A 2D Model of Aswan High Dam Reservoir For The Purpose of Flood Management

M. M. Soliman[1], M. A. Gad[2*], Ashraf M. El-Moustafa[3]

Abstract

High Aswan Dam (AHD) is one of the most important projects in the history of Egypt it has provided full control on the discharges released to the Egyptian irrigation network system. An escape (spillway) is provided at the western side of the dam to permit excess water discharge and control the maximum level of the upstream reservoir. Another, uncontrolled, spillway was constructed at the end of Khor Tushka (on the western side of Lake Nasser at about 256 km upstream the dam). This spillway is connected to Tushka depression by a canal by which the excess flood can be turned to the depression.

The present paper presents research progress in the development of a 2D simulation model of AHDR. The modeling study aims to determine the optimal management policy for the reservoir in flood conditions by modeling the physical problem via a 2D routing model. This study aims also to the development of bathymetric charts for AHDR, build a geographical database for the reservoir.

Introduction

Routing is a process used to predict the temporal and spatial variations of a flood hydrograph as it moves through a river reach or reservoir. The effects of storage and flow resistance within a river reach are reflected by changes in hydrograph shape and timing as the flood wave moves from upstream to downstream. Routing is very important in Flood forecasting, reservoir and channel design, floodplain studies, and watershed simulations.

There is a two main routing techniques: ***hydraulic routing***, which is based on the solution of the partial differential equations of unsteady open channel flow (the St.Venant equations), and ***hydrologic routing*** that employs the continuity equation (inflow minus outflow equals the rate of change of storage) and any other relationship between storage and outlet discharge.

Stanley S. Butler (1982) presented an alternate reservoir flood routing approach applicable for routing design floods determined from statistically derived design storms. The approach treated routing as an instantaneous discharge point-function process instead of an average discharge incremental time procedure, avoiding some of the difficulties and errors in the traditional methods. **Tawatchai Tingsanchali and Shyam K. Manandhar (1985)** developed an analytical diffusion model for flood routing; the basic diffusion equation is linear zed about an average depth and takes into account backwater effect and lateral flows. **Francisco N. Correia, Filipe C. Rego, Maria DA Graça Saraiva and Isabel Ramos (1997)** Intergraph GIS is used as the basis for storing and overlaying information and for displaying results. Idrisi GIS, supported by a common PC, is used for running the hydrologic and the hydraulic models. **Bruno Molino, Michele Greco and John S. Rowan (2000)** applied a physically based two-dimensional model to the case-study site of Abbeystead Reservoir, U.K.

The model, developed for density currents, solves the Navier-Stokes equation coupled to a general sediment transport equation. **T. R. Neelakantan1 and N. V. Pundarikanthan (2000)** a back propagation neural network is trained in their work to approximate the simulation model developed for the Chennai city water supply problem. The neural network is used as a submodel in a Hooke and Jeeves nonlinear programming model to find ‘‘near optimal policies.’’ The results are further refined using the conventional simulation-optimization model. **Roger Moussa, and Claude Bocquillon (2001)** presented a computational method for the solution of the diffusive wave problem with lateral inflow, based on the fractional-step technique.

The Problem Definition

As the maximum expected inflow (**figure 1)** at Dongola station (750 km upstream AHD) is obviously greater than the outflow from Aswan High Dam added with the evaporation losses and seepage losses. This will lead to an increase in the volume of water stored in the reservoir upstream AHD and hence will cause the water level to rise over the designed level of the AHD.

This study aims to the development of bathymetric charts for AHDR, build a geographical database for the reservoir, model water losses, and to inspect any possible requirements to increase the capacity of Tushka spillway.

