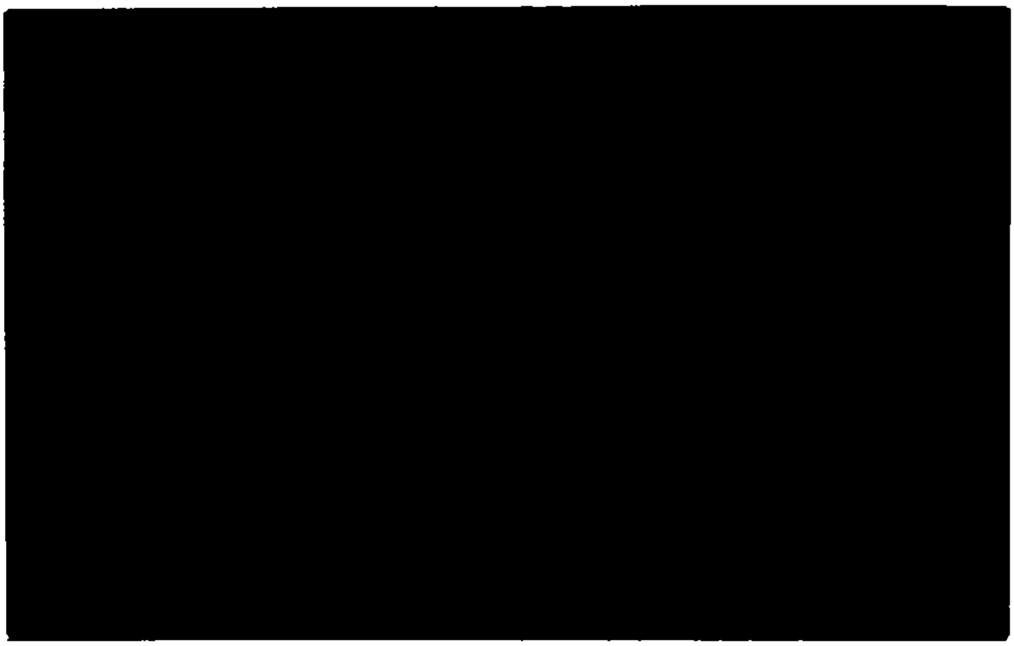
Institute of Hydrology

Natural Environment Research Council



A Study of Dambo Hydrology in Southern Africa

Field Mission 1 Trip Report

M.P. McCartney

with a contribution from I. Mapaure (National Herbarium and Botanical Gardens, Zimbabwe)

Institute of Hydrology
Crowmarsh Gifford
Wallingford
Oxfordshire
OX10 8BB
UK

Tel: 01491 838800
Fax: 01491 692424
Telex: 849365 Hydrol G

MPM
October 1995

Contents

1. Introduction

The Institute of Hydrology (IH) in collaboration with the Department of Geology at the University of Zimbabwe (UZ) and the Zimbabwe Department of Research and Specialist Services (DR&SS) is conducting a study of the key hydrological processes occurring in headwater catchments containing dambos. The primary aim of the study is to characterise the key hydrological pathways within dambo catchments and to determine how they influence downstream river flows. The study is a combined fieldwork and modelling study. A catchment suitable for conducting the fieldwork has been selected. It is located near Marondera, 70km south-east of Harare. A location map is shown in Figure 1. Details of the background to the project are given in McCartney (1995).

This report summarises the collaborative links that have been established and describes the first field mission undertaken by Matthew McCartney (MPM). The objectives of the field mission (undertaken between 12/06/95 and 28/08/95) were three-fold:

- To organise project logistics in Zimbabwe to enable fieldwork to be conducted;
- To carry out a preliminary soil and vegetation survey within the catchment;
- To install equipment to allow monitoring of spatial and temporal variation of the watertable, soil moisture and rainfall within the study catchment through the next two wet seasons (i.e. October 1995 - April 1996 and October 1996 - April 1997).

In the next section a brief description of the organisations and people collaborating with IH is given. Section 3 reviews the project logistics pertaining specifically to work in Zimbabwe. Sections 4 to 7 describe work conducted during the first field mission and section 8 is a brief outline of the work to be conducted in the next field mission. Appendix A contains copies of important documents relating to MPMs residence and employment status in Zimbabwe. Appendix B is a diary of the key events and principle meetings that occurred in the first field mission. Appendix C describes the methodology of analyses conducted on soil samples obtained from pits dug during the soil survey of the catchment. Appendix D is a copy of the report of the vegetation survey conducted during this field mission. Other than the vegetation survey no detailed results are presented in this report. Results arising directly from the work conducted during this field mission will be reported in a future technical note, when the hydrological implications of all the data collected have been evaluated.

2. Collaboration

Permission to conduct research in Zimbabwe has been obtained from the Research Council of Zimbabwe (see Appendix A). The project is being done in collaboration with two organisations, as described below.

2.1 THE DEPARTMENT OF GEOLOGY AT THE UNIVERSITY OF ZIMBABWE

In order to facilitate links and enable use of some University facilities MPM is registered as an Honorary Research Associate within the Department. The chairman of the Department is Dr. T.G. Blekensop and the person most closely linked to this project is Mr. Richard Owen who has long-term interests in dambos and their potential use for agriculture. Richard Owen was the principle organiser of a conference entitled "Dambo Farming in Zimbabwe: water management, cropping and soil potentials for smallholder farming in the wetlands", held in Harare in September 1992. He is also a key member of the SAREC research team that is investigating the "nature and suitability of a number of different aquifer types in Zimbabwe for use as water resource for subsistence irrigation" (SAREC, 1994).

2.2 THE DEPARTMENT OF RESEARCH AND SPECIALIST SERVICES

The catchment chosen to do the fieldwork is at the Grasslands Research Station (GRS) near Marondera. This station is an establishment of DR&SS. The principle research interests at the station are in cattle breeding. Also at "Grasslands" are two other DR&SS research stations, the Horticultural Research Centre (HRC) and the Soils Productivity Laboratory (SPRL). Although the catchment chosen for the research is owned by GRS, for this project the closest collaborative links have been estalished with HRC. This is because the work proposed is more directly related to the work of this station; HRC have research programmes investigating dambo agriculture. The head of station at HRC is Dr. John Jackson and the person most closely linked to this project is Mr. Fabian Chigumira who has long-term interests in the development of agriculture on dambos. He is a member of the SAREC research team, and is presently conducting research to determine the effect of dambo cultivation on water use and attempting to devise optimal water use strategies for horticultural crop production on dambos (Chigumira *et al.*, 1994).

Informal links have also been established with Mr. Isiah Mharapara of DR&SS. Isiah Mharapara is head of station at the Lowveld Research Station in Chiredzi. He has long-term interests in the use of dambos for agriculture (Mharapara, 1994). He is presently conducting experiments on paired catchments containing dambos, in order to investigate the impact of ridge and furrow methods of cultivation. He is also developing a Zimbabwe Wetlands Conservation Programme. MPM and Isiah Mharapara have agreed to keep each other informed on the progress of their respective studies.

3. Project logistics

3.1 IMPORTATION OF SCIENTIFIC EQUIPMENT INTO ZIMBABWE

The scientific equipment needed to conduct the planned fieldwork at GRS was despatched by air to Harare on 02/06/95. The equipment consists essentially of a neutron probe; the tools required to install neutron probe access tubes and piezometers; and equipment/chemicals required to conduct hydrochemical monitoring experiments. The freighting company "Abingdon Freight Forwarders" was used because they have a great deal of experience of shipping neutron probes which, because they are radioactive, have to be sent as a "hazardous good".

On the recommendation of the UZ buyer it was decided to import the equipment into the country on a temporary import licence. This avoids payment of the high import duties that are applied in Zimbabwe. However, in order to get temporary import privileges it is necessary to have a reputable organisation to act as a "guarantor" that the equipment will be re-exported. Commercial banks will act as guarantors but charge a considerable fee (i.e. of the order of 10% of the value of the goods being imported). For this project the British High Commission (BHC) agreed to act as guarantor providing that in reality the Institute of Hydrology accepted responsibility for re-exporting the equipment. The importation forms were signed by Irene Welch (head of the project support unit at the BHC) on 13/06/95 and the equipment was cleared through customs on 14/06/95. Customs officials would only allow a one year temporary import licence and it must be renewed before 14/06/96.

3.2 PROJECT VEHICLE

A Peugeot 505 SR Sedan has been purchased as a project vehicle. It was checked by a mechanic in Harare before purchase and was found to be in reasonable condition. Although it has done a high mileage (over 270,000 km) this is typical of suitable vehicles that could be purchased within the project budget. It is not ideal because the boot is not big enough to transport some of the larger pieces of equipment (e.g. the hydrapower auger) into the field. However, it is suitable for most day to day requirements and John Jackson has given permission for HRC station vehicles (and drivers) to be used for occasional transport of equipment into the catchment.

3.3 RESEARCH PERMIT

In order to conduct research in Zimbabwe it is necessary to obtain a research permit from the Zimbabwe Research Council, and in order to get this it is essential to have the support of at least one local organisation. A research permit was obtained for this study. It is valid from 12/06/95 (Appendix A). The application for this study was only successful because of strong support from both UZ and DR&SS.

3.4 TEMPORARY EMPLOYMENT PERMIT

In order for non-Zimbabwean Nationals to work in Zimbabwe for periods of more than 6 weeks it is necessary to obtain an employment permit from the Department of Immigration. Processing of applications can take several months and MPM submitted his application through UZ in February 1995. MPM obtained a permit valid until 21/06/98 from the Department of Immigration on 20/07/95 (Appendix A). As with the research permit this application was successful largely because of strong support from UZ and DR&SS.

