WATER SUPPLY FACILITIES AND SYSTEMS IMPROVEMENT FOR EDO CENTRAL SENATORIAL DISTRICT, EDO STATE

BY

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CERTIFICATION

This is to certify that this research work was carried out by Oigbochie Francis Osolase of the Department of Civil Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Akure, in Partial Fulfilment of the requirement for the award of master of Engineering (M. Eng.) in Civil Engineering (Water Resources and Environmental Engineering Option). It has not been submitted elsewhere for the award of any degree or diploma.

2/12/04
Engr. (Dr.) A. M. Oguntuase
Supervisor

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ABSTRACT

The Edo State Central Senatorial District comprising of five Local Government Areas with about one hundred and fifty six towns, communities and camps has a population of three hundred and seventy-two thousand, one hundred and twenty-two (372,122) people by the 1991 census figure. There are three surface water schemes - Ugbalo; Iyagun and Ibiekuma across the Senatorial District, yet the major problem of the area is inadequate water supply. About seventy–five percent of the population have no access to portable water supply. The three water schemes service range is limited and bedevilled with deficiency and decay of facilities resulting in ineffectiveness of the supply systems.

The existing water supply facilities in the Senatorial District were appraised, the technical problems affecting them identified and the required improvements and modifications for optimisation of the schemes based on the reality of times were articulated. The streams flow capacities from the measurement taken showed that much more water can be abstracted from the streams for enhanced supply to the communities. Other sources (Ella and Amendokhian streams) with high flow potential were identified for development to extend water supply coverage of the Senatorial District.

The outcome of this study showed that the three existing water schemes in the area are capable of an increased daily total output of about One hundred and twenty-five thousand, five hundred and twenty-six cubic metres per day

(125,526m^3/d). The other identified surface water sources have potential for increased water supply to the area with about Sixty thousand cubic metres/day (60,000 m^3/d)

With a projected population of about one million, one hundred fifty-one thousand, four hundred and seventy-nine people (1,151,479) by the year 2028 and water demand of one hundred and ninety-three thousand, four hundred and fifty cubic metres/day (193,450 m^3/d) the three existing water schemes and the addition of the proposed two new surface water schemes at Igueben and Uromi, will enhance water supply to the area to about one hundred and seventy thousand, seven hundred and seventy-six cubic metres per day (170,776 m^3/d). While the shortfall would be augmented from underground water sources (boreholes). With each of the three existing and the two proposed schemes located in one of the five Local Government Areas comprising the Senatorial District respectively, and the booster stations linkage; the upgrading of the schemes and the development of the proposed ones the demand of the area will be met within the projected period.

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CHAPTER ONE

INTRODUCTION

1.1 Description of Project Area

The Edo Central Senatorial District of Edo State is the Ishan Division of the old Western Regional Government and Midwestern Region of Nigeria. (Fig. 1.1) It now has five Local Government Areas namely: Esan Central Local Government Area with headquarters at Irrua; Esan West Local Government Area with headquarters at Ekpoma; Esan North East Local Government Area with Uromi as headquarters; Esan South East Local Government Area with Ubiaja as headquarters and Igueben Local Government Area with Igueben as headquarters (fig 1.2)

The Edo State Central Senatorial District was fortunate to have three established surface water schemes namely; (1) Ugbalo water scheme-Northern Ishan water scheme at Ugbalo/Ibore in Esan Central Local Government Area and established in 1957 under the former Western Regional Government of Nigeria. (2) the Iyagun water scheme, at Ewohimi in Esan South East Local Government Area which came on stream in 1967 under the National water rehabilitation programme of the Federal Government of Nigeria; and (3) the Ibiekuma water scheme inside the Ambrose Alli University Campus Ekpoma which was established in 1994, funded by the European Economic Commission. There are boreholes projects established in the area over the years. But the major problem still facing the Senatorial District up till now is potable water supply.

1.2 Geographical Boundary

The Edo Central Senatorial District is bounded in the North by Etsako West and East Local Government Areas of Edo State, in the West by Owan West and East Local Government Areas of Edo State; in the South by Uhumwode Local Government Area of Edo State and in the East by the Ika and Oshimilli Local Government Areas of Delta State. The area is a plateau with altitude range of 183m to 416m above mean sea level (MSL). The total area of the Senatorial District is about 2,825km^2 which is 14.3% of the total area of Edo State. It lies within the latitude 6^0 25' N – 7^0 56'N and longitude 5^0 19' – 6^0 38'E (Edo State Ministry of Lands and Surveys. 1991).

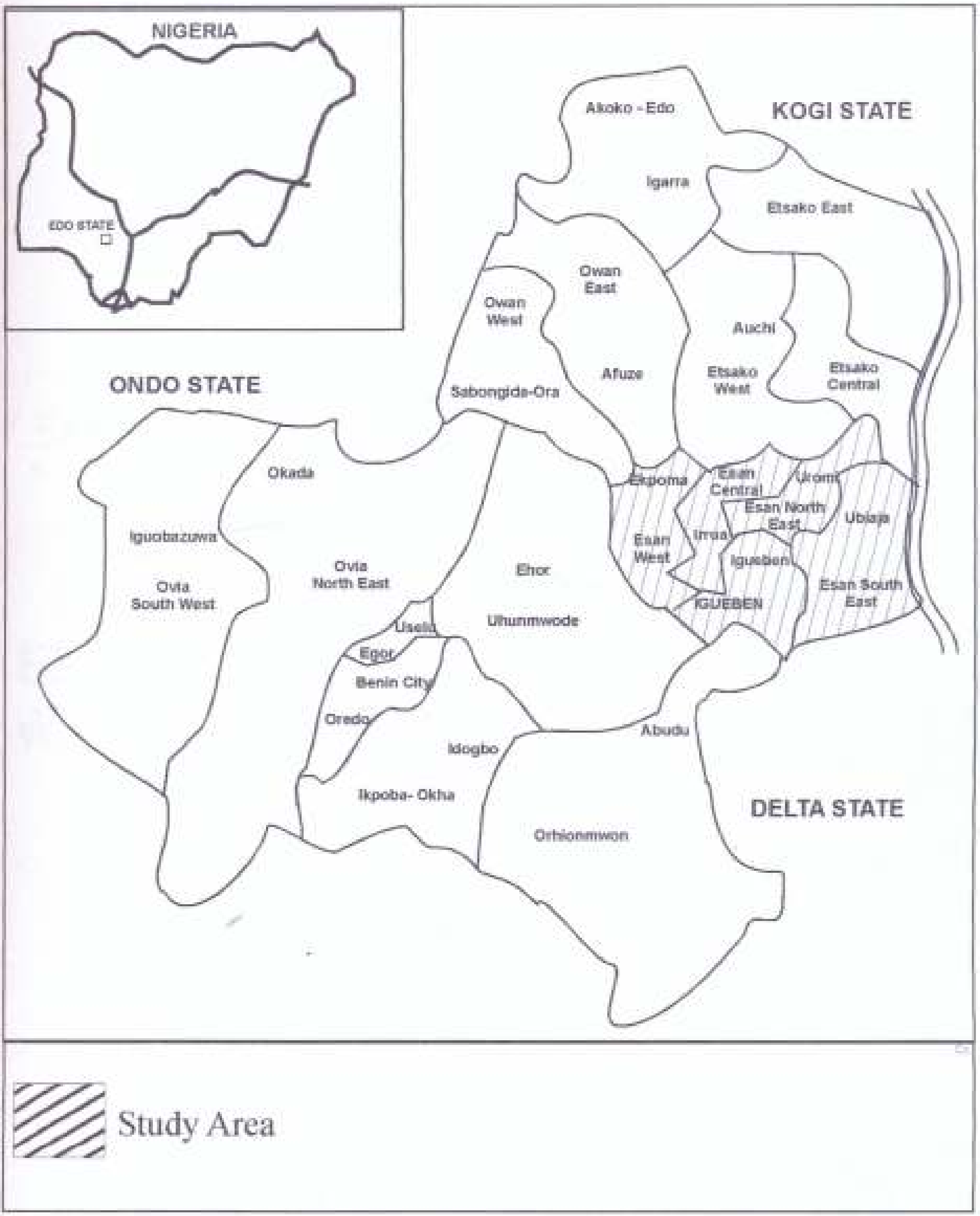


FIG. 1.1 MAP OF EDO STATE, NIGERIA.

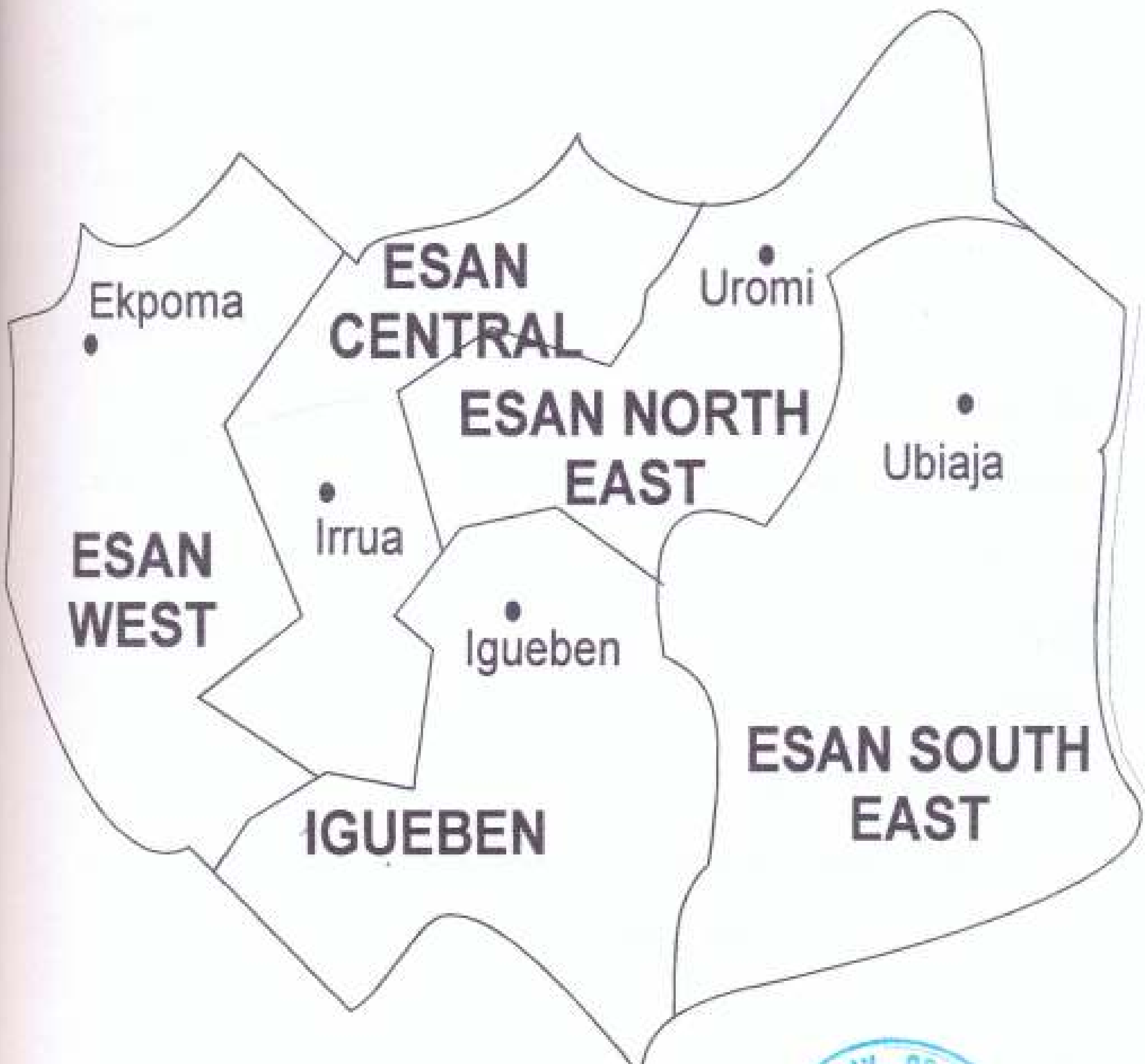


FIG 1.2 LOCAL GOVERNMENT AREAS IN THE EDO STATE CENTRAL SENATORIAL DISTRICT

1.3 Population

The population of the Senatorial District is about three hundred and seventy-two thousand, one hundred and twenty-two people (372,122) in 1991 National Population census projected to one million, one hundred and eighty seven thousand, one hundred and seventy-five for 2028 (A1.1). The respective census of the five Local Government Areas and the towns and villages populating the area are shown in appendices A1.2 – A1.6.

1.4 Economic/Industrial Activities

The people of the area are predominantly small-scale farmers with yam, cassava, rice, corn, fruits (oranges, pineapple), plantain etc. as major crops. The people also support economic crops such as rubber, cocoa and palm produce.

There are other developmental efforts in the area such as the State University-Ambrose Alli University Ekpoma, Bendel Feeds and flour mills at Ewu, Irrua Specialist Teaching Hospital at Irrua. There are other small scale industries especially of private concern that are rapidly springing up in the area. The establishment of the State University in the area in 1982 catalyzed many other developmental efforts in the area and the consequent rapid population growth.

1.5 Objective of the Project

The main objective of this research work is to evaluate the existing schemes visa-viz their capacities, present outputs, operational methods, area presently served and articulate ways of improvement to enhance their services to the larger are of the Senatorial District.

The specific objectives of the project are to:

(i) Evaluate the water use and demand on the population and development of the area.

(ii) Evaluate the streams and the intakes' capacities of the existing schemes.

(iii) Source for other means of possible water supply to the senatorial district.

(iv) Design the water systems facilities for the improvement of supply to the senatorial district.

(v) Make necessary recommendations for the execution and maintenance of the infrastructural facilities for the optimal service of the area.

1.6 Expected Contribution to Knowledge

The research work is expected to serve as a reference document for Governments, Agencies, and Organizations planning and undertaking water supply development projects in the Senatorial District. The procedures developed can be adapted to similar regional projects in the country.

CHAPTER TWO

LITERATURE REVIEW

Water resources have been critical to human society for domestic, agricultural, industrial and recreational activities. The technical background information on the overall quantities of water available and the requirements for various uses proceeds a discussion of management alternative. The growing population and expansion in individual, commercial and other activities primed the need for increased water supply and distribution (Gary & Henry 1989).

It has been predicted that shortage of water in many parts of the world is likely to increase and that it is already a major constraint on economic growth (Elservier 1999). And that by the year 2025, as much as two thirds of the world's population will experience period of water stress (DFID, 1999). Therefore the optimization of water supply system facilities for effective water supply for the ever growing population of the developing world should be a consideration in water resources management.

2.1 Water Supply System Facilities

Water supply system facilities capable of supplying sufficient quantity of potable water is a necessity for any modern city or community. A modern water supply system facilities comprise of the following

i) Sources(s) of water supply

ii) Storage Facilities;

iii) Transmission (to treatment) Facilities ;

iv) Treatment Facilities;

v) Transmission (from treatment) and Intermediate Storage Facilities and

vi) Distribution Facilities

In the development of water supplies, the quantity and quality of the water are of paramount importance. The relationship of these two factors to each of the functional elements is shown in table 2.1. Also not every functional element will be incorporated in each water supply system depending on the source of the supply. For example, where ground water is the source of water supply, storage and transmission facilities usually are not required. In some instances treatment facilities may not be required as shown in fig. 2.1

2.2 Source(s) of Water Supply

The two main sources of water supply are surface water and ground water. These sources are influenced by geography, climate and human activities.

Surface water are the rivers, lakes and seas. One major disadvantage of surface water is the exposure to pollution of all kinds. Industrial, Municipal wastes and runoff from urban, agricultural areas and erosion of soil usually find their way to bodies of surface water. Because of the exposure of surface water to various contamination and pollution, extensive treatment is usually done when surface water source is used for water supply to cities and communities (Linsley and Franzini; 1979)

Table 2.1 Functional Elements of Public Water Supply Systems

Functional Element	Principal Concern in Facilities Design (Primary/Secondary)	Description
Source(s) of Supply	Quantity/Quality	Surface water sources of supply such as river, lake and reservoirs or ground water sources.
Storage	Quantity/Quality	Facilities used for storage of surface water, usually located at or near the source of supply
Transmission	Quantity/Quality	Facilities used to transport water from storage to treatment facilities
Treatment	Quantity/Quality	Facilities used to improve or after the quantity of water
Transmission	Quantity/Quality	Facilities use to transport treated water to intermediate facilities and to one or more points for distribution
Distribution	Quantity/Quality	Facilities used to distribute water to individual users connected to the systems

(Source: Linsley & Franzini, 1979)

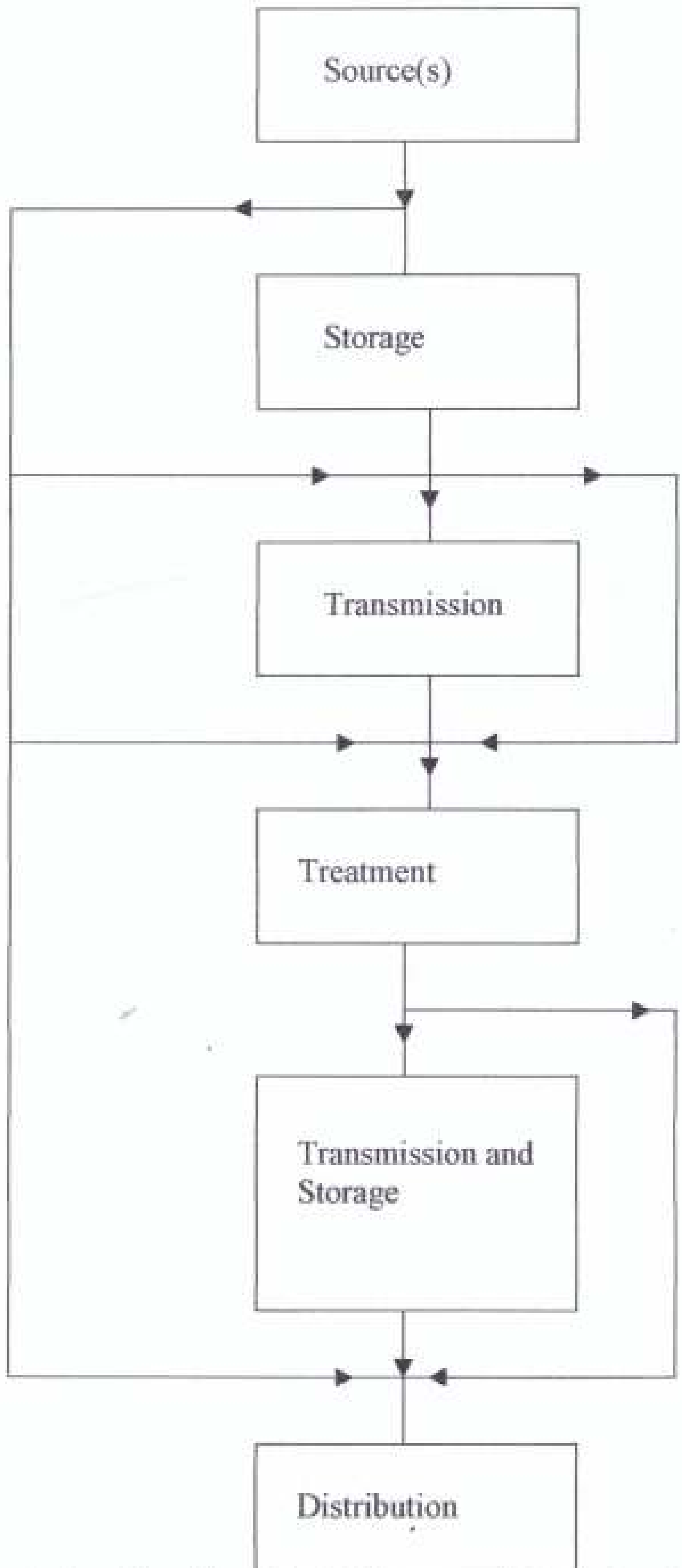


Fig. 2.1 Inter relationship of functional Elements of Water Supply

Ground Water is water that has percolated downward from the ground surface through this soil pores to the formation of saturated soil known as ground water reservoirs or acquifers. Withdrawal of water from the acquifers is usually by wells. The capacity of acquifers is dependent on the rate of infiltration into the soil. The depth of acquifers vary from one place to another depending on the hydrological and geological nature of the place. Ground water is not as susceptible to pollution and contamination as surface water but once polluted, its restoration is difficult and long term. Most pathogenic organisms and many undesirable substances are removed by the filtering action of the soil particles. Ground water therefore requires less treatment than the surface water. Although well water are of limited quantity, it has uniform quality and free from turbidity but may require softening because of hardness caused by the presence of metallic ions (Henry & Heinke 1989)

2.3. Storage Facilities

A water supply for municipal, irrigation or hydroelectric project drawing water from a stream may be unable to satisfy the demand of its consumers during extremely low flows or becomes a raging torrent after heavy rains and constitute danger to activities along its bank due to overflow. A storage or conservation reservoir can then retain excess water from periods of rainy season for use during periods of drought.

Streams of perennial flow, storage facilities are provided so as to draw sufficient water required. Hydraulic structures such as dam and weirs are readily the storage facilities before transmission to treatment plants.

2.4 Transmission

The conveyance of large quantity of water for relatively long distance between the source of water, the treatment plant and the point of storage for distribution is known as transmission. Pipelines which are usually the materials for transmission for potable water supply vary from cast iron, PVC, cement – asbestos, precast or in-situ reinforced concrete and steel. Their use depend on many factors such as:

(i) The ability of the material to withstand both the internal pressures and external loads.;

(ii) The durability of the material- resistance to corrosion for cast iron and steel pipes, to rotting and corrosion for steel – wood pipes and erosion and disintegration for plastic pipes;

(iii) The carrying capacity of the material;

(iv) The degree of ease of transportation, handling and laying;

(v) The safety, economy and availability of manufactured and required sizes; and

(vi) The availability of skilled labour for laying and maintenance.