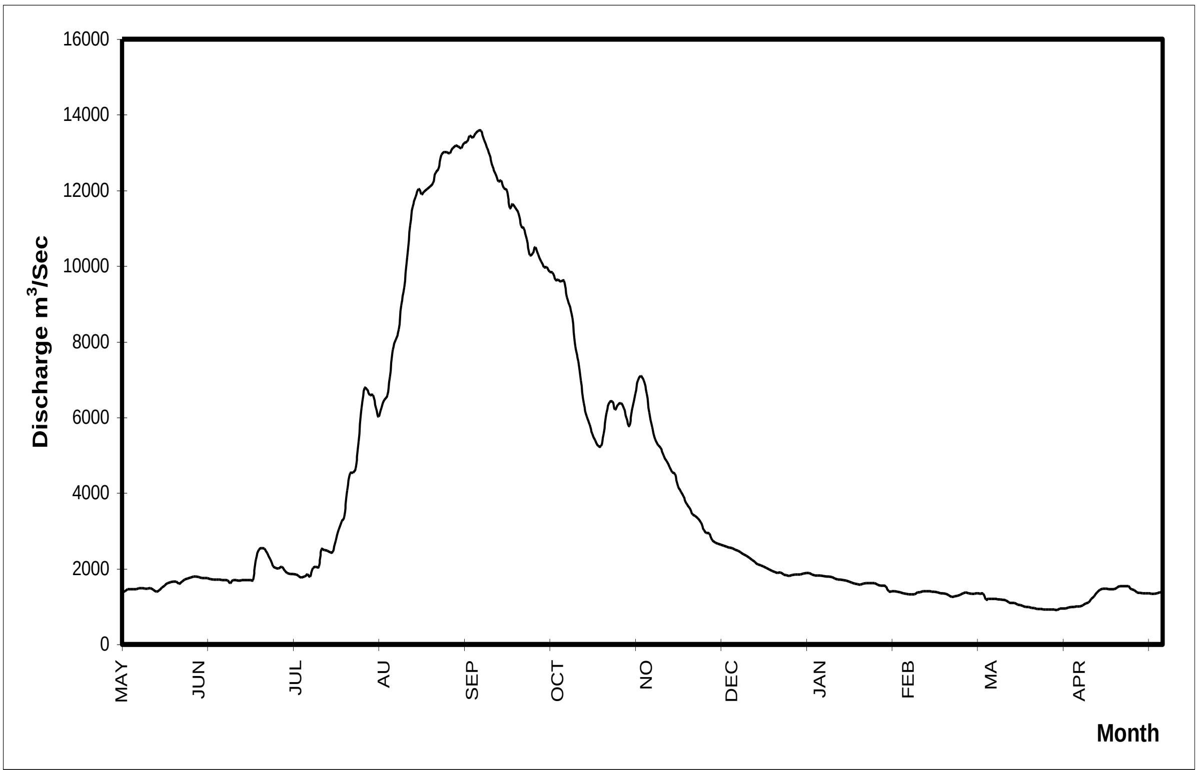

Figure 1: Maximum expected discharge at Dongola station

There have been several attempts to use combined simulation-optimization models to solve reservoirs operation problems efficiently. In many cases, complex simulation models are available, but direct incorporation of them into an optimization framework is computationally prohibitive.

The choice of a routing model is influenced by many factors, such as the required accuracy, the type and availability of data, the type of information desired (flow hydrographs, stages, velocities, etc.), and the familiarity and experience of the user with a given method. The modeler must take all of these factors into consideration when selecting an appropriate routing technique for a specific problem.

Methodology

Modeling a flood wave through out a huge reservoir with a sophisticated lay out such as the AHDR (**figure 2**) requires a finite element mesh of the bathymetry and the use of the finite difference form of the St. Venant equations in the routing process to obtain acceptable results.

