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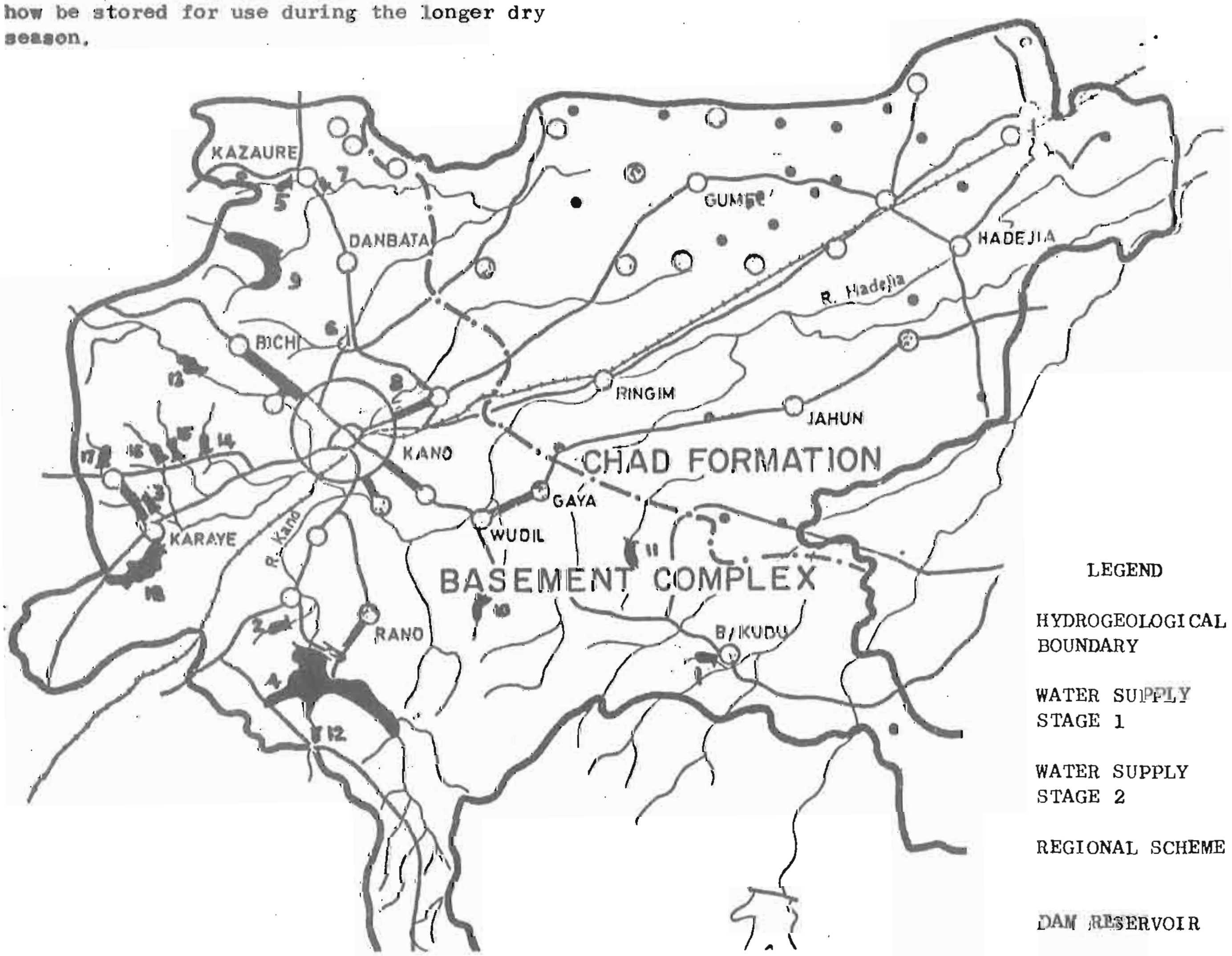
ENGINEERING MEASURES FOR THE DEVELOPMENT OF SURFACE WATER RESOURCES IN KANO STATE

Kano State is a small state with a large population dependent mostly upon agriculture for existence. The fact that the northern parts of the State are situated in the semi-arid zone of West Africa makes the provision of water for both domestic, industrial and agricultural purposes of paramount importance. The State has 4-5 months of rainfall during the summer and 6-7 months of dry season. Unless adequate groundwater is available the water that comes during the rainy season must somehow be stored for use during the longer dry season.

