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F.D.W.R./E.D.F. WATER RESOURCES PROJECT

GROUNDWATER RESEARCH  
DEPARTMENT

National Water Resources Institute  
Kaduna

Interim Report Nr. 3  
February 1985

MRT CONSULTING ENGINEERS  
(NIGERIA) LTD.

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## CONTENTS

Summary	(i)
1. Logistics and Infrastructure	1
1.1 Consultant Staff Movements	1
1.2 Appointment of Counterpart Staff	1
1.3 Accommodation	3
1.3.1 Consultant Staff	3
1.3.2 Counterpart Staff	3
1.4 Transport	3
1.4.1 Licensing of Project Vehicles	3
1.4.2 Local Purchase	3
1.5 Payments	4
2. Progress - Establishment	5
2.1 Offices	5
2.2 Workshops and Stores	5
2.3 Equipment	6
2.3.1 Drilling Equipment	6
2.3.2 Geophysical Equipment	8
2.3.3 Hydrogeological Equipment	8
3. Progress - Operation	10
3.1 Drilling	10
3.2 Geophysics	12
3.3 Experimental Catchment Study Research Project	14
3.4 Training	15
4. Programme of Work	17
4.1 Experimental Catchment Study	17
4.2 Other Research Projects	17
Figure 1 Experimental Catchment Area	11

## SUMMARY

This report describes the progress of the FDWR/EDF Water Resources Project in the period December 1984 to February 1985, and plans for future work.

The main accomplishment of the project during the report period was the start of field operations in the Experimental Catchment Area near Kaduna. Up until the end of February 15 vertical electrical soundings, combined with constant separation resistivity traversing, have been carried out, and 2 boreholes have been drilled. The first borehole was completed in the fresh basement and produced very little water; the second borehole was completed as a shallow test well in the alluvial/weathered basement aquifer occupying the fadama along the stream courses, and produced about 180 m<sup>3</sup>/day during a short airlift test.

Work is likely to continue in the Experimental Catchment Area until early April when the drilling equipment will be brought back to the base workshop for checking and servicing. It is hoped that the next research project area will be selected shortly, and the necessary logistical arrangements made so that the equipment can be mobilised after the servicing work has been completed. However, the future success of the programme, which will take the research teams and equipment away from Kaduna State, will be very dependent on whether satisfactory arrangements can be made to ensure that progress in the field is not held up for financial reasons. Another important factor is the supply of two further vehicles by the Institute, since logistical support will be severely stretched if only the three existing vehicles are available.

(ii)

Mr R.S. Jackson arrived in Kaduna in early January to take over from Mr Ball as hydrogeologist/project co-ordinator. However, Mr Jackson came on a temporary basis for a 3 month input and it is not known at this stage whether a suitable replacement for him has yet been found.

The two test pumps included in the EDF supply contracts have still not been cleared from Lagos port. This is a cause of some concern since they are vital for the determination of well characteristics and aquifer hydraulic properties.

## 1. LOGISTICS AND INFRASTRUCTURE

### 1.1 Consultant Staff Movements

Mr R.S. Jackson arrived in Kaduna on 10 January 1985 to take over as hydrogeologist/project co-ordinator from Mr D.M. Ball who resigned from the Consultant and left Nigeria on 25 November 1984. Mr Jackson came on a temporary basis for a 3 month input; it is not known at this stage whether a suitable replacement for him has yet been found. Mr Jackson was issued with a three-week visitor's visa by the Nigerian High Commission in London. The Immigration Department in Kaduna were unable to extend this visa or to issue a residence permit. On 25 January Mr Jackson travelled to Lagos to see the Federal Department of Water Resources and the Delegation of the Commission of the European Communities to Nigeria regarding this problem and to apply for a residence permit from the head office of the Immigration Department. The residence permit was issued on 6 February.

Mr L.J.F. Cunningham, the geophysicist for the project, was issued with a residence permit in January.

Mr J. Rigg, the driller mechanic supplied by the drilling rig manufacturer (Halco), departed for home leave on 23 December 1984 and returned to Nigeria on 11 January 1985. He intends taking further leave during April.

### 1.2 Appointment of Counterpart Staff

At a meeting of the Groundwater Research Department's staff with the Institute's Acting Director on 1 February it was announced that Mr E.A. Moge kwu (the Institute's Principal Hydrogeologist) would assume the role of Co-ordinator to liaise between the FDWR/EDF Project and the Institute in matters concerning project administration and staffing.