3.5 INPUTS FROM ZIMBABWEAN PERSONNEL

At MPMs request Mr Phillipe Tavuyanage of the agricultural extension service (AGRITEX) surveyed the position and elevation of all equipment installed prior to 10/08/95 (see section 6). Also at MPMs request Mr Isaac Mapaure of the National Herbarium and Botanic Gardens undertook a vegetation survey of the catchment (see section 7 and Appendix D). Through HRC, 5 casual labourers were employed between 26/06/95 and 29/06/95 to dig soil pits. Chris Mhlanga, who had previously assisted John Butterworth of IH in a similar catchment study at Romwe in southern Zimbabwe, was employed for a month (15/07/95 to 18/08/95) to act as an experienced field assistant. Luckmore Chigwaze one of the 5 casual labourers, was also employed to assist with the installation of access tubes, piezometers and raingauges. Mr Munyaraeki Tseriwa conducted many of the soil analyses carried out at SPRL. Other less formal inputs are noted in the acknowledgements section.

4. Soil survey

A preliminary soil survey was conducted between 28/06/95 and 17/07/95. The survey involved the logging of soil profiles in 21 holes augered in 3 transects within the catchment (Figure 2). A further 6 exploratory holes were augered in a short transect between 01/08/95 and 04/08/95. Samples were collected in plastic bags and the soil profiles, logged using the approach given in Landon (1984). For each soil horizon, notes were made on colour (determined using Munsell colour charts), the presence of roots, texture (determined by feel and using the flow diagram given in Rowell, 1994) and carbonate content (determined by reaction with dilute hydrochloric acid).

Five soil pits were dug and the profiles in these were logged in a similar manner to the auger holes. From those horizons which were soft enough to allow undisturbed samples to be collected, cores were obtained for determining dry bulk density. Although the soil in many of the horizons were too hard for cores to be taken, the pits have been fenced to keep out people and cattle and it is hoped that in the coming rainy season, when the soils have wetted up sufficiently, it will be possible to obtain cores. Samples were collected from all the horizons in each pit for tests not requiring undisturbed samples. All samples were air dried and screened through a 2 mm sieve. The tests conducted at SPRL to date are:

- dry bulk density for those horizons from which cores could be taken;
- particle size analysis (hydrometric method);
- measurement of soil pH (in 0.01M $CaCl_2$ solution);
- measurement of soil electrical conductivity (in a 5:1 water solution)

The methodology used in each of these tests is described in Appendix C. It is planned to conduct further tests on the samples collected in order to determine organic matter content, cation exchange capacity and water release curves (see section 8.1.1).

Samples taken from a total of eight representative soil horizons (Table 1) have been returned to the UK. These will be despatched to Cadarache France, in order to determine calibration curves for the neutron probe using the method of neutron bombardment.

Table 1 Soil samples collected for determination of neutron probe calibration curves

Soil Pit	Depth of sample (cm)	Texture†
1	45-115	Clay
1	115-190	Sandy clay
1	190-210	Loamy sand
2	60-110	Clay
2	110-230	Loamy sand
4	85-175	Sandy clay loam
5	10-60	Loamy sand
5	60-170	Sandy loam

† texture determined by particle size analysis at SPRL (see Appendix C)

The results from the soil survey will be reported in a future technical note.

5. Equipment installation

5.1 NEUTRON PROBE ACCESS TUBES

Between 18/07/95 and 31/07/95 21 access tubes were installed in the catchment. A main transect of 16 access tubes (AT01 to AT16) was installed from the southern to the northern interfluve, across the widest point of the catchment. This transect crosses the centre of the catchment just upstream of the end of the channel (Figure 2). Five access tubes (AT17 to AT21) were installed in a second short transect, covering only the lower part of the soil catena (i.e. the dambo) on the southern side of the catchment. This transect was established closer to the catchment outlet than the main transect (Figure 2).

Initially 15 tubes 4.88 m long and 6 tubes all about 2.0 m long were available to the study. A further 4 3.30 m tubes were provided by HRC. All tubes were installed with 0.20 m remaining above ground level. Plastic caps were fixed on the top of all tubes to prevent rain falling directly into them.

All the holes drilled for the access tubes were augered by hand. As an experiment, one tube (AT02) was installed without the use of guide tubes by augering directly through the aluminium access tube. However, it was felt that a tighter fit was obtained and there was less chance of damaging the aluminium access tubes (e.g. by denting it on stones in the side of the augered hole) when the guide tubes were used. Consequently, they were used for the installation of all other tubes.

One problem encountered was that the aluminium bungs for the bottom of the tubes did not always provide a totally water tight seal. Consequently, despite the liberal use of silicon grease to try and seal the bottom of the tubes, soon after installation water seeped into some of the tubes that had been installed to depths below the water table (i.e. those close to the bottom of the slope). In order to stop water getting into the tubes, liquid cement was poured into the bottom of all those on the main transect. In all cases, once the cement had set there was no further seepage of water. Water did not get into the tubes on the second transect and so these tubes were left with just the aluminum bungs.

Between 23/08/95 and 25/08/95, measurements were made using the neutron probe in all the access tubes. In one or two tubes cement splashed onto the sides of the tube and dents in the tube wall, that must have occurred during installation, prevented the probe going all the way down the tube. These obstructions were removed using a special adaptor that screws onto auger extension rods. This adaptor consists of a wedge shaped piece of metal, with a width that is exactly the internal diameter of the access tubes. By lowering this into the access tubes and turning at the point where the obstruction occurred it was possible to smooth out dents and knock off the cement obstructions.

The readings obtained from the neutron probe may give an idea of the soil moisture status of the soils at the middle of the dry season. However, caution will be needed in interpreting the results because it was necessary to add water to many of the holes in order to drill them as deeply as they were augered.

Table 2 gives details of the access tubes and Figure 3 is a schematic showing the relative position and depths of the access tubes installed.

Table 2 *Access tubes*

Access tube no.	Location	Vegetation type and dominant species	Elevation (m)†	Depth■ (m)	Comment
AT01	Main transect; interfluve on southern side of the stream channel.	Open woodland *Brachestystegia spiciformis*	23.15	2.65 (2.40)	Rock at 2.70m. Tube should really be deeper because trees can extract water from up to 7.0m
AT02	Main transect, southern side of the stream channel - 132m downslope of AT01.	*Hyparrhenia filipendula* grassland at ecozone with miombo woodland	19.99	3.40 (3.15)	Rock at 3.40m - previous attempts in the vicinity had struck rock at depths as shallow as 0.30m
AT03	Main transect, southern side of the stream channel - 121m downslope of AT02.	*Hyparrhenia filipendula* grassland	17.65	4.20 (4.00)	Too hard to auger below 4.20m
AT04	Main transect, southern side of the stream channel - 156m downslope of AT03.	*Hyparrhenia filipendula* grassland in formerly cultivated area full of weeds (blackjack)	14.34	4.00 (3.80)	Too hard to auger below 4.00m
AT05	Main transect, southern side of the stream channel - 98m downslope of AT04.	*Hyparrhenia filipendula* grassland in formerly cultivated area full of weeds (blackjack)	12.72	2.90 (2.65)	Rock at 2.90m
AT06	Main transect, southern side of the stream channel - 109m downslope of AT05.	*Hyparrhenia filipendula* grassland in area locally dominated by *Sporobolus pyramidalis* (wetter area)	10.26	3.60 (3.30)	Rock at 3.60m
AT07	Main transect, southern side of the stream channel - 68m downslope of AT06.	*Hyparrhenia filipendula* grassland	9.06	3.00 (2.75)	Rock at 3.00m
AT08	Main transect, southern side of the stream channel - 50m downslope of AT07.	*Hyparrhenia filipendula* grassland in area locally dominated by *Andropogen chinenesis* (wetter area)	7.98	3.30 (3.10)	Too hard to auger below 3.30m

Access tube no.	Location	Vegetation type and dominant species	Elevation (m)†	Depth■ (m)	Comment
AT09	Main transect, southern side of the stream channel - 67m downslope of AT08 at the tip of the stream channel.	*Hyparrhenia filipendula* grassland	7.03	4.25 (3.95)	Too hard to auger below 4.25m
AT10	Main transect, northern side of the stream channel - 29m from AT09.	*Hyparrhenia filipendula* grassland in area locally dominated by *Arundinella nepalensis* (wetter area)	6.89	2.10 (1.85)	Rock at 2.10m
AT11	Main transect, northern side of the stream channel - 40m upslope from AT10.	*Hyparrhenia filipendula* grassland in area locally dominated by *Arundinella nepalensis* (wetter area)	7.32	4.30 (4.00)	Too hard to auger below 4.30m
AT12	Main transect, northern side of the stream channel - 82m upslope from AT11.	*Hyparrhenia filipendula* grassland in area locally dominated by *Aristida junciformis*	8.29	4.10 (3.80)	Too hard to auger below 4.10m
AT13	Main transect, northern side of the stream channel - 134m upslope from AT12.	*Hyparrhenia filipendula* grassland	9.52	4.50 (4.20)	Too hard to auger below 4.50m
AT14	Main transect, northern side of the stream channel - 120m upslope from AT13.	*Hyparrhenia filipendula* grassland in area locally dominated by *Aristida juniciformis*	10.75	4.60 (4.30)	
AT15	Main transect, northern side of the stream channel - 146m upslope from AT14.	*Hyparrhenia filipendula* grassland at ecozone with mixed sparse woodland	13.10	4.65 (4.40)	Length of access tube
AT16	Main transect, northern side of the stream channel - 146m upslope from AT15.	Mixed sparse woodland *Julbernardia globiflora*	16.04	4.30 (3.95)	Too hard to auger below 4.30m
AT17	Second transect, channel centre	Vlei channel grassland	1.56	1.75 (1.65)	Water prevented augering below 1.75 m

