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Water Reservoir Area and Volume Determination Using Geoinformation Technologies and Remote Sensing

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Abstract: ***This article presents the method for calculating the area and volume of the water reservoir using Remote Sensing and Geoinformation Technologies. All calculations were performed for the Tashtepa water reservoir which recommended for construction in the Tashkent region. The territory of Tashtepa water reservoir was explored using the Google Earth program, was identified the alignment for the construction of dams, and the file was saved as a KML (Keyhole Markup Language) format. The alignment and the digital elevation model of the reservoir area from the online database were uploaded to the Global Mapper program which one of the geographic information system programs. Contours were formed in the digital elevation model, there was defined the longitudinal profile of the alignment along dams, surface and volume of the water reservoir were obtained for each circuit and based on the results were obtained curve lines between contour and area F=f(H), contour and volume W=f(H).***

Keywords**:** ***Tashtepa water reservoir, geographic information systems, remote sensing, Google Earth, Global Mapper v11.01, digital elevation model, contour, a transverse profile of line of the dam, area of the reservoir, the volume of reservoir.***

I. INTRODUCTION

At the time of advanced hydrotechnical construction development in market economy conditions, it is important to obtain accurate information on geographical location of a certain site in a short time. Geoinformation System (GIS) originated in the 60s of the last century is becoming the integral part in many spheres of economy [1, 2, 3].GIS are software products, operated with specialists-analytics, containing of collection, operation, analysis, modeling and imaging spatial geographical data, originated from connection of mathematics, informatics and geography, which are intended for creating, visualization and analysis of data, located on the Earth surface, for which gridding and interaction with spatial objects is important [4,5,6].Remote Sensing (RS) is the observation of the Earth surface via land, aviation and space means, equipped with various types of camera gear. Wave lengths, accepted by camera

equipment, range from fractions of micrometer (visible optical radiation) to meters (radio waves). RS methods can be passive, i.e. use natural refraction or secondary heat radiation from the objects on the Earth surface, caused by solar activity, and active, which use forced radiation from objects, initiated by artificial source of directional operation [7, 8].Digital model of the relief is the digital image of Earth elevation with respect to any coordinate system, the simplest form and digital characteristics of topographical surface, it can be used in determining detentions and uplands at any point of earth, creating 3D models of the earth surface, obtaining hydrological and geological analysis, surveying natural resources, managing agriculture [9, 10, 11, 12].

It is hard to imagine the effective operation of GIS without satellite research methods of our planet's regions. RS is based on the collection of information about the earth surface without practically contacting it; obtained data about the energy refracted from objects can be subsequently processed, analyzed and used in practice. Nowadays around the world GIS and RS is widely used in the sphere of water resource management and water use, including in obtaining hydrological, morphological and hydro meteorological data from world ocean, seas, lakes, rivers, water reservoirs and other water bodies in short period of time. Remote sensing can be used in determining a potential location for water reservoir construction, estimate its volume, modeling groundwater, determine possible erosion zones, mudflood risk and mudflood stable areas and etc. [13, 14, 15].

Global Mapper is one of GIS programs by innovational cartography software company Blue Marble Geographics. It is becoming popular among other GIS programs for its options to read more than 200 types of files and capability to enter global database, as well as for its simplicity and eligible program interface. Global Mapper has options for processing, editing, reprocessing and publishing topographical maps in 2D and 3D formats, including on the basis of raster images from satellites, digital relief models, vector data, obtained in GIS, as well as for its options for developing contours and site profiles, designing fill-in and cut-in volumes, and for capability to download GPS directly [16, 17].

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II. METHODS

The research is conducted in Toshtepa water reservoir territory planned to build to improve water provision for Tashkent region.

In terms of Google Earth online software capabilities observations were held in the territory of Toshtepa water reservoir. Site topography was studied, optimal site was chosen for construction and dam location section was set using command Add Path. The dam location section was saved in KML format (Fig. 1).

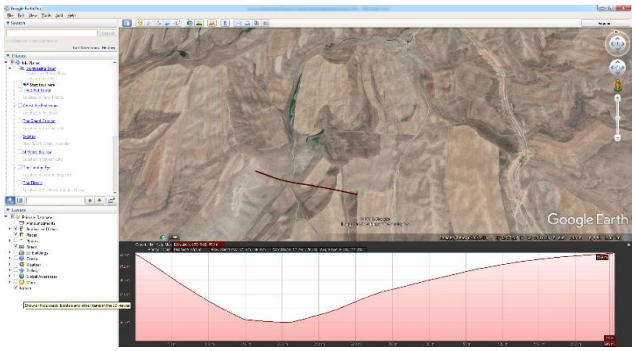

Fig. 1. Dam location section (Google Earth)

