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DGPS & GIS Technique for Reservoir Capacity Assessment: A Case Study of Bindusara Reservoir, Tal / Dist – Beed, Maharashtra, India.

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ABSTRACT

One of the essential inputs required for effective water planning of reservoir is assessment of its present storage capacity. It is therefore essential for the irrigation manager to know the quantum of water available in the live storage zone. The capacity assessment surveys provide information about shrinkage in water spread at different levels which is useful to estimate the actual water spreads. The water-spread area of the reservoir reduces with the sedimentation at different levels. The water-spread area and the elevation information are used to calculate the volume of water stored between different levels. These capacity values are then compared with the previously calculated capacity values to find out change in capacity between different levels. The DGPS based technique combination with the GIS technology can be very useful for reservoir capacity assessment study. The application of DGPS surveying are becoming more significant, cost effective and can provide more reliable positioning relatively quickly compared with traditional methods. This paper presents the field DGPS survey technique with integration of Arc-GIS technology for capacity assessment of Bindusara medium project in Beed District of Maharashtra. DGPS with L1 and L2 frequency were used to predict unknown elevation. The generated database helps to prepare the revised contour map of the submergence area of the project.

Keywords : DGPS, GIS, Survey, Submergence area, Elevation, Frequency, Hydrographic.

I. INTRODUCTION

The capacity of reservoir is gradually reducing due to silting hence sedimentation of reservoir is important to all the water resources development agencies. Silting encroaches in dead as well as live capacity of the reservoirs. This reduction in capacity of the reservoir has long and short term impact on the functioning of the project. Sedimentation adversely affect irrigation planning, drinking water supply, power generation etc. Correct assessment of sedimentation rate is essential for estimating useful life of reservoir and preparing reservoir operation schedule. The capacity assessment survey also provides the information about shrinkage in water spread at different levels. The water spread area reduces with the sedimentation at different levels. The water spread area and elevation information are used to calculate the volume of water stored between different levels. These capacity values are compared with the original capacity values to find out the change in capacity due to sedimentation at different levels. Impact of sedimentation is more significant on multipurpose reservoir. In some of the reservoirs rate of sedimentation is higher than what was

considered at the planning stage. Therefore it becomes necessary to conduct the sedimentation study of reservoirs at regular interval. This will make data available for deriving siltation indices of different regions and river basins on the basis of which further design of reservoirs can be planned. These surveys also helps in selection of appropriate measures for controlling sedimentation, efficient management and operation of reservoirs.

The Sedimentation surveys has been carried out by different techniques viz DGPS based Hydrographic survey, DGPS based ground survey and Satellite based Remote sensing survey etc. Now a days GPS has become a standard surveying technique. The Differential GPS (DGPS) technique allows the user to get the unknown levels more precisely by eliminating the errors. The GPS positioning is dependent on the GPS receiver collecting and processing usable signals from a minimum four GPS satellites. In this technique two GPS units are operated sub sequentially. One is stationary called as base unit and other is moving called as rover unit. The base unit is required to collect position data at a known firm location. Simultaneously the rover unit moves around the field for collecting field positions. The base receiver measures the timing error and provide the correct information to the rover receiver. The base receiver receives the same satellite signals as the rover receiver. The data collected from base receiver and positions collected from rover receiver are allow for post processing for eliminating errors and obtaining more precise readings. With this technique Resource Engineering Centre of Water Resources Department, Government of Maharashtra has carried out research in the field DGPS based ground survey. By the application of GPS and GIS technique the spatial and non spatial features can be accurately mapped in lesser time. The three dimensional survey in any weather condition can be done. With the GIS software geo referencing of non spatial information helps the authorities to develop the necessary statistics and analysis. The survey based on this technique are faster, economical and more reliable as compared with other methods.

The present paper describes the field DGPS survey method and GIS technique for reservoir capacity assessment.

II. STUDY AREA

The Bindusara reservoir lies at latitude 18^0 45' 45" north and longitude 75^0 44' 30" east. The reservoir was constructed on Bindusara river near village Palli in Taluka and District Beed. The dam serves the drinking water supply of Beed city. The dam was completed in 1955. Total catchment area of the reservoir is 188.42 sq.km. The designed gross storage capacity at FRL is 13.125 Mm^3 and live storage capacity between FRL and MDDL is 9.705 Mm^3. The FRL and MDDL of the reservoir are 565.85m and 559.76m respectively.