Access tube no.	Location	Vegetation type and dominant species	Elevation (m)†	Depth (m)■	Comment
AT18	Second transect, southern side of stream channel - 18m upslope from AT17.	Veli channel grassland	2.42	2.75 (2.45)	Very hard compact sand - couldn't auger deeper than 2.75 m
AT19	Second transect, southern side of stream channel - 24m upslope from AT18.	*Hyparrhenia filipendula* grassland	3.17	2.75 (2.50)	Very hard compact sand - couldn't auger deeper than 2.75 m
AT20	Second transect, southern side of the stream channel - 55m upslope from AT19.	*Hyparrhenia filipendula* grassland	4.69	2.00 (1.80)	Very hard compact sand - couldn't auger deeper than 2.00 m
AT21	Second transect, southern side of the stream channel - 54m upslope from AT20.	*Hyparrhenia filipendula* grassland	6.37	3.00 (2.80)	Length of access tube

† Elevation is relative to the top of the weir.

■ Number in brackets is depth to which tubes can be read.

5.2 PIEZOMETERS

Between 01/08/95 and 22/08/95, 48 piezometers were installed in the catchment. Most of the holes for these piezometers were augered by hand, but in a few instances where the ground was very hard and the piezometers had not penetrated as far as desired, the hydrapower augering machine was used in an attempt to drive the holes deeper. Table 3 gives details of all the piezometers installed and a note is made in those instances where the hydrapower auger was used. The relative position and depths of the piezometers installed is shown in Figure 3.

A piezometer was placed on either side of each access tube in the main transect. These piezometers, P1a and P1b to P16a and P16b, were placed approximately 5.0 m from the access tubes. Piezometers were made from 32 mm pvc pipe that was perforated over the required depth using a hacksaw. The pvc pipe came in 6.0 m lengths and this was the deepest that any of the piezometers were installed. After installation, short cutoffs of aluminium access tube were put around the tops of the pvc pipe. These were sealed in place using concrete. A small area around the tops of each piezometer was also concreted in order to prevent water seeping down the sides of the tubes. Rubber bungs were placed in the aluminium tubes to prevent rain falling directly into the hole.

In those locations where clay was found in the soil profile, one of the piezometers was perforated only below the clay layer. Gravel chips (4 mm) purchased from a local quarry were placed around the perforated length of the tube. An attempt was made to isolate the bottom of the tube from the hole above, by sealing above the gravel using bentonite clay (Figure 4). It is hoped that the bentonite clay will prevent water infiltrating down the sides of the tube. This was done in the piezometers on the west of each of the access tubes AT07 to AT14 (i.e. piezometers P7b to P14b). At each of these locations a third piezometer was installed with its bottom just penetrating the top of the clay layer. It is hoped that these tubes will give an indication of water both above and below the clay layer.

Eight piezometers were installed along the length of the stream channel to investigate the watertable beneath the stream bed and possible transmission losses along the stream. The aluminium tubes concreted around the tops of these piezometers extend some 1.0 m above the stream bed to prevent over topping during periods when the stream is flowing.

Table 3 *Piezometers*

Piezometer no.*	Location	Depth (m)	Comment†
P1a	5m to east of access tube 1	3.20	Rock at 3.50m
P1b	5m to west of access tube 1	6.00	Length of pvc tube
P2a	5m to east of access tube 2	6.00	Length of pvc tube
P2b	5m to west of access tube 2	6.00	Length of pvc tube
P3a	5m to east of access tube 3	3.95	Rock at 3.95m
P3b	5m to west of access tube 3	5.35	Rock at 5.35m
P4a	5m to east of access tube 4	3.40	Mechanical augering below 2.80m, but rock at 3.40m
P4b	5m to west of access tube 4	2.00	Mechanical augering below 1.80m, but rock at 2.00m
P5a	5m to east of access tube 5	4.00	Mechanical augering below 1.70m, but water prevented augering below 4.00m. Perforated from 2.50 to 4.00m
P5b	5m to west of access tube 5	1.65	Mechanical augering below 1.50m, but too hard to auger below 1.65m
P6a	5m to east of access tube 6	2.35	Mechanical augering below 0.90m, but too hard to auger below 2.35m
P6b	5m to west of access tube 6	2.50	Mechanical augering below 2.30m, but too hard to auger below 2.50m
P7a	5m to east of access tube 7	3.00	Too hard to auger below 3.00m
P7b	5m to west of access tube 7	3.05	Too hard to auger below 3.05m
P7c	5.5m to west of access tube 7	1.45	Sandy clay at 1.20m
P8a	5m to east of access tube 8	2.85	Too hard to auger below 2.85m
P8b	5m to west of access tube 8	3.45	Too hard to auger below 3.45m
P8c	5.5m to west of access tube 8	1.20	Sandy clay at 1.00m
P9a	5m to east of access tube 9	4.10	Water prevented augering below 4.10m
P9b	5m to west of access tube 9	4.50	Water prevented augering below 4.50m. Perforated from 2.90 to 4.50m; bentonite seal above 2.60m
P9c	5.5m to west of access tube 9	1.10	Clay at 0.9m
P10a	5m to east of access tube 10	4.60	Water prevented augering below 4.60m
P10b	5m to west of access tube 10	3.00	Water prevented augering below 3.00m. Perforated from 1.70 to 3.00m; bentonite seal above 1.70m

Piezometer no.■	Location	Depth (m)	Comment†
P10c	5.5m to west of access tube 10	0.90	Clay at 0.80m
P11a	5m to east of access tube 11	4.50	Water prevented augering below 4.50m
P11b	5m to west of access tube 11	3.10	Rock at 3.10m - other holes tried in vicinity, but none got deeper. Perforated from 2.5 to 3.10m; bentonite seal above 2.10m
P11c	5.5m west of access tube 11	1.10	Clay at 0.90m
P12a	5m to east of access tube 12	6.00	Length of pvc tube
P12b	5m to west of access tube 12	6.00	Length of pvc tube. Perforated from 4.00 to 6.00m; bentonite seal above 2.0m - tube tight below this
P12c	4.5m to west of access tube 12	3.00	To east of piezometer 12b, because many rocks to the west of 12b, prevented augering below 1.0m. No clay, but shallow piezometer will enable shallow water table to be investigated
P13a	5m to east of access tube 13	6.00	Length of pvc tube
P13b	5m to west of access tube 13	6.00	Length of pvc tube. Perforated from 5.00 to 6.00m - below clay; bentonite seal above 1.10m - tube tight below this
P13c	5.5m west of access tube 13	1.60	Sandy clay at 1.50m
P14a	5m to east of access tube 14	6.00	Length of pvc tube
P14b	5m to west of access tube 14	5.60	Perforated from 5.00 to 5.60m - below clay; bentonite seal above 2.0m - tube tight below this
P14c	5.5m to west of access tube 14	3.50	Clay at 3.10m
P15a	5m to east of access tube 15	5.80	Length of pvc tube
P15b	5m to west of access tube 15	6.00	Length of pvc tube
P16a	5m to east of access tube 16	6.00	Length of pvc tube
P16b	5m to west of access tube 16	6.00	Length of pvc tube
P17 (P24)	Centre of the dambo, but upstream of the channel	2.50	Clay from 0.50-2.00m, mix of sand and clay 2.00-2.50m - water prevented augering below 2.50m
P18 (P23)	Centre of the dambo, upstream of the channel	1.85	Clay from 0.40-1.30m, coarse sand and gravel from 1.30-1.85m - too hard to auger below 1.85m
P19 (P17)	Stream channel	1.70	Rock at 1.70m

Piezometer no.■	Location	Depth (m)	Comment†
P20 (P22)	Stream channel	2.50	Clay from 0.20-2.40m - water and gravel prevented augering below 2.50m
P21 (P18)	Stream channel	2.30	Clay from 0.30-0.80m, sand from 0.80-2.30m, rock at 2.30m
P22 (P19)	Stream channel	1.50	Sand throughout, no clay - water prevented augering below 1.50m
P23 (P20)	Stream channel	1.50	Sand throughout, no clay - water prevented augering below 1.50m
P24 (P21)	Stream channel	1.40	Sand throughout, no clay - water prevented augering below 1.40m

■ Number in brackets is the number on the sample bags, obtained during augering of these holes.

† All depths are relative to the ground surface. Unless stated pvc tubes were perforated for about 3/4 of their length or to within 1.0 m of the surface.

5.3 RAINGAUGES

On 11/08/95, four raingauges (RG1 to RG4) were installed in the catchment. These were installed at various locations and at different elevations in order to give an idea of the spatial distribution of precipitation in the catchment during rainfall events (Figure 2). A fifth raingauge (labelled RG5 on Figure 2) was already installed in the catchment.

