GEOSERVICES MARITIME PVT. LTD.

REPORT ON TOPOGRAPHIC & BATHYMETRIC SURVEY FOR ASSESSMENT OF RESERVOIR CAPACITY & SEDIMENTATION IN MESHWO RESERVOIR, GUJARAT, INDIA UNDER NATIONAL HYDROLOGY PROJECT

GMPL REPORT NUMBER: P - SUR-BATHY-009-2020-21-WRD-MESHWO
SURVEY PERIOD: Bathymetry: 28 JAN TO 02 FEB 2021
Topography: 31 JAN TO 09 FEB 2021

Prepared for:	**Water Resources Investigation Division, Ahmedabad** **(Govt. Of Gujarat)**	Equity Efficiency Sustainability WRD
Client Reference:	**Executive Engineer** **Water resources investigation Division Ahmedabad.**	

LOCATION MAP

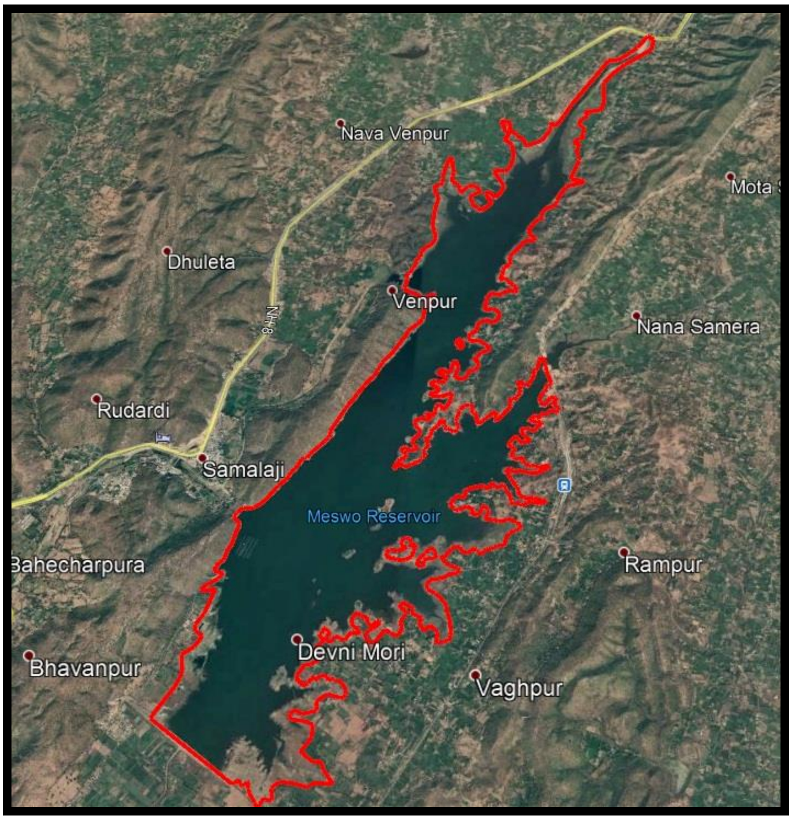


Figure 1.1-1 LOCATION MAP

LOCATION MAP SHOWING SURVEY AREA “MESHWO RESERVOIR”, GUJARAT, INDIA

DOCUMENT ARRANGEMENT

REPORT OF SURVEY WITH CHART / DRAWING

CONTENTS

TABLES

FIGURES

1 INTRODUCTION, OBJECTIVE & SCOPE OF WORK

1.1 General

Water Resources Investigation Division (WRD) has awarded the contract to Geoservices Maritime Pvt Ltd (GMPL), Navi Mumbai for carrying out Topographic and Bathymetric Survey at Meshwo Reservoir, Gujarat. The survey services provided by GMPL comprise of the provision of well-qualified survey personnel and equipment in order to obtain, interpret and report on acquired topographic & bathymetric survey data at the client specified locations.

This report contains the results of survey as against the scope of work and the methodology adopted to achieve the specifications and schedule of the survey work undertaken at Meshwo Reservoir.

1.1.1 LIST OF ABBREVIATIONS USED

CM	Central Meridian
DGPS	Differential Global Positioning System
CSRS	Canadian Spatial Reference System
FRL	Full Reservoir Level
GMPL	Geoservices Maritime Private Limited
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
KHz	Kilohertz
HSE	Health Safety Environment
MSL	Mean Sea Level
m	metre
M Cu. m	Million Cubic metre
Sq. Km	Square Kilometre
MDDL	Minimum Draw Down Level
m/s	meter per second
ms	milliseconds
MWL	Maximum Water Level
QA/QC	Quality Assurance / Quality Control
Rev	Revision
RTK	Real Time Kinematic
SBES	Single Beam Echo Sounder
TBM	Temporary Bench Mark
UTM	Universal Transverse Mercator
WGS 84	World Geodetic System 1984
WRD	Water Resources Investigation Division

1.1.2 Units

- UTM grid coordinates and all linear measurements expressed in metres (m).
- Angular values expressed in degrees (°).
- Time and dates expressed as “09:00 on 24 Jan 2021”.

