## Introduction

Mr R J Peart and Mr J Davies visited Zimbabwe during the period 30th October - 2nd December to field test EKS geophysical surveying equipment with the assistance of Ministry of Water Resources Development (MWRD). A variety of hydrogeological environments were visited at widespaced localities within Zimbabwe. Counterpart officers and assistants were supplied by MWRD. At the time of the visit Zimbabwe was in the grip of a major drought, similar in intensity to the last major drought that ended in 1992. Towards the end of the visit heavy rains within the north Matabeleland, Midlands and west Mashonaland areas signalled the end of the drought.

Hydrogeological data available from the sites visited are outlined below. These include a locality map, simple geological and hydrogeological data and specific references. The sites visited are shown on Figure 1 and listed in Table 1.

Detailed data are available from collector well sites constructed by BGS since 1982. These data are derived from a number of reports describing studies of Basement Complex aquifers and Collector Well systems, undertaken in Zimbabwe during the 1980's. A typical section through weathered basement is shown of Figure 2. The preferred horizon for drilling horizontal boreholes into from these wells is the brecciated zone at the base of the weathered regolith layer (Figure 3). Typical aquifer data, safe yields and specific capacity data for collector well systems constructed within weathered basement aquifers are presented in Table 2. Unfortunately the quality of data from the borehole and sand river sites visited are very variable. Some of these are held by consultants within Zimbabwe and are not available from the MWRD groundwater data system.

The BGS installed collector wells continue to be operated successfully. At the collector well sites visited they were frequently the only reliable source of water within their respective areas during the recent prolonged drought.

| Site No. | Location | Grid Ref |
|---|---|---|
| 1a (CW) | Hatcliff Willowtree | TR 993 412 |
| 1b (CW) | Hatcliff Windpump | TR 982 403 |
| 2a (CW) | Murape School, Seke | UR 081 039 |
| 2b (CW) | Marikopo School, Seke | UQ 118 984 |
| 3a (Bh) | Bh 14 Stamford Farm | TR 812 353 |
| 3b (Bh) | Bh 15 Stamford Farm | TR 814 353 |
| 3c (Bh) | Bh 17 Stamford Farm | TR 815 351 |
| 4a (Bh) | Bh 40a Nhondamapango Village | UR 769 783 |
| 4b (Bh) | Bh 40b Nhondamapango (Matambadzo) | UR 756 794 |
| 4c (Bh) | Bh 45a Chivhinge Village | UR 726 908 |
| 4d (Bh) | Bh 45b Chivhinge Village | UR 729 906 |
| 5 (CW) | Romwey | TN 673 037 |
| 6 (CW) | Chiredzi Agric Res Sta | UM 515 757 |
| 7a (CW) | Machoka | VM 083 760 |
| 7b (CW) | Masekesa | VM 078 799 |
| 8 (SR) | Gudo's Pool, Save River | VN 183 017 |
| 9a (Bh) | Bh 14 Mushikavanhu Irr Sch | VN 264 401 |
| 9b (Bh) | Bh 11 Mushikavanhu Irr Sch | VN 266 416 |
| 9c (Bh) | Bh 16 Mushikavanhu Irr Sch | VN 264 345 |
| 9d (Bh) | Bh 17 Mushikavanhu Irr Sch | VN 264 340 |
| 10a (SR) | Bwemula School, Umzingwane R. (basalt) | QG 614 025 |
| 10b (SR) | Bwemula School, Umzingwane R. (sdst) | QG 606 035 |
| 11a (SR) | Cawood Ranch, Umzingwane R. (basalt) | QF 879 685 |
| 11b (SR/Bh) | Cawood Ranch, Umzingwane R. (basalt) | QF 873 689 |
| 12 (SR) | Zhove Dam, Umzingwane R. (basalt) | QF 799 823 |
| 13a (Bh) | Habane Township, Esingodini | QH 038 531 |
| 13b (Bh site) | Esingodini Agric College | QH 029 511 |
| 14a (Bh) | Bh 99, Nyamandhlovu | PJ 321 031 |

| | | |
|---|---|---|
| 14b (Bh) | Bh 79, Nyamandhlovu Well Field | PJ 440 074 |
| 14c (Bh) | Bh 95, Nyamandhlovu Well Field | PJ 438 048 |
| 14d (Bh) | Test Bh, Nyamandhlovu | PH 407 997 |
| 15 (CW) | Ndambuleni School, Lupane | PK 008 061 |
| 16a (Bh) | Mudingule village | MK 647 764 |
| 16b (Bh) | Zwabo Village | MK 517 807 |
| 16c (Bh) | Ilambo School | MK 813 659 |
| 16d (Bh) | Ilambo Village | MK 815 640 |
| 17a (Bh) | Intundhla Railway Siding | NK 323 022 |
| 17b (Bh) | Kennedy Railway Siding | NK 175 145 |
| 17c (Bh) | Water Loop Railway Siding | NK 052 247 |
| 18a | RTZ Empress mine spillage area | QK 560 583 |
| 18b | RTZ Empress mine slimes dam | QK 589 572 |
| 19 (CW) | Mukumba School, Chiota | UQ 162 767 |
| 20 (CW) | St Lioba's School, Wedza | UQ 633 398 |

Key
SR - sand river
CW - collector well
BH - borehole

Table 1. Location of EKS Survey Sites Visited in Zimbabwe

## Area 1 - Hatcliff Agricultural Research Station, Harare

### Site 1a - Willowtree Collector Well, Hatcliff.

Data collected during the EKS survey:-
Collector well depth 10.1m, water level 9.03m from top of casing (toc at ground level).

The Willowtree collector well was designed to provide irrigation water at 2 l/sec for 10 hours per day using an animal powered pump. This pumping system is currently out of use due to the water table being below pump intake level.

Investigation drilling, surface geophysical surveys, well construction and well test pumping are described in Wright et al (1985). 29 investigation boreholes were drilled to assess the depth of weathered bedrock. 77 Schlumberger VES soundings were undertaken along 8 lines radiating from borehole 12. Weathered regolith thickness varies from 8 to 15m across the site (figure 1). Typically clay/silt content varies from 78 to 95% in the upper 6m. From 6 to 9m sandy material occurs, with weathered bedrock below 9m. The collector well was located at borehole 29 where the thickest regolith was located (14.9m). During well excavation silts and clays were found to 4.5m depth. From 4.5 to 14.9m sandy friable and fractured weathered Basement Complex epidiorite was found. Six horizontal boreholes were drilled radially from the base of the well, most being 25 to 30m long. On completion, the water table in the well was 6.10m bgl. During well test water was pumped at 3.6 l/sec, a transmissivity of 50 $m^2$/day being calculated for the surrounding aquifer.

### Site 1b - Windpump Collector Well, Hatcliff.

Data collected during the EKS survey:-
Collector well depth 8.79m, water level 3.76m (toc at gl).

The Windpump collector well is located upon metabasalt of the Arcturus Formation south of a dolerite dyke that crops out as a prominent east-west trending ridge. The well is equipped with a windmill to supply water for stock watering and irrigation at a rate of 2 l/sec.

Investigation drilling, surface geophysical surveys, well construction and well test pumping are described in Wright et al (1985). Five investigation boreholes were drilled to depths of 10 to 26m without encountering bedrock. 43 Schlumberger VES soundings were undertaken along 8 lines radiating from borehole 7. Weathered regolith is composed of clays with some sands at 0-6m, sands and gravels at 6-10m, and weathered bedrock at 15-26m. The collector well was located at borehole 7 where the deepest zone of weathering was recognised. Four horizontal boreholes were drilled radially from the base of the well, most being 28 to 30m long. On completion, the water table in the well was 3.57m bgl. During well testing water was pumped at 6 l/sec, a transmissivity of 27 $m^2$/day being calculated for the surrounding aquifer.

**Area 2 - Seke**

**Site 2a - Murape Collector Well, Seke.**

Data collected during the EKS survey:-
Collector well depth 14.4m, water level 6.68m (toc), water level 5.70m (bgl).

The Murape collector well was installed as the water source for Murape school (600 pupils and 75 residential staff) and the local population. It was the only reliable water source for the local population during the recent drought when the school borehole dried up.

Investigation drilling, surface geophysical surveys, well construction and well test pumping are described in Wright et al (1985). 22 investigation boreholes were drilled to assess the depth of weathered bedrock. A series of Schlumberger VES soundings were undertaken across the site. The collector well was located between boreholes 14 and 15 upon the deepest zone of weathering, 18.6-22.2m thick. During well excavation, sand and gravel with clay were found to 8m depth. From 8 to 14.25m friable and fractured basement material composed of weathered augen granitic gneiss was found. Six, 30m long, horizontal boreholes were drilled radially from the base of the well. On completion the water table in the well was 3.68m bgl. During a well test water was pumped at 1.53 l/sec, a transmissivity of 7 $m^2$/day being calculated for the surrounding aquifer.

**Site 2b - Marikopo Collector Well, Seke.**

Data collected during the EKS survey:-
Collector well depth 12.9m, water level 12.42m (toc), water level 11.17m (bgl).

The Marikopo collector well was installed as the water source for a primary/ secondary school of several hundred pupils and staff. It was the only reliable water source for the local population during the recent drought. Water was often collected in 200 litre drums on scotch carts to be transported to a widespaced network of surrounding communities.

The collector well is located in the upper valley of the Madedzurgwi stream near the watershed with the main Hunyani River, on Older Gneiss Complex rocks. An extensive dolerite sill occurs close to the school. Investigation drilling, surface geophysical surveys, well construction and well test pumping are reported in Wright et al (1985). 53 investigation boreholes were drilled to assess depth of weathered bedrock. 52 Schlumberger VES soundings and EM34 traverses were undertaken across the site. The collector well was located between boreholes 38 and 28 upon the deepest zone of weathering, 12.2-13m deep. During well excavation sand and gravel with clay were found to 6m depth with clay between 2 and 5m. From 6 to 11.7m friable and fractured basement material composed of weathered granite was found. Massive granite bedrock was encountered at 12m depth. Eight horizontal

boreholes were drilled radially from the base of the well, six being 30m long the other two being 15 and 27m in length. On completion the water table in the well was 5.374m bgl. No long term pumping test was conducted upon this well due to its poor yield of 910 l/day, inadequate to supply the local school.

