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APPENDICES

1. INTRODUCTION

1.1. OBJECTIVES OF THE PROJECT

The main objectives of the project as outlined in the RFP are:

- To study the Hydrological data of the major river catchments and identify suitable locations for the development of Major Multi – Purpose Dams within the State;

- To study the Geological formations and determine their suitability for the development of Multi – Purpose Dams;

- To carry out demand studies for potable water supply, irrigation and electricity for the intended communities to be served by each of the Major Multi – Purpose Dams; The intended communities are the major Towns of Kaduna, Zaria and Kafanchan, etc. and neighbouring communities.

- To determine Gross Storage for each of major impounding reservoirs to support, particularly, large scale irrigation, potable water supply and hydro – power purposes;

- To carry out preliminary design for each of the Multi–Purpose Dams hydropower generation station, Power transmission lines, substations, irrigation schemes and water supply schemes;

1.2. SCOPE OF WORK

The Scope of Work consists of the following tasks:

A. <u>Data Collection and Analysis</u>

The collection covers data related to meteorology, hydrology, geology, population, demands, etc. as well as any relevant reports and existing studies.

B. <u>Inception Report:</u>

The present Inception Report is based on the first Project team visit to the Project area and their discussions with the relevant authorities and on the collection and first analysis of the available data. It contains the Consultants' approach, methodology, staffing, work plan, reporting, time schedule, etc.

C. <u>Desk Studies:</u>

These studies include mainly:

(a) Hydrological and Water Resources Studies.

(b) Geological Studies

(c) Demand Studies for Domestic Water, Irrigation, and Electricity

(d) Identification on the available maps of possible / potential dam sites.

(e) Water Balance studies to compare resources to demands

D. Site Visit to the Potential Dam sites

After sites are identified on the maps, and analyzed through desk studies, all potential sites are visited by a multi-disciplinary team to assess the access, the geomorphologic and geological conditions, vegetal cover, etc.

E. Environmental Impact Assessment

It includes:

(a) Desk study assessment and SWOT analysis during initial site selection to help determine the preferred sites from each group of the alternatives;

(b) An EIA Scoping Study to determine the most significant potential environmental impacts, and hence the EIA Terms of Reference for approval by the Nigerian environmental authorities within the Preliminary Design Stage;

(c) An Environmental Impact Assessment (EIA) for each selected site in the light of preliminary dam design.

F. Sites options study

Based on desk studies identification and sites visit, the sites options to be subject to further studies and investigations are determined.

The sites are then compared on the basis of multi-criteria analysis: Hydrology, geology, Hydropower output, Impact on the Environment, Economical efficiency, etc.

The sites comparison will lead to a sites ranking and recommendations of sites to be selected for multi-purpose dams' construction.

G. Site Investigations

For the selected sites, an initial site investigation campaign will be launched to allow the preparation of the preliminary design. It will include topographic surveys and Geotechnical Investigations.

H. Feasibility Report

Based on the investigations results, feasibility of dams in each site will be assessed. The analysis will take all relevant parameters into consideration: Dam type, geomorphology, local geological and geotechnical features, hydrology, hydropower output, economical efficiency, etc.

I. Preliminary Design

At this stage all feasible alternatives regarding the location as well as the type of the dams / hydropower plants and appurtenances will be studied. The alternatives will be compared and the most appropriate one selected based on a multi-criteria analysis. A preliminary design will be prepared for the selected alternative.

Based on the findings of the study, the Consultants will prepare a detailed site investigations programme for the Detailed Design of each dam and hydropower plant.

2. MOBILIZATION AND DATA COLLECTION

2.1. DEPLOYMENT OF CONSULTANT'S STAFF

After signing the Contract, the Consultants started mobilising for the project immediately. This comprised establishing the Project Team at a fully functional level, starting desk studies and obtaining necessary visas.

Once all the arrangements were concluded, the following staff members arrived to Kaduna on May 22, 2008. The purpose of this Trip was to present the first findings of Desk Studies, coordinate actions with the Ministry and begin visits to potential sites.

The following table shows the Consultant's personnel who participated to this trip:

Position	Name
Resident Manager	Gamal Abu-Heneidy
Project Manager	Mohamed Monkachi
Dams and Hydropower Plant Expert	Marco Braghini
Geotechnical Expert	Nassim Abi Fadel
GIS and Environmental Engineer	Dunia Tabet
Energy Economist	Peter Butt
Water Infrastructure Engineer	Dauda Ilya
Town Planner	Dada Bolaji

2.2. MEETINGS WITH CLIENT

Several meetings were held with at the Ministry of Water Resources. An introductory meeting was held at the Ministry Permanent Secretary's office on May 22, 2008. The purpose of this meeting was to introduce the team, coordinate all activities, and obtain the Client's view and considerations on the project. Several other meeting were held with the following ministries and bodies to discuss technical matters and obtain data:

- Ministry of Industry and Commerce to obtain data location, types and sizes of main industries commercial companies, economic and population growth data, state commercial and industrial plan, etc.;
- Irrigation and Water Board responsible to discuss specific issues and collect data;
- Nigerian Geological Survey to obtain geophysical and other seismic data.
- Kaduna Distribution Company to obtain current electricity demand data and forecast demand growth.

Finally, after all sites were visited a presentation was made to the Ministry Permanent Secretary on the first findings and the action plan for next project phases.

2.3. DATA COLLECTION / REQUESTED DATA

Data covering the following areas has been requested:

- Site conditions, including topographical, geological, geotechnical and hydrological aspects;
- Water and power demand related aspects.
- Industrial and commercial growth projections.

Hydrological data required for this project are mainly the following:

- Daily rainfall records for stations close to the selected sites and their catchments;
- Daily flows or water heights records and maximum peak flows for hydro stations located on the rivers where the sites are located or the tributaries of those rivers;
- Sedimentation data on stations on the rivers where the sites are located or on rivers which catchment characteristics are close to the studied catchments;
- Bathymetric surveys of existing dams.

The main data needed to cover the agronomic water demand and later on the design of the irrigation schemes are as follows:

- Land use;
- Soil classification;
- Land topography;
- Cultivable and irrigable land;
- Cultivated lands;

- Socio-economic data including demography, land tenure and ownership, crop cost, etc.;
- Cropping patterns and production;
- Climatic data;
- Existing water sources and existing irrigation systems;
- Livestock population and water demand.

2.4. COLLECTED DATA AND GIS

The Consultants initiated data collection at an early stage of the Project. Topographic maps were collected for the entire project area and locations of possible dam sites from previous reports were also collected.

Additional data was also collected from the following bodies;

- Kaduna State Agricultural Development Project (KADP), Ministry of Agriculture;
- Kaduna State Water Board, Ministry of Water Resources; and
- Kaduna Distribution Company.

Collected economic data is listed in Appendix A, Table 1. Initial examination of the data questions the accuracy of the breakdown of average demand data. For example, there is even split between weekday and weekend average demands and between daytime and night time average commercial and industrial demands. This is highly unlikely considering most commercial and industrial firms shut down over weekends and at night.

The collected documents are summarized in Appendix A, Table 2.

Geographic information such as maps and station locations were all entered in the Geographic Information System of the project which acts as a database for all geography-related data collected during the project. The GIS database will be developed on ArcGIS technology from ESRI and will be used for data analysis and maps production.

2.5. LIST OF MISSING DATA

Collected hydrological data are for stations spread over the entire state but they are limited to specific years. The data lacks mainly maximum discharge or stage at recording stations; only mean daily values were collected. Any additional data will be collected if available.

The sediments aspects have not been covered so far. Shika dam bathymetric survey has been requested from the Kaduna State Water Board.

Additional information was requested on existing dams' capacities and on water quality.

Missing domestic water supply related data which still need to be collected include the following:

- Updated population for main cities;
- Water supply system capacities and shortage;
- Need in power supply to operate the existing water supply system.

Since such data has not been collected in recent years, the Consultants have suggested sending to Kaduna State Water Board a questionnaire to obtain the data for the main cities and their surroundings, or at least at the local government level.

Missing or yet to be updated agronomic data include the following:

- Updated demographic data;
- Land tenure data;

- Updated crop production cost and income;
- Updated State Livestock Population at State and Local Governments levels, or more localized scale;
- Crop areas percent of total agricultural area and production at State and Local Governments levels, or more localized scale;
- Crop water requirements locally recommended by the local institutes.

Some of the electricity demand data that have been requested have not been delivered (see Table 1). In addition, economic data requested from the Ministry of Industry and Commerce are yet to be submitted (see Appendix A - Table 3)

3. SITES IDENTIFICATION

3.1. Present situation

Kaduna state has constructed a number of dams mainly for potable water supply and irrigation. The identification of existing dams is extremely important for new sites search as new sites can impact the existing ones either in a positive or negative way.

The main existing dams are the following:

- Kangimi dam on Kangimi river, a tributary of Kaduna river. It supplies water to Kaduna City.
- Shika dam on Galma river. It supplies water to Zaria.
- Bagoma dam on Kusheriki river. It supplies water to Birnin Gwari.
- Gimbawa dam on Dare Biyar river. It supplies water to Ikara water works.
- Saminaka barrage on the Karami river. It supplies water to the Saminaka Water Works.
- Gurara dam on the Gurara river. It is a recently constructed federal dam which main purposes are water supply to Abuja and hydropower generation for Kaduna state (the hydropower plant under construction has an installed capacity of 30 MW).

Other medium size dams are:

- ABU dam (Ahmadu Bello University Dam),
- Bomo dam (University Dam),
- Likarbu dam (Federal Dam),
- Paki dam,
- Jaji dam (Military facility).

Furthermore, there are many small throughout the state.

It should be also noted that the major Hydroelectric Shiroro dam in Niger State is located on the Kaduna river, close to Kaduna state border.

This important dam has to be taken into consideration for any new development of Kaduna river.

3.2. New sites identification

New sites identification throughout Kaduna State has been conducted by using the following information:

- Topographical maps at 1/50,000 scale with full state coverage,
- Digital Terrain Model derived from satellite images (SRTM - Shuttle Radar Topography Mission -USGS),
- Satellite images from Google Earth,
- Previous studies (Parkman, Jica).

Sites preliminary selection was made according to the following criteria:

- Relatively narrow valleys to construct cost-effective dams,
- Large catchment areas to allow for major dams development,
- Large reservoirs to impound important amounts of water (based on rough runoff estimates),
- Reservoirs should not flood existing dams, towns or important villages,
- Preference is given to sites located upstream of main supply areas to allow for supply by gravity without need for pumping stations.

Finally, 9 potential sites have been selected at this stage. Figure 1 shows these dams' locations. The following table gives the main features of the potential sites:

Name	River	Lat.	Long.	Catchment Area_(Km^2)	Specific Yield (mm)*	Average Annual Runoff (MCM)*
Galma 1	Galma	10,7767	8,4325	1064	170	181
Galma 3	Likarbu	10,8558	7,8108	1036	140	145
Bakin Kogi	Kaduna	9,9333	8,3567	1685	300	505
Masaka	Tubo	10,4764	7,2297	5866	150	880
Yola/Buruku	Tubo	10,6042	7,2300	5621	110	618
Babbon Kogi	Babbon Kogi	9,7658	7,9442	1020	400	408
Upper Tubo	Tubo	10,8017	7,2967	2950	110	324
Karami& Kaduna	Kaduna	10,5050	7,8292	10057	315	3168
Itisi	Kaduna	10,4466	7,8769	5882	315	1853

