IAEA-ASSISTED SAHEL PROJECT RAF7011: PROGRESS REPORT ON THE IULLEMEDEN (SOKOTO) BASIN IN NIGERIA

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Paper presented at the First Coordination & Governance Meeting on Project RAF7011: Integrated and Sustainable Management of the Shared Aquifer Systems and Basins of the Sahel Region, Vienna, Austria, 5 – 8 May 2014 .

OUTLINE OF PRESENTATION

1. Overview of Geology and Hydrology
2. The Main Hydrogeological Problems
3. Criteria Used in Selecting Sampling Points
4. List of Participating Staff of Counterpart Institutions and assigned responsibilities
5. The Main Problems Encountered in Field Work
6. Geometry & Hydrogeological Characteristics of the Aquifers

6.1 Satellite Imageries, Geological Maps & Cross Sections; Geological Succession

6.2 Strata Logs of Boreholes and Hydrographs

6.3 Sampling Campaigns: 2013 – 2015

6.4 Baseline Hydro-chemical and Isotope Data

1. OVERVIEW OF GEOLOGY AND HYDROLOGY OF NIGERIA

- The Sedimentary basins of prime hydrogeological significance in Nigeria are discernible from the **Geological Map**. Groundwater also occurs in some areas within the Basement Complex but with comparatively lower yields from boreholes except in deeply weathered or fractured locations.

- There are eight (8) Hydrological basins in Nigeria which together with the drainage networks are shown in the **Hydrology Map**.

- The location of the **Iullemeden (Sokoto) basin** is well defined in the two Maps.