All the gauges are the Zimbabwe Meteorological Department standard raingauges. These gauges are constructed by a company called Prodorite and are made from pvc pipe. Figure 5 shows the recommended installation of these gauges. Although it is now common practice in catchment studies in the UK to install gauges with the orifice at ground-level, this was not done in this study. There were two reasons for this; firstly, grasses in the catchment grow up to 1.0 m high and would shield a gauge set with its orifice at ground-level, and secondly, if the data obtained from the gauges installed are to be compared with the long-term records from the Grasslands meteorological site (where rainfall records extend back to 1956) then it is important to have the same type of gauge in the catchment. In the catchment all gauges were fixed with the orifice at 0.85 m above ground-level.

Table 4 Raingauges

Raingauge no.	Location	Elevation (m)†
RG1	Close to stream channel, just upstream of the weir,	-0.66
RG2	Just downslope of the treeline on the southern side of the catchment; west of the track.	9.60
RG3	Just downslope of the treeline on the southern side of the catchment; west of the railway.	18.80
RG4	Just downslope of the treeline on the northern side of the catchment; west of the railway.	14.71
RG5	Previously installed raingauge - close to settlement, within trees on the southern side of the catchment.	24.30

† Elevation is relative to the top of the weir.

5.4 SOIL WATER SAMPLERS

With the aim of collecting soil water for chemical analyses, three porous cup water samplers were installed on 18/08/95. They were installed about 10 m to the east of soil pits 1, 2 and 4. Each was installed to a depth of 1.80 m and great care was taken to disturb the surrounding soils and the hole walls as little as possible. As each hole was augered the soil brought out was collected. In order to get a good contact between the porous cup and the surrounding soil, a slurry was made from some of the soil collected from the bottom of the hole. This was done by removing all large stones and as much as possible of the coarse sand and gravel fraction and then mixing the remaining soil with water. The slurry was poured back into the hole before the sampler was pushed in. Although in each case there was a reasonably tight fit between the samplers and the hole walls, where necessary the space between the tube and the hole wall was backfilled using soil augered from the hole. Where this was done the soils were put back in the same order that they had been removed. This should prevent water running directly down the sides of the tube, thereby bypassing the soil matrix.

When it has been established that the smaples installed to date work satisfactorily (scheduled for early in the second field mission), a further 13 will be installed at other locations within the catchment. Despite the fact that care was taken to disturb the soil as little as possible it is envisaged that it will be necessary to collect samples for quite a long period of time before the soil water chemistry truly reflects the chemistry of water in the surrounding undisturbed soil.

6. Equipment survey

Between 08/08/95 and 10/08/95, a survey was made of the locations of all the exploratory auger holes, the soil pits and the neutron probe access tubes. Although they had not been installed, the location of the raingauges had been decided and these positions were also surveyed. The survey was conducted by Mr. P. Tavuyanago of the Agricultural Extension Service (AGRITEX). The survey was conducted to determine the exact position and elevation of the auger holes and equipment relative to the top of the weir at the catchment outlet. A magnetic north line was fixed (by surveying two points along a line on a bearing of 00:00 determined using a compass) so that all the positions surveyed could be located exactly on a map of the catchment (Figure 2).

Although the height of the weir above sea level is not known exactly (Hydro-Branch do not have any need for this information), the 1:25,000 orthophoto of the area (obtained from the Surveyor Generals Office) places it at about 1611 m. The survey allows the elevation of the soil horizons previously determined only relative to the ground surface to be fixed to a common datum. A further survey will be conducted during the next field mission to fix the position of equipment installed since 10/08/95.

7. Vegetation survey

A vegetation survey was conducted in the catchment, by Mr. Isaac Mapaure, a Senior Research Officer at the National Herbanium and Botanical Gardens. Isaac Mapaure first visited the catchment on 03/08/95 and made a second visit on 16/08/95.

Seven vegetation types have been identified in the catchment area, ranging from woodland through wooded grassland to grassland and eucalyptus tree plantations. These are mapped in Figure 6. The grassland is by far the largest of the vegetation types in the catchment. Two distinct types based on species dominance can be recognised. These are the channel and the *Hyparrhenia filipendula* grasslands. Species dominace of these two types is largely determined by their tolerance to periodic waterlogging. Within the *Hyparrhenia filipendula* grassland small areas are dominated by particular grass species (e.g. *Arundinella nepalensis* and *Andropogen chinenesis*) that are indicative of wetter conditions within these areas.

Over much of the catchment there is evidence of disturbance by cattle. This is not surprising since the catchment is used predominantly by GRS as pasture. Furthermore on the southern slopes of the catchment there is also evidence that this part of the catchment has in the past been used for cultivation. There are old contour ridges in places and a wide range of weeds, dominated by *Bidens biternata* (commonly known as blackjack), that only occur in areas that have been ploughed. The area with the greatest density of bunds is downslope of the miombo wood close to the Grasslands Sheep Unit and between the main track and the railway line.

An attempt was made to ascertain the history of cultivation within the catchment from Mr. B. Kamanga, the GRS farm manager. The GRS farm maps refer to the region that contains the highest density of contour bunds as "Drifield". The farm records make reference to "vlei-maize" that was planted in the Conservation and Extension Drainage Trail area in October 1972. Maize was grown in this area until at least 1979. However, one of the old farm hands at GRS stated that this referred to maize grown on a different dambo and that ever since he had been at the GRS (sometime in the 1960s) there had been bunding in the Drifield catchment, but it had not been used for cultivation of crops. It therefore seems probable that the contour bunding pre-dates the 1960s, but what the purpose of the bunds was and the crops grown in the area remains unknown.

Isaac Mapaure has proposed that a further visit is conducted during the wet season when it is easier to identify some grass species. A copy of the vegetation survey report that he wrote is included in this report as Appendix D.

8. Field Mission 2

The primary objective of the second mission will be to make field observations through the 1995/96 wet season and the start of the 1996 dry season.

8.1 WORK TO BE CONDUCTED

Following the start made during the first field mission, further work will be undertaken to determine soil physical and chemical characteristics and their spatial variability within the catchment.

Monitoring of temporal changes in hydrological variables will be conducted throughout the field mission. In addition to the monitoring of rainfall, soil moisture and groundwater levels, it is intended that hydrochemical measurements will be made and ground-truth information collected for calibrating remotely sensed data. The aspects of data collection are discussed below

8.1.1 Catchment soil characterisation

The following analyses of soil characteristics will be undertaken:

- Completion of field description of soil profiles from all auger holes drilled to date and possibly additional holes;
- Determination of organic matter content (samples already collected from each of the horizons in the soil pits);
- Determination of cation exchange capacity (samples already collected from each of the horizons in the soil pits);
- Determination of dry bulk density (undisturbed cores to be taken from each of the horizons in the soil pits, once the soils wet up sufficiently);
- Determination of water release curves (samples already collected from each of the horizons in the soil pits);
- Determination of saturated hydraulic conductivity (to be measured in-situ, possibly using a Guelph permeameter (owned by SPRL) or using the auger hole method (van Beers, 1963).

8.1.2 Hydrochemistry

It is hoped that monitoring of streamwater chemistry will provide useful information that will assist in the identification of hydrological pathways within the catchment. Hydrochemistry will be used as an indicator of water sources, where it moves and how fast it travels.

Streamwater will be collected each week throughout the rainy season. More regular samples (hourly) will be collected during storm events. All samples will be collected manually. Soil water will be obtained at various locations within the catchment and at different depths in the soil profile (up to 2.0 m) using the soil water samplers. The following determinands will be measured:

- alkalinity - indicator of the groundwater component of streamflow;
- conductivity - indicator of evaporation;
- chloride - indicator of evaporation;
- isotopes - indicator of rainfall/runoff processes (hydrograph separation) and the age of the water;
- pH

Alkalinity, conductivity and pH measurements will be made in Zimbabwe at GRS. Samples for isotopic analysis and chloride determination will be shipped to IH. Rain water will be collected in order to determine background concentrations of chloride and for isotopic analysis.

8.1.2 Ground-truth for remote sensing

Synthetic aperture radar (SAR) data collected by satellite ERS1 and/or ERS2 will be obtained from the European Space Agency. These data have the potential to provide information on the spatial and temporal changes in surface soil moisture.

