DETAILED PROJECT REPORT FOR AWARA DAM/OYIMO RIVER SMALL HYDRO POWER DEVELOPMENT, IKARE, AKOKO NORTH EAST L.G.A, ONDO STATE

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- Consultant
- Client

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2.5 ACRONYMS AND ABBREVIATIONS

CBO	Community-Based Organizations
GDP	Gross Domestic Product
GEF	Global Environmental Facility
ESHA	European Small Hydropower Association
HH	House Hold
IEA	International Energy Agency
IPP	Independent Power Producers
IRR	Internal Rate of Return
kW	Kilowatt
kWh	Kilowatt hours
kWe	kilowatt electrical
LEDs	Light Emitting Diodes
MDGs	Millennium Development Goals
MH	Micro-Hydropower
MHP	Micro-Hydropower Plant
MW	Mega Watt
NBRRI	Nigerian Building Road Research Institute
NGO	Non-Governmental Organisation

NPV	Net Present Value
SGP	Small Grants Programme (GEF)
NIMET	Nigeria Meteorological Agency
ITDG	Intermediate Technology Development Group
CB	Circuit Breaker
G_1, G_2	Generator units 1, 2
CRIN	Cocoa Research Institute of Nigeria

2.6 DEFINITIONS

Community

Refers to a group of individuals who come together to address common life and livelihood needs that can be met by the provision of energy services. In some countries, a group of individuals is defined as community because of the geographical proximity. In others, a community is defined by its socio-economic context, which may be urban, peri-urban or rural.

Climate Change

As defined by the United Nations Framework Convention on Climate Change UNFCC), refers to a change in climate that is directly or indirectly attributable to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Environment

The sum total of all surrounding conditions that influence the growth, behaviour and development of living forms.

Energy Efficiency

Refers to the use of less energy for delivering an energy service with similar outputs to a service provider through more efficient means.

Energy Services

Refers to the end user applications of an energy delivery system that meet tangible and/or intangible life and livelihoods needs and social services (e.g., recreation, lighting, cooking, communications, transportation, heating).

Human Development Index

A composite index that measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, as measured by life expectancy at birth; knowledge, as measured by the adult literacy rate and the combined gross enrolment ratio for primary, secondary and tertiary schools; and a decent standard of living, as measured by Gross Domestic Product per capita in purchasing power parity US dollars.

Livelihood

Comprises people, their capabilities and their means of living, including food, income, and assets. Assets can be tangible (resources and stores), or intangible (claims and access). A livelihood is environmentally sustainable when it maintains or enhances the local and global assets on which livelihoods depend, and has net beneficial effects on other livelihoods. A livelihood is socially sustainable when it can cope with and recover from stress and shocks, and provide for future generations.

Local Benefits

Life and livelihood benefits, tangible or intangible, accrued by local communities in the area where a project is implemented. Such benefits are distinct from the global environmental benefits of a project, which accrue to all human beings, regardless of where they reside.

Micro-hydropower

Any power scheme below 100 kilowatts (kWe) and above 5 kWe is referred to in this publication as a micro-hydropower scheme. A power scheme below kWe is commonly referred to as a Pico-Hydropower.

Partnership

Refers to the joint application and deployment of human, technical and/or financial resources for a common purpose. While the objectives of different partners in a partnership may be different, the goal is similar.

Renewable Energy

Refers to those naturally occurring energy systems that are self-replenishing or vast in resources, including Small Hydropower, biomass, solar, wind, among others.

2.7 ACKNOWLEDGEMENT

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We are indeed very grateful to you all.

To God be the glory, Amen.

3.0 SALIENT FEATURES

I.	**GENERAL**		**SCHEME I**	**SCHEME II**
3.1	Name of Project:		Awara Dam/Oyimo River SHP	Awara Dam/Oyimo River SHP
3.2	Location			
3.2.1	State:		Ondo State	Ondo State
3.2.2	L.G.A:		Akoko North East LGA	Akoko North East LGA
3.2.3	Access :		0.8Km off Awara Road	2Km off Ado-Ikare Road
3.2.4	Nearest Rail:		Osogbo	Osogbo
3.2.5	Nearest Airport:		Akure Airport	Akure Airport
3.3	Geographical			
3.3.1	Longitude:		7^{o}·30’ and 8^{o}.00’E	
3.3.2	Latitude:		5^{o}·30’ and 6^{o}.00’N	
3.4	Details of Site			
3.4.1	Name of River:		Awara River	Elemoro River
3.4.2	Catchment area:		1.984 $x10^{6}m^{2}$	$196.8x10^{6}$ Km^{2}
3.4.3	Topography:		Undulating terrain with outcrops of rocks	
3.5	Hydrology			
4.5.1	Min. discharge:	-	$0.0098m^{3}/s$	1.28 m^{3}/s
4.5.2	Max. Flood discharge:	-	$0.1607m^{3}/s$	260.88 m^{3}/s
4.5.3	Min. Water level:	-	371.85m	321.5203m
4.5.4	Max. Water level:	-	379.85m	322.206m
II	**PROJECT FEATURES**			
3.6	Diversion (New Construction):			
3.6.1	Type:	-	No	Weir
3.6.2	Length of Canal:	-	N/A	N/A
3.6.3	Tail water level Qmax :	-	N/A	N/A
3.6.4	Tail water level Qmin:	-	N/A	N/A
3.7	Headrace Channel:			
3.7.1	Shape:	-	N/A	N/A
3.7.2	Size:	-	N/A	N/A
3.7.3	Bed slope:	-	N/A	N/A
3.7.4	Material of lining:	-	N/A	N/A

3.7.5	Design Discharge:	-	N/A	N/A
3.7.6	Free Board:	-	N/A	N/A
3.7.7	Side slope:	-	N/A	N/A

3.8 Desilting Tank:

3.8.1	Size of Tank:	-	N/A	N/A
3.8.2	Material:	-	N/A	N/A
3.8.3	Particle size elimination:	-	N/A	N/A

3.9 Forebay Tank /Basins

3.9.1	Capacity:	-	N/A	N/A
3.9.2	Free board:	-	N/A	N/A
3.9.3	Spillway capacity:	-	N/A	N/A
3.9.4	Maximum dyke height:	-	N/A	N/A
3.9.5	Flood capacity:	-	N/A	N/A
3.10	Power Canal			
3.10.1	Type:	-	N/A	N/A
3.10.2	Material:	-	N/A	N/A
3.10.3	Length:	-	N/A	N/A
3.10.4	Design discharge:	-	N/A	N/A
3.10.5	Thickness size:	-	N/A	N/A
3.10.6	Depth:	-	N/A	N/A

3.11 Penstock

3.11.1	Material:	-	Mild Steel	Mild Steel
3.11.2	Nos:	-	One	One
3.11.3	Length :	-	25m	25m
3.11.4	Design discharge:	-	0.11 m^3/s	10.8 m^3/s
3.11.5	Thickness:	-	25mm	110.0mm
3.11.6	Diameter:	-	300mm	1.2m (Bifurcation of 2x600mm)

3.12 Power house

3.12.1	Type:	Bungalow	Bungalow
3.12.2	Net Head:	10m	12m
3.12.3	Power House Dimension:	4 x 4 m	20.55 x10 m
3.12.4	Installed capacity (turbines)	1 x 10kW	3 x 400kW

3.13 Turbine

3.13.1	Type:	Cross Flow	Cross Flow
3.13.2	Nos:	1Nos	3Nos
3.13.3	Capacity:	10kW	400kW

3.14	Generator Type:	-	Synchronous	Synchronous
	3.14.1 Capacity:	-	12.5KVA	3 x 500KVA
	3.14.2 Volume:	-	400V	400V
3.15	Generators Transformers:			
	3.15.1 Nos:	-	Nil	3
	3.15.2 Capacity/Voltage:	-	Nil	1.5MVA
3.16	Annual Energy Generation:	-	87,600kWhr	10.512GWhr
	3.16.1 At 75% load factor (Million units):	-	65,700kWhr	7.884GWhr
	3.16.2 At 60% load factor (Million units):	-	52,560kWhr	6.3072GWhr
3.17	Estimates of cost			
	3.17.1 Total Cost	₦ 14,477,931.66		₦ 1,016,669,791.00
	3.17.1.1 Civil works	₦ 6,700,960.00		₦ 737,000,000.28
	3.17.1.2 E & M works	₦ 4,420,200.00		₦ 61,590,035.00
	3.17.1.3 O & M	₦ 1,680,887.28		₦ 13,778,789.58
	3.17.1.4 Power Evacuation Costs	₦ 500,000.00		₦ 17,470,443.00
	3.17.2 Cost of installation per kW	₦ 1,447,793.17kW		₦ 847,224.83/kW
3.18	Revenue Generation			
	3.18.1Generation Cost/year:	₦1, 324,512.00		₦ 158,941,440.00
3.19	Alternative Energy Cost/yr			
	3.21.1 PHCN:	N/A		
	3.21.2 Diesel Generator: (Water treatment plant)	₦112, 250,880.00		
3.20	Internal Rate of Return	Nil		25.01%
3.21	Payback Period	Nil		7

4.0 BRIEF SOCIAL CONTEXT

4.1 Project Background

A Bank of Industry/Ondo State Government/UNIDO Regional Centre for Small Hydro Power for Africa, Abuja collaborative effort was born on 23rd December, 2010. One of the resolutions of the body was the need to embark on a reconnaissance survey of all perennial water sources and existing water production facilities in the state with a view to assessing their viability for SHP development pre-feasibility studies.

32 water sources of various sizes and nature were identified across the three senatorial districts of the state (**Table 4.1**) out of which eleven, believed to possess potentials for significant SHP generation were selected and scheduled for further reconnaissance survey as shown in **Table 4.2**

Table 4.1: Water Sources in Ondo State

S/No	Senatorial District	Local Govt Area	Water Sources	Location	Remark
1		Ese-Odo	Aroqbo Creek	Aroqbo	Not Developed
2		Ese-Odo	River Oluwa	lqho Aduwo	Not Developed
3		Ese-Odo	Ikerekere Stream	Idepe	Not Developed
4		llaie	Igbokoda River	Igbokoda	Not Developed
5		llaie	River T alita	Atijere	Not Developed
6		llale	Kurawe Stream	Mahin	Not Developed
7	**South**	lIaje	Ifara River	Ago Church	Not Developed
8		lIaje	Akuii River	Agerige	Not Developed
9		Irele	Omi Stream	Ode-Omi	Not Developed
10		Odiobo	Ominla River	Odigbo	Not Developed
11		Okitipupa	Orniiu River	liu-Odo	Not Developed
12		Okifiouoa	Lowolomo	Igbotako	Developed
13		Okitipupa	Agbure Spring	Ode-Aye	Developed
14		Okitipupa	Atan Spring	Ode-Irele	Developed
15		Akure North	Ogbese River	Oqbese	Developed
16		Akure South	Ala River	Akure	Developed
17		Akure South	Ukere Spring	Oshinle Akure	Developed
18		Ifedore	Owena River	Sokoto	Developed
19	**Central**	Ifedore	Owena River	Igbara-Oke	Developed
20		Ifedore	Owena River	Owena-Ondo	Developed
21		lIe-	Oni River	Okeigbo	Developed
22		lIe-Oluji/Oke-	Awo Spring	lIe-Oluji	Not Developed
23		Ondo West	Odowo River	Odowo	Not Developed
. 24		Akoko North	Awara River	Awara Ikare	Developed
25		Akoko South	IsowolObe	Ifira Akoko	Not Developed
26		Akoko South	Ebomi Lake	Ipesi	Not Developed
27		Akoko South	Ako Spring	Oba Akoko	Not Developed
28	**North**	Akoko South	Oyimo River	Supare	Not Developed
29		Ose	Oruju Spring	Ifon	Developed
30		Ose	Oqbasa River	Idoani	Developed
31		Owo	Ose River	Ose- Owo	Developed
32		Owo	Oiuobere/Oobes	Owo	Not Developed

Table 4.2: Selected Water Sources for Reconnaissance Survey.

S/No	SENATORIAL DISTRICT	LOCAL GOVERNMENT AREA	RIVER	LOCATION	DATE
1	**South**	Okitipupa	Oluwa River	Ode-Aye	20-01-2011
2	**Central**	Akure North	Oqbese River	Ogbese	19-01-2011
3		Ifedore	Owena River	Sokoto	
4		Ifedore	Owena River	Igbara-Oke	
5		Ifedore	Owena River	Owena-Ondo Rd	
6		lle-lluj/Okeiqbo	Oni River	Okeigbo	
7		Ondo West	Odowo River	Odowo	
8	**North**	Akoko North East	Awara River	Awara, Ikare	18-01-2011
9		Akoko South West	Oyimo River	Supare	
10		Ose	Ogbasa River	Idoani	
11		Owo	Ose River	Ose- Owo	

4.2 Community Brief

The Awara Dam/Oyimo River is about 7km off the Ikare-Ado-Ekiti motorway. The immediate communities are residential dwellers as well as Orimolade CAC Community. A lot of agricultural activities are carried out in the immediate environment. The religious beliefs are predominantly Islam, Christianity and some Traditionalist.

4.3 Electric Power Access

Access to electric power is yet to be fully met at the Awara community since the existing 11KV radial line is not energised. The water treatment plant at the dam even though not fully operational as a result of delay in extending electricity grid to the project site has two diesel generator sets available for its operation.

The old treatment plant has been upgraded with a new scheme fitted with modern operating system beside the old Plant. The two treatment plants can operate simultaneously if fully powered. A simultaneous operation of the two plants would fill up the over head water distribution tank in 48hours as compared to 72hours when each plants operates above.

A 2x800kVA diesel generators are available as the major source of power for the treatment plants. These generators consume about 162.4litres of diesel per hour at 80% load and a cost of N112,250,880.00 annually for a twelve hour-day operation.

The PHCN supply is delivered through a 1x500kVA, 11kV transformer which is yet to be energised. The PHCN Power supply in the country at present is severally described as epileptic, which implies that the plants will most of the time be generator-driven. The power supply arrangement at the plants is as shown in **Figure 4.3.1** and drwg No. 7/9.

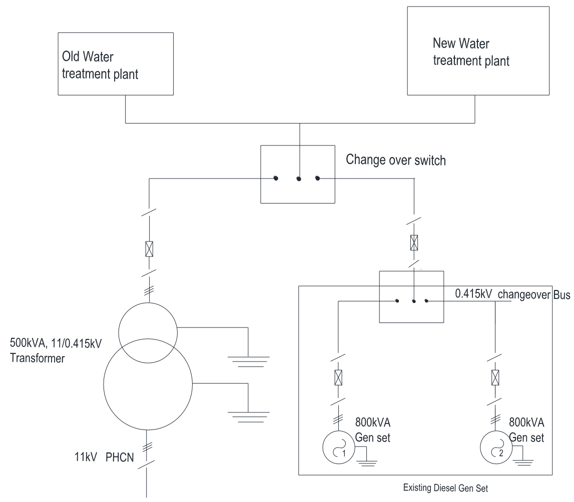


Figure 4.3.1 Power Supply Diagram at Awara Dam Water Treatment Scheme

The Ondo State government, concerned about the high operating cost on fossil fuel, resolved to source for a more freindly, cheaper and reliable source of power. This source of power is to be delivered by a small hydropower generating plant. This small hydropower plant when commissioned will ensure an un-interruptible power supply to the water treatment plant and the immediate community.

However, Hydrology report has revealed that the power realizable from the SHP if built at Awara would not deliver enough power to run the Water treatment plants. However, since Oyimo River is about 5km from Awara dam and with a better hydrology analysis, it was selected for the SHP plant. The SHP to be built comprises three units of 400kW power turbines generating a total of 1.2MW of Electricity.

The new power arrangement for the scheme is as shown in the **Figure 4.3.2** and Drwg No.7/9

4.4 Socio-Economic Activities

The immediate communities are predominantly farmers. The traditional method of palm kernel cracking is predominant hence great opportunities for agro-processing exists and thereby adding value to resources and materials.

4.5 Government Policies (Financial, Industrial, Economic, Environment etc.)

4.5.1 Industrial

The overriding objective of industrial policy is to accelerate the pace of industrial development by radically increasing value added at every stage of the value chain. One specific policy thrusts very relevant to productive use of the energy from the SHP plant is ‘ Establish a structured and efficient micro, small, and medium – size enterprise sector to enhance sustainable economic development, generate employment, and create wealth.

4.5.2 Financial

The policy thrust is to build and foster a competitive and healthy financial system to support development and to avoid systemic distress. One such thrust is to develop a structure of incentives to enable the financial system to play a developmental role by financing the real sector of the economy.

4.5.3 Environment

The policy thrust focuses on ensuring a safe and healthful environment that secures the economic and social well- being of Nigerians on a sustainable basis. The specifics of the agenda are enumerated in the Environmental Renewal and Development Initiative, the primary objectives of which are "to take full inventory of Nigeria's natural resources, assess the level of environmental damage, as well as design and implement restoration and rejuvenation measures aimed at halting further degradation of our environment.''

4.5.4 Infrastructure Development

Infrastructure needs cut across sectors and is central to economic development. Nigeria's infrastructure does not meet the needs of the average investor, inhibiting investment and increasing the cost of doing business. The government policy thrust is to develop and maintain adequate and appropriate infrastructure that is conducive to private sectors-driven economic growth and development, ensuring private sector participation in the process and creation of a competitive business environment.

Some specific policy thrusts are:

- Provide counterpart funding for major infrastructure projects, such as either energy infrastructures, for which the resource involvement is too high or the incentive too low for private sector participation.
- Increase the share of renewable energy in the total energy mix.

4.5.5 Macro-economy

The policy thrust is to take bold steps to plug leakages in order to achieve macroeconomic stability and support a more efficient use of resources to grow the economy. One specific policy thrusts is to sustain a rapid, broad- based GDP growth rate outside of the oil sector that is consistent with poverty reduction, employment generation and a sustainable environment.

4.5.6 Energy

The national energy policy recognizes the multi-dimensional nature of energy and therefore addresses diverse issues such as research and development, energy pricing and financing, legislation, energy efficiency, environment etc. The overall thrust of the energy policy is the optimal utilization of the nation's energy resources for sustainable development.

4.5.6.1 Hydropower

Some of the specific policies on hydropower are:

- The nation shall pay particular attention to the development of the mini and micro hydropower schemes
- The exploitation of hydro resources shall be done in an environmentally sustainable manner.
- A target of 10% contribution to the fuel mix by 2025.

5.0 PROJECT CONCEPTUALIZATION

5.1 Objectives

The main objective is to harness Small Hydropower potential available from Awara Dam as shown in - Figure 5.1. A successful implementation of the community – level small hydropower would focus on removing policy, technical, and institutional barriers to scaling-up off-grid energy systems, such as this SHP option to meet energy services demands in Nigeria's remote, off-grid communities, close to Awara Dam in Ikare, Akoko North East L.G.A of Ondo State.

Figure 5.1 Awara Dam Site

The inefficiency of PHCN as a national public utility has been a major cause of high degree of poverty in the rural areas since electricity is a stimulant for economic growth in any society. It is not an over statement to mention that the poor state of power supply in the society coupled with high cost of running diesel engine has led to the closing down of some notable factories in our society. Even, inadequate water supply in most cases could be traced to lack of power supply to the Waterworks.

Therefore, developing an independent, reliable, affordable and renewable energy source will be a big boost in breaking the poverty cycle so common in the rural areas of Nigeria since this base energy will act as a catalyst for the development of other local resources and the creation of productive opportunities. This will invariably lead to potential improvement in the well being of the rural poor on a long-term basis from both governmental and private initiatives and efforts.

UNIDO's energy strategy aims at helping developing countries to achieve the following objectives:

- Enhance access of the poor to modern energy sources based on renewable energies such as SHP.
- Increase the competitiveness of their industries by reducing industrial energy intensity
- Reduce their impact on climate change by decreasing the carbon emissions of their industries from conventional fuels and promoting renewable energy technologies.
- Increase the viability of their enterprises, particularly in rural areas, by augmenting availability of renewable energy for productive uses, a job creation resulting in poverty level reduction.

5.2 Project Description

FEASIBILITY STUDIES, PRELIMINARY & FINAL ENGINEERING DESIGN FOR SMALL AND MEDIUM HYDRO POWER PLANT AT AWARA DAM, IKARE, ONDO STATE.

Awara Dam is located in Akoko North East Local Government of Ondo State. The project area is situated between Latitudes 5^0: 30' – 6^0:50' N and Longitudes 7^0:30' and 8:00^0 E

The major river within this area and which is also of relevance in this project is the River Asanodi on which Awara Dam was constructed in 1955. This river originates a few kilometers upstream of the Dam.

A small-scale electricity project that will use the Hydro Power Potentials of Asanodi River is being proposed to be built to serve the electrical energy needs of:

i) Water Treatment Plant at Awara

ii) The operations of the Awara Dam if necessary.

iii) Awara village and other neighboring Communities and environs.

CLIENT:
ONDO STATE GOVERNMENT,
GOVERNOR'S OFFICE,
OBAFEMI AWOLOWO AVENUE,
ALAGBAKA,AKURE,
ONDO STATE.NIGERIA.

CONSULTANT:
UNIDO-RC-SHP in Africa,
2^{ND} FLOOR,
WAEC BUILDING,
10 ZAMBEZI CRESCENT,
MAITAMA, ABUJA .

5.3 Project Benefits

UNIDO recognizes that linking rural energy with productive uses can create employment opportunities, raise income levels and improve quality of life in rural areas. The multi-functional platform, which was launched in West Africa in the 1990s, is a good example for providing access to energy to the poorest rural communities and promoting productive uses.

Micro and Small hydropower schemes have little or no environmental impact and can provide a range of valuable energy services especially in rural areas. In regions with hydropower potential, this form of renewable energy is the most cost-effective opportunity to energize on/off-grid areas and mini-grids.

Micro and Small hydropower can be applied to satisfy low to medium voltage electric power needs such as lighting or telecommunication and to provide motive power for small/cottage industries, such as palm Kernel and other agro-processing activities abundant in the Awara Dam axis in Ikare, Ondo State.

Renewable energy has become a global success story. According to the 2007 REN_{21} report the renewable energy sector now accounts for 2.4 Million jobs globally, has doubled electricity generating capacity since 2004 to 240 Giga watts (2007). Renewable energy represents 18 per cent of the global final consumption (2012). Projected target of 30% by 2020 was declared at the Vienna Energy forum in 2011.

- Renewables, excluding large hydropower and biomass, representing 5 per cent of global power capacity and 3 to 4 per cent of global generation.
- Many renewable technologies and industries have been growing at rates of 20 to 60 per cent
- Investments in new renewable capacity reached $US 100 billion in 2012.

Tungu – Kabiri community project (Kenya) has stimulated changes in national policy and encouraged efforts to build domestic capacity to produce micro-hydro system components. The challenge is to develop technical specifications, allowing decentralized systems to operate independently and in competition with other options where feasible. The SHP project proposed for Awara Dam will benefit the community in several ways such as:

5.3.1 Employment

The project will provide employment to the teaming youths of the community during construction and after commissioning. During construction, the youths will be actively involved in the civil works and after commissioning, the project will create the following vacancies:

- Power house operators
- Equipment mechanics
- Management staffs
- Revenue collectors
- Security Officers.

Other indirect employment like viewing centres, welding shops and ICT centres, are very likely to come into operation.

5.3.2 Food Processing and Storage

The tedious and unsafe methods of food processing and storage currently engaged by women will be replaced by modern methods, since there will be reliable electric power, a more efficient substitute to the others. This will add value to the crops produced in the area and relieve the women and children of the heavy burden of wasted farm produce and long distance travels in search of food processing machines.