**Marikopo School, Seke.**

EKS surveys were undertaken at Marikopo school to investigate shallow clayey weathered layers on dolerite bedrock.

**Dema River, Seke.**

EKS surveys were conducted at an outcrop of Basement meta-granite with pegmatitic veins on the riverbank down stream of the dam at Dema.

**Area 3 - Stamford Farm.**

**Site 3a Borehole No. 14**

**Site 3b Borehole No. 15**

**Site 3c Borehole No. 17**

Many boreholes have been drilled on the Goodhope and Stamford farms for Mr Arnott and his son. Each borehole is equipped with an electrical submersible pump capable of producing about 1.25 l/sec. Borehole yields have declined during the last decade in response to increase groundwater abstraction in the district as farmers try to compensate for the effects of repeated cycles of drought. In consequence, with the lack of recharge and increased abstraction water levels must have dropped but by how much is not known since nobody undertakes long or short term water level monitoring. Fortunately Mr Arnott and his son understand the worth of groundwater and that it is a limited resource that depends upon recharge of rainfall.

Baldock (1991) describes the area, part of the Harare district, as being underlain by rocks of the Passaford and Murowodzi Formations that include metadacites with iron formations overlying Gwebi Member and meta-arenites with interbedded meta-rhyollites, phyllites, metadolerites and metagabros. Phyllites and metadacites appear to predominate in the Stamford area where they are seen to have weathered to form near surface thick clays mined to the north of Stamford for brick making.

Only the boreholes on Stamford farm were located at suitable distances away from major power lines to permit EKS surveys to be undertaken. EKS surveys were undertaken in turn at each of three boreholes all equipped with electrical submersible pumps. Prior to survey the pump in the adjacent borehole had to switched off. Information regarding the borehole lithological logs and resistivity profiles undertaken on Samford Farm need to be obtained from Jeremy Prince (to be contacted).

**Area 4 - Japanese Aid Drilling Sites, Murewa**

The Japanese funded the drilling of a series of 54 village water supply borehole sites within the Uzumba, Maramba and Pfungwe Communal Land areas north of Murewa. According to Stidolph (1977) the local rocks are Younger Granites with ardamalites and granodiorites intruded as specific stocks. These rocks have very poor water yielding properties, hence most of the boreholes drilled were either dry or low yielding. Two villages, Nhondamapango and Chivhinge were visited. Dry and yielding boreholes had been drilled at both villages. Unfortunately the Japanese company undertaking the drilling were not wiling to provide detailed data from the boreholes visited, some information was however obtained from a local driller and chip samples found on site.

**Site 4a - Nhondamapango Village, Borehole No. 40A**

Depth 61m
Yield dry
Geological log (from samples left at site)
0- 2m ferrecrete
2- 4m sandy clay
4-13m off white micaceous granite
14-50m hard granitic gneiss, much black mica

A hand dug well about 5m deep is used as a source of water for small garden adjacent to the drill site. The water appears to seep from the base of the ferrecrete layer.

**Site 4b - Nhondamapango Village (Matambadzo), Borehole No. 40b**

Depth 55m
Yield 0.15 l/sec
Static water level 12m
First water struck 47m
Drilled diameter 0- 5m @8.25 inches,
5-55m @ 6.5 inches,
cased with 4 inch Proterite PVC.

Borehole site is located adjacent to a large flowing spring used to gravity feed a garden plot irrigation scheme. The borehole had not yet been equipped.

**Site 4c - Chivhinge Village, Borehole No. 45a**

Depth 50m
Yield dry
Geological log
0- 3m soil with ferrecrete
3-15m soft gneiss with large crystalline chips
3-50m Hard gneiss fine dust returns
Borehole mostly drilled in granitic gneiss with much black biotite mica.

This borehole was drilled at the western edge of a large field adjacent to well equipped with a bush pump that according to local farmers is not able to supply sufficient water for large

meetings and celebrations.

**Site 4d - Chivhinge Village, Borehole No. 45b**

Depth 37m
Yield 0.42 l/sec
Geology
0 - 37m  light fawn coloured weathered granite

This borehole had been drilled in the middle of a large, long time cultivated field. It had been equipped with Mk2 Bush Pump which the local farmers would like to use as a source of irrigation water, hence its location.

Possible pollution problem from agro-chemicals, applications discussed with farmers.

**Area 5 - Romwey**

**Site 5 - Romwey Collector Well**

Chilton and Talbot (1992) describe installation of a collector well at Romwey during 1991. This is the main water source for three small villages of more than 100 families. Romwey is located at the junction of the Limpopo mobile belt, to the south, and the Zimbabwe Kraton, to the north. Granitic gneiss with interbedded bands of mafic rocks underlie the area. During 1990 four exploration boreholes were drilled at locations shown on Figure . The geological logs of these boreholes are presented in Tables . Weathering to depths in excess of 17m was recorded in these boreholes. Excavation of the well was begun in 1990; the geological log of the well is presented in Table . Four laterals were drilled out from the base of the well as shown in Figure . Lateral 3 has the highest rate of water inflow. During testing, the well was pumped for 100 minutes at 4.38 l/sec for a drawdown of 5.45m. A transmissivity of 0.98 $m^2$/day and storage coefficient of 1.30 were determined from analysis of test data. A long term safe discharge rate of 0.96 l/sec was determined from data obtained from a series of short term tests conducted over a long period of time.

## Area 6 - Chiredzi Agricultural Station

### Site 6 - Chiredzi Collector Well

Data collected during the EKS survey:-
Collector well water level 6.16m (toc), water level 5.77m (bgs).

Chilton and Talbot (1990) describe installation of a collector well at the Chiredzi Agricultural Research Station during 1989. Water is pumped from this well to a demonstration small-scale irrigation scheme. The research station is underlain by interbedded gneisses, schists, marbles and argillaceous rocks of the Precambrian Beit Bridge Group (Swift et al (1953). These rocks are intruded by Karroo age dolerite dykes. The location of nine exploration boreholes drilled in 1988 are shown on Figure  the drilling results being presented in Table . Weathering to depths of 10-26m were recorded in these boreholes. Excavation of the well, located between boreholes 12 and 13 was begun in February 1989. The geological log of the well is presented in Table . Four laterals were drilled from the base of the well as shown in Figure . Significant inflows of water occur from laterals 1 and 4. The well was test pumped for 130 minutes at 5.58 l/sec for a drawdown of 7.05m. A transmissivity of 7.0 $m^2$/day and storage coefficient of 0.2 were determined from analysis of test data. A long term safe discharge rate of 2.97 l/sec was determined from data obtained from a series of short term tests conducted over a long period of time.

**Area 7 - South Save Plan International Collector Wells**

The South Save area is underlain by a series of Karroo age basalts interbedded with andersites (Swift et al, 1953). The black fine grained olivine basalts contain phenocrysts of olivine. The rocks weather dark brown weathered. The andesites include pyroxene and feldspar phenocrysts. These are fine grained, grey or black rocks that weather brown or purple.

Plan International financed the installation of two large diameter wells Machoka School and Masekesa designed to supply irrigation water to garden plots. They were excavated into andesitic rocks; described as basalts in the geological logs (Thompson, Lovell, Chilton and Macdonald 1995).

**Site 7a - Machoka School Large Diameter Well No. 7**

Details of the exploration borehole was drilled at this site are as follows:-

| | |
|---|---|
| Depth | 18m |
| Diameter | 150mm |
| First water strike | 8m |
| Rest water level | 7.92m (21/4/94) |
| Yield by air lift | 0.65 l/sec |

Geology

| | |
|---|---|
| 0 - 3m | Clay |
| 3 - 7m | Weathered Basalt |
| 7 - 10m | Harder basalt with break at 9m |
| 10 - 18m | Weathered hardish basalt |

Details of the large diameter well are as follows:-

Geological log

| | |
|---|---|
| 0 - 3m | Clay |
| 3 - 4m | Soft friable weathered basalt |
| 4 - 5m | Weathered basalt some calcrete |
| 5 - 6m | Grey fine grained weathered basalt |
| 6 - 7m | Reddish black basalt |
| 7 - 8m | Pale grey weathered to fresh basalt with black phenocrysts of olivine |
| 8 - 9m | Grey basalt with green-grey clay |
| 9 - 10m | Grey basalt |
| 10 - 11m | Dark grey to reddish purple basalt some quartz filled vesicles and veins |
| 11 - 12m | Fresh basalt, little iron staining |
| 12 - 13m | Dark grey basalt with green patches, some quartz filled vesicles |
| 13 - 14m | Reddish basalt with green phenocrysts and pale greenish grey basalt with dark green phenocrysts |
| 14 - 16m | Greenish grey basalt and reddish basalt both with dark green phenocrysts |
| 16 - 17m | Pale grey basalt |
| 17 - 18m | Grey basalt, some weathering, some calcite veining |

Pumping test results

| | |
|---|---|
| Date | 25/10/94 |
| Duration | 5hrs |
| Volume dewatered | 2.25$m^3$ |
| Volume pumped | 18$m^3$ |

| | |
|---|---|
| Rest water level | 7.86m |
| Pumped water level | 8.51m |
| Drawdown | 0.65m |
| Yield | 1.0 l/sec |

Laterals have not been drilled from the base of this well. Although not in regular use due to a local administrative dispute water from this well is used by pupils and staff at the adjacent school.