This is a very welcome move since in the short term it will enable the Consultant's staff to devote more time to training and research supervision, but more importantly in the long term it will ensure that the Department will have an effective head after the Consultant's departure.

Following a review of the staffing levels for the Department as a whole, a need was recognised for two more drivers and two technician/mechanics. One of the drivers is required for the Land Rovers, and the other is required to replace one of the truck drivers who has resigned. The technician/mechanics are seen as being essential to ensure that adequate maintenance of the drilling equipment and vehicles is carried out both in the base workshop and in the field. As a temporary measure the Institute has provided the services of one of its mechanics to assist the project until these staff can be recruited.

Ten applicants for the post of driver were tested in one of the Land-Rovers on 21 February. A short-list of five was then drawn up, and these were tested in the flat-bed support truck on the following day at the drilling site. Letters of appointment to the two successful candidates are presently being prepared by the Institute's administration Department.

Notices calling for applications for the post of technician/mechanic were displayed in the Institute in mid-February. Fourteen applications were submitted by the deadline of 28 February. Interviews will be held during March to choose the most suitable candidates.

Two of the field assistants appointed in October 1984 were dismissed in February since they were found to be completely unsuitable for project work and a bad influence on the rest of the staff.

### 1.3 Accommodation

#### 1.3.1 Consultant Staff

Mr Jackson is staying with Mr Cunningham at 16 Kabir Road, Kaduna. At the end of January Mr Rigg moved out of the Preussag mess and is now living in the mess of another company. Payment of the rent for Mr Rigg's new accommodation has not yet been effected by the Institute.

#### 1.3.2 Counterpart Staff

All four houses rented by the Institute for the senior staff in the northern part of Kaduna are now occupied - one by Mr Odusanya and his wife, one by Mr Okedi and the other two are shared by Mr Oyinlola/Mr Olusola and Mr Owolabi/Mr Eduvie. However, the houses are only partially furnished, and several important items that the staff are entitled to, such as fridges and cookers, are still outstanding.

### 1.4 Transport

#### 1.4.1 Licensing of Project Vehicles

The rig and two support trucks were issued with FGN (Federal Government of Nigeria) licence numbers in January, and enabled the drilling research programme to start.

#### 1.4.2 Local Purchase

There is a provision in the local currency budget for the procurement of two more vehicles. The Institute is attempting to enquire from PAN about the purchase of a Peugeot 504 saloon and a 504 estate. It is hoped that there will be no undue delay in the supply of these vehicles, since they will be essential when the research programme moves to distant parts of the country.

1.5 Payments

A further payment was made in Naira into the Consultant's bank account in Kaduna in December 1984.

Local expenses paid for by the Consultant for the period July to October, for which a claim was submitted on 22nd November 1984, were reimbursed by the Institute on 27th December 1984.

Claims for expenses incurred in November and December, were submitted early in the following months, and were reimbursed on the 18th February 1985.

2. PROGRESS - ESTABLISHMENT

2.1 Offices

The new offices for the Groundwater Research Department have been repainted. Security bars have been fitted to the windows which were not already provided with them. As no airconditioners have yet been obtained, the doors which are to be blocked up have been temporarily fastened shut, while other doors have had bolts fitted on the inside for increased security.

The use which can be made of these offices is limited by the lack of furniture. Some desks and chairs have been supplied by the Institute, but financial problems have delayed purchases of the bulk of the furniture.

An order was placed by the Institute early in January for a photocopier and an electronic typewriter. These items have not yet been delivered, as the supplier ran out of stock and has apparently been having problems in clearing new stock through Customs.

2.2 Workshops and Stores

The stores area within the workshop has been provided with a roof to improve security and lights have been fitted in the stores themselves. The only remaining work required for the workshop is the fitting of a sliding door between the workshop and the other half of the building.

## 2.3 Equipment

### 2.3.1 Drilling Equipment

The last two crates of equipment, which were delivered to Lagos by the S.S. Stena Ionia on the 14th May 1984, were still in the docks there at the end of February. The crates contain the test pumpsets, general spares and vehicle manuals.

Various items supplied by Halco to make good deficiencies previously noted were brought to Kaduna by Mr Rigg on his return from leave.