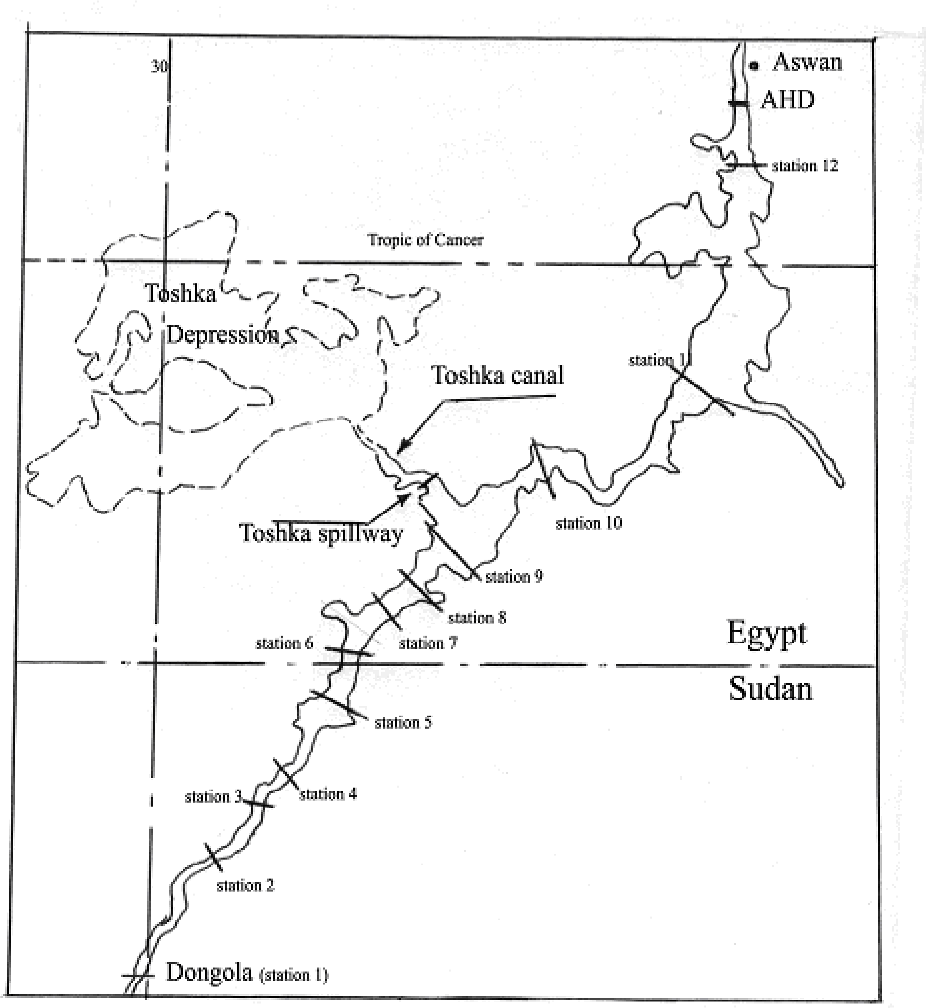

Figure 2: The Aswan High Dam Reservoir along with Toshka Depression

The system constraints are basically the dynamic conservation of mass within the 2D reservoir system, and the minimum and the maximum allowable limits for the water release and the reservoir level.

The cross sections profiles obtained from the Egyptian Hydraulic Research institute (HRI) and the AHDA **(figure 3)** were used along with the GPS coordinates of the sections head point in a Microsoft Excel spreadsheet to transform all the points into (E,N) coordinates with a known elevation Z.