1.2 Objective

The main objective of the topographic and bathymetric survey of reservoir is as follow:

i) To estimate and study the sedimentation behaviour of reservoir in different zones including horizontal zones throughout the reservoir as well as vertical zones namely dead storage, live storage and flood storage if any.

ii) To upgrade Elevation-Area-Capacity table and curves of the reservoir at regular intervals.

iii) To emphasize on the importance of conducting hydrographic surveys at regular intervals for better operation and water management of the reservoir.

1.3 Scope of Work

The Scope of work for Geoservices Maritime Pvt Ltd was to mobilise, install, interface, operate all survey systems and provide all required survey personnel to undertake Topographic and Bathymetric survey services at Meshwo Reservoir.

The detailed scope of work was:

i) To measure the water depth of the Meshwo Reservoir at with respect to MSL.

ii) Line spacing shall be 25 m with continues echo sounding.

iii) Reservoir for water level changes during survey shall be tabulated.

iv) Data processing using HYPACK software shall be used.

v) Topographic survey shall be conducted from FRL water level with reasonable overlap with hydrographic survey.

vi) The area not covered under Hydrographic survey up to Maximum Water Level (MWL) shall be surveyed by taking levels at 25 m interval (25 m x 25 m grid).

vii) To carry out the data processing and interpretation of data and preparing of results, charts and drawings.

viii) Estimation of Sedimentation in the Reservoir shall be calculated if previous data is available.

ix) Gross and Live storage capacity of the Reservoir at every 10 m interval shall be provided.

x) Cross Sections showing the bed profile at 100 m interval shall be prepared.

xi) L-Section of the Reservoir may be prepared with lowest bed level at every survey line.

2 SALIENT FEATURES OF MESHWO RESERVOIR

MESHWO RESERVOIR PROJECT		
I	**LOCATION**	
	Coordinates	Latitude 23°41' N Longitude 73°24' E
	River	Meshwo
	Village	Shamlaji
	Taluka	Bhiloda
	District	Sabarkantha
	State	Gujarat
	Nearest Railway Station	Shamlaji Road Railway Station (SJS)
	Purpose	Irrigation & Flood Control
II	**HYDROLOGY**	
	Catchment Area	259 Sq. Km
	Mean Annual Rainfall	864 mm
III	**DAM**	
	Dam Type	Earthen
	Length of the top of the dam	168 m with Saddle length 2024 m
IV	**RESERVOIR**	
	MDDL	197.82 m
	FRL	214.590 m
	HFL/MWL	219.160 m
	Gross Storage Capacity at F.R.L.	82.12 M Cu. m
	Dead Storage Capacity	4.87 M Cu. m
	Live Storage Capacity	77.25 M Cu. m
	Area at FRL	11.16 Sq. m
V	**SPILLWAY**	
	Type	Waste weir
	Length of Spillway	61 m
	Maximum Discharge	2067 m^3/s
	Type, Nos. and Size of Gates	Ungated
VII	**CANAL**	
	Length of canal	30.20 km
	Capacity	7.8 m3/s
	Gross command area	34763 ha
	Culturable command area	28369 ha

Table 2-1 SALIENT FEATURES OF RESERVOIR

3 EXECUTIVE SUMMARY OF RESULTS

GMPL had mobilised their survey team, equipment and Survey Boat “Aqua Marina” which was deployed in the Meshwo Reservoir survey area from 28 Jan to 02 Feb 2021 to acquire bathymetric survey data and Topographic data as per mutually agreed scope and relevant survey specifications.

Trimble DGPS system, Sonarmite BTX Echo sounder (210 kHz) were utilised to acquire the bathymetric data within the Meshwo Reservoir area. A value of 1500 m/s was used as the average velocity of sound in water, which was applied in the setup during acquisition. The data so obtained was then processed and contouring was done using Hypack software. Pentax RTK /Geomax Auto level and Tripod were used for topographic survey in the area.

Topographic and bathymetric data was reduced to Mean Sea Level (MSL). All the data is plotted on scale of 1:5000 for Meshwo reservoir area.

The DGPS observation were made for about 4.5 Hours at Meshwo Dam top near spill way. Four Temporary Bench Marks were established.

The values depicted in the charts are the elevation with respect to MSL.