These included:

- brake air line, 7 core cable and connector for the mud pump trailer
- rear light assembly for the compressor
- bearing collars and seals for the gearbox air seal on the drilling rig.
- air swivel extracting tools
- assorted washers and O rings.

Two inner tubes for the drilling rig truck have been purchased locally, and enquiries are being made for the procurement of a tyre for the compressor and one drum of Drill Aid foam.

It is not known what progress has been made by Hydreq in the supply of items to make good deficiencies noted by the Provisional Acceptance Committee in September 1984; (viz. 12 v batteries for support truck, tool kit and clock for Peugeot car, door lock cylinders and keys for the Land Rover van, cable and socket for lighting tower, 42 m of 8" steel casing and 6 m of 10" steel casing).

As noted in the last Interim Report (pages 11 to 15) several other deficiencies came to light after the Provisional Acceptance Committee met.

The most serious deficiencies were found on the water tanker (the suction hose and tanker pipework were different diameter) and the generator set (no compression on one of the cylinders due to damage to the piston and cylinder head). Hydreq, who supplied these items, has agreed to send the necessary replacement parts.

It is not known what progress has been made by Halco to supply the items for the rig and mudpump that came to light after the Provisional Acceptance Committee met.

A 3 inch, high pressure ball valve is required for the discharge line of the mudpump to control the pump pressure while using the mixing line for mud preparation. Without this valve the discharge line is not able to contain the pressure and there is a danger it could blow off and injure someone. Attempts are being made to find a local supplier for this valve.

A lockable caravan has been loaned from the FDWR office in Kaduna for use as a mobile workshop and store on site. A work bench has been installed and it is planned to put in wiring for lights and power points for connection to the generator.

A ceremony to hand over the equipment from the EEC/EDF to the FDWR is scheduled to take place in mid-March. The head of the EEC's Development Department in Brussels will be attending, and it is planned that the ceremony takes place at the drilling site in the Experimental Catchment Area.

### 2.3.2 Geophysical Equipment

A replacement input amplifier circuit board for the ABEM Terrameter was received on 28 December 1984. When the new board was fitted, the equipment functioned correctly, and could be used for field work. However, on 22nd February the Terrameter suddenly stopped working during field work. The error code displayed again indicated a fault in the input amplifier circuit board. The instrument will be returned to the manufacturers for checking and repair in accordance with the guarantee.

The well-logging equipment has been used and is working correctly.

### 2.3.3 Hydrogeological Equipment

Very little hydrogeological equipment was included in the EDF supply contracts. Consequently it has been necessary to borrow as much equipment as possible from existing FDWR Zonal Offices since most items are not stocked by local survey equipment suppliers.

The following items of equipment are presently on loan from the FDWR office in Kaduna:

- 2 nrs Brunton type compass/clinometers
- 3 nrs. 50m carbon fibre reinforced tape measures
- 20 nrs. 200 ml capacity sample bottles
- 5 nrs. 1 lb geological hammers, fibre glass shaft
- 1 nr. Beckman Chem-mate pH/mV meter with 2 electrodes
- 1 nr. Hach DR/EL-4 portable laboratory (some chemicals supplemented by FDWR Sokoto office)

A set of sieves, a sieve shaker and a balance have been borrowed from the Institute's hydraulic workshop.

A replacement holding-down rod was made for the shaker in the workshops of the Federal Superphosphate Fertilizer Company.

Three particle size distribution analyses have so far been carried out with this equipment.

In spite of the equipment that has so far been borrowed, several essential items are still outstanding, particularly electrolytic conductivity (EC) meters and suitable graph paper for plotting pumping test and chemical data. In order to rectify this situation a request has been made to the EEC office in Lagos to procure these outstanding items from the project's contingency fund.

### 3. PROGRESS - OPERATIONS

#### 3.1 Drilling

The test borehole was completed in the NWRI compound on 17 December 1984, at a total depth of 92 m; 8 inch steel casing was installed to 40.8m and the open hole below taps the fresh basement complex and 4 m of the weathered zone. The well has not yet been pump tested. Subject to satisfactory testing the well may be equipped with a windmill and used to supplement the Institute's water supply.