On the whole, the quantity of water expected from the source and the topographical relationship with the point of distribution determine the materials and other machineries for water transmission (Henry & Heinke, 1989).

2.5 Treatment Facilities

One of the great achievements of modern technology has been to drastically reduce the incidence of water borne disease such as cholera and typhoid fever. These diseases are no longer the great risk to public health that they were once were. The key to these advances was the recognition that the contamination of pubic water supplies by human wastes was the main source of infection and that it could be eliminated by more effective water treatment.

Today's water treatment plants are designed to provide water continuously that meets drinking water standards at the tap. There are four main considerations involved in accomplishing this; source selection, protection of water quality, treatment method to be used and prevention of recontamination. Common precautions to prevent ground surface water pollution include prohibiting the discharge of sanitary and storm sewers close to water reservoirs, installing fences to prevent pollution from recreational uses of water and restrictions on the application of fertilizers and pesticides in area that drain to the reservoir.

The following are the usual water treatment facilities for potable water supply.

(i) Screening;

(ii) Coagulation/flocculation;

(iii) Sedimentation;

(iv) Filtration; and

(v) Disinfections

These water treatment operations fulfill one or more of the three key tasks:

(a) Removal of particulate substances such as sand and clay, organic matters, bacteria and algae;

(b) Removal of dissolved substance such as those causing colour, and hardness;

(c) Removal or destruction of pathogenic bacteria and viruses.

The actual selection of treatment facilities and processes depends on the type of water source and the desired quality (Tebutt, 1983).

2.6 Distribution Facilities

Extensive distribution systems are needed to deliver water to individual consumers in the required quantity and under satisfactory pressure. It is a major investment in any municipal or community water works.

2.7 Treated Water Storage

Storage is necessary in any municipal water supply system to meet the variable water demand to provide for fire protection and for emerging needs.

Surface Reservoirs: - They are located where they will provide sufficient water pressure either by natural elevation on a hill or through the use of pumps.

Stand Pipes: - These are basically tall cylindrical tanks whose upper portion constitutes the useful storage to produce the necessary pressure head and whose lower portion serves as support to the structure.

Elevated storage tanks: - These are used where the topographic relationship vary with attendant low pressure. They also serve as pressure stabilizers especially if well placed near high consuming area.

Distribution Network: - Until water is delivered to the consumer at home or place of need, the essence of the whole water work has not been fulfilled. A distribution network that deliver water to the consumer at the appropriate place of need is a major and very important aspect of water supply systems.

Usually pipes are used for distribution network for water supply. Other appurtenances are valves, which regulate the flow to different areas of need. Various types of pipes are in use ranging from cast iron, steel, concrete, asbestos and PVC. The choice of any of these materials is dependent on the pressure, location and economic consideration. The pattern of distribution main, street layout, topography and pipe sizes all affect the cost and reliability of the system.

Two major systems of water distribution are in use. They are the Branching and Grid methods and their choice are dependent on the community street plan and location of distribution reservoir. (Linsley & Franzini 1979)

CHAPTER THREE

EXISTING WATER SUPPLY SCHEMES

Before the establishment of any modern water supply scheme in the area, the people sustained their water needs from springs, streams, ponds and rain water collection during rainy season. It must be noted that springs and streams are not available all over the area under review. Some communities had to travel up to ten kilometer in search of stream water. Local ponds dug by communities for storing flood water during rainy season and for use during dry period was a common phenomenon in the area. The water from this source which is highly turbid is then treated for clarity with Alum before use. This situation persisted for a long time until the first ever modern water supply scheme was established in the area in 1957.

3.1 Northern Ishan Water Scheme-Ugbalo/Ibore Water Scheme

The Edo Central Senatorial District had its first modern water supply scheme established in 1957 under the Old Western Region Government of Nigerian and was located at Ugbalo and Ibore in Irrua. The source of the water is from a spring in Ugbalo about 9km north of Uromi and 11km North East of Irrua. The intake structure and head works are both located at Ugbalo. The water from the intake passes through steel screen to an underground reinforced concrete rèservoir where chemicals such as chlorine, and Alum are added before transmitting to the booster station at

Ibore through a 300mm diameter steel pipe. From Ibore booster station where a surface 500m^3 Braithwaite tank is located, water is boosted through two-200mm diameter A/C pipe line to Ewu where a 500m^3 surface braithwaite steel tank is also located for distribution to the Ewu Community and the other pipe line is linked to the gigantic 3,750m^3 ground level Braithwaite steel reservoir. At Ivue From the Ivue high elevation ground tank, water is further distributed to secondary reservoir tanks in Irrua, Opoji, Ekpoma, Uromi and Ubiaja where 150mm A/C pipe trunk is laid along the major streets of the respective town with stand pipe taps at intervals where the people fetch water. The nominal capacity of the scheme is 4,800m^3/day based on the low and high lift pumps discharge rate of 200m^3/hour (Edo State Urban Water Board B/City). Deterioration resulting mainly from lack of maintenance and oldage of the facilities and the rapid growth and expansion of the area has rendered the scheme incapacitated and not able to meet up to 30% of the water need of the area.

3.2 Iyagun Water Scheme-Ewohimi

The Iyagun water scheme was established in 1967 under the National water rehabilitation scheme of the Federal Government of Nigeria.

It consist of:

a) A weir and intake structure with a low lift pump house containing two number-30kw pumps and provision for a third.

The raw water from the intake is transmitted to the Headwork about 300m from the intake in a 300mm diameter A/C pipe.

b) The Head works consist of:

i. Chemical dosage plant for Chlorine and Lime (2 Units each) without provision for Alum.

ii. It has also rapid sand filtration system of 4 No-3.5m x 3.5x3.2m depth.

iii. 3 No-160kw high lift pumps of $123m^3/hr$ and 210m head, which transmit water to Ewohimi sub-station about 6km from Headworks in 350mm/300mm diameter A/C pipes where 2 No –$1000m^3$ capacity ground level steel reservoirs are located.

iv. 2 Nos-310KVA and 300KVA capacity stand by generators.

v. The station is also linked with NEPA-11KVA line.

c) The sub-station consists of

i. 2 Nos-11KW pumps for supply of water to the Ewohimi $400m^3$ elevated over head tank which distribute water to the community by gravity.

ii. 2 No – 15KW pumps for the supply of water to the $600m^3$ over head tank in Ebelle 10km from the Ewohimi sub-station.

This $600m^3$ over head tank then supplies the Ebelle community and an- $80m^3$ capacity over head tank at a lower elevation at Izogen- a smaller community at a distance of 3km from Ebelle. The $80m^3$ tank only serves the Izogen Community.

iii. The Ewohimi sub-station has a 60KVA stand by generator and also linked with a-33KVA NEPA sub-station which extends 11KVA line to the Head works and Intake.

The present set up at the Intake and Headworks has a nominal capacity of $2952m^3$/day. (Edo State Urban Water Board. B/City).

3.3 Ibiekuma Water Scheme -Ekpoma

The Ibiekuma water scheme was built and handed over to the Edo State University Ekpoma in 1994 under a tripartite agreement between the Edo State University, the National planning commission and the European Economic commission and was funded by the EEC.

The water scheme consists of the following

a) Weir and Intake: A weir (concrete sheet pilling 9 to 12m deep and 30m total length and intake on the Ibiekuuma stream with a low lift pump house containing 2 No-90KW pumps of head 75m and pump discharge capacity of $300m^3$/hr through a-300mm ductile steel pipe to the treatment plant. There is also provision for a third pump.

b) Headworks: Consists of the following:

i. Treatment plant of chemical dosage-2 Units each of chlorine, Alum and Lime. It also has Aeration, Rapid sand filtration (2Units)

ii. A $500m^3$ ground level reinforced concrete reservoir which receives and store treated water for high lifting to the distribution reservoir.

iii. A high lift pump house with 2 Nos-250kw-211m head pump through a-300mm diameter ductile steel pipe to the distribution reservoir in the campus about 4.9m from the Headworks

iv. A generating house with 2 Nos-700KVA capacity generating sets and also recently linked with a 11KVA NEPA line.

v. A chemical store/office building with capacity to store chemical of upwards one year.

c) Distribution Reservoir

A – $500m^3$ ground level reinforced concrete reservoir which is situated about 4.9m from the headworks and at about the highest level on the University campus distributes water by gravity through pipe network to the entire University campus.

The Ibiekuma water scheme presently serves only the Ambrose Alli University Campus with only about 20% of the students living on campus while the rest 80% and all the staff of the University live in the Ekpoma and neighbouring towns where there is no pipe borne water. The scheme has a nominal capacity of $7{,}200m^3$/day.(A.A.U. Ekpoma)

3.4 Borehole Scheme

The low water table in the Senatorial District with the accompanied high cost of extracting water from such depth has made Borehole sinking in the area very expensive to construct and maintain. A number of Boreholes have been sunk but could not stand the test of time primarily because of the cost of running and maintenance. Available records of Boreholes within the area show fifteen numbers out of which only two at Ugboha are functioning. Table 3.1 shows the geophysical data of these Boreholes as obtained from Benin-Owena River Basin Authority in Benin City, Federal Ministry of Water Resources, Benin City & Nigeria Water Resources Development (NWRD) Benin City.

3.5 Rain Water Harvesting

Although this is not a scheme established by Government or any organized body but by individuals and institutions as an improvised means of collecting and storing water during rainy period; the water so collected is used during the dry season. The ineffectiveness of the established water schemes to distribute water to majority of the communities in the area, the high cost of drilling boreholes impelled the inhabitants to resort to construction of rain water "well". Virtually every house with affordable means has underground built storage locally called of "well" between $10m^3$ to $25m^3$ capacity into which roof water and storm water runoff from gutters are stored and sedimented with alum. Some people further disinfect the water with chlorine while many use the water without further treatment. This source of water supplies about 60% of water requirements of the inhabitants of this area up till date with the attendant hazards. (Field Studies)

Table 3.1 Existing Boreholes Data In Edo State Central Senatorial District

S/No	Locality	L.G.A	Total Depth (m)	Aquifer thickness (m)	S.W.L (m)	D.W.L (m)	Yield $m^3/_h$	Draw Down (m)	Specific Capacity	Aquifer Type
1.	Iruekpen	Esan West	251.0	188.5 193.5	135.5	103.6	30	28.14	1.07	Fine medium
2.	Bensu I	"	231.0	220.2 244.5	130.0	171.3	28.1	41.3	0.70	Coarse sst medium to fine
3.	Ekpoma A	"	231.6	135-148.2 192.8-201.6 206.1-230.5 168.3-183.5	189.9	175.0	26.6	45.1	0.63	"
4.	Ekpoma I	"	216.5	201.2 216.5	176.2	193.3	14.1	17.1	0.82	"
5.	Ekpoma II	"	239.3	214.9 236.3	165.0	182.2	36.2	10.6	3.42	"
6.	Ekpoma	"	278.5	236.6-274.3 258.1-269.9	171.6	182.3	20.0	10.7	1.87	Medium grained sst
7.	Ekpoma III	"	278.7	222.9-289.6	-	-	-	-	-	-
8.	Uromi	Esan North East	289.6	759.1-289.6	195.1	201.2	201.2	6.1	12.9	Fine to coarse
9.	Ubiaja II	Esan South East	222.5	156-161 166-177 183-196 213-221	34.5	72.65	72.65	38.5	0.28	Sand
10.	Uzea	Esan Noth East	164.9	145.4-161	84.1	103.7	49.8	19.5	2.56	Light grey sand
11.	Ugboha II	Esan S.E	191.5	164.6-194.5	71.6	96	36.2	24.4	1.48	f. coarse
12.	Ugboha III	"	186.0	-	45.7	61.24	55.8	15.5	3.6	"
13.	Ugboha IV	"	159.6	-	62.5	79	45.4	15.54	2.92	"
14.	Irrua	Esan Central	289.5	265.5-578.4 259.3-270.8	175.4	198.6	26.2	18.2	0.93	Medium grain sst
15.	Ewu	"	286.7	271.3-283.6	185.2	201.1	88.2	11.9	1.98	-

Sources: **Benin-Owena River Basin Authority, Benin City**
Federal Ministry of Water Resources, Benin City
Nigeria Water Resources Development (NWRD), Benin City

CHAPTER FOUR

METHODOLOGY

The three existing surface water schemes in the study area (Ugbalo; Iyagun and Ibiekuma) were visited and inventory of the facilities in the schemes were obtained from Edo State Urban Water Board in Benin City and on the site. The details of Ibiekuma water scheme which is located and operated by the Ambrose Alli University was obtained from the University Water Works Division.

The relevant maps were obtained from the Edo State Urban Water Board and the Ministry of Lands and Surveys, while the population data were sourced from the office of the National Population Commission (NPC) in Benin City. The discharges of the rivers on which the schemes are located were measured during the dry and wet seasons.

Additional stream data for Ella stream located in Igueben Local Government Area and Amendokhian stream located in Uromi-Esan North East Local Government Area of Edo State were provided by Benin Owena River Benin Authority and Giomo-Irhe consultants Ltd Benin City that have done some work on the streams respectively.

The capacities of the three existing water schemes were evaluated based on field measurement and estimated spillway discharges. Questionnaires were administered for the purpose of water use in the area and the average water consumption per capita/day was obtained. From the population figures obtained, projection for twenty-five years (2003-2028) was made. The existing schemes were then evaluated and expanded facilities for them were designed for new design period of twenty-five years.

4.1 Water use and Demand

Water use and demand in any community, country or region are dependent on climatic conditions, and activities in the area. Primarily, water uses are mainly, domestic, agricultural, industrial, institutional and recreational. Hence there is variation in water use and demand from one area to another. However water use are also categorized according to the level of development (Henry & Heinke, 1989) as shown in Table 4.1

4.2 Water Use.

A survey of water consumption by families of different status in the area under consideration shows that the per capita water demand per day vary from 20 – 100 liters (Table 4.2). This survey and enquiries were carried out in three towns – namely, Ekpoma, Uromi and Ewu in three out of the five Local Government areas constituting the Senatorial District under consideration. The categories of users range from Professors and senior administrative staff of University and Local Government Councils living in official quarters where water is supplied more regularly and freely to other workers, traders and peasant farmers who have no access to free water but buy from commercial water hawkers

It is worth mentioning that almost every home in this area under consideration has under ground water reservoir popularly called "well" connected to roof for rain water collection during the rainy season. It is a major mean of water conservation for the dry season. Because of the absence of regular potable water supply in this area, the people have developed strict and moderate water management for domestic and other uses. Tables 4.1 and 4.2 show the range of water consumption rate applicable in rural area of developing world (Henry & Heinke, 1989), and the adapted in the area under consideration.

Table 4.1 – Water Use in Rural Areas of the Developing World
(Source: Henry & Heinke, 1989)

Region	Average Daily Water Consumption per person (l.p.c.d)	
	Minimum	Maximum
Africa	15	35
Southeast Asia	30	70
West Pacific	30	95
Eastern Mediterranean	40	85
Latin America & Caribbean	70	190
Normal Range	35	90

Table 4.2- Adapted Daily Water Consumption for the Area

Class of Consumption	Range of Consumption (l..p.c.d)	Average (l.p.c.d)
Domestic	20 – 100	60
Commercial & Industrial	15 – 45	30
Institutional (Public)	10 – 30	20
Others (fire demand, losses and unaccounted for)	20 – 40	30
	65 – 215	140

4.3 Water Demand

Water demand is a consequence of water use per capita/day and the population of the people at a given time. From table 4.2 an average of 140 litres/capita/day has been computed. From table 1.1 the 1991 population of the Edo state Central Senatorial District is three hundred and seventy–two thousand, one hundred and twenty–two (372,122). Thus, using 1991 as base and a design period of twenty–five years from 2003 and using the formula:

$Pn = Py(1+r)^t$

Where Pn = projected population

Py = Present population

r = growth rate (%)

t = projected period (years)

r = 3.1% (NPC recommendation for the area)

We have:

Py = 372.122

t = 37years (from 1991 to 2028)

$\therefore Pn = 372.122\ (1 + 3.1/100)^{37}$

$= 1,151,479.$

Using a consumption rate of 140 litres/capita/day and allowing for peak demand of 1.2 times the average daily demand, we have:

$1,151479 \times 140 \times 1.2 = 193.45 \times 10^6$ litres/day $= 193,450\ m^3/d$

CHAPTER FIVE

FIELD AND LABORATORY WORKS

5.1 Stream Capacities

In the course of investigating the capacities of the streams which the existing water schemes in the area are using, measurements of the stream discharges were taken. Discharge can be measured by several methods; the choice of method depends on the condition encountered at a particular site. Most methods are based on the measurement of velocity and cross-sectional areas of a given location.

5.2 Measurement of Discharge with Current Meter:

A current meter is an instrument used to measure the velocity of a flowing water. The principle of operation is based on the proportionality between the velocity of water and the resulting angular velocity of the rotor. The current meter is suspended in the flow at a desired depth on a wading for shallow channels or suspended on a wire from bridge, cableway or boat. The velocity of flow at that point is measured by counting revolutions of the current meter rotor during a short period measured with a stop watch. (Wanielista, 1990)

The velocity of the water is determined from the rating of the meter. The rating formula is of the form:

$$V = an + b \qquad ...5.1$$

Where

V is the velocity (m/s)

n is the number of revolution per second

a and b are constants.

The current meter used for this study was a model BFM002 obtained from Benin Owena-river Basin Authority in Benin City.

Measurement and reduction to stream discharges are summarized in appendix A5. Table 5.1 provides a summary of the stream discharges.

5.2.1 Measurement Procedure

Two measurements for each of the three streams were taken on a different months and the average of the measurements was used for the evaluation of the final discharge. The constants a and b for this equipment are a = 0.1108 and b = 0.0225

$\therefore$ Velocity (V) = 0.1108n + 0.0225 ...5.2

The following should be noted in the calculation in appendices A5.1 – A5.6

(i) The measurement of water depth is to the nearest 0.01m at 1m intervals across the channel over 5m wide and 0.5m for channel below 5m wide.

(ii) The depth observed (column 3) is of 0.6 times the depth (column 2) and the average of 0.2 and 0.8 times the depth for depths below 1m and above respectively.

At these depths a reasonable estimates of the mean velocity are got.

(iii) The revolution per second is obtained from the observed revolution at the ten seconds intervals for each measurement.

(iv) The velocity is obtained from the calibration chart for the current meter used

(v) The area is calculated with depth and width measured.

(vi) The flow discharge is got by using the formula Q = VA

where Q = Discharge (m^3/s)

V = Velocity (m/s)

A = Area (m^2)

Calculation results are shown in Appendix 5.7

Measurement of stream flow for Ugbalo and Ibiekuma streams were carried out down stream of their respective intake structures because of inaccessibility upstream of their respective intake while that of Iyayun was carried upstream of its intake structure.

Below is the summary of average discharge computation for the combined dry and wet seasons.

Taking mid November of the year to mid march of the next year as the dry season i.e. 5 months, and the rest 7months as the wet season.

Take x as dry season in months and y as wet season in months

∴ For Ugbalo stream measurement:

we have average discharge $= \dfrac{0.168x + 0.159y}{x + y}$ m^3/s

$$= \frac{(0.168 \text{ x } 5) + (0.159 \text{ x } 7)}{12} = 0.163 \text{ m}^3/\text{s}$$

$$= \underline{14{,}083 \text{ m}^3/\text{d}}$$

Similarly,

$$\text{Iyagun} = \frac{(2.613 \times 5) + (1.884 \times 7)}{12} = 2.188\ m^3/s$$

$$= \underline{189{,}043\ m^3/d}$$

$$\text{And Ibiekuma} = \frac{(0.273 \times 5) + (0.198 \times 7)}{12} = 0.288\ m^3/s$$

$$= \underline{19{,}699\ m^3/d}$$

Table 5.1 Stream Measurements/Average Discharge for existing water supply schemes in Edo Central Senatorial District

	Stream	Date of measurement	Discharge		Average Discharge (m^3/day)
			m^3/s	m^3/day	
1	Ugbalo River	30-1-03 3-4-03	0.168 0.159	14,515 13,738	14,083
2	Iyagun	30-12-02 3-4-03	2.613 1.884	225,763 162,778	189,043
3	Ibiekuma	30-1-03 27-3-03	0.273 0.198	23,587 17,107	19,699

5.3 Discharge Measurement of other streams by Agencies

(a) Ella Stream

This stream is located in Igueben-Igueben local Government Area of Edo State Central Senatorial District. The measurement of the stream was undertaken in 1994 by the Benin-Owena River Basin Authority Benin City. It was a feasibility study aimed at utilizing the stream as source of potable water supply to Igueben. Current meter operated by wading through the stream was used and the results obtained are shown in tables. A5.8 -10.

From the discharges at the three locations along the stream, the average flow discharge is.

$$\frac{\underline{0.215 + 0.216 + 0.326 \text{ m}^3/\text{s}}}{3}$$

$$= \quad 0.2523\text{m}^3/\text{s}$$

$$\text{or} \quad = \quad \mathbf{\underline{21{,}799m^3/day}}$$

(b) **Amendokhian Stream**

The Amendokhian stream is located in Amendokhian in Uromi-Esan North East Local Government Area of the Senatorial District.