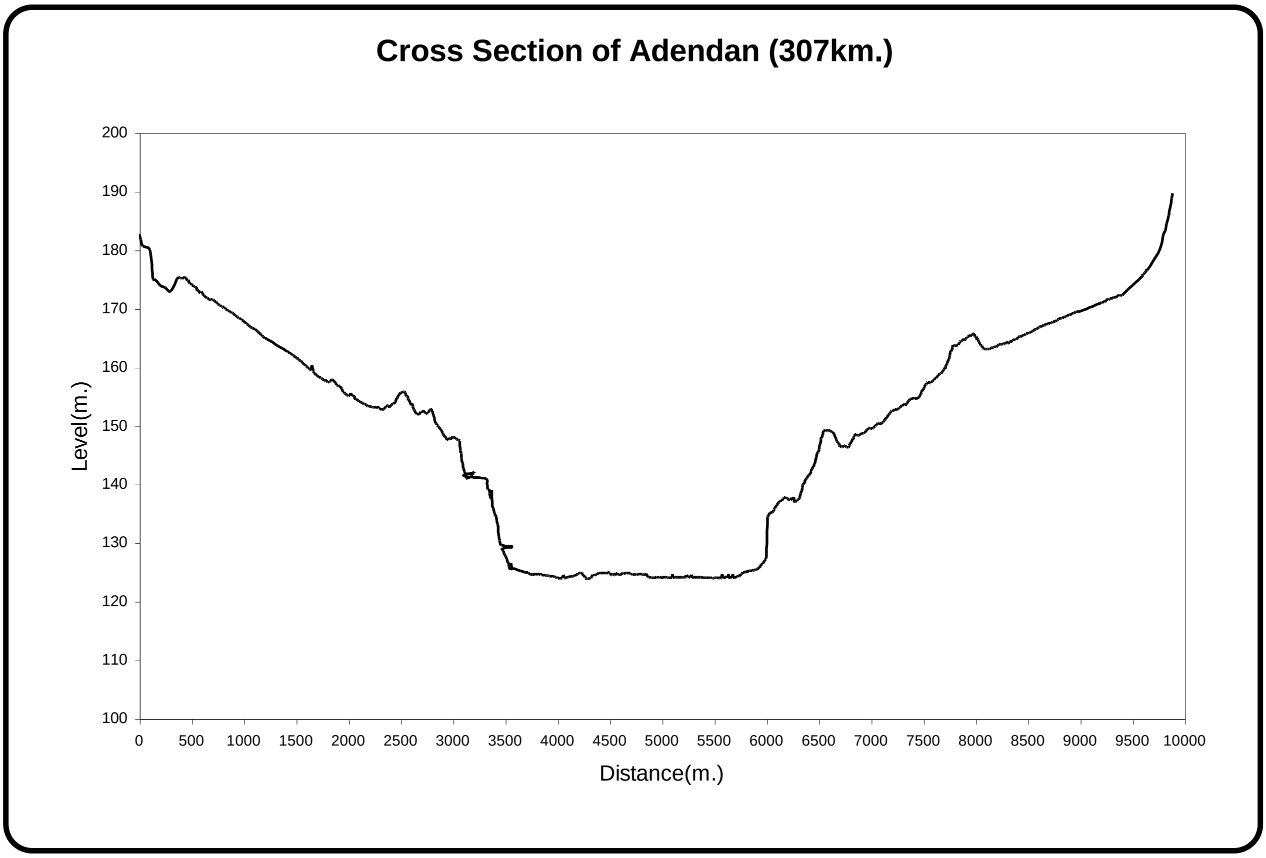

Figure 3: Cross section at Adenean (307 km US AHD)

The Geographic Information System (GIS) application has been recognised as a powerful mean to integrate and analyse data from various sources. In this work the (GIS) tool was used to form a scatter mesh of point with defined projected coordinate system, using the results of the Microsoft Excel spreadsheet (points with known E, N, Z).

The RMA2 surface water modeling system program was used to generate the finite element mesh of the bathymetry by means of interpolation using the cross sections profiles obtained from the Egyptian Hydraulic Research institute (HRI) and the AHDA.

The Longitudinal section of the reservoir **(figure 4)** was very useful to obtain a better result of the generated mesh.