- The Minimum elevation within Meshwo reservoir is 195.06m above MSL and
- The Maximum depth within Meshwo reservoir is 16.48 m.
- Area covered by bathymetric survey is 7.801 Sq.km
- Area covered by topographic survey is 5.235 Sq. km

According to recent survey, total area of reservoir at FRL 214.59 m is 10.595 Sq. Km, corresponding storage capacity is 72.368 M Cu. m, and Dead storage at 197.82 m is 0.177 M Cu. m.

The comparison between 1968 and 2021(53 years) data results in a rate of siltation (silt index) of 7.104 Ham/100 Sq. Km/year. Annual percentage loss of gross storage capacity, live storage capacity and dead storage capacity is 0.22%, 0.12% and 1.8% respectively.

The comparison of 1998 and 2021 data with respect to 1968 impounding data at FRL 214.59 m results in silt index of 37.308 Ham/100 Sq. Km/year and 7.104 Ham/100 Sq. Km/year respectively.

4 RESOURCES FOR SURVEY WORK

4.1 Personnel

Following staff were involved during the survey work.

Offshore Survey Personnel	
Name	**Function**
Amit Singh	Party Chief
Samraj Dwivedi	Survey Engineer
Ashish Patil	Survey Engineer
Abhijith Cherapi	Surveyor
Abhijith K	Land Surveyor
Onshore Project Management and Data QC	
Sudhir Walia	Project Manager
KSN Murthy	Survey Manager
Dhaval Patel	Data Processor

Table 4.1-1 LIST OF PERSONNEL

4.2 Details of Equipment used

Following equipment and survey sensors were mobilised for the Topographic and Bathymetric survey data acquisition carried out at Meshwo reservoir. The equipment setup and configuration diagram has been presented in Figure 4.1.

Survey Equipment/Systems Used for the Data Acquisition	
Equipment/System	**Description/Make/Model**
Software / Navigation	HYPACK Navigation and Data Acquisition Software
Positioning	Trimble DGPS
Single Beam Echo Sounder	Sonarmite BTX Echo sounder with Accessories
RTK	Pentax RTK system
Auto Level	Geomax Auto Level & Tripod
Survey Boat	“Aqua Marine” with OBM
Laptop	Dell Laptops
Power Supply	12v Battery & Inverter

Table 4.2-1 LIST OF EQUIPMENT USED FOR SURVEY

4.3 Survey Vessel

Survey Boat 'Aqua Marine' was utilised for carrying out the bathymetric survey.

4.3.1 Survey Boat Specifications

Survey Boat 'Aqua Marine' Specifications	
Length overall	3.56m
Breadth moulded	1.88m
Draft	0.50m

Table 4.3-1 SURVEY BOAT SPECIFICATIONS - 'AQUA MARINE'

4.3.2 Survey Boat Offset Diagram

The location of the various survey sensors on the survey boat 'Aqua Marine' is given in the vessel-offset diagram on the chart accompanying this report.