1. GEOLOGICAL MAP OF NIGERIA SHOWING GROUNDWATER AREAS

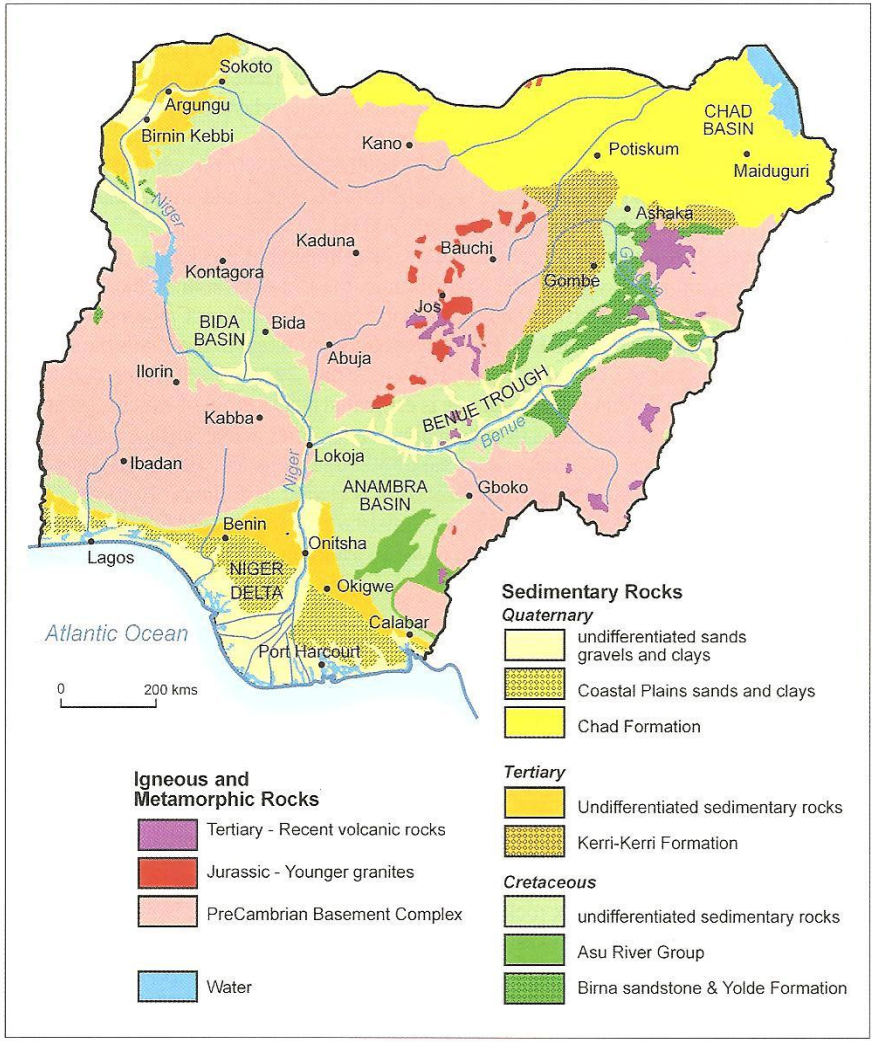
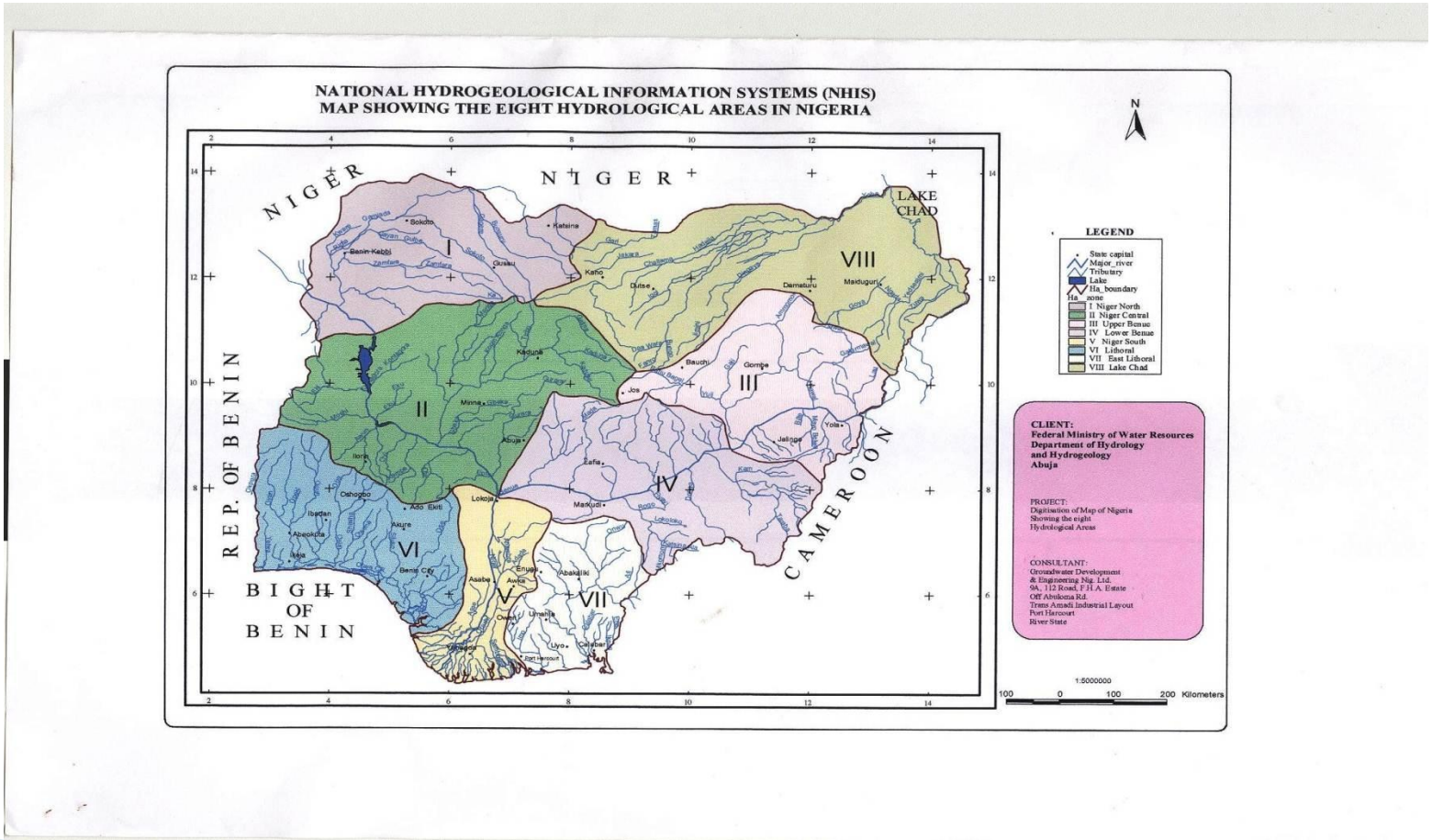


Figure 2. Generalized geological map of Nigeria (from MacDonald *et al.*, 2005).

SW Nigeria. The Precambrian Basement rocks of south-eastern Nigeria occur in three

1. OVERVIEW OF HYDROLOGY OF NIGERIA



2. THE MAIN HYDROGEOLOGICAL PROBLEMS TO BE ADDRESSED

Background

- The Iullemeden (Sokoto) Basin experiences low and limited rainfall with mean annual figure often below 600mm towards the Nigeria-Niger border and occurs mainly within four months of the year (June – Sept.).
- Furthermore, high temperatures and very low humidity prevalent in the area result in high rate of annual potential evapotranspiration (>1500mm) and recurring episodes of drought and desertification.
- Consequent on all the above, there is **increasing reliance and latent stress on groundwater** to meet the various water needs of the people (domestic, irrigation, industry, horticulture, aquaculture, animal husbandry).