**Site 7b - Masekesa Collector Well No. 8**

Details of the deeper of two exploration boreholes drilled at this site are as follows:-

| | |
|---|---|
| Depth | 30m |
| Diameter | 150mm |
| First water strike | 18m |
| Main water strike | 18m |
| Rest water level | 9.24m (21/4/94) |
| Yield by air lift | 0.36 l/sec |

Geology

| | |
|---|---|
| 0 - 6m | Soft |
| 6 - 7m | Hard pieces |
| 7 - 8m | Weathered |
| 8 - 9m | Basalt |
| 9 - 14m | Decomposed basalt |
| 14 - 17m | Moist decomposed basalt |
| 17 - 18m | First water strick in decomposed basalt |
| 18 - 19m | Decomposed basalt |
| 19 - 23m | Hard pieces slightly weathered basalt |
| 23 - 26m | Quite hard basalt |
| 26 - 30m | Hard basalt |

Details of the Large diameter well are as follows:-

Geological log

| | |
|---|---|
| 0 - 1m | Black sandy, silty soil |
| 1 - 2m | Grey clay |
| 2 - 4m | Grey basalt, some iron staining, some white quartz and calcite partings |
| 4 - 4.5m | Grey basalt, some white calcrete |
| 4.5 - 5m | Grey and weathered brown-buff basalt, some calcite |
| 5 - 6m | Weathered grey basalt and white calcite |
| 6 - 7m | Slightly weathered grey basalt some calcite |
| 7 - 8m | Grey slightly weathered to fresh basalt with calcite |
| 8 - 9m | Grey slightly weathered basalt |
| 9 - 10m | Grey slightly weathered basalt |
| 10 - 11m | Very weathered basalt some clay, no calcite |
| 11 - 12m | Weathered reddish basalt, some friable very weathered basalt |
| 12 - 13m | Weathered reddish basalt |
| 13 - 14m | Slightly reddish weathered basalt |
| 14 - 18m | Coarse grained grey basalt with buff-reddish iron staining, some weathering |

Four horizontal laterals were drilled at 90 degree intervals at a depth of 16m in this well. These laterals are 9, 19.5, 27

and 27m long, drilled into weathered andesite.

Pumping test results, after drilling of the laterals

| | |
|---|---|
| Date | 11/11/94 |
| Duration | 5hrs |
| Volume dewatered | 9.46$m^3$ |
| Volume pumped | 18$m^3$ |
| Rest water level | 9.49m |
| Pumped water level | 12.22m |
| Drawdown | 2.73m |
| Yield | 1.0 l/sec |

Water pumped from this well is used for crop irrigation within an extensive garden adjacent to the well.

**Area 8 - Save River**

**Site 8 - Gudo's Pool Sand River (Save River)**

Gudo's Pool is an embayment eroded by the Save River down stream of the faulted contact between the Upper Karroo Stormberg Sandstones and the younger Stormberg basaltic lavas. This embayment has been infilled with a reported 21 m of Recent alluvial sands overlying Karroo Basalt. The water table within these sands was noted at about 2m below the surface. The local population obtain drinking and washing water from shallow wells excavated into the bed of the Save River at this point.

**Area 9 - Mushikavanhu irrigation scheme**

The development of the alluvial aquifers of the Lower Save Valley has been reviewed by Broderick and Mutirwara (1995). They conclude that the Middle Save Valley has developed along a prominent north - south trending fracture zone of block faulting interpreted from aeromagnetic survey data. The three parallel faults recognised are, from east to west, the Great Save Fault, the Mennell Fault and the Mushikavanhu Fault. The Recent alluvial sediments deposited within this down faulted trench are up to 110m thick. They are derived from fan cones deposited along the eastern escarpment and fluviatile sediments deposited by the Save River. A basal boulder bed, underlying most of the Recent sediments, forms the main, confined aquifer within this alluvial sediment sequence. It is separated from the overlying unconfined sandy aquifer and confined by the Save clay unit. The upper unconfined aquifer is in hydraulic continuity with the Save River, the river being the main source of recharge for the former. Aquifer transmissivities up to 1500 $m^2$/day and yields of 40-100 l/sec obtained from these aquifer units. These sediments thin to the south within the Mushikavanu area, feathering out to the south on Karroo sediments. A series of production boreholes have recently been drilled to supply irrigation water to the Mushikavanu communal land area. EKS surveys were undertaken adjacent to four of these borehole sites.

**Site 9a - Borehole No. 11**

RWL 11.65m from gl (11/11/95)

Geological log
 0 -  6m clay with touches of sand
 6 - 12m river sand
12 - 13m fine to medium sand
13 - 28m river sand
28 - 30m fine sand
30 - 44m river sand
44 - 50m whitish grey clay with some medium sand
50 - 55m fine to coarse sand
55 - 65m light grey clay in fine to medium sand
65 - 70m fine sand
70 - 75m sand and clay 50%/50%
75 - 81m clean fine to medium sand
81 - 84m Sandy clay, light brown clay with 40% medium sand

Drilled diameter @ 20 inches by direct circulation mud flush
Construction log
 0 - 30m steel casing 300mm
30 - 45m PVC screen 300mm
45 - 51m steel casing 300mm
51 - 57m PVC screen 300mm
57 - 66m steel casing 300mm
66 - 72m PVC screen 300mm
72 - 75m steel casing 300mm
75 - 81m PVC screen 300mm
81 - 84m steel casing 300mm

First water struck @ 7-10m
Main supply @ 26-30m
Water level - 10.5m bgl

Yield - Air test @ 90-100 l/sec
Step test - 60 min steps - date of test 19/3/95
SWRL 11.15m below toc

| Step No. | Max pumped WL | Q (l/min) | Q (l/sec) |
|---|---|---|---|
| 1 | 16.14m | 1975 | 32.9 |
| 2 | 18.25m | 2780 | 46.3 |
| 3 | 20.85m | 3650 | 60.8 |
| 4 | 22.40m | 4250 | 70.8 |

Constant discharge test for 2880 mins
Water level 11.15m bgl, Q - 4240 l/min (70.6 l/sec)
Steady state after 1100 mins, drawdown 11.26m
Recovery to 0.10m below start wl by 1600 mins.

**Site 9b - borehole No. 14**

Water level 9.55m from gl (11/11/95)

Geological log
 0 - 5m Top soil
 5 - 24m Clay
24 - 57m Sand
57 - 63m Clay
63 - 76m Sand
76 - 80m Clay

First water struck - 27m
Main supply - 31m

Yield - by air lift 70-80 l/sec

**Site 9c - borehole No. 16**

Water level 6.11m bgl (11/11/93)

Geological log
 0 - 5m dark brown clayey soil
 5 - 7m Granitic and felsic boulders
 7 - 12m Very coarse clean sand
12 - 42m Coarse sand fining downward to fine to medium sand. Light brown, very fine felsic clayey material in sand. Clayey material increases with depth to 42m.
42 - 88m Light brown/grey very fine sand matrix in framework of coarse sand.
88 - 90m Bouldery material of sand and dark grey silt, largest grains some 5mm in diameter.

Drilled diameter 17.5 inches

Construction log
 0 - 30m plain steel casing

30 - 48m PVC screen
48 - 51m plain steel casing

Yield by air lift 80 l/sec

Step test - 60 minute steps - date tested 5/9/95, SWL - 6.32m

| Step No. | pumped wl | Q l/min | Q l/sec |
|---|---|---|---|
| 1 | 11.37m | 1870 | 31.4 |
| 2 | 14.33m | 2720 | 45.3 |
| 3 | 17.67m | 3620 | 61.1 |
| 4 | 19.93m | 4240 | 72.1 |

Constant discharge test - 2880 mins duration, SWL 6.32m
Yield - 4190 l/min, drawdown of 13.26m at steady state achieved by 1440 mins.
Recovery to 0.05m after 2880 mins

**Site 9d - Borehole No. 17**

Geological log
 0 -  5m top soil
 5 - 17m Coarse sand
17 - 34m Sand and some clay
34 - 43m Clay and sand
43 - 49m Fine sand and clay
49 - 60m Fine to coarse sand
60 - 79m Hard sandstone

Drilled diameter
 0 - 53m @ 17.5 inches
53 - 79m @ 8.5 inches

Construction log
 0 - 22.9m plain steel casing
22.9 - 25.8m PVC screen
25.8 - 28.05m plain steel casing
28.05 - 48.35m PVC screen
48.35 - 51.50m plain steel casing
Borehole depth 51.38m btoc

First water struck - 10m

Yield by air lift 60-70 l/sec

Step test - date of test 11/9/95, SWL 6.81m

| Step No. | Pumped WL | Q l/min (l/sec) |
|---|---|---|
| 1 | 16.08m | 1780 (29.8) |
| 2 | 22.38m | 2730 (45.5) |
| 3 | 26.48m | 3350 (56.3) |
| 4 | 27.79m | 3540 (60.4) |

Constant discharge test - 12/9/95
Q - 3020 l/min, SWL - 6.88m, steady state not achieved, drawdown of 18.65m after 2880 mins.
Recovery, rapid - 3m after 30 secs, recovered fully by 2340 mins.

**Area 10 - Umzingwane Sand River, Bwemula School.**

At Bwemula School Precambrian Basement quartz-feldspar gneisses are faulted against brown-red weathered Forest Sandstones. The latter have been intruded by dolerite dykes. The faulted junction is traversed by the incised bed of the Umzingwane River that has been infilled with recent alluvial sediments (Thompson, 1975).

**Site 10a - Bwemula School**

An EKS traverse was undertaken across the Umzingwane River upstream of Bwemula School where the sand filled river is underlain by finely bedded Forest Sandstone, as seen to crop out to the north-east of Bwemula school. The river sands thicken downstream of the faulted contact between the Precambrian gneisses and the Karroo sandstones, an embayment having been incised below the junction (Owen, 1989).

**Site 10b - Sevuli Dip**

An EKS traverse was undertaken across the Umzingwane River near Sevuli Dip upstream of Bwemula School where the river is underlain by Precambrian Basement quartz-feldspar gneisses. The river sands rapidly thin upstream of the faulted contact between the Precambrian gneisses and the Forest Sandstones towards a set of rapids about 1 km upstream.

## Area 11 - Umzingwane Sand River, Cawood Mazunga Ranch

The Cawood Mazunga Ranch is underlain by basalts upstream of the contact with underlying Forest Sandstones. Much groundwater is abstracted by Mr Paul Bristow for citrus irrigation from the Umzingwane sand river. Numerous boreholes have been drilled to depths of about 23m. The sand river sediments are complex. Groundwater abstraction from the river has caused water levels to decline to 9m below the sand river surface. Water quality has declined, especially down stream where recharge of run-off water from the citrus plantation, laced with agrochemicals and salinity picked up on passage through the over bank sediments, may occur. Borehole yields of up to 142 l/sec have been obtained using electrical submersible pumps (Thompson, A.O., 1975).

### Site 11a - Cawood Ranch Sand River Traverse

An EKS traverse was undertaken across the Umzingwane River at a point where a party from Lund University had undertake several resistivity traverses. Some near-surface clays were noted on both sides of the river (Owen, personal communication).

### Site 11b - Cawood Ranch Drilling Site

Undertook an EKS survey adjacent to the latest drill site. Inspected 3m deep exploration pit along centre line of the river, where saw 2m of clean sands and gravels above orange-red lateritised coarse sands.

