
T14	8611081600	27081634	81081658	90082156	91082205	133082220	136082240	137
T14	8611090059	138090123	144090153	160090203	167090222	188090227	195090252	198
T14	8611091346	200091446	201091506	204091530	214091615	221091704	226091918	227
T14	8611091958	230092018	231092032	233100026	233100105	234100130	237100254	239
T14	8611100319	241100344	242100528	243100536	-1101720	0101730	2101750	5
T14	8611102327	5131225	5131225	-977141817	0141819	0142138	0150232	2
T14	8611151532	2151533	2151550	3151558	4151611	4151629	5151642	5
T14	8611151656	6151706	6151715	7151725	7151754	8151806	9151808	10
T14	8611151824	10151834	11151849	11151910	12151951	13152048	15152051	15
T14	8611152149	16152217	17152228	17152254	18152303	18152310	19152323	20
T14	8611152330	20152332	21152348	21152357	22160030	22160031	23160047	24
T14	8611160114	24160117	24160143	25160440	27160441	27160948	27170604	27
T14	8611170606	27171155	28171156	30171158	32171159	34171202	36171204	37
T14	8611171214	37171221	37171354	38171934	40171837	41171840	44171843	47
T14	8611171846	48171850	50171856	52171901	52180004	52180005	52180006	52
T14	8611180039	53180042	53180044	54180047	54181455	55181457	56181504	56
T14	8611181701	57181705	58181708	59181709	61181712	62181717	64181724	67
T14	8611181726	67181733	71181736	73181739	76181742	77181747	79181754	79
T14	8611181759	80181801	81181804	82181820	82181821	82181823	82181847	82
T14	8611181852	82181857	83181904	84181916	84181923	84181925	85181944	85
T14	8611190236	85200152	85200153	85201202	86201205	88201209	90201211	92
T14	8611201214	93201217	93201221	99201223	103201226	106201229	109201231	111
T14	8611201238	114201241	115201245	118201248	121201251	125201253	126201255	127
T14	8611201301	131201305	134201307	137201314	142201317	146201318	0201319	0
T14	8611201322	1201326	2201327	2201355	3201356	4201359	5201402	8
T14	8611201404	10201407	12201409	15201410	17201412	19201413	20201416	22
T14	8611201419	24201420	25201422	26201423	28201425	28201426	29201428	30
T14	8611201429	30201431	31201433	32201436	32201438	34201442	34201443	35
T14	8611201445	36201446	37201449	37201450	38201457	38201505	39201506	40
T14	8611201514	40201518	41201522	42201523	42201527	43201528	43201534	44
T14	8611201535	45201538	46201540	47201553	47201556	48201600	49201602	50
T14	8611201605	50201609	51201611	52201612	53201615	54201618	55201621	55
T14	8611201625	58201628	60201630	62201631	63201632	65201635	68201637	71
T14	8611201639	73201641	74201644	78201647	81201648	82201649	83201650	84
T14	8611201652	85201654	86201657	87201658	89201701	89201702	90201708	90
T14	8611201709	90201909	90201910	91202000	91202001	-977202001	91202012	91
T14	8611210200	91210230	92210254	93210319	96210339	98210409	99210423	101
T14	8611210448	103210528	104210543	105210607	110210622	115210632	116210657	118
T14	8611210806	118210826	119220049	119220109	121220123	124220143	125220148	135
T14	8611220157	141220217	145220232	148220246	149221840	148221845	149221855	149
T14	8611221904	153221909	156221919	157221954	157262007	157262027	161262041	173
T14	8611262113	236262132	247262134	-1262139	8262204	8262218	14262223	20
T14	8611262238	25262302	28262337	34262356	39270011	45270021	47270543	48
T14	8611271433	46271433	-977272301	0272303	0272350	1272353	1272354	2
T14	8611272356	2272357	3272358	3280011	3280012	4280014	4280212	5
T14	8611280216	5280348	5280350	6280444	7280455	7280502	7280503	8
T14	8611280504	8280614	8280616	8280840	9281715	9281716	9281717	9
T14	8611290333	9290335	9290351	10290352	10290358	11290359	11290406	12
T14	8611290419	12290420	12290454	13290455	14290656	16290700	16291018	17
T14	8611291019	17291130	17291131	17291133	17291707	17291708	18291808	18
T14	8611291809	18291811	18291814	20291816	22291817	23291819	24291820	25
T14	8611291823	25291849	26291850	27291858	27291946	28291947	28300545	29
T14	8612021215	29021218	29021320	29021321	29021324	30021341	31021342	31

T14	8612021821	32021827	33021835	34021843	36021846	40021851	43021855	46
T14	8612021900	49021907	50021910	50021913	51021917	52021921	51021923	53
T14	8612021926	56021930	58021933	59021936	60030630	61030631	61030633	61
T14	8612030640	61030645	62030647	63030719	63030810	63041701	0041704	0
T14	8612041722	1041724	2041725	7041726	9041727	15041728	28041730	44
T14	8612041731	61041732	73041735	80041738	86041740	93041742	96041747	103
T14	8612041750	107041752	112041754	113041755	114041756	115041759	116041811	117
T14	8612041813	117041822	117041826	119041831	120041844	121041845	122041848	123
T14	8612041853	124041932	125041938	126041945	127042002	127042007	129042011	130
T14	8612042015	133042017	135042022	136042026	137050957	138050958	138051100	138
T14	8612051900	138051901	138052000	139052002	140052003	144052004	146052006	147
T14	8612052010	148052011	149052013	150052016	151052017	152052019	156052020	157
T14	8612052021	159052025	161052029	162052033	163052039	164052048	164060300	164
T14	8612061900	164061902	164061959	164062001	167062004	170062008	174062011	179
T14	8612062013	193062015	185062018	189062021	192062022	200062023	210062024	214
T14	8612062026	216062027	217062030	218062033	218062056	219062058	220062059	222
T14	8612062100	226062102	237062104	246062107	256062110	264062112	267062118	272
T14	8612062120	276062124	278062125	280062128	281062132	283062135	289062137	290
T14	8612062140	297062143	307062146	318062149	332062151	342062152	351062153	354
T14	8612062156	360062159	367062201	370062204	374062205	378062206-977062206		130
T14	8612062217	129062222	144062242	147062326	149070055	149070144	151070159	153
T14	8612071543	155071613	176071651	248071653	1071703	40071713	60071717	63
T14	8612071742	64071817	81071845	173071920	193071959	217072024	240072025	0
T14	8612072040	19072100	21072154	22091337	22091347	41091406	72091446	80
T14	8612091649	81091713	89091803	91091832	97091857	98091912	100091941	100
T14	8612092011	112092026	129092105	141092144	145092224	147111316	146111326	1
T14	8612111332	0130225	0130320	2130424	5130503	6130717	7130802	10
T14	8612141826	9141850	14141910	18142039	19142049,	23142114	.23150037	24
T14	8612150107	26150141	27161613	25161647	27171613	28171653	37171708	40
T14	8612171752	43171901	51171926	52172055	52172200	58172234	61172353	64
T14	8612180013	65180058	71180122	72181200	72181200-977191317		0191319	0
T14	8612191347	1191348	1191349	2191351	5191352	15191353	17191354	19
T14	8612191355	20191359	20191400	21191405	21191407	22191538	22191540	22
T14	8612192233	22192235	23192306	24192310	24192313	25192315	25192317	26
T14	8612192328	26192331	27192337	27200002	28200003	28200206	29200207	30
T14	8612200732	30221404	30221407	31221450	31221453	32221458	33221459	47
T14	8612221502	55221504	62221507	65221509	65221511	66221534	66221535	70
T14	8612221538	92221542	106221545	111221546	118221547	124221548	126221552	127
T14	8612221602	129221604	137221605	141221606	142221609	143221731	145221736	148
T14	8612221740	152221744	161221745	173221748	181221749	183221751	199221753	209
T14	8612221756	217221758	220221800	221221803	224221807	224222257	225222324	225
T14	8612230003	225230010	226230103	228230105	229230107	230230118	230230820	231
T14	8612230821	231230823	231231042	231231100	232231150	232231801	0231803	0
T14	8612231829	0231832	1231837	1231937	1240743	2240745	2241106	3
T14	8612241132	3241239	4241240	4241242	4242020	4242022	5242026	6
T14	8612242139	6251718	6251720	6251817	6251821	6252327	6252328	7
T14	8612252329	9260041	9260042	10260158	12260202	13260205	14260211	14
T14	8612260219	15260221	16260223	16260225	17260230	20260238	22260240	23
T14	8612260242	25260244	25260245	26260247	28260254	30260258	33260301	33
T14	8612260305	34260306	35260326	35260327	36260509	37260518	38280336	38
T14	8612280337	38280357	38280359	41280401	45280404	46280408	46280411	47
T14	8612280413	49280417	57280418	63280419	80280421	95280424	100280427	104
T14	8612280431	109280434	114280437	122280439	132280440	143280443	152280448	157
T14	8612280452	161280458	164280503	166280507	167280511	167280514	171280519	183
T14	8612280521	186280527	195280534	211280535	213280538	215280540	222280544	224
T14	8612280549	228280558	235280602	240280604	244280605	246280607	248280611	248
T14	8612281140	250281145	251281236	250291215	250291218	250291333	250291335	251
T14	8612291339	252291345	252291356	253291401	253291407	254291414	254291421	256
T14	8612291432	257291454	260291508	262291518	264291527	264291535	266291544	268
T14	8612291554	269291606	270291615	270291627	270291645	271291713	271291736	272
T14	8612291752	273291757	274291808	275291815	275291833	276300730	278300731	280
T14	8612300732	282300733	282300736	282300755	282301955	282301956	283302059	283
T14	8612302100	290302101	292302114	292302131	293302149	294302216	294310229	293
T14	8612310239	295310250	296310306	298310327	299310346	299311256	299311257	300
T14	8612311300	300000000	0000000	0000000	0000000	0000000	0000000	0

APPENDIX D.21

SUBROUTINE : RESANL

(FILE : RESANL)

```
C     RESERVOIR YIELD ANALYSIS
C
      SUBROUTINE RESANL(DAMPER,DAMSTO,SIMSQ,SUPPIR,DAMET,OVERFL,K,RFL,I,WG2111
     *IEMPTY,ICONSC,SURFAR,XDRAFT,WRIRR,PUMPIN)                        WG19/6
C
      DIMENSION DAMPER(32),SAREA(32),DAMSTO(32),SIMSQ(32),SUPPIR(33),   WG15/1
     *DAMET(32),OVERFL(37),DRAFT(32),RFL(37),HAIRR(12),XDRAFT(12),      WG23/1
     *PUMPIN(12)                                                        WG19/6
      COMMON/RESAN/WIDTH,TANB,AREA,HAIRR,DAMCAP,QNORM,SEEP,RESCON,      WG2111
     *RESEXP,ARCAP
C
      IF(WRIRR.EQ.0.)DRAFT(K)=XDRAFT(I)*1000000                         WG23/1
      IF(WRIRR.EQ.1.)DRAFT(K)=SUPPIR(K)                                 WG23/1
      IF(ARCAP.EQ.1.)THEN
        SAREA(K)=RESCON*((DAMSTO(K-1)*1.E-6)**RESEXP)*100.
      ELSE
        Y=0.0
        W=0.0
        T=0.0
C     CALCULATE THE SURFACE AREA FOR PREVIOUS DAY'S VOLUME
        Y=(DAMPER(K-1)*0.01)**0.333
        W=Y*WIDTH
        T=TANB*W/2
        SAREA(K)=1.0E-4*(W*T/2)
      ENDIF
C     DAM STORAGE (M**3)
      IF(WRIRR.EQ.1.)DAMSTO(K)=DAMSTO(K-1)+(SIMSQ(K)*AREA*1000.)-       WG23/1
     *(DRAFT(K)*HAIRR(I)*10.)-(DAMET(K)*SAREA(K)*10.)+(RFL(K+5)*SURFAR*  WG23/1
     *10.)-QNORM-SEEP+PUMPIN(I)                                         WG19/6
      IF(WRIRR.EQ.0.)DAMSTO(K)=DAMSTO(K-1)+(SIMSQ(K)*AREA*1000.)-       WG23/1
     *DRAFT(K)-(DAMET(K)*SAREA(K)*10.)+(RFL(K+5)*SURFAR*10.)-QNORM-SEEP+ WG23/1
     *PUMPIN(I)                                                         WG19/6
      IF(DAMSTO(K).GT.DAMCAP)THEN
        OVERFL(K+5)=(DAMSTO(K)-DAMCAP)/(AREA*1000.)+(QNORM+SEEP)/(AREA*
     *  1000.)
        DAMSTO(K)=DAMCAP
        DAMPER(K)=DAMSTO(K)/DAMCAP*100.
        GO TO 10
      ELSE
        OVERFL(K+5)=0.0+(QNORM+SEEP)/(AREA*1000.)
      ENDIF
      IF(DAMSTO(K).LE.0.)THEN
        DAMSTO(K)=0.0
        DAMPER(K)=0.0
        GO TO 10
      ELSE
        OVERFL(K+5)=0.0+(QNORM+SEEP)/(AREA*1000.)
        DAMPER(K)=DAMSTO(K)/DAMCAP*100.
      ENDIF
   10 IF(DAMPER(K).LT.0.5)THEN
        IEMPTY=IEMPTY+1
        IF(DAMPER(K-1).GT.0.5)ICONSC=ICONSC+1
      ENDIF
      END
```

APPENDIX D.22

SUBROUTINE : WATFL2

(FILE : WATFL2)

```
1STORAGE:2
1DEBUG
C *******************************************************************WAT00010
C                                                                     WAT00020
C     INITIALIZING SUBROUTINE FOR THE USE OF THE RICHARD'S EQUATION   WAT00030
C     IN THE ACRU MODEL - BASED ON J L HUTSON, WATFLO FINITE DIFFERENCE WAT00040
C                           MODEL                                     WAT00050
C                                                                     WAT00060
C *******************************************************************WAT00070
                                                                      WAT00080
      SUBROUTINE WATFL2(DEPAHO,DEPBHO,MOIST,E,WP1,WP2,FC1,FC2,PO1,PO2) WAT00090
                                                                      WAT00100
      REAL AET,L,N,KK,M,MAXDT,IRATE,IRRBEG,IRRIG,NDEPTH,              WAT00110
     *MINPOT,NPOT,MOIST,KS,ERAIN,DEPAHO,DEPBHO,PPDEPT,PGAP,WP1,WP2,FC1, WAT00120
     *FC2,PO1,PO2
      INTEGER FDAY,LDAY,MININT,NIRR,BOTBOU,PDEPTH,R47,NODES,R45,R14,  WAT00130
     1W,R30,R46,R9,R49,R50,R51,R52,R55,MON,DAYY,AHOFRA,BHOFRA         WAT00140
      DIMENSION B(20),A(20),G(20),L(20),E(20),H(20),KK(20),           WAT00150
     *M(20),P(20),S(20),IRRIG(20),T(20),U(20),V(20),OPOT(20),Z(20),   WAT00160
     *Y(11,2),ROOTF(20),Y1(20,2),Y2(20,2),Y3(20,2),Y4(20,2),ER(20),   WAT00170
     *IRATE(20),DEPTH(20),IRRBEG(20),NPOT(20),MOIST(20),KS(20),MON(2), WAT00180
     *DAYY(2)                                                         WAT00190
C     CHARACTER OUT*12                                                WAT00200
      COMMON/WATFLO/L,N,M,MAXDT,IRATE,IRRBEG,IRRIG,                   WAT00210
     *NDEPTH,MINPOT,NPOT,KS,MININT,NIRR,BOTBOU,PDEPTH,                WAT00220
     *R47,NODES,R45,R14,W,R30,R46,R9,R49,R50,R51,R52,R55,B,A,G,       WAT00230
     *H,P,S,T,U,V,OPOT,Z,Y,ROOTF,Y1,Y2,Y3,Y4,ER,DEPTH,MON,DAYY,R10,   WAT00240
     *R16,R18,R19,R20,R22,R24,R25,R27,R28,R32,R33,R34,R35,R36,R37,R38, WAT00250
     *R39,R40,R41,R42,R43,R54,POT,PRINT,AHOFRA,BHOFRA                 WAT00260
      COMMON/COUNT/I,IYR,NDYM,IYEAR,K                                 WAT00270
C     COMMON/WATFLO2/OUT                                              WAT00280
      CONTINUE                                                        WAT00290
C                                                                     WAT00640
C                                                                     WAT00650
      PI=3.14159                                                      WAT00660
      WRITE(6,*)'   '
      READ(15,9501)PGAP                                               WAT00670
      READ(15,9510)MININT,BOTBOU,MINPOT,PDEPTH,NODES,PRINT,MAXDT      WAT00680
C                                                                     WAT00690
C                                                                     WAT00700
C     ----------------------------------------------------------------WAT00710
C                SET THE DEPTH EQUAL TO ACRU INPUT                    WAT00720
                                                                      WAT00730
C     ----------------------------------------------------------------WAT00740
                                                                      WAT00750
      PPDEPT = DEPAHO + DEPBHO                                        WAT00760
      PDEPTH = INT(PPDEPT*1000)                                       WAT00770
C                                                                     WAT00780
C     ----------------------------------------------------------------WAT00790
C                                                                     WAT00800
C                                                                     WAT00810
      NDEPTH=FLOAT(PDEPTH/(NODES-3))                                  WAT00820
C                                                                     WAT00830
      READ(15,9501)PGAP                                               WAT00840
      READ(15,9520)(DEPTH(J),NPOT(J),ROOTF(J),A(J),B(J),MOIST(J),KS(J), WAT00850
     1J=1,NODES)                                                      WAT00860
      CLOSE(15)                                                       WAT00870
C                                                                     WAT00880
C     ----------------------------------------------------------------WAT00890
C              RESET PROFILE DEPTHS TO SUIT ACRU INPUT                WAT00900
C     ----------------------------------------------------------------WAT00910
C                                                                     WAT00920
      DO 90 J    = 1,NODES                                            WAT00930
      DEPTH(J) = NDEPTH *(J-1)                                        WAT00940
      WRITE(*,98)J,DEPTH(J)
   98 FORMAT(1X,'Depth ',I3,' = ',F6.0)
   90 CONTINUE                                                        WAT00950
```

```
C
C     --------------------------------------------------------------WAT00960
C                                                                   WAT00970
C  CONVERT KPA TO MM WATR                                           WAT00980
      DO 100 J=1,NODES                                              WAT00990
      NPOT(J)=NPOT(J)*102.2                                         WAT01000
  100 CONTINUE                                                      WAT01010
      MINPOT=MINPOT*102.2                                           WAT01020
C  CALCULATE POINT OF COINCIDENCE OF EXP. & PARABOLIC FUNCTIONS     WAT01030
C                                                                   WAT01040
      DO 500 J=1,NODES                                              WAT01050
      L(J)=2.*B(J)*MOIST(J)/(1.+2.*B(J))                            WAT01060
      G(J)=A(J)*(L(J)/MOIST(J))**(-B(J))                            WAT01070
  500 CONTINUE                                                      WAT01080
C                                                                   WAT01090
C  INITIALIZE VARIABLES                                             WAT01100
C                                                                   WAT01110
      R16=1./FLOAT(MININT)                                          WAT01120
      R14=1                                                         WAT01130
      R22=0.                                                        WAT01140
      R9=0                                                          WAT01150
      R24=0.                                                        WAT01160
      R19=10000000000.0                                             WAT01170
      R20=0.                                                        WAT01180
      DO 600 J=1,NODES                                              WAT01190
      T(J)=0.                                                       WAT01200
      OPOT(J)=NPOT(J)                                               WAT01210
      POT=NPOT(J)                                                   WAT01220
      E(J)=THETA(POT,G(J),MOIST(J),A(J),B(J),L(J))                  WAT01230
  600 CONTINUE                                                      WAT01240
C                                                                   WAT01250
C  CALCULATE INITIAL PROFILE WATER CONTENT, R22                     WAT01260
C                                                                   WAT01270
      DO 700 J=2,NODES-1                                            WAT01280
      R22=R22+E(J)                                                  WAT01290
  700 CONTINUE                                                      WAT01300
C      ______________________________________________________________               WAT01310
C       establiSh the number of nodeS in A & B horizonS with an intermedWAT01320
C       horizon between the two total depth = (Afrac + 1 + Bfrac + 2)*NDWAT01330
C      ______________________________________________________________AT01340
      AHOFRA  = INT(AINT((NODES-3)*(DEPAHO/PPDEPT)))                WAT01350
      BHOFRA  = NODES-AHOFRA-4                                      WAT01360
C     WRITE(16,25)DEPAHO,DEPBHO,AHOFRA,BHOFRA                       WAT01370
  25  FORMAT('DEPAHO = ',F8.3,' DEPBHO = ',F8.3,' A-NODES= ',I3,    WAT01380
     *' B-NODES= ',I3)                                              WAT01390
C     --------------------------------------------------------------
C
C           Set the ACRU porosities, field capacities and wilting points
C                to average Watflow input values.
       PO1=0
       PO2=0
C       FC1=0
C       FC2=0
       WP1=1.0
       WP2=1.0
       POT=-5.0*102.2

       DO 7000 J=1,AHOFRA+1
          PO1=PO1+MOIST(J)
 7000  CONTINUE
       PO1=PO1/(AHOFRA+1)

       DO 7001 J=1,BHOFRA+1
          PO2=PO2+MOIST(J+1+AHOFRA)
 7001  CONTINUE
       PO2=PO2/(BHOFRA+1)
```

```
      DO 7002 J=1,AHOFRA+1
C           EE=THETA(POT,G(J),MOIST(J),A(J),B(J),L(J))
C           FC1=FC1+EE
          EE=THETA(MINPOT,G(J),MOIST(J),A(J),B(J),L(J))
          WP1=MIN(WP1,EE)
 7002   CONTINUE
C        FC1=FC1/(AHOFRA+1)

      DO 7003 J=1,BHOFRA+1
C           FC2=FC2+THETA(POT,G(J+1+AHOFRA),MOIST(J+1+AHOFRA),
C     *     A(J+1+AHOFRA),B(J+1+AHOFRA),L(J+1+AHOFRA))
          EE=THETA(MINPOT,G(J+1+AHOFRA),MOIST(J+1+AHOFRA),
     *    A(J+1+AHOFRA),B(J+1+AHOFRA),L(J+1+AHOFRA))
          WP2=MIN(WP2,EE)
 7003   CONTINUE
C        FC2=FC2/(BHOFRA+1)
      WRITE(*,7004)FC1,FC2,WP1,WP2,PO1,PO2
 7004    FORMAT(6F9.3)
C   ---------------------------------------------------------------
C                                                                       WAT01410
C  FORMATS                                                              WAT01420
C                                                                       WAT01430
                                                                        WAT01440
 9501 FORMAT(4(/),F1.0)                                                 WAT01450
                                                                        WAT01460
 9510 FORMAT(10X,I5,5X,I4,F7.0,I5,I5,F5.1,F6.3)                         WAT01470
 9520 FORMAT(F6.0,F8.1,F6.3,E11.3,F7.3,F7.4,F8.0)                       WAT01480
                                                                        WAT01490
      END                                                               WAT01500
C  RETENTIVITY AND HYDRAULIC CONDUCTIVITY FUNCTIONS CALCULATED          WAT01510
C   BY CAMPBELL'S (1974) EQUATION AND INCLUDING THE WET END             WAT01520
C   MODIFICATION DEVELOPED BY HUTSON (1984).                            WAT01530
      FUNCTION THETA(POT,FG,FF,FQ,FI,FL)                                WAT01540
      IF(POT-FG)6050,6050,6060                                          WAT01550
 6050 THETA=FF*(POT/FQ)**(-1/FI)                                        WAT01560
      GO TO 6061                                                        WAT01570
 6060 THETA=FF*(1.-FL/FF)*(AMIN1(POT,-10.)*AMIN1(POT,-10.))             WAT01580
      THETA=FF-THETA/(FQ*FQ*((FL/FF)**(-2.*FI)))                        WAT01590
 6061 RETURN                                                            WAT01600
      END                                                               WAT01610
                                                                        WAT01620
                                                                        WAT01630
C      SUBROUTINE WATSUB1(AHOFRA,BHOFRA,ROOTF,ROOTA,ROOTB)              WAT01640
C                                                                       WAT01650
C     ------------------------------------------------------------------WAT01660
C                    ROOT FRACTION DISTRIBUTION FOR WATFLO              WAT01670
C     ------------------------------------------------------------------WAT01680
C                                                                       WAT01690
C      INTEGER AHOFRA,BHOFRA,ZZ                                         WAT01700
C      DIMENSION ROOTA(12),ROOTB(12),ROOTF(20)                          WAT01710
C                                                                       WAT01720
C DO 542 ZZ =1,AHOFRA                                                   WAT01730
C SINN=SIN(3.14159*(ZZ-1)/AHOFRA)+SIN(3.14159*ZZ/AHOFRA)                WAT01740
C 542  ROOTF(ZZ)=ROOTA(I)*SINN/2                                        WAT01750
C DO 543 ZZ =1,BHOFRA                                                   WAT01760
C 543  ROOTF(ZZ+AHOFRA)=ROOTB(I)/BHOFRA                                 WAT01770
C .      DO 544 ZZ  =1,(AHOFRA+BHOFRA)                                  WAT01780
C 544      WRITE(*,545)ZZ,ROOTF(ZZ)                                     WAT01790
C 545   FORMAT(1X,'ROOT FRACTION(',I2,') = ',F9.6)                      WAT01800
C                                                                       WAT01810
C      END                                                              WAT01820
                                                                        WAT01830
```

APPENDIX D.23

SUBROUTINE : WATFL3

(FILE : WATFL3)

```
$STORAGE:2
$DEBUG
C  *****************************************************************
C  **      Last Amendment : 13h20 8/7/87                          **
C  **                   ----- W A T F L O -----                   **
C  **                                                             **
C  **     A FINITE DIFFERENCE SOIL WATER FLOW SIMULATION MODEL    **
C  **                                                             **
C  **                         BY                                  **
C  **                                                             **
C  **                    J. L. HUTSON                             **
C  **                                                             **
C  **        UNIVERSITY OF NATAL                                  **
C  **        DEPT. OF SOIL SCIENCE AND AGROMETEOROLOGY            **
C  **        P.O. BOX 375                                         **
C  **        PIETERMARITZBURG 3200                                **
C  **                                                             **
C  *****************************************************************
C  *****************************************************************
C  *****************************************************************

      SUBROUTINE WATFL3(AETT1,AETT2,SEVAP,ERAIN,YEAR,MONTH,DAY,STO1,
     *STO2,ROOTA,ROOTB,DEPAHO,DEPBHO,MOIST,E)                         8/7/87
C

      REAL L,N,I,K,M,MAXDT,IRATE,IRRBEG,IRRIG,NDEPTH,
     *MINPOT,NPOT,MOIST,KS,ERAIN,FRACA,FRACB
      INTEGER FDAY,LDAY,MININT,NIRR,BOTBOU,PDEPTH,R47,NODES,R45,R14,
     *W,R30,R46,R9,R49,R50,R51,R52,R55,MONTH,DAY,MON,DAYY,AFRAC,BFRAC,
     *ZZ,YEAR
      DIMENSION B(20),A(20),G(20),L(20),E(20),H(20),K(20),
     *M(20),P(20),S(20),IRRIG(20),T(20),U(20),V(20),OPOT(20),Z(20),
     *Y(11,2),ROOTF(20),Y1(20,2),Y2(20,2),Y3(20,2),Y4(20,2),ER(20),
     *IRATE(20),DEPTH(20),IRRBEG(20),NPOT(20),MOIST(20),KS(20),MON(2),
     *DAYY(2),STO1(32),STO2(32),ROOTA(12),ROOTB(12)
      COMMON/WATFLO/L,N,M,MAXDT,IRATE,IRRBEG,IRRIG,
     *NDEPTH,MINPOT,NPOT,KS,MININT,NIRR,BOTBOU,PDEPTH,
     *R47,NODES,R45,R14,W,R30,R46,R9,R49,R50,R51,R52,R55,B,A,G,
     *H,P,S,T,U,V,OPOT,Z,Y,ROOTF,Y1,Y2,Y3,Y4,ER,DEPTH,MON,DAYY,R10,
     *R16,R18,R19,R20,R22,R24,R25,R27,R28,R32,R33,R34,R35,R36,R37,R38,
     *R39,R40,R41,R42,R43,R54,POT,PRINT,AFRAC,BFRAC

      COMMON/COUNT/I,IYR,NDYM,IYEAR,K
C
C
      PI=3.14159
C
C  START OF DAILY CYCLE
C
      WRITE(*,22)DAY-1,MONTH,YEAR
   22 FORMAT(1X,3I5)


C      -----------------------------------------------------------
C                   ROOT FRACTION DISTRIBUTION FOR WATFLO
C      -----------------------------------------------------------
C
      FRACA=(DEPAHO*1000-AFRAC*NDEPTH)/(DEPAHO*1000)
      FRACB=(DEPBHO*1000-BFRAC*NDEPTH)/(DEPBHO*1000)
      IF (DAY.EQ.2) THEN
        DO 542 ZZ =2, AFRAC+1
           ROOTF(ZZ)=ROOTA(MONTH)*(1-FRACA)/AFRAC
  542   CONTINUE
        ROOTF(AFRAC+2)=ROOTA(MONTH)*FRACA+ROOTB(MONTH)*FRACB
        DO 543 ZZ =1, BFRAC
           ROOTF(ZZ+AFRAC+2)=ROOTB(MONTH)*(1-FRACB)/BFRAC
  543   CONTINUE
```

```
        ROOTF(NODES-1)=0.0
        ROOTF(NODES)=0.0
        DO 544 ZZ  =2,(NODES)
          WRITE(*,545)ZZ,ROOTF(ZZ)
 544    CONTINUE
 545    FORMAT(1X,'ROOT FRACTION(',I2,') = ',F9.6)
      ENDIF




      R27=0.                                                      8/7/87
      TIME=0.
      R25=0.
      R20=0.
      R14=1
      R45=1
      IRRIG(2)=0.0
      IRRBEG(2)=4
      ER(R45)=SEVAP*15.25
      NIRR=0

      IF (ERAIN.GT. 0.500) THEN
        IF (ERAIN.LE.14.0)THEN
          IF (ERAIN.LT.1.6) THEN
            IRATE(1)=ERAIN*14.0
          ELSE
            IRATE(1) =24.0
          ENDIF
        ELSE
          IRATE(1) =ERAIN*2.0
        ENDIF
        NIRR     =1
        ER(1)    =SEVAP
        IRRBEG(1)=0.2
        IRRIG(1) =ERAIN*0.97418
      ELSE
        IRRIG(1) =0
        IRATE(1) =0
        IRRBEG(1)=3
      ENDIF
C  ---------------------------------------------------------------
C  ASSIGNMENT OF DAILY ETRANS/LAYER TO H(J), WEIGHTED ACCORDING TO
C  ROOT DISTRIBUTION.
      DO 1100 J=2, AFRAC+1
 1100      H(J)=(ROOTF(J)/ROOTA(MONTH))*AETT1                     "
      DO 1102 J=1, BFRAC                                          "
 1102      H(J+2+AFRAC)=(ROOTF(J+2+AFRAC)/ROOTB(MONTH))*AETT2     "
      H(AFRAC+2)= AETT1*FRACA + AETT2*FRACB

C  ---------------------------------------------------------------
C     INCREASE AET TO ACCOUNT FOR SHORT DAILY PERIOD (0.3 - 0.7 OF THE DAY)
C
      DO 1103 J=2,AFRAC+BFRAC+2
         H(J)=H(J)/0.4
 1103 CONTINUE

C
C*****************************************************************
C  CALCULATE NEW TIME STEP
C
      DETT=.0000001
      R25=0.
 1800 R28=R18
      ENDIRR=1.
      IF(R20.GE..1)R20=0.
      IF(R27.GT.0.)ENDIRR= R27/U(1)
```

```
      R30=2


C
C  CALCULATE NEW TIME PERIOD AS MINIMUM OF:
C   1)MAX TIME PERIOD - R16, 2)TIME TO END OF IRRGATION - ENDIRR
C   3)TIME TO END OF .1 DAY PERIOD, 4)TIME FOR MAXIMUM ALLOWABLE
C      FLUX
      R18=AMIN1(MAXDT*NDEPTH/R19,R16,ENDIRR,.1-R20)
      DTIME=ABS(TIME-IRRBEG(R14))
      IF(DTIME.LT.DETT.AND.R27.LE.0.)R18=DETT
      R18=AMAX1(R18,DETT)
      R18=ANINT(R18/DETT)*DETT
      IF(R16.EQ.R18)R30=1
      R19=10.**(-10)
      R20=R20+R18
      R24=R18+R24
      R25=R25+R18
      IF(R20.GE..1)THEN
      R20=.1
      R25=ANINT(R25/.1)*.1
      R24=ANINT(R24/.1)*.1
      ENDIF
C**********************************************************************
C
C  SET TOP BOUNDARY CONDITION TO SIMULATE EVAPORATION RATE,ZERO FLUX
C   PONDED INFILTRATION OR CONSTANT FLUX INFILTRATION
C
      IF(R27)2700,2700,2710
C  IF START OF IRRIGATION, SET HEAD TO DEPTH OF IRRIGATION WATER
 2700 IF(DTIME.LT.DETT)GO TO 2705
      GO TO 2740
 2705 R27=R27+IRRIG(R14)
      R10=0
C       WRITE(10,9100)
C       WRITE(10,9110)TIME
C       WRITE(10,9120)
C       WRITE(10,9130)R25,R27
 2710 IF (IRATE(R14)-999.9)2760,2770,2760
C  EVAP RATE (EV) SET ACCORDING TO TIME OF DAY
C2740 EV=-ER(R45)*AMAX1(0.,SIN(2.*PI*(R25-R18/2.-.25)))
 2740 EV=-ER(R45)*R18
      IF (OPOT(1).LT.MINPOT) EV=0.
      IF (OPOT(1).LT.MINPOT) OPOT(1) = MINPOT
      K(1)=HC(OPOT(1),G(1),KS(1),A(1),B(1),MOIST(1),L(1))
      K(2)=HC(OPOT(2),G(2),KS(2),A(2),B(2),MOIST(2),L(2))
      K(1)=(K(1)+K(2))/2.
      IF(EV-K(1)*(OPOT(1)-300000.-2.*OPOT(2))/(2.*NDEPTH))2490,
     12490,2495
 2490 P(1)=-300000.-OPOT(2)
      M(1)=1.
      GO TO 2780
 2495 M(1)=1.
      P(1)=AMIN1(-NDEPTH,(EV-K(1))*2.*NDEPTH/K(1)-OPOT(1)+OPOT(2))
      GO TO 2780
C  START OF PONDED INFILTRATION
 2770 E(1)=MOIST(1)
      OPOT(1)=0.
      M(1)=0.
      P(1)=0.
      GO TO 2780
C  START OF CONSTANT FLUX INFILTRATION
 2760 NF=0
      HI =0.
      HL=-300000.
      SPOT=OPOT(1)
      K(2)=HC(OPOT(2),G(2),KS(2),A(2),B(2),MOIST(2),L(2))
```

```
 2765 K(1)=HC(SPOT,G(1),KS(1),A(1),B(1),MOIST(1),L(1))
      K(1)=(K(1)+K(2))/2.
      FLUX=K(1)-K(1)*(OPOT(2)-SPOT)/NDEPTH
      IF(ABS(FLUX-IRATE(R14)).LT.1.OR.NF.GT.20)GO TO 2768
      NF=NF+1
      IF(FLUX-IRATE(R14).LT.0.)THEN
      HL=SPOT
      SPOT=(SPOT+HI)/2.
      ELSE
      HI=SPOT
      SPOT=(SPOT+HL)/2.
      ENDIF
      GO TO 2765
 2768 OPOT(1)=SPOT
      M(1)=1.
      P(1)=(IRATE(R14)-K(1))*2.*NDEPTH/K(1)-OPOT(1)+OPOT(2)
C
C INITIALIZE HYDRAULIC CONDUCTIVITIES
C
 2780 R46=0.
      IF(OPOT(1).LT.MINPOT) OPOT(1)=MINPOT
      K(1)=HC(OPOT(1),G(1),KS(1),A(1),B(1),MOIST(1),L(1))
      DO 2800 J=2,NODES
      K(J)=HC(OPOT(J),G(J),KS(J),A(J),B(J),MOIST(J),L(J))
      K(J-1)=(K(J)+K(J-1))/2.
 2800 CONTINUE
C
C  SIMULTANEOUS EQUATION SOLUTION - FORWARD
C
 3500 DO 3600 J=1,NODES
      POT=AMIN1(-10.,OPOT(J)+.58*(NPOT(J)-OPOT(J)))
      Z(J)=DWC(POT,G(J),MOIST(J),B(J),L(J),A(J))
 3600 CONTINUE
      DO 3900 J=2,NODES-1
      S(J)=0.
      IF(R25-R18.GE..3.AND.R25.LE..7)S(J)=R18*H(J)/NDEPTH
 3660 R32=K(J)
      R34=K(J-1)
      R33=2*NDEPTH*NDEPTH*Z(J)/R18+R32+R34
C
      IF(OPOT(J).LT.MINPOT)S(J)=0
      IF(R46-R30)3700,3750,3700
 3750 IF(R25-R18.LT..3.OR.R25.GT..7)GO TO 3700
      T(J)=T(J)+(H(J)*R18-S(J)*NDEPTH)
      R36=R36+S(J)*NDEPTH
 3700 S(J)=S(J)/R18
      R35=R32*OPOT(J+1)+R34*OPOT(J-1)+(R33-2*R32-2*R34)*OPOT(J)
      R35=R35+2*NDEPTH*(K(J-1)-K(J))-S(J)*2*NDEPTH*NDEPTH
      M(J)=R32/(R33-R34*M(J-1))
      P(J)=(R35+R34*P(J-1))/(R33-R34*M(J-1))
 3900 CONTINUE
C
C  SOLUTION OF SIMULTANEOUS EQUATIONS - REVERSE
C
C  SET BOTTOM BOUNDARY CONDITIONS
C
      IF(BOTBOU.EQ.4.AND.NPOT(NODES).GT.0.)NPOT(NODES)=0.
      IF(BOTBOU.NE.4)R9=BOTBOU
      IF(R9.NE.1)GO TO 4100
      NPOT(NODES)=0.
      POT=0.
      E(NODES)=THETA(POT,G(NODES),MOIST(NODES),A(NODES),B(NODES),
     1L(NODES))
      GO TO 4200
 4100 IF(R9.NE.3)GO TO 4150
      NPOT(NODES)=(2*NDEPTH-OPOT(NODES)+OPOT(NODES-1)+
     1P(NODES-1))/(1-M(NODES-1))
```

```
      POT=NPOT(NODES)
      E(NODES)=THETA(POT,G(NODES),MOIST(NODES),A(NODES),B(NODES),
     1L(NODES))
      GO TO 4200
 4150 IF(R9.NE.2)GO TO 4200
      NPOT(NODES)=(P(NODES-1)-OPOT(NODES)+OPOT(NODES-1))/(1-M(NODES-1))
      POT=NPOT(NODES)
      E(NODES)=THETA(POT,G(NODES),MOIST(NODES),A(NODES),B(NODES),
     *L(NODES))
 4200 J=NODES
 4210 J=J-1
      NPOT(J)=M(J)*NPOT(J+1)+P(J)
      POT=NPOT(J)
      IF(R46.LT.R30.AND.J.GT.1)GO TO 4210
      IF(R46-R30)4250,4300,4300
 4250 R46=R46+1
      GO TO 3500
 4300 IF(J.EQ.1.AND.POT.LE.MINPOT)POT = MINPOT
      E(J)=THETA(POT,G(J),MOIST(J),A(J),B(J),L(J))
      U(J)=(K(J)-K(J)*(NPOT(J+1)+OPOT(J+1)-NPOT(J)-
     *OPOT(J))/(2*NDEPTH))*R18
      IF(J.EQ.1.AND.POT.LE.MINPOT)U(1)=-0.000001
      R37=ABS(U(J)/R18)
C  RECORD MAXIMUM FLUX DENSITY
      R19=AMAX1(R19,R37)
      V(J)=V(J)+U(J)
 4500 IF(J.GT.1)GO TO 4210
      DO 4550 J=1,NODES
      OPOT(J)=NPOT(J)
 4550 CONTINUE
C  INCREMENT LEACHATE R38, INFILTRATION R40, EVAPORATION R39
C   TRANSPIRATION R36
C
      IF(U(1).LE.0)R39=R39+U(1)
      ETRANS=-R39+R36
      IF(R9.NE.3)R38=R38+U(NODES-1)
      IF(BOTBOU-4)4600,4650,4600
 4650 R9=3
      IF(NPOT(NODES-1).GT.-NDEPTH)R9=1
C  IF THERE WAS INFILTRATION DURING THE TIME STEP
 4600 IF(U(1).GT.0.)THEN
      R40=R40+U(1)
      IF(R27.GT.0.)THEN
      R27=AMAX1(-0.000001,R27-U(1))
      R10=R10+1
      IF(R27.EQ.0.)R14=MINO(NIRR,R14+1)
C       IF(R10.EQ.4)WRITE(10,9130)R25,R27
      IF(R10.EQ.4)R10=0
      ENDIF
      ENDIF
C  INCREMENT TIME (TOTAL ELAPSED TO END OF TIME STEP)
      TIME=TIME+R18
      TIME=ANINT(TIME/DETT)*DETT
      IF(R20.EQ..1)TIME=ANINT(TIME/.1)*.1
C-----------------------------------------
C  CHECK WHETHER TO PRINT, OTHERWISE RETURN FOR NEW TIME STEP OR DAY
      IF(R20.LT..1)GO TO 1800
      IF(ABS(R24-PRINT).LT.2*DETT)GO TO 5500
      IF(ABS(R25-1.).LT.2*DETT)GO TO 1000
C-----------------------------------------
      GO TO 1800
C  PRINT ROUTINE
 5500 R41=0
C   I)CALCULATE PROFILE WATER CONTENT
      DO 5600 J=2,NODES-1
      R41=R41+E(J)
 5600 CONTINUE
```

```
C     -----------------------------------------------------------------
C         ADJUST THE MOISTURE STORE FOR PASSING BACK TO ACRU
C     -----------------------------------------------------------------
      STO1(DAY)=0.0
      STO2(DAY)=0.0
      DO 5605 J  = 2,AFRAC+1
          STO1(DAY)= STO1(DAY)+E(J)*NDEPTH
 5605 CONTINUE
      DO 5610 J  = 1,BFRAC
          STO2(DAY)= STO2(DAY)+E(J+AFRAC+2)*NDEPTH                      8/7/87
 5610 CONTINUE
      STO1(DAY)=STO1(DAY)+E(AFRAC+2)*(DEPAHO*1000-AFRAC*NDEPTH)
      STO2(DAY)=STO2(DAY)+E(AFRAC+2)*(DEPBHO*1000-BFRAC*NDEPTH)
C     -----------------------------------------------------------------
C
C     MASS BALANCE CHECK
C
      R42=(R41-R22)*NDEPTH
      R43=R40-R42-ETRANS-R38
C
C
       IF (DAY.EQ.2) THEN
       WRITE(10,333)
 333       FORMAT(/'   DATE    TRANSin PEVAPin RAINin INFILTR. TRANSPIR E
     *VAP  STORE-A  STORE-B RECHARGE C.RAIN C.INFIL C.EVAP  C.TRANS C.RE
     *CHRG BALANCE')
       WRITE(*,300)
 300       FORMAT(//'  TRANSin  PEVAPin  RAINin  TRANSP  EVAP   INFIL  RE
     *CHRG C.RECHRG   BAL')
       ENDIF
C
C
       Y(3,1)=  R40-Y(3,1)
       Y(4,1)=  R38-Y(4,1)
       Y(5,1)= -R39-Y(5,1)
       Y(6,1)=  Y(6,1)+ERAIN
       Y(10,1)= R36-Y(10,1)

       WRITE(*,9901)AETT1+AETT2,SEVAP,ERAIN,Y(10,1),Y(5,1),Y(3,1),Y(4,1),
     *R38,R43
 9901 FORMAT(1X,9F8.3)

       WRITE(10,9900)DAY-1,MONTH,YEAR,AETT1+AETT2,SEVAP,ERAIN,Y(3,1),
     *Y(10,1),Y(5,1),STO1(DAY),STO2(DAY),Y(4,1),Y(6,1),R40,-R39,R36,R38,
     *R43
C
       WRITE(11,9910)STO1(DAY),STO2(DAY),Y(3,1),Y(4,1)
C
C      ....>>>>>>>>>>>>routine to output Soil moiSture profile<<<<<<<<...
       WRITE(12,22)DAY-1,MONTH,YEAR
       DO 334 J = 1,NODES-2
        WRITE(12,9930)E(J)
 334   CONTINUE
       WRITE(12,9940)E(NODES-1)
C      ....>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>><<<<<<<<<<<<<<<<<<<<<<<<<<<<...
C
C      Where Y(10) iS WAtflo'S TrAnSpirAtion,
C     Y(5)  iS   "      SurfAce evAporAtion (AccumulAted SurfAce flux),
C     Y(3)  iS   "      AccumulAted SurfAce infiltrAtion,
C     R41   iS   "      Profile wAter content,
C     Y(4)  iS   "      DAily rechArge totAl,
C     R40   iS   "      AccumulAted infiltrAtion,
C     R39   iS   "      AccumulAted SurfAce evAporAtion flux,
C     R36   iS   "      AccumulAted trAnSpirAtion,
C     R38   iS   "      AccumulAted rechArge,
C     R43   iS   "      AccumulAted BAlAnce,
C     STO1  iS   "      WAter content for the A horizon pASSed BAck to A
```

```
C    ST02  iS   "      WAter content for the B horizon pASSed BAck to A2
C
C
C
 9900 FORMAT(1X,I2,'/',I2,'/',I2,15F8.3)
 9910 FORMAT(1X,F9.3,',',F9.3,',',F9.3,',',F9.3)
 9920 FORMAT(1X,I2)
 9925 FORMAT(1X,3I5,'  ',\)
 9930 FORMAT(1X,F7.5,\)
 9940 FORMAT(1X,F7.5)

      Y(3,1)=  R40
      Y(4,1)=  R38
      Y(5,1)= -R39
      Y(10,1)= R36

      DO 5700 J=1,NODES
      T(J)=0.
      V(J)=0.
 5700 CONTINUE
      R24=0
      R47=0
C
C
C
 6100 IF(AINT(R25*10**3+5).LT.10**3)GO TO 1800
C
 1000 CONTINUE
      END
```

APPENDIX D.24

SUBROUTINE : WATFL4

(FILE : WATFL4)

```
1STORAGE:2
      FUNCTION POTL(POT,FL,FF,FQ,FI)
      IF(POT-FL)6040,6030,6030
 6030 POTL=(SQRT(1.-POT/FF))*FQ*((FL/FF)**(-FI))/SQRT(1.-FL/FF)
 6040 IF(POT.LT.FL)POTL=FQ*(POT/FF)**(-FI)
      RETURN
      END
C
      FUNCTION HC(POT,FG,FW,FQ,FI,FF,FL)
      IF(POT.LE.FG)HC=FW*(FQ/POT)**(2.+3./FI)
      IF(POT.GT.FG)HC=FW*((THETA(POT,FG,FF,FQ,FI,FL)/FF)**FI)
     1**(2.+3./FI)
      RETURN
      END
C
      FUNCTION DWC(POT,FG,FF,FI,FL,FQ)
      IF(POT-FG)6070,6070,6080
 6070 DWC=FF*(-POT)**(-1./FI-1.)/(FI*(-FQ)**(-1./FI))
      GO TO 6081
 6080 DWC=-2.*FF*(1.-FL/FF)*AMIN1(-10.,POT)/(FQ*FQ*((FL/FF)**(-2.*FI)))
 6081 RETURN
      END
```

APPENDIX E 2

DAILY RAINFALL AND EVAPORATION DATA

SITE	DATE yr-mn-dy	RAIN (mm)	EVAPORATION (mm)
DEHOEK	85 211	.4	5.0
DEHOEK	85 212	41.8	5.8
DEHOEK	85 213	2.4	1.7
DEHOEK	85 214	4.0	4.5
DEHOEK	85 215	.0	6.5
DEHOEK	85 216	.0	8.0
DEHOEK	85 217	.0	6.5
DEHOEK	85 218	.7	6.0
DEHOEK	85 219	4.7	.1
DEHOEK	85 220	2.7	1.3
DEHOEK	85 221	.6	5.2
DEHOEK	85 222	2.3	5.2
DEHOEK	85 223	.7	8.0
DEHOEK	85 224	.2	7.5
DEHOEK	85 225	2.5	6.2
DEHOEK	85 226	7.9	5.0
DEHOEK	85 227	.4	5.5
DEHOEK	85 228	.4	5.0
DEHOEK	85 3 1	1.7	6.6
DEHOEK	85 3 2	.4	9.3
DEHOEK	85 3 3	.2	6.0
DEHOEK	85 3 4	.0	5.5
DEHOEK	85 3 5	.0	7.0
DEHOEK	85 3 6	.1	4.0
DEHOEK	85 3 7	.8	5.2
DEHOEK	85 3 8	3.0	4.2
DEHOEK	85 3 9	33.6	3.8
DEHOEK	85 310	26.7	4.9
DEHOEK	85 311	9.4	4.2
DEHOEK	85 312	5.0	5.5
DEHOEK	85 313	9.9	3.2
DEHOEK	85 314	.2	3.5
DEHOEK	85 315	.0	4.5
DEHOEK	85 316	1.2	8.5
DEHOEK	85 317	.1	3.5
DEHOEK	85 318	.1	6.0
DEHOEK	85 319	.3	4.8
DEHOEK	85 320	1.3	4.5
DEHOEK	85 321	.0	5.0
DEHOEK	85 322	.0	6.0
DEHOEK	85 323	.0	6.0
DEHOEK	85 324	.0	1.5
DEHOEK	85 325	1.8	.9
DEHOEK	85 326	4.8	4.2
DEHOEK	85 327	.1	4.0
DEHOEK	85 328	.0	5.5
DEHOEK	85 329	.0	5.5
DEHOEK	85 330	.0	5.5
DEHOEK	85 331	.1	3.5
DEHOEK	85 4 1	.0	5.0
DEHOEK	85 4 2	.0	4.0
DEHOEK	85 4 3	.0	5.5
DEHOEK	85 4 4	.6	3.7
DEHOEK	85 4 5	.0	5.0
DEHOEK	85 4 6	.0	7.0
DEHOEK	85 4 7	1.2	9.0
DEHOEK	85 4 8	.0	10.0
DEHOEK	85 4 9	.1	3.5
DEHOEK	85 410	.0	4.0
DEHOEK	85 411	.0	4.0
DEHOEK	85 412	.0	5.0
DEHOEK	85 413	.0	5.0

SITE	DATE yr-mn-dy	RAIN (mm)	EVAPORATION (mm)
DEHOEK	85 414	.0	3.5
DEHOEK	85 415	3.7	5.7
DEHOEK	85 416	1.4	4.1
DEHOEK	85 417	.2	4.0
DEHOEK	85 418	.0	4.5
DEHOEK	85 419	.0	4.5
DEHOEK	85 420	.0	6.0
DEHOEK	85 421	.0	5.5
DEHOEK	85 422	.0	7.0
DEHOEK	85 423	.0	4.5
DEHOEK	85 424	.0	4.0
DEHOEK	85 425	.0	4.0
DEHOEK	85 426	.0	4.0
DEHOEK	85 427	.0	3.0
DEHOEK	85 428	.0	3.0
DEHOEK	85 429	.0	2.0
DEHOEK	85 430	.0	2.5
DEHOEK	85 5 1	.0	4.0
DEHOEK	85 5 2	.0	3.0
DEHOEK	85 5 3	.0	4.0
DEHOEK	85 5 4	.0	4.0
DEHOEK	85 5 5	.0	4.0
DEHOEK	85 5 6	.0	4.0
DEHOEK	85 5 7	2.1	1.2
DEHOEK	85 5 8	.0	2.5
DEHOEK	85 5 9	.0	3.0
DEHOEK	85 510	.0	3.2
DEHOEK	85 511	.6	1.0
DEHOEK	85 512	.0	1.0
DEHOEK	85 513	.0	4.0
DEHOEK	85 514	.0	3.0
DEHOEK	85 515	.0	3.0
DEHOEK	85 516	.0	4.0
DEHOEK	85 517	.0	4.0
DEHOEK	85 518	.0	5.0
DEHOEK	85 519	.0	3.5
DEHOEK	85 520	.0	4.0
DEHOEK	85 521	.0	5.0
DEHOEK	85 522	.0	5.0
DEHOEK	85 523	.0	3.0
DEHOEK	85 524	.0	3.0
DEHOEK	85 525	.0	4.0
DEHOEK	85 526	.0	2.0
DEHOEK	85 527	.0	3.0
DEHOEK	85 528	.0	3.5
DEHOEK	85 529	.0	2.0
DEHOEK	85 530	.0	3.0
DEHOEK	85 531	.0	3.5
DEHOEK	85 6 1	.0	3.0
DEHOEK	85 6 2	.0	2.5
DEHOEK	85 6 3	.0	2.5
DEHOEK	85 6 4	.0	3.5
DEHOEK	85 6 5	.0	3.0
DEHOEK	85 6 6	.0	3.0
DEHOEK	85 6 7	.0	2.5
DEHOEK	85 6 8	.0	3.0
DEHOEK	85 6 9	.0	2.5
DEHOEK	85 610	.0	4.0
DEHOEK	85 611	.0	3.5
DEHOEK	85 612	.0	3.5
DEHOEK	85 613	.0	4.0
DEHOEK	85 614	.0	2.0

DEHOEK	85 615	.0	3.5
DEHOEK	85 616	.0	4.0
DEHOEK	85 617	.0	3.0
DEHOEK	85 618	.0	2.5
DEHOEK	85 619	.0	3.0
DEHOEK	85 620	.0	2.5
DEHOEK	85 621	.0	2.0
DEHOEK	85 622	.2	3.5
DEHOEK	85 623	.0	2.5
DEHOEK	85 624	9.0	.6
DEHOEK	85 625	.7	2.5
DEHOEK	85 626	.0	3.0
DEHOEK	85 627	.0	3.0
DEHOEK	85 628	.0	3.5
DEHOEK	85 629	.0	2.5
DEHOEK	85 630	.0	2.5
DEHOEK	85 7 1	.0	2.5
DEHOEK	85 7 2	.0	3.0
DEHOEK	85 7 3	.0	2.5
DEHOEK	85 7 4	.0	2.5
DEHOEK	85 7 5	.0	4.0
DEHOEK	85 7 6	.0	5.0
DEHOEK	85 7 7	.0	2.5
DEHOEK	85 7 8	.0	3.0
DEHOEK	85 7 9	.0	3.5
DEHOEK	85 710	.0	4.5
DEHOEK	85 711	.0	5.5
DEHOEK	85 712	.0	4.0
DEHOEK	85 713	.0	4.0
DEHOEK	85 714	.0	3.0
DEHOEK	85 715	.0	2.5
DEHOEK	85 716	.0	3.5
DEHOEK	85 717	.0	3.0
DEHOEK	85 718	.0	3.5
DEHOEK	85 719	.0	3.0
DEHOEK	85 720	.0	3.0
DEHOEK	85 721	.0	2.5
DEHOEK	85 722	.0	3.0
DEHOEK	85 723	.0	2.5
DEHOEK	85 724	.0	3.5
DEHOEK	85 725	.0	3.0
DEHOEK	85 726	.0	3.0
DEHOEK	85 727	.0	3.0
DEHOEK	85 728	.0	3.0
DEHOEK	85 729	.0	4.0
DEHOEK	85 730	.0	5.5
DEHOEK	85 731	.0	5.0
DEHOEK	85 8 1	.0	5.5
DEHOEK	85 8 2	.0	9.0
DEHOEK	85 8 3	.0	6.0
DEHOEK	85 8 4	.0	5.0
DEHOEK	85 8 5	.0	6.5
DEHOEK	85 8 6	.0	6.0
DEHOEK	85 8 7	.0	5.0
DEHOEK	85 8 8	.0	6.0
DEHOEK	85 8 9	.0	8.5
DEHOEK	85 810	.0	3.5
DEHOEK	85 811	.0	4.0
DEHOEK	85 812	.0	5.5
DEHOEK	85 813	.0	5.0
DEHOEK	85 814	.0	6.5
DEHOEK	85 815	.0	2.0
DEHOEK	85 816	.0	5.5
DEHOEK	85 817	.0	5.5
DEHOEK	85 818	.0	6.5
DEHOEK	85 819	.0	6.5
DEHOEK	85 820	.0	4.5
DEHOEK	85 821	.0	5.5
DEHOEK	85 822	.0	5.5
DEHOEK	85 823	.0	4.0
DEHOEK	85 824	.0	4.5
DEHOEK	85 825	.0	1.5
DEHOEK	85 826	.0	4.0
DEHOEK	85 827	.0	5.0
DEHOEK	85 828	.0	6.5
DEHOEK	85 829	.0	6.5
DEHOEK	85 830	.0	6.5
DEHOEK	85 831	.0	5.5
DEHOEK	85 9 1	.0	4.0
DEHOEK	85 9 2	.0	5.5
DEHOEK	85 9 3	.0	7.5
DEHOEK	85 9 4	.0	6.0
DEHOEK	85 9 5	.0	6.5
DEHOEK	85 9 6	.0	5.5
DEHOEK	85 9 7	.0	3.5
DEHOEK	85 9 8	.0	5.5
DEHOEK	85 9 9	.0	6.5
DEHOEK	85 910	.0	7.5
DEHOEK	85 911	.0	11.0
DEHOEK	85 912	.3	4.5
DEHOEK	85 913	.0	2.9
DEHOEK	85 914	8.6	.1
DEHOEK	85 915	.8	4.0
DEHOEK	85 916	.8	3.0
DEHOEK	85 917	.0	5.5
DEHOEK	85 918	.0	6.5
DEHOEK	85 919	.0	7.0
DEHOEK	85 920	.0	.4
DEHOEK	85 921	.0	1.2
DEHOEK	85 922	.0	6.5
DEHOEK	85 923	.0	10.5
DEHOEK	85 924	.0	6.5
DEHOEK	85 925	.1	8.5
DEHOEK	85 926	2.8	.0
DEHOEK	85 927	.2	3.5
DEHOEK	85 928	.4	9.0
DEHOEK	85 929	1.3	6.4
DEHOEK	85 930	.1	7.0
DEHOEK	8510 1	.0	12.0
DEHOEK	8510 2	.0	9.0
DEHOEK	8510 3	.0	9.5
DEHOEK	8510 4	.0	13.0
DEHOEK	8510 5	.0	7.0
DEHOEK	8510 6	2.5	.4
DEHOEK	8510 7	.2	2.5
DEHOEK	8510 8	10.0	3.3
DEHOEK	8510 9	.1	1.5
DEHOEK	851010	.0	7.0
DEHOEK	851011	.0	8.5
DEHOEK	851012	.0	9.0
DEHOEK	851013	5.5	5.5
DEHOEK	851014	7.0	4.8
DEHOEK	851015	13.7	3.5
DEHOEK	851016	.0	5.5
DEHOEK	851017	.0	5.0
DEHOEK	851018	.7	4.4
DEHOEK	851019	.0	5.5
DEHOEK	851020	.0	8.0
DEHOEK	851021	.0	7.0
DEHOEK	851022	.0	5.0
DEHOEK	851023	.3	7.0
DEHOEK	851024	.8	6.3

DEHOEK	851025	.0	8.0	DEHOEK	851230	.0	11.0
DEHOEK	851026	.0	6.0	DEHOEK	851231	.0	9.0
DEHOEK	851027	.0	6.0	DEHOEK	860101	.0	3.5
DEHOEK	851028	.8	6.5	DEHOEK	860102	7.2	5.8
DEHOEK	851029	12.7	6.3	DEHOEK	860103	6.1	8.5
DEHOEK	851030	22.7	6.3	DEHOEK	860104	5.9	4.9
DEHOEK	851031	19.0	6.3	DEHOEK	860105	.0	5.0
DEHOEK	8511 1	40.1	6.8	DEHOEK	860106	.1	8.0
DEHOEK	8511 2	3.5	7.0	DEHOEK	860107	.2	7.0
DEHOEK	8511 3	.2	6.0	DEHOEK	860108	3.5	9.1
DEHOEK	8511 4	.3	9.0	DEHOEK	860109	2.0	7.3
DEHOEK	8511 5	.0	8.5	DEHOEK	860110	7.8	7.2
DEHOEK	8511 6	13.2	8.5	DEHOEK	860111	6.0	3.4
DEHOEK	8511 7	5.1	4.7	DEHOEK	860112	4.7	8.1
DEHOEK	8511 8	10.4	1.8	DEHOEK	860113	1.1	9.0
DEHOEK	8511 9	4.0	6.6	DEHOEK	860114	.0	7.5
DEHOEK	851110	.0	3.0	DEHOEK	860115	4.6	8.2
DEHOEK	851111	.0	5.0	DEHOEK	860116	.2	1.0
DEHOEK	851112	.0	5.0	DEHOEK	860117	20.0	6.1
DEHOEK	851113	.0	8.0	DEHOEK	860118	17.2	4.2
DEHOEK	851114	.0	10.2	DEHOEK	860119	39.2	6.1
DEHOEK	851115	.0	6.5	DEHOEK	860120	1.1	5.6
DEHOEK	851116	.0	16.5	DEHOEK	860121	1.7	7.8
DEHOEK	851117	.0	9.5	DEHOEK	860122	3.8	2.2
DEHOEK	851118	.0	10.5	DEHOEK	860123	.6	3.0
DEHOEK	851119	.0	7.0	DEHOEK	860124	1.7	7.4
DEHOEK	851120	.0	6.0	DEHOEK	860125	.0	7.0
DEHOEK	851121	.0	6.8	DEHOEK	860126	.0	6.5
DEHOEK	851122	.0	8.0	DEHOEK	860127	11.9	4.4
DEHOEK	851123	.0	4.5	DEHOEK	860128	8.4	6.1
DEHOEK	851124	.0	7.5	DEHOEK	860129	1.7	7.0
DEHOEK	851125	.0	6.8	DEHOEK	860130	.1	4.5
DEHOEK	851126	17.3	6.8	DEHOEK	860131	.0	7.5
DEHOEK	851127	2.3	5.3	DEHOEK	860201	28.5	5.3
DEHOEK	851128	4.9	.0	DEHOEK	860202	.0	1.2
DEHOEK	851129	20.9	6.8	DEHOEK	860203	.0	4.5
DEHOEK	851130	.4	6.5	DEHOEK	860204	1.2	5.3
DEHOEK	8512 1	.0	6.5	DEHOEK	860205	.4	5.0
DEHOEK	8512 2	.0	7.5	DEHOEK	860206	1.1	2.4
DEHOEK	8512 3	7.3	6.1	DEHOEK	860207	17.6	5.3
DEHOEK	8512 4	12.7	1.8	DEHOEK	860208	1.5	6.0
DEHOEK	8512 5	9.5	4.7	DEHOEK	860209	7.8	5.7
DEHOEK	8512 6	1.5	6.4	DEHOEK	860210	3.3	5.8
DEHOEK	8512 7	7.1	5.2	DEHOEK	860211	45.1	5.3
DEHOEK	8512 8	.1	6.7	DEHOEK	860212	3.1	5.0
DEHOEK	8512 9	.0	8.0	DEHOEK	860213	.2	4.0
DEHOEK	851210	.0	10.0	DEHOEK	860214	.1	3.0
DEHOEK	851211	.2	1.7	DEHOEK	860215	.1	4.0
DEHOEK	851212	.4	2.0	DEHOEK	860216	.1	7.5
DEHOEK	851213	.5	4.5	DEHOEK	860217	.1	8.0
DEHOEK	851214	10.0	6.1	DEHOEK	860218	.1	6.5
DEHOEK	851215	14.8	6.1	DEHOEK	860219	.0	6.5
DEHOEK	851216	3.3	7.5	DEHOEK	860220	.0	7.5
DEHOEK	851217	.3	7.5	DEHOEK	860221	.0	6.0
DEHOEK	851218	20.5	6.1	DEHOEK	860222	3.4	6.6
DEHOEK	851219	1.8	3.5	DEHOEK	860223	4.5	3.5
DEHOEK	851220	.0	6.0	DEHOEK	860224	6.1	7.0
DEHOEK	851221	4.8	1.5	DEHOEK	860225	8.0	2.1
DEHOEK	851222	5.4	.5	DEHOEK	860226	.4	5.0
DEHOEK	851223	4.4	4.5	DEHOEK	860227	.0	5.5
DEHOEK	851224	2.8	5.2	DEHOEK	860228	.0	7.0
DEHOEK	851225	.3	7.8	DEHOEK	860301	.0	8.0
DEHOEK	851226	7.0	6.0	DEHOEK	860302	8.0	6.3
DEHOEK	851227	.1	8.5	DEHOEK	860303	.0	5.5
DEHOEK	851228	.0	9.0	DEHOEK	860304	5.3	4.5
DEHOEK	851229	.0	12.5	DEHOEK	860305	.2	6.2

DEHOEK	860306	2.9	4.8
DEHOEK	860307	.2	6.0
DEHOEK	860308	2.1	5.0
DEHOEK	860309	1.8	2.3
DEHOEK	860310	8.0	4.7
DEHOEK	860311	14.6	5.0
DEHOEK	860312	3.4	3.0
DEHOEK	860313	.0	5.5
DEHOEK	860314	.0	7.0
DEHOEK	860315	.0	5.0
DEHOEK	860316	1.9	1.8
DEHOEK	860317	13.7	.2
DEHOEK	860318	1.2	5.5
DEHOEK	860319	5.9	4.0
DEHOEK	860320	.0	5.0
DEHOEK	860321	.0	5.5
DEHOEK	860322	.0	8.0
DEHOEK	860323	.0	4.7
DEHOEK	860324	28.7	1.3
DEHOEK	860325	.1	4.5
DEHOEK	860326	.0	1.5
DEHOEK	860327	.0	4.5
DEHOEK	860328	.2	4.0
DEHOEK	860329	.0	6.0
DEHOEK	860330	.0	6.0
DEHOEK	860331	.0	3.5
DEHOEK	860401	.0	4.0
DEHOEK	860402	.0	5.5
DEHOEK	860403	.0	5.0
DEHOEK	860404	.0	6.0
DEHOEK	860405	.0	6.0
DEHOEK	860406	.0	5.0
DEHOEK	860407	.0	6.5
DEHOEK	860408	.0	5.5
DEHOEK	860409	.0	4.0
DEHOEK	860410	.1	6.0
DEHOEK	860411	5.4	4.2
DEHOEK	860412	12.0	4.2
DEHOEK	860413	.8	5.0
DEHOEK	860414	.8	3.5
DEHOEK	860415	.0	5.0
DEHOEK	860416	.0	4.0
DEHOEK	860417	.0	4.0
DEHOEK	860418	.0	4.0
DEHOEK	860419	23.6	4.2
DEHOEK	860420	4.0	1.0
DEHOEK	860421	5.7	.4
DEHOEK	860422	1.5	2.5
DEHOEK	860423	.1	3.9
DEHOEK	860424	1.0	3.5
DEHOEK	860425	.0	5.0
DEHOEK	860426	.0	3.0
DEHOEK	860427	.0	5.0
DEHOEK	860428	.0	3.0
DEHOEK	860429	.0	3.0
DEHOEK	860430	.0	4.0
DEHOEK	860501	.0	2.0
DEHOEK	860502	.0	2.0
DEHOEK	860503	.1	3.0
DEHOEK	860504	.3	1.9
DEHOEK	860505	.0	2.5
DEHOEK	860506	.0	3.0
DEHOEK	860507	.0	3.5
DEHOEK	860508	.0	4.0
DEHOEK	860509	.0	4.5
DEHOEK	860510	.0	4.0
DEHOEK	860511	.0	3.0
DEHOEK	860512	.0	4.0
DEHOEK	860513	.0	4.0
DEHOEK	860514	.0	4.0
DEHOEK	860515	.0	4.5
DEHOEK	860516	.0	2.0
DEHOEK	860517	.0	3.0
DEHOEK	860518	.0	3.5
DEHOEK	860519	.0	4.0
DEHOEK	860520	.0	3.5
DEHOEK	860521	.0	3.5
DEHOEK	860522	.0	4.0
DEHOEK	860523	.0	4.0
DEHOEK	860524	.0	3.0
DEHOEK	860525	.0	3.0
DEHOEK	860526	.0	4.0
DEHOEK	860527	.0	3.0
DEHOEK	860528	.0	3.0
DEHOEK	860529	.0	2.0
DEHOEK	860530	.0	4.0
DEHOEK	860531	.0	4.0
DEHOEK	860601	.0	3.0
DEHOEK	860602	.2	8.0
DEHOEK	860603	3.8	2.7
DEHOEK	860604	16.1	3.1
DEHOEK	860605	.3	3.0
DEHOEK	860606	.0	2.0
DEHOEK	860607	.0	2.0
DEHOEK	860608	.0	1.5
DEHOEK	860609	.0	2.5
DEHOEK	860610	.0	3.0
DEHOEK	860611	.0	3.0
DEHOEK	860612	.0	4.0
DEHOEK	860613	.0	3.0
DEHOEK	860614	.0	3.0
DEHOEK	860615	.0	2.0
DEHOEK	860616	.0	3.5
DEHOEK	860617	.0	6.0
DEHOEK	860618	.0	2.0
DEHOEK	860619	.0	2.5
DEHOEK	860620	.0	4.0
DEHOEK	860621	.0	4.5
DEHOEK	860622	.0	2.5
DEHOEK	860623	.0	4.0
DEHOEK	860624	.0	2.5
DEHOEK	860625	.0	3.0
DEHOEK	860626	.0	2.0
DEHOEK	860627	.0	2.5
DEHOEK	860628	.0	3.0
DEHOEK	860629	.0	2.5
DEHOEK	860630	.0	3.5
DEHOEK	860701	.0	2.0
DEHOEK	860702	.0	4.0
DEHOEK	860703	.0	2.0
DEHOEK	860704	.0	3.0
DEHOEK	860705	.0	2.0
DEHOEK	860706	.0	1.5
DEHOEK	860707	.0	3.5
DEHOEK	860708	.0	3.5
DEHOEK	860709	.0	3.0
DEHOEK	860710	.0	3.5
DEHOEK	860711	.0	4.0
DEHOEK	860712	.0	1.5
DEHOEK	860713	.0	2.5
DEHOEK	860714	.0	4.0
DEHOEK	860715	.0	4.0

DEHOEK	860716	.0	2.5
DEHOEK	860717	.0	4.5
DEHOEK	860718	.0	4.5
DEHOEK	860719	.0	3.0
DEHOEK	860720	.0	4.0
DEHOEK	860721	.0	3.5
DEHOEK	860722	.0	5.5
DEHOEK	860723	.0	5.5
DEHOEK	860724	.0	3.0
DEHOEK	860725	.0	2.5
DEHOEK	860726	.0	3.0
DEHOEK	860727	.0	2.5
DEHOEK	860728	.0	3.5
DEHOEK	860729	.0	4.0
DEHOEK	860730	.0	3.5
DEHOEK	860731	.0	3.5
DEHOEK	860801	.0	3.5
DEHOEK	860802	.0	3.5
DEHOEK	860803	.0	3.5
DEHOEK	860804	.0	4.5
DEHOEK	860805	.0	6.0
DEHOEK	860806	.0	5.0
DEHOEK	860807	.0	3.0
DEHOEK	860808	.0	4.0
DEHOEK	860809	.0	2.5
DEHOEK	860810	.0	6.5
DEHOEK	860811	.0	8.0
DEHOEK	860812	.0	3.0
DEHOEK	860813	.0	5.0
DEHOEK	860814	.0	7.0
DEHOEK	860815	.0	4.5
DEHOEK	860816	.0	6.0
DEHOEK	860817	.0	6.0
DEHOEK	860818	.0	2.0
DEHOEK	860819	.0	4.0
DEHOEK	860820	.0	4.0
DEHOEK	860821	.0	3.0
DEHOEK	860822	.0	4.0
DEHOEK	860823	.0	5.5
DEHOEK	860824	.0	9.0
DEHOEK	860825	.0	11.0
DEHOEK	860826	.0	10.0
DEHOEK	860827	.0	6.3
DEHOEK	860828	2.1	5.0
DEHOEK	860829	14.9	5.0
DEHOEK	860830	21.4	.6
DEHOEK	860831	.0	5.0
DEHOEK	860901	.0	4.0
DEHOEK	860902	.0	4.0
DEHOEK	860903	.0	4.0
DEHOEK	860904	.0	7.0
DEHOEK	860905	.0	6.5
DEHOEK	860906	.1	7.0
DEHOEK	860907	.3	8.0
DEHOEK	860908	.5	4.0
DEHOEK	860909	.1	5.0
DEHOEK	860910	.0	11.0
DEHOEK	860911	.0	1.0
DEHOEK	860912	.4	3.7
DEHOEK	860913	1.9	6.1
DEHOEK	860914	.1	7.0
DEHOEK	860915	1.9	6.0
DEHOEK	860916	.0	2.0
DEHOEK	860917	.0	5.0
DEHOEK	860918	.2	4.5
DEHOEK	860919	.0	5.3
DEHOEK	860920	.0	6.5
DEHOEK	860921	.0	8.0
DEHOEK	860922	.3	6.0
DEHOEK	860923	.0	8.0
DEHOEK	860924	.0	7.1
DEHOEK	860925	2.0	.0
DEHOEK	860926	.1	5.5
DEHOEK	860927	.0	5.5
DEHOEK	860928	.0	4.0
DEHOEK	860929	3.9	2.6
DEHOEK	860930	.0	6.0
DEHOEK	861001	.1	4.0
DEHOEK	861002	16.1	.0
DEHOEK	861003	3.3	4.7
DEHOEK	861004	.0	5.5
DEHOEK	861005	.3	5.0
DEHOEK	861006	.0	10.0
DEHOEK	861007	.0	6.0
DEHOEK	861008	.0	4.0
DEHOEK	861009	.7	7.3
DEHOEK	861010	.7	7.6
DEHOEK	861011	.3	7.5
DEHOEK	861012	.0	7.0
DEHOEK	861013	.0	7.0
DEHOEK	861014	.1	5.0
DEHOEK	861015	12.6	.0
DEHOEK	861016	30.2	.0
DEHOEK	861017	1.7	1.3
DEHOEK	861018	.0	8.0
DEHOEK	861019	9.1	.0
DEHOEK	861020	5.0	8.2
DEHOEK	861021	.1	8.0
DEHOEK	861022	.0	8.0
DEHOEK	861023	.1	7.0
DEHOEK	861024	.5	1.3
DEHOEK	861025	8.2	.0
DEHOEK	861026	11.2	7.7
DEHOEK	861027	.4	8.2
DEHOEK	861028	.3	.0
DEHOEK	861029	17.3	.6
DEHOEK	861030	.2	6.5
DEHOEK	861031	12.0	5.3
DEHOEK	861101	.1	4.0
DEHOEK	861102	.0	7.0
DEHOEK	861103	.0	10.0
DEHOEK	861104	.8	4.2
DEHOEK	861105	3.5	.0
DEHOEK	861106	13.6	5.0
DEHOEK	861107	.0	5.5
DEHOEK	861108	14.1	.0
DEHOEK	861109	9.5	2.6
DEHOEK	861110	1.6	4.0
DEHOEK	861111	.0	8.0
DEHOEK	861112	.0	7.0
DEHOEK	861113	.0	8.0
DEHOEK	861114	.1	10.5
DEHOEK	861115	2.1	1.5
DEHOEK	861116	.5	4.0
DEHOEK	861117	2.5	3.9
DEHOEK	861118	3.3	7.0
DEHOEK	861119	.0	2.0
DEHOEK	861120	15.2	4.9
DEHOEK	861121	2.8	4.3
DEHOEK	861122	3.9	6.7
DEHOEK	861123	.0	5.0
DEHOEK	861124	.0	8.0

DEHOEK	861125	.0	7.0
DEHOEK	861126	13.2	.0
DEHOEK	861127	1.0	8.4
DEHOEK	861128	.6	3.0
DEHOEK	861129	1.9	3.5
DEHOEK	861130	.1	7.0
DEHOEK	861201	.0	8.0
DEHOEK	861202	3.2	8.0
DEHOEK	861203	.3	6.0
DEHOEK	861204	13.7	.0
DEHOEK	861205	2.7	8.8
DEHOEK	861206	23.4	.0
DEHOEK	861207	36.0	.0
DEHOEK	861208	.0	4.0
DEHOEK	861209	12.5	.0
DEHOEK	861210	.0	3.0
DEHOEK	861211	.0	6.0
DEHOEK	861212	.0	7.0
DEHOEK	861213	1.0	3.0
DEHOEK	861214	1.5	5.4
DEHOEK	861215	.3	9.4
DEHOEK	861216	.2	4.5
DEHOEK	861217	3.7	4.4
DEHOEK	861218	.8	3.0
DEHOEK	861219	2.8	2.6
DEHOEK	861220	.2	6.0
DEHOEK	861221	.0	7.0
DEHOEK	861222	19.5	.0
DEHOEK	861223	.8	5.0
DEHOEK	861224	.5	7.0
DEHOEK	861225	.3	8.0
DEHOEK	861226	2.9	7.0
DEHOEK	861227	.0	.0
DEHOEK	861228	21.3	6.6
DEHOEK	861229	2.7	3.0
DEHOEK	861230	1.7	5.6
DEHOEK	861231	.7	6.0
DEHOEK	87 1 1	.0	3.5
DEHOEK	87 1 2	.0	5.8
DEHOEK	87 1 3	.9	8.5
DEHOEK	87 1 4	3.8	4.9
DEHOEK	87 1 5	1.8	5.0
DEHOEK	87 1 6	22.6	8.0
DEHOEK	87 1 7	4.7	7.0
DEHOEK	87 1 8	12.4	9.1
DEHOEK	87 1 9	3.3	7.3
DEHOEK	87 110	1.0	7.2
DEHOEK	87 111	1.3	3.4
DEHOEK	87 112	2.1	8.1
DEHOEK	87 113	16.0	9.0
DEHOEK	87 114	2.6	7.5
DEHOEK	87 115	.0	8.2
DEHOEK	87 116	26.9	1.0
DEHOEK	87 117	1.5	6.1
DEHOEK	87 118	.0	4.2
DEHOEK	87 119	.4	6.1
DEHOEK	87 120	6.9	5.6
DEHOEK	87 121	1.0	7.8
DEHOEK	87 122	.0	2.2
DEHOEK	87 123	.0	3.0
DEHOEK	87 124	17.8	7.4
DEHOEK	87 125	.6	7.0
DEHOEK	87 126	4.9	6.5
DEHOEK	87 127	.0	4.4
DEHOEK	87 128	.0	6.1
DEHOEK	87 129	.0	7.0

DEHOEK	87 130	.0	4.5
DEHOEK	87 131	10.5	7.5
DEHOEK	87 2 1	.1	5.3
DEHOEK	87 2 2	10.6	1.2
DEHOEK	87 2 3	1.5	4.5
DEHOEK	87 2 4	.0	5.3
DEHOEK	87 2 5	.0	5.0
DEHOEK	87 2 6	23.7	2.4
DEHOEK	87 2 7	.2	5.3
DEHOEK	87 2 8	.0	6.0
DEHOEK	87 2 9	.0	5.7
DEHOEK	87 210	14.9	5.8
DEHOEK	87 211	.0	5.3
DEHOEK	87 212	11.5	5.0
DEHOEK	87 213	2.4	4.0
DEHOEK	87 214	2.0	3.0
DEHOEK	87 215	.0	4.0
DEHOEK	87 216	.0	7.5
DEHOEK	87 217	9.9	8.0
DEHOEK	87 218	.2	6.5
DEHOEK	87 219	.5	6.5
DEHOEK	87 220	.0	7.5
DEHOEK	87 221	1.1	6.0
DEHOEK	87 222	.0	6.6
DEHOEK	87 223	18.1	3.5
DEHOEK	87 224	1.0	7.0
DEHOEK	87 225	2.6	2.1
DEHOEK	87 226	.0	5.0
DEHOEK	87 227	.0	5.5
DEHOEK	87 228	4.3	7.0
DEHOEK	87 3 1	.1	8.0
DEHOEK	87 3 2	.0	6.3
DEHOEK	87 3 3	9.2	5.5
DEHOEK	87 3 4	2.5	4.5
DEHOEK	87 3 5	3.7	6.2
DEHOEK	87 3 6	31.0	4.8
DEHOEK	87 3 7	1.3	6.0
DEHOEK	87 3 8	.3	5.0
DEHOEK	87 3 9	2.4	2.3
DEHOEK	87 310	.0	4.7
DEHOEK	87 311	.0	5.0
DEHOEK	87 312	.0	3.0
DEHOEK	87 313	.0	5.5
DEHOEK	87 314	.0	7.0
DEHOEK	87 315	1.3	5.0
DEHOEK	87 316	2.3	1.8
DEHOEK	87 317	14.6	.2
DEHOEK	87 318	18.5	5.5
DEHOEK	87 319	1.8	4.0
DEHOEK	87 320	.0	5.0
DEHOEK	87 321	38.1	5.5
DEHOEK	87 322	7.3	8.0
DEHOEK	87 323	1.4	4.7
DEHOEK	87 324	3.6	1.3
DEHOEK	87 325	17.7	4.5
DEHOEK	87 326	.3	1.5
DEHOEK	87 327	.2	4.5
DEHOEK	87 328	1.1	4.0
DEHOEK	87 329	.1	6.0
DEHOEK	87 330	.0	6.0
DEHOEK	87 331	.0	3.5

APPENDIX E 3

DAILY STREAMFLOW DATA (VIM20)

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
850101	0.00				
850102	0.00				
850103	0.00				
850104	21.20				
850105	0.10				
850106	4.90				
850107	11.10	2.28		0.01	
850108	0.60	14.59		0.00	
850109	0.00	3.96		0.00	
850110	0.50	1.52		0.00	
850111	0.10	0.90		0.00	
850112	1.20	0.03		0.00	
850113	23.60	218.60		204.52	
850114	12.70	478.09		391.17	
850115	21.10	156.65		93.59	
850116	15.40	230.57		67.31	
850117	18.60	642.01		221.98	
850118	0.00	269.76		20.99	
850119	0.00	221.74		3.26	
850120	0.00	136.27		0.00	
850121	0.00	82.17		0.00	
850122	0.00	46.81		0.00	
850123	0.00	34.28		0.00	
850124	1.60	26.90		0.00	
850125	1.30	35.53		0.00	
850126	0.50	30.96		0.00	
850127	0.00	25.56		0.00	
850128	0.00	23.72		0.00	
850129	0.50	20.00		0.00	
850130	1.90	19.45		0.01	
850131	0.80	21.28		0.00	
850201	0.00	9.79		0.00	
850202	0.00	5.76		0.00	
850203	11.40	4.05		0.00	
850204	0.40	10.49		0.00	
850205	0.00	7.62		0.00	
850206	0.00	6.37		0.00	
850207	8.10	5.46		0.00	
850208	40.90	298.13		92.55	
850209	23.50	239.22		26.69	
850210	22.50	1159.45		722.01	
850211	0.40	668.08		51.79	
850212	41.80	4824.98		4379.34	
850213	2.40	1869.47		1097.64	
850214	4.00	1367.73		245.41	
850215	0.00	958.40		4.49	
850216	0.00	675.10		0.03	
850217	0.00	511.56		0.00	
850218	0.70	389.64		0.83	
850219	4.70	411.07		37.40	
850220	2.70	514.31		11.59	
850221	0.60	316.92		0.00	

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	v1m20 (mm)	QUICKFLOW v1m28 (mm)	v1m20 (mm)
850222	2.30	254.14		18.09	
850223	0.70	176.75		0.17	
850224	0.20	114.09		0.00	
850225	2.50	79.33		0.95	
850226	7.90	215.70		76.41	
850227	0.40	82.14		0.01	
850228	0.40	67.53		0.00	
850301	1.70	56.84	149.65	0.20	
850302	0.40	66.40	149.65	1.25	
850303	0.20	38.16	149.65	0.00	
850304	0.00	33.62	149.65	0.00	
850305	0.00	27.37	149.65	0.00	
850306	0.10	200.95	149.65	0.00	
850307	0.80	289.52	149.65	0.00	
850308	3.00	289.52	150.77	0.00	
850309	33.60	289.52	2802.39	0.00	2623.17
850310	26.70	289.52	4751.82	0.00	4031.03
850311	9.40	289.52	3022.33	0.00	1502.21
850312	5.00	466.01	1635.68	72.09	163.67
850313	9.90	630.55	1291.62	131.24	158.24
850314	0.20	1211.51	2057.73	245.49	705.47
850315	0.00	1211.51	1016.58	245.49	0.00
850316	1.20	842.25	803.85	13.01	0.00
850317	0.10	821.60	694.21	0.00	0.00
850318	0.10	821.60	613.98	0.00	0.00
850319	0.30	423.69	513.97	0.00	0.00
850320	1.30	139.56	479.78	0.33	0.00
850321	0.00	107.42	447.81	0.00	0.00
850322	0.00	107.42	386.75	0.00	0.00
850323	0.00	107.42	326.53	0.00	0.00
850324	0.00	107.42	289.55	0.00	0.00
850325	1.80	107.42	252.40	0.00	0.00
850326	4.80	136.31	269.35	30.91	1.53
850327	0.10	99.25	335.67	4.79	0.27
850328	0.00	52.35	224.92	0.00	0.00
850329	0.00	47.11	186.86	0.00	0.00
850330	0.00	36.85	155.17	0.00	0.00
850331	0.10	30.88	137.77	0.00	0.00
850401	0.00	28.45	129.15	0.00	0.00
850402	0.00	23.62	122.93	0.00	0.00
850403	0.00	21.00	120.22	0.00	0.00
850404	0.60	20.41	121.55	0.00	0.00
850405	0.00	20.41	113.85	0.00	0.00
850406	0.00	20.41	110.36	0.00	0.00
850407	1.20	23.91	109.34	0.00	0.00
850408	0.00	15.59	94.50	0.00	0.00
850409	0.10	10.70	87.43	0.00	0.00
850410	0.00	9.48	83.88	0.00	0.00
850411	0.00	9.48	75.30	0.00	0.00
850412	0.00	9.48	75.30	0.00	0.00
850413	0.00	9.48	75.30	0.00	0.00
850414	0.00	9.48	75.30	0.00	0.00
850415	3.70	8.71	60.09	0.00	0.00
850416	1.40	7.03	55.65	0.00	0.00
850417	0.20	6.27	53.96	0.00	0.00
850418	0.00	6.27	53.96	0.00	0.00
850419	0.00	5.31	53.96	0.00	0.00
850420	0.00	4.23	53.96	0.00	0.00
850421	0.00	3.83	53.96	0.00	0.00
850422	0.00	3.06	53.96	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
850423	0.00	2.63	53.96	0.00	0.00
850424	0.00	2.25	53.96	0.00	0.00
850425	0.00	2.25	53.96	0.00	0.00
850426	0.00	2.25	53.96	0.00	0.00
850427	0.00	2.25	52.04	0.00	0.00
850428	0.00	2.19	50.17	0.00	0.00
850429	0.00	1.45	45.00	0.00	0.00
850430	0.00	0.98	43.35	0.00	0.00
850501	0.00	0.65	37.43	0.00	0.00
850502	0.00	0.65	37.43	0.00	0.00
850503	0.00	0.65	37.43	0.00	0.00
850504	0.00	0.65	37.43	0.00	0.00
850505	0.00	0.72	37.43	0.00	0.00
850506	0.00	1.45	37.43	0.00	0.00
850507	2.10	1.92	37.43	0.00	0.00
850508	0.00	2.25	37.43	0.00	0.00
850509	0.00	2.25	37.43	0.00	0.00
850510	0.00	2.25	37.43	0.00	0.00
850511	0.60	2.25	37.43	0.00	0.00
850512	0.00	2.25	37.43	0.00	0.00
850513	0.00	2.25	37.43	0.00	0.00
850514	0.00	2.25	35.39	0.00	0.00
850515	0.00	2.25	48.38	0.00	0.00
850516	0.00	2.25	457.92	0.00	1.99
850517	0.00	2.25	852.25	0.00	75.72
850518	0.00	2.25	667.70	0.00	0.00
850519	0.00	2.25	667.70	0.00	0.00
850520	0.00	2.25	667.70	0.00	0.00
850521	0.00	2.25	667.70	0.00	0.00
850522	0.00	2.25	667.70	0.00	0.00
850523	0.00	2.25	667.70	0.00	0.00
850524	0.00	2.25	486.81	0.00	0.00
850525	0.00	2.25	353.87	0.00	0.00
850526	0.00	2.25	353.87	0.00	0.00
850527	0.00	2.25	353.87	0.00	0.00
850528	0.00	2.25	353.87	0.00	0.00
850529	0.00	2.25	353.87	0.00	0.00
850530	0.00	2.25	353.87	0.00	0.00
850531	0.00	2.25	353.44	0.00	0.00
850601	0.00	1.82	87.18	0.00	0.00
850602	0.00	0.96	87.25	0.00	0.00
850603	0.00	0.09	87.25	0.00	0.00
850604	0.00	0.00	87.25	0.00	0.00
850605	0.00	0.00	87.25	0.00	0.00
850606	0.00	1.82	87.25	0.00	0.00
850607	0.00	2.25	87.25	0.00	0.00
850608	0.00	1.09	87.25	0.00	0.00
850609	0.00	0.32	87.25	0.00	0.00
850610	0.00	0.32	87.25	0.00	0.00
850611	0.00	0.03	115.04	0.00	0.00
850612	0.00	0.00	134.44	0.00	0.00
850613	0.00	0.00	134.44	0.00	0.00
850614	0.00	0.00	130.16	0.00	0.00
850615	0.00	0.00	124.81	0.00	0.00
850616	0.00	0.00	124.81	0.00	0.00
850617	0.00	0.00	120.72	0.00	0.00
850618	0.00	0.00	104.21	0.00	0.00
850619	0.00	0.00	91.57	0.00	0.00
850620	0.00	0.00	79.72	0.00	0.00
850621	0.00	0.00	79.72	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
850622	0.20	0.00	79.72	0.00	0.00
850623	0.00	0.00	79.72	0.00	0.00
850624	9.00	0.65	79.72	0.00	0.00
850625	0.70	21.26	70.20	2.15	0.00
850626	0.00	7.76	63.83	0.00	0.00
850627	0.00	3.47	67.28	0.00	0.00
850628	0.00	0.29	80.94	0.00	0.00
850629	0.00	0.00	73.24	0.00	0.00
850630	0.00	0.00	76.58	0.00	0.00
850701	0.00	0.00	76.58	0.00	0.00
850702	0.00	0.30	70.22	0.00	0.00
850703	0.00	0.33	59.58	0.00	0.00
850704	0.00	0.00	60.12	0.00	0.00
850705	0.00	0.00	65.04	0.00	0.00
850706	0.00	0.00	60.98	0.00	0.00
850707	0.00	0.00	60.38	0.00	0.00
850708	0.00	0.00	60.38	0.00	0.00
850709	0.00	0.00	61.48	0.00	0.00
850710	0.00	0.00	71.16	0.00	0.00
850711	0.00	0.00	97.05	0.00	0.00
850712	0.00	0.00	73.22	0.00	0.00
850713	0.00	0.00	73.22	0.00	0.00
850714	0.00	0.00	73.22	0.00	0.00
850715	0.00	0.00	73.22	0.00	0.00
850716	0.00	0.00	73.22	0.00	0.00
850717	0.00	0.00	73.22	0.00	0.00
850718	0.00	0.56	73.22	0.00	0.00
850719	0.00	1.39	68.90	0.00	0.00
850720	0.00	1.45	62.90	0.00	0.00
850721	0.00	1.45	70.28	0.00	0.00
850722	0.00	1.45	70.97	0.00	0.00
850723	0.00	1.45	68.36	0.00	0.00
850724	0.00	1.45	69.36	0.00	0.00
850725	0.00	1.45	100.59	0.00	0.00
850726	0.00	1.45	76.80	0.00	0.00
850727	0.00	1.45	33.57	0.00	0.00
850728	0.00	1.45	33.57	0.00	0.00
850729	0.00	1.45	33.57	0.00	0.00
850730	0.00	1.45	33.57	0.00	0.00
850731	0.00	1.45	33.57	0.00	0.00
850801	0.00	1.45	12.93	0.00	0.00
850802	0.00	1.45	12.20	0.00	0.00
850803	0.00	1.45	14.25	0.00	0.00
850804	0.00	1.45	21.73	0.00	0.00
850805	0.00	1.45	26.24	0.00	0.00
850806	0.00	1.45	36.14	0.00	0.00
850807	0.00	1.45	39.11	0.00	0.00
850808	0.00	1.45	41.81	0.00	0.00
850809	0.00	1.45	58.03	0.00	0.00
850810	0.00	1.45	78.37	0.00	0.00
850811	0.00	1.45	85.30	0.00	0.00
850812	0.00	1.45	71.18	0.00	0.00
850813	0.00	1.45	27.47	0.00	0.00
850814	0.00	1.45	23.81	0.00	0.00
850815	0.00	0.31	19.57	0.00	0.00
850816	0.00	0.00	22.91	0.00	0.00
850817	0.00	0.00	26.66	0.00	0.00
850818	0.00	0.00	38.87	0.00	0.00
850819	0.00	0.00	54.18	0.00	0.00