The dam location section (KML file) is loaded into the Global Mapper program, and using the command the Connect To Online Data command is downloaded Digital Model (SRTM) from the online database Shuttle radar topographic mission. (Fig. 2)

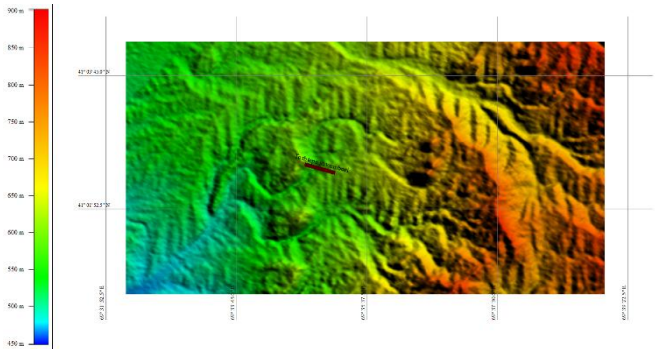

Fig. 2. Digital model of Toshtepa water reservoir territory relief. (Global Mapper)

In order to evaluate reservoir water surface area and volume Generate Contours command was used to generate contours for each meter rise. Surface area is generated for a specified elevation to determine reservoir surface area and volume. Toshtepa water reservoir maximal contour is 600. Edit Line Feature command is used to separate it from contours and generate a new contour. Surface area is generated from this contour and dam location section using Create New Area Features command from Selected Lines option (Fig. 3).

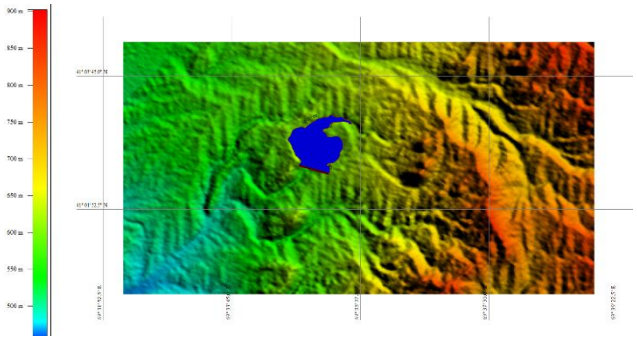

Fig. 3.Reservoir water surface area generated at contour 600

Dam location section (KML file) is saved in Global Mapper program and the site relief digital model obtained using Shuttle Radar Topography Mission (SRTM) is downloaded from online database (Fig. 2).

Using water reservoir digital model, along with determining reservoir total water surface area and its volume, water areas and volumes for each contour was analyzed, sections to be closed with dams for maximal water storage were determined and cross sections were developed.

Having built dam location site cross section with 3D Path Profile command dam location section data such as dam length, mean height can be obtained from Show Path Details option in Option menu (Fig. 4).

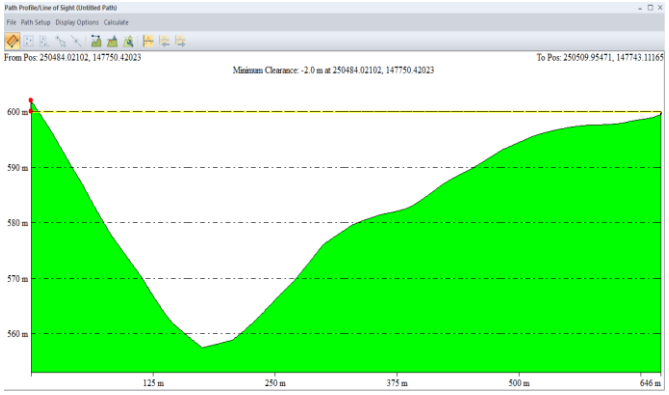

Fig. 4.The longitudinal profile along the bottom of the dam

III. RESULTS

After the area is generated for contour 600 Measure Volume (Cut-and-Fill) command is used to determine reservoir water surface area and volume for each contour. In Volume window we enter (598) in empty cell 1, of Use Same Base Height Value for All Vertices, choose Meters in cell 2, Above Sea Level in cell 3 and press OK. Volumetric Calculations window appear on screen, where we determine the generated contour 598 line (Fill Area, 0.924 km^2) and water reservoir volume (Fill Volume, 12337510 m^3) at 597 m above sea level. We analyse reservoir water surface area and volume for each meter elevation. The area and volume is determined for each contour (contours 557-598). These areas and volumes are inserted in MS Excel table (Table-I).