2. THE MAIN HYDROGEOLOGICAL PROBLEMS TO BE ADDRESSED

2.1 Inadequate information on aquifer wide characterization for regional correlation:

Most of the existing borehole information do not specify the aquifers tapped and the formation/strata logs (showing the hydro-stratigraphic units). Also most of the boreholes are not geo-referenced and altitudes where measured, are often not in metres above mean sea level. Comprehensive geophysical investigations and test drilling (coring) need to be done. Differential GPS should be procured.

2. THE MAIN HYDROGEOLOGICAL PROBLEMS TO BE ADDRESSED (CONTD)

2.2 Data gaps and lack of credible data on aquifer hydraulic parameters viz:-

Static/Dynamic Water Levels in boreholes/wells; Yield; Specific Capacity; Transmissivity; etc. including total depth drilled, position of screens and Water Quality (Hydro-chemistry). Extensive Literature Review to fill-in perceived data gaps and Pumping Tests on strategically selected boreholes (existing/new) for determination of aquifer hydraulic parameters need to be done.

2. THE MAIN HYDROGEOLOGICAL PROBLEMS TO BE ADDRESSED (CONTD)

2.3 The recharge characteristics and hydrodynamics of most of the Aquifers are not well known.

Isotope Hydrology Techniques should be **applied to determine** where unavailable the following information:- origin, recharge and age of groundwater; surface water – groundwater and aquifer – aquifer interconnections including assessment of vulnerability of aquifer to pollution. Recharge zones should be identified and protected. Modalities for Artificial Recharge of the Aquifers could also be explored.

2. THE MAIN HYDROGEOLOGICAL PROBLEMS TO BE ADDRESSED (CONTD)

2.4 Monitoring activities on groundwater level fluctuations and water quality changes are either haphazardly done or non existent in many parts of the basin.

There are localized cases of declining groundwater levels and degradation in water quality. Institutional arrangements for routine Monitoring Activities should be established and sustained by Stakeholders. Coordination and synergy among Stakeholders in the development of water resources in the basin is imperative.

3. CRITERIA USED IN THE SELECTION OF SAMPLING POINTS

The monitoring wells (sampling points) in the Iullemeden Basin in Nigeria have been selected using three (3) main criteria viz:

3.1 **Areal extent of the respective aquifers** in the multi-layered Iullemeden Aquifer System (IAS) was considered in order to ensure adequate coverage of all aquifers in the basin under the monitoring programme. A good number of the sampling points were distributed according to the areal extent of the aquifers on pro rata basis.

3. CRITERIA USED IN THE SELECTION OF SAMPLING POINTS (CONTD)

3.2 Areas within the basin where there is **preponderance (cluster) of boreholes/wells** were considered **critical** as they depict areas with relatively high population density where groundwater could be at risk due to depletion arising from over exploitation and possible degradation in water quality from anthropogenic factors. About half of the number of the sampling points were distributed on this basis.

Localized cases of groundwater problem were included in this category.

3. CRITERIA USED IN THE SELECTION OF SAMPLING POINTS (CONTD)

3.3 Areas identified as possible Recharge Zones for the respective aquifers were also considered.

For **Surface water monitoring**, suitable points upstream, mid stream or downstream of rivers/streams were selected. As for dam reservoirs, convenient locations at the inlet and outlet points were chosen.

4. LIST OF PARTICIPATING STAFF AND ASSIGNED RESPONSIBILITIES

Iullemeden Basin Team:

4.1 Team Members for Field Work:

1. Ibrahim Moriki, Staff of Sokoto Rima River Basin Development Authority (SRRBDA), Sokoto – Team Leader, Field Sampling Campaigns.
2. Bashir Suleiman, Staff of NIHSA, Sokoto Zonal Office
3. Sunday U. Hussaini, Staff of NIHSA, Abuja.
4. Musa Mohammed Mahuta, Staff of SRRBDA, Sokoto.