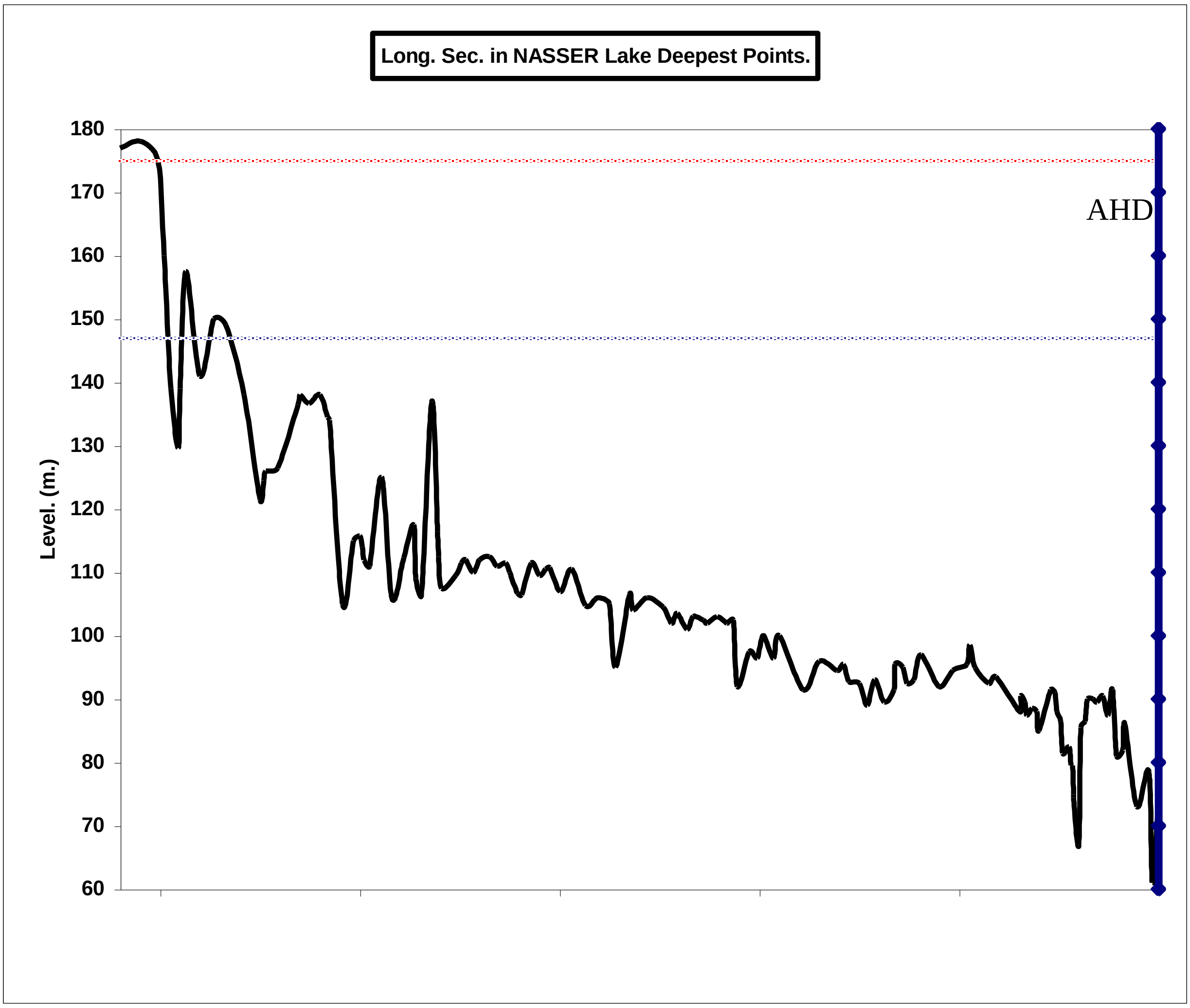

Figure 4: Longitudinal section of the AHD Reservoir

Discussion

In the beginning the flow reaching AHD is greater than the released from AHD. Yet, the water level is less than (178.00) m and hence no discharge is released over Toshka spillway but the water level is increasing in AHD reservoir.

By the end of September the water level will reach (178.00) m and the water begins discharging over Toshka spillway into the depression on the west side of the reservoir through Toshka canal.

By the end of October the water level in Aswan high dam reservoir will reach the level of (182.00) m. at this stage the discharge reaching AHD is more than the out flow of dam. Yet, there must be an increase in the current geometric dimensions of Toshka spillway to increase the discharge over it to keep the water level in AHD reservoir at (182.00) m **Ashraf M. El-Moustafa M.SC. (2002)**.

The Obtained bathymetry mesh is a powerful tool needed in the modeling of the AHD reservoir, so it will be used in further work for the purpose of flood routing to obtain a solution for the reservoir management and the operation plans of the dam.

References

Ashraf M. El-Moustafa, MSC (2002). “Impact of High Dam on Nile flood wave routing”.

Stanley S. Butler (1982). “Point Slope Approach for Reservoir Flood Routing”, Journal of the Hydraulics Division, Vol. 108, No. 10, October 1982, pp. 1102-1113.

Tawatchai Tingsanchali and Shyam K. Manandhar (1985). “Analytical Diffusion Model for Flood Routing”, Journal of Hydraulic Engineering, Vol. 111, No. 3, March 1985, pp. 435-454.

The American Society of Civil Engineers (ASCE). The Internet site at http:/www.asce.com/, the data base web page.