The stream measurement was carried out by Messrs Giomo-Irhe consultants Ltd, Benin City in 2001. It was a feasibility/planning report on enduring water supply scheme for Uromi-the most populous town in Edo Central Senatorial District. The stream measurement was done using float method with following results in Appendix A5.11

Discharge measurement of these other streams by the Agencies are summarized in table 5.2

Table 5.2 Discharge measurement of other streams by Agencies

S/N	Stream	Discharge		Agency
		m^3/s	m^3/day	
1.	Ella	0.2523	21,799	BORDA Benin City 1994
2.	Amendokhian	0.446	38,534	Messr Giomo-Irhe consultant Ltd B/City 2001

5.4 Measurement of Discharges at the intake structure (Structural Method)

The three existing schemes in the Senatorial District-Ugbalo, Iyagun and Ibiekuma have intake structures (weirs), using the physical measurement of the structures one can apply the formula for stream flow, given as (Wanielista, 1990)

$$Q = C_w BH^{3/2} \qquad \text{...5.3}$$

(for rectangular weir with regular length)

$$Q = C_w H^{3/2} (B-0.2.H) \qquad \text{...5.4}$$

(for rectangular weir-with contracted end.)

where Q = discharge (m/s)

Cw = constant (1.84) dependent on shape and roughness.

B = width of weir (m)

H = Head (m)

a) Ugbalo stream

The intake structure is a weir with a contracted end illustrated in fig 5.1

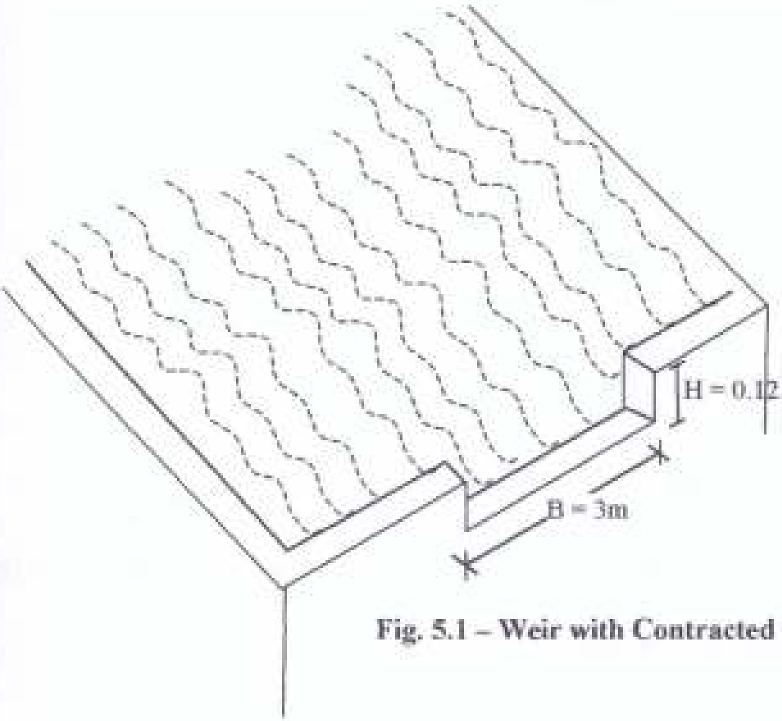


Fig. 5.1 – Weir with Contracted Ends

b) Iyagun stream

The intake structure is a weir with broad crested end as illustrated in fig 5.2

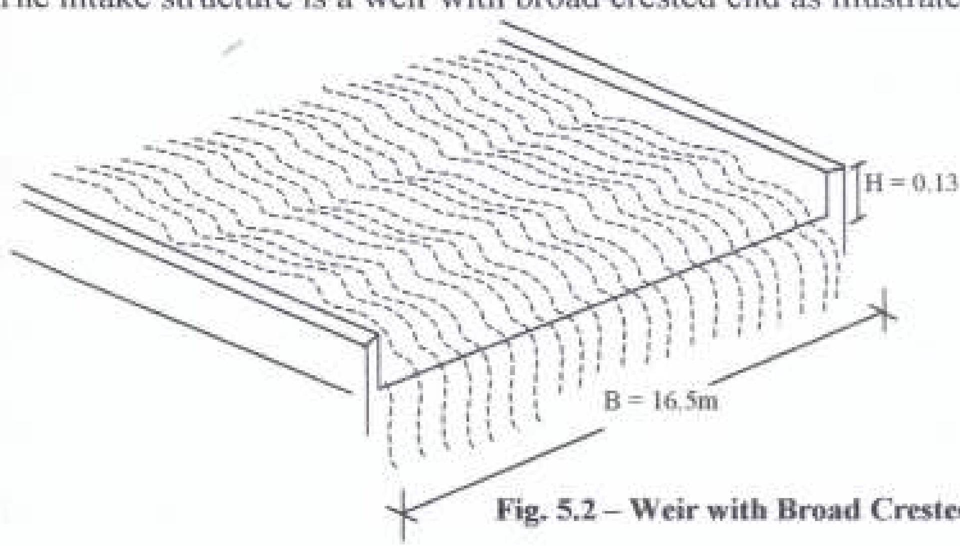


Fig. 5.2 – Weir with Broad Crested Ends

c) Ibiekuma stream

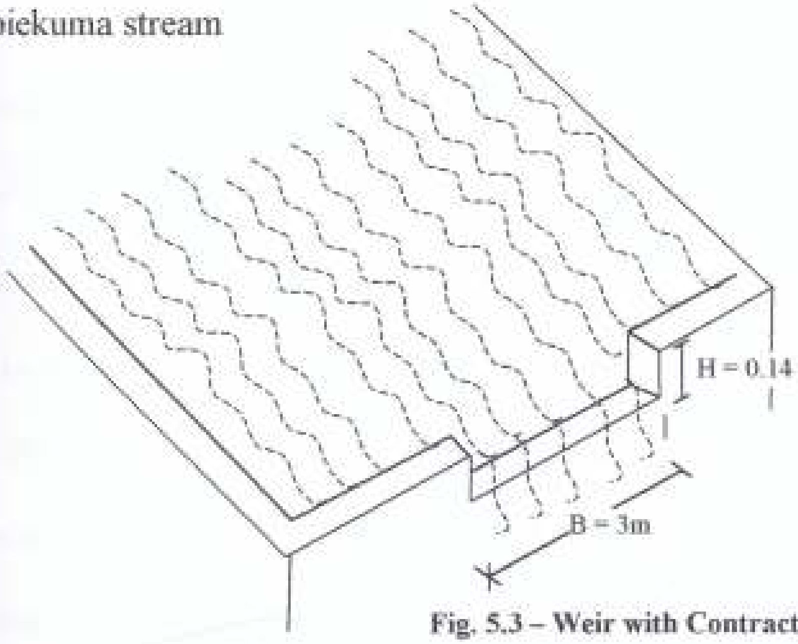


Fig. 5.3 – Weir with Contracted Ends

5.5 Streams on the Edo central Senatorial District and their discharge

The following five streams cover the Edo Central Senatorial District. Table 5.3 shows where the streams are located and the discharges which were later used for design.

Table 5.3 Streams Locations and discharges

i)	Ugbalo Stream	-	Esan Central L.G.A	-	19,667m^3/day
ii)	Iyagun Stream	-	Esan South East L.G.A	-	122,951m^3/day
iii)	Ibiekuman Stream	-	Esan West L.G.A	-	24,750m^3/day
iv)	Ella Stram	-	Igueben L.G.A	-	21,799m^3/day
v)	Amendokhian Stream	-	Esan North East L.G.A	-	38,534m^3/day

5.6 Other sources of water supply - Boreholes

From the geophysical data of the fifteen existing boreholes in the area (table 4.1) an average yield of 32.36m^3/hr is feasible per borehole. Ewaleifoh (1997) has shown that the depth of ground water level in the area is not less that

107m. The aquifer characteristics of the borehole location across the senatorial district are provided in appendix A5-12.

New boreholes can be sunk across the Senatorial District especially those communities far away from the five surface water schemes which will involve long transmission lines. Also within all the five Local Government headquarters, there is need to have at least some five boreholes. It is therefore suggested that each of the five Local Government Areas comprising the project area can have fifteen boreholes, a project quite within their budgetary limits.

Based on this premise, and with an average yield of 32.36m^3/hr per borehole: a total yield of 29,124m^3/day is extractable for a twelve hour operation daily, with this supportive role of boreholes, the surface water schemes will not be overstretched.

5.7 Analysis of Field Results

5.7.1 Existing Scheme:

Table 5.4 presents a comparison of the streams/capacity and the present water output

Table 5.4 Existing Intake Capacity/Present Output

Scheme	Available Capacity (spillway Discharge)	Present Output	Percentage Used	Remark
Ugbalo	19.667m^3/day	4,800m^3/day	24.41	Under utilized
Iyagun	122,951m^3/day	2952m^3/day	2.40	Grossly under utilized
Ihiekuma	24,750m^3/day	7,200m^3/day	29.10	Under utilized
	167,368m^3/day	14,952m/day	18.64	

From the above, these streams are presently underutilized and the intake structures have enough storage that can accommodate much greater volume of water extraction for treatment and distribution. It is important to determine or suggest the maximum percentage of water extraction such that there will still be some minimum flow downstream for economic and ecological purposes.

From the water demand of 193,450 m^3/day (chapter3) these schemes cannot meet the water requirements of the senatorial district at the projected twenty-five year period without augmentation from other sources. It is therefore worthwhile developing the Ella and Amendokhian streams.

The additional capacity of Ella and Amendokhian streams of 60,333m^3/day increases the total discharge of the extractable water to 227,701m^3/day. If borehole water supply as analysed in table 4.1 can take care of 29,124m^3/day, then 164,326m^3/day of the 193,450m^3/day requirements must be supplied by these streams.

Thus $\frac{164,326}{227,701}$ or 72.2 % of the discharge capacity of the streams can be extracted to meet the water demand. Without the boreholes, then $\frac{193,450}{227,701}$ or 84.3% of the streams must be utilized. In considering the downstream uses both economic and ecological, it is safe to use about 75% of the stream discharge

The more the underground water and other sources are exploited, the less the use of surface water from stream. Table 5.5 summarises the expected output from the proposed expanded schemes based on five streams in the District.

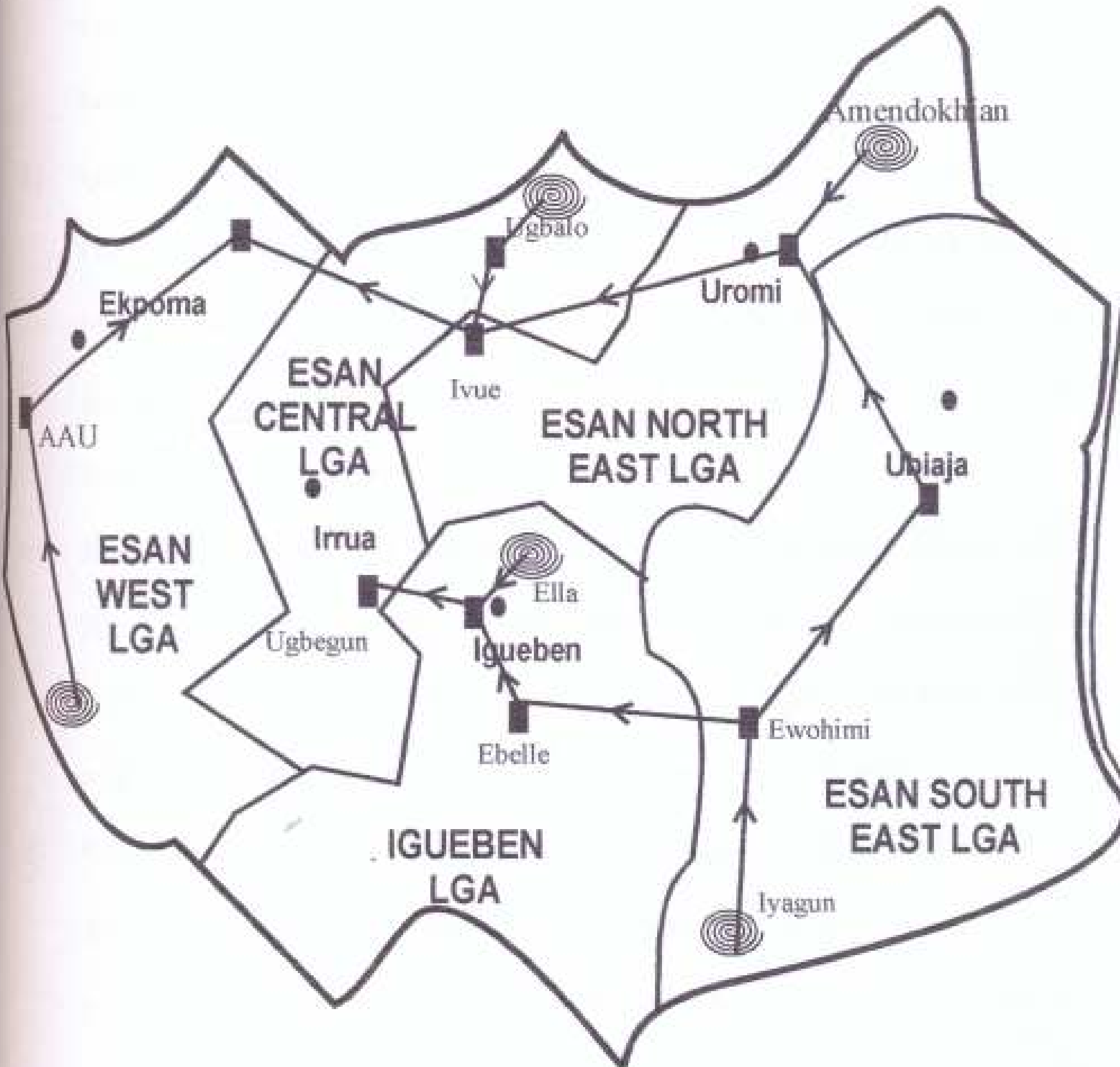
Table 5.5 - Expected Output From the Proposed Expanded/New Schemes

Scheme	Spillway Discharge	Expected Output 75% of Discharge	Source
Ugbalo	19,667m^3/day	14,750m^3/day	Field measurement
Iyagun	122,951m^3/day	92,213m^3/day	Field measurement
Ibiekuma	24,750m^3/day	18,563m^3/day	Field measurement
Ella	21,799m^3/day	16,349m^3/day	Borda B/City
Amendokhian	38,534m^3/day	28,900m^3/day	Giomo-Irhe Consultants B/City
75 Boreholes		170,775m^3/day 29,124m^3/day	
		199,899m^3/day	

Coincidentally, the three existing schemes and the two proposed schemes are evenly spread over the Senatorial District with each of the five Local Government Area having one, even though some may not necessarily be able to meet the need of Local Government Area where it is situated while some have the capacity to serve more than their own Local Government Areas.

5.7.2 Proposed Scheme Allocation

As delineated in the drawing (fig. 5.4) while the five schemes are spread over the five Local Government Areas of the District, their services are not necessarily restricted to the Local Government Area they are located.



IG 5.4 DRAWIING SHOWING THE WATER SCHEMES LOCATIONS
ND BOSTER STATIONS LINKAGE IN THE EDO STATE
ENTRAL SENATORIAL DISTRICT.

(a) Ugbalo Scheme: Ugbalo scheme located in Esan Central Local Government Areas has a capacity of 14,750m^3/day as against the 26,370m^3/day required by the 188,355 persons by the year 2028. The short fall in supply is augmented from both Amendokhian, Ella schemes and boreholes

(b) Iyagun Scheme: This scheme located in Esan South East Local Government Areas has a high capacity of 92,213m^3/day as against the requirement of 38,725m^3 of the 276,608 people by the year 2028. The abundant excess is used to augment supply to Esan West, Igueben and Esan North East Local Government Areas.

(c) Ibiekuma Scheme: This scheme located in Esan West Local Government Area has a capacity of 18,563m^3/day as against the requirement of 37,513m^3/day of the 267,953 people by the year 2028. The short fall is augmented from Iyagun, Ugbalo and Ella schemes and Boreholes.

(d) Ella Scheme: This proposed scheme has a capacity of 16,349m^3/day as against the 21214m^3/day required by the projected population of 151,531 people of Igueben Local Government Area the year 2028. The short fall is augmented from the Iyagun scheme and Boreholes

(e) Amendokhian Scheme: This has a capacity of 28,900m^3/day as against the 37,384m^3/day requirement of the 267031 people Esan North East Local Government Area by the year 2028. The short fall is augmented from Iyagun scheme and boreholes.

5.8 Water Quality Analysis

As required in public water supply water withdrawn for domestic, commercial, institutional and other public uses, physico-chemical analysis was carried out on the raw water of these schemes. This was done with the assistance of the Benin-Owena River Basin/University of Benin Joint Analytical Research laboratory at the University of Benin. The results are shown in Table 5.6.

The PH of the water (5.30; 5.65; 5.25) for Ugbalo, Iyagun and Ibiekuma respectively fall below W. H. O. standard of potable water which is between 6.5 – 8.5. This is an indication of high acidity – the presence of acid former bacteria. This can be rectified by PH correction with chemicals usually lime (Tebutt, 1983).

The high turbidity is attributable to clay and silt particles and other colloidal solids which gives liquid a cloudy appearance. Erosion due to floods and runoff during rainy season and other waste water contribute greatly to high turbidity. The use of Alum for water treatment will keep the value within the acceptable range. Considering pollution, the water from the three sources is not highly polluted as revealed by the chloride values obtained.

As typical of surface water it is exposed to contaminations, and bacteria abound and therefore require treatment with chlorine. Other treatments required are aeration, sedimentation, and filtration.

On a general note, it is recommended that test should be carried out on the raw water more regularly so that the level of water treatment is regulated because of the climatic and seasonal changes which affect the quality of water from the surface sources.

Table 5.6 Water Quality Analysis of the Stream flow for the Water Supply Schemes of the Edo State Central Senatorial District

	Sample History							
	Sample: water							
	Date Sampled	30/1/03	20/5/03	30/1/03	20/5/03	30/1/03	20/5/03	
	Sampling Point Location	INTAKE POINT UGBALO-IRRUA EDO STATE		INTAKE POINT IYAGUN-EWOHIMI EDO STATE		INTAKE POINT IBIEKUMA-EKPOMA EDO STATE		
CHARACTERISTIC/UNIT		1	2	1	2	1	2	WHO STANDARD
1	PH	6.86	5.30	6.57	5.65	6.60	5.20	6.5 – 8.5
2	Turbidity	5.80		5.22		3.48		< 1
3	Total dissolved Solids (mg/L)	40	11.30	38	8.00	45	7.00	1000
4	Total Suspended Solids (mg/L)	7.25	8.4	9.20	6.2	5.5	5.2	-
5	Ammonium (mg/L)	0.72		0.41		0.59		
6	Total alkalinity (mg/L)	65	60.35	40	55.70	55	54.0	50 – 400
7	Salinity (chloride) (mg/L)	28.08	42.54	19.31	31.91	24.57	35.45	250
ANIONS								
8	Nitrate (mg/L)	0.61	0.36	0.25	0.47	0.44	0.16	0 – 50
9	Sulphate (mg/L)	2.09	1.14	1.14	1.94	1.35	0.98	400
10	Phosphate (mg/L)	0.57	0.52	0.48	0.41	0.62	0.30	-
METALS								
11	Sodium (mg/L)	18.50	18.83	17.50	11.42	21.00	15.42	200
12	Potassium (mg/L)	5.91	7.80	3.20	6.00	5.48	6.50	-
13	Calcium (mg/L)	6.41	2.40	7.21	0.80	4.81	1.60	75
14	Magnesium (mg/L)	2.92	4.00	2.92	2.00	2.43	4.00	50
15	Total Hardness $CaCO_3$ (mg/L)	30	100	25	4	30	8	500
TRACE ELEMENT								
16	Total Iron (mg/L)	0.17	0.11	0.24	0.12	0.15	0.18	0.3
17	Lead (mg/L)	0.10	0.08	0.11	0.02	0.13	0.09	0.5
18	Chromium (mg/L)	0.01	0.01	0.02	N.D	0.05	N.D	1.00
19	Copper (mg/L)	0.12	0.01	0.15	0.06	0.18	0.08	-
20	Manganese (mg/L)	0.02	N.D	0.04	N.D	0.02	N.D	
21	Zinc (mg/L)	0.33	0.74	0.65	0.45	0.65	0.7	
22	Cadmium (mg/L)	N. D	N. D	0.001	N. D	N. D	N. D	

NOTE:ND = Not Detected
WHO = World Health Organisation Standard

CHAPTER SIX

WATER FACILITIES IMPROVEMENT

An appraisal of the infrastructural facilities of the existing schemes; indicate that all the facilities require expansion, upgrading and improvements if they have to meet the present day and future water demands of the area. Of particular note is the perennial flow of the streams and the high discharges of the intake structures which need to be exploited.

The purpose of this chapter is to identify the areas of improvement such that the schemes will be harnessed to meet the area's water demand.

6.1 Ugbalo Scheme:

figure 6.1 is a schematic diagram of the existing scheme while figure 6.2 shows the proposed improvement.

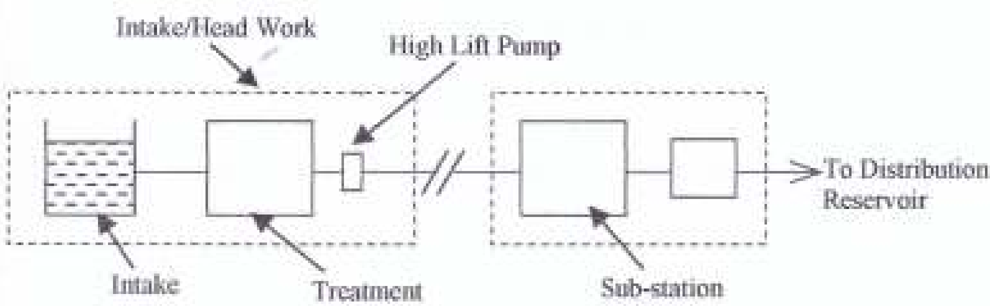


Figure 6.1

In Table 6.1 is detailed the design parameters for the water treatment plant and appurtenances based on the improved (expanded) scheme schematized in Fig 6.2 above

Table 6.1 – Design parameters for Ugbalo Treatment Plant.