Kano State is underlain by two contrasting geological formations. These are the crystalline basement rocks covered by a layer of decomposed rock of varying depth; and the Chad Basin which is underlain by alternative layers of sedimentary clays and sands.

The imaginary line of demarcation between the two formations divides the state into two; running from the North-Western to the South-Eastern part of the State. (Fig. 1).



DAMS 1. BIRNIN KUDU, 2. BAGAUDA, 3. KARAYE, 4. TIGA, 5. IBRAHIM ADAMU, 6. TOMAS, 7. MOHAMMADU AYUBA, 8. JEKARA, 9. GARI, 10. KAFIN CHIRI, 11. WARWADE, 12. TUDUN WADA, 13. WATARI, 14. GUZUGUZU, 15. MAGAGA, 16. PADA, 17. MARESHI, 18. CHALLAWA GORGE.

Figure 1 Water supply schemes in Kano State

The area east of this line is the Chad formation which is very rich in groundwater. Very high yield is obtained from boreholes sunk in this area, while the area west of the line has very small pockets of groundwater and if boreholes are sunk they have very poor yield.

Therefore the Geological conditions and socio-economic patterns of Kano State makes a complete range of water management techniques possible. Thus schemes ranging in scale from the multi-purpose, multi-regional Tiga Dam Project to local well digging and from surface storage to the tapping of artesian water supplies are being pursued under the direction of the Kano State Water Resources and Engineering Construction Agency (WRECA).

Throughout the state over 5000 open walls have been dug into the surface layer on both the crystalline basement rock and the upper strata of the Chad Basin formation and more than 212 teams of men are responsible for the construction and maintenance of these local wells which have provided the main water supply for decades. The depth of wells varies considerably. In the West of the state the average groundwater table is seldom more than twenty metres below the ground surface; but in the Chad formations the depth of the water table frequently exceeds thirty-five metres.

The depth of the groundwater table indicates that within the layer overlaying the Crystalline basement groundwater moves towards the major valleys, showing that percolation from the surface contributes significantly to the recharge of the water table. Within the Chad Basin formation groundwater frequently moves away from the major rivers which are a source of groundwater replenishment. While the variation in the depth of the water table during the course of a year is relatively small open wells experience a very slow yield rate of less than 300 litres per hour. Although their diameters of 1.3 metres allow a large storage capacity and they refill overnight, particularly during the rainy season, alternative water supplies must be established to satisfy the rapidly increasing domestic, agricultural and industrial demand for water.

In the part of Kano State which lies within the Chad Basin the chief concern of WRECA is the discovery and tapping of groundwater supplies. The location of borehole programmes is primarily determined by demand, and towns which are administrative and district headquarters are the centres of initial activity. In the average: towns with a population of 5000 and above are supposed to benefit from the borehole drilling programme. The borehole drilling programme was actually started during the 1972-74 drought when the northern half of the State was declared a disaster area. The State government bought six mud-flash drilling rigs which were used to construct over 160 boreholes within the Chad Formation. Drilling is not very difficult in the largely unconsolidated sands and clays and suitable aquifers are invariably reached within a depth of 100 metres.

As well as providing an adequate yield, the best aquifers are composed of relatively coarse material in order to avoid fine sand; which is extremely abrasive; being washed into the water supply and causing subsequent damage to well casing equipment.

The groundwater in the Chad Formation of Kano State is largely sub-artesian and submersible pumps have to be installed to lift the water to the surface.

In high yielding boreholes these pumps can extract up to 100 cubic metres per hour without lowering the water table; although often the water demand is less than the full capacity of a borehole.