**Preliminary estimates to be checked by Hydrological Studies*

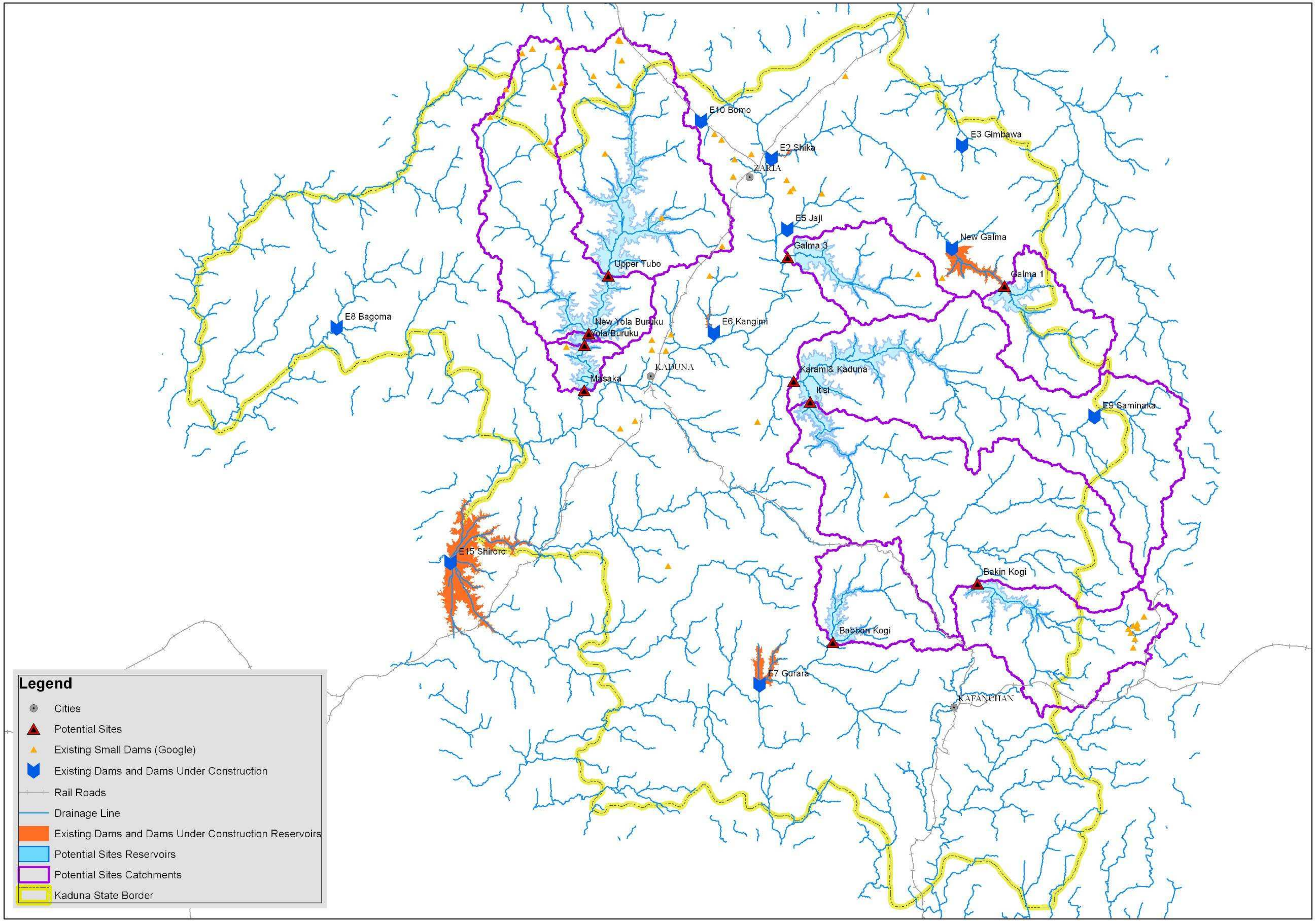


Figure 1 : Existing and new sites locations

4. SITES RECONNAISSANCE

4.1. *Sites access and description*

4.1.1. SITE 1: Yola Buruku

This site located on the Tubo river some 25 km west of Kaduna City. It is accessed easily from Kaduna through the main road A125. The track that leads to the site is located at the right bank of the Tubo river and it is about 2 km long.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 1 : General view of Yola Buruku dam site

4.1.2. SITE 2: Masaka

This site is also located on the Tubo river some 15 km downstream of Yula Buruku site. It can be accessed through the main road A125 then an asphalted road at the right bank of the Tubo river.

It has been noted that a high voltage transmission line is located next to the site on the left bank.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 2 : General view of Masaka dam site

4.1.3. SITE 3: Upper Tubo

This site is also located on the Tubo river some 24 km upstream of Yula Buruku site. It can be accessed through the main road A125 then an asphalted road at the left bank of the Tubo river then a 2.40 km long track.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 3 : General view of Upper Tubo site

4.1.4. SITE 4: Itisi

This site is located on the Kaduna River, some 50 km east of Kaduna City. It can be accessed through the main road A235 then a 19 km long track starting from Kasuwan-Magani.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 4 : General view of Itisi site

4.1.5. SITE 5: Karami & Kaduna

This site is located downstream of the confluency between Karami and Kaduna Rivers, some 42 km east of Kaduna City. It can be accessed through the main road A235 then a 19 km long track starting from Kasuwan-Magani.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 5 : General view of Karami & Kaduna site

4.1.6. SITE 6: Babbon Kogi

This site is located on the Babbon Kogi river, a tributary of Gurara river, about 100 km south east of Kaduna City. It can be accessed through the main road A235, a secondary 10 km long asphalted road from Gumel then a 2.20 long track.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 6 : General view of Babbon Kogi site

4.1.7. SITE 7: Bakin Kogi

This site is located on the upper reach of Kaduna river, about 120 km south east of Kaduna City. It can be accessed through the main road A235, then a 27 km long track starting from Zonkwa.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 7 : General view of Bakin Kogi site

4.1.8. SITE 8: Galma 1

This site is located on the upper reach of Galma river, about 90 km south east of Zaria. It can be accessed directly through the main road A236 as it is located just upstream of the main road bridge.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 8 : General view of Galma 1 site

4.1.9. SITE 9: Galma 3

This site is located on the Likarbu river, a tributary of Galma river, about 30 km south of Zaria. It can be accessed through the main road A236, then an 18 km long track.

The following photo shows the river aspect at the vicinity of the dam site:

Photo 9 : General view of Galma 3 site

4.2. GEOLOGICAL & GEOTECHNICAL ASPECTS

The first visit to the sites of the potential dams allowed identifying their general geological features. Following this first visit, a detailed geological trip will be carried out by an expert geologist. The findings of the first visit are described below:

4.2.1. Geology of Dam Sites

The general topography is flat to slightly undulating. The terrain is either agricultural or covered with shrubs and trees. The cut and fill slopes along the traversed roads reveal a reddish lateritic formation, with occasional outcrops of granite belonging to the formation known as Older Granite. The banks of the rivers are typically formed of silts and sands extending also over the flood plains.

The main geological formations in the region of the dam sites are Precambrian with the following sequence:

- Older Granite (most recent in the Precambrian): consisting of coarse porphyritic biotite granite with the main constituents: quartz, orthoclase, albite and anorthite. They occur as inselbergs with mild to steep sides.
- Paraschists of heterogeneous origin comprise phyllites, chlorite, sericite, biotite and muscovite schists derived from folding of argillaceous rocks. They outcrop in river beds like Kaduna river.
- Gneisses (and pigmatites) derived from the metamorphism and intrusions of the earlier periods. They constitute the predominant formations. They comprise: biotite orthogneiss, biotite paragneiss, hornblende orthogneiss.

4.2.2. Borrow zones

The region of the dams' sites contains natural material suitable for the construction of earthfill or rockfill dams:

- Clay can be obtained from natural product of weathered granite adjacent to rock outcrops.
- Filters, drains and slope protection can be produced from crushed granite or gneiss, or washing of alluvial sands and gravels.
- Recharge for slopes can be excavated from various sources: laterite horizons, alluvial deposits.

4.2.3. Types of Dams

Considering the available borrow materials, dams would mainly be formed of a clay core with earthfill or rockfill recharge under the slopes. The foundation of the clay core will have to be excavated to reach:

- bedrock or laterite to be treated with grouting,
- or silt deposit to be treated with diaphragm wall and/or relief wells.

The thickness of the alluvial deposits and the nature of the base rocks should be identified by a site investigation (comprising borehole drilling and geophysical methods) and laboratory testing. It is important to define the thickness of the alluvial deposits as it affects the cost of the foundation treatment.

Other alternatives, such as RCC dams could be also envisaged in case the bedrock is not very deep and is suitable to such dams.

5. METHODOLOGY FOR NEXT PHASES

5.1. HYDROLOGICAL STUDIES

Physiographical and Geomorphological Studies

On the basis of the sites visit, the review of previous studies and reports, and using available aerial photos and topographic maps or GIS data, watersheds will be delineated on an adequate scale map that could show limits of sub-basins as well as longitudinal profiles of principal watercourses. Moreover, catchment infiltration coefficients for storms of varying intensity and duration will be estimated based on analysis of available satellite imageries. This information will then be used, among others, in hydrologic simulation models.

Analysis of Climatological and Hydrological Data

Collected precipitation data will be analysed in order to determine the average rainfall over the watersheds, as well as the maximum daily rainfall and the temporal structure of the storms to determine peak discharges. Such rainfall runoff transformations will be the only possible solution to remedy for the lack of peak discharge data.

After filling of data gaps, frequency analysis will be performed on daily maximum precipitation as well as monthly averages to determine the required values for different return periods.

Study of Monthly and Annual Watersheds Water Yields

The analysis of the watershed water yield rests on the comparison of several qzQSapproaches such as statistical analysis of streamflow data, water balance, rainfall-runoff modelling, etc. In case limited flood flow data is available / reliable, rainfall-runoff transformations using software such as HEC-HMS (for Hydrologic Engineering Center - Hydrologic Modelling System) or WMS (Watershed Modelling System) as well as regional flow analysis, if such regional equations are available for the Project area. The rainfall runoff model will be developed, modelling the watershed as several sub-catchments. This approach should improve on the results of the previous hydrological study. The limited Amount of flood flow data will be used in model calibration to determine the best set of hydrologic parameters.

Statistical analysis of the annual or monthly streamflow data from nearby or similar catchments could be carried on using software such as HYFRAN (for HYdrologic FRequency ANalysis). Sample output of the software is shown in Figure 2.

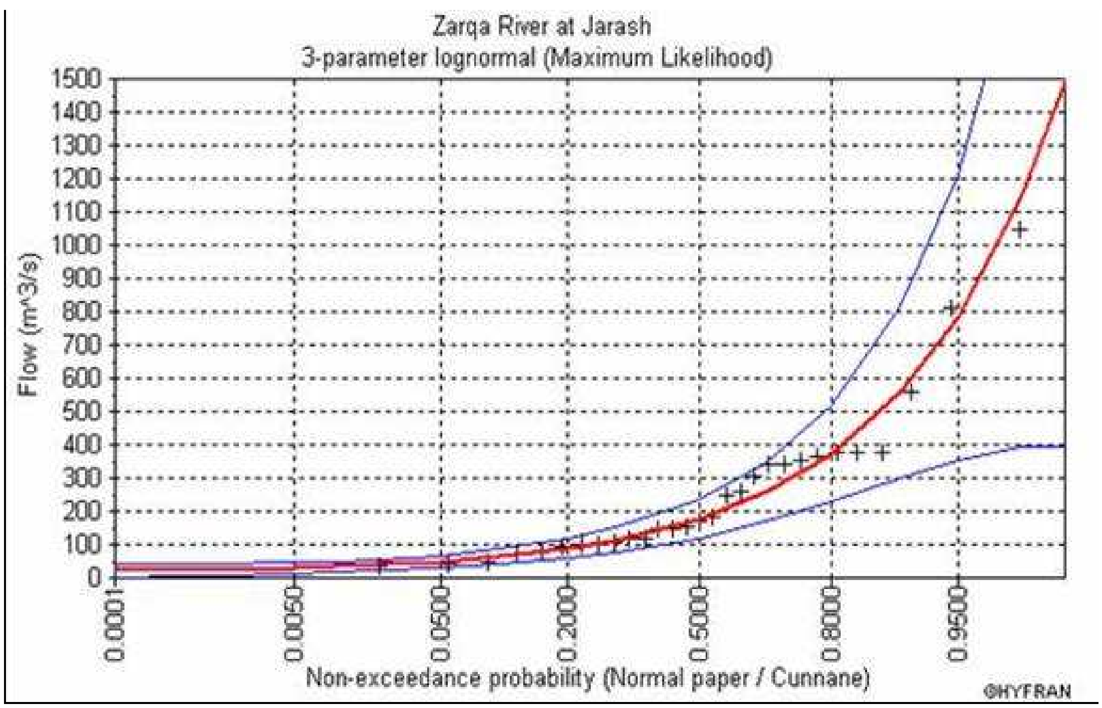


Figure 2 : Sample HYFRAN output concerning adjustment of the 3-parameter lognormal distribution for the flows maxima of the Zarqa River at Jarash in Jordan (Dar Al-Handasah, 2002)

Extreme Flood Studies

Several aspects of flood flows need to be considered when it comes to the spillway design. These include floods of rare occurrence whose analysis could be done through the statistical analysis of recorded peak flows or, by development of the design floods from the selected design storms using a rainfall-runoff model.

Several statistical techniques for flood probability analysis are available and are already computerised. Some of the most commonly used statistical distributions in estimating event magnitudes at various return periods, and for which a computer programme is already available, are: the Lognormal Distribution with Two and Three parameters, Pearson and Log-Pearson Type III, and Type I and Type III Extreme Distributions.

Sedimentation

Many dams in various parts of the world are currently suffering from sedimentation problems. Sedimentation, in general, is a serious problem common to the majority of the dams in Western Africa and which, if not taken into account and controlled, can decrease considerably the economic lifespan of the reservoir. The major effect of sedimentation on a reservoir is the reduction of useful life of the reservoir which directly affects the benefits that can be expected from the Project, and therefore has a major influence on the technical and financial feasibility of the Project. Another aspect to be considered is the effect of sediment deposition level on the outlet works. Depending on data availability, several methods can also be used to estimate the sedimentation of reservoirs. Such methods include the following:

- Sediment Yield Rate Factors

In this method, a weighting of the factors that influence sediment yield, such as rainfall and catchment area characteristics, is applied to determine a sediment yield rate for a basin.