5.3.3 Water Supply Scheme

The project was designed to supply water to Ondo Water Corporation and it is enhanced to do this more than before, Since a very reliably power will now be available from the Awara SHP Plant on 24/7 basis for consistent water production and delivery to end users.

5.3.4 Capacity Building

The project will stimulate changes in policy and encourage efforts to build local capacity to produce small hydro system components. Creating the capacity that will support scaling up, replication and mainstreaming process is of paramount importance. Local capacity for manufacturing MH power components (turbines and electronic load controllers) already exist at EMDI/NASENI,Akure. Creating the capacity that will support scaling up, replication and mainstreaming process is of paramount importance in the area of micro-economic activities.

5.4 Market Analysis and Market Strategy

The load survey in Table **5.4.1** shows the potential and projected groups of consumers within 7km radius of Awara Dam. The respective consumption by percentages is shown below:

Table 5.4.1 Consumption (%) in the Community

Domestic load (CAC Community)	-	300kW
Commercial / Industrial load	-	236kW
Social Services load(NYSC Camp)	-	500kW
	projected load to be firmed up later	
Agro Processing Oil Palm Cracking (10KW),	-	45kW
Cassava Grating (15kW) and Garri processing (15kW)	-	**A-5.1**

The market strategy should also emphasize the reliable power supply from the SHP project, through:

- Public enlightenment of the community on the efficient use of energy through traditional rulers, NGOs. CBOs & Professional institutions
- Reinforcement of the distortions in the network to minimize losses.
- Provide necessary mechanism and framework in order to ensure prompt identification and repair of faults.
- Encourage the formation of community based energy cooperatives and consumers' associations.
- Issues such as institutional requirements, Regulatory challenges, standards, specifications and codes of practice conducive to decentralized energy systems need to be addressed.
- A committee serving as Liaison between the Community, Government and Implementing partners and also responsible for making decision and collecting revenue, and the day – to – day operations and maintenance of the SHP plant is very desirable.

5.4.1 **Institutional Requirements and Reinforcements**

In a country where the ‘infrastructure’ for rural energy services provision is not well developed, the necessary institutional structures such as legal statutes, policies and legislation related to linking community energy initiatives to the mainstream process, need to be publicized so that the community, public and private sectors can take advantage of the opportunity to participate and contribute to its development.

5.4.2 **Sales Programme**

A prepaid metering system is recommended for enhanced revenue collection. The cost of meter will be spread over a period to enable consumers pay conveniently. Consumers’ societies should be encouraged to buy the prepaid cards in bulk to sell to their members on individual agreements. The prepaid cards should be made available at strategic locations in the community; since this business will indirectly contribute to boosting economic activities in the community.

5.5 **Sustainability and Participation**

The World Summit on Sustainable Development in 2002 stipulated in one of its Plan of Implementation that hydropower should be included in the drive to increase the contribution of renewable energy throughout the world. This is quoted below.

“Diversifying energy supply by developing advanced, cleaner, more efficient and cost-effective energy technologies, including fossil fuel technologies and renewable energy technologies, hydro included, and their transfer to developing countries on concessional terms as mutually agreed.”

Hydropower is complex and brings a range of economic, social and environmental risks. Some are inherent in the sector; many can and must be addressed by thoughtful implementation of good practices and a commitment to a sustainable triple bottom line approach (World Bank 2009).

1. **Economic Dimensions**

In economic terms, sustainability can be described as the maintenance of capital. The efficient use of economic resources requires that the best options are selected, that alternatives have been carefully evaluated, and that there are no hidden and unforeseen costs that could emerge in the future.

Hydropower is generated by water flowing through turbines as long as the reliability of the water resource is maintained; economic sustainability is not an issue. Once constructed and capital expenditure amortized, a project is virtually immune to further inflationary pressures. Operation and maintenance costs remain low while electricity can be produced very cheaply over many human generations.

Economically sustainable projects also have favourable energy payback ratios (the amount of energy derived from a scheme compared with that put into its construction and operation). Lastly, there can be no sustainable development without demonstration of sound and equitable distribution of economic benefits. The high level of service provided by multi-purpose hydropower is a driving force for local, national and regional development. For these reasons, hydropower is a powerful catalyst for sustainable development.

2. Social Dimensions

Hydropower schemes have the ability to significantly reduce poverty and enhance quality of life in the communities they serve. Families with little access to water and energy services spend a disproportionate amount of money and time on these two resources and their reliance on poor quality fuels along with a lack of access to sanitation and drinking water present essential health risks.

While small-scale, decentralized development can bring light and power to remote and rural communities, large-scale hydropower infrastructure with reservoirs, often provides multiple-use benefits, particularly through increased availability, reliability and quality of fresh water supplies and reduced flood risk.

It is increasingly being recognized that social responsibility cannot be achieved without systematic community participation. Hydropower developments are therefore nowadays mostly developed by recognizing entitlements and sharing benefits with directly affected people, communities or other stakeholders.

3. Environmental Dimensions

Hydropower projects do not export impacts such as acid rain or atmospheric pollution and rarely increase greenhouse gases. Therefore, hydropower has a valuable contribution to make to combat global warming and can enhance inter-and intra-generational equity.

While hydropower projects can have impacts on their local environment where, for example, the basin and ecosystem are sometimes permanently altered, these changes can be mitigated if well-managed and have to be considered in relation to the project benefits and in comparison to other energy options. Hydropower has the possibility to integrate in the basin hydrology and to create opportunities for recreation and ecotourism as well as mitigate ecosystem disruption through multiple strategies.

During the past two decades research and international hydropower sustainability initiatives, have substantially improved understanding of the nature and mitigation of impacts of dams on riverine ecosystems, particularly those associated with hydropower developments. In line with this increased knowledge base, the management of environmental impacts arising from hydropower continues to improve. Changes in the approach to project planning and design have resulted in maximization of positive outcomes and the reduction in severity or avoidance of negative impacts. In the light of sustainability, contemporary industry best practice considers topics such as downstream flow regimes, rare and endangered species, passage of fish species, pest species and impact of construction

5.6 Improving and Promoting Sustainable Practices

"The dam and hydro profession today does not only comprise technicians, but it is a multi-disciplinary body including environmental specialists, ecologist, biologists, social scientists and economists. Together they represent a wealth of expertise which can ensure that future projects are planned, constructed and operated with full respect for society and the environment" (IEA Hydro 2000).

In 1995, the International Hydropower Association (IHA) was formed under the auspices of UNESCO as a forum to promote and disseminate good practice and further knowledge about hydropower. The association represents the hydropower sector internationally and has the mission to champion continuous improvement and sustainable practices, building consensus through strong partnerships with other stakeholders, and driving initiatives to increase the contribution of renewables, especially hydropower. IHA decided to take the initiative to act towards improving sector performance by raising awareness of impacts, promoting good practice, providing sustainability measurement guidance, recognizing good practice and disseminating knowledge through communication of good examples.

i. Raising Awareness

IHA published *The Role of Hydropower in Sustainable Development* (IHA 2003). This paper aimed to increase awareness of the role hydropower can play in sustainable development as an important source of renewable energy as well as a provider of reliable water resources. It addressed the beneficial side of hydropower while proposing ways to mitigate or avoid detrimental effects.

ii. Promoting Good Practice

IHA developed the *IHA Sustainability Guidelines*, with their most recent version published in 2004. The guidelines promote good practice in an effort to fill the gap of missing implementation guidance for sustainable hydropower and have been an internal tool for the sector to adjust its practices in the environmental, social and economic spheres.

iii. Measuring Good Practices

In order to overcome the lack of a tool by which to assess the hydropower's sustainability performance, IHA developed the *IHA Sustainability Assessment Protocol* to assist the hydropower sector in evaluating performance against criteria in the *IHA Sustainability Guidelines*. The Protocol promotes and makes measurable the consideration of environmental, social and economic sustainability in the assessment of new energy supply options, new hydro projects and the implementation, management and operation of new and existing hydropower facilities. The *IHA Sustainability Assessment Protocol* started life as a Compliance Protocol in early 2004 and was adopted by IHA members in 2006. It has recently undergone a mutli-stakeholder review by the Hydropower Sustainability Assessment Forum (HSAF).

iv. Communicating Examples

It is important to record and to disseminate good and proven best practice. This is especially important for hydropower development in developing countries where most new projects are and will be built. Particular issues might have no precedence and expertise may be lacking, however in different circumstances, it is helpful for engineers, planners and operators in these countries to be able to draw from the experiences of others.

While hydropower schemes and their establishment always have a unique aspect with regards to their setting, social and environmental challenges and technical opportunities, it is not necessary to reinvent the wheel for every project. Several databases have been set up to collect examples and to make them available for future project planners and operators, e.g. DDP Good Practice and Lessons Learnt Database, IEA Hydro Annex 8 on Hydro Good Practices, IHA Blue Planet Prize, and Sustainable Hydro Website.

It is important to state at this juncture that the majority of stakeholders at the early stages of formulating the policy for the development of Small Hydro power potentials of rivers, streams and rivulets in Nigeria, based the implementation of the schemes on private sector (investor) participation with high level of involvement of the benefiting communities. The management of the schemes will therefore be a collective/co-operative participatory agreement between the private sector organization or the foreign donor agency with expressed interest in the Small Hydro Power schemes, the benefiting community or communities.

6.0 DATA COLLECTION AND ANALYSIS

6.1 Meteorology

Climate is the primary features that contribute to the hydrology of a region and is largely dependent on the geographical position on the earth's surface. Climatic factors of importance are rainfall, its duration, its intensity and aerial distribution. Other parameters are temperature, sunlight, relative humidity and evaporation.

The climate of the project site can be divided into dry season (Nov-Feb) and the wet season (March-October) each year. The basic metrological data collected is shown in Table 6.1.1-Table 6.1.7, which are rainfall, sunlight hours, evaporation, relative humidity, maximum and minimum temperature, and rainy days per month.

The average temperature varied from 23.9^{0}C – 26.7^{0}C depending on the season of the year.

Table 6.1.1 Rainfall record CRIN OWENA STATION AKURE(1985-2005)

MONTH/ YEARS	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL	AVERAGE
1985	10.5	9	151	100.3	16.3	264.8	261.7	222.5	288.1	108	18	0.5	1450.7	120.9
1986	16.3	60.9	176.6	120.2	159.7	215.6	910.2	243.1	216	313	20	5.8	2457.4	204.8
1987	10.5	6	110.6	24	89.2	74.8	255.3	394.2	190.6	219.6	8.8	5.8		0
1988	7	54	89.1	187.6	239	186.6	97.1	124.7	325.4	387.9	2	48.2	1748.6	145.8
1989	10.5	24.6	30.2	211.4	186.5	275.4	313.4	212.6	158.4	135.1	45.5	5.8		0
1990	6.5	46	4	167.1	173.1	133.9	273.1	165	206.4	168.4	14.1	37.7	1395.3	116.3
1991	16.5	34.9	77.4	234.6	239.7	188.4	357.2	267.9	233.9	173.3	43	5	1871.8	155.9
1992	10.5	24.6	35	103.1	217.9	159.6	167.4	138.9	349.5	155.6	52.2	5.8	1420.1	118.3
1993	10.5	31	125.6	241.8	48.3	134.1	48.8	141.4	300.9	112.4	78.5	9.5	1282.8	106.9
1994	26.5	52.3	69.7	70	155.6	118.6	255.2	151.8	219.2	174.3	36	5.8	1335	111.3
1995	10.5	38.1	156.9	82.6	228.3	203.2	236.5	381.9	505.8	235.1	67.2	5.8	2151.9	179.3
1996	72.5	13	112.4	125.9	217.1	184.9	202.9	154.9	277.8	124.5	43	5.8	1534.7	127.9
1997	26.7	24.6	84.8	138.2	258.6	240.4	81.9	132.6	148.5	185.3	98.1	22.8	1442.5	120.2
1998	5	51	92.1	99.8	191.2	164.9	142.3	115.3	231.4	322	67.2	5.8	1488	124
1999	3.5	23.9	62	95.8	133.6	152.6	118.5	241.6	79.3	213.5	96.9	5.8	1227	102.2
2000	1.3	24.6	15.1	185.8	124.4	364.4	148.6	195.1	201.9	102.7	13.8	5.8	1383.5	115.3
2001	31	24.6	163.4	169.3	137.6	188	269.9	71	113.5	148.3	43	5.8	1365.4	113.8
2002	10.5	3.6	142	151.8	39.8	216.5	344.1	239.7	213.4	258.9	161.8	5.8	1787.9	148.9
2003	1.7	25.2	54.2	215.7	123.6	199.9	72.6	92.6	243.2	199.8	63.9	5.8	1298.2	108.2
2004	10.5	62.8	23	129.9	158.8	197.7	128.5	181.1	265.1	137.4	59	5.8	1359.6	113.3

Table 6.1.2 Sunshine (hrs per day) for ONDO NIMET OFFICE.

MONTH	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL	AVERAGE
YEARS														
1991	5.1	5.5	3.7	4.9	4.5	4.6	2.2	1.2	2.4	3.9	6.1	5.9	50	4.166667
1992	6.1	6.9	4.4	5.2	5.5	4.1	2	1.7	2.8	4.3	6.6	7.3	56.9	4.741667
1993	5.9	7.1	6.2	5.9	5.9	4.8	2.5	2.1	4.1	5.7	4.6	6.1	60.9	5.075
1994	4.6	4.9	6.9	5.7	5.6	5.3	5.3	6.1	2.9	5.5	7.8	7.7	68.3	5.691667
1995	5.9	7.2	6	5.2	6.1	5.4	2.7	2.4	3.6	4.7	7.4	6.7	63.3	5.275
1996	5.2	6.6	6.5	5.1	8.7	4.6	4	2.6	2.2	4.2	8	3.2	60.9	5.075
1997	6.3	5	6.3	5.5	5.6	5.4	4.3	3.4	3.6	6.6	7.3	6.4	65.7	5.475
1998	6.1	6.2	5.6	6.5	5.9	5.2	3.2	1.8	4.2	4	6.6	7.8	63.1	5.258333
1999	6.6	7.3	5.1	6.3	5.5	5	4.1	2.7	4.1	5.8	7.2	7.5	67.2	5.6
2000	6.7	6.5	6.3	5.2	6.2	4.7	3.2	2.9	3.8	5.2	7.2	7.3	65.2	5.433333
2001	5.4	5.6	4.8	5.9	5.3	4.3	3.1	2.3	2.9	5.4	6.8	7.4	59.2	4.933333

Table 6.1.3 Number of Rainy days AKOKO NORTH EAST LGA.

MONTH/ YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	AVAERAGE
2000														
2001	0	0	0	0	6	10	13	13	15	6	2	0	65	5.41666667
2002	0	1	10	6	7	4	17	16	13	14	3	0	91	7.58333333
2003	2	3	0	6	3	10	0	10	19	9	6	0	68	5.66666667
2004	2	2	1	7	9	12	6	10	11	7	0	0	67	5.58333333
2005	0	2	5	5	5	13	11	5	9	9	0	2	66	5.5

Table 6.1.4 Maximum Temperature(^oC) for AKOKO NORTH EAST LGA.

MONTH/ YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2000	35.4	36.3	36.8	34.4	31.5	31.12	30	29	29.3	29.9	30.4	33.02
2002					32.3	29	29.6	29	29.4	32.1	35.4	34.6
2003	34.44	34.2	31.8	32.29	31.34	30.03	30.44	23.1	29.9	32.23	32.13	32
2004	33.52	35.15	34.94	33.3	31.74	29.04	30.32	29.2	30.9	30.24	33.2	39.05
2005	34.2	28.14	35	33.7	31.3	28.03	29.3	29.21	29.43	31.05	32.58	34.08
AVERAGE	34.39	33.45	34.64	33.42	31.64	29.44	29.93	27.9	29.79	31.1	32.74	34.55

Table 6.1.5 Minimum Temperature(^oC) for AKOKO NORTH EAST LGA.

MONTH/ YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2000									19.7			
2001	16.9	17.4	18.6	19.1	20.4	19.9	16	12.1	13.4	14.2	16.2	13.5
2003	18.29	20.96	20	21.02	25.06	24.2	29.8	22.34	22.57	13.32	23.23	23.92
2004	19	19.34	20.71	21.4	21	20	18.9	17.97	19	19	18.96	18.58
2005	16.9	22.68	22.7	22.2	22.4	23.47	21.8	21.3	19.78	21.93	21.53	21.7
AVERAGE	34.39	33.45	34.64	33.42	31.64	29.44	29.93	27.9	29.79	31.104	32.74	34.55

Table 6.1.6 Pan Evaporation (mm) for AKOKO NORTH EAST LGA

MONTH/ YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	AVERAGE
2001					1.5	1.2	1	0.61	0.67	1.25		2.38	8.61	0.956667
2002	1.8	2.7	1.76	1.4	1.12	2.01	0.97	0.67	0.43	1.2	2.5	1.9	18.46	1.538333
2003	1.28	1.6	1.8	1.2	1.32	1.07	1.22	0.45	0.8	1.58	1.43	4.06	17.81	1.484167
2004	1.14	1.23	1.53	1.38	5.84	0.89	0.92	0.65	0.87	1.04	1.65	1.46	18.6	1.55
2005	1.21	1.11	1.4	1.1	1.03	0.87	0.73	0.67	0.91	0.9	1.2	1.78	12.91	1.075833

Table 6.1.7 Relative Humidity (Percent) for AKOKO NORTH EAST LGA

MONTH/ YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	AVERAGE
2000	54.9	96	48.6	68.4	71.9	70	76.5	77.4	78.5				642.2	71.35556
2001	66.1	67.1	68	69	70.9	70	78.95	82.7	81.4	81.5	66.4	59.7	861.75	71.8125
2003	56.23	65.2	60	70.97	92	92.22	77.97	83.2	82.59	71.8	71.08	60	883.26	73.605
2004	63	57.41	57.45	70.7	72.99	78.19	77.83	82.7	75.4	74.63	68.2	63.19	841.69	70.14083
2005	47.4	55.64	64.25	70	74.8	78	81.3	78.4	83.35	75.75	84.35	65.06	858.3	71.525

6.2. Geology Of Awara Dam

The project area lies within the un-differentiated basement complex of Nigeria. The area falls specifically within the Schist Belts of Nigeria. The rock types are mainly Schist, granite gneiss, Migmatite, gneiss, pegmatite, quartzite, and granites.

The site geology reveal rock exposures of weathered layers at the river channel, parent rock and outcrops at the proposed power house location close to the river channel. **(Figures 1-3).**

Fig 6.1: SHOWING THE WEATHERED ROCK EXPOSURE AT THE RIVER CHANNEL AT AWARA DAM.

Fig6.2: SHOWING THE PARENT ROCK AT THE RIVER CHANNEL AT AWARA DAM.

Fig 6.3: SHOWING THE ROCK EXPOSURE AT THE PROPOSED POWER HOUSE LOCATION.

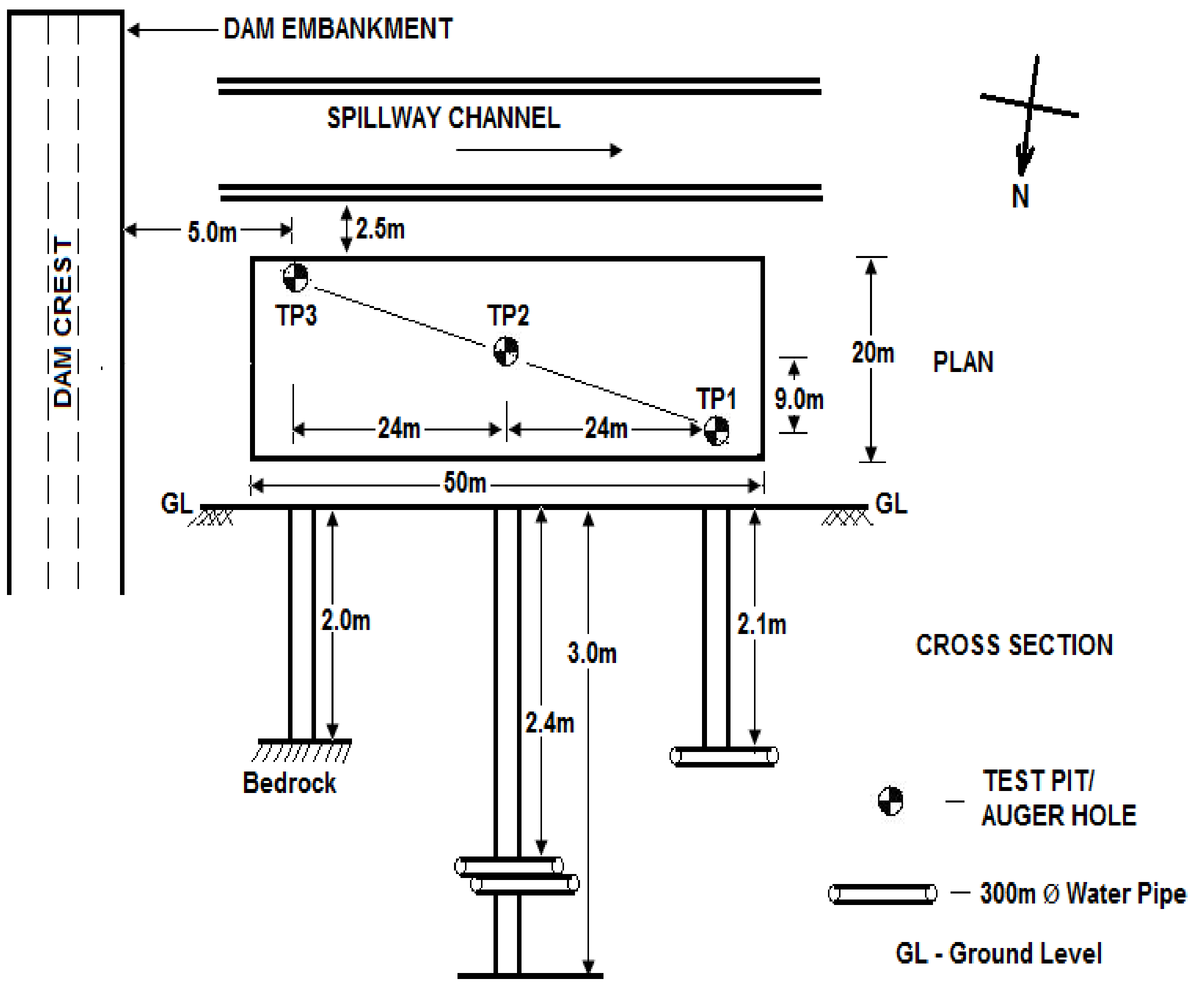
6.3. Topographic Conditions

Entering from Ikare town, towards the Awara dam, we descended into a valley with visible outcrop of rocks on both sides of the Dam. The basic soil type is a mixture of Lateritic and rocky soil. The land has a lot of green cover that disallows erosion. A Topo sheet for the Awara Dam/Oyimo River is attached as Annexure 6.3.1

6.4. SUBSOIL AND FOUNDATION INVESTIGATION

6.4.1 Introduction

This is the report of a subsurface investigation that was made for the foundation of the proposed power house in the small hydropower project, Awara, Ondo State. The site plan and borehole locations are shown in **Drawing 6.4.1**.



DRAWING 6.4.1 SMALL HYDROPOWER PROJECT SITE, AWARA, ONDO STATE, SITE PLAN SHOWING TEST PIT LOCATIONS IN THE PROPOSED POWER HOUSE AREA.

This report includes a brief description of the field and laboratory investigations undertaken and the results obtained, our analysis of soil conditions and our comments and recommendations, more specifically;

- Collecting of disturbed and undisturbed samples from all the three locations
- Conducting laboratory tests as approved by the client on all the soil samples from the three locations
- Evaluating of field and laboratory results and recommendations.