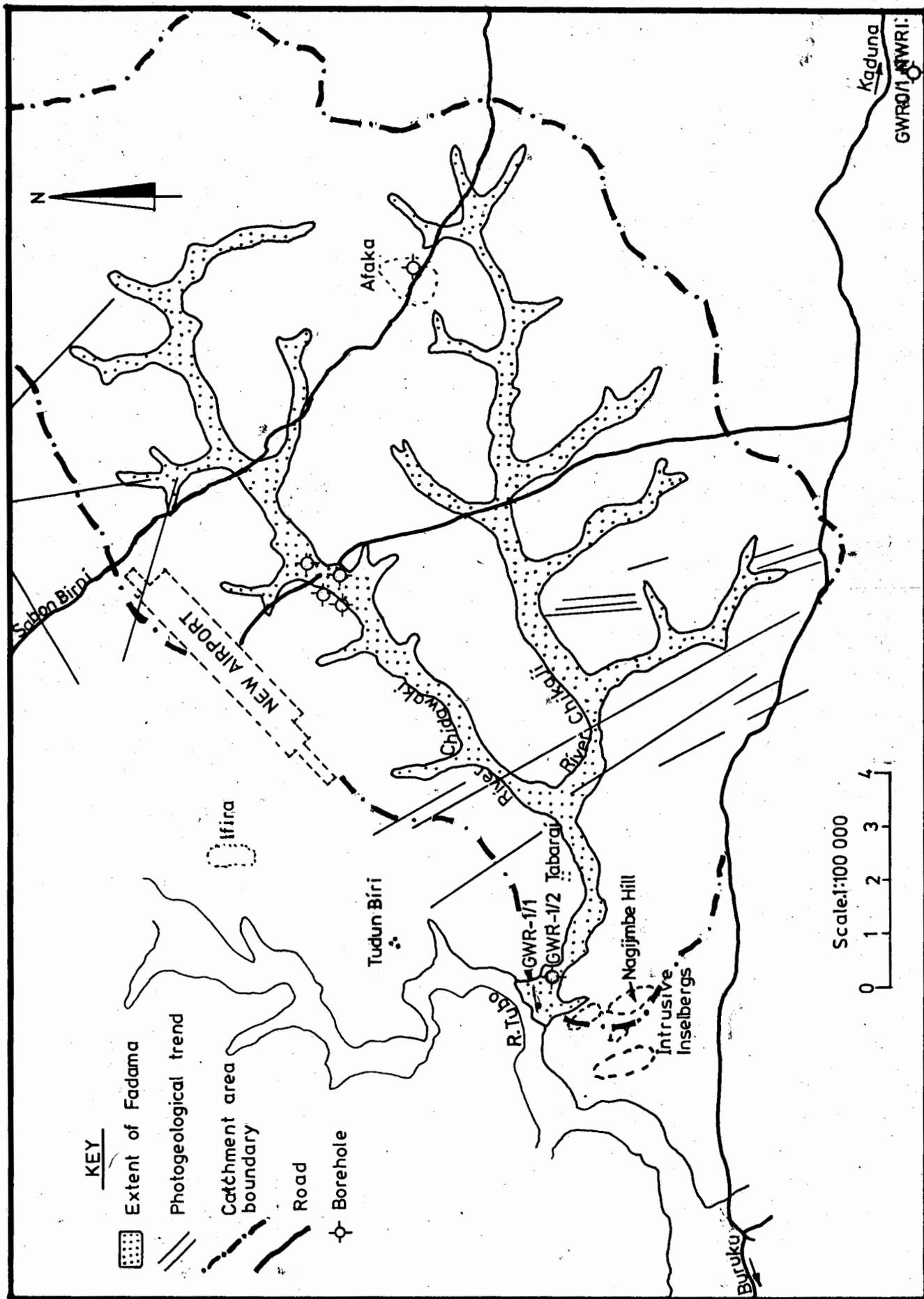
Following the registration of the rig and support trucks in January the drilling equipment was mobilised to the Experimental Catchment Area near Buruku. Two boreholes have so far been drilled on the fadama of the River Chidawaki about 800 m from its confluence with the River Tubo. The location of these boreholes - GWR-1/1 and GWR-1/2 - is shown on Figure 1.

GWR-1/1 was drilled to 102 m into the fresh basement complex.

The overlying alluvium and weathered zone was cased off with 6 inch steel casing and a sampling test was carried out by airlift to assess the yield and water quality. Geophysical logs were run before the installation of casing and after the completion of drilling.