- Reservoir Survey Data

This method is based on data obtained from surveys of existing reservoirs in the same region as the proposed dams.

- Sediment Sampling Data

This method is based on actual measurements of sediment load being carried by a stream at a particular location.

Once the sediment inflow to the reservoir has been estimated and compared to other estimates, the reservoir trap efficiency would all be considered to reach a reliable estimate of the effect of the sediment deposition on the life and operation of the reservoir. All previous sediment load computations will be reviewed and adapted to the sites conditions.

Dam Yield and Reliability of Water Supply

Following the determination of the water resources availability and the agreement with the Client on water demand, the Consultants will perform the discharge regulation and subsequently determine the useful volume (live storage). The hydrologic balance will be thoroughly analysed using a monthly time step. Different dams' storages will be assessed and the corresponding water reliabilities estimated.

To determine live storage, reliabilities and the regulation discharge, the Consultants will use conventional methods on spreadsheets or reservoir simulation models (such as HEC 5, ResSim, etc) allowing to take into consideration demand variation, if any. Moreover, these types of computer software packages allow simulating the reservoir exploitation according to different filling scenarios.

Routing of Design Floods through the Reservoir

The effect of flood routing through the storage volume will be studied for every spillway alternative and every return period to determine its spillage capacity and safe dimensions. This will allow an evaluation of a comparison based on cost and performance of each alternative.

At the final design phase, the wave flood propagation will be re-examined based on an updated rating curve to optimise the combination between the stored flood volume in the dam and the spillage capacity of the spillway.

Stream Flow Diversion During Construction

The nominal flood considered during construction period must be chosen with extreme care. It must be accepted by the administration and explicitly stated in the tender documents. The stream flow diversion during construction phase must also be defined, in view of the fact that it will likely have an impact on dams design and outlet works as well as on construction method and schedule.

5.2. WATER DEMAND STUDIES

5.2.1. Domestic Water

5.2.1.1 Approach

The Domestic Water Demand Study shall cover the main cities in shortage of water. According to the TOR, main cities are: Kaduna, Zaria and Kafanchan and the neighbouring communities. Presently Kaduna State is covered by nine water supply schemes: Kaduna, Zaria, Saminaka, Kafanchan, Kangoro, Birnin Gwary, Ikara, Zonkwa, Kwoi.

The Consultants objectives are to estimate the present demand and deficiencies for those schemes as well as future demand for the horizon of the project which is 2025. Moreover, in general, domestic water consumption is estimated based on the income-level of the population. It is therefore important to consider that the general services for the low income people can be improved by supplying additional water. Finally, in addition to domestic water, the demand for other sectors (industrial) will be evaluated.

5.2.1.2 Methodology

a) Identification of the Demand

For the Water Demand Study, the Consultants will work closely with the Kaduna State Water Board to evaluate the present and future demands of the main urban centers.

At a first stage, the main urban centers will be defined. Existing structures and water resources deployed to serve each will be identified. Residential and working population, main industries, as well as future growth of the residential population and potential industrial developments will be estimated.

The domestic water demand will be based on the population working and/or residing in the main urban centers. The adopted consumptions will be in line with the overall Federal Policy but will be tailored geographically depending on local conditions.

The design peak factors normally related to the water supply system are Peak Daily Demand (PDD) and Peak Hourly Demand (PHD). For a feasibility study, the PHD is not applicable because the hourly variation in demand shall be satisfied from the storage to be provided in each sector.

b) Proposed Water Schemes

Based on the initial evaluation of the demand and the location and capacities of the dams, the Consultants will evaluate the alternatives of supplying one or more than one water supply systems. Proposed water schemes will recommend additional main structures such as reservoirs, pumping stations, conveyors.

5.2.2. Agronomic Water

5.2.2.1 Approach

The Irrigation Demand Study shall cover the areas potentially to be irrigated with water coming from dams of the first dam-sites selection.

The outcome of this Water Demand Study should provide the needed agricultural and irrigation inputs that shall be used, among other criteria, to “fine select”, out of the first selection, the final dam-sites that the feasibility study shall tackle.

In the feasibility study, several irrigation scheme characteristics shall be examined and discussed whether they are: 1) technically sound, 2) adapted to local environment and 3) economically feasible. That should allow the identification of the adequate irrigation schemes that the Irrigation Preliminary Design shall examine.

Once the adequate irrigation scheme characteristics, respective to the final dam-sites, are identified, the Irrigation Preliminary Design shall study more in depth the possible alternatives per irrigation scheme with regards to their needs, components and cost estimates.

Then an analysis and comparative studies among the identified alternatives of the same scheme shall allow the recommendation of the best irrigation solutions per scheme.

To be noted, that if the preliminary study will necessitate some assumptions to be made, these assumptions must be verified and checked in field to prepare the ground for the Detailed Irrigation Design Stage.

5.2.2.2 Methodology

a) Identification of the irrigation schemes

The irrigation scheme, or the “so called” irrigable land areas per dam-site, shall be determined using: the 1/50,000 topographical maps and the maps of the Directorate of Overseas surveys of the British government prepared for the Nigerian government. These maps present specific zone classifications with regards to: soil type, agricultural development areas, agro-ecological zones, and land use maps. These maps shall be updated, if needed, through site investigation missions.
To be noted that priority shall be given to the scheme lands located downstream of the dam site around the “fadamas” that run with the slope. This shall favour the use of low-cost irrigation system such as the gravity system. Furthermore, the size of each irrigation scheme shall be dictated, as well, by the livestock population estimated for the studied area.

b) Cropping Patterns

The review of the already existing cropping patterns per irrigation scheme, and/or proposing the new patterns shall be conducted taking into account the following essential factors:

- The traditional agricultural practices and calendar per scheme,
- The climatic conditions that dominate in and around the scheme,
- The soil suitability for each studied cropping pattern,
- The adaptability of the new agricultural crops to all the above,
- The economic profit of the studied or suggested patterns.

c) Irrigation Water Requirements

Based on the above proposed cropping calendars the irrigation Water Requirements (IWR) shall be determined according to the following steps:

ETo

This is the crop evapo-transpiration rate from a reference surface that is not short of water.

The available reference Evapo-transpiration data (ETo), obtained from the previous studies conducted in the region, shall be used. In addition, an estimation of the ETo monthly values for the same areas, shall be obtained using the electronic data base of the *International Water Management Institute* (*IWMI*). The two ETo values shall allow to calculate an adjustment factor that will be used, to correct the ETo-*IWMI* value where the latter is the only available datum.

CWR

Once the monthly ETo values are calculated, the monthly Water Requirements by crop shall be obtained using the following formula: CWR = ETo x Kc where Kc is the crop coefficient.

IWR

The Irrigation Water Requirements (IWR) by crop shall be obtained by subtracting the monthly effective rainfall (Pe) of the monthly CWR as follows: IWR = CWR – Pe.

The total IWR by cropping pattern is then obtained by adding up the individual IRWs by crop per month. The sum of the twelve monthly IRWs values shall give the yearly IWR that should be converted into m^3/ha/year to determine the Command Area discussed in the sections here-after.

To be noted that, the effective rainfall (Pe) are estimated using the USDA method applied to the total rainfall Pt by month.

d) Livestock Total Water Consumption

The livestock population per irrigation scheme shall be estimated extrapolating the figures available for the whole Kaduna State or those available, if any, at Local Government level (LG) for each scheme. These

figures will be obtained from previous studies conducted in the area and from the field mission rapid surveys at LG levels.
As per the livestock Water Consumption the daily consumption figures provided by the "*State-Wide Water Resources Master plan*" for Kaduna State, shall be used as guidelines. These daily consumptions are: Cattles (50 lit.), sheep (5 lit.), goats (3 lit.) and pigs (11 lit.)

As such, the Total Livestock Water Consumption during a year (TLWC) shall be obtained multiplying the total number of livestock heads by the above daily water consumption by head by 30 days by 12 months.

e) Scheme Water Supply and the Command Area

The Command Area (CA), of a water source, is the extent of area which can be reliably irrigated from that water source (FAO manual no.6).
For this case study the Scheme Water Supply shall be each proposed reservoir.

To calculate the Command Area (CA) per reservoir, the Consultants shall proceed as follows:
- In first place we must deduct the TLWC (Total Livestock Water Consumption) in m^3/year of the yearly expected reservoir volume allocated for the agronomic applications.
- Then the balance of that water volume must be measured to the yearly IWR to determine the maximum allowable area that can be irrigated or the CA in hectare.

5.2.2.3 List of Reference Documents

In addition to the list of collected documents and to the sources mentioned above, the following resources shall be consulted in determining all the above:
- The collected field information, though various missions, regarding the cropping patterns, economic indicators, livestock population, etc.
- The *European Digital Archive of Crops options maps of Nigeria.*

- *AQUASTAT – FAO's* Information System.
- *FAO* publications on Forage Legumes in Farming Systems in Sub-Saharan Africa,
- *USDA – FEWS NET* Publications – Nigeria Food Security Outlook.
- *World Sweet Potato Atlas* – Nigeria.
- The *FAO "Irrigation and Water Management*" manuals no. 3, 4 and 6,
- The FAO *"Irrigation and drainage"* papers no. 24, 33, 47 and 56,
- FAO CLIMWAT database for Nigeria.
- *FAO Livestock Sector Brief* – Nigeria, March 2005,
- *Country Studies/Area Handbook* by the Federal Research Division of the Library of Congress - US.

5.3. Electricity Demand Studies

Until the power system in Nigeria is sufficiently resourced estimation of electricity demand will need to be adapted to take into account some special measures. Table 1 reveals gaps in the availability and accuracy of electricity demand data. A detailed study of demand is not within the scope of this project as such a study cannot be completed within the time frame of the project. Ordinarily such a study would involve the following phases:

1. Data collection and database development – this will involve the:
    a. identification of data requirement and gaps; and
    b. development of a database and the updating of that database.

Historic power system operating data and economic data are required for the development of load forecast. The collection of all historic operating data as well as the development of the database is a one-off effort which will require considerable amount of manpower involving, data collection, data entry from hard copies and data validation to ensure that the data is transferred accurately into a database. For subsequent load forecasts, only the previous year's data needs to be collected and entered into the database.

2. Data validation and analysis – the collected data will need to be analysed to ensure reliability and a preliminary analysis will need to be performed to understand the data.

3. Selection and implementation of suitable methodologies – A suitable method which will suit the data and special circumstances in Kaduna State and Nigeria in general will need to be selected to develop the forecast.

4. Preparation of assumptions –the forecasts will depend on the validity of the assumptions. The management of the Power Holding Company of Nigeria and all key ministries, including the Ministry of Commerce and Industry, Ministry of Manpower, etc. will have be involved in the approval of the assumptions.

5. Development of forecasts – forecasts will be developed for different customer categories.

We understand that the Power Holding Company of Nigeria (PHCN) has embarked on a detailed load demand study which will include demand estimated for Kaduna Distribution Company, down to the undertaking level. The results of this study, the first since 1988, are due in about 24 months. However, for the purpose of this task an interim arrangement that will match the time frame of the project is proposed. This would require working closely with PHCN, the Rural Electrification Agency (REA) and key State Ministries.

A study of electricity demand requires accurate historical and existing electricity demand data as well as accurate economic and other non-economic data such as weather data. Tables 1 and 2 do not provide this comfort. The purpose is to have a clear idea of the long-term industrial and commercial development of Kaduna State and where such industries and commerce would be located, and the programme for rural electrification and their associated load projections by the REA.

5.3.1. Methodology

Electricity demand estimation methods are based on two main approached – the global top-down approach and the disaggregated bottom-up approach. Global forecasts are based on estimating the overall load of the system and are mainly used for generation planning.

The method that will be adopted for this exercise is the disaggregated bottom-up method. This methodology is data intensive. It requires a detailed examination of electricity use in Kaduna State and would closely address issues of load shedding and captive power in the State. Because of the absence of accurate reliable data a survey of electricity use in Kaduna State will need to be conducted. Ordinarily this will be a detailed survey but for the purpose of this task a higher level approach of working closely with Kaduna Distribution Company, REA and relevant Ministries such as te Ministry Industry and Commerce, will be adopted. A reasonable estimate of the true electricity demand in Kaduna State will be obtained by investigating the historic and un-met consumption of electricity in each customer category.