STREAMFLOW DATA

		DAILY FLOW		QUICKFLOW	
DATE	RAINFALL (mm)	v1m28 (mm)	v1m20 (mm)	v1m28 (mm)	v1m20 (mm)
850820	0.00	0.00	70.55	0.00	0.00
850821	0.00	0.00	60.59	0.00	0.00
850822	0.00	0.00	61.92	0.00	0.00
850823	0.00	0.00	60.30	0.00	0.00
850824	0.00	0.00	49.14	0.00	0.00
850825	0.00	0.00	51.28	0.00	0.00
850826	0.00	0.00	49.43	0.00	0.00
850827	0.00	0.00	46.35	0.00	0.00
850828	0.00	0.00	41.20	0.00	0.00
850829	0.00	0.00	40.05	0.00	0.00
850830	0.00	0.00	40.05	0.00	0.00
850831	0.00	0.00	40.05	0.00	0.00
850901	0.00	0.00	40.70	0.00	0.00
850902	0.00	0.00	51.64	0.00	0.00
850903	0.00	0.00	50.72	0.00	0.00
850904	0.00	0.00	57.17	0.00	0.00
850905	0.00	0.00	71.86	0.00	0.00
850906	0.00	0.00	86.74	0.00	0.29
850907	0.00	0.00	65.48	0.00	0.00
850908	0.00	0.00	61.97	0.00	0.00
850909	0.00	0.00	52.68	0.00	0.00
850910	0.00	0.00	41.28	0.00	0.00
850911	0.00	0.00	40.05	0.00	0.00
850912	0.30	0.00	40.05	0.00	0.00
850913	0.00	0.00	40.05	0.00	0.00
850914	8.60	0.00	61.73	0.00	0.00
850915	0.80	0.24	70.47	0.00	0.00
850916	0.80	2.06	44.04	0.00	0.00
850917	0.00	2.25	40.47	0.00	0.00
850918	0.00	2.33	37.64	0.00	0.00
850919	0.00	2.04	37.64	0.00	0.00
850920	0.00	0.65	37.64	0.00	0.00
850921	0.00	0.65	37.64	0.00	0.00
850922	0.00	0.65	37.64	0.00	0.00
850923	0.00	0.65	44.43	0.00	0.00
850924	0.00	0.65	43.21	0.00	0.00
850925	0.10	0.65	44.87	0.00	0.00
850926	2.80	0.67	44.87	0.00	0.00
850927	0.20	2.45	42.86	0.00	0.00
850928	0.40	0.61	33.95	0.00	0.00
850929	1.30	0.00	32.83	0.00	0.00
850930	0.10	0.00	34.65	0.00	0.00
851001	0.00	0.00	32.37	0.00	0.00
851002	0.00	0.00	33.14	0.00	0.00
851003	0.00	0.00	42.50	0.00	0.00
851004	0.00	0.00	44.63	0.00	0.00
851005	0.00	0.00	43.64	0.00	0.00
851006	2.50	0.00	55.83	0.00	0.00
851007	0.20	0.00	59.56	0.00	0.00
851008	10.00	0.00	65.41	0.00	0.00
851009	0.10	0.00	65.20	0.00	0.00
851010	0.00	0.00	65.20	0.00	0.00
851011	0.00	0.00	56.86	0.00	0.00
851012	0.00	0.00	43.15	0.00	0.00
851013	5.50	0.00	35.79	0.00	0.00
851014	7.00	0.41	30.88	0.00	0.00
851015	13.70	28.36	83.50	2.47	1.25
851016	0.00	13.29	56.87	0.00	0.00
851017	0.00	5.59	40.05	0.00	0.00
851018	0.70	3.62	40.05	0.00	0.00
851019	0.00	3.06	40.05	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	v1m20 (mm)	QUICKFLOW v1m28 (mm)	v1m20 (mm)
851020	0.00	3.06	39.75	0.00	0.00
851021	0.00	3.57	26.38	0.00	0.00
851022	0.00	1.72	26.63	0.00	0.00
851023	0.30	1.53	29.63	0.00	0.00
851024	0.80	1.53	33.78	0.00	0.00
851025	0.00	1.53	34.66	0.00	0.00
851026	0.00	1.53	46.02	0.00	0.00
851027	0.00	1.53	59.20	0.00	0.00
851028	0.80	1.53	64.96	0.00	0.00
851029	12.70	0.61	82.52	0.00	0.01
851030	22.70	34.78	196.24	10.98	2.02
851031	19.00	94.65	335.28	31.46	32.27
851101	40.10	600.29	3464.92	530.74	3053.67
851102	3.50	159.07	1132.51	50.77	413.44
851103	0.20	24.60	231.18	0.00	0.01
851104	0.30	10.57	137.89	0.00	0.00
851105	0.00	6.17	135.89	0.00	0.00
851106	13.20	28.53	234.85	17.99	96.65
851107	5.10	28.70	198.89	0.72	1.98
851108	10.40	90.91	309.36	21.16	0.95
851109	4.00	28.98	232.14	0.00	0.00
851110	0.00	24.00	187.85	0.00	0.00
851111	0.00	16.60	181.21	0.00	0.00
851112	0.00	6.85	131.90	0.00	0.01
851113	0.00	2.36	57.03	0.00	0.00
851114	0.00	1.40	50.70	0.00	0.00
851115	0.00	0.08	39.87	0.00	0.00
851116	0.00	0.00	37.64	0.00	0.00
851117	0.00	0.00	45.39	0.00	0.00
851118	0.00	0.00	47.44	0.00	0.00
851119	0.00	0.00	49.60	0.00	0.00
851120	0.00	0.00	42.46	0.00	0.00
851121	0.00	3761.82	13694.51	3723.62	13531.91
851122	0.00	123.26	595.23	16.81	61.82
851123	0.00	15.87	321.79	0.00	0.00
851124	0.00	6.25	309.25	0.00	0.00
851125	0.00	7.94	338.84	0.00	4.04
851126	17.30	323.10	978.64	267.72	588.09
851127	2.30	150.32	530.13	11.02	13.38
851128	4.90	155.02	399.03	36.11	7.90
851129	20.90	951.91	1938.50	611.42	945.67
851130	0.40	632.08	1510.69	126.04	193.07
851201	0.00	232.32	611.41	0.00	0.00
851202	0.00	113.02	343.67	0.00	0.03
851203	7.30	166.72	420.35	58.71	83.91
851204	12.70	502.14	1250.76	181.99	279.90
851205	9.50	319.97	517.58	100.59	39.09
851206	1.50	284.18	590.27	19.37	12.06
851207	7.10	181.10	307.32	47.77	3.30
851208	0.10	173.47	403.39	8.02	5.77
851209	0.00	74.37	214.26	0.00	0.00
851210	0.00	35.30	124.10	0.00	0.00
851211	0.20	72.10	105.08	0.00	0.00
851212	0.40	80.49	98.69	0.00	0.00
851213	0.50	59.85	109.81	0.00	0.01
851214	10.00	50.27	104.24	8.06	0.79
851215	14.80	237.90	336.90	112.47	53.85
851216	3.30	189.92	490.89	40.08	91.88
851217	0.30	70.26	235.49	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
851218	20.50	2104.32	3448.52	2053.14	3277.00
851219	1.80	1310.19	2761.43	912.79	1557.85
851220	0.00	550.40	1194.22	5.84	0.94
851221	4.80	483.12	1033.15	88.33	86.57
851222	5.40	809.80	1671.96	337.55	509.32
851223	4.40	832.08	1763.79	269.74	361.27
851224	2.80	637.78	1491.08	59.65	74.15
851225	0.30	430.77	1100.50	0.08	0.01
851226	7.00	498.21	1144.93	168.99	305.57
851227	0.10	407.77	962.09	21.37	18.94
851228	0.00	245.61	549.40	0.02	0.00
851229	0.00	173.38	432.19	0.15	0.02
851230	0.00	100.55	287.46	0.06	0.00
851231	0.00	73.53	259.57	0.00	0.23
860101	0.00	64.39	287.08	0.00	0.01
860102	7.20	76.16	283.11	17.84	0.06
860103	6.10	129.91	443.47	21.91	12.66
860104	5.90	116.75	411.26	22.52	6.62
860105	0.00	84.48	416.66	0.00	0.00
860106	0.10	39.73	264.95	0.00	0.60
860107	0.20	26.74	172.68	0.00	0.00
860108	3.50	32.21	171.31	6.31	2.33
860109	2.00	30.34	188.74	0.22	0.00
860110	7.80	34.18	125.93	9.81	0.19
860111	6.00	44.49	183.41	10.09	0.54
860112	4.70	49.41	215.70	7.94	0.17
860113	1.10	28.35	187.78	0.00	0.00
860114	0.00	20.88	132.95	0.00	0.00
860115	4.60	13.04	85.96	0.00	0.02
860116	0.20	17.32	90.57	0.02	0.00
860117	20.00	271.66	815.67	228.84	630.19
860118	17.20	344.01	873.82	154.06	198.90
860119	39.20	2716.91	5301.41	2403.44	4385.49
860120	1.10	1551.48	3727.18	982.23	2065.18
860121	1.70	585.39	1314.63	7.06	9.60
860122	3.80	591.37	1233.95	51.11	102.66
860123	0.60	465.32	985.38	0.11	8.74
860124	1.70	337.95	712.74	1.87	0.03
860125	0.00	280.53	564.80	0.02	0.11
860126	0.00	197.26	449.90	0.00	0.00
860127	11.90	442.35	815.16	260.06	388.71
860128	8.40	503.13	1174.45	159.73	288.48
860129	1.70	422.42	1030.70	73.52	104.22
860130	0.10	157.75	522.79	0.00	0.00
860131	0.00	108.27	366.22	0.06	0.00
860201	28.50	1906.21	4199.13	1695.86	3527.41
860202	0.00	973.20	2330.25	424.41	754.47
860203	0.00	581.83	1365.71	0.48	0.00
860204	1.20	999.82	1896.20	437.47	521.02
860205	0.40	608.67	1180.60	1.01	0.00
860206	1.10	471.33	967.43	1.45	0.97
860207	17.60	958.89	1633.99	501.25	541.50
860208	1.50	910.58	2074.46	300.15	561.27
860209	7.80	591.69	1210.54	56.08	20.86
860210	3.30	918.92	2201.25	300.44	749.90
860211	45.10	8644.59	18530.62	8126.32	17175.85
860212	3.10	1636.27	3791.56	840.37	1461.90
860213	0.20	1377.13	2926.89	243.51	208.48

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
860214	0.10	977.76	2044.20	0.06	0.00
860215	0.10	762.35	1668.96	0.00	0.00
860216	0.10	590.29	1360.83	0.23	0.00
860217	0.10	463.71	1158.67	0.01	0.03
860218	0.10	352.03	970.55	0.00	0.08
860219	0.00	288.72	846.92	0.03	0.02
860220	0.00	215.51	737.14	0.00	0.00
860221	0.00	158.75	607.67	0.00	0.00
860222	3.40	138.04	590.57	13.24	9.49
860223	4.50	175.38	752.71	26.47	36.95
860224	6.10	179.43	762.60	30.35	68.64
860225	8.00	149.25	535.52	50.10	66.85
860226	0.40	121.41	589.24	0.03	5.62
860227	0.00	67.24	400.50	0.00	0.00
860228	0.00	41.00	336.03	0.01	0.00
860301	0.00	23.44	288.05	0.00	0.00
860302	8.00	35.97	247.27	13.87	0.34
860303	0.00	39.16	331.52	0.03	0.78
860304	5.30	61.38	294.71	27.58	28.61
860305	0.20	52.74	441.61	0.83	44.80
860306	2.90	40.70	271.75	1.45	0.00
860307	0.20	22.32	211.58	0.00	0.00
860308	2.10	17.53	174.24	0.06	0.00
860309	1.80	42.84	205.52	4.08	0.00
860310	8.00	84.96	475.34	36.08	198.82
860311	14.60	174.13	670.75	100.76	245.98
860312	3.40	267.22	974.87	87.35	274.50
860313	0.00	88.56	450.01	0.00	0.00
860314	0.00	48.15	316.88	0.00	0.00
860315	0.00	30.65	218.85	0.01	0.00
860316	1.90	40.61	185.28	0.01	0.00
860317	13.70	173.66	382.86	33.29	5.42
860318	1.20	164.71	436.83	0.13	0.00
860319	5.90	72.28	238.03	8.48	0.00
860320	0.00	59.62	226.92	0.00	0.00
860321	0.00	35.54	178.27	0.00	0.00
860322	0.00	21.22	134.28	0.00	0.00
860323	0.00	17.07	112.25	0.00	0.00
860324	28.70	1945.72	4042.83	1778.59	3490.35
860325	0.10	227.65	623.93	0.00	0.00
860326	0.00	122.38	386.78	0.00	0.00
860327	0.00	78.93	301.82	0.00	0.00
860328	0.20	51.52	247.79	0.01	0.00
860329	0.00	43.78	203.09	0.00	0.00
860330	0.00	31.33	186.80	0.03	0.00
860331	0.00	26.89	155.98	0.00	0.00
860401	0.00	21.07	136.22	0.00	0.00
860402	0.00	17.18	134.44	0.00	0.00
860403	0.00	14.87	115.64	0.00	0.00
860404	0.00	12.49	110.36	0.00	0.00
860405	0.00	9.83	110.36	0.00	0.00
860406	0.00	9.48	110.36	0.00	0.00
860407	0.00	8.69	110.36	0.00	0.00
860408	0.00	6.27	110.36	0.00	0.00
860409	0.00	6.55	112.16	0.00	0.00
860410	0.10	9.03	128.44	0.00	0.00
860411	5.40	8.46	118.62	0.07	0.00
860412	12.00	68.20	242.72	9.98	0.35
860413	0.80	40.50	274.06	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
860414	0.80	26.90	179.88	0.00	0.00
860415	0.00	14.79	125.76	0.00	0.00
860416	0.00	14.69	110.78	0.00	0.00
860417	0.00	13.34	110.36	0.00	0.00
860418	0.00	9.37	110.36	0.00	0.00
860419	23.60	153.48	543.04	106.35	269.44
860420	4.00	67.10	315.12	0.14	0.00
860421	5.70	158.17	365.45	27.77	0.20
860422	1.50	137.51	309.51	0.41	0.00
860423	0.10	96.34	192.57	0.00	0.00
860424	1.00	38.44	148.92	0.16	0.22
860425	0.00	27.20	137.76	0.00	0.00
860426	0.00	15.76	102.07	0.00	0.00
860427	0.00	12.69	95.23	0.00	0.00
860428	0.00	7.87	90.32	0.00	0.00
860429	0.00	7.87	86.61	0.00	0.00
860430	0.00	7.87	92.84	0.00	0.00
860501	0.00	10.01	111.73	0.00	0.00
860502	0.00	14.86	148.46	0.00	0.00
860503	0.10	12.82	240.51	0.00	0.00
860504	0.30	12.77	282.22	0.00	0.00
860505	0.00	11.29	257.38	0.00	0.00
860506	0.00	11.25	132.83	0.00	0.00
860507	0.00	12.18	115.51	0.00	0.00
860508	0.00	8.16	93.57	0.00	0.00
860509	0.00	6.27	88.62	0.00	0.00
860510	0.00	6.27	88.62	0.00	0.00
860511	0.00	6.27	88.62	0.00	0.00
860512	0.00	6.27	88.70	0.00	0.00
860513	0.00	6.27	107.07	0.00	0.00
860514	0.00	6.27	95.16	0.00	0.00
860515	0.00	6.27	91.09	0.00	0.00
860516	0.00	6.27	88.62	0.00	0.00
860517	0.00	6.27	88.62	0.00	0.00
860518	0.00	5.85	88.62	0.00	0.00
860519	0.00	4.26	88.62	0.00	0.00
860520	0.00	1.57	87.62	0.00	0.00
860521	0.00	0.65	78.15	0.00	0.00
860522	0.00	0.18	72.79	0.00	0.00
860523	0.00	0.00	70.01	0.00	0.00
860524	0.00	0.00	70.01	0.00	0.00
860525	0.00	0.00	70.01	0.00	0.00
860526	0.00	0.00	70.01	0.00	0.00
860527	0.00	0.00	80.45	0.00	0.00
860528	0.00	0.00	87.61	0.00	0.00
860529	0.00	0.00	88.19	0.00	0.00
860530	0.00	0.00	84.61	0.00	0.00
860531	0.00	0.00	80.93	0.00	0.00
860601	0.00	0.00	80.59	0.00	0.00
860602	0.20	0.00	80.59	0.00	0.00
860603	3.80	0.00	82.80	0.00	0.00
860604	16.10	32.74	113.92	10.47	0.00
860605	0.30	16.81	147.71	0.53	0.00
860606	0.00	2.23	102.90	0.00	0.00
860607	0.00	0.30	100.73	0.00	0.00
860608	0.00	0.00	94.67	0.00	0.00
860609	0.00	0.00	91.63	0.00	0.00
860610	0.00	0.00	88.62	0.00	0.00
860611	0.00	0.00	88.62	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
860612	0.00	0.00	88.62	0.00	0.00
860613	0.00	0.00	88.62	0.00	0.00
860614	0.00	0.00	88.62	0.00	0.00
860615	0.00	0.00	88.62	0.00	0.00
860616	0.00	0.00	88.62	0.00	0.00
860617	0.00	0.00	88.62	0.00	0.00
860618	0.00	0.00	88.62	0.00	0.00
860619	0.00	0.00	84.89	0.00	0.00
860620	0.00	0.00	76.58	0.00	0.00
860621	0.00	0.00	76.58	0.00	0.00
860622	0.00	0.00	76.58	0.00	0.00
860623	0.00	0.00	76.58	0.00	0.00
860624	0.00	0.00	76.58	0.00	0.00
860625	0.00	0.00	76.58	0.00	0.00
860626	0.00	0.00	73.79	0.00	0.00
860627	0.00	0.00	70.01	0.00	0.00
860628	0.00	0.00	70.01	0.00	0.00
860629	0.00	0.00	70.01	0.00	0.00
860630	0.00	0.00	70.01	0.00	0.00
860701	0.00	0.00	70.01	0.00	0.00
860702	0.00	0.00	70.01	0.00	0.00
860703	0.00	0.00	70.01	0.00	0.00
860704	0.00	0.00	70.01	0.00	0.00
860705	0.00	0.00	70.01	0.00	0.00
860706	0.00	0.00	70.01	0.00	0.00
860707	0.00	0.00	69.00	0.00	0.00
860708	0.00	0.00	65.20	0.00	0.00
860709	0.00	0.00	57.46	0.00	0.00
860710	0.00	0.00	55.66	0.00	0.00
860711	0.00	0.00	53.96	0.00	0.00
860712	0.00	0.00	53.96	0.00	0.00
860713	0.00	0.00	53.96	0.00	0.00
860714	0.00	0.00	53.96	0.00	0.00
860715	0.00	0.00	59.83	0.00	0.00
860716	0.00	0.00	65.73	0.00	0.00
860717	0.00	0.00	69.02	0.00	0.00
860718	0.00	0.00	70.01	0.00	0.00
860719	0.00	0.00	70.01	0.00	0.00
860720	0.00	0.00	70.01	0.00	0.00
860721	0.00	0.00	70.01	0.00	0.00
860722	0.00	0.00	74.87	0.00	0.00
860723	0.00	0.00	82.88	0.00	0.00
860724	0.00	0.00	85.78	0.00	0.00
860725	0.00	0.00	83.07	0.00	0.00
860726	0.00	0.00	73.10	0.00	0.00
860727	0.00	0.00	70.01	0.00	0.00
860728	0.00	0.00	61.07	0.00	0.00
860729	0.00	0.00	53.96	0.00	0.00
860730	0.00	0.00	46.48	0.00	0.00
860731	0.00	0.00	43.28	0.00	0.00
860801	0.00	0.00	40.05	0.00	0.00
860802	0.00	0.00	40.05	0.00	0.00
860803	0.00	0.00	40.05	0.00	0.00
860804	0.00	0.00	40.05	0.00	0.00
860805	0.00	0.00	43.32	0.00	0.00
860806	0.00	0.00	47.59	0.00	0.00
860807	0.00	0.00	80.67	0.00	0.00
860808	0.00	0.00	88.62	0.00	0.00
860809	0.00	0.00	88.62	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
860810	0.00	0.00	88.62	0.00	0.00
860811	0.00	0.00	88.62	0.00	0.00
860812	0.00	0.00	88.62	0.00	0.00
860813	0.00	0.00	88.62	0.00	0.00
860814	0.00	0.00	88.62	0.00	0.00
860815	0.00	0.00	88.62	0.00	0.00
860816	0.00	0.00	88.62	0.00	0.00
860817	0.00	0.00	88.62	0.00	0.00
860818	0.00	0.00	86.12	0.00	0.00
860819	0.00	0.00	75.31	0.00	0.00
860820	0.00	0.00	60.41	0.00	0.00
860821	0.00	0.00	55.46	0.00	0.00
860822	0.00	0.00	53.96	0.00	0.00
860823	0.00	0.00	53.96	0.00	0.00
860824	0.00	0.00	54.58	0.00	0.00
860825	0.00	0.00	68.19	0.00	0.00
860826	0.00	0.00	56.31	0.00	0.00
860827	0.00	0.00	56.31	0.00	0.00
860828	2.10	0.00	43.15	0.00	0.00
860829	14.90	9.17	25.30	5.61	0.00
860830	21.40	127.30	477.31	55.90	218.21
860831	0.00	5.11	158.27	0.00	0.00
860901	0.00	2.72	129.50	0.00	0.00
860902	0.00	3.19	133.23	0.00	0.00
860903	0.00	5.00	134.44	0.00	0.00
860904	0.00	6.27	104.77	0.00	0.00
860905	0.00	6.27	74.51	0.00	0.00
860906	0.10	6.05	85.71	0.00	0.00
860907	0.30	3.16	98.33	0.00	0.00
860908	0.50	2.25	120.58	0.00	0.00
860909	0.10	2.25	128.07	0.00	0.00
860910	0.00	2.25	120.61	0.00	0.00
860911	0.00	1.53	99.63	0.00	0.00
860912	0.40	0.24	76.58	0.00	0.00
860913	1.90	0.00	83.86	0.00	0.00
860914	0.10	3.06	79.86	0.00	0.00
860915	1.90	5.44	73.68	0.00	0.00
860916	0.00	1.97	72.48	0.00	0.00
860917	0.00	1.75	64.77	0.00	0.00
860918	0.20	1.30	58.21	0.00	0.00
860919	0.00	0.54	53.96	0.00	0.00
860920	0.00	0.00	53.96	0.00	0.00
860921	0.00	0.00	53.96	0.00	0.00
860922	0.30	0.00	53.96	0.00	0.00
860923	0.00	0.00	53.96	0.00	0.00
860924	0.00	0.00	53.96	0.00	0.00
860925	2.00	0.00	52.01	0.00	0.00
860926	0.10	0.00	49.41	0.00	0.00
860927	0.00	0.00	45.25	0.00	0.00
860928	0.00	0.00	44.87	0.00	0.00
860929	3.90	0.49	45.75	0.00	0.00
860930	0.00	2.89	47.54	0.00	0.00
861001	0.10	6.76	46.53	0.00	0.00
861002	16.10	39.62	55.86	6.87	0.00
861003	3.30	38.87	72.83	0.00	0.00
861004	0.00	23.99	56.85	0.00	0.00
861005	0.30	26.78	53.96	0.00	0.00
861006	0.00	5.66	55.02	0.00	0.00
861007	0.00	2.09	60.38	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
861008	0.00	0.24	57.19	0.00	0.00
861009	0.70	0.00	53.03	0.00	0.00
861010	0.70	0.00	47.81	0.00	0.00
861011	0.30	0.00	46.60	0.00	0.00
861012	0.00	0.00	46.60	0.00	0.00
861013	0.00	0.00	46.60	0.00	0.00
861014	0.10	0.00	63.04	0.00	0.00
861015	12.60	0.14	74.19	0.00	0.81
861016	30.20	144.86	216.65	79.61	29.73
861017	1.70	33.86	198.58	0.00	0.00
861018	0.00	12.40	96.90	0.00	0.00
861019	9.10	44.58	153.28	26.41	23.08
861020	5.00	41.39	254.39	10.12	57.90
861021	0.10	23.75	137.79	0.00	0.00
861022	0.00	9.69	79.26	0.00	0.00
861023	0.10	7.27	69.35	0.00	0.00
861024	0.50	5.65	65.39	0.00	0.00
861025	8.20	60.51	126.32	21.77	1.61
861026	11.20	69.37	162.71	0.90	0.00
861027	0.40	29.04	114.14	0.00	0.00
861028	0.30	86.16	109.60	29.37	2.32
861029	17.30	170.67	490.59	18.45	57.03
861030	0.20	33.22	166.34	0.00	0.00
861031	12.00	110.96	301.98	45.12	11.97
861101	0.10	53.55	256.76	0.00	0.00
861102	0.00	25.90	131.59	0.00	0.00
861103	0.00	12.73	110.24	0.00	0.00
861104	0.80	8.85	100.73	0.00	0.00
861105	3.50	9.22	100.73	0.00	0.00
861106	13.60	137.58	371.19	21.26	41.61
861107	0.00	50.33	218.24	0.06	0.00
861108	14.10	123.03	226.52	43.37	41.82
861109	9.50	216.05	600.63	50.51	63.69
861110	1.60	109.66	293.92	0.00	0.00
861111	0.00	55.66	143.16	0.00	0.00
861112	0.00	30.85	82.74	0.00	0.00
861113	0.00	18.73	55.88	0.00	0.00
861114	0.10	14.05	51.26	0.00	0.00
861115	2.10	12.79	44.87	0.00	0.00
861116	0.50	17.46	44.87	0.00	0.00
861117	2.50	18.76	48.63	0.03	0.00
861118	3.30	25.06	55.84	1.16	0.00
861119	0.00	21.12	55.56	0.00	0.00
861120	15.20	113.77	209.98	55.20	44.77
861121	2.80	109.60	228.77	4.90	0.00
861122	3.90	71.30	146.40	6.25	0.00
861123	0.00	34.72	86.71	0.00	0.00
861124	0.00	16.18	71.11	0.00	0.00
861125	0.00	7.36	70.01	0.00	0.00
861126	13.20	16.82	70.48	7.73	0.00
861127	1.00	33.36	91.49	4.77	0.00
861128	0.60	6.24	70.01	0.00	0.00
861129	1.90	7.07	70.01	0.00	0.00
861130	0.10	4.93	66.42	0.00	0.00
861201	0.00	3.86	54.41	0.00	0.00
861202	3.20	4.17	47.00	0.00	0.00
861203	0.30	5.62	40.63	0.00	0.00
861204	13.70	7.53	75.32	0.01	7.93
861205	2.70	5.39	69.76	0.00	0.00

STREAMFLOW DATA

DATE	RAINFALL (mm)	DAILY FLOW v1m28 (mm)	DAILY FLOW v1m20 (mm)	QUICKFLOW v1m28 (mm)	QUICKFLOW v1m20 (mm)
861206	23.40	84.15	559.39	77.00	484.71
861207	36.00	2000.93	11076.53	1916.10	10732.70
861208	0.00	984.78	3230.37	585.81	1877.72
861209	12.50	655.39	2386.07	173.73	353.49
861210	0.00	595.77	2256.39	60.47	161.02
861211	0.00	338.89	1276.10	0.00	0.00
861212	0.00	254.57	705.42	0.01	0.01
861213	1.00	261.41	637.81	0.02	0.00
861214	1.50	223.00	569.57	0.36	0.00
861215	0.30	183.54	454.24	0.02	0.00
861216	0.20	116.22	293.63	0.02	0.00
861217	3.70	103.66	249.44	0.39	0.01
861218	0.80	163.36	405.58	0.94	0.04
861219	2.80	100.25	511.00	0.32	5.40
861220	0.20	66.32	589.44	0.00	0.00
861221	0.00	42.82	520.81	0.00	0.00
861222	19.50	241.44	703.10	185.31	260.96
861223	0.80	143.62	477.21	6.07	13.49
861224	0.50	62.53	256.03	0.12	0.00
861225	0.30	37.21	201.23	1.80	0.01
861226	2.90	34.56	280.15	0.00	0.07
861227	0.00	141.24	368.92	92.34	129.72
861228	21.30	82.02	354.63	0.36	0.00
861229	2.70	72.89	333.94	0.00	0.00
861230	1.70	47.05	308.03	0.01	0.00
861231	0.70	32.46	241.84	0.00	0.00
870101	0.00	16.36	154.34	0.00	0.00
870102	0.00	13.36	144.20	0.00	0.00
870103	0.90	16.78	156.58	0.00	0.00
870104	3.80	24.69	180.24	4.67	0.50
870105	1.80	27.18	153.66	0.10	0.00
870106	22.60	208.84	481.64	183.57	325.78
870107	4.70	246.89	706.88	62.15	120.48
870108	12.40	238.28	491.80	103.17	80.72
870109	3.30	345.53	903.47	88.48	158.09
870110	1.00	203.76	542.51	7.21	0.92
870111	1.30	113.38	372.84	0.08	0.00
870112	2.10	77.87	227.21	5.96	0.00

APPENDIX E 4

PIEZOMETRIC DATA

GROUNDWATER LEVELS OF de Hoek BOREHOLES 2,4,5,7,9,12,13,14,17,18

Date	Depth(M)	Date	Depth(M)	Date	Depth(M)	Date	Depth(M)	Date	Depth(M)	Date	Depth(M)	Date	Depth(M)	Date	Depth(M)	Date	Depth(M)	Date	Depth(M)
BOREHOLE	GW2		GW4		GW5		GW7		GW9		GW12		GW13		GW14		GW17		GW18
120285	62.74	50285	39.49	190285	15	120285	18.79	120285	27.39	120285	13.6	120285	16.19	120285	6.93	120285	3.16	190285	17.17
120385	62.57	190385	39.1	120385	14.7	120385	18.95	150385	27.42	120385	12.96	140385	15.66	120385	6.79	120385	2.76	120385	16.7
160485	59.19	160485	39.24	160485	13.92	160485	19.02	120485	27.51	160485	13.63	120485	15.75	120485	6.85	120485	3.39	160485	16.72
140585	59.15	280585	39.4	140585	13.73	140585	19.06	170585	27.57	170585	14.1	170585	15.8	170585	6.95	170585	3.63	140585	17.1
110685	59.1	110685	39.4	110685	13.76	110685	19.09	140685	27.62	110685	14.32	140685	16.05	210685	6.99	140685	3.74	110685	17.31
90785	58.97	90785	39.53	90785	13.97	230785	19.22	160785	27.71	90785	14.77	160785	15.93	190785	7.35	190785	3.74	90785	17.51
200885	59.13	200885	39.62	200885	14.22	200885	19.57	230885	27.72	200885	15.29	230885	16.37	230885	7.1	230885	3.84	230885	17.72
240985	59.2	240985	39.65	240985	14.44	240985	19.52	270985	27.79	240985	15.6	270985	16.53	240985	7.14	270985	3.97	240985	17.8
221085	59.36	221085	39.76	221085	14.65	221085	19.65	251085	27.83	221085	15.68	251085	16.59	251085	7.21	251085	3.95	221085	17.9
30285	60.54	261185	39.82	51185	14.73	261185	19.03	221185	27.9	221185	15.59	221185	16.4	261185	7.08	221185	3.24	261185	17.79
171285	60.45	171285	39.68	171285	14.94	171285	18.86	151285	27.95	171285	15.33	171285	16.21	171285	6.94	171285	3.45	171285	17.54
140186	60.4	140186	39.51	140186	14.72	140186	18.95	140186	27.97	140186	14.94	140186	15.99	140186	6.86	140186	3.32	140186	17.27
110286	60.12	110286	39.26	110286	14.46	110286	18.76	110286	28	110286	13.83	110286	15.46	110286	6.59	110286	2.71	110286	17.01
130386	59.95	270386	39.54	130386	13.75	130386	18.95	170386	28.12	130386	14.53	170386	15.47	130386	6.77	130386	3.17	130386	16.75
100486	59.91	100486	39.43	240486	13.37	100486	18.96	210486	28.17	100486	15	210486	15.84	100486	6.88	210486	3.3	100486	17.1
150586	59.9	150586	39.48	150586	13.35	150586	19.11	200586	28.21	150586	15.19	200586	16.12	150586	6.94	200586	3.55	150586	17.22
190686	59.95	120686	39.48	120686	13.75	120686	19.14	190686	28.28	260686	15.5	190686	16.11	120686	7.08	190686	3.78	120686	17.52
100786	59.9	100786	39.64	170786	13.78	100786	19.08	30786	28.29	310786	15.75	170786	16.1	100786	7	30786	3.69	100786	17.4
40986	60.12	70886	39.61	70886	13.56	70886	19.06	210886	28.38	210886	15.93	210886	16.38	70886	7	210886	4.22	70886	17.9
180986	60.1	40986	39.56	180986	14.15	40986	19.13	40986	28.32	40986	15.98	40986	16.26	40986	7.05	40986	4.3	180986	17.57
21086	60.3	21086	39.8	161086	14.92	21086	19.38	21086	28.32	21086	16.25	21086	16.44	21086	7.07	21086	3.86	21086	17.55
61186	60.4	61186	40.01	61186	14.65	261185	19.03	131186	28.45	201186	16.34	61186	16.51	201186	7.23	61186	3.75	61186	17.59
231286	60.33	231286	39.84	231286	14.62	171285	18.86	231286	28.42	231286	15.91	231286	16.07	231286	6.98	231286	3.35	231286	17.17
290187	61.57	220187	39.72	150187	14.31	140186	18.95	150187	28.41	220187	15.86	150187	16.09	150187	6.97	150187	3.2	220187	17.23
190287	59.9	190287	39.65	190287	13.8	110286	18.76	190287	28.4	190287	16	190287	15.75	120287	6.88	120287	3.08	190287	17
190387	60	50387	39.59	50387	13.32	130386	18.95	130386	27.8	130386	15.75	130386	15.6	50387	6.79	50387	3.2	50387	16.79

APPENDIX E 5

SOIL PROFILES

GRIFFIN SERIES

Location Characteristics

Site No:	18
Terrain:	Midslope
Aspect:	North East
Slope:	20%
Vegetation:	Grassland (past and present)
Parental material:	Upper Beaufort Sandstone

Profile Characteristics:		Description:
Depth (mm)	Horizon	
0 - 280	Orthic A	Dark brown (7.5YR4/4, dry); sandy clay; massive; friable; sticky; good drainage, few very fine mottles; diffuse smooth transition.
280 - 770	Yellow-brown Apedal B	Yellow-brown (7.5YR4/6, moist); sandy clay; massive; friable; sticky; good drainage; few very fine mottles; diffuse smooth transition.
770 - 900+	Red Apedal B	Dark red (2.5YR3/6, moist); sandy clay; massive; friable; sticky; good drainage.

NORMANDIEN SERIES

Location Characteristics

Site No:	27
Terrain:	Bottomland
Aspect:	North
Slope:	5%
Vegetation:	Grassland (past and present)
Parental material:	Upper Beaufort Mudstone

Profile Characteristics:		Description:
Depth (mm)	Horizon	
0 - 200	Orthic A	Dark yellowish brown (10YR3/3, dry); sandy clay; weak fine blocky; few clayskins on ped faces (10YR3/2, moist); friable; sticky; good internal drainage, few medium hard Fe-Mn concrections; gradual smooth transition.
200 - 620	Yellow-brown Apedal B	Uniform colour (10YR4/6); sandy clay; massive; friable; sticky; good drainage; few medium hard Fe-Mn concretions; gradual smooth transition.
620 - 900+	Soft Plinthic B	Brownish yellow (10YR6/6, moist); clay; massive; hard; plastic; poor drainage; many fine mottles; few medium hard Fe-Mn concretions.

NORMANDIEN SERIES

Location Characteristics

Site No:	28
Terrain:	Midslope
Aspect:	North
Slope:	5%
Vegetation:	Grassland (past and present)
Parental material:	Upper Beaufort Mudstone

Profile Characteristics: Description:

Depth (mm)	Horizon	Description
0 - 300	Orthic A	Dark yellowish brown (10YR3/4, dry); sandy clay; massive; friable; sticky; moderate internal drainage; gradual smooth transition. smooth transition.

300 - 780 Yellow-brown Apedal B

Yellowish brown (10YR5/6); sandy clay; Apedal B massive; friable, sticky; moderate/poor internal drainage; few very fine mottles; few clayskins on root channels; few large hard Fe-Mn concretions; abrupt smooth transition.

780 - 900+ Soft Plinthic B

Red (2.5YR5/8, moist) with gley (5YR8/3, moist); clay; massive; hard; plastic; moderate/poor internal drainage; hard Fe-Mn concretionary layer at 780 - 800 mm depth.

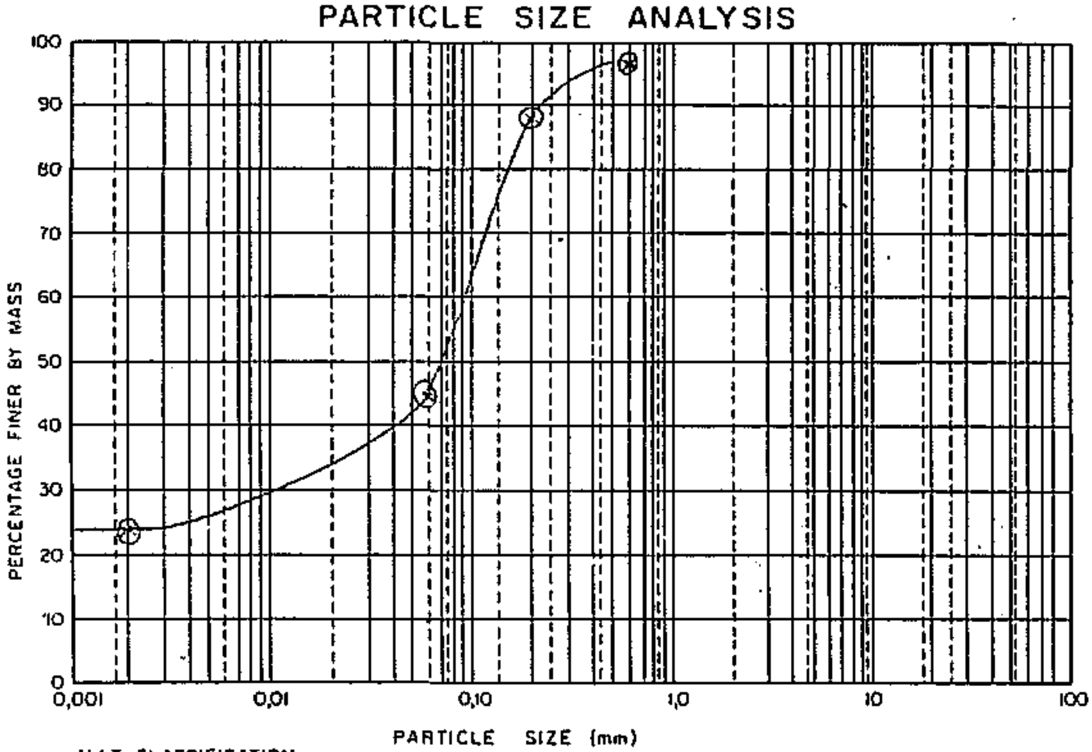
APPENDIX E.6

PARTICLE SIZE ANALYSIS

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 830-0007/8

Client ______ Job No ______
Project ______ Date ______
Reference ______ Technician ______
Client Job No ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

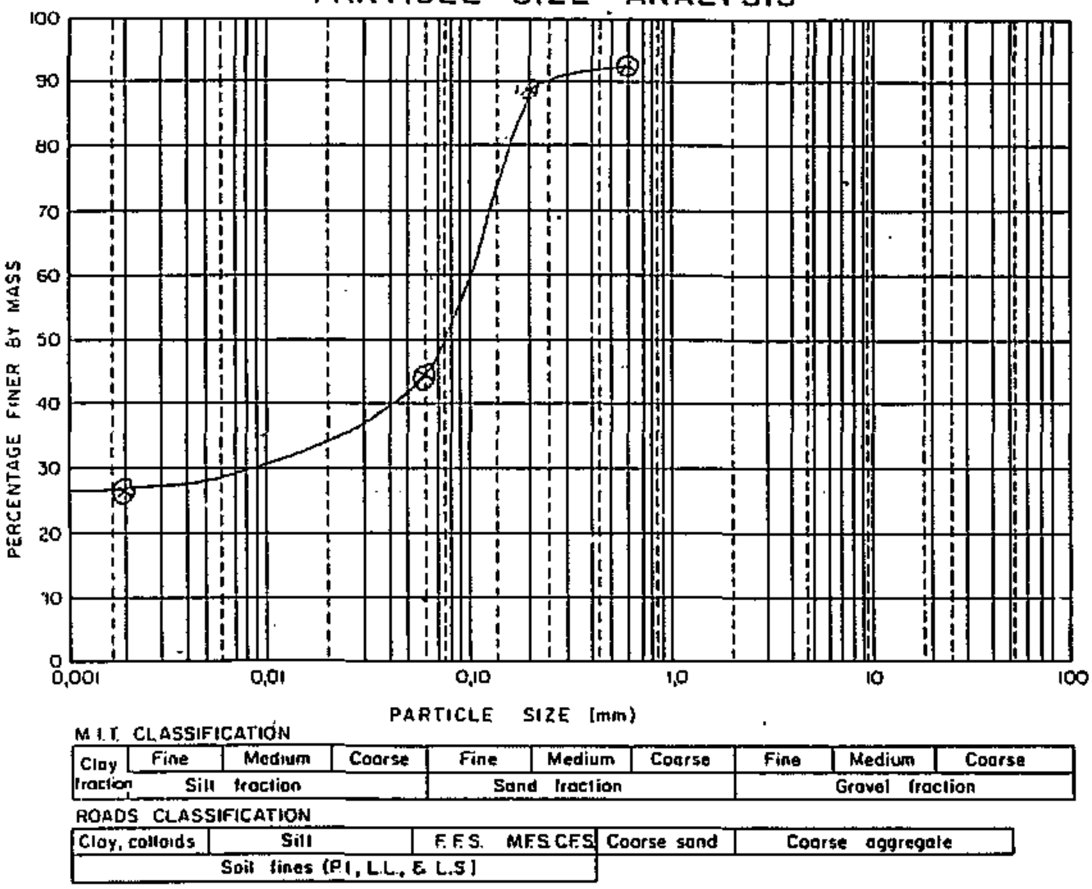
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	SITE 18			
HOLE No				
DEPTH	20			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job No ______
Project ______ Date ______
Reference ______ Technician ______
Client Job No ______ Checked by ______

PARTICLE SIZE ANALYSIS



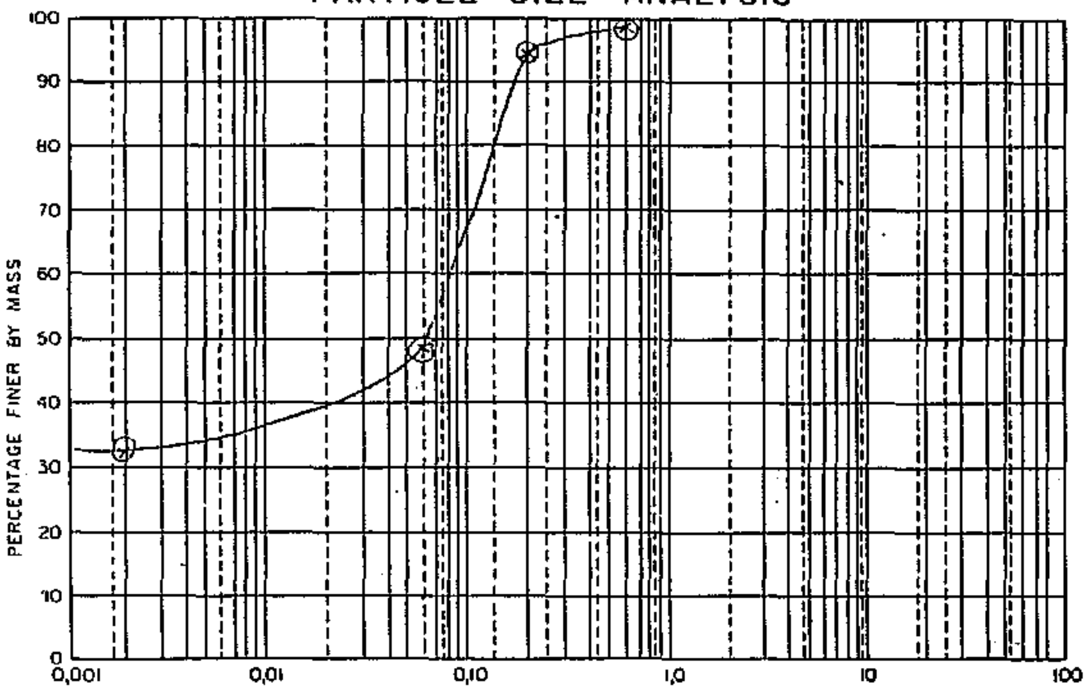
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	SITE 18			
HOLE No				
DEPTH	250			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ____________________ Job Nº ________
Project ____________________ Date ________
Reference ____________________ Technician ________
Client Job Nº ____________________ Checked by ________

PARTICLE SIZE ANALYSIS



M I T CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

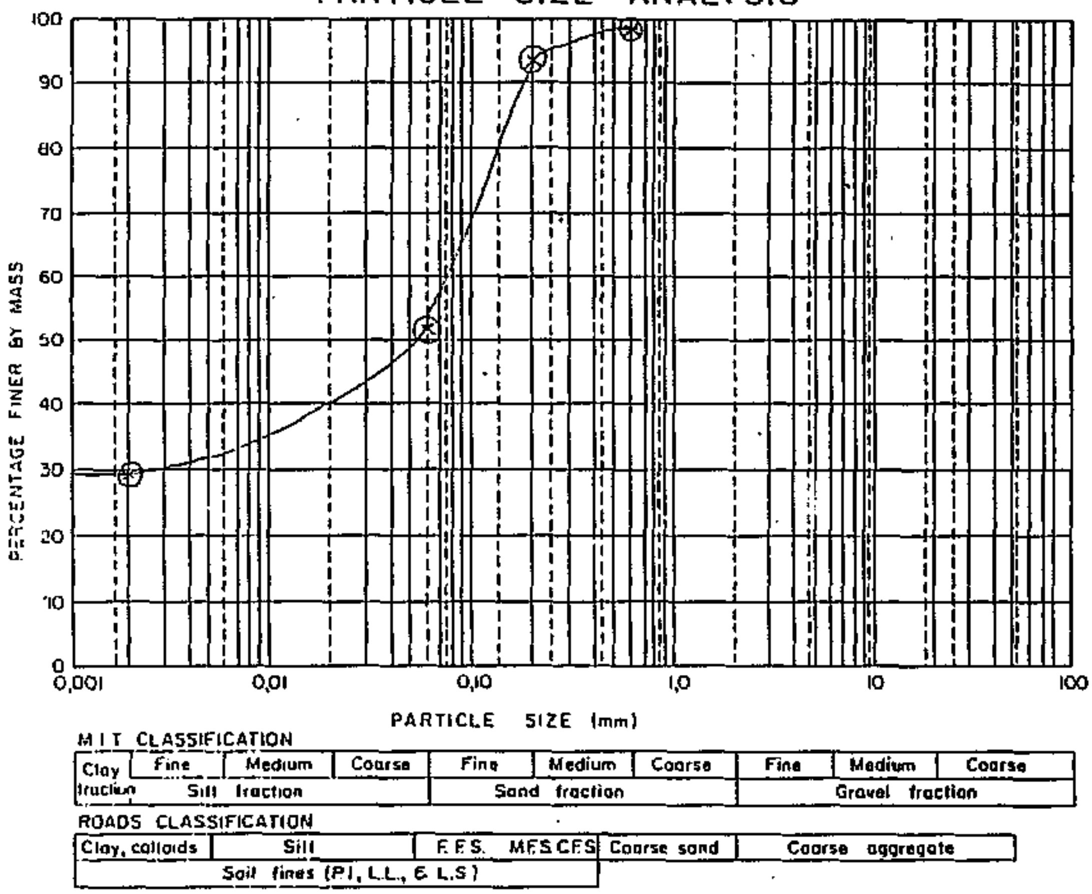
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 18			
HOLE Nº				
DEPTH	550			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ________ Job Nº ________
Project ________ Date ________
Reference ________ Technician ________
Client Job Nº ________ Checked by ________

PARTICLE SIZE ANALYSIS



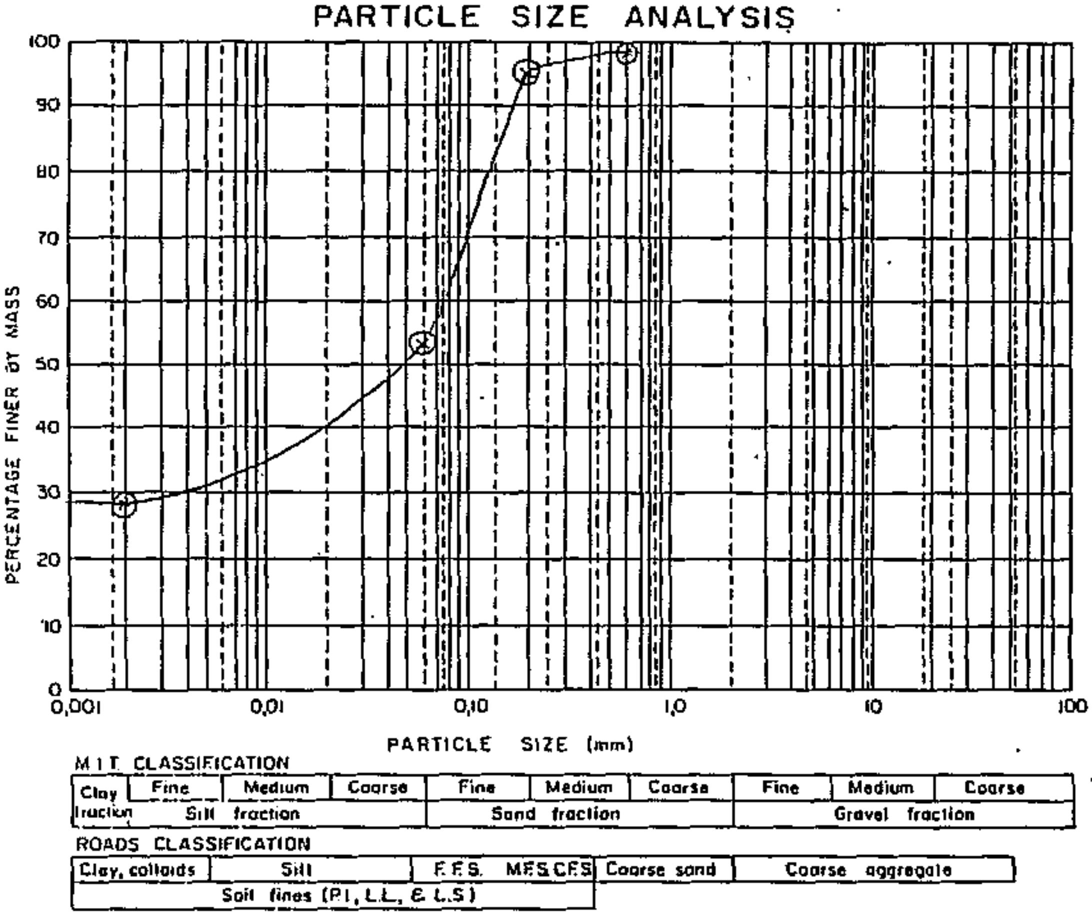
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 18			
HOLE Nº				
DEPTH	900			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 838-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



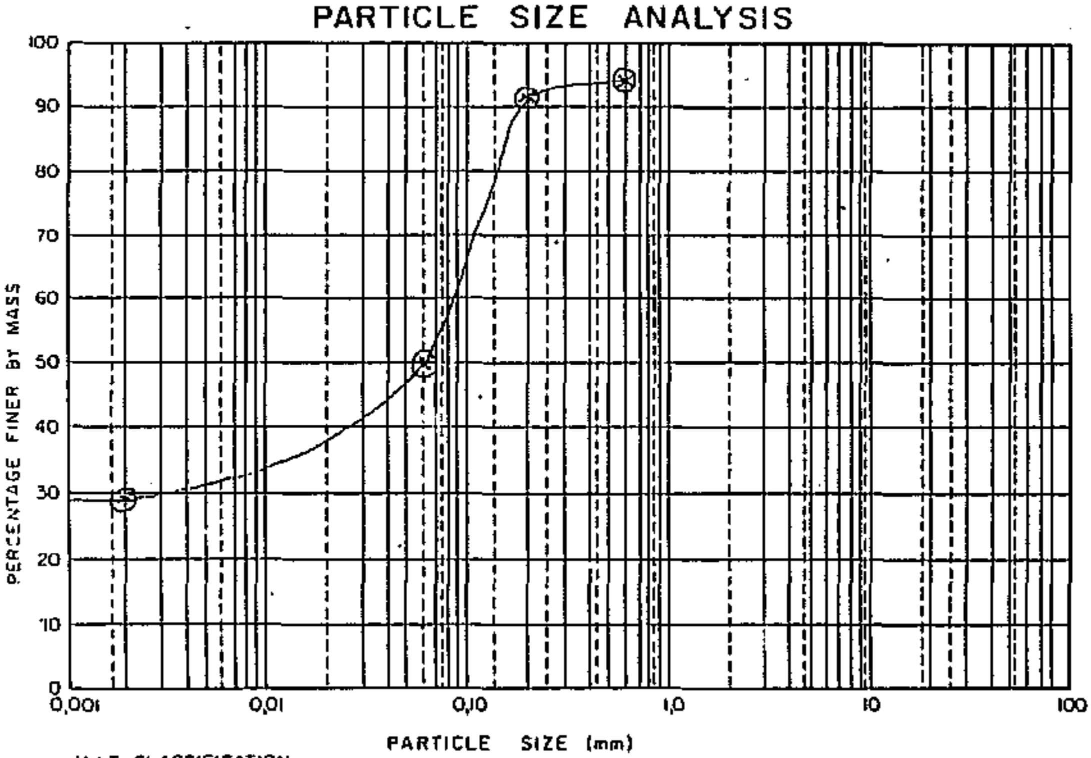
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 27			
HOLE Nº				
DEPTH	20			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job No ______
Project ______ Date ______
Reference ______ Technician ______
Client Job No ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

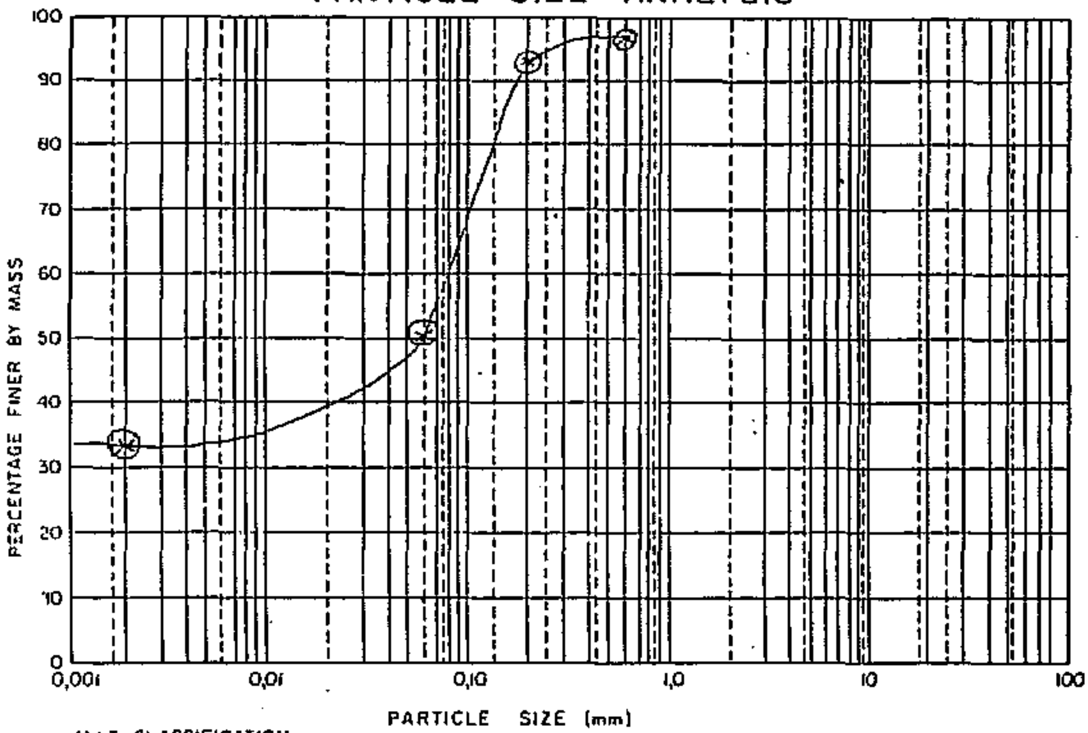
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	SITE 27			
HOLE No				
DEPTH	200			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client		Job Nº	
Project		Date	
Reference		Technician	
Client Job Nº		Checked by	

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

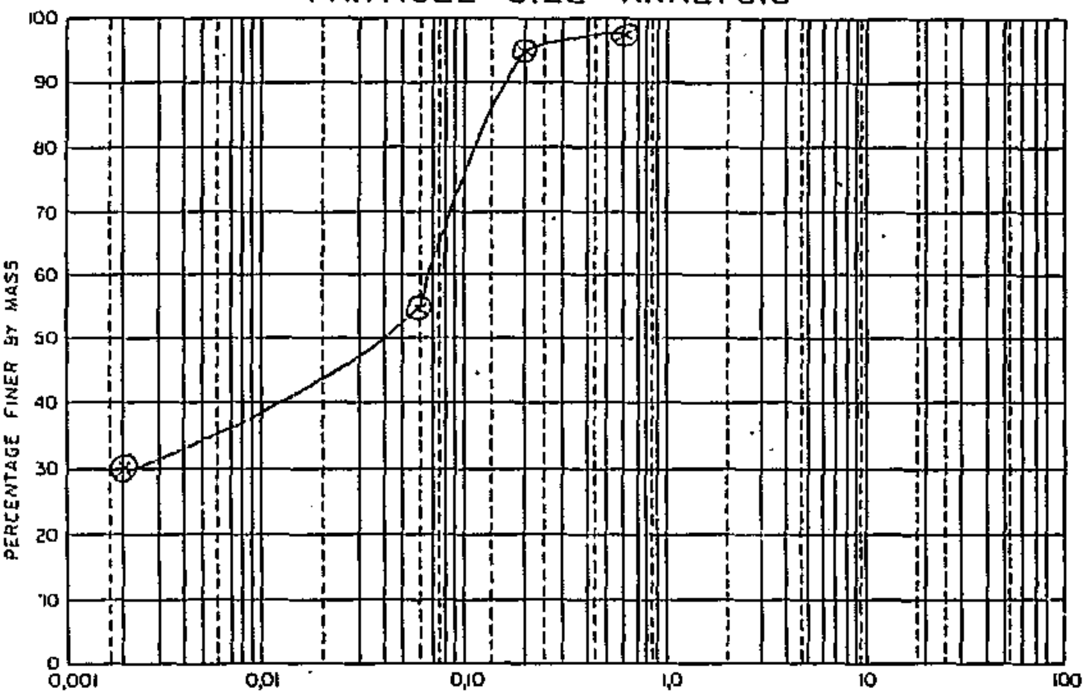
SAMPLE Nº	SITE 27			
HOLE Nº				
DEPTH	500			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB

No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M I T CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

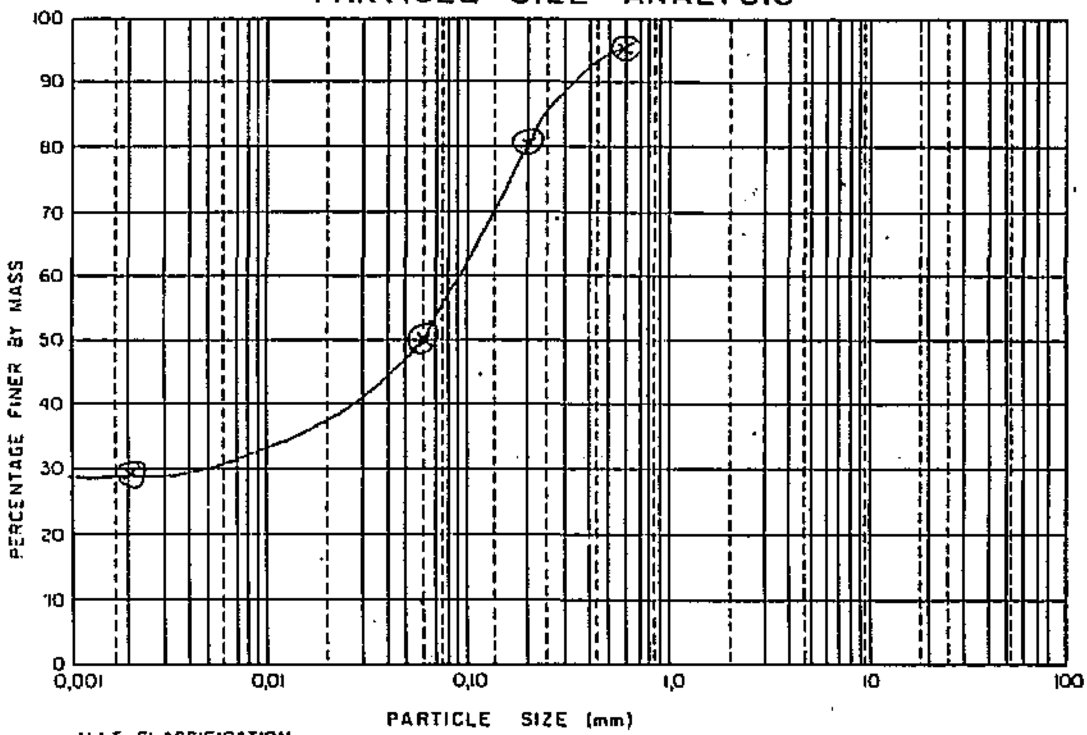
SAMPLE Nº	SITE 27			
HOLE Nº				
DEPTH	500			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB

No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job No ______
Project ______ Date ______
Reference ______ Technician ______
Client Job No ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

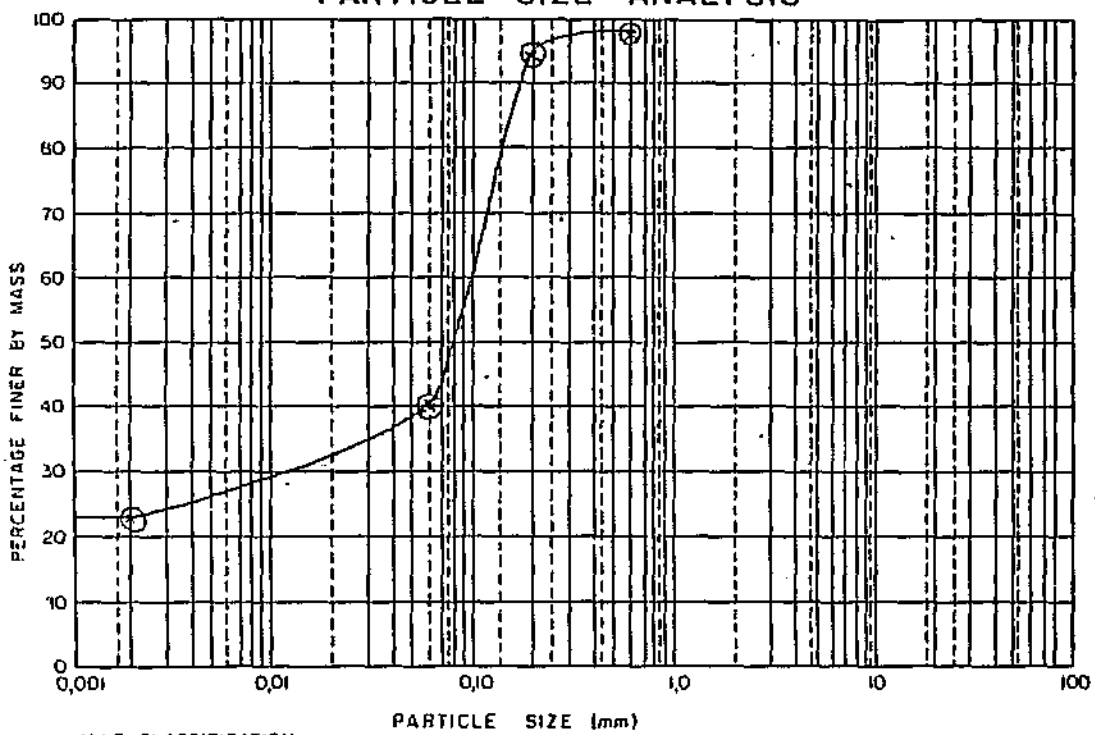
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	SITE 27			
HOLE No				
DEPTH	900			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ____________ Job Nº ____________
Project ____________ Date ____________
Reference ____________ Technician ____________
Client Job Nº ____________ Checked by ____________

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

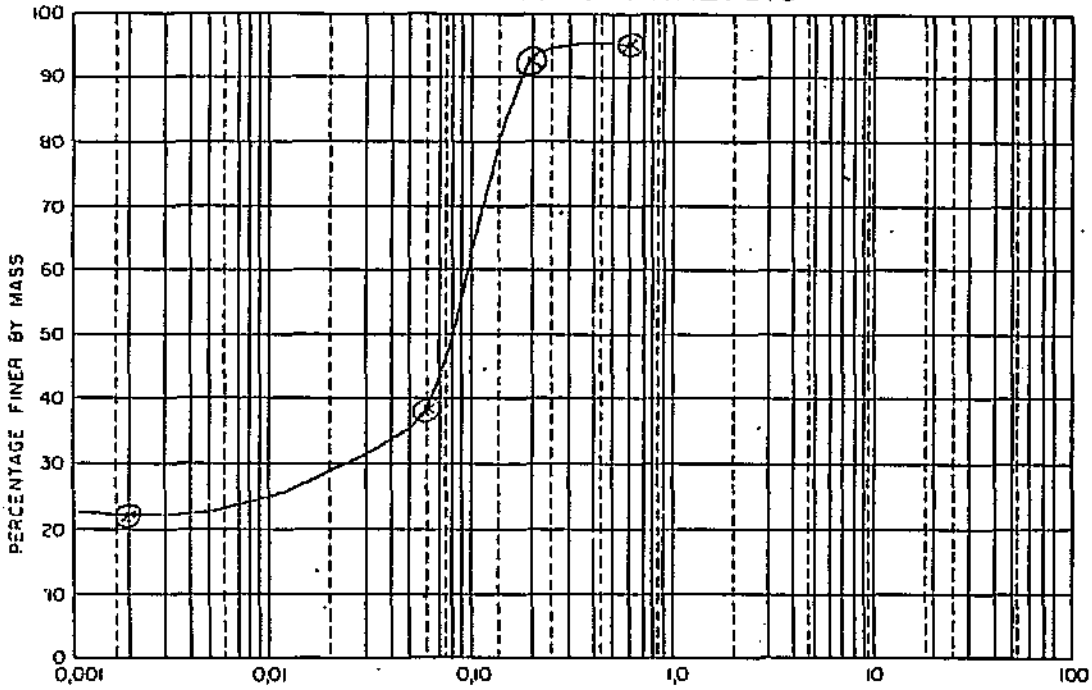
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 28			
HOLE Nº				
DEPTH	20			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



PARTICLE SIZE (mm)

M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

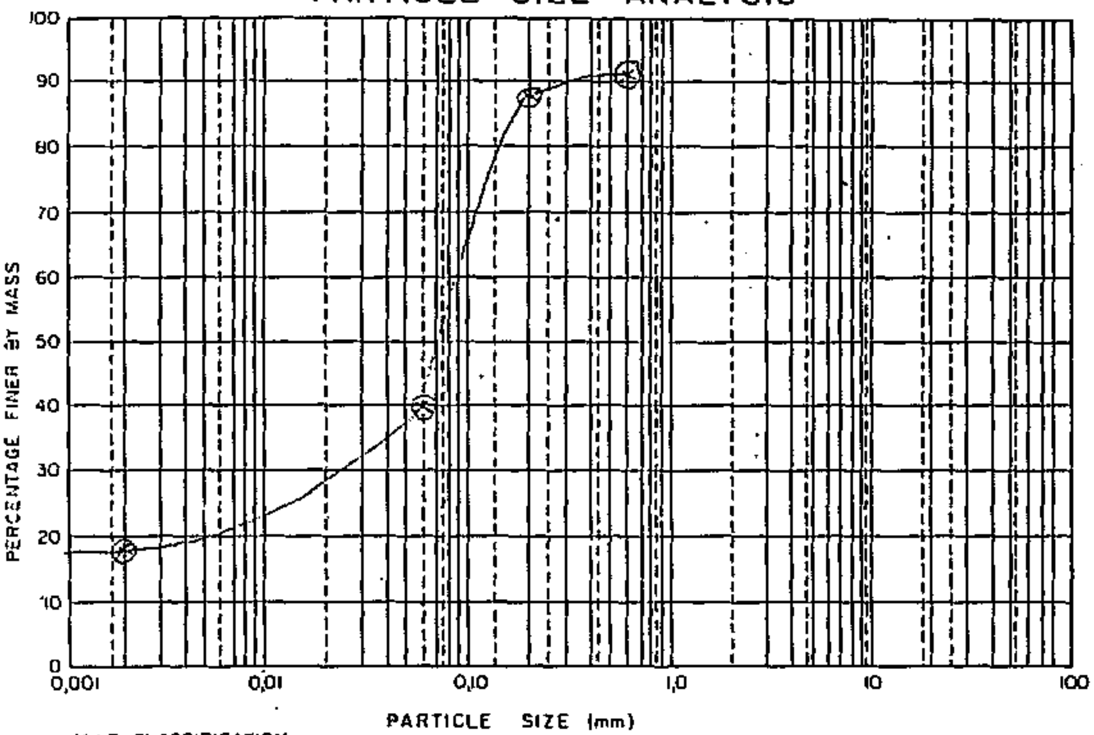
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 28			
HOLE Nº				
DEPTH	200			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______________________ Job Nº ________
Project ______________________ Date ________
Reference ______________________ Technician ________
Client Job Nº ______________________ Checked by ________

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

ATTERBERG LIMITS & SOILS CLASSIFICATION

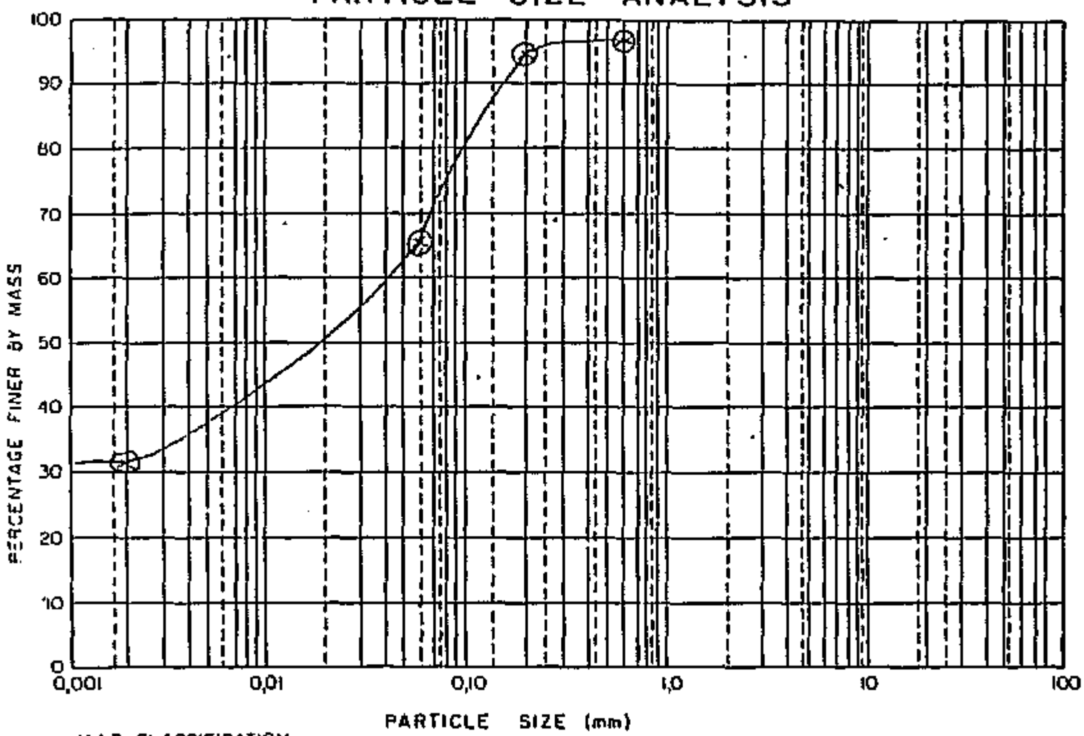
SAMPLE Nº	SITE 28			
HOLE Nº				
DEPTH	500			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB

No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______________________ Job Nº ________
Project ______________________ Date ________
Reference ______________________ Technician ________
Client Job Nº ______________________ Checked by ________

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

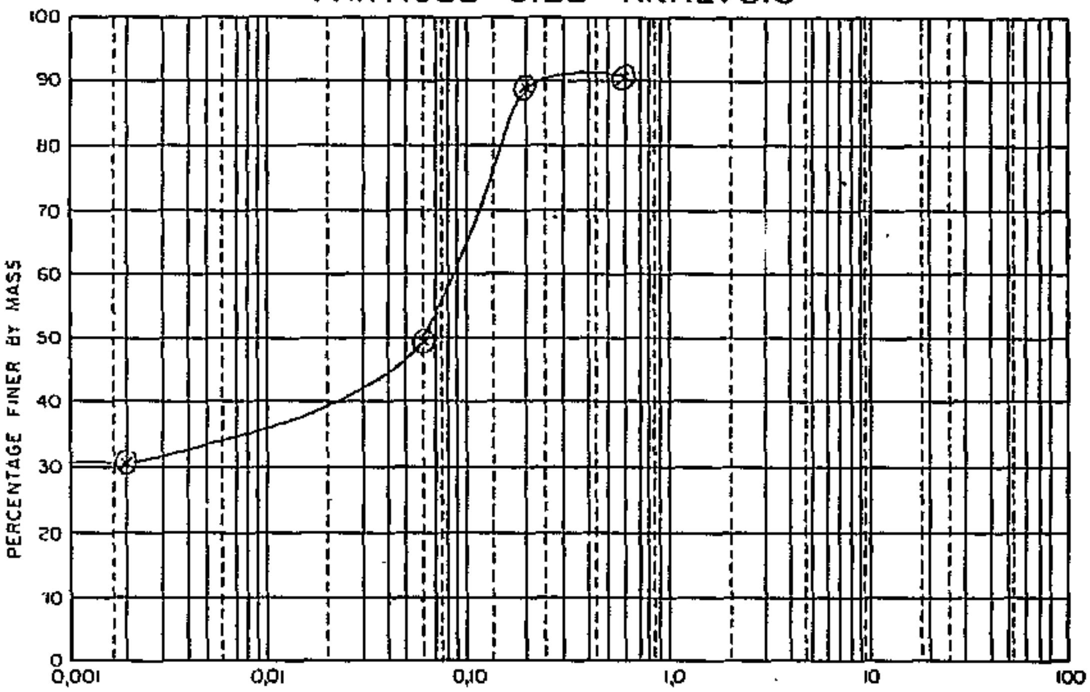
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 28			
HOLE Nº				
DEPTH	900			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.E.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

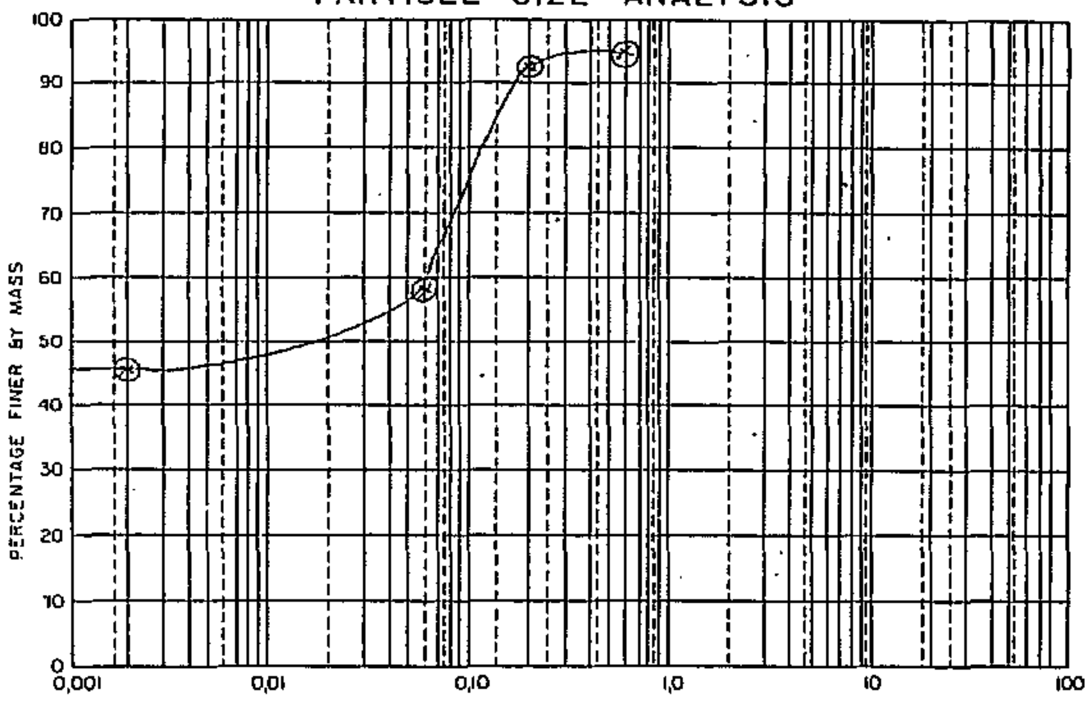
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 32			
HOLE Nº				
DEPTH	20			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. MES.CES	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

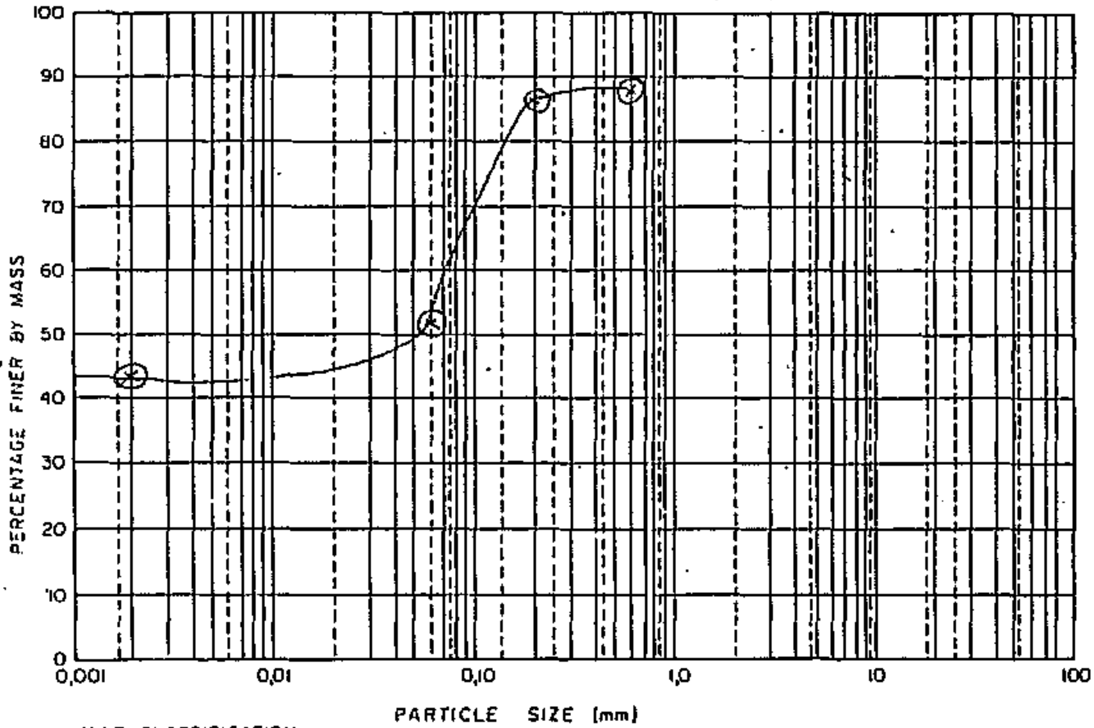
SAMPLE Nº	SITE 32			
HOLE Nº				
DEPTH	300			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB

No. 3 Village Road
Selby, Johannesburg
Tel 836-8007/8

Client	Job Nº
Project	Date
Reference	Technician
Client Job Nº	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

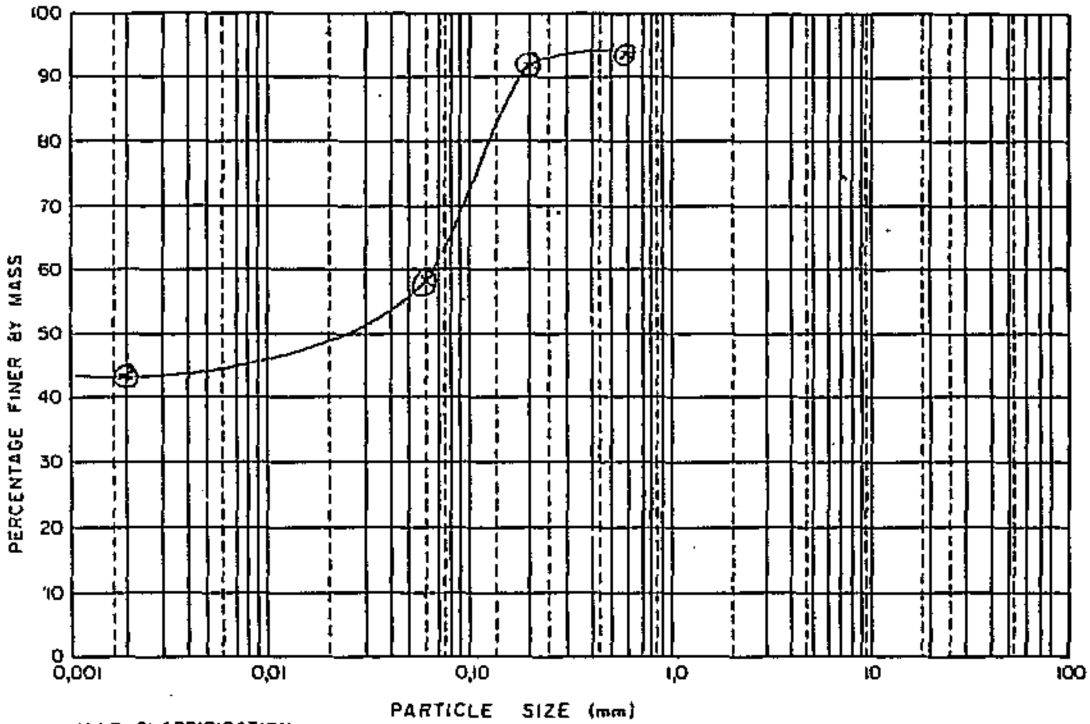
Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 32			
HOLE Nº				
DEPTH	600			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB No 3 Village Road Selby, Johannesburg Tel 836-9007/8	
Client	Job Nº
Project	Date
Reference	Technician
Client Job Nº	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

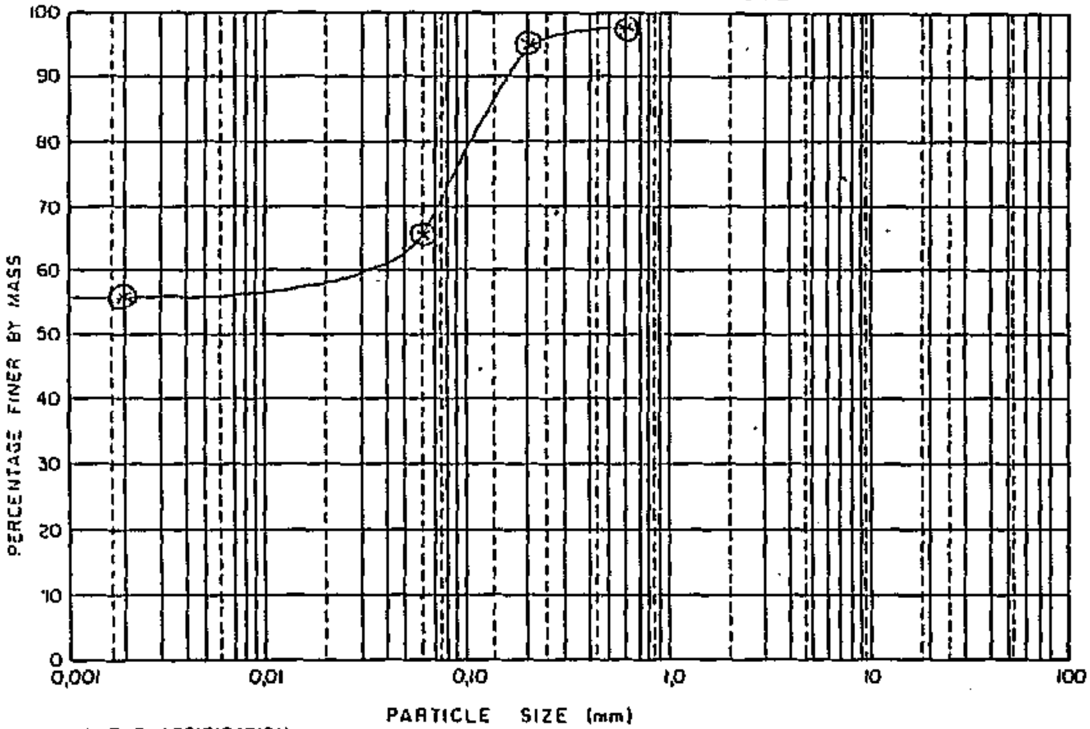
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 32			
HOLE Nº				
DEPTH	900			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

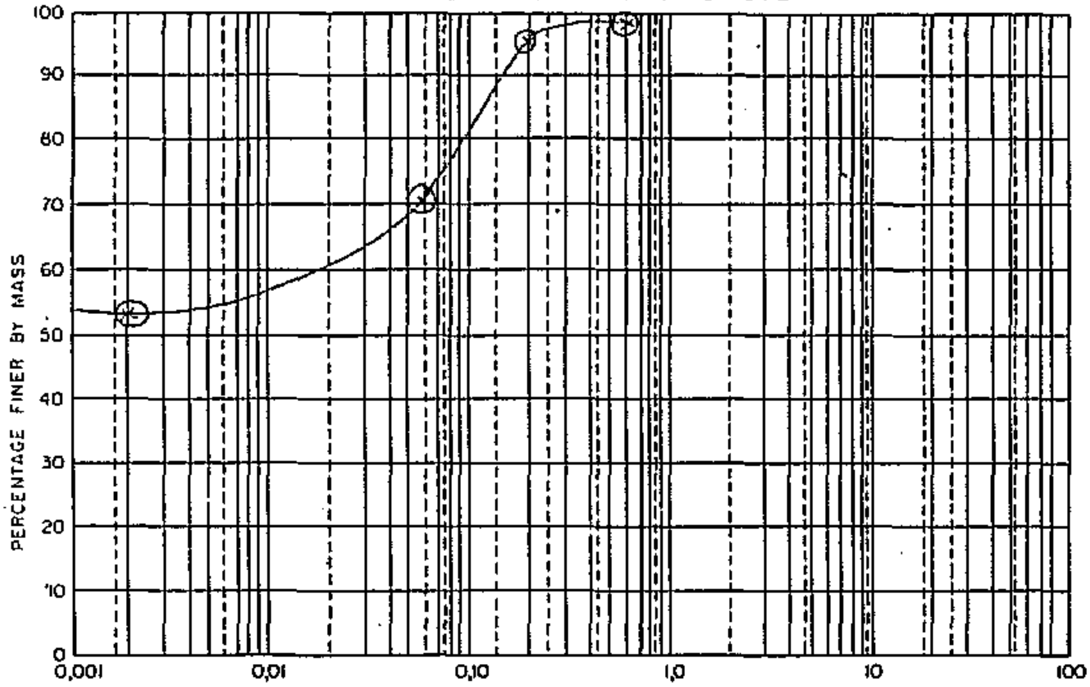
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE B2			
HOLE Nº				
DEPTH	200			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job No ______
Project ______ Date ______
Reference ______ Technician ______
Client Job No ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

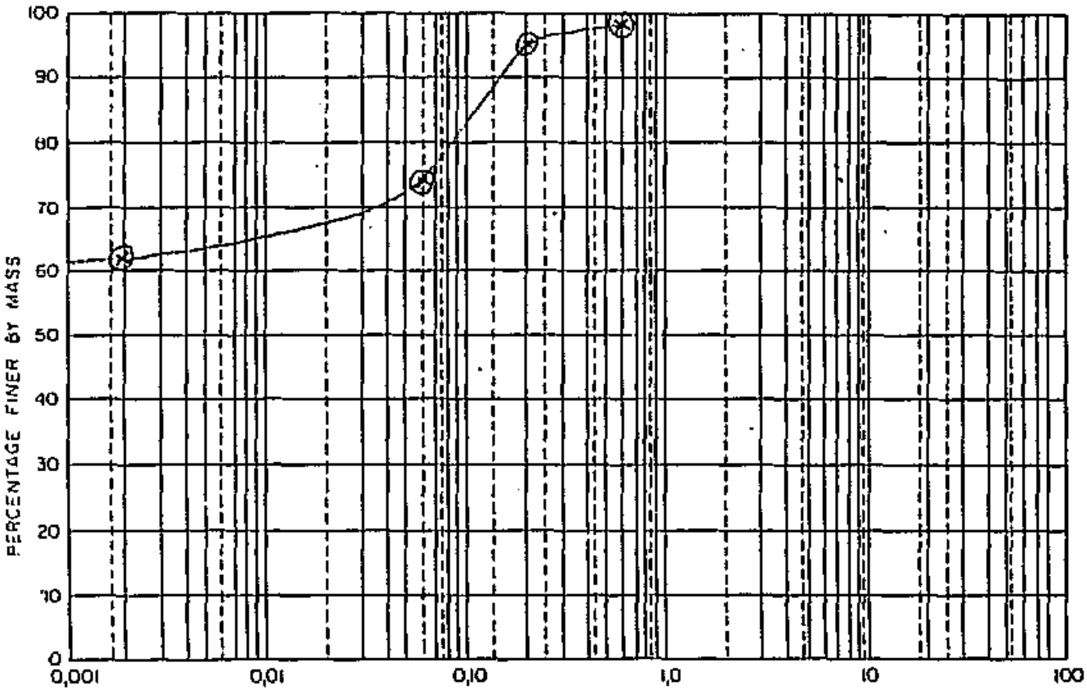
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	SITE 37			
HOLE No				
DEPTH	620			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

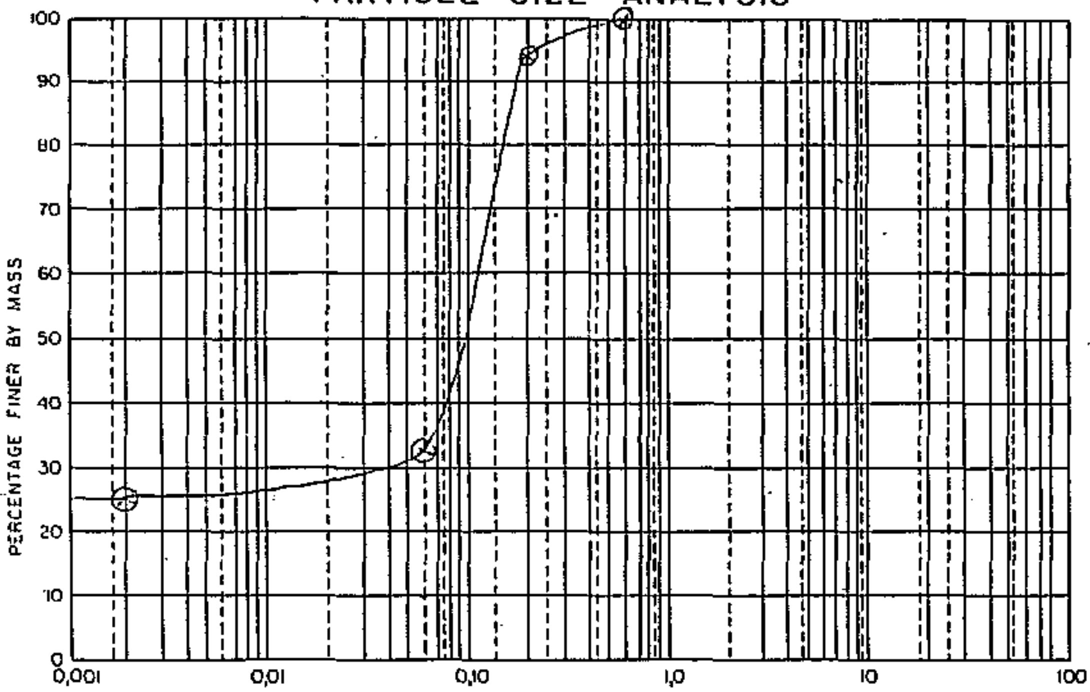
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 87			
HOLE Nº				
DEPTH	900			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

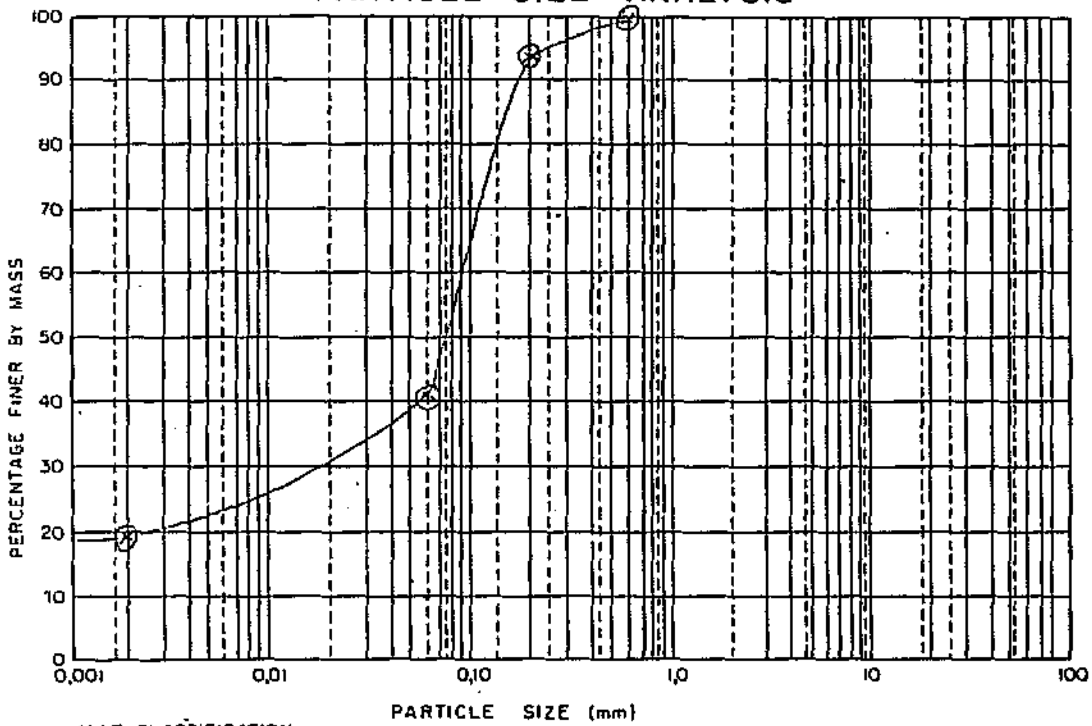
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 47			
HOLE Nº				
DEPTH	100			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 830-0007/8

Client		Job Nº	
Project		Date	
Reference		Technician	
Client Job Nº		Checked by	

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.E.S.C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

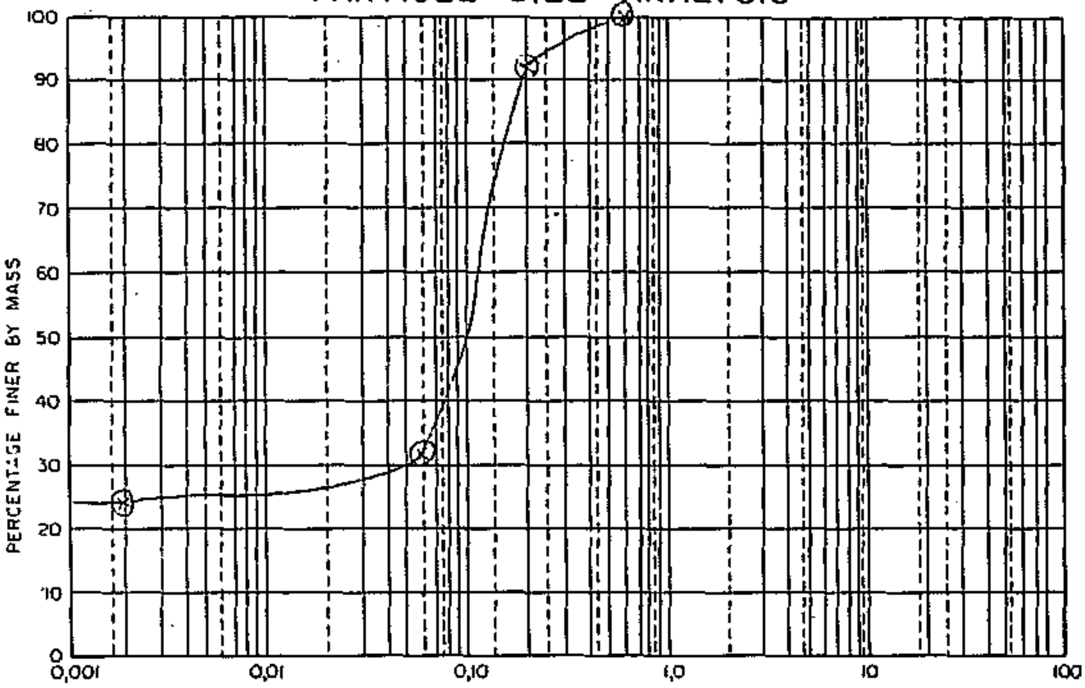
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 42			
HOLE Nº				
DEPTH	240			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 030-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

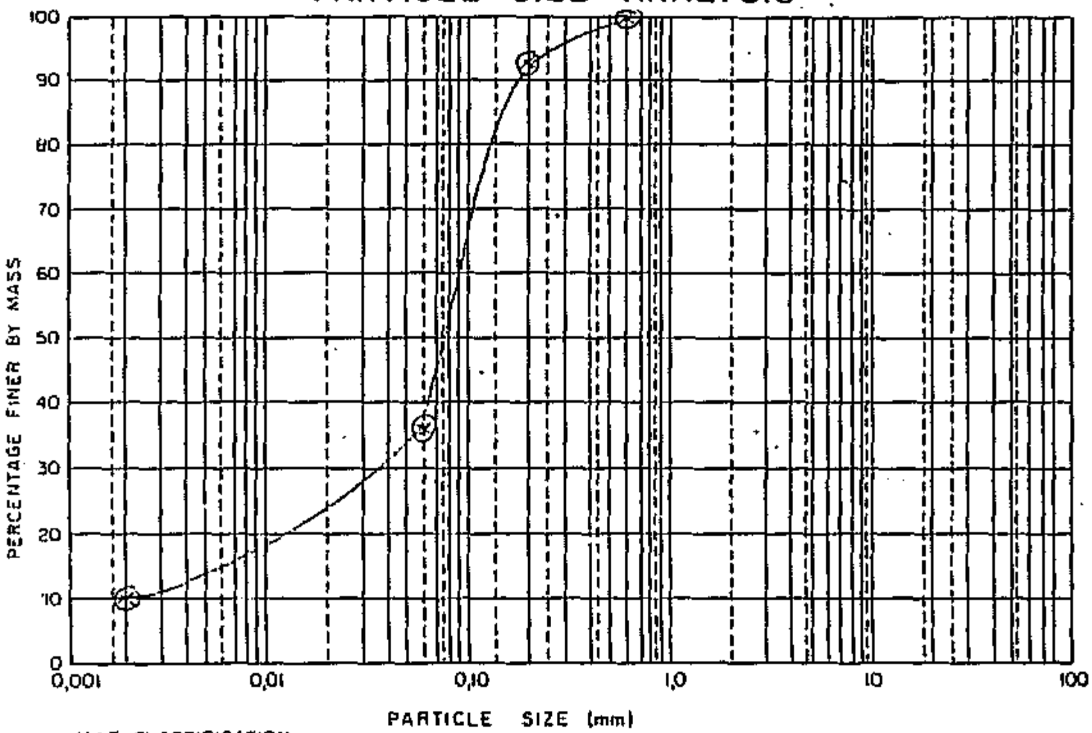
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 42			
HOLE Nº				
DEPTH	320			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-0007/8

Client ____ Job No ____
Project ____ Date ____
Reference ____ Technician ____
Client Job No ____ Checked by ____

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.E.S.	M.E.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

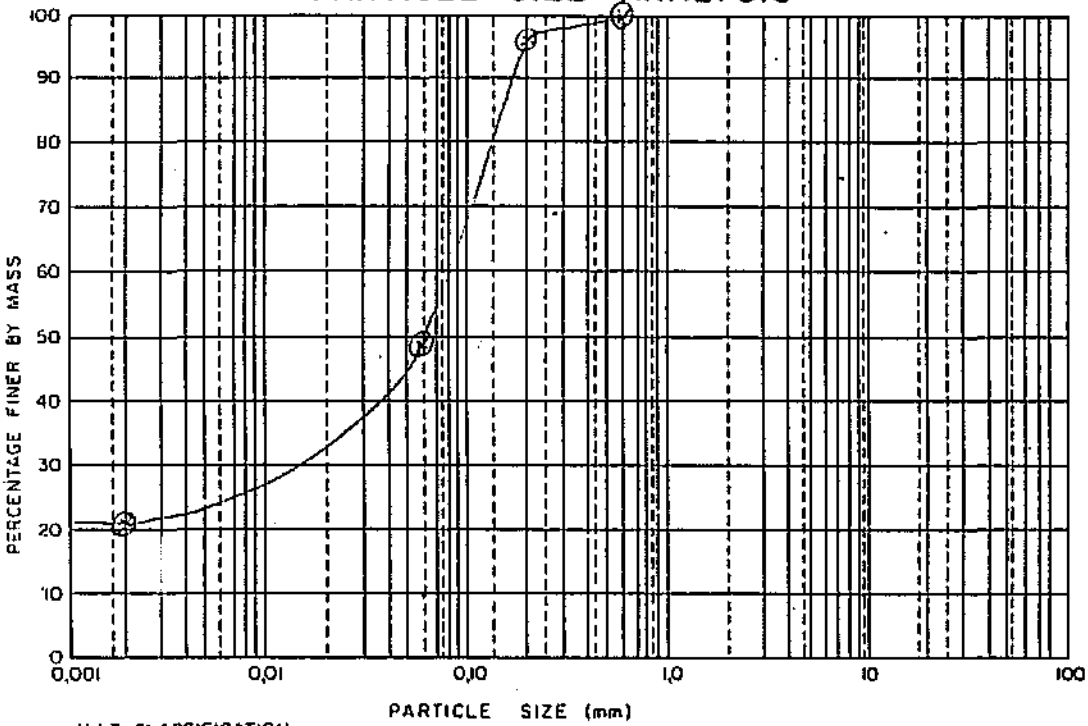
SAMPLE No	SITE 42			
HOLE No				
DEPTH	420			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB

