WORKSHOP

ON

RESERVOIR SEDIMENTATION ASSESSMENT USING REMOTE SENSING DATA

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Module 3

Hydrographic Survey of a Reservoir Using Differential Global Positioning System

BY

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Abstract

Sediment deposition is a continuous and complex problem drawing the attention of many hydraulic researchers. Sediments in a river originating from the land erosion process in the catchment area are propagated along with the river flow and are deposited in the reservoir, thereby reducing the storage capacity, increasing the backwater levels, forming shoals and affecting intakes of irrigation and power channels. Frequent hydrographic surveys and preventive measures are, there fore, necessary for the better management of the reservoirs. Hydrographic survey mainly involves with depth measurements at known positions and usage of the data to determine level versus spread area and level versus capacity of a reservoir. The contour map prepared by using the same data may help in identifying the zones of sediment deposition and in taking appropriate preventive measures.

Hydrographic survey of Gangapur Reservoir was conducted using Differential Global Positioning System (DGPS) for position fixing, Echo Sounder for depth measurement and a Personal Computer with commercially available Hydrographic survey software for survey planning, navigation, data collection and analysis. The technique and the instruments/ equipments required for conducting such a survey are described in this paper. Waterspread area and capacity as obtained from this survey are also presented.

Introduction

Sediments in a river which originates from the land erosion process in the catchment area, are propagated along with the river flow and are deposited in the reservoir. This has adverse effects such as reduction in storage capacity, increase in backwater levels, formation of shoals and thereby affecting intakes of irrigation and power channels. Therefore, realistic estimation of sediment deposition pattern in the reservoir is of utmost importance for estimating the storage volumes for planning and management of available storages.

Estimation of reservoir capacity by hydrographic survey is generally carried out when reservoir water level is at FRL. Basic observation practices for hydrographic survey are use of position fixing equipments and collection of depth data at the defined position. The collected data is then analyzed to obtain contour plot of the reservoir bed, cross sections and to evaluate quantum of water in the reservoir. The results can be compared with the earlier topography to obtain information about the sediment deposition at any cross section, total volume of sediment deposition and distribution of sediment across the reservoir.

In conventional hydrographic survey method, pillars are erected for survey guidance of the boat along a cross section line and usually a theodolite is used for position fixing and sounding lines/ranging rods are used for depth measurement. It is time consuming and laborious process. In the later years, the above equipments are replaced by PC compatible electronic equipment such as range-range positioning equipment and echosounder. Though this method enhanced the speed, it has its own limitations such as erecting several reference stations alongwith the shore line making the presurvey tedious. The use of DGPS based hyrographic survey system may help in over coming the above limitations/short comings and making the position fixing simple and accurate.

DGPS based survey system.

DGPS based hydrographic survey system comprises the following:

- Differential Global positioning system
- Echo sounder for depth data measurement
- Personal Computer with Hydrographic Survey Software data collection and processing.
- Motorized boat
- Supporting factor - UPS, ballerin, Walkie talkie, Safety equipments etc.

A typical equipment set up is shown in fig 1.

Global positioning system:

The Global positioning system consists of three segments

- The space segment consisting of satellites which broadcast signals.
- The control segment from where the entire system is monitored and steered.
- The user segment including many types of receiver.

The space segment provides global coverage with four to eight simultaneously observable satellites at any time of day. These satellites are configured, primarily, to provide the user with a capability of determining his position expressed by latitude, longitude and elevation. The satellite constellation is continously monitored and steered atleast once in a day by a control segment located on the earth. The user segment consists of GPS receiver which continously track signals from satellites in view. The position determination is based on measurements of time of arrival of coded train of pulses emitted simultaneously from 3 or 4 satellites whose positions are defined by satellite orbit message.