Data collection will begin from Kaduna Distribution Company. A questionnaire that categorises customers according to customer class will be sent to Kaduna Distribution Company requesting data from the undertaking level in each distribution zone. The supply needs for each customer class will be broken down into utilisation types and forecasts would be developed according to specific explanatory variables such as the number of customers and the corresponding per capita consumption. A step by step approach to perform the load forecast will involve the following steps:

1. Collection of historical operating data.

2. Collection of customer data: customer data will be segregated according to injection substations and then into customer class. For greater accuracy and depending on the technical capability of Kaduna Distribution Company, the data may be further segregated according to feeder.

3. Estimation of un-serviced and suppressed demands: determining the un-serviced and suppressed demands is a critical part of this task. Total energy sales can be obtained from customer database and billing information. However, estimating what could have been if electricity supply was available to meet all demand is a huge task. From the feeder outage register that could be obtained from Kaduna Distribution Company the total number of hours a feeder was out of service could be compiled. Applying that figure to the suppressed consumption, the un-served demand can be estimated in a very rough form.

4. Collection of economic and non-economic data: A key input into electricity demand estimation is economic data and other non-economic data. As indicated above, this will provide a clear idea of the long-term industrial and commercial development of the State and where such industries and commerce would be located, as well as the programme for rural electrification developed by the REA. Economic and non-economic data would be required from the following sources at least:

    i. State Planning Commission
    ii. Ministry of Industry and Commerce
    iii. REA
    iv. Ministry responsible for manpower and employment

5. Estimation of distribution losses: if Kaduna Distribution Company used computer software for distribution planning the estimation of technical losses will be straightforward. The figure will be obtained from Kaduna Distribution Company. Estimate of non-technical losses will also be obtained from Kaduna Distribution Company, although the figure could also be obtained by subtracting total energy sales and technical losses from the energy received from the transmission system

Forecasts will be developed for each customer category. To encourage cooperation of Kaduna Distribution Company, development of the methodology and results of the task will be shared with them.

5.4. GEOLOGICAL & GEOTECHNICAL STUDIES

5.4.1. Geological works

The geological works shall comprise both desk studies and field visits. The main aspects that will be examined prior to the field works shall comprise:

- Existing geological maps,
- Existing geological and hydrogeological reports related to the dams, reservoirs and regional geology of Kaduna state,
- Aerial and satellite photos of dam sites and reservoirs,
- Reports on the seismicity of the dams region,
- Existing subsurface investigation records (borehole logs, geophysical surveys, laboratory test results)
- Preparation of geological maps indicating the location of the potential dams.

The field works shall comprise:

- The visit of each potential dam site,
- The description of the existing geological formations,
- The type of soil deposits, and their expected thickness at the dam site,
- The recognition of any problematic ground conditions unfavourable to dam construction,
- The identification of potential borrow zones: clay, rock, aggregates, fill,
- The degree of difficulty of access.

Other key geological issues comprise:

- the watertightness of the reservoir storage,
- the stability of the slopes in and around the reservoir,
- Defects in rock masses: faults, fractured zones of high permeability.

5.4.2. Site Investigations

The consultants shall prepare the document that provide the requirements of the tasks for assessing the preliminary geotechnical conditions of the selected dam sites in agreement with the client; these tasks to be carried out by the contractor shall include, but are not limited to:

- Boreholes in dam foundations, with extraction of rock, soil and water samples,
- In situ tests to evaluate geotechnical parameters,
- Identification of borrow zones,
- Chemical analysis of soil and water,
- Geophysical surveys, mainly to identify the thickness of alluvial deposits.
- Placing monitoring equipment and keeping track of data records.

The consultants shall supervise the investigations, review the contractor's works, and interpret the test results. The field investigation data shall contribute to the refinement of the geological sections of the selected dam sites.

5.4.3. Geotechnical Design Criteria

The criteria for the design of the dams shall be in accordance with internationally renowned standards. The consultants shall apply the requirements of:

- ICOLD (International Committee on large dams),
- USBR (United States Bureau of Reclamation),
- References and articles applicable in dam engineering practice.

5.4.4. Geotechnical Report

The geotechnical report shall encompass but shall not be limited to the following design issues:

- Foundation stability,
- Consideration to unfavourable rock joints and weak soil layers,
- Potential liquefaction of saturated sand layers,
- Stability of open-cut excavations,
- Stability of underground excavations and structures (if any),
- Ground stabilization methods,
- Development of pore water pressures,
- Foundation cut-off and drainage systems,
- Integrity of foundation of dam
- Quality and properties of dam materials,
- Zoning of dam fill,
- Dam and foundation instrumentation and monitoring,
- Guidelines for the safety of the works,
- Recommendations for detailed site investigations.

5.5. HYDROPOWER POTENTIAL

The main data concerning the hydropower potential estimate of the examined sites are shown in the following table:

Site	River	Average flow*	Reservoir Volume*	Dam Height*	Average Power*	Annual Energy output*
		[m^3/s]	[m^3*10^6]	[m]	[MW]	[GWh]
Galma 1	Galma	5.7	120	31	1.9	8.5
Galma 3	Likarbu	4.6	96	28	1.4	6.0
Bakin Kogi	Kaduna	16	330	35	6.1	27
Masaka	Tubo	28	580	34	10	45
Yola/Buruku	Tubo	20	410	29	6.2	27
Babbon Kogi	Babbon Kogi	13	270	35	4.8	21
Upper Tubo	Tubo	10	210	27	3.0	13
Karami & Kaduna	Kaduna	100	2'100	40	43	190
Itisi	Kaduna	59	760	40	25	110

* roughly estimated data

Reservoirs have been foreseen quite large (of the same order of magnitude as the catchment annual runoff to permit an adequate dead storage for sedimentation).

Estimated annual energy production is not very high (0.04 ÷ 0.06 kWh/m^3) but it is quite similar to other multi-purpose plants in similar conditions.

These values are reported just as an indication since they have been obtained from historical data regarding hydrology of Nigeria and from perfunctory investigations on topographical maps.

In the next few months, the information collected during site visits and from archive research will permit to carry out a strict study oriented to obtain exact data about possible installed power, energy production, cost of installations and incomes due to energy selling and so on.

The energy potential of the examined sites will be determined resorting to the sequential streamflow routing (SSR) method, the best viable method for evaluating storage projects regulated for multiple purposes including power.

The SSR method uses the continuity equation to route streamflow through the project and thus it accounts for the variation in reservoir elevation resulting from reservoir regulation.

The data that will be analyzed for energy potential studies are:

- historical streamflow records;
- reservoirs characteristics;
- tailwater data;
- installed capacity and efficiency of power units;
- head losses;
- non-power operating criteria;
- generation requirements.

Historical streamflow records

Criteria (routing interval, length of records, etc.) that will be followed to determine daily inflow are described in section 5.1.

Just as an indication, hereafter graphs of daily discharges registered on river Kaduna (at Kaduna South and Bakin Kogi) and Tubo (miles 20 Lagos Road) in 1980 (when rainfalls in Kaduna South were 1,200 mm, a typical value) are reported.

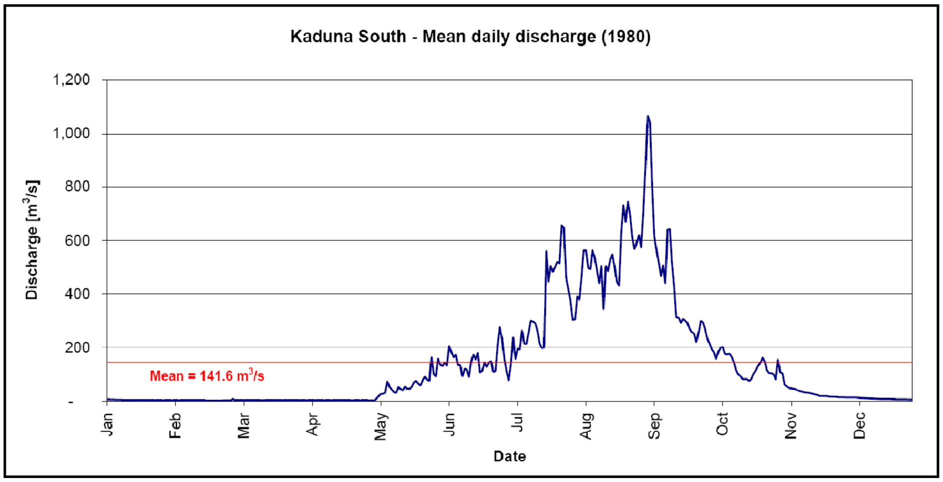


Figure 3 : Mean daily discharge at Kaduna South station (1980)

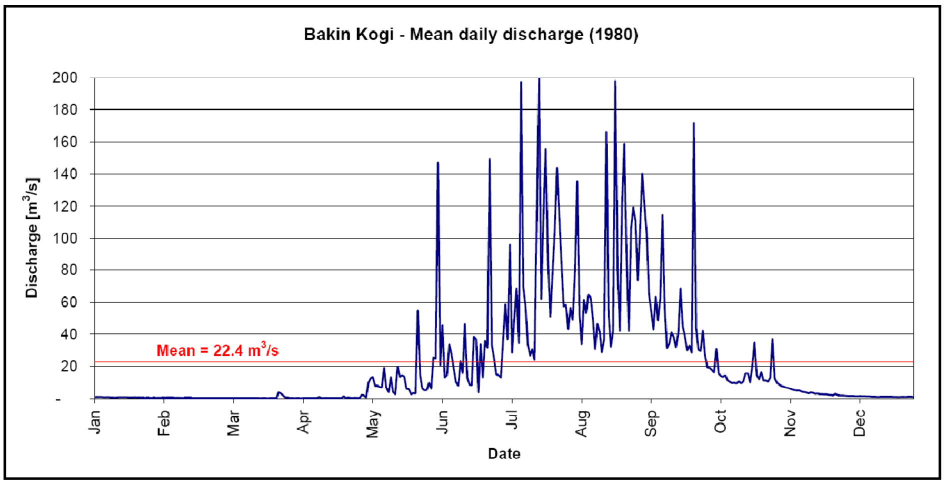


Figure 4 : Mean daily discharge at Bakin Kogi station (1980)

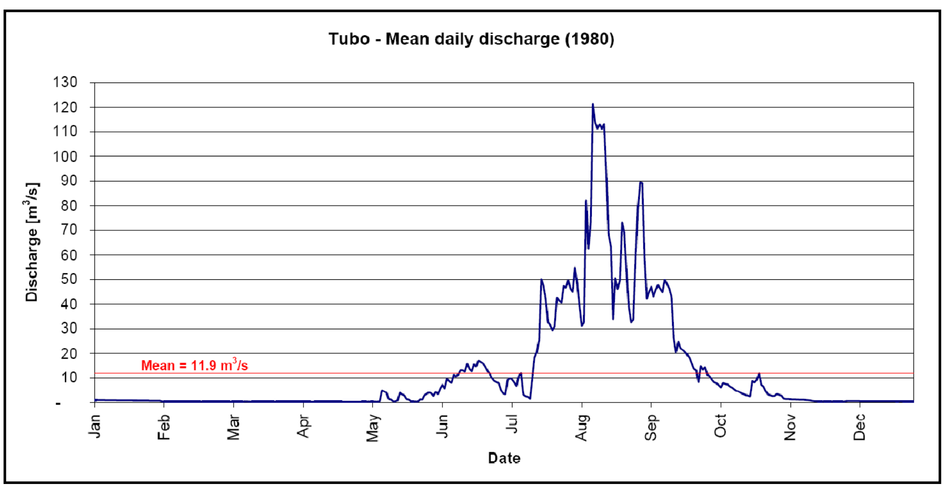


Figure 5 : Mean daily discharge at Tubo station (1980)

It is possible to observe that discharges vary from 1 to 1,000 percent of the mean value during the year and discharges overcome the mean value only 3 months in the year.

Not all of the streamflow passing the dam site may be available for power generation. Consequently all consumptive losses (reservoir surface evaporation losses and diversions for irrigation or water supply) and non-consumptive losses (requirements of fish passage facilities, other project water requirements, leakage through or around dam and other embankment structures, leakage around spillway or regulating outlet gates, leakage through turbine wicket gates) will be estimated considering all the collected data.

Reservoirs characteristics

Total reservoir storage may be divided into functional zones:

- the top zone would be the flood control storage space, which, if necessary, would be kept empty except when regulating floods;
- below the flood control zone would be the power or conservation storage zone; this space would store water to be used to serve various at-site and downstream water uses, which include power generation, irrigation, municipal and industrial water supply and, in case, navigation, water quality, fish and wildlife, and recreation;
- below the conservation zone is the dead storage zone, which is kept full at all times to provide minimum head for power generation, sedimentation storage space, etc.

The type of reservoir data that will be analyzed include storage volume versus reservoir elevation data and surface area versus elevation data. Maximum and/or minimum reservoir elevations will also be identified.

Tailwater data

It will be necessary to reflect the dynamic variation of tailwater during peaking operations (i.e., the fact that the tailwater elevation response lags changes in discharge).

A lag of the streamflow hydrography will be applied to reflect the time required for tailwater to adjust to changes in discharges, or more sophisticated routing techniques will be applied.

