ASSESMENT OF TAGWAI DAM FOR DE-SILTING

BY

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MATRIC No. 2004/18345EA

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIRMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

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DECLARATION

I hereby declare that this projects work is a record of research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communications, published and unpublished work were duly referenced in the text.

Ajibade, Gbenga paul

19/02/'10

Date

CERTIFICATION

This project entitled "De-Silting of Taqwai Dam" by Ajibade Gbenga Paul, meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

17/02/10

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10/2/2010

External Examiner

Date

DEDICATION

This project is dedicated to **God Almighty** for his guidance, strength and protection through the cause of my study. To my blessed parents Mr. and Mrs. AJIBADE and also to every member of my dearest family

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ABSTRACT

A research was carried out using bathymetric survey method. The inefficiency of the dam is due to presence of large volume of silt in the dam as a result of movement of the surrounding soil into the dam. To increase the life span of the dam and to maximize its usefulness, there is a need for it to be de-silted. The retention capacity of the dam is calculated to be $93555000m^3$ and the volume of silt present is also calculated to be $75690450m^3$ which accounts to 80.9% of the retention capacity. The present volume of the dam is $17864550m^3$ which also account to 19.1% of the retention capacity. The average volume of silt flowing into the water per annum is $2441627.419m^3$. It is searched that it will cost about #12867376500 to de-silt this dam.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

De-silting of water is the removing of silt from flowing as well as static bodies of water. It is known that the effective life span of dams is considerably reduced by the inflow into and settling in such dams of large quantities of silt that is material of earthy, mainly inorganic nature carried in finely divided form by flowing water and deposited to form fine-grained sediments. Hitherto it has been exceedingly difficult, in fact, all but impossible, to prevent the inflow into dams the build-up of voluminous silt deposits in such dams. Bijker (2007)

As a result of large deposit of silt in dams, it becomes imperative to provide water of improved purity for agriculture, domestic, industrial or other use.

It is a further object to provide a method and means for removing silt from the water flowing into dams, and so to prevent or at least decrease the deposition of voluminous quantities of silt in such dams, and to extend the effective life span of such lakes and dams. Joseph (1986)

1.2 Problem statement

Dam is known to be facing the problem of deposition of soil, it is known that the effective life span of dams are considerably reduced by the inflow into and settling in such dams a large quantity of silt, that is, material finely divided form by flowing water and deposited to form fine grand sediments it has been difficult or impossible to prevent the inflow of silt into dams and the build-up of voluminous silt deposit in such dams.

1.3 Objective of the study

1. To assess the quantity of silt in the dam.
2. To estimate the cost of implication of de-silting the dam.

1.4 Justification of the study

Dams are constructed to create retention or detention. Retention reservoirs are those designed to store water for supply purpose as irrigation, municipal, industrial and domestic water supply, and hydropower. These reservoirs accumulate water during period of plentiful supply and store it for relatively long period of time to be used later for the purpose for which it is met for. To avoid rapid loss in water storage space must be maintained by means of reducing sediment inflow or its removal must be provided.

1.5 Scope of the study

The project covers the determination of the original depth, the new depth, the surface area, the coordinate of all the points taken and the reduced level of the points.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 History

Dam is a barrier or structure across a stream, river, or waterway for the purpose of confining and controlling the flow of water. Grand Anicut dam on river Kaveri (1st-2nd century) The sizable Roman Harbaqa Dam in Syria is 21 m high and 365 m long.

The Roman dam at Cornalvo in Spain has been in use for almost two millennia.The word dam can be traced back to Middle English, and before that, from Middle Dutch, as seen in the names of many old cities. Adam L (2006)

Most early dam building took place in Mesopotamia and the Middle East. Dams were used to control the water level, for Mesopotamia's weather affected the Tigris and Euphrates rivers, and could be quite unpredictable. Donald R (1996)

The earliest known dam is situated in Jawa, Jordan, 100 km northeast of the capital Amman. This gravity dam featured a 9 m high and 1 m wide stone wall, supported by a 50 m wide earth rampart. The structure is dated to 3000 BC. The Ancient Egyptian Sadd Al-Kafara at Wadi Al-Garawi, located about 25 kilometers south of Cairo, was 102m long at its base and 87 m wide. The structure was built around 2800 or 2600 B.C. as a diversion dam for flood control, but was destroyed by heavy rain during construction or shortly afterwards. Needham and Joseph (1986)

The Romans were also great dam builders, with many examples such as the three Subiaco Dams on the river Anio in Italy. Many large dams also survive at Mérida in Spain

The oldest surviving and standing dam in the world is believed to be the Quatinah barrage in modern-day Syria. The dam is assumed to date back to the reign of the

Egyptian Pharaoh Sethi (1319–1304 BC), and was enlarged in the Roman period and between 1934-38. It still supplies the city of Homs with water. Eflatun Pinar is a Hittite dam and spring temple near Konya, Turkey. It's thought to the time of the Hittite empire between the 15th and 13 century BC. The Kallanai is a massive dam of unhewn stone, over 300 meters long, 4.5 meters high and 20 meters (60 ft) wide, across the main stream of the Kaveri river in India. The basic structure dates to the 2nd century AD. The purpose of the dam was to divert the waters of the Kaveri across the fertile Delta region for irrigation via canals. Du Jiang Yan is the oldest surviving irrigation system in China that included a dam that directed waterflow. It was finished in 251 B.C. A large earthen dam, made by the Prime Minister of Chu (state), Sunshu Ao, flooded a valley in modern-day northern Anhui province that created an enormous irrigation reservoir (62 miles in circumference), a reservoir that is still present today. Rashed et al. (1996)

In Iran, bridge dams were used to provide hydropower through water wheels, which often powered water-raising mechanisms. The first was built in Dezful, which could raise 50 cubits of water for the water supply to all houses in the town. Also diversion dams were known.[9] Milling dams were introduced which the Muslim engineers called the Pul-i-Bulaiti. The first was built at Shustar on the River Karun, Iran, and many of these were later built in other parts of the Islamic world. Rashed et al. (1996) Water was conducted from the back of the dam through a large pipe to drive a water wheel and watermill. In the 10th century, Al-Muqaddasi described several dams in Persia. He reported that one in Ahwaz was more than 3,000 feet long, and that it had many water-wheels raising the water into aqueducts through which it flowed into reservoirs of the city. Another one, the Band-i-Amir dam, provided irrigation for 300 villages. Bijker (2007)

In the Netherlands, a low-lying country, dams were often applied to block rivers in order to regulate the water level and to prevent the sea from entering the marsh lands. Such dams often marked the beginning of a town or city because it was easy to cross the river at such a place, and often gave rise to the respective place's names in Dutch. For instance the Dutch capital Amsterdam (old name Amstelredam) started with a dam through the river Amstel in the late 12th century, and Rotterdam started with a dam through the river Rotte, a minor tributary of the Nieuwe Maas. The central square of Amsterdam, covering the original place of the 800 year old dam, still carries the name Dam Square or simply the Dam. Antiker W (1986)

2.2 Types Of Dam

2.2.1 By size

International standards define large dams as higher than 15-20 meters and major dams as over 150-250 meters in height. Antiker W (1986)

The tallest dam in the world is the 300-meter-high Nurek Dam in Tajikistan.