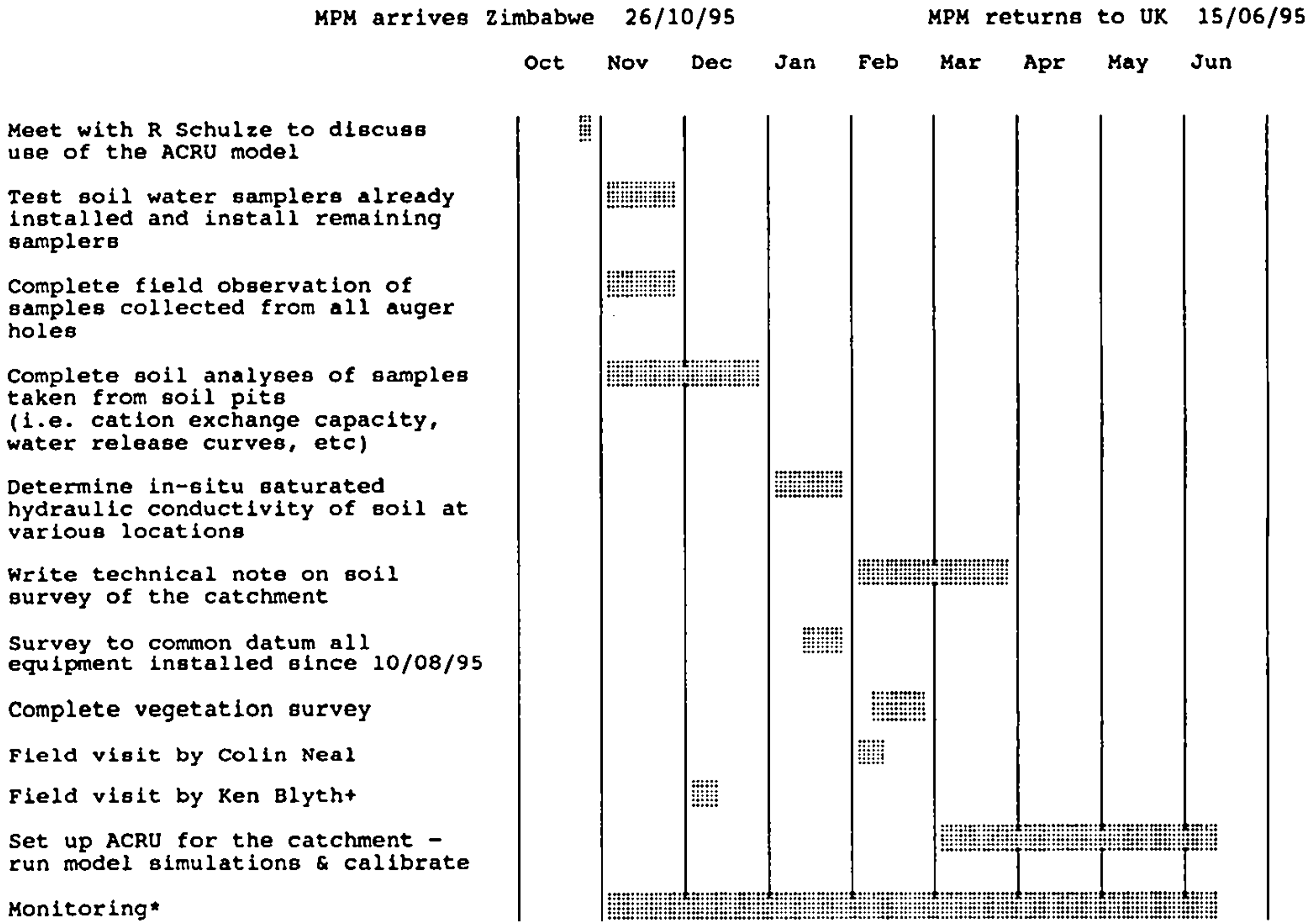
Near surface soil moisture measurements will be made in transects across the dambo and interfluve using a surface capacitance insertion probe (SCIP) at times when the satellite ERS1 and/or ERS2 overpass the catchment. The data collected will be used to provide ground truth for the SAR data. Volumetric soil moisture measurements will be made at several locations within the catchment and covering a range of soil moisture conditions in order to calibrate the SCIP.

8.2 TIMETABLE

MPM will arrive in Zimbabwe on 26/10/95 and it is proposed that he will remain in Zimbabwe until the middle of June 1996. A short field visit will be made by Dr. Colin Neale of IH. He will assist MPM with the field design and sample collection/methodology required for the hydrochemical monitoring. Mr. Ken Blyth, also of IH, will make a short field visit. He will assist MPM with the field design and data collection procedures required for collecting ground truth SCIP data. Both these visits will be of about two weeks duration.

Table 5 details the proposed timetable for the second field mission.

Table 5 *Timetable for Field Mission Two*



* Generally weekly monitoring but more intensive (daily and sub-daily for the hydrochemistry) during and after rainfall events.

\+ Exact timing dependent on soil moisture status and satellite overpasses.

Note - Sequence of tasks and when they are conducted may change, depending on the frequency and occurence of rainfall events.

Acknowledgements

Chris Mhlanga and Luckmore Chigwaze for their assistance and hard work in installing all the equipment.

Dr. John Jackson (Head of Station), Mr. Fabian Chigumira (Senior Research Officer), Mr. Norman Madzogo (Farm Manager) and numerous other members of staff at HRC, who assisted in many different ways.

Mr. Richard Owen of the Geology Department at UZ for his advice, and assistance in obtaining a research permit and tempory employment permit for me.

Mr. Andrew Musarurwa (assistant buyer at UZ) who sorted much of the paperwork required for importing the equipment.

Dr. Peter Ntendy (Head of Station at GRS) for permission to conduct the research at GRS.

Mr. Ben Kamanga (Farm Manager at GRS) for spending time trying to ascertain the history of cultivation within the catchment.

Mr. Owen Mandimimgana (Head of Station at SPRL) who gave permission for me to make use of the SPRL facilities and Mr. Munyaraeki Tseriwa who conducted many of the analyses.

Mr. Isaac Mapaure (National Herbarium and Botanic Gardens) for his time conducting a comprehensive vegetation survey.

Mr. Phillipe Tavuyanago (AGRITEX) for his time conducting a survey to fix the location and elevation of the instrumentation installed in the catchment.

Mrs. Martin (Meteorological Department) who provided historic meteorological records and gave me permission to obtain data from the GRS met station in the future.

Mr. J. Spurway (Head of the Pedology and Soil Survey Section of DR&SS) for his time obtaining references for me.

Various IH staff for advise on instrumentation and working in Zimbabwe.

References

Chigumira, F. Nenguwo, N. & Jackson, J.E. 1994. Managed vegetable crop trials on dambos in Owen, R., Verbeek, K., Jackson, J. and Steenhuis, T. (editors) Dambo farming in Zimbabwe: water management, cropping and soil potentials for smallholder farming in the wetlands.

Landon, J.R. 1984. Booker Tropical Soil Manual. Longman Group Limited, Harlow, England.

McCartney, M.P. 1995. A study of dambo hydrology in southern Africa - project proposal. Institute of Hydrology, Wallingford, Oxfordshire, England.

Mharapara, I. 1994. A fundamental approach to dambo utilization in Owen, R., Verbeek, K., Jackson, J. and Steenhuis, T. (editors) Dambo farming in Zimbabwe: water management, cropping and soil potentials for smallholder farming in the wetlands.

Rowell, D.L. 1994. Soil Science, Methods and Applications, Longman, Essex.

SAREC, 1994. Project No. 7. UZ Progress Report January 1994.

van Beers, W.F.J. 1953. The auger hole method - field measurement of the hydraulic conductivity of soil below the water table. International Institute for Land Reclamation and Improvement, Wagenigen, The Netherlands.