In case where a downstream reservoir should encroach upon the project being studied (i.e., the project being studied discharges into a downstream reservoir instead of into an open river reach), during periods when encroachment occurs, the project tailwater elevation will be based on the elevation of the downstream reservoir.

Installed capacity and efficiency of power units

The powerplant installed capacity establishes an upper limit on the amount of water that can be turbined. The kind of turbine installed establishes a lower limit on the amount of water that can be turbined.

Installed capacity and turbines kind (Francis or Kaplan - see figures below) and characteristics will be therefore variables considered in evaluating the hydro projects, and several energy estimates may be made for alternative plant sizes.

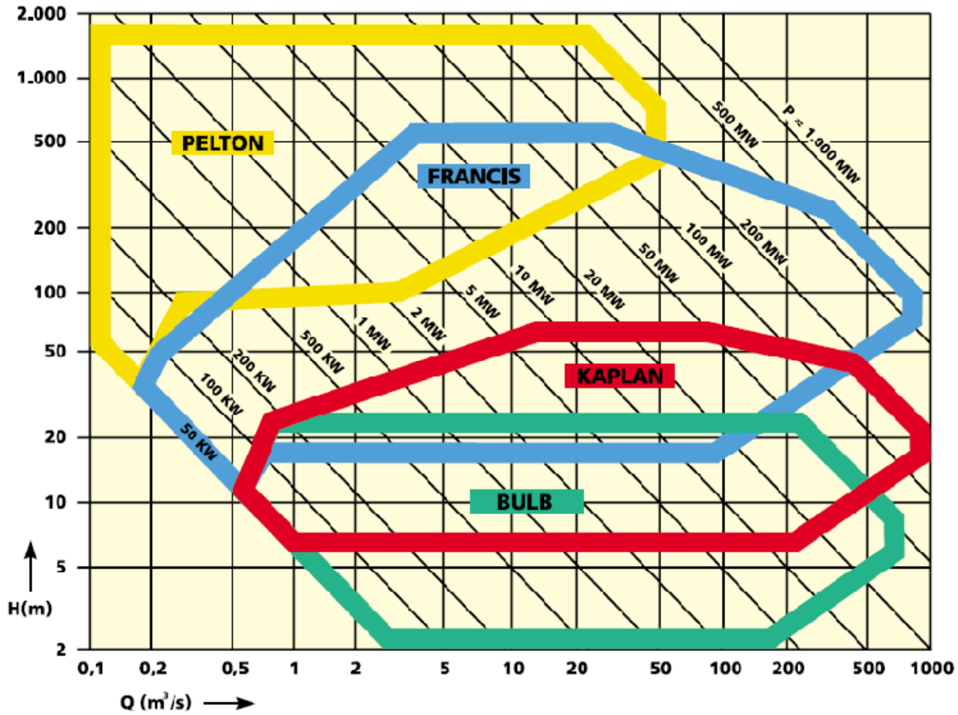


Figure 6 : Recommended turbine types

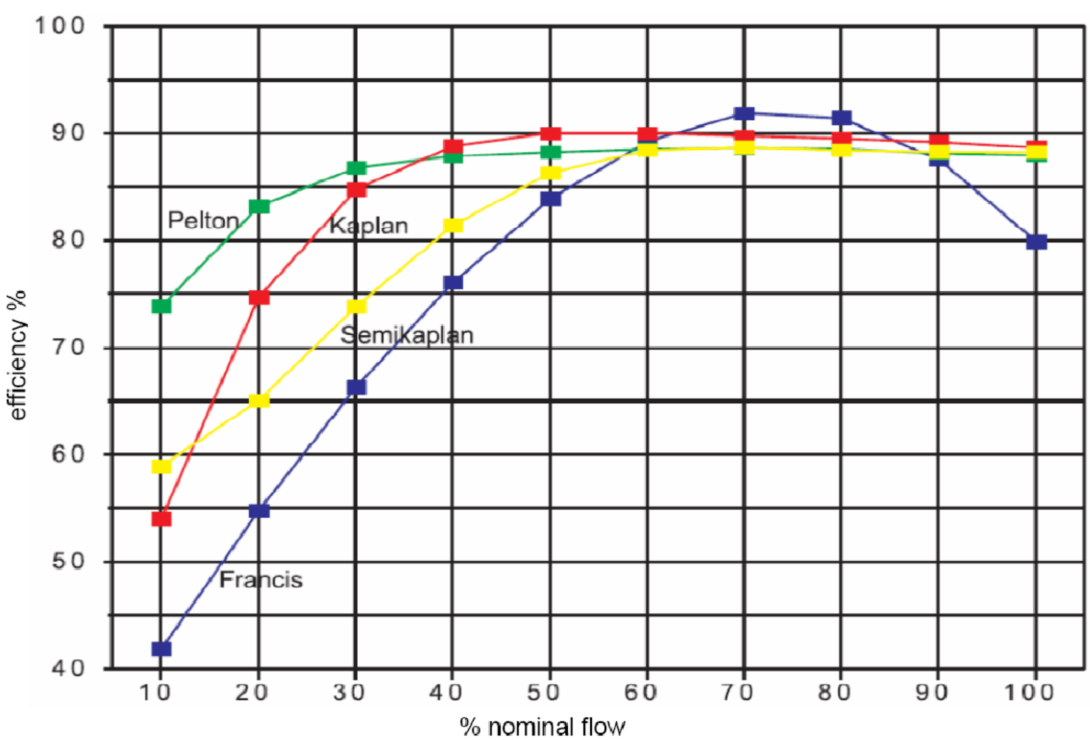


Figure 7 : Efficiency of different turbine types

The efficiency of turbine-generator units varies with head, discharge and turbine type. For preliminary studies, a fixed overall efficiency of 85 percent will be assumed. Once a turbine design will be chosen, an average efficiency based on the characteristics of that unit will be used.

Head losses

Head losses include primarily friction losses in the trashracks, intake structure, and penstock (hydraulic losses between the entrance to the turbine and the draft tube exit are accounted for in the turbine efficiency).

Also if penstocks will be quite short, and the losses across the trash racks will be the major consideration, a head loss versus discharge relationship will be used.

Non-power operating criteria

A number of operating criteria may exist for governing project functions other than power, and these often affect the energy output of hydro projects, especially those projects having conservation or flood control storage.

These constraints could include the following:

- minimum discharge requirements;
- storage release schedules for downstream uses (navigation, irrigation, water supply, water quality, etc.);
- flood control requirements;
- minimum pool elevation required to permit pumping from reservoir for irrigation and other purposes.

All these aspects will be analyzed and, in case, discussed in technical meetings at the Ministry of Water Resources.

5.6. ENVIRONMENT IMPACT ASSESSMENT

Following the visits to the potential dam sites by Dr. John Davey, Chartered Environmental Specialist and Chartered Water and Environment Manager, during the period 16-26th June 2008, the *most significant* potential environmental impacts have been identified, and subjectively assessed in sufficient detail to be fully incorporated into the next stage of the project, site selection.

From discussion with the Project Proponent and the Kaduna State Environmental Protection Authority, the regulatory agency for environmental issues within the project area, guidance on all aspects of Environmental Assessment (EA) for the new Kaduna dams will, where appropriate, be drawn from the following:

- The Laws of the Republic of Nigeria;
- World Bank Operational Procedures OP 4.01[1] and associated documents;
- The recommendations of the World Commission on Dams[2] and the Nigerian Dams and Development Forum; and,
- Recommendations of the UNEP Dams and Development Project[3].

In relation to fundamental energy and water policy, a review of which is required under World Bank EA procedures, the Project Proponent has already formulated the strategy whereby future energy and urban water supply requirements will primarily be supplied from hydroelectric dams. On the basis that adoption of this strategy by the Kaduna State Government was preceded by full and transparent consideration of all appropriate issues, the EA for the new dams will not readdress this policy.

Given the overall similarity between the environmental attributes of the various dam site options, a single generic Scoping Report and EIA Terms of Reference covering all the selected dam sites will be issued prior to Preliminary Design. Nigerian law requires this to be approved by the

[1] *Environmental Assessment.* World Bank Operational Manual, Operational Policies OP 4.01, World Bank, October 1999.
[2] *Environmental and Social Impact Assessment for Large Scale Dams – Thematic Review.* World Commission on Dams, 2000.
[3] *A Compendium of Relevant Practices for Improved Decision-Making on Dams and their Alternatives.* United Nations Environment Programme, Dams and Development Project, 2007.

regulatory agency prior to the commencement of any necesary Environmental Impact Assessment (EIA) Study. Since dams are regarded as Category 1 projects, requiring full EIAs, separate EIA reports will be produced for each of the selected dam sites the Project Proponent wishes to pursue to Detailed Design.

The geographical extent of the area over which Environmental Assessments in general and EIA Studies in particular are undertaken is rarely limited to that directly affected by engineering construction. The World Bank[4] defines the area of influence of a dam project as extending from the upper limits of the surface water catchment of the impounded reservoir as far downstream as the estuary, coast and off-shore zone. In the case of the Upper Niger sub-catchments in Kaduna State, extending the EIA to the coast is obviously somewhat excessive, but downstream impacts will be significant and Assessment will need to continue to where base flow contribution from incoming tributaries is such that the restriction on natural surface water flow from the catchment above the dam is no longer considered to impart significant environmental impact.

[4] *Environmental Assessment Sourcebook*. World Bank Technical Paper 140, Volume 2, 1991.

APPENDICES

APPENDIX A : *Tables*

Table 1: Electricity Demand and Use Data - Supplied by Kaduna Distribution Company

Total supply by PHCN to Kaduna distribution Zone:	5% of power generated
Percentage of total supply to Kaduna State	61.5%
Level of unmet demand	209MW
Level of suppressed demand	209MW
End-use of electricity by customer category in Kaduna State:	(%)
Industrial	16.93
Commercial	16.85
Agriculture	6.93
Residential	59.40
Power shedding in Kaduna State (average number of hours in a year) to:	(Hours)
Industry	5,040
Commerce	6,205
Agriculture	6,205
Residential	5,975
	MWh
Weekly average industrial demand:	2,345.00
Weekday average demand	312.73
Weekend average demand	312.73
Public holiday average demand	312.73
Day time average demand (06:30 hrs – 18:30hrs)	
Night time average demand (18:30hrs – 06:30hrs)	156.37
Weekend average peak demand	
Weekday average off-peak demand	156.37
Weekend average off-peak demand	
Public holiday average peak demand	
Public holiday average off-peak demand	
	MWh
Weekly average commercial demand	2,363.00
Weekday average demand	76.20
Weekend average demand	76.20
Public holiday average demand	76.20
Day time average demand (06:30 hrs – 18:30hrs)	
Night time average demand (18:30hrs – 06:30hrs)	38.10
Weekend average peak demand	
Weekday average off-peak demand	38.10

Weekend average off-peak demand Public holiday average peak demand Public holiday average off-peak demand	
  Weekly average residential demand Weekday average demand Weekend average demand Public holiday average demand Day time average demand (06:30 hrs – 18:30hrs) Night time average demand (18:30hrs – 06:30hrs) Weekend average peak demand Weekday average off-peak demand Weekend average off-peak demand Public holiday average peak demand Public holiday average off-peak demand	MWh 8,344.00
  Weekly average agriculture demand Weekday average demand Weekend average demand Public holiday average demand Day time average demand (06:30 hrs – 18:30hrs) Night time average demand (18:30hrs – 06:30hrs) Weekend average peak demand Weekday average off-peak demand Weekend average off-peak demand Public holiday average peak demand Public holiday average off-peak demand	MWh 972.40
Existing connection cost by voltage level Industry Commerce Residential	
Existing use of distribution system cost by voltage level Industry (yy industrial tariff) Commerce (zz commercial tariff) Residential (aaa residential tariff)	D1, D2, D3, D4, D5 C1, C2, C3, C4 R1, R2, R3, R4, R5 (note: check each tariff against published rates)