Intended purposes include providing water for irrigation to a town or city water supply, improving navigation, creating a reservoir of water to supply industrial uses, generating hydroelectric power, creating recreation areas or habitat for fish and wildlife, retaining wet season flow to minimise downstream flood risk and containing effluent from industrial sites such as mines or factories. Some dams can also serve as pedestrian or vehicular bridges across the river as well. When used in conjunction with intermittent power sources such as wind or solar, the reservoir can serve as pumped water storage to facilitate base load dampening in the power grid. Few dams serve all of these purposes but some multi-purpose dams serve more than one. Joseph (1986)

A saddle dam is an auxiliary dam constructed to confine the reservoir created by a primary dam either to permit a higher water elevation and storage or to limit the extent of a reservoir for increased efficiency. An auxiliary dam is constructed in a low spot or saddle through which the reservoir would otherwise escape. On occasion, a reservoir is contained by a similar structure called a dike to prevent inundation of nearby land. Dikes are commonly used for reclamation of arable land from a shallow lake. This is similar to a levee, which is a wall or embankment built along a river or stream to protect adjacent land from flooding. An overflow dam is designed to be over topped. A weir is a type of small overflow dam that are often used within a river channel to create an impoundment lake for water abstraction purposes and which can also be used for flow measurement.

A check dam is a small dam designed to reduce flow velocity and control soil erosion. Conversely, a wing dam is a structure that only partly restricts a waterway, creating a faster channel that resists the accumulation of sediment.A dry dam is a dam designed to control flooding. It normally holds back no water and allows the channel to flow freely, except during periods of intense flow that would otherwise cause flooding downstream.

A diversionary dam is a structure designed to divert all or a portion of the flow of a river from its natural course. Bijker (2007)

2.2.2 By structure

Based on structure and material used, dams are classified as timber dams, arch-gravity dams, embankment dams or masonry dams, with several subtypes.

Dams vary in size from small earth embankments for farm use to high, massive concrete structures for water supply, hydropower, irrigation, navigation, recreation, sedimentation control, and flood control. As such, dams are cornerstones in the water resources development of river basins. Morelon (1996)

Dams are now built to serve several purposes and are therefore known as multipurpose. The construction of a large dam requires the relocation of existing highways, railroads, and utilities from the river valley to elevations above the reservoir.

The two principal types of dams are embankment and concrete. Appurtenant structures of dams include spillways, outlet works, and control facilities; they may also include structures related to hydropower and other project purposes. See also Electric power generation; Irrigation (agriculture); Water supply engineering. Dams are built for specific purposes. In ancient times, they were built only for water supply or irrigation. Early in the development of the United States, rivers were a primary means of transportation, and therefore navigation dams with locks were constructed on the major rivers. Hill (1996)

Dams have become more complex to meet large power demands and other needs of modern countries. In addition to the standard impounded reservoir and the appurtenant structures of a dam (spillway, outlet works, and control facility), a dam with hydropower requires a powerhouse, penstocks, generators, and switchyard. The inflow of water into the reservoir must be monitored continuously, and the outflow must be controlled to obtain maximum benefits. Under normal operating conditions, the reservoir is controlled by the outlet works, consisting of a large tunnel or conduit at stream level with control gates. Under flood conditions, the reservoir is maintained by both the spillway and outlet works. See also Reservoir. Morelon (1996)

. 2.2.2.1 Masonry Dams

Arch dams

Gordon Dam, Tasmania is an arch dam.

Daniel-Johnson Dam at Manic 5 hydro-electric centrale, Quebec, Canada is a multiple arch dam. In the arch dam, stability is obtained by a combination of arch and gravity action. If the upstream face is vertical the entire weight of the dam must be carried to the foundation by gravity, while the distribution of the normal hydrostatic pressure between vertical cantilever and arch action will depend upon the stiffness of the dam in a vertical and horizontal direction. When the upstream face is sloped the distribution is more complicated. The normal component of the weight of the arch ring may be taken by the arch action, while the normal hydrostatic pressure will be distributed as described above. For this type of dam, firm reliable supports at the abutments (either buttress or canyon side wall) are more important. The most desirable place for an arch dam is a narrow canyon with steep side walls composed of sound rock. The safety of an arch dam is dependent on the strength of the side wall abutments, hence not only should the arch be well seated on the side walls but also the character of the rock should be carefully inspected. Guinness Book of Records (1997)

Two types of single-arch dams are in use, namely the constant-angle and the constant-radius dam. The constant-radius type employs the same face radius at all elevations of the dam, which means that as the channel grows narrower towards the bottom of the dam the central angle subtended by the face of the dam becomes smaller. Jones Falls Dam, in Canada, is a constant radius dam. In a constant-angle dam, also known as a variable radius dam, this subtended angle is kept a constant and the variation in distance between the abutments at various levels are taken care of by varying the radii. Constant-radius dams are much less common than constant-angle dams. Parker Dam is a constant-angle arch dam. Lucas (2006)

A similar type is the double-curvature or thin-shell dam. Wild horse Dam near Mountain City, Nevada in the United States is an example of the type. This method of construction minimizes the amount of concrete necessary for construction but transmits large loads to the foundation and abutments. The appearance is similar to a single-arch dam but with a distinct vertical curvature to it as well lending it the vague appearance of a concave lens as viewed from downstream. The multiple-arch dam consists of a number of single-arch dams with concrete buttresses as the supporting abutments, as for example the Daniel-Johnson Dam, Québec, Canada. The multiple-arch dam does not require as many buttresses as the hollow gravity type, but requires good rock foundation because the buttress loads are heavy. Renewable Global Status Report 2006

2.2.2.2 Gravity Dams

The Gilboa Dam in the Catskill Mountains of New York State is an example of a "solid" gravity dam.In a gravity dam, stability is secured by making it of such a size and shape that it will resist overturning, sliding and crushing at the toe. The dam will not overturn provided that the moment around the turning point, caused by the water pressure is smaller than the moment caused by the weight of the dam. This is the case if the resultant force of water pressure and weight falls within the base of the dam. However, in order to prevent tensile stress at the upstream face and excessive compressive stress at the downstream face, the dam cross section is usually designed so that the resultant falls within the middle at all elevations of the cross section (the core). For this type of dam, impervious foundations with high bearing strength are essential. When situated on a suitable site, gravity dams can prove to be a better alternative to other types of dams. When built on a carefully studied foundation, the gravity dam probably represents the best developed example of dam building. Since the fear of flood is a strong motivator in many regions, gravity dams are being built in some instances where an arch dam would have been more economical. Mohamed B. (2007)

Gravity dams are classified as "solid" or "hollow". This is called "Zoning". The core of the dam is zoned depending on the availability of locally available materials, foundation conditions and the material attributes. The solid form is the more widely used of the two, though the hollow dam is frequently more economical to construct. Gravity dams can also be classified as "overflow" (spillway) and "non-overflow." Grand Coulee Dam is a solid gravity dam and Itaipu Dam is a hollow gravity dam. A gravity dam can be combined with an arch dam, an arch-gravity dam, for areas with massive amounts of water flow but less material available for a purely gravity dam. Mohammed B. (2007)

2.2.2.3 Embankment Dams

The San Luis Dam near Los Banos, California is an embankment dam.Main article: Em Embankment dams are made from compacted earth, and have two main types, rock-fill and earth-fill dams. Embankment dams rely on their weight to hold back the force of water, like the gravity dams made from concrete.Recently there have been some interesting developments in the production of a composite core fill for smaller embankments by a British company, (The Instant Barrage Company). This compositinn core fill has certain advantages in that it will not dry out in long periods of exposure to dry conditions. Needham (1986)

2.2.2.4 Rock-fill Dams

Rock-fill dams are embankments of compacted free-draining granular earth with an impervious zone. The earth utilized often contains a large percentage of large particles hence the term rock-fill. The impervious zone may be on the upstream face and made of masonry, concrete, plastic membrane, steel sheet piles, timber or other material. The impervious zone may also be within the embankment in which case it is referred to as a core. In the instances where clay is utilized as the impervious material the dam is referred to as a composite dam. To prevent internal erosion of clay into the rock fill due to seepage forces, the core is separated using a filter. Filters are specifically graded soil designed to prevent the migration of fine grain soil particles. When suitable material is at hand, transportation is minimized leading to cost savings during construction. Rock-fill dams are resistant to damage from earthquakes. However, inadequate quality control during construction can lead to poor compaction and sand in the embankment which can lead to liquefaction of the rock-fill during an earthquake. Liquefaction potential can be reduced by keeping susceptible material from being saturated, and by providing adequate compaction during construction. An example of a rock-fill dam is New Melones Dam in California. Lucas (2006)