Differential operation of GPS:

For differential operation two GPS receivers are used. In this technique a continous tracking receiver (reference receiver) is installed at a known position and the mobile receiver is located on the survey boat. Atleast 4 common satellite are required to be tracked by both the receivers. Comparing computed ranges with measured preudoranges, the reference site can transmit corrections via VHF/UHF link to mobile receiver. The mobile receiver applies these correction in the computation and evaluates the position accurately. The position accuracy of 1m or even better on the local grid can be achieved with differential operation of GPS.

Echosounder

Echosounder is an electroacoustic instrument that determines the depth of water by measuring the time required for the burst of acoustic energy to travel from a transducer to stream bed and reflect back to the transducer. The travel time of the acoustic energy in the water is measure of water depth for a known average velocity of sound in the water column. Since the velocity of sound varies with temperature, density and salinity of the medium calibration of echosounder at various depths is essential in assuring the accuracy of depth measurement. Measurement of sound velocity in water can be performed using a calibration unit such as Digibar.

Personal Computer for data acquisition and processing:

A pentium PC with window based operating system is suitable for hydrographic survey work. The echosounder and GPS receiver, both installed on boat, can be connected to PC through serial ports. VGA splitter shall be used to provide additional monitor for Helmsman's display for the boatman.

Hydrographic Survey Software:

Hydrographic Survey Software consists of modules to support different survey activities such as

- Survey preparation
- Navigation
- Data Collection
- Data analysis
- Data presentation

Field survey of Gangapur Reservoir near Nasik

An earthen dam is constructed across river Godavari near Trimbakeswar in Nasik district of Maharashtra in 1965. The dam is 3.81 Km. long and 36.57 m high. A layout Plan was prepared to represent the survey area of 6000 m x 6000 m in a local coordinate system. A line spacing of 100 m was felt adequate to cover the entire reservoir. Totally 68 lines were planed for sampling. Reservoir contour plan was used for this purpose.

Head regulator chamber on the left bank canal system was found suitable for installation of a reference station which was at 4950 m N, 4510 m E with respect to local coordinate system.

In the boat, echosounder with transducer, mobile GPS receiver with antenna were installed and interfaced with personal computer. At the beginning of each survey session the Initialization file comprising line files, boundary files and device driver files was made active. I/O test was performed to get the device status. Navigation parameters such as event basis, cross track error limit, starting line number, and line increment etc. were entered. Boat is then moved to the beginning of the selected line as close to the bank as possible. The distance to the bank in the direction of path line was estimated and recorded in the log book.

After positioning the boat on line, the data logging was started. Boat driver was given guidance to position the boat on selected track with the help of Helmsman's display. The boat speed of 3-4 knots/hour was maintained. A transducer draft of 0.5 m was maintained through out the survey. The program automatically opens the data file with name composed of line number and time tag. The position and depth data along with time tag was continuously logged in the data file. The boat was moved to the end of line as close to the bank as possible and data logging was stopped. The end distance to the bank in the direction of path line was estimated and recorded in the log book. Pathline survey activities were also entered in the log book giving details such as file name, path line, starting and ending positions on the pathline, starting and ending time of the pathline and distances to banks. This data is, necessarily, be inserted in each line file through edit mode during analysis. Next line was selected and pathline procedure was repeated. The raw data files were stored in raw data directory.

The survey area of about 22 sq. km inclusive of about 68 line files was completed within 7 days period. The raw data files contain the depth, XY position, time tag and other survey related information. Data needs to be prepared for analysis by applying draft corrections, noise removal if any and end distance corrections. The raw data is the depth information collected at different locations in the reservoir below the water surface measured with respect to the diaphragm of the transducer. The depths are required to be converted to true ground elevation with respect to MSL. The reservoir water level data recorded in the logbook was used as reference and draft corrections were applied for the transducer submergence to convert depth data into bed elevation.

Multiple reflections of sonic wave may occur because of various reasons, such as underwater inhabitants crossing the sonic beam or reflections from suspended materials. This can be observed as overshoots, undershoots or spikes in the depth data collected along the survey line. These spurious data in the time series were removed by applying smoothing techniques provided in the edit module of the software.