No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job No ______
Project ______ Date ______
Reference ______ Technician ______
Client Job No ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

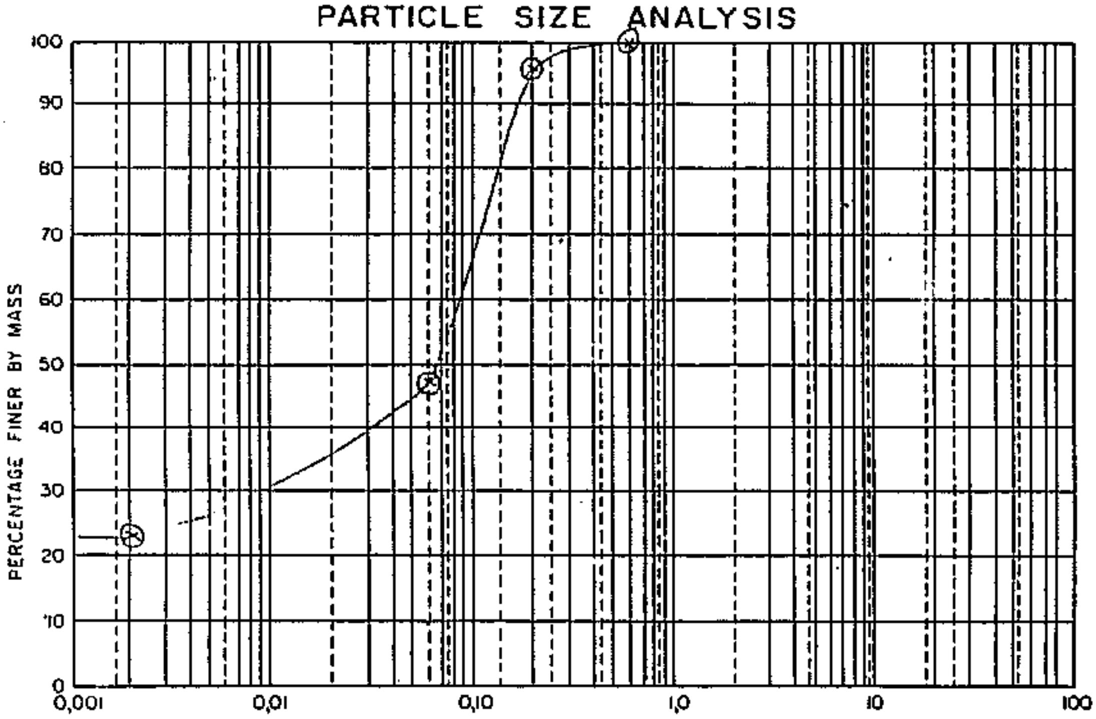
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	SITE 42			
HOLE No				
DEPTH	600			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 830-9007/8

Client ______________________ Job No ______
Project ______________________ Date ______
Reference ______________________ Technician ______
Client Job No ______________________ Checked by ______

PARTICLE SIZE ANALYSIS



M I T CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

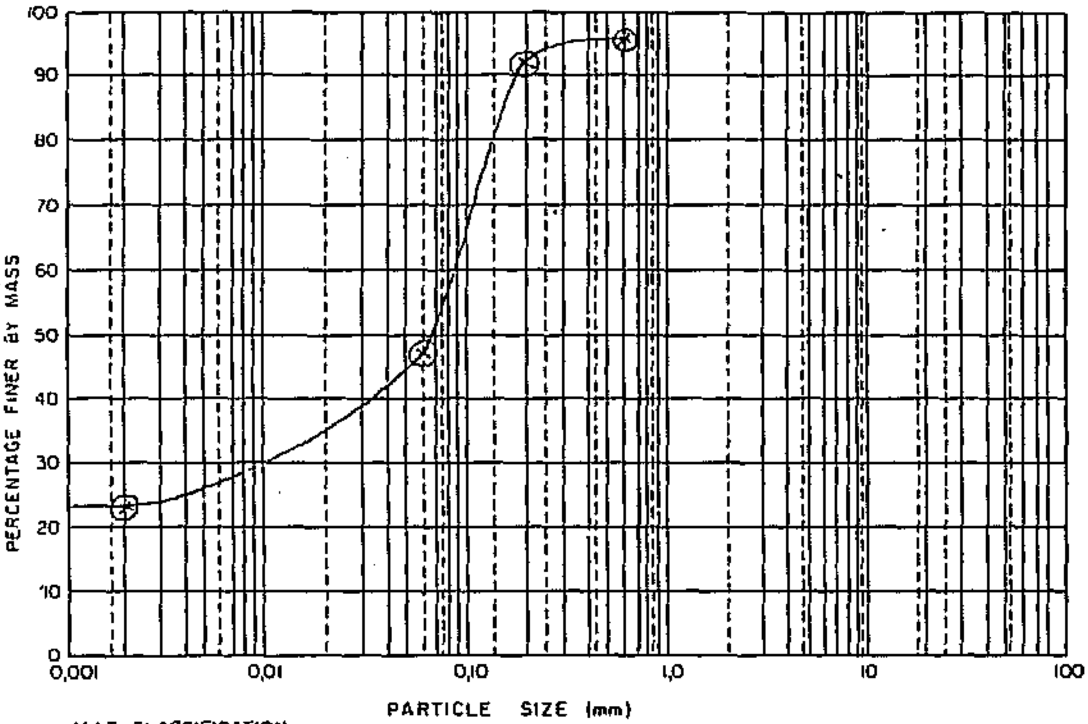
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	SITE 42			
HOLE No				
DEPTH	900			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

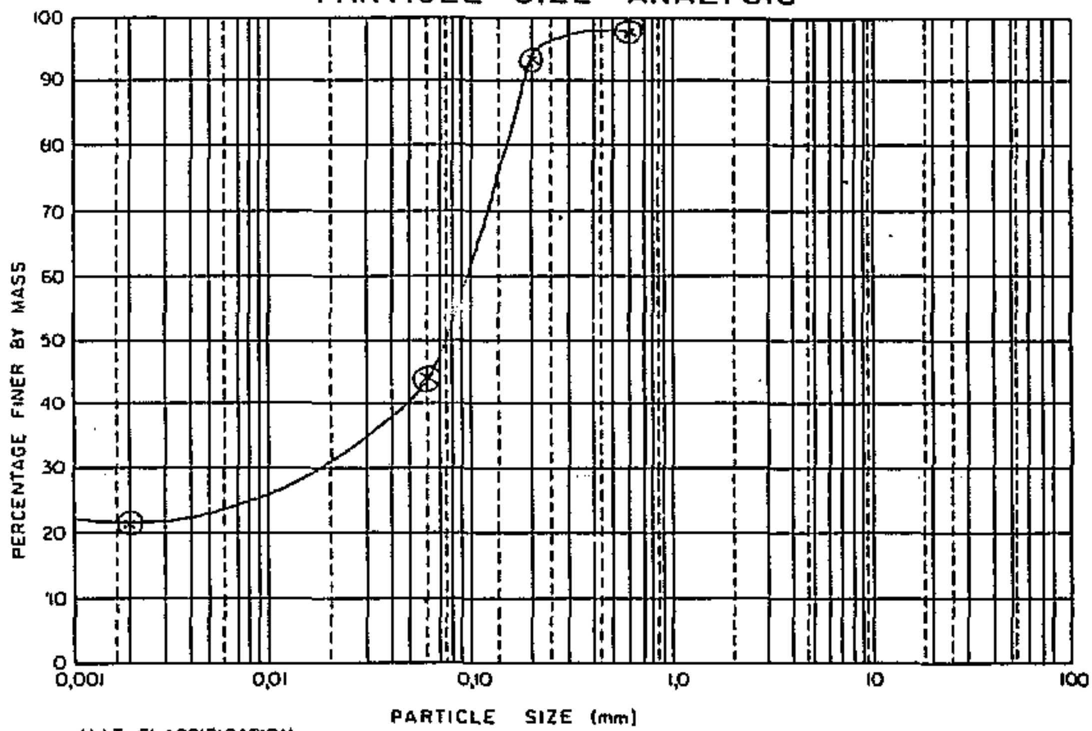
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 110			
HOLE Nº				
DEPTH	20			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client		Job Nº	
Project		Date	
Reference		Technician	
Client Job Nº		Checked by	

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

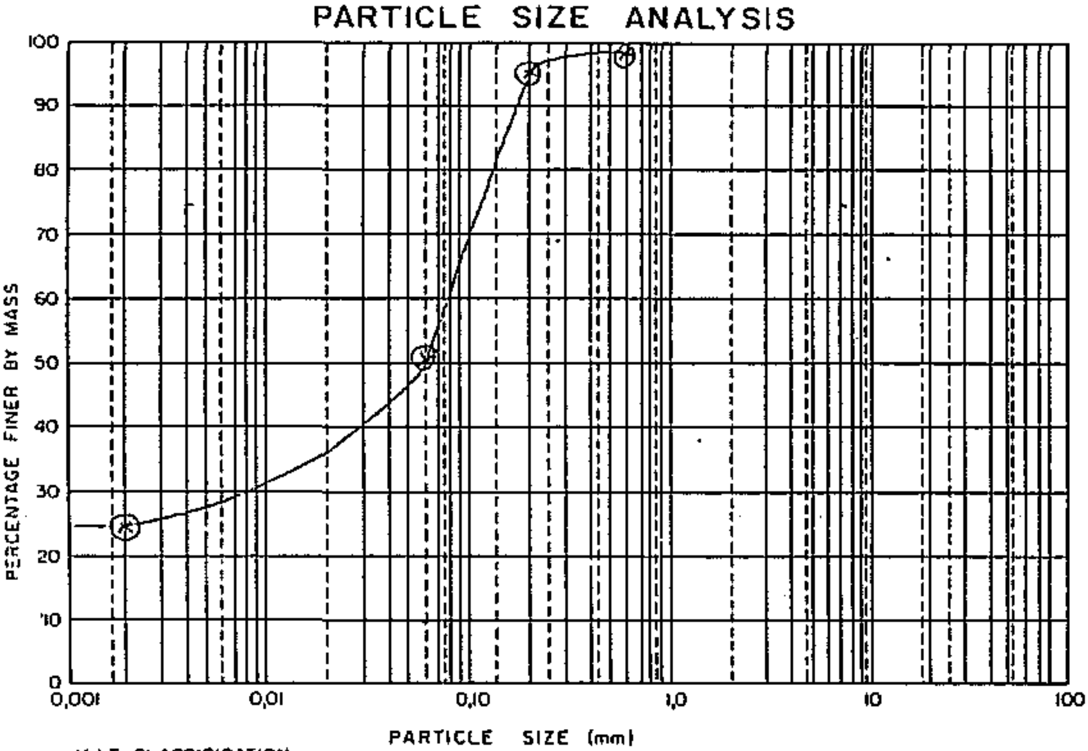
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 110			
HOLE Nº				
DEPTH	200			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 830-9007/8

Client ____________ Job Nº ____________
Project ____________ Date ____________
Reference ____________ Technician ____________
Client Job Nº ____________ Checked by ____________

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

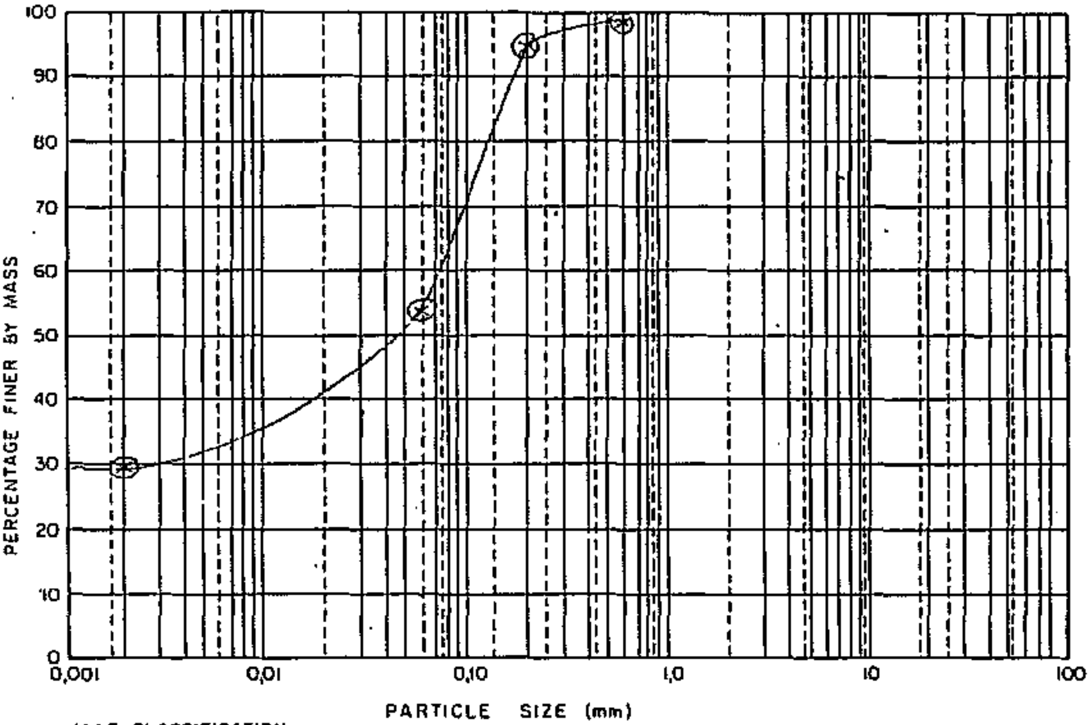
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 110			
HOLE Nº				
DEPTH	300			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay; colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

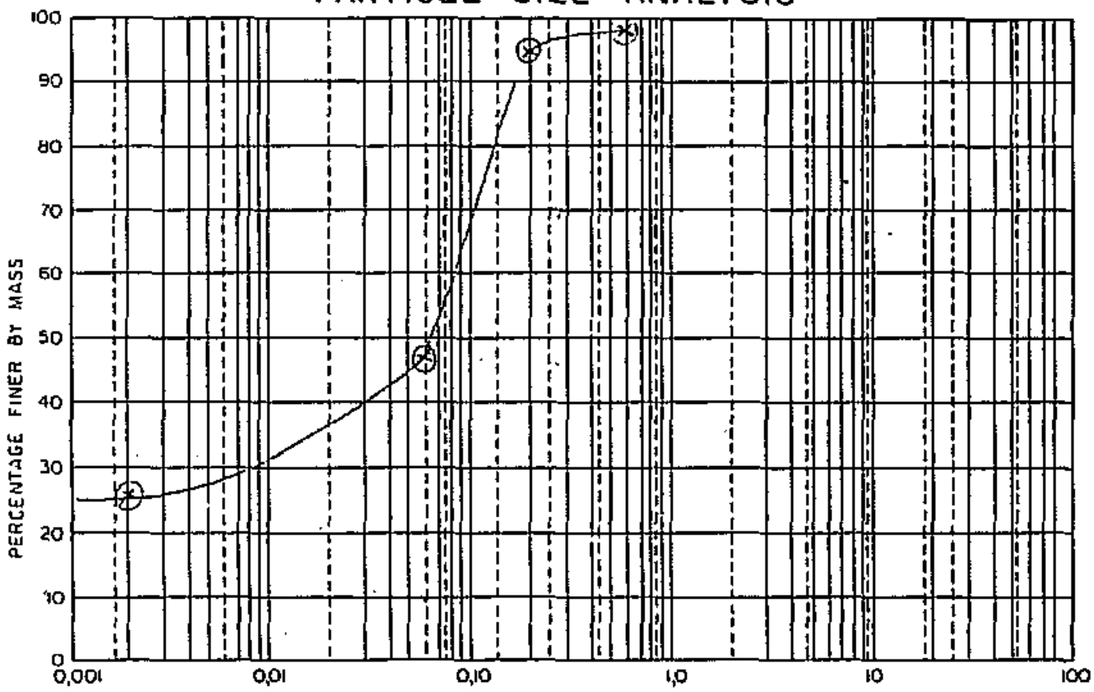
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 110			
HOLE Nº				
DEPTH	4.50			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M I T CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

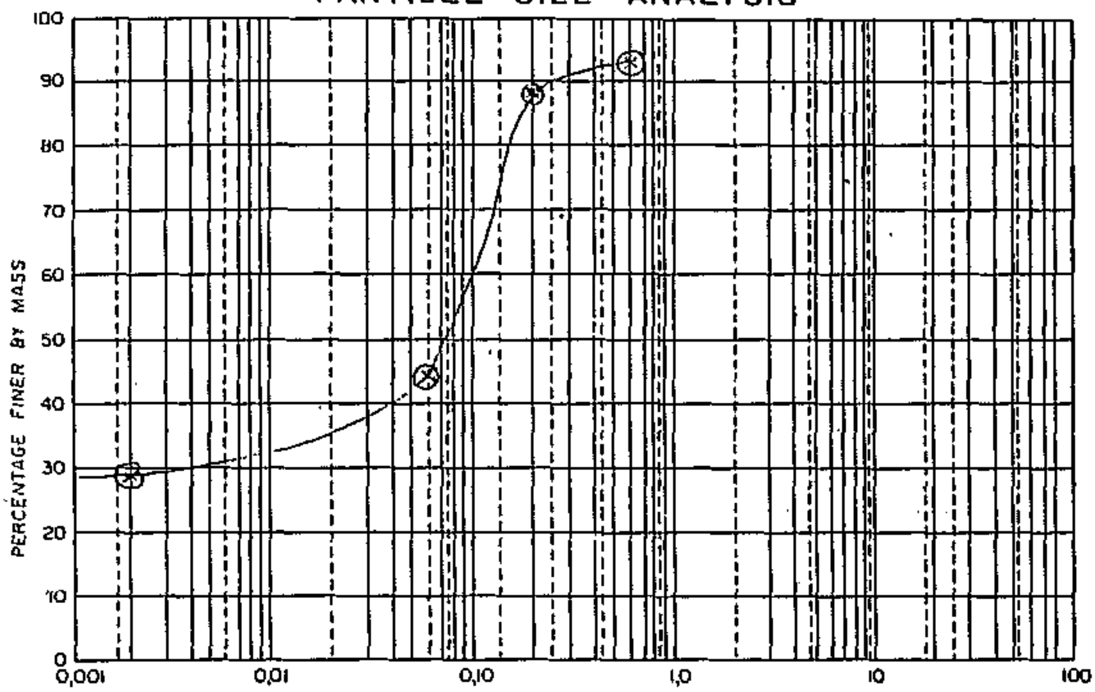
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 110			
HOLE Nº				
DEPTH	650			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job No ______
Project ______ Date ______
Reference ______ Technician ______
Client Job No ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

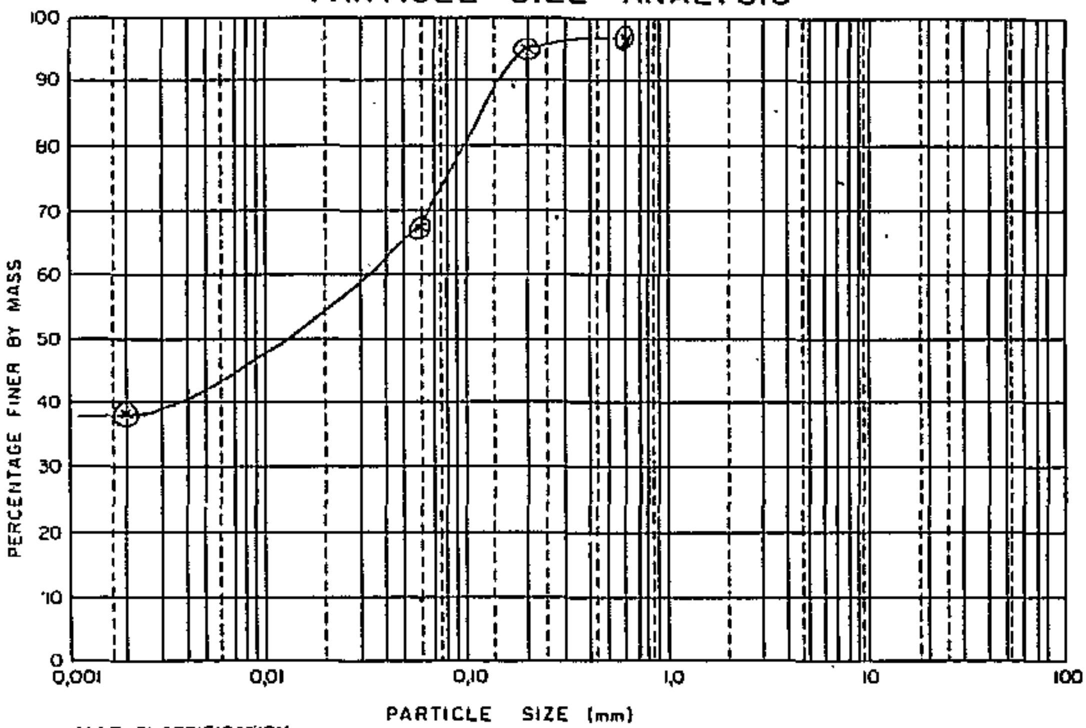
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	SITE 110			
HOLE No				
DEPTH	900			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 838-008770

Client ____________ Job Nº ____________
Project ____________ Date ____________
Reference ____________ Technician ____________
Client Job Nº ____________ Checked by ____________

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

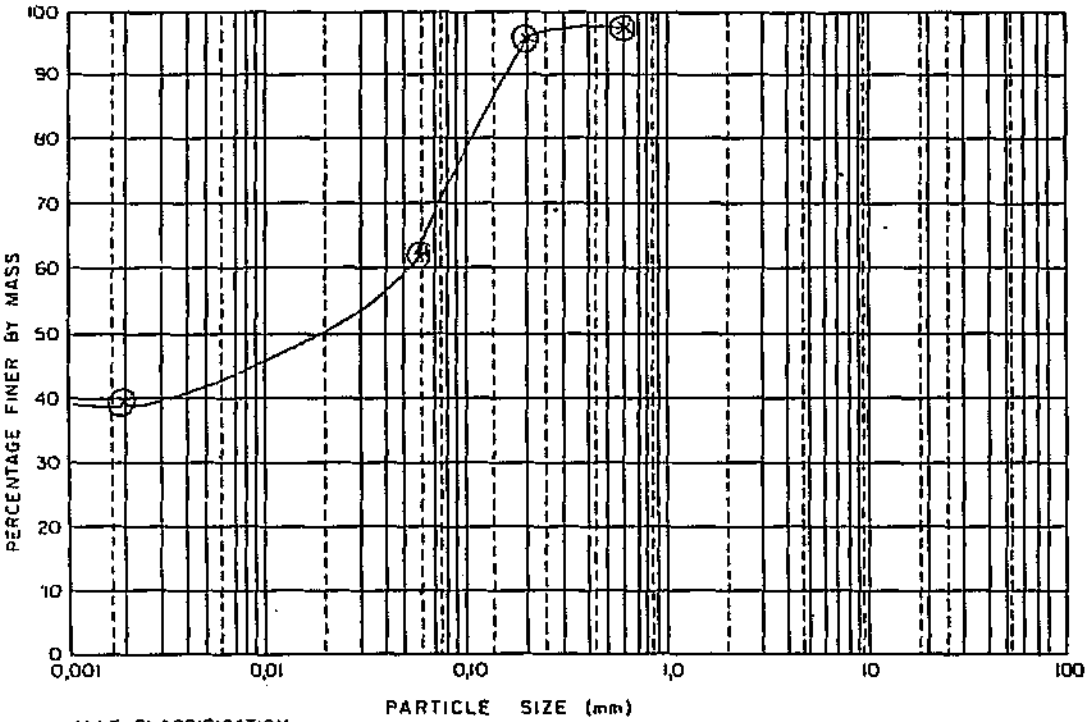
Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 112			
HOLE Nº				
DEPTH	30			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB No 3 Village Road Selby, Johannesburg Tel 836-9007/8	Client	Job Nº
	Project	Date
	Reference	Technician
	Client Job Nº	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

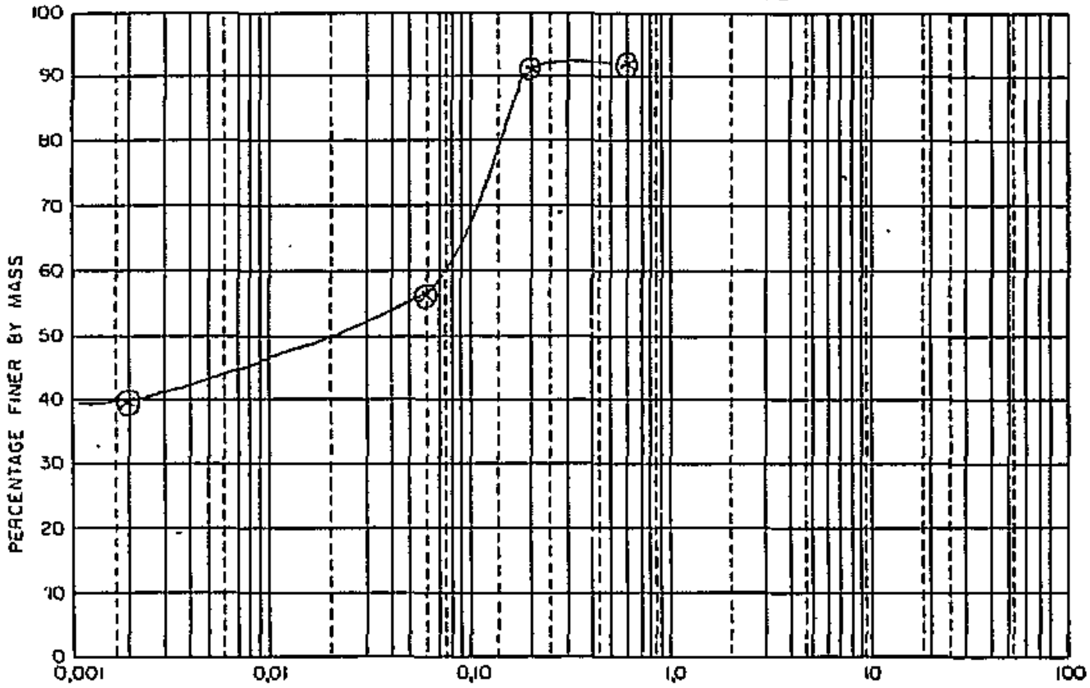
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 115			
HOLE Nº				
DEPTH	20			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9807/8

Client		Job Nº	
Project		Date	
Reference		Technician	
Client Job Nº		Checked by	

PARTICLE SIZE ANALYSIS



M.I.T CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

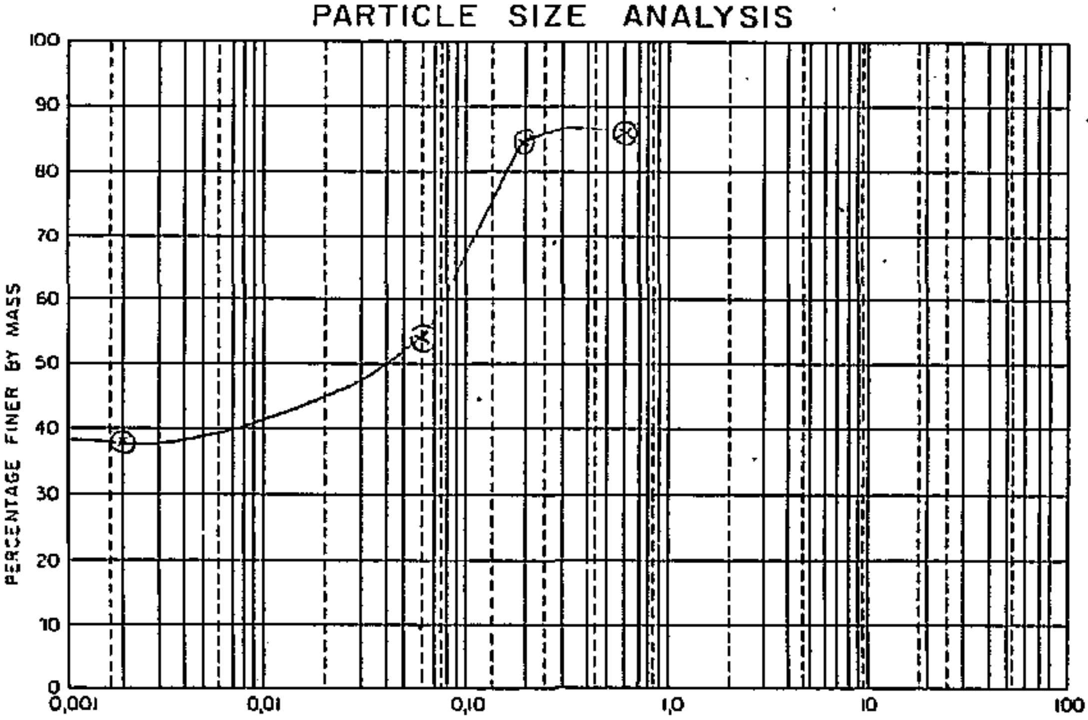
SAMPLE Nº	SITE 115			
HOLE Nº				
DEPTH	200			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB

No 3 Village Road
Selby, Johannesburg
Tel 836-0607/8

Client ________________ Job Nº ________
Project ________________ Date ________
Reference ________________ Technician ________
Client Job Nº ________________ Checked by ________

PARTICLE SIZE ANALYSIS



PARTICLE SIZE (mm)

M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

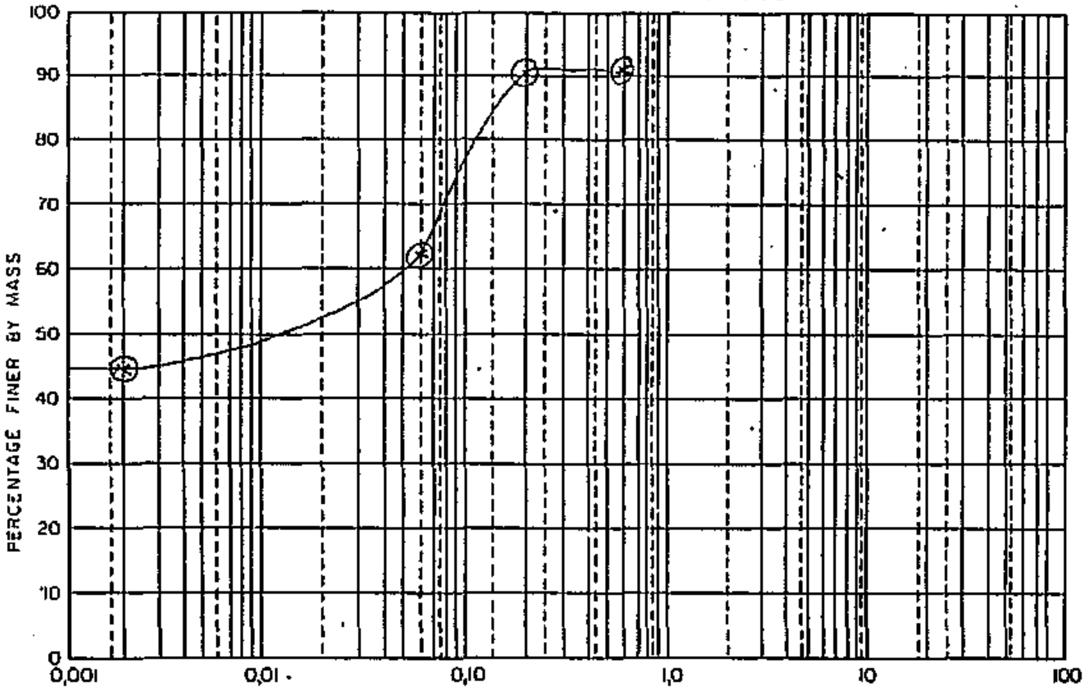
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 115			
HOLE Nº				
DEPTH	500			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______________________ Job Nº ____________
Project ______________________ Date ____________
Reference ______________________ Technician ____________
Client Job Nº ______________________ Checked by ____________

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S C.F.S	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

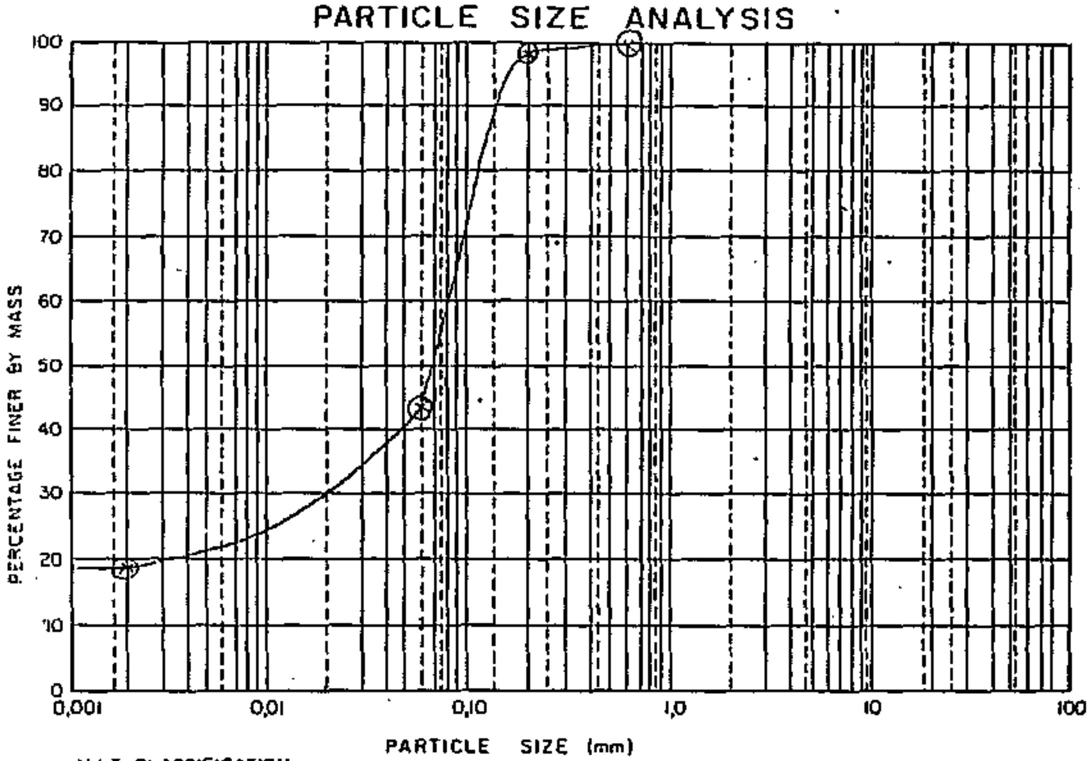
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 115			
HOLE Nº				
DEPTH	900			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client	Job Nº
Project	Date
Reference	Technician
Client Job Nº	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.E.S.	M.E.S.	C.E.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

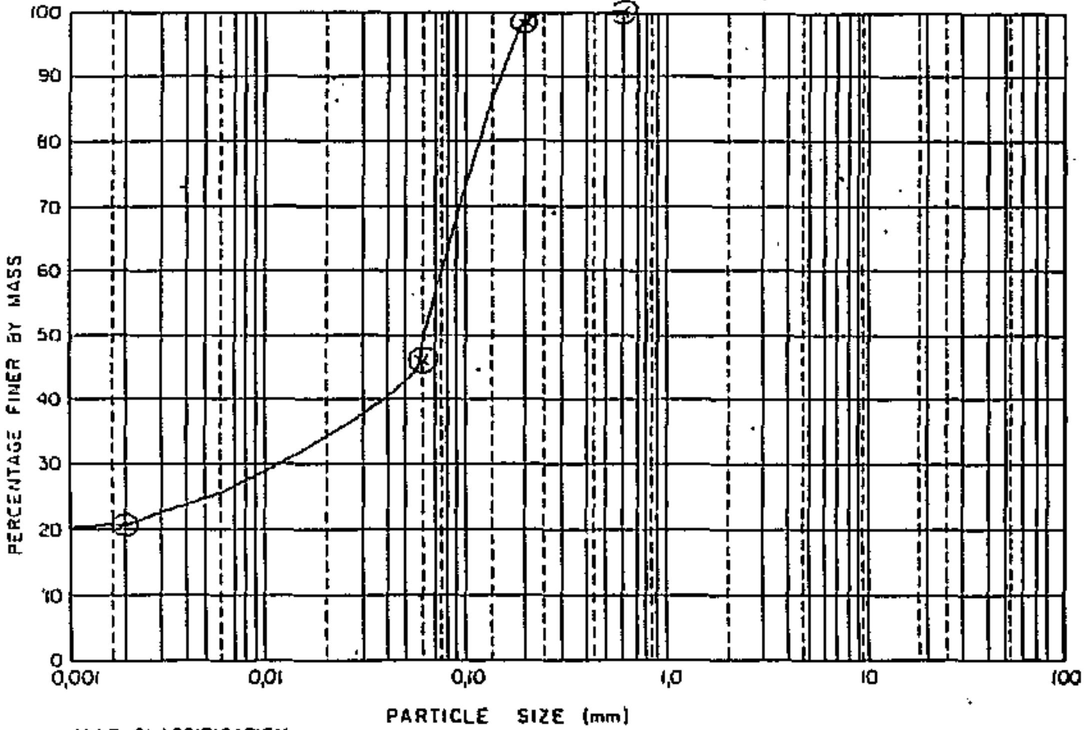
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 120			
HOLE Nº				
DEPTH	20			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client ______ Job Nº ______
Project ______ Date ______
Reference ______ Technician ______
Client Job Nº ______ Checked by ______

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

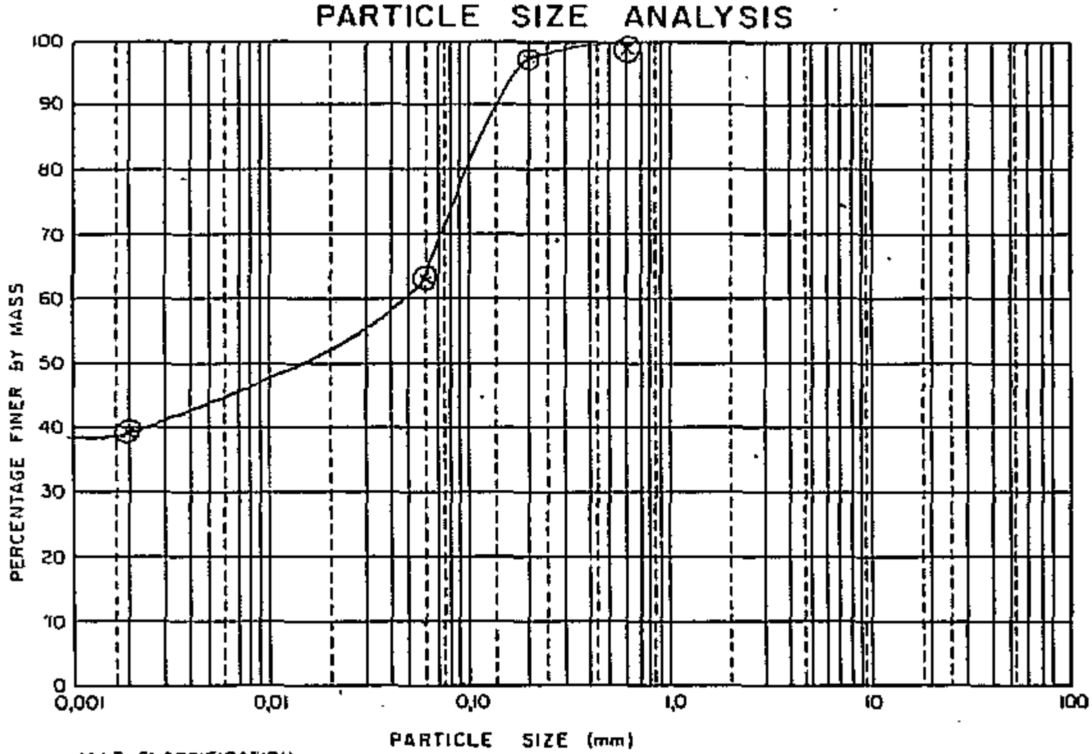
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 120			
HOLE Nº				
DEPTH	200			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No. 3 Village Road
Selby, Johannesburg
Tel 830-9007/8

Client		Job Nº	
Project		Date	
Reference		Technician	
Client Job Nº		Checked by	

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.E.S.	M.E.S. C.E.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

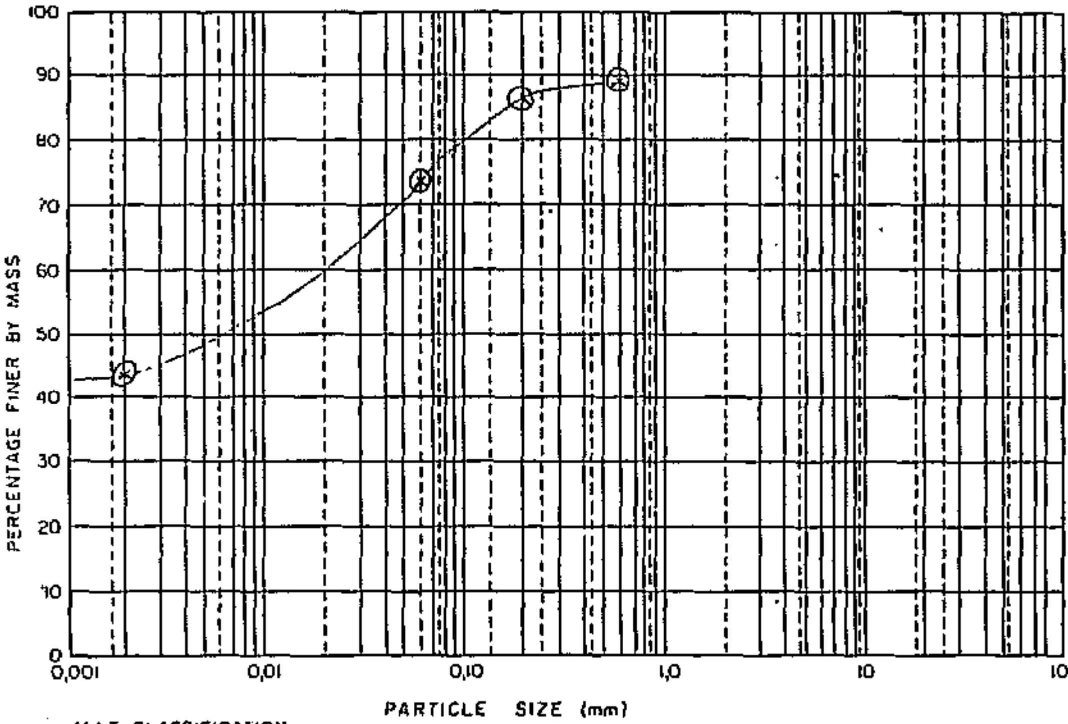
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 100			
HOLE Nº				
DEPTH	500			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
No 3 Village Road
Selby, Johannesburg
Tel 836-5007/8

Client ______________________ Job Nº ________
Project ______________________ Date ________
Reference ______________________ Technician ________
Client Job Nº ______________________ Checked by ________

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	SITE 120			
HOLE Nº				
DEPTH	700			
PLOTTING CODE				
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

APPENDIX E.7

FIELD CAPACITY

O:>FILE OF FIELD CAPACITEIS FOR ALL SITES V1MDL
SUCTION = 5KPA

SITE	DEPTH (M)	MOIST (KG/M3)	BULK DENSITY (KG/M3)
18	.03	317.	1595
18	.25	367.	1468
18	.55	307.	1397
18	.90	333.	1475
27	.02	422.	1500
27	.20	390.	1533
27	.30	346.	1305
27	.50	340.	1508
27	.90	320.	1560
28	.02	360.	1517
28	.20	347.	1650
28	.50	336.	1639
28	.90	364.	1662
28	.90	362.	1662
32	.02	354.	963
42	.10	375.	1457
42	.24	300.	1304
42	.32	349.	1440
42	.60	315.	1567
42	.90	306.	1692
110	.02	468.	1565
110	.20	327.	1430
110	.20	297.	1430
110	.30	299.	1424
110	.45	308.	1497
110	.65	284.	1566
110	.90	304.	1616
112	.02	305.	1066
115	.02	372.	1451
115	.20	345.	1422
115	.20	379.	1422
115	.50	286.	1340
115	.90	370.	1475
120	.02	425.	1198
120	.20	272.	1198
120	.50	326.	1711
120	.70	451.	1405

FIELD CAPACITIES ALL SITES V1N20
SUCTION=10KPA

SITE	DEPTH (M)	MOIST (KG/M3)	BULK DENSITY (KG/M3)
18	.02	317.	1595
18	.02	328.	1595
18	.25	312.	1468
18	.55	277.	1397
18	.90	326.	1475
27	.02	379.	1500
27	.02	403.	1500
27	.02	526.	1500
27	.20	408.	1533
27	.20	385.	1533
27	.30	290.	1305
27	.50	452.	1508
27	.50	387.	1508
27	.50	362.	1508
27	.90	316.	1560
28	.02	384.	1517
28	.02	372.	1517
28	.20	370.	1650
28	.20	355.	1650
28	.70	398.	1662
28	.70	299.	1662
28	.70	378.	1662
42	.10	332.	1304
42	.24	345.	1304
42	.32	258.	1440
42	.60	291.	1567
42	.70	296.	1692
110	.02	417.	1563
110	.20	306.	1430
110	.20	277.	1430
110	.20	315.	1430
110	.30	293.	1424
110	.45	300.	1497
110	.65	288.	1566
110	.90	299.	1616
112	.02	380.	1066
112	.02	350.	1066
112	.20	304.	1066
112	.30	401.	1422
115	.02	381.	1451
115	.02	373.	1451
115	.20	383.	1422
115	.20	349.	1422
115	.50	262.	1340
120	.02	419.	1198
120	.02	245.	1198
120	.20	391.	1526
120	.20	331.	1526
120	.50	306.	1711
120	.70	421.	1403

APPENDIX E.8

WILTING POINT

WILTING POINTS FOR ALL SITES VINZO DE HOEK
SUCTION=1500KPA

SITE	DEPTH (M)	MOIST (KG/M3)	BULK DENSITY (KG/M3)
19	.02	148.	1595
19	.25	141.	1468
19	.55	141.	1397
19	.90	201.	1475
27	.02	165.	1590
27	.20	171.	1533
27	.30	137.	1395
27	.50	154.	1508
27	.90	199.	1560
28	.02	121.	1517
28	.20	133.	1659
28	.50	192.	1629
28	.90	257.	1662
32	.02	146.	963
32	.20	149.	963
32	.90	207.	1473
42	.10	147.	1455
42	.24	114.	1304
42	.32	73.	1449
42	.42	109.	1414
42	.60	142.	1567
42	.90	151.	1692
110	.02	172.	1565
110	.20	152.	1430
110	.30	156.	1424
110	.45	174.	1497
110	.65	163.	1566
110	.90	136.	1616
112	.02	194.	1066
115	.02	139.	1451
115	.20	186.	1422
115	.50	163.	1340
120	.02	105.	1198
120	.20	121.	1526
120	.50	179.	1711
120	.70	230.	1405

EOF:39

APPENDIX E.9

WET AND DRY BULK DENSITY

SITE	DEPTH	SAT MOIST	DRY B. DENS	WET B. DENS	2.70 DRY e	WET e	DERIVED WET BD	DERIVED SAT MOIST	DRY n	WET n	
18.00	0.03	406.00	1595.00	2001.00	0.69	0.70	2004.26	409.26	0.41	0.41	411.18
18.00	0.25	174.00	1468.00	1642.00	0.84	1.65	1924.30	456.30	0.46	0.62	622.35
18.00	0.55	441.00	1397.00	1838.00	0.93	1.03	1879.59	482.59	0.48	0.51	507.06
18.00	0.90	453.00	1475.00	1928.00	0.83	0.83	1928.70	453.70	0.45	0.45	454.12
27.00	0.02	469.00	1500.00	1969.00	0.80	0.75	1944.44	444.44	0.44	0.43	430.00
27.00	0.20	403.00	1533.00	1936.00	0.76	0.82	1965.22	432.22	0.43	0.45	449.41
27.00	0.30	420.00	1305.00	1725.00	1.07	1.34	1821.67	516.67	0.52	0.57	573.53
27.00	0.50	424.00	1508.00	1932.00	0.79	0.82	1949.48	441.48	0.44	0.45	451.76
27.00	0.90	381.00	1560.00	1941.00	0.73	0.81	1982.22	422.22	0.42	0.45	446.47
28.00	0.02	383.00	1517.00	1900.00	0.78	0.89	1955.15	438.15	0.44	0.47	470.59
25.00	0.20	370.00	1650.00	2020.00	0.64	0.67	2039.99	388.99	0.37	0.40	400.00
23.00	0.50	431.00	1639.00	2070.00	0.65	0.59	2031.96	392.96	0.39	0.37	370.59
28.00	0.90	546.00	1662.00	2208.00	0.62	0.41	2046.44	384.44	0.38	0.29	289.41
32.00	0.20	511.00	963.00	1474.00	1.80	2.59	1606.33	643.33	0.64	0.72	721.18
42.00	0.10	370.00	1455.00	1825.00	0.86	1.06	1916.11	461.11	0.46	0.51	514.71
42.00	0.24	312.00	1304.00	1616.00	1.07	1.76	1821.04	517.04	0.52	0.64	637.65
42.00	0.32	392.00	1440.00	1832.00	0.88	1.04	1906.67	466.67	0.47	0.51	510.59
42.00	0.60	358.00	1567.00	1925.00	0.72	0.84	1986.63	419.63	0.42	0.46	455.88
42.00	0.90	314.00	1692.00	2006.00	0.60	0.69	2065.33	373.33	0.37	0.41	408.24
110.00	0.02	497.00	1430.00	1927.00	0.89	0.83	1900.37	470.37	0.47	0.45	454.71
110.00	0.20	436.00	1524.00	1960.00	0.77	0.77	1959.56	435.56	0.44	0.44	435.29
110.00	0.30	401.00	1424.00	1825.00	0.90	1.06	1896.59	472.59	0.47	0.51	514.71
110.00	0.45	375.00	1497.00	1872.00	0.80	0.95	1942.56	445.56	0.45	0.49	487.06
110.00	0.65	342.00	1566.00	1908.00	0.72	0.87	1986.00	420.00	0.42	0.47	465.88
110.00	0.90	411.00	1606.00	2017.00	0.68	0.67	2011.19	405.19	0.41	0.40	401.76
112.00	0.02	341.00	1066.00	1407.00	1.53	3.18	1671.19	605.19	0.61	0.76	760.59
112.00	0.20	514.00	1233.00	1747.00	1.19	1.28	1776.33	543.33	0.54	0.56	569.59
115.00	0.02	399.00	1451.00	1850.00	0.86	1.00	1913.59	462.59	0.46	0.50	500.00
115.00	0.20	430.00	1422.00	1852.00	0.90	1.00	1895.33	473.33	0.47	0.50	492.92
115.00	0.50	377.00	1340.00	1717.00	1.01	1.37	1843.70	503.70	0.50	0.58	578.24
115.00	0.90	497.00	1475.00	1972.00	0.83	0.75	1928.70	453.70	0.45	0.43	428.24
120.00	0.02	493.00	1198.00	1691.00	1.25	1.46	1754.30	556.30	0.56	0.59	593.53
120.00	0.20	393.00	1526.00	1919.00	0.77	0.85	1960.81	434.81	0.43	0.46	459.41
120.00	0.50	365.00	1711.00	2076.00	0.58	0.58	2077.30	366.30	0.37	0.37	367.06
120.00	0.70	494.00	1405.00	1899.00	0.92	0.89	1884.63	479.63	0.48	0.47	471.19

APPENDIX E.10

SATURATED HYDRAULIC CONDUCTIVITY

SATURATED HYDRAULIC CONDUCTIVITY DATA VIZO DE HOEY

SITE	DEPTH(MM)	SAMPLE NO	LENGTH(CM)	HEAD(MM)	AREA(CM2)	TIME(MIN)	VOL(CM3)	K/SAT(MM/DAY)	TEMP
18	30	1	24.3	45.5	17.7	98.0	.5	8.	22
18	30	2	24.1	41.0	17.7	98.0	3.8	54.	22
18	30	3	24.3	46.0	17.7	99.0	4.0	63.	23
18	250	1	24.1	36.0	17.7	59.0	24.0	328.	21
18	250	2	24.1	40.0	17.7	99.0	45.0	683.	21
18	250	3	19.7	33.0	17.7	64.0	59.0	1391.	22
18	550	1	24.4	45.0	17.7	141.0	3.0	32.	22
19	900	1	24.1	34.0	17.7	9.0	114.2	14554.	22
27	20	1	19.9	33.0	17.7	292.0	135.5	630.	23
27	20	2	24.0	35.0	17.7	79.0	2.9	43.	22
27	20	3	24.3	33.0	17.7	64.0	5.4	93.	25
27	200	1	23.9	37.0	17.7	296.0	4.6	20.	23
27	200	2	24.0	43.0	17.7	78.0	2.1	39.	22
27	200	3	24.0	39.0	17.7	75.0	2.7	45.	24
27	300	1	24.0	46.0	17.7	99.0	73.5	1169.	22
27	500	1	24.0	39.0	17.7	287.0	2.5	12.	23
27	500	2	24.2	33.0	17.7	13.0	131.5	11222.	25
27	500	3	23.9	39.7	17.7	92.0	7.7	104.	22
27	500	4	21.0	47.8	17.7	78.6	2.3	54.	21
27	900	1	24.3	44.0	17.7	79.0	2.3	43.	21
28	20	1	23.4	39.2	17.7	127.0	3.3	35.	24
28	20	2	23.0	37.0	17.7	127.0	3.3	34.	24
28	20	4	24.7	35.0	17.7	124.0	2.0	19.	23
28	20	5	23.8	32.5	17.7	124.0	2.4	22.	22
28	200	1	24.0	39.6	17.7	960.0	.0	0.	24
28	200	2	23.7	44.5	17.7	960.0	.0	0.	23
28	200	3	23.7	38.5	17.7	127.0	1.7	18.	23
28	500	1	24.5	33.0	17.7	64.0	4.6	77.	22
28	500	2	24.3	47.0	17.7	299.0	2.1	12.	21
28	500	3	24.5	42.0	17.7	299.0	1.8	9.	21
28	900	1	24.2	37.4	17.7	976.0	153.0	[illegible]	23
28	900	2	23.9	40.0	17.7	976.0	2.5	3.	23
28	900	3	24.5	44.0	17.7	976.0	4.7	7.	23
32	20	1	22.8	43.0	17.7	99.0	2.6	41.	21
32	20	1	24.0	42.0	17.7	53.0	5.2	89.	22
32	20	2	24.5	36.0	17.7	73.0	11.0	141.	22
32	900	1	19.1	35.0	17.7	78.0	110.0	2163.	21
42	100	1	24.4	45.0	17.7	141.0	7.8	32.	22
42	100	2	23.9	35.0	17.7	141.0	92.0	912.	22
42	100	3	24.1	48.0	17.7	97.0	3.9	71.	21
42	240	1	24.2	45.0	17.7	103.0	2.3	34.	21
42	240	2	24.3	49.0	17.7	65.0	4.3	105.	21
42	320	1	24.2	41.0	35.5	78.0	219.0	1778.	21
42	320	2	24.5	42.0	17.7	113.0	1.6	25.	21
42	420	1	24.3	49.0	17.7	279.0	2.2	12.	21
42	600	1	24.3	42.0	17.7	279.0	92.0	433.	21
42	900	1	24.3	38.0	17.7	279.0	74.0	315.	21
110	20	1	24.6	42.0	17.7	155.0	2.3	21.	22
110	20	2	23.9	45.5	17.7	155.0	5.8	53.	22
110	20	3	24.3	45.0	17.7	155.0	1.9	19.	22
110	200	1	24.0	40.0	17.7	79.0	2.8	43.	22
110	200	2	24.1	41.5	17.7	79.0	13.1	232.	25
110	200	3	24.2	40.0	17.7	79.0	61.9	1054.	25
110	300	1	24.2	41.0	17.7	93.0	2.2	33.	22
110	450	1	24.2	40.0	7.7	93.0	1.9	63.	22
110	650	1	24.0	48.0	17.7	53.0	2.1	37.	22
110	900	1	24.1	49.3	17.7	141.0	2.8	[illegible]	22
112	20	1	23.5	48.0	17.7	60.0	65.0	[illegible]	23
112	20	2	24.0	38.5	17.7	287.0	52.4	238.	23
115	20	1	24.4	39.0	17.7	98.0	54.0	717.	21
115	20	2	24.3	44.0	17.7	89.0	2.5	41.	21
115	20	3	24.4	39.0	17.7	87.0	5.9	86.	21
115	200	1	23.8	34.0	17.7	112.0	2.0	21.	24
115.	200	2	24.3	31.0	17.7	112.0	2.7	25.	24
115	200	3	24.2	40.0	17.7	112.0	6.0	72.	24
115	200	4	24.3	47.0	17.7	77.0	2.9	59.	22
115	500	1	24.2	37.0	17.7	112.0	4.5	53.	24
115	900	1	23.2	48.0	17.7	79.0	1.9	39.	21
120	20	1	24.0	37.0	17.7	124.0	4.6	47.	22
120	20	2	24.0	36.0	17.7	124.0	5.1	50.	25
120	20	3	24.0	41.0	17.7	124.0	5.2	50.	22
120	200	1	24.3	41.0	17.7	96.0	1.5	21.	21
120	200	2	24.7	49.0	17.7	98.0	3.3	48.	21
120	200	3	24.1	39.5	17.7	98.0	12.7	168.	21
120	500	1	24.0	40.0	17.7	290.0	.3	0.	23
120	700	1	24.1	36.0	17.7	976.0	5.9	7.	23

APPENDIX E.11

DERIVATION OF CAMPBELL'S a AND b COEFFICIENTS

ORTHIC A		DEHOEK				G=2.7 CALC				
site	depth	moist	sat.moist	% moist	Bulk D	SAT.MOIST	suction	θ/θs	log(P)	log(θ/θs)
42	0.24	300	370		1304	517	5	0.580229	0.698970	-0.23640
120	0.2	272	393		1526	435	5	0.625553	0.698970	-0.20373
110	0.3	299	401		1424	473	5	0.632680	0.698970	-0.19881
110	0.2	297	436		1524	436	5	0.681887	0.698970	-0.16628
110	0.2	327	436		1524	436	5	0.750765	0.698970	-0.12449
120	0.02	425	493		1198	556	5	0.763981	0.698970	-0.11691
18	0.03	317	406		1595	409	5	0.774570	0.698970	-0.11093
18	0.25	369	374		1468	456	5	0.808685	0.698970	-0.09222
42	0.1	375	370		1455	461	5	0.813253	0.698970	-0.08977
28	0.02	360	383		1517	438	5	0.821639	0.698970	-0.08531
27	0.2	380	403		1533	432	5	0.879177	0.698970	-0.05592
28	0.2	347	370		1650	389	5	0.892285	0.698970	-0.04949
27	0.02	422	469		1500	444	5	0.9495	0.698970	-0.02250
110	0.02	468	497		1430	470	5	0.994960	0.698970	-0.00219
110	0.3	293	401		1424	473	10	0.619984	1	-0.20761
110	0.2	277	436		1524	436	10	0.635969	1	-0.19656
42	0.24	345	370		1304	517	10	0.667263	1	-0.17570
18	0.25	312	374		1468	456	10	0.683766	1	-0.16509
110	0.2	306	436		1524	436	10	0.702551	1	-0.15332
42	0.1	332	370		1455	461	10	0.72	1	-0.14266
110	0.2	315	436		1524	436	10	0.723214	1	-0.14073
120	0.02	419	493		1198	556	10	0.753195	1	-0.12309
120	0.2	331	393		1526	435	10	0.761243	1	-0.11847
18	0.03	317	406		1595	409	10	0.774570	1	-0.11093
18	0.03	328	406		1595	409	10	0.801447	1	-0.09612
28	0.02	372	383		1517	438	10	0.849027	1	-0.07107
27	0.02	379	469		1500	444	10	0.85275	1	-0.06917
110	0.02	417	497		1430	470	10	0.886535	1	-0.05230
27	0.2	385	403		1533	432	10	0.890745	1	-0.05024
120	0.2	391	393		1526	435	10	0.899233	1	-0.04612
27	0.02	403	469		1500	444	10	0.90675	1	-0.04251
28	0.2	355	431		1650	389	10	0.912857	1	-0.03959
27	0.2	408	403		1533	432	10	0.943958	1	-0.02504
28	0.2	370	370		1650	389	10	0.951428	1	-0.02162
42	0.6	286	340	0.1542	1567	420	33	0.680799	1.518513	-0.16699
28	0.27	274	690	0.1424	1650	389	33	0.704504	1.518513	-0.15211
117	0.2	357	440	0.2081	1360	496	33	0.720111	1.518513	-0.14260
46	0.3	375	546	0.1839	1662	384	33	0.974172	1.518513	-0.01136
117	0.2	203	440	0.1296	1360	496	100	0.408022	2	-0.38931
28	0.27	207	690	0.1114	1650	389	100	0.531908	2	-0.27416
42	0.6	239	340	0.1323	1567	420	100	0.569368	2	-0.24460
46	0.3	244	546	0.1281	1662	384	100	0.635155	2	-0.19712
117	0.2	178	440	0.1158	1360	496	300	0.358865	2.477121	-0.44504
28	0.27	192	690	0.1043	1650	389	300	0.494060	2.477121	-0.30621
42	0.6	228	340	0.1268	1567	420	300	0.542261	2.477121	-0.26579
46	0.3	226	546	0.1198	1662	384	300	0.588400	2.477121	-0.23032
117	0.2	132	440	0.0885	1360	496	800	0.266062	2.903089	-0.57501
42	0.6	163	340	0.0944	1567	420	800	0.389258	2.903089	-0.40976
28	0.27	158	690	0.0876	1650	389	800	0.407358	2.903089	-0.39002
46	0.3	193	546	0.104	1662	384	800	0.501790	2.903089	-0.29947
120	0.02	106	493		1198	556	1500	0.190545	3.176091	-0.72000
42	0.24	114	370		1304	517	1500	0.220487	3.176091	-0.65661
28	0.02	121	383		1517	438	1500	0.276162	3.176091	-0.55883
120	0.2	121	393		1526	435	1500	0.278279	3.176091	-0.55551
117	0.2	141	440	0.09382	1360	496	1500	0.283712	3.176091	-0.54712
18	0.25	141	374		1468	456	1500	0.309009	3.176091	-0.51002
42	0.1	147	370		1455	461	1500	0.318795	3.176091	-0.49648
42	0.6	136	340	0.0797	1567	420	1500	0.323393	3.176091	-0.49026
28	0.2	133	370		1650	389	1500	0.342	3.176091	-0.46597
110	0.2	152	436		1524	436	1500	0.348979	3.176091	-0.45719
110	0.3	166	401		1424	473	1500	0.351253	3.176091	-0.45437
18	0.02	148	406		1595	409	1500	0.361628	3.176091	-0.44173
27	0.02	165	469		1500	444	1500	0.37125	3.176091	-0.43033
110	0.02	178	497		1430	470	1500	0.378425	3.176091	-0.42201
28	0.27	148	690	0.0821	1650	389	1500	0.379495	3.176091	-0.42079
27	0.2	171	403		1533	432	1500	0.395529	3.176091	-0.40271

ORTHIC A

Regression Output:		
Constant		0.770157
Std Err of Y Est		0.397329
R Squared		0.830786
No. of Observations		52
Degrees of Freedom		50
X Coefficient(s)	-4.55234	
Std Err of Coef.	0.290551	

site	depth	moist	sat.moist	% moist	Bulk D	suction	O/Os	log(P)	log(O/Os)
110	0.2	327	436			5	0.75	0.698970	-0.12493
110	0.2	297	436			5	0.681192	0.698970	-0.16673
29	0.2	347	370			5	0.937837	0.698970	-0.02787
42	0.1	375	370			5	1.013513	0.698970	0.005829
110	0.02	468	497			5	0.941649	0.698970	-0.02611
27	0.2	380	403			5	0.942928	0.698970	-0.02552
37	0.02	422	469			5	0.899786	0.698970	-0.04596
110	0.3	299	401			5	0.745635	0.698970	-0.12747
18	0.03	317	406			5	0.780788	0.698970	-0.10746
120	0.2	272	393			5	0.692111	0.698970	-0.15982
120	0.02	425	493			5	0.862068	0.698970	-0.06445
18	0.25	369	374			5	0.986631	0.698970	-0.00584
42	0.24	300	370			5	0.810810	0.698970	-0.09108
23	0.02	360	383			5	0.939947	0.698970	-0.02689
110	0.02	417	497			10	0.839034	1	-0.07622
110	0.2	277	436			10	0.635321	1	-0.19700
23	0.2	355	431			10	0.823665	1	-0.08424
29	0.2	370	370			10	1	1	0
26	0.02	372	383			10	0.971279	1	-0.01265
37	0.2	385	403			10	0.955334	1	-0.01984
110	0.2	306	436			10	0.701834	1	-0.15376
27	0.2	408	403			10	1.012406	1	0.005355
120	0.2	391	393			10	0.994910	1	-0.00221
37	0.02	403	469			10	0.859275	1	-0.06586
42	0.1	332	370			10	0.897297	1	-0.04706
120	0.02	419	493			10	0.849898	1	-0.07063
18	0.25	312	374			10	0.834224	1	-0.07871
18	0.03	329	406			10	0.807881	1	-0.09265
120	0.2	331	393			10	0.842239	1	-0.07456
110	0.3	293	401			10	0.730673	1	-0.13627
110	0.2	315	436			10	0.722477	1	-0.14117
37	0.02	379	469			10	0.808102	1	-0.09253
120	0.02	245	493			10	0.496957	1	-0.30368
42	0.6	273	340	0.1542	1500	33	0.804320	1.518513	-0.09457
25	0.54	509	546	0.2343	1662	33	0.931433	1.518513	-0.03084
23	0.27	276	690	0.1424	1662	33	0.399951	1.518513	-0.39799
117	0.2	357	440	0.2081	1360	33	0.812246	1.518513	-0.09031
45	0.3	375	546	0.1839	1662	33	0.685925	1.518513	-0.16372
45	0.3	244	546	0.1281	1662	100	0.447219	2	-0.34947
117	0.2	203	440	0.1296	1360	100	0.460227	2	-0.33702
25	0.54	369	546	0.1818	1662	100	0.676352	2	-0.16982
23	0.27	208	690	0.1114	1662	100	0.301967	2	-0.52003
117	0.2	178	440	0.1158	1360	300	0.404803	2.477121	-0.39275
25	0.54	368	546	0.1812	1662	300	0.673625	2.477121	-0.17158
42	0.6	218	340	0.1268	1500	300	0.640645	2.477121	-0.19338
23	0.27	194	690	0.1043	1662	300	0.280481	2.477121	-0.55209
25	0.54	303	546	0.1541	1662	800	0.554526	2.903089	-0.25607
45	0.3	193	546	0.104	1662	800	0.353316	2.903089	-0.45193
42	0.6	156	340	0.0944	1500	800	0.459883	2.903089	-0.33735
23	0.27	160	690	0.0876	1662	800	0.231260	2.903089	-0.63589
120	0.2	121	393			1500	0.307888	3.176091	-0.51160
18	0.02	148	406			1500	0.364532	3.176091	-0.43825
42	0.24	114	370			1500	0.308109	3.176091	-0.51129
110	0.02	178	497			1500	0.358148	3.176091	-0.44593
45	0.3	226	546	0.1198	1662	1500	0.414298	3.176091	-0.38268
117	0.2	141	440	0.09382	1360	1500	0.320012	3.176091	-0.49483
25	0.54	305	546	0.1551	1662	1500	0.558795	3.176091	-0.25275
23	0.02	121	383			1500	0.315926	3.176091	-0.50041
42	0.1	147	370			1500	0.397297	3.176091	-0.40088
120	0.02	106	493			1500	0.215010	3.176091	-0.66754
18	0.25	141	374			1500	0.377005	3.176091	-0.42365
110	0.3	166	401			1500	0.413965	3.176091	-0.38303
37	0.02	165	469			1500	0.351812	3.176091	-0.45368
42	0.6	130	340	0.0797	1500	1500	0.382059	3.176091	-0.41785
29	0.2	133	370			1500	0.359459	3.176091	-0.44435
27	0.2	171	403			1500	0.424317	3.176091	-0.37230

Regression Output:

Constant	0.663916
No. of Observations	23
Degrees of Freedom	21
X Coefficient(s)	-6.95565

E HORIZON

site	depth	moist	sat.moist	% moist	Bulk D	G=2.7 CALC SAT.MOIST	suction	O/Os	log(P)	log(O/Os)
42	0.32	349	392		1440	467	5	0.747857	0.698970	-0.12618
110	0.45	308	375		1497	446	5	0.691271	0.698970	-0.16035
120	0.5	326	365		1500	444	5	0.7335	0.698970	-0.13459
110	0.65	234	342		1497	446	5	0.637406	0.698970	-0.19558
42	0.32	258	392		1440	467	10	0.552857	1	-0.25738
110	0.45	300	375		1497	446	10	0.673316	1	-0.17178
120	0.5	306	365		1500	444	10	0.6895	1	-0.16209
110	0.65	258	342		1497	446	10	0.646384	1	-0.18950
117	0.54	340	365	0.1743	1611	403	33	0.843153	1.518513	-0.07409
42	0.6	226	340	0.1542	1567	420	33	0.680799	1.518513	-0.16698
117	0.54	214	365	0.1175	1611	403	100	0.531807	2	-0.27424
42	0.6	239	340	0.1323	1567	420	100	0.567358	2	-0.24460
117	0.54	193	365	0.1072	1611	403	300	0.479592	2.477121	-0.31912
42	0.6	229	340	0.1268	1567	420	300	0.542261	2.477121	-0.26579
117	0.54	154	365	0.0873	1611	403	800	0.382047	2.903089	-0.41758
42	0.6	163	340	0.0944	1567	420	800	0.389258	2.903089	-0.40976
110	0.45	174	375		1497	446	1500	0.390523	3.176091	-0.40835
120	0.5	179	365		1500	444	1500	0.40275	3.176091	-0.39496
117	0.54	170	365	0.0955	1611	403	1500	0.421721	3.176091	-0.37497
42	0.6	136	340	0.0797	1567	420	1500	0.323393	3.176091	-0.49026
110	0.65	163	342		1497	446	1500	0.365835	3.176091	-0.43671
					AVERAGE =	431				

E HORIZON

Regression Output:

Constant		0.266[illegible]
Std Err of Y Est		0.4[illegible]
R Squared		0.781[illegible]
No. of Observations		[illegible]7
Degrees of Freedom		[illegible]5
X Coefficient(s)	-6.55380	
Std Err of Coef.	0.694220	

FLINTHIIC de hoek G=2.7

site	depth	moist	sat.moist	% moist	Bulk D	CALC SAT.MOIST	suction	O/Os	log(F)	log(O/Os)
110	0.9	304	411		1606	405	5	0.750274	0.698970	-0.12477
42	0.6	315	358		1567	420	5	0.750661	0.698970	-0.12455
27	0.9	320	381		1560	422	5	0.757994	0.698970	-0.12039
42	0.9	306	370		1692	373	5	0.819642	0.698970	-0.08637
28	0.9	362	546		1562	421	5	0.858675	0.698970	-0.06606
28	0.9	364	546		1562	421	5	0.863620	0.698970	-0.06357
120	0.7	451	494		1405	480	5	0.940308	0.698970	-0.02672
42	0.6	291	358		1567	420	10	0.693459	1	-0.15897
110	0.9	299	411		1606	405	10	0.737934	1	-0.13198
27	0.9	316	381		1560	422	10	0.749421	1	-0.12585
42	0.9	296	370		1692	373	10	0.792857	1	-0.10090
120	0.7	421	494		1405	480	10	0.877760	1	-0.05662
28	0.9	378	546		1562	421	10	0.896836	1	-0.04728
28	0.9	388	546		1562	421	10	0.920562	1	-0.03594
28	0.9	399	546		1562	421	10	0.946660	1	-0.02380
42	0.6	286	340	0.1542	1567	420	33	0.680799	1.518513	-0.16698
42	0.6	239	340	0.1323	1567	420	100	0.569368	2	-0.24460
117	0.9	261	365	0.1323	1711	366	100	0.712209	2	-0.14739
46	0.9	302	546	0.1514	1692	373	100	0.809586	2	-0.09227
35	0.54	348	546	0.1818	1567	420	100	0.829730	2	-0.08106
42	0.6	228	340	0.1268	1567	420	300	0.542261	2.477121	-0.26579
117	0.9	227	365	0.117	1711	366	300	0.618931	2.477121	-0.20835
46	0.9	293	546	0.1478	1692	373	300	0.786025	2.477121	-0.10456
35	0.54	347	546	0.1812	1567	420	300	0.826366	2.477121	-0.08291
42	0.6	163	340	0.0944	1567	420	800	0.389258	2.903089	-0.40976
117	0.9	187	365	0.0995	1711	366	800	0.510373	2.903089	-0.29211
35	0.54	285	546	0.1541	1567	420	800	0.680278	2.903089	-0.16731
42	0.6	136	340	0.0797	1567	420	1500	0.323393	3.176091	-0.49026
42	0.6	142	358		1567	420	1500	0.338393	3.176091	-0.47057
110	0.9	156	411		1606	405	1500	0.385009	3.176091	-0.41452
42	0.9	151	370		1692	373	1500	0.404464	3.176091	-0.39311
27	0.9	198	381		1560	422	1500	0.468947	3.176091	-0.32887
117	0.9	182	365	0.0962	1711	366	1500	0.497187	3.176091	-0.30347
120	0.7	280	494		1405	480	1500	0.583783	3.176091	-0.23374
28	0.9	257	546		1562	421	1500	0.609753	3.176091	-0.21484
46	0.9	256	546	0.1313	1692	373	1500	0.685012	3.176091	-0.16430
35	0.54	288	546	0.1551	1567	420	1500	0.685502	3.176091	-0.16399

AVERAGE = 411

PLINTHIIC

Regression Output:

Constant		1.272914
Std Err of Y Est		0.637253
R Squared		0.512874
No. of Observations		30
Degrees of Freedom		29
X Coefficient(s)	-4.85731	
Std Err of Coef.	0.694609	

42	0.6	315	358			5	0.879888	0.698970	-0.05557
42	0.9	306	314			5	0.974522	0.698970	-0.01120
42	0.6	291	358			10	0.812849	1	-0.08999
42	0.9	296	314			10	0.942675	1	-0.02563
42	1.2	273	340	0.1542	1500	33	0.804320	1.518513	-0.09457
35	0.9	509	546	0.2343	1662	33	0.931433	1.518513	-0.03084
42	1.2	229	340	0.1323	1500	100	0.672670	2	-0.17219
35	0.9	369	546	0.1818	1662	100	0.676352	2	-0.16952
42	1.2	218	340	0.1263	1500	300	0.640645	2.477121	-0.19339
35	0.9	368	546	0.1812	1662	300	0.673625	2.477121	-0.17159
42	1.2	155	340	0.0944	1500	800	0.459883	2.903089	-0.33735
35	0.9	303	546	0.1541	1662	800	0.554526	2.903089	-0.25607
42	1.2	130	340	0.0797	1500	1500	0.322068	3.176091	-0.41735
42	0.6	142	359			1500	0.396648	3.176091	-0.40159
42	0.9	151	314			1500	0.480891	3.176091	-0.31795
35	0.9	305	546	0.1551	1662	1500	0.558785	3.176091	-0.25275
120	0.7	451	494			5	0.912955	0.698970	-0.03955
120	0.7	421	494			10	0.852226	1	-0.06944
117	0.72	362	365	0.1743	1711	33	0.989537	1.518513	-0.00456
117	0.72	228	365	0.1175	1711	100	0.624137	2	-0.20471
117	0.72	205	365	0.1072	1711	300	0.562856	2.477121	-0.24960
117	0.72	156	365	0.0837	1711	800	0.428198	2.903089	-0.36835
117	0.72	181	365	0.0955	1711	1500	0.494939	3.176091	-0.30544
120	0.7	280	494			1500	0.566801	3.176091	-0.24656

E HORIZON

de Hoek

site	depth	moist	sat.moist	% moist	Bulk D	suction	O/Os	log(P)	log(O/Os)
18	0.55	307	441			5	0.696145	0.698970	-0.15730
18	0.55	277	441			10	0.628117	1	-0.20195
18	0.55	141	441			1500	0.319727	3.176091	-0.49521
27	0.3	346	420			5	0.823809	0.698970	-0.08417
27	0.5	340	424			5	0.801886	0.698970	-0.09588
27	0.5	362	424			10	0.853773	1	-0.06865
27	0.3	290	420			10	0.690476	1	-0.16085
27	0.5	452	424			10	1.066037	1	0.027772
27	0.5	387	424			10	0.912735	1	-0.03965
27	0.5	154	424			1500	0.363207	3.176091	-0.43984
27	0.3	137	420			1500	0.326190	3.176091	-0.48652
28	0.5	336	431			5	0.779582	0.698970	-0.10813
28	0.27	276	690	0.1424	1662	33	0.399951	1.518513	-0.39799
28	0.27	208	690	0.1114	1662	100	0.301967	2	-0.52003
28	0.27	194	690	0.1043	1662	300	0.280481	2.477121	-0.55209
28	0.27	160	690	0.0876	1662	800	0.231260	2.903089	-0.63589
28	0.5	102	431			1500	0.236658	3.176091	-0.62587
28	0.27	149	690	0.0821	1662	1500	0.215441	3.176091	-0.66667
35	0.54	505	546	0.2329	1662	33	0.924178	1.518513	-0.03424
35	0.54	445	546	0.2113	1662	100	0.815503	2	-0.08857
35	0.54	415	546	0.1998	1662	300	0.760038	2.477121	-0.11916
35	0.54	380	546	0.1861	1662	800	0.695007	2.903089	-0.15738
35	0.54	350	546	0.1741	1662	1500	0.641666	3.176091	-0.19269
42	0.32	349	392			5	0.890306	0.698970	-0.05046
42	0.32	258	392			10	0.658163	1	-0.18166
42	0.6	273	340	0.1542	1500	33	0.804320	1.518513	-0.09457
42	0.6	229	340	0.1323	1500	100	0.672670	2	-0.17219
42	0.6	218	340	0.1268	1500	300	0.640645	2.477121	-0.19338
42	0.6	156	340	0.0944	1500	800	0.459883	2.903089	-0.33735
42	0.32	73	312			1500	0.233974	3.176091	-0.63083
42	0.6	130	340	0.0797	1500	1500	0.382068	3.176091	-0.41705
46	0.32	375	546	0.1839	1662	33	0.655925	1.518513	-0.16372
46	0.32	244	546	0.1281	1662	100	0.447219	2	-0.34947
46	0.32	226	546	0.1199	1662	300	0.414298	2.477121	-0.38268
46	0.32	193	546	0.104	1662	800	0.353316	2.903089	-0.45183
46	0.32	226	546	0.1198	1662	1500	0.414298	3.176091	-0.38268
110	0.45	308	375			5	0.821333	0.698970	-0.08548
110	0.65	284	342			5	0.830409	0.698970	-0.08070
110	0.65	288	342			10	0.842105	1	-0.07463
110	0.45	300	375			10	0.8	1	-0.09691
110	0.45	174	375			1500	0.464	3.176091	-0.33348
110	0.65	163	342			1500	0.476608	3.176091	-0.32193
117	0.54	361	365	0.1743	1711	33	[illegible]	1.518513	-0.00456
117	0.54	[illegible]	365	0.1175	1711	100	[illegible]	2	[illegible]
117	0.54	205	365	0.1072	1711	300	0.562856	2.477121	-0.24960
117	0.54	164	365	0.0873	1711	800	0.448377	2.903089	-0.34835
117	0.54	181	365	0.0755	1711	1500	0.494939	3.176091	-0.30544
120	0.5	326	365			5	0.893150	0.698970	-0.04907
120	0.5	306	365			10	0.838356	1	-0.07657
120	0.5	179	365			1500	0.490410	3.176091	-0.30943

Regression Output:

Constant		1.0321[illegible]
Std Err of Y Est		0.65[illegible]
R Squared		0.541[illegible]
No. of Observations		[illegible]
Degrees of Freedom		4
X Coefficient(s)	-0.05405	
Std Err of Coef.	0.492087	

APPENDIX E.12

TROXLER CALIBRATION

DE HOEK - TROXLER CALIBRATOIN

Orthic A

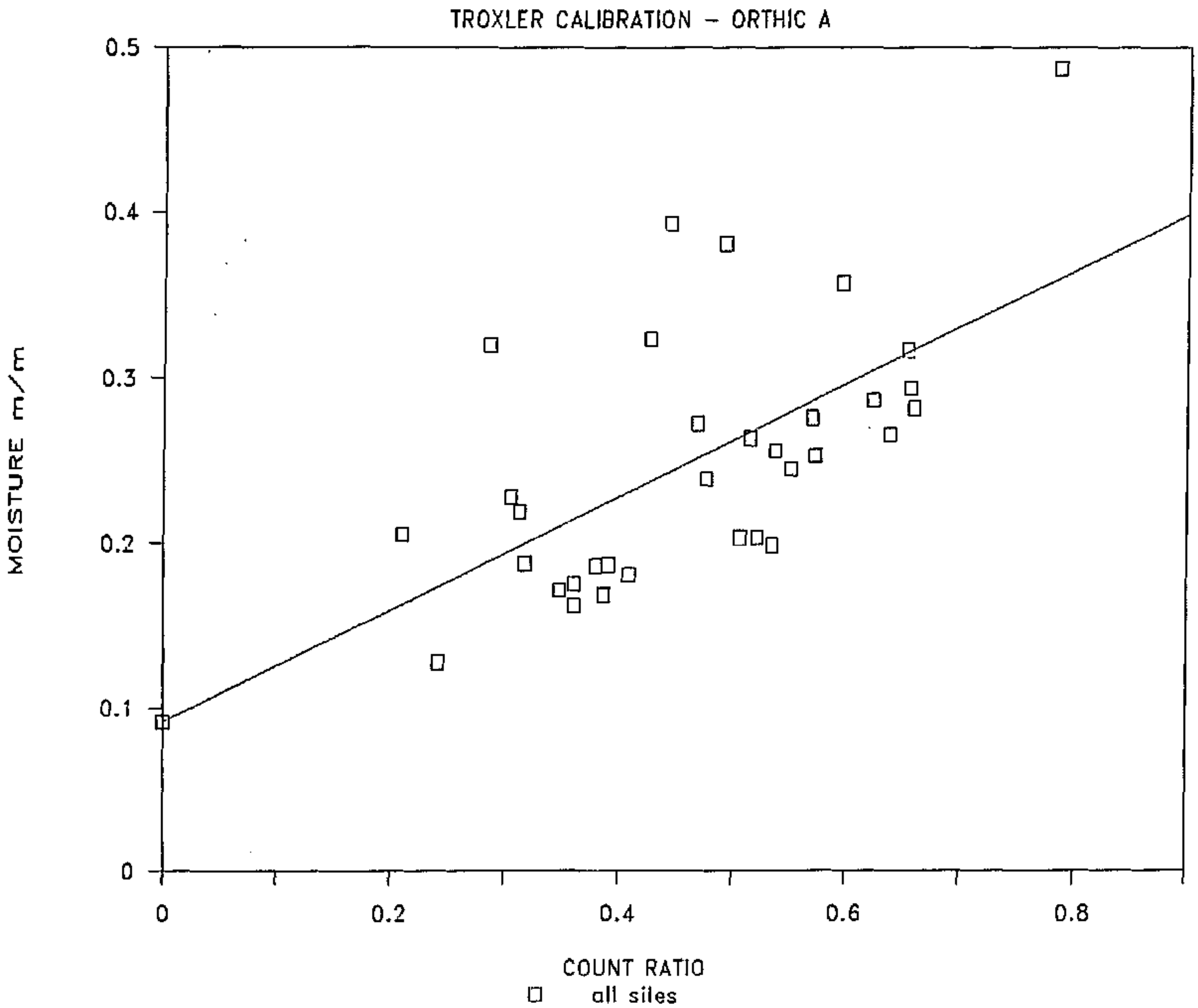
SITE	DEPTH	COUNT RATIO	WET MASS	DRY MASS	CONTAINER MASS	DRY BULK DENSITY	G = 2.7 MOISTURE MASS	GRAV MOISTURE	MOISTURE m/m	SAT MOIST m/m
		0.000							0.091	
		I							0.433	
18	0.2	0.313	35.60	32.90	14.8	1468	2.7	0.149	0.219	0.456
18	0.2	0.521	521.40	459.65	14.8	1468	61.75	0.139	0.204	0.456
18	0.3	0.408	181.30	163.00	14.8	1468	18.3	,0.123	0.181	0.456
18	0.3	0.534	527.65	466.50	14.8	1468	61.15	0.135	0.199	0.456
18	0.3	0.660	665.10	560.50	14.8	1468	104.6	0.192	0.281	0.456
27	0.2	0.570	489.50	417.10	14.8	1533	72.4	0.180	0.276	0.432
27	0.2	0.639	501.10	429.30	14.8	1533	71.8	0.173	0.266	0.432
27	0.2	0.514	520.45	446.35	14.8	1533	74.1	0.172	0.264	0.432
28	0.2	0.624	487.80	417.90	14.8	1650	69.9	0.173	0.286	0.389
28	0.2	0.537	557.20	484.40	14.8	1650	72.8	0.155	0.256	0.389
28	0.2	0.242	194.70	181.80	14.8	1650	12.9	0.077	0.127	0.389
28	0.3	0.573	602.00	523.90	14.8	1650	78.1	0.153	0.253	0.389
28	0.3	0.657	582.00	496.30	14.8	1650	85.7	0.178	0.294	0.389
28	0.3	0.360	219.30	199.60	14.8	1650	19.7	0.107	0.176	0.389
42	0.2	0.506	471.25	411.10	14.8	1340	60.15	0.152	0.203	0.504
42	0.2	0.348	250.50	223.70	14.8	1340	26.8	0.128	0.172	0.504
42	0.3	0.390	246.30	219.70	14.8	1440	26.6	0.130	0.187	0.467
42	0.3	0.551	518.65	445.55	14.8	1440	73.1	0.170	0.245	0.467
110	0.2	0.596	457.10	373.20	14.8	1524	83.9	0.234	0.357	0.436
110	0.2	0.210	72.00	65.20	[illegible]	1524	6.8	0.135	0.206	0.436
110	0.2	0.317	422.70	377.90	14.8	1524	44.8	0.123	0.188	0.436
110	0.2	0.426	504.30	418.60	14.8	1524	85.7	0.212	0.323	0.436
110	0.3	0.360	695.20	625.50	14.8	1424	69.7	0.114	0.163	0.473
110	0.3	0.468	618.90	522.00	14.8	1424	96.9	0.191	0.272	0.473
110	0.4	0.476	555.50	481.20	14.8	1497	74.3	0.159	0.238	0.446
110	0.4	0.655	739.80	613.30	14.8	1497	126.5	0.211	0.316	0.446
110	0.4	0.379	233.80	209.60	14.8	1497	24.2	0.124	0.186	0.446
110	0.4	0.386	391.30	353.10	14.8	1497	38.2	0.113	0.169	0.446
120	0.2	0.492	506.45	408.45	14.8	1526	98	0.250	0.381	0.435
120	0.2	0.443	524.60	420.05	14.8	1526	104.55	0.257	0.393	0.435
120	0.2	0.305	568.30	496.40	14.8	1526	71.9	0.149	0.228	0.435
120	0.2	0.286	211.90	177.80	14.8	1526	34.1	0.209	0.319	0.435
120	0.2	0.785	397.10	304.50	14.8	1526	92.6	0.320	0.488	0.435

ALL Regression Output:

Constant	0.091162
Std Err of Y Est	0.062874
R Squared	0.367835
No. of Observations	33
Degrees of Freedom	31

X Coefficient(s) 0.341669

Std Err oRegressio0.080447


TROXLER CALIBRATION - ORTHIC A
MOISTURE m/m
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
COUNT RATIO
all siles

E.12.2.

Apedal B

		0.000							0.000	
		1.000							0.432	
18	0.4	0.503	543.70	484.65	14.8	1397	59.05	0.126	0.176	0.483
18	0.4	0.440	209.00	185.20	14.8	1397	23.8	0.140	0.195	0.483
18	0.5	0.448	194.20	171.40	14.8	1397	22.8	0.146	0.203	0.483
18	0.5	0.479	471.00	421.40	14.8	1397	49.6	0.122	0.170	0.483
18	0.6	0.602	300.10	252.50	14.8	1397	47.6	0.200	0.280	0.483
18	0.6	0.486	494.20	441.65	14.8	1397	52.55	0.123	0.172	0.483
18	0.6	0.463	196.50	173.00	14.8	1397	23.5	0.149	0.208	0.483
18	0.7	0.536	546.20	488.70	14.8	1397	57.5	0.121	0.170	0.483
18	0.7	0.526	168.50	144.80	14.8	1397	23.7	0.182	0.255	0.483
18	0.8	0.576	230.10	195.70	14.8	1475	34.4	0.190	0.280	0.454
18	0.8	0.573	534.60	474.00	14.8	1475	60.6	0.132	0.195	0.454
18	0.9	0.630	565.00	493.20	14.8	1475	71.8	0.150	0.221	0.454
18	0.9	0.671	638.00	530.60	14.8	1475	107.4	0.208	0.307	0.454
18	0.9	0.628	184.70	155.60	14.8	1475	29.1	0.207	0.305	0.454
18	1	0.664	228.00	190.30	14.8	1475	37.7	0.215	0.317	0.454
18	1	0.695	643.10	532.80	14.8	1475	110.3	0.213	0.314	0.454
18	1	0.656	477.70	413.70	14.8	1475	64	0.160	0.237	0.454
18	1.1	0.690	502.70	430.90	14.8	1475	71.8	0.173	0.255	0.454
18	1.1	0.705	168.50	140.30	14.8	1475	28.2	0.225	0.331	0.454
27	0.3	0.699	570.95	466.65	14.8	1305	104.3	0.231	0.301	0.517
27	0.3	0.603	431.80	372.85	14.8	1305	58.95	0.165	0.215	0.517
27	0.3	0.604	632.60	549.50	14.8	1305	83.1	0.155	0.203	0.517
27	0.3	0.440	234.60	195.80	14.8	1305	38.8	0.214	0.280	0.517
27	0.4	0.698	478.00	416.60	14.8	1450	61.4	0.153	0.222	0.463
27	0.4	0.499	251.50	216.90	14.8	1450	34.6	0.171	0.248	0.463
27	0.4	0.671	526.45	451.35	14.8	1450	75.1	0.172	0.249	0.463
27	0.4	0.592	514.35	445.60	14.8	1450	68.75	0.160	0.231	0.463
27	0.4	0.555	591.80	513.20	14.8	1450	78.6	0.158	0.229	0.463
27	0.5	0.630	620.30	526.50	14.8	1508	93.8	0.183	0.276	0.441
27	0.5	0.553	451.40	390.75	14.8	1508	60.65	0.161	0.243	0.441
27	0.5	0.527	544.20	470.30	14.8	1508	73.9	0.162	0.245	0.441
27	0.5	0.515	144.90	128.10	14.8	1508	16.7	0.147	0.222	0.441
27	0.6	0.549	568.75	489.70	14.8	1508	79.05	0.166	0.251	0.441
27	0.6	0.507	548.10	472.50	14.8	1508	75.6	0.165	0.249	0.441
27	0.6	0.613	658.50	562.90	14.8	1508	95.6	0.174	0.263	0.441
27	0.6	0.521	115.40	98.50	14.8	1508	16.9	0.202	0.304	0.441
27	0.6	0.642	540.40	459.90	14.8	1508	80.5	0.181	0.273	0.441
28	0.3	0.360	223.10	190.75	14.8	1500	32.35	0.184	0.276	0.444
28	0.3	0.657	582.00	496.30	14.8	1500	85.7	0.178	0.267	0.444
28	0.4	0.434	236.50	204.50	14.8	1500	32	0.169	0.253	0.444
28	0.4	0.590	643.55	558.75	14.8	1500	84.8	0.156	0.234	0.444
28	0.4	0.646	465.90	397.70	14.8	1500	68.2	0.178	0.267	0.444
28	0.5	0.480	247.05	209.00	14.8	1500	38.05	0.196	0.294	0.444
28	0.5	0.554	589.30	509.05	14.8	1500	80.25	0.162	0.244	0.444
28	0.5	0.644	562.90	504.50	14.8	1500	58.4	0.119	0.179	0.444
28	0.6	0.505	234.80	197.60	14.8	1500	37.2	0.204	0.305	0.444
28	0.6	0.620	631.10	544.10	14.8	1500	87	0.164	0.247	0.444
28	0.6	0.570	669.40	576.10	14.8	1500	93.3	0.166	0.249	0.444
28	0.7	0.542	411.20	352.95	14.8	1500	58.25	0.172	0.258	0.444
28	0.7	0.630	541.50	458.90	14.8	1500	82.6	0.186	0.279	0.444
28	0.7	0.502	248.35	207.90	14.8	1500	40.45	0.209	0.314	0.444

18 Regression Output:

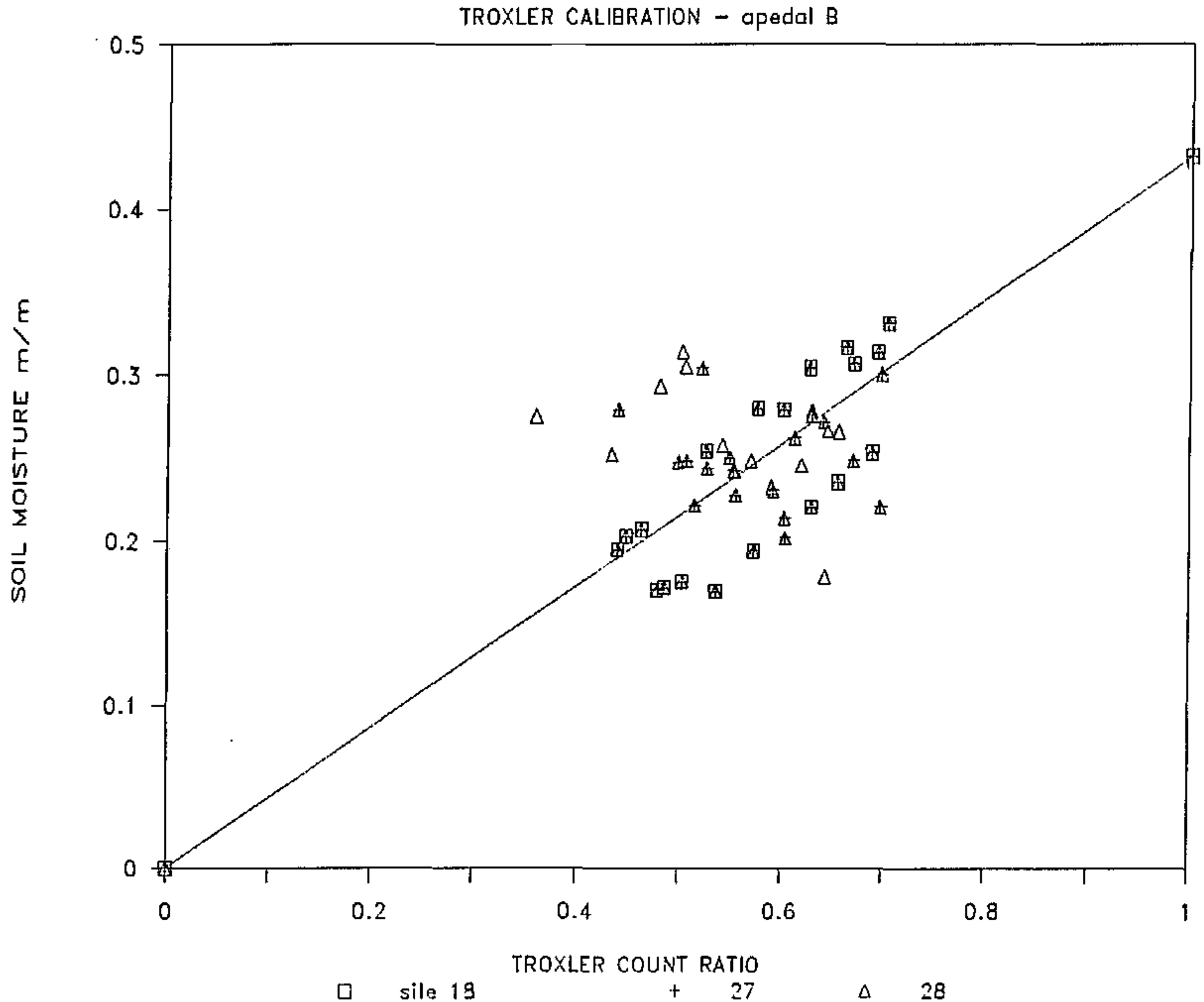
Constant	-0.04259
Std Err of Y Est	0.035704
R Squared	0.622937
No. of Observations	19
Degrees of Freedom	17
X Coefficient(s)	0.492148
Std Err of Coef.	0.092865

27 Regression Output:

Constant	0.754847
Std Err of Y Est	0.029340
R Squared	0.000404
No. of Observations	18
Degrees of Freedom	16
X Coefficient(s)	-0.00789
Std Err of Coef.	0.098161

28 Regression Output:

Constant	0.349892
Std Err of Y Est	0.031751
R Squared	0.175789
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	-0.15937
Std Err of Coef.	0.097622


TROXLER CALIBRATION - apedal B
SOIL MOISTURE m/m
0.5
0.4
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1
TROXLER COUNT RATIO
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+ 27
Δ 28

E.12.4.