The yield of the well was very low, estimated at about 14 m<sup>3</sup>/day. Drawdown was probably in excess of about 80m. It was concluded that the fresh basement complex is virtually impermeable, with the only water occurring in minor cracks and fissures. The water appeared to be fresh, but no measurements on quality have so far been carried out because of the lack of necessary equipment.

Figure 1 Experimental Catchment Area



GWR-1/2 was drilled to the top of the fresh basement complex at 15m, and 6 inch PVC screen was installed opposite the alluvial and weathered basement aquifer, consisting of medium-coarse sand, sandstone and wood remains. The aquifer permeability was estimated to be about 4 m/day from a short airlift pumping test. The water is fresh but appears to have a significant iron content. The well was tested at 178 m<sup>3</sup>/day which produced a drawdown of about 3.70 m after 240 minutes of pumping. This yield is probably sufficient to irrigate about 2 ha of dryfoot crops if the Institute is interested in establishing a small irrigation project.

### 3.2 Geophysics

Geophysical field work has been carried out in the Experimental Catchment Study Area, primarily to provide training for the counterpart staff. A total of 15 vertical electrical soundings, combined with constant separation resistivity traversing, using various electrode spacings, has been completed in the vicinity of the first two boreholes and along a line towards the southern end of a prominent hill (Nagijmbe Hill) about 1.4 km to the southwest of the borehole sites. The majority of the soundings have made use of the BGS multicore cables (the Offset Wenner array), although two have been performed with the Schlumberger array for comparison.

Field work using the Schlumberger array has proved to be considerably slower, particularly because of the lack of radios; once larger values of the current electrode spacings are reached, communication by shouting or waving becomes unreliable or even impossible, and time is lost in passing instructions.

With the Offset Wenner array, field work was initially slow, because of the inexperience of the counterpart staff, but acceptable rates of progress were being achieved just before the Terrameter stopped working at the end of February.

Interpretation of the soundings has been carried out using the BBC microcomputer belonging to the Consultant. Programmes have been written for the reduction of field data to apparent resistivity values for both the Schlumberger and Offset Wenner arrays. The use of these programmes has provided an introduction to the use of a computer by the counterpart staff.

A full evaluation of the results will have to await the completion of drilling in the area, as only then will it be possible to make full use of the borehole data for correlation.

### 3.3 Experimental Catchment Study Research Project

Following a meeting of the Institute's Research Committee on 11th January to discuss the Experimental Catchment Study, a visit was made to the area by committee members on 16 January. The proposed drilling site was inspected and a survey was made of the area around Tudun Biri Village and along the River Tubo. The water level in a dug well at the village was about 12 m; the water was muddy and slightly salty.

As mentioned in Sections 3.1 and 3.2 groundwater fieldwork so far carried out has consisted of the drilling of two boreholes in the fadama of the River Chidwaki near the confluence with the River Tubo, and the carrying out of 15 vertical electrical soundings between the fadama and Nagijmbe Hill.

The only aquifer of any significance occurs within the fadama deposits, consisting of alluvial sand, and weathered basement clayey silt, and sand and sandstone. The alluvial sands contain significant wood and vegetation remains. The base of the aquifer lies at about 16 m, and the water table at about 2 m. The fresh basement consists of banded gneiss and quartzite and is virtually impermeable, the only water probably occurring in minor cracks and fissures.

The extent of fadama in the area is shown on the Geological Survey of Nigeria's photogeological map (sheet 123), which forms the basis of Figure 1. The area of the fadama has been determined by dotcounting and planimeter to be 23.6 km<sup>2</sup>. Taking an average aquifer thickness of, say, 7m for the fadama as a whole, an aquifer volume of the order of 165 m<sup>3</sup> is indicated.

Assuming a specific yield of 10% (a value typically applied to clayey sands and sandstones) the amount of water in storage can be estimated to be around 16.5 million m<sup>3</sup>. These figures are, of course, very tentative at this stage and should be refined once further field data become available, particularly piezometer observations during pumping tests for specific yield determinations.

It is not known what progress has been made by other departments of the Institute in setting up meteorological and river gauging stations in the catchment area, to enable an assessment to be made of the hydrological components including groundwater recharge.