There are well over 70 water supply schemes utilising borehole water. About 60 per-cent of them are described as first-stage water supply schemes and the rest are called second-stage or full developed water schemes. The first stage scheme consists of a minimum of two boreholes joined together by submersible pumps powered by diesel generating sets. This set up provides water through a few standpipes located around the pump house. WRECA has standardised on the design of a reliable generating/pumping station that could be quickly and efficiently installed, serviced on site and maintained at a base workshop. The station is made of prefabricated aluminium sheets and can be erected together with the pumps and generating sets within one to two weeks. The Challawa workshop with its mechanical-, electrical-, machine-, welding-shops and stores sections coupled with its 'on load' test bed carries out in depth servicing of the station bimonthly. By reducing turn round times the much needed water supply in the rural areas is guaranteed. Figure 1 shows the location of some of the first stage and the second stage water supply schemes. The second stage water supply is a development of the first stage when overhead tank and reticulation system is provided.

Due to the drought of 1972-74 the Kan State Government gave a lot of attention to the provision of water to the affected areas and almost neglected the Basement Complex areas. As a result of which the area is now one of the hardest hit as far as water shortage is concerned. As there is very little groundwater in these areas, the only major source of water are the streams and rivers that drain into the Hadejia river system. The fact that these rivers are seasonal makes the conservation of the endless amount of water that flows away during the short rainy season very essential. Before Kano State was created in 1968 there was not a single dam of any significance, save the small cattle through dams temporarily constructed on yearly basis. The state was therefore fortunate that the first Military regime had water supply and agriculture as its priority. Indeed it would have no other choice because the greatest single problem disturbing the very existence and wellbeing of the people in the rural areas of the state has been and is still lack of adequate water supply. In some of these areas people have to travel up to 10 KM in order to fetch drinking water.

Under its water resources development programme; the Kano State Government embarked upon the construction of dams in the Basement Complex areas of the State. So far 20 earth dams have been completed and more are being planned.

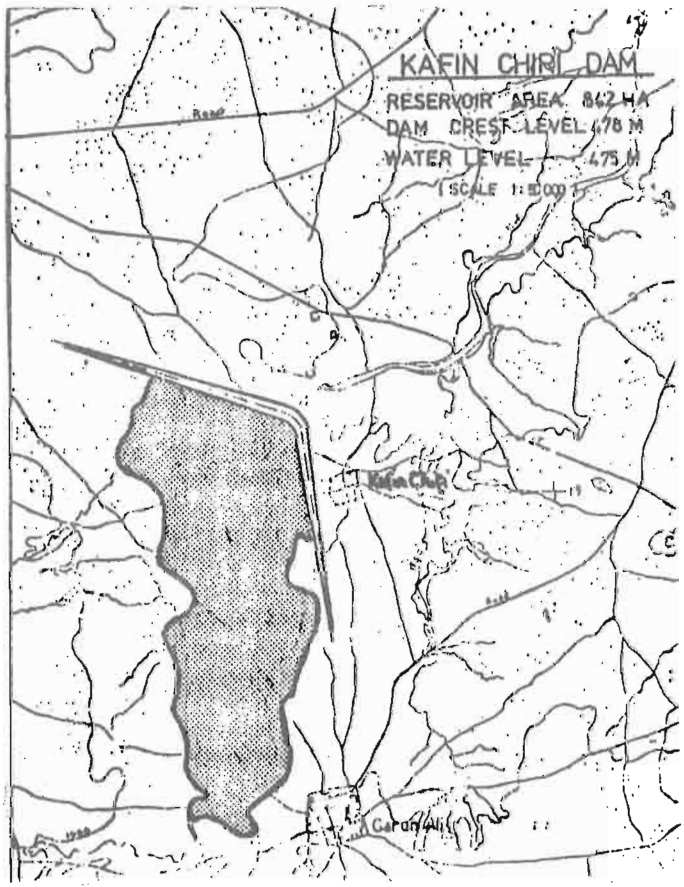
The first earth dam constructed in the State for the storage of water was B/Kudu, about 100 Km South-East of Kano, within the Basement Complex.

This dam was constructed in 1969 by direct labour using a combination of labour intensive and capital intensive methods out of necessity.