2.2.2.5 Earth-fill Dams

Earth-fill dams, also called earthen, rolled-earth or simply earth dams, are constructed as a simple embankment of well compacted earth. A homogeneous rolled-earth dam is entirely constructed of one type of material but may contain a drain layer to collect seep water. A zoned-earth dam has distinct parts or zones of dissimilar material, typically a locally plentiful shell with a watertight clay core. Modern zoned-earth embankments employ filter and drain zones to collect and remove seep water and preserve the integrity of the downstream shell zone. An outdated method of zoned earth dam construction utilized a hydraulic fill to produce a watertight core. Rolled-earth dams may also employ a watertight facing or core in the manner of a rock-fill dam. An interesting type of temporary earth dam occasionally used in high latitudes is the frozen-core dam, in which a coolant is circulated through pipes inside the dam to maintain a watertight region of permafrost within it. Tarbela Dam also Know Tora Bela Dam (Pashto) is a large dam on the Indus River in Pakistan. It is located about 50 km (31 mi) northwest of Islamabad, and a height of 485 ft (148 m) above the river bed and a reservoir size of 95 sq mi (250 km2) makes it the largest earth filled dam in the world. The principal element of the project is an embankment 9,000 feet (2743 meters) long with a maximum height of 465 feet (143 meters). The total volume of earth and rock used for the project is approximately 200 million cubic yards (152.8 million cu. Meters) which makes it the largest man made structure in the world , except for the Great Chinese Wall which consumed somewhat more material. Because earthen dams can be constructed from materials found on-site or nearby, they can be very cost-effective in regions where the cost of producing or bringing in concrete would be prohibitive. Roshdi & Régis (1996)

2.2.2.6 Asphalt-Concrete Core

A third type of embankment dam is built with asphalt concrete core. The majority of such dams are built with rock and/or gravel as the main fill material. Almost 100 dams of this design have now been built worldwide since the first such dam was completed in 1962. All asphalt-concrete core dams built so far have an excellent performance record. The type of asphalt used is a viscoelastic-plastic material that can adjust to the movements and deformations imposed on the embankment as a whole, and to settlements in the foundation. The flexible properties of the asphalt make such dams especially suited in earthquake regions. Lucas (2006)

2.2.2.7 Coffer Dams

A cofferdam during the construction of locks at the Montgomery Point Lock and Dam

A cofferdam is a (usually temporary) barrier constructed to exclude water from an area that is normally submerged. Made commonly of wood, concrete or steel sheet piling, cofferdams are used to allow construction on the foundation of permanent dams, bridges, and similar structures. When the project is completed, the cofferdam may be demolished or removed. See also causeway and retaining wall. Common uses for cofferdams include construction and repair of off shore oil platforms. In such cases the cofferdam is fabricated from sheet steel and welded into place under water. Air is pumped into the space, displacing the water allowing a dry work environment below the surface. Upon completion the cofferdam is usually deconstructed unless the area requires continuous maintenance.

2.2.2.8 Timber Dams

A timber crib dam in Michigan, photographed in 1978.Timber dams were widely used in the early part of the industrial revolution and in frontier areas due to ease and speed of construction. Rarely built in modern times by humans because of relatively short lifespan and limited height to which they can be built, timber dams must be kept constantly wet in order to maintain their water retention properties and limit deterioration by rot, similar to a barrel. The locations where timber dams are most economical to build are those where timber is plentiful, cement is costly or difficult to transport, and either a low head diversion dam is required or longevity is not an issue. Timber dams were once numerous, especially in the North American west, but most have failed, been hidden under earth embankments or been replaced with entirely new structures. Two common variations of timber dams were the crib and the plank. Timber crib dams were erected of heavy timbers or dressed logs in the manner of a log house and the interior filled with earth or rubble. The heavy crib structure supported the dam's face and the weight of the water. Splash dams were timber crib dams used to help float logs downstream in the late 19th and early 20th centuries. Timber plank dams were more elegant structures that employed a variety of construction methods utilizing heavy timbers to support a water retaining arrangement of planks. Very few timber dams are still in use. Timber, in the form of sticks, branches and withes, is the basic material used by beavers, often with the addition of mud or stones. Bijika (2007)

2.2.2.9 Steel Dams

Red Ridge steel dam, b. 1905, Michigan.A steel dam is a type of dam briefly experimented with in around the turn of the 19th-20th Century which uses steel plating (at an angle) and load bearing beams as the structure. Intended as permanent structures, steel dams were an (arguably failed) experiment to determine if a construction technique could be devised that was cheaper than masonry, concrete or earthworks, but sturdier than timber crib dams.

2.2.2.10 Beaver Dams

Beavers create dams primarily out of mud and sticks to flood a particular habitable area. By flooding a parcel of land, beavers can navigate below or near the surface and remain relatively well hidden or protected from predators. The flooded region also allows beaver access to food, especially during the winter. Hydraulic turbine and electrical generator

As of 2005, hydroelectric power, mostly from dams, supplies some 19% of the world's electricity, and over 63% of renewable energy.[16] Much of this is generated by large dams, although China uses small scale hydro generation on a wide scale and is responsible for about 50% of world use of this type of power. Wasserbau (2005)

Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator; to boost the power generation capabilities of a dam, the water may be run through a large pipe called a penstock before the turbine. A variant on this simple model uses pumped storage hydroelectricity to produce electricity to match periods of high and low demand, by moving water between reservoirs at different elevations. At times of low electrical demand, excess generation capacity is used to pump water into the higher reservoir. When there is higher demand, water is released back into the lower reservoir. Antiker (1986)

2.2.2.11 Hydroelectric Dam in cross section Spillways

Spillway on Llyn Brianne dam, Wales soon after first fill.Main article: Spillway

A spillway is a section of a dam designed to pass water from the upstream side of a dam to the downstream side. Many spillways have floodgates designed to control the flow through the spillway. Types of spillway include: A service spillway or primary spillway passes normal flow. An auxiliary spillway releases flow in excess of the capacity of the service spillway. An emergency spillway is designed for extreme conditions, such as a serious malfunction of the service spillway. A fuse plug spillway is a low embankment designed to be over topped and washed away in the event of a large flood. Fusegate elements are independent free-standing block set side by side on the spillway which work without any remote control. They allow to increase the normal pool of the dam without compromising the security of the dam because they are designed to be gradually evacuated for exceptional events. They work as fixed weir most of the time allowing over spilling for the common floods. The spillway can be gradually eroded by water flow, including cavitation or turbulence of the water flowing over the spillway, leading to its failure. It was the inadequate design of the spillway which led to the 1889 over-topping of the South Fork Dam in Johnstown, Pennsylvania, resulting in the infamous Johnstown Flood (the "great flood of 1889").

Erosion rates are often monitored, and the risk is ordinarily minimized, by shaping the downstream face of the spillway into a curve that minimizes turbulent flow, such as an ogee curve. Bijker (2007).