6.4.2 <u>Geology</u>

Detailed geological survey of this area was carried out by the consultant geologist for the project. From the general geologic map of Nigeria, the rock at this location is a Basement Complex. On top of the Basement Complex is a deposit of overburden which varies from location to location at the site.

6.4.3 <u>Field And Laboratory Investigations</u>

The field investigation undertaken consisted of collecting bulk samples from the site. The test/trial pit method of subsoil exploration was used. A test pit is simply a hole dug in the ground that is large enough for a ladder to be inserted, thus permitting a close examination of the sides. With this method, relatively undisturbed block samples of soils were collected. The final depth of each test pit was 2.1 m and about 1.2m x 1.2m wide i.e. 1.2m x 1.2m x 2.1m pit. The types of samples collected for the laboratory analysis are as follows;

(i)Disturbed samples

(ii)Undisturbed sample.

The pit was sunk by hand excavation with the aid of spade and digger, with the collection of samples at 0.3m, 0.75m, 1.5m and 2.1m depth. Soil sample was also collected at 3.0m depth for one of the test pit locations (TP3). All the samples retrieved were visually identified on site at the time of sampling, and taken to our Soil Mechanics Laboratory for more careful examination and detailed identification and classification. Relevant indices and engineering property tests approved by the client including natural moisture content, unconfined compression and grain size distribution were performed on samples from each location. Pocket Penetrometer test was performed on samples IN SITU at each location. Estimates of relevant parameters such as bearing capacity were made from results of these laboratory tests. The pocket Penetrometer results shown are the average of three readings.

6.4.4 <u>Subsurface Conditions</u>

Very detailed logs of borings are shown in each of the individual logs in Appendix A. The top soil in test pit 1 (TP1) consists of dark brown gravelly SAND to a depth of about 0.30 metres. The top soil in TP2 and TP3 consists of dark brown sandy silty CLAY with some gravels to a depth of about 0.30 metres. Immediately below this and up to a depth of 0.75 metres in TP1; 3.0 metres in TP2, is a layer of brownish medium to stiff, lateritic, sandy silty CLAY. Immediately below the top soil and up to a depth of 1.5m in TP3 is a layer of yellowish brown medium to stiff sandy silty CLAY with mica flakes. Underlying this in TP1 and TP3 is a zone of brownish stiff gravelly silty CLAY which merges into weathered rock and bedrock in TP3. The groundwater level was not encountered in any of the three test pits. Two buried water pipes of about 300mm diameter each were encountered at 2.4 metres depth in TP2 while one buried water pipe of about 300mm diameter was encountered at 2.1 metres depth in TP1. Most of the overburden materials in TP1 and TP2 are likely to be backfill materials. The bedrock was encountered at a depth of 2.0 metres in only one of the three test pit locations (TP3) within the 20m by 50m investigation area. This implies an inclined or uneven surface underlying bedrock. We recommend the moving of the power house away from the buried water pipelines if the pipelines cannot be relocated.

6.4.5 <u>Analysis Of Soil Conditions</u>

Results of the laboratory testing are summarized in **Table 6.4.5.1** below

TABLE 6.4.5.1 SMALL HYDROPOWER PROJECT, AWARA SUBSOIL INVESTIGATION

SUMMARY OF LABORATORY TESTING RESULTS

BORE HOLE	DEPTH (m)	NMC (%)	Specific Gravity (G_s)	$C = q_u/2$ kN/m^2	Average Pocket Penetrometer value	ATTERBERG LIMITS				SIEVE ANALYSIS, % PASSING							
						LL (%)	PL	PI (%)	LS (%) (mm)	#4 4.76 (mm)	#7 2.36 (mm)	#14 1.18 (mm)	#25 0.6 (mm)	#36 0.425 (mm)	#72 0.212 (mm)	#100 0.15 (mm)	#200 0.075 (mm)
1	0-0.3	7.1	2.59		190	41.3	9.5	31.8	2.9	100.0	52.2	43.9	31.7	22.1	10.9	8.2	6.5
1	0.3-0.75	11.1	2.51		380	23.2	4.9	18.3	2.9	100.0	96.3	93.0	83.7	71.8	40.6	32.0	24.4
1	0.75-1.50	10.5	2.60		307	31.0	19.3	11.7	7.9	100.0	86.7	82.7	72.7	60.3	34.5	29.1	25.5
1	1.50-2.10	10.8	2.45	103	280	32.0	23.4	8.6	6.4	100.0	93.6	89.9	80.9	69.7	44.8	37.3	32.5
2	0-0.3	10.1	2.53		227	37.0	24.3	12.7	6.4	100.0	93.3	88.3	76.7	62.6	35.1	28.4	24.8
2	0.3-0.75	14.9	2.51		210	43.0	21.4	21.6	10.0	100.0	97.8	95.2	86.4	73.1	38.9	34.7	32.1
2	0.75-1.50	15.3	2.49		213	34.0	21.1	12.9	9.3	100.0	98.1	95.3	86.0	68.8	41.3	33.8	29.8
2	1.50-2.10	16.8	2.48		287	34.0	20.0	13.8	9.3	100.0	98.9	97.4	91.1	79.7	46.4	39.5	36.0
2	2.10-3.00	17.1	2.46	361	393	39.0	24.4	14.6	11.4	100.0	99.0	97.1	90.0	79.0	52.0	43.0	38.8
3	0-0.3	13.6	2.51		210	30.2	10.3	19.9	10.0	100.0	97.0	92.2	76.5	58.0	35.5	30.7	27.6
3	0.3-0.75	11.9	2.56		253	30.7	9.6	21.1	6.4	100.0	92.3	86.1	74.0	56.5	34.9	30.8	28.6
3	0.75-1.50	15.7	2.44		350	40.7	8.9	31.8	10.7	100.0	94.6	90.4	79.3	64.6	39.1	33.1	29.8
3	1.50-2.00	14.1	2.65	377	447	34.5	25.9	8.6	9.3	100.0	60.1	55.1	43.5	34.0	22.4	19.4	17.6

NMC – Natural Moisture Content
LL – Liquid Limit
PL – Plastic Limit
PI – Plasticity Index
LS – Linear Shrinkage
C–Cohesion determined from Unconfirmed Compression Test

6.4.6 Determination Of Bearing Capacity

The strength values obtained for TP3 would be used for bearing capacity determination since most of the overburden materials in TP1 and TP2 up to a depth of about 2.0 metres are likely to be backfill materials from the previous excavation for the 300 mm diameter water pipes located at the site observed during this investigation

From Table 6.4.5.1, the Unconfined Compressive Strength from the pocket Penetrometer is;

$q_u = 447.0kPa$ (Average Pocket Penetrometer reading for TP3)

$q_u = 447.0kPa \quad = 447.0kN/m^2$

From the general relationship of consistency and Unconfined Compression Strength of Clays, Table A.2 (Ola, 1989), this soil can be described as Hard Clay since

$q_u > 383kN/m^2$

$$\tau_f = c_u = \frac{q_u}{2} = \frac{447.0}{2} kN/m^2 = 223.5kN/m^2$$

For general shear failure (Stiff soil) $c = c_u$

Assuming $\phi = 0$ from the Unconfined Compression Test results

Ultimate bearing capacity $q_{ult} = 1.3cN_c$ (for a square footing)

N_c = 5.14 (for $\phi = 0$) FIG. A..15, (Ola, 1989)

$q_{ult} = 1.3 \times 223.5 \times 5.14 = 1493.43kN/m^2$

Net Bearing Capacity = $q_{ult} - q$, where $q = \gamma D_f$

Take D_f = 1.5m and γ = 22 kN/m^2 Table A.2 (Ola, 1989)

q = 1.5 x 22 = 33 kN/m^2

q_{net} = 1493.43 – 33 = 1460.43 kN/m^2

Net allowable bearing capacity $q_{all} = \frac{q_{ult} - q}{F.S} = \frac{q_{ult} - q}{3}$

= 1460.43 / 3 = 486.81 kN/m^2

If and when this site becomes submerged/ water logged this value could reduce to about half i.e

About q'_{all} = 243.40 kN/m^2 ≈ 240 kN/m^2

This is a relatively stable bearing capacity value.

6.4.7 Recommendations

Square or rectangular Pad footings (Column bases) tied with ground beams to forestall differential settlement can be used at a depth of about 1.5 metres below the ground surface for the building, with an allowable bearing capacity of 240 kN/m^2 and allowable settlement of about 25mm. Position of buried water pipelines within the vicinity of the dam should be ascertained and avoided in placing the foundation for the proposed power house for the small hydropower project.

6.4.8 General Statement Of Limitations

The foregoing analysis and recommendations have been presented on the assumption that actual soil conditions at the sites do not deviate significantly from the conditions encountered in the samples taken at the sites during this investigation. If the real conditions are found to be significantly different then it may be necessary to review our analysis and recommendations. It is therefore important that the foundation construction be done under the supervision of competent engineering personnel who will be able to assess the effect of any unexpected difference between the actual soil conditions and those encountered in this investigation.

6.5. Hydrology

The quality and quantity of water contained in surface stream or river at any time is of considerable importance in water resources planning and management. Hence, the knowledge of the quantity and quality of stream flow is crucial in its comprehensive management, hydro power generation inclusive. Asanodi River which originates from the hills south west of Ikare township flows through deep valley to discharge into the Awara dam reserviour, while, the Elemoro river that originates from Irun and Ogbagi hills flows into the proposed weir at Oyimo.

The raining season starts in March/April and the runoff starts almost immediately due to the geological nature of soils in the surrounding area of the catchment basin. The peak flow is experienced in July/August/Sept yearly. The flow regime is predominantly influenced by the hilly catchment area which starts from the land divide, around the periphery of the hills as described above south west of Ogbagi and Ikare Township. There are about eight tributaries flowing into the Asanodi River as observed in the 1:50,000 Ikole-Southwest Topo sheet, While about 19 tributaries flow into Elemoro River. (See **Figure 6.4.1**)

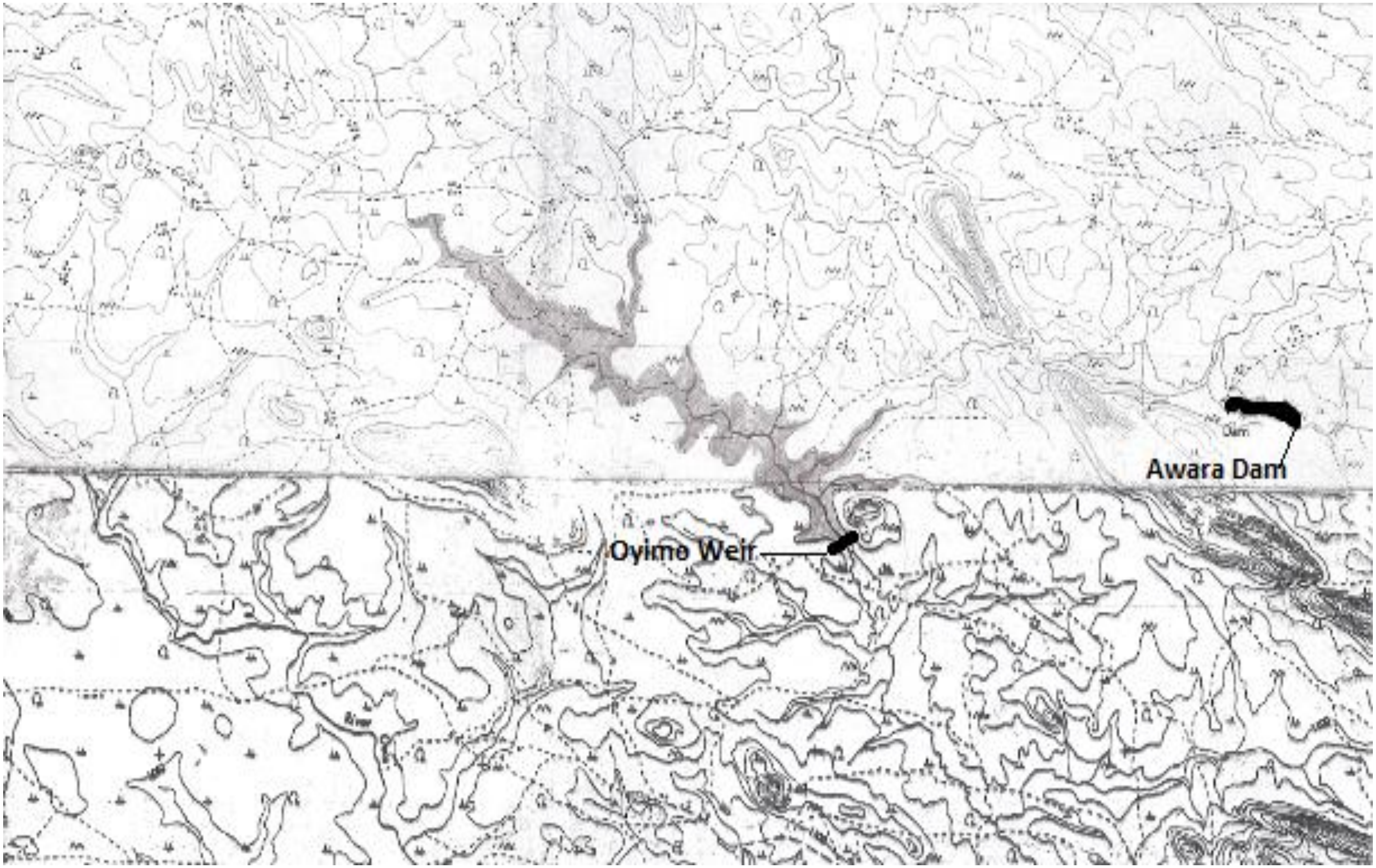


Figure 6.5.1 - General Orientation of the Proposed Weir and Awara Dam

6.5.1 Insitu-flow Determination (Alternative A)

The Awara river was not gauged hence there is no flow records available at site. As at the time of visit, it was not possible to determine any insitu-flow as there is no water flowing over the spillway. However, the reservoir was full to the brim of the spillway level.

6.5.2 Run-Off Generation

It was particularly important to generate runoff from the catchment basin of river Asanodi to allow for adequate evaluation of flow pattern through the months and season of the year since no measured flow records were available during the study.

The rainfall data in **Table 6.1.1** was used to generate runoff based on the following assumptions.

1. The rainfall that contributed run-off is evenly distributed over the catchment basin.
2. The catchment basin run-off coefficient was taken as 90% because of the observed characteristics of the basin and the meteorology.

Table 6.5.2.1 shows the generated run-off and the basic data, catchment area and the 21 year average rainfall used for this purpose.

Table 6.5.2.1 Direct runoff generation using Average Rainfall Data (1985-2005) (Awara Dam Catchment Area)

Month	25yrs Monthly Average Rainfall (m)	Catchment area(m^2) x10^6	Volume of runoff (m^3) x10^6	Adjustment for runoff coeff 90% x10^6	Discharge m^3/s
Jan	0.0147	1.984	0.0291648	0.02624832	0.0098
Feb	0.0305	1.984	0.060512	0.0544608	0.022511905
March	0.0965	1.984	0.191456	0.1723104	0.064333333
April	0.1421	1.984	0.2819264	0.25373376	0.097891111
May	0.157	1.984	0.311488	0.2803392	0.104666667
June	0.1928	1.984	0.3825152	0.34426368	0.128533333
July	0.2234	1.984	0.4432256	0.39890304	0.148933333
August	0.1962	1.984	0.3892608	0.35033472	0.1308
Sept	0.2333	1.984	0.4628672	0.41658048	0.160717778
Oct	0.1921	1.984	0.3811264	0.34301376	0.128066667
Nov	0.0512	1.984	0.1015808	0.09142272	0.035271111
Dec	0.1003	1.984	0.1989952	0.17909568	0.066866667

The runoff of the basin was calculated using equation below.

Runoff = catchment Area (m^2) x Rainfall (m) x Coeff. - - - - - - - - - - - - - - - - - - 6.3

6.5.3 Estimation of Catchment Area

The calculation of the catchment area was determined using topographical map of scale 1:50,000 of the project area.Annex 6.5.1 the catchment area was delineated and the area calculated as shown on **Figure 6.1**. The catchment area was delineated and the area was planimetered. The catchment area was calculated to be 1.984 x 10^6 m^2. This figure was used in the determination of the runoff for the drainage basin as shown on **Table 6.5.2.1.**

6.5.4 Existing Infrastructure at Site

The Awara River dam was constructed in 1958 and has stood the test of time. The infrastructure is solid except for the spillway that needs urgent rehabilitation.

The Awara dam has no available written report that could be used as a guide on the as-built dam parameters. However, the consultant undertook an intensive survey to determine the physical dimensions of the dam.

The reservoir volume was determined by carrying out survey of the reservoir surface area and determining the approximate volume by using the following formula 6.5.4

$$Q = \frac{A \times D}{3} \text{ --------------------------------------6.5.4}$$

Where:

Q = Volume of reservoir (m^3)
A = Surface Area at full supply level (m^2) [$11.42x10^4$m]
D = Maximum Depth (m) [10.5m]

This assumes that the reservoir is a pyramid whose base is the water surface.

$$Q = \frac{11.42x10^4 \; x \; 10.5}{3}$$

$$= 399700m^3$$

$$= 0.4x10^6 \; m^3$$

Therefore the maximum reservoir storage volume **$4.00x10^5$ m^3**

The basic engineering data of the dam is shown below.

- Dam type – Homogenous type
- Dam height – 11.34m
- Crest Width – 5.0m
- Spillway length– 30.6m

- Reservoir Area – 11.42×10^4 m^2
- Reservoir Volume – 0.3997×10^6 m^3
- Full supply level – EL 379.85m
- Penstock intake level-EL 369.37m
- Flood Volume – 14.1×10^6 m^3
- Catchment drainage Area – 1.984×10^6m^2

  The topographical survey of the basic infrastructure is shown on **Figure 6.5.4.1**

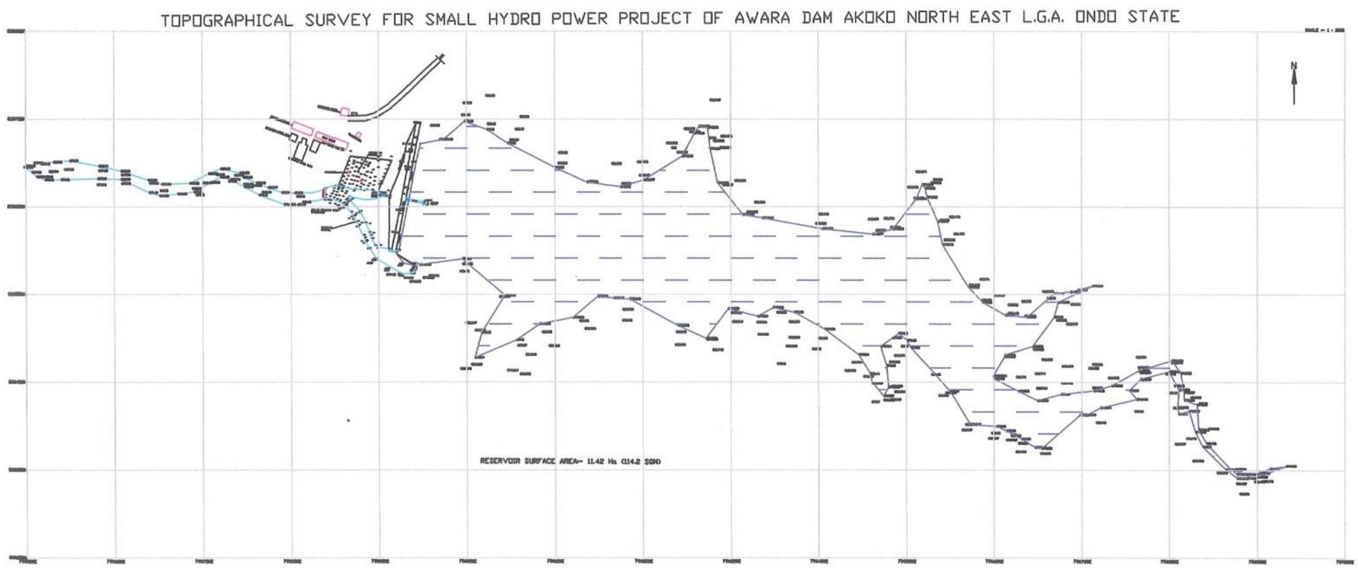


Figure 6.5.4.1 Topographical Survey of Awara Dam Site

Note: Reservoir Surface Area = 11.42H

6.4.5 <u>Reservoir Operational Simulation (Alternative A)</u>

The reservoir Simulation was carried out by balancing the inflows and storage into the Awara Dam Reservoir. A computation of storage simulation, balancing the inflows in the reservoir and available stored water on the one hand and the releases for purpose of power generation and water supply as well as losses for evaporation and percolation on the other. This computation is based on inflow data generated (**Table 6.5.5.1**) for years 2000 to 2005. This computation is shown on **Table 6.5.5.2**.

