INTRODUCTION

The proposed Arch dam will be referred to as Plot Ten Dam. It is located in Nyandarua South District, Kinangop Division, Nyakio Location. It is on Karati River, about 3 kilometres downstream of Njabini-Magumu road Karati Bridge.

Design was carried out by Eng. Phillip Gichuki and Paul Gichuki being the assistant designer. The design period started on December 2008 and ended on the beginning of February 2009. Construction of the dam started on mid Feb. 09 and is expected to end by April.

Salient features of the dam are shown in the Appendix.

PURPOSE

During a family gathering held in Dec. 08 it was noted that there was a dire need to have a reliable water source especially to cater for livestock requirement. From the discussions held then it emerged that there were more than two possible sites to develop a dam/pan to harvest runoff water.

It was finally agreed that a masonry dam across the river was best suited due to the suitability of the site in terms of cost and the capacity of the built structure.

The dam is expected to harvest runoff water that usually occurs during wet seasons. The river does not have a normal flow and hence compensation flow will not be provided unless marginally through the scour pipe installed at the lowest level of the dam.

Drawings

Drawings are attached in the Appendix that includes topo survey, structural, site layout, water level, and auxiliary structures.

CATCHMENT AREA & DAM SITE

Catchment area is approximately 15 km^2. The longest path of the river is about 8 km from the dam location. Maximum altitude of the area is 2700 a.m.s.l. and the altitude at dam site is 2600 a.m.s.l. The mean annual rainfall is 1600mm and means annual evaporation is 1000mm. Karati river drains into Lake Naivasha that falls in Rift Valley Water Basin.

The dam is located in a gorge along the river channel and thus the choice of a Masonry Arch dam. The area is gently sloping toward West with a slope of 0.125%. The general topography of the area is undulating flat land that generally slopes from East to West.

The soils of the area are loam soils with patches of murram and the area is generally grassland. At the site we have weathered tuff that is about 1.5 m deep, underlay by un-weathered base rock that forms a sound foundation of the dam structure.

For the last 10 years there has been a lot of change in land use within the basin due to increased cultivation acreage. This has resulted in increased sediment load of the river water. The river sheds its load in depressions occurring along its course. The results are reduced river capacity due to filling up of the previous depression with silt. A recent rehabilitation of Njabini-Magumu road resulted in a lot of silt being swept into the stream. This phenomenon has highly reduced the reliability of the river as a source of water especially during dry spells. This calls for an urgent intervention like the purpose of the proposed project.

With the increased period of dry spells and global warming that is prevailing, the droughts are getting tougher and longer as time elapses. Harvesting runoff occurring in wet season is a noble action that will alleviate the suffering especially livestock. When water is left to flow without storing some it translates to wastage as during the wet season nobody needs the water in the stream and is actually seen as dirty and people at this time rely on roof water.

ENVIRONMENTAL IMPACT

Due to the high altitude of the area (2600 a.m.s.l.) and above, the impounding is not expected to adversely affect the neighbourhood. The reservoir is expected to improve aquatic ecosystem where small fish and crustaceans can be reared even if only for maintaining healthy aquatic ecology in the reservoir. The area is expected to receive increased human activity such as fetching water and watering livestock. For this reason the reservoir will be fenced and watering point both for domestic and livestock provided.

Reservoir

The impounded area is 7,723 m^2. The capacity of the dam is 9,535 m^3 with a dead storage of 80 m^3. The fetch of the dam is 185 m. Maximum depth of the water is 4 m near the dam and has an average depth of 1.5 m for the whole reservoir.

DAM DESIGN

The wall is a 7.5 m high double masonry wall with columns and beams as shown in the drawings in the appendix. The design of this dam followed the guide lines laid down in ‘Guidelines for the Design, Construction and Rehabilitation of Small Dams and Pans in Kenya 1992’

All the lateral loads are carried by the beams that transfer the same to columns that are keyed to the base rock foundation. The columns are treated as cantilever with a fixed end in the keying. An arched prop ending at 1/3 h of the dam was provided to give a more stable base of the wall and also to prevent sliding. Design calculation for the reinforcement steel results are attached in the Appendix.