2.3 Dam Creation

2.3.1 Common Purposes

Power generation Hydroelectric power is a major source of electricity in the world. Many countries have rivers with adequate water flow, that can be dammed for power generation purposes. For example, the Itaipu on the Paraná River in South America generates 14 GW and supplied 93% of the energy consumed by Paraguay and 20% of that consumed by Brazil as of 2005. Water supply Many urban areas of the world are supplied with water abstracted from rivers pent up behind low dams or weirs. Examples include

London - with water from the River Thames and Chester with water taken from the River Dee. Other major sources include deep upland reservoirs contained by high dams across deep valleys such as the Claerwen series of dams and reservoirs. Stabilize water flow / irrigation Dams are often used to control and stabilize water flow, often for agricultural purposes and irrigation. Others such as the Berg Strait dam can help to stabilize or restore the water levels of inland lakes and seas, in this case the Aral Sea. Flood prevention Dams such as the Blackwater dam of Webster, New Hampshire and the Delta Works are created with flood control in mind. Land reclamation Dams (often called dykes or levees in this context) are used to prevent ingress of water to an area that would otherwise be submerged, allowing its reclamation for human use. Water diversion A typically small dam used to divert water for irrigation, power generation, or other uses, with usually no other function. Occasionally, they are used to divert water to another drainage or reservoir to increase flow there and improve water use in that particular area. Recreation and aquatic beauty Dams built for any of the above purposes may find themselves displaced by time of their original uses. Nevertheless the local community may have come to enjoy the reservoir for recreational and aesthetic reasons. Often the reservoir will be placid and surrounded by greenery, and convey to visitors a natural sense of rest and relaxation. Joseph (1986)

2.4 Location

The discharge of Takato Dam One of the best places for building a dam is a narrow part of a deep river valley; the valley sides can then act as natural walls. The primary function of the dam's structure is to fill the gap in the natural reservoir line left by the stream channel. The sites are usually those where the gap becomes a minimum for the required storage capacity. The most economical arrangement is often a composite structure such as a masonry dam flanked by earth embankments. The current use of the land to be flooded should be dispensable. Significant other engineering and engineering geology considerations when building a dam include: permeability of the surrounding rock or soil, earthquake faults, landslides and slope stability, water table, peak flood flows, reservoir silting environmental impacts on river fisheries, forests and wildlife (see also fish ladder), impacts on human habitations, compensation for land being flooded as well as population resettlement removal of toxic materials and buildings from the proposed reservoir area. Impact assessment. Impact is assessed in several ways: the benefits to human society arising from the dam (agriculture, water, damage prevention and power), harm or benefits to nature and wildlife (especially fish and rare species), impact on the geology of an area - whether the change to water flow and levels will increase or decrease stability, and the disruption to human lives (relocation, loss of archeological or cultural matters underwater). Joseph (1986)

2.5 Environmental Impact

Wood and garbage accumulated because of a dam Main article: Environmental impacts of dams Dams affect many ecological aspects of a river. Rivers depend on the constant disturbance of a certain tolerance. Dams slow Water exiting a turbine usually contains very little suspended sediment, which can lead to scouring of river beds and loss of riverbanks; for example, the daily cyclic flow variation caused by the Glen Canyon Dam was a contributor to sand bar erosion. Older dams often lack a fish ladder, which keeps many fish from moving up stream to their natural breeding grounds, causing failure of breeding cycles or blocking of migration paths. Even the presence of a fish ladder does not always prevent a reduction in fish reaching the spawning grounds upstream. In some areas, young fish ("smolt") are transported downstream by barge during parts of the year. Turbine and power-plant designs that have a lower impact upon aquatic life are an active area of research. A large dam can cause the loss of entire ecospheres, including endangered and undiscovered species in the area, and the replacement of the original environment by a new inland lake. Depending upon the circumstances, a dam can either reduce or increase the net production of greenhouse gases. An increase can occur if the reservoir created by the dam itself acts as a source of substantial amounts of potent greenhouse gases (methane and carbon dioxide) due to plant material in flooded areas decaying in an anaerobic environment. A study for the National Institute for Research in the Amazon found that Hydroelectric dams release a large pulse of carbon dioxide from above-water decay of trees left standing in the reservoirs, especially during the first decade after closing. This elevates the global warming impact of the dams to levels much higher than would occur by generating the same power from fossil fuels. According to the World Commission on Dams report (Dams And Development), when the reservoir is relatively large and no prior clearing of forest in the flooded area was undertaken, greenhouse gas emissions from the reservoir could be higher than those of a conventional oil-fired thermal generation plant. For instance, In 1990, the impoundment behind the Balbina Dam in Brazil(closed in 1987) had over 20 times the impact on global warming than would generating the same power from fossil fuels, due to the large area flooded per unit of electricity generated. A decrease can occur if the dam is used in place of traditional power generation, since electricity produced from hydroelectric generation does not give rise to any flue gas emissions from fossil fuel combustion (including sulfur dioxide, nitric oxide, carbon monoxide, dust, and mercury from coal). The Tucurui dam in Brazil (closed in 1984) had only 0.4 times the impact on global warming than would generating the same power from fossil fuels. Large lakes formed behind dams have been indicated as contributing to earthquakes, due to changes in loading and/or the height of the water table. Joseph (1986)

2.6 Human Social Impact

The impact on human society is also significant. For example, the Three Gorges Dam on the Yangtze River in China is more than five times the size of the Hoover Dam (U.S.), and will create a reservoir 600 km long to be used for hydro-power generation. Its construction required the loss of over a million people's homes and their mass relocation, the loss of many valuable archaeological and cultural sites, as well as significant ecological change. It is estimated that to date, 40-80 million people worldwide have been physically displaced from their homes as a result of dam construction. Lucas (2006)

2.7 Economics

Construction of a hydroelectric plant requires a long lead-time for site studies, hydrological studies, and environmental impact assessment, and are large scale projects by comparison to traditional power generation based upon fossil fuels. The number of sites that can be economically developed for hydroelectric production is limited; new sites tend to be far from population centers and usually require extensive power transmission lines. Hydroelectric generation can be vulnerable to major changes in the climate, including variation of rainfall, ground and surface water levels, and glacial melt, causing additional expenditure for the extra capacity to ensure sufficient power is available in low water years. Once completed, if it is well designed and maintained, a hydroelectric power source is usually comparatively cheap and reliable. It has no fuel and low escape risk, and as an alternative energy source it is cheaper than both nuclear and wind power.[citation needed] It is more easily regulated to store water as needed and generate high power levels on demand compared to wind power, although dams have life expectancies while renewable energies do not. Joseph (1986)

2.8 Dam Failure

The reservoir emptying through the failed Teton Dam

International special sign for works and installations containing dangerous forces Dam failures are generally catastrophic if the structure is breached or significantly damaged. Routine deformation monitoring of seepage from drains in and around larger dams is necessary to anticipate any problems and permit remedial action to be taken before structural failure occurs. Most dams incorporate mechanisms to permit the reservoir to be lowered or even drained in the event of such problems. Another solution can be rock grouting - pressure pumping portland cement slurry into weak fractured rock.

During an armed conflict, a dam is to be considered as an "installation containing dangerous forces" due to the massive impact of a possible destruction on the civilian population and the environment. As such, it is protected by the rules of International Humanitarian Law (IHL) and shall not be made the object of attack if that may cause severe losses among the civilian population. To facilitate the identification, a protective sign consisting of three bright orange circles placed on the same axis is defined by the rules of IHL. Gorges (2006)

The main causes of dam failure include spillway design error (South Fork Dam), geological instability caused by changes to water levels during filling or poor surveying

(Vajont Dam, Malpasset), poor maintenance, especially of outlet pipes (Lawn Lake Dam, Val di Stava Dam collapse), extreme rainfall (Shakidor Dam), and human, computer or design error (Buffalo Creek Flood, Dale Dike Reservoir, Taum Sauk pumped storage plant). Gorges (2006)

A notable case of deliberate dam failure (prior to the above ruling) was the Royal Air Force 'Dam busters' raid on Germany in World War II (codenamed "Operation Chastise"), in which three German dams were selected to be breached in order to have an impact on German infrastructure and manufacturing and power capabilities deriving from the Ruhr and Eder rivers. This raid later became the basis for several films.