Table 6.5.5.1 Inflow Generation for Real-time Simulation of Awara Reservoir Behaviour (1999-2005) (m^3)

MONTH YEAR		APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR
1999/ 2000	R(m)	0.0958	0.1336	0.1526	0.1185	0.2416	0.0793	0.2315	0.0969	0.0058	0.0013	0.0246	0.0151
	I (m^3)	**171098.8**	**238609.6**	**272543.6**	**211641**	**431497.6**	**141630**	**413459**	**173063.4**	**10358.8**	**2321.8**	**43935.6**	**26968.6**
	e(m)	0.0013	0.0022	0.0012	0.0009	0.0006	0.0007	0.0012	0.0017	0.0023	0.0014	0.0017	0.0016
	E(m^3)	**14.846**	**25.124**	**13.704**	**10.278**	**6.852**	**7.994**	**13.704**	**19.414**	**26.266**	**15.988**	**19.414**	**18.272**
2000/ 2001	R(m)	0.1858	0.1244	0.3644	0.1486	0.1951	0.2019	0.1027	0.0138	0.0058	0.031	0.0246	0.1634
	I (m^3)	**331838.8**	**222178.4**	**650818.4**	**265399.6**	**348448.6**	**360593**	**183422.2**	**24646.8**	**10358.8**	**55366**	**43935.6**	**291832.4**
	e(m)	0.0013	0.0022	0.0012	0.0009	0.0006	0.0007	0.0012	0.0017	0.0023	0.0014	0.0017	0.0016
	E(m^3)	**14.846**	**25.124**	**13.704**	**10.278**	**6.852**	**7.994**	**13.704**	**19.414**	**26.266**	**15.988**	**19.414**	**18.272**
2001/ 2002	R(m)	0.1693	0.1376	0.188	0.2699	0.071	0.1135	0.1483	0.043	0.0058	0.0105	0.0036	0.142
	I (m^3)	**302369.8**	**245753.6**	**335768**	**482041.4**	**126806**	**202711**	**264863.8**	**76798**	**10358.8**	**18753**	**6429.6**	**253612**
	e(m)	0.0013	0.0022	0.0012	0.0009	0.0006	0.0007	0.0012	0.0017	0.0023	0.0014	0.0017	0.0016
	E(m^3)	**14.846**	**25.124**	**13.704**	**10.278**	**6.852**	**7.994**	**13.704**	**19.414**	**26.266**	**15.988**	**19.414**	**18.272**
2002/ 2003	R(m)	0.1518	0.0398	0.2165	0.3441	0.2397	0.2134	0.2589	0.1618	0.0058	0.0017	0.0252	0.0542
	I (m^3)	**271114.8**	**71082.8**	**386669**	**614562.6**	**428104.2**	**381132**	**462395.4**	**288974.8**	**10358.8**	**3036.2**	**45007.2**	**96801.2**
	e(m)	0.0013	0.0022	0.0012	0.0009	0.0006	0.0007	0.0012	0.0017	0.0023	0.0014	0.0017	0.0016
	E(m^3)	**14.846**	**25.124**	**13.704**	**10.278**	**6.852**	**7.994**	**13.704**	**19.414**	**26.266**	**15.988**	**19.414**	**18.272**
2003/ 2004	R(m)	0.2157	0.1236	0.1999	0.0726	0.0926	0.2432	0.1998	0.0639	0.0058	0.0105	0.0628	0.023
	I (m^3)	**385240.2**	**220749.6**	**357021.4**	**129663.6**	**165383.6**	**434355**	**356842.8**	**114125.4**	**10358.8**	**18753**	**112160.8**	**41078**
	e(m)	0.0013	0.0022	0.0012	0.0009	0.0006	0.0007	0.0012	0.0017	0.0023	0.0014	0.0017	0.0016
	E(m^3)	**14.846**	**25.124**	**13.704**	**10.278**	**6.852**	**7.994**	**13.704**	**19.414**	**26.266**	**15.988**	**19.414**	**18.272**
2004/ 2005	R(m)	0.1299	0.1588	0.1977	0.1285	0.1811	0.2651	0.1374	0.059	0.0058	0.0105	0.0056	0.2513
	I (m^3)	**232001.4**	**283616.8**	**353092.2**	**229501**	**323444.6**	**473469**	**245396.4**	**105374**	**10358.8**	**18753**	**10001.6**	**448821.8**
	e(m)	0.0013	0.0022	0.0012	0.0009	0.0006	0.0007	0.0012	0.0017	0.0023	0.0014	0.0017	0.0016
	E(m^3)	**14.846**	**25.124**	**13.704**	**10.278**	**6.852**	**7.994**	**13.704**	**19.414**	**26.266**	**15.988**	**19.414**	**18.272**

Table 6.5.5.2 Reservoir Simulation for Awara Dam SHP Development (x $10^5 m^3$)

YEAR		Apr. 1	May. 2	Jun. 3	Jul. 4	Aug. 5	Sept. 6	Oct. 7	Nov. 8	Dec. 9	Jan. 10	Feb. 11	Mar. 12
2000/2001	I	3.32	2.22	6.51	2.65	3.48	3.61	1.83	0.25	0.104	0.55	0.44	2.92
	R	0.30	3.0	3.0	3.0	3.0	3.0	3.0	0.30	0.30	0.30	0.30	0.30
	S	3.0	2.24	4.0	3.65	4.0	4.0	2.83	2.78	2.58	2.83	2.97	4.0
	O	0	0	1.75	0	0.13	0.61	0	0	0	0	0	1.59
	E	0.000148	0.00025	0.000137	0.000102	0.000068	0.000079	0.000137	0.000194	0.000262	0.000159	0.000194	0.000182
2001/2002													
	I	3.024	2.46	3.36	4.82	1.27	2.03	2.65	0.77	0.104	0.188	0.064	2.54
	R	0.30	3.0	3.0	3.0	3.0	3.0	3.0	0.30	0.30	0.30	0.30	0.30
	S	4.0	3.46	3.82	4.0	2.27	1.30	0.95	1.42	1.22	1.11	0.87	3.11
	O	2.72	0	0	1.64	0	0	0	0	0	0	0	0
	E	0.000148	0.00025	0.000137	0.000102	0.000068	0.000079	0.000137	0.000194	0.000262	0.000159	0.000194	0.000182
2002/2003													
	I	2.71	0.71	3.87	6.15	4.28	3.81	4.62	2.89	0.104	0.030	0.45	0.97
	R	0.30	3.0	3.0	3.0	3.0	3.0	3.0	0.30	0.30	0.30	0.30	0.30
	S	4	1.71	2.58	4	4	4	4	4	3.8	3.50	3.65	4
	O	1.52	0	0	1.73	1.28	0.81	1.62	2.59	0	0	0	0.32
	E	0.000148	0.00025	0.000137	0.000102	0.000068	0.000079	0.000137	0.000194	0.000262	0.000159	0.000194	0.000182
2003/2004													
	I	3.85	2.21	3.57	1.30	1.65	4.34	3.57	1.14	0.104	0.188	0.122	0.411
	R	0.30	3.0	3.0	3.0	3.0	3.0	3.0	0.30	0.30	0.30	0.30	0.30
	S	4	3.21	3.78	2.08	0.73	2.07	2.64	3.48	3.28	3.17	3.99	4.0
	O	3.55	0	0	0	0	0	0	0	0	0	0	0.10
	E	0.000148	0.00025	0.000137	0.000102	0.000068	0.000079	0.000137	0.000194	0.000262	0.000159	0.000194	0.000182

2004/2005

I	2.32	2.84	3.53	2.30	3.23	4.73	2.45	1.05	0.104	0.188	0.10	4.49
R	0.30	3.0	3.0	3.0	3.0	3.0	3.0	0.30	0.30	0.30	0.30	0.30
S	4.0	3.84	4.0	3.30	3.53	4	3.45	4	3.80	3.69	3.49	4
O	2.02	0	0.37	0	0	1.26	0	0.20	0	0	0	3.68
E	0.000148	0.00025	0.000137	0.000102	0.000068	0.000079	0.000137	0.000194	0.000262	0.000159	0.000194	0.000182

Max Reservoir Storage = 4 x $10^5 m^3$

Key: I – Inflow

O – Outflow

S – Storage

E – Evaporation

R - Release

The table above allows the forecast of possible water demand for both power generation and water supply for municipal use, as a function of inflow and stored water for generating power. Throughout the simulation it is important that wastage/spillage from the spillway is kept minimal as much as possible and is equally used for municipal water supply. It is also important that wastage/spillage from the spillway is kept minimal as much as possible.

The following assumptions were made for the computation of **Table 6.5.5.2**.

i. There is extremely dry season between a real dry season
ii. The reservoir level must not fall below dead storage level in the following season before the end of June in any year.
iii. The Water supply is guaranteed always for both municipal use and power generation depending on the inflow into Awara reservoir.

The actual demand for power based on the capacity of dam can be supplied if there is enough water in the reservoir. It could be seen from simulation **Table 6.5.5.2**, that 3 x $10^5 m^3$ could be supplied during the months of May to October every year to meet the need of power generation and municipal water supply could be met without depleting the reservoir to its dead storage level. This amount of water will also be made available for power generation and water supply.

The five years of simulation, with real time data, allows the testing of the reservoir for real performance. It can be concluded from the reservoir simulation that:

i. Water for power generation and water supply will be very low(0.30 x 10^5 m^3) in the dry season as opposed to its availability of (3.0 x 10^5 m^3) in the wet season.
ii. Water for municipal supply will be met as water for power use is met.

6.5.6 Flow Duration Analysis (Scheme I)

The discharge required for each month of the year for power generation and water supply was extracted from **Table 6.5.5.2** and retabulated below in **Table 6.5.6.1.**

Table 6.5.6.1 Monthly Simulation Discharge for Awara Reservoir Management

Month	**Volume x 10^5 m^3**	**Average discharge Q (m^3/s)**
January	0.3	0.0112
February	0.3	0.0120
March	0.3	0.0112
April	0.3	0.0116
May	3.0	0.112
June	3.0	0.1158
July	3.0	0.1119
August	3.0	0.1119
September	3.0	0.1158
October	3.0	0.112
November	0.3	0.0116
December	0.3	0.0112

The Exceedence table was then developed and is shown below on **Table 6.5.6.2**, the flow duration curve was plotted as in **Figure 6.5.6.1**.

Table 6.5.6.2 Monthly Excedences for Awara Reservoir Simulated Releases.

Discharge Q ($x10^{-2}m^3$)	Ranking (Months)	Percentage Exceedence %
11.58	1	8.3
11.58	1	8.3
11.20	4	33.33
11.20	4	33.33
11.19	6	41.67
11.19	6	50.0
1.16	8	58.0
1.16	8	66.67
1.12	12	100.00
1.12	12	100.00
1.12	12	100.00
1.12	12	100.00

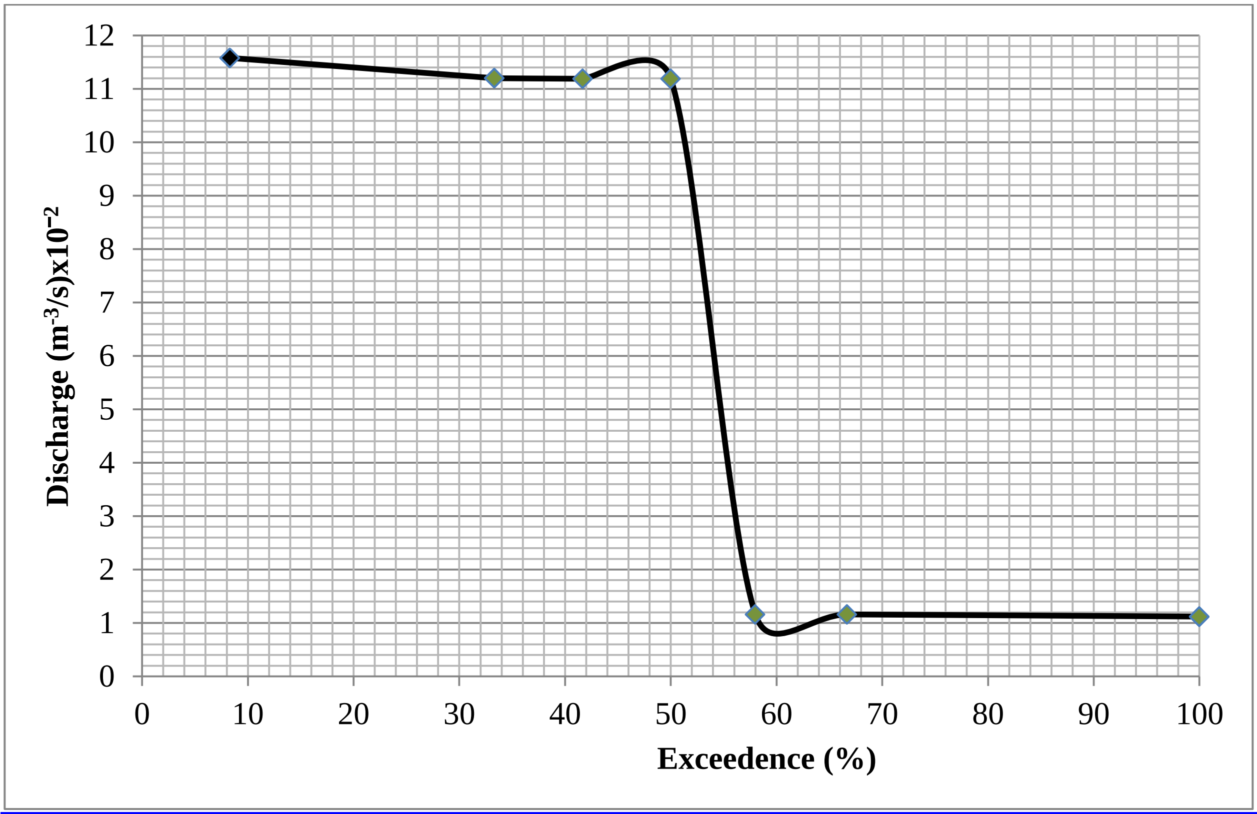


Figure.6.5.6.1 Flow Duration Curve (Scheme I) Asanodi River Site at Awara Dam.

6.5.7 <u>Institu Flow Determination(Scheme II)</u>

During the design investigation stage of the Awara Dam SHP project, Elemoro River which is about 6km downstream of Asanodi River and has greater catchment area than Asanodi River was discovered.

It was later learnt that AOP Consult Ltd conducted feasibility studies in 2002 for a proposed dam at this site. Important useful data was collected and analyzed from their report of 2002.

The River Elemoro flows southward to meet river Ovia few kilometers before Owo Dam site. The Elemoro River was not gauged according to the report and up till now there is no gauging station.

6.5.8 <u>Run-Off Generation (Scheme II)</u>

As mentioned earlier, it is important to generate the run –off from the Elemoro river catchment basin to determine monthly flows based on rainfall data.

The rainfall data adapted from AOP Consult Ltd of 2002 was used to generate the run-off from the catchment basin using the basic assumptions earlier stated in section 6.5.2.

Table 6.5.8.1 shows the generated run-off and the basic data, catchment area, and the average rainfall data used for this purpose.

Table 6.5.8.1 Average Rainfall and run-off for Elemoro River at OYIMO village, Ikare (Catchment Area = 196.8km^2)(1938-1992)

Months	Average Rainfall (mm/month) +	Volume of RunOff(m^3)/Month at 90% coeff.	Average Discharge (m^3/s)
January	16.80	2,975,616.00	1.28
Febuary	36.40	6,447,168.00	2.49
March	97.60	17,286,912.00	6.67
April	123.00	21,785,760.00	8.41
May	125.10	22,157,712.00	8.55
June	191.50	33,918,480.00	13.1
July	189.60	33,581.952.00	12.96
August	158.10	28,002,672.00	10.80
September	230.20	40,773,024.00	15.73
October	169.00	29,933,280.00	11.55
November	56.80	10,060,416.00	3.88
December	21.20	3,754,944.00	1.45

(+) Adapted From "Construction of OYIMO DAM" by AOP Consult Ltd 2002

6.5.9 Estimation of Catchment Area (Scheme II)

The Catchment Area which is 196.8km^2 was estimated by AOP Consult Ltd in 2002. This value was used in the determination of the run off volume for the Elemoro River as shown on **Table 6.5.8.1**

6.5.10 Existing Infrastructure at Site (Scheme II)

As at the time of our study no infrastructure exists at the site. However it is proposed to build a weir of height 10m across the river at the location of the proposed dam to raise the water head for the proposed Awara Dam/Oyimo River Small Hydro Power development.

6.5.11 Flow Duration Analysis.(Scheme II)

The average discharge (m^3/s) generated per month was extracted from **Table 6.5.8.1** and retabulated in **Table 6.5.11.1** for exceedence analysis and flow duration curve production. The flow duration curve is shown in **Figure 6.5.11.1**

Table 6.5.11.1 Monthly Exceedences for Oyimo Reservoir Simulated Releases.

Discharge Q ($x10^{-2}m^3$)	Ranking (Months)	Percentage Exceedence %	Potential Power at Exceedence (KW)
15.73	1	8.33	1,321.32
13.1	2	16.67	1,100.4
12.96	3	25.00	1088.64
11.55	4	33.33	970.20
10.8	5	41.67	907.20
8.55	7	50.00	718.20
8.41	8	58.33	706.44
6.67	9	66.67	560.28
3.88	9	75.00	325.92
2.49	10	83.33	209.16
1.45	11	91.67	121.80
1.28	12	100.00	107.52

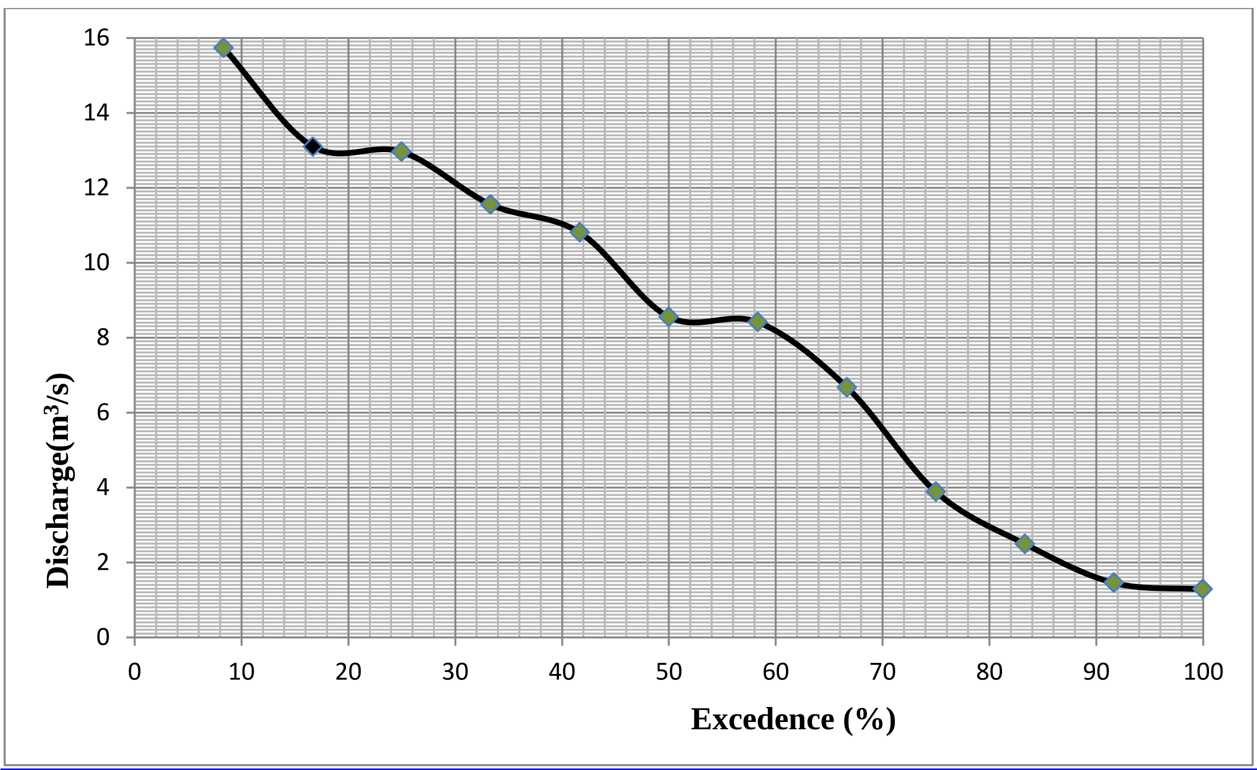


Figure.6.5.11.1 Flow Duration Curve (Scheme II) Elemoro River Site.

6.6 Analysis for Power Demand

6.6.1 Load Survey

Awara dam was initially constructed primarily for water supply to Ikare community.The water treatment plants at Awara dam is presently powered through 2 diesels generators, 2x 800KVA. There are plans to connect these water treatment plants to the public power supply but the infrastructure is not yet fully in place.

The two water schemes were surveyed and the load consumption was analysed as shown in **Tables 6.6.1** and **6.6.2** respectively. The water schemes are therefore considered as the major load centres. There is a possibilty of the CAC Church, the NYSC Orientation Camp and other negbouring communities that are within 5km radius of the proposed Awara Dam SHP as other load centres depending on the estimated supply of the proposed SHP plant.

Table 6.6.1: Load Demand for Old Water Scheme

EQUIPMENT/ FITTING	RATING (KW)	TOTAL NO OF EQUIPMENT	NO. OPERATIONAL AT A TIME	DIVERSITY FACTOR %	TOTAL POWER REQUIREMENT (KW)
Raw water pump	11	2	1	0.85	9.35
Treated Water (High Lift) Pumps for supply to town	160	2	1	0.85	68
Back Wash Pumps	18.5	1	1	0.7	12.95
Chemical Mixers/ Desolution for Alum	0.75	2	1	0.7	0.525
Chemical Mixers/ Desolution for Lime	0.75	2	1	0.7	0.525
Chemical Mixers/ Desolution for Chlorine	0.18	2	1	0.7	0.126
Chemical Dozing pumps for alum and lime	0.37	4	2	0.7	0.518
Chemical Dozing pumps for Chlorine	0.37	2	1	0.7	0.259
Security Lighting (Halogen)/Lighting Points	0.2	20	90	0.7	12.6
Total					**104.853**

Table 6.6.2: Load Demand for New Water Scheme

EQUIPMENT/ FITTING	RATING (KW)	TOTAL NO OF EQUIPMENT	NO. OPERATIONAL AT A TIME	DIVERSITY FACTOR %	TOTAL POWER REQUIREMENT (KW)
Raw water pump	18.5	2	1	0.85	15.725
Air blower	11	2	1	0.85	9.35
Treated Water (High Lift) Pumps for supply to town	160	1	1	0.85	68
Filter pump	18.5	2	1	0.5	9.25
Back Wash Pumps	18.5	1	1	0.7	12.95
Chemical Mixers/ Desolution for Lime	0.75	2	1	0.7	0.525
Chemical Mixers/ Desolution for Alum	0.75	2	1	0.7	0.525
Chemical Mixers/ Desolution for Chlorine	0.18	2	1	0.7	0.126
Chemical Dozing pumps for alum	0.37	2	1	0.7	0.259
Chemical Dozing pumps for lime	0.37	2	1	0.7	0.259
Chemical Dozing pumps for Chlorine	0.37	4	2	0.7	0.518
Air conditioners	0.75	2	2	0.8	1.2
Security Lighting (Halogen)/Lighting Points	0.2	40	90	0.7	12.6
Total					131.287

SUMMARY

Old Water Scheme	104.853kW
New Water Scheme	131.287kW
Total	**236.14kW**

7.0 DESCRIPTION OF THE PROPOSED SCHEME

The proposed Awara dam SHP plant is the existing structures on ground. Hence, the proposed scheme is the ‘’Behind the Dam Type SHP’’. The scheme will not in any way conflict with the location and operation of the existing water schemes already on ground at the Awara dam.

The fifty Five (55) year old Awara Dam was constructed for water supply to the communities, irrigation and flood control. The water supply objective cannot be fully exploited as a result of poor power supply from the public power source and the high cost of diesel to power the diesel generating plants.

The existing structures at the site are;

1. Dam embarkment/Reservoir
2. Weir
3. Intake tower/Bridge
4. 300mm Intake pipe for water treatment plants
5. 500mm Desilting pipe
6. Water treament plants (Old and New)

The ‘’Behind the Dam type SHP’’ will make use of the water resources without interfaring with the existing structures as above. A penstock is to be attached to the exiting 500mm desilting pipe with appropiate valves to create room for both the SHP penstock and desilting pipe to operate without hindrance.

The penstock is to convey the water to the power house to drive the turbine and discharge the water immediately through a tail race to the natural course of the river.

The proposed SHP design is to capture all the spilled water through the spillway for power generation. This implies that, very little spillage is projected through the existing spillway and this should not have any effect on the environment since the tailrace discharge is very close to the spillway thereby maintaning the existing ecosystem.

The proposed SHP scheme consists of the following basic components;

i. Penstock
ii. Power House/Turbines
iii. Tail Race

The schematic diagram is shown in and **Figure 7.0** and **Drawing AW/1/7**

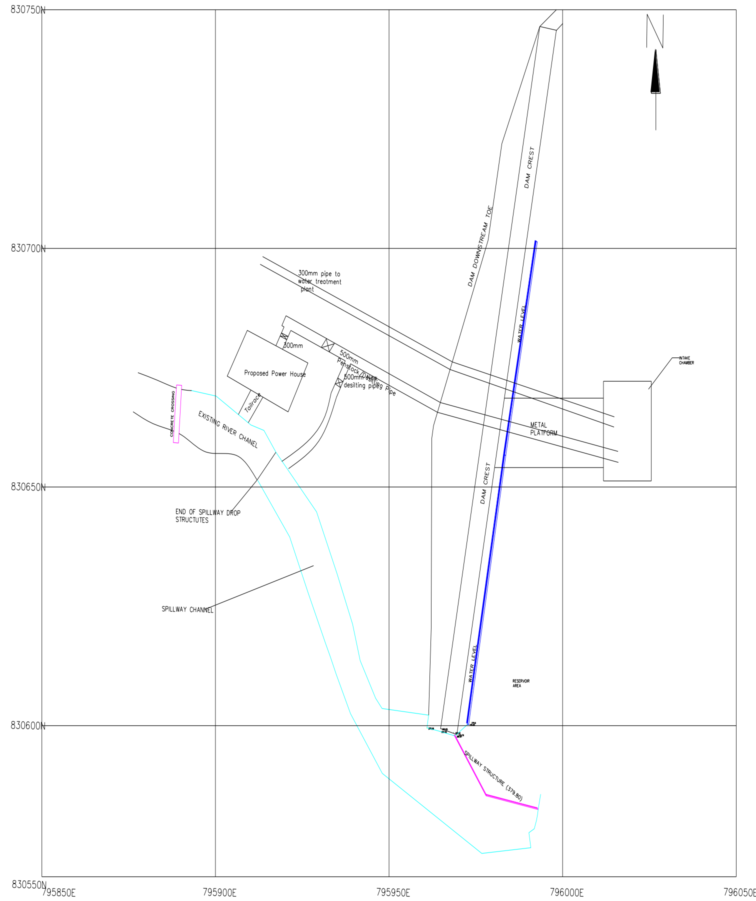


Figure 7.0 Schematic Layout of Proposed Awara Dam SHP.