Plinthic

		0.000							0.130	
		1.000							0.387	
27	0.7	0.578	541.20	463.40	14.8	1560	77.8	0.173	0.271	0.422
27	0.7	0.534	220.30	186.90	14.8	1560	33.4	0.194	0.303	0.422
27	0.7	0.515	499.40	429.50	14.8	1560	69.9	0.169	0.263	0.422
27	0.766666	0.592	387.83	331.70	14.8	1560	56.13333	0.177	0.276	0.422
27	0.8	0.700	682.20	574.10	14.8	1560	108.1	0.193	0.302	0.422
27	0.8	0.536	503.70	432.60	14.8	1560	71.1	0.170	0.265	0.422
27	0.8	0.540	183.90	155.90	14.8	1560	28	0.198	0.310	0.422
27	0.866666	0.613	476.87	405.70	14.8	1560	71.16666	0.182	0.284	0.422
27	0.9	0.639	539.50	459.60	14.8	1560	79.9	0.180	0.280	0.422
27	0.9	0.585	569.00	489.10	14.8	1560	79.9	0.168	0.263	0.422
27	0.9	0.582	224.70	190.70	14.8	1560	34	0.193	0.302	0.422
27	1	0.643	646.80	548.00	14.8	1560	98.8	0.185	0.289	0.422
27	1	0.721	669.70	568.40	14.8	1560	101.3	0.183	0.285	0.422
27	1	0.620	562.50	474.80	14.8	1560	87.7	0.191	0.297	0.422
27	1	0.637	486.00	413.25	14.8	1560	72.75	0.183	0.285	0.422
27	1	0.623	226.50	190.90	14.8	1560	35.6	0.202	0.315	0.422
27	1.1	0.697	597.00	512.00	14.8	1560	85	0.171	0.267	0.422
27	1.1	0.666	567.40	472.10	14.8	1560	95.3	0.208	0.325	0.422
27	1.1	0.664	645.60	540.60	14.8	1560	105	0.200	0.312	0.422
27	1.1	0.650	202.80	170.10	14.8	1560	32.7	0.211	0.328	0.422
28	0.8	0.541	547.30	469.75	14.8	1562	77.55	0.170	0.266	0.421
28	0.8	0.515	253.50	212.20	14.8	1562	41.3	0.209	0.327	0.421
28	0.9	0.606	266.30	226.90	14.8	1562	39.4	0.186	0.290	0.421
28	0.9	0.651	542.35	461.00	14.8	1562	81.35	0.182	0.285	0.421
28	1	0.717	260.00	212.80	14.8	1562	47.2	0.238	0.372	0.421
28	1	0.749	604.15	498.30	14.8	1562	105.85	0.219	0.342	0.421
28	1.1	0.789	258.00	207.00	14.8	1562	51	0.265	0.414	0.421
28	1.1	0.802	674.60	547.95	14.8	1562	126.65	0.238	0.371	0.421
42	0.5	0.418	254.80	224.80	14.8	1567	30	0.143	0.224	0.420
42	0.5	0.590	572.95	488.05	14.8	1567	84.9	0.179	0.281	0.420
42	0.6	0.531	259.30	229.20	14.8	1567	30.1	0.140	0.220	0.420
42	0.6	0.646	530.75	445.90	14.8	1567	84.85	0.197	0.308	0.420
42	0.7	0.675	432.75	362.55	14.8	1567	70.2	0.202	0.316	0.420
42	0.7	0.598	246.20	209.40	14.8	1567	36.8	0.189	0.296	0.420
42	0.8	0.666	574.40	482.35	14.8	1692	92.05	0.197	0.333	0.373
42	0.8	0.613	280.40	236.90	14.8	1692	43.5	0.196	0.331	0.373
42	0.9	0.616	310.90	263.30	14.8	1692	47.6	0.192	0.324	0.373
42	0.9	0.664	720.05	608.40	14.8	1692	111.65	0.188	0.318	0.373
42	1	0.754	272.70	234.10	14.8	1692	38.6	0.176	0.298	0.373
42	1	0.842	589.75	506.65	14.8	1692	83.1	0.169	0.286	0.373

28 Regression Output:

Constant	0.093030
Std Err of Y Est	0.035217
R Squared	0.594835
No. of Observations	8
Degrees of Freedom	6
X Coefficient(s)	0.358211
Std Err of Coef.	0.120692

27 Regression Output:

Constant	0.232526
Std Err of Y Est	0.020319
R Squared	0.073700
No. of Observations	20
Degrees of Freedom	18
X Coefficient(s)	0.094941
Std Err of Coef.	0.079334

42 Regression Output:

Constant	0.171835
Std Err of Y Est	0.033420
R Squared	0.291802
No. of Observations	12
Degrees of Freedom	10
X Coefficient(s)	0.193690
Std Err of Coef.	0.095420

Plinthic continued

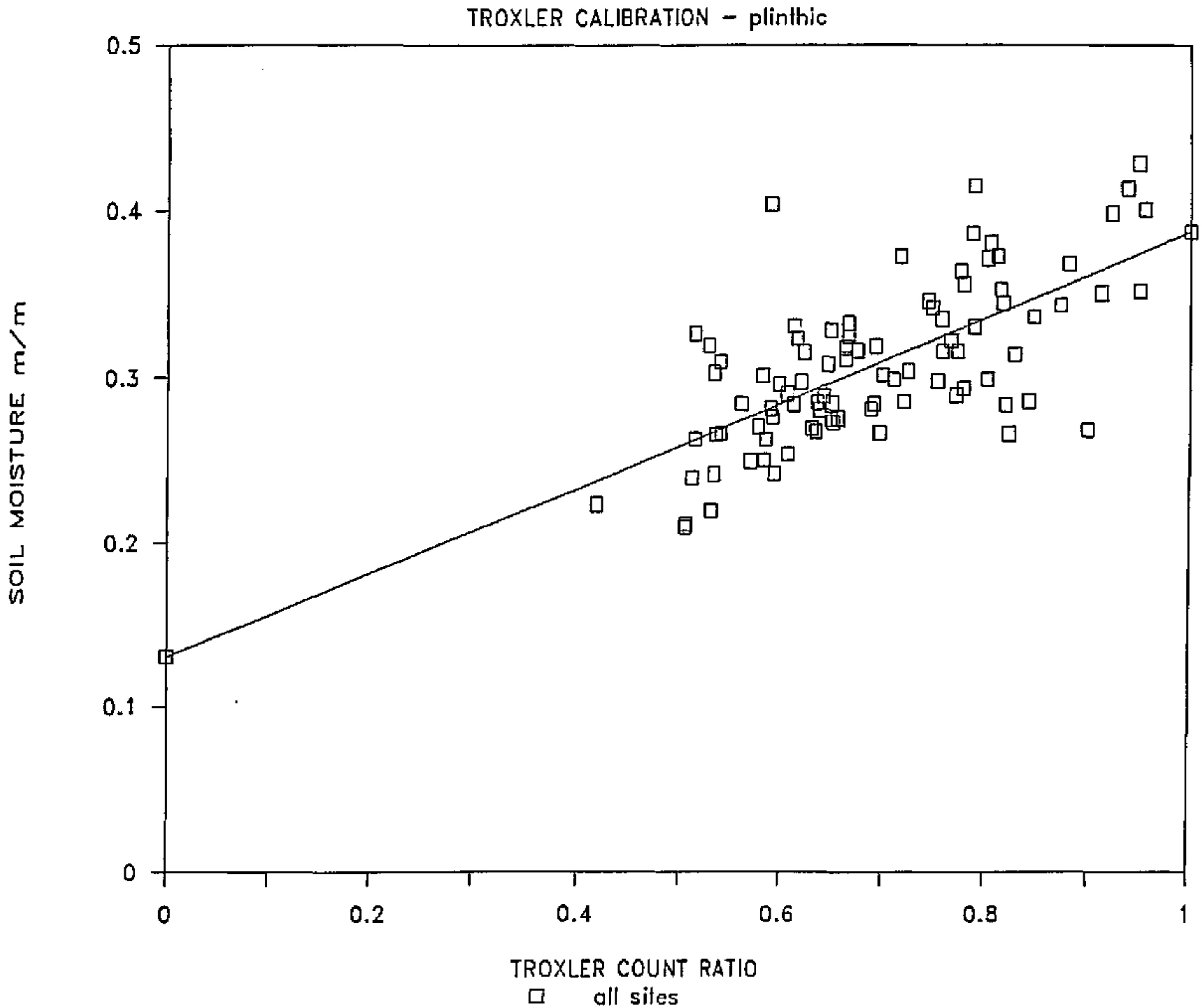
110	0.7	0.506	249.70	221.70	14.8	1566	28	0.135	0.212	0.420
110	0.7	0.779	695.50	580.10	14.8	1566	107.4	0.187	0.293	0.420
110	0.7	0.505	484.70	429.10	14.8	1566	55.6	0.134	0.210	0.420
110	0.7	0.570	653.40	565.60	14.8	1566	87.8	0.159	0.250	0.420
110	0.8	0.787	607.30	492.50	14.8	1606	114.8	0.240	0.386	0.405
110	0.8	0.534	231.00	202.70	14.8	1606	28.3	0.151	0.242	0.405
110	0.8	0.583	612.00	531.40	14.8	1606	80.6	0.156	0.251	0.405
110	0.8	0.650	616.50	528.60	14.8	1606	87.9	0.171	0.275	0.405
110	0.9	0.607	601.40	521.40	14.8	1606	80	0.158	0.254	0.405
110	0.9	0.656	544.20	466.80	14.8	1606	77.4	0.171	0.275	0.405
110	0.9	0.631	271.80	234.90	14.8	1606	36.9	0.168	0.269	0.405
110	0.9	0.779	562.30	463.00	14.8	1606	99.3	0.222	0.356	0.405
110	1	0.776	657.00	538.50	14.8	1606	118.5	0.226	0.363	0.405
110	1	0.691	727.80	620.70	14.8	1606	107.1	0.177	0.284	0.405
110	1	0.652	652.40	559.80	14.8	1606	92.6	0.170	0.273	0.405
110	1.1	0.725	614.90	519.40	14.8	1606	95.5	0.189	0.304	0.405
110	1.1	0.689	670.00	572.50	14.8	1606	97.5	0.175	0.281	0.405
120	0.5	0.512	643.00	556.60	14.8	1500	86.4	0.159	0.239	0.444
120	0.5	0.529	247.80	206.90	14.8	1500	40.9	0.213	0.319	0.444
120	0.5	0.561	424.90	359.55	14.8	1500	65.35	0.190	0.284	0.444
120	0.5	0.815	665.80	541.90	14.8	1500	123.9	0.235	0.353	0.444
120	0.5	0.693	674.35	558.65	14.8	1500	115.7	0.213	0.319	0.444
120	0.6	0.589	245.70	196.70	14.8	1500	49	0.269	0.404	0.444
120	0.6	0.594	653.30	564.60	14.8	1500	88.7	0.161	0.242	0.444
120	0.6	0.711	591.35	495.60	14.8	1500	95.75	0.199	0.299	0.444
120	0.6	0.635	573.15	488.65	14.8	1500	84.5	0.178	0.267	0.444
120	0.65	0.745	474.55	387.60	14.8	1484	86.95	0.233	0.346	0.450
120	0.7	0.758	590.20	479.30	14.8	1405	110.9	0.239	0.335	0.480
120	0.7	0.811	547.65	435.90	14.8	1405	111.75	0.265	0.373	0.480
120	0.7	0.805	693.10	548.60	14.8	1405	144.5	0.271	0.380	0.480
120	0.7	0.802	416.25	345.90	14.8	1405	70.35	0.212	0.299	0.480
120	0.8	0.922	605.10	474.80	14.8	1405	130.3	0.283	0.398	0.480
120	0.8	0.937	418.95	327.15	14.8	1405	91.8	0.294	0.413	0.480
120	0.8	0.948	265.90	207.30	14.8	1405	58.6	0.304	0.428	0.480
120	0.8	0.954	648.65	508.10	14.8	1405	140.55	0.285	0.400	0.480
120	0.8	0.950	485.20	391.00	14.8	1405	94.2	0.250	0.352	0.480
120	0.9	0.880	584.65	466.30	14.8	1405	118.35	0.262	0.368	0.480
120	0.9	0.872	608.90	492.20	14.8	1405	116.7	0.244	0.343	0.480
120	0.9	0.899	875.50	737.40	14.8	1405	138.1	0.191	0.269	0.480
120	0.9	0.912	248.10	201.50	14.8	1405	46.6	0.250	0.351	0.480
120	1	0.823	587.60	496.45	14.8	1405	91.15	0.189	0.266	0.480
120	1	0.828	531.80	437.30	14.8	1405	94.5	0.224	0.314	0.480
120	1	0.847	198.90	163.30	14.8	1405	35.6	0.240	0.337	0.480
120	1	0.817	578.25	467.20	14.8	1405	111.05	0.245	0.345	0.480
120	1	0.820	428.70	359.20	14.8	1405	69.5	0.202	0.284	0.480
120	1.1	0.759	747.00	612.70	14.8	1405	134.3	0.225	0.316	0.480
120	1.1	0.767	594.50	486.40	14.8	1405	108.1	0.229	0.322	0.480
120	1.1	0.790	248.70	204.10	14.8	1405	44.6	0.236	0.331	0.480
120	1.1	0.773	577.40	474.20	14.8	1405	103.2	0.225	0.316	0.480
120	1.1	0.772	628.00	523.30	14.8	1405	104.7	0.206	0.289	0.480

110 Regression Output:

Constant	-0.02836
Std Err of Y Est	0.019926
R Squared	0.844682
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.472933
Std Err of Coef.	0.052362

120 Regression Output:

Constant	0.160883
Std Err of Y Est	0.041452
R Squared	0.299795
No. of Observations	33
Degrees of Freedom	31
X Coefficient(s)	0.216478
Std Err of Coef.	0.059420


TROXLER CALIBRATION - plinthic
SOIL MOISTURE m/m
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0.4
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0.2
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0.2
0.4
0.6
0.8
1
TROXLER COUNT RATIO
all sites

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		0.000							0.032	
		0.800							0.365	
42	0.3	0.551	518.65	445.55	14.8	1440	73.1	0.170	0.244	0.467
42	0.3	0.390	246.30	219.70	14.8	1440	26.6	0.130	0.187	0.467
42	0.4	0.562	518.20	446.85	14.8	1440	71.35	0.165	0.238	0.467
42	0.4	0.393	255.60	229.30	14.8	1440	26.3	0.123	0.177	0.467
42	0.5	0.418	254.80	224.80	14.8	1500	30	0.143	0.214	0.444
42	0.5	0.590	572.95	488.05	14.8	1500	84.9	0.179	0.269	0.444
110	0.4	0.386	391.30	353.10	14.8	1497	38.2	0.113	0.169	0.446
110	0.4	0.655	739.80	613.30	14.8	1497	126.5	0.211	0.316	0.446
110	0.4	0.476	555.50	481.20	14.8	1497	74.3	0.159	0.238	0.446
110	0.4	0.379	233.80	209.60	14.8	1497	24.2	0.124	0.186	0.446
110	0.5	0.508	462.80	405.30	14.8	1497	57.5	0.147	0.220	0.446
110	0.5	0.413	544.80	490.20	14.8	1497	54.6	0.115	0.172	0.446
110	0.5	0.656	595.00	503.70	14.8	1497	91.3	0.187	0.280	0.446
110	0.5	0.419	224.30	201.30	14.8	1497	23	0.123	0.185	0.446
110	0.6	0.532	652.20	573.10	14.8	1566	79.1	0.142	0.222	0.420
110	0.6	0.444	764.50	686.70	14.8	1566	77.8	0.116	0.181	0.420
110	0.6	0.461	242.30	217.90	14.8	1566	24.4	0.120	0.188	0.420
110	0.6	0.672	691.50	588.20	14.8	1566	103.3	0.180	0.282	0.420
110	0.7	0.506	249.70	221.70	14.8	1566	28	0.135	0.212	0.420
110	0.7	0.505	484.70	429.10	14.8	1566	55.6	0.134	0.210	0.420
110	0.7	0.570	653.40	565.60	14.8	1566	87.8	0.159	0.250	0.420
110	0.7	0.779	695.50	588.10	14.8	1566	107.4	0.187	0.293	0.420
120	0.3	0.471	560.10	483.80	14.8	1413	76.3	0.163	0.230	0.477
120	0.3	0.835	517.50	409.70	14.8	1413	107.8	0.273	0.386	0.477
120	0.3	0.494	525.10	436.00	14.8	1413	89.1	0.212	0.299	0.477
120	0.3	0.453	262.70	215.30	14.8	1413	47.4	0.236	0.334	0.477
120	0.3	0.629	492.25	399.95	14.8	1413	92.3	0.240	0.339	0.477
120	0.4	0.529	448.45	377.20	14.8	1563	71.25	0.197	0.307	0.421
120	0.4	0.515	308.50	254.70	14.8	1563	53.8	0.224	0.351	0.421
120	0.4	0.677	492.15	402.35	14.8	1563	89.8	0.232	0.362	0.421
120	0.4	0.511	534.60	459.50	14.8	1563	75.1	0.169	0.264	0.421
120	0.4	0.861	582.20	466.00	14.8	1563	116.2	0.258	0.403	0.421

42 Regression Output:

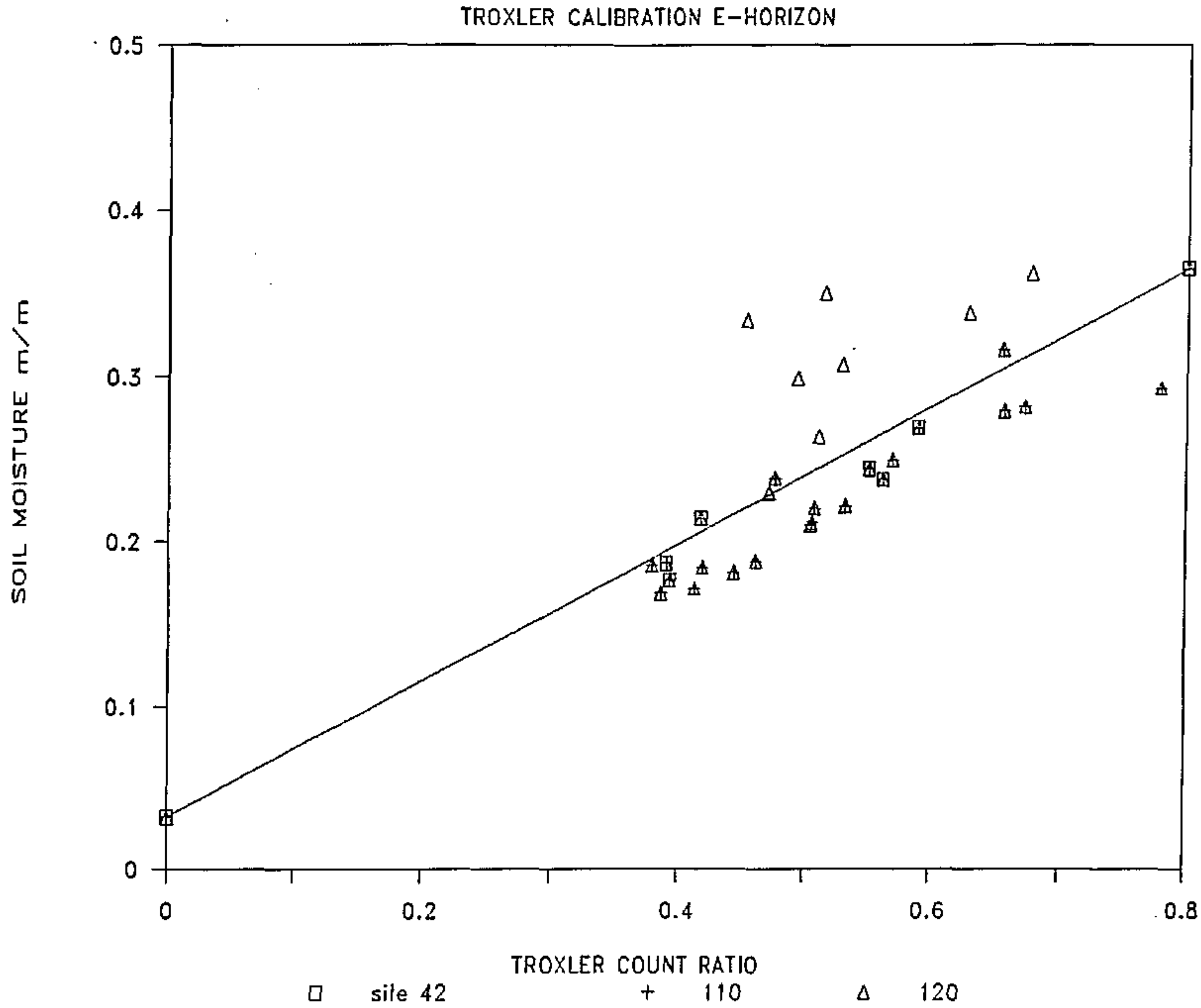
Constant	0.046347
Std Err of Y Est	0.012764
R Squared	0.896889
No. of Observations	6
Degrees of Freedom	4
X Coefficient(s)	0.361906
Std Err of Coef.	0.061354

120 Regression Output:

Constant	0.159689
Std Err of Y Est	0.035324
R Squared	0.611747
No. of Observations	10
Degrees of Freedom	8
X Coefficient(s)	0.280626
Std Err of Coef.	0.079041

110 Regression Output:

Constant	0.028848
Std Err of Y Est	0.017896
R Squared	0.863629
No. of Observations	16
Degrees of Freedom	14
X Coefficient(s)	0.375959
Std Err of Coef.	0.039927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SOIL MOISTURE m/m
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0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
TROXLER COUNT RATIO
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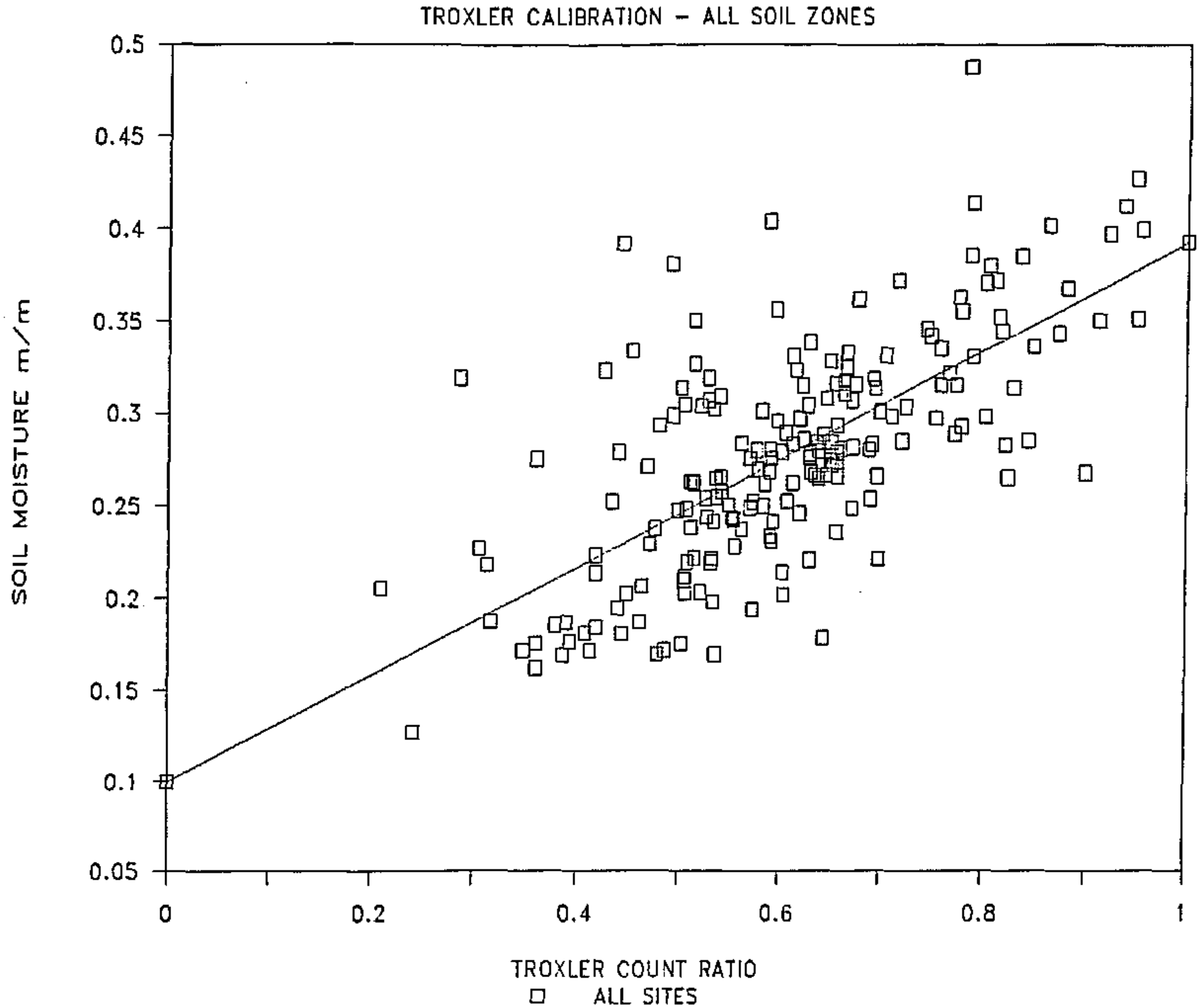
+ 110
Δ 120



TROXLER CALIBRATION - ALL SOIL ZONES
SOIL MOISTURE m/m
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0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.2
0.4
0.6
0.8
1
TROXLER COUNT RATIO
ALL SITES

E.12.10.

F.

A P P E N D I X F

ZUURBEKOM CATCHMENT

C O N T E N T S

DRAWINGS

APPENDICES

1. REASONS FOR SELECTING THE CATCHMENT FOR STUDY

The details of the catchment selection are presented in Appendix A. The main reasons are summarised as follows:

- the catchment consists of a dolomite aquifer which is bounded on three sides by dolerite dykes and on the fourth side by the dolomite wedging out onto the underlying, relatively impermeable Black Reef Formations. The compartment is hydraulically well defined.

- A considerable amount of drilling and monitoring has been done over the years. Monitoring includes water levels, water quality, and streamflow gauging.

  The Department of Environment Affairs (DEA) have carried out a lot of work in the area (Fleisher, 1981) and Steffen, Robertson and Kirsten have recently completed a hydrogeological study for Randfontein Estates (Steffen, Robertson and Kirsten, 1983). Steffen, Robertson and Kirsten are also currently investigating the water budget of the slimes and return water dams and had submitted a surface and ground water pollution investigation proposal for JCI.

  From the monitoring point of view there were 23 boreholes that the DEA had been equipped with autographic water level recorders, and a further 13 boreholes observed on a monthly basis, located in the compartment. These provided a good data bank and it was felt that no further boreholes or instrumentation were required. There appeared to be gauging stations on the Wonderfontein Spruit near the northern and southern compartment boundaries. There also appeared to be two stations at suitable positions on the Klip River, but these were closed.

- The compartment is close to Johannesburg, providing easy access for data collection, particularly for sudden storm events.

There are some aspects which detract from the catchment's suitability for recharge research. The main objections are:

- the inflows and outflows are complex due to ongoing mining and dewatering activity;
- the Rand Water Board was planning to increase abstraction from the compartment;
- the dewatering activities in adjacent compartments could induce losses through the dykes which could not be quantified;
- the stream flow records through the catchment had ceased at the time of investigation and reconstruction work was being done on the Donaldson dam.

The Steering Committee decided that despite the possible problems, the other factors were favourable for utilizing the catchment.

2. GEOGRAPHICAL SETTING

The locality of the catchment is shown in fig F1. The total catchment area is $150km^2$ and bounded by the Kliprivier dyke in the east and Gemsbokfontein dyke in the west. The magazine dyke splits the compartment in two as shown in fig F2. The area selected for instrumentation is on the west of the magazine dyke where there was assumed to be less disturbance of the ground water regime.

Cooke 1 and 2 shafts are within the main catchment, and extract and recharge water for dewatering control.

To the east, the Rand Water Board pumping station extracts about 25Ml/day from the dolomite, and has been doing this for many years.

Only Cooke 2 shaft is in the sub catchment and it was felt that by installing a weir at the upstream end of the Wonderfontein Spruit the inflow and outflow could be adequately measured. The sub compartment was bounded by dykes on all sides with apparently little seepage taking place over the boundaries. The influence of Bekkersdaal township was not known but was not expected to be a major problem.

Further geographic details are presented in section 4.

3. AVAILABLE HISTORIC RECORDS

The records that were made available are:

- Rand Water Board pumping records;
- Dept of Environment Affairs water level records of 23 autographic recorders and 6 monthly dipped boreholes. Levels were examined from 1980 to the present;
- Mine pumping and recharge records for Cooke 1 and 2 shafts, were obtained from Randfontein Estates Gold Mine (REGM);
- Geological Survey residual gravity map;
- Meteorological and hydrological information for the weather stations and weirs in the area were obtained from the Weather Bureau and the Hydrological Research Institute.

Other available data included geophysical plans, geological structure plans, thermal infra red linescans from JCI records.

The Dept of Agriculture provided soil type and land use maps.
Further information in processed form was extracted from a study by Fleisher, 1981 for the Dept of Water Affairs (report GH3169).

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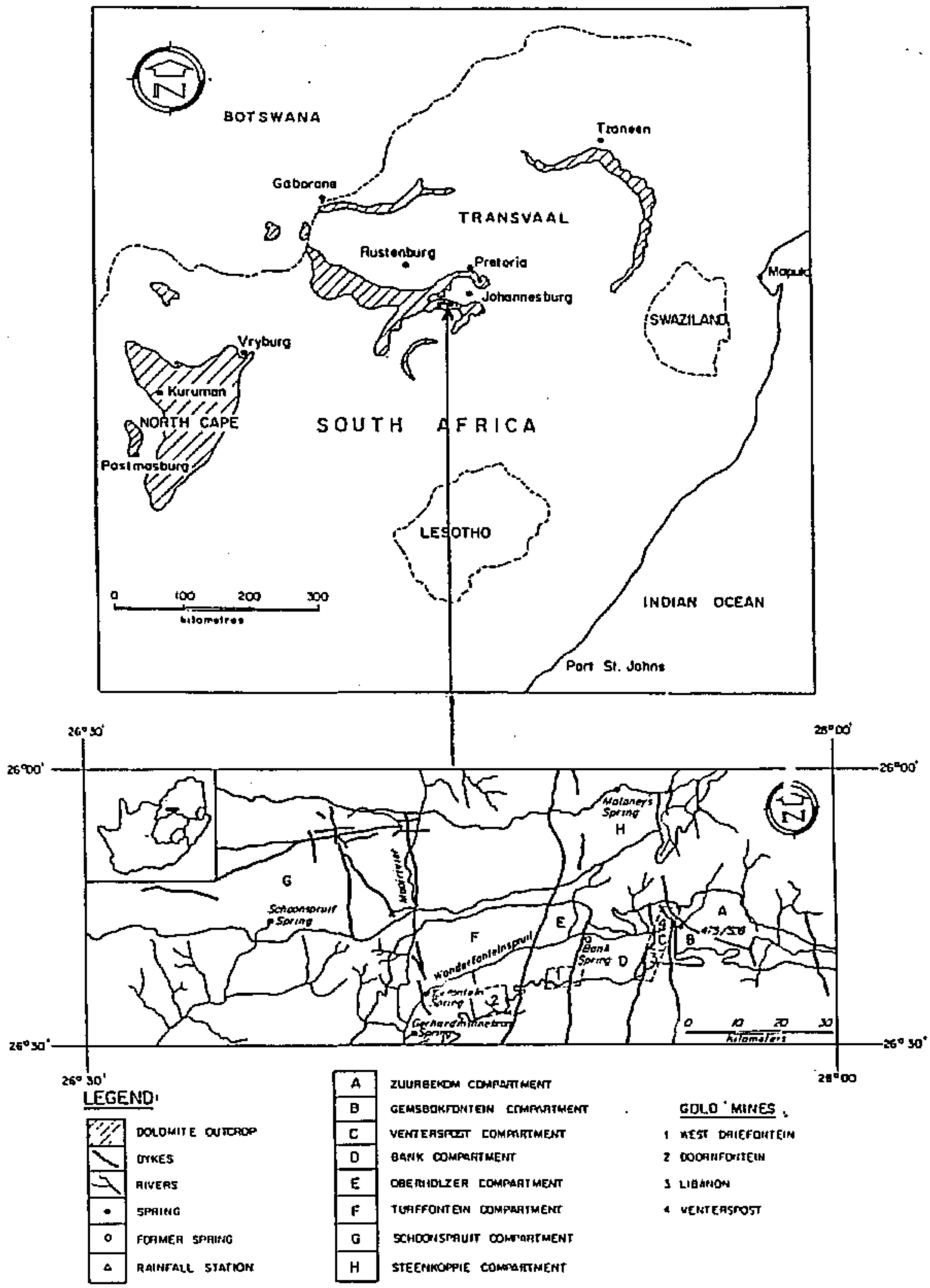

FIG F.1 Locality of site and dolomite compartments

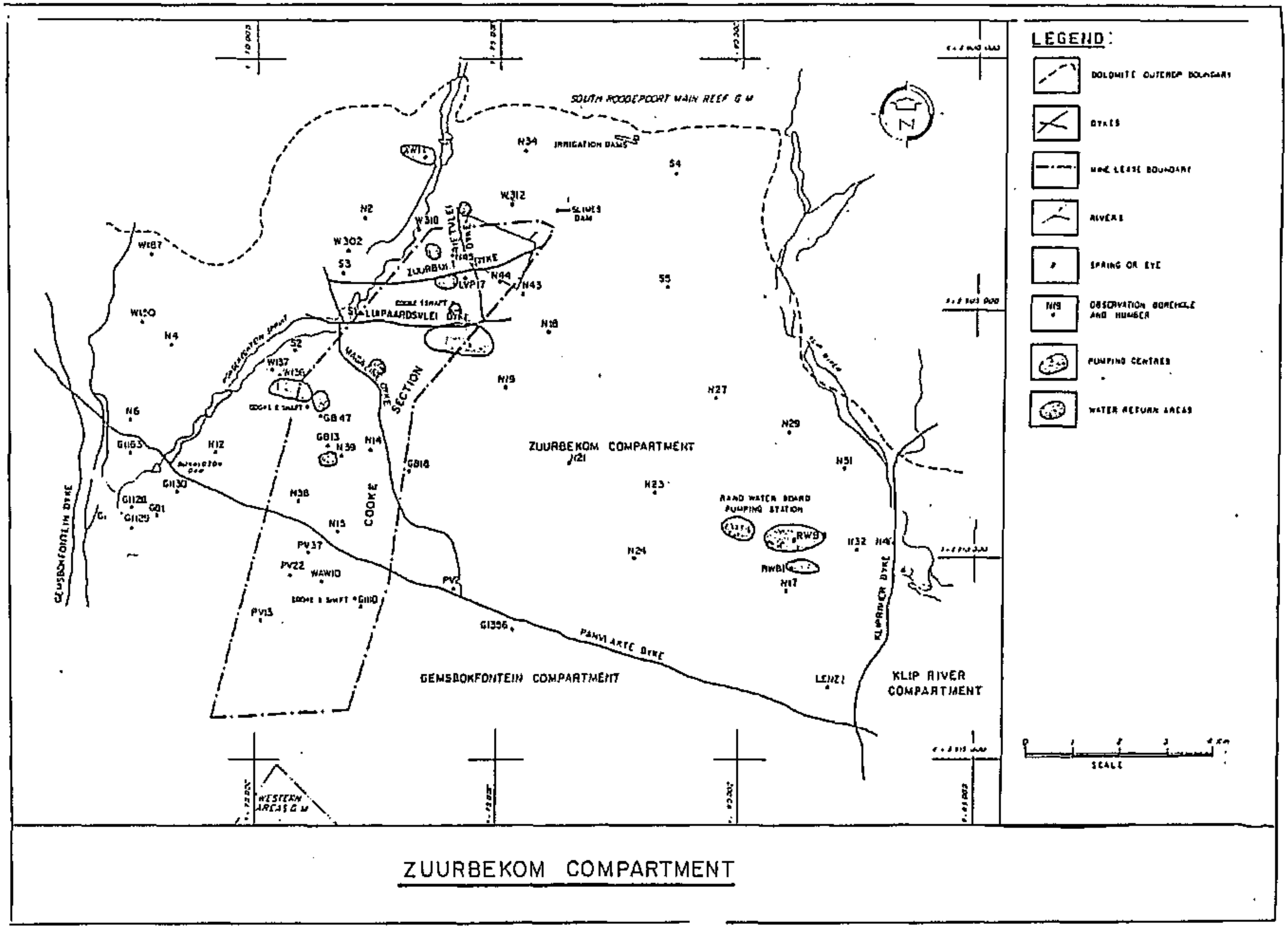

FIG F.2 Site plan showing borehole positions

4. CATCHMENT DESCRIPTION

4.1 Topography

The topography is characteristically highveld and consists of a smooth, flat surface ranging in elevation from 1500 to 1700 m.a.m.s.l. The ground surface slopes gently from the south east and north west towards the Wonderfontein Spruit (Fig F2).

4.2 Available photography

Air photographs at a scale of approximately 1:50 000 are available as well as 1:10 000 orthophotographs.

4.3 Geology

4.3.1 Stratigraphy

The rocks underlying the area consist of dolomites of the Malmoni subgroup of the Chuniespoort series together with the weathering products, as well as areas of karoo sediments, infilling topographic lows in the dolomite surface.

The dolomite is a mixture of dolomite, dolomitic limestone and cherty dolomite with intercalated chert beds and nodules.

4.3.2 Structure

The dolomites were subjected to repeated phases of folding, which has left them dipping about 20' to the south and wedging out to the north against the basal conglomerates of the Black Reef.

At various tectonic events, diabase dykes and sills have intruded. Major northerly trending syenitic dykes of Pilansberg age, form the major north south compartment boundaries, and the east west trending dykes are of a later age (Day 1980) but are still pre-karoo.

Jointing is very well developed in north westerly and north easterly directions. Solution weathering has widened these joints and the joint pattern is recognisable on detailed gravity surveys carried out by JCI. The major joints are recognisable on landsat imagery. The structural geology is represented in fig F3.

4.3.3. Weathering and soils

The dolomites are extensively weathered, particularly along the major joints. Drilling has shown decomposed dolomite and wad to depths of more than 200m. The bedrock surface is consequently very irregular and pinnacled. In the upper part of the weathering profile, chert nodules are common. The near surface is littered with chert rubble in some areas. The whole area is overlain by kalahari sand up to 1,5m in thickness.

The "soil" profile is often greater than 10m thick and these thicknesses are significant in terms of the mode of recharge. Recharge should primarily be through the soil profile and a limited amount would be direct, bypassing the soil profile.

The soils have been mapped by the Dept of Agriculture and the distribution of soils is shown in fig F4.* The main soil type is a Hutton which consists of sandy loam or sandy clay loam with chert gravel.

* Fig F4 is enclosed in envelope at end of document.

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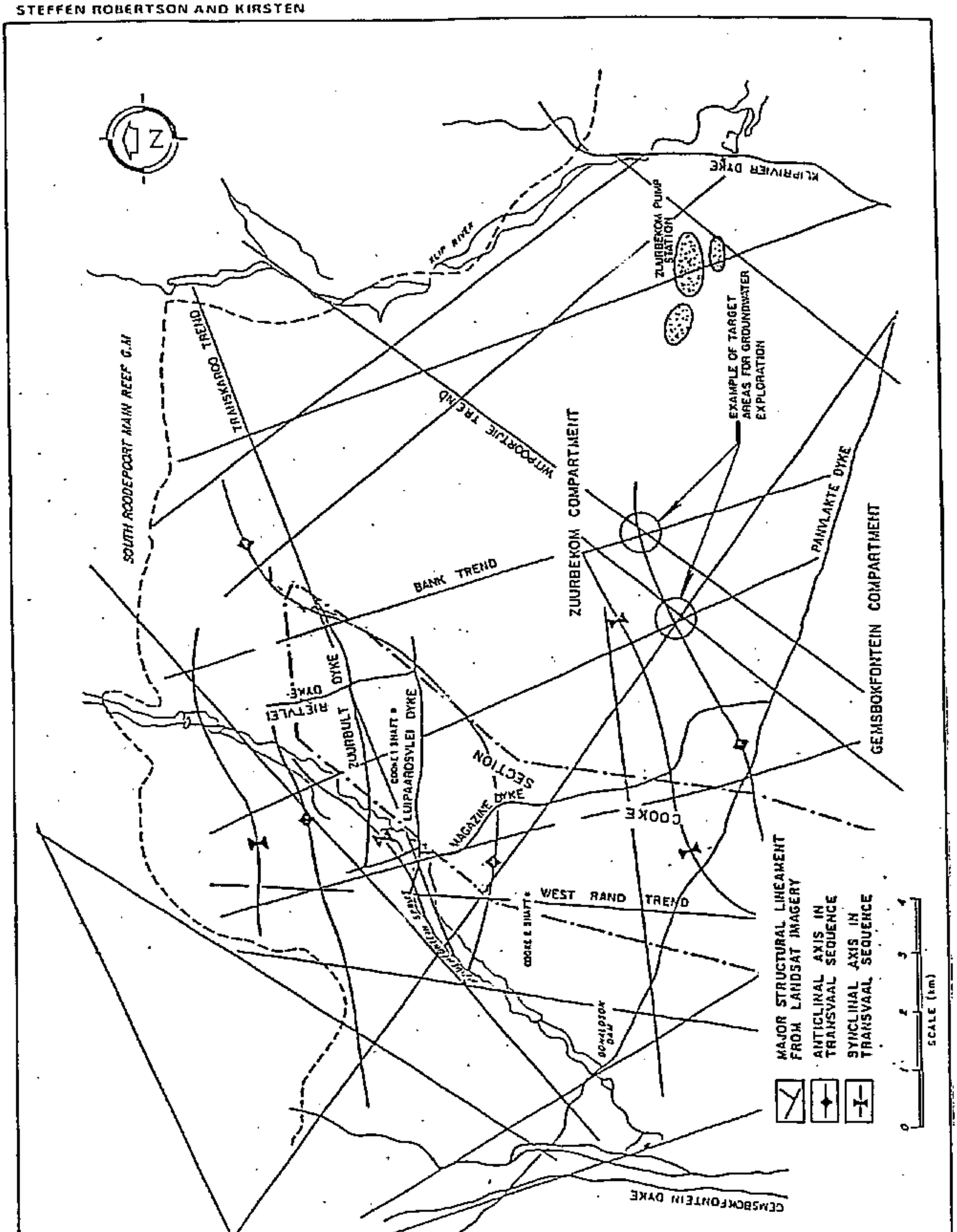

FIG F.3 GEOLOGICAL STRUCTURE OF ZUURBEKOM COMPARTMENT

4.4 Hydrology

Two water courses cross the area as shown on fig F2. The Wonderfontein Spruit in the west feeding from the north into Donaldson dam, and the klip river which flows southwards along part of the eastern boundary of the compartment. Both streams are perennial.

4.5 Hydrogeology

Development of permeability and karst in the dolomites is described by Fleischer (1981) and is not repeated here.

The resultant hydrogeological model is described by Connelly (1987) as one of very high transmissivity and storage along the solution weathered joints with very low transmissivity and storage in the rock mass. The progressively downward migration of the water table in geological time has resulted in high transmissivity and storage in the zone of active water table fluctuation with rapid decreases with depth, in the less weathered material.

These details influence mine dewatering and water supply but do not influence recharge from rainfall.

The depth to water table is variable but is generally greater than 20 metres.

The original ground water flow regime was the eastern two thirds of the compartment flowed towards the south east towards the Klipriver eye. The Rand Water Board pumping station subsequently increased hydraulic gradients towards the south east but the extraction of 25 Ml/day did not materially lower water levels.

Ground water in the western third of the compartment flows towards the Wonderfontein Spruit.

As soon as Cooke 1 and 2 shafts began dewatering in the early 1980's, the impact on ground water flow was evident.

Contours of piezometric surface are shown in fig F5 for January 1983. Piezometric records through to the present, indicate continual changes in the contours in Zuurbekom and Gemsbokfontein due to variations in the discharges, artificial and natural recharges.

Continuous water level recorders have shown the piezometric surface to respond to diurnal earthtide changes (Fleisher 1981). This implies semi confined or confined aquifer conditions.

In terms of aquifer characteristics, Transmissivity ranges from about 250m^2/day to several thousand m^2/day, and is highly anisotropic. The storage coefficient is also very variable, but an average value for the Zuurbekom dolomite of 1,3 was calculated (SRK 1983). In the highly transmissive zones, storage values of the order of 10% could be found, decreasing rapidly with depth.

4.6 Climate

The climate is sub-humid with typical summer rainfall and dry winters, although precipitation occurs from about September through to May. The highest occurs from November to February. The mean annual rainfall decreases from 700 mm in the east to 590 mm in the west (Fleischer 1981). Most of the rain occurs as storm events, resulting in marked variations in rainfall events between stations.

4.7 Land use

Most of the catchment area is owned either by RECM or the RWB and has been left as pasture. There is some agricultural activity and some urban development. The land use is illustrated on Dwg 3346/21. Fig. 4 is attached to the back of Appendix F.

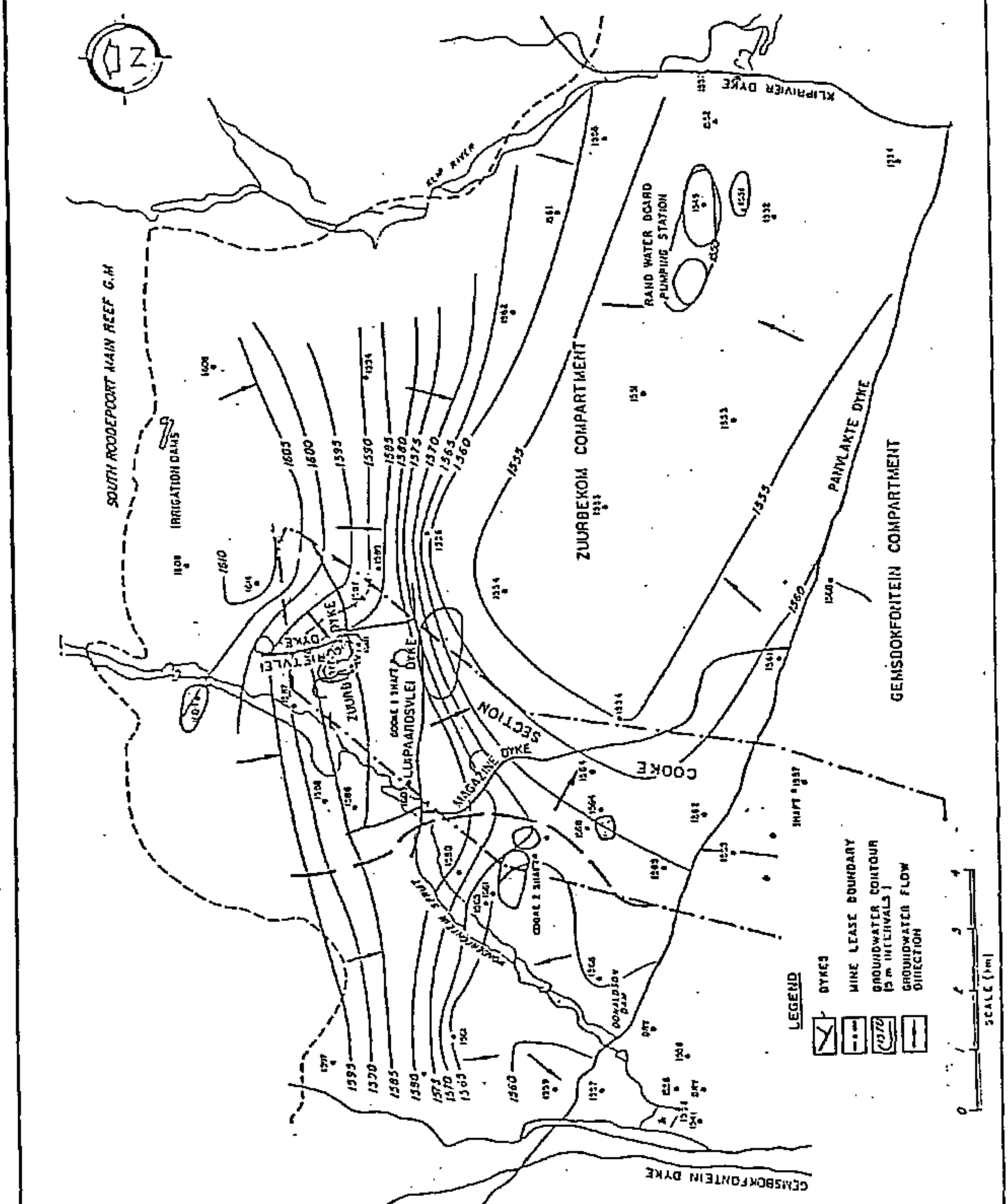

FIG F.5 GROUNDWATER CONTOURS : JANUARY 1983

5. CATCHMENT INSTRUMENTATION

At the start of the project there were 23 boreholes equipped with autographic water level recorders and a further 13 monthly-monitored boreholes in the compartment. It was therefore considered that no further monitoring boreholes or instrumentation would be required.

There were two streamflow gauging stations located on the Wonderfontein Spruit but due to remedial works on the dam these could not be recalibrated.

Three daily weather stations are located in the compartment and several others are sited in the near vicinity. An additional autographic rain gauge was installed to provide a continuous record of meteorological conditions.

The field work and instrumentation consisted of:-

- Trial pits for determining soil moisture characteristics;
- Installation of 61 access tubes for troxler soil moisture measurements;
- Installation of tensiometers and moisture blocks;
- 1 Autographic rain gauge

The project was planned so that the personnel initially monitoring the boreholes and gauging stations could continue to do so. The monitoring of the tension meters and lysimeters was done by a technician from Steffen, Robertson & Kirsten.

6. MONITORING AND DATA ACQUISITION

Dwg 3346/22 shows the access tubes and monitoring points as originally established. Due to difficulties of reading all the tubes within a reasonable time period, and destruction of some of the tensiometers, the ongoing monitoring was reduced to 8 sites. These sites have been renumbered for convenience. The new numbers are shown on dwg 3346/22 and have been used in the data records for site identification. The new numbers are as follows:

NEW NO	OLD NO
1	12
2	32
3	23
4	8
5	64
6	68
7	2
8	47
9	46

6.1 Regular monitoring

The following table summarises the weather station data.

WEATHER STATION DATA

PARAMETER	PERIOD FROM :	TO :
Daily rainfall	10.12.84	11.3.87
Daily evaporation	15.03.85	26.02.87
Daily temp, humidity and pressure	15.11.84	26.02.87
Daily windspeed	20.03.86	12.02.87
Daily sunlight	Instrument not working properly	

Daily rainfall and evaporation figures were digitised and captured on disk. (Appendix F 1). All other data has been recorded but not captured on disk.

- Access tubes No 2, 3, 5, 6, 7, 8 and 9 were monitored regularly on a weekly basis using the Troxler moisture density gauge, and the results down loaded onto disk. Summary records of Troxler profiles are presented in Appendix F2.

- Tensiometer and moisture block readings

  Four tensiometers and four moisture blocks were installed at access tube 8 and four tensiometers and eight moisture blocks at site 2. Tensiometers at site 3 were never operative. The tensiometers were monitored on a weekly basis initially in 1985 then from 21.02.86 to 19.11.86 but were finally destroyed by vandalism in November 1986. Tensiometer records are presented in Appendix F 3.

  Dwg 3346/22 shows the positions of the access tubes and tensiometers installed by SRK. The existing boreholes and weather stations are also shown.

  The layout of access tubes was decided to assess the spatial variation in soil moisture conditions after rainfall events, within a single soil type as well as in different morphological and soil areas. In practice it was found that it was not possible to record the data from so many holes in a reasonable period of time after a rainfall event, and selected tubes were monitored on an ongoing basis.

- weather station

The weather station was located within the fenced area of Cooke 2 shaft, and mine personnel assisted in running the station. Details of the location and layout of the station are shown in figs F6 and F7.

For the other instruments, the various landowners were contacted for access permission.

Protection of instruments was a problem. Access tubes were not a problem provided they were out of the way, as there was nothing to damage.

- water level records

Water level data recorded on a monthly basis as well as by continuous water level recorders was collected by DWA. This data has been summarised by Fleischer (1981).

Figure F 8 shows automatic water level records versus rainfall for borehole SS55 over the rainy season of 1975 - 1976. The conclusion drawn by Fleischer was that there is a component of immediate recharge followed by a delayed recharge of 4 to 6 months. In an area of no rock outcrop, it is not clear by what method the direct recharge gets to the ground water.

Figure F 9 shows water level responses over a longer period for boreholes W302 and W187. The graph shows substantial water level rises after the heavy rains of 1970/71 and 75/76.

F.16.

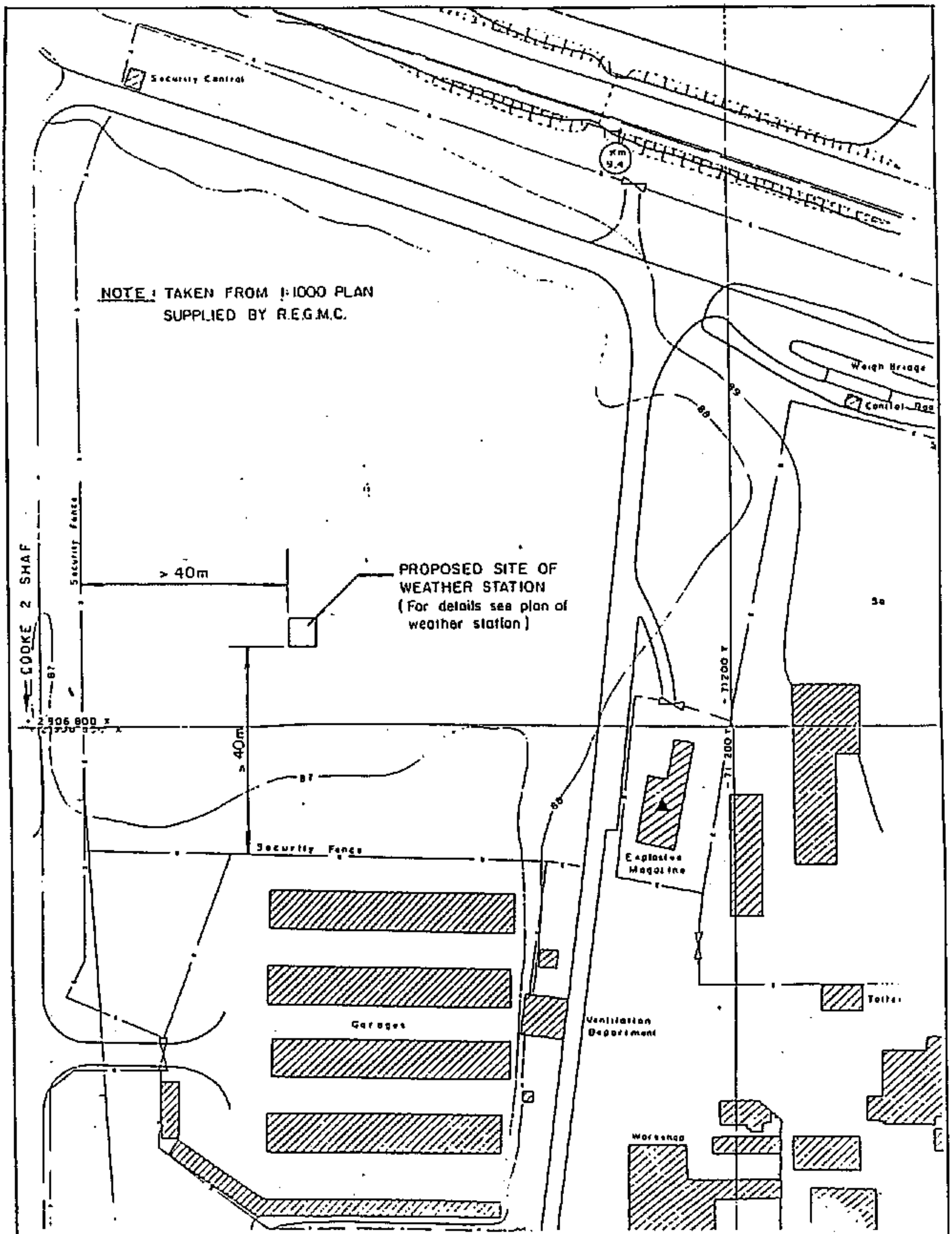

FIG.F.6 ZUURBEKOM : PROPOSED SITE OF WEATHER STATION

SCALE 1:1000

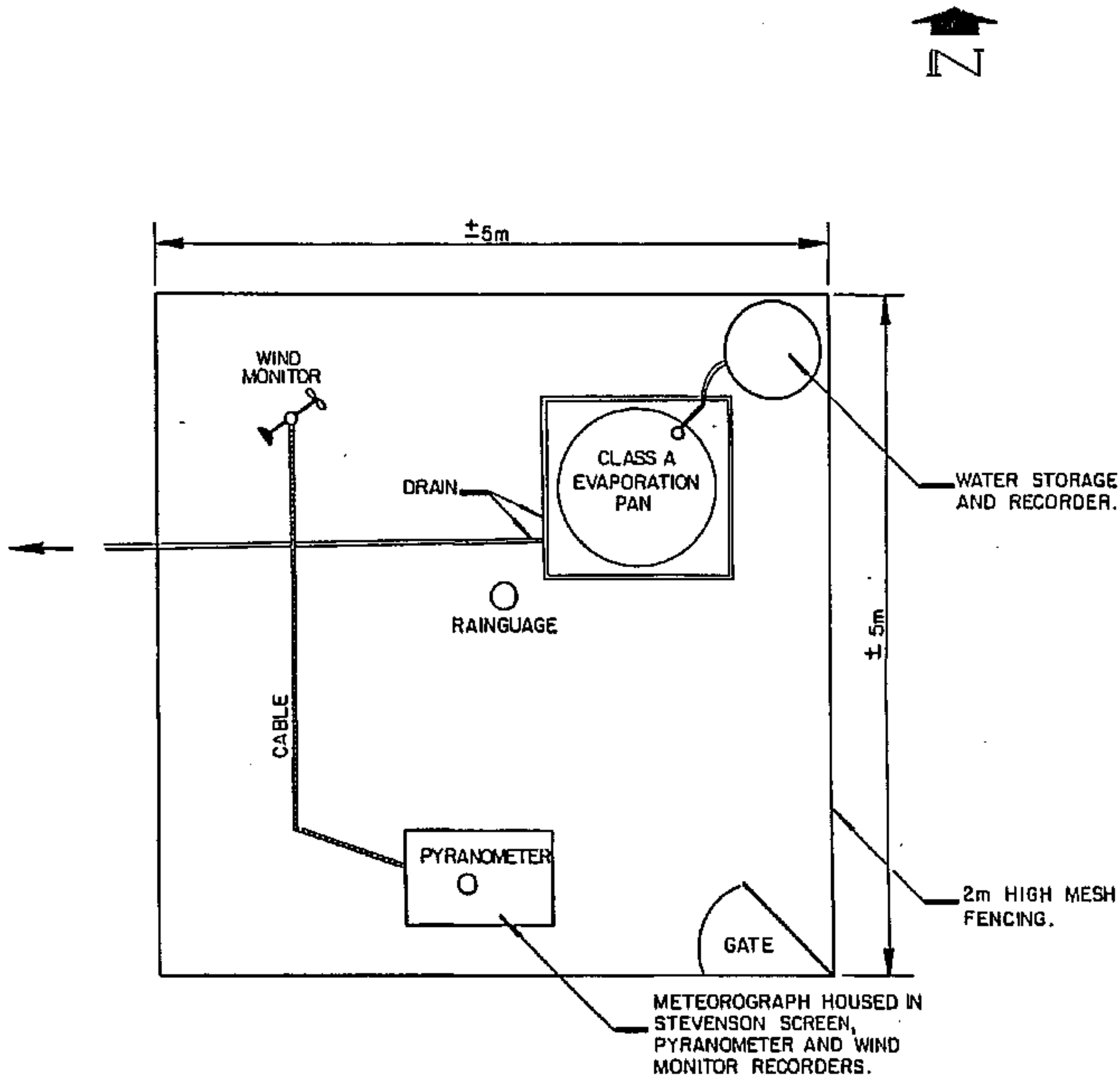

FIG F.7 PLAN OF WEATHER STATION

SCALE 1:50

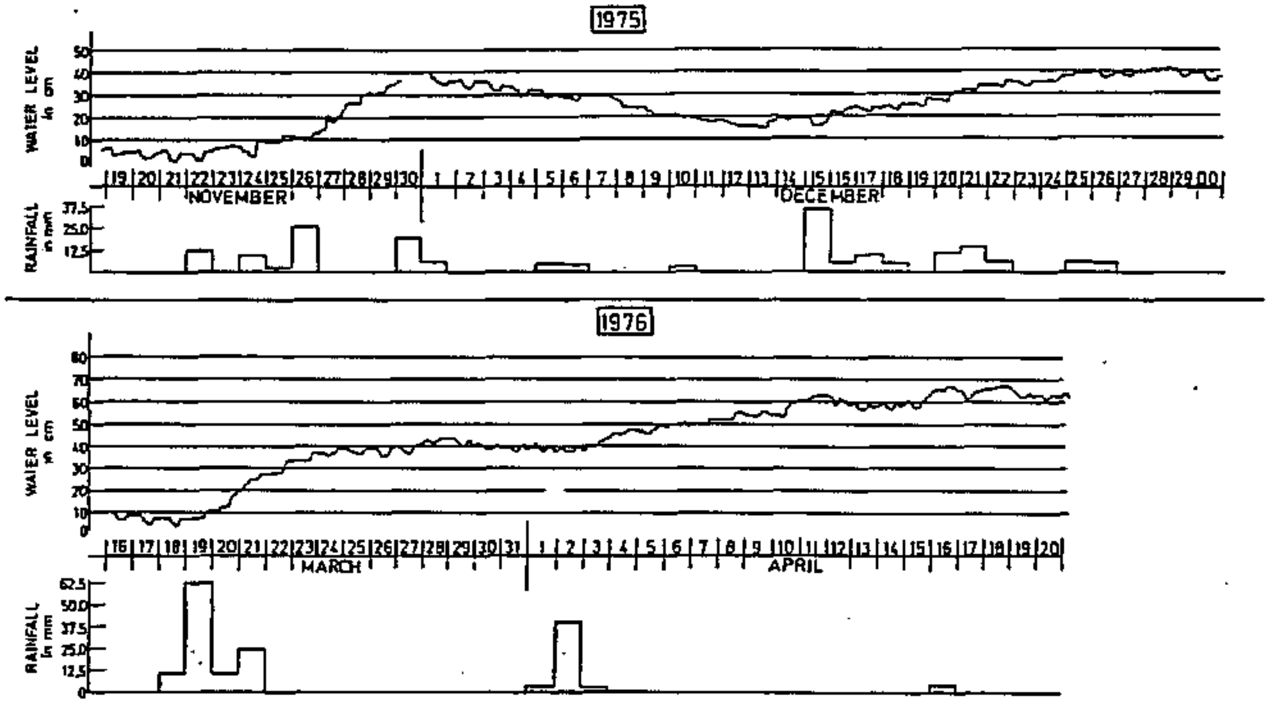

FIG F.8

AUTOMATIC WATER LEVEL RECORDING IN BOREHOLE SS55 vs DAILY RAINFALL

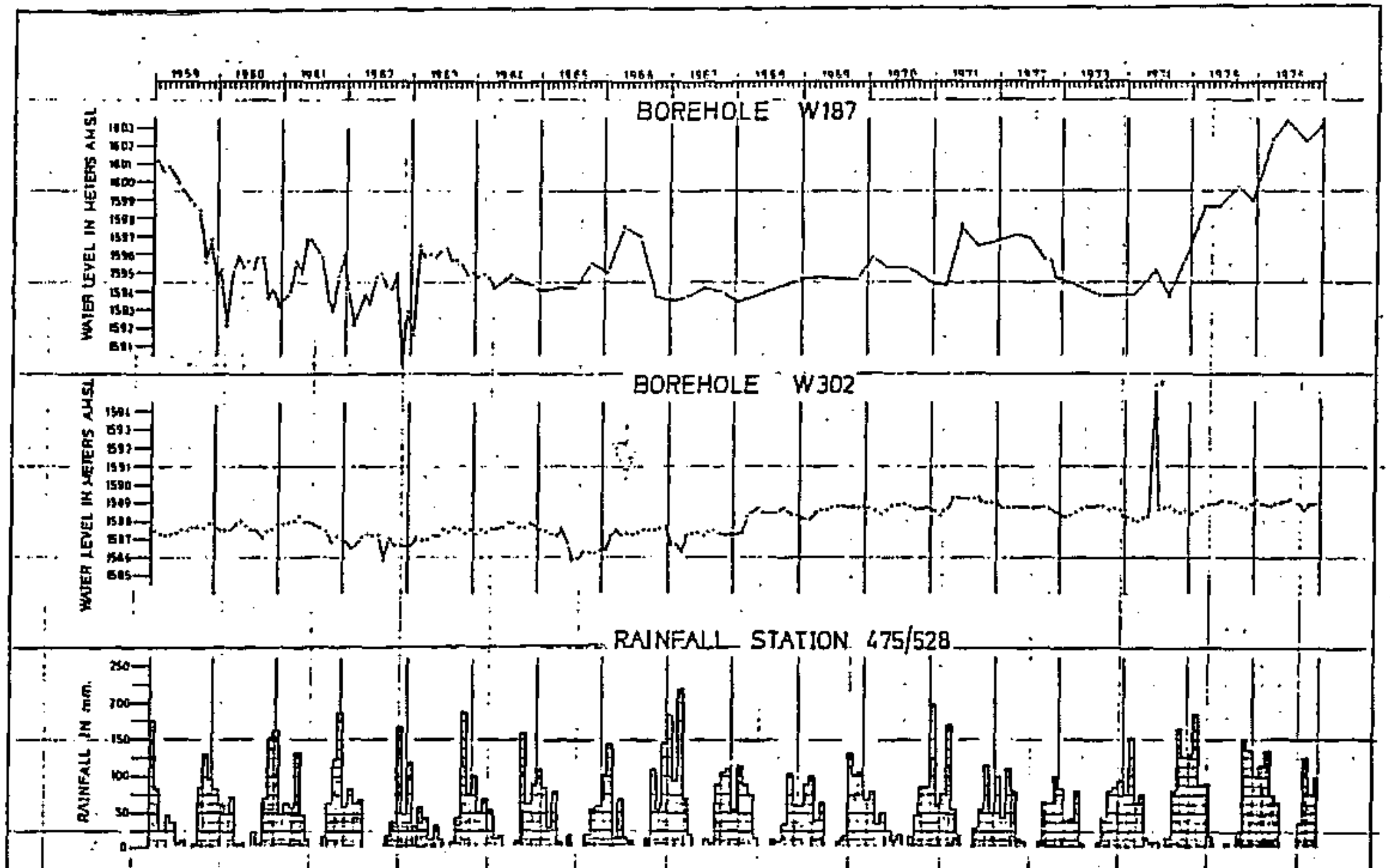

Fig. F9

MONTHLY GROUNDWATER LEVELS IN BOREHOLES
AND MONTHLY RAINFALLS

F.19.

In winter periods where very little rain falls, it is apparent that there is a considerable recession of the water table in some boreholes. The period of 1959 to 1963 in borehole W187 illustrates this. This would presumably mean that extractions of natural flow was drawing off storage.

The fact that water levels fluctuated within the same bounds each year ie there has been no net drawdown over the past fifty years or so, would suggest that the extraction by RWB has been similar to the flow that would have occurred at the Klipfontein eye.

6.2 Specific testing

6.2.1 Infiltration tests

Three double ring infiltration tests were done in July 1985 at various sites in the catchment. The methodology has been described in appendix F4.

The first series of tests were carried out by setting up the 3 rings at one site to assess the infiltration characteristics of the soil.

One test was a control test and no water was added. 50mm and 100mm of water were added to the other inner rings. The time for infiltration was measured and after 24 hours, soil samples were obtained at 100 mm intervals with a selby auger. The moisture contents and densities of those samples were then measured in the laboratory.

Test 1 was done near access tube 8.
Test 2 was done near access tube 3.
Test 3 was done near access tube 2.

During the tests the migration of the wetting front was monitored using the troxler in the access tubes. Permeabilities were then calculated.

The results are presented in Appendix F 5.

7. RECHARGE ESTIMATES

Under natural conditions, the outflow from the dolomite compartments of the Far West Rand at Springs was equivalent to the natural recharge. Assuming no net lateral flow losses, the Klip River Eye was formerly the main outlet for Zuurbekom Compartment. Abstraction at Zuurbekom pump station lowered the water table in the vicinity of the eye, causing it to cease flowing, except after exceptional rainfall. Taking annual abstraction at the pump station to be equivalent to outflow at the eye gives a recharge figure of 12% (SRK, 1983). Enslin and Kriel (1967) arrived at a similar figure of 13%. Fleischer (1981) derived a figure of 12,8% for the Gemsbokfontein Compartment using a ground water balance equation. The average annual recharge to Zuurbekom Compartment has been calculated at $12 \times 10^6 m^3$ for the period 1972 to 1982 (SRK, 1983).

$$P + L + E_S + E_T = R_N + R_A + I_s \pm S$$

where

P	=	Ground water abstraction
L	=	Leakage from the compartment
E_S	=	Effluent seepage
E_T	=	Evapotranspiration of ground water
R_N	=	Natural recharge
R_A	=	Artificial recharge
I_s	=	Influent seepage
S	=	Change in storage

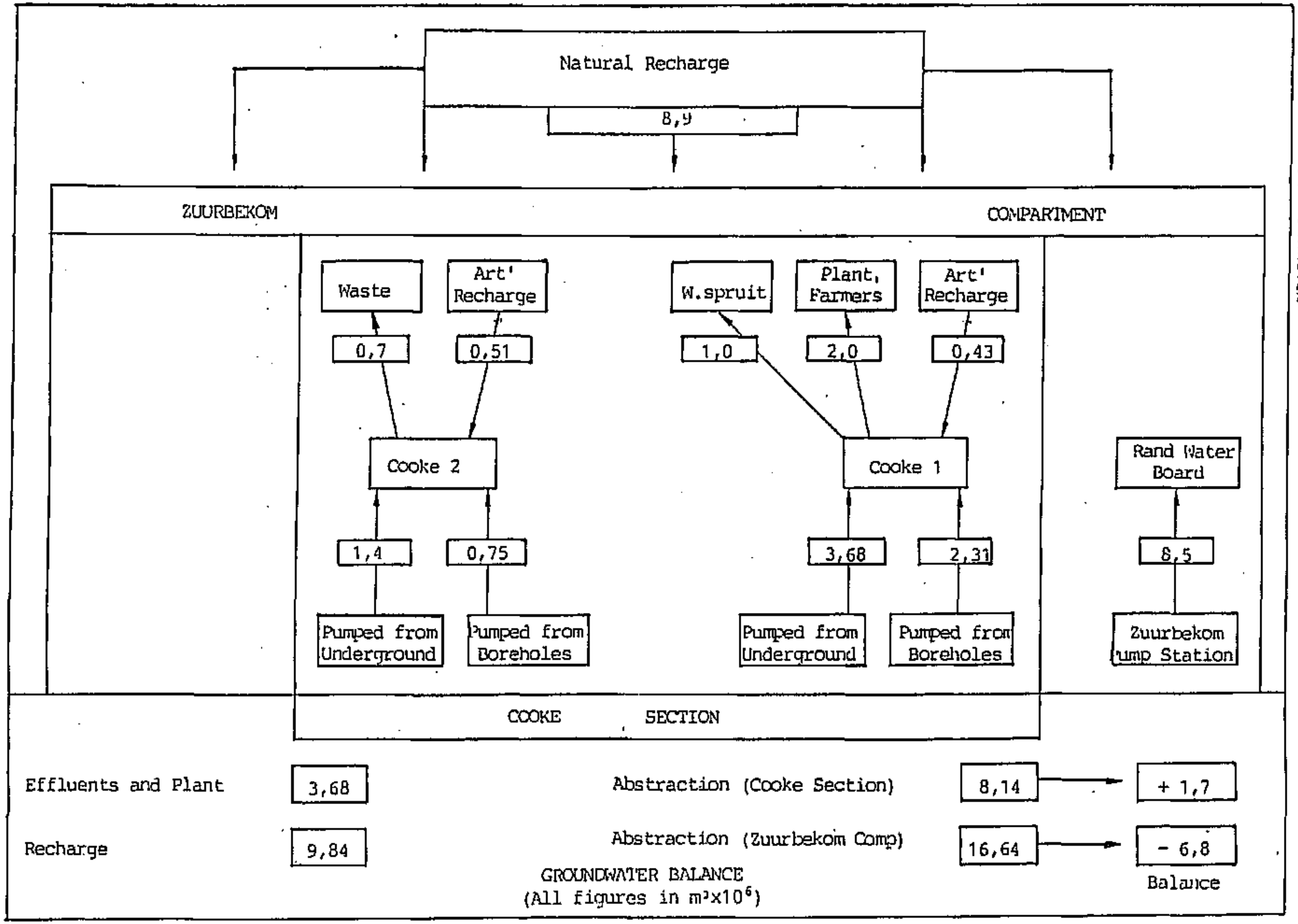

FIG F.11 Ground water balance Zuurbekom compartment, 1982

The terms E_S, E_T and I_S are not well defined in the Compartment. In comparison to the other terms of the equation, which are well defined, they are considered insignificant and will be ignored.

Ground water abstraction takes place at two main centres, Zuurbekom pump station and Cooke Section of Randfontein Estates Gold Mine. These qualities are metered. Leakage from the compartment takes place into the underground mine workings at Cooke Section and this is also monitored. Leakage through the bounding dykes of the Compartment is unknown. Natural recharge has been estimated as previously discussed and artificial recharge at Cooke Section is metered. Thus the Components of the ground water balance equation for Zuurbekom Compartment are largely quantified. A balance has been drawn up for 1982 and is shown in Fig F11. Substituting these figures into the balance equation gives:

$$11,56^{*}(P) + 5,1\ (L) = 8,9\ (R_N) + 0,94(R_A) \pm S$$

$$16,7 = 9,84 \pm S$$

$$S = 6,9 \times 10^6 m^3.$$

* All figures in $m^3 \times 10^6$

This indicates that in 1982 ground water was 'mined' from storage in the Compartment.

APPENDIX F 1

DAILY RAINFALL AND EVAPORATION

SITE	DATE yr-mn-dy	RAIN (mm)	EVAPORATION (mm)
ZUURBE	85 1 1	0.0	15.0
ZUURBE	85 1 2	0.0	15.0
ZUURBE	85 1 3	0.25	15.0
ZUURBE	85 1 4	0.5	15.0
ZUURBE	85 1 5	4.0	15.0
ZUURBE	85 1 6	6.5	15.0
ZUURBE	85 1 7	0.0	15.0
ZUURBE	85 1 8	3.25	15.0
ZUURBE	85 1 9	0.0	15.0
ZUURBE	85 110	14.25	15.0
ZUURBE	85 111	0.0	15.0
ZUURBE	85 112	0.0	15.0
ZUURBE	85 113	0.0	15.0
ZUURBE	85 114	0.0	15.0
ZUURBE	85 115	3.0	15.0
ZUURBE	85 116	7.75	15.0
ZUURBE	85 117	12.0	15.0
ZUURBE	85 118	0.0	15.0
ZUURBE	85 119	0.0	15.0
ZUURBE	85 120	0.0	15.0
ZUURBE	85 121	0.0	15.0
ZUURBE	85 122	2.0	15.0
ZUURBE	85 123	0.0	15.0
ZUURBE	85 124	10.25	15.0
ZUURBE	85 125	0.25	15.0
ZUURBE	85 126	0.0	15.0
ZUURBE	85 127	0.25	15.0
ZUURBE	85 128	0.0	15.0
ZUURBE	85 129	14.0	15.0
ZUURBE	85 130	6.25	15.0
ZUURBE	85 131	0.0	12.0
ZUURBE	85 2 1	0.0	12.0
ZUURBE	85 2 2	0.0	12.0
ZUURBE	85 2 3	0.0	12.0
ZUURBE	85 2 4	0.0	12.0
ZUURBE	85 2 5	0.0	12.0
ZUURBE	85 2 6	0.0	12.0
ZUURBE	85 2 7	7.0	12.0
ZUURBE	85 2 8	14.5	12.0
ZUURBE	85 2 9	0.0	12.0
ZUURBE	85 210	0.0	12.0
ZUURBE	85 211	0.0	12.0
ZUURBE	85 212	0.0	12.0
ZUURBE	85 213	1.5	12.0
ZUURBE	85 214	5.5	12.0
ZUURBE	85 215	0.0	12.0
ZUURBE	85 216	0.0	12.0
ZUURBE	85 217	0.0	12.0

SITE	DATE yr-mn-dy	RAIN (mm)	EVAPORATION (mm)
ZUURBE	85 218	0.0	12.0
ZUURBE	85 219	0.0	12.0
ZUURBE	85 220	1.0	12.0
ZUURBE	85 221	0.0	12.0
ZUURBE	85 222	0.5	12.0
ZUURBE	85 223	0.0	12.0
ZUURBE	85 224	0.0	12.0
ZUURBE	85 225	5.0	12.0
ZUURBE	85 226	0.5	12.0
ZUURBE	85 227	17.0	12.0
ZUURBE	85 228	0.0	12.0
ZUURBE	85 3 1	0.0	11.0
ZUURBE	85 3 2	2.25	11.0
ZUURBE	85 3 3	0.0	11.0
ZUURBE	85 3 4	0.0	11.0
ZUURBE	85 3 5	0.0	11.0
ZUURBE	85 3 6	0.0	11.0
ZUURBE	85 3 7	0.0	11.0
ZUURBE	85 3 8	0.0	11.0
ZUURBE	85 3 9	0.0	11.0
ZUURBE	85 310	0.0	11.0
ZUURBE	85 311	0.0	11.0
ZUURBE	85 312	0.0	11.0
ZUURBE	85 313	0.0	11.0
ZUURBE	85 314	3.0	11.0
ZUURBE	85 315	0.0	11.0
ZUURBE	85 316	0.0	11.0
ZUURBE	85 317	1.0	11.0
ZUURBE	85 318	0.0	11.0
ZUURBE	85 319	0.0	11.0
ZUURBE	85 320	0.0	3.0
ZUURBE	85 321	0.0	27.0
ZUURBE	85 322	0.0	17.0
ZUURBE	85 323	0.0	1.5
ZUURBE	85 324	0.0	8.5
ZUURBE	85 325	0.0	9.5
ZUURBE	85 326	11.5	12.6
ZUURBE	85 327	0.0	13.0
ZUURBE	85 328	0.0	3.5
ZUURBE	85 329	0.0	17.0
ZUURBE	85 330	0.0	17.0
ZUURBE	85 331	0.0	1.5
ZUURBE	85 4 1	0.0	8.5
ZUURBE	85 4 2	0.0	9.5
ZUURBE	85 4 3	0.0	12.6
ZUURBE	85 4 4	0.0	13.0
ZUURBE	85 4 5	0.0	1.5
ZUURBE	85 4 6	1.0	8.5

SITE	DATE yr-mn-dy	RAIN (mm)	EVAPORATION (mm)
ZUURBE	85 4 7	2.0	9.
ZUURBE	85 4 8	0.0	3.
ZUURBE	85 4 9	0.0	3.
ZUURBE	85 410	0.0	3.
ZUURBE	85 411	0.0	3.
ZUURBE	85 412	0.0	5.
ZUURBE	85 413	0.0	11.
ZUURBE	85 414	0.0	2.
ZUURBE	85 415	0.0	6.
ZUURBE	85 416	0.0	4.
ZUURBE	85 417	0.0	11.
ZUURBE	85 418	0.0	10.
ZUURBE	85 419	0.0	11.
ZUURBE	85 420	0.0	10.
ZUURBE	85 421	0.0	13.
ZUURBE	85 422	0.0	13.
ZUURBE	85 423	0.0	0.
ZUURBE	85 424	0.0	5.
ZUURBE	85 425	0.0	1.
ZUURBE	85 426	0.0	9.
ZUURBE	85 427	0.0	9.
ZUURBE	85 428	0.0	10.
ZUURBE	85 429	0.0	6.
ZUURBE	85 430	0.0	12.
ZUURBE	85 5 1	0.0	1.
ZUURBE	85 5 2	3.75	5.
ZUURBE	85 5 3	0.0	5.
ZUURBE	85 5 4	0.0	5.
ZUURBE	85 5 5	0.0	13.
ZUURBE	85 5 6	0.0	6.
ZUURBE	85 5 7	0.0	6.
ZUURBE	85 5 8	0.0	1.
ZUURBE	85 5 9	0.0	0.
ZUURBE	85 510	0.0	8.
ZUURBE	85 511	0.0	11.
ZUURBE	85 512	7.0	6.
ZUURBE	85 513	0.0	6.
ZUURBE	85 514	0.0	6.
ZUURBE	85 515	0.0	6.
ZUURBE	85 516	0.0	6.
ZUURBE	85 517	0.0	3.
ZUURBE	85 518	0.0	9.
ZUURBE	85 519	0.0	
0.25			
ZUURBE	85 520	0.0	5.
ZUURBE	85 521	0.0	4.
ZUURBE	85 522	0.0	14.
ZUURBE	85 523	0.0	10.
ZUURBE	85 524	0.0	16.

ZUURBE	85 525	0.0	4.0
ZUURBE	85 526	0.0	4.0
ZUURBE	85 527	0.0	4.0
ZUURBE	85 528	0.0	0.1
ZUURBE	85 529	0.0	0.5
ZUURBE	85 530	0.0	3.0
ZUURBE	85 531	0.0	7.0
ZUURBE	85 6 1	0.0	9.0
ZUURBE	85 6 2	0.0	5.0
ZUURBE	85 6 3	0.0	5.0
ZUURBE	85 6 4	0.0	5.0
ZUURBE	85 6 5	0.0	3.0
ZUURBE	85 6 6	0.0	3.5
ZUURBE	85 6 7	0.0	3.5
ZUURBE	85 6 8	0.0	6.5
ZUURBE	85 6 9	0.0	13.0
ZUURBE	85 610	0.0	13.0
ZUURBE	85 611	0.0	7.0
ZUURBE	85 612	0.0	1.0
ZUURBE	85 613	0.0	1.0
ZUURBE	85 614	0.0	1.0
ZUURBE	85 615	0.0	1.0
ZUURBE	85 616	0.0	1.0
ZUURBE	85 617	0.0	0.5
ZUURBE	85 618	0.0	1.5
ZUURBE	85 619	0.0	5.0
ZUURBE	85 620	0.0	13.5
ZUURBE	85 621	0.0	0.5
ZUURBE	85 622	0.0	12.5
ZUURPE	85 623	0.0	
ZUURBE	85 624	0.0	9.5
ZUURBE	85 625	0.0	0.5
ZUURBE	85 626	0.0	6.5
ZUURBE	85 627	0.0	8.0
ZUURBE	85 628	0.0	9.5
ZUURBE	85 629	0.0	0.5
ZUURBE	85 630	0.0	9.5
ZUURBE	85 7 1	0.0	6.5
ZUURBE	85 7 2	0.0	5.0
ZUURBE	85 7 3	0.0	5.0
ZUURBE	85 7 4	0.0	10.0
ZUURBE	85 7 5	0.0	18.0
ZUURBE	85 7 6	0.0	7.5
ZUURBE	85 7 7	0.0	0.1
ZUURBE	85 7 8	0.0	0.1
ZUURBE	85 7 9	0.0	13.0
ZUURBE	85 710	0.0	4.5
ZUURBE	85 711	1.5	7.0
ZUURBE	85 712	0.0	1.0
ZUURBE	85 713	0.0	1.0
ZUURBE	85 714	0.0	1.0
ZUURBE	85 715	0.0	1.0
ZUURBE	85 716	0.0	1.0
ZUURBE	85 717	0.0	0.5
ZUURBE	85 718	0.0	1.5
ZUURBE	85 719	0.0	5.0
ZUURBE	85 720	0.0	13.5
ZUURBE	85 721	0.0	0.5
ZUURBE	85 722	0.0	12.5
ZUURBE	85 723	0.0	0.25
ZUURBE	85 724	0.0	9.5
ZUURBE	85 725	0.0	0.5
ZUURBE	85 726	0.0	6.5
ZUURBE	85 727	0.0	8.0
ZUURBE	85 728	0.0	9.5
ZUURBE	85 729	0.0	0.5
ZUURBE	85 730	0.0	9.5
ZUURBE	85 731	0.0	6.5
ZUURBE	85 8 1	0.0	5.0
ZUURBE	85 8 2	0.0	5.0
ZUURBE	85 8 3	0.0	10.0
ZUURBE	85 8 4	0.0	18.0
ZUURBE	85 8 5	0.0	7.5
ZUURBE	85 8 6	0.0	0.1
ZUURBE	85 8 7	0.0	0.1
ZUURBE	85 8 8	0.0	13.0
ZUURBE	85 8 9	0.0	4.5
ZUURBE	85 810	0.0	7.0
ZUURBE	85 811	0.0	5.0
ZUURBE	85 812	0.0	0.5
ZUURBE	85 813	0.0	16.0
ZUURBE	85 814	0.0	0.0
ZUURBE	85 815	0.0	11.0
ZUURBE	85 816	0.0	7.0
ZUURBE	85 817	0.0	13.0
ZUURBE	85 818	0.0	7.0
ZUURBE	85 819	0.0	8.0
ZUURBE	85 820	0.0	10.0
ZUURBE	85 821	0.0	10.0
ZUURBE	85 822	0.0	6.0
ZUURBE	85 823	0.0	11.5
ZUURBE	85 824	0.0	12.5
ZUURBE	85 825	0.0	10.0
ZUURBE	85 826	0.0	13.5
ZUURBE	85 827	0.0	1.0
ZUURBE	85 828	0.0	12.5
ZUURBE	85 829	0.0	7.0
ZUURBE	85 830	0.0	18.
ZUURBE	85 831	9.25	14.
ZUURBE	85 9 1	0.0	14.
ZUURBE	85 9 2	0.0	14.
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ZUURBE	85 9 4	0.0	7.
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ZUURBE	85 9 7	0.0	7.
ZUURBE	85 9 8	0.0	7.
ZUURBE	85 9 9	0.0	7.
ZUURBE	85 910	0.0	7.
ZUURBE	85 911	0.0	7.
ZUURBE	85 912	0.0	14.
ZUURBE	85 913	0.0	15.
ZUURBE	85 914	0.0	8.
ZUURBE	85 915	0.0	8.
ZUURBE	85 916	0.0	10.
ZUURBE	85 917	0.0	12.
ZUURBE	85 918	0.0	13.
ZUURBE	85 919	0.0	15.
ZUURBE	85 920	0.0	10.
ZUURBE	85 921	0.0	16.
ZUURBE	85 922	0.0	6.
ZUURBE	85 923	0.0	0.
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ZUURBE	85 925	0.0	19.
ZUURBE	85 926	3.0	22.
ZUURBE	85 927	10.25	10.
ZUURBE	85 928	0.0	28.
ZUURBE	85 929	0.0	20.
ZUURBE	85 930	0.0	20.
ZUURBE	8510 1	0.0	10.
ZUURBE	8510 2	0.0	13.
ZUURBE	8510 3	0.0	29.
ZUURBE	8510 4	0.0	12.
ZUURBE	8510 5	0.0	25.
ZUURBE	8510 6	0.0	6.
ZUURBE	8510 7	0.0	11.
ZUURBE	8510 8	0.0	8.
ZUURBE	8510 9	0.0	11.
ZUURBE	851010	0.0	10.
ZUURBE	851011	0.0	18.
ZUURBE	851012	0.0	17.
ZUURBE	851013	0.5	15.
ZUURBE	851014	3.75	12.
ZUURBE	851015	1.0	12.
ZUURBE	851016	0.0	12.
ZUURBE	851017	0.0	5.

ZUURBE	851018	10.25	10.0	ZUURBE	8512 6	0.0	6.0	ZUURBE	86 124	0.0	15.
ZUURBE	851019	0.0	23.4	ZUURBE	8512 7	0.0	12.5	ZUURBE	86 125	1.25	15.
ZUURBE	851020	0.0	23.4	ZUURBE	8512 8	10.0	16.0	ZUURBE	86 126	0.0	15.
ZUURBE	851021	0.0	21.0	ZUURBE	8512 9	20.0	22.5	ZUURBE	86 127	0.0	15.
ZUURBE	851022	0.0	12.0	ZUURBE	851210	0.0	22.5	ZUURBE	86 128	3.25	15.
ZUURBE	851023	0.0	17.0	ZUURBE	851211	0.0	22.5	ZUURBE	86 129	0.0	15.
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ZUURBE	851025	0.0	15.0	ZUURBE	851213	1.0	14.0	ZUURBE	86 131	0.0	15.
ZUURBE	851026	1.0	14.5	ZUURBE	851214	0.5	12.0	ZUURBE	86 2 1	3.0	18.
ZUURBE	851027	0.0	20.5	ZUURBE	851215	0.0	13.0	ZUURBE	86 2 2	9.0	18.
ZUURBE	851028	0.0	21.5	ZUURBE	851216	9.0	20.5	ZUURBE	86 2 3	0.0	18.
ZUURBE	851029	28.0	7.8	ZUURBE	851217	0.0	20.5	ZUURBE	86 2 4	2.0	18.
ZUURBE	851030	40.5	7.8	ZUURBE	851218	0.0	4.0	ZUURBE	86 2 5	1.5	18.
ZUURBE	851031	17.5	7.8	ZUURBE	851219	0.0	18.0	ZUURBE	86 2 6	2.75	18.
ZUURBE	8511 1	19.0	7.8	ZUURBE	851220	0.0	18.0	ZUURBE	86 2 7	0.5	18.
ZUURBE	8511 2	6.0	7.8	ZUURBE	851221	0.0	18.0	ZUURBE	86 2 8	0.0	18.
ZUURBE	8511 3	0.0	7.8	ZUURBE	851222	0.0	18.0	ZUURBE	86 2 9	0.25	23.
ZUURBE	8511 4	0.0	7.8	ZUURBE	851223	0.0	18.0	ZUURBE	86 210	1.0	20.
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ZUURBE	8511 6	0.0	7.8	ZUURBE	851225	0.0	18.0	ZUURBE	86 212	0.0	15.
ZUURBE	8511 7	0.0	7.8	ZUURBE	851226	0.0	18.0	ZUURBE	86 213	0.0	9.
ZUURBE	8511 8	6.0	7.8	ZUURBE	851227	0.0	18.0	ZUURBE	86 214	0.0	12.
ZUURBE	8511 9	0.0	7.8	ZUURBE	851228	3.25	18.0	ZUURBE	86 215	0.0	4.
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ZUURBE	851112	0.0	7.8	ZUURBE	851231	0.0	19.0	ZUURBE	86 218	0.0	9.
ZUURBE	851113	0.0	15.5	ZUURBE	86 1 1	1.5	15.0	ZUURBE	86 219	0.0	6.
ZUURBE	851114	0.0	25.5	ZUURBE	86 1 2	11.5	15.0	ZUURBE	86 220	0.0	8.
ZUURBE	851115	0.0	25.5	ZUURBE	86 1 3	0.5	15.0	ZUURBE	86 221	0.0	0.
ZUURBE	851116	0.0	23.5	ZUURBE	86 1 4	0.0	15.0	ZUURBE	86 222	0.0	0.
ZUURBE	851117	0.0	20.0	ZUURBE	86 1 5	0.0	15.0	ZUURBE	86 223	0.5	5.
ZUURBE	851118	0.0	30.0	ZUURBE	86 1 6	0.0	15.0	ZUURBE	86 224	0.0	15.
ZUURBE	851119	0.0	28.0	ZUURBE	86 1 7	0.0	15.0	ZUURBE	86 225	0.0	9.
ZUURBE	851120	1.0	19.6	ZUURBE	86 1 8	0.0	15.0	ZUURBE	86 226	0.0	14.
ZUURBE	851121	6.0	11.0	ZUURBE	86 1 9	0.0	15.0	ZUURBE	86 227	0.0	12.
ZUURBE	851122	0.0	15.5	ZUURBE	86 110	0.0	15.0	ZUURBE	86 228	0.0	4.
ZUURBE	851123	1.0	15.0	ZUURBE	86 111	0.0	15.0	ZUURBE	86 3 1	6.6	14.
ZUURBE	851124	0.5	19.5	ZUURBE	86 112	0.0	15.0	ZUURBE	86 3 2	10.0	10.
ZUURBE	851125	0.0	16.0	ZUURBE	86 113	0.0	15.0	ZUURBE	86 3 3	0.0	10.
ZUURBE	851126	18.0	17.9	ZUURBE	86 114	0.0	15.0	ZUURBE	86 3 4	0.0	14.
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ZUURBE	851128	0.0	17.9	ZUURBE	86 116	0.0	15.0	ZUURBE	86 3 6	1.0	14.
ZUURBE	851129	1.5	17.9	ZUURBE	86 117	0.0	15.0	ZUURBE	86 3 7	3.5	8.
ZUURBE	851130	4.0	17.9	ZUURBE	86 118	0.0	15.0	ZUURBE	86 3 8	0.0	8.
ZUURBE	8512 1	0.0	17.9	ZUURBE	86 119	0.0	15.0	ZUURBE	86 3 9	21.5	13.
ZUURBE	8512 2	0.0	13.0	ZUURBE	86 120	0.0	15.0	ZUURBE	86 310	4.0	13.
ZUURBE	8512 3	0.0	12.0	ZUURBE	86 121	0.0	15.0	ZUURBE	86 311	0.0	13.
ZUURBE	8512 4	1.5	14.0	ZUURBE	86 122	0.0	15.0	ZUURBE	86 312	5.0	13.
ZUURBE	8512 5	0.0	12.0	ZUURBE	86 123	0.0	15.0	ZUURBE	86 313	0.0	13.

ZUURBE	86 314	0.5	13.0
ZUURBE	86 315	0.25	13.0
ZUURBE	86 316	2.0	13.0
ZUURBE	86 317	1.0	13.0
ZUURBE	86 318	1.5	13.0
ZUURBE	86 319	0.0	13.0
ZUURBE	86 320	0.5	13.0
ZUURBE	86 321	0.0	11.0
ZUURBE	86 322	0.0	12.0
ZUURBE	86 323	0.0	9.5
ZUURBE	86 324	0.0	9.5
ZUURBE	86 325	0.0	16.0
ZUURBE	86 326	0.0	11.0
ZUURBE	86 327	0.0	6.5
ZUURBE	86 328	0.0	6.5
ZUURBE	86 329	0.0	10.0
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ZUURBE	86 4 7	0.0	8.0
ZUURBE	86 4 8	0.0	6.0
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ZUURBE	86 410	0.0	12.5
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ZUURBE	86 421	0.0	13.0
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ZUURBE	86 522	0.0	6.0
ZUURBE	86 523	0.0	4.0
ZUURBE	86 524	0.0	2.5
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ZUURBE	86 526	0.0	2.0
ZUURBE	86 527	0.0	4.0
ZUURBE	86 528	0.0	3.0
ZUURBE	86 529	0.0	2.0
ZUURBE	86 530	0.0	0.5
ZUURBE	86 531	0.0	0.5
ZUURBE	86 6 1	0.0	7.0
ZUURBE	86 6 2	0.0	11.0
ZUURBE	86 6 3	5.0	11.0
ZUURBE	86 6 4	16.5	10.0
ZUURBE	86 6 5	0.0	4.0
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ZUURBE	86 612	0.0	4.0
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ZUURBE	86 618	0.0	6.5
ZUURBE	86 619	0.0	9.
ZUURBE	86 620	0.0	0.
ZUURBE	86 621	0.0	7.
ZUURBE	86 622	0.0	0.2
ZUURBE	86 623	0.0	0.
ZUURBE	86 624	0.0	0.
ZUURBE	86 625	0.0	5.
ZUURBE	86 626	0.0	6.
ZUURBE	86 627	0.0	0.
ZUURBE	86 628	0.0	2.
ZUURBE	86 629	0.0	7.
ZUURBE	86 630	0.0	3.
ZUURBE	86 7 1	0.0	6.
ZUURBE	86 7 2	0.0	6.
ZUURBE	86 7 3	0.0	7.
ZUURBE	86 7 4	0.0	0.
ZUURBE	86 7 5	0.0	0.
ZUURBE	86 7 6	0.0	4.
ZUURBE	86 7 7	0.0	4.
ZUURBE	86 7 8	0.0	4.
ZUURBE	86 7 9	0.0	7.
ZUURBE	86 710	0.0	3.
ZUURBE	86 711	0.0	2.
ZUURBE	86 712	0.0	4.
ZUURBE	86 713	0.0	7.
ZUURBE	86 714	0.0	9.
ZUURBE	86 715	0.0	7.
ZUURBE	86 716	0.0	7.
ZUURBE	86 717	0.0	11.
ZUURBE	86 718	0.0	0.
ZUURBE	86 719	0.0	1.
ZUURBE	86 720	0.0	5.
ZUURBE	86 721	0.0	4.
ZUURBE	86 722	0.0	8.
ZUURBE	86 723	0.0	13.
ZUURBE	86 724	0.0	2.
ZUURBE	86 725	0.0	3.
ZUURBE	86 726	0.0	9.
ZUURBE	86 727	0.0	3.
ZUURBE	86 728	0.0	2.
ZUURBE	86 729	0.0	5.
ZUURBE	86 730	0.0	7.
ZUURBE	86 731	0.0	5.
ZUURBE	86 8 1	0.0	0.
ZUURBE	86 8 2	0.0	0.
ZUURBE	86 8 3	0.0	0.
ZUURBE	86 8 4	0.0	2.
ZUURBE	86 8 5	0.0	9.
ZUURBE	86 8 6	0.0	14.