Table 2: List of collected data

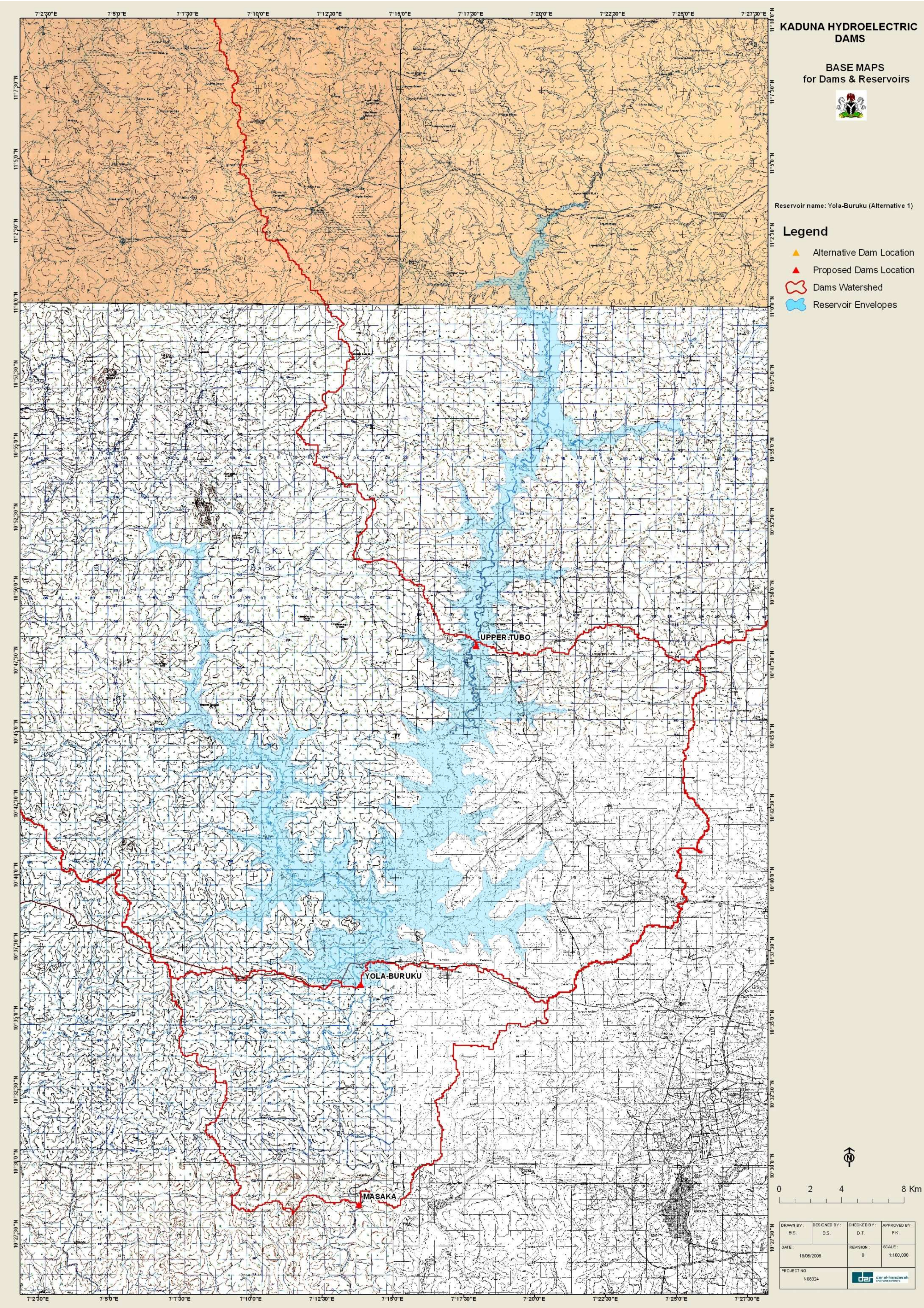
General	Kaduna State Administrative Map
Dams	Map of Existing Dams (JICA)
Dams and irrigation	List of Dams and Irrigation Projects (JICA)
Water	The Study on the National Water Resources Master Plan (NWRMP) – Volume 2 - Draft Final Report (JICA – August 1994)
Water	The Study on the National Water Resources Master Plan (NWRMP) – Volumes 1,2, 3 & 4 - Final Report (JICA – March 1995)
Water	Water resources Master Plan - Parkman 1997 (4 Volumes)
Water	Shallow aquifer study (Final Report)
Hydrology	Map of Major Runoff Stations (JICA)
Hydrology	List of Major Runoff Stations
Hydrology	Catchment Area Maps
Hydrology	Average Monthly rainfall in Kaduna State 2002-2005
Hydrology	Compiled Hydro data 1990-1994
Hydrology	Compiled Hydro data 1995-2000
Hydrology	Compiled Hydro data 2001-2005
Hydrology	Hydro-Meteorological Annual Report (1977-1978)
Hydrology	Hydro-Meteorological Annual Report (1988 Annual Report)
Hydrology	Hydro-Meteorological Year Book (1972-73)(1973-74)(1974-75)
Hydrology	Meteorological Data (1981-1982) Volume 1
Hydrology	Hydrometeorogical annual report 1989
Hydrology	Hydrometeorogical year book 1975-1977
Hydrology	Hydrometeorogical year book 1979-1980
Hydrology	Hydrometeorogical year book 1987
Hydrology	Hydrological year book 1983/84
Hydrology	Hydrological year book 1985/86
Hydrology and climate	Climatological Data Book (KDSWB) Zonkia 2004 – 2007
Hydrology and climate	Climatological Data Book (KDSWB) Kaduna North 2004 – 2007
Hydrology and climate	Climatological Data Book (KDSWB) Kaduna South 2004 – 2007
Hydrology and climate	Climatological Data Book (KDSWB) Kachia 2004 – 2007
Hydrology and climate	Climatological Data Book (KDSWB) Saminaka 2004 – 2007
Hydrology and climate	Climatological Data Book (KDSWB) Kangimi 2004 – 2007
Hydrology and climate	Climatological Data Book (KDSWB) Ikara 2004 – 2007
Topography	88 topo maps scale 1:50,000
Geology	Geological map of Nigeria (1/2,000,000)

Geology	The Geology of parts of Niger, Zaria and Sokoto provinces - 1957
Geology	Geology of Nigeria (edited by C.A. Kogbe)
Geology	A summary of the Geology and Mineral Resources of Kaduna State - March 2000
Agriculture	Agricultural production 1985 -2005 KADP
Irrigation	Study of Irrigation potential of Shallow Aquifers in Fadama areas of Kaduna State
Irrigation	Reactivation and expansion pilot Irrigation schemes - Final Report: Annex 1 Pedology: Volume 1
Irrigation	Reactivation and expansion pilot Irrigation schemes - Final Report Annex 3: Hydrology Volume 1
Irrigation – hydrology	Reactivation and expansion pilot Irrigation schemes - Feasibility Report Annex 4: Hydrology
Irrigation	Reactivation and expansion pilot Irrigation schemes - Annex 5: Engineering
Irrigation and economics	Reactivation and expansion pilot Irrigation schemes - Feasibility Report Annex 6: Economics
Dams and irrigation	Irrigation schemes and dams - Enviplan 2007
Dams and irrigation	Irrigation schemes and earth dams - Afri International 2006
Dams	Pamphlet - Gurara Dam - 2007
Power	Design of 132KV substation - COB DECROWN
Other	Directory of Business Establishments in Kaduna State 2006
	Feasibility Study / Progress of Downstream Projects in Nigeria

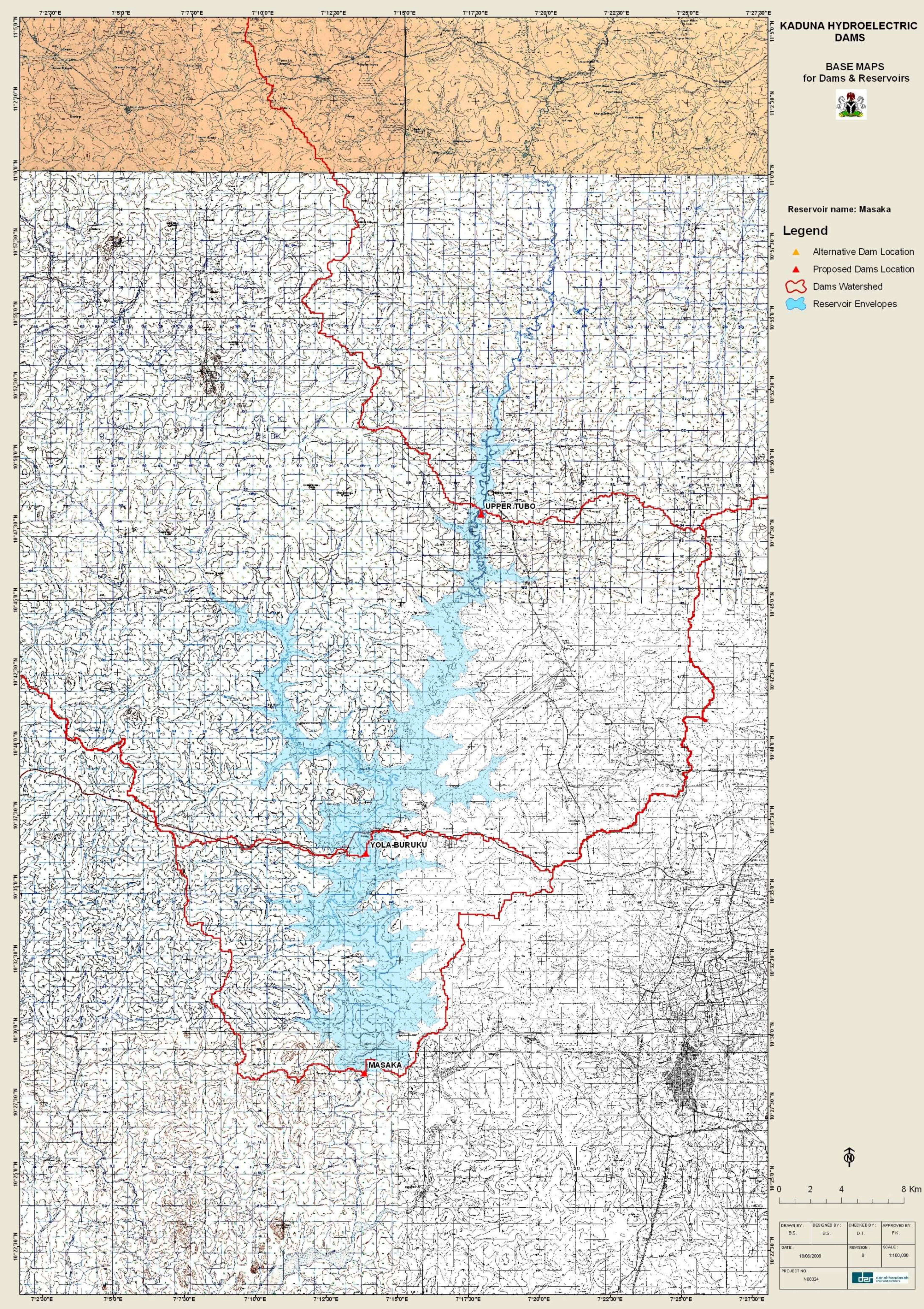
Table 3: Data Requested From Ministry Of Industry & Commerce

1. Population data	
2. Economic growth date a. By sector i. Industry ii. Commerce iii. Agriculture b. By area of the state i. Northern area ii. Southern area iii. Eastern area iv. Western area v. Central area	
3. Top 20 industries: a. Location b. Product type c. Level of production d. Planned expansion within a time line of 5 years e. Available capacity of stand-by generation	
4. Medium and small enterprises: a. Product type b. Average level of production c. Planned expansion of medium and small enterprises	