8.0 DESIGN DATA – HYDRO POWER DEVELOPMENT

8.1 Design Criteria

The design criteria involve the following considerations:

- Analysis of Meteorological, Hydrological, Geological and Geotechnical data.
- Analysis of Topographical and Land Survey.
- Analysis of Power demand.
- Social, techno-economic and financial viability appraisal.
- Sustainability
- Political, Government Policy and objectives
- Ecological/Environmental Impact Assessment
- Community Participation
- Electric Power improvement/Evacuation.
- Operation and Maintenance
- Availability of Water and construction materials.
- Demographic/ Specified population to serve.
- Consideration of potential problems.
- Power regulatory bodies
- Recreational facilities potential.
- Existing Awara Earth dam that was constructed in 1958
- Water Supply production needs
- Existing 33kVHigh Tension Line.
- The two sites will operate as cascades (The flow released after Awara SHP generation will flow into Elemoro river at Oyimo for further power generation)

Penstocks and Tail water channel design Considerations:

- It is a conveyance from the Dam reservoir to the Turnine.
- Its design involves the selection of pipe material, economic diameter, and save thickness.
- Since its installation takes a significant components of the power plant construction, selection of a particular diameter should be optimized.
- Penstock bursting is very dangerous, hence careful design is imperative, to save cost losses.
- Dessign is based on total pressure which are the combination of dynamic and static pressure, inside the pipe.
- Steep ground profile is usually provided for best results in generating adequate momentum.
- In locating penstocks, changing from gentle to steeper slope should be avoided to prevent the development of negative pressures inside the pipe.
- Minimum bends should be selected to avoid more head losses and the need to involve anchoring designs.
- There is no need for surge tank because the elevation difference between the turbine and the reservoir Outlet pipe is low(0.6m). Also, the distance is short (30m), having a grade of 2%.

- High internal pressure waves created by sudden closure of valves are to be dampened by the Dam reservoir.

In view of the general observed storage conditions and catchment size of Awara dam, it was necessary to investigate other options around the vicinity of the dam that could supply more energy or at least augment the energy possibilities of Awara SHP.

The following options were investigated:

Option A: This involves the total determination of power output possibilities of Awara Dam. All discussed fully in chapter 6.This is catagorised as scheme I.

Option B: This involves investigating Elemoro river which is about 6 kilometer downstream of Awara Dam. A weir was proposed at Oyimo that could raise Elemoro river water elevation for power generation. Detailed hydrology was discussed in chapter 6. In this situation, the Oyimo SHP will serve as a cascade for the Awara SHP. This is catagorised as scheme II

8.2 Design Parameters

The underlisted design parameters were derived from the above design criteria for Scheme I

Design flow	=	0.11 m^3/s (50%)
Rated Net Head	=	10.0m
Gross Head	=	10.5 m
Desired turbine centreline setting to Tailwater	=	2.0m
System frequency	=	60 Hz
Efficiency Priority	=	5
Site Elevation	=	373.08m
Water Temperature	=	24°C

Turbine Sizing

Minimum output	=	8kW
Maximum output	=	10kW
Recommended	=	10kW
Operating Head range	=	8-12 m
Operating Flow range	=	0.088m^3/s-0.132 m^3/s

Elevation Profile

Dam crest level	=	381.00m
Water level at dam	=	379.85m
Weir crest level	=	379.80m
Invert level of Raw water pipe (300mm diam)	=	369.66m

Invert level of Flush pipe (500mm diam). Adopted Penstock

Lowest ground level at Power House location	=	371.33m
Highest ground level at Power House Location	=	375.85m
Downstream Channel level at Weir	=	377.27m
Downstream Channel level at 20m distance	=	374.83m
Downstream Channel level at 200m distance	=	369.57m

8.2.1 Scheme I

i. Design Discharge	=	$0.11m^3/s$ (50%)
ii. Gross Head	=	10.5m
iii. Resevior normal supply level	=	379.72m
iv. Reseviour live storage	=	$4.0x10^5m^3$

8.2.2 Scheme II

i.	Design Discharge	=	$10.8m^3/s$
ii.	Gross- Head	=	12.5m
iii.	Elevation at weir	=	323.5m

8.2.3 Power Potential

The power potential of the scheme can be calculated from the following relationship:

$$P=K\ Q_d\ H_g \text{-------------------------------------} 8.2.3.1$$

Where

P = Power Potential (kW)
H_g = Gross Head (m)
Q_d = Design Flow (m^3/s)
K = Factor = 7

The design flow was 10.8m3/s with a flow exceedence of 41.67%.
Substituting known values we have:

P = 7x 10.5 x 0.11
= 8.08kW **(Scheme I)**

P = 7x 10.8 x 12.5
= 945kW **(Scheme II)**

The range of potentials for all exceedence percentages are shown on **Table 6.5.11.1**

8.3 Design Calculations

8.3.1 Weir

8.3.1 Diversion Weir

For efficient and functional weir design it is necessary to know the possible maximum run-off from the catchment area for at least a return period of 25years. This flow value was determined using Fuller's formula, thus:

$Q_{flood} = C\,A^{0.8}\,(1+0.8 \log T)\,(1+2.76A^{-0.3})$ ---8.3.1.1

Where

Q_{flood} = rate of maximum run-off for a return period T (m^3/s)

T = return period in years
A = catchment area Km^2
C = dimensionless coefficient = 1.2 for Oyimo River site

The catchment area (A = 196.8Km^2) obtained from AOP Consult Ltd report of 2002. The value T was assumed to be 25 years. Fuller's equation is one of the earliest empirical maximum flood generation equation that included return period as one of its parameters. Its prediction is closest to Gumbel equations.

Substituting known values, we have

$Q_{flood} = 1.2\,(196.8)^{0.8}(1+0.8\log 25)[1+2.76(196.8)^{-0.3}]$

$= 1.8 \times 68.43\,[2.118][1.00]$
$= 1.8 \times 144.935$
$Q_{flood} = 260.88 m^3/s$

Determination of Head over Weir

The lead above weir could be determined using the weir equation viz:

$Q = C_w\,L_w(h_{top})^{1.5}$ --8.3.1.2a

Where

Q = discharge over weir (m^3/s)
L_w = length of weir (m)
h_{top} = head over weir crest level(m)

Re-writing equation 8.3.1.3 with htop as subject we have

$h_{top} = \left[\frac{Q}{CwLw}\right]^{0.667}$ ---8.3.1.2b

Also

$L_w = \frac{Q}{Cw(htop)1.5}$ --8.3.1.2c

Our aim is to select the values of L_w such that it is within the available physical site conditions and at the same time the value of h_{top} does not cause any appreciable backWater curve that may cause inundation of surrounding area behind the weir.

From cross-sectional survey of the weir axis(figure 8.2.2.1) the maximum width allowable for a head 10m is 218m. For different values of htop the value of L_w was determined as shown below

L_w(m)	h_{top}(m)	Q_{flood} (m^3/s)
200	0.706	260.88
335.40	0.50	260.88
721.666	0.30	260.88

From above the width of weir was selected to be 200m, the resultant back water curve will not have any serious effect on adjacent land; as the water level above the weir (htop0 is just about 0.706m.

i. **<u>Determine Water Elevation above weir at Normal dry season flow:</u>**

From Table 6.5.8.1, the January flow Q = 1.28m^3/s, L=200m, C=2.2
Determine h_{top} using equation 8.3.1.2b

$$h_{top} = \left[\frac{1.28}{2.2x200}\right]^{0.667}$$

. = 0.0203m i.e. [Elv 321.5203m]

See figure 8.2.2.1

ii. **<u>Determine Water Elevation above weir at flood flow period:</u>**

Q_{flood} = 260.88 m^3/s

Lw = 200m

C = 2.2

Substituting known values into equation 8.3.1.2b we have

$$h_{top} = \left[\frac{260.88}{2.2x200}\right]^{0.667}$$

= 0.7056m i.e [Elv 322.206m] (See figure 8.2.2.1)

iii. **Determine Water Surface Elevation at design flow Conditions:**

The design flow $= 10.8 m^3/s$
L_w $= 200m$
C $= 2.2$

$$h_{top} = \left[\frac{10.80}{2.2x200}\right]^{0.667}$$

$= 0.0844$ i.e. [Elv 325.584] (See figure 8.2.2.1)

8.3.2 Penstock Design (Scheme I)

Estimating Losses in the pipeline (Using Hazen-Williams formular)

$$\text{Major losses } (h_L) = \frac{V^{1.85}L}{(1.3128C_H)^{1.85} R^{1.17}}$$

Where

V (velocity) $= 3.16$ m/s
L (length of pipe) $= 25$m
C_H = Hazen-Williams coefficient = 120(new welded steel).
R = Hydraulic radius = Area/wetted perimeter

$$= \pi D^2/4\pi D$$
$$= D/4$$
$$= 0.6/4$$
$$= 0.15$$

$$h_L = \frac{(3.16)^{1.85} \times 25}{(1.312 \times 120)^{1.85}(0.15)^{1.17}}$$

$$h_L = 0.167m$$

Minor losses (h_{Lm}) in pipeline include enlargements, abrupt contractions, bends and Valves and fittings.

$$h_{Lm} \quad \text{(1 No enlargement)} = K_L \frac{(V1-V2)2}{2g}$$

$$K_L = 0.17$$

$$h_{Lm} \quad \text{(1 No } 45^0 \text{ Bend)} = K_L \frac{V^2}{2g}$$

$$K_L = 0.37$$

$$h_{Lm} \quad \text{(1 No Gate valve)} = K_L \frac{V^2}{2g}$$

$$K_L = 0.2$$

$$\text{Total losses} = \frac{V^2}{2g}[K_{Elargement} + K_{bend} + K_{gate}] + h_L$$

$$= \frac{V^2}{2g} [0.17+0.37+ 0.2] +0.167$$
$$= 0.50 (0.74) +0.167$$
$$= 0.3766 + 0.167$$
$$= 0.544m$$

8.3.2 Intake screening considerations

The Penstock line should be protected from any blockage such as straying of fish and other aquatic life and it has been provided in the design.

8.3.3 Design of Tail Water Channel

Scheme I

Design Discharge =0.11m^3/s. this will be the flow through the tail race canal

Scheme II

Design Discharge =10.8 m^3/s. this will be the flow through the tail race canal

Design Calculations

Option A

Using Manning's equation

$$Q = \frac{(BH + NH^2)^{5/2} S^{1/2}}{n\left[\left(B + 2H\sqrt{1 + N^2}\right)\right]^{2/3}} - - - - - - - - - - - - - 8.3.3.1$$

Where

Q = Flow rate in canal (m^3/s)
n = Manning's co-efficient
H = Optimum canal height (m)
B = Canal bed width (m)
N = side slope value(h/v) = 0 for rectangular channels
S = Channel bottom slope

Known values are:

N=0 rectangular Channel
Q= 0.11(m^3/s)
B= 1.0m (assumed)
n = 0.020(concrete)
S= 0.001

Substituting above

$$0.11 = \frac{\left((1\times H)+(0\times H)^2\right)^{5/2} 0.0001^{0.5}}{0.02\left[\left(1+2H\sqrt{1+0^2}\right)\right]^{2/3}}$$

$$0.11 = \frac{(H)^{2.5}(0.001)^{0.5}}{0.02\left[\left(1+2H\sqrt{1}\right)\right]^{0.667}}$$

Perform iteration with different values of H, such that LHS = RHS. (see Below)

Q	H
0.2403	1
0.056	0.5
0.1513	0.8
0.1143	0.7 ok

Select 0.7m as the normal depth of flow
The actual depth of channel shall be normal depth of flow plus free-board of 0.7m therefore actual depth = 1.4m
The shape of the channel is as shown below:

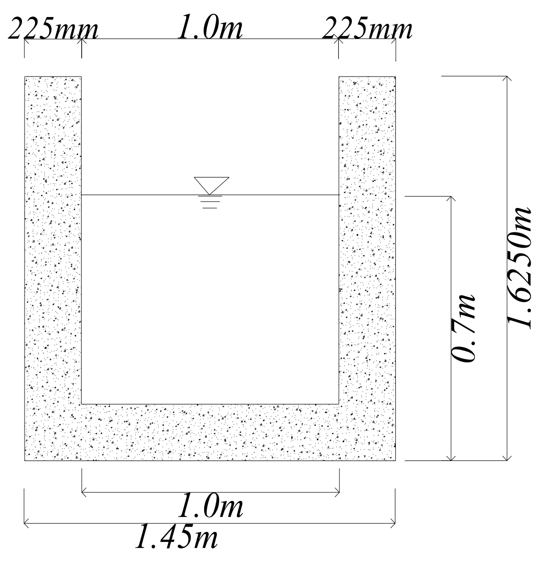


Figure 8.3.3.1 Cross-section of the Tailrace Channel (Scheme I)

Option B

Using equation 8.3.3.1 and substituting these known values we have:

Let Q = 10.80m^3/s

B = 3.0m

n = 0.020 (concrete)

S = 0.001

Substituting above

$$10.80 = \frac{\left((3H) + (0 \times H)^2\right)^{2.5} 0.0001^{0.5}}{0.02\left[\left(3 + 2xH\sqrt{1+0^2}\right)\right]^{0.667}}$$

$$0.11 = \frac{(3H)^{2.5}(0.001)^{0.5}}{0.02\left[\left(3 + 2H\sqrt{1}\right)\right]^{0.667}}$$

Perform iteration with different values of H, such that LHS = RHS. (See Below)

Q	H
12.0411	2
6.5009	1.5
10.7988	1.90 ok

Select 1.90m as the normal depth of flow

The actual depth of channel shall be normal depth of flow plus free-board of 0.7m therefore actual depth = 2.60m.

The shape of the channel is as shown below

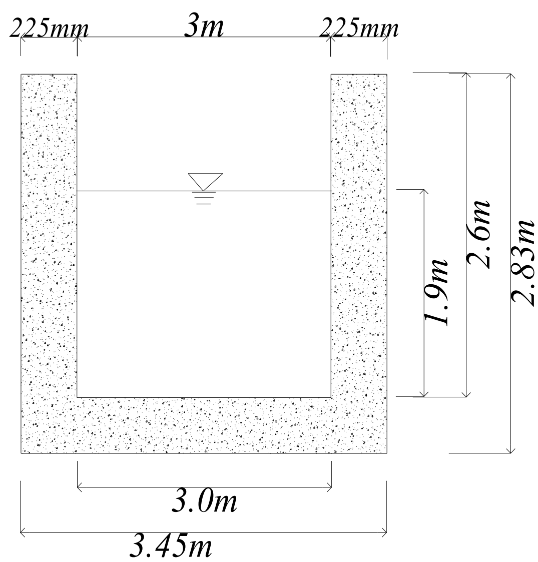


Figure 8.3.3.2 Cross-section of the Tailrace Channel (Scheme II)

8.4 Equipment Selection/Design Calculations Scheme I

Design head (H_d) = 10.5m

Design discharge (Q_d) = 0.11m^3/s at 50% execedence

The power potential at the site is Calculated as

$$P = KQ_d H_d \qquad \text{...}8.1$$

Where K is the efficiency of the system which is taken as 7

Therefore

$P = 7 \times 0.011 \times 10.5$

P= 8.085kW

Considering the avalable power of 8kW, a single unit 10kW turbine is selected for ease of operation and optimum cost of investment in electromechanical equipment and civil works. The unit capcity for the turbine is therefore 10kW, and the unit discharge per turbine 0.11m^3/s

This turbines is also expected to handle variation in flow of up to 20% without any significant change in the efficiency of the system.

Turbine Specific speed selection

(i) Specific speed N_s is calculated using the formulae;

$$N_S = N\frac{\sqrt{P}}{H^{1.25}} \qquad \text{...8.3}$$

Where Ns = specific speed

N= Turbine synchronous speed(rpm)

P= power of tubine (kW)

Selecting a generator synchronous speed of 750rpm the specific speed is calculated as ;

$$N_S = 750\frac{\sqrt{10}}{10.5^{1.25}} = 125.4$$

This value of specific speed fall within the range of specific speed of cross flow turbine which is 20-200.

On the basis of cost and ability to accomodate low flows, the cross flow turbine is therefore selected for installation at the site.

Turbine Parameters

Design head, H = 10.5m

Design Flow, Q=0.11m^3/s

From the formula $LD = 2.627\frac{Q}{\sqrt{H}}$ ...8.4

Where, L is the length of runner;

D is the runner diameter

Q is the design flow,

H is the net head

$$LD = 2.627\frac{0.11}{\sqrt{10.5}}$$

LD=0.015

Taking the values of D from 0.3m-1.0m, the corresponding values of L can be tabulated as follows;

Table 8.2: Values of D and L

Runner Diameter D(m)	Runner Length L(m)
0.1	0.15
0.2	0.08
0.3*	0.05*
0.4	0.04
0.5	0.03
0.6	0.03
0.7	0.02
0.8	0.02
0.9	0.02
1	0.02

From the table, a convinient value of 0.3m is selected for the runner diameter and corresponding value 0.05m for the runner width.

However the closets available standard dimension for cross flow turbine is 32/10. Therfore Dis take as 32cm and L as 10cm

Blade spacing (t)

Blade spacing is the distance between the tips of adjacent blades on the outer periphery and its calculated by using equation.

$$t = \frac{kD}{\sin\beta}$$

....8.5

Where k =0.087 and β = 30^o

$$t = \frac{0.087x0.3}{\sin 30^o}$$

t = 0.052m = 5.2cm

t = 4.4cm

Select t=5cm

The radius of curvature of the blades ρ is

The radius of curvature of the runner blades is calculated using equation 8.6.

ρ = 0.163XD 8.6

ρ = 0.163x0.3
= 0.049m
ρ = 5cm

Number of Blades Z

The number of blades on the runner is calculated using equation 8.7

$$Z = \frac{\pi D}{t} \quad \text{..8.7}$$

$$Z = \frac{\pi x 0.3}{0.104} = 9.06$$

Select Z = 9

<u>Equipment Selection/Design Calculations Scheme II</u>

Design head (H_d) = 12m

Design discharge (Q_d) = 10.8m^3/s

The power potential at the site is Calculated using equation 8.4.1 below.

$$P = KQ_d H_d \quad \text{..8.4.1}$$

Where K is the efficiency of the system which is taken as 7

Therefore
$P = 7 \times 10.8 \times 12$

P= 907.2kW

Considering the available power of 907.2kW, a 3x400kW system is considered for installation at the site for ease of operation and optimum cost of investment in electromechanical equipment and civil works. The rated unit capcity for each turbine is therefore 400kW, and the unit discharge per turbine is computed using equation 8.4.2 below. It is necessary to say that these turbines are also expected to handle variation in flow of up to 20% without any significance change in the efficiency of the system.

$$Q_T = \frac{Q_d}{3} \quad \text{.........} 8.4.2$$

$$Q_T = \frac{10.8}{3} = 3.6\text{m}^3/\text{s}$$

Using available selection chart by plotting the power of 400kW, flow of 3.6m^3/s and head of 10.8m on the chart in Fig.8.4.1 below, Cross flow Turbine and Kaplan turbine are adequate and suitable turbines, while the francis turbine is partially captured within the envelope as a suitable turbine.

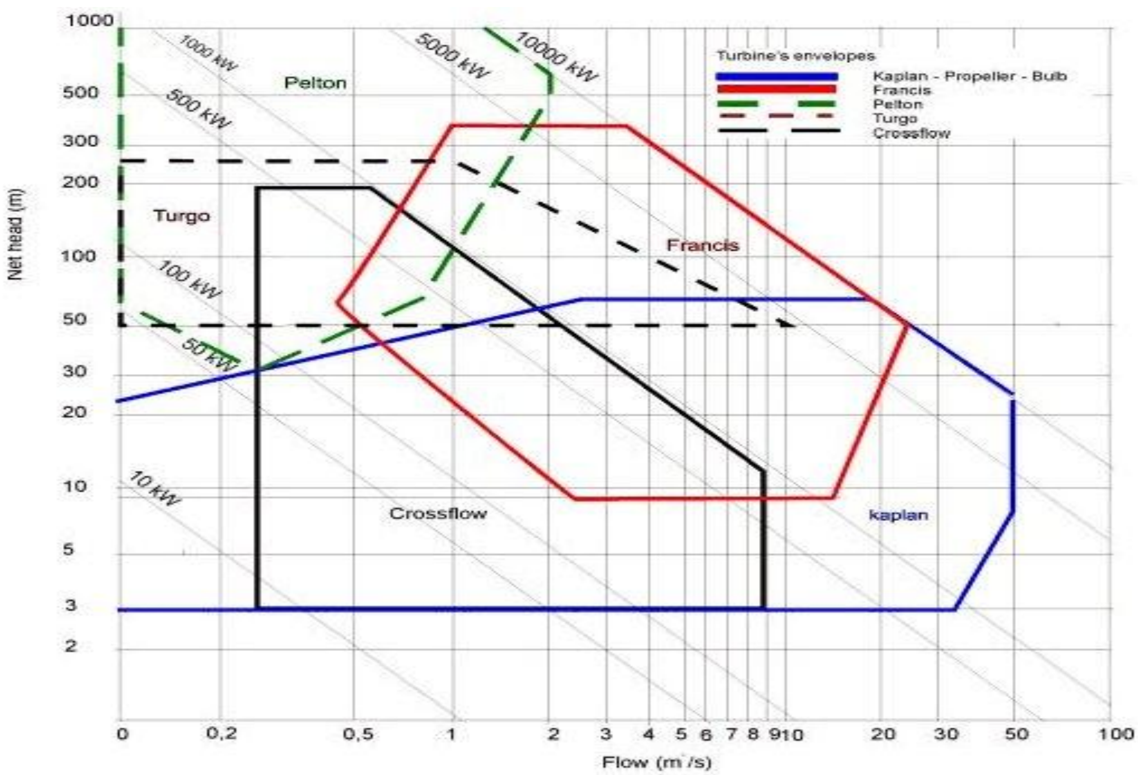


Figure. 8.4.1 Turbine selection chart based on Head, Power and Flow

Table 8.4.1 Comparing a kaplan turbine and Cross flow turbine for best runner selection

S/N	Parameter	Kaplan	Cross flow
1	Civil work	May require deep excavation for installation below the tail water race to avert cavitation	Less escavation is required, has no cavitation effects.
2	Cost	Both cost of civil work and turbine auxillary equipment will increase	Cost of civil work is lesser and has less auxillary equipments
3	Compartibility with medium head and low flows	Less compartible with low flows	Accomadates low flows easily at medium heads.
4	Efficiency	Considering the low flows per turbine, the efficiency will be lesser	Efficiency is 1-4% higher than that of Kaplan of the same size.
5	Local Content	No local content capacity in components manufacture	Avalable local content in components manufacture at EMDI/NASENI, Akure
6	Cavitation	Can be affected by cavition	Has no cavitional effects

The Cross flow runner is therfore selected as the most suitable runner for the Oyimo proposed plant.