Parameter/Item	Unit	Old	New	Remark
River Discharge	m^3/d	19,667	19,667	
Intake Discharge	m^3/d	4,800	14,750	Using 75% 0f River Discharge
Transmission pipe diameter from intake to headworks	mm	300	450	D I Pipe
Rapid mix (flash mix)	m	-	1.8x1.8x1.8	New Construction
Flocculation	m	-	13.5x7x3.5	" "
Sedimentation	m	-	4Nos – 22 x7.5x4	" "
Filtration	m	-	3N – 4.5x4.5	" "
Chlorine	kg/d	-	18	" "
Alum	kg/d	-	37	" "
Clear Water Tank	m^3	500	2,500	" "
Low lift pump	Kw	-	6No – 60Kw each	" "
High lift pump	Kw	2No – 160Kw	6No – 100Kw each.	" "

The design table and procedures are shown in Appendix 6.1 and 6.2 (a) – (g)

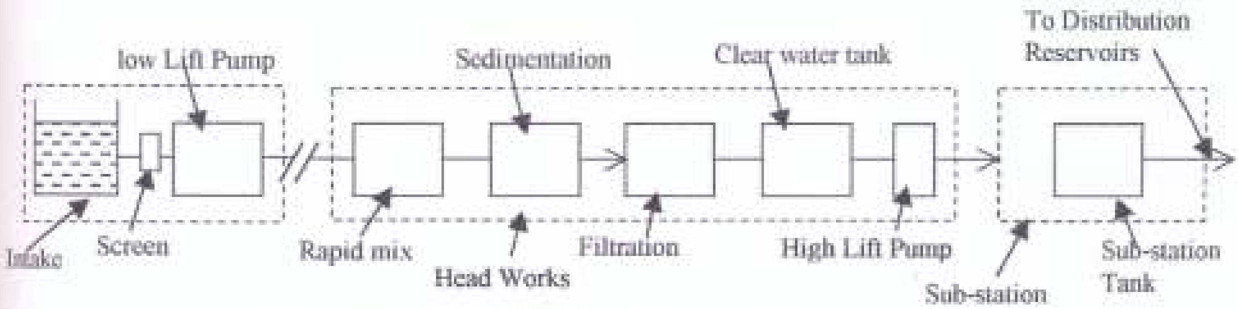


Figure 6.2 – Proposed Improvement

6.2 Iyagun Scheme

Figure 6.3 shows the schematic diagram of the proposed improvement of Iyagun water scheme.

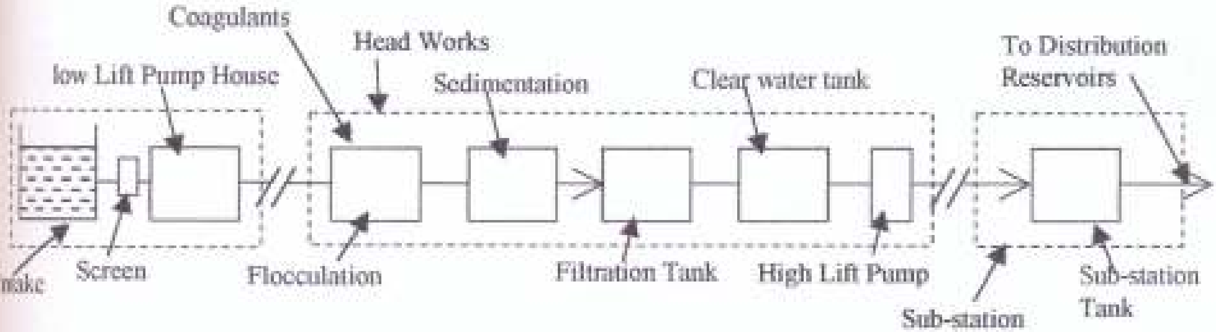


Figure 6.3 – Flow diagram for Treatment Plant

Table 6.2 – Design Parameters for Iyagun Treatment Plant

Parameter/Item	Unit	Old	New	Remark
River Discharge (Q)	m^3/d	122,951	122,951	
Intake Discharge	m^3/d	2,952	92,213	Using 75% Q
Transmission pipe diameter from intake to headworks	mm	300	825	
Rapid mix (flash mix)	m	-s	4x4x2	
Flocculation	m	-	4No – 15.5x7.75x4	
Sedimentation	m	4No – 3.5x3.5x3.2	8No – 38x13x4	
Filtration	m	4x4	9x9	
Chlorine	kg/d	-	111	
Alum	kg/d	-	231	
Clear Water Tank	m^3	500	15,370	
Low lift pump	Kw	2No – 3okw each	6No – 220Kw each	
High lift pump	Kw	3No – 160Kw each	6No – 900Kw each.	

The design table and procedures are shown in Appendices 6.1 and 6.3 (a) – (g)

6.3 Ibiekuma Scheme

Figure 6.4 shows the schematic diagram of the proposed improvement of Ibiekuma water scheme while Table 6.3 details the design parameter for the treatment plant and appurtenance based on the proposed improvement of the Ibiekuma water scheme schematized in Fig 6.4

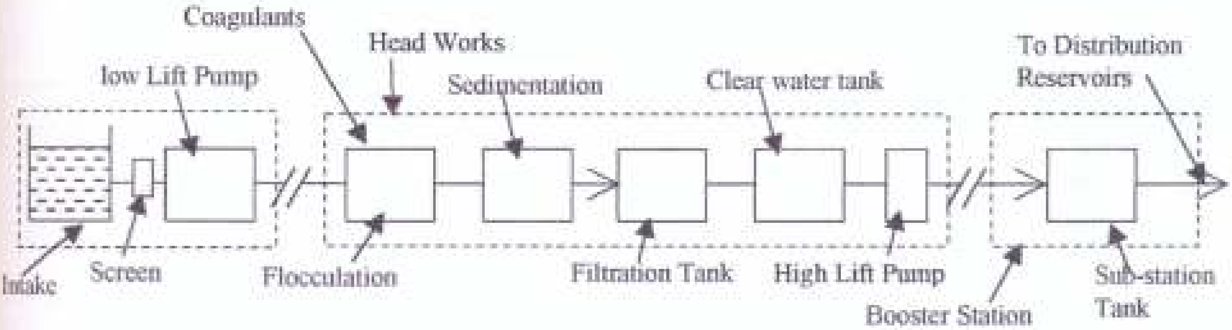


Figure 6.4

Table 6.3 Design Parameters for Ibiekuma Treatment Plant

Parameter/Item	Unit	Size		Remark
		Old	New	
River Discharge (Q)	m^3/d	24,750	24,750	
Intake Discharge	m^3/d	7,200	18,553	Using 75% Q
Transmission pipe diameter from intake to headworks	mm	300	450	
Rapid mix (flash mix)	m	1.5x1.5	2x2	
Flocculation	m	5x3.5x2	2No – 10.6x5.5x3.5	
Sedimentation	m	2No – 5x4x4	4No – 24.1x8.1x4	
Filtration	m	2No – 3.5x3.5	3No – 4.7x4.7	
Chlorine	kg/d	-	22.3	
Alum	kg/d	-	47	
Clear Water Tank	m^3	500	3100	
Low lift pump	Kw	2No – 90kw each	6No – 75Kw each	
High lift pump	Kw	2No – 250Kw each	6No – 175Kw each	

The design table and procedure are shown in Appendices 6.1 and 6.4 (a) – (g)

6.4 Ella Stream

Figure 6.5 shows the schematic diagram of the proposed Ella water scheme at Igueben. It should be noted that there are no existing structure on ground and the design of the treatment plant is based on 75% utilization of the measured stream flow.

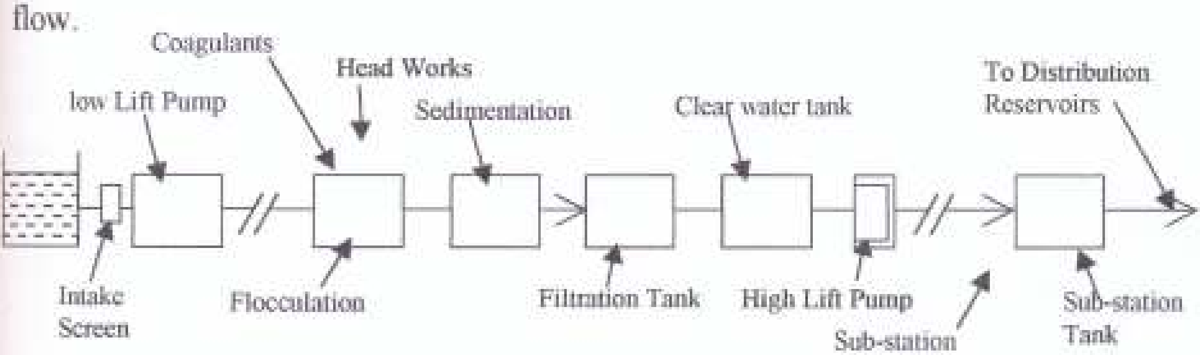


Figure 6.5

Below is table 6.4 showing the design parameters and size of the proposed treatment plant and appurtenance based on the Fig. 6.5

Table 6.4 **Design parameter for Ella treatment plant**

Parameter/Item	Unit	Size	Remark
Intake			
River Discharge	m^3/d	21,799	Using 75% River Discharge
Intake Discharge	m^3/d	16,349	
Transmission pipe diameter from intake to headworks	mm	450	
Treatment Plant			
Rapid mix (flash mix)	m	1.8x1.8x1.8	
Flocculation	m	2No – 10x5x3.5 each	
Sedimentation	m	4No – 23x7.6x4 each	
Filtration	m	3No – 4.5x4.5	
Chlorine	kg/d	20	
Alum	kg/d	41	
Clear Water Tank	m^3	2,750	
Low lift pump	Kw	6No - 40kw each	
High lift pump	Kw	6No – 75kw each	

The design table and procedures are shown in Appendices 6.1 and 6.5 (a) –(g)

6.50 Amendokhian Stream

Fig. 6.6 shows the schematic diagram of the proposed Amendokhian water scheme at Uromi. There are no existing infrastructure on ground. The design of the treatment plant is based on the utilization of 75% of the measured stream flow.

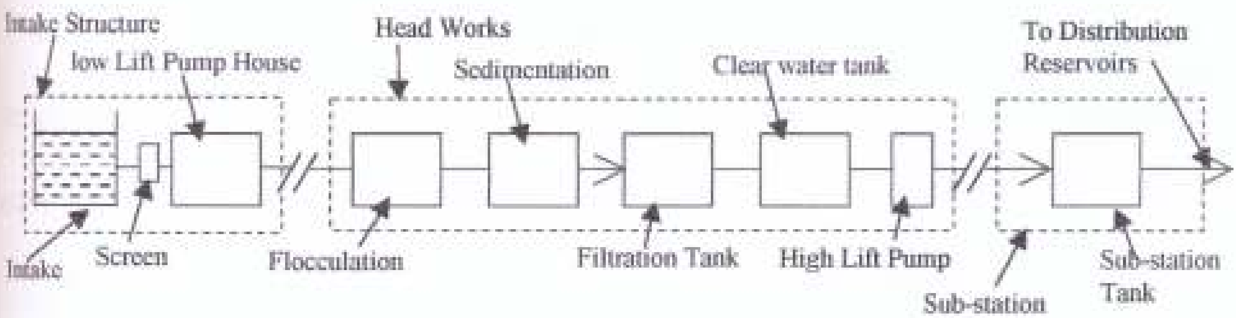


Figure 6.6

Below is a table which shows the design parameters and size of the proposed treatment plant and other appurtenance based on the Fig. 6.6

Table 6.5 **Design parameter for Amendokhian treatment plant**

Parameter/Item	Unit	Size	Remark
Intake			
River Discharge	m^3/d	38,534	Using 75% River Discharge
Intake Discharge	m^3/d	28,90116,349,,,,	
Transmission pipe diameter from intake to headworks	mm	525	
Treatment Plant			
Rapid mix (flash mix)	m	2.4x2.4x2	
Flocculation	m	3No – 10x5x4 each	
Sedimentation	m	6No – 25x8.3x4 each	
Filtration	m	3No – 5.8x5.8 each	
Chlorine	kg/d	35	
Alum	kg/d	73	
Clear Water Tank	m^3	4850	
Low lift pump	Kw	6No - 110	
High lift pump	Kw	6No – 200	

The design table and procedures are shown in appendices 6.1 and 6.6 (a) –(g)

6.9 Pumping Stations

For the overall success of any water supply scheme, pumping stations are vital segment of the whole system. Pumps are used for the abstraction of water from surface and ground water sources, boosting of water from low to high service area and for maintaining or enhancing the desired pressure in water supply distribution system.

The selection and capacity of pump is influenced by many factors such as the source of water, the yield expected, the head to be overcome and the conveyance material.

For surface water scheme with an intake structure, centrifugal pumps are recommended (McGrawHills, - Pump Handbook 1976) while other water supply system structures components are designed based on projected service period of 5 to 50 years, pump capacities are usually based on 5 to 10 years demand projection after which additional pumps are installed for future demand, (Pump Handbook Pumps 1976). However the capacity and number of pumps for a particular scheme are determined by the discharge expected. Table 6.6 gives a guide for selection of appropriate pumps in water systems.

Table 6.6 - Guide for Selection of Pumps

S/No	Discharge (m^3/s)	No of Pumps	Remark
1	Up to 0.032 m^3/s	2 of Pumps	One working, one on stand
2	(0.0332 – 0.095) m^3/s	3 of Pumps	Two working, one on stand
3	(0.095 – 0.19) m^3/s	4 of Pumps	Three working one on stand
4	Above 0.19 m^3/s	6 of Pumps	Four working two on stand

Sources: Anis – AL- Liayi; Shamim Ahmed 1978
Water Supply Engineering Design
Wogn J.N – Basic Pipeline Hydraulics – 1997

Appendix 6.7 (a) – (e) and Appendix 6.1 show the calculation procedure for the pump size and the summary for each scheme.

6.9 Substations- Booster Stations

Considering the topographic relationship between the scheme Intakes, Headworks and the distance apart, there is need for booster stations to further transmit water to higher levels and far distances from the headworks. The booster stations are also necessary for inter link (inter-station) of schemes for augmentation in times of higher demand from any station especially when some of the schemes have the capacity to serve beyond their catchments area

(a) **Ugbalo Scheme:**

Since a new Headworks is proposed for this scheme, it will be more effective to have a booster station at Ivue in addition to the Ibore sub-station. The Ivue station which already has a gigantic 3750m^3 surface reservoir will boost water to Irrua, and argument supply to Ekpoma sub-station in Esan West L.G.A. It will also receive augmentation from Uromi –sub-station of Amendokhian scheme. Ibore sub-station will then serve Ewu, Udowo/Eidenu/Ughohare tanks; including the boosting of the Ivue reservoir. (See Fig 6.7)

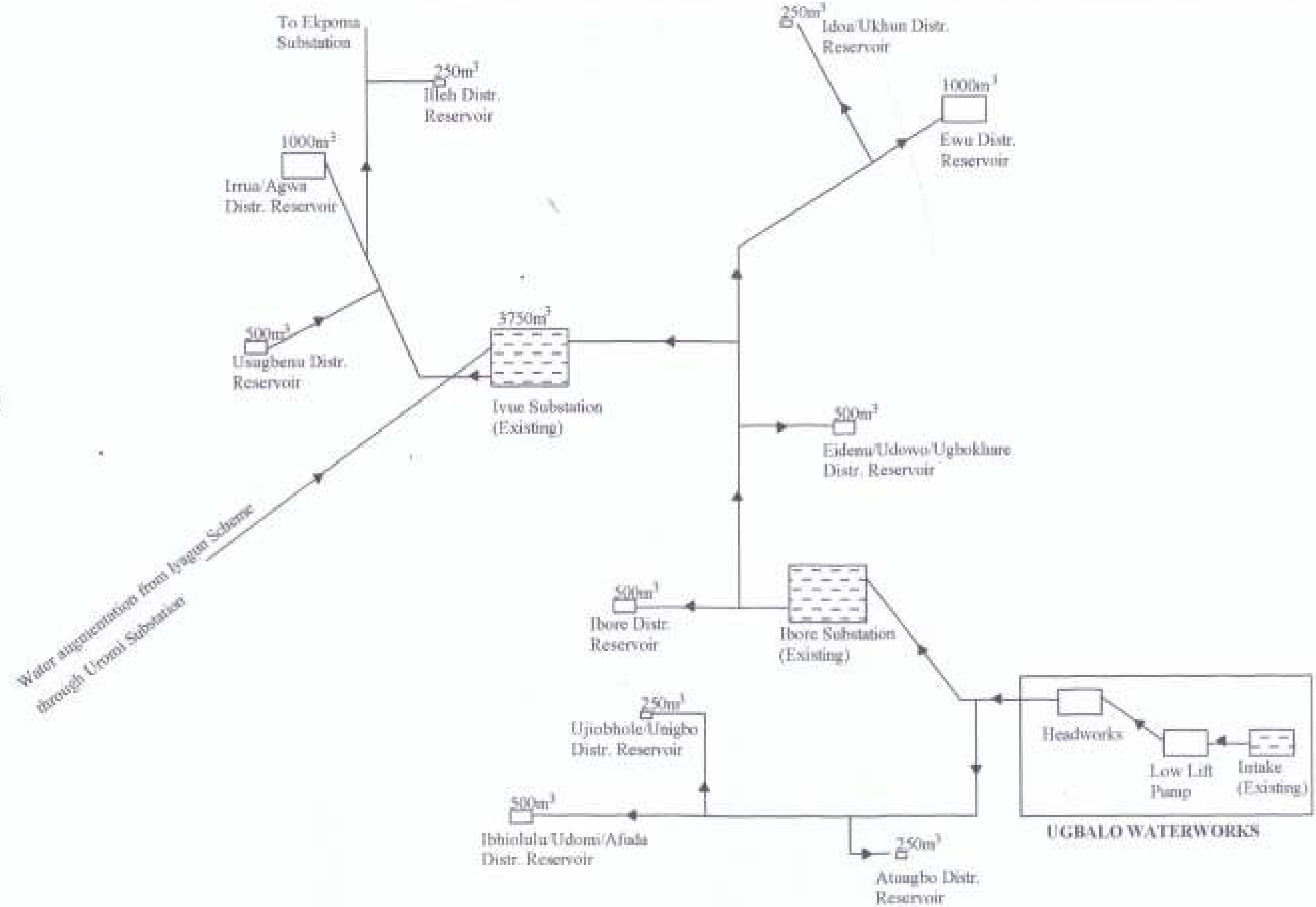


Fig. 6.7
Diagramatic Representation of The Scope of Service of the Proposed Expansion of Ugbalo Water Scheme - Irrua

(b) **Iyagun Scheme:**

Iyagun scheme which has a high capacity discharge and proposed to serve beyond the catchment area, requires many booster stations so as to meet the desired service. Apart from the Ewohimi main station other booster stations proposed are

(i) Ubiaja station: Ubiaja station will receive supply from Ewohimi main station and boost supply to Ugboha, Illushi, Okhuessan and within Ubiaja town. Ubiaja station will also boost supply to Amendokhian- Uromi station Esan North West L.G A as part of inter- scheme argumentation

(ii) Ebelle station: This station will receive supply from Ewohimi main station and boost supply to Ewossa, Ekpon and Ebelle towns in Igueben L.G.A, boost supply to Ogwa, Ujiogba and Urohi in Esan West L.G.A and argument supply to Igueben station in Igueben L. G. A (See Fig. 6.8).

(c). **Ibiekuma Scheme:**

This scheme is hundred percent restricted to University campus, Iruekpen, Ekpoma and it immediate environs. It requires two booster stations, the main one at the University Campus where supply from the Headworks will be boosted to the second station at Ekpoma town. The main in station in the campus will also boost water to the University reservoir. Iruekpen town reservoir and Idumebo reservoir.

The Ekpoma sub-station will boost supply to Ekpoma town reservoirs, Emuhi and Egoro communities. The Ekpoma sub-station will also receive augmentation supply from the Ivue sub-station of Ugbalo scheme (Fig. 6.9).