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ZUURBE	86 8 7	0.0	5.0	ZUURBE	86 925	1.0	9.0	ZUURBE	861113	0.0	20.
ZUURBE	86 8 8	0.0	0.1	ZUURBE	86 926	0.0	9.0	ZUURBE	861114	0.0	16.
ZUURBE	86 8 9	0.0	0.25	ZUURBE	86 927	0.0	11.5	ZUURBE	861115	0.0	15.
ZUURBE	86 810	0.0	12.0	ZUURBE	86 928	0.0	11.0	ZUURBE	861116	0.0	21.
ZUURBE	86 811	0.0	11.0	ZUURBE	86 929	0.0	8.0	ZUURBE	861117	1.0	17.
ZUURBE	86 812	0.0	13.0	ZUURBE	86 930	0.0	12.0	ZUURBE	861118	2.25	16.
ZUURBE	86 813	0.0	9.0	ZUURBE	8610 1	0.0	12.0	ZUURBE	861119	30.75	16.
ZUURBE	86 814	0.0	0.1	ZUURBE	8610 2	3.0	11.5	ZUURBE	861120	0.0	18.
ZUURBE	86 815	0.0	2.0	ZUURBE	8610 3	0.0	11.0	ZUURBE	861121	0.0	18.
ZUURBE	86 816	0.0	12.0	ZUURBE	8610 4	0.0	8.0	ZUURBE	861122	4.25	18.
ZUURBE	86 817	0.0	18.5	ZUURBE	8610 5	0.0	12.0	ZUURBE	861123	4.5	18.
ZUURBE	86 818	0.0	13.0	ZUURBE	8610 6	6.5	6.0	ZUURBE	861124	0.0	18.
ZUURBE	86 819	0.0	2.5	ZUURBE	8610 7	0.0	10.0	ZUURBE	861125	0.0	18.
ZUURBE	86 820	0.0	7.0	ZUURBE	8610 8	0.0	6.5	ZUURBE	861126	13.0	18.
ZUURBE	86 821	0.0	0.1	ZUURBE	8610 9	1.5	14.5	ZUURBE	861127	1.0	18.
ZUURBE	86 822	0.0	2.5	ZUURBE	861010	0.0	22.0	ZUURBE	861128	3.25	18.
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ZUURBE	86 824	0.0	12.0	ZUURBE	861012	0.0	11.0	ZUURBE	861130	0.0	18.
ZUURBE	86 825	0.0	15.0	ZUURBE	861013	0.0	15.0	ZUURBE	8612 1	0.0	18.
ZUURBE	86 826	0.0	17.0	ZUURBE	861014	0.0	20.0	ZUURBE	8612 2	0.0	18.
ZUURBE	86 827	0.0	18.0	ZUURBE	861015	0.0	17.0	ZUURBE	8612 3	6.0	18.
ZUURBE	86 828	0.0	14.0	ZUURBE	861016	17.0	29.0	ZUURBE	8612 4	0.0	18.
ZUURBE	86 829	2.0	7.0	ZUURBE	861017	0.0	20.0	ZUURBE	8612 5	0.0	19.
ZUURBE	86 830	32.0	12.0	ZUURBE	861018	0.0	20.0	ZUURBE	8612 6	0.0	14.
ZUURBE	86 831	0.0	12.0	ZUURBE	861019	29.5	20.0	ZUURBE	8612 7	0.0	10.
ZUURBE	86 9 1	0.0	12.0	ZUURBE	861020	0.0	20.0	ZUURBE	8612 8	6.0	18.
ZUURBE	86 9 2	0.0	12.0	ZUURBE	861021	0.0	20.0	ZUURBE	8612 9	0.0	18.
ZUURBE	86 9 3	0.0	12.0	ZUURBE	861022	0.0	20.0	ZUURBE	861210	43.25	18.
ZUURBE	86 9 4	0.0	12.0	ZUURBE	861023	0.0	20.0	ZUURBE	861211	0.0	18.
ZUURBE	86 9 5	0.0	12.0	ZUURBE	861024	0.0	20.0	ZUURBE	861212	0.0	18.
ZUURBE	86 9 6	0.0	12.0	ZUURBE	861025	3.5	20.0	ZUURBE	861213	1.5	18.
ZUURBE	86 9 7	0.0	12.0	ZUURBE	861026	0.0	20.0	ZUURBE	861214	0.0	18.
ZUURBE	86 9 8	0.0	12.0	ZUURBE	861027	0.0	20.0	ZUURBE	861215	0.0	18.
ZUURBE	86 9 9	0.0	12.0	ZUURBE	861028	41.0	20.0	ZUURBE	861216	0.0	18.
ZUURBE	86 910	0.0	12.0	ZUURBE	861029	0.0	20.0	ZUURBE	861217	44.5	18.
ZUURBE	86 911	0.0	15.0	ZUURBE	861030	0.0	20.0	ZUURBE	861218	0.0	18.
ZUURBE	86 912	0.0	8.0	ZUURBE	861031	4.5	20.0	ZUURBE	861219	1.0	18.
ZUURBE	86 913	0.0	15.5	ZUURBE	8611 1	0.0	20.0	ZUURBE	861220	0.0	18.
ZUURBE	86 914	0.0	14.0	ZUURBE	8611 2	0.0	20.0	ZUURBE	861221	0.0	18.
ZUURBE	86 915	0.0	7.5	ZUURBE	8611 3	0.0	20.0	ZUURBE	861222	1.0	18.
ZUURBE	86 916	0.0	9.0	ZUURBE	8611 4	0.0	20.0	ZUURBE	861223	7.0	18.
ZUURBE	86 917	0.0	6.5	ZUURBE	8611 5	4.5	20.0	ZUURBE	861224	0.0	18.
ZUURBE	86 918	0.0	11.0	ZUURBE	8611 6	16.0	20.0	ZUURBE	861225	15.5	18.
ZUURBE	86 919	1.0	7.0	ZUURBE	8611 7	0.0	20.0	ZUURBE	861226	0.0	18.
ZUURBE	86 920	0.25	5.0	ZUURBE	8611 8	18.5	20.0	ZUURBE	861227	8.5	18.
ZUURBE	86 921	4.0	6.6	ZUURBE	8611 9	0.0	20.0	ZUURBE	861228	13.0	18.
ZUURBE	86 922	0.0	6.5	ZUURBE	861110	0.0	20.0	ZUURBE	861229	2.0	18.
ZUURBE	86 923	0.0	11.5	ZUURBE	861111	0.0	20.0	ZUURBE	861230	7.5	18.
ZUURBE	86 924	0.0	14.0	ZUURBE	861112	0.0	20.0	ZUURBE	861231	0.0	18.

ZUURBE	87 1 1	0.0	18.0
ZUURBE	87 1 2	0.0	18.0
ZUURBE	87 1 3	0.0	18.0
ZUURBE	87 1 4	3.0	3.8
ZUURBE	87 1 5	3.0	8.0
ZUURBE	87 1 6	0.0	5.0
ZUURBE	87 1 7	22.5	3.0
ZUURBE	87 1 8	1.5	15.0
ZUURBE	87 1 9	3.5	15.0
ZUURBE	87 110	0.0	15.0
ZUURBE	87 111	12.5	15.0
ZUURBE	87 112	0.0	15.0
ZUURBE	87 113	8.5	15.0
ZUURBE	87 114	0.0	15.0
ZUURBE	87 115	11.5	15.0
ZUURBE	87 116	0.0	15.0
ZUURBE	87 117	0.0	15.0
ZUURBE	87 118	0.0	15.0
ZUURBE	87 119	13.5	15.0
ZUURBE	87 120	10.5	15.0
ZUURBE	87 121	0.0	15.0
ZUURBE	87 122	0.0	15.0
ZUURBE	87 123	16.25	15.0
ZUURBE	87 124	0.0	15.0
ZUURBE	87 125	0.0	15.0
ZUURBE	87 126	0.0	15.0
ZUURBE	87 127	0.0	15.0
ZUURBE	87 128	0.0	15.0
ZUURBE	87 129	0.0	15.0
ZUURBE	87 130	1.0	15.0
ZUURBE	87 131	0.0	15.0
ZUURBE	87 2 1	0.0	14.0
ZUURBE	87 2 2	3.5	14.0
ZUURBE	87 2 3	5.25	14.0
ZUURBE	87 2 4	1.25	14.0
ZUURBE	87 2 5	0.0	14.0
ZUURBE	87 2 6	10.0	14.0
ZUURBE	87 2 7	0.0	14.0
ZUURBE	87 2 8	0.0	14.0
ZUURBE	87 2 9	0.0	14.0
ZUURBE	87 210	0.0	14.0
ZUURBE	87 211	0.0	14.0
ZUURBE	87 212	0.0	14.0
ZUURBE	87 213	0.0	14.0
ZUURBE	87 214	0.0	14.0
ZUURBE	87 215	0.0	14.0
ZUURBE	87 216	0.0	14.0
ZUURBE	87 217	0.0	14.0
ZUURBE	87 218	0.0	14.0
ZUURBE	87 219	0.0	14.0
ZUURBE	87 220	0.0	14.0
ZUURBE	87 221	0.0	14.0
ZUURBE	87 222	0.0	14.0
ZUURBE	87 223	1.0	14.0
ZUURBE	87 224	0.0	14.0
ZUURBE	87 225	0.0	14.0
ZUURBE	87 226	0.0	14.0
ZUURBE	87 227	19.5	14.0
ZUURBE	87 228	10.5	14.0
ZUURBE	87 3 1	1.75	11.0
ZUURBE	87 3 2	0.0	11.0
ZUURBE	87 3 3	0.0	11.0
ZUURBE	87 3 4	9.5	11.0
ZUURBE	87 3 5	0.0	11.0
ZUURBE	87 3 6	0.0	11.0
ZUURBE	87 3 7	0.0	11.0
ZUURBE	87 3 8	0.0	11.0
ZUURBE	87 3 9	0.0	11.0
ZUURBE	87 310	0.0	11.0
ZUURBE	87 311	0.0	11.0
ZUURBE	87 312	0.0	11.0
ZUURBE	87 313	0.0	11.0
ZUURBE	87 314	0.0	11.0
ZUURBE	87 315	0.0	11.0
ZUURBE	87 316	0.0	11.0
ZUURBE	87 317	0.0	11.0
ZUURBE	87 318	50.0	11.0
ZUURBE	87 319	0.0	11.0
ZUURBE	87 320	0.0	11.0
ZUURBE	87 321	0.0	11.0
ZUURBE	87 322	0.0	11.0
ZUURBE	87 323	0.0	11.0
ZUURBE	87 324	0.0	11.0
ZUURBE	87 325	0.0	10.0
ZUURBE	87 326	0.0	10.0
ZUURBE	87 327	0.0	10.0
ZUURBE	87 328	0.0	10.0
ZUURBE	87 329	0.0	10.0
ZUURBE	87 330	0.0	10.0
ZUURBE	87 331	0.0	10.0

APPENDIX F 2

SUMMARY RESULTS OF TROXLER CALIBRATION AND PROFILES

ZUURBEKOM TROXLER CALIBRATION

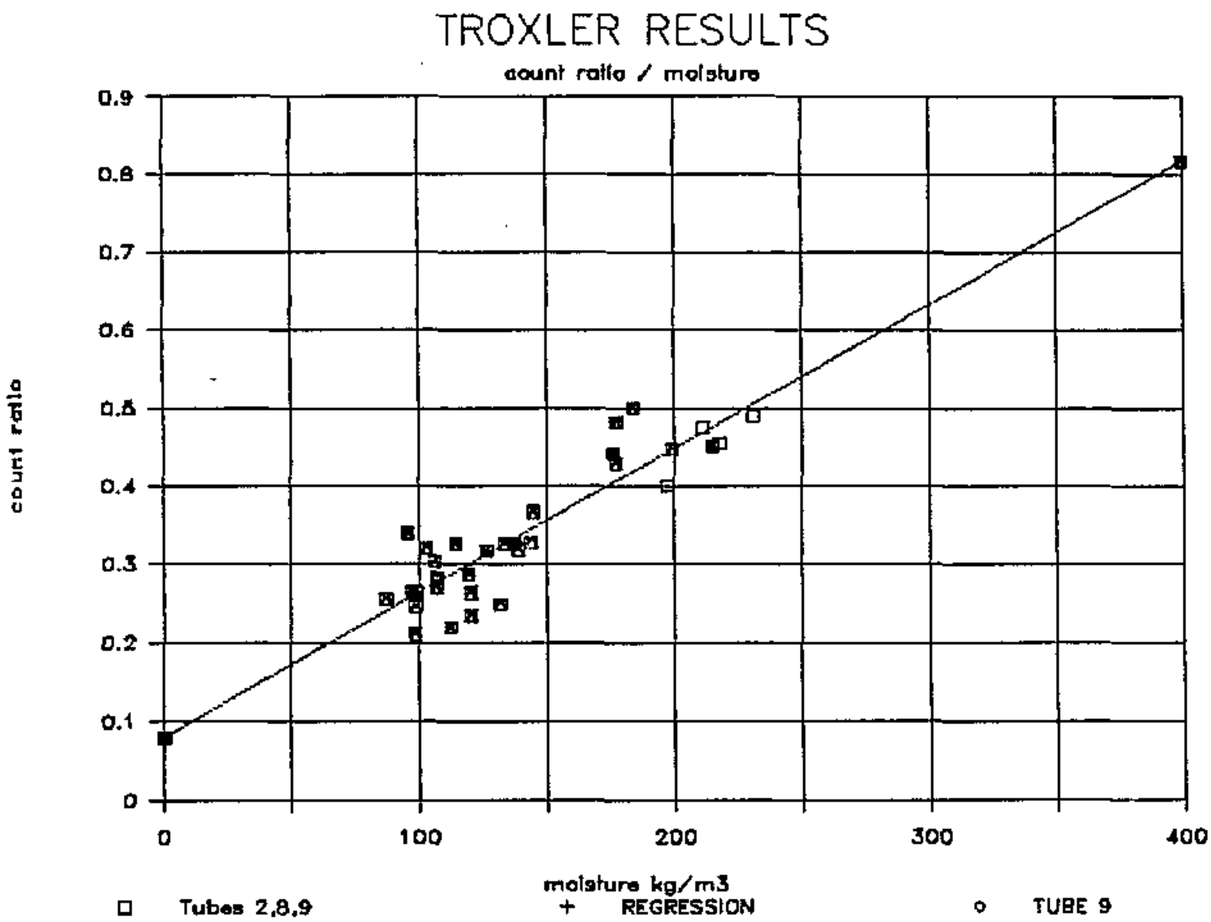
UPDATED 6/1/87

COUNTS PER SECOND	STD COUNT	COUNT RATIO	DRY DENSITY	ACCESS TUBE	% MOISTURE CONTENT	MOISTURE CONTENT(Kg/m3)
		0.818				400.0
262	928	0.282	1644		6.1	106.8
315		0.339	1729		5.3	95.8
297		0.320	1518	8	6.3	102.8
231		0.249	1507		8.0	131.6
196		0.211	1579		5.9	98.3
251		0.270	1544		6.5	106.5
245		0.264	1601	9	7.0	120.0
304		0.328	1673		7.9	143.7
245		0.264	1373		6.7	99.1
281		0.303	1241		7.9	105.7
302		0.325	1773	7	6.0	114.0
341		0.367	2080		6.5	144.8
398		0.429	1795		9.0	176.9
286	898	0.318	1699	2	7.5	138.6
293		0.326	1644		7.7	137.5
285		0.317	1729		6.8	126.2
257		0.286	1729		6.5	119.2
292		0.325	1799		6.9	133.3
210		0.234	1518	8	7.3	120.1
236		0.263	1518		6.0	96.7
229		0.255	1507		5.5	87.0
221		0.246	1579		5.9	98.6
197		0.219	1544		6.8	112.1
400	905	0.442	1795	7	8.9	175.8
453		0.501	1795		9.3	183.8
436		0.482	1795		9.0	177.3
403	899	0.448	1795		10.0	199.4
406		0.452	1795		10.7	215.1
423	889	0.476	1860	6	10.2	211.3
435		0.489	1860	6	11.1	231.1
356		0.400	1507	8	11.6	197.8
404		0.454	1729	2	11.2	218.1

Regression Output:

Constant	0.07911197
Std Err of Y Est	0.04062712
R Squared	0.79825006
No. of Observations	32
Degrees of Freedom	30

X Coefficient(s)	0.00184668
Std Err of Coef.	0.00016950


TROXLER RESULTS
count ratio / moisture
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
count ratio
0
100
200
300
400
moisture kg/m3
Tubes 2,8,9
+ REGRESSION
o TUBE 9

5 March 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0510.
	.3	0619.
	.4	0693.
	.5	0742.
	.6	0779.
	.7	0826.
	.8	0833.
	.9	0885.
	1.0	0941.
	1.1	0978.
2	.2	0329.
	.3	0372.
	.4	0381.
	.5	0391.
	.6	0400.
	.7	0416.
	.8	0418.
	.9	0445.
	1.0	0495.
	1.1	0521.
	1.2	0515.
	1.3	0531.
	1.4	0532.
	1.5	0538.
	1.6	0557.
3	.2	0263.
	.3	0288.
	.4	0292.
	.5	0329.
	.6	0402.
	.7	0398.
	.8	0420.
	.9	0476.
	1.0	0552.
	1.1	0630.
	1.2	0733.
4	.2	0313.
	.3	0387.
	.4	0452.
	.5	0501.
	.6	0506.
	.7	0496.
	.8	0468.
	.9	0476.
	1.0	0552.
	1.1	0625.
	1.2	0709.
5	.2	0337.
	.3	0386.
	.4	0435.
	.5	0458.
	.6	0462.
	.7	0477.
	.8	0494.
	.9	0502.
	1.0	0511.
	1.1	0515.
	1.2	0522.
	1.3	0538.
	1.4	0571.
	1.5	0633.
6	.2	0283.
	.3	0342.
	.4	0386.
	.5	0420.
	.6	0479.
	.7	0530.
	.8	0564.
	.9	0604.
	1.0	0676.
	1.1	0720.
	1.2	0693.
	1.3	0613.
	1.4	0657.
7	.2	0302.
	.3	0535.
	.4	0640.
	.5	0687.
	.6	0714.
	.7	0764.
	.8	0792.
	.9	0819.
	1.0	0821.
	1.1	0822.
	1.2	0767.
	1.3	0752.
	1.4	0824.
	1.5	0842.
	1.6	0849.
	1.7	0878.

STANDARD COUNT = 1491.

6 March 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
B224	.2	1480.
1	.2	0855.
2	.2	0282.
	.3	0337.
	.4	0363.
	.5	0378.
	.6	0382.
	.7	0387.
	.8	0405.
	.9	0437.
	1.0	0492.
	1.1	0508.
	1.2	0507.
	1.3	0528.
	1.4	0543.
	1.5	0538.
	1.6	0560.
3	.2	0229.
	.3	0264.
	.4	0261.
	.5	0294.
	.6	0382.
	.7	0391.
	.8	0415.
	.9	0463.
	1.0	0544.
	1.1	0612.
	1.2	0669.
4	.2	0335.
	.3	0404.
	.4	0465.
	.5	0512.
	.6	0502.
	.7	0496.
	.8	0482.
	.9	0490.
	1.0	0537.
	1.1	0633.
	1.2	0685.
5	.2	0326.
	.3	0394.
	.4	0427.
	.5	0443.
	.6	0462.
	.7	0477.
	.8	0500.
	.9	0499.
	1.0	0502.
	1.1	0503.
	1.2	0527.
	1.3	0542.
	1.4	0589.
	1.5	0624.
6	.2	0293.
	.3	0354.
	.4	0387.
	.5	0421.
	.6	0477.
	.7	0541.
	.8	0572.
	.9	0628.
	1.0	0698.
	1.1	0759.
	1.2	0713.
	1.3	0616.
	1.4	0584.
7	.2	0322.
	.3	0549.
	.4	0637.
	.5	0685.
	.6	0715.
	.7	0758.
	.8	0796.
	.9	0837.
	1.0	0808.
	1.1	0827.
	1.2	0756.
	1.3	0767.
	1.4	0827.
	1.5	0836.
	1.6	0829.
	1.7	0881.

STANDARD COUNT = 0730.,

12 March 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	1519.
	.3	1530.
	.4	1537.
	.5	1521.
	.6	1517.

STANDARD COUNT = 1506.,

13 March 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	1485.
	.3	0514.
4	.2	1472.
	.3	0431.
	.4	0705.
	.5	0669.
	.6	1489.

STANDARD COUNT = 0648.,

14 March 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0485.
	.3	0520.
	.4	0529.
	.5	0537.
	.6	0549.
2	.2	0620.
	.3	0658.
	.4	0664.
	.5	0678.
	.6	0713.

STANDARD COUNT = 1483., 1483.,

15 March 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0704.
	.3	0808.
	.4	0859.
	.5	0894.
	.6	0886.
	.7	0861.
	.8	0862.
	.9	0863.
	1.0	0924.
	1.1	0983.
2	.2	0480.
	.3	0513.
	.4	0527.
	.5	0531.
	.6	0522.
	.7	0534.
	.8	0548.
	.9	0563.
	1.0	0596.
	1.1	0606.
	1.2	0634.
	1.3	0651.
	1.4	0653.
	1.5	0661.
	1.6	0685.
3	.2	0418.
	.3	0470.
	.4	0465.
	.5	0434.
	.6	0436.
	.7	0389.
	.8	0408.
	.9	0471.
	1.0	0556.
	1.1	0614.
	1.2	0664.
4	.2	0544.
	.3	0591.
	.4	0632.
	.5	0657.
	.6	0674.
	.7	0705.
	.8	0728.
	.9	0775.
	1.0	0831.
	1.1	0941.
	1.2	1019.
5	.2	0530.
	.3	0571.
	.4	0582.
	.5	0553.
	.6	0511.
	.7	0475.
	.8	0503.
	.9	0502.
	1.0	0512.
	1.1	0510.
	1.2	0522.
	1.3	0539.
	1.4	0594.
	1.5	0628.
6	.2	0421.
	.3	0463.
	.4	0500.
	.5	0547.
	.6	0589.
	.7	0628.
	.8	0653.
	.9	0689.
	1.0	0773.
	1.1	0833.
	1.2	0810.
	1.3	0770.
	1.4	0746.
7	.2	0534.
	.3	0733.
	.4	0774.
	.5	0828.
	.6	0834.
	.7	0837.
	.8	0816.
	.9	0832.
	1.0	0827.
	1.1	0830.
	1.2	0742.
	1.3	0766.
	1.4	0825.
	1.5	0822.
	1.6	0837.
	1.7	0876.

STANDARD COUNT = 1491.,

20 March 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0642.
	.3	0751.
	.4	0839.
	.5	0874.
	.6	0875.
	.7	0887.
	.8	0859.
	.9	0878.
	1.0	0946.
	1.1	0966.
2	.2	0427.
	.3	0461.
	.4	0480.
	.5	0485.
	.6	0498.
	.7	0501.
	.8	0518.
	.9	0538.
	1.0	0576.
	1.1	0594.
	1.2	0615.
	1.3	0609.
	1.4	0645.
	1.5	0648.
	1.6	0678.
3	.2	0330.
	.3	0408.
	.4	0408.
	.5	0410.
	.6	0422.
	.7	0390.
	.8	0412.
	.9	0479.
	1.0	0559.
	1.1	0630.
	1.2	0670.
4	.2	0428.
	.3	0524.
	.4	0586.
	.5	0630.
	.6	0640.
	.7	0672.
	.8	0665.
	.9	0706.
	1.0	0774.
	1.1	0846.
	1.2	0963.
5	.2	0452.
	.3	0503.
	.4	0529.
	.5	0529.
	.6	0521.
	.7	0492.
	.8	0483.
	.9	0498.
	1.0	0498.
	1.1	0507.
	1.2	0524.
	1.3	0543.
	1.4	0575.
	1.5	0619.
6	.2	0342.
	.3	0399.
	.4	0449.
	.5	0500.
	.6	0561.
	.7	0595.
	.8	0618.
	.9	0656.
	1.0	0768.
	1.1	0797.
	1.2	0798.
	1.3	0749.
	1.4	0716.
7	.2	0393.
	.3	0640.
	.4	0750.
	.5	0776.
	.6	0809.
	.7	0837.
	.8	0824.
	.9	0820.
	1.0	0802.
	1.1	0809.
	1.2	0746.
	1.3	0752.
	1.4	0821.
	1.5	0838.
	1.6	0844.
	1.7	0872.

STANDARD COUNT = 1495.,

27 March 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0555.
	.3	0677.
	.4	0776.
	.5	0834.
	.6	0845.
	.7	0870.
	.8	0850.
	.9	0867.
	1.0	0934.
	1.1	0960.
2	.2	0334.
	.3	0390.
	.4	0422.
	.5	0437.
	.6	0436.
	.7	0455.
	.8	0461.
	.9	0487.
	1.0	0539.
	1.1	0584.
	1.2	0587.
	1.3	0610.
	1.4	0631.
	1.5	0629.
	1.6	0647.
3	.2	0255.
	.3	0292.
	.4	0307.
	.5	0324.
	.6	0378.
	.7	0377.
	.8	0405.
	.9	0467.
	1.0	0541.
	1.1	0614.
	1.2	0680.
4	.2	0403.
	.3	0454.
	.4	0527.
	.5	0578.
	.6	0612.
	.7	0621.
	.8	0629.
	.9	0665.
	1.0	0730.
	1.1	0829.
	1.2	0909.
5	.2	0395.
	.3	0445.
	.4	0478.
	.5	0498.
	.6	0487.
	.7	0478.
	.8	0487.
	.9	0510.
	1.0	0505.
	1.1	0510.
	1.2	0520.
	1.3	0538.
	1.4	0581.
	1.5	0627.
6	.2	0271.
	.3	0326.
	.4	0385.
	.5	0416.
	.6	0484.
	.7	0539.
	.8	0566.
	.9	0619.
	1.0	0686.
	1.1	0774.
	1.2	0792.
	1.3	0743.
	1.4	0703.
7	.2	0401.
	.3	0585.
	.4	0718.
	.5	0770.
	.6	0792.
	.7	0840.
	.8	0833.
	.9	0836.
	1.0	0814.
	1.1	0825.
	1.2	0743.
	1.3	0758.
	1.4	0827.
	1.5	0840.
	1.6	0852.
	1.7	0881.

STANDARD COUNT = 1495.,

3 April 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0535.
	.3	0673.
	.4	0753.
	.5	0818.
	.6	0828.
	.7	0857.
	.8	0848.
	.9	0864.
	1.0	0942.
	1.1	0958.
2	.2	0319.
	.3	0360.
	.4	0384.
	.5	0385.
	.6	0399.
	.7	0412.
	.8	0436.
	.9	0480.
	1.0	0543.
	1.1	0567.
	1.2	0590.
	1.3	0596.
	1.4	0603.
	1.5	0632.
	1.6	0646.
3	.2	0230.
	.3	0257.
	.4	0248.
	.5	0270.
	.6	0343.
	.7	0366.
	.8	0390.
	.9	0432.
	1.0	0505.
	1.1	0595.
	1.2	0640.
4	.2	0330.
	.3	0420.
	.4	0479.
	.5	0538.
	.6	0577.
	.7	0588.
	.8	0604.
	.9	0639.
	1.0	0695.
	1.1	0782.
	1.2	0884.
5	.2	0368.
	.3	0422.
	.4	0476.
	.5	0474.
	.6	0484.
	.7	0498.
	.8	0517.
	.9	0501.
	1.0	0509.
	1.1	0521.
	1.2	0549.
	1.3	0585.
	1.4	0643.
6	.2	0309.
	.3	0342.
	.4	0376.
	.5	0425.
	.6	0485.
	.7	0535.
	.8	0549.
	.9	0615.
	1.0	0703.
	1.1	0753.
	1.2	0751.
	1.3	0695.
	1.4	0680.
7	.2	0374.
	.3	0588.
	.4	0704.
	.5	0758.
	.6	0804.
	.7	0828.
	.8	0835.
	.9	0855.
	1.0	0809.
	1.1	0811.
	1.2	0738.
	1.3	0775.
	1.4	0839.
	1.5	0843.
	1.6	0845.
	1.7	0890.

STANDARD COUNT = 1491.,

10 April 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0508.
	.3	0631.
	.4	0727.
	.5	0789.
	.6	0821.
	.7	0870.
	.8	0839.
	.9	0873.
	1.0	0927.
	1.1	0961.
2	.2	0275.
	.3	0341.
	.4	0359.
	.5	0374.
	.6	0374.
	.7	0395.
	.8	0406.
	.9	0436.
	1.0	0488.
	1.1	0547.
	1.2	0574.
	1.3	0590.
	1.4	0605.
	1.5	0596.
	1.6	0633.
3	.2	0231.
	.3	0243.
	.4	0237.
	.5	0266.
	.6	0340.
	.7	0356.
	.8	0399.
	.9	0451.
	1.0	0516.
	1.1	0602.
	1.2	0637.
4	.2	0325.
	.3	0392.
	.4	0477.
	.5	0525.
	.6	0550.
	.7	0578.
	.8	0576.
	.9	0606.
	1.0	0657.
	1.1	0752.
	1.2	0845.
5	.2	0349.
	.3	0411.
	.4	0444.
	.5	0453.
	.6	0461.
	.7	0481.
	.8	0481.
	.9	0501.
	1.0	0509.
	1.1	0507.
	1.2	0517.
	1.3	0549.
	1.4	0594.
	1.5	0638.
6	.2	0244.
	.3	0310.
	.4	0350.
	.5	0392.
	.6	0441.
	.7	0494.
	.8	0512.
	.9	0570.
	1.0	0635.
	1.1	0708.
	1.2	0731.
	1.3	0698.
	1.4	0685.
7	.2	0308.
	.3	0534.
	.4	0650.
	.5	0728.
	.6	0771.
	.7	0816.
	.8	0835.
	.9	0834.
	1.0	0823.
	1.1	0839.
	1.2	0771.
	1.3	0743.
	1.4	0806.
	1.5	0835.
	1.6	0837.
	1.7	0866.

STANDARD COUNT = 1484.,

18 April 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0484.
	.3	0610.
	.4	0704.
	.5	0770.
	.6	0803.
	.7	0854.
	.8	0847.
	.9	0870.
	1.0	0926.
	1.1	0971.
2	.2	0250.
	.3	0329.
	.4	0350.
	.5	0361.
	.6	0368.
	.7	0382.
	.8	0388.
	.9	0420.
	1.0	0469.
	1.1	0530.
	1.2	0551.
	1.3	0559.
	1.4	0585.
	1.5	0602.
	1.6	0601.
3	.2	0213.
	.3	0237.
	.4	0230.
	.5	0265.
	.6	0330.
	.7	0355.
	.8	0386.
	.9	0441.
	1.0	0515.
	1.1	0602.
	1.2	0634.
4	.2	0315.
	.3	0385.
	.4	0449.
	.5	0502.
	.6	0524.
	.7	0543.
	.8	0545.
	.9	0572.
	1.0	0638.
	1.1	0738.
	1.2	0833.
5	.2	0284.
	.3	0382.
	.4	0421.
	.5	0452.
	.6	0464.
	.7	0468.
	.8	0480.
	.9	0509.
	1.0	0507.
	1.1	0501.
	1.2	0520.
	1.3	0532.
	1.4	0575.
	1.5	0618.
6	.2	0252.
	.3	0322.
	.4	0357.
	.5	0390.
	.6	0438.
	.7	0482.
	.8	0505.
	.9	0553.
	1.0	0622.
	1.1	0708.
	1.2	0723.
	1.3	0683.
	1.4	0643.
7	.2	0296.
	.3	0520.
	.4	0647.
	.5	0697.
	.6	0748.
	.7	0803.
	.8	0828.
	.9	0837.
	1.0	0824.
	1.1	0841.
	1.2	0762.
	1.3	0752.
	1.4	0814.
	1.5	0834.
	1.6	0847.
	1.7	0862.

STANDARD COUNT = 1487.,

22 April 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA %VOL
1	.2	021.3
	.3	019.8
	.4	020.0
	.5	019.7
	.6	020.1
	.7	019.2
	.8	016.2
	.9	021.0
	1.0	020.3
	1.1	020.1
	1.2	020.0
	1.3	020.9
	1.4	020.5
	1.5	020.4
	1.6	021.3
	1.7	021.7
	1.8	021.2
	1.9	021.0
	2.0	020.8
	2.1	021.1
	2.2	020.7
	2.3	021.2
	2.4	020.7
	2.5	020.4
	2.6	020.9
	2.7	020.7
	2.8	021.0
	2.9	020.7
	3.0	020.6
	3.1	020.9
	3.2	020.1
	3.3	020.7
	3.4	021.0
	3.5	019.9
	3.6	020.8
	3.7	020.5
	3.8	019.9
	3.9	020.0
	4.0	019.9
	4.1	019.4
	4.2	020.0
	4.3	020.4
	4.4	020.2
	4.5	019.3
	4.6	018.1
	4.7	016.8
	4.8	012.4
	4.9	019.3
	5.0	019.3
	5.1	019.4
	5.2	020.9
	5.3	019.4
2	.2	020.3
	.3	019.9
	.4	019.9

STANDARD COUNT = 1510., 065.3,

24 April 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0472.
	.3	0606.
	.4	0681.
	.5	0753.
	.6	0799.
	.7	0844.
	.8	0831.
	.9	0851.
	1.0	0921.
	1.1	0960.
2	.2	0263.
	.3	0336.
	.4	0361.
	.5	0362.
	.6	0369.
	.7	0381.
	.8	0401.
	.9	0432.
	1.0	0480.
	1.1	0523.
	1.2	0540.
	1.3	0565.
	1.4	0572.
	1.5	0567.
	1.6	0600.
3	.2	0219.
	.3	0236.
	.4	0230.
	.5	0259.
	.6	0325.
	.7	0345.
	.8	0383.
	.9	0438.
	1.0	0496.
	1.1	0584.
	1.2	0631.
4	.2	0272.
	.3	0357.
	.4	0422.
	.5	0488.
	.6	0499.
	.7	0526.
	.8	0514.
	.9	0540.
	1.0	0592.
	1.1	0686.
	1.2	0810.
5	.2	0321.
	.3	0378.
	.4	0430.
	.5	0457.
	.6	0449.
	.7	0474.
	.8	0482.
	.9	0504.
	1.0	0511.
	1.1	0513.
	1.2	0522.
	1.3	0543.
	1.4	0576.
	1.5	0625.
6	.2	0262.
	.3	0320.
	.4	0364.
	.5	0392.
	.6	0431.
	.7	0475.
	.8	0503.
	.9	0545.
	1.0	0619.
	1.1	0692.
	1.2	0705.
	1.3	0666.
	1.4	0643.
	1.5	0670.
7	.2	0301.
	.3	0517.
	.4	0644.
	.5	0691.
	.6	0734.
	.7	0812.
	.8	0793.
	.9	0839.
	1.0	0817.
	1.1	0818.
	1.2	0757.
	1.3	0754.
	1.4	0820.
	1.5	0842.
	1.6	0850.
	1.7	0862.

STANDARD COUNT = 1496.,

1 May 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0465.
	.3	0613.
	.4	0697.
	.5	0766.
	.6	0797.
	.7	0847.
	.8	0826.
	.9	0864.
	1.0	0933.
	1.1	0952.
2	.2	0209.
	.3	0307.
	.4	0346.
	.5	0350.
	.6	0364.
	.7	0370.
	.8	0390.
	.9	0400.
	1.0	0450.
	1.1	0500.
	1.2	0512.
	1.3	0534.
	1.4	0549.
	1.5	0570.
	1.6	0585.
3	.2	0227.
	.3	0237.
	.4	0221.
	.5	0264.
	.6	0332.
	.7	0345.
	.8	0387.
	.9	0431.
	1.0	0507.
	1.1	0587.
	1.2	0631.
4	.2	0303.
	.3	0379.
	.4	0444.
	.5	0487.
	.6	0496.
	.7	0517.
	.8	0513.
	.9	0525.
	1.0	0591.
	1.1	0695.
	1.2	0803.
5	.2	0294.
	.3	0385.
	.4	0417.
	.5	0455.
	.6	0447.
	.7	0460.
	.8	0477.
	.9	0496.
	1.0	0509.
	1.1	0510.
	1.2	0525.
	1.3	0546.
	1.4	0567.
	1.5	0616.
6	.2	0233.
	.3	0317.
	.4	0354.
	.5	0374.
	.6	0434.
	.7	0466.
	.8	0502.
	.9	0534.
	1.0	0591.
	1.1	0675.
	1.2	0675.
	1.3	0653.
	1.4	0634.
7	.2	0285.
	.3	0498.
	.4	0623.
	.5	0673.
	.6	0712.
	.7	0780.
	.8	0811.
	.9	0832.
	1.0	0822.
	1.1	0825.
	1.2	0789.
	1.3	0736.
	1.4	0798.
	1.5	0862.
	1.6	0831.
	1.7	0849.

STANDARD COUNT = 1487.,

8 May 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0483.
	.3	0612.
	.4	0691.
	.5	0766.
	.6	0805.
	.7	0846.
	.8	0833.
	.9	0867.
	1.0	0938.
	1.1	0949.
2	.2	0222.
	.3	0308.
	.4	0345.
	.5	0364.
	.6	0367.
	.7	0356.
	.8	0380.
	.9	0406.
	1.0	0443.
	1.1	0494.
	1.2	0512.
	1.3	0517.
	1.4	0551.
	1.5	0544.
	1.6	0549.
3	.2	0215.
	.3	0237.
	.4	0220.
	.5	0250.
	.6	0321.
	.7	0346.
	.8	0381.
	.9	0435.
	1.0	0521.
	1.1	0593.
	1.2	0618.
4	.2	0281.
	.3	0361.
	.4	0428.
	.5	0475.
	.6	0483.
	.7	0508.
	.8	0495.
	.9	0522.
	1.0	0573.
	1.1	0666.
	1.2	0778.
5	.2	0313.
	.3	0385.
	.4	0430.
	.5	0448.
	.6	0454.
	.7	0468.
	.8	0489.
	.9	0503.
	1.0	0512.
	1.1	0498.
	1.2	0513.
	1.3	0546.
	1.4	0562.
	1.5	0621.
6	.2	0278.
	.3	0325.
	.4	0361.
	.5	0381.
	.6	0435.
	.7	0466.
	.8	0495.
	.9	0538.
	1.0	0607.
	1.1	0661.
	1.2	0669.
	1.3	0627.
	1.4	0623.
7	.2	0294.
	.3	0514.
	.4	0635.
	.5	0682.
	.6	0710.
	.7	0764.
	.8	0790.
	.9	0830.
	1.0	0808.
	1.1	0817.
	1.2	0770.
	1.3	0744.
	1.4	0808.
	1.5	0834.
	1.6	0847.
	1.7	0866.

STANDARD COUNT = 1497.,

15 May 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0504.
	.3	0610.
	.4	0688.
	.5	0762.
	.6	0796.
	.7	0839.
	.8	0837.
	.9	0865.
	1.0	0919.
	1.1	0953.
2	.2	0299.
	.3	0335.
	.4	0353.
	.5	0358.
	.6	0364.
	.7	0381.
	.8	0395.
	.9	0428.
	1.0	0464.
	1.1	0495.
	1.2	0515.
	1.3	0535.
	1.4	0546.
	1.5	0553.
	1.6	0580.
3	.2	0240.
	.3	0237.
	.4	0227.
	.5	0262.
	.6	0323.
	.7	0344.
	.8	0393.
	.9	0438.
	1.0	0513.
	1.1	0594.
	1.2	0641.
4	.2	0298.
	.3	0362.
	.4	0428.
	.5	0473.
	.6	0479.
	.7	0495.
	.8	0490.
	.9	0520.
	1.0	0571.
	1.1	0652.
	1.2	0771.
5	.2	0316.
	.3	0375.
	.4	0421.
	.5	0452.
	.6	0445.
	.7	0473.
	.8	0483.
	.9	0492.
	1.0	0497.
	1.1	0515.
	1.2	0517.
	1.3	0542.
	1.4	0574.
	1.5	0622.
6	.2	0288.
	.3	0324.
	.4	0350.
	.5	0383.
	.6	0431.
	.7	0473.
	.8	0517.
	.9	0565.
	1.0	0611.
	1.1	0647.
	1.2	0661.
	1.3	0634.
	1.4	0618.
7	.2	0304.
	.3	0516.
	.4	0621.
	.5	0688.
	.6	0710.
	.7	0764.
	.8	0791.
	.9	0825.
	1.0	0817.
	1.1	0825.
	1.2	0770.
	1.3	0738.
	1.4	0808.
	1.5	0833.
	1.6	0828.
	1.7	0873.

STANDARD COUNT = 1508.,

22 May 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0462.
	.3	0592.
	.4	0675.
	.5	0744.
	.6	0784.
	.7	0831.
	.8	0840.
	.9	0849.
	1.0	0906.
	1.1	0947.
2	.2	0254.
	.3	0326.
	.4	0349.
	.5	0355.
	.6	0361.
	.7	0370.
	.8	0393.
	.9	0416.
	1.0	0460.
	1.1	0487.
	1.2	0496.
	1.3	0510.
	1.4	0545.
	1.5	0549.
	1.6	0569.
3	.2	0223.
	.3	0238.
	.4	0229.
	.5	0245.
	.6	0322.
	.7	0346.
	.8	0380.
	.9	0425.
	1.0	0496.
	1.1	0581.
	1.2	0614.
4	.2	0302.
	.3	0374.
	.4	0435.
	.5	0470.
	.6	0489.
	.7	0493.
	.8	0497.
	.9	0515.
	1.0	0583.
	1.1	0668.
	1.2	0770.
5	.2	0335.
	.3	0405.
	.4	0434.
	.5	0445.
	.6	0466.
	.7	0462.
	.8	0490.
	.9	0506.
	1.0	0507.
	1.1	0502.
	1.2	0529.
	1.3	0550.
	1.4	0578.
	1.5	0633.
6	.2	0279.
	.3	0334.
	.4	0357.
	.5	0390.
	.6	0438.
	.7	0470.
	.8	0513.
	.9	0545.
	1.0	0602.
	1.1	0653.
	1.2	0635.
	1.3	0632.
	1.4	0613.
7	.2	0297.
	.3	0524.
	.4	0628.
	.5	0680.
	.6	0718.
	.7	0746.
	.8	0802.
	.9	0821.
	1.0	0801.
	1.1	0810.
	1.2	0773.
	1.3	0758.
	1.4	0825.
	1.5	0835.
	1.6	0843.
	1.7	0867.

STANDARD COUNT = 1497.,

29 May 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0458.
	.3	0602.
	.4	0680.
	.5	0750.
	.6	0784.
	.7	0835.
	.8	0833.
	.9	0859.
	1.0	0919.
	1.1	0950.
2	.2	0272.
	.3	0336.
	.4	0350.
	.5	0361.
	.6	0373.
	.7	0373.
	.8	0399.
	.9	0430.
	1.0	0457.
	1.1	0491.
	1.2	0512.
	1.3	0520.
	1.4	0552.
	1.5	0551.
	1.6	0575.
3	.2	0224.
	.3	0243.
	.4	0217.
	.5	0247.
	.6	0324.
	.7	0348.
	.8	0375.
	.9	0415.
	1.0	0504.
	1.1	0585.
	1.2	0618.
4	.2	0304.
	.3	0379.
	.4	0437.
	.5	0475.
	.6	0489.
	.7	0493.
	.8	0482.
	.9	0516.
	1.0	0577.
	1.1	0676.
	1.2	0769.
5	.2	0344.
	.3	0390.
	.4	0431.
	.5	0448.
	.6	0447.
	.7	0476.
	.8	0496.
	.9	0511.
	1.0	0521.
	1.1	0515.
	1.2	0530.
	1.3	0543.
	1.4	0571.
	1.5	0635.
6	.2	0271.
	.3	0330.
	.4	0356.
	.5	0378.
	.6	0427.
	.7	0464.
	.8	0499.
	.9	0519.
	1.0	0579.
	1.1	0646.
	1.2	0633.
	1.3	0619.
	1.4	0605.
7	.2	0287.
	.3	0502.
	.4	0629.
	.5	0681.
	.6	0715.
	.7	0753.
	.8	0803.
	.9	0830.
	1.0	0825.
	1.1	0815.
	1.2	0769.
	1.3	0752.
	1.4	0795.
	1.5	0838.
	1.6	0831.
	1.7	0848.
99	.2	0345.
	.3	0355.

STANDARD COUNT = 1506.,

5 June 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA COUNT RATIO
1	.2	0.287
	.3	0.396
	.4	0.453
	.5	0.500
	.6	0.522
	.7	0.547
	.8	0.547
	.9	0.555
	1.0	0.600
	1.1	0.632
2	.2	0.187
	.3	0.226
	.4	0.234
	.5	0.244
	.6	0.242
	.7	0.250
	.8	0.272
	.9	0.298
	1.0	0.312
	1.1	0.334
	1.2	0.343
	1.3	0.355
	1.4	0.362
	1.5	0.366
	1.6	0.391
3	.2	0.147
	.3	0.156
	.4	0.155
	.5	0.172
	.6	0.221
	.7	0.235
	.8	0.249
	.9	0.292
	1.0	0.334
	1.1	0.398
	1.2	0.421
4	.2	0.193
	.3	0.249
	.4	0.288
	.5	0.316
	.6	0.317
	.7	0.322
	.8	0.330
	.9	0.347
	1.0	0.386
	1.1	0.455
	1.2	0.509
5	.2	0.180
	.3	0.246
	.4	0.277
	.5	0.292
	.6	0.298
	.7	0.302
	.8	0.323
	.9	0.337
	1.0	0.339
	1.1	0.332
	1.2	0.349
	1.3	0.353
	1.4	0.376
	1.5	0.399
6	.2	0.170
	.3	0.215
	.4	0.235
	.5	0.258
	.6	0.280
	.7	0.303
	.8	0.322
	.9	0.349
	1.0	0.386
	1.1	0.429
	1.2	0.425
	1.3	0.410
	1.4	0.406
7	.2	0.189
	.3	0.331
	.4	0.416
	.5	0.451
	.6	0.476
	.7	0.512
	.8	0.529
	.9	0.563
	1.0	0.547
	1.1	0.549
	1.2	0.524
	1.3	0.491
	1.4	0.539
	1.5	0.562
	1.6	0.556
	1.7	0.585

STANDARD COUNT = 1.000,

12 June 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA COUNT RATIO
1	.2	0.284
	.3	0.389
	.4	0.445
	.5	0.498
	.6	0.518
	.7	0.546
	.8	0.551
	.9	0.554
	1.0	0.594
	1.1	0.621
2	.2	0.175
	.3	0.213
	.4	0.227
	.5	0.238
	.6	0.240
	.7	0.243
	.8	0.258
	.9	0.280
	1.0	0.308
	1.1	0.332
	1.2	0.331
	1.3	0.341
	1.4	0.359
	1.5	0.360
	1.6	0.381
3	.2	0.139
	.3	0.155
	.4	0.145
	.5	0.160
	.6	0.217
	.7	0.233
	.8	0.246
	.9	0.274
	1.0	0.319
	1.1	0.371
	1.2	0.406
4	.2	0.193
	.3	0.241
	.4	0.285
	.5	0.317
	.6	0.319
	.7	0.332
	.8	0.317
	.9	0.332
	1.0	0.382
	1.1	0.437
	1.2	0.506
5	.2	0.204
	.3	0.250
	.4	0.274
	.5	0.292
	.6	0.295
	.7	0.315
	.8	0.319
	.9	0.332
	1.0	0.336
	1.1	0.333
	1.2	0.346
	1.3	0.348
	1.4	0.382
	1.5	0.406
6	.2	0.158
	.3	0.206
	.4	0.228
	.5	0.247
	.6	0.272
	.7	0.301
	.8	0.315
	.9	0.332
	1.0	0.373
	1.1	0.412
	1.2	0.417
	1.3	0.405
	1.4	0.402
7	.2	0.187
	.3	0.338
	.4	0.416
	.5	0.445
	.6	0.477
	.7	0.501
	.8	0.528
	.9	0.564
	1.0	0.536
	1.1	0.543
	1.2	0.515
	1.3	0.484
	1.4	0.529
	1.5	0.563
	1.6	0.553
	1.7	0.575

STANDARD COUNT = 1.000,

19 June 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA COUNT RATIO
1	.2	0.324
	.3	0.388
	.4	0.456
	.5	0.513
	.6	0.536
	.7	0.555
	.8	0.547
	.9	0.567
	1.0	0.607
	1.1	0.635
2	.2	0.183
	.3	0.224
	.4	0.239
	.5	0.239
	.6	0.242
	.7	0.250
	.8	0.258
	.9	0.288
	1.0	0.312
	1.1	0.336
	1.2	0.332
	1.3	0.349
	1.4	0.358
	1.5	0.356
	1.6	0.390
3	.2	0.150
	.3	0.154
	.4	0.148
	.5	0.168
	.6	0.218
	.7	0.232
	.8	0.260
	.9	0.287
	1.0	0.328
	1.1	0.391
	1.2	0.413
4	.2	0.191
	.3	0.244
	.4	0.284
	.5	0.316
	.6	0.321
	.7	0.332
	.8	0.322
	.9	0.333
	1.0	0.377
	1.1	0.441
	1.2	0.506
5	.2	0.223
	.3	0.263
	.4	0.287
	.5	0.302
	.6	0.300
	.7	0.318
	.8	0.328
	.9	0.334
	1.0	0.342
	1.1	0.340
	1.2	0.344
	1.3	0.368
	1.4	0.387
	1.5	0.420
6	.2	0.165
	.3	0.209
	.4	0.229
	.5	0.253
	.6	0.278
	.7	0.298
	.8	0.316
	.9	0.337
	1.0	0.378
	1.1	0.412
	1.2	0.421
	1.3	0.403
	1.4	0.393
7	.2	0.188
	.3	0.337
	.4	0.429
	.5	0.455
	.6	0.469
	.7	0.505
	.8	0.525
	.9	0.551
	1.0	0.543
	1.1	0.540
	1.2	0.509
	1.3	0.483
	1.4	0.528
	1.5	0.564
	1.6	0.559
	1.7	0.583

STANDARD COUNT = 1498., 1.000,

27 August 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
1	.2	0426.
	.3	0568.
	.4	0652.
	.5	0726.
	.6	0757.
	.7	0809.
	.8	0803.
	.9	0828.
	1.0	0902.
	1.1	0938.
4	.2	0277.
	.3	0361.
	.4	0422.
	.5	0456.
	.6	0466.
	.7	0473.
	.8	0480.
	.9	0501.
	1.0	0561.
	1.1	0641.
	1.2	0742.
2	.2	0249.
	.3	0318.
	.4	0341.
	.5	0351.
	.6	0367.
	.7	0360.
	.8	0392.
	.9	0423.
	1.0	0458.
	1.1	0508.
	1.2	0504.
	1.3	0525.
	1.4	0527.
	1.5	0542.
	1.6	0576.
3	.2	0223.
	.3	0237.
	.4	0215.
	.5	0261.
	.6	0329.
	.7	0346.
	.8	0378.
	.9	0433.
	1.0	0507.
	1.1	0578.
	1.2	0620.
8	.2	0275.
	.3	0325.
	.4	0345.
	.5	0344.
	.6	0360.
	.7	0373.
	.8	0374.
	.9	0360.
	1.0	0339.
	1.1	0311.
	1.2	0313.
	1.3	0331.
	1.4	0346.
	1.5	0387.
	1.6	0440.
5	.2	0296.
	.3	0371.
	.4	0403.
	.5	0437.
	.6	0449.
	.7	0468.
	.8	0476.
	.9	0497.
	1.0	0504.
	1.1	0509.
	1.2	0515.
	1.3	0530.
	1.4	0567.
	1.5	0607.
6	.2	0251.
	.3	0302.
	.4	0345.
	.5	0369.
	.6	0424.
	.7	0449.
	.8	0465.
	.9	0517.
	1.0	0564.
	1.1	0624.
	1.2	0604.
	1.3	0580.
	1.4	0571.
7	.2	0271.
	.3	0495.
	.4	0624.
	.5	0666.
	.6	0699.
	.7	0746.
	.8	0776.
	.9	0823.
	1.0	0795.
	1.1	0808.
	1.2	0759.
	1.3	0736.
	1.4	0788.
	1.5	0833.
	1.6	0832.
	1.7	0848.

STANDARD COUNT = 1487.,

12 September 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
2	.2	0270.
	.3	0323.
	.4	0345.
	.5	0347.
	.6	0369.
	.7	0367.
	.8	0386.
	.9	0407.
	1.0	0457.
	1.1	0481.
	1.2	0491.
	1.3	0515.
	1.4	0540.
	1.5	0536.
	1.6	0572.
3	.2	0231.
	.3	0233.
	.4	0221.
	.5	0257.
	.6	0332.
	.7	0350.
	.8	0381.
	.9	0441.
	1.0	0506.
	1.1	0588.
	1.2	0624.
8	.2	0302.
	.3	0336.
	.4	0335.
	.5	0361.
	.6	0369.
	.7	0381.
	.8	0367.
	.9	0359.
	1.0	0339.
	1.1	0302.
	1.2	0316.
	1.3	0325.
	1.4	0354.
	1.5	0403.
	1.6	0447.
5	.2	0270.
	.3	0366.
	.4	0406.
	.5	0437.
	.6	0437.
	.7	0459.
	.8	0481.
	.9	0489.
	1.0	0496.
	1.1	0523.
	1.2	0513.
	1.3	0537.
	1.4	0567.
	1.5	0615.
6	.2	0296.
	.3	0310.
	.4	0335.
	.5	0351.
	.6	0407.
	.7	0456.
	.8	0472.
	.9	0493.
	1.0	0546.
	1.1	0609.
	1.2	0610.
	1.3	0589.
	1.4	0584.
7	.2	0296.
	.3	0517.
	.4	0629.
	.5	0661.
	.6	0703.
	.7	0765.
	.8	0787.
	.9	0812.
	1.0	0806.
	1.1	0801.
	1.2	0748.
	1.3	0724.
	1.4	0794.
	1.5	0835.
	1.6	0818.
	1.7	0850.

STANDARD COUNT = 1512.,

2 October 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA COUNT RATIO
2	.2	0.196
	.3	0.222
	.4	0.236
	.5	0.236
	.6	0.245
	.7	0.256
	.8	0.268
	.9	0.285
	1.0	0.312
	1.1	0.326
	1.2	0.331
	1.3	0.351
	1.4	0.356
	1.5	0.370
3	.2	0.225
	.3	0.278
	.4	0.295
	.5	0.295
	.6	0.316
	.7	0.309
	.8	0.342
	.9	0.371
	1.0	0.421
	1.1	0.439
	1.2	0.440
5	.2	0.220
	.3	0.257
	.4	0.288
	.5	0.306
	.6	0.308
	.7	0.312
	.8	0.321
	.9	0.334
	1.0	0.338
	1.1	0.334
	1.2	0.350
	1.3	0.359
	1.4	0.382
	1.5	0.419
6	.2	0.172
	.3	0.213
	.4	0.230
	.5	0.250
	.6	0.280
	.7	0.305
	.8	0.320
	.9	0.333
	1.0	0.375
	1.1	0.410
	1.2	0.417
	1.3	0.393
	1.4	0.394
7	.2	0.200
	.3	0.329
	.4	0.419
	.5	0.444
	.6	0.472
	.7	0.491
	.8	0.520
	.9	0.549
	1.0	0.544
	1.1	0.539
	1.2	0.514
	1.3	0.480
	1.4	0.526
	1.5	0.557
	1.6	0.560
	1.7	0.572
8	.2	0.345
	.3	0.350
	.4	0.348
	.5	0.361
	.6	0.372
	.7	0.366
	.8	0.364
	.9	0.341
	1.0	0.320
	1.1	0.305
	1.2	0.293
	1.3	0.302
	1.4	0.307
	1.5	0.344
	1.6	0.393
9	.2	0.388
	.3	0.387
	.4	0.373
	.5	0.389
	.6	0.399
	.7	0.404
	.8	0.398
	.9	0.391
	1.0	0.364
	1.1	0.326
	1.2	0.333
	1.3	0.324
	1.4	0.343
	1.5	0.402
	1.6	0.474

STANDARD COUNT = 0.995,

11 October 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA COUNT RATIO
2	.2	0.174
	.4	0.231
	.6	0.235
	.8	0.268
	1.0	0.312
	1.2	0.339
	1.4	0.359
	1.6	0.391
3	.2	0.104
	.4	0.226
	.6	0.258
	.8	0.293
	1.0	0.357
	1.2	0.440
	1.4	0.476
5	.2	0.204
	.4	0.284
	.6	0.306
	.8	0.323
	1.0	0.335
	1.2	0.353
	1.4	0.384
	1.6	0.419
6	.2	0.167
	.4	0.240
	.6	0.271
	.8	0.321
	1.0	0.387
	1.2	0.414
	1.4	0.397
7	.2	0.180
	.4	0.418
	.6	0.468
	.8	0.525
	1.0	0.542
	1.2	0.513
	1.4	0.532
	1.6	0.559

STANDARD COUNT = 1.000,

1 November 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA KG/CU.M
8	.2	0260.
	.4	0246.
	.6	0255.
	.8	0265.
	1.0	0238.
	1.2	0222.
	1.4	0241.
	1.6	0271.
9	.2	0246.
	.4	0240.
	.6	0219.
	.8	0128.
	1.0	0097.
	1.2	0089.
	1.4	0100.
	1.6	0158.
3	.2	0192.
	.4	0203.
	.6	0195.
	.8	0235.
	1.0	0287.
	1.2	0268.
2	.2	0207.
	.4	0231.
	.6	0224.
	.8	0212.
	1.0	0196.
	1.2	0194.
	1.4	0217.
	1.6	0231.
5	.2	0209.
	.4	0221.
	.6	0145.
	.8	0150.
	1.0	0164.
	1.2	0178.
	1.4	0199.
6	.2	0181.
	.4	0201.
	.6	0195.
	.8	0190.
	1.0	0240.
	1.2	0214.
	1.4	0220.
7	.2	0200.
	.4	0289.
	.6	0286.
	.8	0274.
	1.0	0284.
	1.2	0257.
	1.4	0287.
	1.6	0296.

STANDARD COUNT = 0653.,

6 November 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA COUNT RATIO
8	.2	0.367
	.4	0.386
	.6	0.410
	.8	0.397
	1.0	0.357
	1.2	0.337
	1.4	0.289
	1.6	0.424
9	.2	0.353
	.4	0.367
	.6	0.374
	.8	0.362
	1.0	0.279
	1.2	0.211
	1.4	0.217
	1.6	0.347
2	.2	0.177
	.4	0.365
	.6	0.401
	.8	0.416
	1.0	0.422
	1.2	0.439
	1.4	0.425
	1.6	0.429
3	.2	0.241
	.4	0.337
	.6	0.295
	.8	0.393
	1.0	0.502
	1.2	0.240
7	.2	0.182
	.4	0.490
	.6	0.441
	.8	0.605
	1.0	0.563
	1.2	0.506
	1.4	0.530
	1.6	0.554
	1.8	0.556
898	.2	0.997

STANDARD COUNT = 1.000,

7 December 1985

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
BB	.2	1480.
8	.2	0357.
	.3	0369.
	.4	0377.
	.5	0376.
	.6	0392.
	.7	0405.
	.8	0409.
	.9	0384.
	1.0	0371.
	1.1	0365.
	1.2	0398.
	1.3	0399.
	1.4	0453.
9	.2	0419.
	.3	0414.
	.4	0401.
	.5	0389.
	.6	0393.
	.7	0382.
	.8	0382.
	.9	0359.
	1.0	0359.
	1.1	0323.
	1.2	0304.
	1.3	0313.
	1.4	0319.
2	.2	0378.
	.3	0397.
	.4	0398.
	.5	0400.
	.6	0404.
	.7	0431.
	.8	0464.
	.9	0484.
	1.0	0555.
	1.1	0594.
	1.2	0589.
	1.3	0610.
	1.4	0603.
	1.5	0624.
3	.2	0359.
	.3	0400.
	.4	0371.
	.5	0375.
	.6	0441.
	.7	0475.
	.8	0540.
	.9	0622.
	1.0	0715.
	1.1	0810.
5	.2	0377.
	.3	0444.
	.4	0478.
	.5	0493.
	.6	0501.
	.7	0532.
	.8	0566.
	.9	0587.
	1.0	0588.
	1.1	0604.
	1.2	0617.
	1.3	0648.
	1.4	0689.
6	.2	0360.
	.3	0402.
	.4	0437.
	.5	0471.
	.6	0518.
	.7	0576.
	.8	0601.
	.9	0633.
	1.0	0707.
	1.1	0791.
	1.2	0795.
	1.3	0759.
	1.4	0812.

STANDARD COUNT = 1480.

6 March 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0213.
	.3	0240.
	.4	0260.
	.5	0275.
	.6	0271.
	.7	0282.
	.8	0295.
	.9	0305.
	1.0	0310.
	1.1	0308.
	1.2	0331.
	1.3	0342.
6	.2	0373.
	.3	0192.
	.4	0210.
	.5	0225.
	.6	0245.
	.7	0274.
	.8	0303.
	.9	0316.
	1.0	0344.
	1.1	0397.
	1.2	0427.
	1.3	0409.
	1.4	0415.
2	.2	0218.
	.3	0212.
	.4	0216.
	.5	0225.
	.6	0245.
	.7	0253.
	.8	0261.
	.9	0288.
	1.0	0322.
	1.1	0319.
	1.2	0342.
	1.3	0350.
	1.4	0347.
8	.2	0218.
	.3	0215.
	.4	0221.
	.5	0232.
	.6	0228.
	.7	0231.
	.8	0229.
	.9	0215.
	1.0	0196.
	1.1	0203.
	1.2	0216.
	1.3	0238.
9	.2	0204.
	.3	0220.
	.4	0216.
	.5	0211.
	.6	0230.
	.7	0223.
	.8	0227.
	.9	0215.
	1.0	0191.
	1.1	0183.
	1.2	0174.
	1.3	0178.
	1.4	0204.
3	.2	0142.
	.3	0146.
	.4	0144.
	.5	0173.
	.6	0222.
	.7	0232.
	.8	0272.
	.9	0326.
	1.0	0401.
	1.1	0464.
7	.2	0260.
	.3	0367.
	.4	0391.
	.5	0425.
	.6	0459.
	.7	0495.
	.8	0516.
	.9	0506.
	1.0	0505.
	1.1	0482.
	1.2	0446.
	1.3	0492.

S T A N D A R D   C O U N T   =
908.,0,919091,0.8.5.,

13 March 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0235.
	.3	0250.
	.4	0270.
	.5	0270.
	.6	0283.
	.7	0296.
	.8	0301.
	.9	0311.
	1.0	0308.
	1.1	0309.
	1.2	0322.
	1.3	0355.
6	.2	0216.
	.3	0224.
	.4	0251.
	.5	0279.
	.6	0304.
	.7	0320.
	.8	0348.
	.9	0396.
	1.0	0413.
	1.1	0407.
	1.2	0403.
9	.2	0202.
	.3	0221.
	.4	0218.
	.5	0221.
	.6	0221.
	.7	0228.
	.8	0219.
	.9	0209.
	1.0	0194.
	1.1	0178.
	1.2	0174.
	1.3	0181.
	1.4	0205.
8	.2	0270.
	.3	0220.
	.4	0227.
	.5	0226.
	.6	0229.
	.7	0222.
	.8	0234.
	.9	0221.
	1.0	0195.
	1.1	0196.
	1.2	0197.
	1.3	0213.
	1.4	0240.
3	.2	0181.
	.3	0148.
	.4	0170.
	.5	0223.
	.6	0244.
	.7	0279.
	.8	0325.
	.9	0397.
	1.0	0304.
2	.2	0260.
	.3	0230.
	.4	0231.
	.5	0248.
	.6	0262.
	.7	0300.
	.8	0322.
	.9	0327.
	1.0	0332.
	1.1	0348.
	1.2	0355.
7	.2	0290.
	.3	0306.
	.4	0334.
	.5	0336.
	.6	0352.
	.7	0387.
	.8	0400.
	.9	0417.
	1.0	0397.
	1.1	0387.
	1.2	0387.
	1.3	0430.
	1.4	0467.

STANDARD COUNT = 907., 0
090,217.9.,

20 March 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0235.
	.3	0243.
	.4	0270.
	.5	0270.
	.6	0276.
	.7	0292.
	.8	0302.
	.9	0309.
	1.0	0320.
	1.1	0321.
	1.2	0314.
	1.3	0343.
6	.2	0368.
	.3	0226.
	.4	0207.
	.5	0222.
	.6	0240.
	.7	0279.
	.8	0311.
	.9	0324.
	1.0	0346.
	1.1	0406.
	1.2	0409.
	1.3	0403.
8	.2	0230.
	.3	0226.
	.4	0226.
	.5	0232.
	.6	0233.
	.7	0236.
	.8	0221.
	.9	0216.
	1.0	0203.
	1.1	0198.
	1.2	0205.
	1.3	0219.
9	.2	0204.
	.3	0218.
	.4	0220.
	.5	0224.
	.6	0224.
	.7	0228.
	.8	0214.
	.9	0202.
	1.0	0193.
	1.1	0175.
	1.2	0171.
	1.3	0180.
3	.2	0209.
	.3	0168.
	.4	0149.
	.5	0140.
	.6	0173.
	.7	0216.
	.8	0236.
	.9	0279.
	1.0	0315.
	1.1	0399.
	1.2	0455.
2	.2	0269.
	.3	0260.
	.4	0225.
	.5	0231.
	.6	0251.
	.7	0276.
	.8	0301.
	.9	0317.
	1.0	0332.
	1.1	0335
	1.2	0352.
	1.3	0345.
7	.2	0308.
	.3	0376.
	.4	0412.
	.5	0434.
	.6	0466.
	.7	0506.
	.8	0508.
	.9	0504.
	1.0	0499.
	1.1	0485.
	1.2	0441.
	1.3	0459.
	1.4	0508.

STANDARD COUNT = 902., 0902.,

20 March 1986 BU

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0235.
	.3	0243.
	.4	0270.
	.5	0270.
	.6	0276.
	.7	0292.
	.8	0302.
	.9	0309.
	1.0	0320.
	1.1	0321.
	1.2	0314.
	1.3	0343.
6	.2	0368.
	.3	0226.
	.4	0207.
	.5	0222.
	.6	0240.
	.7	0279.
	.8	0311.
	.9	0324.
	1.0	0346.
	1.1	0406.
	1.2	0409.
	1.3	0403.
8	.2	0230.
	.3	0226.
	.4	0226.
	.5	0232.
	.6	0233.
	.7	0236.
	.8	0221.
	.9	0216.
	1.0	0203.
	1.1	0198.
	1.2	0205.
	1.3	0219.
9	.2	0204.
	.3	0218.
	.4	0220.
	.5	0224.
	.6	0224.
	.7	0228.
	.8	0214.
	.9	0202.
	1.0	0193.
	1.1	0175.
	1.2	0171.
	1.3	0180.
3	.2	0209.
	.3	0168.
	.4	0149.
	.5	0140.
	.6	0173.
	.7	0216.
	.8	0236.
	.9	0279.
	1.0	0315.
	1.1	0399.
	1.2	0455.
2	.2	0269.
	.3	0260.
	.4	0225.
	.5	0231.
	.6	0251.
	.7	0276.
	.8	0301.
	.9	0317.
	1.0	0332.
2	1.1	0335.
	1.2	0352.
	1.3	0345.
7	.2	0308.
	.3	0376.
	.4	0412.
	.5	0434.
	.6	0466.
	.7	0506.
	.8	0508.
	.9	0504.
	1.0	0499.
	1.1	0485.
	1.2	0441.
	1.3	0459.
	1.4	0508.

STANDARD COUNT = 902., 0902.,

26 March 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0286.
	.3	0374.
	.4	0441.
	.5	0472.
	.6	0497.
	.7	0519.
	.8	0503.
	.9	0495.
	1.0	0484.
	1.1	0441.
	1.2	0472.
	1.3	0509.
8	.2	0212.
	.3	0218.
	.4	0219.
	.5	0227.
	.6	0227.
	.7	0234.
	.8	0227.
	.9	0210.
	1.0	0208.
	1.1	0197.
	1.2	0196.
	1.3	0216.
	1.4	0241.
9	.2	0318.
	.3	0219.
	.4	0216.
	.5	0223.
	.6	0224.
	.7	0224.
	.8	0216.
	.9	0208.
	1.0	0188.
	1.1	0179.
	1.2	0175.
	1.3	0184.
	1.4	0147.
3	.2	0142.
	.3	0142.
	.4	0177.
	.5	0208.
	.6	0222.
	.7	0227.
	.8	0253.
	.9	0311.
	1.0	0387.
	1.1	0446.
2	.2	0221.
	.3	0230.
	.4	0224.
	.5	0225.
	.6	0233.
	.7	0245.
	.8	0250.
	.9	0287.
	1.0	0307.
	1.1	0333.
	1.2	0349.
	1.3	0353.
	1.4	0345.
6	.2	0229.
	.3	0249.
	.4	0287.
	.5	0298.
	.6	0318.
	.7	0353.
	.8	0388.
	.9	0412.
	1.0	0396.
	1.1	0399.
5	.2	0226.
	.3	0256.
	.4	0268.
	.5	0270.
	.6	0279.
	.7	0295.
	.8	0296.
	.9	0307.
	1.0	0303.
	1.1	0305.
	1.2	0322.
	1.3	0350.
	1.4	0376.

STANDARD COUNT = 916., 0916.,

3 April 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0281.
	.3	0373.
	.4	0407.
	.5	0430.
	.6	0459.
	.7	0493.
	.8	0508.
	.9	0503.
	1.0	0503.
	1.1	0477.
	1.2	0434.
8	.2	0202.
	.3	0213.
	.4	0215.
	.5	0227.
	.6	0227.
	.7	0226.
	.8	0215.
	.9	0198.
	1.0	0200.
	1.1	0207.
	1.2	0216.
	1.3	0232.
9	.2	0212.
	.3	0215.
	.4	0216.
	.5	0222.
	.6	0221.
	.7	0218.
	.8	0209.
	.9	0187.
	1.0	0170.
	1.1	0174.
	1.2	0178.
	1.3	0196.
	1.4	0135.
3	.2	0138.
	.3	0143.
	.4	0212.
	.5	0225.
	.6	0249.
	.7	0299.
	.8	0363.
	.9	0437.
2	.2	0197.
	.3	0206.
	.4	0216.
	.5	0224.
	.6	0227.
	.7	0237.
	.8	0248.
	.9	0281.
	1.0	0306.
	1.1	0316.
	1.2	0326.
	1.3	0334.
	1.4	0335.
6	.2	0177.
	.3	0214.
	.4	0219.
	.5	0251.
	.6	0270.
	.7	0300.
	.8	0309.
	.9	0341.
	1.0	0384.
	1.1	0412.
	1.2	0394.
	1.3	0392.
5	.2	0210.
	.3	0245.
	.4	0268.
	.5	0274.
	.6	0274.
	.7	0292.
	.8	0302.
	.9	0308.
	1.0	0314.
	1.1	0310.
	1.2	0318.
	1.3	0340.
	1.4	0376.

STANDARD COUNT = 909., 0912.,

10 April 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0295.
	.3	0366.
	.4	0405.
	.5	0430.
	.6	0452.
	.7	0482.
	.8	0494.
	.9	0503.
	1.0	0497.
	1.1	0477.
	1.2	0438.
	1.3	0458.
	1.4	0504.
8	.2	0208.
	.3	0211.
	.4	0224.
	.5	0231.
	.6	0225.
	.7	0227.
	.8	0223.
	.9	0214.
	1.0	0196.
	1.1	0191.
	1.2	0200.
	1.3	0208.
9	.2	0195.
	.3	0218.
	.4	0215.
	.5	0221.
	.6	0228.
	.7	0219.
	.8	0221.
	.9	0204.
	1.0	0183.
	1.1	0181.
	1.2	0166.
	1.3	0176.
	1.4	0207.
3	.2	0135.
	.3	0140.
	.4	0136.
	.5	0205.
	.6	0218.
	.7	0237.
	.8	0284.
	.9	0353.
	1.0	0422.
2	.2	0194.
	.3	0207.
	.4	0213.
	.5	0214.
	.6	0227.
	.7	0233.
	.8	0250.
	.9	0270.
	1.0	0303.
	1.1	0309.
	1.2	0314.
	1.3	0327.
	1.4	0333.
6	.2	0189.
	.3	0202.
	.4	0224.
	.5	0240.
	.6	0276.
	.7	0294.
	.8	0306.
	.9	0340.
	1.0	0382.
	1.1	0406.
	1.2	0388.
	1.3	0396.
5	.2	0213.
	.3	0240.
	.4	0252.
	.5	0264.
	.6	0272.
	.7	0282.
	.8	0310.
	.9	0304.
	1.0	0308.
	1.1	0310.
	1.2	0323.
	1.3	0338.
	1.4	0374.

STANDARD COUNT = 910., 0910.,

16 April 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0374.
	.3	0388.
	.4	0407.
	.5	0425.
	.6	0448.
	.7	0494.
	.8	0505.
	.9	0513.
	1.0	0504.
	1.1	0473.
	1.2	0433.
	1.3	0478.
	1.4	0519.
8	.2	0358.
	.3	0339.
	.4	0266.
	.5	0226.
	.6	0223.
	.7	0234.
	.8	0226.
	.9	0235.
	1.0	0222.
	1.1	0190.
	1.2	0201.
	1.3	0217.
	1.4	0243.
9	.2	0282.
	.3	0322.
	.4	0258.
	.5	0259.
	.6	0260.
	.7	0266.
	.8	0254.
	.9	0237.
	1.0	0229.
	1.1	0226.
	1.2	0354.
	1.3	0261.
3	.2	0295.
	.3	0298.
	.4	0271.
	.5	0210.
	.6	0220.
	.7	0227.
	.8	0258.
	.9	0298.
	1.0	0356.
	1.1	0423.
	1.2	0459.
2	.2	0312.
	.3	0456.
	.4	0266.
	.5	0244.
	.6	0262.
	.7	0270.
	.8	0273.
	.9	0304.
	1.0	0324.
	1.1	0343.
	1.2	0359.
	1.3	0373.
	1.4	0385.
6	.2	0392.
	.3	0323.
	.4	0336.
	.5	0339.
	.6	0316.
	.7	0305.
	.8	0308.
	.9	0338.
	1.0	0385.
	1.1	0412.
	1.2	0389.
	1.3	0379.
5	.2	0358.
	.3	0373.
	.4	0342.
	.5	0301.
	.6	0296.
	.7	0288.
	.8	0311.
	.9	0301.
	1.0	0303.
	1.1	0304.
	1.2	0327.
	1.3	0342.
	1.4	0375.

STANDARD COUNT = 948., 0 0
0,948936,8.6.9.,

24 April 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0326.
	.3	0394.
	.4	0409.
	.5	0449.
	.6	0484.
	.7	0488.
	.8	0498.
	.9	0483.
	1.0	0476.
	1.1	0446.
	1.2	0475.
	1.3	0511.
8	.2	0249.
	.3	0244.
	.4	0239.
	.5	0233.
	.6	0227.
	.7	0232.
	.8	0223.
	.9	0215.
	1.0	0201.
	1.1	0197.
	1.2	0208.
	1.3	0217.
	1.4	0247.
9	.2	0241.
	.3	0234.
	.4	0231.
	.5	0237.
	.6	0242.
	.7	0243.
	.8	0239.
	.9	0220.
	1.0	0207.
	1.1	0195.
	1.2	0201.
	1.3	0199.
	1.4	0238.
3	.2	0259.
	.3	0264.
	.4	0236.
	.5	0214.
	.6	0224.
	.7	0230.
	.8	0256.
	.9	0309.
	1.0	0379.
	1.1	0441.
2	.2	0271.
	.3	0271.
	.4	0266.
	.5	0247.
	.6	0249.
	.7	0255.
	.8	0265.
	.9	0285.
	1.0	0319.
	1.1	0331.
	1.2	0343.
	1.3	0357.
	1.4	0354.
6	.2	0280.
	.3	0297.
	.4	0309.
	.5	0336.
	.6	0333.
	.7	0318.
	.8	0312.
	.9	0341.
	1.0	0373.
	1.1	0400.
	1.2	0388.
	1.3	0382.
5	.2	0312.
	.3	0329.
	.4	0325.
	.5	0304.
	.6	0280.
	.7	0295.
	.8	0293.
	.9	0309.
	1.0	0308.
	1.1	0318.
	1.2	0316.
	1.3	0337.
	1.4	0377.

STANDARD COUNT = 913., 0 091,313.6.

1 May 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0391.
	.3	0401.
	.4	0409.
	.5	0435.
	.6	0483.
	.7	0526.
	.8	0773.
	.9	0818.
	1.0	0499.
	1.1	0534.
	1.2	0498.
	1.3	0545.
	1.4	0628.
8	.2	0347.
	.3	0353.
	.4	0340.
	.5	0230.
	.6	0229.
	.7	0232.
	.8	0221.
	.9	0215.
	1.0	0202.
	1.1	0202.
	1.2	0207.
	1.3	0219.
	1.4	0247.
9	.2	0234.
	.3	0227.
	.4	0222.
	.5	0232.
	.6	0239.
	.7	0232.
	.8	0229.
	.9	0213.
	1.0	0193.
	1.1	0184.
	1.2	0192.
	1.3	0213.
3	.2	0243.
	.3	0238.
	.4	0210.
	.5	0209.
	.6	0224.
	.7	0230.
	.8	0266.
	.9	0325.
	1.0	0388.
	1.1	0441.
2	.2	0293.
	.3	0277.
	.4	0260.
	.5	0256.
	.6	0248.
	.7	0259.
	.8	0263.
	.9	0294.
	1.0	0317.
	1.1	0329.
	1.2	0338.
	1.3	0359.
	1.4	0361.
6	.2	0287.
	.3	0299.
	.4	0311.
	.5	0316.
	.6	0332.
	.7	0320.
	.8	0313.
	.9	0343.
	1.0	0388.
	1.1	0416.
	1.2	0396.
	1.3	0395.
5	.2	0370.
	.3	0363.
	.4	0325.
	.5	0289.
	.6	0281.
	.7	0294.
	.8	0295.
	.9	0302.
	1.0	0304.
	1.1	0305.
	1.2	0322.
	1.3	0338.
	1.4	0384.

STANDARD COUNT = 918., 0918.,

8 May 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0386.
	.3	0415.
	.4	0423.
	.5	0439.
	.6	0479.
	.7	0492.
	.8	0503.
	.9	0497.
	1.0	0492.
	1.1	0470.
	1.2	0489.
	1.3	0526.
8	.2	0222.
	.3	0226.
	.4	0224.
	.5	0222.
	.6	0234.
	.7	0227.
	.8	0229.
	.9	0221.
	1.0	0200.
	1.1	0194.
	1.2	0205.
	1.3	0222.
	1.4	0240.
9	.2	0214.
	.3	0227.
	.4	0219.
	.5	0227.
	.6	0233.
	.7	0226.
	.8	0222.
	.9	0213.
	1.0	0186.
	1.1	0184.
	1.2	0184.
	1.3	0190.
	1.4	0211.
3	.2	0211.
	.3	0211.
	.4	0198.
	.5	0219.
	.6	0223.
	.7	0235.
	.8	0270.
	.9	0325.
	1.0	0382.
	1.1	0443.
2	.2	0253.
	.3	0259.
	.4	0244.
	.5	0241.
	.6	0240.
	.7	0263.
	.8	0268.
	.9	0291.
	1.0	0324.
	1.1	0330.
	1.2	0343.
	1.3	0353.
6	.2	0267.
	.3	0292.
	.4	0301.
	.5	0318.
	.6	0319.
	.7	0313.
	.8	0317.
	.9	0331.
	1.0	0382.
	1.1	0394.
	1.2	0380.
	1.3	0379.
5	.2	0302.
	.3	0315.
	.4	0317.
	.5	0280.
	.6	0281.
	.7	0291.
	.8	0301.
	.9	0302.
	1.0	0298.
	1.1	0313.
	1.2	0324.
	1.3	0340.
	1.4	0370.

STANDARD COUNT = 922., 0922.,

15 May 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0507.
	.3	0536.
	.4	0509.
	.5	0514.
	.6	0522.
	.7	0504.
	.8	0524.
	.9	0510.
	1.0	0522.
	1.1	0486.
	1.2	0442.
	1.3	0504.
	1.4	0527.
8	.2	0426.
	.3	0302.
	.4	0229.
	.5	0236.
	.6	0239.
	.7	0242.
	.8	0228.
	.9	0213.
	1.0	0209.
	1.1	0195.
	1.2	0208.
	1.3	0220.
	1.4	0242.
9	.2	0207.
	.3	0235.
	.4	0252.
	.5	0276.
	.6	0299.
	.7	0280.
	.8	0230.
	.9	0236.
	1.0	0252.
	1.1	0212.
	1.2	0256.
	1.3	0220.
	1.4	0219.
3	.2	0197.
	.3	0194.
	.4	0189.
	.5	0220.
	.6	0230.
	.7	0248.
	.8	0266.
	.9	0323.
	1.0	0386.
	1.1	0436.
	1.2	0470.
2	.2	0229.
	.3	0238.
	.4	0234.
	.5	0236.
	.6	0250.
	.7	0267.
	.8	0274.
	.9	0293.
	1.0	0333.
	1.1	0333.
	1.2	0350.
	1.3	0362.
	1.4	0355.
6	.2	0250.
	.3	0268.
	.4	0302.
	.5	0318.
	.6	0340.
	.7	0354.
	.8	0323.
	.9	0410.
	1.0	0412.
	1.1	0406.
	1.2	0389.
	1.3	0383.
5	.2	0277.
	.3	0297.
	.4	0314.
	.5	0284.
	.6	0287.
	.7	0291.
	.8	0301.
	.9	0299.
	1.0	0306.
	1.1	0317.
	1.2	0316.
	1.3	0337.
	1.4	0370.

STANDARD COUNT = 1024., 1024.,

22 May 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0370.
	.3	0407.
	.4	0639.
	.5	0689.
	.6	0617.
	.7	0494.
	.8	0502.
	.9	0501.
	1.0	0498.
	1.1	0473.
	1.2	0457.
	1.3	0487.
	1.4	0506.
8	.2	0736.
	.3	0463.
	.4	0242.
	.5	0236.
	.6	0232.
	.7	0229.
	.8	0223.
	.9	0209.
	1.0	0202.
	1.1	0197.
	1.2	0203.
	1.3	0214.
	1.4	0239.
9	.2	0212.
	.3	0261.
	.4	0263.
	.5	0243.
	.6	0231.
	.7	0222.
	.8	0227.
	.9	0216.
	1.0	0187.
	1.1	0174.
	1.2	0172.
	1.3	0185.
	1.4	0206.
3	.2	0186.
	.3	0215.
	.4	0190.
	.5	0204.
	.6	0220.
	.7	0239.
	.8	0264.
	.9	0315.
	1.0	0378.
	1.1	0435.
2	.2	0213.
	.3	0234.
	.4	0249.
	.5	0235.
	.6	0236.
	.7	0249.
	.8	0263.
	.9	0281.
	1.0	0318.
	1.1	0327.
	1.2	0335.
	1.3	0333.
	1.4	0352.
6	.2	0225.
	.3	0244.
	.4	0265.
	.5	0292.
	.6	0294.
	.7	0304.
	.8	0314.
	.9	0341.
	1.0	0376.
	1.1	0397.
	1.2	0389.
	1.3	0382.
5	.2	0245.
	.3	0275.
	.4	0286.
	.5	0274.
	.6	0277.
	.7	0295.
	.8	0301.
	.9	0295.
	1.0	0306.
	1.1	0305.
	1.2	0316.
	1.3	0344.
	1.4	0362.

STANDARD COUNT = 946., 0
094,896.4.,

30 May 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0338.
	.3	0396.
	.4	0430.
	.5	0440.
	.6	0473.
	.7	0490.
	.8	0497.
	.9	0489.
	1.0	0489.
	1.1	0465.
	1.2	0439.
	1.3	0502.
	1.4	0507.
8	.2	0204.
	.3	0209.
	.4	0214.
	.5	0219.
	.6	0227.
	.7	0225.
	.8	0223.
	.9	0209.
	1.0	0195.
	1.1	0196.
	1.2	0203.
	1.3	0211.
	1.4	0237.
9	.2	0203.
	.3	0217.
	.4	0217.
	.5	0219.
	.6	0228.
	.7	0216.
	.8	0221.
	.9	0211.
	1.0	0183.
	1.1	0179.
	1.2	0177.
	1.3	0183.
	1.4	0206.
3	.2	0166.
	.3	0165.
	.4	0178.
	.5	0174.
	.6	0214.
	.7	0227.
	.8	0242.
	.9	0259.
	1.0	0315.
	1.1	0384.
	1.2	0428.
	1.3	0462.
2	.2	0215.
	.3	0221.
	.4	0230.
	.5	0227.
	.6	0241.
	.7	0237.
	.8	0254.
	.9	0288.
	1.0	0320.
	1.1	0313.
	1.2	0328.
	1.3	0338.
	1.4	0339.
6	.2	0222.
	.3	0237.
	.4	0255.
	.5	0313.
	.6	0292.
	.7	0307.
	.8	0303.
	.9	0349.
	1.0	0370.
	1.1	0391.
	1.2	0382.
	1.3	0373.
5	.2	0226.
	.3	0264.
	.4	0273.
	.5	0270.
	.6	0286.
	.7	0281.
	.8	0297.
	.9	0308.
	1.0	0307.
	1.1	0307.
	1.2	0324.
	1.3	0323.
	1.4	0362.

STANDARD COUNT = 927., 0
492,097.6.,

12 June 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0367.
	.3	0390.
	.4	0410.
	.5	0434.
	.6	0469.
	.7	0479.
8	.2	0229.
	.3	0231.
	.4	0222.
	.5	0229.
	.6	0230.
	.7	0233.
	.8	0227.
	.9	0218.
	1.0	0202.
	1.1	0199.
	1.2	0200.
	1.3	0214.
	1.4	0238.
9	.2	0202.
	.3	0221.
	.4	0214.
	.5	0221.
	.6	0231.
	.7	0227.
	.8	0227.
	.9	0209.
	1.0	0187.
	1.1	0187.
	1.2	0178.
	1.3	0182.
	1.4	0208.
3	.2	0205.
	.3	0183.
	.4	0185.
	.5	0215.
	.6	0224.
	.7	0242.
	.8	0264.
	.9	0308.
	1.0	0375.
	1.1	0434.
	1.2	0474.
2	.2	0241.
	.3	0231.
	.4	0228.
	.5	0236.
	.6	0231.
	.7	0241.
	.8	0261.
	.9	0278.
	1.0	0319.
	1.1	0317.
	1.2	0318.
	1.3	0334.
	1.4	0350.
5	.2	0232.
	.3	0258.
	.4	0267.
	.5	0262.
	.6	0283.
	.7	0281.
	.8	0293.
	.9	0303.
	1.0	0302.
	1.1	0303.
	1.2	0317.
	1.3	0344.
	1.4	0373.
6	.2	0229.
	.3	0235.
	.4	0241.
	.5	0269.
	.6	0279.
	.7	0299.
	.8	0312.
	.9	0335.
	1.0	0376.
	1.1	0390.
	1.2	0381.
	1.3	0361.

STANDARD COUNT = 953., 0 1
0,950720,3.4.8.,

19 June 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0241.
	.3	0254.
	.4	0272.
	.5	0270.
	.6	0271.
	.7	0292.
	.8	0301.
	.9	0303.
	1.0	0306.
	1.1	0309.
	1.2	0319.
	1.3	0337.
	1.4	0368.
6	.2	0229.
	.3	0237.
	.4	0237.
	.5	0257.
	.6	0277.
	.7	0295.
	.8	0310.
	.9	0335.
	1.0	0371.
	1.1	0383.
	1.2	0372.
	1.3	0371.
8	.2	0211.
	.3	0212.
	.4	0223.
	.5	0221.
	.6	0232.
	.7	0229.
	.8	0231.
	.9	0212.
	1.0	0197.
	1.1	0194.
	1.2	0200.
	1.3	0216.
	1.4	0240.
9	.2	0212.
	.3	0220.
	.4	0219.
	.5	0226.
	.6	0233.
	.7	0221.
	.8	0219.
	.9	0217.
	1.0	0183.
	1.1	0170.
	1.2	0177.
	1.3	0181.
	1.4	0212.
	1.5	0247.
2	.2	0241.
	.3	0230.
	.4	0226.
	.5	0225.
	.6	0236.
	.7	0242.
	.8	0253.
	.9	0287.
	1.0	0310.
	1.1	0320.
	1.2	0315.
	1.3	0339.
3	.2	0201.
	.3	0185.
	.4	0163.
	.5	0196.
	.6	0225.
	.7	0231.
	.8	0265.
	.9	0303.
	1.0	0375.
	1.1	0433.

STANDARD COUNT =
500., 0050,200.4.,

26 June 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
6	.2	0213.
	.3	0216.
	.4	0243.
	.5	0267.
	.6	0288.
	.7	0303.
	.8	0302.
	.9	0342.
	1.0	0381.
	1.1	0395.
	1.2	0372.
	1.3	0366.
5	.2	0236.
	.3	0260.
	.4	0272.
	.5	0271.
	.6	0281.
	.7	0289.
	.8	0309.
	.9	0305.
	1.0	0310.
	1.1	0309.
	1.2	0332.
	1.3	0357.
	1.4	0387.
8	.2	0203.
	.3	0213.
	.4	0214.
	.5	0226.
	.6	0231.
	.7	0221.
	.8	0230.
	.9	0208.
	1.0	0198.
	1.1	0198.
	1.2	0207.
	1.3	0208.
	1.4	0244.
9	.2	0219.
	.3	0218.
	.4	0221.
	.5	0224.
	.6	0223.
	.7	0221.
	.8	0222.
	.9	0201.
	1.0	0185.
	1.1	0180.
	1.2	0183.
	1.3	0190.
3	.2	0200.
	.3	0183.
	.4	0173.
	.5	0201.
	.6	0226.
	.7	0228.
	.8	0283.
	.9	0326.
	1.0	0409.
	1.1	0436.
2	.2	0232.
	.3	0224.
	.4	0225.
	.5	0232.
	.6	0235.
	.7	0247.
	.8	0266.
	.9	0294.
	1.0	0316.
	1.1	0320.
	1.2	0334.
	1.3	0336.
	1.4	0346.
7	.2	0226.
	.3	0247.
	.4	0294.
	.5	0325.
	.6	0361.
	.7	0394.
	.8	0415.
	.9	0405.
	1.0	0380.
	1.1	0369.
	1.2	0400.

STANDARD COUNT =
922., 0092,932.3.,

3 July 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
6	.2	0228.
	.3	0233.
	.4	0263.
	.5	0280.
	.6	0297.
	.7	0314.
	.8	0352.
	.9	0387.
	1.0	0385.
	1.1	0360.
5	.2	0233.
	.3	0251.
	.4	0269.
	.5	0271.
	.6	0272.
	.7	0295.
	.8	0298.
	.9	0314.
	1.0	0301.
	1.1	0316.
	1.2	0327.
	1.3	0338.
	1.4	0371.
8	.2	0208.
	.3	0213.
	.4	0215.
	.5	0220.
	.6	0225.
	.7	0226.
	.8	0215.
	.9	0208.
	1.0	0198.
	1.1	0190.
	1.2	0205.
	1.3	0218.
	1.4	0235.
9	.2	0207.
	.3	0224.
	.4	0217.
	.5	0216.
	.6	0221.
	.7	0222.
	.8	0217.
	.9	0199.
	1.0	0179.
	1.1	0181.
	1.2	0176.
	1.3	0189.
	1.4	0302.
3	.2	0205.
	.3	0183.
	.4	0176.
	.5	0205.
	.6	0226.
	.7	0231.
	.8	0263.
	.9	0381.
	1.0	0438.
	1.1	0470.
2	.2	0235.
	.3	0226.
	.4	0223.
	.5	0228.
	.6	0235.
	.7	0239.
	.8	0268.
	.9	0293.
	1.0	0312.
	1.1	0314.
	1.2	0338.
	1.3	0330.
	1.4	0334.
7	.2	0222.
	.3	0247.
	.4	0300.
	.5	0306.
	.6	0357.
	.7	0385.
	.8	0402.
	.9	0410.
	1.0	0407.
	1.1	0368.
	1.2	0387.
	1.3	0424.

STANDARD COUNT =
916., 0 00,912191,6.8.7.,

10 July 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0206.
	.3	0246.
	.4	0286.
	.5	0318.
	.6	0344.
	.7	0367.
	.8	0396.
	.9	0421.
	1.0	0401.
	1.1	0375.
	1.2	0397.
	1.3	0421.
2	.2	0221.
	.3	0233.
	.4	0225.
	.5	0671.
	.6	0244.
	.7	0244.
	.8	0270.
	.9	0293.
	1.0	0307.
	1.1	0309.
	1.2	0330.
	1.3	0332.
	1.4	0339.
3	.2	0203.
	.3	0186.
	.4	0179.
	.5	0208.
	.6	0224.
	.7	0233.
	.8	0271.
	.9	0324.
	1.0	0397.
	1.1	0443.
9	.2	0210.
	.3	0221.
	.4	0213.
	.5	0216.
	.6	0225.
	.7	0224.
	.8	0222.
	.9	0207.
	1.0	0188.
	1.1	0173.
	1.2	0179.
	1.3	0186.
	1.4	0215.
	1.5	0258.
	1.6	0315.
8	.2	0211.
	.3	0209.
	.4	0215.
	.5	0230.
	.6	0251.
	.7	0224.
	.8	0225.
	.9	0208.
	1.0	0197.
	1.1	0192.
	1.2	0199.
	1.3	0224.
	1.4	0237.
6	.2	0204.
	.3	0216.
	.4	0238.
	.5	0261.
	.6	0283.
	.7	0301.
	.8	0311.
	.9	0342.
	1.0	0383.
	1.1	0392.
	1.2	0364.
	1.3	0371.
5	.2	0230.
	.3	0260.
	.4	0264.
	.5	0266.
	.6	0283.
	.7	0287.
	.8	0305.
	.9	0303.
	1.0	0312.
	1.1	0309.
	1.2	0324.
	1.3	0342.
	1.4	0378.

STANDARD COUNT = 909., 0909.,

17 July 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0219.
	.3	0245.
	.4	0275.
	.5	0271.
	.6	0283.
	.7	0281.
	.8	0300.
	.9	0296.
	1.0	0300.
	1.1	0315.
	1.2	0322.
	1.3	0345.
	1.4	0373.
6	.2	0198.
	.3	0218.
	.4	0225.
	.5	0250.
	.6	0277.
	.7	0292.
	.8	0299.
	.9	0334.
	1.0	0369.
	1.1	0382.
	1.2	0378.
	1.3	0361.
8	.2	0214.
	.3	0214.
	.4	0226.
	.5	0232.
	.6	0227.
	.7	0222.
	.8	0204.
	.9	0199.
	1.0	0190.
	1.1	0203.
	1.2	0216.
9	.2	0208.
	.3	0222.
	.4	0219.
	.5	0217.
	.6	0226.
	.7	0229.
	.8	0224.
	.9	0205.
	1.0	0185.
	1.1	0169.
	1.2	0177.
	1.3	0176.
	1.4	0210.
	1.5	0254.
2	.2	0218.
	.3	0227.
	.4	0223.
	.5	0229.
	.6	0235.
	.7	0245.
	.8	0257.
	.9	0287.
	1.0	0309.
	1.1	0313.
	1.2	0319.
	1.3	0341.
	1.4	0334.
3	.2	0190.
	.3	0187.
	.4	0170.
	.5	0199.
	.6	0227.
	.7	0232.
	.8	0267.
	.9	0311.
	1.0	0379.
	1.1	0441.

STANDARD COUNT =
907., 0090,897.1.,

25 July 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0208.
	.3	0210.
	.4	0221.
	.5	0222.
	.6	0240.
	.7	0231.
	.8	0218.
	.9	0225.
	1.0	0210.
	1.1	0200.
	1.2	0194.
	1.3	0206.
	1.4	0209.
	1.5	0238.
2	.2	0213.
	.3	0220.
	.4	0227.
	.5	0230.
	.6	0235.
	.7	0243.
	.8	0260.
	.9	0283.
	1.0	0310.
	1.1	0312.
	1.2	0310.
	1.3	0334.
	1.4	0335.
3	.2	0189.
	.3	0180.
	.4	0172.
	.5	0216.
	.6	0228.
	.7	0231.
	.8	0236.
	.9	0259.
	1.0	0300.
	1.1	0376.
	1.2	0427.
7	.2	0205.
	.3	0241.
	.4	0285.
	.5	0321.
	.6	0365.
	.7	0382.
	.8	0394.
	.9	0399.
	1.0	0390.
	1.1	0371.
	1.2	0381.
	1.3	0423.
6	.2	0195.
	.3	0218.
	.4	0225.
	.5	0263.
	.6	0267.
	.7	0290.
	.8	0302.
	.9	0328.
	1.0	0367.
	1.1	0392.
	1.2	0362.
	1.3	0368.
5	.2	0217.
	.3	0251.
	.4	0271.
	.5	0261.
	.6	0276.
	.7	0297.
	.8	0300.
	.9	0296.
	1.0	0305.
	1.1	0309.
	1.2	0320.
	1.3	0337.
	1.4	0369.
9	.2	0282.
	.3	0220.
	.4	0238.
	.5	0218.
	.6	0223.
	.7	0228.
	.8	0219.
	.9	0200.
	1.0	0184.
	1.1	0180.
	1.2	0185.
	1.3	0224.
	1.4	0302.