8.4.2 Specific Speed Selection

(ii) Specific speed is calculated using equation 8.4.3 below

$$N_S = N\frac{\sqrt{P}}{H^{1.25}} \quad \ldots\ldots 8.4.3$$

Where Ns = specific speed

N= Turbine synchronous speed(rpm)

P= power of tubine (kW)

Cross flow specific speed can be estimated using equation 8.4.4;

$$N_S = \frac{513.25}{H^{0.505}} \quad \ldots\ldots 8.4.4$$

$$N_S = \frac{513.25}{12^{0.505}} = 146.33$$

Turbine synchronous speed can then be calculated from equation 8.4.3 as

$$146.33 = N\frac{\sqrt{400}}{12^{1.25}}$$

N = 163.4rpm

8.4.3 Generator Synchronous Speed Selection

Considering the 50Hz frequency system operated in Nigeria and a 14 pole generator coupled by step up transmission system, a 500rpm speed is selected as synchronous speed of generator.

8.4.4 Transmission Ratio (T_r)

This is obtain using the equation 8.4.5 below

$$T_r = \frac{N_g}{N_t} \quad \text{...8.4.5}$$

N_g = generator synchronous speed

N_t = Turbine speed

Therefore,

$$T_r = \frac{500}{163.4} = 3.1$$

A step up tramsmission ratio of 1:3.1 is required between turbine and generator

8.4.5 Turbine Parameters

Design head= 12m

Q=3.6m^3/s

Using the formula, $LD = 2.627\frac{Q}{\sqrt{H}}$ 8.4.6

Where, L is length of runner;

D is the runner diameter

Q is the design flow,

H is the net head

Substituting all known parameters we have below that

$$LD = 2.627\frac{3.6}{\sqrt{12}}$$

LD=2.7

Considering the values of D in the range 0.7m-1.9m, the corresponding values of L calculaated are in table 8.4.5.1 below:

Table 8.4.5.1: Values of D and L

Runner Diameter D(m)	Runner Length L(m)
0.7	3.86
0.8	3.38
0.9	3.00
1	2.70
1.2	2.25
1.3	2.08
1.4*	1.93*
1.5	1.80
1.6	1.69
1.7	1.59
1.8	1.50
1.9	1.42

From Table 8.4.2 above, a convenient value of 1.4m is selected for the runner diameter with a corresponding runner width of 1.93m.

i. **Blade spacing (t)**

Blade spacing is the distance between the tips of adjacent blades on the outer periphery and it is calculated using equation 8.4.7.

$$t = \frac{kD}{\sin\beta} \quad \text{.......................................} 8.4.7$$

Where k =0.087 and β = 30^o

$$t = \frac{0.087x1.4}{\sin 30^o}$$

t = 0.224m

ii. **Area of thickness of jet**

The area of jet can be determined using equation 8.4.8, this also enables us to calculate the optimum thickness of the jet which is the same as the nozzle width,

$$s = 0.22\frac{Q}{L\sqrt{H}} \qquad \text{...8.4.8}$$

$$s = 0.22\frac{3.6}{1.93\sqrt{12}}$$

S = 0.118m^2

iii. The radius of curvature of the blades, ρ

The radius of curvature of the runner blades is calculated using equation 8.4.9.

ρ = 0.163XD 8.4.9

ρ = 0.163x1.4
 = 0.2282m
Select ρ = 0.228m

iv. Number of Blades Z

The number of blades on the runner is calculated using equation 8.4.10

$$Z = \frac{\pi D}{t} \qquad \text{...8.4.10}$$

$$Z = \frac{\pi x 1.4}{0.224} = 19.63$$

Select Z = 20

Table 8.4.5.2: Turbine Specification

S/N	Parameter	Value
1	Type	Crossflow
2	Capacity	400(kW)
3	Orientation	Horizontal
4	Length or with of runner (L)	1.93m
5	Runner diameter (D)	1.4
6	Runner speed	163rpm
7	Blade spacing (t)	0.224m
8	Nozzle width (s)	0.118m
9	Radius of curvature (ρ)	0.228m
10	Number of blades Z	20

Table 8.4.5.3 : Genarator Parameters

S/N	Parameter	Value
1	Type	Synchronous
2	Orientation	Horizontal
3	Capacity	500(kVA)
4	Voltage	400V
5	Frequency/Phase angle	50Hz/0.8
6	Runner speed	500rpm
7	Coupling/transmission	Axial/1:3.1 gear system

8.5 Energy Generation Scheme I

The proposed installed power potential is 10kW taking into consideration the design head and flow of the dam.

The average annual energy generation of the plant = 10kW x 24hrs x 365days

= 87,600kWh/yr

= 87,600kWh/yr

The net annual energy generation of the plant is taken at 90% plant factor

$$= 87{,}600kWh/yr \times 0.9$$

$$= \underline{78{,}840kWh/yr}$$

Energy Generation Scheme II

The proposed installed power potential is 1200kW taking into consideration the design head and flow of the dam.

The average annual energy generation of the plant = 1200kW x 24hrs x 365days

= 10,512,000kWh/yr

= 10.512GWh/yr

The net annual energy generation of the plant is taken at 90% plant factor

$$= 10.512 GWh/yr \times 0.9$$

$$= \underline{9.4608 GWh/yr}$$

8.6 Expected Revenue Scheme I

Installed capacity = 10kW

Operating time = 24hr/day

Net annual generation = 78,840kWh/yr

Suggested tariff (NERC, MYTO A_3-Ibadan DISCO)= ₦16.8/kWh

Annual revenue = 78,840 X 16.8

= ₦1,324,512.00/yr

Life expectancy of the plant = 50 years

Expected Revenue Scheme II

Installed capacity = 1200kW

Operating time = 24hr/day

Net annual generation = 9.4608GWh/yr

Suggested tariff (NERC, MYTO A_3-Ibadan DISCO)= ₦16.8/kWh

Annual revenue = 9,460,800 X 16.8

= ₦158,941,440.00/yr

Life expectancy of the plant = 50 years.

8.7 Retsrceen Energy Analysis Model

The design parameters for the Awara Dam/Oyimo River SHP development were simulated using the Retscreen Energy Model for Small Hydro Power. The result of the simulation is shown in **A 8.7.1**

9.0 COST ESTIMATES

9.1 Costs Estimates for Awara Dam SHP (Scheme I)

9.1.0 Civil Works BEME for Awara Dam SHP(Scheme II)

ITEM	DESCRIPTION	UNIT	QTY	RATE(N)	AMOUNT(N)
1.0	**POWER HOUSE FOUNDATION**				
1.1	Excavation in any material except rock for foundation and cart away excavated materials as directed.	m^3	306.0	900	275,400.00
1.2	Ditto in rock.				
1.3	Level and compact bottom of excavation and place grade U1500 as blinding (50mm thick).	m^2	6.6	1,200	7,200.00
1.4	Provide and place concrete grade 25 in walls.	m^3	1.32	30,000	63,600.00
1.5	Provide and place concrete grade 25 in Stilling floor.	m^3	0.66	30,000	19,800.00
1.6	Ditto in Draft tube chamber wall.				
1.7	Provide and fix steel shuttering.				
1.8	Ditto in stilling basin wall.	m^3	0.75	30,000	27,000.00
1.9	Provide and place in position 225 Hollow sandcrete blocks.	m^2	23	2,500	57,500.00
1.10	Provide and place weak concrete grade 15 in walls of foundation.	m^3	3.5	15,000	52,500.00
1.11	Provide and fix according to the drawings high tensile steel reinforcements.	m	201	200	40,260.00
1.12	Backfilling of foundation with approved material by the engineer.	m^3	66.0	1,000	66,000.00
1.13	Provide and fix on site formwork to accommodate concrete.	m^3	283	1,200	285,600.00

	C/F				894,860.00
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**RATE(₦)**	**AMOUNT(₦)**
	B/F				894,860.00
2.0	**POWER HOUSE FLOOR**				
2.1	Provide and place concrete grade 20 in slab.	m^3	4.5	30,000	135,000.00
2.2	Provide and fix steel shuttering.				
2.3	Provide and fix according to the drawing high tensile steel reinforcements.	m	132	200	26,400.00
3.0	**WALKWAY**				
3.1	Construct concrete walkWay round the Power House as shown in the drawings.	m^3	7.0	30,000	210,000.00
3.2	Provide and fix B.R.C mesh type A242 inside the walkWay concrete	m^2	47	850	39,950.00
4.0	Construct stone pitching round the Power House as shown in the drawing.	m^2	99.0	3,500	346,500.00
5.0	**POWER HOUSE SUPER STRUCTURE**				
5.1	Provide and place in position 225mm Hollow sandcrete blocks.	m^2	39.0	2,500	99,000.00
5.2	Supply to site and install in position approved door complete to the main entrance to the control room and Power House.	No	1	22,000	22,000.00
5.3	Supply to site and fix in position 1200mm x 1200mm Aluminum window and glass complete to the control room and Power House.	No	3	18,000	54,000.00
5.4	1:2:4 Reinforced concrete (Cement: Fine aggregate: Coarse	m^3	1	30,000	30,000.00

	aggregate) in lintel.				
5.4a	Provide and fix according to the drawings high tensile steel reinforcements in Lintel.	m	38	200	7,600.00
	C/F				1,865,310.00
	B/F				1,865,310.00
5.5	Concrete (Cement: Fine aggregate: Coarse aggregate) in columns.	m^3	0.66	30,000	19,800.00
5.5a	Provide and fix according to the drawings high tensile steel reinforcements in Column.	m	69	200	13800.00
5.6	Supply to site and place in position louvered blocks.	m^2	9.9	2000	19,800.00
5.7	Construct 300mm x 225mm roof beam as shown in drawings.				
6.0	**ROOFING**				
6.1	Supply to site and fix wooden thruss, all as a unit as shown in the drawing.	L.S			132,000.00
6.2	Eaves and berges in roof edges.	m^2			50,000.00
6.3	0.55 gauge stocco Alluminium corrugated roofing sheets laid on roof thruss nailed to the satisfaction of the Consultant.	m^2	33	2,600	45,800.00
7.0	**FLOOR, WALL AND CEILING FINISHING**				
7.1	40mm thick (1:4) cement and sand mortar floor screed toweled finish.	m^2	25	500	8,250.00
7.2	12mm thick (1:4) cement and				

	sand plastering on walls, internally, externally and on reveals.	m^2	87	350	30,450.00
	C/F				2,185,210.00
	B/F				2,185,210.00
8.0	**PAINTING**				
8.1	Prepare and apply 2 undercoats and one finishing coat of emulsion paint on walls internally, externally, reveals and fascia board.	m^2	99	400	39,600.00
9.0	**TAIL RACE CHANNEL**				
9.1	Clearing of site including cutting of trees, shrubs and cart away to spoil.	m^2	198	25	4,950.00
9.2	Excavation in any material except rock to depth not exceeding 4.0m and cartaway surplus as directed.	m^3	316	1000	316,000.00
9.3	Level compact bottom of excavation and place concrete grade U1500 as blinding (50mm thick) for 20m distance.	m^2	66	1200	79,200.00
9.4	Provide and place concrete grade 25 in box channel for 20m distance.	m^3	35	30,000	1,050,000.00
9.5	Provide and fix wrought shuttering.	m^2	425	2000	850,000.00
9.6	Provide and fix high tensile steel reinforcement.	m	2940	200	588,000.00

9.7	.Supply to site excavate soil, lay, join twin 500mm UPVC pipe including backfilling.				
10.0	Provide 5 tonnes capacity overhead travelling and lifting crane on 300mm x 250mm Universal Beam as shown in the drawing.	L.S			330,000.00
11.0	Provide concrete stairs at locations shown in the drawing.	L.S			198,000.00
	C/F				5,640,960.00
	B/F				5,640,960.00
12.0	Provide approved screen at exit of pipe to the river channel.	L.S			130,000.00
13.0	Provide for general landscaping and linking of water works waste flow to tail race channel.	L.S			330,000.00
14.0	Provisional for Fittings	L.S			600,000.00
15.0	**GRAND TOTAL**				**6,700,960.00**

9.1.1 Electro-Mechanical Cost for Awara Dam SHP (Scheme I)

S/N	Description of Item	Unit	Quantity	Unit Rate (USD)	USD	Naira @ 159/$
1	10kW Cross flow Turbine	Set	1	5,400	5,400	858,600.00
2	3Phase Synchronous generator 12.5kVA, 415V, 0.8PF,50Hz, Horizontal type	Set	1	6,500	6,500	1,033,500.00
3	Butterfly valve	Set	1	400	400	63,600.00
4	Automatic Component (Electronic Load Controllers)	Set	1	500	500	79,500.00
5	Provide for Earthing of all electrical devices/equipment in the Power house	Lump	Sum	1,200	1,200	190,800.00
6	Provide for installation of the equipment and training of recommended Engineers.	Lump	Sum	4300	4,300	683,700.00
7	Freight Cost	Lump	Sum	5,500	5,500	874,500.00
8	Insurance and duty	Lump	Sum	4,000	4,000	636,000.00
	Sub Total				**27,800**	**4,420,200.00**

9.1.2 Summary of Costs for Awara Dam SHP (Scheme I)

BILL NO	DESCRIPTION	AMOUNT ₦
1	POWER HOUSE AND TAIL RACE	**6,700,960.00**
2	ELECTRO – MECHANICAL WORKS	4,420,200.00
3	POWER EVACUATION	500,000.00
4	SUB- TOTAL (1)	11,621,160.00
5	CONSULTANCY SUPERVISION, 13%	1,510,750.80
6	SUB – TOTAL (2)	13,131,910.80
7	CONTINGENCY , 5%	656,595.54
8	SUB – TOTAL (3)	13,788,506.34
9	ADD VAT 5%	689,425.32
10	**GRAND TOTAL(A)**	**14,477,931.66**

9.2 Costs Estimates for Oyimo River SHP (Scheme II)

9.2.0 Electro-Mechanical Equipment cost for Oyimo River SHP Project (Scheme II)

S/N	Description of Item	Unit	Quantity	Unit Rate (USD)	USD	Naira @ 159/$
1	400kW Cross flow Turbine	Set	3	35,280	105,840	16,828,560.00
2	3Phase Synchronous generator 500kVA, 415V, 0.8PF,50Hz, Horizontal type	Set	3	48,100	144,300	22,943,700.00
3	Excitation System	Set	3	3,075	9,225	1,466,775.00
4	Butterfly valve DN500	Set	3	1,860	5,580	887,220.00
5	Automatic Component (Electronic Load Controllers)	Set	3	7,540	22,620	3,596,580.00
6	Synchronization panel with voltmeter, ammeter frequency meter, power factor meter	Nos	3	13,720	41,160	6,544,440.00
7	Provide for Earthing of all electrical devices/equipment in the Power house	Lump	Sum	2,100	2,100	333,900.00
8	Lightning arrester:-1lightning arrester indoor and the 2nd arrester outdoor.	Set	3	900	2,700	429,300.00
9	D.C System Inverter (230V AC from 110V DC)	Lump	Sum	2,000	2,000	318,000.00
10	Provide for installation of the equipment and training of recommended Engineers.	Lump	Sum	11240	11,240	1,787,160.00
11	Provide and install a 10 tonnes crane (EOT) including; slip line-Htype, steel track and accessories	Nos	1	5600	5,600	890,400.00
12	Freight Cost	Lump	Sum	22,000	22,000	3,498,000.00
13	Insurance and duty	Lump	Sum	13,000	13,000	2,067,000.00
	Sub Total				**387,365**	**61,591,035**

9.2.1 Power Evacuation (Oyimo River SHP Scheme II)

S/N	Description of Item	Unit	Quantity	Unit Rate (USD)	USD	Naira @ 159/$
1	4 x 500mm^2 PVC/SWA/PVC (armoured cable)	M	250	105.00	26,250	4,173,750.00
2	Provide and install 1x 1.5mVA,0.415/11kV, 50Hz step up transformer	No	1	45,271.00	45,271	7,198,089.00
3	Provide and install 2100A, O.415KV Isolator	No	3	630.50	1,892	300,748.50
4	Provide and install 2100A, O.415KV Circuit breaker	No	3	630.50	1,892	300,748.50
5	Provide and install 100A, 11KV Isolator	No	3	843.00	2,529	402,111.00
6	Provide and install 100A, 11KV Circuit breaker	No	3	843.00	2,529	402,111.00
7	Provide and install 100A, 11KV current transformer	No	3	505.00	1,515	240,885.00
8	1500mm^2 Al, cables for transmission and distribution from power house to Awara water treatment plant	M	14,000	2.00	28,000	4,452,000.00
9	Provide for connection at the water treatment plant and provision for connection to existing 11kV line for transmission to town	Lump sum	Lump sum	3,500.00	3,500	556,500.00
	Sub Total				**109,877**	**17,470,443.00**

9.2.2 Summary of Costs for Oyimo River SHP (Scheme II)

BILL NO	DESCRIPTION	AMOUNT ₦
1	PRELIMINARIES (PROVISIONAL)	20,000,000.00
2	ADDITIONAL SITE INVESTIGATION (PROVISIONAL)	2,000,000.00
3	FOUNDATION TREATMENT	5,000,000.00
4	RIVER DIVERSION WORKS & COFFERDAM	40,000,000.00
5	BOTTOM OUTLET WORKS	20,000,000.00
6	SPILLWAY WORKS	500,000,000.00
7	ELECTRO – MECHANICAL WORKS	61,591,035.00
8	ACCESS ROAD	150,000,000.00
9	POWER EVACUATION	17,470,443.00
10	SUB- TOTAL (1)	816,061,478.00
11	CONSULTANCY SUPERVISION, 13%	106,087,992.00
12	SUB – TOTAL (2)	922,149,470.00
13	CONTINGENCY , 5%	46,107,474.00
14	SUB – TOTAL (3)	968,256,944.00
15	ADD VAT 5%	48,412,847.00
16	**GRAND TOTAL (B)**	**1,016,669,791.00**

Awara Dam/ Oyimo River SHP Development

Grand Total = Grand Total (A) + Grand Total (B)

= 14,477,931.66 + 1,016,669,791

Grand Total =₦1,031,147,723

9.3 Operation and Maintenance Cost for Awara Dam SHP (Scheme I)

1. Personnel costs (including medicals etc)
   - Salary cost for 2 operators

     = ₦124, 330.74/m

     = ₦1, 491,968.88 p.a

2. Maintenance and Repair (E/M Equipment)
   - E/M investment from cost estimates = ₦ 4,420,200
   - O/M cost (2% p.a of capital cost) = ₦ 88,404.00
3. Maintenance and Repair (Civil works)
   - Civil works investment estimates = ₦6,700,960.00
   - O & M (1.5 % p.a. of capital cost) = ₦ 100,514.40
4. Administration and overheads

   Total = ₦ 1,680,887.28

Operation and Maintenance Cost for Oyimo River SHP (Scheme II)

1. Personnel costs (including medicals etc)
   - Salary cost for 2 operators

     = ₦124, 330.74/m

     = ₦1, 491,968.88 p.a

2. Maintenance and Repair (E/M Equipment)
   - E/M investment from cost estimates = ₦ 61,591,035.00
   - O/M cost (2% p.a of capital cost) = ₦ 1,231,820.70
3. Maintenance and Repair (Civil works)
   - Civil works investment estimates = ₦ 737,000,000.00
   - O & M (1.5 % p.a. of capital cost) = ₦ 11,055,000.00
4. Administration and overheads

   Total = ₦ 13,778,789.58

9.4 Supervision of Construction Cost for Awara Dam/Oyimo River Cascade Scheme.

9.4.1 Supervision of Construction Cost for Awara Dam SHP (Scheme I)

The supervision of construction is often considered as project management for which UNIDO as a matter of policy charges 13% of the project cost, which in this case is ₦ 1,641,419.52 (10,388.731 USD).

Supervision of Construction Cost for Oyimo River SHP (Scheme II)

The supervision of construction is often considered as project management for which UNIDO as a matter of policy charges 13% of the project cost, which in this case is ₦ 106,087,992.00 (671,442.99 USD).

Grand Total (Cascade Scheme) = ₦ 1,641,419.52 + ₦ 106,087,992.00
= ₦ 107,729,411.52

10.0 ENVIRONMENTAL IMPACT ASSESSMENT

10.1 Introduction:

Environmental Impact Assessment of the Awara Dam was carried as at the time the Dam was constructed in the 1955s and beyond.

The effect of SHP on the environment is always negligible. In other words it is benign to the environment.

Three numbers heavy duty generators have been proposed to run the Water Treatment Plant under construction. One can imagine the degree of air pollution that will occur from the exhaust gases. This pollution will be eliminated by executing this SHP project in the shortest possible time.

10.1.1 Background

In Nigeria, Carrying out any major project requires an Environment Impact Assessment in line with the statutory provisions of the Federal Ministry of Environment and other relevant laws of the country. The essence of this assessment is to ensure that the proposed project does not impact negatively on the environment both during execution and operation at the completion of the project.

This EIA is conducted to determine the baseline environmental state of the project location and surroundings by giving a description of the physical and social components of the environment. In addition, the EIA will determine the possible positive and /or negative impacts of the proposed Awara Dam small hydro power project will have on its immediate environment. Primarily, the characteristics and sources of environmental degradation and negative or positive effects will be identified and highlighted. It will also recommend the control measures for the envisaged impacts and an environmental management plan that will ensure the sustainability of the small hydro project and the environment.

10.1.2 Objectives of the EIA

The objectives of the EIA were to:

- Determine and evaluate the potential impacts of the proposed project activities on the identified environmental sensitivities and interaction between the sensitivities;
- Identify the environmental sensitivities of the project area;
- Acquire baseline data of the environment as well as the socio-economic and health conditions of the host community.
- Use baseline data to describe and characterize the study areas
- Recommend appropriate mitigation measures; and
- Develop an environmental management plan.

10.1.3 Scope of the EIA

The scope included:

- Project infrastructure and process description.
- Review of pertinent literature;
- Desktop baseline data gathering (biophysical, social And health)
- Prediction and evaluation of potential impacts;

- Determination of appropriate mitigation measures;
- Preparation of an environmental management plan
- Report preparation.

10.1.4 Administrative and Regulatory Framework

The environmental costs of haphazard development of Industrial facilities and water resources projects are enormous and such cost compromise the sustainability of the environment in the long term. This coupled with the fast rate at which our natural resources are dwindling, necessitates the incorporation of environmental assessment as a planning and resources management tools in the development of projects and industrial facilities in Nigeria. In furtherance to this, there are regulatory legislations, guidelines and standards that govern the assessment of environmental impacts of developmental projects.

10.1.5 Structure of the Report:

The EIA report of Awara small hydro power project is divided into parts as follows:-

The first part presents the introduction, legal and administrative and regulatory frame work, while the second part discusses project justification and sustainability. Part three handles the project description. Part four, Environmental description. Part five highlights the predicted impacts of proposed project while part six profers mitigation measures for the impacts. Part seven provides the environmental management plan and part eight the Decommission and abandonment and finally part nine the conclusion and recommendations.

10.2 Justification of Project

In Nigeria as a developing Nation, there is need to increase the energy supply in order to bring about the improvement in the quality of life of her people. It is not an over statement to mention that power supply in our society has been dwindling, irregular and insufficient. The situation worsens the poverty level in our society. The progress towards energy self reliance is probably best achieved through development of renewable energy resources as these energies will eventually be the only sources available to sustain the communities. Of all the renewable energy sources, small hydro power is the only renewable energy sources which have sufficient potential to meet many developing countries needs for the next decade. Although the environmental impacts of SHP are not yet major and yet, the environmental precaution are available, which can be implemented to prevent damage and mitigate the environmental impacts. There are at present very few SHP project in Nigeria, yet there abound several sites that can support such laudable projects to enhance better living conditions of our people.