**Area 12 - Umzingwane Sand River, Zhove Dam Site**

The Zhove Dam has recently been constructed, emplaced across the Umzingwane River upstream of the junction of the latter with the Zhove River. This dam is designed to impound water flowing down the Umzingwane and Luhani Rivers. Water will be released down the river during the dry season to maintain levels of water within the sand river to sustain irrigation systems located down stream at localities such as the Cawood Ranch. During dam construction a trench was excavated through the sand river alluvial sediments to found the dam core upon the underlying Karroo Basalts. Apparently the cross-section through the recent river sands deposited within the trench were mapped by Mr Dumbie of the Minerals Department in Bulawayo. These sands are up to 20m thick according to Thompson (1975).

**Site 12 - Upstream Side of Zhove Dam Site**

On the upstream side of the dam an EKS traverse was run across the entrenched sand filled bed of the Umzingwane river, between two former dewatering boreholes. The results of a seismic traverse run along the same section were made available for correlative purposes.

## Area 13 - Esingodini

The Esingodini area was visited to test the EKS equipment at typical green stone formation site. Unfortunately the first site visited was adjacent to Habane Township, located upon faulted Ncema Complex granitic mesotonalites and diorites. This borehole obtained groundwater from weathered pegmatitic granites. The second site was located at the Esingodini agricultural college at the junction of the Ncema Complex and Kensington Formations.

### Site 13a - Habane Township Borehole No. B/7038

Grid ref QH038529
Geological log
 0 -  3m clayey top soil
 3 - 21m highly weathered pegmatitic granite
21 - 60m Fairly weathered pegmatitic granite
Yield 6.2 $m^3$/hr
Main water struck - 22m

### Site 13b - Agricultural College Possible Borehole Drilling Site

This site is located at the possibly faulted junction of Ncema complex granitic mesotonalites/diorites and Kensington Formation metamicrodiorite-porphyry vent rock, both of Archean age (Garson, 1991).

**Area 14 - Nyamandhlovu Water Supply Boreholes**

The geology of the Nyamandhlovu area is outlined by Amm (1940) and MacGregor and Ferguson (1937). Groundwater occurrence at Nyamandhlovu as developed by Rhodesia Railways is described by MacDonald (1970). Groundwater probably occurs at the junction of basalts and baked sandstones, and at depth within fractured and jointed sandstones. The Nyamandhlovu aquifer has been extensively developed as a source of groundwater for Bulawayo. Numerous high yielding boreholes have been installed for the latter purpose.

**Site 14a - Borehole No. 99, Nyamandhlovu.**

This borehole appears to pass through the Nyamandhlovu basalts and sandstones into the Forest Sandstone Group.

located 1km west of Nyamandhlovu clinic
Geological log

| | | |
|---|---|---|
| 0 | - 2m | Brown soil |
| 2 | - 3m | Purple brown soil/ weathered basalt |
| 3 | - 5m | Green brown very weathered basalt |
| 5 | - 9m | Light green grey very weathered basalt |
| 9 | - 12m | Light purple weathered basalt |
| 12 | - 13m | Light green very weathered basalt |
| 13 | - 14m | Brick red and light green weathered basalt |
| 14 | - 15m | Purple brown weathered basalt |
| 15 | - 20m | Purple brown and light green weathered basalt, some calcite |
| 20 | - 25m | Purple weathered basalt with white calcite |
| 25 | - 30m | Light grey fairly weathered basalt |
| 30 | - 32m | Black hard basalt |
| 32 | - 35m | Black hard basalt with brick red speckled white fragments |
| 35 | - 55m | Pink and light brown fine sand and silts |
| 55 | - 68m | Light pink silty fine sandstones |
| 68 | - 78m | Dark pink silty fine sandstones |
| 78 | - 80m | White siltstones with thin pink sandstones, very friable |
| 80 | - 83m | Pink fine sandstones with thin white siltstones |
| 83 | - 91m | Light brown and cream siltstones with some fine sandstones |
| 91 | - 95m | Light brown, cream and dark brown sandy siltstones |
| 95 | - 97m | Baked brick-red, pink and yellow silts, some black basalt fragments |
| 97 | - 103m | Light pink to cream and off white siltstones and white silcretes |
| 103 | - 123m | Light pink fine silty sandstones with grey silcretes |
| 123 | - 127m | Light pink silty fine sandstones with much black silcrete and some yellow siltstones |
| 127 | - 129m | Light pink fine sandstones, many silcrete nodules and some light brick red siltstones |
| 129 | - 133m | Pink fine sandstones, much pink to white/grey silcrete and calcrete, some pink siltstones |
| 133 | - 135m | Pink fine sandstones with some pink and cream siltstones |
| 135 | - 137m | Dark pink silty fine sandstones with much light |

grey and cream siltstones
137 - 139m Dark pink to brick red siltstones with grey pink silcrete
139 - 141m Dark pink fine sandstones with some brick red siltstones
141 - 152m Brick red siltstones
152 - 157m Pink fine sandstones and brick red siltstones
157 - 159m Brick red and white siltstones
159 - 161m Brick red siltstones
161 - 163m Brick red and cream siltstones
163 - 193m Brick red siltstones with subordinate patchy cream siltstones
193 - 212m Brick red siltstones with grey limey? sediments
212 - 214m Brick red and cream siltstones
214 - 216m Brick red siltstones and light grey silcrete
216 - 229m Brick red siltstones.

**Site 14b - Production Site, Borehole 79**

This borehole appears to pass through the Nyamandhlovu basalts and sandstones into the upper Forest Sandstone Group.

Grid ref PJ440074
Depth 102m
Yield at test $50m^3$/hour (7.2 l/sec)
SWRL 22.5m
First water struck 28m
Geological log
 0 -  1m Black soil, basalt rubble
 1 -  2m Hard black basalt
 2 -  3m Reddish basalt becomes slightly weathered
 2 - 13m Hard basalt
13 - 15m Basalt
15 - 18m Weathered brown basalt
18 - 20m Sandstone with basalt pebbles
20 - 28m Creamy fine sandstone
28 - 35m Creamy white fine sandstones
35 - 36m White sandstone and basalt
36 - 37m Creamy sandstone with occasional basalt pebbles
37 - 46m Khaki fine sandstones
46 - 52m Cream fine sandstone
52 - 60m Brown to khaki fine sandstone
60 - 67m Cream sandstones
67 - 71m Brown to khaki sandstone
71 - 72m Cream sandstone
72 - 74m Brown and khaki sandstones
74 - 102m Slightly red to khaki sandstones
Borehole equipped with a Mono pump with surface electrical motor and shaft drive
Borehole construction
0 - 42m 200mm casing
42 - 48m 200mm screen
rest probably open hole at 165mm

**Site 14c - Production Site, Borehole No. 95 Nyamandhlovu Aquifer**

This borehole appears to pass through the lower part of the Nyamandhlovu basalts and sandstones into the Forest Sandstone Group.

Grid ref PJ438048
Depth 90m
Yield 10.08 $m^3$/hr
SWRL 32.7m
Geological log
 0 -  8m Hard basalt
 8 - 15m Weathered basalt mixed with sandstone
15 - 16m Coarse reddish sandstone
16 - 20m Fine pink sandstone
20 - 32m Fine sandstone becoming slightly pink with depth
32 - 34m Pink hard fine sandstone
34 - 56m Reddish hard fine sandstone
56 - 73m Pinkish hard fine sandstone
73 - 90m Pink to white sandstones with white pellets (pipe sandstones)

**Site 14d - Test Borehole Site at 10km Peg on Road to Nyamandhlovu**

This borehole was still being drilled when the site was visited. Drilling had reached a depth of 86m using down the hole hammer with air and foam flush. No basalt was encountered during drilling from examination of the drilled formation cuttings. The borehole was reported to have been drilled through a sequence of fine sandstones and silts, that are white towards the top and brick red towards the bottom of the borehole. These fine sandstones appear to belong to the Forest Sandstone Group. Apparently granite was encountered at 86m.

**Area 15 - Lupane**

**Site 15 - Ndambuleni School Collector Well**

Collector well depth 7m, water level 3.50m toc, water level 3.09m bgl.

The Ndambuleni School collector well is located within a small alluvial plain. The well was in use until just before our visit. Inspection showed that the pump was broken but that there was still plenty of water in the well. It had been the main reliable source of water for the local population during the last prolonged drought.

Initial site investigation included the drilling of a line of auger holes traversing the valley. The flood plain is 300m across. Soft sands are 9m thick along the centre of the valley but thin to 0m at the edges. A thin layer of stones underlies the soft sands at the edges of the plain. Excavation of the dug well was halted when a hard consolidated sandstone was met at 7m depth. It is possible that the flood plain at the dug well is underlain by a coarse relatively fast thin aquifer through which most of the groundwater flow would occur since the full depth of alluvium at the dug well may not be penetrated. The walls of the well did not collapse during digging and the only significant inflow of water was through the base of the well. Well construction and test pumping are described in Herbert and Rastall (1991). 7 shallow auger holes were drilled to assess the depth of soft sand across the valley. Two horizontal boreholes were drilled in opposite directions from the base of the well, to 19m and 15m. Water flowed from the longer lateral, the shorter one being dry. A sample of muddy medium to fine sand obtained from the wall of one of the laterals indicated that the sandy alluvial material may have a permeability of 1 m/day or less. On completion the water table in the well was 2.36m bgs. During a series of short term pumping tests the well was pumped at discharge rates of 0.75 l/sec, 4.4 l/sec and 6 l/sec. Transmissivities of 2.2 to 6.5 $m^2$/day and unconfined storage coefficients of 0.0004 to 0.05 were calculated for the surrounding aquifer.

**Area 16 - Hwange Area, Danida Boreholes**

The geology of the area east of Hwange is described by Watson, (1960). Danida undertook the drilling of a number of village water supply boreholes. Of these those at Mudingule Village and Zwabo Village were drilled into tight Karroo age Ripple Flags of the Escarpment Series. These are a thick sequence of maroon shales that grade upwards into grey, flaggy, ripple-marked silts with limestone and sandstone bands. The Ilambo area is underlain by Archean age leucocratic paragneiss. At the Ilambo school site these basement rocks may be overlain by thin Lower Wankie Sandstones of Lower Karroo age. At all four sites the country rocks appear at or very near ground surface. Weathered regolith development is most probably minimal in thickness. Groundwater is most probably derived from linear fracture zones, difficult to identify using the EKS method.