B/Kudu was one of the most populated towns in Kano State and at that time it used to experience acut shortage of water during the long period of dry season due to the fact that there is very little, if any groundwater in the area. So all the local open wells become very dry immediately after the rainy season. Life used to be unbearable for the people of the place and there used to be seasonal migration out of the town during the season. The town now has a modern water treatment plant and its size has trebled over the last ten years.

The very few eath moving plants that were used in the construction of B/Kudu Dam became the nucleus of WRECA construction team - then under the Ministry of Works and Survey.

The author was the Project Engineer in charge of two of the dams so far constructed. Below is a brief description of the design and method of construction of one of the two dams.



The name of the dam is Kafin Chiri Dam and it is located about 60 Km South-east of Kano City. The Dam was designed by the Planning and Design Division of WRECA. Figure 2 shows the location of the Dam and Figure 3 shows a typical cross-section of the Dam. The construction period of the Dam was from October 1976 to November 1977. The Dam was zoned earthfill with a crest width of 7.62 m (figure 3). The clay core was central with slopes at 1:1 upstream and downstream. The central core was filled with the best material available locally.

The material used was classified as SC or CL on the USCS triangle. The upstream and downstream zones were filled with miscellaneous material. In all cases the fill was compacted to 95% of maximum dry density. The volume of earth fill was 600 000m^3. It was compacted in 150 mm layers. The upstream slope is 1:3 and the downstream 1:2.5. The upstream face was protected by three layers of sand, fine aggregate and a layer of hand-placed rip-rap in that order. Between the core and the downstream layer there was a chimney-filter of selected coarse sand, 1 m thick; allowing flow into a blanket filter of the same material and thickness under the downstream zone (figure 3). Being a direct-labour construction all the personnel and plant belong to WRECA except the local contract labour that was employed for placing the upstream slop protection.

There were over 100 Agency employees made up of site supervisors; foremen, machine operators, mechanics, greasers, soil laboratory technicians, storekeepers, electricians and survey assistants. The site office consisting of the Project Engineer's office, soil lab, and radio room was made of timber planks and aluminium roofing sheets.

Figure 2 Layout of Kafin Chiri Dam

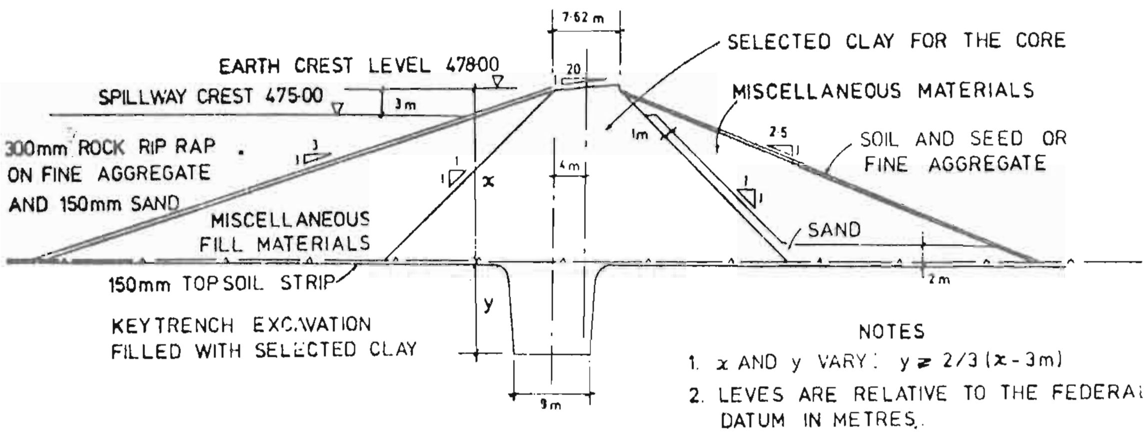


Figure 3 Typical cross section of the dam

The site workshop was made of Aluminium roofing sheets and the store was a mobile store on wheels. The machines used were as follows:

3 D8H/D8K Caterpillar bulldozers
5 621B Caterpillar scrapers
5 TS14 Terex scrapers
2 TS/4B Terex scrapers
3 D6C Caterpillar bulldozers
1 14G Caterpillar grader
3 C450 Hyster earth compactors
2 150 mm dewatering pumps
6 Lister generating sets
2 concrete mixers
4 compressors of union sizes
2 small mechanical vibrators
3 flatt lorries
5 water tankers (various)
2 fuel tankers
4 Land-rovers
2 Mini-moke
3 pneumatic rock drills

The climate of the area controls the timing and methods of construction.