The loads considered in the calculations are; self weight, hydrostatic loading (including uplift), hydrostatic loads induced by seismic action, and live load resulting in human traffic on the crest of the dam. The safety factor used for this design was 1.6 while that for seismic load is 1.015 of the factored load.

Site Investigation

A survey was carried out on the site to determine the levels of the dam, reservoir, and the immediate area. The survey was utilised to draw contours of the area and also to determine the capacity of the reservoir resulting from the impoundment. It was further used to determine the impounded area in terms of land parcel that is presented in the Appendix.

Preliminary site investigations were carried out to determine the depth of the foundation that was finally found to be 1.5 m deep. A trench was dug across the gorge with the following dimensions: 9x1x1.5 m.

Several investigation holes were done especially at the proposed end of the dam wall to a depth of 1.2 m where the base rock was encountered.

Freeboard

The net freeboard was designed at 0.5m with a gross freeboard of 1 m. Going with the previous experience this freeboard is deemed adequate to protect the dam against overtopping.

Wind speed and tide

From the limited data available it is clear that the prevailing wind is from Easterly direction. A wind speed of 25m/s is taken for calculation of the wind tide.

$S = \frac{V^2 F}{1400D}$ (Saville *et al*, 1962) S=0.05 m

Where; S increase in elevation
V wind speed (mph)
F total fetch (miles)
D average reservoir depth (ft)

Wave run-up is only significant when considering freeboard allowance and thus is only estimated for the maximum fetch for full reservoir. According to the small fetch of the reservoir the wind run-up will have insignificance in the freeboard allocation.

Water Stop Structure

A bracket of 1.5 m was provided behind the dam to increase the length of flow path with a net effect of reducing uplift against the dam wall. Monitoring will be carried out after the dam is full to determine any abnormal water loss from leak and necessary measures taken.

Capacity

The gross capacity of the dam is 9,535 m^3 with a dead storage of 80 m^3. The current estimated demand from the reservoir is 5 m^3/day calculated as stipulated in 'Practice Manual for Water Supply Services in Kenya 2005'.

SPILLWAY

The spillway is located on an adjacent depression that runs parallel to the dammed valley. The spillway is taken to be adequate since it has a wider channel than the dammed valley i.e. 10 m wide spillway as compared to 5 m wide valley of the river. The flow over the spillway is expected to be

critical and hence the discharge over it will be higher as compared to that of the river. The length of the spillway is 100m.

Energy Dissipater

An ogee wall will be placed at the end of the spillway and a deflection bucket constructed downstream of the wall. The discharge water will have lost enough energy and thus will be discharged back to the stream without risking scouring and erosion of the river channel at this point.

DRAW-OFF SYSTEM

This will be composed of 4" scour pipe and 4" off-take pipes. The length of the off-take pipe will be 15 m to be terminated in a trough and a 'T' to a clean water stand. Both the off-take and the scour pipe will have a gate valve housed in a valve chamber as shown in the drawings in the Appendix.

COST ESTIMATES

A summary of cost estimate is summarised in the table below:

CONSTRUCTION SCHEDULE

Design; 3 wk

Foundation Excavation; 3 wk

Construction; 5 wk

Plumbing works; 4 days

Fencing; 1 wk

Rip rap Protection; 2 wk

Water Point Installation; 1 wk

Cattle Trough; 2 wk

OPERATION AND MAINTAINANCE

The dam will be run as a communal property for the near neighbourhood and the major one when necessary especially in case of a major drought. The community will be allowed to access water through the watering point provided. Maintenance cost will be borne by the community to ensure the continued services of the dam. Labour will be voluntary if siltation occur in a short time.

The users of the dam will be expected to follow proper usage of the facility by abiding to simple rules such as watering their animals exclusively from the watering point and not into the reservoir directly. This will go a long way in maintaining the quality of the water stored.

Survey Beacons

Three Survey beacons are constructed near the site for monitoring the settling/distortion of the dam structure after construction.