Location map

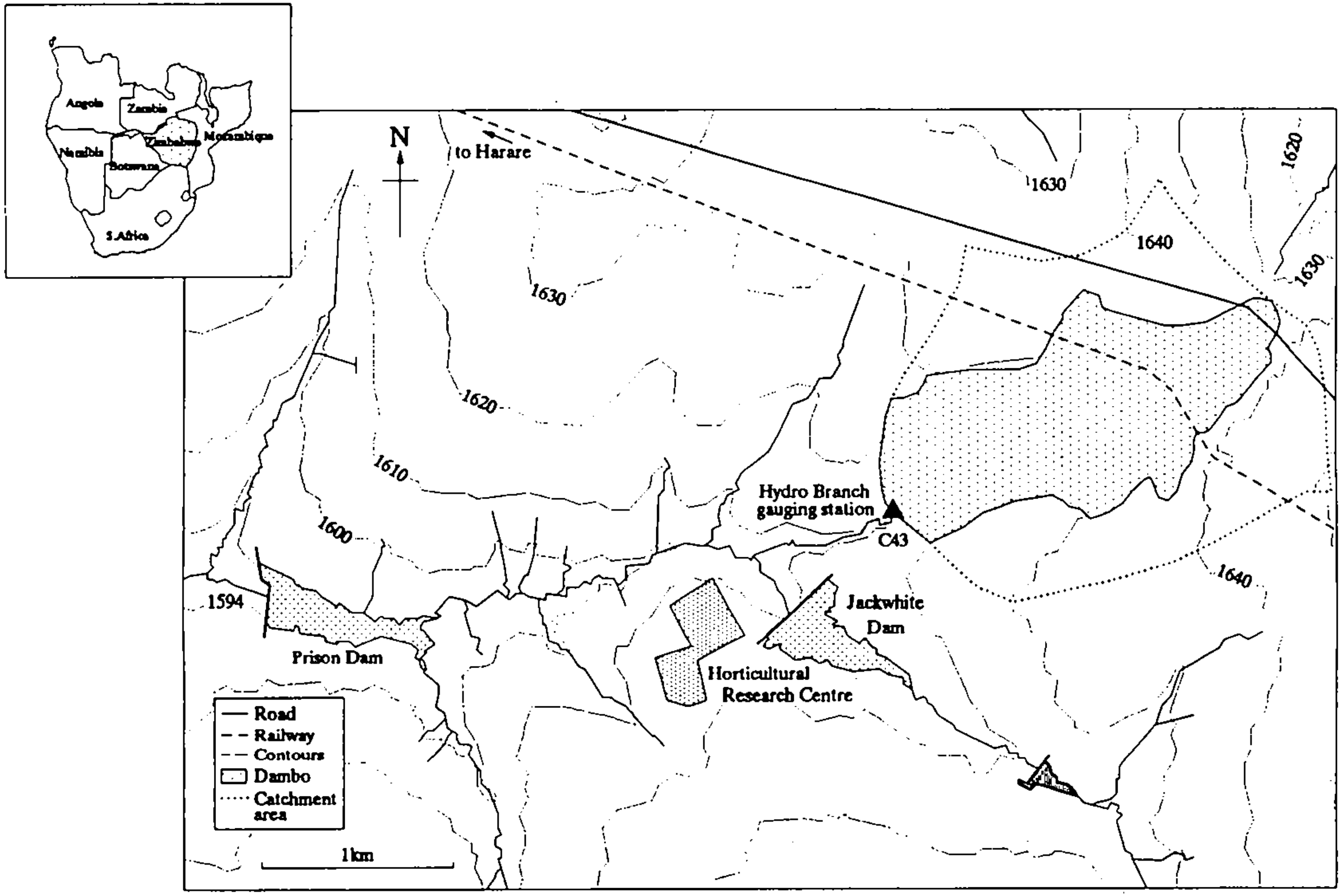


Figure 1

Location of neutron probe access tubes, raingauges, auger holes and soil pits

Figure 2

GRS SHEEP UNIT

		P1a	AT01	P1b								
		3.20	*2.65*	*6.00*								
		P2a	AT02	P2b								
		6.00	*3.40*	*6.00*								
		P3a	AT03	P3b								
		3.95	*4.20*	*5.35*								
		P4a	AT04	P4b								
		3.40	*4.00*	*1.80*								
		P5a	AT05	P5b					AT21			
		4.00	*2.90*	*1.65*					*3.00*			
		P6a	AT06	P6b					AT20			
		2.35	*3.60*	*2.50*					*2.00*			
		P7a	AT07	P7b	P7c				AT19			
		3.00	*3.00*	*1.45*	*1.45*				*2.75*			
		P8a	AT08	P8b	P8c				AT18			
		2.85	*3.30*	*1.20*	*1.20*				*2.75*			
		P9a	AT09	P9b	P9c				AT17			
		4.10	*4.25*	*4.50*	*1.10*				*1.75*			
P17	P18					P19	P20	P21		P22	P23	WEIR
1.85	*2.59*					*1.70*	*2.30*	*1.50*		*1.50*	*1.30*	
		P10a	AT10	P10b	P10c							
		4.50	*2.10*	*3.00*	*0.90*							
		P11a	AT11	P11b	P11c							
		4.50	*4.30*	*3.10*	*1.10*							
		P12a	AT12	P12c	P12b							
		6.00	*4.10*	*3.00*	*6.00*							
		P13a	AT13	P13b	P13c							
		6.00	*4.50*	*6.00*	*1.60*							
		P14a	AT14	P14b	P14c							
		6.00	*4.60*	*5.60*	*3.50*							
		P15a	AT15	P15b								
		5.80	*4.68*	*6.00*								
		P16a	AT16	P16b								
		6.00	*4.30*	*6.00*								

Figure 3 *Schematic showing arrangement of access tubes and piezometers installed and their depths (not to scale). Nos. in italics are the installed depths in metres*

Piezometer installed below clay layer

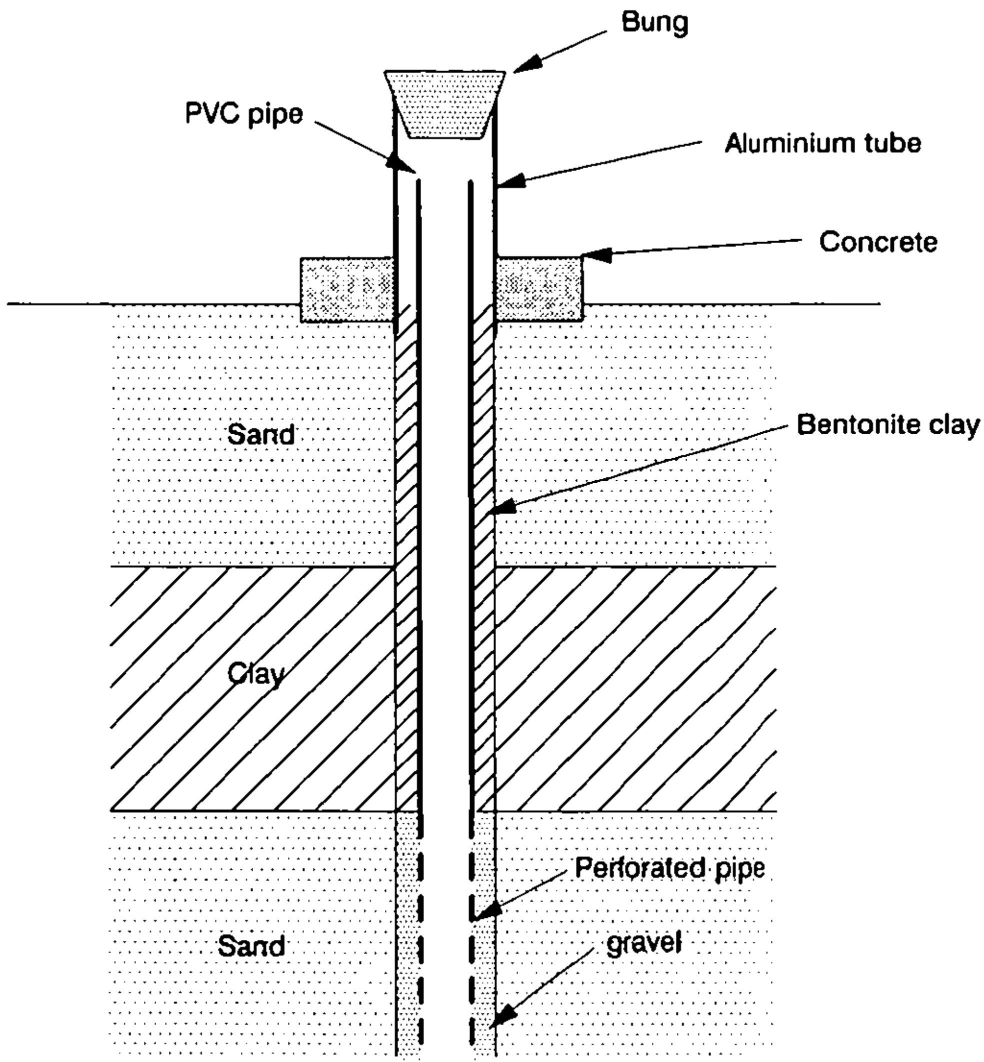


Figure 4

Raingauge and stand

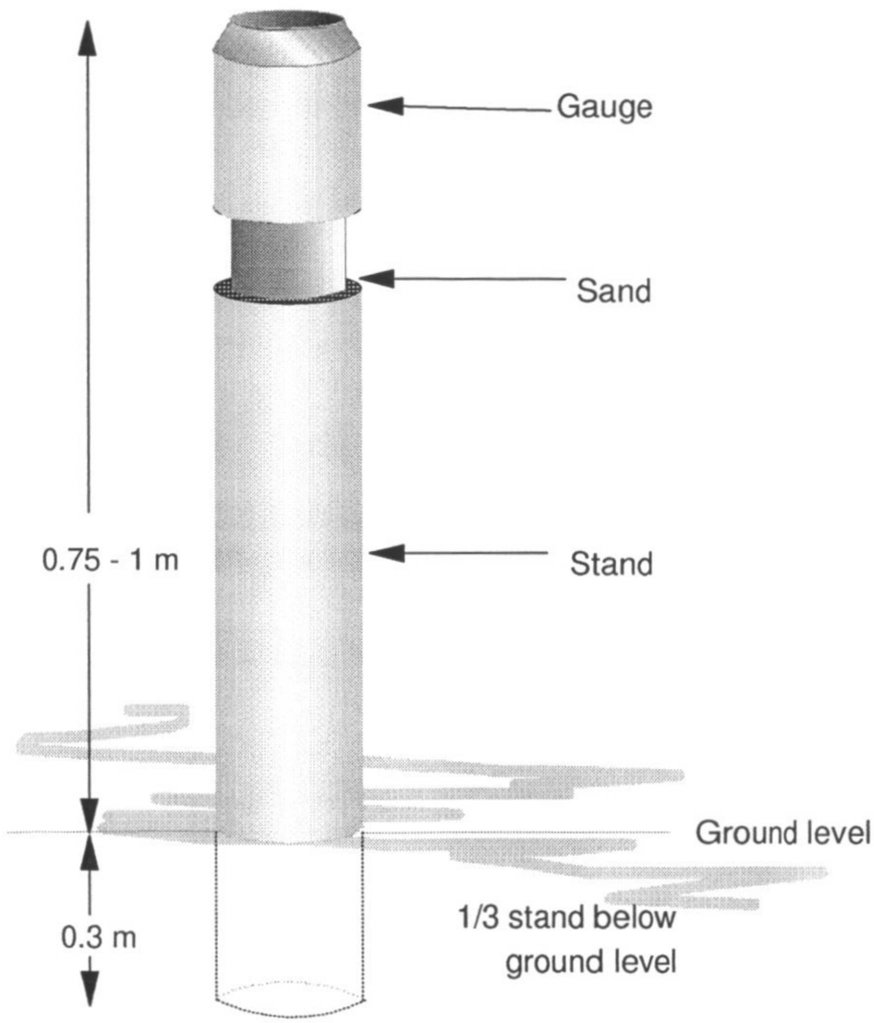


Figure 5

A map showing the vegetation types in the catchment area

Figure 6

Appendix A: Copies of important project documentation relating to work in Zimbabwe

G.P. & S. 42914-V.

FORM RA.3

Research Act, Section 26A.