Since 2007, the Dutch IJkdijk foundation is developing, with an open innovation model an early warning system for levee/dike failures. As a part of the development effort, full scale dikes are destroyed in the IJkdijk fieldlab. The destruction process is monitored by sensor networks from an international group of companies and scientific institution

All dams are designed and constructed to meet specific requirements. First, a dam should be built from locally available materials when possible. Second, the dam must remain stable under all conditions, during construction, and ultimately in operation, both at the normal reservoir operating level and under all flood and drought conditions. Third, the dam and foundation must be sufficiently watertight to control seepage and maintain the desired reservoir level. Finally, it must have sufficient spillway and outlet works capacity as well as freeboard to prevent floodwater from overtopping it. Gorges (2006)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

Material

Taqwai dam water

Equipments

- Echo sounder .This is an instrument for determining lake or ocean floor depth. Echo sounding is the technique of using sound pulses directed from the surface vertically down to measure the distance to the bottom by means of sound waves.
- Global Positioning System GPS. This is satellite-based navigation system made up of 24 satellites placed into orbit. GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this inform
- Boat. Boat was used to navigate the water.
- The graphic recorder takes the information from echo sounder as a raw data while the data goes through further processing to interpret it to distance.

3.2 Methods

The method employed in this work is Bathymetric survey method. Bathymetry referred to the measurement of ocean depth through depth sounding, that is, the study of underwater depth of lake or depth floor.

3.2.1 Procedure

The echo sounder function is based on the principle that water is an excellent medium for the transmission of sound waves and that sound pulse will bounce of a reflecting returning to its source as an echo.

The time interval between the initiation of a sound pulse and echo returned from the bottom is used as to determine the depth of bottom. The system consist of transmitter a receiver that picks up the reflected echo, electronic timing and amplification equipment, and an indicator or graphic recorder.

The graphic recorder takes the information from echo sounder as a raw data while the data goes through further processing to interpret it to distance.

The echo sounder is placed in the boat and its cord is placed on the surfacse of the water, a position is taken and the GPS is immediately notified to take the coordinate of the point while the echo sounder button is pressed simultaneously to send the pulse into the water.

Distance is measured by multiplying half the time from the signal's outgoing pulse to its return by the speed of sound in the water which is approximately 1.5kilometers per second .The interval between the initiation of sound pulse and echo returned from the bottom is used to determine the depth of the bottom.

3.2.2 Geographical Information System of the Dam (G.I.S)

Geographic Information System (GIS) is any system that captures, stores, analyzes, manages, and presents data is linked to location. This is presented in appendix 2.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 Presentation of result

Retention capacity = 935550litres

Volume of silt in the dam =75690450m^3

Cost of de-silting the dam = ₦128676500

4.2 Discussion of Result

From the result obtained, the dam has the capacity of retaining 9355000m^3 (935550litres) of water. The result also shows that 75690450m^3 of the retaining capacity has been taken over by silt. That is, 80.9% of the total capacity of the dam has been taken over by silt.

This implies that the present volume of the dam water is 17864550m^3 (178645.5litres) and this also account for 19.1% of the total capacity of the dam.

The dam has annual silt inflow of 2441627.419m^3

It was also obtained that the cost of de-silting the dam is ₦12,867,376,500 if 1m^3 is de-silted for ₦170.

4.2.1 Easting and Northing values

These are the longitudinal and latitudinal values that indicate the coordinate of each measured depth at a particular position. These positions are picked and recorded by GPS receiver.

4.2.2 Depths

These are the different depths of the dam measured by the use of echo sounder. Several points are taking on the dam and their different depths are measured, the values obtained from these measured depths are used to calculate the average depth of the dam which is used as the present depth of the dam.

The hydraulic height (construction depth of the dam water) is deducted from the present depth to know the height of the silt. The height of the silt is multiplied by the surface area of the dam to know the volume of the silt which is $75690450m^3$.

4.2.3 Reduced level (RL)

These are the reduced level obtained from reducing the dam area to a common datum, choosing Minna as the datum. This was done to have a common and the same level ground for the survey.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Having carried out this study with the following results; The retaining capacity of 93555000m^3 (955550litres), Volume of silt is 75690450m^3, present volume of dam water is 17864550 (178645.5litres) and the cost of de-silting the dam at ₦12,867,376,500. It is important to know that Taqwai dam has the capacity of meeting domestic, industrial, agricultural needs of Minna and its environ if de-silted and well managed. Therefore, there is a need for government to act quickly and de-silt Taqwai dam to solve the problem of water that confronts the residents of Minna and its environ.

5.2 Recommendations

This study was carried out using equipments that are efficient and precise.

- It is recommended that best practice should be encouraged around the dam vicinity to reduce the inflow of silt into the dam. Practice like planting of trees at the bank of the dam to increase soil compaction and reduce erosion.
- It is recommended that further research should be carried out to know the direct effect of the dam on individual citizen and the environment
- It is recommended that analysis should also be carried out to know the economic importance of the dam.

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APPENDIX 1

TAQWAI DAM PROJECT DATA

Average Annual Precipitation	1270mm
Catchments Area	110 kl2
Average Annual Runoff	25 x 106m3
Type of Dam	zoned earth fill
Crest Length	1900m
Crest level	259m O.D
Freeboard	3.0m
Maximum flood level	257.5m O.D
Full supply level	256m O.D
Crest width	10m
Maximum structural height	25m O.G.L
Hydraulic height	21m
Maximum width of base	150m
Total storage capacity	24.9 x 106 (20194 Ac. Ft.)
Dead storage capacity	1.6 x 106m3
Surface area of lake	440ha
Total volume of earth works	870000m3
Construction period	1977 – 78

(Taqwai dam project data from River board Minna)

APPENDIX 2

Geographical information system

APPENDIX 3

α

Presentation of result

EASTING	NORTHING	DEPTH(m)	RL
241977.901	1059109.929	0.5	255.634
242002.096	1059115.060	1.1	255.034
242020.076	1059107.875	1.9	254.234
242051.914	1059109.277	0.9	255.234
242081.827	1059111.553	0.8	255.334
242111.741	1059113.829	0.8	255.334
242134.232	1059036.166	2.3	253.834
242140.116	1059065.583	1.7	254.434
242146.000	1059095.000	1.6	254.534
242159.000	1059018.000	2.4	253.734
242185.500	1059032.062	3.2	252.934
242207.222	1058972.443	2.9	253.234
242209.783	1059045.007	0.6	255.534
242219.912	1058995.513	2.9	253.234
242234.000	1059022.000	0.6	255.534
242238.000	1058961.000	2.3	253.834
242262.577	1058978.203	4.0	252.134
242267.995	1058908.765	1.1	255.034
242286.330	1058932.510	4.3	251.834
242287.155	1058995.407	0.6	255.534
242295.750	1058780.240	0.9	255.234
242304.665	1058956.255	2.3	253.834
242315.907	1058802.460	0.9	255.234
242320.000	1058841.000	0.8	255.334
242323.000	1058980.000	2.1	254.034
242336.063	1058824.679	2.2	253.934
242339.397	1058863.885	0.8	255.334
242356.219	1058846.899	2.4	253.734
242358.795	1058886.771	4.7	251.434
242364.000	1058703.000	0.8	255.334
242376.375	1058869.120	3.1	253.034
242378.192	1058909.656	0.7	255.434
242389.000	1058673.000	1.7	254.434
242391.656	1058714.624	2.1	254.034
242396.531	1058891.340	4.1	252.034
242397.590	1058932.541	0.7	255.434
242401.623	1058700.215	2.6	253.534