A digibar was used to determine velocities at various depths and the average of observed velocities was used for sounding the reservoir bottom. As there was negligible change in the sonic velocities observed over the entire depth, the average value was considered. However the software provides the facility to apply velocity corrections either during survey or during post processing.

The shallow regions of the reservoir could not be surveyed with the system, as it was not possible to maneouvre the boat in these regions. The bank distances recorded in the logbook were used for linear interpolation of the intermediate data between the end point bed elevation on the survey line and the water level elevation recorded for the corresponding day.

The edited data files were stored in edit directory which were used for analysis. The edited data was used to obtain cross sections along the survey lines, to generate surface model of the reservoir bed, to generate 2D/3D contour plots of the reservoir bed and to evaluate volumes below different levels in the reservoir using Triangular Irregular Network (TIN) model.

The water spread area and the storage capacity estimates for each contour level were computed using the TIN model starting from the deepest contour level incrementing the contour level by 1 metre. Volume can also be evaluated using prismoidal method, end area method etc. available with the software package, but TIN modeling is considered to be more accurate.

The water level vs water spread area and water level vs storage capacity of Gangapur reservoir were evaluated and presented in fig.2 and fig.3 respectively. The water spread area and storage capacity st FRL and at MDDL are also shown in the figures.

Conclusions

The DGPS based hydrographic survey system provides an easy and elegant way to estimate the storage capacity of the reservoir. At Gangapur, the entire reservoir of about 22 sq. Km could be surveyed with in a week's time. This method is accurate, fast and most convenient wherein the line of sight and communication difficulties make the conventional method very cumbersome. The DGPS based survey is expensive to start with, but in the long run the cost factor becomes immaterial considering the fact that hydrographic survey is required to be carried out quite often.

Acknowledgements

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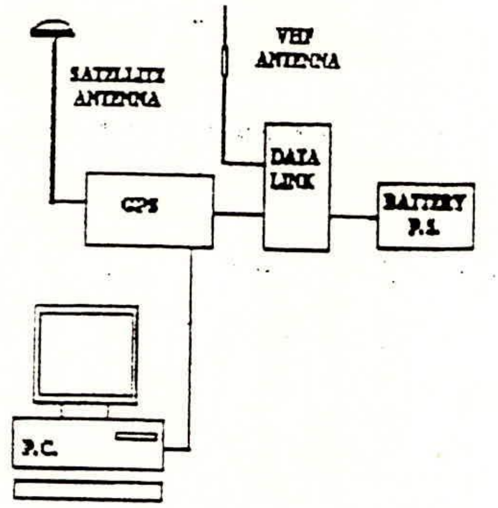
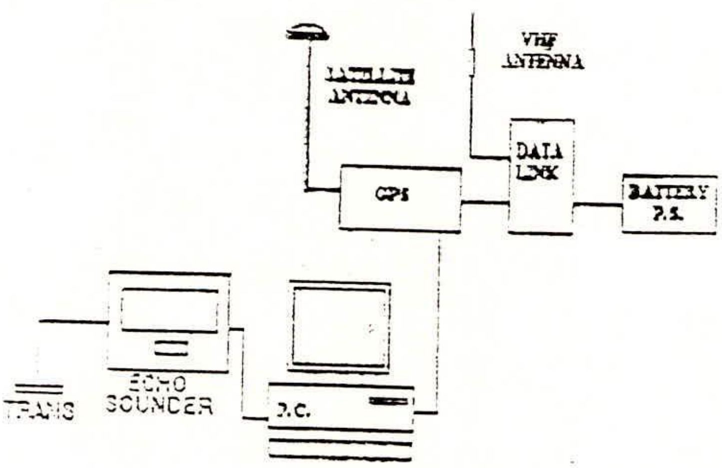