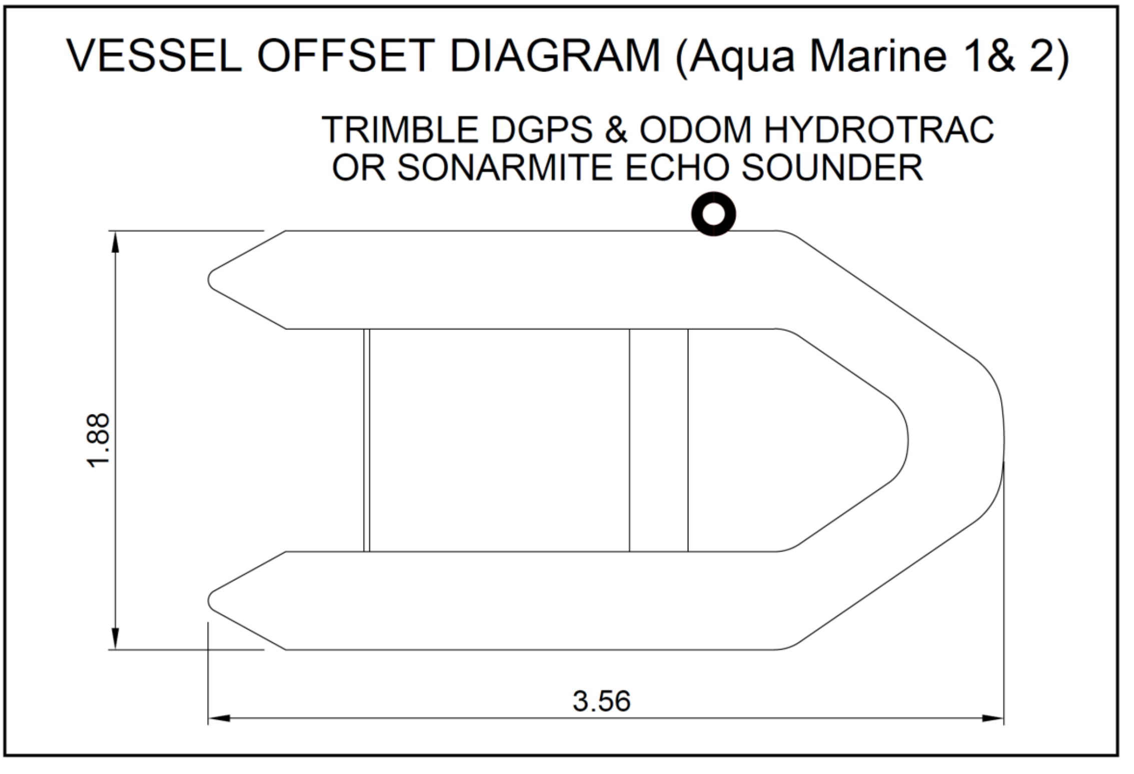


Figure 4.3-1 SURVEY BOAT ' AQUA MARINE' OFFSET DIAGRAM

5 DETAILED METHODOLOGY OF SURVEY

5.1 Mobilisation

The bathymetric survey equipment were mobilised on board “Aqua Marine” on 28 Jan 2021. After successful installation, testing and calibrations of survey equipment, the team proceeded for Data acquisition.

Pentax RTK, Geomax auto level, Tripod and necessary supporting equipment/tools were mobilised for Topographic survey.

All survey equipment was installed and configured for bathymetric Survey on board “Aqua Marine” as per Figure given below.

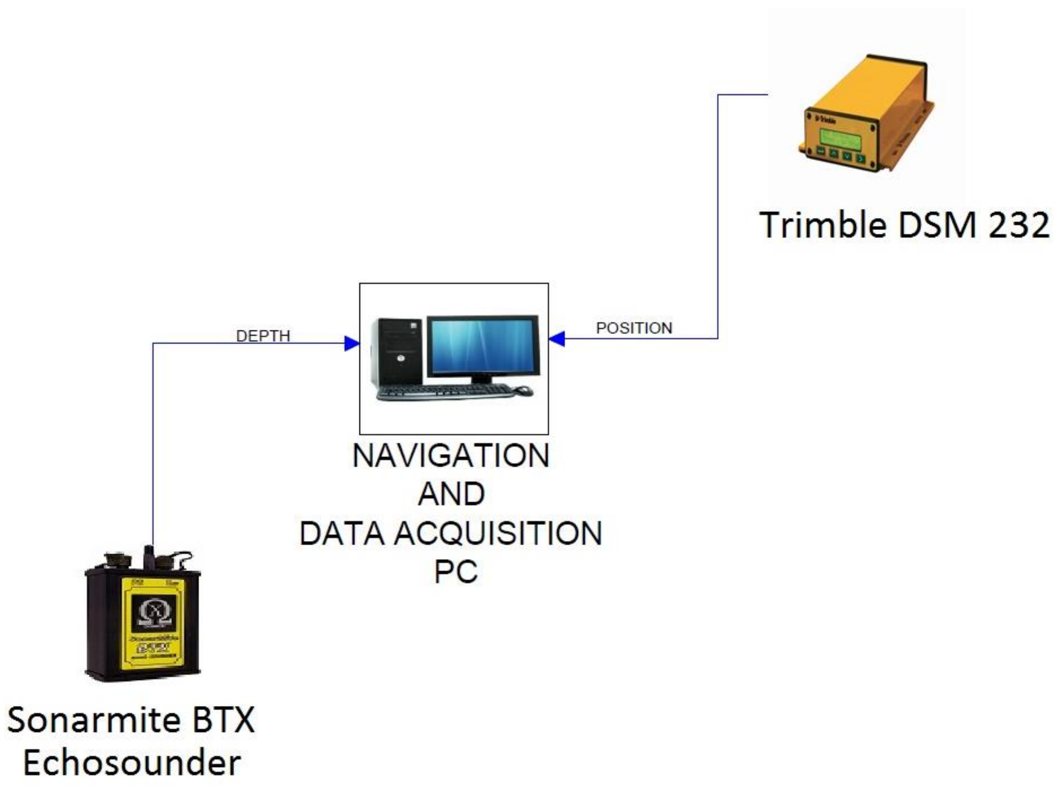


Figure 5.1-1 SBES SURVEY EQUIPMENT CONFIGURATION DIAGRAM ON BOARD

5.2 Geodesy

The survey operations were conducted in WGS 84 spheroid, Universal Transverse Mercator projection system based on following Geodetic parameters:-