**Site 16a - Mudingule Village**

| | |
|---|---|
| Borehole No. | 8157 |
| Grid Ref | MK 647 764 |
| depth | 70m |
| Yield | 0.11 l/sec |
| First water struck level | 27.0m |
| Main water struck level | 40.0m |
| Casing | 0-24m |

Geology
0 - 70m Sandstone

**Site 16b - Zwabo Village**

| | |
|---|---|
| Borehole No. | 8211 |
| Grid Ref | MK 517 807 |
| depth | 79m |
| Yield | 3.33 l/sec |
| First water struck level | 31.0m |
| Main water struck level | 69.0m |
| Static water level | 31.0m |

Geological log and penetration rate

| | | |
|---|---|---|
| 0 - 4m | Sand | 18 mins/m |
| 4 - 79m | Granitic rock | 9 mins/m |

Drilling - date drilled 15/3/95
0 - 6m @ 215mm
6 - 79m @ 150mm
Casing - nil

**Site 16c - Ilambo School - 40 km post**

| | |
|---|---|
| Borehole No. | 8203 |
| Grid Ref | MK 817 646 |
| depth | 61m |
| Yield | 0.32 l/sec |
| First water struck level | 42.0m |
| Main water struck level | 42.0m |

Geological log and penetration rate

| | | |
|---|---|---|
| 0 - 4m | Overburden | 6 mins/m |
| 4 - 19m | Sandy soil | 2 mins/m |
| 19 - 61m | Granite | 8 mins/m |

Drilling
0 - 18m @ 215mm
18 - 61m @ 150mm
Steel casing 0 - 18m @ 150mm

**Site 16d - Ilambo Lay-by**

| | |
|---|---|
| Borehole No. | 8204 |
| Grid Ref | MK 793 657 |
| Depth | 61m |
| Yield | 0.18 l/sec |
| First water struck level | 18.0m |
| Main water struck level | 47.0m |

Geological log and penetration rate

| | | |
|---|---|---|
| 0 - 4m | Over burden - clay | 12mins/m |
| 4 - 58m | Gneissic rock | 3mins/m |
| 58 - 61m | Hard gneiss | 4mins/m |

Drilling
0 - 15m @ 215mm
15 - 61m @ 150mm
Steel casing 0 - 15m @ 150mm

## Area 17 - National Railways of Zimbabwe Production Boreholes

(Lockett, N.H., 1979, MacDonald, D., 1970.).

### Site 17a - Intundhla Siding

According to MacDonald (1970) a copious unconfined supply of water was encountered in the Kalahari age pipe sandstone above the Karroo Basalts and a smaller confined supply found beneath the basalts. The borehole was plugged at 207.3m to exclude the poorer quality confined sub-basalt Karroo waters.

| | |
|---|---|
| Borehole No. | G 3/406 |
| Height amsl | 1029.1m |
| Bh depth | 293.5m |
| Cased | 0-207.3m |
| Rest water level | 12.19m |
| Test yield | 6.67 l/sec |
| Test pumping water level | 76.2m |
| Drawdown | 64.01m |
| Total dissolved solids | 270ppm |
| pH | 8.4 |

| | Geology |
|---|---|
| 0- 97m | Kalahari System sand, sandstones, pipe sandstones and silcrete |
| 97-217m | Jurassic Basalts |
| 217-293.5m | Upper Karroo sandstones, mudstones and shales |

### Site 17b - Kennedy Siding

| | |
|---|---|
| Borehole No. | G 3/56 |
| Height amsl | 1028.7m |
| Bh depth | 64.0m |
| Cased | 0-35.4m |
| Rest water level | 8.2m |
| Test yield | 3.83 l/sec |
| Test pumping water level | 61.9m |
| Drawdown | 53.7m |
| Total dissolved solids | 546ppm |
| pH | 7.4 |

| | Geology |
|---|---|
| 0- 64m | Kalahari System sand, sandstones, pipe sandstones and silcrete |

### Site 17c - Water Loop Siding

According to MacDonald (1970) at Water Loop some 91m of Kalahari System sediments including pipe sandstones overlie Basement Complex Gneisses. Water occurs in the pipe sandstone beneath loose, unconsolidated and running sands. Water Loop provided Dett with between 1125 and 1665 $m^3$/day of water in 1970.

Borehole No. G 3/139

| | |
|---|---|
| Height amsl | 1056.9m |
| Bh depth | 94.5m |
| Cased | 0-86.0m |
| Rest water level | 18.7m |
| Test yield | 11.25 l/sec |
| Test pumping water level | 44.5m |
| Drawdown | 25.8m |
| Total dissolved solids | 245ppm |
| pH | 7.4 |

Geology

| | |
|---|---|
| 0 - 56m | Kalahari System running sands. |
| 56 - 87m | Kalahari system pipe sandstones, |
| 87 - 94.5m | Quartz schist |

## Area 18 - RTZ Empress Mine

The area around the Empress Mine is underlain by pale greenish grey to slightly bluish grey, fine to medium grained, in part porphyritic, massive or locally foliated, pyroxene bearing andesitic lava of the Maliyami Formation of the Archean Bulawayan Group (Sutton, 1979).. The Empress Mine ore body is a copper-nickel rich metagabbro pyrite and pyrrhotite ores predominating. The mine was brought into production in 1968. Due to lack of ore the mine was effectively abandoned by RTZ on Zimbabwean independence. Unfortunately, since the government had hoped that the mine would prove to be a major mining development RTZ have not been in a position to officially close the site until the present time. RTZ are currently clearing the site of polluting materials. These have primarily accumulated within the vicinity of the mines smelter and concentrator units. Two areas of major concern are an area of concentrate spillage and the slimes dams. Initial assessments of the environment implications of the site in its present condition are outlined in RTZ (1993) and RTZ (1994).

### Site 18a - Spillage Area, Empress Mine

EKS surveys were conducted to determine the likelihood of seepages of contaminated groundwater from the spillage impoundment on the Empress Stream into the Ngondoma River via vlei alluvial sediments. These surveys traverses were undertaken upstream of the impoundment to the base of the waste dump and then down stream of the impoundment. The finely milled concentrate material forms a low porosity cap to thin, pre-existing vlei alluvial sediments. Some water should still move through these sediments during the wet season. Such sediments should be present along the valley downstream of the impoundment.

### Site 18b - Slimes Dam, Empress Mine

EKS surveys were undertaken to assess the likelihood of contaminated water seeping through the base of the slimes dam into the catchment of the Mangwarangwara River. A north-south traverse was conducted through the central part of slimes dam No. 3 followed by a second traverse conducted normal to the first. The tailings dam material is composed of finely milled waste material that should have a very low porosity.

**Area 19 - Chiota**

**Site 19 - Mukumba School**

Collector well depth 11.5m, depth of regolith m, water level 7.20m from top of casing (toc), water table 6.15m below ground surface (bgs).

The Mukumba School collector well was very much in use. Originally the well was to be the water source for the local school (1200 pupils and residential staff), the school garden and population in the surrounding area. It proved to be the only reliable water source for the surrounding rural population during the recent drought when the school borehole dried up. Water has been obtained from this well by bucket but a top slab had been cast for the installation of a bush pump.

Initial site investigation drilling, surface geophysical surveys, well construction and well test pumping are described in Wright et al (1987). 13 widely spaced shallow investigation boreholes were drilled to assess the depth of weathered bedrock beneath the site area. These data were supplemented with the results of a series of Schlumberger vertical electrical resistivity soundings (VES) and EM34-3 traverses undertaken systematically across the site. On the basis of the borehole and geophysical data collected the collector well was located adjacent to borehole No. 8 where the deepest zone of weathering was located in excess of 10m depth. During well excavation stiff grey clay was found to 1.5m followed by buff quartz-mica sediments to 4.2m. Fresh granite was met at 4.2m below which regolithic weathered rock was found becoming very dark greenish below 7.5m. The mineralogy of the geological profile is shown o Figure  .The well was completed at a depth of 11m. Four horizontal boreholes were drilled radially, at equiangular directions, from the base of the well, all 40m long. A further four inclined holes were drilled to lengths of 14, 30, 30 and 30m. On completion the water table in the well was 3.29m bgs. During a long term pumping test conducted upon the well water was pumped at 6.4 l/sec, a rate of constant rate of inflow of 1.12 l/sec being recorded.

**Area 20 - Wedza**

**Site 20 - St Lioba's School, Wedza**

grid ref UQ 6326 3979, sheet No. WEDZA 1831 D1 (Wright et al 1988)

The St Lioba's School collector well was installed as the water source for the school and the local population. It was the only reliable water source for the local population during the recent drought when the school borehole dried up.

Investigation drilling, surface geophysical surveys, well construction and well test pumping are outlined in Wright et al (1988). 8 investigation boreholes were drilled to assess the depth of weathered bedrock. The 'core and tor' type of weathering posed a great problem to exploratory drilling at this site as shown in Figure . A series of Schlumberger VES soundings and EM34-3 traverses were undertaken across the site. The collector well was located 50m to the southeast of borehole 8 where the zone of weathering exceeded 19m depth. The geological profile and mineralogy with depth found during well excavation to 13m depth are shown in Figure .

No record of drilling of horizontal laterals from this were is available. It was noted that an adequate yield was obtained from this collector well under test. The dry season water table varies from 2 to 3m.

Diary
October 1995

30th  Flight BA53 London (Heathrow) to Harare, Depart 21-25hrs

31th  Arrive Harare, driven by BHC driver to the Bronte hotel. To the MWRD where met Mr Lawrence Singayi. Took Landrover 80TCE104 to the Eastlea workshops where the vehicle was checked and cleaned. Purchased $21 of petrol and distilled water, battery almost dry. To Enfield Engineering to order a steel plate. At Bronte Hotel exchanged a ?50 travellers check. Purchased $100 of petrol. Discussions with Mr Earnie Milner, Botswana GS geophysicist.