III. METHODOLOGY

In the DGPS technique firstly the site visit was done and the location for base station was finalised. Then the field survey by DGPS equipment was done the submergence area. After that the raw data collected by Base and Rover units are corrected by using post processing technique. After that the post processed data is used for crating drawing in TBC and ARC-GIS software. The calculations are done for area and volume measurements of the software generated contours and finally the results are tabulated. The detailed methodological flow chart of this research work is shown in fig1. Various steps of the investigation are also given below.

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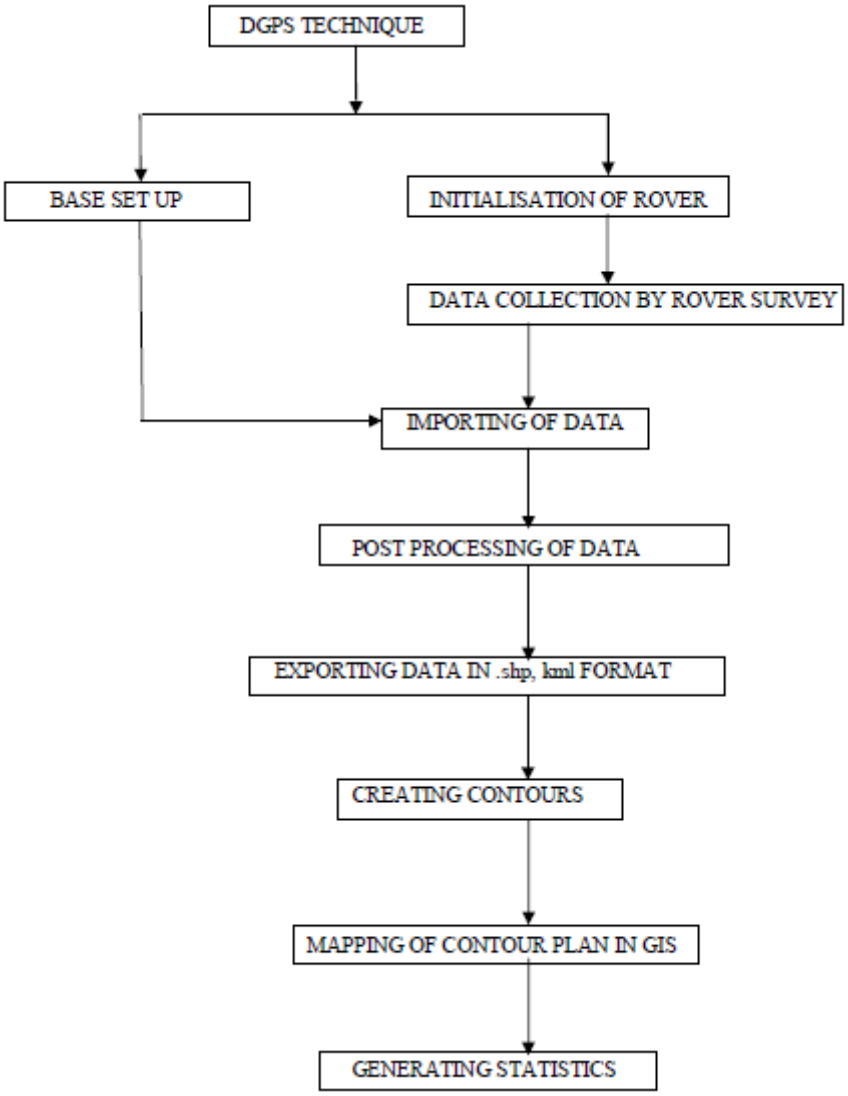

Fig 1. Flow chart of the methodology adopted

3.1 DGPS Survey

The DGPS survey was conducted with Trimble R-4 instrument. The base station was set up on firm ground near waste weir to collect the position data as shown in fig.2. After initialisation of Rover unit submergence survey was done. The data from nalls, roads, submergence, hills various dam points etc were recorded as shown in fig3. The collected data were stored in base and rover unit. The collected data was imported in Trimble Business Centre (TBC) version 2.7 software for post processing as shown in fig.4. Firstly the base position was corrected for satellite signal error with respect to final orbit data as shown in fig.5. Then the rover data were corrected relatively with the base data and the point level data with filed information is prepared as shown in table 1.