Global Positioning System Geodetic Parameters	
Datum:	World Geodetic System 1984 (WGS84)
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
Semi minor axis:	b = 6 356 752.314 245 m
Inverse Flattening:	$^{1}/_{f}$ = 298.257 223 563
Local Datum Geodetic Parameters	
Datum:	World Geodetic System 1984 (WGS84)
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
Inverse Flattening:	$^{1}/_{f}$ = 298.257 223 563
Local Projection and Grid Parameters	
Map Projection:	Universal Transverse Mercator
Grid System:	UTM Zone 43 N
Central Meridian:	075° 00’ 00” East
Latitude of Origin:	0° 00’ 00” North
False Easting:	500 000 m
False Northing:	0 m

Table 5.2-1 GEODETIC PARAMETERS

5.3 Survey work at Field

5.3.1 Benchmark and Base station setup

The details of Bench Marks are presented in the table The DGPS observation were made for about 4.5 Hours at Dam top near spill way. Four Temporary Bench Marks were established, below:

BM Observation and T.BM. Information _ Meshwo Reservoir South Gujarat					
Location	**Latitude (N)**	**Longitude (E)**	**Easting (m)**	**Northing (m)**	**Elevation (m) W.r.t MSL**
OBS MESH	23°40'59.228"	073°2327.000"	335917.097	2620069.824	221.664
T.B.M.01	23°40'57.676"	073°23'25.453"	335872.588	2620022.585	221.687
T.B.M.02	23°40'58.535"	073°23'29.093"	335976.024	2620047.834	222.192
T.B.M.03	23°40'34.851"	073°23'24.428"	335835.641	2619320.789	220.727
T.B.M.04	23°44'25.284"	073°25'44.259"	339875.318	2626364.877	223.770

Table 5.3-1 BENCH MARK DETAILS

Figure 5.3-1 DGPS Observation at Dam top

5.3.2 Topographic and Bathymetric Survey

For topographic survey, Pentax RTK base was used for DGPS observation on top of dam. Four Hrs. of DGPS observation was carried out. Dam authority provided benchmark elevation value of 221.664 m. RTK DGPS Base station was set up at OBS MESH made by GMPL and configured to transmit the correction. Two rovers receiving RTK corrections from the base took spot level from water level to HFL.

For bathymetric survey, Aqua Marine boat was mobilised as shown in Figure 5.1-1. Plan line for survey was prepared parallel to dam axis and at 25 m intervals. Survey boat was run on afore mentioned plan line to acquire position as well as depth.

5.4 Survey Systems

5.4.1 TRIMBLE DGPS:

TRIMBLE DGPS system was used during survey.
• Differential correction signals received on board during survey operations continuously from the Satellite based augmentation system.
• The positioning data as well as heading data received with high reliability and integrity.

TRIMBLE DGPS was the primary positioning system currently used for all the surveys. GMPL has provided, install, operate and maintain a Differential Global Positioning System (DGPS) acceptable to the EIC, which fully covered the site of the works and was constantly in operation during the all the surveys. The age of pseudo- range correctors used in position computation was not exceeded 20 seconds; however, any horizontal positioning interpolation was never exceeded the accuracy. Horizontal Dilution of Precision (HDOP) was monitored, and was never exceeded 2 nominally. Satellite geometry alone is not a sufficient statistic for determining horizontal positioning accuracy. Other variables, including satellite pseudo range residual, were used in conjunction with HDOP to estimate horizontal accuracy. A minimum of four satellites were used to compute all positions, Horizontal and Vertical offsets between the GPS antenna and transducer(s) were observed and applied with a precision better than 0.01m. The system was consisting of master receiving reference station (Base) and DGPS Navigator unit (Rover). The navigator’s units (Rover) were installed on Survey launch. The composition was consisting navigational software, track plotters, data storage facilities, echo sounders, sufficient spares to enable uninterrupted operation of the system to the accuracy specified and on-board computers.

5.4.2 Single beam Echo sounder

The single beam echo sounder ‘Sonarmite BTX’ with an accuracy of 0.01m was deployed and in principle, higher frequency of 210 kHz was operated. Echo Sounder equipment was calibrated daily before and after use, by means of a bar-check in the survey area. The calibration results were found satisfactory.

5.4.3 HYPACK Software

HYPACK is a Windows™-based software package used primarily for hydrographic surveying and data processing.

HYPACK performs all of the tasks necessary to complete Single Beam Echo sounder data acquisition /processing from beginning to end. This all-in- one module provides the surveyor with all of the tools needed to design their survey, collect data, process it, reduce it to w.r.t MSL, and generate final products. Whether collecting hydrographic survey data or environmental data, or positioning a vessel in an engineering project, HYPACK provides the tools needed to complete the job.

This software can be interfaced simultaneously to Echo sounders and attitude sensors.

5.4.4 RTK System

Pentax RTK system consists of one Base and Rover Module was used for Topographic Survey.