November 1995

1st  To Barclay's Bank opposite Meikles Hotel where exchanged ?300 of travellers cheques. To Enfield Engineering to collect steel plate. To MWRD to meet Sam Sunguro and Lawrence Sengayi.Discussed a work plan, including EKS surveys at Hatcliff and Seke. Purchased required tools for EKS work and vehicle including hammers, table and chair. At the Survey Department to purchase series of 1:250 000 scale maps. While in the sales office my bag was stolen from the Landrover front seat while Mr Peart was almost sitting on it. Reported theft to the central police station, gave statement between 12-00 and 12-40. Back to the Bronte for lunch and check on items stolen.

List of items stolen:-
1. Small red/green rucksack
2. Reading glasses in brown holder
3. Olympus OM2N single lens reflex camera with 50 mm lens in hard
   black leather case
4. Olympus 70-200mm telephoto lens in soft black leather case
5. Official 1995 A5 size diary with light blue cover
6. Street map of Harare folded with index
7. 1:1 000 000 scale geological map of Zimbabwe
8. 1:1 000 000 scale topographic map of Zimbabwe
9. Two photocopied reports on Sand Rivers project in Botswana.
10. Two rolls of 200 ASA, 36 exp, 35mm Kodak Gold film
11. Field note book with yellow cover
12. Set of keys to UK home and to case.
13. Soft white hat

Took luggage case to Messers Lock and Key for case locks to be picked. Also had 2 keys for the landrover cut for $75. To MWRD to inform Lawrence Singayi of theft. Contacted Jeremy Prince and Graham Smith, of Sesi. Folded topographic maps. At 17-30 had discussions with Jeremy Prince, Tim Broderick and Roger Peart about EKS work over weekend and alluvial sediments in Mozambique. Passed on 4 UNSAs reports. They borrowed the Vietnam EKS report.

2nd  Hatcliff - Willow Tree, Hatcliff - Windmill and Seke -

Murape sites.

To the MWRD office where met Lawrence Sengayi and Sam Sunguro. With them to Hatcliff at 9.00 where set up EKS equipment at the booster station thinking that it had been constructed over the Willow Tree collector well site. Found that steel plate was too heavy. Latterly undertook three EKS surveys at the Willow Tree site; located on southern extension of Dombashawa lineament in metabasalt rocks. Then to the Windmill site on the southerly extension of the Mazowe lineament; where undertook two sets of EKS surveys. Dropped off Sam Sunguro at MWRD at 15-00hrs. To Chitungweza from where went to Murape school in Seke. This collector well still very much in use. Only assured source of water for local village and school during recent drought. Undertook 4 sets of readings at this site. Very hot weather, cloudless sky. Returned to Harare.

3rd  Seke - Marikopo, Dema river site
To MWRD where met the Japanese drilling team management at Lawrence Sengayi's office. Arrange to visit some of their drill sites on Tuesday. Called the police station re theft of belongings. Told that the case had been assigned a CID reference number. With Kelvin and a technician to Chitengweza where collector fuel before driving to the Marikopo school collector well site where undertook a series of EKS surveys. Very hot cloudless day. From the collector well drove to the school's football pitch located upon a dambo area. Operating bush pump on borehole adjacent to the school. From there to Dema to undertake a series of EKS surveys upon outcrop of granitic gneiss adjacent to river down stream of a dam. Returned to MWRD and thence back to the Bronte where contacted Richard Owen re a meeting with him on Monday morning.

4th  Good Hope and Stamford farms.
Met Jeremy Prince at 11-10 am at the Bronte followed him out to Good Hope farm where met Mr Peter Arnott. Farm is located near the Iron Mask range. He has drilled numerous water abstraction boreholes both upon Good Hope and his son's farm at Stamford. Jeremy Prince has conducted a grid resistivity survey of both farms. So Peter Arnott has a very good feel for the water resources of his farms. Has noted how yields have declined, advised him to monitor his water levels, a point backed up by Jeremy Prince, so that water table movement can be correlated with rainfall/recharge events to give him a much better idea of his available water resources. Water table used to be much higher adjacent to main farm house, for the road leading to it used to be saturated black cotton soil. Has remained dry now for a number of years.Taken to meet Duncan Arnott on Stamford. Shown a high density network of boreholes drilled about 200m apart. Most produce about 1000 gph from weathered to faulted felsites. Local succession is as follows:-

Black cotton soils
Dambo clays
Weathered felsites
Felsites

Unfortunately no groundwater levels have been recorded. Appear to have dewatered the weathered zone as pumping costs have risen and yields have declined. However what ever recharge takes place through the black cotton soils and cracking clays is sufficient to maintain present pumping levels. About 40 boreholes equipped with electrical submersible pumps are operated producing about 40000 gph for the irrigation of crops. Peter Arnott is aware of the need to conserve water resources therefore he only pumps at about a third of the levels recommended by drillers. Main crops are potatoes and maize, most of the latter being used a s feed for 1000 head or so of beef cattle. Undertook initial tests at borehole No. 15. Thick upper clay layer 26-30m thick. Had lunch with Peter Arnott and his family. Returned to Stamford where undertook tests at boreholes No. 14 and 17. (need borehole logs and resistivity data from Jeremy Prince). Finished at 17-30hrs. After sundowners with Duncan Arnott and his family returned to Harare.

5th Harare.
At the Bronte Hotel met Tom Davis of RTZ and discussed with him a planned visit to the Empress Nickel mine. Moved from the Bronte Hotel to the George Hotel in Avondale. Drove out to look at the Great Dyke towards sunset.

6th To MWRD where attempted to phone the police from the office of Mr Sengayi. To Enfield engineering where obtained 4 x 1.5m mild steel rods. Visited Mr Richard Owens at the Geology Dept at University of Zimbabwe, Harare. Obtained a copy of his book on alluvial aquifers in Zimbabwe, need to see appendices. Discussed studies undertaken along the Umzingwane sand river at the Zhove Dam site, Cawood Ranch and the northern edge of the basalts. Used Birmingham developed Wenner array resistivity surveys. Also similar surveys undertaken upon the Shangani river north east of Lupane. Noted three possible sites of which two are cliff sites at the faulted margins of the basalts. Increased thicknesses of alluvium found in sand rivers at lithological junctions. Noted reference:-
Jonas Falk, Asa Joelsson and Marten Rundgren, 1995. Geophysical mapping of dambo aquifers in Zimbabwe. A master of science thesis. Department of Engineering Geology, Institute of Technology, Lund University. ISN: LUTVDG/TVGT--5042--SE.Box 118, S-22100 LUND, Sweden. FAX (0)462229127.
Owens commented that most of the geomorphological ideas of Lister have now been debunked. To the Geological Survey dept to buy maps. To Eastlea to get points sharpened on steel rods. To Survey Department to purchase maps and collect vehicle insurance from British High Commission. To MWRD to discuss drilling at the southern end of the Save Valley with My Van Neiwkoop. Fleetingly discussed the possible use of collector wells. Needs yields of 50-60 l/sec but may be unobtainable via boreholes where thickness of the saturated aquifer is only 10-15m thick. There have been three phases of work:-

1. Nyamanyazi - Birchenough Bridge, high yields of 50-60 l/sec and low yields of 1-2 l/sec on edge of the Save River.

2. 15 boreholes drilled between Mushekavana and the Middle Sabi irrigation scheme. All drilled by MWRD using direct circulation mud flush, yields of 50-60 l/sec, all drilled to about 90m.

3. 15 boreholes to be drilled between Mushekavana and St Peters. Alluvium thins to the south to 20m then to 0m at the outcrop of Karroo Sandstones and then basalts.

To the bank to exchange ?300 travellers cheques. To Eastlea for rods thence to Sesi to discuss EKS with Graham Smith and his geophysicist. Possible test sites available in the Banket area. Returned to Harare. Contacted Chris Lovell by phone to discuss visits to the Chiredzi sites.

7th To MWRD where met Lawrence Sengayi. Obtained copy of report on Nyanyadze south groundwater project from Nr Van Neiwkoop. Drove to Morehwa area with Mr Sengayi to see Japanese rigs and 4 sites drilled by them. Japanese had left for Harare. Saw Tone 300 drilling rig at drill camp, with mobile workshops and large compressors. Japanese team very well equipped. Japanese hydrogeologist already back in Japan, MWRD hydrogeologist attached to the project may be on leave. Were not allowed to see drill records. At drill camp obtained services of MWRTD driller as guide to two successful and two unsuccessful sites. Taken to site No. 45 at Matambadzo. Noted massive whale backed topographic hills enroute. Conducted EKS surveys at first site where successful borehole drilled. At adjacent area noted irrigation of garden plots using water obtained from spring systems that flow even during periods of drought. At second site note unsuccessful dry borehole located next to well that taps water seepage from base of ferrecrete layer. Water from well is used for irrigation of garden plot. From Nakiwa drove north along dirt road into the Uzunma area northwest of Masanbanaka School. There noted successful borehole located in middle of field cultivated since 1920, use of chemical fertilisers since 1950 according to Agritex directions, pesticides and herbicides since 1970/80. Need to check agro-chemical residues. Borehole already equipped with a bush pump. Good supply of water. Well located 250m to west still produces fair amount of water, equipped with a bush pump but insufficient yield to supply celebration parties! Farmers would like to irrigate field using water pumped from successful borehole. Discussed drip irrigation techniques with them. Undertook EKS surveys adjacent to successful borehole and dry borehole drilled to the WNW. Returned to Morehwa and thence to Harare.

8th Checked out of the George Hotel, Harare. To the University for photocopies then to a hardware store for jump leads and other tools. To MWRD where met Lawrence Sengayi, acting head since Sam Sunguro in Capetown at a modelling conference. Met Mr Raijmakar who supplied borehole location maps of the Mushikhavana area. Visited Mr Jeremy Prince at Highlands, returned two maps and borrowed a third. Obtained fuel for the Landrover. Collected Joseph from the MWRTD office, left Harare at 10-55 to drive to Mutare via Marondera

and Rusape. At Tanganda Junction several fuel receipts flew out of the window in strong winds. Noted that the drought affected Mpudzi area looked like Bikita in 1992, very hot and dry with no grass. Visited Birchenough Bridge to photograph the Sabi River. Near the southern edge of the Middle Sabi project experienced electrical problems with the vehicle at sunset. Helped by the police and the Middle Save mechanical workshops. Spark plug leads in the wrong order, drove south through dust storms to the Tambuti Lodge where arrived at 1-40 am.