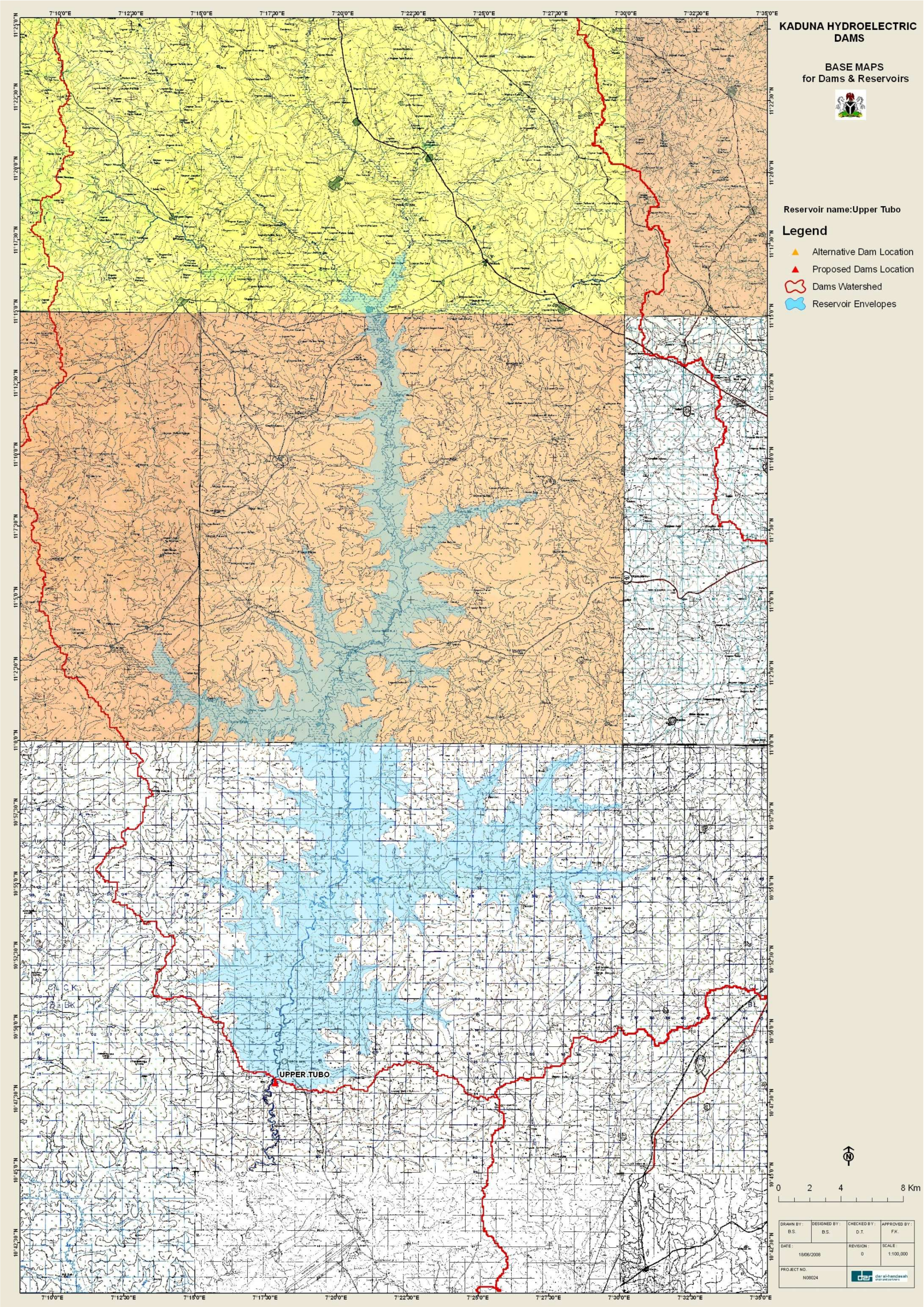
APPENDIX B : *Maps of potential sites*



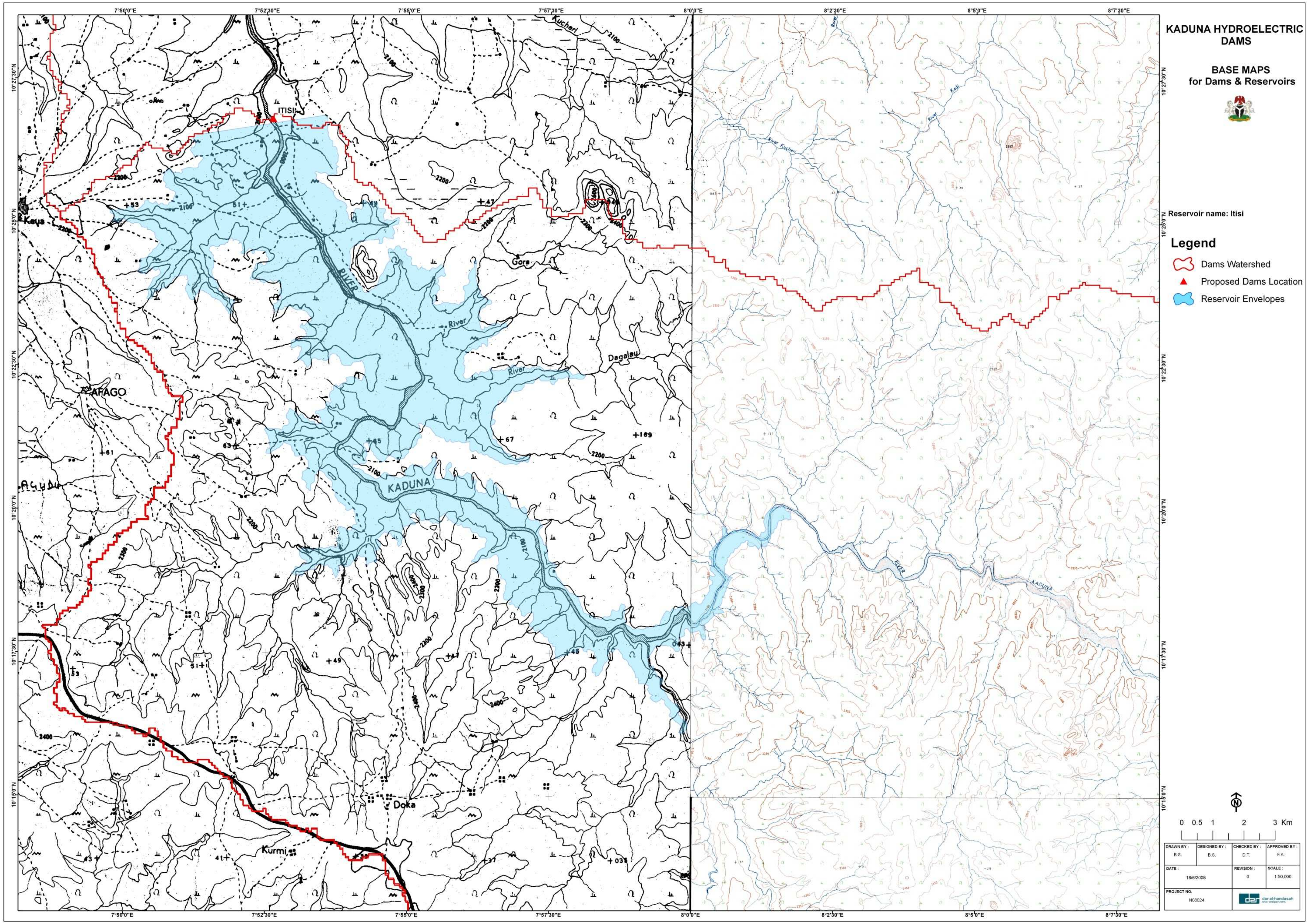
SITE 1: YULA BURUKU



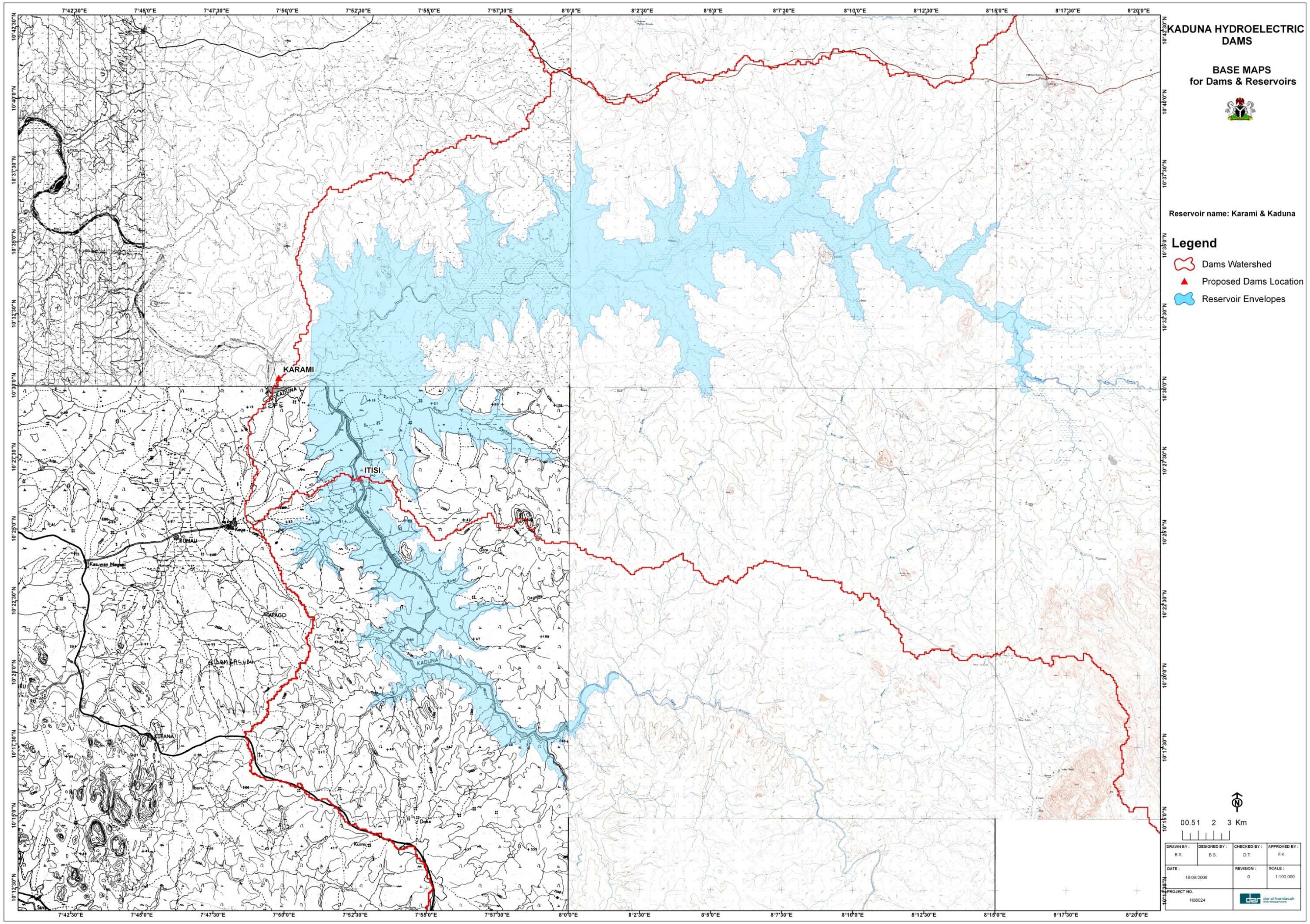
SITE 2: MASAKA



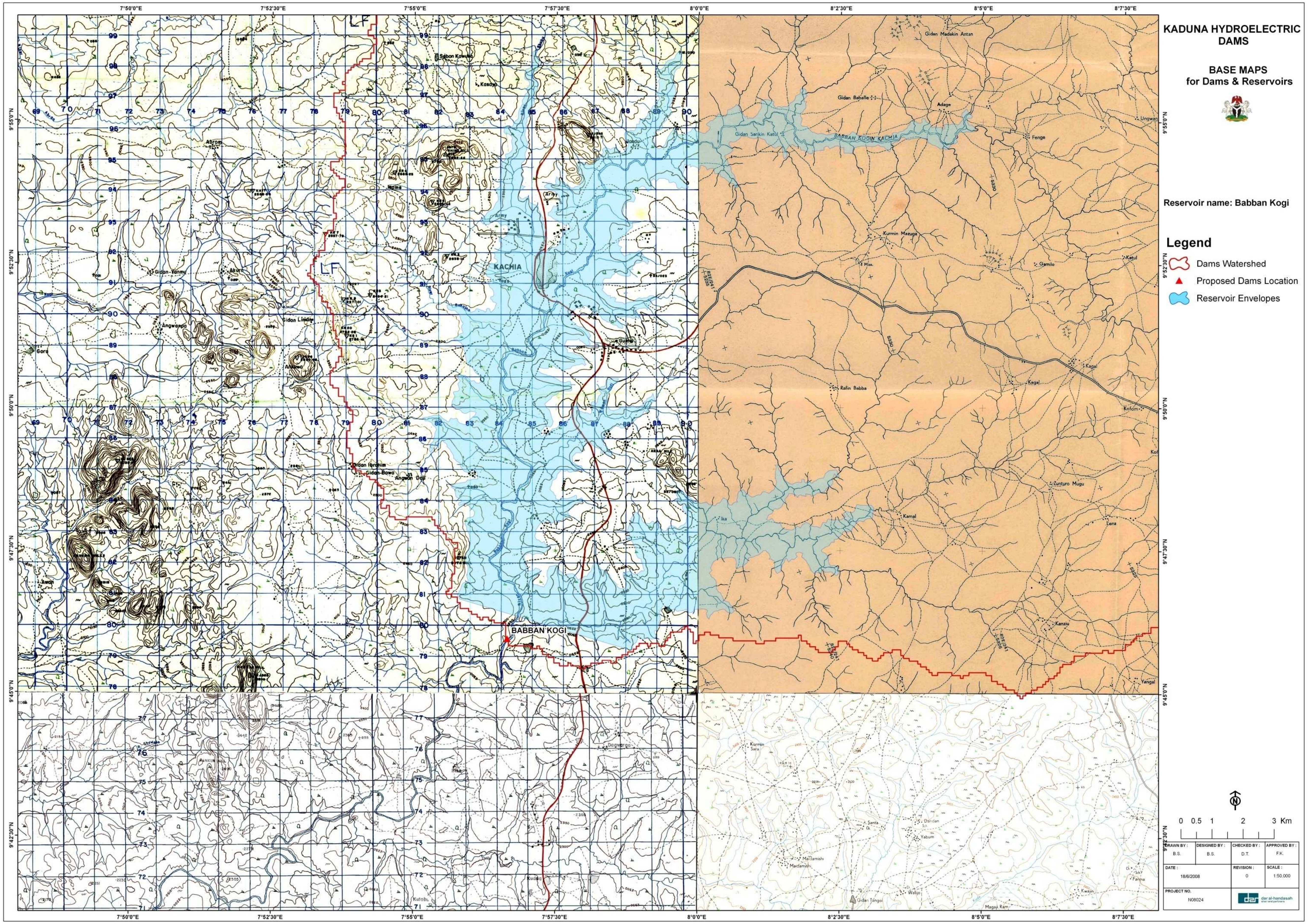
SITE 3: UPPER TUBO


KADUNA HYDROELECTRIC DAMS
BASE MAPS for Dams & Reservoirs
Reservoir name: Itisi
Legend
Dams Watershed
Proposed Dams Location
Reservoir Envelopes
0 0.5 1 2 3 Km
DRAWN BY : B.S.
DESIGNED BY : B.S.
CHECKED BY : D.T.
APPROVED BY : F.K.
DATE : 18/6/2008
REVISION : 0
SCALE : 1:50,000
PROJECT NO. N08024
ITISI
Kaya
AFAGO
Gora
Dagalau
Doka
Kurmi
RIVER
KADUNA
River Kucheri