№ 02016

RESEARCH ACT, 1986

RESEARCH COUNCIL OF ZIMBABWE

CERTIFICATE OF REGISTRATION

Name ...MR. MATHEW McCARTNEY...

Nationality: ....BRITISH.................. Passport No.: B356386

Institution of Affiliation in Zimbabwe: ..DEPT. OF GEOLOGY, UNIVERSITY OF ZIMBABWE

..P.O. BOX MP. 167...

..MOUNT PLEASANT...

Residential Address in Zimbabwe: ....

The bearer has been registered to conduct research in the field of .... HYDROLOGY ....

in terms of section 26A of the Research Act, 1986.

Expiry date: ....31 JUNE 1998..........

....

Signature of Bearer

......P. KABANDA (MRS)..........

Issuing Officer

Research Council of Zimbabwe

Date: ..12 JUNE 1995..........

This receipt is not valid unless it is stamped

SCIENTIFIC LIAISON OFFICE

12 JUN 1995

P.O. BOX CY 294, CAUSEWAY

G.F. & S. 40980-S.
Form No. I.F.8

Regulations, Section 23

REF: A/12151/95

№ 27692

IMMIGRATION ACT, 1979

Temporary Employment Permit

Subject to the conditions stated hereunder, the holder:

Name Matthew Peter McCARTNEY

Date of birth 11 August 1966 Place of birth Mbala, Zambia

Marital status: Married/Single/Divorced/Widowed*

Together with the following dependants:

Spouse ——

Children under the age of 18 years:

1. 4.
2. 5.
3. 6.

Nationality (a) holder British (b) Spouse

is permitted to enter or remain in Zimbabwe:

[redacted]

*(b) for a period from 21 June 1995 to 21 June 1998

* *Delete or complete as appropriate*

and the holder may, whilst in Zimbabwe, engage in the occupation or profession of RESEARCHER

with UNIVERSITY OF ZIMBABWE

(state employer, if applicable)

for Chief Immigration Officer

Date-stamp

Department of Immigration Control Headquarters
23 JUN 1995

[redacted]

CONDITIONS:

This permit is issued subject to the following conditions:

1. The holder must not engage in any occupation other than the occupation, if any, specified in this permit.
2. The holder must not enter employment in Zimbabwe with any employer other than the employer, if any, specified in this permit.
3. The dependants mentioned in this permit must not enter any employment or engage in any occupation in Zimbabwe.
4. Together with all the dependants mentioned in this permit, the holder must leave Zimbabwe before the expiry of the period, if any, specified in this permit, and must surrender this permit to an immigration officer upon his departure from Zimbabwe at the end of that period.
5. The holder must ensure that the dependants listed in this permit comply with conditions 3 and 4 above.
6. The holder any dependant(s) must comply with any other conditions that may from time to time be imposed.

NOTE: For the purposes of this permit, "Occupation" means any work or other activity for gain, or any regular work not for gain but in the interests of any business undertaking operating in Zimbabwe.

Appendix B: Diary of key events during field mission 1

12/06/95	MPM arrives in Zimbabwe. Meeting with Richard Owen, principal collaborator in the Geology Department at the University of Zimbabwe.
13/06/95	Meeting with Irene Welch (Head of the project support unit at the British High Commission) in which she agreed that the High Commission would act as guarantors for the importation of equipment.
14/06/95	Equipment released and collected from Zimbabwe customs.
15/06/95	MPM visits Romwe research catchment to liaise with John Butterworth and to collect neutron probe access tube and installation equipment.
16/06/95-25/06/95	Organising project logistics (e.g. purchase of vehicle, finding somewhere to live, opening of bank accounts etc.) and preliminary survey of the catchment.
26/06/95	Meeting with Dr. P. Ntendy (Head of Station at Grasslands Research Station) to discuss plans for the project.
26/06/95-13/07/95	Preliminary soil survey conducted; exploratory holes augered and 5 soil pits dug.
14/07/95	Meeting with Mr.I. Mharapara (Head of Station at Chiredzi Research Station) to discuss project progress and collaboration.
17/07/95	Soil pits logged and samples taken from all horizons for analyses at the Soil Productivity Laboratory at Grasslands.
18/07/95-31/07/95	Installation of 21 neutron probe access tubes.
20/07/95	Meeting with Mrs. Martin at Meteorological Department to discuss collection of data from the Grasslands Research met. site.
	Obtained Temporary Employment Permit - valid until 21/06/98.
01/08/95-22/08/95	Installation of 48 piezometers.
03/08/95	First visit to the catchment by Mr. I. Mapaure (Senior Research Officer at the National Herbarium and Botanical Gardens) to conduct vegetation survey.
08/08/95-10/08/95	Survey of exploratory auger holes and access tubes to fix locations and elevations by Mr. P.Tavuyanago of AGRITEX.
11/08/95	Installation of 4 Zimbabwe Met. Dept. standard raingauges in the catchment.
14/08/95	Presentation on the project given to UZ Geology Department (including chairman of the Department Dr. T. Blekensop) during lunch-time seminar.
	Meeting with Mr. J. Spurway (Head of the Pedology and Soil Survey Section of DR&SS) to discuss the project and collect information on a previous soil survey conducted at Grasslands.
16/08/95	Second visit to catchment by Mr. I. Mapaure to complete the vegetation survey.
19/08/95	MPM visits Chiredzi to liaise with Chris Lovell.
21/08/95	Meeting with Mr. Luxemburg (Hydro-Branch) to discuss availability of flow data from the C43 weir at the catchment outlet.

23/08/95-25/08/95	First measurements made using the neutron probe to check that it works and to sort out problems with lowering the source down some of the access tubes.
25/08/95	Meeting with Mr. B. Kamanga (GRS Farm Manager) in an attempt to ascertain the history of cultivation in the catchment.
28/08/95	MPM returns to UK

Appendix C: Methodologies used in analysis of soil samples collected from soil pits

The methods of soil analyses used are the standard techniques applied by the Soil Productivity Research Laboratory.

C.1 DRY BULK DENSITY

Three cores were obtained from each soil horizon. The cores were weighed as soon as they were brought to the laboratory (i.e. within 3 hours of collection) and then oven dried at 105°C for 24 hours. Since the volume of the soil cores was known the density of the soil was calculated from the dry weight.

Thus:

$$\text{Dru bulk density} = \frac{\text{mass (dry soil)}}{\text{volume}}$$

For each horizon the mean of the results obtained from the three cases was assumed to represent the correct dry bulk density.

C.2 PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

Soil samples were air dried and screened through a 2 mm sieve. 50 g of soil were transferred to a conical flask and treated with 50 ml of 30% hydrogen peroxide solution to destroy organic matter. 100 ml of 10% sodium hexametaphosphate ("Calgon") was added as a dispersing agent. The sample was shaken and left to slake. After 3 hours the soil suspension was transferred to a soil dispersing cup and stirred with a multimix machine for 10 minutes. The dispersed soil solution was transferred to a glass cylinder and distilled water added to the one litre mark.

A plunger was inserted and moved up and down several times to mix the sample. The time was noted immediately the plunger was removed. The hydrometer was put in the suspension column and the first reading (H1) was made at the top of the meniscus after 40 seconds. The hydrometer was taken out and the temperature of the suspension (T1) noted. The suspension was left to stand undisturbed for 3 hours after which a second reading H2 was also recorded. The temperature (T2) was also recorded at this time.

To determine the particle size distribution of the soil it was first necessary to correct the hydrometer readings to a temperature of 20°C. For every degree over 20°C, 0.36 was added to the hydrometer reading. For every degree below 20°C, 0.36 was subtracted from the hydrometer reading. Also 2.0 was subtracted from every hydrometer reading to compensate for the added dispersing agent and hydrogen peroxide (Day, 1953).

The calculation to determine the particle size analysis was as follows:

Corrected hydrometer reading at the end of 40 seconds was divided by the amount of absolute dry soil taken and multiplied by 100. This result was the percentage of material still in suspension at the end of 40 seconds. This percentage was subtracted from 100 and the result represents the percentage of material settled out at the end of 40 seconds. This represents the sand fraction (2 mm to 0.05 mm). The corrected hydrometer reading at the end of three hours was divided by the weight of the soil and multiplied by 100; the result was the percentage of material still in suspension at the end of three hours and considered to be clay ($\leq$ 0.002 mm). The percentage of silt (0.05 mm to 0.002 mm) was obtained by difference, that is by subtracting the combined percentage of clay and sand from 100.

Thus:

Percentage sand	= 100 - 2(H1 +0.36(T1-20)-2.0)
Percentage clay	= 2(H2 + 0.36(T2-20)-2.0)
Percentage silt	= 100 - (percentage sand + percentage clay)

C.3 pH MEASUREMENT

Soil samples were air dried and screened through a 2 mm sieve. 75 ml of 0.01M calcium chloride solution was added to 15g of soil. The sample was shaken on a reciprocating shaker for 30 minutes. Shortly before taking the readings the pH meter was checked with buffer solutions 7 and 4, making allowances for temperature. After shaking, the electrode was dipped in the solution. The value was recorded when the display stabilised.

C.4 EC MEASUREMENT

Soil samples were air dried and screened through a 2 mm sieve. 40g of soil was dissolved in 200ml of deionised water (ratio of 1:5). The samples were shaken vigorously and left for two hours. Shortly before taking the readings the EC meter was checked with a solution of analar potassium chloride with a known conductivity of 1.413 μScm^{-1}. The solutions were swirled just before the readings were made and the electrode was dipped in the solution. The value was recorded when the display stabilised.