9th  Drove to the agricultural research station at Chiredzi where met Terence Dube. Organised accommodation for Joseph via the deputy head of the station. Received detailed instructions from Chris Lovell. Drove to the Romwey site via Triangle for fuel. Met Patrick Moriarty and Chris. Undertook several EKS surveys with the help of Patrick Moriarty, the lads from Chiredzi and Chris. Completed work programme by 15-30. Returned to Triangle and thence to the Tambuti Lodge via Chiredzi.

10th  Drove from the Tambuti Lodge Hotel to the Chiredzi Agricultural station where undertook a series of EKS surveys at the collector well site. Discussed the EKS method with the director of the station at the site. Visited the Plan International Office in Chiredzi where met Dr Jim Alexander. Dr Alexander indicated that he was very pro collector well systems to the extent that US$500,000 has been donated for the construction of up to 20 additional collector well systems. Agreed to us visiting the two collector wells funded by Plan in the Sangwe area. Drove to the Sangwe area where visited the collector well at Machoka (site 7) and that at Masekesa (site 8). Also viewed the deepening of a local hand dug well in basalt. Undertook EKS surveys at both collector well sites. Although that at Machoka is being used by the school children no garden has yet been laid out due to a dispute between local community leaders. Observation well has been backfilled. At Masekesa the collector well is being extensively used for the supply of irrigation water to an extensive garden, the work being undertaken by the women and children of the village. Water levels (via an observation well) and abstraction rates (via inline Kent flow meters) are being monitored routinely by a local person. Problems with defective wiring on Landrover but eventually returned to Chiredzi.

11th  To Chiredzi to collect Terence and Joseph then via Tambuti Lodge to collect Roger and equipment to Chisembanjie and thence to St Peter's where drove onto that part of the Save River known as Gudo's Pool. Here there is 21m of saturate sand above a basalt basement. Undertook a series of EKS surveys using both the short and long electrodes. From there drove north along the main road taking photographs of the drought affected areas. From the 234 km peg drove west across the Save flood plain to Chisembuwe Township. From there went north to the site of borehole No. 14 of the Mushandikhi scheme where undertook a series of EKS surveys. Drove on to borehole No. 11 where undertook further EKS surveys. Drove into the area south of Chisembuwe where undertook EKS surveys at

boreholes 16 and 17. Then drove south and then along an indistinct track eastward to the main road. Returned to Chiredzi.

12th  Rest day at the Tambuti lodge, undertook analysis of data, maintenance on Landrover and read reports.

13th  Drove from the Tambuti Lodge Hotel, via Chiredzi to Beitbridge where checked into the Beitbridge Hotel. Weather very hot and dry.

14th  Drove from Beitbridge along the Bulawayo road and onto the Cawood/Marzunga Ranch. Just before the hill turned to the right entering the ranch via citrus to the right and prickly pears to the left. At the office was directed to the main farm where met Mrs Cawood who redirected us to her son in law's farm, Mr Paul Bristow. Over tea on the lawn explained what we were after. He described his drilling activities, has drilled many boreholes in the bed of the Umzingwane sand river - on his half - for the abstraction of large quantities of water for the irrigation of citrus. Was also told of the activities of a group of Swedish women geophysicists who undertook resistivity surveys across the river as part of a join project with the University of Zimbabwe, Harare. Uses an old Steyns cable tool percussion rig to bail down 12" steel pipe to the base of the sand river. Lands 8" proderite casing with hand sawn slots to the bottom, withdraws the temporary steel casing and develops up the resultant well. Can take several days of surging, backwashing and over pumping to fully develop a borehole. Wells drilled to about 50 feet. Has a very good appreciation of the complex nature of sand river sediments, and groundwater occurrence in them. Abstraction from the river has caused water levels to decline to 27 feet below the sand river surface. Water quality to has declined, especially down stream where there may be inflow of water from the citrus plantation, laced with agrochemicals and salinity picked up on passage through the over bank sediments, that may contain evaporates. Some wells have been tested up to 22,000 ghp, all are equipped with electrical submersible pumps. Has attempted to us water points by jetting but insufficient yield. Clays present near surface, reckons that within historical times these were reed beds in which hippos dwelt all year round, in that case the upper two metres or so of sands could have been derived from modern day erosion of soils and weathered rocks stripped of vegetation by sheep and goats within the communal lands. With the soils removed water flows of the land in sheet floods with high erosive power instead of seeping through supplying water gradually to stream and river systems thereby maintaining an all the year round rate of flow. Hence the demise of the hippos and the choking of river systems with sand debris. From there drove to the Zhove Dam site where met the resident site engineer Mr Knowledge Mudzengere and his assistant Charles. Discussed the construction of the dam with them before driving onto the dam wall and being shown the site in detail. From there drove to the Zenani mission from where drove south along the Umzangweni River to the Bewumela school site on to the sand river where undertook two series of EKS surveys on basalt and sandstone. Returned to Beitbridge. Very

hot weather throughout the day.

15th  Drove from Beitbridge to the Umzangwane River at the Cawood Ranch with Joseph and local labourer Kelvin. Dropped crew off on causeway downstream of Cawood Ranch. Located line of Swedish resistivity survey. Drove landrover to line across the river through very heavy sand. Undertook EKS traverse to about half way when computer programme went u/s. Drove back to Beitbridge to reprogramme computer. Returned to the Cawood ranch to complete EKS traverse across Umzangwane River. Undertook EKS survey adjacent to drill site. Inspected 3m deep exploration pit along centre line of the river, where saw 2m of clean sands and gravels above orange-red lateritised coarse sands. Drove back to Beitbridge.

16th  Checked out of the Beitbridge Hotel. Had exhaust pipe welded up at local garage, exchanged ?300 of travellers cheques at local bank. Drove along Bulawayo road to the Zhorve dam site where met the resident site engineer Mr Knowledge Mudzengere who supplied additional information on the dam site exploration including sight of a series of photographs of the site trench. Drove to the upstream side of the dam where undertook an EKS traverse across the sand river. Extremely hot, about 46 degrees C in the shade but no shade! Drove via Tod's Motel to Bulawayo where checked into the Bulawayo Sun Hotel.

17th  Visited the Bulawayo MWRD office where obtained details of boreholes in the Nyamadhlovu area from Mr Blessing. Met young hydrogeologist of Italian consultants. Undertook repairs to exhaust on Landrover. Bad dose of the squits all day.

18th  Drove from Bulawayo along the West Nicholson road to Esingodini where undertook a series of EKS surveys at the Habane Township site located downstream of sewerage ponds. Borehole equipped with a small electrical submersible pump. Appears to be located upon a fault zone, much milky quartz with slickenslides. Bare rock at outcrop a diorite, fine grained, foliated green grey colour. Fault may pass beneath the sewerage ponds - possible pollution problem. On to the agricultural college where undertook another series of EKS surveys upstream of borehole. Survey sites located adjacent to termite mounds. Returned to Bulawayo.

19th  Drove from Bulawayo to Nyamandhlovu sites after heavy rain storm in Bulawayo. Noted drilling rig operating on roadside 10km south of Nyamandhlovu. To MWRD drill camp where employed a labourer and noted 8" plastic screen with 1mm wedge slot. Drove to drilling site of borehole No. 99, 1km west of railway station where noted that the drilling rig had been removed for repair. Logged geological samples at well head. Undertook a series of EKS surveys. Acquired an additional survey assistant at this site. Drove to the Nyamandhlovu aquifer development area where a large number of boreholes equipped with Mono pumps powered by surface mounted electrical motors for water supply to Bulawayo. On way to the area office climbed up scarp feature capped with a thick deposit of ferrecrete. From the central office drove to borehole site No.

79 located at the edge of a vlei with black cotton soil on weathered basalt. All boreholes have overhead electrical power supply cables. Weather overcast but no rain. Undertook 3 EKS surveys at this site, before driving to site of borehole No. 95 located on basalt seen cropping out at site. Undertook 3 EKS surveys. Returned to the drill camp and drill site at Nyamandhlovu to drop off labourers. Drove to drilling site 10km south of Nyamandhlovu where borehole was being drilled by Martinelli and Associates for the MWRD. Borehole had been drilled to a depth of 86m by the time first EKS surveys had been completed. These were affected by vibrations caused by rig during drilling with down the hole hammer air flush equipment. Second series of EKS surveys undertaken some distance from the rig while rods were being abstracted. Large storm was approaching the site towards sunset. Returned to Bulawayo, very heavy rain during the night.

20th  Drove from Bulawayo to Gwayi River first rains at Gwayi during the night

21st  Drove from Gwayi River to Lupane collected data at the DDF office drove via Makuvula school to Ndambulevi school to collector well installed by P Rastall during 1991. Pump only recently u/s heavy down pour undertook eks traverse across the valley. Returned via Lupane to Gwayi River.

22nd  Drove from Gwayi River to Hwange where called at the DDF office where held discussions with Mr Kenneth Chicowere. To Lukosi Mission thence to Chibanda. Returned to Mudingule village where undertook EKS survey at recently drilled borehole. Could not find Chibule Village - incorrect grid reference - resettlement area. To Zwabe village site. undertook eks at this site on Ecca Grits upon granite? Along Dekke Valley to Hwange to the Baobab Hill Hotel Good view of escarpment grits. To Ilambo school and Ilambo lay by sites EKS on sandstones at first site and upon amphibolitic gneisses at second, both sites equipped with bush pumps.

23rd  Drove from Gwayi River to Kennedy siding from where drove south along the railway to Intandhla where undertook a series of EKS surveys. Returned to Kennedy where undertook another series of EKS surveys, thence to Water Loop where adjacent to the MWRD source of water for Dett from 7 boreholes formerly used for the railway supply. Returned to the Gwayi River Hotel.

24th  Drove from Gwayi River to Kadoma via Bulawayo and Gweru. Met Mr John Merry of RTZ with whom discussed a programme of work at the Empress nickel mine.

25th  Drove to the RTZ office at Eiffel Flats but Mr Mallon not present. Drove from Kadoma to the Empress Mine where met Mr Chris Goldhawk while undertaking an EKS traverse of the concentrate spillage area. Following lunch undertook EKS survey of the area downstream of the dam. Returned to Kadoma.