INSTRUMENT SETUP AT REFERENCE STATION



INSTRUMENT SETUP AT MOBILE STATION

Fig. 1 GPS BASED HYDROGRAPHIC SURVEY SYSTEM

Reservoir Level Vs Water Spread Area Curve

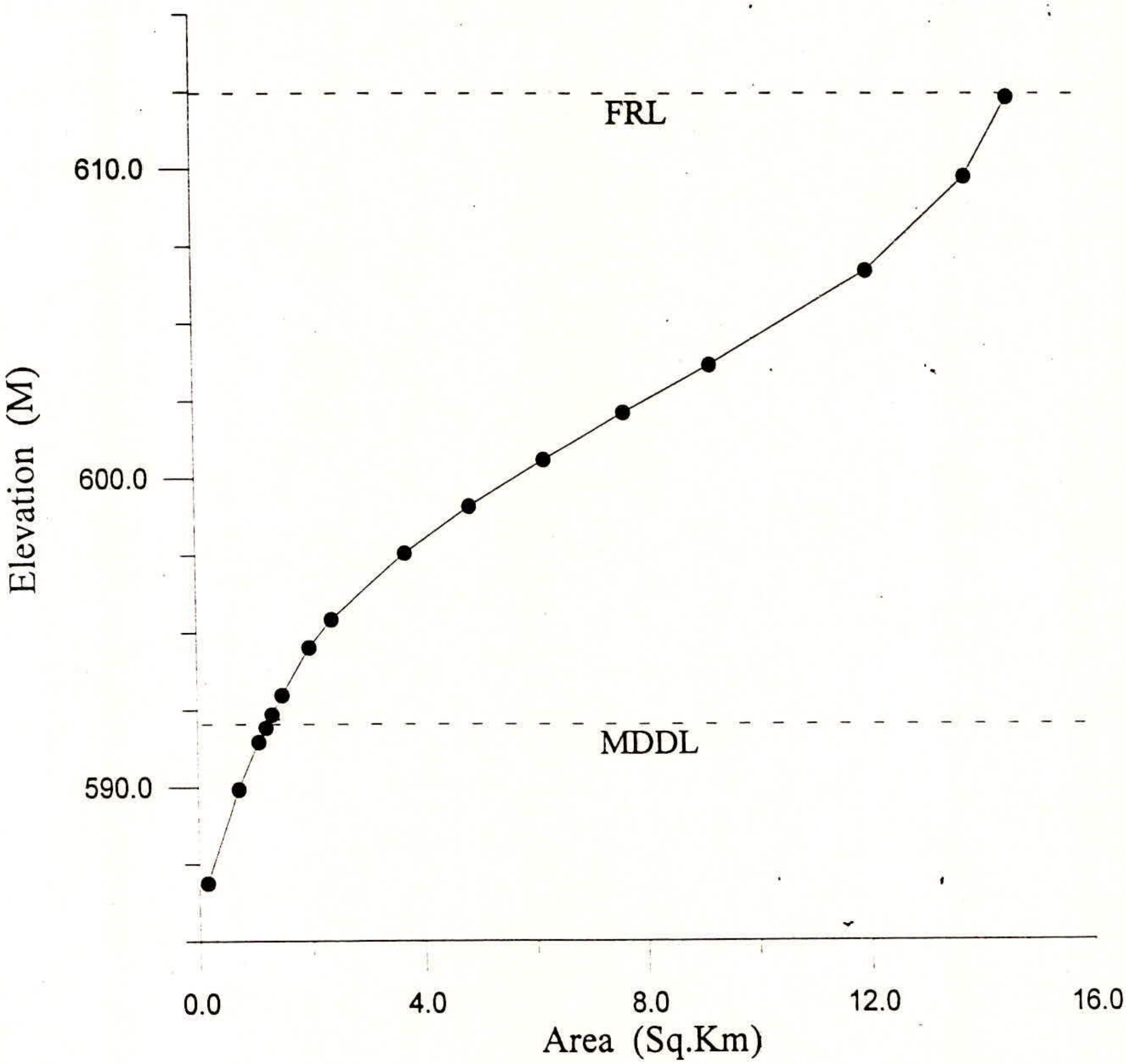


Figure 2

Reservoir Level Vs Storage Capacity Curve

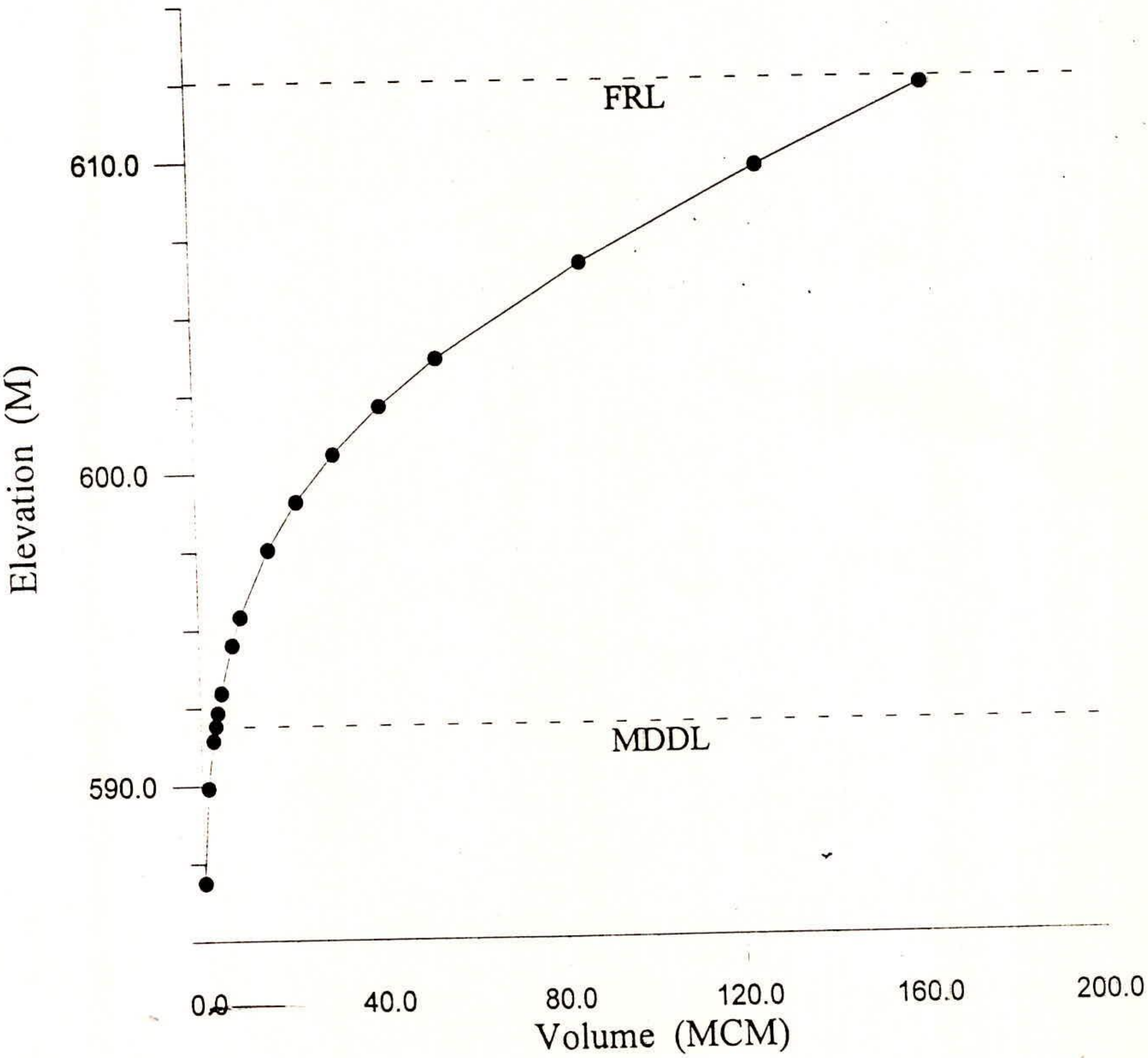


Figure 3