#### 3.4 Training

The fieldwork continues to be carried out hand in hand with on-the-job training. During the drilling of GWR-0/1 in the Institute compound and GWR-1/1 in the Experimental Catchment Area the crew was introduced to mud drilling, and down-the-hole hammer drilling with compressed air. Crew members were trained in the collection and bagging of cutting samples of the formations being drilled, and in recording penetration rate, the condition of the circulating fluid (mud weight, density and viscosity, water discharge), water losses etc.

A different drilling method was used for GWR-1/2 - only water was used as a circulating fluid and the hole was kept open by temporary casing following the bit. After the completion of drilling smaller diameter permanent casing and gravel pack material were installed inside the temporary casing as it was being withdrawn. The crew was trained in gravel pack sieving and installation.

During the middle of February a rota system was initiated amongst the counterpart hydrogeologists and those technicians and field assistants not attached to the drilling crew, to ensure that staff were introduced to both geophysical and hydrogeological fieldwork and data analysis.

As mentioned in Section 3.2 training has been given in resistivity soundings and traversing using both the Offset Wenner and Schlumberger arrays. In the office staff have been introduced to data processing and interpretation using the Consultant's microcomputer. The word processing facility of the machine is being used to prepare training notes on geophysical techniques and interpretation procedures.

In hydrogeology, training has been given in formation sample description, particle size analysis, geophysical well logging, chemical analysis, and pumping test operation and data plotting. Standard borehole logs and completion reports have been prepared to encourage a uniform approach to data collection and presentation. Standard lithology symbols and abbreviations have been recommended. A set of training papers prepared for another project undertaken by the Consultant has been circulated amongst the staff, and textbooks belonging to Mr Jackson are being widely read.

As part of the training exercise an effort will be made to collect as many existing reports on groundwater investigations in Nigeria as possible. A recommendation has been made to the Permanent Secretary of the Federal Ministry of Agriculture, Water Resources and Rural Development that all government and aid agencies involved in groundwater work should include a clause in future terms of agreement with contractors, consultants and others required to produce reports, that at least two copies of any report must be delivered to the Institute.

4. PROGRAMME OF WORK

4.1 Experimental Catchment Study

Drilling of a third borehole - GWR-1/3, close to the River Chidawaki where the fadama aquifer may be at its thickest - is about to start. Two further boreholes are planned, and will probably be completed as piezometers in the fadama aquifer near to GWR-1/2 or GWR-1/3. It is expected that this work will be completed in early April, at about the time that Mr Rigg is due to go on home leave for two weeks. While Mr Rigg is away the opportunity will be taken to check over the equipment in the base workshop and carry out maintenance duties before the move to the next research project area.

The resumption of resistivity fieldwork depends on how long the Terrameter will be under repair in Europe and whether it can be quickly cleared through customs on arrival back in Nigeria.

4.2 Other Research Projects

The Niger State Water Board wrote to the Institute in December requesting assistance with the problems of groundwater resources in that State. However, no details were given on what sort of problems have been identified, and the Board has been asked to supply further information to assist the planning of a possible research programme. The Board may be visited in the near future if no response is forthcoming.

A request was received from Lemaco Ltd. in January for advice on the potential for groundwater development on a 2050 ha farm situated near Udawa village some 74 km from Kaduna along the Kontagora road.

Further information is awaited from Lemaco, since it may be possible to give the necessary advice on the basis of a 'desk study' of existing borehole and other data.

A questionnaire to gather proposals for possible research projects was sent to all the State Water Boards, River Basin and Rural Development Authorities and FDWR zonal Offices in early February. It is hoped that the response will be sufficient to enable a definite research programme to be formulated for 1985 and 1986. The general aim of such a programme while the Consultant's staff are attached to the Institute should be to carry out investigations in each of the areas representing the main geological and climatic environments of Nigeria, so that the counterparts will gain the necessary experience to be able to undertake work in any part of the Country after the consultants' departure.

However, the actual execution of the research programme will be very dependant on whether satisfactory financial arrangements can be made to enable the field teams to operate in any part of the Country. Ideally, a senior member of the field team should administer an imprest account sufficient to cover operational expenses on a monthly basis. It will be impractical to run a drilling programme several hundred kilometres from Kaduna if a trip has to be made back there to request an advance each time an expenditure arises. The sort of delay which could occur was experienced in the Experimental Catchment Area when the start of drilling was held up by 10 days while an advance was awaited for the purchase of a bulk supply of diesel.