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Fig 2. Base set up

Fig 3. Initialisation of Rover

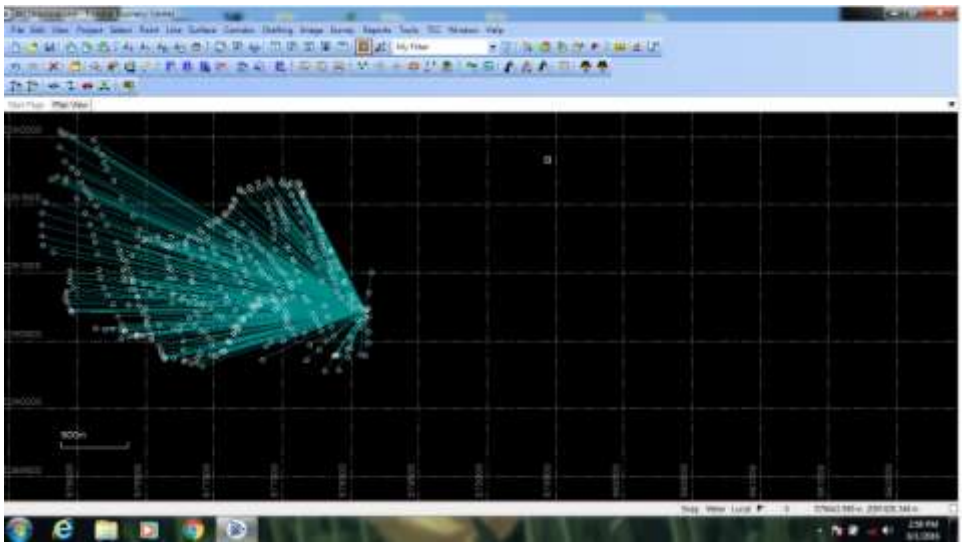

Fig 4. Importing of Base and Rover data

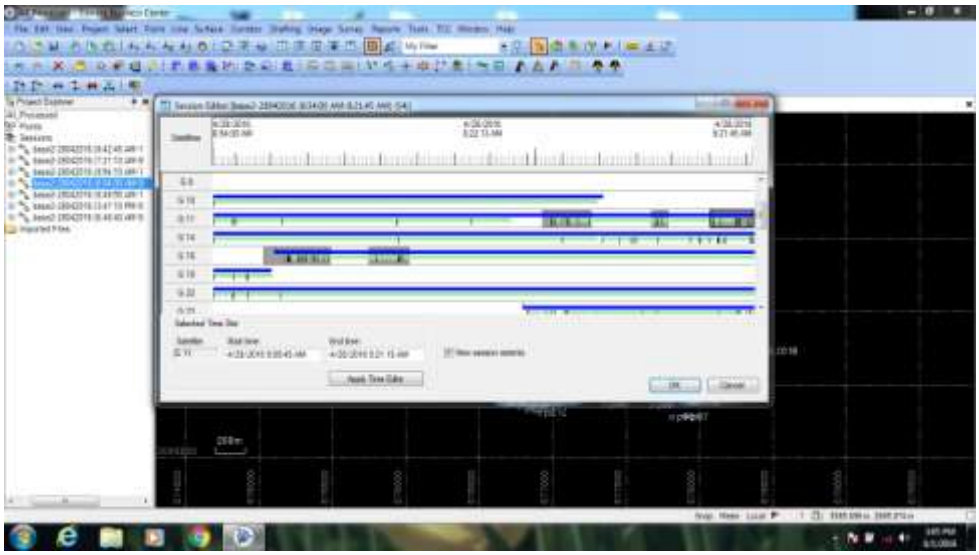

Fig 5 Signal correction

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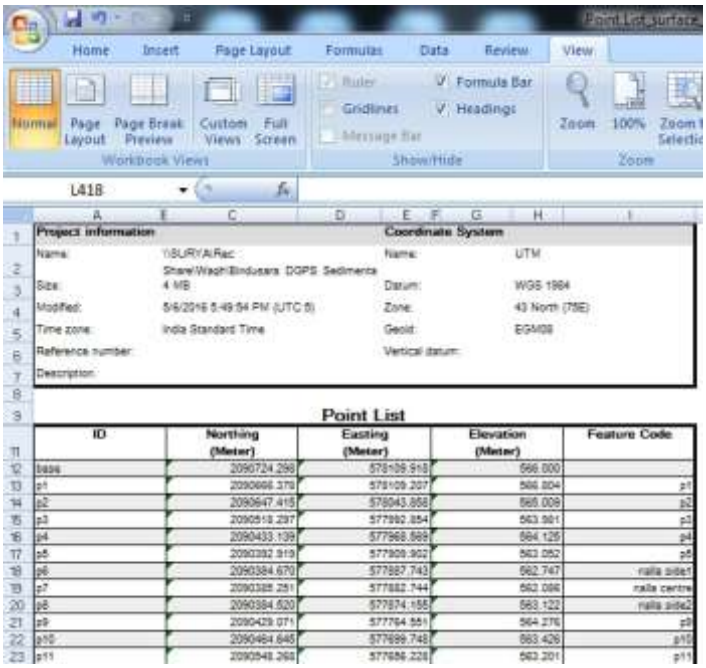
Table 1 Processed point data