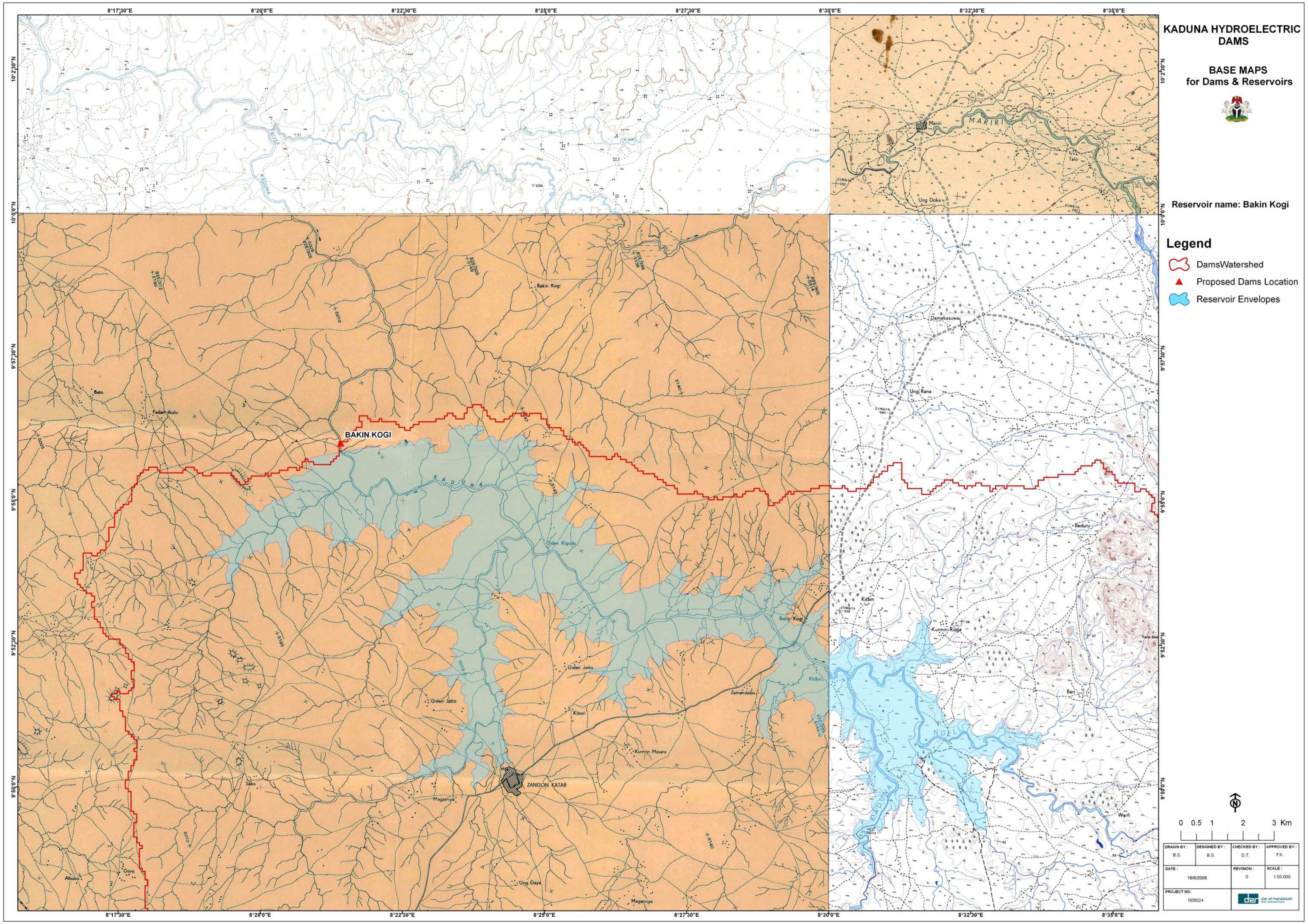
SITE 4: ITISI



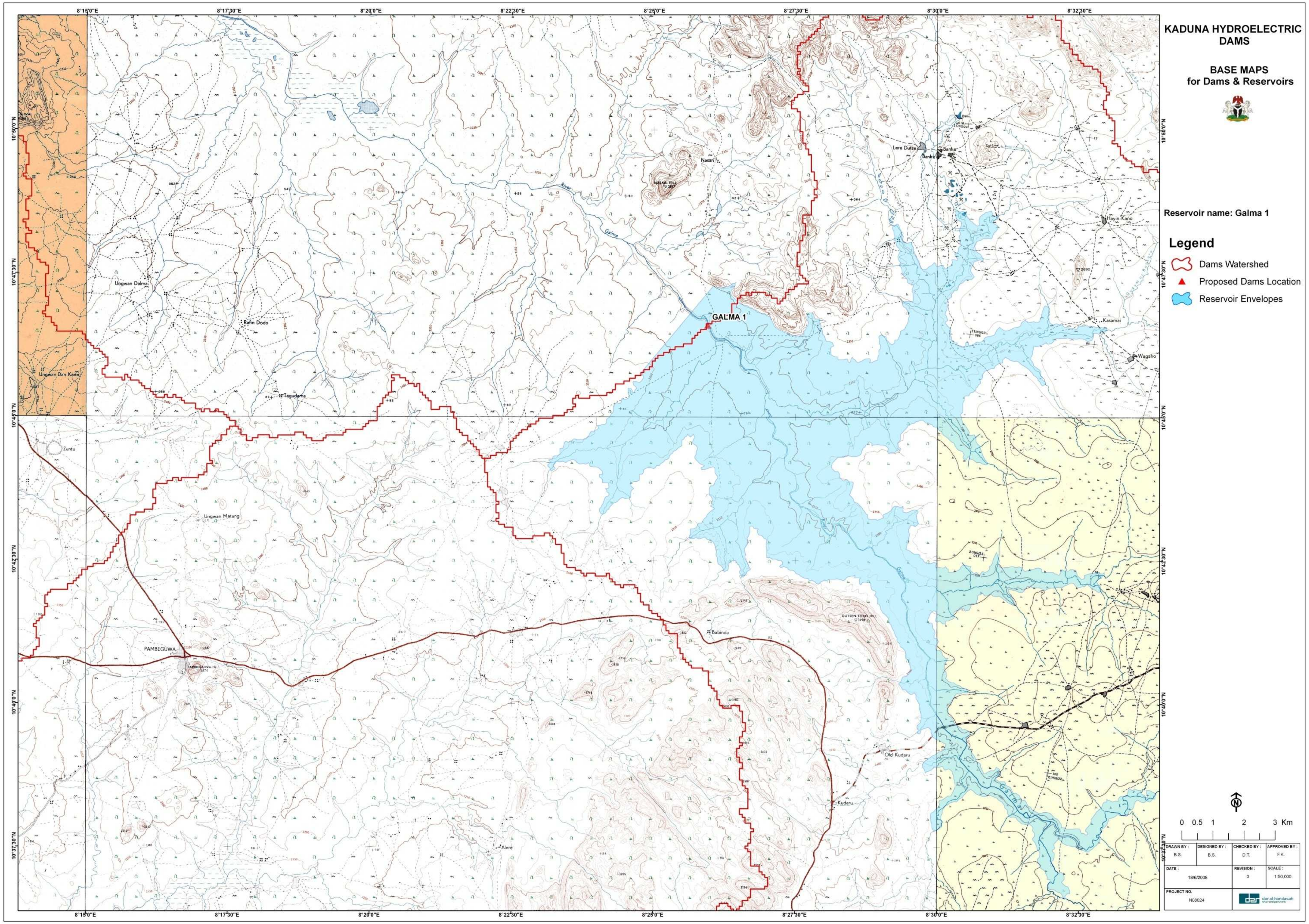
SITE 5: KARAMI & KADUNA



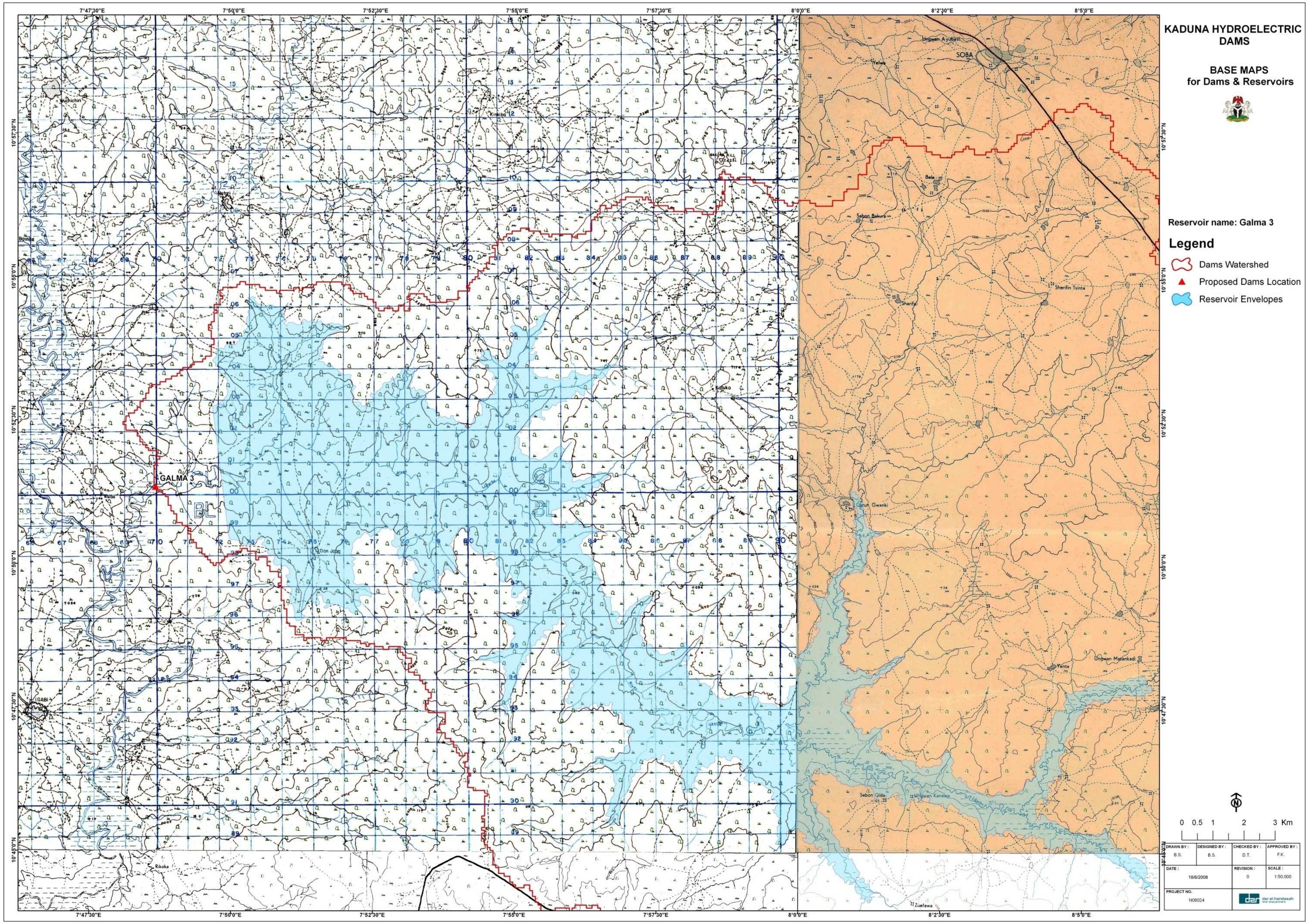
SITE 6: BABBON KOJI



SITE 7: BAKIN KOJI



SITE 8: GALMA 1



SITE 9: GALMA 3