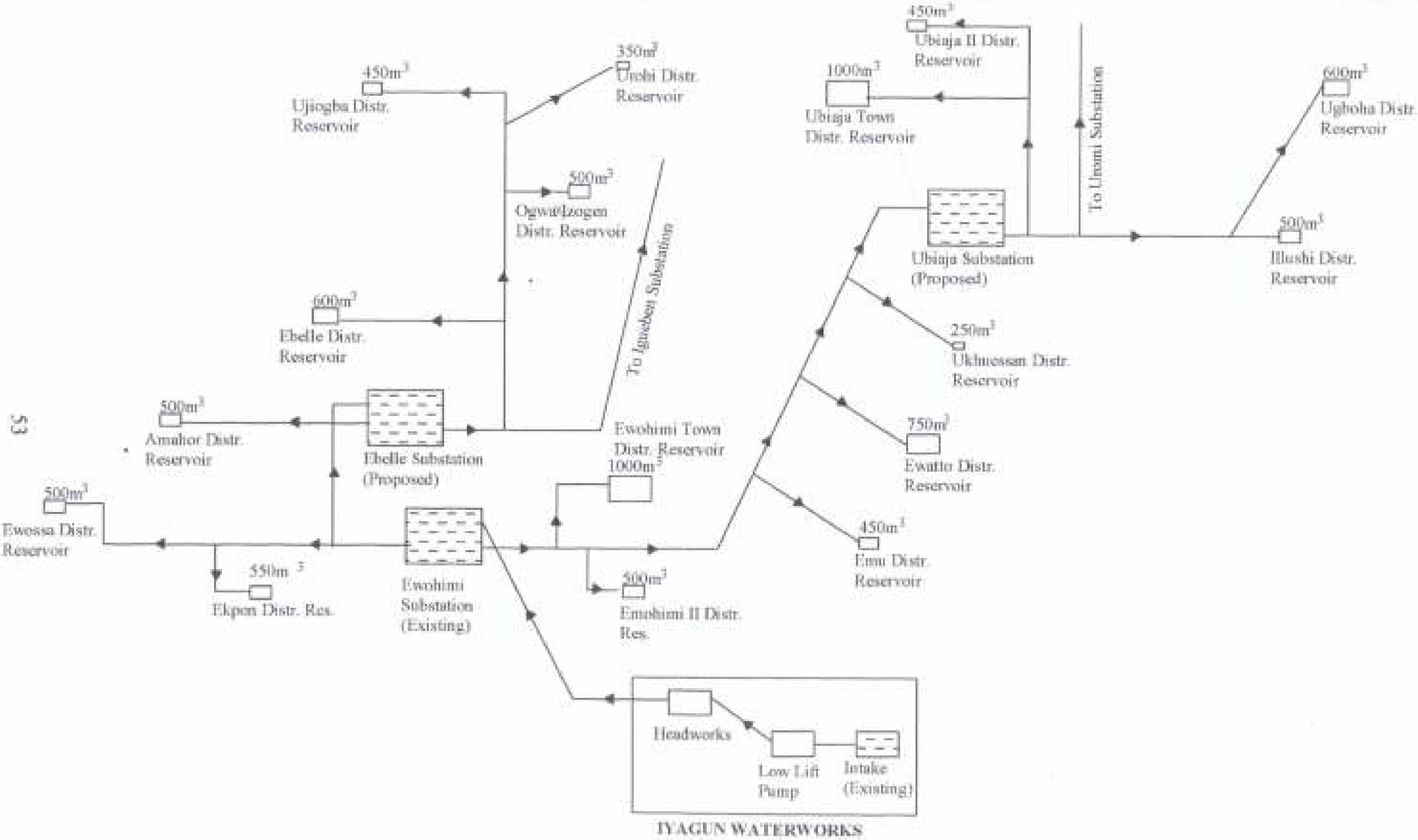


Fig. 6.8
Diagramatic Representation of The Scope of Service of the Proposed Expansion of Iyagun Water Scheme

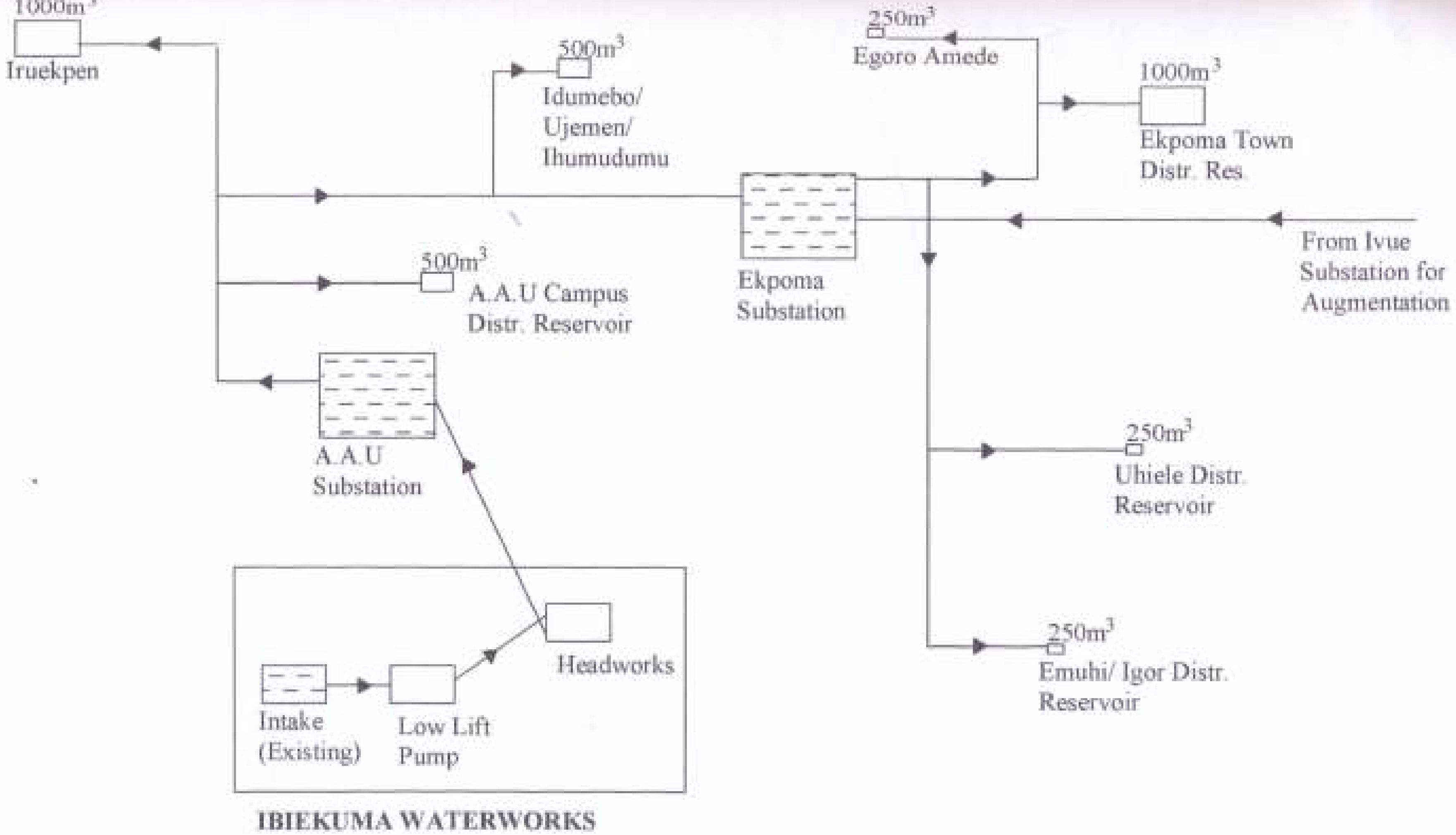


Fig. 6.9
Diagramatic Representation of The Scope of Service of the Proposed Expansion of Ibiekuma Water Scheme

(d). **Ella Scheme:** This scheme requires a substation at Igueben and Ugbegun. Igueben main-substation will boost supply to reservoirs in Igueben town, Ekekhen reservoir and also to the Ugbegun booster station in Esan Central L.G.A. The Ugbegun station will boost supply to Ugbegun, Ebudin, Opoji in Esan Central L.G.A. Igueben station will also receive augmentation supply form Ebelle sub-station of Iyagun scheme (Fig. 6.10).

(e) **Amendokhian Scheme:** This scheme which has its Intake and Headworks at Amendokhian requires a sub-station at Uromi to boost supply to service reservoirs in Uromi town and its environs. It will also receive augmentation supply from Ubiaja substation of Iyagun scheme and also boost supply to Ivue substation of Ugbalo scheme (Fig. 6.11).

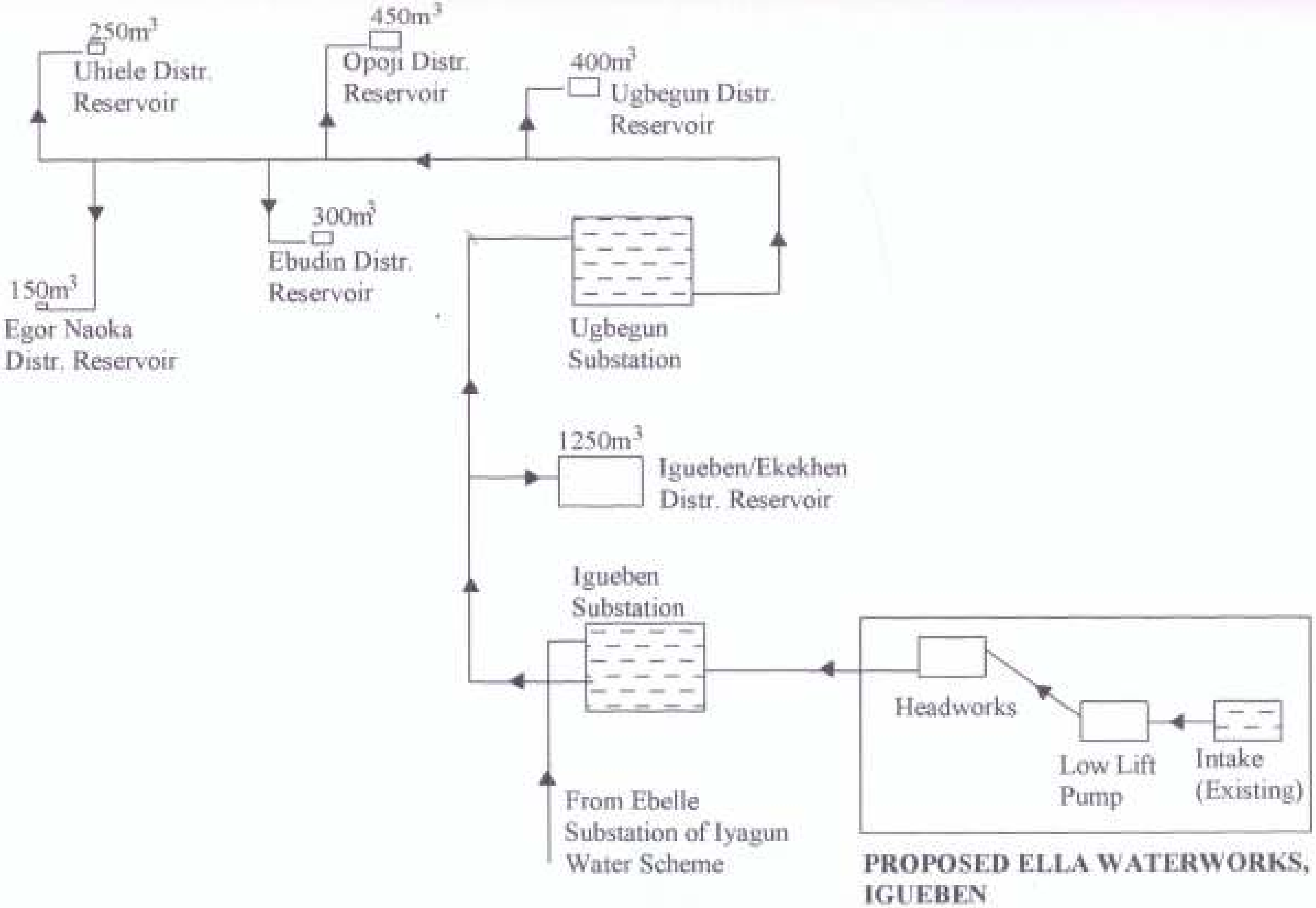


Fig. 6.10

Diagramatic Representation of The Scope of Service of the Proposed Ella Water Scheme - Igueben

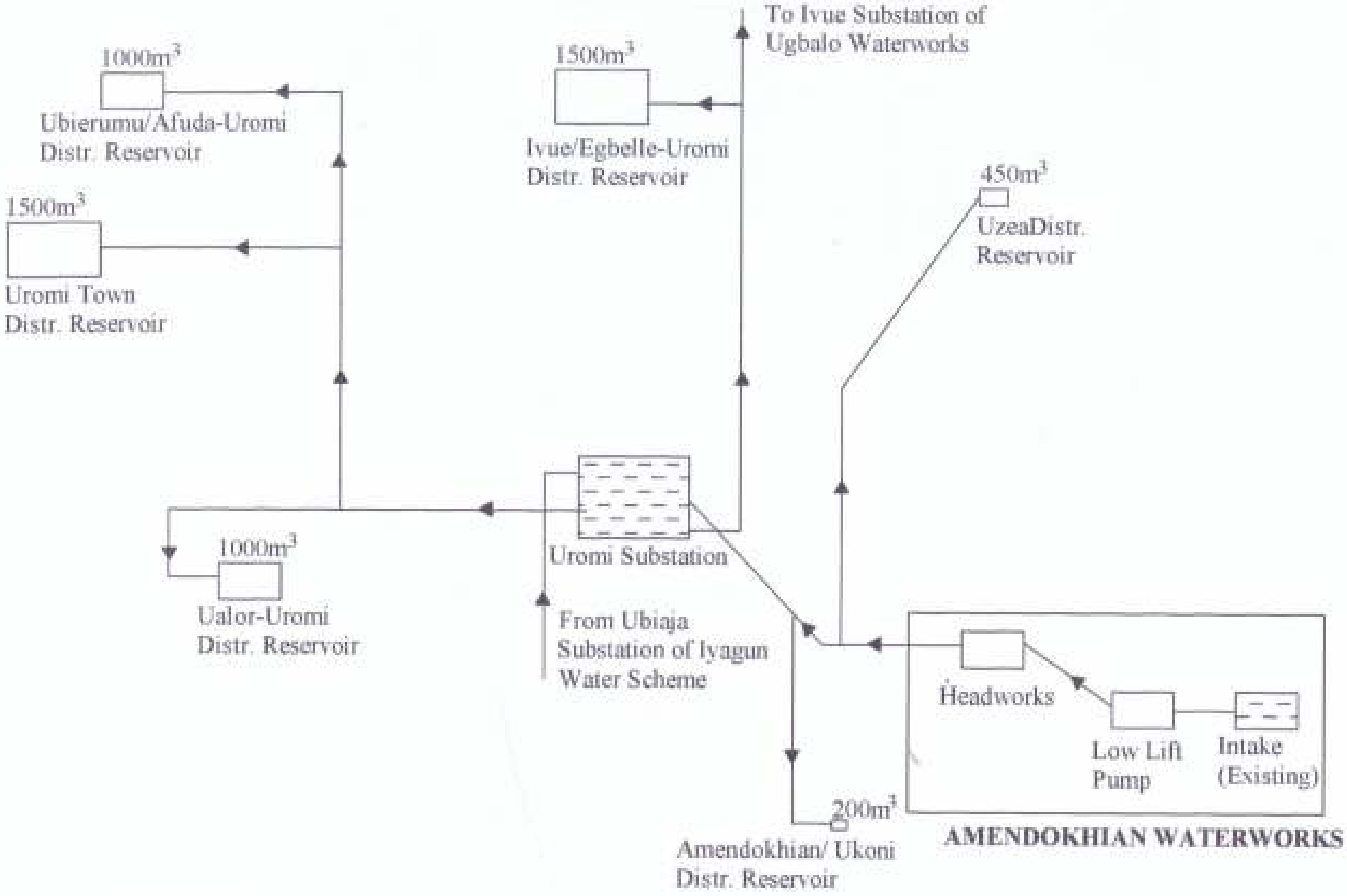


Fig. 6.11

Diagramatic Representation of The Scope of Service of the Proposed Amendokhian Water Scheme - Uromi

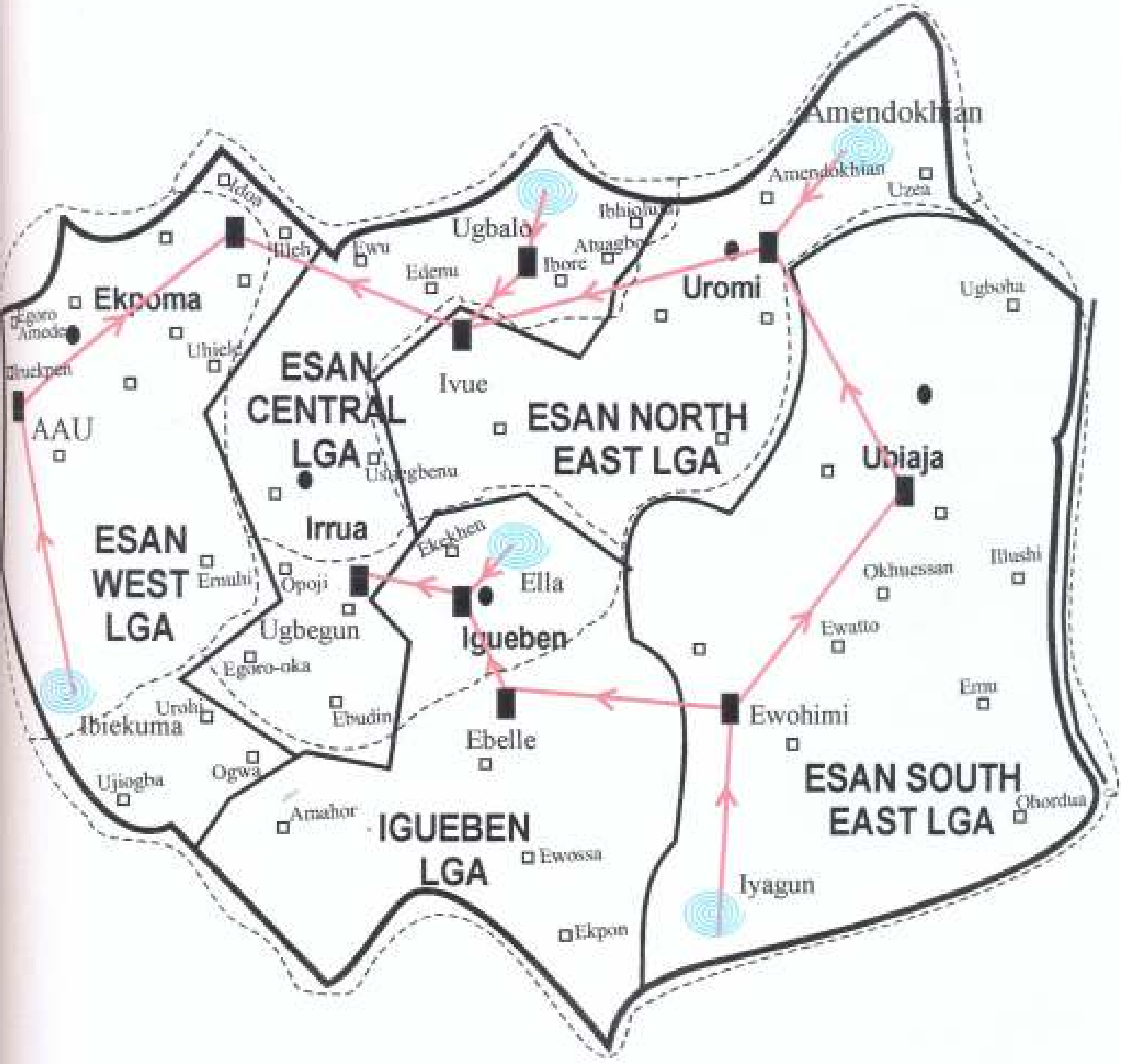


Fig. 5.12

Map showing the water schemes locations, Booster Stations linkage for augmentation, service area coverage of each of the schemes and distribution reservoir locations across the Senatorial District		
	■	Water Distribution Booster Station Reservoirs
	□	Water Distribution Service Reservoirs
	→	Linkage of Booster Stations Reservoirs to the various Schemes for Augmentation.
		Location of Intake/Headworks.
	-------	Service area of each of the five Water Schemes

6.8 Service Reservoirs (Distribution Reservoirs)

Service reservoirs may be constructed as tanks or water towers. They are used for equalizing the rate of flow and for emergencies. Depending upon the utility, purpose, and topography, reservoirs may be underground or elevated.

Generally the equalizing volume of water tank is about $^1/_6$ to $^1/_3$ of the total daily demand. (Anis-AL-Layia,: Shamim Ahmad 1976). Based on this premise, $^1/_6$ of the total daily demand was used for the location of service reservoirs across the study area. Some communities are jointly served by one reservoir depending on proximity and location of the reservoir. See Figures 6.7 – 6.11 for service reservoir allocation.