Project information

Name:	\\SURYA\Rac Share\Wash\Bindusara DGPS Sediments
Size:	4 MB
Modified:	5/6/2016 5:49:54 PM (UTC 5)
Time zone:	India Standard Time
Reference number:	
Description:	

Coordinate System

Name:	UTM
Datum:	WGS 1984
Zone:	43 North (75E)
Geoid:	EGM08
Vertical datum:	

Point List

ID	Northing (Meter)	Easting (Meter)	Elevation (Meter)	Feature Code
base	2090724.298	578109.918	566.000	
p1	2090666.379	578109.207	566.004	p1
p2	2090647.415	578043.858	565.009	p2
p3	2090518.287	577992.854	563.561	p3
p4	2090433.139	577968.869	564.125	p4
p5	2090392.919	577909.902	563.052	p5
p6	2090384.670	577887.743	562.747	nalla side1
p7	2090388.251	577882.744	562.086	nalla centre
p8	2090384.520	577874.155	563.122	nalla side2
p9	2090429.071	577764.551	564.276	p9
p10	2090484.645	577699.748	563.426	p10
p11	2090548.268	577656.228	562.201	p11

3.2 Georeferencing of the Data

The well distributed control points were used for geo-referencing of the collected points during field survey. In this process co-ordinate system used was WGS-84 and map projection was UTM. The area comes under UTM 43 North. The geoid model used was EGM 2008.

3.3 Contouring in TBC

Post processed data was imported in TBC software. By using surface creation tool surface was created and then contour of the surface was drawn at 1m interval as as shown in fig 6. Then the map was exported in kml for area and volume calculation in ARC-GIS.

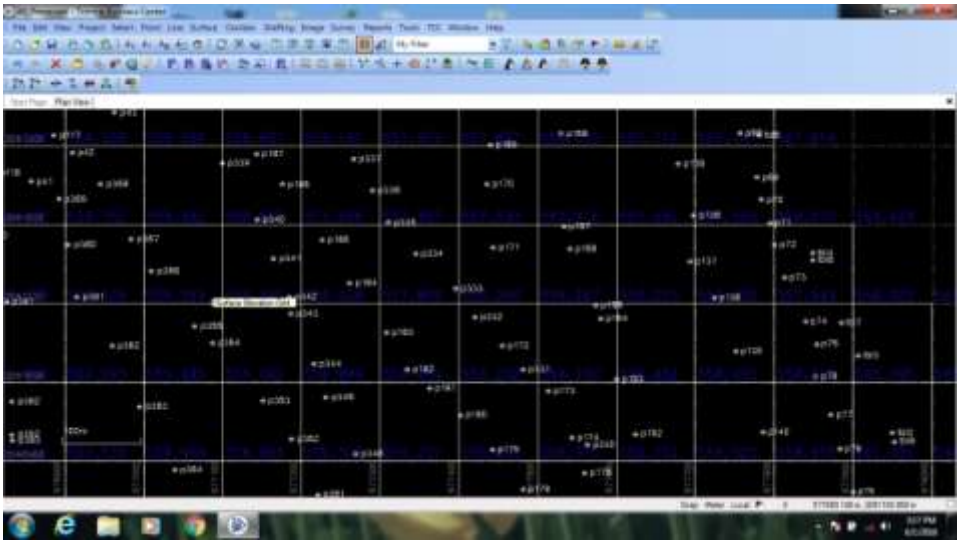


Fig 6. Creating contour in TBC software at 1m interval.

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3.4 Mapping in GIS

In ARC-CATALOG firstly Geodatabase is created for the said project. In the Geodatabase the feature data sets are created as per the project requirements. WGS – 84 and UTM – 43 North projections are given to the feature data sets. In the feature data sets the feature classes e.g contours, dam line, waste weir etc are created. Then the contour map in kml setup was imported in Arc-GIS 9.3 version. Final contour map of the submergence area was prepared by using editor and trace tool in ARC-MAP as shown in 6. The area of each contour was measured in GIS. Then this measured area is compared with the original survey (design) area as shown in table 2. The capacity between successive contours was calculated by prismoidal formula and compared with the original capacity as shown in table 3. Table 4 shows the siltation rate in gross storage, live storage and dead storage of the Bindusara reservoir.