STANDARD COUNT = 914., 0914.,

7 August 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0208.
	.3	0249.
	.4	0296.
	.5	0313.
	.6	0347.
	.7	0386.
	.8	0392.
	.9	0412.
	1.0	0405.
	1.1	0372.
	1.2	0394.
	1.3	0429.
8	.2	0626.
	.3	0212.
	.4	0217.
	.5	0220.
	.6	0232.
	.7	0223.
	.8	0220.
	.9	0208.
	1.0	0201.
	1.1	0195.
	1.2	0196.
	1.3	0218.
	1.4	0247.
9	.2	0204.
	.3	0224.
	.4	0216.
	.5	0217.
	.6	0227.
	.7	0219.
	.8	0217.
	.9	0210.
	1.0	0190.
	1.1	0174.
	1.2	0179.
	1.3	0184.
	1.4	0206.
3	.2	0176.
	.3	0176.
	.4	0167.
	.5	0196.
	.6	0227.
	.7	0237.
	.8	0273.
	.9	0311.
	1.0	0370.
	1.1	0430.
2	.2	0202.
	.3	0224.
	.4	0225.
	.5	0229.
	.6	0231.
	.7	0238.
	.8	0253.
	.9	0278.
	1.0	0319.
	1.1	0318.
	1.2	0326.
	1.3	0333.
	1.4	0341.
	1.5	0194.
6	.2	0233.
	.3	0220.
	.4	0249.
	.5	0278.
	.6	0297.
	.7	0306.
	.8	0319.
	.9	0366.
	1.0	0376.
	1.1	0368.
	1.2	0365.
5	.2	0228.
	.3	0244.
	.4	0265.
	.5	0262.
	.6	0282.
	.7	0299.
	.8	0300.
	.9	0309.
	1.0	0313.
	1.1	0312.
	1.2	0326.
	1.3	0346.
	1.4	0377.

STANDARD COUNT = 917., 0917.,

14 August 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0205.
	.3	0221.
	.4	0217.
	.5	0226.
	.6	0222.
	.7	0224.
	.8	0206.
	.9	0199.
	1.0	0196.
	1.1	0203.
	1.2	0209.
	1.3	0242.
9	.2	0210.
	.3	0221.
	.4	0210.
	.5	0224.
	.6	0227.
	.7	0223.
	.8	0219.
	.9	0208.
	1.0	0182.
	1.1	0176.
	1.2	0183.
	1.3	0184.
	1.4	0209.
	1.5	0250.
6	.2	0177.
	.3	0205.
	.4	0225.
	.5	0243.
	.6	0277.
	.7	0293.
	.8	0297.
	.9	0338.
	1.0	0363.
	1.1	0384.
	1.2	0370.
	1.3	0354.
5	.2	0208.
	.3	0257.
	.4	0266.
	.5	0261.
	.6	0278.
	.7	0283.
	.8	0294.
	.9	0307.
	1.0	0312.
	1.1	0304.
	1.2	0328.
	1.3	0346.
	1.4	0397.
7	.2	0178.
	.3	0262.
	.4	0325.
	.5	0356.
	.6	0391.
	.7	0396.
	.8	0401.
	.9	0409.
	1.0	0374.
	1.1	0388.
	1.2	0428.
2	.2	0194.
	.3	0215.
	.4	0221.
	.5	0228.
	.6	0233.
	.7	0242.
	.8	0260.
	.9	0286.
	1.0	0314.
	1.1	0308.
	1.2	0322.
	1.3	0340.
3	.2	0336.
	.3	0168.
	.4	0176.
	.5	0167.
	.6	0198.
	.7	0228.
	.8	0240.
	.9	0270.
	1.0	0310.
	1.1	0376.
	1.2	0431.

STANDARD COUNT = 914., 0914.,

20 August 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0173.
	.3	0227.
	.4	0300.
	.5	0322.
	.6	0354.
	.7	0383.
	.8	0401.
	.9	0418.
	1.0	0406.
	1.1	0379.
	1.2	0382.
	1.3	0420.
2	.2	0202.
	.3	0217.
	.4	0227.
	.5	0225.
	.6	0230.
	.7	0244.
	.8	0261.
	.9	0288.
	1.0	0313.
	1.1	0313.
	1.2	0325.
	1.3	0332.
	1.4	0340.
3	.2	0161.
	.3	0165.
	.4	0164.
	.5	0200.
	.6	0224.
	.7	0254.
	.8	0283.
	.9	0317.
	1.0	0386.
	1.1	0438.
8	.2	0189.
	.3	0210.
	.4	0214.
	.5	0216.
	.6	0226.
	.7	0229.
	.8	0220.
	.9	0204.
	1.0	0193.
	1.1	0193.
	1.2	0200.
	1.3	0223.
9	.2	0207.
	.3	0216.
	.4	0217.
	.5	0224.
	.6	0229.
	.7	0217.
	.8	0221.
	.9	0200.
	1.0	0183.
	1.1	0183.
	1.2	0178.
	1.3	0183.
	1.4	0216.
6	.2	0185.
	.3	0206.
	.4	0218.
	.5	0246.
	.6	0265.
	.7	0285.
	.8	0306.
	.9	0334.
	1.0	0371.
	1.1	0382.
	1.2	0358.
	1.3	0366.
	1.4	0928.
5	.2	0253.
	.3	0266.
	.4	0261.
	.5	0270.
	.6	0280.
	.7	0302.
	.8	0303.
	.9	0316.
	1.0	0317.
	1.1	0341.
	1.2	0374.

STANDARD COUNT =
905., 0090,235.5.,

27 August 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
6	.2	0187.
	.3	0199.
	.4	0226.
	.5	0243.
	.6	0268.
	.7	0285.
	.8	0308.
	.9	0336.
	1.0	0371.
	1.1	0388.
	1.2	0358.
	1.3	0368.
5	.2	0223.
	.3	0250.
	.4	0265.
	.5	0268.
	.6	0280.
	.7	0284.
	.8	0304.
	.9	0298.
	1.0	0288.
	1.1	0310.
	1.2	0323.
	1.3	0351.
	1.4	0369.
8	.2	0265.
	.3	0209.
	.4	0215.
	.5	0216.
	.6	0224.
	.7	0227.
	.8	0220.
	.9	0212.
	1.0	0190.
	1.1	0193.
	1.2	0201.
	1.3	0215.
	1.4	0238.
9	.2	0210.
	.3	0219.
	.4	0221.
	.5	0225.
	.6	0222.
	.7	0220.
	.8	0219.
	.9	0211.
	1.0	0182.
	1.1	0173.
	1.2	0179.
	1.3	0189.
2	.2	0214.
	.3	0191.
	.4	0217.
	.5	0223.
	.6	0230.
	.7	0230.
	.8	0245.
	.9	0263.
	1.0	0292.
	1.1	0316.
	1.2	0318.
	1.3	0326.
	1.4	0332.
	1.5	0342.
3	.2	0146.
	.3	0162.
	.4	0166.
	.5	0194.
	.6	0220.
	.7	0236.
	.8	0274.
	.9	0319.
	1.0	0390.
	1.1	0434.
7	.2	0174.
	.3	0216.
	.4	0284.
	.5	0306.
	.6	0327.
	.7	0371.
	.8	0408.
	.9	0406.
	1.0	0386.
	1.1	0367.
	1.2	0399.

STANDARD COUNT = 906., 0906.,

3 September 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0329.
	.3	0297.
	.4	0245.
	.5	0223.
	.6	0231.
	.7	0225.
	.8	0230.
	.9	0213.
	1.0	0196.
	1.1	0194.
	1.2	0200.
	1.3	0225.
	1.4	0251.
9	.2	0345.
	.3	0347.
	.4	0328.
	.5	0316.
	.6	0304.
	.7	0294.
	.8	0285.
	.9	0267.
	1.0	0245.
	1.1	0248.
	1.2	0242.
	1.3	0253.
	1.4	0281.
2	.2	0315.
	.3	0324.
	.4	0334.
	.5	0325.
	.6	0290.
	.7	0262.
	.8	0243.
	.9	0265.
	1.0	0292.
	1.1	0315.
	1.2	0311.
	1.3	0328.
	1.4	0335.
	1.5	0349.
5	.2	0331.
	.3	0281.
	.4	0267.
	.5	0266.
	.6	0272.
	.7	0290.
	.8	0302.
	.9	0308.
	1.0	0304.
	1.1	0308.
	1.2	0332.
	1.3	0346.
	1.4	0379.
6	.2	0304.
	.3	0314.
	.4	0319.
	.5	0298.
	.6	0273.
	.7	0307.
	.8	0337.
	.9	0379.
	1.0	0375.
	1.1	0362.
	1.2	0371.
7	.2	0287.
	.3	0330.
	.4	0332.
	.5	0322.
	.6	0341.
	.7	0374.
	.8	0410.
	.9	0415.
	1.0	0399.
	1.1	0372.
	1.2	0398.
3	.2	0292.
	.3	0281.
	.4	0263.
	.5	0243.
	.6	0239.
	.7	0236.
	.8	0271.
	.9	0322.
	1.0	0393.
	1.1	0435.

STANDARD COUNT = 928., 0928.,

10 September 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
22	.2	0222.
	.3	0221.
	.4	0286.
	.5	0232.
	.6	0232.
	.7	0228.
	.8	0229.
	.9	0287.
	1.0	0293.
	1.1	0209.
	1.2	0214.
	1.3	0206.
	1.4	0210.
	1.5	0200.
	1.6	0205.
	1.7	0284.
	1.8	0287.
	1.9	0185.
	2.0	0186.
	2.1	0183.
	2.2	0256.
	2.3	0257.
	2.4	0264.
	2.5	0199.
	2.6	0196.
	2.7	0199.
	2.8	0196.
	2.9	0298.
	3.0	0292.
	3.1	0013.
	3.2	0076.
	3.3	0247.
2	.2	0275.
	.3	0290.
	.4	0289.
	.5	0280.
	.6	0275.
	.7	0257.
	.8	0265.
	.9	0287.
	1.0	0300.
	1.1	0315.
	1.2	0332.
	1.3	0332.
	1.4	0337.
88	.2	0186.
	.3	0173.
	.4	0208.
	.5	0213.
	.6	0208.
	.7	0236.
	.8	0237.
	.9	0185.
	1.0	0184.
	1.1	0229.
	1.2	0171.
	1.3	0172.
	1.4	0180.
	1.5	0227.
	1.6	0221.
	1.7	0200.
	1.8	0202.
	1.9	0203.
	2.0	0198.
	2.1	0189.
	2.2	0197.
8	.2	0224.
	.3	0243.
	.4	0231.
	.5	0221.
	.6	0228.
	.7	0226.
	.8	0226.
	.9	0224.
	1.0	0213.
	1.1	0192.
	1.2	0201.
	1.3	0204.
	1.4	0221.
9	.2	0282.
	.3	0288.
	.4	0281.
	.5	0279.
	.6	0282.
	.7	0265.
	.8	0253.
	.9	0245.
	1.0	0214.
	1.1	0206.
	1.2	0218.
	1.3	0225.
	1.4	0255.
3	.2	0189.
	.3	0262.
	.4	0265.
	.5	0250.
	.6	0244.
	.7	0232.
	.8	0246.
	.9	0276.
	1.0	0327.
	1.1	0379.
	1.2	0437.
6	.2	0253.
	.3	0273.
	.4	0291.
	.5	0305.
	.6	0312.
	.7	0287.
	.8	0293.
	.9	0307.
	1.0	0344.
	1.1	0385.
	1.2	0388.
	1.3	0354.
	1.4	0363.
5	.2	0284.
	.3	6192.

STANDARD COUNT = 898., 0898.,

17 September 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0216.
	.3	0249.
	.4	0313.
	.5	0315.
	.6	0353.
	.7	0389.
	.8	0393.
	.9	0417.
	1.0	0388.
	1.1	0371.
	1.2	0398.
8	.2	0193.
	.3	0223.
	.4	0227.
	.5	0223.
	.6	0227.
	.7	0226.
	.8	0221.
	.9	0219.
	1.0	0214.
	1.1	0197.
	1.2	0195.
	1.3	0204.
	1.4	0223.
9	.2	0231.
	.3	0256.
	.4	0252.
	.5	0246.
	.6	0258.
	.7	0264.
	.8	0255.
	.9	0240.
	1.0	0225.
	1.1	0209.
	1.2	0197.
	1.3	0212.
	1.4	0205.
	1.5	0243.
2	.2	0212.
	.3	0255.
	.4	0273.
	.5	0273.
	.6	0266.
	.7	0274.
	.8	0260.
	.9	0261.
	1.0	0287.
	1.1	0313.
	1.2	0324.
	1.3	0338.
	1.4	0335.
3	.2	0160.
	.3	0231.
	.4	0241.
	.5	0237.
	.6	0240.
	.7	0237.
	.8	0274.
	.9	0326.
	1.0	0400.
	1.1	0437.
6	.2	0224.
	.3	0254.
	.4	0272.
	.5	0288.
	.6	0293.
	.7	0289.
	.8	0292.
	.9	0303.
	1.0	0345.
	1.1	0372.
	1.2	0376.
	1.3	0362.
	1.4	0358.
5	.2	0247.
	.3	0275.
	.4	0270.
	.5	0263.
	.6	0269.
	.7	0273.
	.8	0285.
	.9	0304.
	1.0	0304.
	1.1	0308.
	1.2	0311.
	1.3	0326.
	1.4	0349.
	1.5	0379.

STANDARD COUNT = 906., 0906.,

24 September 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0153.
	.3	0187.
	.4	0230.
	.5	0291.
	.6	0302.
	.7	0337.
	.8	0375.
	.9	0398.
	1.0	0407.
	1.1	0393.
	1.2	0368.
	1.3	0411.
8	.2	0189.
	.3	0218.
	.4	0220.
	.5	0226.
	.6	0224.
	.7	0227.
	.8	0222.
	.9	0209.
	1.0	0195.
	1.1	0197.
	1.2	0208.
	1.3	0218.
9	.2	0229.
	.3	0238.
	.4	0236.
	.5	0240.
	.6	0242.
	.7	0245.
	.8	0236.
	.9	0221.
	1.0	0191.
	1.1	0193.
	1.2	0189.
	1.3	0201.
	1.4	0234.
2	.2	0236.
	.3	0241.
	.4	0262.
	.5	0249.
	.6	0258.
	.7	0255.
	.8	0265.
	.9	0292.
	1.0	0311.
	1.1	0312.
	1.2	0326.
	1.3	0329.
3	.2	0344.
	.3	0200.
	.4	0220.
	.5	0215.
	.6	0239.
	.7	0233.
	.8	0242.
	.9	0281.
	1.0	0320.
	1.1	0402.
	1.2	0432.
6	.2	0238.
	.3	0244.
	.4	0268.
	.5	0287.
	.6	0274.
	.7	0292.
	.8	0308.
	.9	0336.
	1.0	0375.
	1.1	0381.
	1.2	0372.
	1.3	0361.
5	.2	0258.
	.3	0275.
	.4	0269.
	.5	0272.
	.6	0280.
	.7	0288.
	.8	0302.
	.9	0303.
	1.0	0312.
	1.1	0323.
	1.2	0324.
	1.3	0343.
	1.4	0385.

STANDARD COUNT = 888., 0888.,

1 October 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0220.
	.3	0224.
	.4	0223.
	.5	0228.
	.6	0230.
	.7	0226.
	.8	0213.
	.9	0198.
	1.0	0197.
	1.1	0197.
	1.2	0216.
9	.2	0218.
	.3	0236.
	.4	0232.
	.5	0236.
	.6	0234.
	.7	0229.
	.8	0229.
	.9	0217.
	1.0	0192.
	1.1	0191.
	1.2	0185.
	1.3	0201.
	1.4	0227.
2	.2	0213.
	.3	0234.
	.4	0240.
	.5	0245.
	.6	0252.
	.7	0259.
	.8	0266.
	.9	0295.
	1.0	0312.
	1.1	0317.
	1.2	0319.
	1.3	0329.
	1.4	0348.
3	.2	0194.
	.3	0203.
	.4	0203.
	.5	0222.
	.6	0236.
	.7	0232.
	.8	0277.
	.9	0327.
	1.0	0399.
	1.1	0435.
7	.2	0187.
	.3	0223.
	.4	0288.
	.5	0316.
	.6	0349.
	.7	0375.
	.8	0406.
	.9	0409.
	1.0	0394.
	1.1	0371.
	1.2	0395.
6	.2	0225.
	.3	0240.
	.4	0258.
	.5	0275.
	.6	0279.
	.7	0288.
	.8	0303.
	.9	0333.
	1.0	0364.
	1.1	0369.
	1.2	0358.
	1.3	0359.
5	.2	0249.
	.3	0262.
	.4	0279.
	.5	0268.
	.6	0271.
	.7	0282.
	.8	0301.
	.9	0306.
	1.0	0309.
	1.1	0315.
	1.2	0323.
	1.3	0347.
	1.4	0382.

STANDARD COUNT = 904., 0904.,

8 October 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0210.
	.3	0210.
	.4	0214.
	.5	0217.
	.6	0222.
	.7	0230.
	.8	0225.
	.9	0205.
	1.0	0191.
	1.1	0191.
	1.2	0209.
	1.3	0220.
9	.2	0225.
	.3	0225.
	.4	0225.
	.5	0241.
	.6	0227.
	.7	0234.
	.8	0229.
	.9	0215.
	1.0	0202.
	1.1	0199.
	1.2	0190.
	1.3	0196.
	1.4	0234.
2	.2	0214.
	.3	0213.
	.4	0229.
	.5	0227.
	.6	0229.
	.7	0248.
	.8	0265.
	.9	0291.
	1.0	0308.
	1.1	0317.
	1.2	0328.
	1.3	0337.
	1.4	0347.
3	.2	0175.
	.3	0180.
	.4	0185.
	.5	0218.
	.6	0233.
	.7	0238.
	.8	0276.
	.9	0322.
	1.0	0394.
	1.1	0430.
7	.2	0183.
	.3	0223.
	.4	0277.
	.5	0305.
	.6	0334.
	.7	0380.
	.8	0410.
	.9	0409.
	1.0	0394.
	1.1	0369.
	1.2	0390.
6	.2	0216.
	.3	0227.
	.4	0250.
	.5	0263.
	.6	0277.
	.7	0281.
	.8	0300.
	.9	0340.
	1.0	0363.
	1.1	0381.
	1.2	0356.
	1.3	0356.
5	.2	0235.
	.3	0251.
	.4	0258.
	.5	0266.
	.6	0277.
	.7	0288.
	.8	0302.
	.9	0307.
	1.0	0313.
	1.1	0318.
	1.2	0323.
	1.3	0351.
	1.4	0374.
	1.5	0377.

STANDARD COUNT =
902., 0 00,904040,2.2.6.,

15 October 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0198.
	.3	0209.
	.4	0208.
	.5	0221.
	.6	0223.
	.7	0234.
	.8	0219.
	.9	0213.
	1.0	0196.
	1.1	0192.
	1.2	0205.
	1.3	0218.
9	.2	0212.
	.3	0225.
	.4	0221.
	.5	0227.
	.6	0235.
	.7	0221.
	.8	0229.
	.9	0207.
	1.0	0189.
	1.1	0182.
	1.2	0184.
	1.3	0196.
	1.4	0222.
2	.2	0198.
	.3	0220.
	.4	0220.
	.5	0222.
	.6	0233.
	.7	0247.
	.8	0258.
	.9	0293.
	1.0	0306.
	1.1	0312.
	1.2	0327.
	1.3	0336.
	1.4	0336.
3	.2	0160.
	.3	0165.
	.4	0172.
	.5	0198.
	.6	0221.
	.7	0236.
	.8	0274.
	.9	0317.
	1.0	0384.
	1.1	0436.
7	.2	0178.
	.3	0217.
	.4	0266.
	.5	0293.
	.6	0337.
	.7	0373.
	.8	0407.
	.9	0416.
	1.0	0388.
	1.1	0363.
	1.2	0396.
6	.2	0210.
	.3	0227.
	.4	0235.
	.5	0263.
	.6	0278.
	.7	0286.
	.8	0303.
	.9	0337.
	1.0	0380.
	1.1	0376.
	1.2	0356.
	1.3	0359.
5	.2	0228.
	.3	0254.
	.4	0263.
	.5	0261.
	.6	0274.
	.7	0289.
	.8	0306.
	.9	0315.
	1.0	0297.
	1.1	0313.
	1.2	0326.
	1.3	0348.
	1.4	0381.

STANDARD COUNT = 912., 0912.,

17 October 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0190.
	.3	0219.
	.4	0272.
	.5	0297.
	.6	0336.
	.7	0368.
	.8	0399.
	.9	0414.
	1.0	0385.
	1.1	0370.
	1.2	0402.
	0	0
2	.2	0209.
	.3	0218.
	.4	0225.
	.5	0226.
	.6	0238.
	.7	0243.
	.8	0251.
	.9	0291.
	1.0	0302.
	1.1	0317.
	1.2	0331.
	1.3	0331.
	1.4	0334.
8	.2	0215.
	.3	0213.
	.4	0217.
	.5	0224.
	.6	0234.
	.7	0231.
	.8	0214.
	.9	0209.
	1.0	0194.
	1.1	0196.
	1.2	0201.
	1.3	0215.
9	.2	0221.
	.3	0227.
	.4	0219.
	.5	0228.
	.6	0231.
	.7	0229.
	.8	0222.
	.9	0206.
	1.0	0188.
	1.1	0185.
	1.2	0183.
	1.3	0189.
3	0.2	0223.
	.3	0163.
	.4	0176.
	.5	0204.
	.6	0223.
	.7	0235.
	.8	0273.
	.9	0316.
	1.0	0390.
	1.1	0422.
6	.2	0206.
	.3	0219.
	.4	0227.
	.5	0257.
	.6	0273.
	.7	0290.
	.8	0303.
	.9	0333.
	1.0	0380.
	1.1	0377.
	1.2	0358.
	1.3	0368.
5	.2	0238.
	.3	0250.
	.4	0256.
	.5	0270.
	.6	0270.
	.7	0288.
	.8	0297.
	.9	0301.
	1.0	0300.
	1.1	0316.
	1.2	0324.
	1.3	0354.
	1.4	0377.

STANDARD COUNT = 907., 0907.,

21 October 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0258.
	.3	0214.
	.4	0214.
	.5	0221.
	.6	0227.
	.7	0233.
	.8	0220.
	.9	0211.
	1.0	0198.
	1.1	0193.
	1.2	0208.
	1.3	0224.
2	.2	0326.
	.3	0323.
	.4	0320.
	.5	0269.
	.6	0236.
	.7	0236.
	.8	0260.
	.9	0285.
	1.0	0307.
	1.1	0312.
	1.2	0325.
	1.3	0327.
	1.4	0337.
7	.2	0318.
	.3	0335.
	.4	0340.
	.5	0316.
	.6	0348.
	.7	0392.
	.8	0398.
	.9	0406.
	1.0	0389.
	1.1	0377.
	1.2	0399.
	1.3	0424.

STANDARD COUNT = 903., 0903.,

22 October 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0306.
	.3	0328.
	.4	0332.
	.5	0331.
	.6	0349.
	.7	0380.
	.8	0393.
	.9	0402.
	1.0	0396.
	1.1	0371.
	1.2	0396.
8	.2	0258.
	.3	0226.
	.4	0215.
	.5	0226.
	.6	0229.
	.7	0230.
	.8	0222.
	.9	0200.
	1.0	0199.
	1.1	0198.
	1.2	0205.
	1.3	0215.
9	.2	0336.
	.3	0320.
	.4	0290.
	.5	0264.
	.6	0251.
	.7	0239.
	.8	0241.
	.9	0231.
	1.0	0225.
	1.1	0217.
	1.2	0204.
	1.3	0200.
	1.4	0234.
2	.2	0304.
	.3	0310.
	.4	0307.
	.5	0286.
	.6	0252.
	.7	0241.
	.8	0260.
	.9	0297.
	1.0	0308.
	1.1	0315.
	1.2	0333.
	1.3	0332.
	1.4	0348.
3	.2	0273.
	.3	0261.
	.4	0217.
	.5	0207.
	.6	0223.
	.7	0232.
	.8	0270.
	.9	0319.
	1.0	0394.
	1.1	0428.
6	.2	0301.
	.3	0303.
	.4	0279.
	.5	0263.
	.6	0281.
	.7	0286.
	.8	0302.
	.9	0339.
	1.0	0373.
	1.1	0374.
	1.2	0363.
	1.3	0363.
5	.2	0356.
	.3	0358.
	.4	0335.
	.5	0294.
	.6	0279.
	.7	0280.
	.8	0303.
	.9	0308.
	1.0	0305.
	1.1	0314.
	1.2	0328.
	1.3	0350.
	1.4	0381.

STANDARD COUNT = 897., 0897.,

24 October 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0237.
	.3	0224.
	.4	0217.
	.5	0219.
	.6	0228.
	.7	0230.
	.8	0224.
	.9	0206.
	1.0	0199.
	1.1	0196.
	1.2	0201.
	1.3	0215.
2	.2	0286.
	.3	0290.
	.4	0289.
	.5	0271.
	.6	0242.
	.7	0242.
	.8	0264.
	.9	0292.
	1.0	0306.
	1.1	0307.
	1.2	0324.
	1.3	0328.
	1.4	0344.
7	.2	0279.
	.3	0328.
	.4	0337.
	.5	0318.
	.6	0342.
	.7	0381.
	.8	0397.
	.9	0407.
	1.0	0377.
	1.1	0370.
	1.2	0403.
	1.3	0419.

STANDARD COUNT = 910., 0910.,

29 October 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0394.
	.3	0406.
	.4	0395.
	.5	0343.
	.6	0315.
	.7	0300.
	.8	0303.
	.9	0306.
	1.0	0296.
	1.1	0314.
	1.2	0317.
	1.3	0351.
	1.4	0386.
6	.2	0355.
	.3	0364.
	.4	0375.
	.5	0356.
	.6	0307.
	.7	0294.
	.8	0301.
	.9	0339.
	1.0	0374.
	1.1	0380.
	1.2	0347.
	1.3	0368.
8	.2	0276.
	.3	0232.
	.4	0221.
	.5	0229.
	.6	0227.
	.7	0231.
	.8	0220.
	.9	0212.
	1.0	0200.
	1.1	0203.
	1.2	0209.
	1.3	0224.
9	.2	0431.
	.3	0424.
	.4	0408.
	.5	0384.
	.6	0342.
	.7	0288.
	.8	0283.
	.9	0295.
	1.0	0282.
	1.1	0268.
	1.2	0264.
	1.3	0254.
	1.4	0279.
2	.2	0385.
	.3	0392.
	.4	0396.
	.5	0366.
	.6	0350.
	.7	0282.
	.8	0263.
	.9	0296.
	1.0	0313.
	1.1	0316.
	1.2	0323.
	1.3	0323.
	1.4	0339.
3	.2	0341.
	.3	0326.
	.4	0278.
	.5	0237.
	.6	0230.
	.7	0236.
	.8	0276.
	.9	0347.
	1.0	0405.
	1.1	0453.
7	.2	0375.
	.3	0397.
	.4	0384.
	.5	0398.
	.6	0391.
	.7	0408.
	.8	0398.
	.9	0394.
	1.0	0375.
	1.1	0394.

STANDARD COUNT = 907., 0907.,

5 November 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0286.
	.3	0315.
	.4	0362.
	.5	0387.
	.6	0426.
	.7	0442.
	.8	0430.
	.9	0406.
	1.0	0391.
	1.1	0364.
	1.2	0400.
5	.2	0331.
	.3	0348.
	.4	0343.
	.5	0338.
	.6	0341.
	.7	0319.
	.8	0307.
	.9	0303.
	1.0	0306.
	1.1	0311.
	1.2	0333.
	1.3	0347.
	1.4	0369.
6	.2	0286.
	.3	0297.
	.4	0324.
	.5	0348.
	.6	0365.
	.7	0345.
	.8	0312.
	.9	0334.
	1.0	0372.
	1.1	0382.
	1.2	0362.
	1.3	0357.
8	.2	0235.
	.3	0232.
	.4	0223.
	.5	0219.
	.6	0229.
	.7	0228.
	.8	0220.
	.9	0207.
	1.0	0199.
	1.1	0199.
	1.2	0203.
	1.3	0229.
9	.2	0312.
	.3	0318.
	.4	0313.
	.5	0322.
	.6	0314.
	.7	0293.
	.8	0283.
	.9	0255.
	1.0	0225.
	1.1	0221.
	1.2	0217.
	1.3	0232.
	1.4	0249.
	1.5	0285.
	1.6	0306.
2	.2	0307.
	.3	0302.
	.4	0310.
	.5	0301.
	.6	0300.
	.7	0310.
	.8	0311.
	.9	0330.
	1.0	0333.
	1.1	0340.
3	.2	0275.
	.3	0268.
	.4	0255.
	.5	0258.
	.6	0259.
	.7	0272.
	.8	0343.
	.9	0413.
	1.0	0472.
	1.1	0504.

STANDARD COUNT = 914., 0914.,

13 November 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0306.
	.3	0349.
	.4	0379.
	.5	0401.
	.6	0436.
	.7	0473.
	.8	0475.
	.9	0448.
	1.0	0395.
	1.1	0373.
	1.2	0397.
8	.2	0251.
	.3	0229.
	.4	0226.
	.5	0230.
	.6	0229.
	.7	0236.
	.8	0222.
	.9	0212.
	1.0	0195.
	1.1	0193.
	1.2	0205.
	1.3	0218.
9	.2	0336.
	.3	0340.
	.4	0334.
	.5	0331.
	.6	0326.
	.7	0305.
	.8	0272.
	.9	0242.
	1.0	0211.
	1.1	0206.
	1.2	0207.
	1.3	0210.
	1.4	0241.
2	.2	0316.
	.3	0325.
	.4	0331.
	.5	0338.
	.6	0333.
	.7	0345.
	.8	0344.
	.9	0336.
	1.0	0323.
	1.1	0318.
	1.2	0324.
	1.3	0326.
	1.4	0342.
3	.2	0301.
	.3	0323.
	.4	0315.
	.5	0297.
	.6	0294.
	.7	0311.
	.8	0361.
	.9	0428.
	1.0	0495.
	1.1	0515.
6	.2	0304.
	.3	0316.
	.4	0332.
	.5	0352.
	.6	0387.
	.7	0395.
	.8	0337.
	.9	0343.
	1.0	0370.
	1.1	0379.
	1.2	0358.
	1.3	0355.
5	.2	0337.
	.3	0343.
	.4	0363.
	.5	0341.
	.6	0349.
	.7	0311.
	.8	0314.
	.9	0303.
	1.0	0314.
	1.1	0317.
	1.2	0322.
	1.3	0347.
	1.4	0377.

STANDARD COUNT = 917., 0917.,

19 November 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
8	.2	0219.
	.3	0226.
	.4	0225.
	.5	0235.
	.6	0239.
	.7	0230.
	.8	0223.
	.9	0208.
	1.0	0195.
	1.1	0199.
	1.2	0206.
	1.3	0225.
9	.2	0269.
	.3	0281.
	.4	0285.
	.5	0285.
	.6	0292.
	.7	0290.
	.8	0260.
	.9	0236.
	1.0	0206.
	1.1	0196.
	1.2	0197.
	1.3	0205.
	1.4	0233.
	1.5	0261.
2	.2	0271.
	.3	0288.
	.4	0302.
	.5	0306.
	.6	0323.
	.7	0332.
	.8	0327.
	.9	0310.
	1.0	0326.
	1.1	0337.
	1.2	0335.
3	.2	0235.
	.3	0264.
	.4	0273.
	.5	0275.
	.6	0284.
	.7	0307.
	.8	0367.
	.9	0424.
	1.0	0473.
	1.1	0511.
6	.2	0255.
	.3	0280.
	.4	0305.
	.5	0324.
	.6	0359.
	.7	0374.
	.8	0346.
	.9	0337.
	1.0	0378.
	1.1	0372.
	1.2	0356.
	1.3	0372.
5	.2	0296.
	.3	0329.
	.4	0310.
	.5	0317.
	.6	0332.
	.7	0327.
	.8	0307.
	.9	0306.
	1.0	0306.
	1.1	0310.
	1.2	0319.
	1.3	0361.
	1.4	0376.
7	.2	0357.
	.3	0365.
	.4	0377.
	.5	0376.
	.6	0415.
	.7	0444.
	.8	0452.
	.9	0419.
	1.0	0402.
	1.1	0376.
	1.2	0400.

STANDARD COUNT = 905.

25 November 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0336.
	.3	0341.
	.4	0341.
	.5	0327.
	.6	0324.
	.7	0335.
	.8	0323.
	.9	0305.
	1.0	0306.
	1.1	0305.
	1.2	0330.
	1.3	0361.
	1.4	0374.
6	.2	0288.
	.3	0292.
	.4	0294.
	.5	0319.
	.6	0351.
	.7	0351.
	.8	0331.
	.9	0338.
	1.0	0370.
	1.1	0379.
	1.2	0363.
	1.3	0360.
8	.2	0226.
	.3	0224.
	.4	0226.
	.5	0221.
	.6	0232.
	.7	0227.
	.8	0228.
	.9	0211.
	1.0	0195.
	1.1	0196.
	1.2	0209.
	1.3	0226.
9	.2	0265.
	.3	0273.
	.4	0268.
	.5	0272.
	.6	0276.
	.7	0267.
	.8	0256.
	.9	0231.
	1.0	0204.
	1.1	0198.
	1.2	0201.
	1.3	0211.
	1.4	0242.
2	.2	0324.
	.3	0314.
	.4	0313.
	.5	0317.
	.6	0314.
	.7	0315.
	.8	0331.
	.9	0329.
	1.0	0316.
	1.1	0326.
	1.2	0336.
3	.2	0268.
	.3	0277.
	.4	0269.
	.5	0271.
	.6	0279.
	.7	0310.
	.8	0360.
	.9	0425.
	1.0	0490.
	1.1	0514.
7	.2	0305.
	.3	0333.
	.4	0370.
	.5	0396.
	.6	0419.
	.7	0448.
	.8	0441.
	.9	0419.
	1.0	0401.
	1.1	0386.
	1.2	0404.

STANDARD COUNT = 905., 0905.,

18 December 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0358.
	.3	0371.
	.4	0399.
	.5	0404.
	.6	0426.
	.7	0443.
	.8	0461.
	.9	0438.
	1.0	0382.
	1.1	0371.
	1.2	0401.
2	.2	0393.
	.3	0402.
	.4	0400.
	.5	0400.
	.6	0400.
	.7	0393.
	.8	0401.
	.9	0411.
	1.0	0398.
	1.1	0419.
	1.2	0406.
	1.3	0383.
	1.4	0371.
3	.2	0356.
	.3	0369.
	.4	0358.
	.5	0338.
	.6	0341.
	.7	0363.
	.8	0433.
	.9	0495.
	1.0	0548.
	1.1	0563.
8	.2	0443.
	.3	0429.
	.4	0444.
	.5	0476.
	.6	0477.
	.7	0486.
	.8	0475.
	.9	0450.
	1.0	0424.
	1.1	0431.
	1.2	0431.
	1.3	0461.
6	.2	0366.
	.3	0370.
	.4	0388.
	.5	0398.
	.6	0423.
	.7	0437.
	.8	0447.
	.9	0510.
	1.0	0580.
	1.1	0594.
	1.2	0596.
	1.3	0593.
5	.2	0402.
	.3	0395.
	.4	0376.
	.5	0373.
	.6	0378.
	.7	0339.
	.8	0307.
	.9	0288.
	1.0	0303.
	1.1	0310.
	1.2	0323.
	1.3	0351.
	1.4	0372.

STANDARD COUNT = 902., 0902.,

23 December 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0281.
	.3	0380.
	.4	0381.
	.5	0425.
	.6	0452.
	.7	0474.
	.8	0480.
	.9	0426.
	1.0	0378.
	1.1	0409.
8	.2	0339.
	.3	0350.
	.4	0352.
	.5	0373.
	.6	0375.
	.7	0390.
	.8	0381.
	.9	0356.
	1.0	0332.
	1.1	0332.
	1.2	0345.
	1.3	0363.
2	.2	0317.
	.3	0324.
	.4	0354.
	.5	0356.
	.6	0355.
	.7	0372.
	.8	0371.
	.9	0396.
	1.0	0407.
	1.1	0421.
	1.2	0426.
	1.3	0426.
	1.4	0426.
3	.2	0277.
	.3	0310.
	.4	0300.
	.5	0306.
	.6	0355.
	.7	0428.
	.8	0470.
	.9	0539.
	1.0	0553.
6	.2	0297.
	.3	0317.
	.4	0335.
	.5	0374.
	.6	0400.
	.7	0437.
	.8	0442.
	.9	0497.
	1.0	0574.
	1.1	0594.
	1.2	0583.
	1.3	0598.
5	.2	0325.
	.3	0335.
	.4	0347.
	.5	0350.
	.6	0344.
	.7	0352.
	.8	0339.
	.9	0320.
	1.0	0308.
	1.1	0320.
	1.2	0327.
	1.3	0345.
	1.4	0369.

STANDARD COUNT = 889., 0889.,

31 December 1986

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0337.
	.3	0359.
	.4	0393.
	.5	0410.
	.6	0442.
	.7	0472.
	.8	0485.
	.9	0474.
	1.0	0437.
	1.1	0408.
	1.2	0422.
6	.2	0311.
	.3	0320.
	.4	0337.
	.5	0351.
	.6	0385.
	.7	0414.
	.8	0426.
	.9	0479.
	1.0	0557.
	1.1	0584.
	1.2	0571.
	1.3	0576.
:	.2	0359.
	.3	0376.
	.4	0366.
	.5	0359.
	.6	0359.
	.7	0353.
	.8	0352.
	.9	0312.
	1.0	0297.
	1.1	0309.
	1.2	0324.
	1.3	0360.
8	.2	0373.
	.3	0365.
	.4	0397.
	.5	0391.
	.6	0395.
	.7	0383.
	.8	0357.
	.9	0332.
	1.0	0332.
	1.1	0348.
	1.2	0372.
2	.2	0358.
	.3	0361.
	.4	0379.
	.5	0363.
	.6	0392.
	.7	0387.
	.8	0394.
	.9	0406.
	1.0	0417.
	1.1	0427.
	1.2	0438.
	1.3	0457.
	1.4	0458.
3	.2	0308.
	.3	0330.
	.4	0314.
	.5	0303.
	.6	0328.
	.7	0340.
	.8	0423.
	.9	0479.
	1.0	0539.
	1.1	0547.

STANDARD COUNT = 907., 0907.,

4 January 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0291.
	.3	0309.
	.4	0310.
	.5	0331.
	.6	0340.
	.7	0355.
	.8	0363.
	.9	0354.
	1.0	0345.
	1.1	0331.
	1.2	0364.
6	.2	0251.
	.3	0291.
	.4	0321.
	.5	0352.
	.6	0376.
	.7	0404.
	.8	0446.
	.9	0524.
	1.0	0543.
	1.1	0536.
	1.2	0574.
8	.2	0309.
	.3	0323.
	.4	0335.
	.5	0337.
	.6	0333.
	.7	0323.
	.8	0302.
	.9	0276.
	1.0	0267.
9	.2	0242.
	.3	0241.
	.4	0265.
	.5	0268.
	.6	0291.
	.7	0291.
	.8	0294.
	.9	0266.
	1.0	0268.
	1.1	0277.
2	.2	0302.
	.3	0314.
	.4	0327.
	.5	0332.
	.6	0344.
	.7	0354.
	.8	0381.
	.9	0396.
	1.0	0412.
	1.1	0430.
	1.2	0449.
	1.3	0461.
6	.2	0194.
	.3	0238.
	.4	0285.
	.5	0370.
	.6	0390.
	.7	0450.
	.8	0508.
	.9	0535.
7	.2	0306.
	.3	0354.
	.4	0395.
	.5	0442.
	.6	0464.
	.7	0472.
	.8	0485.
	.9	0454.
	1.0	0449.
	1.1	0480.

STANDARD COUNT = 901., 0901.,

7 January 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0241.
	.3	0282.
	.4	0345.
	.5	0370.
	.6	0406.
	.7	0448.
	.8	0461.
	.9	0450.
	1.0	0431.
	1.1	0414.
	1.2	0426.
8	.2	0323.
	.3	0314.
	.4	0324.
	.5	0337.
	.6	0350.
	.7	0345.
	.8	0337.
	.9	0314.
	1.0	0300.
	1.1	0294.
	1.2	0304.
	1.3	0329.
2	.2	0289.
	.3	0307.
	.4	0314.
	.5	0326.
	.6	0335.
	.7	0348.
	.8	0356.
	.9	0384.
	1.0	0402.
	1.1	0407.
	1.2	0435.
	1.3	0430.
	1.4	0440.
3	.2	0200.
	.3	0235.
	.4	0247.
	.5	0273.
	.6	0294.
	.7	0326.
	.8	0400.
	.9	0463.
	1.0	0521.
	1.1	0539.

STANDARD COUNT = 916., 0916.,

16 January 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0340.
	.3	0340.
	.4	0354.
	.5	0355.
	.6	0391.
	.7	0447.
	.8	0447.
	.9	0451.
	1.0	0428.
	1.1	0434.
	1.2	0310.
6	.1	0291.
	.2	0287.
	.3	0327.
	.4	0364.
	.5	0389.
	.6	0404.
	.7	0445.
	.8	0525.
	.9	0554.
	1.0	0531
	1.1	0553.
5	.1	0319
	.2	0324.
	.3	0303.
	.4	0305
	.5	0315.
	.6	0333.
	.7	0318.
	.8	0310.
	.9	0313.
	1.0	0319
	1.1	0354
	1.2	0373.
2	.1	0368
	.2	0352.
	.3	0377.
	.4	0366.
	.5	0386.
	.6	0390
	.7	0383.
	.8	0409.
	.9	0416.
	1.1	0430.
	1.2	0442
	1.3	0464.
	1.4	0478.
3	0.1	0306.
	0.2	0295.
	0L3	0267.
	0.4	0278.
	0.5	0303.
	0.6	0358.
	0.7	0416.
	0.8	0466.
	0.9	0532.
	1.0	0551

STANDARD COUNT = 920., 0920.,

28 January 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0342.
	.3	0342.
	.4	0351.
	.5	0357.
	.6	0372.
	.7	0371.
	.8	0386.
	.9	0386.
	1.0	0366.
	1.1	0337.
	1.2	0331.
	1.3	0353.
	1.4	0376.
6	.2	0299.
	.3	0305.
	.4	0336.
	.5	0373.
	.6	0401.
	.7	0416.
	.8	0431.
	.9	0482.
	1.0	0553.
	1.1	0570.
	1.2	0561.
	1.3	0568.
8	.2	0365.
	.3	0357.
	.4	0354.
	.5	0369.
	.6	0382.
	.7	0379.
	.8	0361.
	.9	0345.
	1.0	0319.
	1.1	0318.
9	.2	0302.
	.3	0304.
	.4	0322.
	.5	0335.
	.6	0361.
	.7	0363.
	.8	0361.
	.9	0346.
	1.0	0311.
	1.1	0308.
	1.2	0303.
2	.2	0335.
	.3	0338.
	.4	0357.
	.5	0367.
	.6	0380.
	.7	0385.
	.8	0385.
	.9	0410.
	1.0	0417.
	1.1	0441.
	1.2	0466.
	1.3	0470.
3	.2	0244.
	.3	0287.
	.4	0283.
	.5	0299.
	.6	0309.
	.7	0351.
	.8	0422.
	.9	0483.
	1.0	0535.
	1.1	0557.
7	.2	0312.
	.3	0350.
	.4	0392.
	.5	0418.
	.6	0469.
	.7	0493.
	.8	0499.
	.9	0492
	1.0	0471.
	1.1	0476.
	1.2	0502.

STANDARD COUNT = 819., 0879.,

12 February 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0260.
	.3	0281.
	.4	0280.
	.5	0302.
	.6	0313.
	.7	0345.
	.8	0352.
	.9	0339.
	1.0	0331.
	1.1	0325.
	1.2	0364.
	1.3	0374.
6	.2	0238.
	.3	0242.
	.4	0287.
	.5	0312.
	.6	0351.
	.7	0359.
	.8	0407.
	.9	0475.
	1.0	0516.
	1.1	0505.
	1.2	0528.
8	.2	0269.
	.3	0303.
	.4	0293.
	.5	0293.
	.6	0293.
	.7	0278.
	.8	0265.
	.9	0233.
	1.0	0236.
	1.1	0251.
9	.2	0224.
	.3	0222.
	.4	0224.
	.5	0242.
	.6	0236.
	.7	0230.
	.8	0220.
	.9	0202.
	1.0	0211.
	1.1	0227.
2	.2	0281.
	.3	0290.
	.4	0309.
	.5	0322.
	.6	0335.
	.7	0365.
	.8	0383.
	.9	0395.
	1.0	0421.
	1.1	0432.
3	.2	0173.
	.3	0186.
	.4	0229.
	.5	0270.
	.6	0327.
	.7	0368.
	.8	0439.
	.9	0493.
	1.0	0542.
7	.2	0224.
	.3	0292.
	.4	0351.
	.5	0413.
	.6	0447.
	.7	0461.
	.8	0457.
	.9	0441.
	1.0	0431.
	1.1	0452.

STANDARD COUNT = 896., 0896.,

20 February 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
7	.2	0200.
	.3	0245.
	.4	0304.
	.5	0325.
	.6	0386.
	.7	0423.
	.8	0438.
	.9	0445.
	1.0	0416.
	1.1	0411.
	1.2	0445.
3	.2	0157.
	.3	0153.
	.4	0162.
	.5	0216.
	.6	0246.
	.7	0333.
	.8	0402.
	.9	0482.
	1.0	0504.
2	.2	0226.
	.3	0244.
	.4	0252.
	.5	0281.
	.6	0301.
	.7	0328.
	.8	0348.
	.9	0380.
	1.0	0381.
	1.1	0389.
8	.2	0241.
	.3	0248.
	.4	0254.
	.5	0257.
	.6	0265.
	.7	0250.
	.8	0235.
	.9	0217.
	1.0	0212.
	1.1	0230.
	1.2	0220.
9	.2	0217.
	.3	0223.
	.4	0230.
	.5	0226.
	.6	0227.
	.7	0201.
	.8	0182.
	.9	0190.
	1.0	0203.
5	.2	0231.
	.3	0255.
	.4	0274.
	.5	0270.
	.6	0317.
	.7	0324.
	.8	0329.
	.9	0322.
	1.0	0332.
	1.1	0359.
	1.2	0374.
6	.2	0209.
	.3	0226.
	.4	0247.
	.5	0284.
	.6	0324.
	.7	0337.
	.8	0379.
	.9	0439.
	1.0	0472.
	1.1	0457.
	1.2	0486.

STANDARD COUNT = 890., 0890.,

26 February 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
6	.2	0198.
	.3	0213.
	.4	0227.
	.5	0253.
	.6	0283.
	.8	0337.
	.9	0373.
	1.0	0419.
	1.1	0449.
	1.2	0456.
	1.3	0471.
5	.2	0238.
	.3	0254.
	.4	0274.
	.5	0272.
	.6	0278.
	.7	0299.
	.8	0302.
	.9	0311.
	1.0	0313.
	1.1	0321.
	1.2	0336.
	1.3	0340.
	1.4	0375.
8	.2	0228.
	.3	0242.
	.4	0244.
	.5	0249.
	.6	0252.
	.7	0249.
	.8	0242.
	.9	0229.
	1.0	0212.
	1.1	0209.
	1.2	0227.
9	.2	0215.
	.3	0224.
	.4	0222.
	.5	0228.
	.6	0225.
	.7	0225.
	.8	0223.
	.9	0205.
	1.0	0184.
	1.1	0188.
	1.2	0195.
	1.3	0230.
2	.2	0218.
	.3	0219.
	.4	0229.
	.5	0243.
	.6	0264.
	.7	0275.
	.8	0298.
	.9	0345.
	1.0	0373.
	1.1	0378.
	1.2	0401.
	1.3	0398.
	1.4	0412.
3	.2	0153.
	.3	0152.
	.4	0156.
	.5	0189.
	.6	0226.
	.7	0254.
	.8	0323.
	.9	0375.
	1.0	0445.
	1.1	0493.
7	.2	0182.
	.3	0256.
	.4	0300.
	.5	0320.
	.6	0385.
	.7	0439.
	.8	0446.
	.9	0418.
	1.0	0403.
	1.1	0434.

STANDARD COUNT = 906., 0906.,

6 March 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
6	.2	0233.
	.3	0224.
	.4	0243.
	.5	0261.
	.6	0290.
	.7	0310.
	.8	0336.
	.9	0370.
	1.0	0416.
	1.1	0447.
	1.2	0437.
	1.3	0452.
5	.2	0277.
	.3	0266.
	.4	0269.
	.5	0273.
	.6	0284.
	.7	0293.
	.8	0314.
	.9	0317.
	1.0	0318.
	1.1	0311.
	1.2	0325.
	1.3	0361.
	1.4	0377.
8	.2	0295.
	.3	0260.
	.4	0250.
	.5	0253.
	.6	0250.
	.7	0244.
	.8	0237.
	.9	0215.
	1.0	0213.
	1.1	0207.
9	.2	0230.
	.3	0236.
	.4	0229.
	.5	0235.
	.6	0238.
	.7	0236.
	.8	0221.
	.9	0212.
	1.0	0182.
	1.1	0179.
	1.2	0186.
	1.3	0221.
2	.2	0262.
	.3	0252.
	.4	0231.
	.5	0244.
	.6	0265.
	.7	0291.
	.8	0314.
	.9	0345.
	1.0	0369.
	1.1	0379.
	1.2	0396.
	1.3	0405.
	1.4	0399.
3	.2	0156.
	.3	0149.
	.4	0154.
	.5	0205.
	.6	0224.
	.7	0273.
	.8	0305.
	.9	0353.
	1.0	0443.
	1.1	0484.
7	.2	0239.
	.3	0265.
	.4	0301.
	.5	0367.
	.6	0407.
	.7	0437.
	.8	0432.
	.9	0416.
	1.0	0404.
	1.1	0431.

STANDARD COUNT = 900., 0900.,

11 March 1987

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
6	.2	0222.
	.3	0225.
	.4	0236.
	.5	0264.
	.6	0292.
	.7	0327.
	.8	0370.
	.9	0418.
	1.0	0450.
	1.1	0441.
5	.2	0247.
	.3	0257.
	.4	0272.
	.5	0262.
	.6	0288.
	.7	0304.
	.8	0320.
	.9	0312.
	1.0	0320.
	1.1	0330.
	1.2	0359.
	1.3	0389.
8	.2	0259.
	.3	0243.
	.4	0244.
	.5	0249.
	.6	0249.
	.7	0232.
	.8	0223.
	.9	0208.
	1.0	0207.
9	.2	0223.
	.3	0230.
	.4	0230.
	.5	0225.
	.6	0219.
	.7	0205.
	.8	0184.
	.9	0183.
	1.0	0193.
2	.2	0239.
	.3	0232.
	.4	0240.
	.5	0246.
	.6	0279.
	.7	0318.
	.8	0340.
	.9	0365.
	1.0	0364.
	1.1	0389.
	1.2	0393.
	1.3	0406.
3	.2	0148.
	.3	0153.
	.4	0149.
	.5	0191.
	.6	0235.
	.7	0290.
	.8	0348.
	.9	0435.
	1.0	0484.
7	.2	0204.
	.3	0264.
	.4	0298.
	.5	0311.
	.6	0370.
	.7	0400.
	.8	0422.
	.9	0430.
	1.0	0410.
	1.1	0392.
	1.2	0432.

STANDARD COUNT = 429., 0429.,

24 March 1988

ACCESS TUBE No.	DEPTH (M.)	TUBE-DEPTH DATA MEAS. COUNT
5	.2	0377.
	.3	0386.
	.4	0368.
	.5	0321.
	.6	0293.
	.7	0297.
	.8	0310.
	.9	0320.
	1.0	0310.
	1.1	0317.
	1.2	0324.
	1.3	0362.
	1.4	0389.
6	.2	0336.
	.3	0346.
	.4	0335.
	.5	0325.
	.6	0305.
	.7	0314.
	.8	0327.
	.9	0325.
	1.0	0367.
	1.1	0420.
	1.2	0438.
	1.3	0419.
	1.4	0423.
8	.2	0405.
	.3	0359.
	.4	0336.
	.5	0305.
	.6	0261.
	.7	0241.
	.8	0227.
	.9	0227.
	1.0	0208.
	1.1	0212.
	1.2	0233.
9	.2	0370.
	.3	0351.
	.4	0304.
	.5	0246.
	.6	0226.
	.7	0221.
9	.2	0206.
2	.2	0370.
	.3	0368.
	.4	0368.
	.5	0334.
	.6	0324.
	.7	0301.
	.8	0303.
	.9	0336.
	1.0	0362.
	1.1	0362.
	1.2	0390.
	1.3	0382.
	1.4	0399.
3	.2	0346.
	.3	0338.
	.4	0290.
	.5	0249.
	.6	0251.
	.7	0297.
	.8	0343.
	.9	0434.
	1.0	0487.
7	.2	0351.
	.3	0391.
	.4	0419.
	.5	0473.
	.6	0494.
	.7	0480.
	.8	0459.
	.9	0408.
	1.0	0394.
	1.1	0431.

STANDARD COUNT = 933., 0933.,

APPENDIX F 3

TENSIOMETER RECORDS

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
20.3.85	1	30	38		
		30	134		
		60	231		
	2	30	92		
		30	120		
		60	187		
		60	176		
		90	126		
		90	125		
		120	149		
		120	210		
	3	30	280		
		30	225		
		60	116		
		60	208		
27.3.85	1	30	71		
		30	150		
		60	248		
	2	30	67		
		30	120		
		60	175		
		60	181		
		90	141		
		90	133		
		120	61		
		120	210		
	3	30	355		
		30	270		
		60	64		
		60	234		
3.4.85	1	30	77		
		60	150		
		60	280		
	2	30	76		2
		30	116	10	2
		60	215	10	2.2
		60	155	30	12.2
		90	45	30	2.25
		90	118	60	4
		120	60	60	2.5
		120	215	90	2
				90	1.3
	3	30	292		
		30	210		
		60	95		
		60	174		

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
6.3.85	1	30	86		
		30	58		
		60	261		
	2	30	84		
		30	133		
		60	216		
		60	164		
		90	140		
		90	138		
		120	166		
		120	248		
	3	30	251		
		30	303		
		60	211		
		60	83		
14.3.85	1	30	88		
		30	112		
		60	139		
	2	30	87		
		30	116		
		60	151		
		60	148		
		90	129		
		90	118		
		120	147		
		120	184		
	3	30	147		
		30	162		
		60	166		
		60	122		
15.3.85	1	30	32		
		30	84		
		60	151		
	2	30	105		
		30	145		
		60	178		
		60	162		
		90	138		
		90	128		
		120	155		
		120	121		
	3	30	162		
		30	180		
		60	202		
		60	171		

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
10.4.85	1	30	42		
		330	124		
		60	277		
	2	30	77	10	.4
		30	107	10	.25
		60	220	30	.25
		60	172	30	.45
		90	75	60	.55
		90	116	60	.5
		120	72	90	.4
		120	186	90	.4
	3	30	232		
		30	219		
		60	109		
		60	175		
8.5.85	1	vandelised			
	2	30	66	10	.25
		30	83	10	.2
		60	122	30	.25
		60	133	30	.3
		90	52	60	.3
		90	127	60	.3
		120	56	90	.3
		120	225	90	.3
	3	330	240		
		30	186		
		60	102		
		60	180		
15.5.85	2	30	41	10	1.25
		30	66	10	3.7
		60	130	30	.25
		60	100	30	.25
		90	104	60	.25
		90	94	60	.25
		120	97	90	.25
		120	142	90	.3
	3	30	195		
		30	168		
		60			
		60	141		
22.5.85	2	30	55		
		30	76		
		60	147		
		60	110		
		90	73		
		90	102		
		120	128		
		120	146		
	3	30	210		
		30	199		
		60			
		60	127		

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
5.6.85	2	30	65		
		30	67		
		60	120		
		60			
		90	75		
		90	95		
		120	130		
		120	145		
12.6.85	2	30	55		
		30	72		
		60	170		
		60			
		90	102		
		90	102		
		120	132		
		120	130		
19.6.85	2	30	50		
		30			
		60	175		
		60			
		90	98		
		90	100		
		120	129		
		120	140		
21.2.86	8	50	230	50	1
		50	200	50	1
		50	broken	50	1.75
		50	broken	50	1.75
	2	30	150	10	.5
		30	230	10	.25
		60	150	30	.5
		60	50	30	4.25
				60	9.5
				60	8
				90	4
6.3.86	8	50	260	50	.4
		50	240	50	.5
		50	kenbro	50	.75
		50	broken	50	.65
	2	30	150	10	.5
		30	230	10	.25
		60	150	30	.5
		60	50	30	4.25
				60	9.5
				60	8
				90	4

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
13.3.86	8	50	broken	50	.5
		50	175	50	.5
		50	180	50	.75
		50	160	50	.5
	2	30	140	10	10
		30	140	10	10
		60	60	30	.5
		60	70	30	.75
				60	.75
				60	1
				90	1
20.3.86	8	50	175	50	.5
		50	77	50	.5
		50	124	50	.75
		50	21.4	50	.75
	2	30	135	10	10
		30	165	10	10
		60	21	30	3.5
		60	185	30	2.25
				60	.75
				60	.5
				90	.5
26.3.86	8	50	225	50	.25
		50	260	50	.25
		50	225	50	.75
		50	230	50	.5
	2	30	140	10	1.75
		30	225	10	.25
		60	195	30	.5
		60	55	30	.5
				60	.5
				60	.5
				90	.25
3.4.86	8	50	225	50	.25
		50	23	50	.25
		50	195	50	.5
		50	228	50	.5
	2	30	brocken	10	0
		30	220	10	0
		60	318	30	0
		60	412	30	.25
				60	.25
				60	.25
				90	.25

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
10.4.86	B	50	230	50	.25
		50	285	50	.25
		50	240	50	.25
		50	265	50	.25
	2	30	0	10	.25
		30	265	10	.25
		60	225	30	.25
		60	13	30	.25
				60	.25
				60	.25
				90	.25
16.4.86	B	50	170	50	.5
		50	160	50	.25
		50	12	50	.5
		50	175	50	.5
	2	30	145	10	10
		30	130	10	10
		60	150	30	.25
		60	200	30	10
				60	5
				60	5.5
				90	.25
24.4.86	B	50	215	50	3
		50	205	50	.25
		50	165	50	.5
		50	15	50	.5
	2	30	158	10	9
		30	205	10	10
		60	265	30	.75
		60	200	30	10
				60	5
				60	7.75
				90	.25
1.5.86	B	50	240	50	2
		50	100	50	.5
		50	50	50	.5
		50	100	50	.5
	2	30	145	10	10
		30	178	10	10
		60	194	30	.5
		60	260	30	9
				60	5
				60	6.5
				90	.25

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
8.5.86	8	50	227	50	.75
		50	98	50	.5
		50	139	50	.75
		50	90	50	.5
	2	30	154	10	7.25
		30	200	10	5.75
		60	190	30	.5
		60	250	30	8
				60	4
				60	4
				90	.25
15.5.86	8	50	135	50	.25
		50	248	50	.25
		50	183	50	.5
		50	245	50	.5
	2	30	154	10	1
		30	216	10	.25
		60	189	30	.25
		60	272	30	1
				60	1.25
				60	1.75
				90	.25
22.5.86	8	50	210	50	.25
		50	250	50	.25
		50	198	50	.25
		50	182	50	.25
	2	30	78	10	.25
		30	78	10	.25
		60	205	30	.25
		60	292	30	.25
				60	.5
				60	.5
				90	.25
30.5.86	8	50	202	50	.25
		50	196	50	.25
		50	240	50	.25
		50	98	50	.25
	2	30	Vandalised	10	0
		30	Vandalised	10	0
		60	Vandalised	30	0
		60	Vandalised	30	.25
				60	.25
				60	.25
				90	.25

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
5.6.86	8	50	Vandelised	50	.25
		50	Vandelised	50	.25
		50	Vandelised	50	.25
		50	Vandelised	50	.25
	2	30	Vandelised	10	9.2
		30	Vandelised	10	9.5
		60	Vandelised	30	.25
		60	Vandelised	30	.25
				60	.25
				60	.25
				90	.25
12.6.86	8	50	198	50	.25
		50	197	50	.25
		50	165	50	.25
		50	147	50	.25
	2	30	140	10	9
		30	gone	10	9.5
		60	178	30	.25
		60	269	30	.25
				60	.25
				60	.25
				90	.25
19.6.86	8	50	135	50	.25
		50	40	50	.3
		50	90	50	0
		50	118	50	.25
	2	30	160	10	8.5
		30	gone	10	8.5
		60	210	30	0
		60	200	30	:25
				60	0
				60	0
				90	0
27.6.86	8	50	175	50	.25
		50	210	50	.25
		50	145	50	.25
		50	275	50	.25
	2	30	140	10	5.5
		30	gone	10	5.25
		60	185	30	.5
		60	267	30	.75
				60	.25
				60	.25
				90	.25

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
3.7.86	8	50	200	50	.25
		50	80	50	.25
		50	92	50	.25
		50	235	50	.25
	2	30	vandalised	10	.25
		30	vandalised	10	2.25
		60	vandalised	30	1
		60	vandalised	30	.25
				60	.25
				60	.25
				90	.25
10.7.86	8	50	200	50	.25
		50	80	50	.25
		50	9.2	50	.25
		50	235	50	.25
	2	30	vandalised	10	2
		30	vandalised	10	1
		60	vandalised	30	1
		60	vandalised	30	.25
				60	.25
				60	.25
				90	.25
23.7.86	8	50	125	50	.25
		50	165	50	.25
		50	vandalised	50	.25
		50	345	50	.25
	2	30	vandalised	10	.25
		30	vandalised	10	.25
		60	vandalised	30	.25
		60	vandalised	30	.25
				60	.25
				60	.25
				90	.25
7.8.86	8	50	176	50	.25
		50	190	50	.25
		50	138	50	.25
		50	214	50	.25
	2	30	vandalised	10	.25
		30	vandalised	10	.25
		60	vandalised	30	.25
		60	vandalised	30	.25
				60	.5
				60	.25
				90	.25

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
14.8.86	8	50	180	50	.25
		50	vandalised	50	.25
		50	vandalised	50	.25
		50	vandalised	50	.25
	2	30	vandalised	10	.25
		30	vandalised	10	.25
		60	vandalised	30	.25
		60	vandalised	30	.25
				60	.25
				60	.25
				90	.25
20.8.86	8	50	160	50	.25
		50		50	.25
		50		50	.25
		50		50	.25
	2	30		10	.25
		30		10	.25
		60		30	.25
		60		30	.25
				60	.25
				60	.25
				90	.25
3.8.86	8	50	122	50	.25
		50		50	.25
		50		50	.25
		50		50	.25
	2	30		10	10
		30		10	10
		60		30	6
		60		30	1
				60	.25
				60	.25
				90	.25
10.9.86	8	50	190	50	.75
		50		50	.75
		50		50	.75
		50		50	.75
	2	30		10	9.5
		30		10	9.5
		60		30	1.25
		60		30	.25
				60	.25
				60	.25
				90	.25

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
17.9.86	8	50	170	50	1
		50		50	.25
		50		50	.75
		50		50	.5
	2	30		10	6.5
		30		10	5.5
		60		30	9
		60		30	2.25
				60	3
				60	0
				90	0
24.9.86	8	50	170	50	.5
		50		50	.5
		50		50	.5
		50		50	.5
	2	30		10	4.25
		30		10	1
		60		30	1.5
		60		30	2
				60	.25
				60	1
				90	.25
1.10.86	8	50	190	50	.25
		50		50	.25
		50		50	.25
		50		50	.25
	2	30		10	1
		30		10	.25
		60		30	.5
		60		30	1
				60	1.5
				60	.25
				90	.25
15.10.86	8	50	305	50	.25
		50		50	.25
		50		50	.25
		50		50	.25
	2	30		10	.25
		30		10	.25
		60		30	.2
		60		30	.2
				60	.2
				60	.2
				90	.1

Tensiometer and moisture block readings
for the Zuurbekom catchment area

Date	Access tube No.	Tensiometer depth (cm)	Height of mercury (mm)	Moisture block depth (cm)	Reading on moisture meter
22.10.86	8	50	150	50	.25
		50		50	.25
		50		50	.25
		50		50	.25
	2	30		10	10
		30		10	10
		60		30	.25
		60		30	.25
				60	.25
				60	.25
				90	.25
29.10.86	8	50	142	50	.5
		50		50	.5
		50		50	.5
		50		50	.5
	2	30		10	6
		30		10	9
		60		30	10
		60		30	10
				60	1
				60	.5
				90	2
13.11.86	8	50	280	50	.5
		50		50	.5
		50		50	.5
		50		50	.5
	2	30		10	10
		30		10	3
		60		30	5
		60		30	10
				60	0
				60	10
				90	10
19.11.86	8	50	175	50	.5
		50		50	.5
		50		50	.5
		50		50	.5
	2	30		10	4
		30		10	2
		60		30	10
		60		30	10

APPENDIX F 4

INFILTRATION TESTING

APPENDIX F 4

INITIAL INFILTRATION STUDIES

1. INTRODUCTION

Infiltration rings were set up at Zuurbekom on the 14 July 1985 to try and get an idea of the infiltration properties of the surrounding soils.

2. DESCRIPTION OF APPARATUS

The double ring infiltrometers used consist of steel cylinders with an inside diameter of 308mm and a height of 300 mm. The area of the inner ring was 754cm^2. The volume of water required for a 50mm and 100m depths of water was 3770 cm^3 and 7540cm^3. Other apparatus included a range of augers, weighing apparatus and drying apparatus.

3. METHOD

Three double ring infiltrometers were used at each site. They were pushed into the soil to a depth of about 40cm, and the inside and outside edges were waxed into the soil. Water was poured into two of the rings (corresponding to depths of 5cm and 10cm respectively) and timed to see how long it took for the water to enter the soil. A third ring with no water was used as a control. The tops of the rings were sealed to prevent evaporation, and 24 hrs later the soil was mechanically augered using a selby auger. Soil samples were collected every 10 cm where possible using the selby auger, and further samples were collected using a screw type auger whenever the selby auger could not be pushed further into the soil. The moisture contents and densities of the soil collected with the selby auger, and moisture contents of the soil samples were measured.

The results are summarised in Table F 4.1 and illustrated diagrammatically in figures F 4.1 and F 4.2.

4. **RESULTS**

10 cm water added on 11/7/85 at 9.00 am.
10 cm water added on 14/7/85 at 9.00 am.

Augered on 15/7/85 at ± 9.00 am.

SOIL DEPTH	MASS OF WET SOIL (g)	MASS OF DRY SOIL (g)	MOIST CONTENT % DRY MASS	DENSITY WET	DENSITY DRY
0 - 10cm	234,85	208,7	12,53 %	1695	1506
0 - 20cm	239	214,4	11,47 %	1725	1548
0 - 30cm	271,9	243,2	11,80 %	1963	1755
0 - 42cm	301,8	268,8	12,28 %	1815	1617
44 - 81cm	528,2	475,1	11,18 %	NO DENSITY SCREW AUGER	

5 cm water on 11/7/85 at 9.00am.
5cm water on 14/7/85 at 9.00am.

SOIL DEPTH	MASS OF WET SOIL (g)	MASS OF DRY SOIL (g)	MOIST CONTENT % DRY MASS	DENSITY WET	DENSITY DRY
0 - 10cm	257,2	226,50	13,55 %	1856	1635
10 - 20cm	233,8	212,3	10,13 %	1688	1532
20 - 30cm	231,3	210,8	9,72 %	1669	1521
30 - 42cm	295,00	273,8	7,74 %	1774	1647
52 - 100cm	494,9	493,10	0,37 %	NO DENSITY SCREW AUGER	

CONTROL - No water added
Augered - 15/7/85 at ± 9.00 am.

SOIL DEPTH	MASS OF WET SOIL (g)	MASS OF DRY SOIL (g)	MOIST CONTENT % DRY MASS	DENSITY WET	DENSITY DRY
0 - 10cm	155,2	148,1	4,79 %	1120	1069
10 - 20cm	187,5	178,7	4,92 %	1353	1289
20 - 30cm	261,5	248,4	5,27 %	1887	1793
30 - 40cm	214	203,3	5,26 %	1544	1467
40 - 50cm	255,1	240,2	6,20 %	1841	1734
50 - 60cm	243,8	227,5	7,16 %	1760	1642
60 - 75cm	386,7	356,5	8,47 %	1861	1715
75 - 105cm	502,7	464,5	8,22 %	NO DENSITY SCREW AUGER	

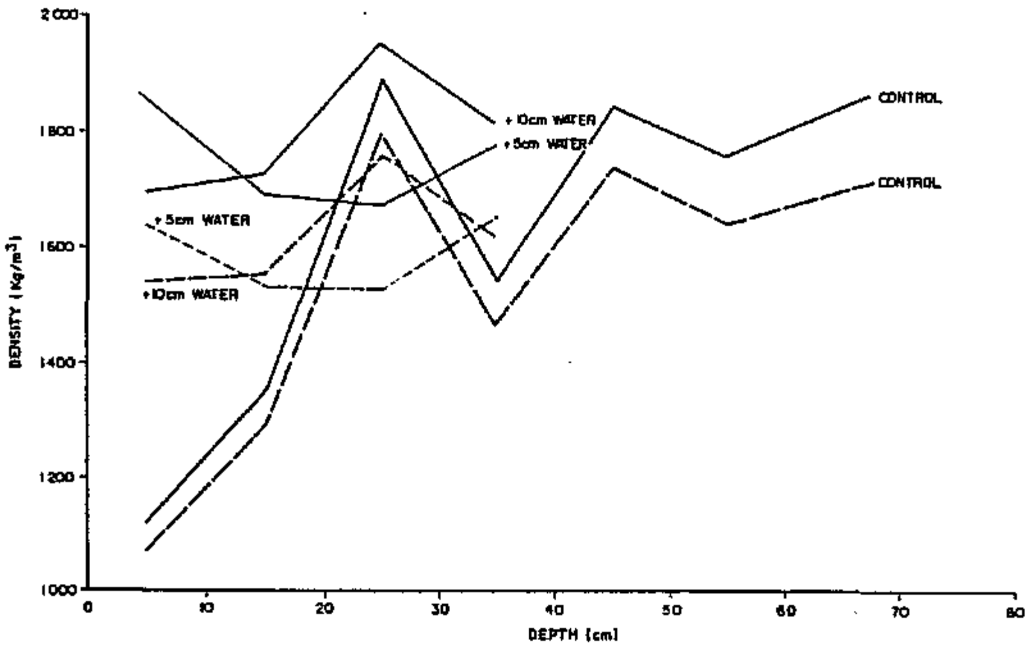


FIG F 4.1 BULK DENSITY WITH DEPTH : INFILTRATION TESTS

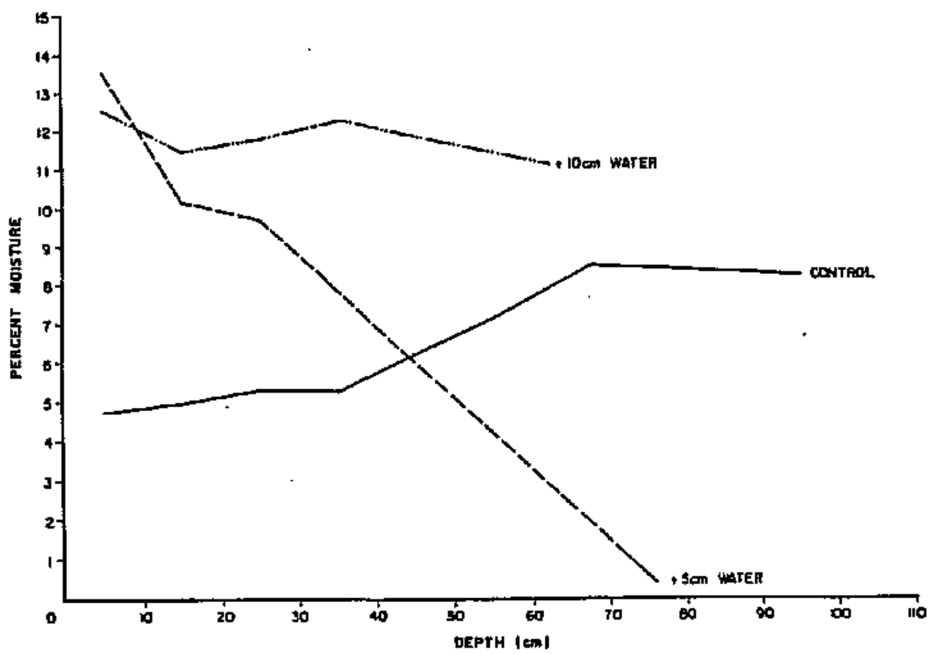


FIG F 4.2 MOISTURE CONTENT WITH DEPTH : INFILTRATION TESTS

ACCESS TUBE 5

WATER ADDITIONS		1 12.14		2 12.35	3 13.05		4 13.35						
TIME	11.40	12.20	12.30	12.55	13.10	13.30	14.05	14.25	14.45	15.00	15.20	10.30	10.30
DATE	4.11.85	4.11.85	4.11.85	4.11.85	4.11.85	4.11.85	4.11.85	4.11.85	4.11.85	4.11.85	4.11.85	5.11.85	6.11.85
COMMENT	No water	wetting	wetting	wetting	wetting	wetting	wetting	Drying	Drying	Drying	Drying	Drying	Drying
	NEUTRON PROBE READINGS (Kg water/m^3)												
DEPTH (m)													
0,2	196	232	316	337	341	342	338	308	304	291	288	224	202
0,3	211											230	219
0,4	217	215	237	306	310	309	309	297	286	285	278	235	225
0,5	208											239	224
0,6	194		201	263	300	298	288	277	269	265	269	236	225
0,7	178											245	232
0,8	163		159	166	186	269	288	284	294	286	280	253	234
0,9	164											259	248
1,0	166			168	165	167	275	295	295	293	295	268	253
1,1	166											284	266
1,2	174						176	229	292	309	317	302	282
1,3	180											312	289
1,4	196							194	199	210	227	320	302
1,5	215								215	221	221	338	327

WATER ADDITIONS

	TIME ADDED	QUANTITY INNER RING (Litres)	DEPTH INNER (cm)	QUANT OUTER (Litres)	DEPTH OUTER (cm)	TIME SUNK IN (inner)	INFILTRATION RATE INNER (cm/h)
1	12.14	10	5,1	30	5,1	12.38	14,57
2	12.35	10	5,1	30	5,1	13.05	10,2
3	13.05	10	5,1	30	5,1	13.35	10,2
4	13.35	10	5,1	30	5,1	14,05	10,2

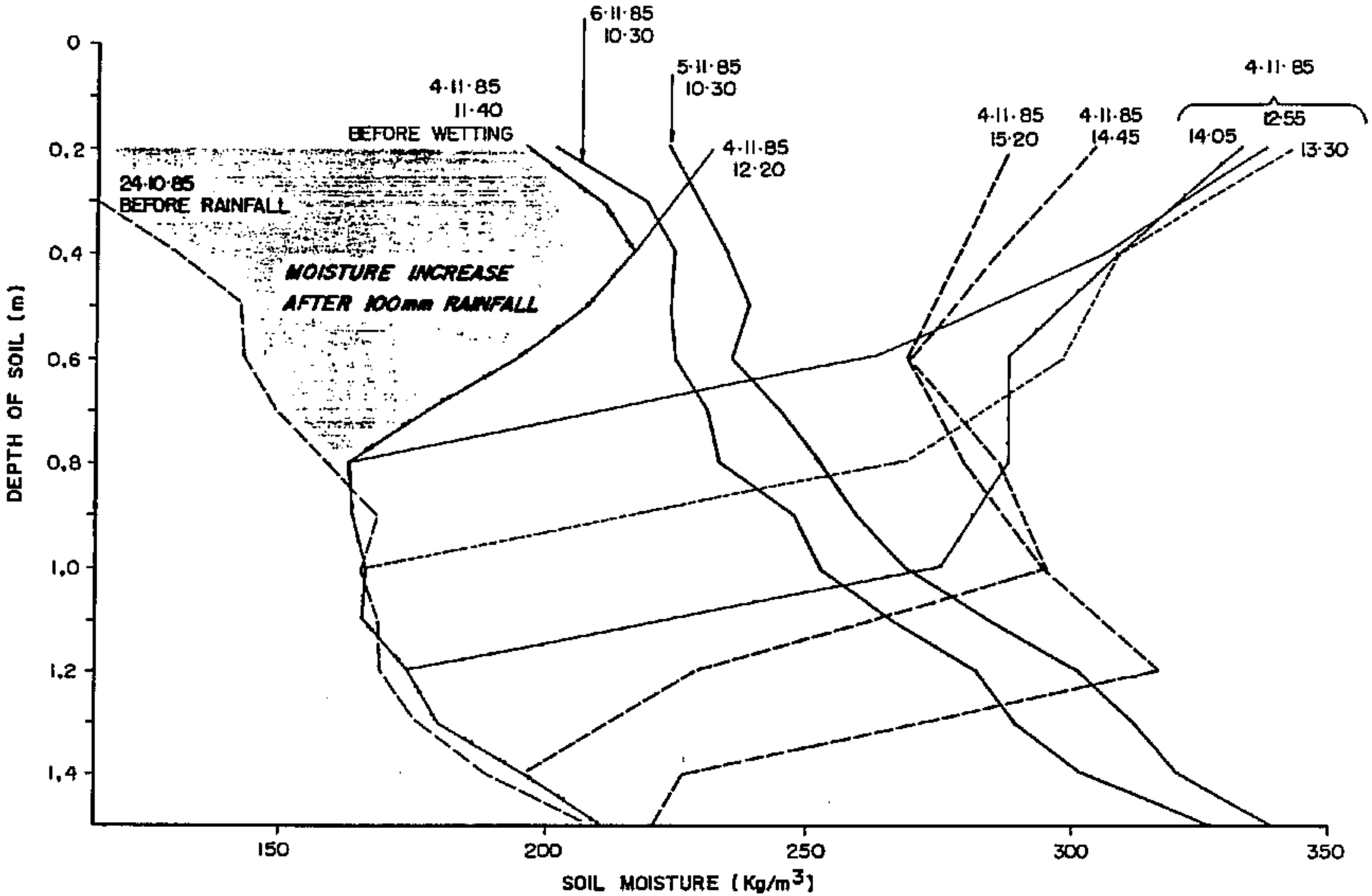
ACCESS TUBE 5
WATER MOVEMENT AND LOSSES IN INFILTRATION EXPERIMENT

A WETTING

TIME DURING EXPERIMENT	ACTUAL AMOUNT OF WATER ENTERED INTO SOIL (Litres)	CALCULATED (from results) AMOUNT OF WATER ENTERED INTO SOIL (Litres)	WATER LOSS FROM SYSTEM (Litres)	WATER GAIN IN SYSTEM (Litres)
12.20	3,0	2,4	0,6	0
12.55	17,0	14,3	2,7	0
13.30	28,3	17,9	10,4	0
14,05	40,0	24,5	15,5	0
14.45 (Drying)	40,0	27,0	13,0	0
15.20 (Drying)	40.0	27,3	12,7	0

B DRYING (Redistribution)

TIMES DURING DRYING	WATER LOSS TO LOWER DEPTH OR WATER LOSS FROM UPPER LEVEL (Litres)	WATER GAIN IN LOWER DEPTH OR WATER LOSS FROM UPPER LEVEL (Litres)	DIFFERENCE (WATER LOSS FROM SYSTEM) (Litres)
14.05 - 14.45	3,3	4,7	GAIN = 1,4 l
14.45 - 15.20	1,8	1,6	0,2


6·11·85
10·30
5·11·85
10·30
4·11·85
11·40
BEFORE WETTING
4·11·85
12·20
4·11·85
15·20
4·11·85
14·45
4·11·85
12·55
14·05
13·30
24·10·85
BEFORE RAINFALL
MOISTURE INCREASE
AFTER 100mm RAINFALL
DEPTH OF SOIL (m)
0
0,2
0,4
0,6
0,8
1,0
1,2
1,4
150
200
250
300
350
SOIL MOISTURE (Kg/m³)

F.4.7.

ACCESS TUBE 6

WATER ADDITIONS		1 9.10		2 9.28	3 9.55		4 10.24				
TIME	8.45	9.15	9.20	9.45	10.02	10.20	10.55	11.15	11.35	14.25	NEUTRON MOISTURE GUAGE BROKE DOWN - READINGS STOPPED
DATE	6.11.85	6.11.85	6.11.85	6.11.85	6.11.85	6.11.85	6.11.85	6.11.85	6.11.85	6.11.85	
COMMENT	No water	wetting	wetting	wetting	wetting	wetting	wetting	Drying	Drying	Drying	
	NEUTRON PROBE READINGS (Kg water/m^3)										
DEPTH (m)											
0,2	153	187	223	339	351	350	333	300	289	215	
0,3	174										
0,4	189	186	192	296	314	313	311	299	297	246	
0,5	200										
0,6	211		210	232	281	300	301	296	291	248	
0,7	226										
0,8	227			228	238	272	310	309	308	269	
0,9	230										
1,0	229				232	228	299	334	345	316	
1,1	233										
1,2	220						218	221	239	338	
1,3	204										
1,4	211							224	213	210	
1,5										221	
1,6											

WATER ADDITIONS

	TIME ADDED	QUANTITY INNER RING (Litres)	DEPTH INNER (cm)	QUANT OUTER (Litres)	DEPTH OUTER (cm)	TIME SUNK IN (inner)	INFILTRATION RATE INNER (cm/h)
1	9.10	10	5,1	30	5,1	9.28	17,0
2	9.28	10	5,1	30	5,1	9.35	11,33
3	9.55	10	5,1	30	5,1	10.24	10,55
4	10.24	10	5,1	30	5,1	by 10,54	+ 10,20

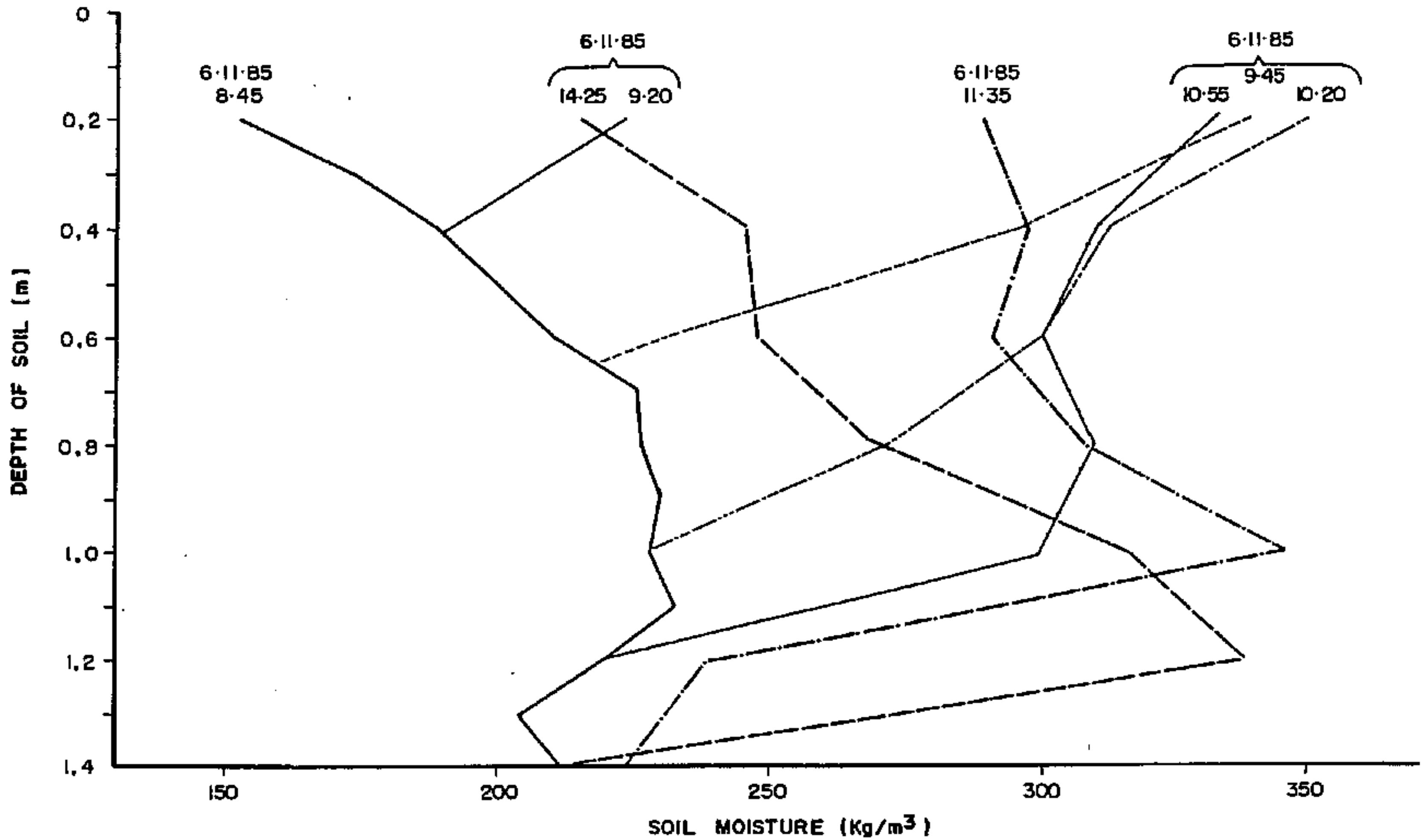
ACCESS TUBE 6
WATER MOVEMENT AND LOSSES IN INFILTRATION EXPERIMENT

A WETTING

TIME DURING EXPERIMENT	ACTUAL AMOUNT OF WATER ENTERED INTO SOIL (Litres)	CALCULATED (from results) AMOUNT OF WATER ENTERED INTO SOIL (Litres)	WATER LOSS FROM SYSTEM (Litres)	WATER GAIN IN SYSTEM (Litres)
9.20	5,55	4,5	1,05	0
9.45	16,29	16,10	0,10	0
10.20	28,62	22,00	6,62	0
10,55	40,00	24,94	15,06	0
11.35 (Drying)	40,00	22,00	18,00	0
14.25 (Drying)	40,00	16,00	24,00	0

B DRYING (Redistribution)

TIMES DURING DRYING	WATER LOSS TO LOWER DEPTH OR WATER LOSS FROM UPPER LEVEL (Litres)	WATER GAIN IN LOWER DEPTH OR WATER LOSS FROM UPPER LEVEL (Litres)	DIFFERENCE (WATER LOSS FROM SYSTEM) (Litres)
10.55 - 11.35	3,3	2,7	0,6
11.35 - 14.25	10	3,1	6,9



DEPTH OF SOIL (m)
0
0,2
0,4
0,6
0,8
1,0
1,2
1,4
150
200
250
300
350
SOIL MOISTURE (Kg/m³)
6·11·85
8·45
6·11·85
14·25
9·20
6·11·85
11·35
6·11·85
9·45
10·55
10·20

F.4.10.

INFILTRATION

1st access tube near tube 8
Time 11.45 16/9/85 Prior to water addition

TIME	DEPTH	COUNT	RATIO	KG lm^3
11.45	,2 m	265	,174	107
	,3	318	,209	130
	,4	334	,220	137
	,5	343	,226	141
	,6	356	,234	147
	,7	360	,237	149
	,8	371	,244	153
	,9	398	,262	165
	1,0	483	,318	201
	1,1	561	,369	233
	1,2	577	,380	240
	1,3	613	,404	255
	1,4	664	,437	276
	1,5	672	,442	279
	1,6	666	,438	277
12.05	1,7	709	,467	295

Water added at 12.00 (20 l)
Readings taken at 12.15 on 16/9/85

TIME	DEPTH	COUNT	RATIO	KG lm^3
12.15	,2	631	,415	262
	,3	565	,372	235
	,4	615	,405	256
	,5	646	,425	269
	,6	642	,423	267
	,7	674	,444	280
	,8	765	,504	318
	,9	821	,540	341
	1,0	847	,558	352
	1,1	886	,583	368
	1,2	897	,591	373
	1,3	927	,610	385
	1,4	957	,630	398
	1,5	923	,608	384
	1,6	731	,481	304
	1,7	721	,475	300
	12.37			

Time 12.45 on 16/9/85

TIME	DEPTH	COUNT	RATIO	KG lm^3
12.45	,2	669	,440	278
	,3	622	,409	259
	,4	586	,386	244
	,5	609	,401	253
	,6	617	,406	257
	,7	624	,411	259
	,8	716	,471	298
	,9	782	,515	325
	1,0	813	,535	338
	1,1	884	,582	367
	1,2	884	,582	367
	1,3	880	,579	366
	1,4	951	,626	396
	1,5	921	,606	383
	1,6	771	,508	320
13.06	1,7	719	,473	299

Time 13.15 on 16/9/85

TIME	DEPTH	COUNT	RATIO	KG lm^3
13.15	,2	666	,438	277
	,3	614	,404	255
	,4	590	,388	245
	,5	591	,389	246
	,6	588	,387	245
	,7	617	,406	257
	,8	694	,457	288
	,9	748	,492	311
	1,0	792	,521	329
	1,1	856	,564	356
	1,2	865	,569	359
	1,3	873	,575	363
	1,4	942	,620	392
	1,5	902	,594	375
	1,6	775	,510	322
13.36	1,7	719	,473	299

Time 13.45 16/9/85

TIME	DEPTH	COUNT	RATIO	KG lm^3
13.45	,2	659	,434	274
	,3	623	,410	259
	,4	582	,383	242
	,5	590	,388	245
	,6	589	,388	245
	,7	613	,404	255
	,8	671	,442	279
	,9	725	,477	301
	1,0	784	,516	326
	1,1	827	,544	344
	1,2	856	,564	356
	1,3	870	,573	362
	1,4	937	,617	390
	1,5	907	,597	377
	1,6	790	,520	328
14.05	1,7	724	,477	301

Time 14.15 16/9/85

TIME	DEPTH	COUNT	RATIO	KG lm^3
14.15	,2	641	,422	267
	,3	614	,404	255
	,4	590	,388	245
	,5	575	,379	239
	,6	578	,381	240
	,7	593	,390	247
	,8	646	,425	269
	,9	711	,468	296
	1,0	769	,506	320
	1,1	837	,551	348
	1,2	843	,555	350
	1,3	879	,579	365
	1,4	919	,605	382
	1,5	888	,585	369
	1,6	785	,517	326
14.36	1,7	725	,477	301

Time 14.45 16/9/85

TIME	DEPTH	COUNT	RATIO	KG lm^3
14.45	,2	638	,420	265
	,3	613	,404	255
	,4	582	,383	242
	,5	559	,368	232
	,6	565	,372	235
	,7	599	,394	249
	,8	652	,429	271
	,9	708	,466	294
	1,0	760	,500	316
	1,1	817	,538	339
	1,2	833	,548	346
	1,3	866	,570	360
	1,4	909	,598	378
	1,5	906	,596	377
	1,6	780	,513	324
15.05	1,7	734	,483	305

Time 15.15 16/9/85

TIME	DEPTH	COUNT	RATIO	KG lm^3
15.15	,2	632	,416	263
	,3	605	,398	252
	,4	580	,382	241
	,5	563	,371	234
	,6	564	,371	235
	,7	588	,387	245
	,8	631	,415	262
	,9	690	,454	287
	1,0	741	,488	308
	1,1	832	,548	346
	1,2	840	,553	349
	1,3	848	,558	352
	1,4	895	,589	372
	1,5	892	,587	371
	1,6	787	,518	327
	1,7	730	,481	303

Time 11.25 17/9/85

TIME	DEPTH	COUNT	RATIO	KG 1m^3
11.25	,2	541	,363	230
	,3	554	,372	235
	,4	528	,355	224
	,5	507	,340	215
	,6	508	,341	215
	,7	509	,342	216
	,8	522	,351	221
	,9	553	,371	235
	1,0	638	,428	271
	1,1	761	,511	323
	1,2	764	,513	324
	1,3	782	,525	331
	1,4	826	,555	350
	1,5	814	,547	345
	1,6	772	,518	327
11.45	1.7	742	,498	315

Prior to augering
GRAVIMETRIC RESULTS (+ 20 litres)

% MOIST	KG/m^3
9.37	176
9,17	172
9,26	174
9,54	179
9,13	171
9,90	186
10,28	193
11,00	206
12,78	239
14,49	272
12,94	243
15,32	287
15,11	283
14,42	270
13,67	256
13,82	259

Augered at 11.55 17/9/85
Gravimetric Results for soil augered in control area

DEPTH	% MOIST Kg/m^3 CONTROL		% MOIST Kg/m^3 + 50 litres H_2O	
,2	3,78	71	9,87	
,3	4,39	82	10,59	
,4	4,77	89	12,48	
,5	5,22	98	12,59	
,6	5,56	104	13,01	
,7	5,80	109	12,64	
,8	6,19	116	11,46	
,9	6,88	129	9,64	
1,0	9,14	171	9,52	
1,1	10,22	192	10,64	
1,2	11,06	207	11,17	
1,3	11,78	221	10,92	
1,4	12,74	239	12,94	
1,5	12,00	225	13,29	
1,6	12,85	241	12,34	
1,7	13,45	252	12,45	
1,8			14,08	

INFILTRATION TEST

Inner ring 50 litres
Outer ring 45 litres

1. 692 min for 2 litres water
2. 7,25 min for 2 litres water

Average = 863 mm/hr

ACCESS TUBE 8

WATER ADDITIONS		1 2 11.30 11.57				3 12.55		4 13.55						
TIME DATE COMMENT	10.58 7.10.85 No water	11.58 7.10.85 wetting	12.21 7.10.85 wetting	12.30 7.10.85 wetting	12.40 7.10.85 wetting	12.55 7.10.85 wetting	13.38 7.10.85 wetting	14.10 7.10.85 Drying	14.36 7.10.85 Drying	15.08 7.10.85 Drying	15.16 7.10.85 Drying	15.36 7.10.85 Drying	16.00 7.10.85 Drying	14.40 8.10.85 Drying
	NEUTRON PROBE READINGS (Kg water/m^3)													
DEPTH (m)														
0,2	118	337	352	357	347	348	358	359	354	354	350	341	330	240
0,3	126	323									343	340	329	232
0,4	139	320	347	348	354	344	357	362	362	352	356	342	331	222
0,5	145	332									352	355	345	233
0,6	154	334	345	357	343	348	357	366	362	357	347	358	348	241
0,7	150	321									348	348	342	244
0,8	143	324	316	318	317	321	332	345	347	350	341	348	343	244
0,9	144	328									335	332	338	235
1,0	129	305	283	276	269	271	275	300	309	312	315	315	311	217
1,1	121	257									271	275	281	198
1,2	117	230					217		236	241	244	254	260	201
1,3	125	205									224	220	238	202
1,4	131	189									206	202	208	205
1,5	151	220									218	210	216	226
1,6	174	226									220	230	224	235

WATER ADDITIONS

	TIME ADDED	QUANTITY INNER RING (Litres)	DEPTH INNER (cm)	QUANT OUTER (Litres)	DEPTH OUTER (cm)	TIME SUNK IN (inner)	INFILTRATION RATE INNER (cm/h)
1	11.30	20	10,2	60	10,2	11.57	22,67
2	11.57	20	10,2	60	10,2	12.55	10,55
3	12.55	20	10,2	60	10,2	13.55	10,20
4	13.55	20	10,2	60	10,2	15,08	8,38

ACCESS TUBE 8
WATER MOVEMENT AND LOSSES IN INFILTRATION EXPERIMENT

A WETTING

TIME DURING EXPERIMENT	ACTUAL AMOUNT OF WATER ENTERED INTO SOIL (Litres)	CALCULATED (from results) AMOUNT OF WATER ENTERED INTO SOIL (Litres)	WATER LOSS FROM SYSTEM (Litres)	WATER GAIN IN SYSTEM (Litres)
12.40	34,83	29,06	5,77	0
13.38	54,33	36,55	17,78	0
15.10	80,00	46,76	33,24	0

B DRYING (Redistribution)

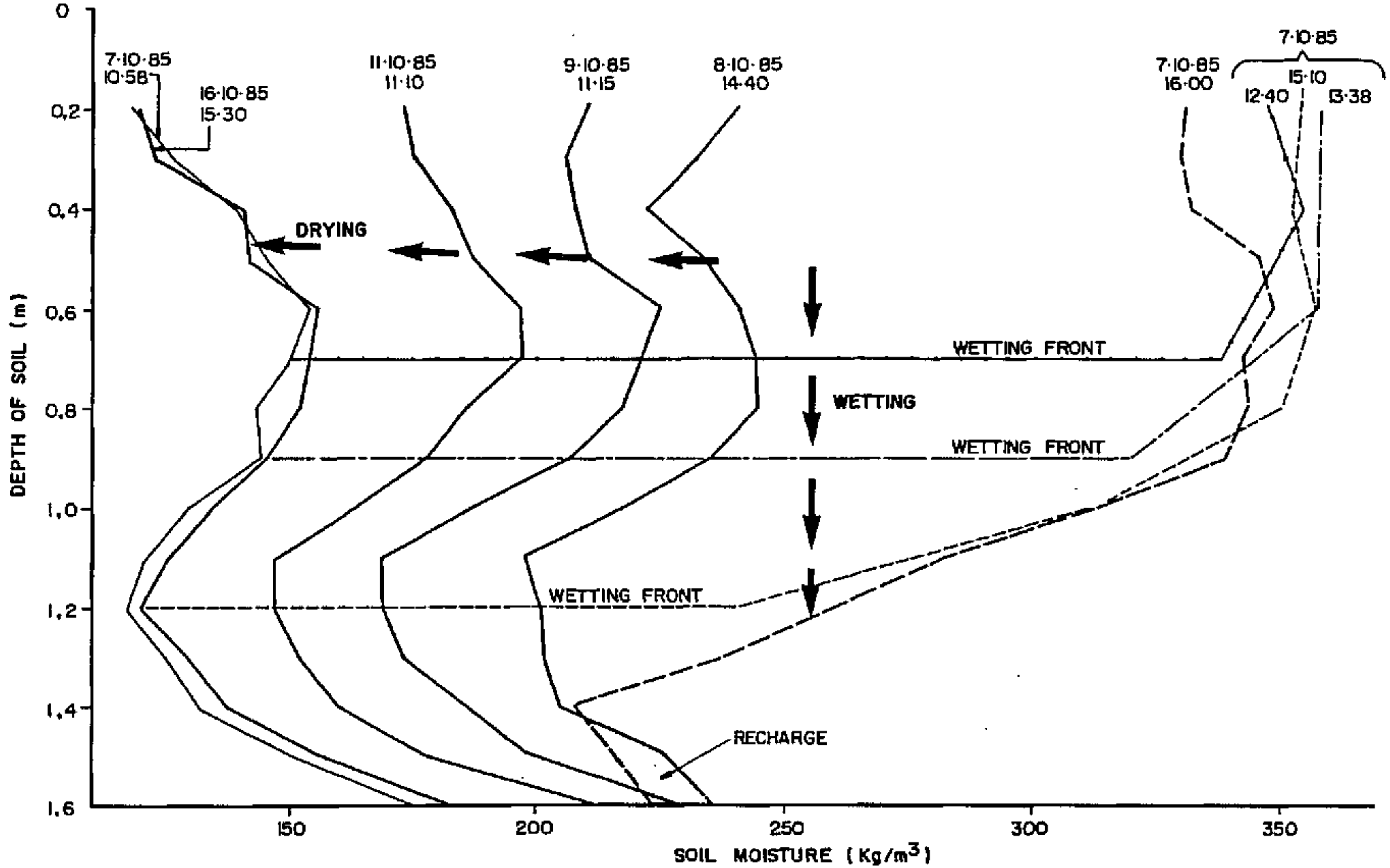
TIMES DURING DRYING	WATER LOSS TO LOWER DEPTH OR WATER LOSS FROM UPPER LEVEL (Litres)	WATER GAIN IN LOWER DEPTH OR WATER LOSS FROM UPPER LEVEL (Litres)	DIFFERENCE (WATER LOSS FROM SYSTEM) (Litres)

ACCESS TUBE 8

WATER ADDITIONS			
TIME	11.45	11.10	15.30
DATE	9.10.85	11.10.85	16.10.85
COMMENT	Drying water	Drying	Drying
	NEUTRON PROBE READINGS (Kg water/m^3)		
DEPTH (m)			
0,2	210	173	119
0,3	206	175	123
0,4	208	183	140
0,5	210	187	142
0,6	225	197	156
0,7	221	197	154
0,8	217	186	152
0,9	207	178	145
1,0	187	163	134
1,1	169	147	125
1,2	169	147	120
1,3	173	152	129
1,4	186	160	137
1,5	198	178	155
1,6	227	210	182

WATER ADDITIONS

TIME ADDED	QUANTITY INNER RING (Litres)	DEPTH INNER (cm)	QUANT OUTER (Litres)	DEPTH OUTER (cm)	TIME SUNK IN (inner)	INFILTRATION RATE INNER (cm/h)


7·10·85
10·58
16·10·85
15·30
11·10·85
11·10
9·10·85
11·15
8·10·85
14·40
7·10·85
16·00
7·10·85
15·10
12·40
13·38
DRYING
WETTING FRONT
WETTING
WETTING FRONT
WETTING FRONT
RECHARGE
DEPTH OF SOIL (m)
SOIL MOISTURE (Kg/m3)
0
0,2
0,4
0,6
0.8
1,0
1,2
1,4
1,6
150
200
250
300
350

F.4.17.