Summary of service reservoir allocation in table 6.7

Table 6.7 Distribution Reservoir Allocation/Sizing

S/N	Town or Community	Projected Population	No & Size of Reservoir	L.G.A	Remark
1	Ewu	33,837	1 Nos – 750m^3	Esan Central L.G.A	
2	Edenu/Udowo/ Ugbohare	13,878	1 No – 350m^3	Esan Central L.G.A	
3	Ibore	11,916	1 No – 300m^3	Esan Central L.G.A	
4	Atuagbo/Afuda/ Ugbalo/Iddumoza	13,420	1 No – 350m^3	Esan Central L.G.A	
5	Ibhiolulu/Udomi /Ujabhole/ Unogbo	17,232	1 No – 450m^3	Esan Central L.G.A	
6	Irrua Town/ Agwa/Eko Iyobhebhe	33,791	1 Nos – 1000m^3	Esan Central L.G.A	
7	Usugbenu-Irrua	11,220	1 No – 300m^3	Esan Central L.G.A	
8	Opoji	18,473	1 No – 450m^3	Esan Central L.G.A	
9	Ugbegun	16,437	1 No – 400m^3	Esan Central L.G.A	
10	Ebudin-Ugbegun	11,681	1 No – 300m^3	Easn Central L.G.A	

Table 6.7 Distribution Reservoir Allocation/Sizing (continued)

11	Uromi	227646	2 Nos – 1500^3 1 N0 – 1000m^{3}0/H 1N0 – 1000m^3 G.L	Easn N. East	
12	Ukoni/ Amendokhian	7448	1 No – 200m^3	Easn N. East	
13	Uzea/Camps	17,068	1 No – 450m^3	Easn N. East	
14	Other Camps	13,380	1 No – 350m^3	Easn N. East	
15	Igueben/Ekekhen	49,296	1 N0 – 1250m^3	Igeuben L.G.A	
16	Amabor/Izekor Camp	22,837	1 N0 – 500m^3	Igeuben L.G.A	
17	Ekpon	23,322	1 N0 – 550m^3	Igeuben L.G.A	
18	Ewossa/Okalo /Udoneria	22,444	1 N0 – 500m^3	Igeuben L.G.A	
19	Ebelle/Other Camps	25024	1 N0 –600m^3	Igeuben L.G.A	
20	Iruepken	35177	1 N0 –1000m^3	Esan West L.G.A	
21	Egoro	9180	1 N0 –250m^3	Esan West L.G.A	
22	Ukhun/Idoa	9119	1 N0 –250m^3	Esan West L.G.A	
23	Illeh	9834	1 N0 –250m^3	Esan West L.G.A	
24	Ekpoma	124,956	1 N0 –1000m^2 4 N0 – 500m^3	Esan West L.G.A	
25	Igor/Emuhi	9719	1No – 250m^3	Esan West L.G.A	
26	Uhiele	9398	1No – 250m^3	Esan West L.G.A	
27	Egoro Naoka	5248	1No – 150m^3	Easn West L.G.A	
28	Urohi	12,922	1No – 350m^3	Easn West L.G.A	
29	Ogwa/Izogen	21,345	1No – 500m^3	Easn West L.G.A	
30	Ujiogba/Ebute Camps	18,294	1No – 450m^3	Easn West L.G.A	
31	Ubiaja & Environ	59,498	1 – 1000m^3 1 – 500m^3	Esan S.E. L.G.A	
32	Illushi & Environs	20,728	1 – 450m^3	Esan S.E. L.G.A	
33	Ugboha	24,127	1 – 500m^3	Esan S.E. L.G.A	
34	Okhuessan	7962	1 – 200m^3	Esan S.E. L.G.A	
35	Emu & Environs	17029	1 – 450m^3	Esan S.E. L.G.A	
36	Ohordua & Environs	20,089	1 – 450m^3	Esan S.E. L.G.A	
37	Ewatto	31055	1 – 750m^3	Esan S.E. L.G.A	
38	Ewohimi & Environs	63,010	1 – 1000m^3 1 – 500m3	Esan S.E. L.G.A	

6.9 Distribution Network

The overall purpose of all the various stages of any water scheme is to deliver potable water to consumers at homes and places of use. When the other functional elements of the scheme have been completed to the point of service reservoirs, the next and last function is to deliver the water to the consumers near the point of need.

The type of distribution network is influenced by the location of the service reservoir and the town planning of the community. **Grid** and **Branching** methods are commonly used. Because of the disperse nature of these localities, branching system is recommended especially as it will be cheaper to commence while extension will be continuous as developments dictate. The task here is to give some guide on the type and sizes of pipes for good service network.

Using economic diameter of pipes for pumping station, pipe work and valves (Escritt 1978); the various sizes of recommended economic pipe diameter for distribution network in the various towns/communities comprising Edo Central Senatorial District is detailed in Table 6.8

Table 6.8 Recommended Economic Pipe Diameter for Distribution Network for the Communities

S/N	Town/Community/L.G.A	Population	Reservoir Capacity (m^3)	Flow Rate m^3/s	Economic pipe Diameter (mm)
	Esan Central L.G.A				
1	Ewu	33,837	750	0.066	250mm
2	Eidenu/Udowo/ Ugboghare ”	13,878	350	0.027	200
3	Ibore ”	11,916	300	0.023	175
4	Atuagbo/Afuda/ Ugbalo/Idumoza ”	13,420	350	0.026	200
5	Ibhiolulu/Udomi/ Ugbahole/Unogbo ”	17,232	450	0.034	200
6	IrruaTown/Agawa/ Eko Iyobhebhe ”	33,791	1000	0.066	300
7	Usugbenu ”	11,220	300	0.022	175
8	Opoji ”	18,473	450	0.036	200
9	Ugbegun ”	16,437	400	0.032	200
10	Ebudin ”	11,681	300	0.023	175
	Esan N.E.L.G.A				
11	Uromi	227,646	2N0s-1500 2 Nos-1000	0.125 0.083	375 300
12	Ukoni	7,448	200	0.015	300
13	Uzea/Camps	17,068	450	0.033	150
14	Other Camps	13,380	350	0.026	200
	Igueben L.G.A				
15	Igueben/Ekekhan	49,296	1250	0.096	200
16	Amahor/Ugun/Izekor Camp	22,837	500	0.044	300
17	Ekpon	23,322	550	0.045	225
18	Ewossa/Okalo/Udoneria	22,4444	500	0.045	225
19	Ebelle/other Camps	25,024	600	0.049	225
	Esan West L.G.A				
20	Iruekpen	35,177	1000	0.069	300
21	Egoro	9,180	250	0.018	150
22	Ukhun/Idoa	9119	250	0.018	150
23	Illeh	9834	250	0.019	175
24	Ekpoma	124,956	1 N0-1000 4 N0s-500	0.083 0.042	300 225
25	Igor/Emuhi	9719	250	0.019	175
26	Uhiele	9398	250	0.018	150
27	Egoro Naoka	5248	150	0.0102	125

Table 6.8 Recommended Economic Pipe Diameter for Distribution Network for the Communities (Continued)

28	Urohi	12,922	350	0.025	175
29	Ogwa/Izogen	21,345	500	0.042	225
30	Ujiogba/Ebute/Camp	18,294	450	0.036	200
	Esan South East L.G.A				
31	Ubiaja & Environs	59,498	1-1000 1-450	0.083 0.038	300 225
32	Illushi & Environs	20,728	500	0.040	225
33	Ugboha	24,127	600	0.047	225
34	Okhuessan	7962	200	0.016	150
35	Emu & Environs	17,029	450	0.033	200
36	Ohordu & Environs	20,098	500	0.039	225
37	Ewatto	31,055	750	0.060	250
38	Ewohimi & Environs	63,010	1-1000 1-500	0.083 0.042	300 225

CHAPTER SEVEN

PROJECT COST ESTIMATE

The entire research will not be complete without attempting to assess the cost implication of all the proposals made. In the light of this, a bill of quantities for the proposals is hereby presented. It is in thee phases-

(i) The cost of expansion of the three existing schemes – Ugbalo, Iyagun and Ibiekuma,

(ii) The cost of the two new proposed schemes-Ella and Amendokhian schemes and

(iii) Cost of reactivation of existing boreholes and sinking additional ones.

For the expansion of the three existing schemes, cognizance was taken on the facilities that are still usable such as the intake structures-weirs and the pump houses. Most of the pumps require upgrading and increase in number in the three old schemes. Additional treatment plants are required in both Iyagun and Ibiekuma schemes while Ugbalo scheme, requires fresh modern treatment plant. The substations of the old scheme will still be used with upgrading of the pumps while additional sub-stations are introduced to enhance the boosting of water to major communities where reservoirs are provided. Transmission lines are expanded and also the distribution or service reservoirs with the attendant distribution network expansion to the communities.

For the proposed two new water schemes, all necessary provisions are made for modern facilities from the Intake to the Distribution network.

Provisions are also made for the reactivation of the abandoned old boreholes and the sinking to new Boreholes in strategic locations across the whole Senatorial District especially where it is economical to the extension from the surface water schemes.

Bills I, II and III show the necessary provisions for the proposed schemes.

BILL I

7.1 Bill of Quantities For The Expansion/Upgrading of Equipment/ Machinery of The Three Existing Scheme (Ugbalo, Iyagun & Ibiekhuma)

Table 7.1

				Ugbalo	**Iyagun**	**Ibiekuma**
Description of Work/Material	Qty	Unit	Rate	Amt ₦(million)	Amt	Amt
Preliminaries (site preparation and equipment to site	Item		L/S	5m	10m	5m
Access road (tarred) from Intake to Headworks and to substations.	"		"	30	45	30
Intake structure rehabilitation	"		L/S	5	5	5
Treatment plant expansion/construction	"		L/S	80	100	55
Pumps (Low & high lift pumps, dosing/mixers, substatin pumps. And other electro-mechanical mechineries/pumps						
Sub-station reservoirs	"		L/S	55	75	40
Distribution reservoirs	"		L/S	8	24	18
Transmission/distribution pipe network	"		L/S	60	80	70
Generators	"		L/S	150	300	150
Chemicals (Chlorine Alum line and others) for one year operation	"		L/S	30	30	30
Contingencies	"		P/S	20	30	20
Consultancy fees	"			46	80	45
				₦514m	**₦818m**	**₦ 493m**

Table 7.2 Bill of Quantities for the Construction of two new Water Schemes From Ella Stream Igueben and Amendokhian Uromi

Description of Work/Material	Qty	Unit	Rate	ELLA Amt (million) ₦	AMENDOKHIAN Amt (million) ₦
Preliminaries (site preparation and equipment to site	Item		L/S	10	12
Access road to Intake and	"		L/S	75	90
Headwork and substations	"				
Construction of Intake structure			L/S	125	150
(weir Intake well, pump house and earth work)	"		L/S	150	180
Construction of treatment plants, storage office building generator house and fencing	"		L/S	105	120
Pumps (low and high lift pumps, dosing/mixing pumps substation pumps, electrical/mechanical machineries and panels)					
Construction of sub-station reservoirs and pump house	"		L/S	30	40
Construction of service reservoirs within their area of coverage	"		L/S	150	180
Transmission/distribution pipe net work of various sizes and necessary fittings and connections	"		L/S	300	350
Generators for the various operations	"		L/S	50	75
Allow for NEPA substation and necessary connections					
Chemicals (chlorine, alum line and others) for one year operation	"		L/S	100	120
Contingencies	"		L/S	30	45
Constancy Services (Civil,	"		P/S	50	75
Mechanical & Electrical)	"		P/S	118	144
				₦ 1,293m	₦ 1,581m

BILL III

Tale 7.3 REACTIVATION OF 15 EXISTING OLD BOREHOLES AND SINKING OF 60 NEW BOREHOLES

Item No	Description of Work Material	Qty	Unit	Rate	Amount
(a)	Reactivation of 15 existing Boreholes	15	No	₦2.5m	₦ 37.5millon
(b)	Sinking of 60 new Borehole across the senatorial district	60	No	₦ 4m	₦ 240million
					₦ 277.5m

Table 7.4 – Summary of Bills I, II, and III

	SUMMARY				
	BILL 1				
	Expansion/upgrading of equipment/mechineries of the three existing schemes				₦ 514m
	(a) Ugbafo Water Scheme				
					₦ 818m
	(b) Iyagun water scheme				₦ 493m
	(c) Ibiekuma water scheme				
					₦ 11,825m
	BILL II				
	Construction of two new water schemes:				
	(a) Ella scheme-Igueben				₦ 1,293m
	(b) Amendokhian scheme –Uromi				₦ 1,581m
					₦ 2,874m
	BILL III				
	Reactivation of 15 existing old boreholes and sinking of 60 new bore holes				
	(a) Reactivation of 15 old boreholes				₦ 37.5m
	(b) Sinking of 60No new boreholes				₦ 24.0m
					₦ 277.5m
	Total – Bill I + II+ III				**₦ 4,976.5m**

7.2 Funding

Water under the constitution of the Federal Republic of Nigeria falls within the concurrent list which implies that Federal, State and Local Governments can undertake its development. Water is an essential necessity of life and should be a social responsibility of government.

A tripartite arrangement of the federal, state and local government should fund the initial capital outlay with assistance of foreign agencies such as World Bank, European Union, Africa Development Bank and such organization seeking to help developing countries. There after on completion, appropriate tariff will be instituted so as to fund the running and maintenance of the schemes.

CHAPTER EIGHT

CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

(i). The Senatorial District of a population of 372,122 people in 1991 with a growth rate of 3.1% and a design period of twenty – five years from 2003 presents a projected population of 1,151,479 by 2028.

(ii). The existing water supply systems are grossly inadequate to meet the present requirement of the area.

(iii). Based on the projected population, about 193.45×10^6 litres/day is required for adequate supply at 168 litres/capita/day.

(iv). There is sufficient surface water sources within the Senatorial District to meet the demand if they are properly exploited.

(v). The existing water schemes need to be expanded and upgraded to increase their output.

(vi). The surface water supply schemes can also be supplemented by ground water (boreholes and wells) and in some cases direct rainwater harvesting. This is to be considered under a conjunctive water use system.

(vii). The preliminary estimates for the water supply facility development indicates that such is within the economic reach of the District.

8.2 Recommendations.

(i). For actual physical development of the facilities analysed, there is a need for detailed topographic, geological and geophysical surveys of the sites.

(ii). Detailed cost estimates of the projects will be undertaken leading to the normal engineering tendering and contract procedures.

(iii). All the streams including the three major ones being exploited in the Senatorial District need to be gauged for planning and project development. This is a general deficiency in water resources development in Nigeria.

(iv). The hydrology and geohydrology of the various catchments within the Senatorial District need to studied in detail for domestic, industrial and agricultural water supply purposes.

(v). Phased development of the schemes should be embarked upon with a fifteen year development programme for the actualization of the objectives in the following:

(a). The first five years should be used to develop the Amendokhian scheme in Uromi – Esan North East L. G. A., which is the fast growing industrial and commercial centre of the Senatorial District.

(b). It is also recommended that within the five years, the Ibiekuma scheme should be expanded to assuage the water demand of the highly populated and developing University town of Ekpoma and environs in Esan West L. G. A.

(c). The next five years period should be for the rehabilitation and expansion of the Iyagun and Ugbalo schemes in Esan South East and Esan Central L. G. As to decentralize the water supply across the district.

(d). The last five years for the development of Ella Scheme in Igueben L.G.A of the Senatorial District.

(e). In each of these phases stated above, it is expected that boreholes are rehabilitated and sunk across the Senatorial District to augment supply from the schemes.

(vi). Appropriate tariff for water supply to individual homes, institutions and industries should be charged so that these schemes can be runned and maintained.

(vii). Full fledge ministry in charge of water resources development at National and State levels is highly recommended with competent trained personnel manning the various sections.

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APPENDIX

A1.1 EDO STATE CENTRAL SENATORIAL DISTRICT – POPULATION

S/No.	L.G.A	1991	2003	2028
1.	Esan West	86,594	124,908	276,259
2.	Esan Central	60,871	87,804	194,196
3.	Esan North East	86,296	124,479	275,309
4.	Igueben	84,970	70,637	156,228
5.	Esan South East	89,391	128943	285,183
		372,122	536,771	1.187,175

A1.2 – ESAN WEST LOCAL GOVERNMENT AREA – POPULATION

S/No	Community	Population		
		1991	2003	2028
1.	Iruekpen	11,368	16,398	35,177
2.	Oraede-Egoro	255	368	789
3.	Egoro-Amede	1,380	1,991	4,270
4.	Egoro-eguare	607	876	1,878
5.	Egoro-Farm Settlement	725	1,046	2,243
6.	Ukhun	1,196	1,725	3,701
7.	Ekori and others	43	62	133
8.	Idoa	1,708	2,464	5,285
9.	Illeh	1,178	4,584	9,834
10.	Ekpoma	40,382	58,250	124,965
11.	Igor-emuhi	3,141	4,531	9,719
12.	Ikhirolo	302	436	936
13.	Uhiele	3,037	4,381	9,398
14.	Egoro-Noaka	1,696	2,446	5,248
15.	Urohi	4,176	6,024	12,922
16.	Akugbe Camp and others	590	851	1,826
17.	Upper Izogen	927	1,337	2,869
18.	Ogwa	5,971	8,613	18,476
19	Ujogba	5,138	7,411	15,899
20.	Okhiwa Camp and others	290	418	897
21.	Ebute	484	698	1,498
		86,594	124,910	267,953

A1.3 – ESAN CENTRAL LOCAL GOVERNMENT AREA – POPULATION

S/No	Community	Population		
		1991	**2003**	**2028**
1.	Ewu	10,935	15,773	33,837
2.	Eko Noukuo	404	583	1,250
3.	Eidenu-Irrua	2,071	2,987	6,408
4.	Udowo-Irrua	1,276	1,828	3,921
5.	Ugbokhare-Irrua	1,147	1,655	3,549
6.	Ibore-Irrua	3,851	5,555	11,916
7.	Ugbalo-Irrua	183	264	566
8.	Atuagbo-Irrua	2,393	3,452	7,405
9.	Ekilo-Irrua	544	785	1,683
10.	Okhiromi-Irrua	118	170	365
11.	Eko-Waya and Others-Irrua	223	322	690
12.	Idumuozo-Irrua	564	814	1,745
13.	Afuda-Irrua	1,197	1,727	3,704
14.	Ihiolulu-Irrua	1,424	2,054	4,406
15.	Ohe-Irrua	772	1,114	2,389
16.	Udomi-Irrua	838	1,209	2,593
17.	Unogbo-Irrua	301	434	931
18.	Ujabholo-Irrua	2,234	3,223	6,913
19	Eko-Iyobhebhe-Irrua	269	388	832
20.	Agwa-Irrua	694	1,001	2,148
21.	Eko-Kakuchi and others	384	554	1,188
22.	Irrua	9,957	14,363	30,811
23.	Usugbenu-Irrua	3,626	5,230	11,220
24.	Opoji	5,970	8,612	18,473
25.	Ugbegun	5,312	7,662	16,437
26.	Ebudin Ugbegun	3,775	5,445	11,861
27.	Ehizogie Camp-Irrua	241	348	746
28.	Eko Imoamen	177	255	548
		60,871	87,807	188,355

A1.4 – ESAN NORTH EAST LOCAL GOVERNMENT AREA – POPULATION

S/No	Community	Population		
		1991	2003	2028
1.	Uromi	73,568	106,119	227,646
2.	Ukoni	2,407	3,472	7,448
3.	Eko-Ibadin	223	322	690
4.	Eko-Ojah and others	259	374	801
5.	Ewoiki-Uzea	619	893	1,915
6.	Ebago Camp and others	120	173	371
7.	Ebun-Uzea/Okuaza/Idugbon	745	1,088	2,333
8.	Kanni Camp others	128	186	396
9.	Olinlin Uzea	812	1,171	2,513
10.	Ebulen-Uzea	1,115	1,608	3,450
11.	Nweke Camp and others	446	643	1,380
12.	Iyogbe Camp and others	495	714	1,532
13.	Uroh-uzea	1,027	1,481	3,178
14.	Rreni Camp and others	229	330	709
15.	Onoje Camp/Amahi Camp	137	198	424
16.	Okpodo Camp	279	403	863
17.	Okpa Tawo Camp	589	850	1,823
18.	Isoko/Ibo Camp and others	222	320	687
19	Okwo Shimili/Alah Camp	460	664	1,423
20.	Adagbafuja camp and others	301	434	931
21.	Iyebi Camp and others	369	532	1,142
22.	Odunu Camp and others	257	371	795
23.	Fulani Camp others	90	130	279
24.	Leprosy Shelter	4	6	12
25.	Ogbeide Camp and others	164	237	508
26.	Abakhala Camp/Okohide Camp	106	153	328
27.	Omakwu Camp and others	309	446	956
28.	Comaku Camp /Feed Camp	439	633	1,358
29.	Nwojiea Camp and others	369	532	1,142
		86,296	124,483	267,033

A1.5 – IGUEBEN LOCAL GOVERNMENT AREA – POPULATION

S/No	Community	Population 1991	2003	2028
1.	Amahor Water Side	811	1,170	2,510
2.	Izekor Camp	296	427	916
3.	Ugun	2,432	3,508	7,526
4.	Amahor	3,278	4,728	10,143
5.	Idumodin and others	563	812	1,742
6.	Ekpon	7,537	10,872	23,233
7.	Ekekhen	808	1,166	2,50-0
8.	Igueben	15,931	22,980	49,296
9.	Okalo	1,596	2,303	4,939
10.	Ewossa	5,470	7,890	16,926
11.	Udoneria Eahakuna	187	270	579
12.	Ebelle	8,087	11,665	25,024
13.	Udoneria Idukpen	214	309	662
14.	Quarters	299	431	925
15.	Udoneria	1,213	1,750	3,754
16.	Udo Camp and others	246	355	761
		48,970	70,636	151,525

A1.6 – ESAN SOUTH LOCAL GOVERNMENT AREA – POPULATION

S/No	Community	Population		
		1991	2003	2028
1.	Ubiaja	16,187	23,349	50,088
2.	Ahia Ubiaja	658	949	2,036
3.	Ukhuanlen-Ubiaja	590	851	1,826
4.	Udakpa-Ubiaja	794	1,145	2,457
5.	Ugbo Camp	544	785	1,683
6.	Palmer's Camp and others	455	656	1,408
7.	Onogholo	237	342	733
8.	Gilberti's Camp	268	387	829
9.	Augustine Camp and others	432	623	1,337
10.	Oria Igo Quarters	799	1,153	2,472
11.	Oria Ogbokpa Quarter	400	577	1,238
12.	Nnanan Camp and others	435	628	1,346
13.	Ega Camp and others	534	770	1,652
14.	Illushi	3,727	5,376	11,533
15.	Gab Camp	374	540	1,157
16.	Ikeken	1,287	1,857	3,982
17.	Eke-Oghenyen	232	335	718
18.	Ifeku Island (Ajoke Camp)	110	159	340
19	Ugboha	7,797	11,247	24,127
20.	Okhuessan	2,573	3,712	7,962
21.	Orakhuan-Emu	1,373	1,981	4,249
22.	Ogbeme Camp	391	564	1,210
23.	Odogume 1	502	724	1,553
24.	Okpenu Camp and others	431	622	1,334
25.	Odi Ojele Camp and others	35	51	108
26.	Igbemaka Camp	377773	538	1,154
27.	Atower Camp and others	308	444	953
28.	Uroh town Ajauma 1	232	335	718
29.	Uroh Ajauma Quarters	367	529	1,136
30.	Urho-Arokefe Quarters	244	352	755
31.	Uroh-Ochechie Quarters	101	146	313
32.	Uroh town-Ajanna II	225	325	696
33.	Obor Camp II	471	679	1,457
34.	Inyelen and others	426	615	1,318
35.	Chukwu Camp and others	255	368	789
36.	Obor Camp/Osaji and others	285	411	882

37.	Cyril Camp and otherrs	158	228	489
38.	Orowa Camp I	101	146	313
39.	Orowa camp II	210	303	650
40.	James Camp and others	246	355	761
41.	Mr. Broco Camp and others	333	480	1,030
42.	Emonokhua	1,320	1,904	4,085
43.	Ozor Camp/Ivbiozi Camp	59	85	183
44.	Usolo-Emu	4,130	5,957	12,780
45.	Ohordua Uokhuen I	745	1,088	2,333
46.	Ohordua Eguare	1,071	1,545	3,314
47.	Ohordua Ozenyen	283	408	876
48l	Ohordua Orrekhie	736	1,062	2,278
49.	Ohordua Ibhiedu	1,411	2,035	4,366
50.	Ohordua (Eguare/Akpoza)	455	656	1,408
51.	Ohordua (Oriwa Quarters)	395	570	1,222
52.	Ohordua Ologua	830	1,197	2,568
53.	Ohorddua Oniwa Village	363	524	1,123
54.	Hordua Uokhuen II	197	284	610
55.	Ewatto	9,569	13,803	29,610
56.	Ewatto Iddumuromi Abhui	467	674	1,445
57.	Ewohimi	20,363	29,373	63,010
58.	Asaboro Camp and others	225	325	696
59.	Oddigie Camp 'A' and others	321	463	993
60.	Ezeani Camp and others	197	284	610
61.	Ibo Camp (Ohordua) and others	272	392	842
62.	Ekuku Camp and others	250	361	774
		89,391	128,628	276,609

A5 – Stream Flow Measurement

A5.1 - DISCHARGE MEASUREMENTS UGBALO STREAM
1ST MEASUREMENT

RIVER-UGBALO
DATE-30-1-03
TIME START-12.50 P.M.
FINISH-1.15 P.M.