26th  Drove from Kadoma to the Empress Mine where met Chris Goldhawk. Drove onto the No. 3 slimes dam. Undertook two EKS

traverses across the slimes dam at right angles to each other past the two observation wells. Returned to Kadoma.

27th  Drove to RTZ offices at Eiffel Flats where photocopied parts of relevant reports. Drove from Kadoma to Harare where booked into the Cresta Lodge Hotel. Visited CID office at the central police station, no news of stolen property.

28th  To MWRD for discussions with Mr Sengayi and Joseph. Reconfirmed flight tickets with BA. Drove to Chitengwiza and then on to the Mukumbe school collector well site. Collector well has not yet been equipped with a bush pump, but top slab has recently been cast and awaits fitting. Much water is raised by hand from this site using rope and bucket. Water is transported from this site in 200 l drums on scotch carts. Proved to be the only reliable source of water during the recent prolonged drought. Undertook an EKS traverse across the site. RWL (btoc) 7.20m, 6.15 m (bgs), well depth 11.5 m (btoc). Drove to Wedza from where drove to St Lioba's school with difficulty, passing the Maruta school site en route. Note a recently drilled borehole equipped with a bush pump. This borehole tended to dry up during dry periods. On to the collector well which is very well used. This well formed the only reliable source of water during the recent drought periods. Water was collected here from outlying areas in 200 l drums on scotch carts. Undertook an EKS traverse due south from the collector well at 30m intervals. Returned to Harare through heavy rain, very poor driving conditions.

29th  To MWRD for discussions with Joseph and Mr Sengayi. Need information re the Hatcliff sites, none present at MWRD. Obtained limited data on Sabi Valley holes Nos 11, 16 and 17. Obtained location map of the Japanese drilled boreholes north of Morehwa with very limited tabulated data. Limited data available from 8 dewatering boreholes drilled for the Zorve dam. Visited the windmill site at Hatcliff but weather too wet to undertake EKS surveys. Returned to hotel via bank to change US dollar travellers cheques and purchase air port tax stamp (US$20). To the Geological Survey to purchase memoirs ($250) and the Survey Department for the purchase of 1:50 000  and 1:250 000 scale topo maps (33 x $20 and 3 x $25 - $735). Very heavy rain with much thunder and lightening.

30th  To MWRD to collect borehole information from Sabi Valley, Nyamandlhovu aquifer and the Hwange area. Met Sam Sungoro to arrange meeting tomorrow. No data yet available from the Japanese boreholes north of Morehwa. Tried to contact Jeremy Prince but he's in Mozambique and Tim B is in the Zambezi Valley, neither back in the office until Monday. Back to hotel, Roger out to do shopping. Returned then out in rain to the Wambles for a meal, pilchards $44, rump steak $91, plus dessert  - came to about $180. Obtained $250 of fuel from petrol station adjacent to the Wombles. Back to hotel.

December 1995

1st  To BHC at 8-30 for meeting with Robin Cadwallader (senior engineering advisor BDDCA based in Harare) and Mike Edwards

(second sec AID to be replaced by young woman straight from UK). Outlined aims of project and where we had been, Roger described the method and equipment. Highly mobile, easy and quick to use, just have to refine interpretation of the results. Good results from sand rivers and weathered bedrock especially at collector well sites. Noted that collector well sites very successful during drought periods when they formed the only reliable source of water in large areas. People used to collect water in 44 gallon drums transported long distances on Scotch carts and pick-up trucks. Robin had to leave after 30 mins. Mentioned the Lupane project, based upon Bikita - needs a significant hydrogeological input. Will be in contact re this, due to start in 9-12 months time. Need to call in to see him on way back from Botswana in July-August next year. Continued discussions with Mike Edwards for an additional 30 mins or so. To Borrowdale to do some shopping at Bon Marche. Had lunch at the Keg and Sable ($54). Back to hotel, then to MWRD for meeting with Sam Sunguro and Lawrence Sengayi at 14-00. Described system and results to Sam Sunguro, discussed the results for nearly 2 hours. Also chatted about fluoride related health problems in the Sabi Valley (hot springs waters) and goitre as well as possible problems with agro residues in areas such as north of Morehwa. Greater care needs to be taken when locating site for borehole drilling as quality of water supplied may be detrimental to health in the long term. Also discussed Bikita (will get results from Joseph Njiniki) and Lupane. Government not happy with the way aid donors are circumventing MWRD via NGOs and RDCs to do groundwater projects. No detailed data passed on to MWRD as no detailed data collected, those that are are held by DDF at district level. To the Quality Inn for drinks with Lawrence and Joseph. Returned to hotel through very heavy rainfall.

2nd Met Robin Cadwallader at the Cresta Hotel car park passed on letter for Robin Herbert. Supplied him with new telephone and fax numbers for the Wallingford office. To central Harare to do some last minute shopping. Attacked by car thieves in Baker St. stole wallet containing travellers cheques, cheque book, passport and airline ticket as well as yellow note book. Reported to the police at Harare Central Police station. Obtained 4 passport photos for $40. To the British High Commission at 14-00 where met Mr Bowyer who issued emergency passport. Back to hotel to complete packing. To the Sheraton Hotel with Ishmail the BHC driver to collect replacement airline ticket. Had to contact Wagon Lit on emergency telephone number to obtain correct ticket number and authorization for issuing of replacement ticket. Back to hotel to check out. Arrange for Landrover to be collected by Ishmail on Monday to be driven to the MWRD and the keys to be held by the BHC (Mike Edwards/Eileen Welch). Checked in for flight BA052 to London Heathrow at 18-30hrs. Had to pay US$20 airport tax again. Had also to pay ?200 excess baggage. Allocated seats 28D and E with plenty of leg room. Bought duty frees took off on time at 22-10 after calling Jan from public call box using up phone cards.

3rd Arrived at Heathrow at 6-05, called Jan then Sport after collection of heavy luggage. Taken to Oxford via Wallingford

where dropped off IH chap.

References

Amm, F.L., (1940). The Geology of the Country around Bulawayo. Southern Rhodesia Geological Survey Bulletin No. 35. (Reprinted 1965).

Baldock, J.W., 1991. The Geology of the Harare Greenstone Belt and Surrounding Granite Terrain. Zimbabwe Geological Survey, Bulletin No. 94.

Broderick, T.J. and Mutirwara, P., 1995. A review of groundwater investigations within the Middle Save alluviums between the Tanganda River and the Mushikavanhu communal lands, Chipinge District. Middle Sabi Farmers' Association and Regional Water Authority, Harare.

Chilton, P.J. and Talbot, J.C., 1990. Collector wells for small scale irrigation: Siting, construction, testing and operation of a collector well at the Lowveld Research station, Chiredzi. British Geological Survey Technical Report WD/90/20.

Chilton, P.J. and Talbot, J.C., 1992. Collector wells for small scale irrigation: Construction and testing of a collector well at the Tamwa/Sihambe/Dhobani Kraals and further work at Chiredzi. British Geological Survey Technical Report WD/92/27.

Herbert, R. and Rastall, P., 1991. Development of Horizontal Drilling for Alluvial Aquifers of High Permeability. ODA/BGS R & D Project (91/7). FINAL REPORT ON WORK IN ZIMBABWE. BGS Technical Report WD/91/50.

Garson, M.S., 1991. Bulawayo Geology Sheet, scale 1:100,000, to accompany Geological Survey Bulletin No. 93.

Interconsult, 1985. National Master Plan for Rural Water Supply and Sanitation. Volume 2/2 Hydrogeology. Prepared for the Ministry of Energy and Water Resources and Development, Republic of Zimbabwe. 4 maps.

Lister, L.A., 1987. The Erosion Surfaces of Zimbabwe. Zimbabwe Geological Survey Bulletin No. 90.

Lockett, N.H., 1979. The Geology of the Country Around Dett. Rhodesia Geological Survey Bulletin No. 85.

MacDonald, D., 1970. The development of railway borehole water supplies on the Bulawayo-Dett section since 1950. The Rhodesian Science News, vol. 4, No. 12, pp 398-405.

MacGregor, A.M. and Ferguson, J.C., 1937. The Geology of the Country Around the Queen's Mine, Bulawayo District. Southern Rhodesia Geological Survey, Bulletin No. 30. Reprinted 1972.

Owen, R.J.S., 1989. The use of shallow alluvial aquifers for small scale irrigation, with reference to Zimbabwe. University of Zimbabwe and Southampton University, final report of ODA Project R4239.

Stidolph, P.A., 1977. The Geology of the Country Around Shamva. Rhodesia Geological Survey Bulletin No. 78.

Sutton, E.R., 1979. The Geology of the Mafungabusi Area. Rhodesia Geological Survey Bulletin No. 81.

Swift, W.H., 1962. The Geology of the Middle Sabi Valley. Southern Rhodesia Geological Survey Bulletin No. 52.

Swift, W.H., White, W.C., Wiles, J.W. and Worst, B.G., 1953. The Geology of the Lower Sabi Coalfield. Southern Rhodesia Geological Survey Bulletin No. 40.

Thomas, D.S.G. and Shaw, P.A., 1991.The Kalahari Environment. Cambridge University Press.

Thompson, A.O., 1975. The Karoo Rocks in the Mazunga Area, Beitbridge District. Rhodesia Geological Survey Short Report No. 40.

Thompson, D.M., Lovell, C.J., Chilton, P.J. and MacDonald, D.M.J., 1995. Small scale irrigation using collector wells: site reports. BGS technical report WC/95/75.

Watson, R.L.A., 1960. The Geology and Coal Resources of the Country Around Wankie, Southern Rhodesia. Southern Rhodesia Geological Survey Bulletin No. 48.

Wright, E.P., Murray, K.H., Herbert, R., Kitching, R. and Carruthers, R., 1985. BGS/ODA - Zimbabwe Government Collector Well Project. Interim Report (March 1985).

Wright, E.P., Herbert, R., Murray, K.H., Carruthers, R.M., Kitching, R., McFarlane, M.J., Hindson, L.L. and Mainala, S., 1987. Collector Well Programme, Zimbabwe and Malawi, 1986-7. BGS Technical Report with appendices.

Wright, E.P., Herbert, R., Murray, K.H., Ball, D., Carruthers, R.M., McFarlane, M.J. and Kitching, R., 1988. Final report of the Collector Well Project 1983-1988. BGS Technical Report WD/88/31.