4.2 Administrative Duties:

1. J.A. Shamonda, DG NIHSA, Abuja – Project Coordinator
2. A.A. Adedeji, Director (HGP), Abuja – IAEA Desk Officer
3. C.M. Maduabuchi, Consultant (Isotope Hydrology) NIHSA & National Water Expert of Nigeria

4. LIST OF PARTICIPATING STAFF AND ASSIGNED RESPONSIBILITIES

4.3 Laboratory Work:

1. Hassan Ahmed, National Water Resources Institute (NWRI), Kaduna - Head of Laboratory Operations (He holds an M.Sc. Degree in Analytical Chemistry)
2. Cletus Musa, NIHSA, Kaduna Zonal Office

4.4 Data Collation, Analyses and Interpretation:

1. Christopher M. Maduabuchi – Consultant (Isotope Hydrology), NIHSA and National Water Expert of Nigeria under Project RAF7011
2. Albert A. Adedeji – Director (HGP), NIHSA, Abuja
3. Sunday U. Hussaini – Principal Hydrogeologist, NIHSA, Abuja
4. Ojo B. Clement – GIS Officer, NIHSA, Abuja
5. Evans Chimdiga – GIS Officer, NIHSA, Abuja

5. MAIN PROBLEMS ENCOUNTERED IN FIELD WORK

5.1 The difficulty in accessing some of the sampling points due to the sandy nature of the terrain and the enormous distances from the team's base in Sokoto.

5.2 Isolated security challenges in some parts of the project area though more pronounced in the Chad basin area.

5.3 Altitude of sampling points, in meters above mean sea level, measured with Garmin GPS are not accurate for leveling purposes. Differential GPS is required.

5. MAIN PROBLEMS ENCOUNTERED IN FIELD WORK

5.4 Depths and static water levels of some sampling boreholes could not be measured as they are sealed. There is paucity of credible hydrogeological data as adequate records are rarely kept.

5.5 Only one data logger was installed in the Iullemeden basin in 2011 but additional 20 Nos. were procured by Nigeria and installed in February 2014 to enhance groundwater level monitoring in the basin.

5.6 Inadequacy of fund to fully accommodate project implementation following reduced annual allocations to NIHSA in successive national budgets.

6. GEOMETRY AND HYDROGEOLOGICAL CHARACTERISTICS OF THE AQUIFERS

Preamble

- The Iullemeden basin covers an area of about 500,000km^2 and consists of Sedimentary deposits.
- In Nigeria where about 60,000km^2 of it occurs, it is known as the **SOKOTO BASIN** and covers the States of Kebbi, Sokoto, Zamfara and parts of Katsina with about 5.1million inhabitants. It lies between longitudes 3^{o}40'E and 8^{o}E and latitudes 10^{o}30'N and 13^o 50'N.
- The Iullemeden basin is a multi aquifer system with total exploitable groundwater reserves estimated at about 2000km^2. It represents one of the major freshwater reservoirs of West Africa.

6. GEOMETRY AND HYDROGEOLOGICAL CHARACTERISTICS OF AQUIFERS

6.1 Satellite Imageries, Geological Maps & Cross Sections; Geological Succession

- A mosaic of Satellite Imageries of the Nigerian sector of the Iullemeden Basin procured by JICA in 1992 and a colour Geological Map subsequently derived from them are presented. A schematic Geological Map of the basin and three (3) Geological Cross Sections have been drawn showing Principal Aquifers and Confining layers, including a Conceptual Geological Succession.