242414.246	1058727.430	1.1	255.034
242416.688	1058913.560	5.2	250.934
242419.313	1058726.248	2.1	254.034
242426.868	1058754.645	1.7	254.434
242436.844	1058935.780	1.7	254.434
242439.491	1058781.860	2.4	253.734
242446.969	1058737.872	2.3	253.834
242452.114	1058809.076	4.4	251.734
242457.000	1058958.000	0.7	255.434
242464.737	1058836.291	0.8	255.334
242474.626	1058749.496	5.4	250.734
242477.360	1058863.506	6.3	249.834
242489.982	1058890.721	5.2	250.934
242494.000	1058682.000	1.2	254.934
242496.775	1058970.935	1.1	255.034
242497.522	1058940.944	2.1	254.034
242498.268	1058910.954	2.8	253.334
242499.014	1058880.963	3.5	252.634
242499.761	1058850.972	4.6	251.534
242500.507	1058820.981	6.1	250.034
242501.254	1058790.991	4.1	252.034
242502.282	1058761.121	2.8	253.334
242502.605	1058917.936	3.2	252.934
242502.729	1058710.702	2.5	253.634
242511.458	1058739.404	3.1	253.034
242515.228	1058945.152	3.2	252.934
242520.188	1058768.106	1.3	254.834
242522.246	1058651.955	0.7	255.434
242527.851	1058972.367	2.3	253.834
242528.917	1058796.808	1.9	254.234
242531.157	1058680.601	2.2	253.934
242537.646	1058825.510	3.1	253.034
242540.068	1058709.248	2.9	253.234
242540.474	1058999.582	2.0	254.134
242546.375	1058854.212	3.5	252.634
242548.979	1058737.894	2.8	253.334
242553.096	1059026.797	0.9	255.234
242555.104	1058882.914	5.0	251.134
242557.890	1058766.539	1.9	254.234
242563.834	1058911.615	7.0	249.134
242566.801	1058795.186	2.5	253.634
242572.563	1058940.317	5.3	250.834
242575.712	1058823.832	3.9	252.234

242581.292	1058969.019	3.6	252.534
242584.623	1058852.478	4.9	251.234
242590.021	1058997.721	2.6	253.534
242593.534	1058881.124	6.7	249.434
242598.750	1059026.423	2.1	254.034
242352.871	1058897.633	4.4	251.734
242602.445	1058909.770	7.6	248.534
242607.480	1059055.125	1.0	255.134
242611.356	1058938.416	5.5	250.634
242617.389	1058814.609	4.3	251.834
242618.000	1058634.001	0.8	255.334
242620.267	1058967.062	4.1	252.034
242622.262	1058663.697	1.1	255.034
242626.523	1058693.392	2.4	253.734
242629.178	1058995.707	3.7	252.434
242630.785	1058723.088	2.8	253.334
242430.382	1058823.953	4.3	251.834
242635.046	1058752.784	3.3	252.834
242638.089	1059024.354	3.2	252.934
242639.308	1058782.480	2.7	253.434
242642.982	1058348.426	0.8	255.334
242643.570	1058812.176	2.3	253.834
242646.137	1058615.888	0.8	255.334
242646.328	1058378.238	1.6	254.534
242646.999	1059053.000	2.3	253.834
242647.831	1058841.871	3.1	253.034
242649.673	1058408.052	3.0	253.134
242417.991	1058835.375	4.3	251.834
242651.852	1058645.338	2.1	254.034
242652.093	1058871.567	3.5	252.634
242653.019	1058437.865	4.2	251.934
242656.354	1058901.262	3.7	252.434
242656.364	1058467.678	5.3	250.834
242657.566	1058674.789	3.0	253.134
242659.710	1058497.491	5.5	250.634
242660.616	1058930.959	3.8	252.334
242663.055	1058527.304	6.2	249.934
242663.281	1058704.240	2.3	253.834
242664.878	1058960.654	4.5	251.634
242404.943	1058846.792	4.3	251.834
242666.400	1058557.117	7.2	248.934
242668.995	1058733.690	1.4	254.734
242669.139	1058990.350	5.9	250.234

242669.746	1058586.929	4.8	251.334
242673.091	1058616.742	3.9	252.234
242673.264	1058762.778	1.7	254.434
242673.401	1059020.046	6.1	250.034
242676.437	1058646.555	4.1	252.034
242677.170	1058792.230	1.8	254.334
242677.662	1059049.742	2.3	253.834
242679.782	1058676.368	4.2	251.934
242680.678	1058820.120	2.9	253.234
242682.000	1058272.000	1.1	255.034
242397.581	1058856.303	4.4	251.734
242683.128	1058706.181	2.5	253.634
242686.473	1058735.994	1.9	254.234
242687.000	1058846.999	3.7	252.434
242688.584	1058301.269	2.3	253.834
242692.711	1058767.255	2.5	253.634
242694.611	1058796.344	2.3	253.834
242695.169	1058330.537	7.3	248.834
242696.509	1058825.433	2.9	253.234
242311.852	1058913.398	4.3	251.834
242699.855	1058855.245	3.9	252.234
242701.753	1058359.806	8.9	247.234
242703.200	1058885.058	8.9	247.234
242706.546	1058914.871	8.8	247.334
242708.027	1058870.827	4.5	251.634
242708.338	1058389.074	8.8	247.334
242708.536	1058975.583	8.8	247.334
242709.891	1058944.684	8.5	247.634
242712.357	1058900.842	5.5	250.634
242712.603	1059005.396	8.5	247.634
242712.968	1058932.640	7.7	248.434
242714.864	1059035.209	8.6	247.534
242714.922	1058418.343	9.9	246.234
242718.572	1059066.108	8.2	247.934
242718.689	1058963.411	8.0	248.134
242721.507	1058447.611	10.0	246.134
242723.594	1059094.757	6.3	249.834
242724.073	1058995.276	8.3	247.834
242727.444	1059123.561	3.8	252.334
242728.091	1058476.880	9.8	246.334
242730.482	1059027.835	6.5	249.634
242733.309	1059153.373	1.3	254.834
242734.675	1058506.148	9.3	246.834

242735.111	1059057.648	8.0	248.134
242736.655	1059183.187	1.7	254.434
242740.000	1059213.000	1.1	255.034
242741.260	1058535.417	8.6	247.534
242743.116	1059084.577	7.9	248.234
242744.797	1059116.549	3.2	252.934
242747.844	1058564.685	8.8	247.334
242749.000	1059146.000	1.2	254.934
242754.429	1058593.953	9.4	246.734
242761.013	1058623.222	10.4	245.734
242767.598	1058652.491	8.3	247.834
242774.182	1058681.759	9.2	246.934
242780.767	1058711.028	9.5	246.634
242787.351	1058740.296	8.8	247.334
242793.935	1058769.564	8.7	247.434
242800.520	1058798.833	8.6	247.534
242807.104	1058828.102	7.7	248.434
242812.562	1058433.357	2.6	253.534
242813.689	1058857.370	7.3	248.834
242820.273	1058886.639	5.2	250.934
242826.858	1058915.906	5.1	251.034
242833.442	1058945.176	5.2	250.934
242840.026	1058974.444	5.8	250.334
242846.611	1059003.713	6.8	249.334
242853.195	1059032.980	10.3	245.834
242859.780	1059062.250	9.1	247.034
242866.364	1059091.517	10.9	245.234
242872.949	1059120.786	8.7	247.434
242879.533	1059150.055	5.6	250.534
242886.118	1059179.324	6.1	250.034
242892.702	1059208.592	6.1	250.034
242899.286	1059237.861	6.1	250.034
242905.871	1059267.129	8.2	247.934
242912.455	1059296.398	6.8	249.334
242919.040	1059325.666	6.5	249.634
242925.624	1059354.935	6.8	249.334
242932.208	1059384.204	5.7	250.434
242938.793	1059413.472	6.2	249.934
242945.377	1059442.741	5.2	250.934
242951.962	1059472.009	5.3	250.834
242958.546	1059501.278	6.3	249.834
242965.131	1059530.546	5.9	250.234
242971.715	1059559.815	4.8	251.334