Appendix D: The vegetation of a grassland catchment area in Marondera by Mr. I Mapaure

Seven vegetation types have been identified in the catchment area, ranging from woodland through wooded grassland to grassland and exotic plantations. These are described below and mapped at a scale of 1:25000 (Figure 6).

D.1 MIOMBO WOODLAND

Three small patches of miombo woodland occur in the catchment area, one of which is heavily disturbed and virtually devoid of a shrub layer. This vegetation type occurs on the higher sand areas of the catchment.

Much of the woodland is dominated by *Brachystegia spiciformis* which forms almost pure stands in some places. The canopy, which consists mainly of this species, is up to 10 m and formed by more or less even-aged trees, save for a few older emergents. This is mainly true for the larger area of miombo woodland. Other common trees include *Julbernardia globiflora, Parinari curatellifolia, Cussonia arborea, Burkea africana* and *Ochna pulchra.*

The small miombo patch in the north-west of the catchment area is some what different in character and *Julbernardia globiflora* is co-dominant. It has a significant number of *Parinari curatellifolia* trees on the edges. There are virtually no grass and shrub layers with high occurrences of *Achyranthes aspera* and *Bidens pilosa* in most areas. This is indicative of disturbance by cattle which find shade under the trees. The narrow belt of miombo in the eastern part of the catchment is also devoid of natural undergrowth. There are also lots of weeds including *Bidens pilosa, Amaranthus hybridus, Solanum delagoense* and *Datura stramonium.*

In the intact miombo to the south the shrub layer is sparse with occasional bare patches on the ground. It consists of a mixture of several species among which *Eriosema engleranum, Pavetta schumanniana, Lopholaena coriifolia, Helichrysum krausii* and *Rhynchosia resinosa* are prominent. Typical on the ground forming discontinuous mats is *Leptactinia benguelensis.* The grass layer is also poorly developed with very few occasional tufts of *Sporobolus pyramidalis, Melinis repens* and *Arundinella nepalensis.*

D.2 MIXED SPARSE WOODLAND

On the edges of the catchment area to the north-west on sandy soils is a small patch of sparse woodland which, in some places, assumes the structure of a wooded grassland. It comprises a mixture of species whose dominance varies from place to place.

The most common trees in this woodland are *Combretum molle, Strychnos spinosa, Burkea*

africana, *Albizia antunesiana* and *Vangueria infausta*. Other occasional trees include *Cussonia arborea*, *Ekebergia benguelensis*, *Ozoroa insignis*, *Acacia sieberiana* and *Faurea speciosa*. The common shrubs are *Euclea crispa*, *Lippia javanica*, *Maytenus senegalensis*, *Eriosema ellipticum*, *Eriosema engleranum*, *Pavetta schumanniana*, *Lopholaena coriifolia* and *Maytenus heterophylla*. *Phytolacca dodecandra* is also a common scramber in the thickety formations on some of the low termitaria. Also prominent are the subshrubs *Combretum platypetalum* subsp. *oatesii*, *Parinari capensis* and *Eugenia malangensis* at the edges with the grassland on sandy soils.

The grass layer is mostly well developed in places on higher ground and somewhat patchy in disturbed lower places towards the west. More frequent grasses are *Hyparrhenia filipendula*, *Pogonarthria squarrosa*, *Sporobolus pyramidalis*, *Aristida junciformis*, *Hyperthelia dissoluta* and *Perotis patens*.

A lot of termitaria occur in this area, supporting a different kind of vegetation. The most common grass on termitaria is *Cynodon dactylon* whilst common woody species are *Solanum delagoense*, *Protasparagus laricinus*, *Pavetta gardeniifolia*, *Pavetta schumanniana*, *Diospyros lycioides*, *Solanum incanum*, *Chenopodium ambrosioides*, *Leucas martinicensis* and *Ocimum urticifolium*.

D.3 GRASSLAND

The grassland is by far the largest of all the vegetation types in the catchment area. Two distinct types based on species dominance can be recognized. These are the vlei channel and the *Hyparrhenia filipendula* grasslands. Species dominance of these two types is largely determined by their tolerance to periodic waterlogging.

D.3.1 Vlei Channel grassland

This grassland is found as a narrow belt of up to 10m along the vlei channel. It is characterised by grass and sedge species which can tolerate periodic waterlogging. Species dominance is not uniform along the whole channel but rather exhibits mosaics of local dominances of different species. The wettest parts of the vlei channel, especially towards the weir, support *Polygonum senegalense*, *Cyperus digitatus*, *Ranunculus multifidus*, *Verbena bonariensis* and, sometimes, *Typha latifolius*. The Common grasses some of which show local dominances are *Hemarthria altissima*, *Paspalum urvillei*, *Arundinella nepalensis*, *Aristida junciformis* and *Themeda triandra*. Other herbs include *Senecio strictifolius*, *Helichrysum* species and *Kniphofia linearifolia*. The common aquatic macrophyte is *Potamogeton thunbergii* which is quite abundant in the pools.

D.3.2 *Hyparrhenia filipendula* grassland

This medium grassland of up to 1.2 m is found in the rest of the vlei area extending from the vlei channel grassland to the woodlands and wooded grasslands on the higher ground. It is dominated by *Hyparrhenia filipendula*. Localised dominances of other grass species are also evident. There is a small patch of grassland to the north of the stream close to the weir which is dominated by *Aristida junciformis*. Small areas dominated by *Setaria incrassata*, Sporobolus pyramidalis and *Loudetia simplex* also occur. Species composition tends to vary

from place to place but the overall dominant grass remains *Hyparrhenia filipendula*. Other common grasses within this type are *Pogonarthria squarrosa*, *Hyperthelia dissoluta*, *Sporobolus pyramidalis*, *Cynodon dactylon*, *Eragrostis chapellieri*, *Setaria pumila*, *Stereochlaena cameronii* and *Eragrostis superba*.

There are quite a number of broad-leaved herbs within the grasses. Their composition also varies from locality to locality. They include *Lannea edulis*, *Lopholaena coriifolia* and *Syzygium guineense* subsp. *huillense*. A lot of termite mounds are scattered within the grassland. These mainly support *Cynodon dactylon* and *Solanum delagoense*.

Certain areas seem to have been cultivated a few seasons ago as evidenced by the loose top soil and contour ridges in some places. Part of this area is still fenced off, apparently to keep out livestock. These areas support a wide range of weed, the dominant species being *Bidens biternata*. Other weeds are *Tagetes minuta*, *Bidens pilosa*, *Conyza albida*, *Sesbania microphylla*, *Oldenlandia corymbosa*, *Dactyloctenium aegyptium* and *Eleusine indica* subsp. *africana*.

D.4 WOODED GRASSLAND

Two patches of wooded grassland occur in the catchment. Their separation is based on the structure, condition and the species composition of the woody component. One is quite tall whilst the other is shorter and degraded.

D.4.1 Tall Wooded Grassland

A wooded grassland with tall grasses is found in a small area between the main area of miombo and the *Hyparrhenia filipendula* grassland in the southern to south-eastern part of the catchment. This area seems to have been cultivated a long time ago but grasses have taken over with scattered trees since its abandonment. This type is characterised by low trees and tall grasses of up to 2m. The main trees are *Brachystegia spiciformis* and *Julbernardia globiflora*. Common shrubs include *Eriosema ellipticum*, *Lopholaena coriifolia*, *Helichrysum krausii*, *Pycnostachys urticifolia* and *Eriosema engleranum*.

The main grasses are *Hyparrhenia filipendula*, *Hyperthelia dissoluta*, *Pogonarthria squarrosa* and *Eragrostis* species.

D.4.2 Degraded Wooded Grassland

A very small patch of degraded grassland occurs in the western part of the catchment. It is characterised by short grasses of up to 1m and high densities of shrubs with occasional open patches. Unlike 4.2 above, a number of termitaria are also found in the area, supporting several woody species.
The common grasses include *Hyparrhenia filipendula*, *Pogonarthria squarrosa*, *Cynodon dactylon*, *Eragrostis chapellieri*, *Perotis patens* and *Heteropogon contortus*. Evidence of degradation comes from the many *Lopholaena coriifolia* shrubs which sometimes form dense clumps in the area with isolated grass tussocks in places. Other common shrubs are *Sida cordifolia*, *Parinari capensis*, *Syzigium guineense* subsp. *huillense*, *Pavetta schumanniana* and *Maytenus senegalensis*. Larger trees are mainly confined to termitaria, among which *Syzygium guineense* subsp. *guineense* and *Acacia sieberiana* are prominent.

D.5 PLANTATIONS

Quite a sizeable area of the catchment is planted with exotics, particularly *Eucalyptus camaldulensis* and other species. The plantations are maily composed of very old coppice of the *Eucalyptus* which has grown to heights of 30m in some cases. A number of indigenous shrubs form the undergrowth. These include *Eriosema engleranum*, *Pavetta schumanniana*, *Helichrysum krausii*, *Gnidia krausiana*, *Rhynchosia resinosa*, *Lippia javanica*, *Indigofera arrecta*, *Blumea alata* and *Euclea crispa*. In some places low trees of *Julbernardia globiflora* and *Brachystegia spiciformis* occur as well as scattered specimens of *Pinus patula*.

There is evidence of a fire which burnt through the main plantation close to the main Harare-Marondera road.

Natural
Environment
Research
Council