The busiest construction period was late October 1976 to April 1977. As the river was dry during that period there was no need for river diversion, but the river had to be impounded before the first rains.

The earth work construction was divided into two shifts. The first shift worked from 7 am to 1 pm while the second worked from 1 pm to 9 pm under electric flood lights. A record was kept of the number of trips completed by each shift and from these figures an estimate of the production rate and availability of each machine was calculated.

The site workshop was responsible for the day to day servicing of the machines. Any major breakdown had to be reported to the base workshop at Tiga by radio. Facilities were available for a complete repair and overhaul of the machines at Tiga. There were also mobile workshops which can be called for at any time.

For most of the construction period on the site work continued 7 days a week. The day after the payment of salaries and wages was observed as work-free day to enable the workers to go to Kano for shopping every month ending.

Before the earth work was started; three small villages were resettled with a combined population of 890. The resettlement exercise was done by the Resettlement Section of WRECA. Normally this involves the acquiring of a new site for the resettlement and the provision of roads plot layouts; open wells and drainage before the people move and build their houses. WRECA also provide laterite material with which some of them construct their houses. Each house and farmland is compensated for in cash. It is up to the owner to build a new house with the money he was given. The compensation money was paid in installments before and after the rains. This was done to stop the farmers from spending the money on trivials as was discovered in the case of the previous dams.

The Kafin Chiri is about 5.4 Km long and is curved at almost 90% (figure 2), other features of the dam are shown on Table 1.

TABLE 1 KAFIN CHIRI DAM PROJECT

PROJECT DATA

1	Average annual rainfall	864 M:1
2	Catchment area	225 KM^2
3	Average annual runoff	35.67M^3M:L
4	Type of dam	ZONED EARTHFILL
5	Crest length	5.405 M
6	Crest elevation	478.00 MOD
7	Full supply level	475.00 MOD
8	Dead storage level	470.00 MOD
9	Top width	7.62 M
10	Maximum height	16 M
11	Maximum base width	96 M
12	Total storage capacity	31.12M^3M:L
13	Dead storage capacity	6.52M^3M:L
14	Active storage capacity	24.60M^3M:L
15	Surface area	842 HA
16	Total volume of fill	0.6M^3M:L
17	Spillway	475 M
	Level	475.00 MOD
	Type Concrete - ogee	
18	Outlet works: Submerged concrete intake with two 600 mm outlets.	
19	Estimated total cost 2.5 million	

A key trench was excavated below the core of the embankment with its centre-line 4 m upstream of the embankment centre-line. The aim was to reach impermeable basement rock but this was only possible over a half length. Where the depth of water expected at any cross-section the trench was considered deep enough unless some unusual geological features were discovered.

Two soil technicians were resident on the site. One at the borrow-pits and the other at the construction site. The one at the construction site was monitoring the dry density of the compacted material using sand-replacement method. Samples of the fill material were also sent to the well-equipped soil laboratory at Tiga where permeability tests, etc. were conducted.

The only controlled outlet consists of two 600 mm diameter 6 mm thick aslphalt lined steel pipes embedded in mass centre with a re-inforced concrete headwall fitted with a week-screen at the upstream and butterfly valves at the downstream end. The mass centre was 0.8 m thick and increased to 1.5 m locally to form three cut-off walls 0.8 m thick in the core zone.

A 50 m long concrete ogee type spillway was constructed about 1.4 Km from the right-hand end of the dam. The site was selected because about 2.5 m below the spillway level there was an impermeable layer of hard rock. A 500 m long spillway channel was constructed to join a tributary of the main river down-stream.

The crest access road was given downstream of 1:20 towards the upstream side (figure 2), as this was found to reduce the erosion at the top of the downstream slope due to rain.