6.1 A MOSAIC OF SATELLITE IMAGERIES OF IULLEMEDEN (SOKOTO) BASIN IN NIGERIA

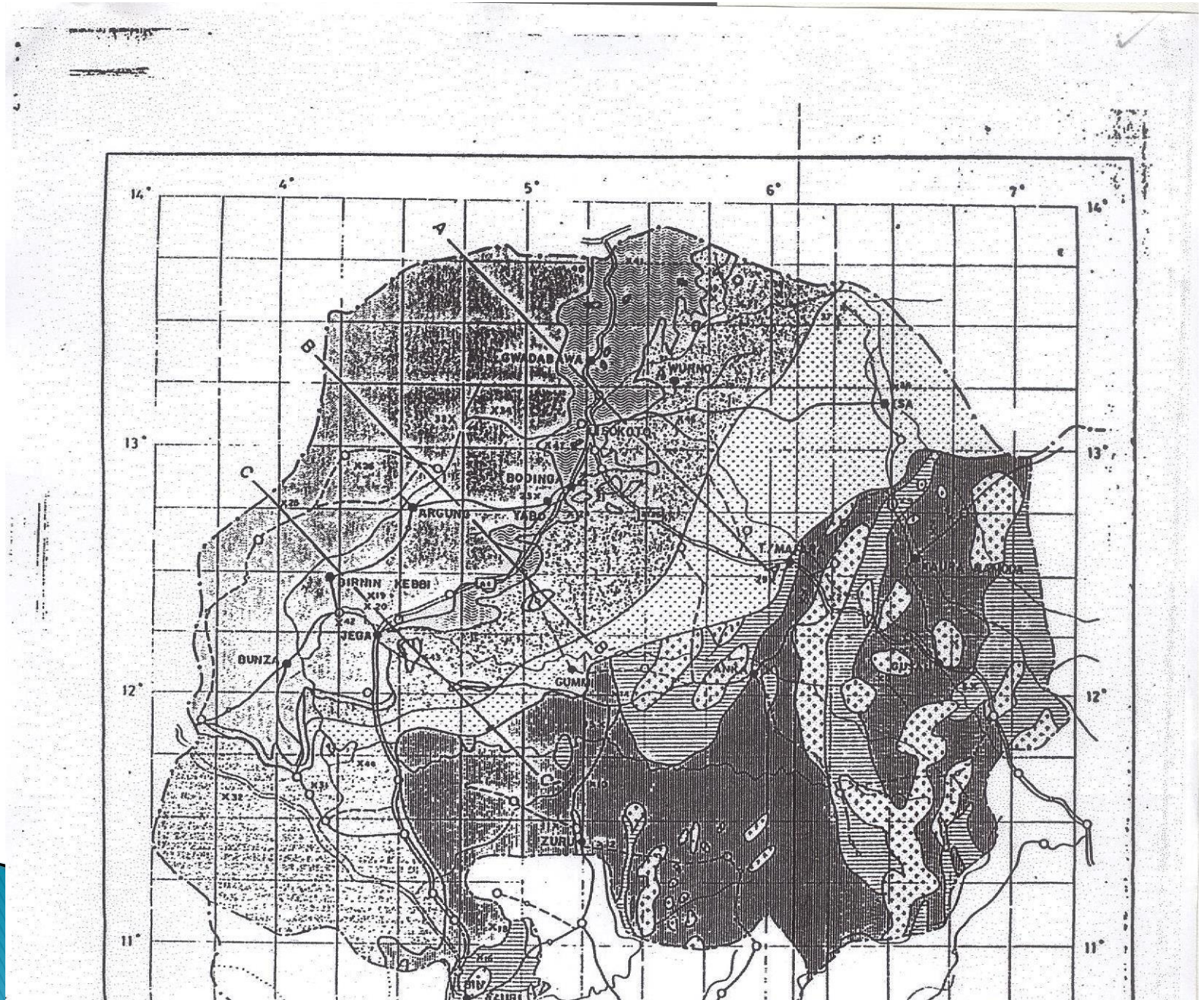
Figure 4: Satellite Imagery of Sokoto Basin

6. GEOMETRY AND HYDROGEOLOGICAL PARAMETERS OF AQUIFERS (CONTD)