242978.299	1059589.083	5.6	250.534
242984.884	1059618.352	5.2	250.934
242991.468	1059647.620	4.2	251.934
242996.000	1058253.000	2.7	253.434
242998.053	1059676.889	4.6	251.534
242999.864	1058282.750	2.3	253.834
243003.728	1058312.499	1.6	254.534
243004.637	1059706.157	4.2	251.934
243007.592	1058342.249	2.1	254.034
243011.222	1059735.426	3.8	252.334
243011.456	1058372.000	2.3	253.834
243015.320	1058401.750	2.4	253.734
243017.806	1059764.694	3.8	252.334
243019.184	1058431.501	2.3	253.834
243023.048	1058461.251	3.1	253.034
243024.000	1058761.067	3.2	252.934
243024.391	1059793.963	3.5	252.634
243026.912	1058491.000	3.4	252.734
243030.776	1058520.751	3.8	252.334
243030.975	1059823.231	3.2	252.934
243034.640	1058550.501	3.1	253.034
243037.559	1059852.500	2.9	253.234
243038.504	1058580.251	2.5	253.634
243042.368	1058610.001	2.7	253.434
243044.144	1059881.767	2.1	254.034
243046.232	1058639.750	2.1	254.034
243050.096	1058669.501	2.2	253.934
243050.728	1059911.036	1.6	254.534
243053.960	1058699.252	3.6	252.534
243057.313	1059940.305	1.1	255.034
243057.824	1058729.001	4.4	251.734
243061.688	1058758.752	6.2	249.934
243063.897	1059969.574	0.9	255.234
243065.552	1058788.502	4.9	251.234
243069.416	1058818.252	4.6	251.534
243073.280	1058848.002	4.6	251.534
243074.000	1060006.000	1.2	254.934
243077.144	1058877.751	4.7	251.434
243081.008	1058907.503	4.9	251.234
243084.873	1058937.252	5.1	251.034
243088.737	1058967.003	5.2	250.934
243089.058	1058861.901	6.3	249.834
243092.601	1058996.753	5.3	250.834

243096.465	1059026.503	6.7	249.434
243100.329	1059056.253	5.3	250.834
243103.390	1059999.980	1.5	254.634
243104.193	1059086.002	5.4	250.734
243105.323	1058887.110	7.6	248.534
243108.057	1059115.753	5.5	250.634
243111.921	1059145.503	6.6	249.534
243115.785	1059175.254	5.2	250.934
243119.649	1059205.003	4.3	251.834
243123.513	1059234.753	3.7	252.434
243127.377	1059264.504	3.6	252.534
243131.241	1059294.254	4.0	252.134
243132.780	1059993.959	1.3	254.834
243135.105	1059324.003	4.3	251.834
243138.969	1059353.754	4.6	251.534
243142.833	1059383.504	4.6	251.534
243146.697	1059413.253	4.7	251.434
243150.561	1059443.005	4.8	251.334
243154.116	1058962.735	6.2	249.934
243154.425	1059472.755	4.9	251.234
243158.289	1059502.505	4.8	251.334
243162.153	1059532.254	4.7	251.434
243162.169	1059987.940	1.7	254.434
243166.017	1059562.005	5.0	251.134
243169.881	1059591.755	6.3	249.834
243173.745	1059621.505	6.1	250.034
243177.609	1059651.255	5.7	250.434
243181.473	1059681.006	5.3	250.834
243185.337	1059710.756	4.8	251.334
243189.201	1059740.506	3.1	253.034
243191.559	1059981.920	2.3	253.834
243193.065	1059770.256	0.8	255.334
243220.949	1059975.899	2.4	253.734
243224.331	1059060.077	5.9	250.234
243250.339	1059969.880	2.5	253.634
243250.784	1059074.265	4.2	251.934
243277.235	1059088.451	4.2	251.934
243279.729	1059963.859	1.6	254.534
243303.688	1059102.639	3.6	252.534
243309.118	1059957.839	1.3	254.834
243330.139	1059116.826	3.6	252.534
243338.508	1059951.820	1.1	255.034
243356.592	1059131.012	3.7	252.434

243367.898	1059945.800	1.7	254.434
243383.044	1059145.200	3.6	252.534
243397.288	1059939.780	1.6	254.534
243409.496	1059159.387	3.5	252.634
243426.678	1059933.761	1.1	255.034
243435.948	1059173.573	3.7	252.434
243456.068	1059927.741	1.1	255.034
243462.400	1059187.760	4.3	251.834
243485.458	1059921.721	1.0	255.134
243487.971	1059203.730	5.8	250.334
243498.045	1059683.295	2.6	253.534
243500.266	1059653.377	3.1	253.034
243502.487	1059623.458	3.4	252.734
243504.709	1059593.542	3.2	252.934
243506.930	1059563.623	2.4	253.734
243509.151	1059533.706	2.5	253.634
243511.372	1059503.789	2.5	253.634
243513.593	1059473.871	2.5	253.634
243514.847	1059915.701	1.0	255.134
243515.815	1059443.953	2.6	253.534
243516.116	1059216.739	5.8	250.334
243518.036	1059414.036	2.6	253.534
243520.257	1059384.118	2.7	253.434
243522.478	1059354.200	3.3	252.834
243524.700	1059324.282	3.7	252.434
243526.921	1059294.365	4.8	251.334
243529.142	1059264.447	7.2	248.934

Calculation Of The Dam Silt Volume

Average depth = Total sum of depths divided by Total number of points taken

$= \frac{1255.13}{313}$

= 4.01m

Volume = Area x Depth,

The Retention Capacity of the dam = Surface Area of the dam x Hydraulic Depth of the dam

The surface area of the dam is 440ha. Such that 1 Hectare = 2.5 Acres

1 Acre = $4050m^2$

That is, the Surface Area = 440 x 2.5 x 405

= $4455000m^2$

The hydraulic construction depth = 21m

Retention Capacity = 4455000 x 21

= $93555000m^3$

The average depth from the result = 4.01m

The silt depth of the dam = 21 – 4.01 = 16.99m

Volume of silt in the dam = 4455000 x 16.99

= $75690450m^3$

$$\text{Annual silt inflow} = \frac{\text{Volume of silt}}{\text{Number of years of accumulation}}$$

Number of year of accumulation is 31yrs

$$\text{Such that: Annual silt inflow} = \frac{75690450}{31}$$

= $2441627.419m^3$

The cost of de-silting the dam

Taking into consideration the cost of moving equipment into the site and other necessities, the cost of removing $1m^3$ is ₦170.