- RTK DGPS Base station was set up at the OBS MESH Made by GMPL and configured to transmit the corrections.
- Pentax RTK Rover was used for DGPS Observation on the top of Dam, near spill way. 4Hrs of DGPS observation was carried out. Bench Mark elevation value of 221.664 m was provided by the Dam authority.

5.5 Data Acquisition and Quality Control

5.5.1 Online Data Quality Control

The online navigation computer was interfaced to Sonarmite BTX Echo Sounder system. Laptop connected to the Navigation network were time synchronized with the GPS (high precision) time signal allowing all data to be precisely time stamped.

<u>Navigation</u>

The DGPS system performed well at all times and the performance of the system was continuously monitored.

<u>Echo Sounder</u>

The digital output from the Sonarmite BTX Echo Sounder was satisfactory throughout the duration of the survey. The quality of obtained soundings were verified by running suitable cross lines and depths were found to be matching.

5.5.2 Data Processing

The bathymetric survey data was logged using Hypack on Navigation System. The quality of the bathymetric data acquired in the field was monitored continuously onboard the survey boat. Survey data was processed in office and handed over to the client.

5.6 Quality Assurance and HSE Procedures

GMPL has fully documented and self-audited Quality Assurance and Health, Safety and Environmental System procedures in place. The same were followed during all surveying tasks, which was undertaken by the company and its personnel.

Competent field survey staffs were deployed by GMPL to constantly monitor acquired data quality whilst the survey progressing, and was duly documented.

5.7 Demobilisation

Upon successful completion of topographic and bathymetric survey at Meshwo Reservoir with due, consent from Client Representative, the survey equipment on board were demobilised on 02 February 2021.

5.8 SURVEY DATA PROCESSING AND INTERPRETATION METHODS

5.8.1 General

The survey data was logged and was processed using the HYPACK Software. Position and depth data were processed and checked to ensure good data quality. The same was used for the automated and manual processing of logged data sets.

5.8.2 Navigation and Positioning

The measured offsets for various survey sensors used during the survey were entered into the navigation system and post processed using Hypack processing to enable track charts to be plotted and the 'corrected' navigation files to be integrated with other sensor data at a later stage.

5.8.3 Bathymetry Data Processing and Analysis

- The SBES bathymetry survey data was logged using HYPACK and further processed.
- Corrected SBES offset position (computed from vessel antenna) was merged into single beam data for true horizontal positioning.
- Velocity value 1500 m/s was used in the survey area.
- SBES data was further corrected for the transducer draft from water level.
- SBES bathymetry data was reduced to Water level w.r.t MSL
- The data was filtered, cleaned, and combined to create geographically positioned bathymetric data set that has been corrected for tides and sound speed.
- The water level were observed during the entire period of survey. The details are as follows:-

Date	Time	Water Level (meters)
28/01/2021	0700	211.71
	1900	211.71
29/01/2021	0700	211.63
	19:00	211.63
30/01/2021	0700	211.50
	1900	211.50
31/01/2021	0700	211.50
	1900	211.50
01/02/2021	0700	211.45
	1900	211.45
02/02/2021	0700	211.43
	1900	211.43

Table 5.8-1 WATER LEVELS

5.8.4 Topographic Data Processing and Analysis

The topographic survey data was cleaned and converted into xyz format. The converted data was merged with the bathymetric data using TIN module of Hypack software and Gridded data (25 x 25 m) was created. This data was used for volume calculations.

5.8.5 Preparation of Drawings

Seven chart has been prepared for Meshwo Reservoir, the details of which are presented in the table below:

Sr. No	Drawing Name	Description	Hard Copy format	Soft Copy format
1	P-SUR-009-Meshwo-Bathy-01	Bathymetry chart part 1	1:5000	PDF & CAD
2	P-SUR-009-Meshwo-Bathy-02	Bathymetry chart part 2	1:5000	PDF & CAD
3	P-SUR-009-Meshwo-Bathy-03	Bathymetry chart part 3	1:5000	PDF & CAD
4	P-SUR-009-Meshwo-Contour-01	Contour chart	1:12500	PDF & CAD
5	P-SUR-009-Meshwo-Overview-01	Overview Map of Reservoir	Paper size A3	PDF & CAD
6	Meshwo Cross Sections	117 Cross Section at 100 m interval	Only soft copy	CAD
7	Meshwo L-Section	L-Section of Reservosir	Only soft copy	CAD

Table 10-2 LIST OF CHARTS

PDF formatted chart has been attached along the report. Native CAD formatted drawing has been provided as softcopy in CD / Hard Disc.

6 DETAILED TOPOGRAPHIC AND BATHYMETRIC SURVEY RESULTS

6.1 General

Kindly refer to drawings in conjunction with the following:

Topographic and bathymetric data was reduced to the water level w.r.t MSL. All the data is plotted on scale of 1:5000 for Meshwo reservoir.