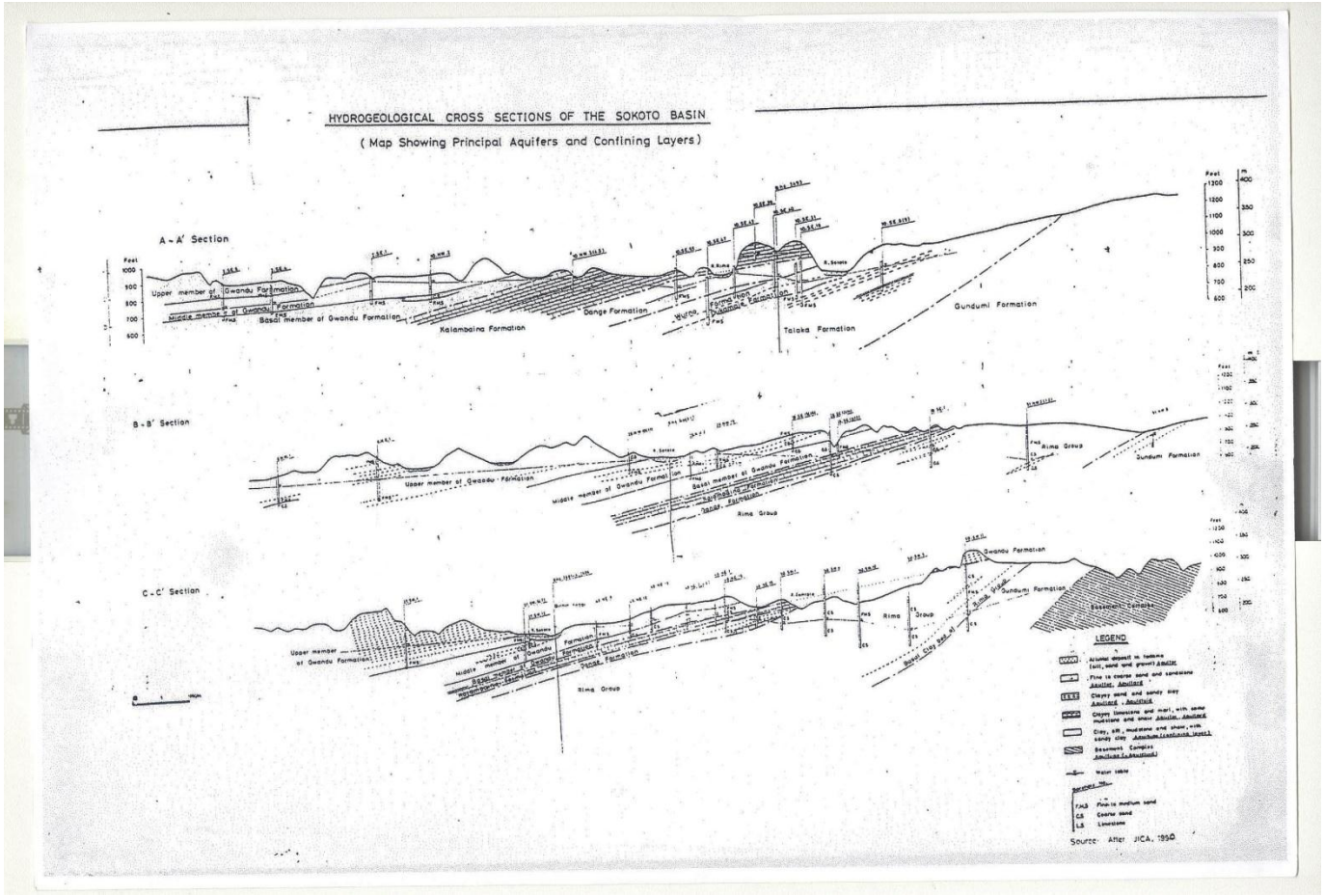
6.1 The Principal Aquifers of the Sokoto basin can be categorized into four distinct sedimentary sequence consisting, from west to east:

- Tertiary Gwandu formation(**Continental Terminal**)
- Tertiary Sokoto Group (Kalambaina and Dange formations);
- Cretaceous Rima Group (Wurno, Dukamaje and Taloka formations) and
- Gundumi-Ilo (**Continental Intercalaire**) formations (Upper Cretaceous/Jurrasic)
- Aquifers of the Sokoto Basin are exploited at various locations within the basin, for domestic, irrigation, horticulture and animal husbandry.

GEOLOGICAL MAP OF IULLEMEDEN (SOKOTO) BASIN

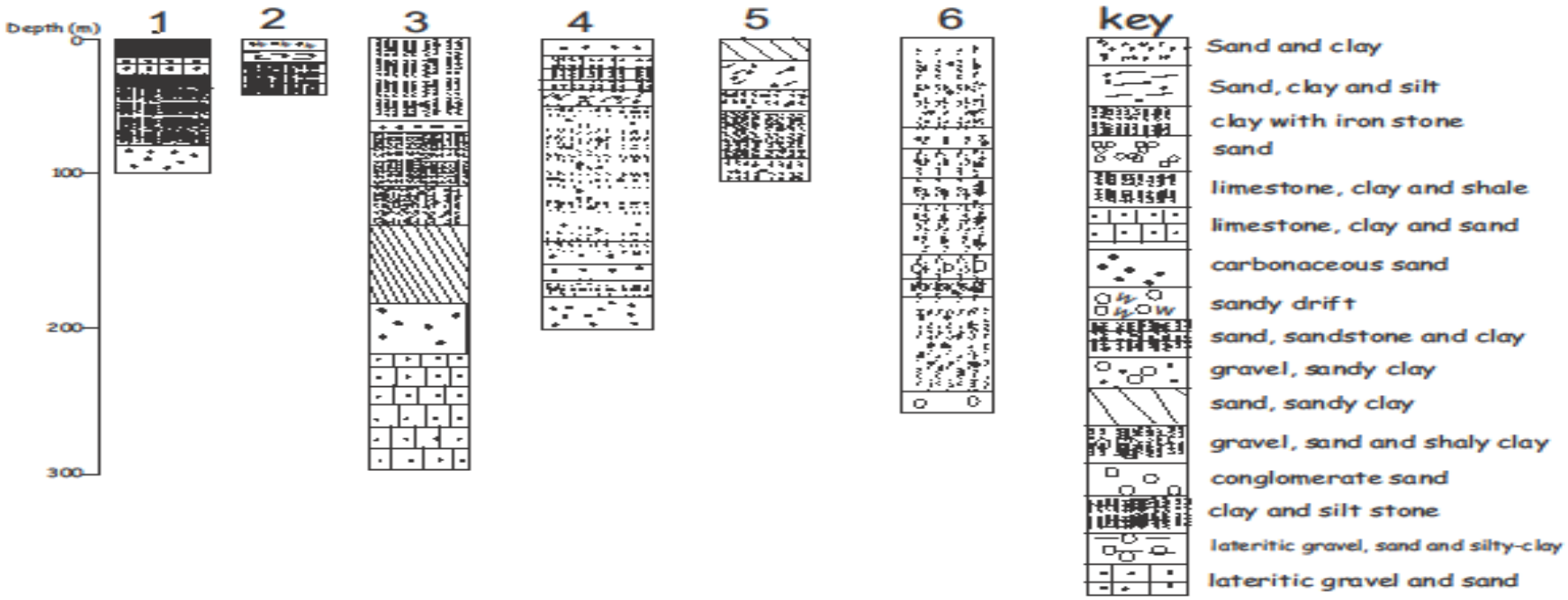


GEOLOGICAL CROSS SECTIONS IN IULLEMEDEN BASIN IN NIGERIA



6.2 GEOLOGICAL SUCCESSION IN THE SOKOTO BASIN (After Kogbe 1979 and Oteze 1991)

Age	Group	Formation	Mean Thickness(m)	Lithology	Origin	Aquifer Potential
Quarter-nary		Alluvium	30	Gravels, sand, silt, clay	Contin-ental	Moder-ate
Tertiary (Eocene-Miocene)	Cont. Terminal	Gwandu	310	Alternation clay & sand	- Ditto -	High
Tertiary: Upper Paleocene	Sokoto	Kalambaina; Dange	51 42	Limesst, clay, shale, calc. deposits	Marine	Moderate ;Aquiclude
Cretaceo-us (Maastric)	Rima	Wurno Dukamaje Taloka	45 26 210	Silt; sand; sst shale;gypsum Sand; Shale	Lacustri Marine - Ditto -	Moderate Aquiclud Good
Late Cre-Upper Jur	Cont. Intercal.	Gundumi-Ilo	310	Clay, sst; pebble bed	Lacustri & Fluvial	High
Pre-Cambrian		Basement Complex		Granite, Gnes, Sch, Meta sedi		Aquiclud to Moder