LOCATION-UGBALO -IRRUA
EDO STATE
METHOD - WADING

Dist. From initial point (m)	Depth (m)	Depth of Observed	No. of Revolutions	Time (secs)	Rev./sec (n)	Velocity m/s		Area (m^2)	Discharge (cumes)
						At point	Mean in vertical		
0	0	0	0	0	0	0	0	0	0
1.00	0.14	0.084	20	10	2.0	0.244	0	0.07	0.017
1.50	0.14	0.084	22	10	2.2	0.266	0	0.07	0.019
2.00	0.16	0.096	29	10	2.9	0.342	0	0.08	0.027
2.50	0.14	0.084	38	10	3.8	0.443	0	0.07	0.031
3.00	0.14	0.084	35	10	3.5	0.410	0	0.07	0.029
3.50	0.13	0.078	37	10	3.7	0.432	0	0.065	0.028
4.00	0.13	0.078	'22	10	2.2	0.266	0	0.065	0.017
5.00	-	-	-	-	-	-	-	-	-
TOTAL DISCHARGE									$0.168m^3/s$

A5.2 - STREAM DISCHARGE MEASUREMENTS UGBALO STREAM
2nd MASUREMENT

RIVER-UGBALO
DATE-3-4-03
TIME START-11.05 P.M.
FINISH-11.28 P.M.

LOCATION-UGBALO-IRRUA
EDO STATE
METHOD - WADING

Dist. From initial point (m)	Depth (m)	Depth of Observed	No. of Revolutions	Time (secs)	Rev/sec (n)	Velocity m/s		Area (m^2)	Discharge (cumes)
						At point	Mean in vertical		
0	0	0	0	0	0	0	0	0	0
1.00	0.13	0.078	30	10	3.0	0.355	-	0.065	0.0230
1.50	0.14	0.084	34	10	3.4	0.399	-	0.070	0.0280
2.00	0.14	0.084	36	10	3.6	0.421	-	0.070	0.030
2.50	0.12	0.072	34	10	3.4	0.399	-	0.060	0.024
3.00	0.12	0.072	32	10	3.2	0.377	-	0.060	0.23
3.50	0.12	0.072	28	10	2.8	0.332	-	0.60	0.020
4.00	0.10	0.062	18	10	1.8	0.222	-	0.05	0.011
5.00	-	-	-	-	-	-	-	-	-
TOTAL DISCHARGE									$0.159m^3/s$

Average Discharge – $\frac{0.168 + 0.159}{2} =$ **$0.164m^3/sec$**

A5.3 - STREAM DISCHARGE MEASUREMENTS IYAGUN STREAM
1ST MEASUREMENT

RIVER-IYAGUN
DATE-30-12-02
TIME START-11.30 A.M.
FINISH-12.-25 P.M.

LOCATION-EWOHIMI, ESAN SOUTH EAST
EDO STATE
METHOD-WADING

Dist. From initial point (m)	Depth (m)	Depth of Observed	No. of Revolutions	Time (secs)	Rev./sec (n)	Velocity m/s		Area (m^2)	Discharge (cumes)
						At point	Mean in vertical		
0	0	0	0	0	0	0	0	0	0
3.	0.67	0.40	21	10	2.1	0.255	0.255	1.005	0.234
4.	0.69	0.41	19	10	1.9	0.233	0.233	0.690	0.161
5.	0.78	0.47	47	10	4.7	0.521	0.521	0.78	0.406
6.	1.00	0.6	54	10	5.4	0.743	0.621	1.00	0.621
7.	1.10	0.22 0.88	25 58	10	2.5 5.8	0.300 0.665	0.483	1.10	0.531
8.	1.10	0.22 0.88	21 43	10	2.1 4.3	0.255 0.499	0.377	1.10	0.415
9.	1.05	0.21 0.84	14 24	10	1.4 2.4	0.178 0.288	0.233	1.05	0.245
12.5	-	-	-	-	-	-	-	-	-
TOTAL DISCHARGE									2.613m^3/s

A5.4 - STREAM DISCHARGE MEASUREMENTS UGBALO STREAM
2nd MASUREMENT

RIVER-IYAGUN
DATE-3-4-03
TIME START-11. A.M
FINISH-11.50 A.M

LOCATION-EWOHIMI, ESAN SOUTH EAST
EDO STATE
METHOD-WADING

Dist. From initial point (m)	Depth (m)	Depth of Observed	No. of Revolutions	Time (secs)	Rev./sec(n)	Velocity m/s		Area (m^2)	Discharge (cumes)
						At point	Mean in vertical		
0	0	0	0	0	0	0	0	0	0
3	0.67	0.40	18	10	1.8	0.222	0.222	1.01	0.224
4	0.72	0.432	33	10	3.3	0.388	0.388	0.72	0.279
5	0.88	0.528	31	10	3.1	0.366	0.366	0.88	0.322
6	1.05	0.21 0.84	22 30	10	2.2 3.0	0.266 0.355	0.311	1.05	0.327
7	1.12	0.224 0.896	22 33	10	2.2 3.3	0.266 0.388	0.327	1.12	0.366
8	1.10	0.22 0.88	15 23	10	1.5 2.3	0.189 0.277	0.233	1.10	0.256
9	1.00	0.60	8	10	0.8	0.111	0.111	1.00	0.111
12.5	-	-	-	-	-	-	-	-	-
TOTAL DISCHARGE									1.884m^3/s

Average Discharge $= \frac{2.613 + 1884}{2} = 2.249 m^3/sec$

A5.5 - STREAM DISCHARGE MEASUREMENTS IBIEKUMA STREAM
1ST MEASUREMENT

RIVER-IBIEKUMA
DATE-30-1-03
TIME START-10.35 A.M.
FINISH-10.-58 A.M.

LOCATION-AMBROSE ALLI UNIVERSITY
EKPOMA EDO STATE
METHOD-WADING

Dist. From initial point (m)	Depth (m)	Depth of Observe d	No. of revolutions	Time (secs)	Rev./sec(n)	Velocity m/s		Area (m^2)	Discharge (cumes)
						At point	Mean in vertical		
0	0	0	0	0	0	0	0	0	0
0.5	o.16	0.096	17	10	1.7	0.211	-	0.4	0.084
1.00	0.23	0.138	17	10	1.7	0.211	-	0.12	0.025
1.50	0.26	0.156	20	10	2.0	0.244	-	0.13	0.023
2.00	0.21	0.126	20	10	2.0	0.244	-	0.11	0.027
2.50	0.21	0.126	19	10	1.9	0.233	-	0.11	0.026
3.00	0.26	0.156	19	10	1.9	0.233	-	0.13	0.030
3.50	0.34	0.204	14	10	1.4	0.178	-	0.17	0.030
4.00	0.46	0.276	5	10	0.5	0.080	-	0.23	0.019
5.00	-	-	-	-	-	-	-	-	-
TOTAL DISCHARGE									$0.273m^3/s$

A5.6 - STREAM DISCHARGE MEASUREMENTS IBIEKUMA STREAM
2nd MASUREMENT

RIVER-IBIEKUMA
DATE-27/3/03
TIME START-3.10 P. M.
FINISH-3.31 P.M.

LOCATION-AMBROSE ALLI UNIVERSITY
CAMPUS-EKPOMA EDO STATE
METHOD-WADING

Dist. From initial point (m)	Depth (m)	Depth of observed	No. of revolutio ns	Time (secs)	Rev./sec(n)	Velocity m/s		Area (m^2)	Discharge (cumes)
						At point	Mean in vertical		
0	0	0	0	0	0	0	0	0	0
2.00	0.25	0.15	10	10	1.0	0.134	-	2.25	0.0335
2.50	0.30	0.18	12	10	1.2	0.156	-	0.15	0.0234
3.00	0.40	0.24	16	10	1.6	0.200	-	0.20	0.040
3.50	0.45	0.27	8	10	0.8	0.113	-	0.22	0.0249
4.00	0.50	0.30	10	10	1.0	0.134	-	0.25	0.0335
4.50	0.56	0.336	4	10	0.4	0.074	-	0.28	0.0207
5.00	0.65	0.390	2	10	0.2	0.054	-	0.41	0.02214
6.00	-	-	-	-	-	-	-	-	-
TOTAL DISCHARGE									$0.198m^3/s$

$$\text{Average Discharge} - \frac{0.271 + 0.198}{2} - 0.235m^3/sec$$

Appendix A5.7 – Calculation Results

a) Ugbalo Stream

From Appendix A5.1 and A5.2, we have

Discharges 0.168m^3/s and 0.159m^3/s

Average discharge (Q) = 0.168 + 0.159

= <u>0.164m^3/s</u>

or **<u>14,126m^3/day</u>**

b) Iyagun Stream

From Appendix A5.3 and A5.4, we have

Discharges (Q) 2.613m^3/s and 1.884m^3/s

$$\text{Having average } Q = \frac{2.613 + 1.884}{2}$$

= 2.2455m^3/s

or = **194,270m^3/day**

c) Ibiekuma Stream

From Appendix A5.5 and A5.6, we have

Discharges (Q) 0.73m^3/s and 0.198m^3/s

Having average of <u>(0.273 + 0.198)</u> m/s

2

Q = 0.2355m^3/s

Or Q = **<u>20347m^3/day</u>**

ELLA STRAM DISCHARGE MEASUREMENTS

A5.8 – First Measurement

Dist. From initial point (m)	Depth (d) (m)	Depth of Observe d (d) (m)	No. of Revolutions (n)	Time (secs)	Rev/sec	Velocity v (m/s)	Area (m^2)	Discharge Q = VA = cumes
0	0	0	0	0	0	0	0	0
0.50	0.23	0.14	18	10	1.8	0.222	0.06	0.013
1.00	0.24	0.14	30	10	3.00	0.355	0.12	0.043
1.50	0.32	0.19	49	10	4.90	0.564	0.16	0.090
2.00	0.44	0.30	33	10	3.30	0.388	0.18	0.069
2.5	-	-	-	-	-	-	-	-
TOTAL DISCHARGE								$0.215m^3/s$

A5.9 – Second Measurement

Dist. From initial point (m)	Depth (d) (m)	Depth of Observed (d) (m)	No. of Revolutions (n)	Time (secs)	Rev/sec	Velocity v (m/s)	Area (m^2)	Discharge Q = VA = cumes
0	0	0	0	0	0	0	0	0
0.50	0.29	0.17	31	10	3.1	0.366	0.07	0.03
1.00	0.30	0.18	45	10	4.5	0.520	0.15	0.08
1.50	0.28	0.17	37	10	3.7	0.432	0.14	0.06
2.00	0.23	0.14	26	10	2.6	0.310	0.12	0.04
2.50	0.17	0.10	11	10	1.1	0.045	0.04	0.006
TOTAL DISCHARGE								**$0.216m^3/s$**

A5-10 – Third Measurement

Dist. From initial point (m)	Depth (d) (m)	Depth of Observed (d) (m)	No. of Revo-lutions (m)	Time (secs)	Rev/sec	Velocity V (m/s)	Area (m^2)	Discharge Q = VA = cumes
0	0	0	0	0	0	0	0	0
0.50	0.14		14	10	1.4	0.178	0.035	0.006
1.00	0.27	0.084	38	10	3.8	0.443	0.125	0.060
1.50	0.23	0.138	44	10	4.4	0.503	0.115	0.060
2.00	0.22	0.132	55	10	5.5	0.628	0.110	0.070
2.50	0.23	0.138	50	10	5.0	0.574	0.115	0.070
3.00	0.23	0.138	32	10	3.2	0.377	0.115	0.043
3.50	0.16	0.096	11	10	1.1	0.145	0.120	0.017
4.50	-	-	-	-		-	-	-
TOTAL DISCHARGE								$0.326 m^3/s$

Table A5-11 – **Amendokhian Stream Discharge Measurement (Float Method)**

Distance (m)	Time (s)	Velocity (m/s)
12	50	0.240
11	40	0.275
8	33	0.242

Average velocity = $\frac{0.240 + 0.275 + 0.242}{3}$

= **0.252m/s**

With of the River = 6m

Length (Per Unit Length of) = 1m

Average depth = 0.295m (minimum)

Flow (Q) = VA

But Area (A) = 0.295 x 6 x1

= $1.77m^2$

$\therefore$ Q = 0.252 x 1.77 = $0.446m^3/s$

= **$38{,}534m^3/day$**

Appendix 5-12 – Aquifer Characteristics in Edo State Central Senatorial District.

A 5-12 (i) Edoha Stream-Ugboha

LAYER	APPT. Res. Pa (ohm.m)	Thickness H (m)	Soil Lithology
1.	775.00	0.08	Sandy Clay
2.	387.50	1.40	"
3.	306.67	13.50	Dry Sand
4.	2970.00	24.00	"
5.	8550.00	132.50	Water Bearing
6.	630.00	Ω	Sand

Total depth – 172.2m

A5-12 (ii) Niger Bank Primary School, Illushi

LAYER	APPT. Res. Pa (ohm.m)	Thickness H (m)	Lithology
1.	1850.00	0.85	Top Soil
2.	5550.00	0.64	Sand
3.	14733.42	2.55	"
4.	18750.00	8.80	"
5.	18000.00	36.30	Sandy Clay
6.	7532.00	150.00	Water bearing sand and very extensive
7.	2997.00	Ω	Water saturated sand

Total Depth – 199.14m

A 5-12 (iii) - Igieduma Quarters, Ekpon

LAYER	APPT. Res. Pa (ohm.m)	Thickness H (m)	Lithology
1.	460	0.8	Top Soil
2.	153.33	0.27	Clay
3.	291.11	3.36	Sandy clay
4.	1400.00	7.35	Dry sand
5.	2250.00	21.88	”
6.	6000.00	74.00	”
7.	1622.71	Ω	Water bearing sand

Total Depth – 107.66m

A5-12 (iv) Idumu-Omoijede, Ewossa

LAYER	APPT. Res. Pa (ohm.m)	Thickness H (m)	Lithology
1.	210.00	0.8	Top Soil
2.	49.00	1.40	Sand
3.	278.18	6.44	Sandy clay
4.	1200.00	4.50	Dry sand
5.	600.00	54.00	Sandy clay
6.	1800	162.50	Dry sand
7.	866.67	Ω	Water bearing sand

Total Depth – 229.64m

A5-12 (v) - Market Quarters, Ebelle

LAYER	APPT. Res. Pa (ohm.m)	Thickness H (m)	Lithology
1.	240.00	0.70	Top Soil
2.	720.00	0.88	Sand
3.	488.89	6.08	Sandy clay
4.	690.00	24.00	Sand
5.	2025.00	112.00	Dry sand
6.	1000.00	Ω	Water bearing sand

Total Depth – 143.66m

5-12 (vi) Illeh Road, Ekpoma

LAYER	APPT. Res. Pa (ohm.m)	Thickness H (m)	Lithology
1.	650.00	0.70	Top Soil
2.	975.00	0.70	Sand
3.	977.78	7.50	Sand
4.	2100.00	25.00	Dry sand
5.	44,200.00	105.00	"
6.	4,333.33	Ω	Water bearing sand

Total Depth – 138.90m

Appendix 6.1

Discharge of Pump (m^3/sec)	Economic Diameter of Suction and Delivery Pipework and Valves connected to the Pump (mm)	Economic Velocity (m/sec)
0.0067m^3/sec	100mm	0.82m/sec
0.0117m^3/sec	125	0.885m/sec
0.18	150	0.97
0.025	175	1.04
0.037	200	1.13
0.05	255	1.22
0.65	250	1.28
0.10	300	1.40
0.175	375	1.53
0.277	450	1.71
0.407	525	1.83
0.567	600	1.95
0.762	675	2.07
0.992	750	2.23
1.258	825	2.32
1.565	900	2.41

Source: L.B Escritt - Water Supply And Building Sanitation Vol. 1. 1978

Apendix 6.2 – Design Procedure for Proposed Improvement of Ugbalo water scheme

Ugablo Intake discharge = $19{,}667m^3/day$ = $0.228m^3/s$

Using 75% of discharge = $14{,}774m^3/dy/sec$ = $0.171m^3/s$

Required pipe diameter for transmission for Intake to Headworks:

Using the formula for economic diameter for pipe carrying discharge over certain distance by pumping plant (Armando Lencaster, 1987)

i.e $D = 0.95\ Q^{0.432}$

Where D = required pipe diameter

Q = discharge

From the above discharge of $0.171m^3/s = 0.171m^3/s$

We have $D = 0.95\ (0.171)^{0.43} = 0.445m$

we have:

$D = 0.375m$

Use . = 450mm

Treatment Plant

(a) Rapid mixing (flash mix)

Given that 19,667m^3 of water to be treated daily.

Take detention time = 30 secs (GLUMRB)

$$\therefore \text{Tank capacity} = \frac{14750 \times 30}{24 \times 60 \times 60} = 5.12\text{m}^3$$

Using a tank depth of 1.8m and square

Sides: we have:

$$L \times B = \sqrt{\frac{5.12}{1.8}} = 1.69$$

$\therefore$ Use 1.8m x 18m x 1.8m depth

(b) Flocculation

Using horizontal paddies mixer in flocculation basin.

Detention time = 30minutes (GLUMRB min) and

(Principles of Water Quality Control – Tebbutt 1983)

$$\text{Tank capacity} = \frac{14750 \times 0.5}{24} = 307.29$$

$$= 307\text{m}^3$$

Use tank depth of = 3.5m

$$\text{Area of the tank} = \frac{307}{3.5} = 87.9\text{m}^2$$

Using rectangular tank of Length: Breadth = 2:1

We have 88m^2 = $2B \times B = 2B^2$

$$\therefore B = \sqrt{\frac{88}{2}} = 6.63$$

$$= 6.6m$$

$$\therefore \text{Length} = 13.2$$

$\therefore$ Use sizes <u>13.5 x 7 x 3.5m depth</u>

(c) <u>Sedimentation Tank</u>

Take detention time of 4hrs (GLUMRB)

$$\therefore \text{Tank capacity} = \frac{14750 \times 4}{24}$$

$$= 2458.33$$

Using a depth of 4m

$$\therefore \text{Area of tank} = \frac{2458.3}{4} = 614.58$$

Using 4 tanks of equal size

$$\text{We have } \frac{614.58m^2}{4} = 153.65$$

Using L:B ratio of 3:1,

$$\text{We have } 3B \times B = 153.65m^2$$

$$B = \sqrt{\frac{153.65}{3}}$$

$$= 7.16$$

$$7.2$$

$$\therefore \text{Length} = 3 \times 7.2 = 21.6$$

$\therefore$ <u>Use sizes (4 No) = 22m x7.5 x 4m depth each</u>

(d) <u>Filtration</u>

Using 3 filter tanks:

Take backwash time of each tank for 20minutes/day

And using filtration rate of 3.5 litres/m^2.s

(1.4-6.8 litres/m^2.s-GLUMRB)

$$\therefore \text{Filter area} = \frac{14750}{(24-1)} \times \frac{1}{60 \times 60} \times \frac{100}{3.5}$$

$$= 50.9m^2$$

$$\therefore \text{Area of each tank} = \frac{509}{3} = 16.965m^2$$

$$= \underline{17m^2}$$

Using square tanks

$$\therefore \text{Each tank} = \sqrt{17}$$

$$= 4.12$$

$\therefore$ <u>Use 3Nos of 4.5m x 4.5m each</u>

(e) <u>Chlorine</u>

Using 1.2mg/litre so as to have 0.2mg/litre residual chlorine:

$$\text{Daily dosage} = 14750 \times 1000 \times \frac{1.20}{10^6}$$

$$= 17.7kg/day$$

$$= 18kg/day$$

(f) Alum

Using 2.5mg/litre for treatment

$$\text{Daily dosage} = 14750 \times \frac{100}{10^6} \times 2.5 \text{ kg/day}$$

$$= 36.875\text{kg/day} = 37\text{kg/day}$$

(g) Clear Water Tank

Since clear water tank serves as equalizing reservoir for high lifting to sub-stations or distribution reservoirs; we use between $^1/_6$ to $^1/_3$ discharge as its capacity (M. Anis Al-Layia & Shamim Ahmad 1978)

$$\therefore \text{For the scheme of discharge} = 14{,}774\text{m}^3\text{/day}$$

$$\text{Use tank capacity of } \frac{14774}{6} = 2462\text{m}^3$$

$$= \underline{2500\text{m}^3}$$

Appendix 6.3 – Design Procedure for the Proposed Improvement of Iyagun Water Scheme.