The dam was almost filled up during the first year. The area-capacity curve for the dam is shown in figure 4.

Kafin Chiri Dam is now over three years old and is performing very well. The primary function of the dam will be to provide raw water for a treatment plant that will supply Garko and Sumaila towns with potable water. Pipeline works from the dam site to the two towns will be starting soon. The Ministry of Agriculture will also be using the water from the dam to irrigate about 1000 acres. Already a booming fishing industry has been established in addition to fore-shore irrigation by some of the displaced farmers.

Kafin Chiri dam is just a typical example of the many earth dams constructed by WRECA. At the moment WRECA is undertaking the con-struction of the 35.7 million naira Challawa Gorge Dam for the Hadejia Jama'are River Basin Development Authority. The dam is going to be half the size of Tiga Dam and would have a capacity of 1 billion cubic meters. Challawa Gorge Dam is also a multi-purpose dam. The second dam under construction by WRECA is the Kagara Dam for the Niger State Water Board. It is also an earth dam and is being built at a cost of 6 million Naira. The construction wing of WRECA has well over 70 scrapers and other earth-moving plants and equipments and has over the years become the fore-front con-tractor as far as earth dams are concerned. Already WRECA has gone into road construction, where it hopes to take the lead very soon.

The experience of WRECA by using DIRECT LABOUR methods to achieve quite a lot at a cheaper rate is worth emolution. Already other state governments from Bendel to Bauchi have started copying the innovation. Despite its successes in the field of construction WRECA has never neglected it primary function that of providing water to the teeming population of Kano State. Gigantic programmes to provide water to every part of the state are being embarked upon in conjunction with the new Ministry of Rural and Community Development.

The task of providing water to the Nigerian population is a gigantic one. More especially when some of the Engineering measures of getting water, like construction of Dams, entail an enormous amount of capital investment. This often is a handicap because of the limited resources available to the state Governments. The cheapest source of water is from a borehole where it can be obtained. In most cases only chlorination is required to make borehole water potable.

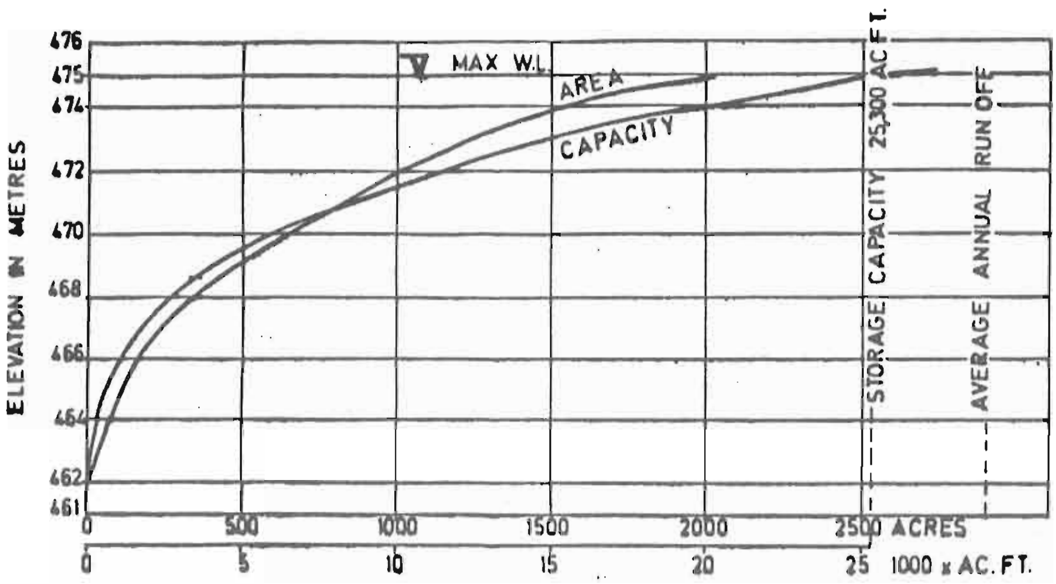


Figure 4 Kafin Chiri Dam, area and storage capacity curves