IV. RESULT AND DISCUSSION

Table 2 : Comparison of Water Spread Areas of Reservoir (Mm^2)

Elevation (m)	Original Survey 1955 (Mm^2)	DGPS Survey 2016 (Mm^2)
565.85 FRL	2.42	1.752
565.00	2.13	1.554
564.00	1.89	1.412
563.00	1.64	1.229
562.00	1.41	1.062
561.00	1.20	0.914
560.00	1.01	0.606
559.76 SILL LEVEL	0.87	0.554

Table 3 : Comparison of Capacities of Reservoir (Mm^3)

Elevation (m)	Original Survey 1955 (Mm3)	DGPS Survey 2016 (Mm^3)
565.85 FRL	13.13	7.975
565.00	11.49	6.571
564.00	9.48	5.088
563.00	7.72	3.769
562.00	6.20	2.624
561.00	4.89	1.637
560.00	3.79	0.882
559.76 SILL LEVEL	3.09	0.743

Table : 4 Siltation in rate in Gross Storage, Live Storage and Dead Storage.

Sr.No	Particulars	Gross Storage	Live Storage	Dead Storage
1	Design Capacity in (Mcum) as per year 1955	13.125	9.705	3.420
2	Present Capacity as observed in (Mcum) as per year 2016	7.975	7.232	0.743
3	Loss in Capacity in (Mcum) during a span of (2016-1955) 61 years	5.150	2.473	2.677
4	Loss in Capacity in (Mcum) per year	0.0844	0.0405	0.0438
5	Catchment area of Bindusara Reservoir in sq.km	188.42		
6	Rate of siltation in Ha-m/100 sq.km/year	4.48	2.151	2.329
7	Percent loss in capacity per year	0.643	0.417	1.283

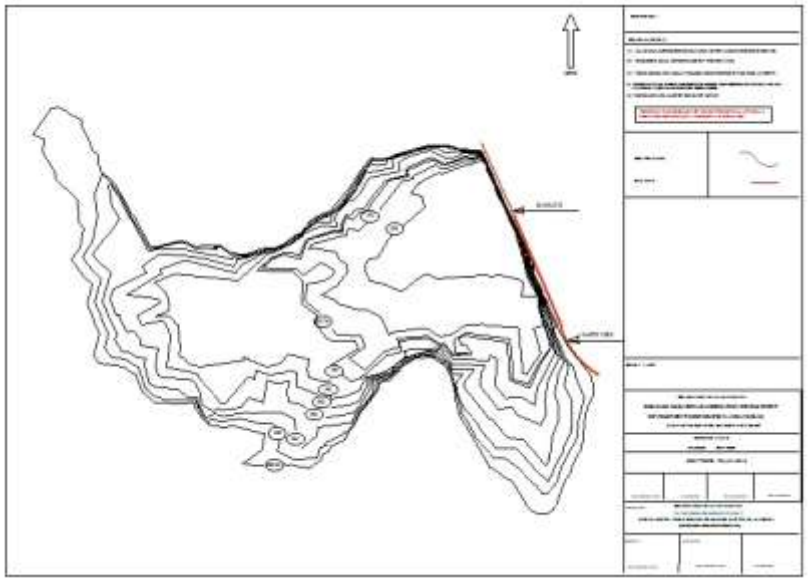

Fig 7 Contour map of the project

V. CONCLUSION

1. The observed rate of siltation for the period 1955 to 2016 is 4.48 Ha-m/ 100 sq.km/ year against design siltation rate of 3.02 Ha-m/ 100 sq.km/ year.
2. The total silt accumulated during the period of 61 years (1955 to 2016) is 5.150 Mcum which is 39.23% of gross storage. The average annual percentage loss in gross capacity due to siltation is 0.643%. The general range of average annual percentage loss in gross storage for the reservoirs surveyed by MERI is 0.17 to 0.88%.
3. The present live storage works out to 7.232 Mcum. Reduction in live storage during the span of 61 years (1955 to 2016) is 2.473 Mcum which is 25.48% of live storage. The average annual percentage loss in live storage due to siltation is 0.417%. The general range of average annual percentage loss in live storage for the reservoirs surveyed by MERI is 0.10 to 0.47%.

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