10.3 Value of the Project

The proposed SHP project at Awara Dam is located at Awara dam in Ikare because of the already existing Infrastructure (dam) which will increase the utilization of the stored water. The project will improve water supply to Ikare and environs by way of regular energy supply to the existing Water Treatment Plant which has just been rehabilitated and upgraded. The project will also benefit the Awara village and neighboring communities with added advantage of energy services in the domestic activities as well as commercial. The use of food preservation appliances like fridges, roasters, freezers will enhance food processing in the locality. The project also has national benefits which includes secure power supply to the people irrespective of power shortages from National grid. This project is independent of PHCN. The electricity generated can be extended very easily to other nearby communities using the existing PHCN network as may be necessary and feasible. The operation of the SHP project will bring about reduction in Green house gases emission since no fossil fuel will be utilized.

The development of this SHP project will facilitate the development of Ondo State and the Communities in particular.

10.4 Sustainability

The Awara Dam SHP project will obtain its water from the existing Awara Dam on Asanodi River. Since it is a renewable energy programme with regular rainfall in the watershed, the reservoir will always receive water which is a basic input for sustainability of the SHP project.

The scheme will be maintained mainly from the revenue generated from the collection of tariffs on electricity consumed by the local industries and other consumers. Member of the communities shall be trained to operate, maintain and manage the scheme.

10.5 Description of the project

10.5.1 Project Location:

The proposed project is located at Akoko North East Local Government in the Northern Senatorial district of Ondo State on Longitude 7^0-30'and 8^0-00 'E and Latitude 5^0-30'and 6^0-00' N.

The Dam which is already existing can serve as a renewable energy source for the running of the SHP that will be installed downstream of the dam.

The dam was built in the 1950^s to supply water to Ikare township, Arigidi, Ugbe, Arigidi Imo, etc all in Akoko North East Local government area of Ondo State.

10.5.1 Project Process and infrastructure:

i Infrastructure

Simple and cost effective type of civil works is planned for the scheme. As has been mentioned, there is a dam existing that will supply the hydraulic head required. Embedded in this dam is the major head works which includes diversion weir, intake, settling basin, and screens.

Part of the penstock, a 500mm diameter steel pipe has been included as part of the already constructed dam. The stilling basin downstream of the weir, the remaining lengths shall be connected at this point to link to the power house. Other civil work parts have been described into details in previous chapter.

ii Process description.

Water that is stored behind a dam provides the potential energy which has to be converted to kinetic energy which in turn is converted to shaft power at the power house. This required energy is delivered through the penstock at high velocity through a set of nozzle that impact on the blades of the turbines thereby giving it a rotational energy.

10.6 Description of Environment

10.6.1 Climate

The project is situated within the northern fringes of the rain-forest belt, the climate should be classified into raining season and dry-season. The raining season starts from the month of April and ends in October while the dry season is between November and March each year.The Basic baseline climatological data is shown on Table 6.1.1through Table 6.1.7 in chapter six.

10.7 Associated and Potential Environment Impact and Mitigation

10.7.1 Health

There is no Impact of the project on water borne disease as envisaged.

10.7.2 Constructional Phase

10.7.2.1 Physical/Chemical impacts

i. Water

The activities of the construction may have some sediment transported into the stream by erosion during construction due to land clearing operations. However the Land to be cleared is so small that it is a temporary effect. The stream flow will not be restricted during construction and no diversion. There will not be any effect on the ground water.

ii Land

The project will not have any negative effect on the land use as the required land area is minimal and very much less than 0.10 hectares. The location of the project is not situated around farmland area that will require resettlement of farmers or payment of compensation..

iii Air

The proposed project will not emit any pollutants gas into the atmosphere. It is environment friendly; in fact, the construction and commissioning of the SHP project will reduce the usage of generator when the supply electricity to the water works is achieved. This is a positive effect of the project on the environment. The dust that will be emitted during construction will only last for a very short period of time.

iv Noise

We expect some noise from the vehicular traffic engine during construction phase of the project. However, the site is far from residential area/quarters and town, therefore its impact is limited.

10.7.2. 2 Ecological impacts:

v. Species and Populations

As far as species and population are concerned, the project land take is small and will not displace any species and their habitat. There are no effluent discharges coming out by the project operations than water which will encourage the growth of necessary species. The project operation will bring about water releases to the downstream during the dry season which has never occurred since the dam project was commissioned fifty – five years ago. No flora or fauna will be affected by the construction operations.

vi Communities and Habitat

By the clearing in the construction phase, no communities will be disturbed at all.

vii. Ecosystem

The ecosystem will not be affected neither will the resultant urbanization that may result from the project will not affect the ecosystem.

10.7.2.3 Aesthetics Impacts

viii. Land

No land beauty shall be affected by the activities in the construction phase, the clearing and the little excavation during construction shall be left unattended to

ix. Air

No odors are expected,

x. Water

No diversion of water in the construction phase is projected.

10.7.2.4 <u>Social Impacts:</u>

xi. Individual Environmental Interests

The proposed action will not have any historical settling, thereby disrupting its continuity.

xii. Individual Well Being

The equipment operating at site will be far from the city center and dwelling places, there is no significant effects.

xiii. Social Interactions:

The project will bring to the project environ labourers who are to be employed during the construction phase, the village around the vicinity of the project will get employment. When the construction is completed, electricity will be available and the economic activities of the people around the project area will improve.

xiv. Community Well Being:

The community well being shall not be affected during the construction phase adversely. Nothing will change adversely in the well being of the community.

10.7.3 Operational phase:

10.7.3.1 Physical / Chemical Impacts

xvi. Water

Water shall be utilized during the operation to run the turbines. The water so released will be utilized downstream for irrigation purposes during the dry-season of the year. No pollution is added to water in any form during the operation phase. No pollutant will be added to the water. There is no ground water effect during the operational phase.

xvii. Land

During the operational phase, the small land was utilized for the erection of power house and the penstock shall not be extended.

xviii. Air:

No pollutants shall be released into the atmosphere as the SHP project utilizes only water to run its turbines.

xix. Noise:

No noise of any considerable output will be released by the operation of the turbines and generators.

10.7.3.3 Ecological Impacts

xx. Species and population:

During the operational stage no species and population will be affected.

xxi. Communities and Habitats:

No community and habitat of animal shall be destroyed during the operational phase, the release of water downstream during the dry season will enhance the survival of the communities and habitats.

xxii. Ecosystem:

No loss of Agricultural land is expected during the operational phase. No vegetation has been destroyed and none shall be destroyed during the operational phase.

10.7.3.4 Aesthetics Impacts

xxiii. Land:

No effect is expected during the operational phase on the aesthetics of the land.

xxiv. Air:

No odours will be released into the air during operational phase

xxv. Water:

No crimination of natural sites, no effluent being discharged into the river, so no color change.

xxvi. Biota:

There is no bush clearing at this operational phase, therefore no animal habitat will be affected There is also no modification in vegetation.

10.7.3.5 Social Impacts

xxviii. Individual Environmental Interests:
At this phase of the project, there is no infringement on settings and no disturbance of continuity.

xxix. Individual Well Being:
During the running of the turbines there will not be any noise that can disturb the psychological well being of any individual. There are no health hazards expected in running the turbines.

xxx. Social Interactions:
The project when it starts to operate will improve the livelihood of the people with regular supply of electricity. There is bound to be influx of people into the environment that has a regular supply of electricity. The operational stage will provide job opportunities for the youth as well as the elderly. More small scale business will spring up. Agro- processing business will also increase; the health and well being of the people will improve generally.

xxxi. Community Well Being:
The proposed operational phase will bring about improvement in the community generally. Security will improve, with street lights, criminals will have no place to hide. The overall environment of the community will improve in all aspects. Poverty will be reduced considerably.

10.7.4 Mitigation:
Generally, the effect of the SHP project is friendlier to the environment than being unfriendly. Therefore only those categories of impacts that require mitigation will be discussed.

10.7.4.1 Constructional Phase

i. Air:
Dust generation during construction will occur when vehicles move to and fro the site. This can be ameliorated by ensuring that the dusty roads are wetted regularly. The use of water browsers to spray exposed land surfaces and particularly areas likely to be disturbed by trucks and other vehicles during the construction A maximum speed of 25km/h will be enforced for all haulage trucks to the site to ensure that dust generation is kept to a maximum.

ii. Noise:
During the construction phase, the ambient noise level may only increase if equipment with heavier noise level is used in the area. As mentioned earlier the site is about 7km to the Ikare-Ado-Ekiti motorway/road in the town. Workers will be mandated to use hearing protective devices which can attenuate noise to acceptable range of 15-22dB (A).

iii Socio economic benefit:
The provision of regular and constant electricity to the community will benefit the people tremendously. Economic activities will improve considerably.

iv. Traffic Effects:

During the haulage of machinery and equipment to site prior to and during construction, there is bound to be heavy traffic. It will cause any hold –up but could be hazardous to children and elderly alike. Warning notices will be placed on both sides of the road network, in town and at the entrance to the water works. At present the access road to the project site is in deplorable condition and possibility of over speeding is very remote. In spite of this, a traffic warden will be appointed to man strategic locations.

v. Occupational safety and health:

Mitigation measures under occupational safety and health will involve the protection of persons or any class of persons working in the premises during the construction stage of the undertaking against any risk of bodily injury or health arising out of the use of any machinery, plant equipment appliance or substance.

vi. Constructional waste disposal:

All waste such broken blocks, stumps of wood, aggregate of sand, gravel and soil will be disposed off appropriately. To reduce waste and also solve the problem of waste disposal, the waste materials will be used in the filling of foundations of construction buildings and depressions; some will be used for landscaping. Those constructional wastes such as pieces of wood and cement wrapping that cannot be used for filling will be disposed off at approved landfill site.

10.7.4.2 Operational Phase

No serious detrimental impacts are expected in the operational phase that will affect the environment that needs mitigation measures.

10.8 Environmental Management Plan

The proponent will undertake continuous monitoring of the significant impact identified. This will make up the managerial tool through which prompt remedial action will be taken to correct unforeseen deviations in effectiveness of mitigation measures.

The SHP project is environment friendly and the negative impacts to be monitored minimal and of short duration (during construction). However the positive impacts can also be measured to prove the accuracy of assumptions concerning SHP projects. Only those impacts that have adverse effects shall be discussed here.

10.8.1 Accident on Site:

This section has to do with plans of the proponent to handle emergencies such as accidents on site, in accordance with the provisions of factories Act No 16 of 1987.

- A properly equipped and manned site clinic to handle emergency situations
- The proponent shall retain the services of a reputable hospital and clinic so that evaluated medical emergencies will receive proper treatment after the first aid administration.
- Operational units: workers shall undergo routine periodic medical check-ups as need arises.

10.8.2 Wastes:

- All waste generated shall be treated
- All waste that can be recycled shall be treated and recycled

10.8.3 Environmental Monitoring

1 Environmental Monitoring Plan

Monitoring of the activities, detection and qualification of any likely impacts arising from the activities of the SHP operation is to be carried out.

2 Monitoring Schedule

Environmental audit shall be conducted every two years. This is to ensure positive as well as negative short range/long – range impacts are well captured

3 Scope of Monitoring Activities/Parameter

The scope of monitoring will cover the following parameters

- Socio-economics
- Occupational health monitoring
- River flow monitoring (downstream and upstream of the dam)
- Accurate levels of reservoir during operations of the SHP

Issues of the parameter to be monitored would include:

a. Socio-economics

To ensure that the establishment and operation of the SHP does not attract the development of negative vices Also to monitor the positive influence of the SHP on the society.

b. Occupational health

This is an attempt to know what type of occupational health hazard is inherent in the project

c. River flow measurement:

Aim is to know the effect of running the SHP on water regime downstream of the project and the dam. Also reservoir elevation data is to be collected for the first two years of operation diligently to ascertain the capacity of the reservoir to be able to handle the proposed electrical energy generating measurement of river inflow upstream of the dam and downstream should be taken at regular intervals of once every two days or once a week depending on whether it rainy season or dry season.

4 Environmental management structure:

All departmental heads will be accountable to maintaining their areas of responsibility to meet environmental and occupational safety standards.

5 Budgetary Allocation

The proponent will finance the environment aspect of SHP from the annual budget and operation costs.

10.8.4 Decommissioning and Abandonment

The SHP system which is designed for Awara project will be assumed to have an expectant life span of 50years. Most hydro-turbines have more expectant lifespan in some cases; this is due to continuous steady operation without high temperature or other stress. At the expiration of the useful life of the project, adequate arrangement will be made to remove all movable assets.

The proponent is committed to ensure that at the expiration of all operations, the project areas will be left in an adequate safe and environment sustainable condition.

10.9 Conclusion:

The proponent has carried out an environment impact assessment of the proposed Small Hydro-Power at Awara Dam. The SHP project is friendly to the environment.

Hydro power is by far the most established renewable resource for electricity generation and commercial investment. Methods of mitigation have been proposed for identified short duration negative impacts. In summary the SHP installation and plants are long lasting e.g. turbines for about 50years or more. Consequently established plants often produce electricity at low cost and create job opportunities in rural areas for the uplifting of the rural people.

Positive socio- economic impact of the project can be categorized as follows:-

1. Development of Agro-Industrial units is enhanced
2. Improvement in Agro-produce
3. Most convenient energy source commercially available and readily available for addition.
4. Multiplier effect of electricity on economy of the two Communities.
5. Water supply to the town now improves by the SHP project for electricity generation.
6. Net improvement in community health
7. Energy self sufficiency in a small unit of society like a remote villages of Awara and environs.
8. Tourism potential – everyone in Ondo State will want to visit Awara Dam, the first SHP project in Ondo State.
9. Direct / indirect benefits of electricity by improving the standard of living of the rural People.
10. Generation of employment opportunities locally and motivation for higher literacy level in the rural community
11. Check on migration from village to towns, thereby checking urban concentration of population.

11.0 POWER EVACUATION/DISTRIBUTION

Power from the Small Hydropower Turbines shall be evacuated through a radial system in compliance with global and local standards.

11.1 System Description

The power evacuation/distribution System shall consist of the following sub-systems:

a. Generating system
b. Power distribution system
c. System protection
d. Lighting system

11.1.1 Generating Sytem

The power to be generated from the small hydropower (SHP) at the Awara Dam/Oyinmo river shall consist of three generators; G1, G2 & G3 with parameters: 0.415kV, 50Hz, and power factor of 0.8.

11.2. Power Evacuation.

The power generated shall be evacuated through a 1x1.5MVA. 0.415/11kV transformer.

This Transformer, will be linked to the radial, single line to deliver generated Electric Power over a 5km distance to the switchyard at Awara Dam site. Sand-crete poles shall be installed at 50meters interval over the 5km distance. The switch yard at Awara Dam shall first and foremeost, supply Power to the water treatment Plants while the excess power is transmitted through the 11kV bus-bars radial like of PHCN, already extended to the water treatment plant, to Awara Community, Orimolade Prayer retreat Camp, NYSC Orientation camp and to the proposed Industrial Park to be located on the Awara Dam road to Ikare. This arrangement is as shown in drwg No. 8/9.

11.3. Power Distribution Network

Provision will be made on the existing 11kV bus bar to allow for further distribution of the power generated to other load centres. The power distribution Network can service the following loads:

1. Awara water treatment plant 1and 2,lighting of the offices and Security lights at the dam and walkWays through the 1x500kVA, 11kV Transformer.

2. NYSC Orientation Camp through a 1x100kVA, 11/0.415kV HVDC.

3. Orimolade Religious Retreat Centre through a 1x100kVA, 11/0.415kV Transformer substation.

4. Awara Community through a 1x100kVA, 11/0.415kV Transformer substation.

5. The Industrial Park through a 1x400kVA, 11/0.415kV Transformer Substation.

Fig 11.3.1 shows the distribution system.

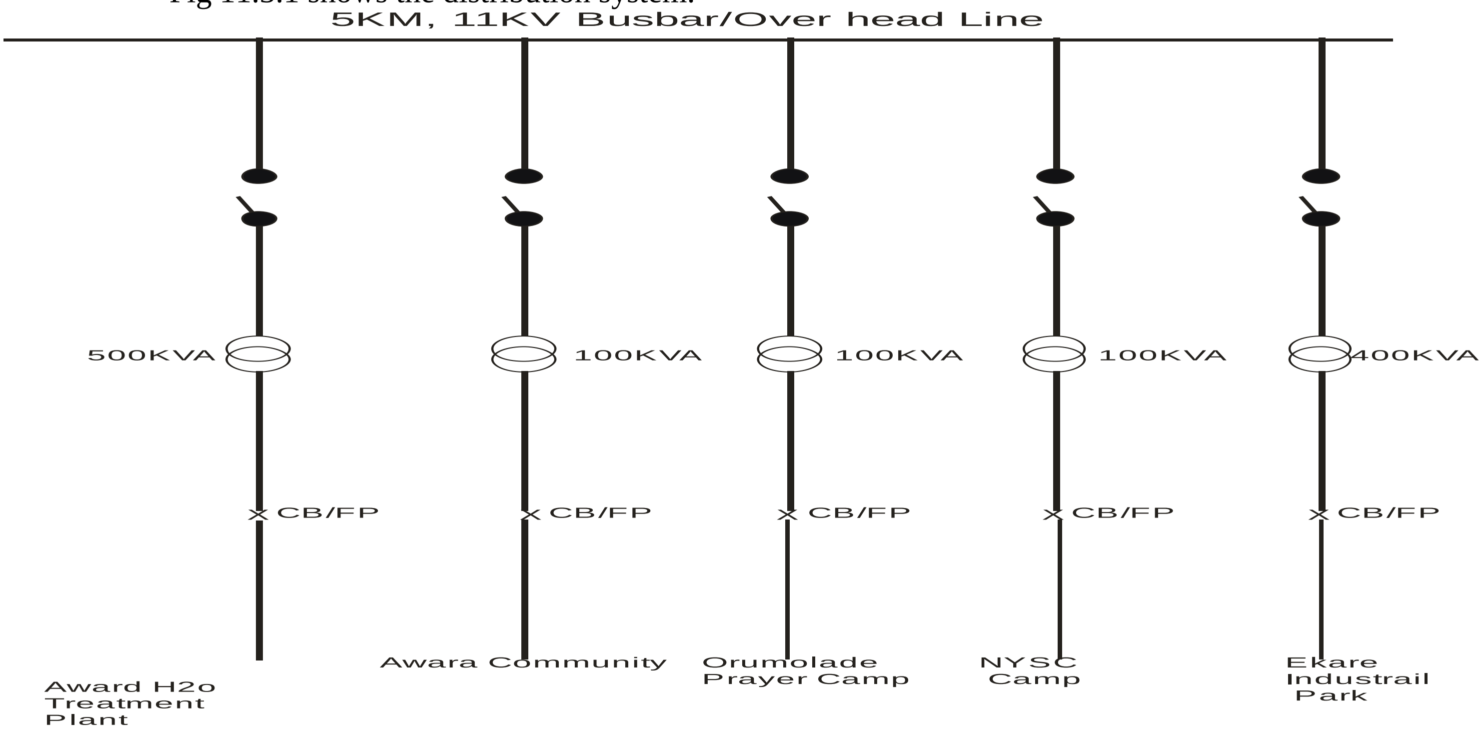


Figure 11.2 Power Distribution Diagram

11.4. <u>Sytem Protection</u>

The system protection will consist of the followings:

1. Generator protection against excess current, under voltage, earth fault and reverse power relays.
2. Turbine protection against over speed, vibration, overtemperature of bearing and emergency switching.
3. Transformer protection against Gas (Buccholz) alarm, high oil temperature, earth fault and over current.
4. Earthing and over-voltage surge protection: Operation and transmission line over voltages could be reduced with a set of lighting arrestor and surge protectors at the generator 415V bus bar and at the step-up transformer. It is very important for the dam to have an outdoor lightning arrestor through effective earthing of the power house, generator, transformer,circuit breaker and other HV and LV equipment.

11.5. <u>Lightning System Protection</u>

The Lightning System Protection shall include: Lightning and Thunder Protection System, Earthing and ripple frequency Protection at the SHP Power house, the step-up transformer and at the dam site (The two water treatment Plants, Water reservoir tanks, Transformer substation, 2x800kVA Generator house, etc).

The lighting system protection includes the dam secuirity lighting earthing, power house, administrative offices and emergency lighting earthing. The single phase 230V AC supply which will be used to supply the lights in various locations of the dam shall be earthed properly. The emergency lighting system which will be from an inverter fed from the power house. AC(for recharging of the accumulators) and used in the control room/switchyard and in other essential secuirity areas shall be earthed. Whenever there is AC failure, the emergency lighting system should come on automatically.

12.0 PROJECT IMPLEMENTATION

The implementation of the project will require approximately eight – ten months (excluding tendering, contract awarding, if required, will need maximum of 2months). The critical path will be the civil works, that is to say the excarvation and installation of penstock and power house and other water conveyance structures. Project implementation cost summarry is shown in **A.12.1**.

13.0 OPERATION AND MAINTENANCE

The small hydropower scheme will be operated according to the recommended load scheduling. The plant will occasionally be shut down in order to carry out necessary maintenance or repair work at the plant.

13.1 Training of Local Personnel

Two employees, at a shift duration preferably skilled people in SHP will be assigned the responsibility of operating the hydropower scheme. They will be instructed in the operation and maintenance of the new electro-mechanical equipment, as well as Dam –reservoir operations.

13.2 Maintenance of Micro Hydro Scheme

The main duties of the operators of the scheme will be:

- Starting and closing down the scheme as required
- Switching the power supply to the different consumer groups on or off according to schedule.
- Observing the operation of the plant on a regular basis by controlling all relevant parts of the scheme.
- Cleaning the intake, the sand trap, the head race and the Forebay from floating debris and sediments.
- Keeping the power house clean at all times
- Carrying out maintenance activities in accordance with defined procedure
- Trouble shooting in case of minor problems with the generation or the transmission of electricity
- Carrying out necessary maintenance works on the civil structures of the scheme.
- Reading the KWh – meters at the power house daily and recording same.
- Maintaining accurate records of the power generation and operation (log book)

In addition to his duties directly related to the operation of the scheme, the operator should also assist the Plant Manager in leading interested visitors / tourists to the MHP facility.

13.3 Spare Parts for Facility

13.3.1 Recommended Spare Parts for Turbine/Generator

1. Bearings
2. Lubricants like multipurpose grease and oils in dust free containers
3. Instruments [voltmeter, pressure gauge, (etc)]
4. Bolts and nuts
5. Fuses, MCBs and ELCBs
6. Cable conductors
7. Lightning arrestors
8. Ballast heaters
9. AVR
10. Gaskets, O rings for all flange joints
11. Two lengths of penstock

12. V-belts and couplings
13. Oil seals, rubber packing, gland ropes(one set)
14. One type each of pipe fitting, connector, ferrules washer etc of hydraulic and water pipe lines
15. One card of each type of electronic controller/governor//protection if applicable
16. One set of indicating lamps and LEDS

13.3.2 Recommended Tools

i. A set of open-ended spanners
ii. Flat and cross-head screwdrivers
iii. Grease gun
iv. Bearing puller
v. Tool rack to neatly place the tools
vi. Emergency rechargeable lights
vii. Digital Multimeter, Tong Tester
viii. Special tools like chain-pulleys, slings, nylon rope etc
ix. Test lamp and Tester
x. Special tools required to dismantle and assemble turbine parts
xi. Tap and dice set
xii. Feeler gauges
xiii. Bench vice, hammer, hacksaw and 1m x 2m Table
xiv. Dial gauge
xv. Spirit level

14.0 FINANCIAL ANALYSIS

14.1 Basis of Assumptions

The following forms the basis of assumptions underlying the detailed financial models built for the assessment of the financial and economic viability of the Awara Dam-Oyimo River SHP.