The values depicted in the charts are the depths with respect to MSL.

- The Minimum elevation within Meshwo reservoir is 195.06m above MSL and
- The Maximum depth within Meshwo reservoir is 16.48 m.

6.2 Capacity and Area Calculation:

Hypack software's TIN (Triangulated Irregular Network) MODEL was used to calculate capacity and area of the reservoir at intervals of 10 cm. In addition, volume was also calculated using prismoidal formula as given below:

V=h/3{A1+A2+ Square Root (A1 * A2)}

where V is volume in M Cu. m between two levels,

h is difference between two level and

A1 & A2 is area in Sq. Km of successive levels

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
195.00	0.000	0.000	0.000	0.000	0.000	
195.10	0.000	0.000	0.000	0.000	0.000	
195.20	0.000	0.000	0.000	0.000	0.000	
195.30	0.000	0.000	0.000	0.000	0.000	
195.40	0.000	0.000	0.000	0.000	0.000	
195.50	0.000	0.000	0.000	0.000	0.001	
195.60	0.000	0.000	0.000	0.000	0.001	
195.70	0.000	0.000	0.000	0.000	0.001	
195.80	0.000	0.000	0.000	0.000	0.001	
195.90	0.000	0.000	0.000	0.000	0.002	
196.00	0.001	0.000	0.001	0.001	0.002	
196.10	0.001	0.000	0.001	0.001	0.002	
196.20	0.001	0.000	0.001	0.001	0.003	
196.30	0.001	0.000	0.001	0.001	0.004	
196.40	0.002	0.000	0.002	0.002	0.006	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
196.50	0.003	0.000	0.003	0.003	0.010	
196.60	0.004	0.000	0.004	0.004	0.016	
196.70	0.006	0.000	0.006	0.006	0.025	
196.80	0.009	0.000	0.009	0.009	0.039	
196.90	0.014	0.000	0.014	0.014	0.058	
197.00	0.021	0.000	0.021	0.021	0.083	
197.10	0.031	0.000	0.031	0.031	0.108	
197.20	0.043	0.000	0.043	0.043	0.131	
197.30	0.057	0.000	0.057	0.057	0.153	
197.40	0.073	0.000	0.073	0.073	0.180	
197.50	0.093	0.000	0.093	0.093	0.211	
197.60	0.115	0.000	0.115	0.115	0.241	
197.70	0.141	0.000	0.141	0.141	0.277	
197.80	0.171	0.000	0.171	0.171	0.314	
197.82	**0.177**	**0.000**	**0.177**	**0.177**	**0.321**	**MDDL**
197.90	0.177	0.027	0.204	0.204	0.351	
198.00	0.177	0.064	0.241	0.241	0.384	
198.10	0.177	0.104	0.281	0.281	0.418	
198.16	0.177	0.129	0.307	0.306	0.438	
198.20	0.177	0.147	0.324	0.324	0.451	
198.30	0.177	0.194	0.371	0.371	0.486	
198.40	0.177	0.245	0.422	0.422	0.529	
198.50	0.177	0.300	0.477	0.477	0.571	
198.60	0.177	0.359	0.536	0.536	0.617	
198.70	0.177	0.423	0.600	0.600	0.652	
198.80	0.177	0.490	0.667	0.667	0.687	
198.90	0.177	0.560	0.737	0.737	0.718	
199.00	0.177	0.633	0.810	0.810	0.745	
199.10	0.177	0.709	0.886	0.886	0.773	
199.20	0.177	0.787	0.965	0.965	0.801	
199.30	0.177	0.869	1.046	1.046	0.832	
199.40	0.177	0.954	1.131	1.131	0.859	
199.50	0.177	1.041	1.218	1.218	0.885	
199.60	0.177	1.131	1.308	1.308	0.908	
199.70	0.177	1.222	1.400	1.399	0.929	
199.80	0.177	1.316	1.494	1.493	0.950	
199.90	0.177	1.413	1.590	1.590	0.974	
200.00	0.177	1.511	1.688	1.688	0.998	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
200.10	0.177	1.612	1.789	1.789	1.022	
200.20	0.177	1.716	1.893	1.893	1.046	
200.30	0.177	1.822	1.999	1.998	1.070	
200.40	0.177	1.930	2.107	2.107	1.093	
200.50	0.177	2.040	2.217	2.217	1.115	
200.60	0.177	2.153	2.330	2.330	1.138	
200.70	0.177	2.268	2.445	2.445	1.160	
200.80	0.177	2.385	2.562	2.562	1.183	