To calculate the cost of removing this volume of silt, we multiply the volume with 170

That is, 75690450 x 170 = ₦12,867,376,500

APPENDIX 4

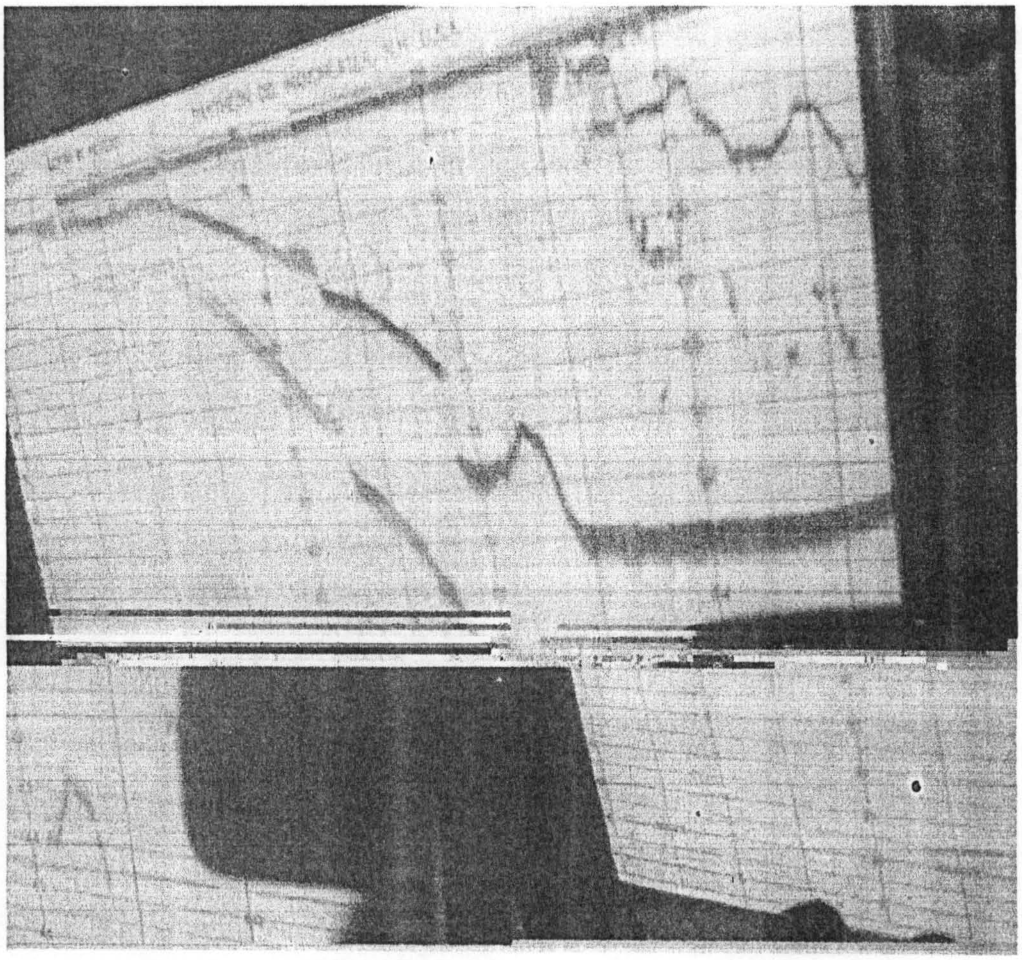

PLATE 1 GRAPHIC RECORDER

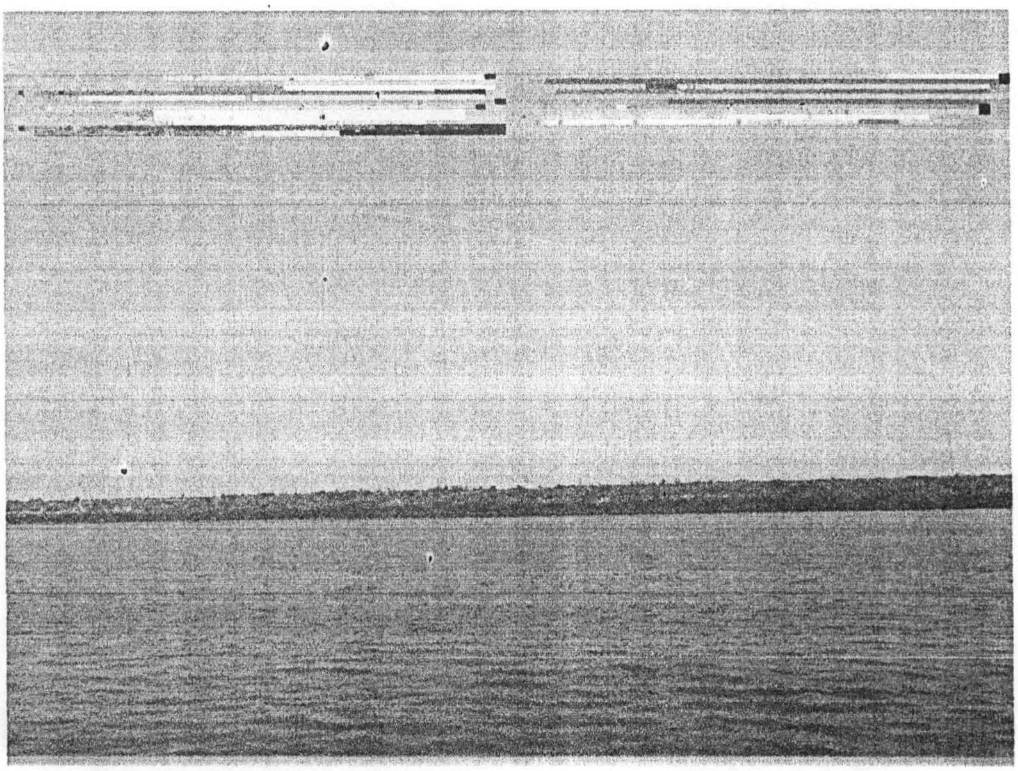

PLATE 2 TAQWAI DAM

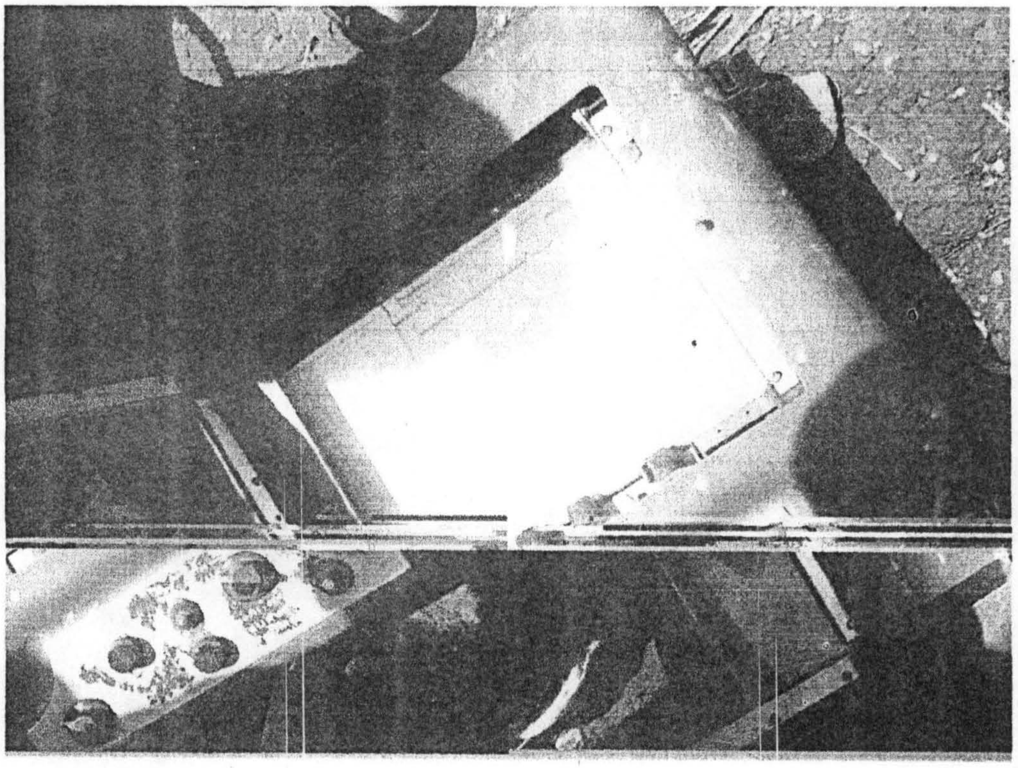

PLATE 3 ECHO SOUNDER