ACCESS TUBE 9
WATER MOVEMENT AND LOSSES IN INFILTRATION EXPERIMENT

A WETTING

TIME DURING EXPERIMENT	ACTUAL AMOUNT OF WATER ENTERED INTO SOIL (Litres)	CALCULATED (from results) AMOUNT OF WATER ENTERED INTO SOIL (Litres)	WATER LOSS FROM SYSTEM (Litres)	WATER GAIN IN SYSTEM (Litres)
11.30	23	24,5	0	1,5
12.00	35,5	32,2	3,3	0
13.05	48,00	41,4	6,6	0
13.38	75,6	45,4	30,2	0

B DRYING (Redistribution)

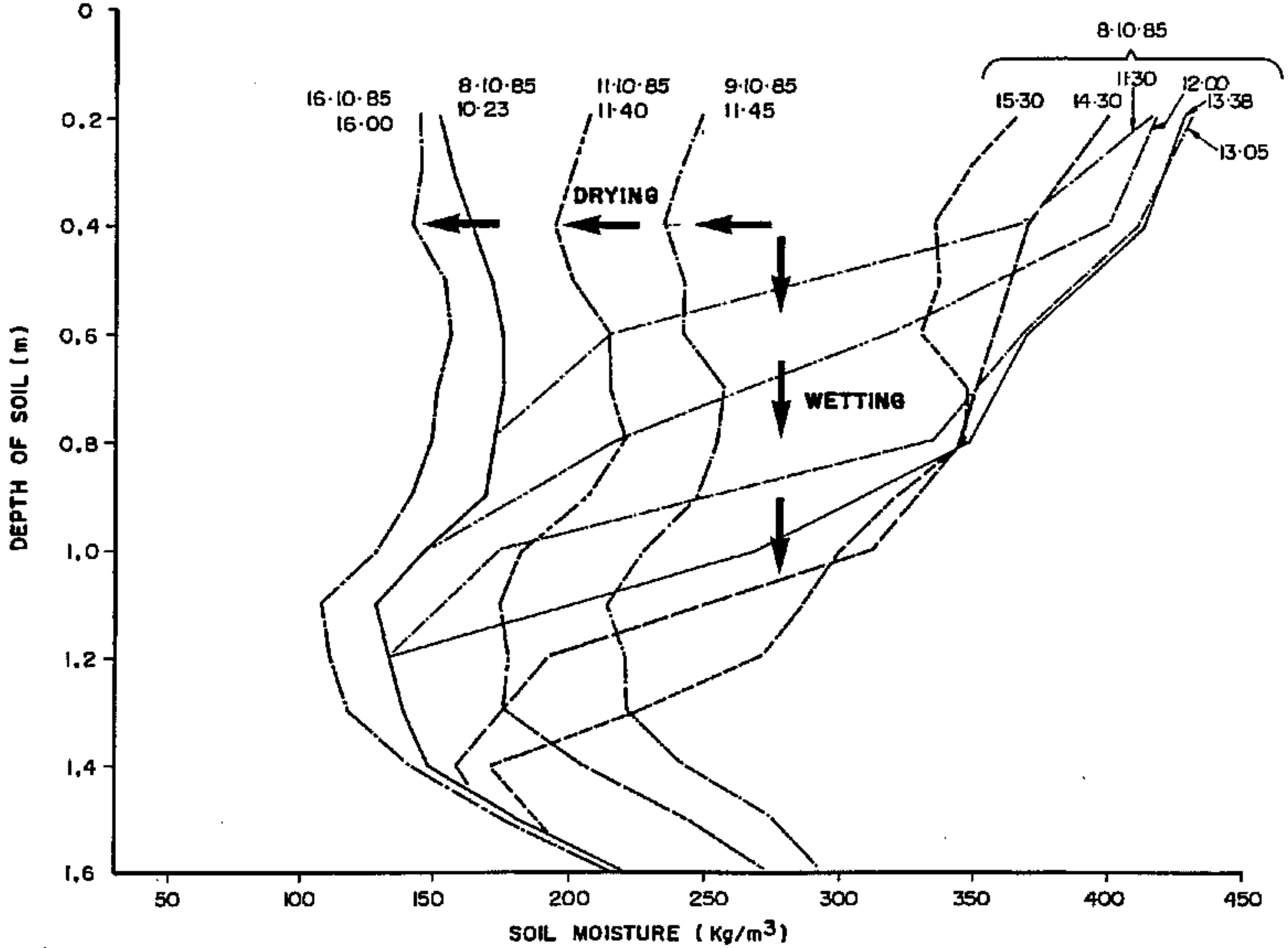
TIMES DURING DRYING	WATER LOSS TO LOWER DEPTH OR WATER LOSS FROM UPPER LEVEL (Litres)	WATER GAIN IN LOWER DEPTH OR WATER LOSS FROM UPPER LEVEL (Litres)	DIFFERENCE (WATER LOSS FROM SYSTEM) (Litres)
13.38 - 14.30	4,1	4,2	0
14.30 - 15.30	4,5	3,1	0,9

ACCESS TUBE 9

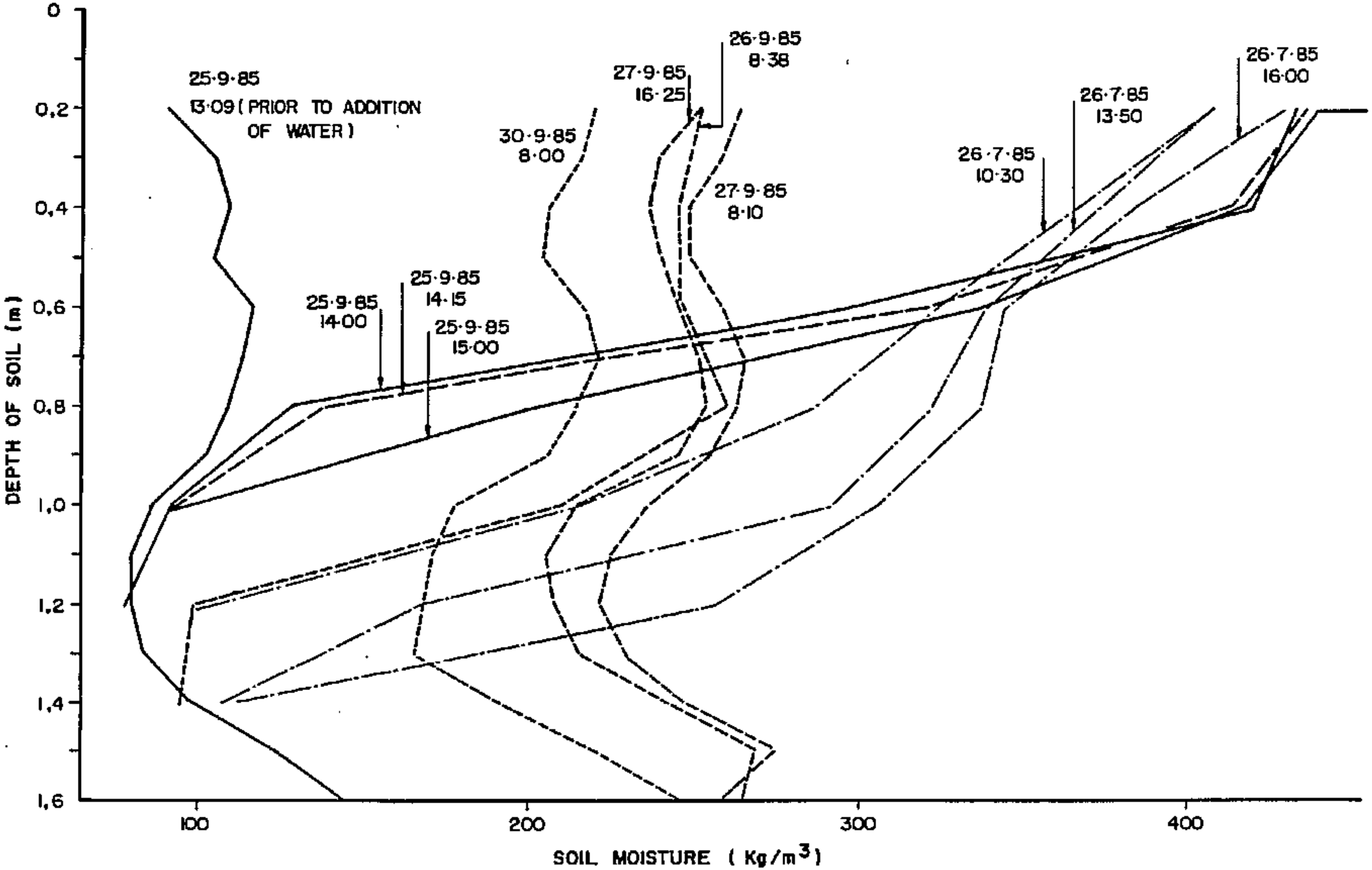
WATER ADDITIONS	1 10.56	2 11.24	3 12.10									
TIME	10.23	11.30	12.00	13.05	13.38	14.00	14.30	15.00	15.30	11.45	11.40	16.00
DATE	8.10.85	8.10.85	8.10.85	8.10.85	8.10.85	8.10.85	8.10.85	8.10.85	8.10.85	9.10.85	11.10.85	16.10.85
COMMENT	No water	wetting	wetting	wetting	wetting	Drying	Drying	Drying	Drying	Drying	Drying	Drying
	NEUTRON PROBE READINGS (Kg water/m^3)											
DEPTH (m)												
0,2	151	413	416	429	427	413	398	379	364	248	206	144
0,3	157								346	240	200	145
0,4	163	366	399	410	412	382	368	340	334	235	194	142
0,5	170								336	242	200	153
0,6	175	214	319	368	369	367	357	336	330	241	214	156
0,7	175								337	257	214	151
0,8	172	186	216	334	348	346	344	335	335	254	220	149
0,9	168								320	247	207	141
1,0	146	144	147	174	269	305	312	314	300	227	182	128
1,1	129								286	213	174	108
1,2	133		127	138	131	149	192	255	271	220	177	111
1,3	138								223	221	176	119
1,4	149					156	159	161	171	241	204	141
1,5	180								186	276	244	175
1,6	219							222	219	293	272	217

WATER ADDITIONS

	TIME ADDED	QUANTITY INNER RING (Litres)	DEPTH INNER (cm)	QUANT OUTER (Litres)	DEPTH OUTER (cm)	TIME SUNK IN (inner)	INFILTRATION RATE INNER (cm/h)
1	10.56	20	10,2	60	10,2	11.24	21,86
2	11.24	20	10,2	60	10,2	12.10	13,30
3	12.10	20	10,2	60	10,2	13.00	12,24
4	13.00	20	10,2	60	10,2	13,49	13,49


8·10·85
16·10·85
16·00
8·10·85
10·23
11·10·85
11·40
9·10·85
11·45
15·30
14·30
11·30
12·00
13·38
13·05
DRYING
WETTING
DEPTH OF SOIL (m)
SOIL MOISTURE (Kg/m3)
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
50
100
150
200
250
300
350
400
450

F.4.20.


25·9·85
13·09 (PRIOR TO ADDITION OF WATER)
30·9·85
8·00
27·9·85
16·25
26·9·85
8·38
27·9·85
8·10
26·7·85
10·30
26·7·85
13·50
26·7·85
16·00
25·9·85
14·00
25·9·85
14·15
25·9·85
15·00
DEPTH OF SOIL (m)
0
0,2
0,4
0,6
0,8
1,0
1,2
1,4
1,6
100
200
300
400
SOIL MOISTURE (Kg/m³)

F.4.21.

SECOND PHASE INFILTRATION TESTING

1. INTRODUCTION

Additional infiltration experiments were conducted in the Zuurbekom area in October/November 1985 to establish the infiltration characteristics of some of the soils in the area and to prove testing techniques.

The experiments were conducted by hammering sets of specially made infiltration rings into the soil, adding water and monitoring the movement of water into the soil with a neutron moisture probe. Four infiltration experiments were conducted, two experiments in an initially dry soil and two in an initially wet soil.

2 LOCATION

The infiltration test were conducted in access tubes 5, 6, 8 and 9. Access tubes 8 and 9 are 100 m apart, and access tubes 5 and 6 are about 4 00 m apart. Experimentation on access tubes 8 and 9 was conducted at the same time, and similarly for access tubes 5 and 6.

3 AIM OF EXPERIMENT

The aim of the experiment was to see how effective the testing techniques are, to try and improve the method of infiltration testing and to get some idea of the infiltration characteristics of some of the soils tested, and saturated hydraulic conductivities.

4 APPARATUS

Two galvanised iron infiltration rings were used in each experiment:- a large outer ring of diameter 1,0 m and a smaller ring of diameter 0,5 m. The rings had a depth of 0,2 m. The rings were knocked into the ground to retain the water level inside. Other apparatus used in the tests was :- a Troxler depth moisture gauge (for soil moisture readings), four 25 litre water containers, a stop watch and access tubes which had previously been installed. The access tubes have a diameter of about 5 cm and a depth into the soil of 1,5 m.

5 TEST METHOD

At each test site the infiltration rings were arranged concentrically around a previously installed access tube. The rings were hammered into the ground to a depth of 0,1 m, leaving 0,1 m of ring above the ground. Vegetation and litter covering the soil was not removed, as these factors have an influence on infiltration. The edges of the rings were sealed with soil to minimise water leakage.

Soil moisture readings were taken every 0,1 m with the neutron probe prior to the addition of water to the rings. An equal depth of water was then added to each of the rings, and the time noted. Water was poured onto plastic bags on the soil surface in the rings to try and prevent the soil surface from being disturbed. The purpose of the outer ring was to try and wet the soil surrounding the inner ring to minimise horizontal movement of water away from the inner ring.

Before addition of water the access tube/soil interface was sealed with soil to prevent water movement down the side of the access tube. As soon as the water in the rings had passed into the soil surface, the time was noted and more water was added. Water was added four times to each ring. Soil moisture readings were taken before addition of water to the rings and then about every half hour while infiltration was taking place. Each addition of water to the infiltration rings of access tubes 5 and 6 was 5 cm and each addition to access tubes 8 and 9 was 10 cm.

After all the water had infiltrated, soil moisture readings were continued every half hour for the rest of the day and then daily for a week to ascertain redistribution and drying curves of the soil.

6 RESULTS

The results for access tubes 5, 6, 8 and 9 are given at the end of this appendix.

The results for each access tube contain times of neutron readings and water additions, a graphical representation of results and water losses and movements in the profile. The graphical results show the wetting front as the water advances through the profile.

7 INTERPRETATION OF RESULTS

The actual amount of water lost from the system can be calculated as follows:-

The actual amount of water in the soil as measured by the moisture gauge is calculated from the graph as follows:-

> The inner ring has a radius of 0,25 m and the area = 0,196 m^2.
> 0,1 m depth of soil in the inner ring has a volume of 0,0196m^3.
> (If the Troxler moisture reading is 300 kg water/m^3, then for 0,1m soil or ,02m^3 soil there is: 6 kg.
> Then for 10 kg water/m^3 and for 0,1 m depth of soil there is: 0,2kg.

Each sequence on the graph corresponding to 10 kg water/m^3 and 0,1 m in depth is equal to 0,2 litres of water.

Then by counting the squares between the different curves on the graph the actual added water in the soil can be calculated. This actual amount of added water in the soil can be compared to the known amount of water added and the loss can be calculated.

8 DISCUSSION

The results show a definite wetting front of moisture moving down the soil profile, and a characteristic curve for each soil. The actual volumes of water added in the experiment are higher than volumes calculated from the graphs, especially in the latter stages of the wetting phase. The water loss from the system is expected to be due to lateral flow of water in the profile.

Infiltration rates also appear to be higher than expected (10-12cm/h). This may also be due to horizontal movement of water and therefore an increase in volume into which water is moving.

The graphs show little or no recharge occuring, but this may be due to horizontal movement of the water, and recharge may be occuring below the level of the access tubes.

The largest problem influencing the results was horizontal water loss, which has an influence on wetting curves, drying curves and infiltration rates. Due to this water loss it is probably better to perform the experiment after a heavy rainfall when the surrounding soil is more wet and sideways capillary forces are less, although this does not prevent the problem. Experimentation at access tubes 5 and 6 was performed after approximately 100 mm of rain had fallen the previous week, and there was still a large water loss.

As the soil does not become saturated the saturated hydraulic conductivities could not be obtained.

9 PROBLEMS IDENTIFIED

The major problem encountered was a loss of water from the system, as this influences the experiment. Another problem was the movement of water into the soil down the side of the access tube as is shown by the results obtained for access tube 8. For access tube 8 the initial wetting readings show water to have entered deep into the soil profile, and this is probably due to water entering the soil down the side of the access tube. The sides of the access tube were then sealed as can be observed by a decrease in moisture at lower levels.

No 'leakage' occured at access tubes 5 and 6 as these were sealed with plastic bags and mud prior to water addition.

Another minor problem was a slight leakage of water of the rings onto the surrounding soil. This problem was rectified by placing mud around the edge of the rings.

10 SUGGESTED IMPROVEMENTS

A major improvement to the system would be to try and decrease or eliminate the horizontal loss of water. This may be achieved by wetting a large area of soil and performing the experiment in the centre of the wetted area. A large area may be wetted using a rainfall simulator. If the area was wetted for days prior to the experiment so that the soil was fairly well saturated, there should be little loss and measurement of a saturated hydraulic conductivity should be possible.

A plastic or similar covering from the rings would reduce evaporation and calculations would be more accurate.

11 CONCLUSION

The infiltration experiments conducted will need a lot of further improvements to enable good useful data to be obtained, but the experiments should provide a good basis for future infiltration experiments.

The data from these experiments cannot be used with confidence due to large water losses from the experiment and other inaccuracies.

APPENDIX F 5

SOIL BULK DENSITIES AND PARTICLE SIZE DISTRIBUTION AND PERMEABILITIES

ZUURBEKOM

PRESSURE (BAR)		0,3	1	2	3	5.5	8.5	10	15
HOLE	DEPTH (mm)	% DRY MASS/WET MASS							
3	200	5.3398	5.057		4.7318		3.513		
	600	12.711	12.556		12.185		12.198		
	1 000	14.164	13.88		12.076		11.04		
	1 200	16.427	14.769		13.2246		12.462		
7	200	4.765	4.559	4.523		3.836			
	600	7.062	6.886	6.876		5.831			
	1 000	6.7281	6.492	6.495		5.996			
	1 400	8.5602	7.418	7.599		7.443			
6	200	6.023	6.303	5.163		5.554			6.098
	600	7.6	8.174	7.287		6.230			7.910
	1 000	5.6	5.185	4.772		4.511			5.503
	1 800	10.88	10.55	9.3		8.249			9.150
5	200	6.77	5.85						
	600	7.00	8.41						
	1 000	8.527	7.55						
	1 200	9.008	7.5						
8	200	8.583	4.51			3.82			
	600	7.387	6.21			5.22			
	1 200	7.986	6.32			5.46			
	1 600	8.25	5.93			5.00			
2	200	8.55	7.19			6.2			
	600	7.616	6.25			5.8			
	1 200	9.7089	6.81			5.6			
	1 600	8.48	7.08			6.2			
9		8.56	7.2			6.41			
		8.321	6.12			5.3			
		8.44	6.7			5.72			
		8.82	6.9			5.91			

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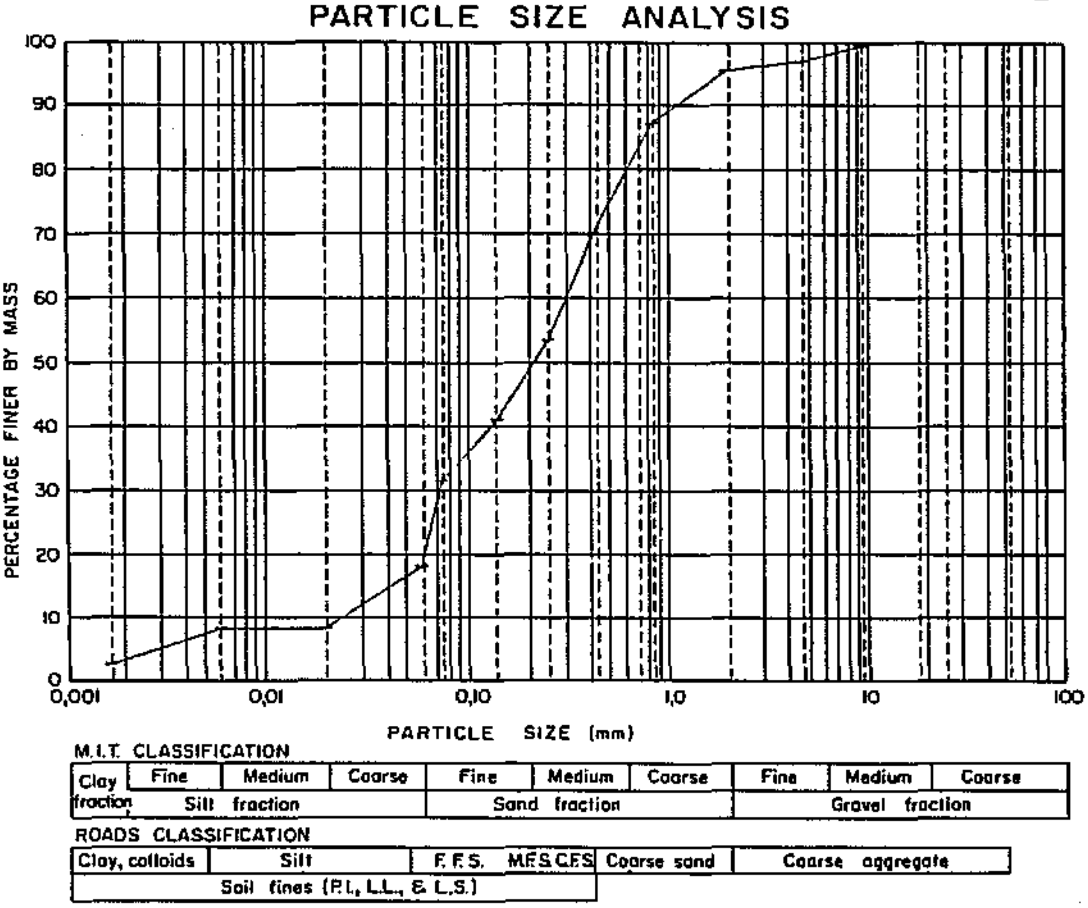
Project Zuurbekom
Reference Len Abrahams
Client Job Nº WRC C1 3346
Job Nº 6078/86
Date 10.9.86
Technician –
Checked by

PARTICLE SIZE ANALYSIS



ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº					
HOLE Nº	H8				
DEPTH	200mm				
PLOTTING CODE	1				
LIQUID LIMIT	18				
PLASTIC LIMIT	11				
PLASTICITY INDEX	7				
LINEAR SHRINKAGE	2.0				
CLAY FRACTION (0,002mm)	3				
P.I. OF WHOLE SAMPLE	5				
GRADING MODULUS	1.04				
P.R.A. CLASSIFICATION	A-2-4				
U.S.C.S. CLASSIFICATION					
SOIL DESCRIPTION					
	LOW 1<*<2				

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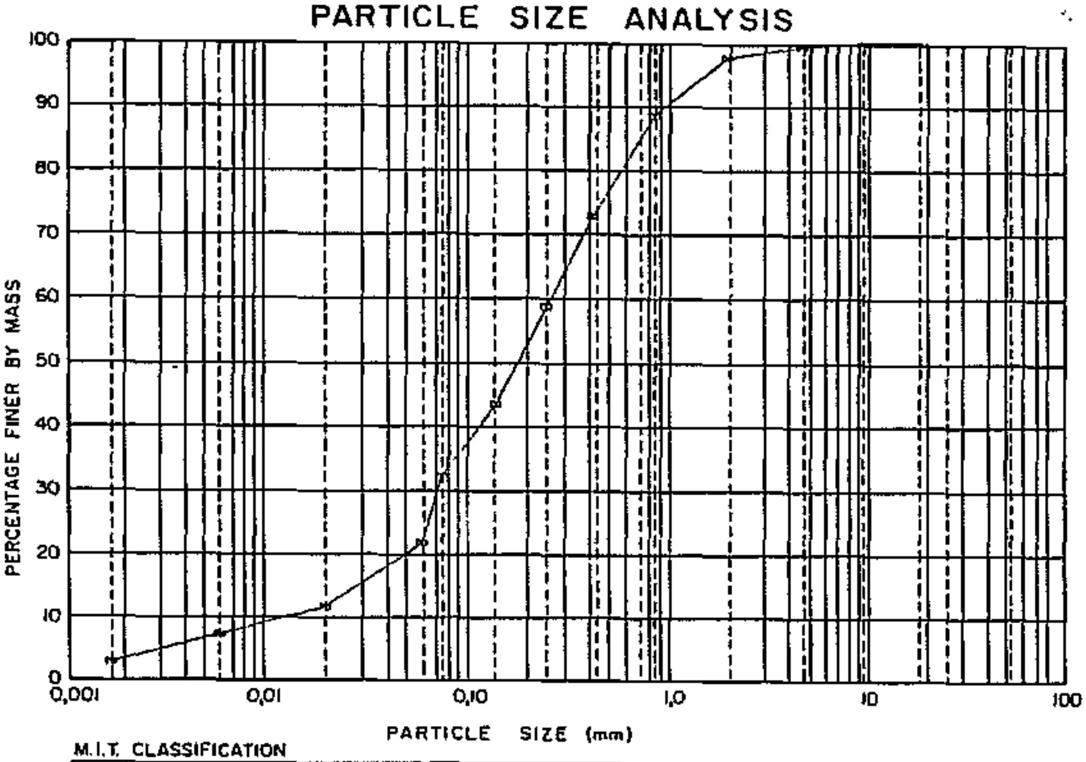
Reference Len Abrahams — Technician
Client Job No WRC C1 3348 — Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No				
HOLE No	H8			
DEPTH	600mm			
PLOTTING CODE	2			
LIQUID LIMIT	20			
PLASTIC LIMIT	12			
PLASTICITY INDEX	8			
LINEAR SHRINKAGE	3.5			
CLAY FRACTION (0,002mm)	3			
P.I. OF WHOLE SAMPLE	5			
GRADING MODULUS	.88			
P.R.A. CLASSIFICATION	A-2-4			
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW 1<=<2			

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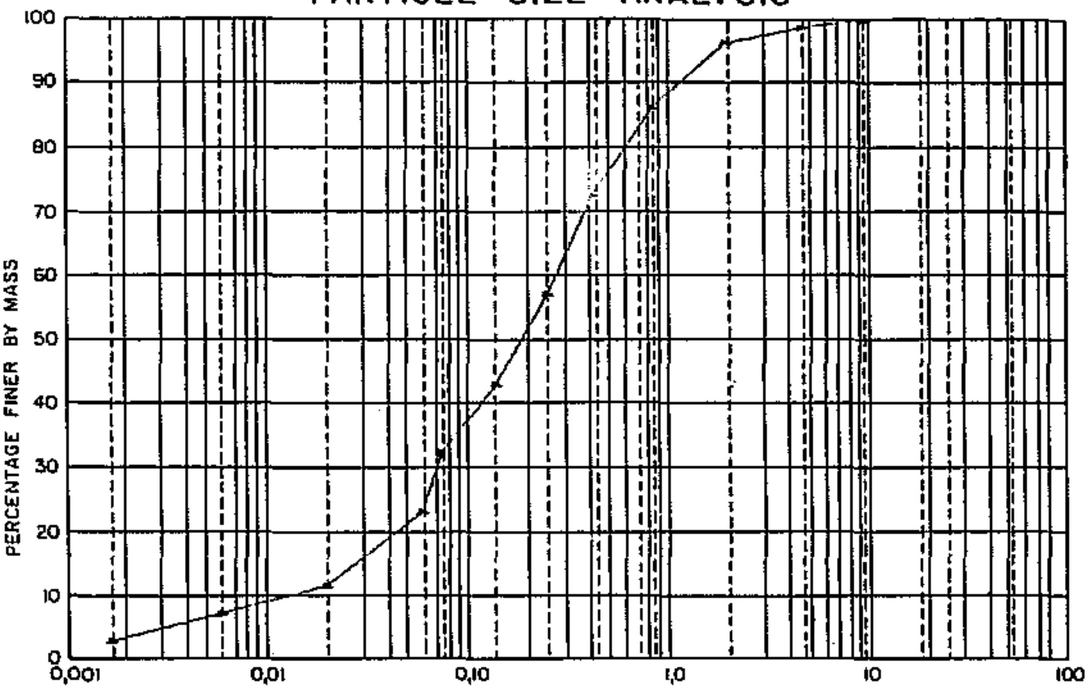
Project Zuurbekom	Date 10.9.88
Reference Len Abrahams	Technician
Client Job NO WRC C1 3348	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE NO				
HOLE NO	H8			
DEPTH	1200mm			
PLOTTING CODE	4			
LIQUID LIMIT	20			
PLASTIC LIMIT	12			
PLASTICITY INDEX	8			
LINEAR SHRINKAGE	3.5			
CLAY FRACTION (0,002mm)	3			
P.I. OF WHOLE SAMPLE	6			
GRADING MODULUS	1.00			
P.R.A. CLASSIFICATION	A-2-4			
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW 1<*<2			

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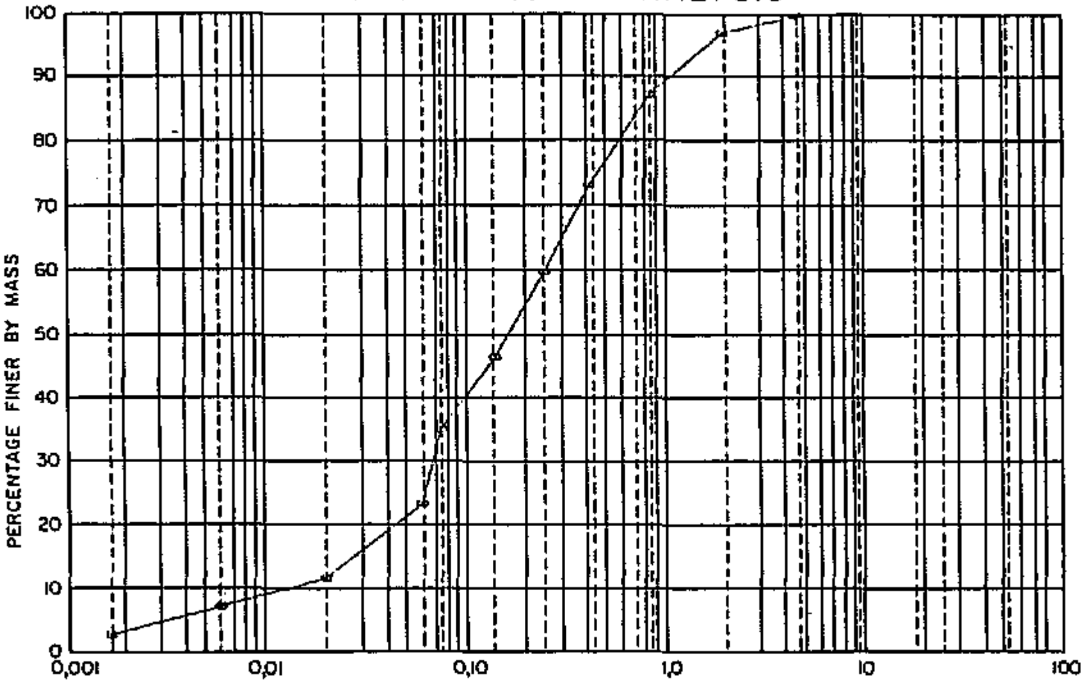
PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No				
HOLE No	H8			
DEPTH	1000mm			
PLOTTING CODE	3			
LIQUID LIMIT	19			
PLASTIC LIMIT	11			
PLASTICITY INDEX	8			
LINEAR SHRINKAGE	3.5			
CLAY FRACTION (0,002mm)	3			
P.I. OF WHOLE SAMPLE	6			
GRADING MODULUS	.95			
P.R.A. CLASSIFICATION	A-2-4			
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW *>2			

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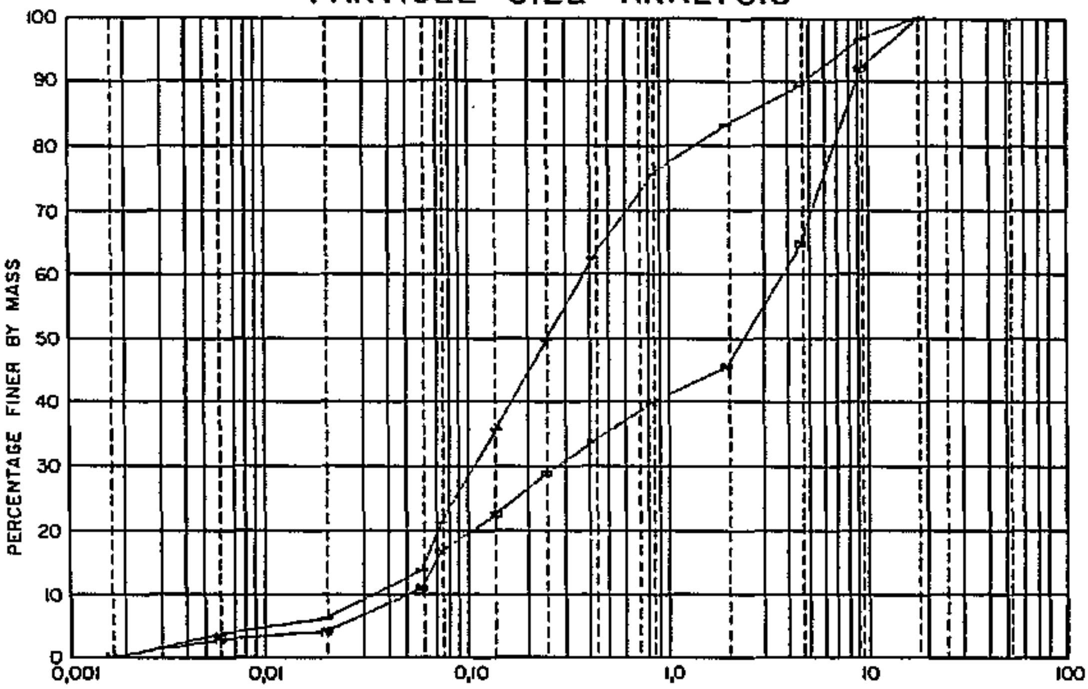
Project	Zuurbekom	Date	28.8.86
Reference	Len Abrahams	Technician	
Client Job No	WRC CI 3346	Checked by	

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	—	—		
HOLE No	7	7		
DEPTH	200	600mm		
PLOTTING CODE	1	2		
LIQUID LIMIT	16	19		
PLASTIC LIMIT	9	12		
PLASTICITY INDEX	7	7		
LINEAR SHRINKAGE	.5	2.0		
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE	4	2		
GRADING MODULUS	1.34	2.05		
P.R.A. CLASSIFICATION	A-2-4	A-2-4		
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW *<.5	LOW *>2		

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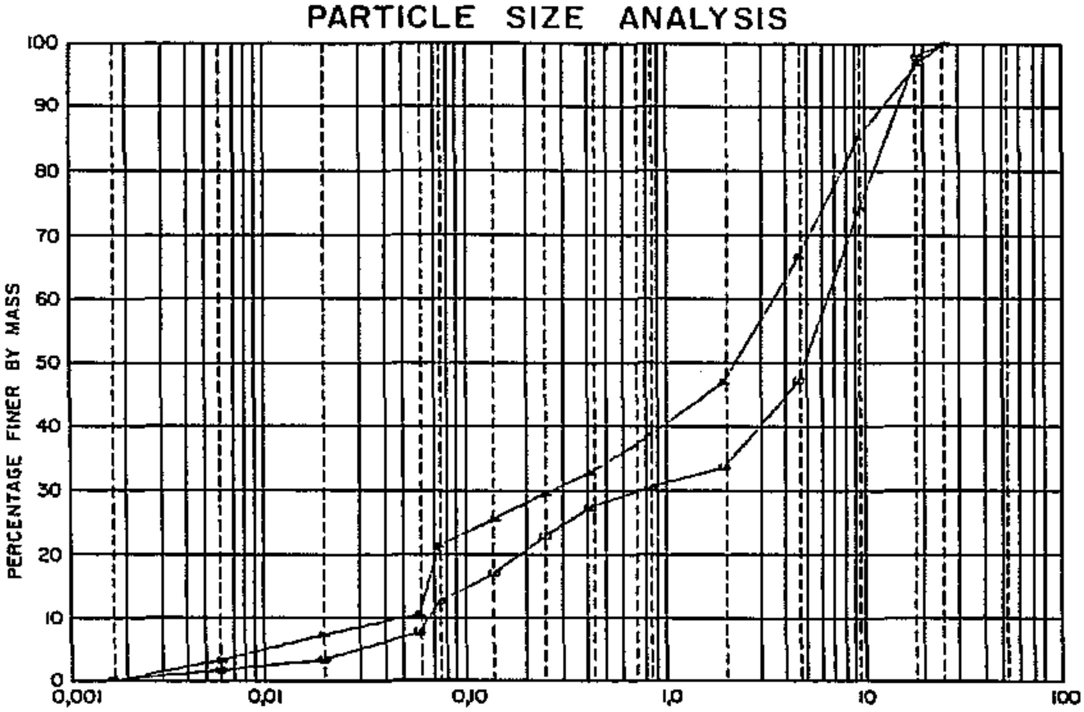
Reference Len Abrahams — Technician
Client Job No WRC CI 3346 — Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	—	—		
HOLE No	7	7		
DEPTH	1000	1400		
PLOTTING CODE	3	4		
LIQUID LIMIT	18	23		
PLASTIC LIMIT	12	14		
PLASTICITY INDEX	6	9		
LINEAR SHRINKAGE	2.0	3.5		
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE	2	3		
GRADING MODULUS	2.27	2.00		
P.R.A. CLASSIFICATION	A-1-a	A-2-4		
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW *<.5	LOW *>2		

Dial-A-Print 3436

GEMLAB
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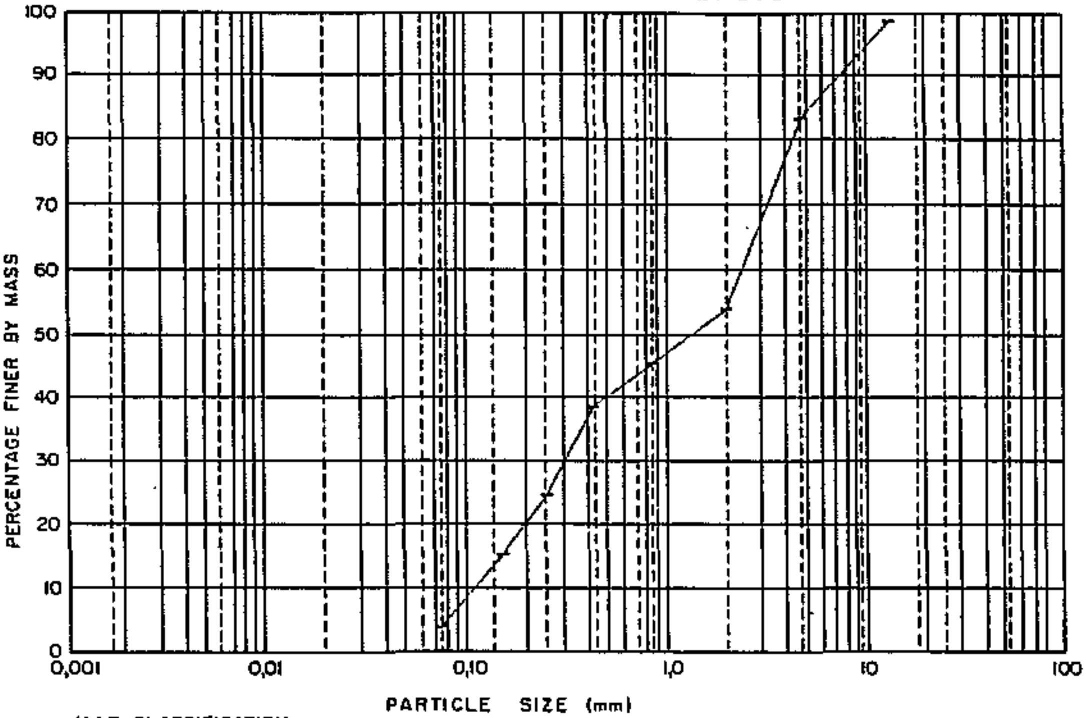
No 3 Village Road
Selby, Johannesburg
Tel 636-9007/8

Client Water Reasearch Commission	Job No 6078/86
Project Zuurbekom	Date 28.8.86
Reference Len Abrahams	Technician
Client Job No WR CI 3346	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	- Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	—			
HOLE No	6			
DEPTH	200m			
PLOTTING CODE	1			
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

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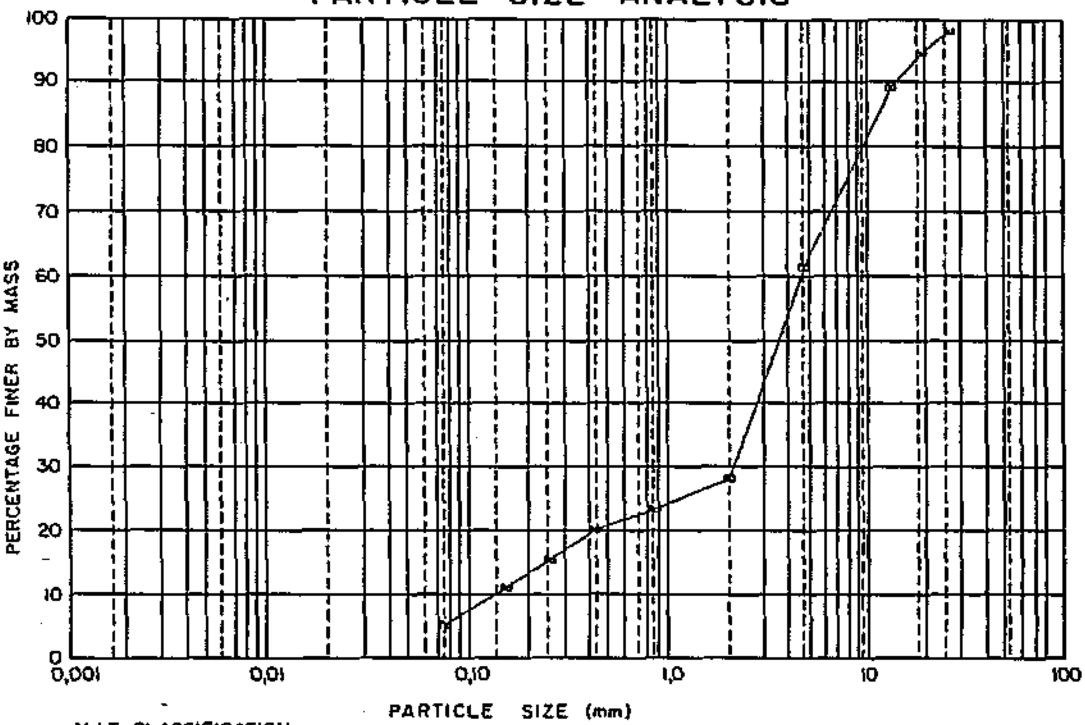
(Reg No 75/03339/07)
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client Water Research Commission	Job No 6078/86
Project Zuurbekom	Date 28. 8. 86
Reference Len Abrahams	Technician
Client Job No WR CI 3346	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

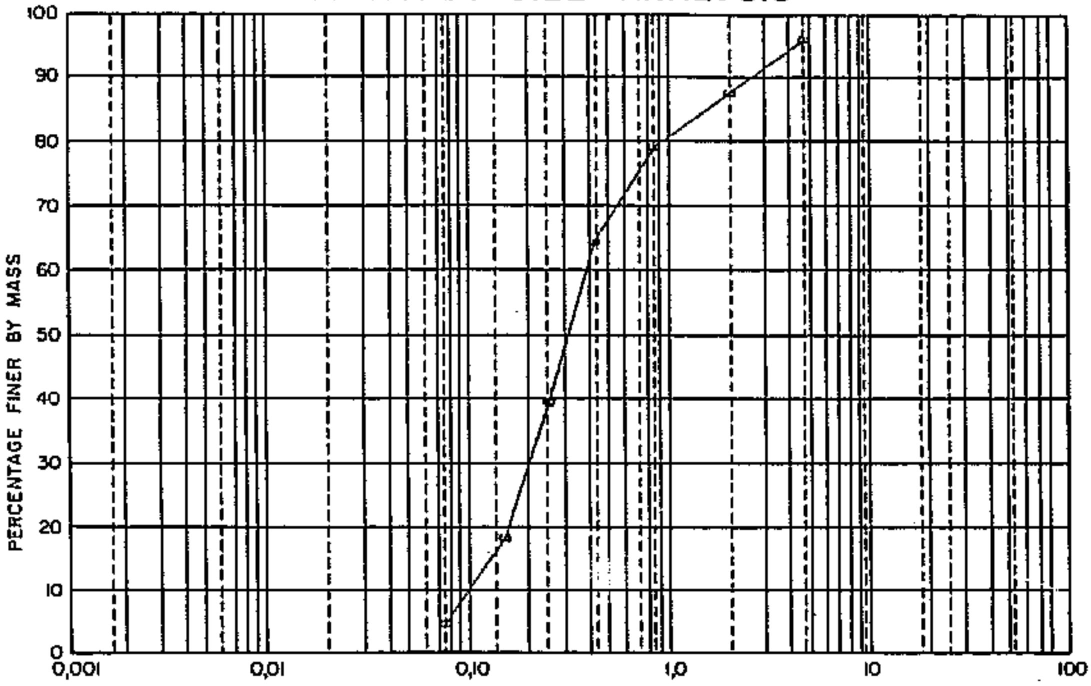
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	–			
HOLE No	6			
DEPTH	600m			
PLOTTING CODE	2			
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
(Reg No 75/05339/07)
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client Water Research Commission
Job No 6078/86
Project Zuurbekom
Date 28.8.86
Reference Len Abrahams
Technician
Client Job No WR CI 3346
Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

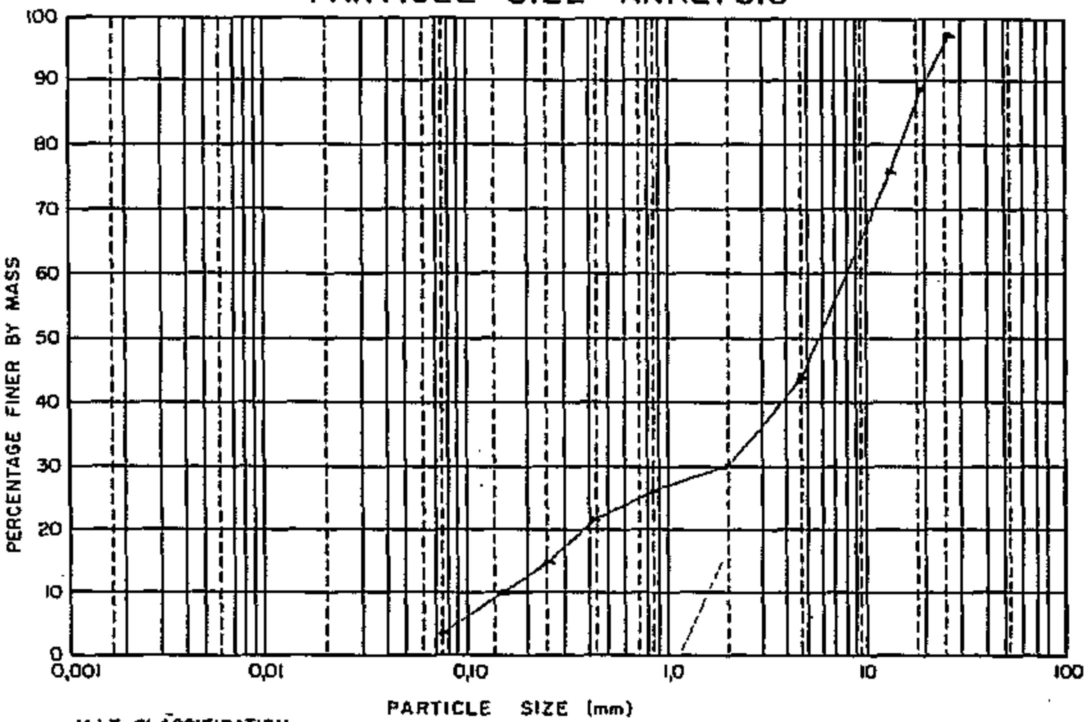
SAMPLE No	—			
HOLE No	6			
DEPTH	1000m			
PLOTTING CODE	3			
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB

(Reg No 75/03335/07)
No 3 Village Road
Selby, Johannesburg
Tel 836-900778

Client Water Research Commission	Job No 6079/86
Project Zuurbekom	Date 28. 8. 86
Reference Len Abrahams	Technician
Client Job No WR CI 3346	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.L., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No				
HOLE No	6			
DEPTH	1800m			
PLOTTING CODE	2			
LIQUID LIMIT				
PLASTIC LIMIT				
PLASTICITY INDEX				
LINEAR SHRINKAGE				
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE				
GRADING MODULUS				
P.R.A. CLASSIFICATION				
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				

GEMLAB
(Reg No 75/03339/07)
No 3 Village Road
Selby, Johannesburg
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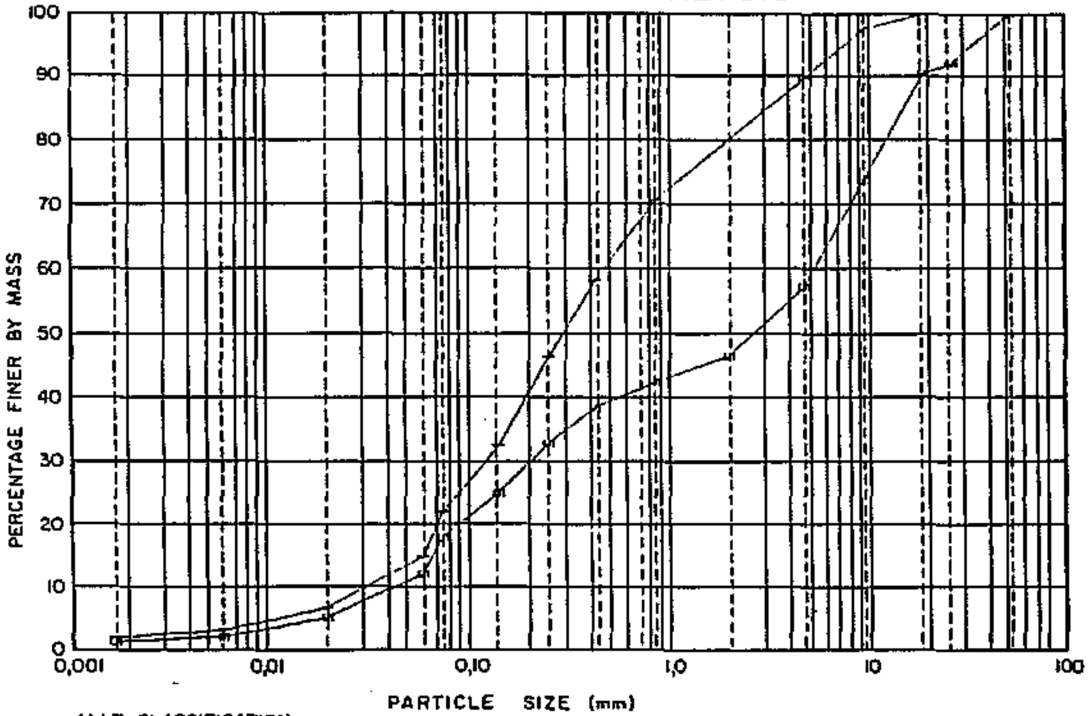
Client Water Research Commission
Job No 6078/86
Project Zuurbekom
Date 10.09.86
Reference Len Abrahams
Technician
Client Job No WRC CI 3346
Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

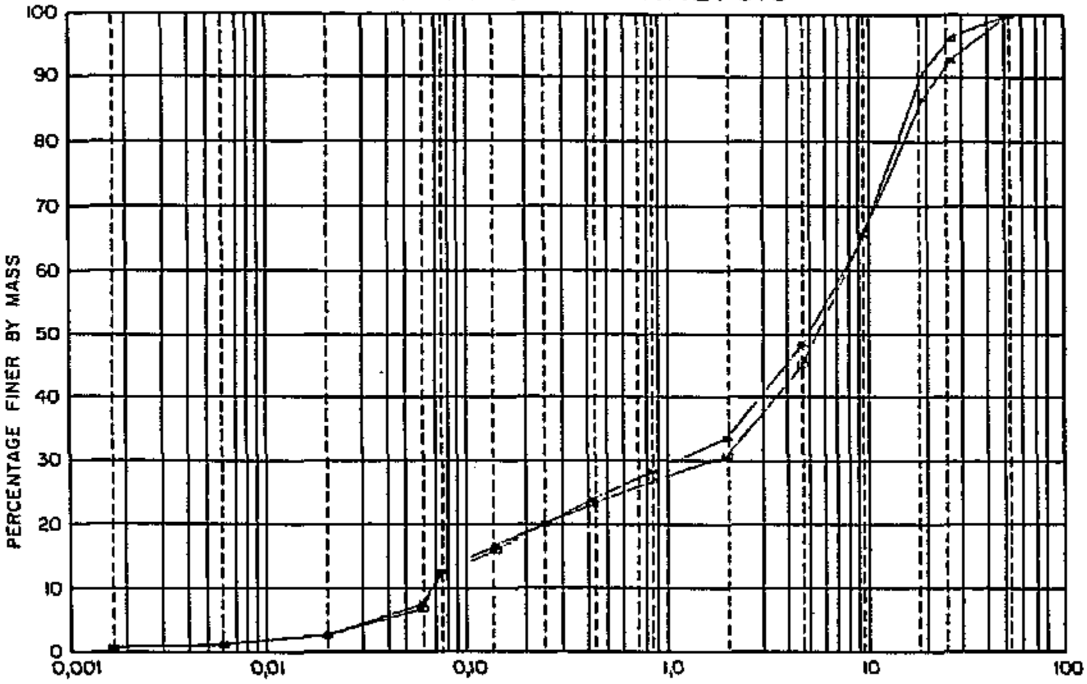
Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	—	–		
HOLE No	H5	H5		
DEPTH	200	600		
PLOTTING CODE	1	5		
LIQUID LIMIT	17	18		
PLASTIC LIMIT	10	11		
PLASTICITY INDEX	7	7		
LINEAR SHRINKAGE	2.0	2.5		
CLAY FRACTION (0,002mm)	2	1		
P.I. OF WHOLE SAMPLE	4	3		
GRADING MODULUS	1.40	1.98		
P.R.A. CLASSIFICATION	A-2-4	A-2-4		
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW 1<*<2	LOW 1<*<2		

GEMLAB (Reg No. 75/03339/07) No. 3 Village Road Selby, Johannesburg Tel 836-9007/8	Client Water Research Commission	Job Nº 6078/86
	Project Zuurbekom	Date 10.09.86
	Reference Len Abrahams	Technician
	Client Job Nº WRC CI 3346	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

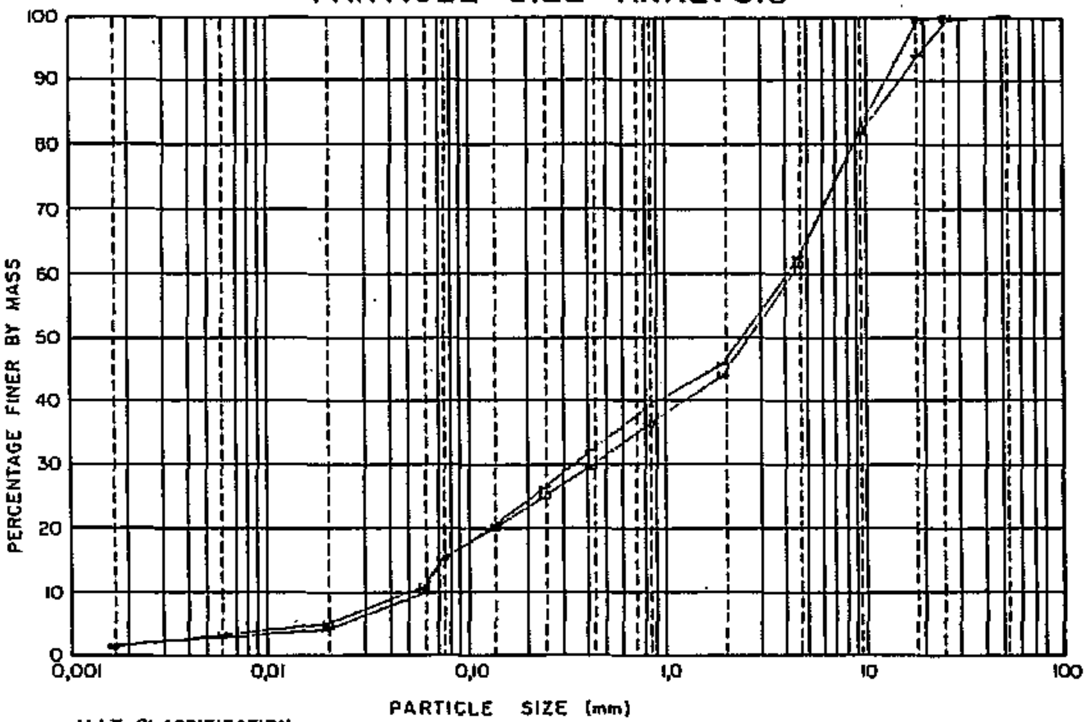
Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE Nº	—	—		
HOLE Nº	H5	H5		
DEPTH	1000	1200		
PLOTTING CODE	3	4		
LIQUID LIMIT	22	21		
PLASTIC LIMIT	14	14		
PLASTICITY INDEX	8	7		
LINEAR SHRINKAGE	3.5	3.5		
CLAY FRACTION (0,002mm)	1	1		
P.I. OF WHOLE SAMPLE	2	2		
GRADING MODULUS	2.34	2.30		
P.R.A. CLASSIFICATION	A-2-4	A-2-4		
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW *>2	LOW 1<*<2		

GEMLAB (Reg No 75/03339/07) No 3 Village Road Selby, Johannesburg Tel 835-9007/8	Client Water Research Commission	Job No 6078/88
	Project Zuurbakom	Date 10.9.88
	Reference Len Abrahams	Technician
	Client Job No WRC C1 3348	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.E.S.C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)					

ATTERBERG LIMITS & SOILS CLASSIFICATION

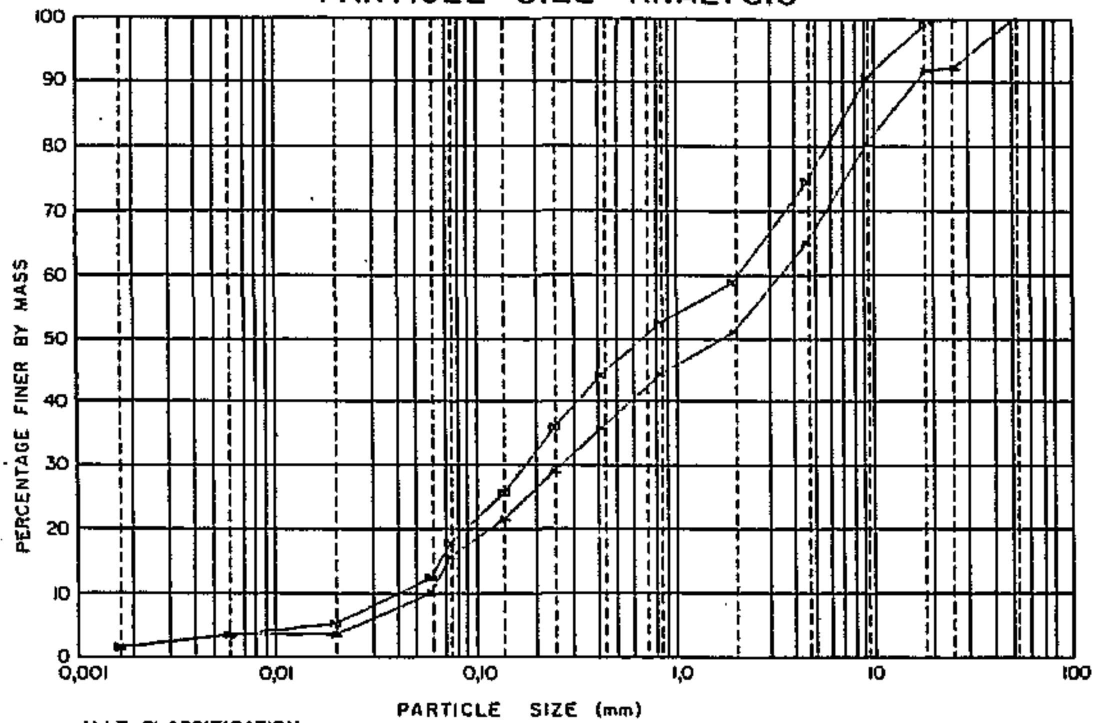
SAMPLE No				
HOLE No	H2	H2		
DEPTH	200mm	1600mm		
PLOTTING CODE	1	3		
LIQUID LIMIT	20	21		
PLASTIC LIMIT	13	14		
PLASTICITY INDEX	7	7		
LINEAR SHRINKAGE	3.5	3.5		
CLAY FRACTION (0,002mm)	1	1		
P.I. OF WHOLE SAMPLE	2	2		
GRADING MODULUS	2.09	2.13		
P.R.A. CLASSIFICATION	A-2-4	A-2-4		
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW 1<a<2	LOW 1<a<2		

GEMLAB

(Reg No 75/03339/07)
No 3 Village Road
Selby, Johannesburg
Tel 836-9007/8

Client Water Research Commission	Job No 6078/86
Project Zuurbekom	Date 10.9.88
Reference Len Abrahams	Technician
Client Job No WRC C1 3348	Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L. & L.S.)					

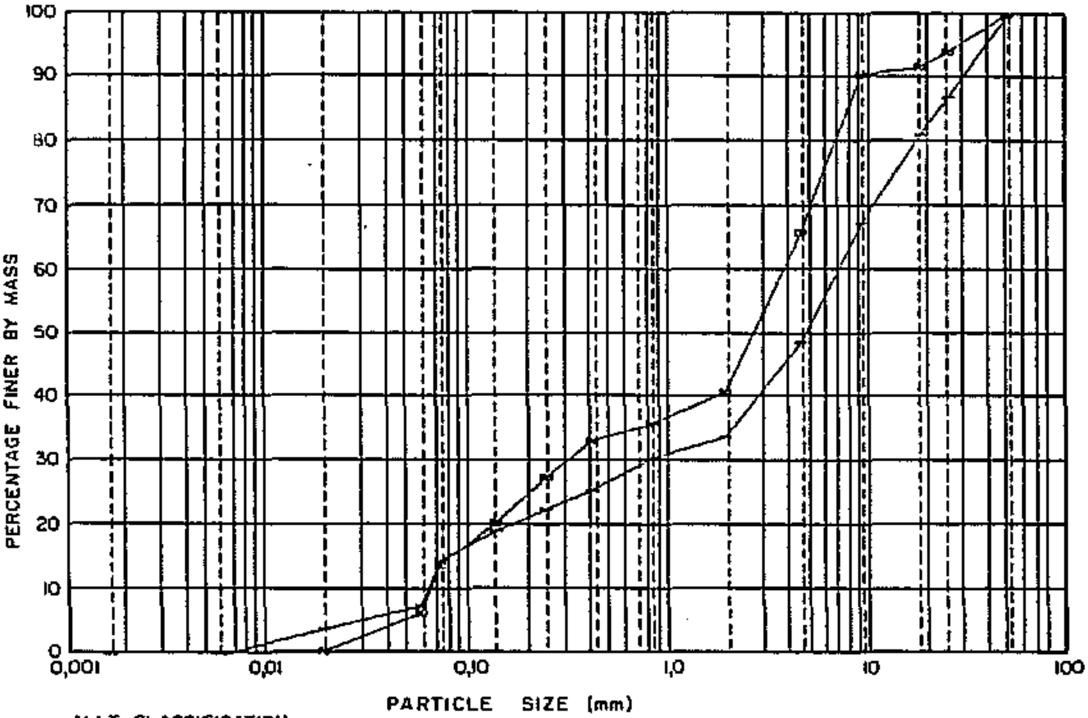
ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No				
HOLE No	H2	H2		
DEPTH	600mm	1200mm		
PLOTTING CODE	2	4		
LIQUID LIMIT	20	19		
PLASTIC LIMIT	14	11		
PLASTICITY INDEX	6	8		
LINEAR SHRINKAGE	2.5	2.5		
CLAY FRACTION (0,002mm)	2	1		
P.I. OF WHOLE SAMPLE	3	3		
GRADING MODULUS	1.80	1.98		
P.R.A. CLASSIFICATION	A-2-4	A-2-4		
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW 1<=<2	LOW =>2		

GEMLAB
(Reg No 75/03319/07)
No 3 Village Road
Selby, Johannesburg
Tel 835-9007/8

Client	Water Research Commission	Job No	6078/86
Project	Zuurbekom	Date	21.8.86
Reference	Len Abrahams	Technician	
Client Job No	CL 3346	Checked by	

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S.	M.F.S.	C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)						

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	—	—		
HOLE No	- 3	- 3		
DEPTH	200m	600m		
PLOTTING CODE	1	2		
LIQUID LIMIT	21	20		
PLASTIC LIMIT	14	12		
PLASTICITY INDEX	7	8		
LINEAR SHRINKAGE	4.0	2.0		
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE	2	3		
GRADING MODULUS	2.28	2.12		
P.R.A. CLASSIFICATION	A-2-4	A-2-4		
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW =<.5	LOW =<.5		
SETS	1	2		

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GEMLAB
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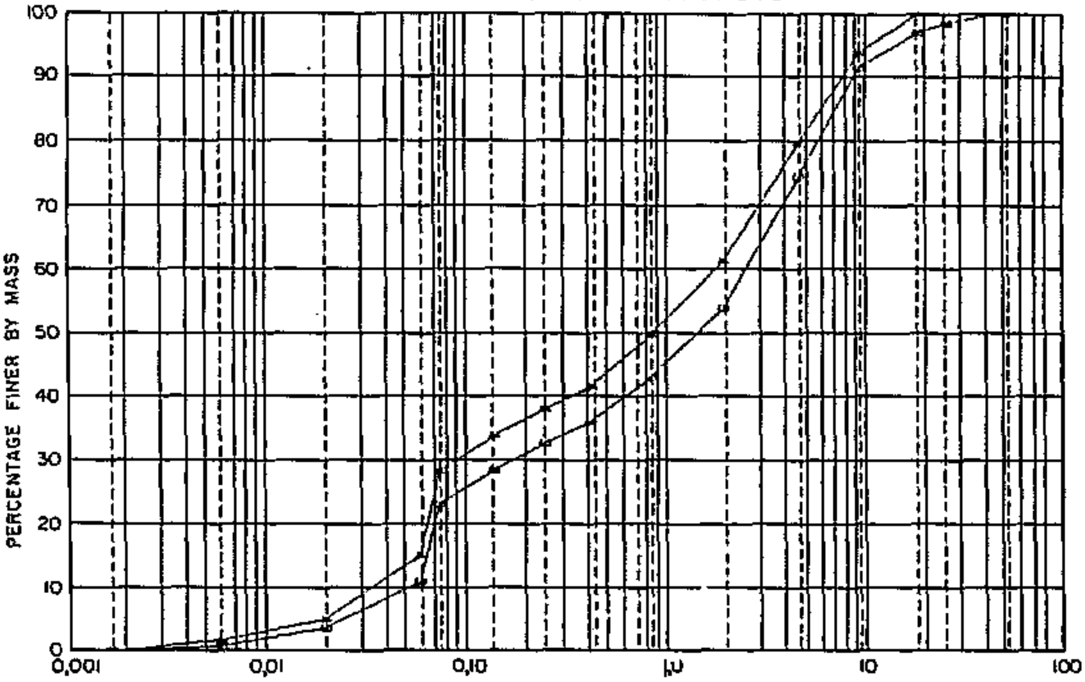
Project Zuurbekom — Date 21.6.86
Reference Len Abrahams — Technician
Client Job No C1 3346 — Checked by

PARTICLE SIZE ANALYSIS



M.I.T. CLASSIFICATION

Clay fraction	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse
	Silt fraction			Sand fraction			Gravel fraction		

ROADS CLASSIFICATION

Clay, colloids	Silt	F.F.S. M.F.S. C.F.S.	Coarse sand	Coarse aggregate
Soil fines (P.I., L.L., & L.S.)				

ATTERBERG LIMITS & SOILS CLASSIFICATION

SAMPLE No	—	—		
HOLE No	- 3	- 3		
DEPTH	1000m	1200m		
PLOTTING CODE	3	4		
LIQUID LIMIT	29	35		
PLASTIC LIMIT	19	27		
PLASTICITY INDEX	10	8		
LINEAR SHRINKAGE	2.5	4.0		
CLAY FRACTION (0,002mm)				
P.I. OF WHOLE SAMPLE	4	3		
GRADING MODULUS	1.88	1.70		
P.R.A. CLASSIFICATION	A-2-4	A-2-4		
U.S.C.S. CLASSIFICATION				
SOIL DESCRIPTION				
	LOW *<.5	LOW *<.5		
SETS	13	14		

ZUURBEKOM DRY DENSITIES

TUBE NO	DEPTH (mm)	DRY DENSITY (Kg/m^3)
2	200	1699
2	600	1644
2	1200	1729
2	1600	1799
3	200	1847
3	600	1381
3	1000	1469
3	1200	1058
5	200	1629
5	600	1790
5	1000	1917
5	1200	2318
6	200	1468
6	600	1765
6	1000	1860
6	1300	1854
7	200	1773
7	600	2080
7	1000	1795
7	1400	1279
8	200	1518
8	600	1507
8	1200	1579
8	1600	1544
9	200	1601
9	600	1673
9	1200	1373

ZUURBEKOM PERMEABILITIES

TUBE NO	DEPTH (mm)	PERMEABILITY (cm/sec)
2	1200	0.00226
3	600	0.00254
3	1200	0.00212
5	1200	0.00337
7	600	0.00238
7	1000	0.000105
7	1400	0.00272
8	200	0.000735
8	1200	0.000625

A P P E N D I X G

MOLOPO CATCHMENT

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LIST OF TABLES

LIST OF FIGURES

LIST OF DRAWINGS

LIST OF APPENDICES

MOLOPO CATCHMENT

1 REASONS FOR SELECTING THE CATCHMENT FOR STUDY

The Molopo Catchment is included in the recharge investigation because the underlying dolomitic aquifer is important to the Department of Water Affairs (DWA) as a ground water resource. Overflow from the Molopo Eye springs are utilised for municipal water supplies to Mafikeng and Mmabatho, in conjunction with borehole and spring supplies from the Grootfontein Groundwater Compartment.

Due to its importance for supply, the DWA has monitored water level and flow data for some years, which provides a background data base. The distance from Johannesburg precluded detailed soil process instrumentation, and work was limited to checking the hyraulic integrity of the dykes, water level, rainfall, evaporation and streamflow monitoring. The catchment would be used to check the recharge assessment methodology in an area of limited information.

2 GEOGRAPHICAL SETTING

The Molopo Eye, which is the main outflow for the Catchment, is situated 50 km north-east of Lichtenberg in the far Western Transvaal. Fig 1 shows the general locality. The Catchment may be located on the 1:250 000 topographical map 2526 Rustenburg, and the 1:50 000 2526 CC Bakerville and 2526 DD Rooigrond maps. The study area is predominantely proportioned among 6 topocadastral farms; Nooitgedacht 332 JP, Vlakplaats 835 JP, Honingklip 354 JP, Klipkuil 352 JP, Ruitelaagte 353 JP and Trekdrift 360 JP.

STEFFEN, ROBERTSON AND KIRSTEN

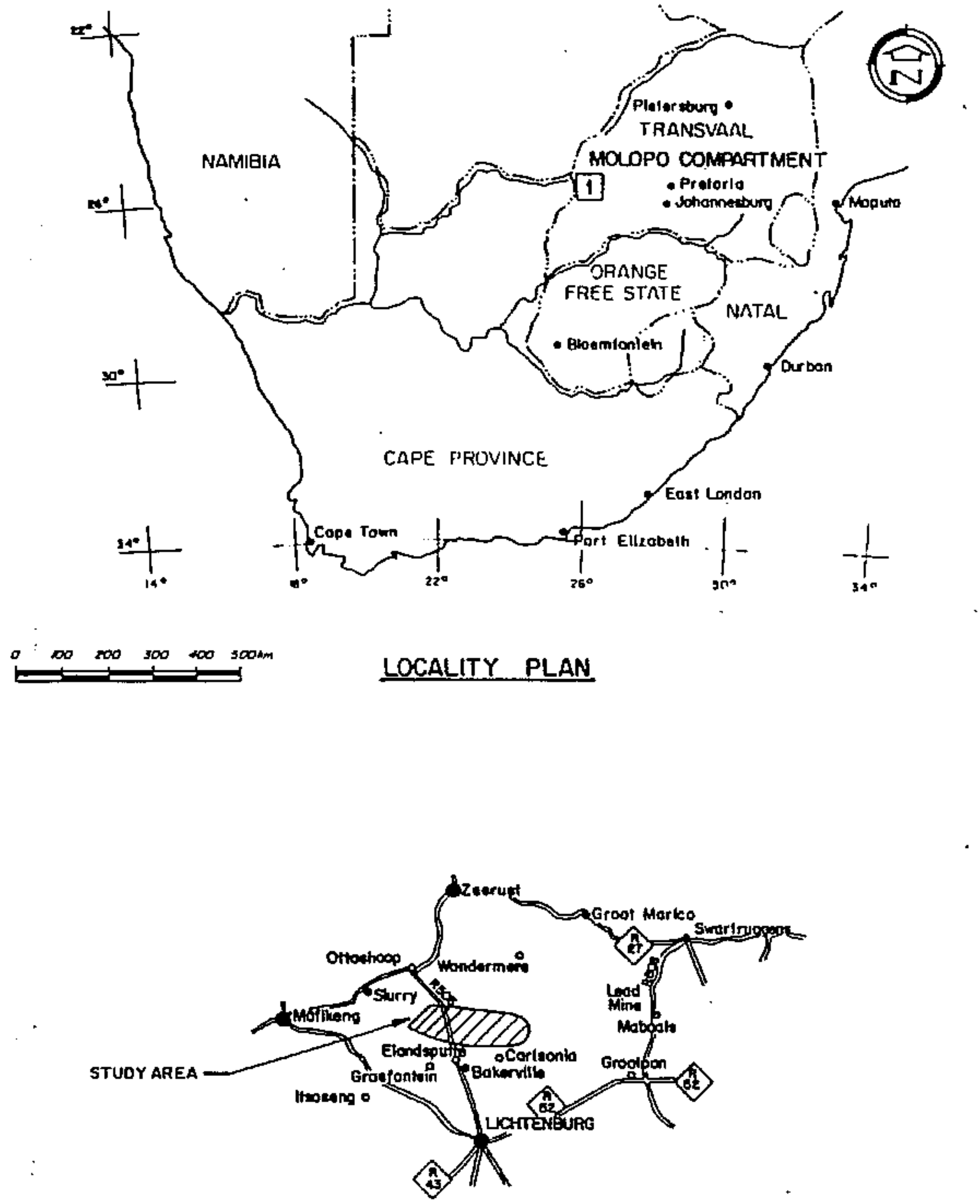

FIGURE NO.1 : MOLOPO CATCHMENT : GENERAL LOCALITY

Drawing 87-1735

3 REVIEW OF AVAILABLE HISTORICAL RECORDS

Generally very little historical information is available for the study area. The Molopo River and surrounds have received attention from the Department of Water Affairs (DWA) from as early as 1955. The Grootfontein Ground Water Compartment, located to the west of the Molopo Compartment, has been extensively studied by the DWA and various internal reports are summarised below.

Mulder (1968) reported that in 1955 and 1964, the Geological Survey and the DWA completed numerous geophysical surveys in the area. These surveys yielded very little information and therefore an aerial magnetic investigation was completed under contract for the Geological Survey. During 1967 a map was published showing the occurrence of various geological features. The evidence obtained from the aeromagnetic survey (Day, 1976) showed that the Grootfontein and Molopo Catchments are essentially separate ground water compartments. Airphoto interpretations and water table elevations were then used to confirm the positions of dykes.

The dykes which form the compartment boundaries are shown in CI3346/20. Hydrocenses carried out by the DWA since 1959 have revealed little information about the hydrogeology of the area. Additional boreholes were drilled by the DWA for inclusion into their regional monitoring network.

Generally, the upper Molopo River is dry. Following relatively high intensity rainfall events, flow does occur. This flow combines with the spring outflow at the Molopo Eye. The magnitude of the combined flows is measured at gauging stations. Streamflow data prior to 1985 are uncertain because of leakage at the gauging stations. The structure was subsequently repaired and the data for the period 1985 to the present appears to be acceptable. Only the latter data were used in this research.

Bredenkamp (1987) correlated the flow at the Molopo eye to derive estimates of recharge for the Catchment, based on spring flow records. Attempts to quantify recharge by means of chloride mass balance calculations proved unsuccessful because of the anomolously high chloride concentration in the rainwater samples.

4 CATCHMENT DESCRIPTION

4.1 Topography

The catchment is typically karstic and characteristically flat with an east-west and north-south gradient of 0,7% and 0,9% respectively. Dwg CI3346/20 shows the topographic details of the study area.

The topographic catchment boundaries cannot easily be ascertained from the map on account of the gentle slopes and wide contour interval. In contrast, the underlying aquifer is defined by the distribution of the enclosing dolerite dykes as shown on Dwg CI3346/20.

4.2 Available photography

Aerial photographs of the study area were obtained from the Division of Geohydrology. The relevant photographic details are:

Flight plan : 496/66
Job No : 754
Strip Nos : 9, photographs 1046 to 1055
10, photographs 514 to 523
11, photographs 01 to 07
Scale : 1/30 000
Date : March, 1975

4.3 Geology

Available geological information for the area is limited. However, geological mapping has been completed for the dolomitic terraine to the west of the Molopo Compartment. The survey shows that the farm Trekdrift 360JP, which is situated in the western corner of the compartment, is underlain by the Lyttleton Formation of the Chuniespoort Group. These Transvaal Supergroup rocks comprise dolomite with chert layers. The SRK drilling investigation also recorded chert formations in borehole G35567 in the central-northern section of the catchment on the farm Vlakplaats 335JP. It can be inferred that the study area is essentially underlain by the Lyttleton Formation, and that the stratigraphically higher Eccles Formation may occur, particularly in the east. The Lyttleton Formation has minor amounts of chert in comparison to the Eccles Formation. Additional geological information was derived from the drilling investigation carried out during the project (refer to chapter 6 for detailed information, Appendix E 3 for the geological logs and Fig 2 for the positioning of these formations within the regional stratigraphic record according to Van Rensburg, 1985).

The site investigation showed that the areas drilled were predominantly underlain by fresh dolomite found at depths varying from 10 metres to 57 metres below surface. The dolomite weathers towards the surface and in some cases, wad and chert bands occur. A number of dolerite intrusions were identified by Day (1976), predominantly orientated NE-SW, NW-SE, and E-W. These features often intersect to effectively divide the dolomite into separate ground water compartments.

STEFFEN, ROBERTSON AND KIRSTEN

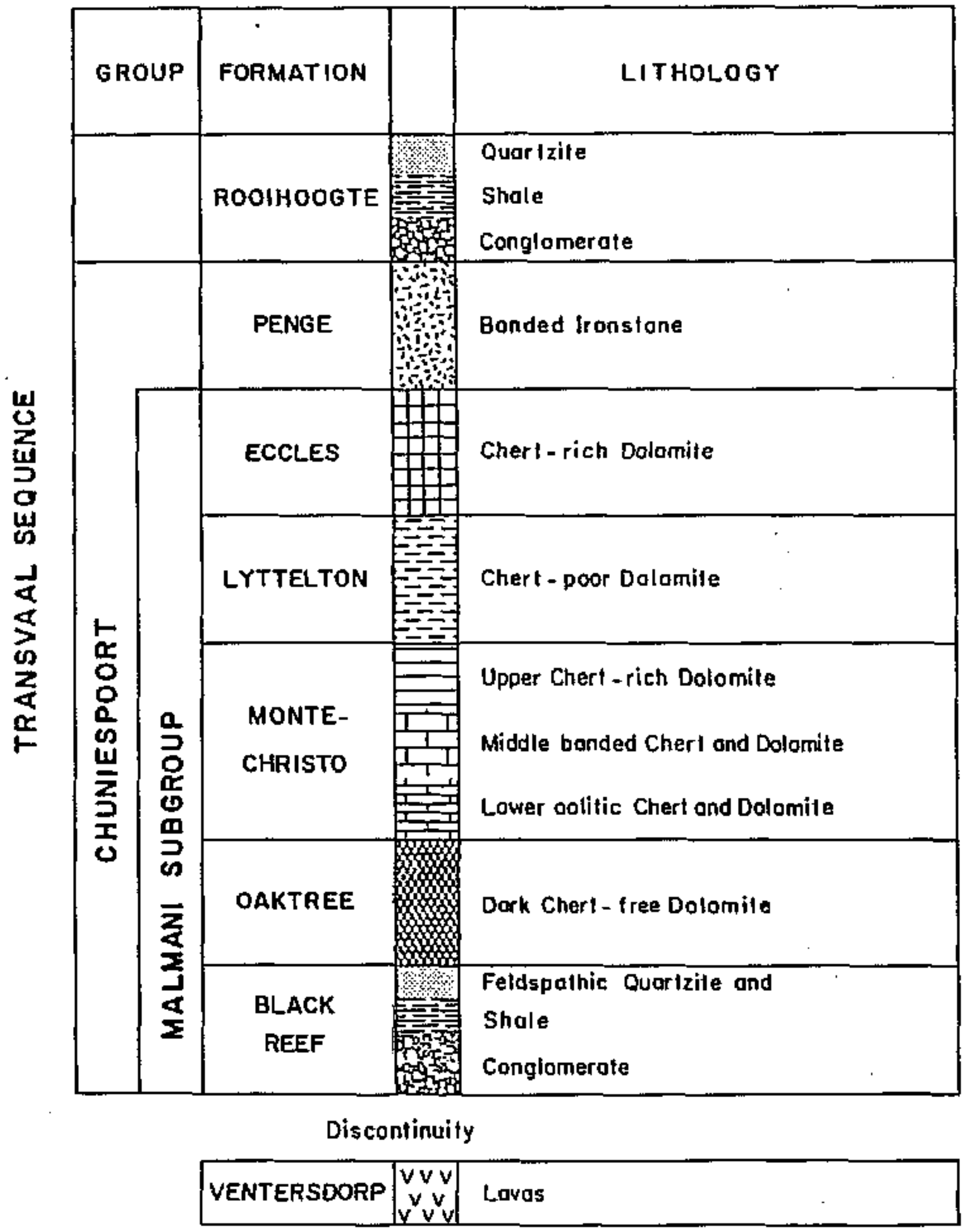

FIGURE NO.2 : LITHOSTRATIGRAPHY OF THE DOLOMITE IN THE FAR WESTERN TRANSVAAL

4.4 Soil type

General soil information was obtained from the 1:250 000 land type series map 2526 Rustenburg. This information was checked during drilling operations in 1984. The Catchment is covered by a thin to non-existant soil layer of Glenrosa and/or Mispah forms. Weathering profiles are generally less than 4 m deep, but some weathered profiles of up to 15 m were recorded at boreholes sites C35564 and G35564 A. These anomolously deep areas of weathering are the result of the ground water concentrations and associated solution weathering adjacent to dyke features.

4.5 Hydrology

The combination of relatively flat topographic gradients and soils of high infiltration capacity ensure that little or no runoff occurs in the Catchment. Streamflow only results as a consequence of above average intensity and duration rainfall events. The only river course of any significance is the so called "Dry Molopo River" which crosses the western corner of the catchment before flowing west into the Molopo River. Fig 3 shows the study area in relation to the regional drainage system. The Molopo Catchment exhibits little or no surface drainage features of any significance. The spring at the Molopo Eye, flows continuously, and the DWA records the flow. The records for two stations, D4M14A and D4M14D, for the period December 1981 to May 1987 are shown in Appendix E 2. Only the first 5 days of each month are given.

LEGEND

DRAINAGE BOUNDARIES

MAIN

SUB

SMALL

OTHER

STUDY AREA

RIVERS

FIGURE NO. 3 : REGIONAL DRAINAGE NETWORKS OF THE DOLOMITE IN THE FAR WESTERN TRANSVAAL

Drawn 87-1735

4.6 Hydrogeology

4.6.1 Introduction

There is a general dearth of information concerning the hydrogeological characteristics of the study area. Hydrocenses carried out by the DWA yield very little information because of the scarsity of boreholes.

4.6.2 Ground water flow

It is thought that the ground water flow in the Molopo Catchment is impeded by impermeable or poorly permeable surrounding formations, and by the dykes which cut through the dolomite as vertical or steeply inclined barriers of low permeability. The dykes therefore divide the dolomite formation into separate compartments.

On a regional basis, ground water flow is determined by topographic gradients, and where these waters intersect local dyke features, flow is diverted parallel to the dyke. When ground water flow reaches the lowest topographic point, the water may overflow the dyke in the form of a spring.

Basically, four dolerite dykes form a rhombohedrally shaped ground water compartment, with the Molopo Eye as the most significant local base level and consequently, the major spring overflow area (Dwg CI3346/20).

Historical ground water level data from selected boreholes were obtained from the DWA. Records for the following boreholes were examined from 1977 onwards:

- Within the compartment, River Catchment No D4N, borehole nos 129, 139, 141, 142, 143, 145 and 147.

- Outside the compartment, River Catchment No D4N, borehole nos. 126, 127, 128, 130, 140, 146, 148 and River Catchment No A3N, borehole nos 008 and 009.

Following the completion of the SRK drilling investigation, additional water level data were collected and analysed from the following boreholes:

- Within the compartment, borehole nos G35563/63A, G35565/65A, G35567, G35568, G35569 and G35570.

- Outside the compartment, borehole nos G35564/64A, G35566 and G35566A.

Ground water level data were contoured on a monthly basis, for the period January 1985 to March 1987. The hydraulic gradient is generally very flat in a northwesterly direction across the catchment, surfacing against the northwestern dyke boundary at the Molopo Eye. Furthermore, these data show that the dolerite dyke which trends approximately north-east/south-west through the middle of the compartment, effectively forms a ground water barrier, such that the compartment may be divided into two hydraulically dissimiliar areas. In the western subcompartment, the flow is towards the western and southern sections. In the adjacent eastern subcompartment, flow is towards the east.
The eastern and western subcompartments cover an area of about 40 and 70 square kilometres, respectively.

Historical water level information (Appendix E 1) shows that water table elevations have generally declined. Between 1985 and 1986, water levels have dropped by in the range 1m to 2m. This may be attributed to the drought conditions experienced in the far Western Transvaal.

No ground water abstraction of any significance has been recorded for the Molopo Catchment.

4.6.3 Aquifer definition and characteristics

No information is available on the various aquifers of the Molopo Catchment, except for the records of the drilling investigation conducted by SRK. The geological logs are presented in Appendix E 3.

Dolomite rock is generally impermeable but the rock mass can be highly transmissive due to the jointing and development of solution features. If a borehole fails to intersect an interconnected fissure it will be either dry or the borehole will be emptied after a brief period of pumping. Only one of the 12 boreholes drilled by SRK intersected a small cavity, to provide an airlift yield of 11 m^3/hr. The remaining boreholes were, for all practical purposes, dry, though most of the holes were drilled in specific target areas which were not potentially good yielding sites. High yielding boreholes are documented for areas close to the Molopo Compartment, and Dr Mulder of the DWA has noted that much of the spring discharge from the catchment disappears into cavernous dolomite terraine a few kilometers from the Molopo Eye on the farm Witkoppies 110JQ.

Work done by Dr Bredenkamp (1987) indicates that a relative strong correlation exists between inferred recharge and spring flow for the study area. Furthermore, Dr Bredenkamp concludes that the very little of the annual precipitation goes to recharging the aquifer deficit. This may mean that the aquifer storage is full, and that the spring flows represent overflow. Even during periods of drought, because the base level of the aquifer is equivalent to the topographic elevation of the Molopo Eye, the reduction in flow would not mean that aquifer storage is depleted. The high yields of the Molopo Eye further suggest that hydraulic connectivity in the aquifer is fairly well developed, and that weathered and cavernous conditions must exist.

If it is assumed that karstic development has taken place, then three aquifer zones are likely to occur. These zones have been defined by dolomite investigations conducted by SRK in the West Rand area. The zones are as follows:

- zone 1 extends from the surface down to the limit of aggressive solution weathering. The depth of this interval will depend on the composition of the host dolomite. Solution cavities and other voids have been widened by circulating ground waters.

- zone 2 extends from the base of zone 1 to the limit of karstic development in the dolomite. Ground waters circulated through fracture regimes which exhibit lower degrees of weathering.

- zone 3 comprises unweathered, relatively impermeable host rock.

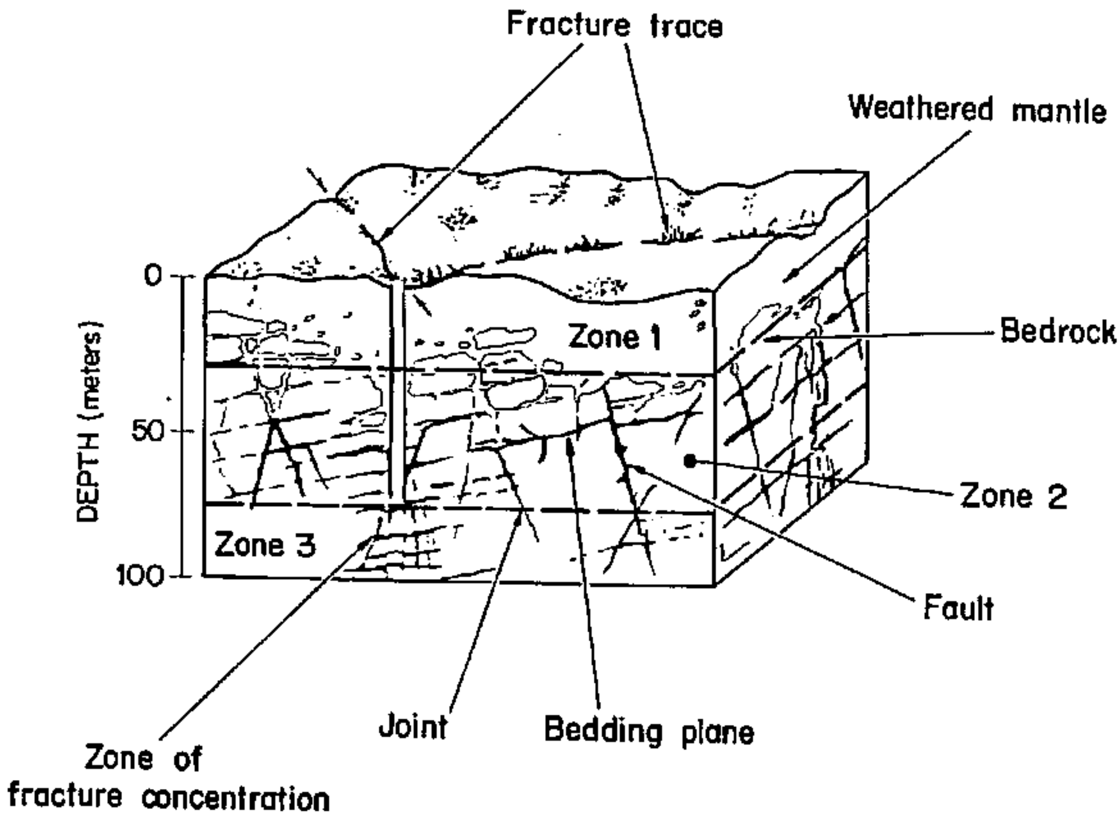

Fig. 4 : TYPICAL AQUIFER DEVELOPMENT IN DOLOMITE TERRAINE

The probable aquifer development described above is diagrammatical presented in Fig 4.

To date, no values for the aquifer characteristics inside the Molopo Compartment have been derived from scientifically conducted pump tests.

Work carried out by Cogho for Grootfontein (1980) gives T-values between 11 000 m2/day and 23 000 m2/day. The T-values close to dykes were as low as 16 m2/day. The tremendous variation on values can be ascribed to the heterogeneity and anisotropic nature of dolomite terraine.

Van Rensburg (1985) derived S-values of between 0,003 and 0,066 using recharge values varying from 1% to 20% of the annual precipitation. The method utilised the following simplified equation:

$$S = \frac{\text{annual recharge (mm)}}{\text{rise in ground water levels due to recharge (mm)}}$$

38 observation boreholes were used covering the entire Grootfontein Ground Water Compartment. It must be noted that the S-values are approximations only because the quantity of ground water abstracted from the compartment was insufficiently quantified, at that stage.

The Division of Geohydrology conducted pump-tests at Slurry (van Rensburg, 1987). Transmissivities (T) were shown to vary between 1479 m2/day and 2218 m2/day and storage coefficients (S) of 10^{-3} to 10^{-5} were obtained. The relatively high transmissivities and low storage coefficients suggest that the dolomitic aquifer is anisotropic, heterogenous and semi-confined to confined.

Historical data suggests that the transmissivities in the Molopo Compartment may vary between $1m^2$/day and 25 $00m^2$/day, depending on the locality and degree of weathering of the dolomite.

The S-values reported by van Rensburg (1987) are at the lower range of the values obtained from the pump-tests completed at Slurry during 1985 (ie 10^{-3}).