1. Project Installed capacity of the project is expected to be 1,200KW.
2. Exchange rate will be at N159 to the US dollar.
3. At takeoff of production, the suggested tariff rate at the NERC, Ibadan Zone as applicable to consumers will be N16.80 per KWH.
4. Year on year revenue growth is projected at 2%.
5. Life expectancy of the project is assumed at 50 years. However, our financial projections and analysis is restricted to 25 years only. Scrap value of the project at this time is assumed to be zero.
6. The assumed business model for the project will be public-private equity participation between the host state government and some interested private investors. The financing structure will be 30% State Government and 70% Local Equity Investors. This is to enable the private investors some measure of control over the project.
7. Corporate tax rate will be 32% but the project will have a tax holiday period of the maximum 5 years.
8. Gross Initial Investment Cost will be N1,031,147,722.49 and will be expended on Civil engineering works, electro-mechanical work procurement and supervision of construction and installation of equipment. It does not include initial operating & maintenance (O & M) expenditure and supervision costs.
9. Initial funding to be secured for the project is estimated at N1.04billion. This is to ensure that enough fund is available to cater for possible cost overrun. The funding structure is 100% equity.
10. In order to ensure effective and efficient liquidity management and also to further enhance the overall investment yield, an average of 50% of cash collection will be invested in fixed deposits with banks at an average rate of 12% per annum.
11. Dividends will be proposed annually at the rate of 60% of the profit after tax and paid in arrears.
12. Weighted average cost of capital incorporating the funding structure in assumption 9 above is estimated at 18%.
13. Construction period is one year on schedule, while production period is 25 years commencing January 1, 2015.

14.2 The Profitability Analysis

Based on the planned production capacity of 1,200KW and the new electricity tariff rate of N16.80 per KWH at the NERC Ibadan Zone (MYTO 2012-2017), we estimate that the take-off revenue will be in the region of N158,941,440.00. Variable margin as a percentage of revenue over the production phase of the project averages 72.2%. This is attributable to the low level of operating & maintenance cost over the production period.

Operating profit margin over the production period is put at an average of 51.5% basically due to the fact that the only other cost apart from O & M expenditure relates to the depreciation of Civil engineering work and electro-mechanical engineering works expenditure. A key feature of small hydro power project is low cost of operating the facility once construction has been completed and the production phase commenced.

The superb level of profitability of the project is further confirmed by the fact that the average return on the gross initial investment amount of N1,031,147,722.49 over the production phase is 24% which is well above the weighted average cost of capital (WACC) estimated at 20%.

We have assumed that an average of 50% of cash collections will be invested in short term deposits with commercial banks at an average interest rate of 12% per annum. This is expected to further enhance the profitability of the project with a further contribution of an average of N76.2million per year to income over the production period.

The cumulative profit after tax by the end of the production period is conservatively put at N4.429billion, at an average of about N177.18million per year. With a dividend payout of 60% over the period, the average dividend paid out amounts to N73.82million per year. It should be noted that dividend payment commences right from the first year.

14.3 Analysis of the Financial Position

The financial position of the project is better illustrated by the balance sheet projections over the production period. It shows the financial health of the project at a particular point in time, usually the end of each of the financial year. The Balance Sheet structure showing the financial position of the project over the period forecasted indicates a very strong potential for the project. The balance sheet position is expected to grow steadily from N1.085 million in 2015 to N2.812billion in 2039. This is made possible by the retention of 40% of annual profit after tax over the production period causing the shareholder's funds to stand at an average of about N1.84 billion per year.

The project maintains a positive net current asset or working capital at an average of N1.293billion over the production period. The implication is that the project will never have to resort to any short-term borrowing in any form to meet its short-term maturing obligations.

The project is expected to be funded exclusively with equity. This almost certainly eliminates any financial risk to the success of the project. We are not in doubt as to the capacity of the project to fund and meet its short- and long-term obligations to creditors in view of it huge cash generating ability and overall viability.

14.4 Cash Generating Capacity

The project's performance reflects its capacity to generate future cash-flows, by using existent resources, and the efficiency level in using new resources. The capacity of generating future cash-flows assumes that the project would have to book revenues from its core electricity-generating activity while efficiently managing its operating expenses. The revenues and expenses are elements strictly tied to the evaluation process of the project's performance.

Once completed, the Awara Dam-Oyimo River SHP Project is expected to be a cash cow. There will be no significant cash outflow from the project other than on the annual operating and maintenance expenditure, dividend and tax payment (beginning from the 6th year in view of the expected 5-year tax holiday).

In view of the epileptic power supply in the country and the fact that the demand for electricity within the community in which the project is to be sited far exceeds the anticipated supply from the project, even at full installed production capacity, the projected revenue from the project is assured.

From the cash projections and estimates, the project is capable of paying returns to owners in form of 60% pay-out of profit after tax yearly in the form of dividends even from the first year of production.

The projected cash balance (including short-term fixed deposit with commercial banks) from the project is expected to grow from N161.87million in the very first year to about N3.079 billion in the final year. This is considered to be very healthy for a project of this scale.

14.5 Statement of Economic Value Added

From our projections, the Awara Dam-Oyimo River SHP Project will generate total revenue of N8.749billion over the production period. The expected Gross Domestic Value Added arising therefrom is estimated at N5.033billion due to the low level of material input cost.

The estimated cost of investment in the project is estimated at N1.031billion translating into a Net Domestic Value Added of N4billion. Participating equity shareholders are expected to take a larger percentage of this amount in the form of dividend payments at 43.6% while government share in the form of taxation payments amount to 28.5%. The rest will be in form of salaries and wages to operators and amount retained for growth.

From the above, it is obvious that this project will no doubt add significant value to all the stakeholders over the production period.

14.6 Project Investment Appraisal

The project's viability was assessed using the following investment appraisal methods:

- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Payback Period (Normal and Discounted)

Net Present Value (NPV)

The net present value method estimates the amount by which shareholders' wealth will increase as a result of undertaking the project. Under this method, we subtracted the cost of investment in the project from the sum of the project's discounted cash flow over the production period, discounted at the project's weighted average cost of capital (WACC), and based on the funding structure of 100% equity.

Our analysis returned a net present value in the sum of N129.82million at a WACC of 18%, meaning that the project is very viable and should be undertaken. This is because the shareholder's (owners) wealth will increase by this amount if the project is undertaken.

Internal Rate of Return (IRR)
This break-even rate is the rate that equates the project's discounted cash flow over the production period with the initial cost of investment. It is thus the rate that will make the net present value of the project equal to zero.

Our analysis shows that the project's internal rate of return is about 25.01%. The equity holders must earn at least this return from the project. Any return below this will not be worthwhile at all. Unless they can find any other investment elsewhere that earns more returns over and above this rate, this project should be invested in.

The project is therefore very viable and should be undertaken.

Payback Period
The payback period, as the name implies, indicates the length of time it will take for the project to recoup the initial investment.

Our analysis of the payback period, using the normal, undiscounted cash flow shows that the project will return the initial investments under 7 years of the production phase.

When the cash flow is discounted to account for the time value of money, we project that the project will, all things being equal, return the estimated cost of investment in about 8 years.

This further confirms that viability of the project and it should thus be undertaken.

14.7 <u>Sensitivity Analysis</u>
We tested the responsiveness of the viability or otherwise of the project to changes in the key financial variables affecting the project such as: investment cost, selling price of electricity (tariff regime) and operation and maintenance cost

Cost of Investment:

Increase in Investment Cost %	New Cost of Investment (N'million)	Net Present Value (NPV) (N'million)	Internal Rate of Return (IRR) %	Normal Payback Period (yrs)	Discounted Payback Period (yrs)
20	1,237.38	-76.41	13.87	7.60	10.38
50	1,546.72	-385.76	-2.84	9.48	13.00
75	1,804.51	-643.54	-16.77	11.05	15.19
100	2,062.30	-901.33	-30.69	12.62	17.37
Base Case	**1,031.15**	**129.82**	**25.01**	**6.34**	**8.64**

The likely major reason for increase in investment cost will be cost overruns associated with negative exchange rate movements at the time of purchase of the electro-mechanical equipment needed for the project, the construction cost of both the spillway at the Awara Dam and the access road to the Oyimo River site. From the result of our analysis as shown above, an increase of more than 20% in the initial cost of setting up the Awara Dam-Oyimo River SHP Project, will cause the net present value to turn negative. Also, the project's payback time for the initial investment will be increased significantly. Finally, the project's internal rate of returns will worsen as a result of any significant cost overrun. It is therefore important for all items of costs to be well managed to prevent any overrun that can render the project unprofitable.

Electricity price tariff:

A critical financial variable to the Awara Dam-Oyimo River SHP Project is the selling price of electricity (the applicable tariff regime). Revenue will only be generated by selling the electricity generated from the project to power distribution companies at the tariff rate set in the NERC Multi Year Tariff Order, 2012. Hence, there will be no demand shortfall throughout the production phase. The average growth rate in the tariff prices is estimated at 8.1% between 2012 and 2017 (period covered by the subsisting Order). We have assumed a worst case scenario of 5% growth in revenue over the project life.

Percentage Drop in Price	New Price (N/MWh)	Net Present Value (NPV) (N'm)	Internal Rate of Return (IRR) %	Normal Payback Period (yrs)	Discounted Payback Period (yrs)
25%	12.60	-200.38	2.83	8.73	11.96
50%	8.40	-530.58	-49.16	14.06	19.38
75%	4.20	-860.78	-313.56	36.44	50.55
Base Case	16.80	129.82	25.01	6.34	8.64

From the above table, it is clear that a sharp decrease in the electricity tariff regime will have a corresponding negative effect on the various parameters. It can be seen for example that a decrease in the tariff rate by about 25% will cause the NPV to turn negative and increase the discounted payback period to almost 12 years. Thus, the project is very sensitive to the electricity tariff regime in place. Fortunately, the pricing policy of the NERC through its MYTO Plan is aimed at protecting investors in the energy sector against this risk. In any case, we do not envisage a situation whereby the electricity tariff rate will drop by as much as even 50% in Nigeria over the production phase of the project.

Despite the above, the project is still expected to be highly profitable and should be undertaken.

Operating Hours:

Frequent breakdown of plant and machineries, occasional production stoppages and many more factors may lead to the reduction in the available production hours estimated at 24 hours per day. We tested the effect of this on the investment parameters. The result is as summarised below:

% Decrease In Operating Hours	Net Present Value (NPV) (N'm)	Internal Rate of Return (IRR) %	Normal Payback Period (yrs)	Discounted Payback Period (yrs)
10%	-2.26	17.86	7.12	9.72
20%	-134.34	8.58	8.12	11.11
40%	-398.50	-21.76	11.30	15.54
Base Case	129.82	25.01	6.34	8.64

A significant decrease in the operating hours during the production period will have a debilitating effect on the success of the project.

Annual Operating & Maintenance (O & M) Cost:

Upon the completion of the project, the only major operating expenses relates to O & M expenditure. A sharp increase in the annual operating and maintenance cost will not have any significant effect on any of the key appraisal parameters as this cost is typically very low compared to the expected level of revenue to be generated during the production period.

14.8 Recommendations

The financial and economic success of the project is contingent upon ensuring that the key assumptions underlying the financial models are not violated. It is therefore important that the following issues be put into perspective:

- During the construction stage, it is imperative that the construction cost is strictly kept under control.
- Efforts should be made to put in place efficient and effective revenue collection procedure. It is heart-warming to learn that the project will make use of prepaid metering system for its cash collection process.
- Attempt should be made to ensure that energy loss is reduced significantly so that maximum capacity output is achieved.

All these and many more will ensure that the revenue target is achieved while costs are managed over the course of the project.

14.9 Conclusion

From our analysis, it can be concluded that the project satisfies all the financial and economic parameters enough to make it a profitable venture and should therefore be undertaken.

15.0 RECOMMENDED BUSINESS MODEL

15.1 REA of Nigeria Proposed Business Model for Mini-Hydro project

The Government of Nigeria in pursuing its policy on providing electricity to the rural communities across the country by 2010, for socio-economic development and raising the standard of living of the rural populace, the Rural Electrification Agency is one agency of the Government committed to achieving this laudable objective by encouraging and promoting the formation of Rural Electricity Users Cooperative Society (REUCS) in its model. In achieving, this REA has already created awareness and sensitize the rural populace in 2008 across the 36states of the Federation including the FCT. The rural communities under REUCS will in agreement with Electricity Distribution Companies administer where applicable, consumption of electricity and set up modalities for operation and maintenance of the networks in their respective communities.

15.1.1 Objectives of REUCS Model

The objectives for formation of REUCS amongst others include and not limited to;

- Promote the use of electricity for domestic and commercial purposes
- Collaborate with Electricity Distribution Companies where applicable for provision of electricity to the communities with a view to owning, operating and maintaining (OOM) the networks.
- Mobilize members of the association to raise capital through micro – finance institutions for economic empowerment and increase productivity.
- Develop a participatory demand driven market oriented national rural electrification model.
- Solicit for government support at all levels in collaboration with the Rural Electrification Agency of Nigeria (REA) and other stakeholders in the electricity industries business in the provision of electricity in the rural areas.

15.1.2 Advantages of REUCS Model

- Encourage community participation in sustainable rural electricity supply through Ownership, Operation, and Maintenance (OOM)
- Boost agricultural productivity, commercial activities and create job opportunities and reducing rural – urban migration.
- Facilitate continue education and training of member on electricity usage, maintenance and safety.
- Create platform for interaction between the rural communities and stakeholders.
- Ensure prompt payment of electricity bills by members through the cooperative societies (REUCS)
- Ensure community's commitment on the protection of their electricity network this will curd vanderlisation and theft of equipment/installation

15.2 Kenya Model

15.2.1 Tunga – Kabiri Community Project

The village community formed a committee to manage the MH scheme. The community members were required to register with the Department of Social Services as a society thus demonstrating their unity purpose. Some 200 members bought shares at approximately 50USD and a sense of a business approach with dividends was introduced at the earliest opportunity. The villagers contributed labour and materials that were required for the scheme. The society was operated by a 13-member committee, which appoints a chairperson. The committee served as a liaison between the rest of the village community, government and implementing partners. The committee was responsible for making decisions and collecting revenue, and the day –to – day operations and maintenance of the scheme. To ensure conformity to rules of procedure as established by 'Society constitution', a patron figure was established and chosen by the community members thus further solidifying local governance. The role of the patron is to guide, facilitate smooth running of the scheme and safeguard public interest.

15.2.2 Thima Community Pico-power project

Thima is a 2.2-KW hydropower project owned by 165 consumers who have formed an association named Thima Community Pico- Hydropower that is registered with the Department of Social Services. It is currently supplying power for lighting to 165 households in Thima village. In this village, a Community Electricity Association (CEA) was formed which elected a committee of 10 members. ITDG, NTU and the Ministry of Energy provided training and technical support. A subscription fee was charged to end users. Consumers provided labor, purchased building materials and financed the cost of establishing a local mini-grid, the cost of house –wiring and cost of establishing a local mini-grid, the cost of the house wiring and cost of purchasing energy – energy saving bulbs. A connection fee was established for the consumers. The CEA obtained necessary licenses, including the special permit from the Ministry of Energy and set up a bank account to save contributions made towards project costs. In terms of costs, the community matched the grants provided through NTU and ITDG.

15.2.3 Kathamba Self-Help Pico-Hydropower Project.

Kathamba is a 1.2KW hydropower project owned by 65 consumers and is also registered with the Department of Social Services as self-help group (Balla 2003). The self-help group has a committee of 12 members. Official from ITDG, NTU and the Ministry of Energy again served as implementing partners providing training and technical assistance. Once again, a subscription fee was charged to end users. The association was registered and opened a bank account. 'Special permits' were obtained with the help of the Ministry of Energy and consumers allowed distribution lines to pass through their land. As in the previous scheme, the community matched the grants provided through NTU and ITDG.

15.3 Guidelines on Business Model Selection

Any business model to be considered should also accommodate the ownership of the power plant, which is crucial for the long-term sustainability of the whole scheme.

In this regard, it is recommended that a Management Committee be formed / put in place to discuss and decide on the various issues pertaining to the ownership and day-to-day operation of the whole scheme.

There are many models available for ownership and some of these are:

- Cooperative
- Individual
- Private Limited Company

- Public Limited Company
- Public Private Partnership

The Management Committee should have a focus on capacity building, in-built monitoring and evaluation processes, dispute redresser, mechanisms, etc to ensure smooth operation of the scheme.

The statutory / legal issues associated with the project should also be addressed by this committee. All the clearances required, like environmental, water regulatory agencies etc should be sought and obtained.

The Management Committee should provide support for the maintenance and the transmission and distribution networks; powerhouse maintenance, as well as water regulation measure, when necessary.

Tariff design and collection should be implemented based on an economic and financial analysis study of the scheme as designed. This is to ensure that the power plant become self-sustaining. Punitive measures for non-payment of tariff should also be developed and agreed upon.

All stakeholders will enter into a mutually binding agreement committing their obligation to the scheme.

16.0 CONCLUSION AND RECOMMENDATION

16.1 Conclusion

The Awara Dam/Oyimo River cascade scheme is profitable. Access to rural energy for productive economic activities can be readily achieved by implementing this scheme. It is highly recommended for investors.

16.2 Recommendation

i. Water Level Gauges are to be installed for monitoring water levels in the Dam especially during dry season.
ii Penstock route is to be cleared, traced and maintained regularly.
iii. Downstream course of the tailrace is to be inspected regularly to ensure no overgrown weeds that could lead to back flow of tailrace water.

Annexure A-5.1

HYDRO POTENTIAL

River :	Ogha (perennial)
Flow Rate(Q):	1.52m^3/s
Head (H):	3.5m
Power:	78.35kW
Energy Cost:	N4,938,537.00 p.a(N8 per unit)

LOAD SURVEY

A	**Agro Processing**		
	I.	Oil Palm Cracking	10 x 3.0KW= 30kW
	II	Cassava Grating	15 x 0.5KW=7.5kW
	III	Garri Processing	15 x 0.5KW=7.5kW
		Sub- Total(A)	**45.0kW**
B	**Small Medium Enterprises**		
	IV	Packaging Farm Produce	4 x 0.45KW = 1.8kW
	V	Drying/Storage (Post Harvest)	10 x 0.2KW = 2.0kW
	VI	Agric. Research/Extension	5 x 0.2 KW = 2.5kW
	VII	Others (Welders, etc)	5 x 0.5KW = 2.5kW
	Sub Total (B)		**7.3kW**
C	**Commercial Enterprises**		
Lighting			3x0.2kW = 0.6kW
Laundry			= 7.0kW
Cyber Business			= 2.0kW
Water Pumping			= 2.0kW
Refrigerator/Freezers			3x0.3kW = 0.9kW
Fans			3x0.1kW = 0.3kW
D.	XIV.	Saw- Milling	1x1.0kW = 10.0kW
	Grand Total		**75.1kW**

Annexure A – 12.1

OYIMO SHP IMPLEMENTATION COST

1. Power Supply

Head (H) [m]	=	12
Flow (Q) [m^3/s]	=	10.8
Potential [kW]	=	1200

2. Equipment Cost **₦61,591,035.00**

3. Capital Investment **₦ 737,000,000.00**

4. Expected Annual Revenue

- Option B: 9,460,800kWh/yr x 16.80
  = **₦ 158,941,440:00/yr**

4.1 Suggested tariff (NERC, MYTO A_3-Ibadan DISCO)

5. Pay-back Period (IRR) years – 7yrs

6. Power Demand [kW]

1. Industrial Load (water treatment plant)	=	236kW
2. Domestic load (CAC Community)	=	300kW
3. Social Services load (NYSC Camp)	=	500kW projected load to be firmed up
4. Agro Processing Oil Palm Cracking	=	45kW
5. Cassava Grating	=	15kW
6. Garri processing	=	15kW
Total	=	1111kW

7 Implementation of Project

● Transportation Cost (15%)	-	Djarkata – Los	189,802.5 USD
● Transportation Cost	-	Los – Awara	5,000.00 USD
● Installation Experts	-	1 No Foreign	12,500.00 USD
		3 Local	12,000.00 USD

Total = 328,224.00 **USD.**

Conversion rate at ₦ 158.00 = 1 USD.

PICTURE ANNEXURES

ENTRANCE TO AWARA DAM

RESERVIOUR

RESERVIOUR AND INTAKE TOWER BRIDGE

INTAKE TOWER BRIDGE

WEIR

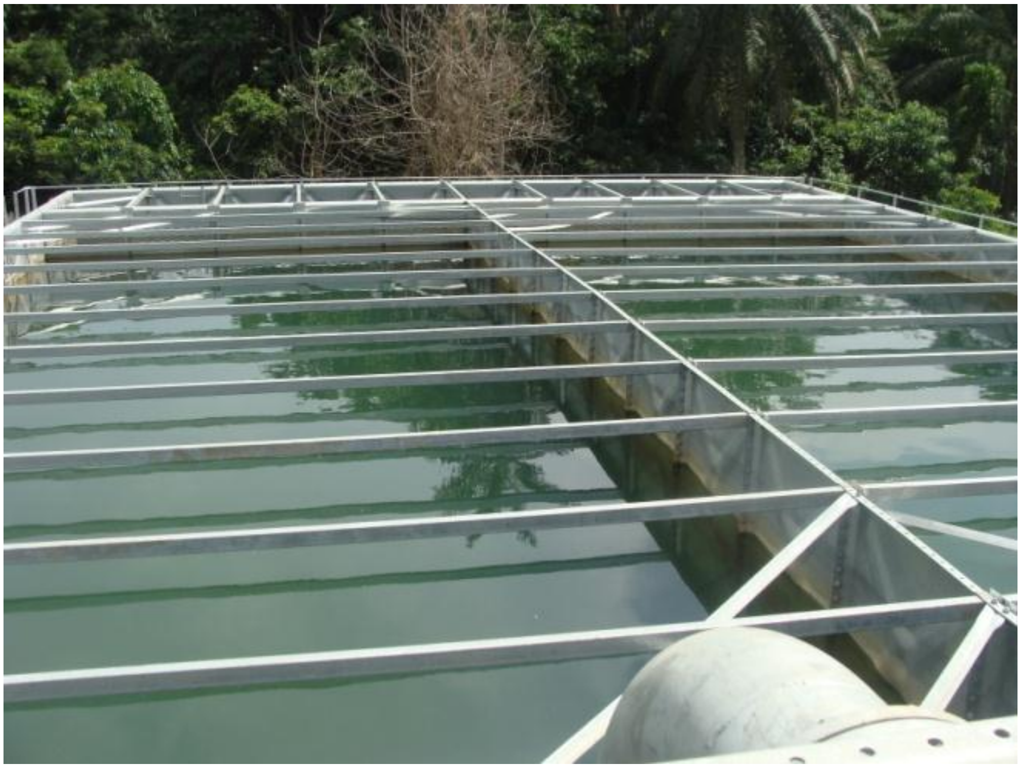
WATER TREATMENT PLANT

EXISTING 2 x 800 kVA DIESIEL GENERATOR

EXISTING TRANSFORMER 500kVA 11/0.415kV

CLEAR WATER TANK

SEDIMENTATION TANK (OLDWATER TREATMENT PLANT)



SEDIMENTATION TANK (NEW WATER TREATMENT PLANT)

OVER HEAD/ DISTRIBUTION TANK.