Intake discharge = $122{,}951 m^3/day$ = $1.423 m^3/s$

Using 75% $Q = 92{,}213 m^3/day = 1.067 m^3/sec$

Required pipe diameter from intake to headworks:

Using the formula: $D = 0.95\, Q^{0.43}$

$= 0.95\,(1.067)^{0.43}$

$= 0.977m$

or from table (13) $= 0.825m$

Use = 0.825

Treatment Plant

a) Rapid Mixing (flash mix)

Given that Q = $92{,}213 m^3/day$

Detention time = 30 secs (GLUMRB)

Tank capacity $= \dfrac{92213 \times 30}{24 \times 60 \times 60} = 32.02 m^3$

Using tank of depth 2m and square sides

We have length (L) x breath (B) $= \dfrac{32.02}{2}$

$\therefore L = B = \sqrt{\dfrac{32.02}{2}} = 4.00m$

$\therefore$ Use size 4.00m x 4.00m x 2m depth

(b) Flocculation

Detention time = 30minutes (GLUMRB)-min)

Tank capacity = $\frac{92213 \times 0.5}{24}$ = $1921m^3$

= $1921m^3$

Using a depth of 4m

$\therefore$ Area of the tank = $\frac{1921}{4}$ = $480.28m^2$

Using four rectangular tanks of L:B of 2:1

We have $\frac{480.28}{4}$ = $120.1m^2$ each tank

$\therefore$ Size = LxB = 2BxB = $2B^2$

i.e $2B^2$ = $120.1m^2$

$\therefore B = \sqrt{\frac{130.1}{2}} = 7.748m$

= 7.75

$\therefore$ L = 15.5

$\therefore$ Use 4 tanks of 15.5 x 7.75 x 4m depth

(c) Sedimentation Tank

Detention time = 4hrs (GLUMRB)

Tank capacity = $\frac{92213 \times 4}{24}$

= $15,369m^3$

Using a depth of 4m

Area of tank $\frac{15369}{4}$ = $3842.2m^2$

Using 8 tank of equal sizes (rectangular)

$\therefore$ Size of each tank $= \dfrac{3842.2}{8} \quad 480.28m^2$

Using L:B ratio of 3:1

We have $3B \times B = 480.28m^2$

$3B^2 = 480.28m^2$

$B = \sqrt{\dfrac{480.280}{3}} = 12.65$

$\therefore L = 3B = 37.96$

$\therefore$ Use 8 tanks of 38 x 13 x 4m depth each

(d) Filtration

Using 4 filter tanks (square tank)

Back wash time of 20 minute/day/tank

And using filtration rate of 3.5 litres/m^2.s (GLUMRB)

$\therefore$ Filter area $= \dfrac{92213}{(24-1^1/_3)} \times \dfrac{1}{60 \times 60} \times \dfrac{1000}{3.5}$

$= \dfrac{92213}{22^2/_3} \times \dfrac{1}{3600} \times \dfrac{1000}{3.5}$

$= 322.83m^2$

Area of each tank $= \dfrac{322.83}{4}$

$= 80.71m^2$

Size of tank $= \sqrt{80.71}$

$= 8.98$

$$= \underline{9m \times 9m}$$

(e) <u>Chlorine</u>

Using 1.2mg/litre

$$\text{Dosage} = \frac{92213 \times 1000 \times 1.2}{10^6} \quad kg/day$$

$$= 110.66$$

$$= \underline{111kg/day}$$

(f) <u>Alum</u>

Using 2.5mg/litre for treatment

$$\text{Daily dosage} = \frac{92213 \times 1000 \times 2.5}{10^6} \; kg/day$$

$$= 230.5 \; kg/day$$

$$= \underline{231kg/day}$$

(g) <u>Clear Water Tank:</u>

Using $^1/_6$ of discharge (Q)

$$\text{i.e } Q = 92213m^3/day$$

$$\therefore \text{Tank capacity} = \frac{92213}{6}$$

$$= 15,368.8m^3$$

$$= \underline{15,370m^3}$$

Appendix 6.4 – Design Procedure for the proposed improvement of Ikiekuma water scheme.

Intake discharge = $24{,}750m^3/day$ = $0.287m^3$

Using 75% Q = $18563m^3/day$ = $0.215m^3/s$

Required pipe diameter for transmission from

Intake to Headwork:

Using the formula: $D = 0.95\ Q^{0.43}$

Where D = required diameter

Q = discharge

$\therefore\quad D = .95\ (0.215)^{0.443}\ 0.491$

or from table (13) = .375m

$\therefore$ Use = <u>450mm</u>

Treatment Plant

(a) Rapid mixing (flash mix)

Quantity of water to be treated daily = $24{,}750m^3$

Detention time = 30secs (GLUMRB)

Tank capacity = $\dfrac{18563 \times 30}{24 \times 60 \times 60} = 6.45m^3$

Using tank depth of 2m and square sides

We have length x Breadth = $\sqrt{\dfrac{6.15}{2}} = 1.795$

<u>Use = 2.0 x 2.0m x depth</u>

(b) <u>Flocculation</u>

Detention time = 30minutes (GLUMRB) min)

Tank capacity $= \frac{18563 \times 0.5}{24} = 386.73m^3$

$= 387m^3$

Using tank depth of $= 3.5m$

Area of the tank $= \frac{387}{3.5} = 110.49m^2$

Using two rectangular tanks of length: breath of 2:1

$\therefore$ We have $\frac{110.49}{2}$ $55.25m^2$ each tank

$\therefore$ Size: $2B \times B = 55.25$

$2B^2 = 55.25m^2$

$B = \sqrt{\frac{55.25}{2}} = 5.26m$

$= 5.3m$

$\therefore$ Length $= 10.6m$

$\therefore$ <u>Use two tanks of 10.6m x 5.5m x 3.5m depth</u>

c) <u>Sedimentation Tank</u>

Detention time = 4hrs (GLUMRB)

$\therefore$ Tank capacity $= \frac{18563}{24} \times 4$

$= 3093.8$

Using a depth of 4m

Area of tanks $= \frac{3093.8}{4} = 773.46m^2$

Using 4 tank of equal size (rectangular)

$$\text{Size of each tank} = \frac{776.46}{4}$$

$$= 193.36m^2$$

Using length: breadth ration of 3:1

$$\text{We have } 3B \times B = 193.36m^2$$

$$3B^2 = 193.36$$

$$\therefore B = \sqrt{\frac{193.36}{3}}$$

$$= 8.63m$$

$$\therefore \text{Length} = 3B = 24.085$$

∴ Use <u>4 tanks of 24.1m x 8.1m x 4m depth</u>

(c) <u>Filtration</u>

Use 3 filter tanks (square tank)

Backwash time = 20minute/day per tank

Use filtration rate of 3.5 litres/m^2.s (GLUMRB)

$$\text{Filter area} = \frac{18563}{(24-1)} \times \frac{1}{60 \times 60} \times \frac{1000}{3.5}$$

$$= \frac{18563}{23} \times \frac{1}{3600} \quad \frac{1000}{3.5}$$

$$= 64.055$$

$$\text{Area of each tank} = \frac{64.06}{3} = 21.35m^2$$

$$\therefore \text{Size of tank} = \sqrt{21.35} = 4.62m$$

$\therefore$ Use <u>3 Nos 4.7m x 4.7m each</u>

(e) <u>Chlorine</u>

Using 1.2mg/litre

$$\therefore \text{Dosage} = \frac{18563 \times 1000}{10^6} \times 1.2$$

$$= 22.28$$

$$= 22.3\text{kg/day}$$

(f) <u>Alum</u>

Using 2.5mg/litre of treatment

$$\therefore \text{Daily dosage} = \frac{18563 \times 2.5 \times 1000}{10^6}$$

$$= 46.41\text{kg/day}$$

$$= \underline{4.41\text{kg/day}}$$

(g) <u>Clear Water Tank:</u>

Using $^1/_6$ of discharge (Q)

$$\text{Where } Q = 18{,}563\text{m}^3\text{/day}$$

$$\therefore \text{Tank capacity} = \frac{18563}{6}$$

$$= 3093.83\text{m}^3$$

Use $\underline{3100\text{m}^3}$

Appendix 6.5 – Design procedure for the proposed Ella Water Scheme

Stream discharge (Q) = 21,799m^3/day = 0.252m^3/s

75% Q = 16349m^3/day = 0.189m^3/s

Required pipe diameter for transmission from intake

To the Headworks = D = 0.95 $Q^{0.43}$

= 0.95 $(0.189)^{0.43}$ = .464m

or from table = .375m

∴ Use <u>450mm</u>

Treatment Plant

(a) Rapid mix (flash mix)

Quantity of water to be treated = 21,799m/day

Detention time = 30secs (GLUMRB)

Tank capacity = $\frac{16349 \times 30}{24 \times 60 \times 60}$ = 5.68m^3

Using tank depth of 1.8m and square sides

We have length or breadth = $\sqrt{\frac{5.68}{1.8}}$ = 1.685

∴ Use <u>1.8m x 1.8m x 1.8m</u>

(b) <u>Flocculation</u>

Detention time = 30minutes (GLUMRB min)

Tank capacity = $\frac{16349 \times 0.5}{24}$

= 340.61/m^3

Using tank depth of 3.5m

$$\therefore \text{Area of the tank} = \frac{340.61m^3}{3.5} = 97.32m^2$$

$$= 97.32$$

Using 2No rectangular tanks of L:B of 2:1

$$\text{Sizes} = 2B \times B = \frac{(97.32)}{2} = 48.66m^2$$

$$\therefore 2B^2 = 48.66$$

$$\therefore B = \sqrt{\frac{48.66}{2}} = 4.93$$

$$\therefore \text{Length (L)} = 9.86$$

$\therefore$ Use <u>2No tanks of 10m x 5m x 3.5m</u>

(c) <u>Sedimentation Tank</u>

Detention time = 4hrs (GLUMRB)

$$\therefore \text{Tank capacity} = \frac{16349 \times 4}{24} = 2724.83$$

$$= 2724.83$$

Using a depth of 4m:

$$\text{Area of tank} \quad \frac{2724.8}{4} = 681.21m^2$$

Using 4 tanks of equal size (rectangular)

$$\text{Size of each tank} = \frac{681.21}{4}$$

$$= 170.30m^2$$

Using L:B rate 3:1

We have 3B x B $=$ 170.30

$$3B^2 = 170.30$$

$$\therefore B = \sqrt{\frac{170.30}{3}} = 7.53$$

$$\therefore L = 3 \times 7.53 = 22.6$$

$\therefore$ Use <u>4 tanks of 23m x 7.6m x 4m depth each</u>

(d) <u>Filtration</u>

Use 3 filter tanks of square sides

Using backwash time of 20 minute/day per tank

and filtration rate of 3.5 litres/m^2.s (GLUMRB)

$$\text{filter area} = \frac{16349}{(24-1)} \times \frac{1}{60 \times 60} \times \frac{1000}{3.5}$$

$$= 56.42\text{m}^2$$

$$\text{Area of each tank} = \frac{56.42}{3} = 18.81\text{m}^2$$

$$\text{Size of tank} = \sqrt{18.81} = 4.34\text{m}^2$$

$\therefore$ Use <u>3 Nos tank of 4.5m x 4.5m</u>

(e) <u>Chlorine:</u>

Using dosage of 1.2mg/lite:

We have $\dfrac{16349 \times 1000 \times 1.2\text{kg}}{10^6}$

$$= 19.62\text{kg/d}$$

$$= \underline{20\text{kg/day}}$$

(f) <u>Alum</u>

Using 2.5mg/litre for treatment

$$\text{Daily dosage} = \frac{16349 \times 1000 \times 2.5}{10^6}$$

$$= 40.87\text{kg/d}$$

$$= \underline{41\text{kg/day}}$$

(g) <u>Clear Water Tank</u>

Using 1/6 of discharge (Q) = 2,725m^3

Use 2,750m^3

Appendix 6.6 – Design procedure for the proposed Amendokhian water scheme at Uromi

Stream discharge (Q) = $38{,}534 m^3/day$ = $0.446 m^3/s$

75% Q = $28{,}901 m^3/day$ = $0.335 m^3/s$

Required pipe diameter for transmission form intake to

The Headworks = D = $0.95 (Q)^{0.443}$

= $0.95(0.335)^{0.43}$ = 0.593m

Or from table (13)

∴ Use = <u>525mm size</u>

<u>Treatment Plant</u>

(a) Rapid mix (flash mix)

Quantity of water to be treated daily = $38.534 m^3$

Detention time = 30 sec (GLUMRB)

Tank capacity = $\frac{28901 \times 30}{24 \times 60 \times 60}$ $10.04 m^3$

Using tank depth of 2m and square sides:

We have: sides = $\sqrt{\frac{10.04}{2}}$ = 2.24

∴ Use <u>2.4m x 2.4m x 2m depth</u>

(b) <u>Flocculation</u>

Detention time = 30 minutes (GLUMRB min)

$$\text{Tanks capacity} = \frac{28.901 \times 0.5}{24}$$

$$= 602.1m^3$$

Using tank of 4m

$$\text{Area of the tank} = \frac{602.1}{4} = 150.53m^2$$

Using 3No rectangular tanks of L:B ratio of 2:1

$$\therefore \text{Sizes of each tank} = 2B \times B = \frac{150.53}{3}$$

$$\text{i.e } 2B^2 = 50.18m^2$$

$$\therefore B = \sqrt{\frac{50.18}{2}} = 5.008$$

$$\therefore L = 10.01$$

$\therefore$ Use 3Nos tanks of 10m x 5m x 4m depth

(c) Sedimentation Tank

$$\text{Detention time} = 4\text{hrs (GLUMRB)}$$

$$\therefore \text{Tank capacity} = \frac{28.901 \times 4}{24}$$

$$= 4816.83m^3$$

Using 6 tanks of rectangular size:

$$\text{We have size of each tank} = \frac{120421}{6}$$

$$= .200.7m^2$$

Using L:B ratio of 3:1

$$\text{We have } 3B \times B = 200.7$$

$$3B^2 = 200.7$$

$$\therefore B = \sqrt{\frac{200.7}{3}} = 8.18$$

$$\therefore L = 24.54$$

$\therefore$ Use <u>6 tanks of 2.5m x 8.3m x 4m depth each</u>

(d) <u>Filtration</u>

Use 3No filter tanks of square sides

Using back washing time of 20 minutes/day/tank and

Filtration rate of 3.5 litrre/m^2.s (GLUMRB)

$$\therefore \text{Filtration area} = \frac{28901}{(24\text{-}1)} \times \frac{1}{60 \times 60} \times \frac{1000}{3.5}$$

$$= 99.73 = 100m^2$$

$$\therefore \text{Area of each tank} = {}^{100}/_{3} = 33.3$$

$$\text{Size of each tank} = \sqrt{33.33} = 5.76$$

$\therefore$ Use <u>3Nos tank of 5.8m x 5.8m each</u>

(e) <u>Chlorine</u>

Using dosage of 1.2mg/litre

We have: $\dfrac{28901 \times 100 \times 1.2kg}{10^6}$

$$= 34.68kg/d = 35kg/day$$

(f) <u>Alum</u>

Using 2.5mg/litre

$$\text{Daily dosage} = \frac{28901 \times 1000 \times 2.5kg}{10^6}$$

$= 72.25 kg/d$

$= \underline{73 kg/day}$

(g) Clear Water Tank

Using $^{1}/_{6}$ of discharge (Q) (Anis, AL-Layia & Shamim 1978)

Where $Q = 28901 m^3/day$

$\therefore$ Tank capacity $= \frac{\underline{28901}}{6} = 4816.83 m^3$

$= 4817 m^3$

$\therefore$ $\underline{\text{Use } 4850 m^3}$

Appendix 6.7 – Determination of Pump Capacity and Number for Each Scheme

(a) Ugbalo Scheme

Discharge Q = $14750m^3/day$

Taking daily operation at 18hrs.

Expected pump discharge = $\frac{14750}{18}$ = $819.44m^3/hr$

Or = $0.228m^3/sec$

Recommended No. of pumps = 6 No (4on, 2 on stand by)

Capacity of each working pump to generate a total $0.228m^3/se$

i.e each pump to generate $\frac{0.228}{4}$ = $0.057m^3/s$

Power of each pump = QH (Armando Lencastre-1987)

Low lift pumps

Where H = 90m

= $9.81KN/m^3$

Q = $0.057m^{3-/s}$

$\therefore$(P) = $9.81 \times 0.057 \times 90$ = 50.33kw

If efficiency = 86%

$\therefore$Required power effective p = $50.33 \times \frac{100}{86}$ = 58.52kw

$\therefore$ Use 6 No – 60kw each

High Lift

Where H = 150m

P = QH = 9.81 x 0.057 x 150

Effective (p) = 83.88kw

∴ Use 6 No pumps of 100kw each

(b) Iyagun:

Discharge = 92m213m^3/day

Taking daily operation for 18hrs

Expected output per hour = $\frac{92213}{18}$ = 5123m^3/hr

Use six pumps (4 working, 2 on standby)

∴ For each pump working, Q = $\frac{1.423}{4}$ = 0.356m3/s

Low Lift

H = 50m

= 9.81KN/m^3

Q = 0.356

∴P = QH = 9.81 x 0.356 x 50

If efficiency = 86%, P = 174.618 x $\frac{100}{86}$ = 203kw

∴Use 6 No – 220kw each

High Lift

H = 210

= 9.8

$$Q = 0.356$$

$$\therefore P = 9.81 \times 0.356 \times 210$$

Efficiency = 86% $\therefore$ effective P = $733.4kw \times \frac{100}{86}$ = 852.8kw

$\therefore$ Use <u>6No – 900kw each</u>

(c) <u>Ibiekuma</u>

$Q = 18{,}563m^3/dday \quad = 0.2215m^3/s$

Taking daily operation of 18hrs

Expected pump discharge $= \frac{18563}{18} = 1031.27m^3/h$

$= 0.287m^3/s$

Using six pumps (4 working while 2 on stand by.

Capacity of each working pump to generate a total of $0.287m^2/s$

$= \frac{0.287}{4} = 0.0718^2/s$

$= 0.072m^3/s$

$\therefore$ Power of pump = QH

For low lift pump: H = 75m

$Q = 0.072m^3/s$

$= 9.81KN/m^3$

$\therefore$ Power (p) $= 9.81 \times 0.072 \times 75$

$= 52.79kw$

$\therefore$ Actual per effective power $= 52.79 \times \frac{100}{86}$

$= 61.38kw$

$\therefore$ Use <u>6 No – 75kw each</u>

<u>High Lift</u>

$H = 211m$

$\therefore P = QH = 9.81 \times 0.072 \times 211$

$= 149kw$

$\therefore$ Use <u>6 No pumps of 175kw</u>

(d) <u>Ella Scheme</u>

$Q = 16{,}349m^3/day$

Operating for 18hrs daily: we have $Q = \frac{16349}{18}$

$= 908.28m^3/hr$

or $= \underline{0.252m^3/sec}$

Use six pumps

Low lift Pump:

$Q = 0.252m^3/s$

$= 9.81KN/m^3$

$H = 50m$ (assumed)

$\therefore$ Power (p) of each pump

assuming 4 pumps working simultaneously while

2 on standby

Q expected from each pump $= \frac{0.252}{4}$

$= 0.0655m^3/s$

$\therefore P = QH = 9.81 \times 0.0655 \times 50$

$= 32.13kw$

$\therefore$ Use <u>6 NO – 40kw pump each</u>

High Lift

$Q = {}^{0.252}/_{4} = 0.0655m^3/s$

$H = 100m$ (assumed)

$= 9.81$

$\therefore P = 9.81 \times 0.0655 \times 100 = 64.26kw$

$\therefore$ <u>Use 6 No – 75kw pump each</u>

(e) <u>Amendokhian</u>

$Q = 28,900m^3/day$

For 18hrs daily operation:

Expected pump output $= \frac{28900m^3/s}{18 \times 3600}$

$= 0.45m^3/sec$

Use six pump (4 on; 2 on standby)

Low lift $\therefore$ Q from each pump working

$= \frac{0.45}{4} = 0.1125m^3/s$

$\therefore$ Power (p) = QH

Where H = 80m

Q = 0.1125

Power (p) = $9.81 \times 0.1125 \times 80$

$= 88.29kw$

Effective $P = 88.29 \times \frac{100}{86} = 102.66kw$

$\therefore$ Use 6 Nos – 110kw each

High Lift

$H = 150m$

$\therefore P = QH = 9.81 \times 0.1125 \times 150 = 165.54k$

$\therefore$ Use 6 No 200kw