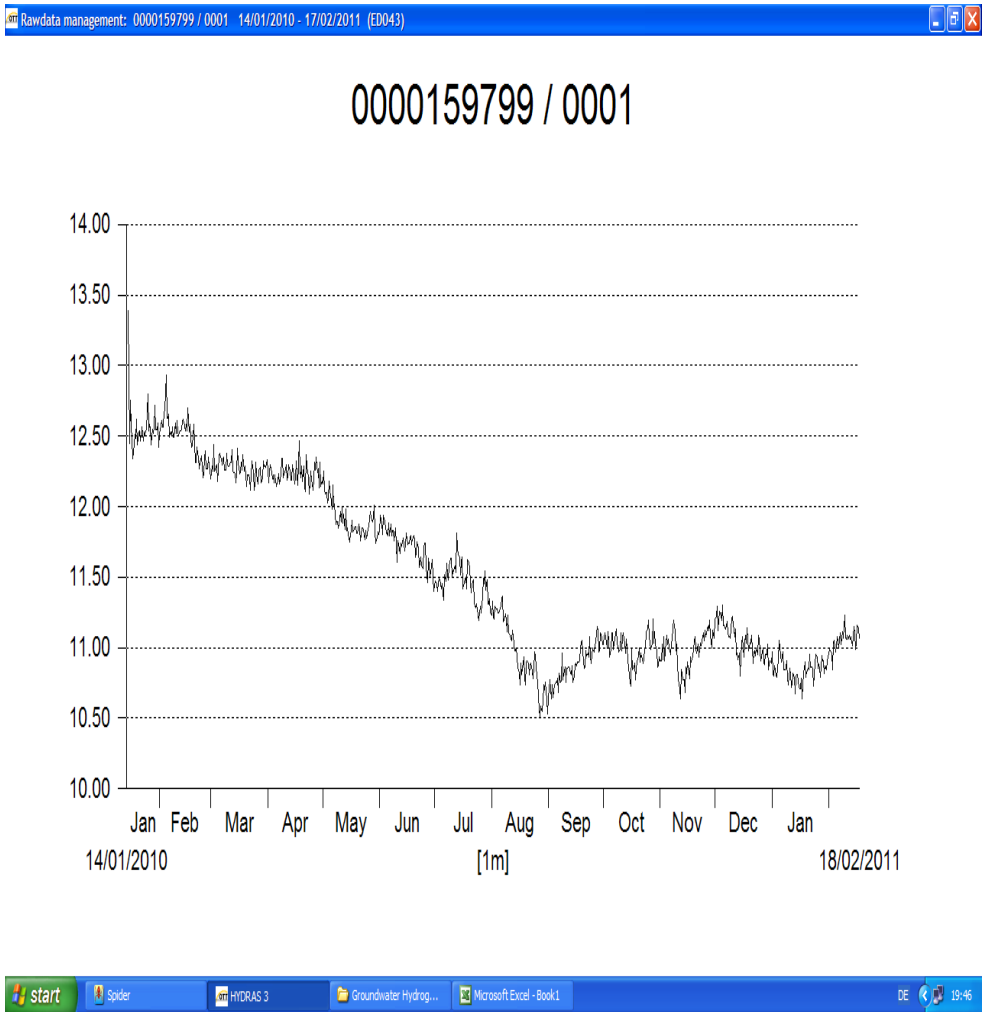
LITHOSTRATIGRAPHIC SECTIONS THROUGH THE IULLEMEDEN BASIN IN NIGERIA

1. Gwandu formation (at Tangaza)
2. Kalambaina formation (Sokoto arca)
3. Kalambaina formation (at Balle)
4. Wurno formation (at Dange Village)
5. Wurno formation (NEPA power station along Sokoto -Gusau road)
6. Gundumi formation (at Girawsi)

6.2 STRATA LOGS OF BOREHOLES

- Six (6) Lithostratigraphic Sections (Strata Logs) through four (4) of the Formations in the Iullemenden (Sokoto) basin have been constructed for 6 boreholes at some locations viz: - **Gwandu** Formation at Tangaza; **Kalambaina** Formation in Sokoto Town & Balle (2 Nos.); **Wurno** Formation at Dange Village & PHCN station, Gusau (2 Nos.) and **Gundumi** Formation at Girawsi.
- It is pertinent to emphasize that construction of similar Strata Logs along defined regional profiles/traverses will **facilitate Aquifer wide Characterization and Correlation.**

6.2 HYDROGRAPH OF THE MONITORING BOREHOLE IN BIRNIN KEBBI IN IULLEMEDEN BASIN (14 Jan.-17 Feb. 2011)



6.2 STRATA LOGS OF WELLS AND HYDROGRAPHS (contd)

- The Hydrograph of the Monitoring Borehole in BIRNIN KEBBI in the Iullemeden (Sokoto) basin shows the Groundwater Level Fluctuation for the Period January 14 – February 17, 2011.
- **Location**: The Monitoring Borehole is behind the State Min. of Water Resources Building within the Godongaji (State) Secretariat, Birnin Kebbi.
- It taps the Sedimentary Aquifer of the Gwandu Formation.
- **Borehole Coordinates**: N 12.47505^0 E 004.24724^0 Altitude: 218m (asl); Borehole Diameter: 150mm; Casing Type: uPVC; Screen Type: uPVC;
- Iniatial S.W.L.: 13.42m; Depth: 100m.

6.3 Sampling Campaigns: 2013 – 2015

- **2013**:

The **First Sampling Campaign** was undertaken in the Nigerian sector of the Iullemeden Basin from **23 to 28 July 2013** (rainy season period). Fifty (**50 Nos.**) water samples were collected and dispatched to CNESTEN Institute in Rabat, Morocco for isotope and chemical analysis and results were received on 29 April 2014.

Preliminary interpretation of isotope and chemical data would be undertaken subsequently. Locations of the sampled points are attached in IAEA's field data format.

6.3 Sampling Campaigns: 2013 – 2015

- **2014**:
- The **Second Sampling Campaign** initially planned for 10 –15 March 2014 was conducted from **11 – 16 April 2014** (dry season period). Thirty seven (**37 Nos.**) water samples collected have been packaged & ready for dispatch to any IAEA-designated laboratory for chemical and isotope analyses. The list of the locations are attached.
- **The Third Sampling Campaign** is scheduled for 11 – 16 August, 2014 (rainy season).
- **2015**:

  Sampling Campaigns in 2015 are planned thus:

  i) 16 – 21 March 2015 (dry season period)

  ii) 07 – 12 August, 2015 (rainy season).

6.3 Sampling Campaigns: 2013 – 2015

- We believe that a total of five (5) sampling campaigns – two (2) in the dry season and three (3) in the rainy season would guarantee adequate coverage of all vital areas in the Iullemeden basin.
- This is with a view to generating adequate chemical and isotope data to complement the limited baseline data in order to effectively determine the water balance situation in the basin and facilitate the development of a viable Mathematical Model for water resources management in the basin.

6.4 Baseline Hydro-chemical and Isotope Data

- Available hydro-chemical and isotope data on the Iullemeden (Sokoto) basin in Nigeria have been forwarded to Dr. Kamel Zouari who is handling the data base for development of Mathematical Models for the respective aquifer systems under the project. They constitute initial input to the data base as additional data would be submitted as soon as they are obtained.
- The data earlier forwarded are hereby resubmitted in Excel format.

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- Thank You for your Attention.