Table-I. Areas and volumes by contours for Toshtepa water reservoir

Contour (H) *(sea level) m*	Area (F) *km²*	Volume (W) *bln. m³*
557	0	0
558	0.000781	0.026812
559	0.002342	0.196205
560	0.00361	0.004976
561	0.00517	0.00944
562	0.00751	0.015704
563	0.01186	0.024869
564	0.01864	0.040176
565	0.02439	0.061607
566	0.02956	0.088609
567	0.0363	0.121277
568	0.0464	0.162596
569	0.0571	0.214208
570	0.0705	0.277781
571	0.0853	0.355802
572	0.1016	0.448726
573	0.1174	0.557915
574	0.1417	0.686713
575	0.1646	0.839868
576	0.185	1.014471
577	0.2049	1.209328
578	0.2267	1.424556
579	0.2536	1.665705
580	0.2845	1.935255
581	0.3146	2.234517
582	0.3437	2.56385
583	0.3742	2.922652
584	0.4057	3.312621
585	0.4347	3.732789
586	0.4666	4.183078
587	0.4993	4.665791
588	0.528	5.179462
589	0.563	5.724822
590	0.596	6.3034
591	0.634	6.918127
592	0.675	7.572868
593	0.713	8.267095
594	0.753	9.000304
595	0.793	9.773073
596	0.832	10.585
597	0.875	11.43874
598	0.924	12.33751

Based on the results obtained, contour and area F=f (H), contour and volume W=f (H) curves were developed (Fig. 5 and 6).

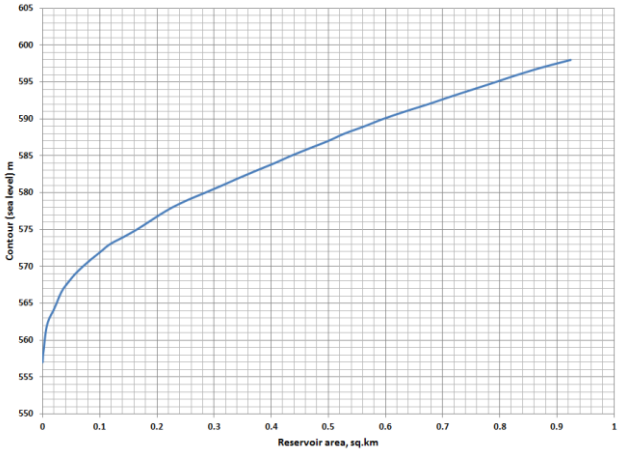

Fig. 5.Contour vs area curve line

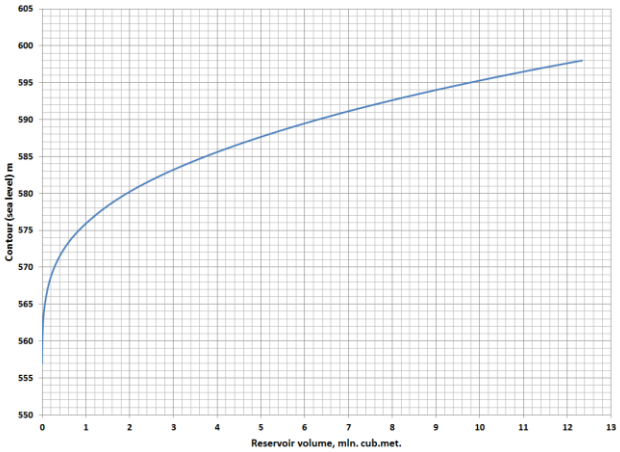

Fig. 6.Contour vs volume curve

IV. DISCUSSION

GIS and RS is being used widely in managing and using water resources around the world, as well as in obtaining hydrological, morphological and hydrometeorological data on the world ocean, seas, lakes, rivers, water reservoirs and other water bodies remotely and in short period of time.

Blue Marble Geographics innovation cartography Software Company's Global Mapper is one of the GIS software programs. It has many capabilities such as getting into global database, opportunity to download over 300 shape files like ESRI, KML, LiDAR, MrSID, SRTM, obtain necessary data from global database and determine distance and area from these data, measure depths and height, develop contours and cross section profiles of the area, measure volumes (fill-in and cut-in), develop formation of basin channels, see simulation of water level change in the area, use Lidar Module functions, export data in more format types than other GIS software programs and others.

Within this researh the software options were used to determine water surface area and volume of Toshtepa water reservoir and to analyse areas and volumes by contours, to develop dam location site profile.

The research work will be useful to study the site relief, measure depths and heights, determine distances and areas, water detention capability, set dam location site and develop its profile, determine water reservoir surface areas and volumes by contours within short period of time.

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