It was noted that the storativity parameter decreased from 10^{-3} to 10^{-5}, from west to east across the Grootfontein Ground Water Compartment; (ie towards the Molopo Catchment). Therefore, historical indications are that S-values should range from 10^{-4} to 10^{-5}.

4.7 Climate

Long term weather characteristics have been recorded at stations located near Slurry and Mafeking. Shorter term measurements were obtained from the weather station set-up by SRK for the investigation. These short term records, from January 1985 to March 1987, were primarily used for water budget assessment for the given period.

The area experiences warm summers with an average diurnal temperature variation between 16°C and 30°C as measured at Mafeking.

During the winter months, the average maximum daily temperature was 19,7°C, while the average minimum temperature was 2,2°C.

Evaporation is very high because of the warm, dry climate. The maximum evaporation rate is 1,67m per year as determined from pan evaporation figures given by the DWA (Bredenkamp and van Rensburg, 1983).

Rainfall occurs primarily during the summer months in the form of thunderstorms. The average yearly rainfall is 560mm. Rainfall data was obtained from the Slurry weather station no. 0508 649 3. Because of seasonal fluctuations and alternating dry and wet years, the monthly and yearly rainfall figures may vary considerable.

4.8 Land use

The Molopo Catchment has remained unaffected by agriculture practises. Little or no irrigation has been documented or observed in recent years. Because the catchment is generally covered by grasslands, stock farming predominates. The springs at the Molopo Eye are utilised for domestic water supply, for locals and the Holiday Resorts.

5 CATCHMENT INSTRUMENTATION

5.1 Meteorological instrumentation

Historically, the nearest weather station to the Molopo Catchment is located at Lichtenberg and therefore it was proposed that two weather stations be established in or near the study area. Following discussions with the Department of Agriculture, it was decided that only one weather station was required because of the small variability of meteorological conditions in the area. The Fanie Labuschagne Pleasure Resort at the Molopo Eye was identified as a suitable site. A weather station was erected in November 1984 and the manager of the resort undertook to change the various charts.

The instrumentation consisted of:

- A Meteorograph which records temperature, humidity and pressure on a monthly chart.
- A Pyranometer for measuring incoming solar radiation.
- A Raingauge with a weekly chart recorder
- An A-pan with a chart recorder was used to monitor evaporation
- Wind Monitor with recorder

5.2 Ground water instrumentation

5.2.1 Introduction

The Molopo Catchment forms an integral part of the DWA's regional ground water level monitoring programme. Approximately 7 boreholes are monitored monthly as shown in Table 1. One of the objectives of the drilling programme undertaken during 1984, was to extend the monitoring network to improve the definition of the ground water table within the catchment. Furthermore, water table information was deemed necessary to determine possible leakage into or out of the compartment. To achieve these objectives, boreholes were drilled at 5 sites, as shown on Dwg CI3346/20.

5.2.2 Selection of suitable boreholes for continuous monitoring

It was decided to install autographic water level recorders in four boreholes; G35565A, G35566, G35569 and G35570.

Boreholes G35565A and G35566 are centrally located on opposite sides of the dyke which forms the northern boundary of the Molopo Ground Water Compartment. Continuous monitoring of borehole G35569 was undertaken for the purpose of obtaining ground water level information in the central part of the study area. Because of the scarcity of monitoring sites in the eastern area of the catchment, borehole G35570 was selected for continuous monitoring. The recorders were installed in December 1984.

6 MONITORING AND DATA AQUISITION

6.1 Regular Monitoring

6.1.1 Meteorological instrumentation

The wind, meteorograph, radiation and evaporation pan recorder charts were changed monthly and the rainfall charts were changed weekly. Numerous problems were experienced with the data recording. Rainfall and evaporation records are presented in Appendix E 4.

6.1.2 Ground water level instrumentation

A local farmer was contracted by SRK to maintain and monitor the SRK observation network on a monthly basis. (Table 1, boreholes G35563 to G35570).

TABLE 1: BOREHOLE MONITORING NETWORK

Boreholes Inside The Malopo Compartment		Boreholes Outside The Molopo Compartment		Farm Name and Number		Instrumentation	Monitoring Method	Monitoring Frequency
SRK BHS	DWA BHS	SRK BHS	DWA BHS					
G35563				Honingklip	354JP	Open borehole	Manual probe	Monthly
G35563A				Honingklip	354JP	Open borehole	Manual probe	Monthly
		G35564		Honingklip	354JP	Open borehole	Manual probe	Monthly
		G35564A		Honingklip	354JP	Open borehole	Manual probe	Monthly
G35565				Uitgevonden	355JP	Recorder	Manual probe	Monthly
G35565A				Vlakplaats	335JP	Recorder	Autographic	Continuous
		G35566			335JP	Open borehole	Autographic	Continuous
		G35566A			335JP	Open borehole	Autographic	Monthly
G35567					335JP	Open borehole	Autographic	Monthly
G35568				Klipkuil	352JP	Recorder	Autographic	Monthly
G35569				Honingklip	354JP	Recorder	Autographic	Continuous
G35570				Klipkuil	352JP	Open borehole	Autographic	Continuous
	DWN 129			Vaalkopje	111JQ	Open borehole	Autographic	Monthly
	DWN 139			Uitgevonden	355JP	Open borehole	Autographic	Monthly
	DWN 141			Ruigtelaagte	353JP	Open borehole	Autogaphic	Monthly
	DWN 142			Klipkuil	352JP	Recorder	Autographic	Monthly
	DWN 143			Wonderfontein	336JP	Open borehole	Autographic	Continuous
	DWN 145			Trekdrift	360JP	Open borehole	Autographic	Monthly
	DWN 147			Mallepoosoog	332JKP	Recorder	Autographic	Monthly
			DWN 126	Elizabeth	357JO	Open borehole	Autographic	Continuous
			DWN 127	Elizabeth	357JO	Open borehole	Autographic	Monthly
			DWN 128	Vaalkopje	111JQ	Open borehole	Autographic	Monthly
			DWN 130	Vaalkopje	111JQ	Open borehole	Autographic	Monthly
			DWN 146	Trekdrift	360JP	Open borehole	Autographic	Monthly
			DWN 148	Mallepoosoog	332JP	Open borehole	Autographic	Monthly
			DWN 140	Uitgevonden	355JP	Open borehole	Autographic	Monthly
			A3N 008	Wonderfontein	336JP	Open borehole	Autographic	Monthly
			A3N 009	Wonderfontein	336JP	Open borehole	Autographic	Monthly

6.2 Specific testing

The drilling investigation showed that soils in the catchment are rarely developed to any substantial thickness. Generally the soils are poorly developed and of a limited extent. Exceptions are a few locations where weathering has taken place because of structural weakness in the underlying rock. Boreholes drilled adjacent to dykes intersected weathered material down to depths of approximately 15m.

The catchment received low priority status in the overall investigation and therefore additional soil surveys and studies of soil hydraulic characteristics were not done. This was deliberate to see if recharge methodology developed, could be used to obtain reasonable answers in areas where this information was lacking.

6.3 Drilling programme

The drilling of twelve boreholes commenced in September 1984 at four localities to extend the existing monitoring network and improve the definition of the piezometric surface in areas where little or no information was available.

To assess the possibility of leakage through the compartment forming dykes, boreholes were drilled on either side of these hydraulic barriers at various localities. The SRK investigation concentrated on the northern and southern compartment boundaries. Boreholes G3556A, G35566, G35565 and G35565A were drilled across the central, northern compartment dyke. Similarly, in the south, on the farm Honingklip 354JP, boreholes G35563, G35564 and G35564A were completed for monitoring purposes. Dwg CI3346/20 shows the relevant borehole positions.

The positions of the boreholes are given on Dwg CI3346/20. Detailed Geological Logs are attached in Appendix E 3.

Sampling

Boreholes were, in general, dry during drilling. The few water strikes observed are recorded on the logs.

Generally, water seeped slowly into the boreholes after drilling. Water levels in the boreholes were monitored on various days after completion to identify local water tables.

Chip samples were collected for every metre drilled, and then bagged. Where the chips were very similar, samples were only bagged over every 5 m intervals. Samples were geologically logged in the field.

Details of drilling

Two boreholes, G35563 and G35563A were completed at site 1 to depths of 82m. Borehole G35563 was used for monitoring. The other borehole was abandoned and closed as no residual water level was recorded.

Boreholes G35564 and G35564A were completed to depths of 76 m and 58 m respectively. Borehole G35564 exhibited a higher ground water level and therefore this borehole was selected for monitoring. The other borehole was suspected to be too close to the dyke. This borehole was abandoned and closed.

Borehole G35568 was completed in the road reserve next to the farm Klipspruit. An additional borehole G35570 was drilled about 150 m south of the first position. Both boreholes were drilled to 64 m.

Five boreholes were drilled on the farm Vlakplaats 335JP. Borehole G35565 was drilled to a depth of 88 m. Boreholes G35565A, G35566, G35566A and G35567 were all drilled to 32 m. The addition drilling was necessary to obtain one reasonable monitoring borehole.

Boreholes G35565A, G35566 and G35567 were incorporated into the monitoring network, while boreholes G35565A and G35566A were abandoned and closed.

Borehole G35569 on the farm Honingklip 354JP and just off the main road from Lichtenburg to Zeerust, was drilled to a depth of 64 m. A cavity was intersected at 58 m, whereafter no sample recovery was possible. After standing for two days, an airlift yield of about 12 m^2/hour was obtained from 40 m below surface.

7 RECHARGE ESTIMATES

7.1 Methodology

Two approaches were used to estimate recharge to the Molopo Compartment. A water balance simulation was completed using PC-MINE to estimate direct recharge. Potential recharge was evaluated using ACRUWAT. Both of these models and their application for recharge estimation are discussed in Chapter 10 of the main report.

7.2 Results

Direct recharge to the ground water regime is estimated to be 20% of the annual rainfall. Potential recharge values of 8% and 6% were obtained for simulations using Mispah and Glenrosa soils respectively. The discrepancy between these values may be attributable to rapid, direct recharge through outcrop and shallow sub outcrop areas which are not included in the potential recharge estimations

ACKNOWLEDGEMENTS

SRK wishes to acknowledge the excellent and prompt co-operation received from the DWA, Division of Geohydrology. In particular we would like to record the help received from Dr Bredenkamp in all matters. Mr J Coetzer helped in retrieving historical records, and the driller Mr Scheepers was always willing to co-operate.

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APPENDIX G 1

HISTORICAL GROUND WATER LEVEL DATA

MOLOPO CATCHMENT GROUNDWATER LEVELS AUGUST 1985

2980	10770	24.67	0	D4N127	
1280	11160	23.255	0	D4N126	
1000	12220	5.938	0	D4N128	
1250	13380	12.968	0	D4N129	
1180	13240	13.776	0	D4N130	
2760	14690	8.631	0	D4N146	
3150	14340	13.992	0	D4N145	
3800	15350	37.002	0	D4N148	
4330	14300	20.162	0	D4N147	
4220	12230	27.662	0	D4N676	G35563
4190	12190	17.302	0	D4N677	G35564
5740	15460	34.502	0	D4N679	G35566
5730	15420	36.468	0	D4N678	G35565
5740	15360	68.336	0		G35565A
5920	15140	26.958	0	D4N680	G35567
4880	12930	24.502	0	D4N681	G35569
5320	11810	26.234	0	D4N139	
5710	10690	23.416	0	D4N140	
7400	11440	12.849	0	D4N141	
8770	16330	37.488	0	A3N009	
8620	14860	22.959	0	A3N008	
8410	14480	42.048	0	D4N143	
8970	14090	23.386	0	D4N142	
9540	12030	28.214	0	C2N545	G35568
9570	11950	20.869	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS OCTOBER 1985

2980	10770		0	D4N1?	
1280	11160	24.474	0	D4N12?	
1000	12220	5.989	0	D4N128	
1250	13380	13.142	0	D4N129	
1180	13240	13.921	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.687	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.078	0	D4N145	
3800	15350	37.179	0	D4N148	
4330	14300	20.097	0	D4N147	
4230	12280		0		G35563A
4220	12230	27.942	0	D4N676	G35563
4190	12190	17.849	0	D4N677	G35564
4170	12150	18.162	0		G35564A
5750	15530	22.618	0		G35566A
5740	15460	29.392	0	D4N679	G35566
5730	15420	46.532	0	D4N678	G35565
5740	15360	65.876	0		G35565A
5920	15140	32.012	0	D4N680	G35567
4880	12930	25.621	0	D4N681	G35569
5320	11810	26.278	0	D4N139	
5710	10690	23.637	0	D4N140	
7400	11440	12.927	0	D4N141	
8150	16320		0	[illegible]	
8770	16330	37.931	0	A3N009	
8620	14860	23.076	0	A3N008	
8410	14480	42	0	D4N143	
8970	14090	23.457	0	D4N142	
9540	12030	28.292	0	C2N545	G355??
9570	11950	24.245	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS NOVEMBER 1985

2980	10770		0	D4N127	
1280	11160	24.615	0	D4N126	
1000	12220	6.124	0	D4N128	
1250	13380	13.451	0	D4N129	
1180	13240	14.126	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.709	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.121	0	D4N145	
3800	15350	37.248	0	D4N148	
4330	14300	20.142	0	D4N147	
4230	12280		0		G35563A
4220	12230	27.892	0	D4N676	G35563
4190	12190	17.814	0	D4N677	G35564
4170	12150	18.016	0		G35564A
5750	15530	22.781	0		G35566A
5740	15460	29.314	0	D4N679	G35566
5730	15420	46.592	0	D4N678	G35565
5740	15360	67.652	0		G35565A
5920	15140	32.241	0	D4N680	G35567
4880	12930	24.612	0	D4N681	G35569
5320	11810	26.521	0	D4N139	
5710	10690	23.912	0	D4N140	
7400	11440	12.107	0	D4N141	
8150	16320		0	D4N144	
8770	16330	38.21	0	A3N009	
8620	14860	23.571	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.891	0	D4N142	
9540	12030	28.331	0	C2N545	G35568
9570	11950	24.31	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS DECEMBER 1985

2980	10770		0	D4N127	
1280	11160	24.746	0	D4N126	
1000	12220	6.321	0	D4N128	
1250	13380	13.21	0	D4N129	
1180	13240	13.982	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.581	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.016	0	D4N145	
3800	15350	37.096	0	D4N148	
4330	14300	20.061	0	D4N147	
4230	12280		0		G35563A
4220	12230	27.418	0	D4N676	G35563
4190	12190	17.412	0	D4N677	G35564
4170	12150	17.921	0		G35564A
5750	15530	22.845	0		G35566A
5740	15460	29.746	0	D4N679	G35566
5730	15420	41.846	0	D4N678	G35565
5740	15360	58.801	0		G35565A
5920	15140	32.049	0	D4N680	G35567
4880	12930	24.628	0	D4N681	G35569
5320	11810	26.321	0	D4N139	
5710	10690	23.712	0	D4N140	
7400	11440	12.981	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.162	0	A3N009	
8620	14860	23.201	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.521	0	D4N142	
9540	12030	28.379	0	C2N545	G35568
9570	11950	24.342	0	E7N84A	B1?3?0

MOLOPO CATCHMENT GROUNDWATER LEVELS JANUARY 1986

2980	10770		0	D4N127	
1280	11160	24.886	0	D4N126	
1000	12220	6.458	0	D4N128	
1250	13380	13.121	0	D4N129	
1180	13240	14.296	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.604	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.036	0	D4N145	
3800	15350	37.143	0	D4N148	
4330	14300	20.162	0	D4N147	
4230	12280		0		G35563A
4220	12230	27.327	0	D4N676	G35563
4190	12190	17.364	0	D4N677	G35564
4170	12150	17.846	0		G35564A
5750	15530	22.491	0		G35566A
5740	15460	29.148	0	D4N679	G35566
5730	15420	41.439	0	D4N678	G35565
5740	15360	56.624	0		G35565A
5920	15140	32.162	0	D4N680	G35567
4880	12930	24.646	0	D4N681	G35569
5320	11810	26.558	0	D4N139	
5710	10690	23.264	0	D4N140	
7400	11440	13.006	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.614	0	A3N009	
8620	14860	23.246	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.558	0	D4N142	
9540	12030	28.391	0	C2N545	G35568
9570	11950	24.387	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS FEBRUARY 1995

2980	10770		0	D4N127	
1280	11160	25.062	0	D4N126	
1000	12220	6.647	0	D4N128	
1250	13380	13.043	0	D4N129	
1180	13240	14.187	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.689	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.057	0	D4N145	
3800	15350	37.024	0	D4N148	
4330	14300	20.036	0	D4N147	
4230	12280		0		G35563A
4220	12230	27.426	0	D4N676	G35563
4190	12190	17.619	0	D4N677	G35564
4170	12150	17.992	0		G35564A
5750	15530	22.486	0		G35566A
5740	15460	28.962	0	D4N679	G35566
5730	15420	41.666	0	D4N678	G35565
5740	15360	53.5	0		G35565A
5920	15140	32.078	0	D4N680	G35567
4880	12930	24.806	0	D4N681	G35567
5320	11810	26.598	0	D4N139	
5710	10690	23.871	0	D4N140	
7400	11440	13.068	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.912	0	A3N009	
8620	14860	23.481	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.682	0	D4N142	
9540	12030	28.466	0	C2N545	G35569
9570	11950	24.418	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS MARCH 1986

2980	10770		0	D4N127	
1280	11160	25.232	0	D4N126	
1000	12220	6.762	0	D4N128	
1250	13380	13.162	0	D4N129	
1180	13240	14.271	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.672	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.129	0	D4N145	
3800	15350	37.269	0	D4N148	
4330	14300	20.142	0	D4N147	
4230	12280		0		G35563A
4220	12230	27.218	0	D4N676	G35563
4190	12190	17.432	0	D4N677	G35564
4170	12150	17.521	0		G35564A
5750	15530	22.321	0		G35566A
5740	15460	26.204	0	D4N679	G35566
5730	15420	40.924	0	D4N678	G35565
5740	15360	51.084	0		G35565A
5920	15140	29.987	0	D4N680	G35567
4880	12930	24.7	0	D4N681	G35569
5320	11810	26.718	0	D4N139	
5710	10690	23.072	0	D4N140	
7400	11440	13.11	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.614	0	A3N009	
8620	14860	23.392	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.619	0	D4N142	
9540	12030	28.592	0	C2N545	G35568
9570	11950	24.457	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS APRIL 1986

2980	10770		0	D4N127	
1280	11160	20.449	0	D4N126	
1000	12220	6.943	0	D4N128	
1250	13380	13.391	0	D4N129	
1180	13240	14.423	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.743	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.116	0	D4N145	
3800	15350	37.962	0	D4N148	
4330	14300	20.168	0	D4N147	
4230	12280		0		G35563A
4220	12230	28.109	0	D4N676	G35563
4190	12190	22.392	0	D4N677	G35564
4170	12150	23.035	0		G35564A
5750	15530	22.686	0		G35566A
5740	15460	28.982	0	D4N679	G35566
5730	15420	41.649	0	D4N678	G35565
5740	15360	45.294	0		G35565A
5920	15140	32.124	0	D4N680	G35567
4880	12930	24.716	0	D4N681	G35567
5320	11810	26.691	0	D4N139	
5710	10690	23.906	0	D4N140	
7400	11440	13.189	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.823	0	A3N009	
8620	14860	23.407	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.71	0	D4N142	
9540	12030	28.646	0	C2N545	G35569
9570	11950	24.496	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS MAY 1986

2980	10770		0	D4N127	
1280	11160	20.528	0	D4N126	
1000	12220	7.069	0	D4N128	
1250	13380	13.431	0	D4N129	
1180	13240	14.592	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.769	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.196	0	D4N145	
3800	15350	37.984	0	D4N148	
4330	14300	20.187	0	D4N147	
4230	12280		0		G35563A
4220	12230	28.342	0	D4N676	G35563
4190	12190	22.617	0	D4N677	G35564
4170	12150	23.467	0		G35564A
5750	15530	22.914	0		G35566A
5740	15460	29.164	0	D4N679	G35566
5730	15420	41.672	0	D4N678	G35565
5740	15360	49.528	0		G35565A
5920	15140	32.148	0	D4N680	G35567
4880	12930	24.746	0	D4N681	G35569
5320	11810	26.931	0	D4N139	
5710	10690	23.948	0	D4N140	
7400	11440	13.198	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.613	0	A3N009	
8620	14860	23.439	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.708	0	D4N142	
9540	12030	28.638	0	C2N545	G35568
9570	11950	24.533	0	C2N546	G35570

MOLOFO CATCHMENT GROUNDWATER LEVELS JUNE 1986

2980	10770		0	D4N127	
1280	11160	25.832	0	D4N126	
1000	12220	7.169	0	D4N128	
1250	13380	13.312	0	D4N129	
1180	13240	14.426	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.784	0	D4N146	
2990	14560		0	D4N004	
[illegible]50	14340	14.136	0	D4N145	
[illegible]	15350	38.832	0	D4N148	
4330	14300	20.203	0	D4N147	
4230	12280		0		G35563A
4220	12230	28.571	0	D4N676	G35563
4190	12190	22.924	0	D4N677	G35564
4170	12150	23.581	0		G35564A
5750	15530	22.994	0		G35566A
5740	15460	24.489	0	D4N677	G35566
5730	15420	36.694	0	D4N678	G35565
5740	15360	43.682	0		G35565A
5920	15140	32.182	0	D4N680	G35567
4880	12930	20	0	D4N681	G35569
5320	11810	26.714	0	D4N139	
5710	10690	23.096	0	D4N140	
7400	11440	13.207	0	D4N141	
8150	16320		0	D4N144	
8770	16330		0	A3N009	
8620	14860		0	A3N008	
8410	14480		0	D4N143	
8970	14090		0	D4N142	
9540	12030	28.869	0	C2N545	G35568
9570	11950	24.618	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER JULY 1986

2980	10770		0	D4N127	
1280	11160	26.019	0	D4N126	
1000	12220	7.71	0	D4N128	
1250	13380	13.476	0	D4N129	
1180	13240	14.493	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.814	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.219	0	D4N145	
3800	15350	38.847	0	D4N148	
4330	14300	20.316	0	D4N147	
4230	12280		0		G35563A
4220	12230	28.616	0	D4N676	G35563
4190	12190	22.986	0	D4N677	G35564
4170	12150	23.623	0		G35564A
5750	15530	22.468	0		G35566A
5740	15460	24.491	0	D4N679	G35566
5730	15420	36.712	0	D4N678	G35565
5740	15360	47.872	0		G35565A
5920	15140	30.101	0	D4N680	G35567
4880	12930	[illegible]25	0	D4N681	G35569
5320	11810	26.822	0	D4N139	
5710	10690	23.197	0	D4N140	
7400	11440	13.238	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.741	0	A3N009	
8620	14860	23.828	0	A3N008	
8410	14480		0	D4N143	
8970	14090	24.812	0	D4N142	
9540	12030	28.971	0	C2N545	G35568
9570	11950	[illegible]	0	C2N546	G35570

MOLOFO CATCHMENT GROUNDWATER LEVELS AUGUST 1986

2980	10770	24.67	0	D4N127	
1280	11160	23.755	0	D4N126	
1000	12220	5.938	0	D4N128	
1250	13380	12.968	0	D4N129	
1180	13240	13.776	0	D4N130	
2760	14690	8.631	0	D4N146	
3150	14340	13.992	0	D4N145	
3800	15350	37.002	0	D4N148	
4330	14300	20.162	0	D4N147	
4220	12230	27.662	0	D4N676	G35563
4190	12190	17.302	0	D4N677	G35564
5740	15460	34.502	0	D4N679	G35566
5730	15420	36.468	0	D4N678	G35565
5740	15360	68.336	0		G35565A
5970	15140	26.958	0	D4N680	G35567
4880	12930	24.502	0	D4N681	G35569
5320	11810	26.234	0	D4N139	
5710	10690	23.416	0	D4N140	
7400	11440	12.849	0	D4N141	
8770	16330	37.488	0	A3N009	
8620	14860	22.959	0	A3N008	
8410	14480	47.048	0	D4N143	
8970	14090	23.386	0	D4N142	
9540	12030	28.211	0	C2N545	G35568
9570	11750	20.869	0	C2N546	G35570

[illegible]

2980	10770		0	D4N127	
1280	11160	26.3	0	D4N126	
1000	12220	7.82	0	D4N128	
1250	13380	13.38	0	D4N129	
1180	13240	14.55	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.63	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.41	0	D4N145	
3800	15350	37.43	0	D4N148	
4330	14300	20.22	0	D4N147	
4230	12280		0		G35563A
4220	12230	28.214	0	D4N676	G35563
4190	12190	22.992	0	D4N677	G35564
4170	12150	23.718	0		G35564A
5750	15530	22.517	0		G35566A
5740	15460	29.641	0	D4N679	G35566
5730	15420	36.814	0	D4N678	G35565
5740	15360	47.021	0		G35565A
5920	15140	30.263	0	D4N680	G35567
4880	12930	25.074	0	D4N681	G35569
5320	11810	26.83	0	D4N139	
5710	10690	24.07	0	D4N140	
7400	11440	13.26	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.61	0	A3N009	
8620	14860	23.66	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.85	0	D4N142	
9540	12030	28.994	0	C2N545	G35568
9570	11950	25.126	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS OCTOBER 1986

2980	10770		0	D4N127	
1280	11160	26.54	0	D4N126	
1000	12220	8.07	0	D4N128	
1250	13380	13.39	0	D4N129	
1180	13240	14.63	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.66	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.15	0	D4N14_	
3800	15350	37.47	0	D4N148	
4330	14300	20.23	0	D4N147	
4230	12280		0		G35563A
4220	12230	28.249	0	D4N676	G35563
4190	12190	22.761	0	D4N677	G35564
4170	12150	23.707	0		G35564A
5750	15530	22.583	0		G35566A
5740	15460	29.31	0	D4N679	G35566
5730	15420	36.871	0	D4N678	G35565
5740	15360	46.2	0		G35565A
5920	15140	30.249	0	D4N680	G35567
4880	12930	29.07	0	D4N681	G35569
5320	11810	26.84	0	D4N139	
5710	10690	24.12	0	D4N140	
7400	11440	13.3	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.61	0	A3N009	
8620	14860	23.69	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.87	0	D4N142	
9540	12030	28.972	0	C2N545	G35568
9570	11950	29.578	0	C2N546	G35570

MOLOPO CATCHMENT GROUNDWATER LEVELS NOVEMBER 1986

2980	10770		0	D4N127	
1280	11160	26.66	0	D4N126	
1000	12220	8.14	0	D4N128	
1250	13380	13.42	0	D4N129	
1180	13240	14.74	0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.65	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.15	0	D4N145	
3800	15350	37.49	0	D4N148	
4330	14300	20.23	0	D4N147	
4230	12280		0		G35563A
4220	12230	28.114	0	D4N676	G35563
4190	12190	22.627	0	D4N677	G35564
4170	12150	23.784	0		G35564A
5750	15530	22.81	0		G35566A
5740	15460	29.43	0	D4N679	G35566
5730	15420	41.85	0	D4N678	G35565
5740	15360	45.452	0		G35565A
5920	15140	32.273	0	D4N680	G35567
4880	12930	20.068	0	D4N681	G35569
5320	11810	26.87	0	D4N139	
5710	10690	24.14	0	D4N140	
7400	11440	13.32	0	D4N141	
8150	16320		0	D4N144	
8770	16330	37.61	0	A3N009	
8620	14860	23.75	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.92	0	D4N142	
9540	12030	28.714	0	C2N545	G35568
9570	11950	24.813	0	C2N546	G35570

MOLUFO CATCHMENT GROUNDWATER LEVELS DECEMBER 1986

2980	10770		0	D4N127	
1280	11160	26.7	0	D4N126	
1000	12220		0	D4N129	
1250	13380	13.45	0	D4N129	
1180	13240		0	D4N130	
2980	10770		0	D4N127	
2760	14690	8.73	0	D4N146	
2990	14560		0	D4N004	
3150	14340	14.15	0	D4N145	
3800	15350	37.57	0	D4N148	
4330	14300	20.25	0	D4N147	
4230	12280		0		G35563A
4220	12230	28.792	0	D4N676	G35563
4190	12190	22.918	0	D4N677	G35564
4170	12150	23.926	0		G35564A
5750	15530	22.979	0		G35566A
5740	15460	29.5	0	D4N679	G35566
5730	15420	39.772	0	D4N678	G35565
5740	15360	41.92	0		G35565A
5920	15140	32.658	0	D4N690	G35567
4880	12930	25.082	0	D4N681	G35569
5320	11810	26.9	0	D4N139	
5710	10690	24.18	0	D4N140	
7400	11440	13.28	0	D4N141	
8150	16320		0	D4N144	
8770	16330	38.52	0	A3N009	
8620	14860	23.81	0	A3N008	
8410	14480		0	D4N143	
8970	14090	23.94	0	D4N142	
9540	12030	28.892	0	C2N545	G35568
9570	11950	24.864	0	C2N546	G35570

APPENDIX G 2

DAILY FLOW IN CUMECS FOR STATIONS D4M14A AND D4M14D

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DAILYFLOW     D4M14D      82 6-86 1
A12,2I2,I1,7(F8.3,I1)
LIST FLOW/D/J2579/DAILY/INFO FOR MORE INFO
AAAAAAAAAAAA
D4M14D      82 619999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M14D      82 629999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M14D      82 639999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M14D      82 649999.9994   0.0002   0.2390   0.2410   0.2440   0.2460   0.2490
D4M14D      82 65   0.2510   0.2530
D4M14D      82 71   0.2560   0.2590   0.2610   0.2630   0.2660   0.2680   0.2710
D4M14D      82 72   0.2740   0.2760   0.2790   0.2820   0.2840   0.2870   0.2900
D4M14D      82 73   0.2920   0.2950   0.2980   0.3000   0.3030   0.3060   0.3090
D4M14D      82 74   0.3110   0.3120   0.3100   0.3090   0.3060   0.3040   0.3020
D4M14D      82 75   0.3000   0.2970   0.2940
D4M14D      82 81   0.2930   0.2930   0.2930   0.2920   0.2910   0.2910   0.2910
D4M14D      82 82   0.2910   0.2900   0.2890   0.2890   0.2890   0.2890   0.2890
D4M14D      82 83   0.2880   0.2870   0.2870   0.2870   0.2870   0.2870   0.2860
D4M14D      82 84   0.2850   0.2850   0.2850   0.2850   0.2850   0.2840   0.2830
D4M14D      82 85   0.2830   0.2830   0.2830
D4M14D      82 91   0.2830   0.2820   0.2810   0.2810   0.2810   0.2810   0.2800
D4M14D      82 92   0.2790   0.2790   0.2790   0.2790   0.2790   0.2780   0.2770
D4M14D      82 93   0.2770   0.2770   0.2770   0.2770   0.2760   0.2750   0.2750
D4M14D      82 94   0.2750   0.2750   0.2750   0.2740   0.2730   0.2730   0.2730
D4M14D      82 95   0.2730   0.2730
D4M14D      82101   0.2730   0.2730   0.2730   0.2730   0.2720   0.2710   0.2710
D4M14D      82102   0.2710   0.2710   0.2710   0.2710   0.2710   0.2710   0.2710
D4M14D      82103   0.2710   0.2710   0.2710   0.2710   0.2700   0.2690   0.2690
D4M14D      82104   0.2690   0.2690   0.2670   0.2670   0.2670   0.2670   0.2670
D4M14D      82105   0.2680   0.2670   0.2670
D4M14D      82111   0.2670   0.2670   0.2670   0.2650   0.2650   0.2650   0.2650
D4M14D      82112   0.2650   0.2650   0.2640   0.2630   0.2630   0.2630   0.2630
D4M14D      82113   0.2630   0.2630   0.2620   0.2620   0.2620   0.2620   0.2620
D4M14D      82114   0.2610   0.2600   0.2600   0.2600   0.2600   0.2600   0.2590
D4M14D      82115   0.2580   0.2580
D4M14D      82121   0.2580   0.2580   0.2580   0.2580   0.2580   0.2580   0.2580
D4M14D      82122   0.2570   0.2560   0.2560   0.2560   0.2560   0.2560   0.2560
D4M14D      82123   0.2560   0.2560   0.2560   0.2560   0.2560   0.2560   0.2550
D4M14D      82124   0.2540   0.2540   0.2540   0.2540   0.2540   0.2540   0.2540
D4M14D      82125   0.2530   0.2520   0.2510
D4M14D      83 11   0.2500   0.2500   0.2500   0.2490   0.2480   0.2470   0.2470
D4M14D      83 12   0.2460   0.2450   0.2440   0.2430   0.2430   0.2420   0.2410
D4M14D      83 13   0.2410   0.2400   0.2390   0.2390   0.2380   0.2370   0.2360
D4M14D      83 14   0.2360   0.2360   0.2360   0.2360   0.2360   0.2350   0.2360
D4M14D      83 15   0.2350   0.2360   0.2360
D4M14D      83 21   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360
D4M14D      83 22   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360
D4M14D      83 23   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360
D4M14D      83 24   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360
D4M14D      83 31   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360
D4M14D      83 32   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360   0.2360
D4M14D      83 33   0.2360   0.2360   0.2350   0.2370   0.2380   0.2380   0.2380
D4M14D      83 34   0.2380   0.2380   0.2380   0.2390   0.2370   0.2400   0.2400
D4M14D      83 35   0.2400   0.2400   0.2400
D4M14D      83 41   0.2400   0.2410   0.2410   0.2410   0.2410   0.2410   0.2410
D4M14D      83 42   0.2410   0.2420   0.2430   0.2430   0.2430   0.2430   0.2430
D4M14D      83 43   0.2430   0.2440   0.2450   0.2450   0.2450   0.00229999.9994
D4M14D      83 449999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M14D      83 459999.99949999.9994
D4M14D      83 619999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M14D      83 629999.99949999.99949999.99949999.99949999.99949999.99949999.9994
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```
D4M140      B3 639999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M140      B3 649999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M140      B3 65   0.0002  0.4130
D4M140      B3 71   0.4240  0.4130  0.4040  0.3950  0.3850  0.3750  0.3670
D4M140      B3 72   0.3570  0.3480  0.3390  0.3300  0.3210  0.3130  0.3040
D4M140      B3 73   0.2950  0.2870  0.2780  0.2690  0.2620  0.2530  0.2450
D4M140      B3 74   0.2380  0.2360  0.2350  0.2350  0.2340  0.2340  0.2340
D4M140      B3 75   0.2340  0.2340  0.2330
D4M140      B3 81   0.2320  0.2320  0.2320  0.2320  0.2320  0.2310  0.2310
D4M140      B3 82   0.2310  0.2310  0.2310  0.2300  0.2290  0.2290  0.2290
D4M140      B3 83   0.2290  0.2280  0.2270  0.2270  0.2270  0.2270  0.2270
D4M140      B3 84   0.2260  0.2250  0.2250  0.2250  0.2250  0.2240  0.2230
D4M140      B3 85   0.2230  0.2230  0.2230
D4M140      B3 91   0.2230  0.2230  0.2220  0.2220  0.2220  0.2220  0.2220
D4M140      B3 92   0.2210  0.2200  0.2200  0.2200  0.2200  0.2190  0.2190
D4M140      B3 93   0.2180  0.2180  0.2140  0.2080  0.2030  0.1980  0.1920
D4M140      B3 94   0.1870  0.1820  0.1770  0.1730  0.1680  0.1630  0.1580
D4M140      B3 95   0.1530  0.1490
D4M140      B3101   0.1440  0.1400  0.1350  0.1310  0.1260  0.1220  0.1180
D4M140      B3102   0.1130  0.1090  0.1050  0.1010  0.0970  0.0920  0.0092
D4M140      B31039999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M140      B31049999.99949999.99949999.99949999.99949999.99949999.99949999.9994
D4M140      B31059999.99949999.99949999.9994
D4M140      B31219999.99949999.9994   0.0002  0.2180  0.2170  0.2160  0.2150
D4M140      B3122   0.2150  0.2140  0.2140  0.2140  0.2140  0.2130  0.2130
D4M140      B3123   0.2120  0.2110  0.2110  0.2110  0.2100  0.2090  0.2070
D4M140      B3124   0.2080  0.2070  0.2070  0.2070  0.2060  0.2050  0.2050
D4M140      B3125   0.2050  0.2040  0.2040
D4M140      B4 11   0.2040  0.2030  0.2020  0.2020  0.2010  0.2000  0.2000
D4M140      B4 12   0.2000  0.2000  0.2000  0.2000  0.2000  0.2000  0.2000
D4M140      B4 13   0.2000  0.2000  0.2000  0.2000  0.2000  0.2000  0.2000
D4M140      B4 14   0.2000  0.2000  0.2000  0.2000  0.2000  0.2000  0.2000
D4M140      B4 15   0.2000  0.2000  0.2000
D4M140      B4 21   0.2000  0.2000  0.2000  0.2000  0.2000  0.2000  0.2000
D4M140      B4 22   0.2000  0.2000  0.2000  0.2000  0.2000  0.2000  0.2000
D4M140      B4 23   0.2000  0.2000  0.2000  0.2000  0.2000  0.2000  0.2000
D4M140      B4 24   0.1990  0.1980  0.1980  0.1980  0.1980  0.1980  0.1980
D4M140      B4 25   0.1980
D4M140      B4 31   0.1980  0.1980  0.1980  0.1980  0.1980  0.1980  0.1980
D4M140      B4 32   0.1980  0.1980  0.1950  0.1910  0.1890  0.1860  0.1830
D4M140      B4 33   0.1800  0.1770  0.1730  0.1710  0.1690  0.1650  0.1620
D4M140      B4 34   0.1590  0.1560  0.1530  0.1510  0.1480  0.1450  0.1420
D4M140      B4 35   0.1390  0.1370  0.1350
D4M140      B4 41   0.1310  0.1280  0.1260  0.1230  0.1200  0.1180  0.1160
D4M140      B4 42   0.1180  0.1200  0.1230  0.1250  0.1270  0.1290  0.1310
D4M140      B4 43   0.1340  0.1360  0.1390  0.1410  0.1440  0.1460  0.1480
D4M140      B4 44   0.1500  0.1530  0.1560  0.1580  0.1610  0.1630  0.1650
D4M140      B4 45   0.1680  0.1700
D4M140      B4 51   0.1730  0.1760  0.1780  0.1810  0.1830  0.1830  0.1830
D4M140      B4 52   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 53   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 54   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 55   0.1830  0.1830  0.1830
D4M140      B4 61   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 62   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 63   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 64   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 65   0.1830  0.1830
D4M140      B4 71   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 72   0.1830  0.1830  0.1830  0.1830  0.1830  0.1830  0.1830
D4M140      B4 73   0.1830  0.1840  0.1850  0.1850  0.1860  0.1860  0.1860
D4M140      B4 74   0.1870  0.1880  0.1880  0.1880  0.1890  0.1900  0.1900
D4M140      B4 75   0.1910  0.1910  0.1910
D4M140      B4 81   0.1910  0.1920  0.1930  0.1930  0.1940  0.1950  0.1950
D4M140      B4 82   0.1414  0.1454  0.1970  0.1970  0.1970  0.1970  0.1970
D4M140      B4 93   0.1970  0.1970  0.1980  0.1980  0.1980  0.1980  0.1980
```

D4M14D	84 84	0.1990	0.1980	0.1980	0.1980	0.1980	0.1990	0.1980
D4M14D	84 85	0.1980	0.1980	0.1990				
D4M14D	84 91	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
D4M14D	84 92	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
D4M14D	84 93	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
D4M14D	84 94	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
D4M14D	84 95	0.2000	0.2000					
D4M14D	84101	0.2000	0.2000	0.2000	0.2000	0.2000	0.2040	0.2070
D4M14D	84102	0.2110	0.2150	0.2190	0.2230	0.2280	0.2320	0.2360
D4M14D	84103	0.2410	0.2450	0.2490	0.2530	0.2570	0.2620	0.2650
D4M14D	84104	0.2700	0.2750	0.2790	0.2830	0.2880	0.2930	0.2970
D4M14D	84105	0.3020	0.3070	0.3110				
D4M14D	84111	0.3160	0.3210	0.3250	0.3290	0.3340	0.3370	0.3430
D4M14D	84112	0.3490	0.3530	0.3540	0.3530	0.3520	0.3510	0.3500
D4M14D	84113	0.3500	0.3490	0.3480	0.3480	0.3470	0.3460	0.3460
D4M14D	84114	0.3450	0.3430	0.3430	0.3420	0.3410	0.3400	0.3390
D4M14D	84115	0.3390	0.3380					
D4M14D	84121	0.3370	0.3370	0.3360	0.3350	0.3350	0.3340	0.3330
D4M14D	84122	0.3330	0.3320	0.3310	0.3300	0.3280	0.3270	0.3260
D4M14D	84123	0.3270	0.3270	0.3260	0.3250	0.3250	0.3240	0.3230
D4M14D	84124	0.3220	0.3210	0.3210	0.3200	0.3190	0.3190	0.3180
D4M14D	84125	0.3170	0.3170	0.3160				
D4M14D	85 11	0.3150	0.3150	0.3140	0.3130	0.3130	0.3130	0.3130
D4M14D	85 12	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 13	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 14	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 15	0.3130	0.3130	0.3130				
D4M14D	85 21	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 22	0.3130	0.3100	0.3080	0.3050	0.3020	0.2990	0.2960
D4M14D	85 23	0.2930	0.2900	0.2880	0.2850	0.2820	0.2790	0.2760
D4M14D	85 24	0.2730	0.2700	0.2680	0.2650	0.2630	0.2600	0.2570
D4M14D	85 31	0.2540	0.2510	0.2500	0.2470	0.2440	0.2410	0.2370
D4M14D	85 32	0.2370	0.2390	0.2410	0.2430	0.2460	0.2490	0.2510
D4M14D	85 33	0.2540	0.2570	0.2590	0.2620	0.2640	0.2670	0.2700
D4M14D	85 34	0.2730	0.2760	0.2780	0.2810	0.2840	0.2870	0.2900
D4M14D	85 35	0.2930	0.2960	0.2980				
D4M14D	85 41	0.3010	0.3040	0.3070	0.3100	0.3120	0.3130	0.3130
D4M14D	85 42	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 43	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 44	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 45	0.3130	0.3130					
D4M14D	85 51	0.3130	0.3130	0.3130	0.3140	0.3150	0.3160	0.3180
D4M14D	85 52	0.3190	0.3200	0.3210	0.3220	0.3230	0.3240	0.3260
D4M14D	85 53	0.3270	0.3280	0.3290	0.3300	0.3310	0.3320	0.3340
D4M14D	85 54	0.3350	0.3360	0.3370	0.3380	0.3390	0.3400	0.3420
D4M14D	85 55	0.3430	0.3450	0.3460				
D4M14D	85 61	0.3470	0.3480	0.3490	0.3510	0.3520	0.3530	0.3540
D4M14D	85 62	0.3530	0.3510	0.3500	0.3490	0.3470	0.3450	0.3430
D4M14D	85 63	0.3420	0.3400	0.3390	0.3380	0.3350	0.3340	0.3330
D4M14D	85 64	0.3320	0.3300	0.3290	0.3280	0.3260	0.3240	0.3230
D4M14D	85 65	0.3220	0.3200					
D4M14D	85 71	0.3190	0.3180	0.3160	0.3140	0.3130	0.3130	0.3130
D4M14D	85 72	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 73	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 74	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 75	0.3130	0.3130	0.3130				
D4M14D	85 81	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 82	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 83	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 84	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130	0.3130
D4M14D	85 85	0.3130	0.3130	0.3130				
D4M14D	85 91	0.3130	0.3130	0.3130	0.3120	0.3120	0.3130	0.3110
D4M14D	85 92	0.3090	0.3060	0.3040	0.3020	0.3000	0.2980	0.2960
D4M14D	85 93	0.2940	0.2920	0.2900	0.2880	0.2860	0.2840	0.2820
D4M14D	85 94	0.2790	0.2760	0.2740	0.2720	0.2700	0.2680	0.2660
D4M14D	85 95	0.2640	0.2620					

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D4M14D	85101	0.2610	0.2590	0.2570	0.2550	0.2550	0.2560	0.2570
D4M14D	85102	0.2590	0.2600	0.2610	0.2620	0.2630	0.2630	0.2640
D4M14D	85103	0.2660	0.2670	0.2680	0.2690	0.2700	0.2710	0.2720
D4M14D	85104	0.2740	0.2750	0.2760	0.2770	0.2780	0.2790	0.2800
D4M14D	85105	0.2820	0.2930	0.2840				
D4M14D	85111	0.2850	0.2860	0.2970	0.2990	0.2900	0.2910	0.2920
D4M14D	85112	0.2930	0.2930	0.2930	0.2920	0.2710	0.2910	0.2910
D4M14D	85113	0.2910	0.2900	0.2890	0.2890	0.2890	0.2890	0.2890
D4M14D	85114	0.2880	0.2970	0.2870	0.2970	0.2970	0.2970	0.2960
D4M14D	85115	0.2850	0.2950					
D4M14D	85121	0.2850	0.2850	0.2940	0.2930	0.2830	0.2930	0.2830
D4M14D	85122	0.2930	0.2940	0.2950	0.2950	0.2850	0.2850	0.2960
D4M14D	85123	0.2870	0.2970	0.2970	0.2870	0.2970	0.2890	0.2890
D4M14D	85124	0.2890	0.2890	0.2890	0.2890	0.2900	0.2910	0.2910
D4M14D	85125	0.2910	0.2910	0.2920				
D4M14D	86 11	0.2930	0.2930	0.2930	0.2930	0.2920	0.2910	0.2910
D4M14D	86 12	0.2900	0.2890	0.2890	0.2890	0.2880	0.2870	0.2870
D4M14D	86 13	0.2860	0.2850	0.2850	0.2850	0.2840	0.2830	0.2830
D4M14D	86 14	0.2820	0.2810	0.2810	0.2810	0.2800	0.2790	0.2790
D4M14D	86 15	0.2780	0.2770	0.2770				

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APPENDIX G 3

DRILLING RECORDS

STEFFEN ROBERTSON AND KIRSTEN INC.
Geotechnical and Mining Engineers.
16th Floor, 20 Anderson Street, Johannesburg.
P.O. Box 8856, Johannesburg, 2000.
Telephone 834-6061. Telex 8-9763.

CLIENT: Water Research Commission

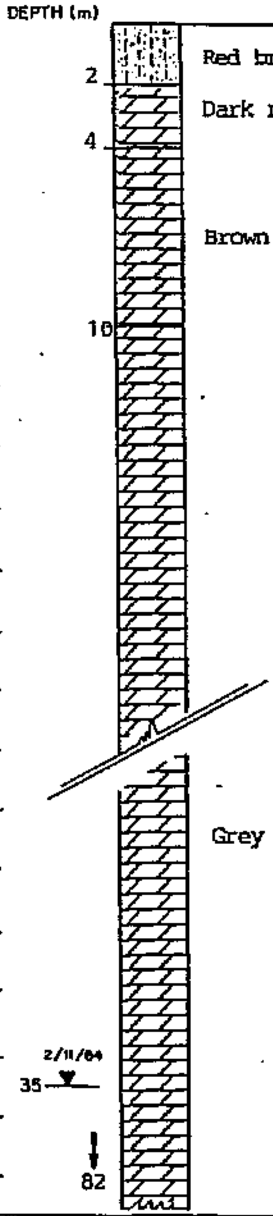
JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO.: CI 3346
SHEET NO.: 1
MADE BY: AAD
DATE: Nov '84

D4N676

G 35563

DEPTH (m)



Red brown transported silty sand with residual nodules.

Dark red clayey silt with gravel, weathered dolomite.

Brown silty sand with grey dolomite gravel.

Grey rock flour to medium chips dolomite.

DRILLING RIG:	DIAM:	DATE:
PROFILE BY:		DATE:
DEPTH W.T.:	WATER DEPTH:	AFTER: HOURS
R.L. OF TOP:	CO-ORDS:	

DISTURBED SAMPLE
UNDISTURBED SAMPLE
2/11/84 35 WATER TABLE DEPTH AND DATE

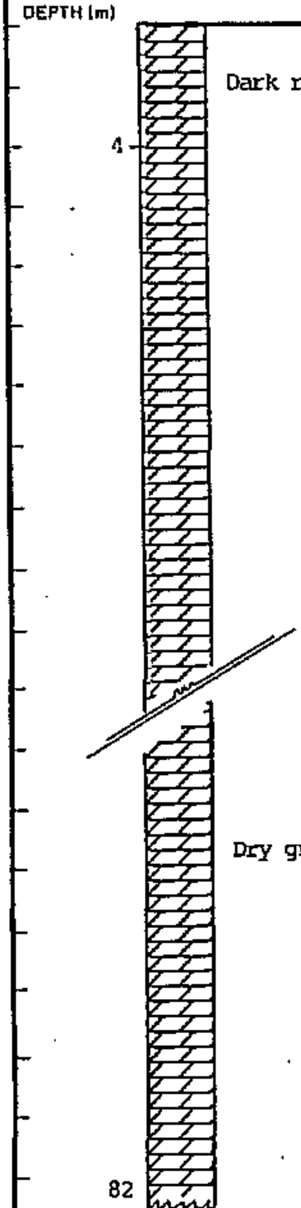
STEFFEN ROBERTSON AND KIRSTEN INC.
Geotechnical and Mining Engineers.
16th Floor, 20 Anderson Street, Johannesburg.
P.O. Box 8856, Johannesburg, 2000.
Telephone 834-6061. Telex 8-9763.

CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO.: CI 3346
SHEET NO.: 1
MADE BY: AAD
DATE: Nov '84

G 35563 A



Dark red clayey silt with gravel weathered dolomite.

Dry grey rock flour to medium chips dolomite.

DRILLING RIG:	DIAM:	DATE:
PROFILE BY :		DATE:
DEPTH W.T. :	WATER DEPTH:	AFTER: HOURS
R.L. OF TOP :	CO-ORDS:	

DISTURBED SAMPLE
UNDISTURBED SAMPLE

STEFFEN ROBERTSON AND KIRSTEN INC.
Geotechnical and Mining Engineers.
16th Floor, 20 Anderson Street, Johannesburg.
P.O. Box 8856, Johannesburg, 2000.
Telephone 834-6061. Telex 8-9763.

CLIENT Water Research Commission

JOB INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO. CI3346
SHEET NO. 1
MADE BY: AAD
DATE Nov '84

D4N677

G 35564

DEPTH (m)

DEPTH (m)	Description
0	Red brown silty sand with course sub-rounded dolomite gravel.
3	Grey silty sand and weathered dolomite gravel.
15	Grey dolomite gravel.
20	Light brown silty sand and grey dolomite gravel.
23 (2/11/84)	
25	Grey, fine to coarse chips dolomite.
40	Grey rock flour to medium chips dolomite.

DRILLING RIG: DIAM: DATE:
PROFILE BY: DATE:
DEPTH W.T.: WATER DEPTH: AFTER: HOURS
R.L. OF TOP: CO-ORDS:
DISTURBED SAMPLE
UNDISTURBED SAMPLE
1/11/84
35 ▼ WATER TABLE DEPTH AND DATE

STEFFEN ROBERTSON AND KIRSTEN INC.
Geotechnical and Mining Engineers.
16th Floor, 20 Anderson Street, Johannesburg.
P.O. Box 8856, Johannesburg, 2000.
Telephone 834-6061. Telex 8-9763.

CLIENT:

JOB

JOB NO.

SHEET NO 2

MADE BY:

DATE:

G 35564
conti

DEPTH (m)

40

Grey rock flour to medium chips dolomite.

76

DRILLING RIG:	DIAM:	DATE:	
PROFILE BY:		DATE:	
DEPTH W.T.:	WATER DEPTH:	AFTER:	HOURS
R.L. OF TOP:	CO-ORDS:		

DISTURBED SAMPLE
UNDISTURBED SAMPLE

STEFFEN ROBERTSON AND KIRSTEN INC.
Geotechnical and Mining Engineers.
16th Floor, 20 Anderson Street, Johannesburg.
P.O. Box 8856, Johannesburg, 2000.
Telephone 834-6061. Telex 8-9763.

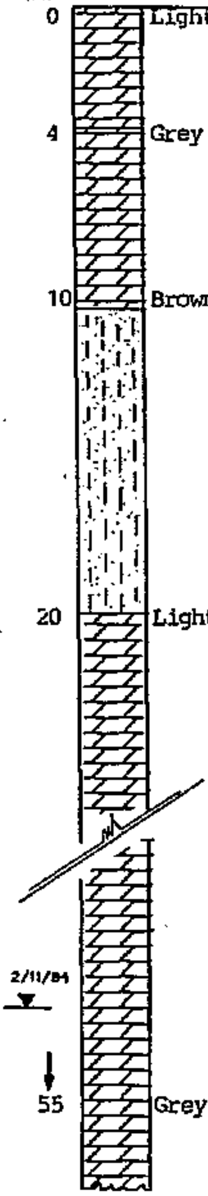
CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo Boreholes

JOB NO. CI 3346
SHEET NO. 1
MADE BY: AAD
DATE: Nov '84

G 35564 A

DEPTH (m)



0 Light brown to grey fine to course gravel weathered dolomite.

4 Grey rock flour to coarse chips dolomite.

10 Brown silty sand and medium chips weathered dolomite.

20 Light grey rock flour to medium chips dolomite.

2/11/84
43

55 Grey rock flour to medium chips dolomite.

DRILLING RIG:	DIAM:	DATE:
PROFILE BY:		DATE:
DEPTH W.T.:	WATER DEPTH:	AFTER HOURS
R.L. OF TOP:	CO-ORDS:	

DISTURBED SAMPLE
UNDISTURBED SAMPLE
2/11/84
35 WATER TABLE DEPTH AND DATE

STEFFEN ROBERTSON AND KIRSTEN INC.
Geotechnical and Mining Engineers.
16th Floor, 20 Anderson Street, Johannesburg.
P.O. Box 8856, Johannesburg, 2000.
Telephone 834-6061, Telex 8-9763.

CLIENT: Water Research Commission

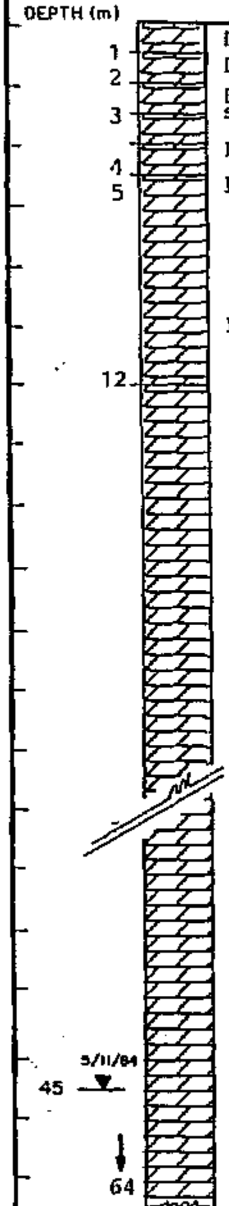
JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO.: CI 3346
SHEET NO.: 1
MADE BY: AAD
DATE: Nov '84

D4N678

G 35565

DEPTH (m)



Dry, light grey rock flour to medium chips dolomite.
Dry, grey rock flour to coarse chips dolomite.
Dry, light grey rock flour and medium chips dolomite and orangy brown silty sand.
Light grey to white rock flour to medium chips dolomite.
Light grey to white rock flour to fine chips dolomite.

Light grey rock flour to medium chips dolomite.

Light grey to white rock flour to medium chips dolomite.

DRILLING RIG:	DIAM:	DATE:
PROFILE BY:		DATE:
DEPTH W.T.:	WATER DEPTH:	AFTER: HOURS
R.L. OF TOP:	CO-ORDS:	

DISTURBED SAMPLE
UNDISTURBED SAMPLE
3/11/84
35 ▼ WATER TABLE DEPTH AND DATE

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CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO.: CI 3346
SHEET NO.: 2
MADE BY: MD
DATE: Nov '84

D4N67B

G 35565 conti

DEPTH (m)

Depth (m)	Description
65	Wet, light grey to grey medium to coarse chips partly weathered dolomite
	Moist grey rock flour to medium chips dolomite.
73	Slightly moist white rock flour to medium chips dolomite.
78	Moist very dark grey rock flour to fine chips dolomite.
80	Moist light grey rock flour to medium chips dolomite.
82	Moist grey fine to coarse chips dolomite.
83	Wet grey rock flour to coarse chips dolomite.
84	Moist grey rock flour to medium chips dolomite.
88	

DRILLING RIG: DIAM: DATE:
PROFILE BY: DATE:
DEPTH W.T.: WATER DEPTH: AFTER: HOURS
R.L. OF TOP: CO-ORDS:
DISTURBED SAMPLE
UNDISTURBED SAMPLE

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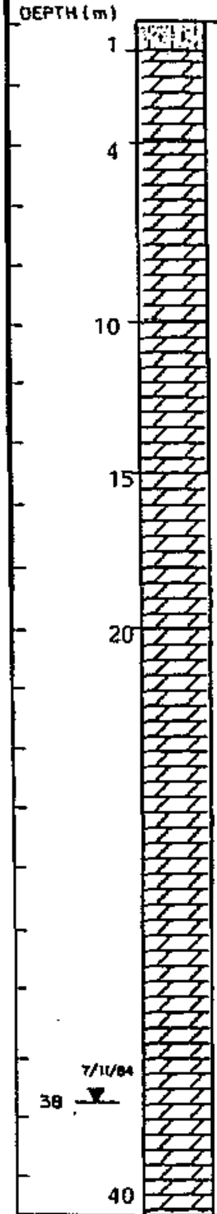
CLIENT: Water Research Commission

JOB. INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO. CI 3346
SHEET NO. 1
MADE BY: AAD
DATE: Nov '84

G 35565 A

DEPTH (m)



Dark reddish brown silty sand with residual nodules.

Brown to grey silty sand and gravel, weathered dolomite.

Grey rock flour to medium chips dolomite.

Light grey rock flour to medium chips, dolomite.

Grey rock flour to coarse chips, partly weathered dolomite.

Light grey to white rock flour to medium chips dolomite.

DRILLING RIG: DIAM: DATE:
PROFILE BY : DATE:
DEPTH W.T. : WATER DEPTH: AFTER: HOURS
R.L. OF TOP : CO-ORDS:
DISTURBED SAMPLE
UNDISTURBED SAMPLE
2/11/84 38 WATER TABLE DEPTH AND DATE

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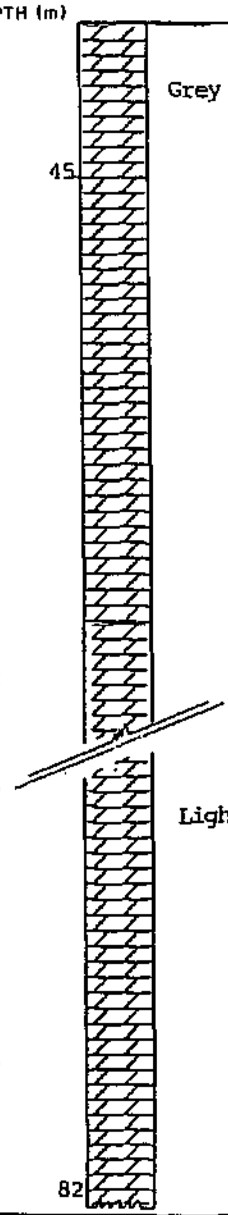
JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO.: CI 3346
SHEET NO.: 2
MADE BY: MD
DATE: Nov '84

G35565 A
conti.

DEPTH (m)

45



Grey rock flour to medium chips dolomite.

Light grey to white rock flour to fine chips dolomite.

82

DRILLING RIG:	DIAM:	DATE:	
PROFILE BY:		DATE:	
DEPTH W.T.:	WATER DEPTH:	AFTER:	HOURS
R.L. OF TOP:	CO-ORDS:		

DISTURBED SAMPLE
UNDISTURBED SAMPLE

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CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE Molopo boreholes

JOB NO.: CI 3346
SHEET NO.: 1
MADE BY: AND
DATE: Nov '84

D4N679
G 35566

DEPTH (m)

Depth (m)	Description
0–4	Light reddish brown to brown silty sand. - transported material and residual dolomite.
4–5	White to grey fine to coarse chips weathered dolomite.
5–8	Brown to grey fine chips weathered dolomite.
8–21	Light grey to grey rock flour to medium chips dolomite.
21–27	Light grey rock flour to fine chips dolomite.
27–29	Light grey to grey rock flour to coarse chips partly weathered dolomite.
29–32	Light grey to grey rock flour to medium chips dolomite.

DRILLING RIG: DIAM: DATE:
PROFILE BY: DATE:
DEPTH W.T.: WATER DEPTH: AFTER: HOURS
R.L. OF TOP: CO-ORDS:
DISTURBED SAMPLE
UNDISTURBED SAMPLE

STEFFEN ROBERTSON AND KIRSTEN INC.
Geotechnical and Mining Engineers.
16th Floor, 20 Anderson Street, Johannesburg.
P.O. Box 8856, Johannesburg, 2000.
Telephone 834-6061. Telex 8-9763.

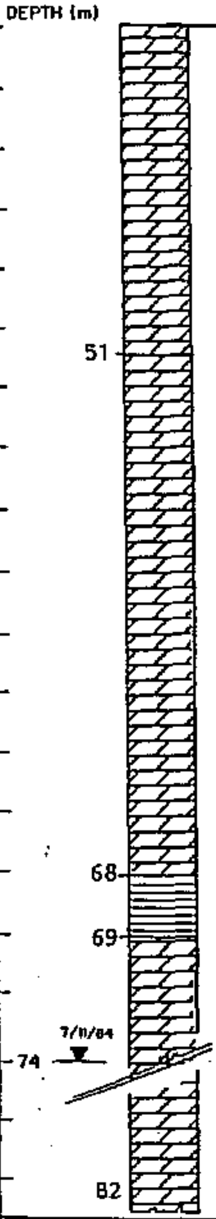
CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE Molopo boreholes

JOB NO: CI 3346
SHEET NO: 2
MADE BY: MD
DATE: Nov '84

DMN679
G 35566
conti

DEPTH (m)



Light grey rock flour to medium chips dolomite.

White to light grey rock flour to fine chips dolomite.

Dark olive rock flour to medium chips of non-dolomitic origin possibly weathered shale or intrusive.

Light grey to white rock flour to fine chips dolomite. EOH

DRILLING RIG:	DIAM:	DATE:
PROFILE BY:		DATE:
DEPTH W.T.:	WATER DEPTH:	AFTER: HOURS

DISTURBED SAMPLE
UNDISTURBED SAMPLE
2/11/04
35 ▼ WATER TABLE DEPTH AND DATE

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P.O. Box 8856, Johannesburg, 2000.
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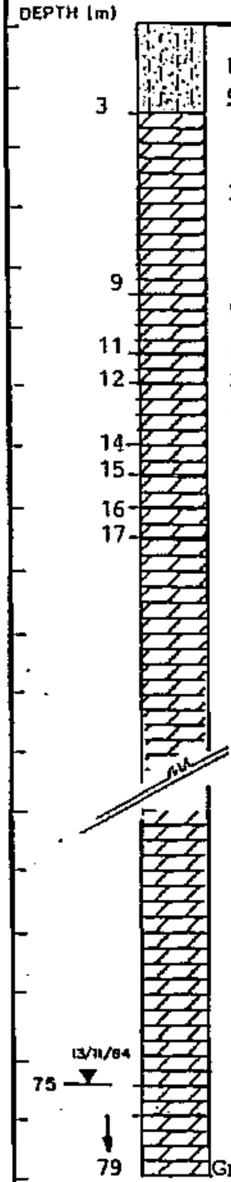
CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO: CI 3346
SHEET NO: 1
MADE BY: AAD
DATE: Nov '84

G 35566 A

DEPTH (m)



Depth (m)	Description
0–3	Dark reddish organge silty sand - transported material and residual dolomite.
3–9	Brown to grey silty sand and gravel, weathered dolomite.
9–11	Grey rock flour to coarse chips weathered dolomite.
11–12	Dark brown clayey silt, wad and grey/brown nodules very weathered dolomite loss of compression.
12–14	Grey rock flour to coarse chips weathered dolomite.
14–15	Brown and grey rock flour to coarse chips weathered dolomite.
15–16	Dark brown clayey silt, wad and coarse gravel, weathered dolomite.
16–17	Grey brown rock flour to coarse chips weathered dolomite.
79	Grey rock flour to medium chips dolomite.

13/11/84 ▼ 75

DRILLING RIG: DIAM: DATE:
PROFILE BY : DATE:
DEPTH W.T. : WATER DEPTH: AFTER: HOURS
R.L. OF TOP : CO-ORDS:
DISTURBED SAMPLE
UNDISTURBED SAMPLE 2/11/84 35 ▼ WATER TABLE DEPTH AND DATE

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CLIENT:
JOB
JOB NO. CI 3346
SHEET NO. 2
MADE BY:
DATE

G 35566 A

DEPTH (m)

80 Dark grey rock flour to medium chips of non-dolomite origin, intrusive.

82 Light grey rock flour to medium chips dolomite.

DRILLING RIG:	DIAM:	DATE:	
PROFILE BY:		DATE:	
DEPTH W.T.:	WATER DEPTH:	AFTER:	HOURS
R.L. OF TOP:	CO-ORDS:		

DISTURBED SAMPLE
UNDISTURBED SAMPLE

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P.O. Box 8856, Johannesburg, 2000.
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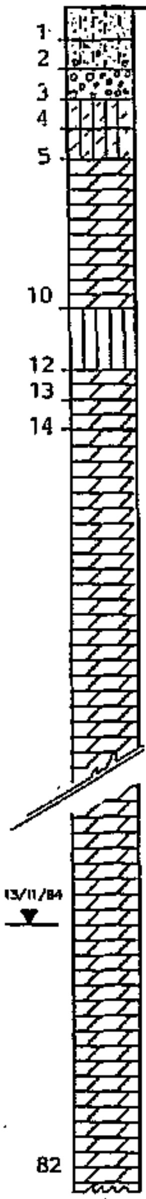
CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE Molopo boreholes

JOB NO: CI 3346
SHEET NO: 1
MADE BY: AND
DATE: Nov '84

D4N680
G 35567

DEPTH (m)



Depth (m)	Description
1	Reddish brown silty sand with dolomite gravel.
2	Light brown silty sand with dolomite gravel.
3	Grey dolomite gravel.
4	Light olive clayey silt of non-dolomitic origin, residual intrusive.
5	Light olive clayey silt and dark brown wad with medium dolomite chips.
10	Grey to white rock flour to medium chips dolomite.
12	Cream to light brown silt with fine chert chips.
13	Cream and grey to light brown rock flour to fine chips dolomite & chert
14	Cream to grey rock flour to medium chips chert and dolomite.
82	Light grey rock flour to medium chips becoming finer with depth, dolomite.

13/11/84
43 ▼

DRILLING RIG: DIAM: DATE:
PROFILE BY: DATE:
DEPTH W.T.: WATER DEPTH: AFTER: HOURS
R.L. OF TOP: CO-ORDS:

DISTURBED SAMPLE
UNDISTURBED SAMPLE
2/11/84
35 ▼ WATER TABLE DEPTH AND DATE

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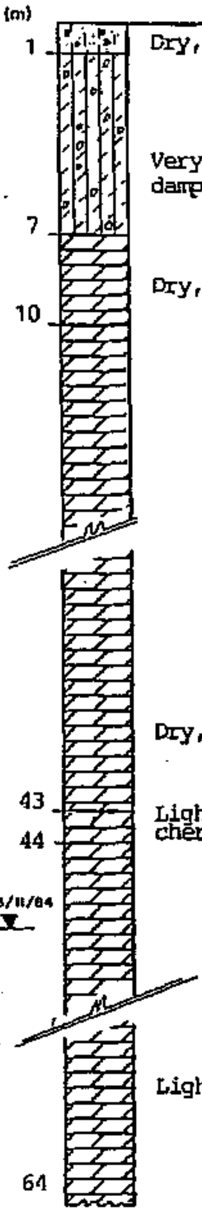
CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE Moloto boreholes

JOB NO.: CI 3346
SHEET NO.: 1
MADE BY: AAD
DATE: Nov '84

C2N545
G 35568

DEPTH (m)



Depth (m)	Description
1	Dry, reddish brown silty sand with dolomite gravel.
	Very dark brown clayey silt with dolomite gravel. Slightly damp from 5m.
7	
	Dry, grey coarse chips and gravel, weathered dolomite.
10	
	Dry, light grey rock flour to medium chips dolomite.
43	Light grey to cream rock flour to medium chips dolomite with possible chert bands.
44	
13/11/84 49 ▼	
	Light grey rock flour to medium chips dolomite.
64	

DRILLING RIG: DIAM: DATE:
PROFILE BY: DATE:
DEPTH W.T.: WATER DEPTH: AFTER: HOURS
R.L. OF TOP: CO-ORDS:

DISTURBED SAMPLE
UNDISTURBED SAMPLE
2/11/84
35 ▼ WATER TABLE DEPTH AND DATE

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CLIENT: Water Research Commission

JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO.: CI 3346
SHEET NO.: 2
MADE BY: AAD
DATE: Nov '84

D4NG01
G 35569
contd

DEPTH (m)	Description
42	Light grey and brown wad and <u>dolomite</u>. Wad from inflow overnight.
	Moist grey rock flour to fine chips <u>dolomite</u>.
57	
58	
59	Wet fine chips to coarse gravel <u>weathered dolomite</u> & <u>wad</u>.
	Loss of compression. No sample recovery from 58m even when drilling with water and foam.
64	

DRILLING RIG: DIAM: DATE:
PROFILE BY : DATE:
DEPTH W.T. : WATER DEPTH: AFTER: HOURS
R.L. OF TOP : CO-ORDS:
DISTURBED SAMPLE
UNDISTURBED SAMPLE

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CLIENT: Water Research Commission

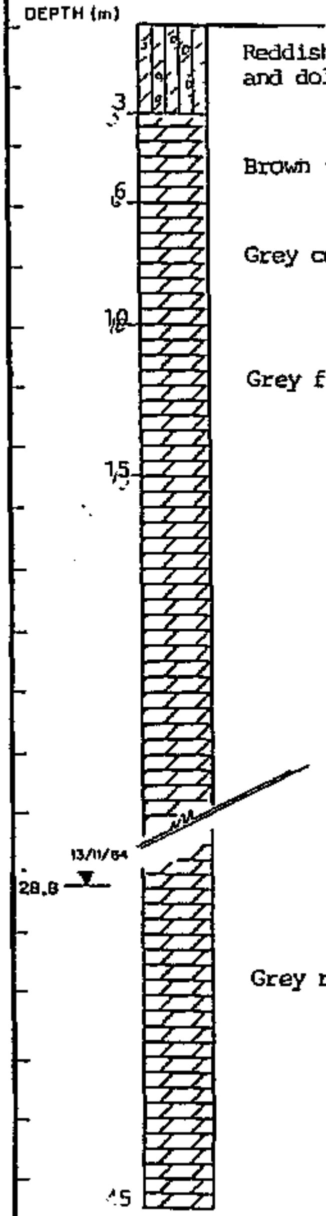
JOB: INVESTIGATION INTO RAINFALL RECHARGE : Molopo boreholes

JOB NO.: CI 3346
SHEET NO.: 1
MADE BY: AAD
DATE: Nov '84

C2N546

G 35570

DEPTH (m)



Reddish brown clayey silt with Fe/Mn coated nodules and dolomite gravel.

Brown to grey silty sand and gravel, weathered dolomite.

Grey coarse chips, weathered dolomite.

Grey fine to coarse chips, weathered dolomite.

Grey rock flour to medium chips dolomite.

DRILLING RIG: DIAM: DATE:
PROFILE BY : DATE:
DEPTH W.T. : WATER DEPTH: AFTER: HOURS
R.L. OF TOP : CO-ORDS:

DISTURBED SAMPLE
UNDISTURBED SAMPLE
2/11/84
35 ▼ WATER TABLE DEPTH AND DATE

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JOB NO.: CI 3346
SHEET NO.: 2
MADE BY: AAD
DATE: Nov '84

C2N546

G 35570
conti

DEPTH (m)

50

55

64

Light grey rock flour to coarse chips dolomite.

Light brown to light grey rock flour to medium chips partly weathered dolomite.

Light grey rock flour to fine chips dolomite.

DRILLING RIG:	DIAM:	DATE:
PROFILE BY:		DATE:
DEPTH W.T.:	WATER DEPTH:	AFTER: HOURS
R.L. OF TOP:	CO-ORDS:	

DISTURBED SAMPLE
UNDISTURBED SAMPLE

APPENDIX G 4

RAINFALL AND EVAPORATION DATA

SRK STATION

DATE	RAINFALL (mm)	EVAP (mm)	DATE	RAINFALL (mm)	EVAP (mm)	DATE	RAINFALL (mm)	EVAP (mm)
JFO 85 1 1	0.0	8.4	85 3 4	0.0	5.2	85 5 5	0.0	3.7
85 1 2	0.0	8.0	85 3 5	0.0	5.2	85 5 6	0.0	3.7
85 1 3	4.0	8.0	85 3 6	0.0	5.2	85 5 7	0.0	3.7
85 1 4	0.0	8.0	85 3 7	0.0	5.2	85 5 8	0.0	3.7
85 1 5	6.5	8.0	85 3 8	0.0	5.2	85 5 9	0.0	3.7
85 1 6	12.5	8.0	85 3 9	0.0	5.2	85 510	0.0	3.7
85 1 7	0.0	8.4	85 310	6.5	5.2	85 511	0.0	3.7
85 1 8	0.0	8.4	85 311	0.0	5.2	85 512	0.0	3.7
85 1 9	0.0	8.4	85 312	0.0	5.2	85 513	0.0	3.7
85 110	0.0	8.4	85 313	0.0	5.2	85 514	0.0	3.7
85 111	0.0	8.4	85 314	10.0	5.2	85 515	0.0	3.7
85 112	0.0	8.4	85 315	0.0	5.2	85 516	0.0	3.7
85 113	0.0	8.4	85 316	0.0	5.2	85 517	0.0	3.7
85 114	0.0	8.4	85 317	0.0	5.2	85 518	0.0	3.7
85 115	36.0	8.4	85 318	0.0	5.2	85 519	0.0	3.7
85 116	0.0	8.4	85 319	0.0	5.2	85 520	0.0	3.7
85 117	11.7	8.4	85 320	0.0	5.2	85 521	0.0	3.7
85 118	6.0	8.4	85 321	0.0	5.2	85 522	0.0	3.7
85 119	0.0	8.4	85 322	0.0	5.2	85 523	0.0	3.7
85 120	0.0	8.4	85 323	0.0	5.2	85 524	0.0	3.7
85 121	0.0	8.4	85 324	0.0	5.2	85 525	0.0	3.7
85 122	0.0	8.4	85 325	0.0	5.2	85 526	0.0	3.7
85 123	0.0	8.4	85 326	0.0	5.2	85 527	0.0	3.7
85 125	0.0	8.4	85 327	0.0	5.2	85 528	0.0	3.7
85 126	0.0	8.4	85 328	0.0	5.2	85 529	0.0	3.7
85 127	0.0	8.4	85 329	0.0	5.2	85 530	0.0	3.7
85 128	0.0	8.4	85 330	0.0	5.2	85 531	0.0	3.7
85 129	0.0	8.4	85 331	0.0	5.2	85 6 1	0.0	2.6
85 130	0.0	8.4	85 4 1	0.0	4.1	85 6 2	0.0	2.6
85 131	0.0	8.4	85 4 2	0.0	4.1	85 6 3	0.0	2.6
85 2 1	0.0	7.6	85 4 3	0.0	4.1	85 6 4	0.0	2.6
85 2 2	1.5	7.6	85 4 4	0.0	4.1	85 6 5	0.0	2.6
85 2 3	15.5	7.6	85 4 5	0.0	4.1	85 6 6	0.0	2.6
85 2 4	0.0	7.6	85 4 6	0.0	4.1	85 6 7	0.0	2.6
85 2 5	0.0	7.6	85 4 7	0.0	4.1	85 6 8	0.0	2.6
85 2 6	0.0	7.6	85 4 8	0.0	4.1	85 6 9	0.0	2.6
85 2 7	0.0	7.6	85 4 9	0.0	4.1	85 610	0.0	2.6
85 2 8	0.0	7.6	85 410	2.5	4.1	85 611	0.0	2.6
85 2 9	0.0	7.6	85 411	0.0	4.1	85 612	0.0	2.6
85 210	0.0	7.6	85 412	0.0	4.1	85 613	0.0	2.6
85 211	0.0	7.6	85 413	0.0	4.1	85 614	0.0	2.6
85 212	0.0	7.6	85 414	0.0	4.1	85 615	0.0	2.6
85 213	0.0	7.6	85 415	0.0	4.1	85 616	0.0	2.6
85 214	0.0	7.6	85 416	0.0	4.1	85 617	0.0	2.6
85 215	0.0	7.6	85 417	0.0	4.1	85 618	0.0	2.6
85 216	0.0	7.6	85 418	0.0	4.1	85 619	0.0	2.6
85 217	0.0	7.6	85 419	0.0	4.1	85 620	0.0	2.6
85 218	0.0	7.6	85 420	0.0	4.1	85 621	0.0	2.6
85 219	0.0	7.6	85 421	0.0	4.1	85 622	0.0	2.6
85 220	0.0	7.6	85 422	0.0	4.1	85 623	0.0	2.6
85 221	0.0	7.6	85 423	0.0	4.1	85 624	0.0	2.6
85 222	0.0	7.6	85 424	0.0	4.1	85 625	0.0	2.6
85 223	0.0	7.6	85 425	0.0	4.1	85 626	0.0	2.6
85 224	2.25	7.6	85 426	0.0	4.1	85 627	7.0	2.6
85 225	12.0	7.6	85 427	0.0	4.1	85 628	0.0	2.6
85 226	0.0	7.6	85 428	0.0	4.1	85 629	0.0	2.6
85 227	0.0	7.6	85 429	0.0	4.1	85 630	0.0	2.6
85 228	0.0	7.6	85 430	0.0	4.1	85 7 1	0.0	3.0
85 3 1	0.0	5.2	85 5 1	0.0	3.7	85 7 2	0.0	3.0
85 3 2	0.0	5.2	85 5 2	10.0	3.7	85 7 3	0.0	3.0
85 3 3	0.0	5.2	85 5 3	0.0	3.7	85 7 4	0.0	1.0
			85 5 4	0.0	3.7	85 7 5	0.0	2.5

DATE	RAINFALL (mm)	EVAP (mm)	DATE	RAINFALL (mm)	EVAP (mm)	DATE	RAINFALL (mm)	EVAP (mm)
85 7 6	0.0	4.5	85 9 6	0.0	9.3	8511 6	0.0	8.1
85 7 7	0.0	2.5	85 9 7	0.0	7.0	8511 7	0.0	8.1
85 7 8	0.0	1.0	85 9 8	0.0	9.5	8511 8	0.0	8.1
85 7 9	0.0	3.0	85 9 9	0.0	6.3	8511 9	0.0	8.1
85 710	0.0	3.0	85 910	0.0	6.3	851110	0.0	8.1
85 711	0.0	2.3	85 911	0.0	11.5	851111	0.0	8.1
85 712	0.0	3.5	85 912	0.0	9.2	851112	0.0	8.1
85 713	0.0	1.3	85 913	0.0	8.2	851113	0.0	8.1
85 714	0.0	3.5	85 914	0.0	7.5	851114	0.0	8.1
85 715	0.0	1.0	85 915	0.0	6.5	851115	0.0	8.1
85 716	0.0	3.0	85 916	0.0	14.0	851116	0.0	8.1
85 717	0.0	3.0	85 917	0.0	9.0	851117	0.0	8.1
85 718	0.0	3.0	85 918	0.0	9.0	851118	0.0	8.1
85 719	0.0	1.2	85 919	0.0	6.3	851119	0.0	8.1
85 720	0.0	3.5	85 920	0.0	6.3	851120	0.0	8.1
85 721	0.0	3.0	85 921	0.0	6.3	851121	0.0	8.1
85 722	0.0	1.2	85 922	0.0	6.3	851122	0.0	8.1
85 723	0.0	1.2	85 923	0.0	6.3	851123	0.0	8.1
85 724	0.0	2.2	85 924	0.0	6.3	851124	0.0	8.1
85 725	0.0	3.5	85 925	0.0	6.3	851125	0.0	8.1
85 726	0.0	2.5	85 926	0.0	6.3	851126	0.0	8.1
85 727	0.0	2.7	85 927	0.0	6.3	851127	0.0	8.1
85 728	0.0	3.0	85 928	0.0	6.3	851128	3.5	8.1
85 729	0.0	1.0	85 929	0.0	6.3	851129	0.0	8.1
85 730	0.0	3.0	85 930	0.0	4.0	851130	0.0	8.1
85 731	0.0	3.0	8510 1	0.0	7.8	8512 1	0.0	9.0
85 8 1	0.0	4.2	8510 2	0.0	7.8	8512 2	0.0	9.0
85 8 2	0.0	4.2	8510 3	0.0	7.8	8512 3	8.0	9.0
85 8 3	0.0	4.2	8510 4	0.0	7.8	8512 4	0.0	9.0
85 8 4	0.0	4.2	8510 5	0.0	7.8	8512 5	0.0	9.0
85 8 5	0.0	4.2	8510 6	0.0	7.8	8512 6	2.0	9.0
85 8 6	0.0	4.2	8510 7	0.0	7.8	8512 7	0.0	9.0
85 8 7	0.0	4.2	8510 8	0.0	7.8	8512 8	0.0	9.0
85 8 8	0.0	4.2	8510 9	5.0	7.8	8512 9	5.5	9.0
85 8 9	0.0	8.3	851010	0.0	7.8	851210	0.0	9.0
85 810	0.0	2.0	851011	0.0	7.8	851211	0.0	9.0
85 811	0.0	16.5	851012	0.0	7.8	851212	0.0	9.0
85 812	0.0	3.0	851013	0.0	7.8	851213	0.0	9.0
85 813	0.0	7.0	851014	0.0	7.8	851214	0.0	9.0
85 814	0.0	6.0	851015	0.0	7.8	851215	0.0	9.0
85 815	0.0	7.5	851016	0.0	7.8	851216	22.0	9.0
85 816	0.0	6.0	851017	0.0	7.8	851217	1.0	9.0
85 817	0.0	4.2	851018	21.5	7.8	851218	3.0	9.0
85 818	0.0	4.2	851019	0.0	7.8	851219	21.5	9.0
85 819	0.0	4.2	851020	0.0	7.8	851220	0.0	9.0
85 820	0.0	4.2	851021	5.0	7.8	851221	0.0	9.0
85 821	0.0	6.5	851022	0.0	7.8	851222	33.0	9.0
85 822	0.0	6.0	851023	0.0	7.9	851223	0.0	9.0
85 823	0.0	6.2	851024	0.0	7.8	851224	0.0	9.0
85 824	0.0	11.0	851025	0.0	7.8	851225	0.0	9.0
85 825	0.0	10.5	851026	0.0	7.8	851226	0.0	9.0
85 826	0.0	10.0	851027	0.0	7.8	851227	0.0	9.0
85 827	0.0	5.0	851028	0.0	7.8	851228	13.0	9.0
85 828	0.0	8.5	851029	0.0	7.8	851229	3.5	9.0
85 829	0.0	10.5	851030	5.0	7.8	851230	0.0	9.0
85 830	0.0	8.5	851031	16.0	7.8	851231	0.0	9.0
85 831	0.0	6.7	8511 1	0.0	8.1	86 1 1	1.5	15.5
85 9 1	0.0	6.3	8511 2	0.0	8.1	86 1 2	0.0	15.7
85 9 2	0.0	6.3	8511 3	0.0	8.1	86 1 3	33.0	9.0
85 9 3	0.0	6.3	8511 4	0.0	8.1	86 1 4	0.0	15.7
85 9 4	0.0	5.0	8511 5	0.0	8.1	86 1 5	0.0	15.7
85 9 5	0.0	3.0				86 1 6	0.0	15.7

DATE	RAINFALL (mm)	EVAP (mm)	DATE	RAINFALL (mm)	EVAP (mm)	DATE	RAINFALL (mm)	EVAP (mm)
86 1 7	0.0	15.7	86 3 9	0.0	10.0	86 5 9	0.0	9.0
86 1 8	0.0	15.7	86 310	1.25	6.0	86 510	0.0	5.0
86 1 9	0.0	15.7	86 311	0.0	4.0	86 511	0.0	3.7
86 110	0.0	16.7	86 312	0.0	14.0	86 512	0.0	3.7
86 111	10.4	17.0	86 313	0.0	7.5	86 513	0.0	3.7
86 112	1.0	17.0	86 314	0.0	10.5	86 514	0.0	3.7
86 113	0.0	17.0	86 315	2.0	10.5	86 515	0.0	3.7
86 114	0.0	15.7	86 316	0.0	10.5	86 516	0.0	3.7
86 115	0.0	8.0	86 317	0.0	10.5	86 517	0.0	3.7
86 116	0.0	11.2	86 318	19.25	10.5	86 518	0.0	5.0
86 117	0.0	8.2	86 319	0.0	10.5	86 519	0.0	9.0
86 118	0.0	10.5	86 320	0.0	10.5	86 520	0.0	4.0
86 119	0.0	15.2	86 321	0.0	10.5	86 521	0.0	6.0
86 120	0.0	5.4	86 322	0.0	10.5	86 522	0.0	9.0
86 121	0.0	8.4	86 323	0.0	10.5	86 523	0.0	4.0
86 122	0.0	6.4	86 324	0.0	20.0	86 524	0.0	5.0
86 123	0.0	8.4	86 325	0.0	15.5	86 525	0.0	7.0
86 124	0.0	8.4	86 326	0.0	5.2	86 526	0.0	7.0
86 125	0.0	8.4	86 327	0.0	5.2	86 527	0.0	6.0
86 126	0.0	8.4	86 328	0.0	5.2	86 528	0.0	9.0
86 127	0.0	8.4	86 329	0.0	5.2	86 529	0.0	6.0
86 128	0.0	8.4	86 330	0.0	5.2	86 530	0.0	4.0
86 129	7.5	8.4	86 331	0.0	5.2	86 531	0.0	3.0
86 130	16.0	8.4	86 4 1	0.0	5.2	86 6 1	0.0	6.0
86 131	0.0	8.4	86 4 2	0.0	5.2	86 6 2	0.0	6.0
86 2 1	0.0	11.0	86 4 3	0.0	11.0	86 6 3	0.0	6.0
86 2 2	0.0	11.0	86 4 4	0.0	11.0	86 6 4	2.5	6.0
86 2 3	6.0	11.0	86 4 5	0.0	11.0	86 6 5	0.0	6.0
86 2 4	0.0	11.0	86 4 6	0.0	11.0	86 6 6	0.0	6.0
86 2 5	1.0	11.0	86 4 7	0.0	11.0	86 6 7	0.0	6.0
86 2 6	2.0	11.0	86 4 8	2.0	11.0	86 6 8	0.0	6.0
86 2 7	0.0	11.0	86 4 9	0.0	11.0	86 6 9	0.0	6.0
86 2 8	6.0	11.0	86 410	0.0	11.0	86 610	0.0	6.0
86 2 9	0.0	11.0	86 411	0.0	11.0	86 611	0.0	6.0
86 210	0.0	11.0	86 412	0.0	25.5	86 612	0.0	6.0
86 211	0.0	11.0	86 413	0.0	13.5	86 613	0.0	6.0
86 212	0.0	25.5	86 414	0.0	12.0	86 614	0.0	6.0
86 213	0.0	13.5	86 415	0.0	12.0	86 615	0.0	6.0
86 214	10.0	12.0	86 416	0.0	12.0	86 616	0.0	6.5
86 215	0.0	12.0	86 417	0.0	12.0	86 617	0.0	5.5
86 216	0.0	12.0	86 418	0.0	12.0	86 618	0.0	9.0
86 217	0.0	12.0	86 419	0.0	12.0	86 619	0.0	7.0
86 218	0.0	12.0	86 420	0.0	20.5	86 620	0.0	7.5
86 219	0.0	12.0	86 421	0.0	17.5	86 621	0.0	9.5
86 220	0.0	20.2	86 422	0.0	13.5	86 622	0.0	3.0
86 221	0.0	17.2	86 423	0.0	19.5	86 623	0.0	0.0
86 222	0.0	13.5	86 424	0.0	0.5	86 624	0.0	6.5
86 223	0.0	19.5	86 425	0.0	4.1	86 625	0.0	7.0
86 224	0.0	0.5	86 426	0.0	4.1	86 626	0.0	0.0
86 225	0.0	7.6	86 427	0.0	4.1	86 627	0.0	11.0
86 226	0.0	7.6	86 428	0.0	4.1	86 628	0.0	4.5
86 227	0.0	7.6	86 429	0.0	4.1	86 629	0.0	2.0
86 228	0.0	7.6	86 430	0.0	4.1	86 630	0.0	1.5
86 3 1	0.0	7.6	86 5 1	0.0	4.1	86 7 1	0.0	5.0
86 3 2	0.0	7.6	86 5 2	0.0	4.1	86 7 2	0.0	7.5
86 3 3	0.0	7.6	86 5 3	0.0	4.1	86 7 3	0.0	5.0
86 3 4	0.0	7.6	86 5 4	0.0	4.1	86 7 4	0.0	19.5
86 3 5	0.0	7.6	86 5 5	11.0	10.0	86 7 5	0.0	3.0
86 3 6	0.0	18.0	86 5 6	0.0	10.0	86 7 6	0.0	3.0
86 3 7	0.0	9.0	86 5 7	0.0	10.0	86 7 7	0.0	3.0
86 3 8	0.0	6.0	86 5 8	0.0	10.0	86 7 8	0.0	3.0
						86 7 9	0.0	3.0

DATE	RAINFALL (mm)	EVAP (mm)	DATE	RAINFALL (mm)	EVAP (mm)	DATE	RAINFALL (mm)	EVAP (mm)
86 710	0.0	3.0	86 910	0.0	14.0	861111	0.0	7.8
86 711	0.0	3.0	86 911	0.0	13.5	861112	0.0	7.8
86 712	0.0	3.0	86 912	0.0	7.5	861113	0.0	11.0
86 713	0.0	3.0	86 913	0.0	7.0	861114	0.0	11.5
86 714	0.0	3.0	86 914	0.0	10.5	861115	0.0	22.5
86 715	0.0	3.0	86 915	0.0	7.5	861116	0.0	22.5
86 716	0.0	5.0	86 916	0.0	21.0	861117	0.0	19.5
86 717	0.0	12.0	86 917	0.0	17.5	861118	0.0	15.0
86 718	0.0	13.0	86 918	0.0	12.0	861119	0.0	10.0
86 719	0.0	8.0	86 919	0.0	16.5	861120	0.0	9.0
86 720	0.0	9.5	86 920	0.0	6.5	861121	0.0	6.0
86 721	0.0	9.0	86 921	0.0	6.5	861122	1.0	7.5
86 722	0.0	6.0	86 922	0.0	5.5	861123	3.5	7.0
86 723	0.0	9.5	86 923	0.0	7.0	861124	0.0	7.0
86 724	0.0	9.5	86 924	0.0	15.5	861125	0.0	11.0
86 725	0.0	8.0	86 925	0.0	21.0	861126	0.0	15.0
86 726	0.0	10.0	86 926	0.0	13.0	861127	0.0	7.8
86 727	0.0	12.5	86 927	0.0	15.0	861128	0.0	7.8
86 728	0.0	5.5	86 928	0.0	15.0	861129	0.0	7.8
86 729	0.0	6.5	86 929	0.0	15.0	861130	0.0	7.8
86 730	0.0	1.5	86 930	0.0	6.3	8612 1	0.0	7.8
86 731	0.0	3.0	8610 1	0.0	7.8	8612 2	0.0	7.8
86 8 1	0.0	3.0	8610 2	0.0	7.8	8612 3	0.0	9.5
86 8 2	0.0	0.5	8610 3	0.0	7.8	8612 4	6.0	24.0
86 8 3	0.0	0.2	8610 4	0.0	7.8	8612 5	1.5	24.0
86 8 4	0.0	4.2	8610 5	0.0	7.8	8612 6	3.0	24.0
86 8 5	0.0	4.2	8610 6	0.0	7.8	8612 7	12.0	24.0
86 8 6	0.0	4.2	8610 7	0.0	7.8	8612 8	0.0	24.0
86 8 7	0.0	5.0	8610 8	0.0	7.8	8612 9	0.0	24.0
86 8 8	0.0	6.5	8610 9	0.0	7.8	861210	9.5	24.0
86 8 9	0.0	14.0	861010	0.0	7.8	861211	0.0	24.0
86 810	0.0	15.5	861011	0.0	7.8	861212	0.0	24.0
86 811	0.0	11.0	861012	0.0	7.8	861213	0.0	17.0
86 812	0.0	9.0	861013	0.0	7.8	861214	0.0	20.0
86 813	0.0	17.0	861014	0.0	7.8	861215	0.0	23.0
86 814	0.0	9.0	861015	0.0	7.8	861216	0.0	20.0
86 815	0.0	14.0	861016	6.0	7.8	861217	0.0	0.0
86 816	0.0	10.0	861017	0.0	7.8	861218	0.0	6.0
86 817	0.0	10.5	861018	0.0	7.8	861219	0.0	5.0
86 818	0.0	8.5	861019	0.0	7.8	861220	0.0	11.5
86 819	0.0	4.2	861020	0.0	7.8	861221	0.0	19.0
86 820	0.0	4.2	861021	20.0	7.8	861222	0.0	21.5
86 821	0.0	4.2	861022	22.0	7.8	861223	0.0	21.0
86 822	0.0	4.2	861023	0.0	7.8	861224	0.0	17.0
86 823	0.0	4.2	861024	0.0	7.8	861225	0.0	14.0
86 824	0.0	4.2	861025	0.0	7.8	861226	0.0	9.0
86 825	0.0	4.2	861026	0.0	7.8	861227	6.0	9.0
86 826	0.0	4.2	861027	0.0	7.8	861228	10.5	9.0
86 827	6.5	4.2	861028	0.0	7.8	861229	12.0	9.0
86 828	0.0	4.2	861029	0.0	7.8	861230	0.0	9.0
86 829	0.0	4.2	861030	0.0	7.8	861231	0.0	9.0
86 830	0.0	4.2	861031	0.0	7.8	87 1 1	0.0	9.0
86 831	0.0	4.2	8611 1	11.0	7.8	87 1 2	0.0	9.0
86 9 1	0.0	11.0	8611 2	11.5	7.8	87 1 3	0.0	9.0
86 9 2	0.0	11.0	8611 3	0.0	7.8	87 1 4	0.0	9.0
86 9 3	0.0	11.0	8611 4	0.0	7.8	87 1 5	0.0	6.0
86 9 4	0.0	11.0	8611 5	0.0	7.8	87 1 6	0.0	20.0
86 9 5	0.0	11.0	8611 6	0.0	7.8	87 1 7	0.0	16.0
86 9 6	0.0	11.0	8611 7	0.0	7.8	87 1 8	0.0	15.0
86 9 7	0.0	11.0	8611 8	0.0	7.8	87 1 9	0.0	0.1
86 9 8	0.0	25.0	8611 9	0.0	7.8	87 110	0.0	0.1
86 9 9	0.0	12.5	861110	0.0	7.8	87 111	0.0	10.0

DATE	RAINFALL (mm)	EVAP (mm)
87 1 12	0.0	16.0
87 1 13	0.0	22.0
87 1 14	0.0	7.0
87 1 15	0.0	5.0
87 1 16	0.0	24.5
87 1 17	0.0	16.0
87 1 18	0.0	16.0
87 1 19	0.0	8.4
87 1 20	0.0	8.4
87 1 21	0.0	8.4
87 1 22	0.0	8.4
87 1 23	0.0	9.4
87 1 24	0.0	8.4
87 1 25	0.0	8.4
87 1 26	0.0	8.4
87 1 27	0.0	8.4
87 1 28	0.0	8.4
87 1 29	0.0	8.4
87 1 30	0.0	8.4
87 1 31	0.0	8.4
87 2 1	0.0	7.6
87 2 2	0.0	7.6
87 2 3	0.0	7.6
87 2 4	0.0	7.6
87 2 5	0.0	7.6
87 2 6	0.0	7.6
87 2 7	0.0	7.6
87 2 8	0.0	7.6
87 2 9	0.0	7.6
87 2 10	0.0	7.6
87 2 11	0.0	7.6
87 2 12	0.0	7.6
87 2 13	0.0	7.6
87 2 14	0.0	7.6
87 2 15	0.0	7.6
87 2 16	0.0	7.6
87 2 17	0.0	7.6
87 2 18	[illegible]	7.6
87 2 19	0.0	7.6
87 2 20	7.5	7.6
87 2 21	0.0	7.6
87 2 22	[illegible]	7.6
87 2 23	0.0	7.6
87 2 24	0.0	7.6
87 2 25	0.0	7.6
87 2 26	0.0	7.6
87 2 27	0.0	7.6
87 2 28	[illegible]	7.6
87 3 1	14.0	5.2
87 3 2	0.0	5.2
87 3 3	0.0	5.2
87 3 4	11.0	5.2
87 3 5	0.0	5.2
87 3 6	0.0	5.2
87 3 7	0.0	5.2
87 3 8	0.0	5.2
87 3 9	0.0	5.2
87 3 10	0.0	5.2
87 3 11	0.0	5.2
87 3 12	0.0	5.2
87 3 13	0.0	5.2
87 3 14	0.0	5.2
87 3 15	0.0	5.2
87 3 16	0.0	5.2
87 3 17	0.0	5.2
87 3 18	0.0	5.2
87 3 19	[illegible]	5.2
87 3 20	12.0	5.2
87 3 21	0.0	5.2
87 3 22	[illegible]	5.2
87 3 23	7.0	5.2
87 3 24	0.0	5.2
87 3 25	0.0	5.2
87 3 26	25.0	5.2
87 3 27	0.0	5.2
87 3 28	0.0	5.2
87 3 29	0.0	5.2
87 3 30	0.0	5.2