200.90	0.177	2.504	2.682	2.681	1.207	
201.00	0.177	2.626	2.803	2.803	1.230	
201.10	0.177	2.750	2.928	2.927	1.255	
201.20	0.177	2.877	3.054	3.054	1.281	
201.30	0.177	3.007	3.184	3.183	1.307	
201.40	0.177	3.139	3.316	3.316	1.335	
201.50	0.177	3.274	3.451	3.451	1.365	
201.60	0.177	3.412	3.589	3.589	1.396	
201.70	0.177	3.553	3.730	3.730	1.429	
201.80	0.177	3.698	3.875	3.875	1.466	
201.90	0.177	3.846	4.023	4.023	1.504	
202.00	0.177	3.998	4.175	4.175	1.538	
202.10	0.177	4.154	4.331	4.331	1.571	
202.20	0.177	4.312	4.490	4.489	1.604	
202.30	0.177	4.475	4.652	4.652	1.639	
202.40	0.177	4.640	4.818	4.817	1.678	
202.50	0.177	4.811	4.988	4.988	1.727	
202.60	0.177	4.986	5.163	5.163	1.784	
202.70	0.177	5.167	5.345	5.344	1.838	
202.80	0.177	5.354	5.531	5.531	1.888	
202.90	0.177	5.545	5.722	5.722	1.937	
203.00	0.177	5.741	5.918	5.918	1.978	
203.10	0.177	5.941	6.118	6.118	2.021	
203.20	0.177	6.145	6.322	6.322	2.059	
203.30	0.177	6.353	6.530	6.529	2.097	
203.40	0.177	6.564	6.741	6.741	2.134	
203.50	0.177	6.779	6.957	6.956	2.172	
203.60	0.177	6.998	7.176	7.175	2.210	
203.70	0.177	7.221	7.399	7.398	2.250	
203.80	0.177	7.449	7.626	7.626	2.294	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
203.90	0.177	7.680	7.857	7.857	2.337	
204.00	0.177	7.916	8.093	8.093	2.386	
204.10	0.177	8.157	8.334	8.334	2.434	
204.20	0.177	8.403	8.580	8.580	2.481	
204.30	0.177	8.653	8.830	8.830	2.523	
204.40	0.177	8.908	9.085	9.085	2.566	
204.50	0.177	9.166	9.344	9.343	2.609	
204.60	0.177	9.430	9.607	9.607	2.656	
204.70	0.177	9.698	9.875	9.875	2.707	
204.80	0.177	9.971	10.148	10.148	2.755	
204.90	0.177	10.249	10.426	10.426	2.805	
205.00	0.177	10.532	10.709	10.709	2.856	
205.10	0.177	10.820	10.997	10.997	2.911	
205.20	0.177	11.114	11.291	11.291	2.969	
205.30	0.177	11.414	11.591	11.591	3.020	
205.40	0.177	11.718	11.895	11.895	3.070	
205.50	0.177	12.028	12.205	12.205	3.125	
205.60	0.177	12.343	12.520	12.520	3.180	
205.70	0.177	12.664	12.841	12.841	3.234	
205.80	0.177	12.990	13.167	13.167	3.287	
205.90	0.177	13.321	13.498	13.498	3.342	
206.00	0.177	13.658	13.835	13.835	3.401	
206.10	0.177	14.001	14.179	14.179	3.463	
206.20	0.177	14.351	14.528	14.528	3.529	
206.30	0.177	14.707	14.884	14.884	3.592	
206.40	0.177	15.069	15.247	15.246	3.653	
206.50	0.177	15.438	15.615	15.615	3.717	
206.60	0.177	15.813	15.990	15.990	3.788	
206.70	0.177	16.195	16.373	16.372	3.857	
206.80	0.177	16.584	16.762	16.762	3.926	
206.90	0.177	16.981	17.158	17.158	3.995	
207.00	0.177	17.384	17.561	17.561	4.065	
207.10	0.177	17.794	17.971	17.971	4.136	
207.20	0.177	18.211	18.388	18.388	4.209	
207.30	0.177	18.636	18.813	18.813	4.287	
207.40	0.177	19.068	19.246	19.246	4.372	
207.50	0.177	19.511	19.688	19.688	4.484	
207.60	0.177	19.965	20.142	20.142	4.587	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
207.70	0.177	20.428	20.605	20.605	4.679	
207.80	0.177	20.900	21.077	21.077	4.761	
207.90	0.177	21.381	21.558	21.558	4.849	
208.00	0.177	21.870	22.047	22.047	4.938	
208.10	0.177	22.368	22.546	22.545	5.027	
208.20	0.177	22.875	23.053	23.052	5.112	
208.30	0.177	23.391	23.568	23.568	5.195	
208.40	0.177	23.914	24.092	24.091	5.277	
208.50	0.177	24.446	24.623	24.623	5.358	
208.60	0.177	24.986	25.163	25.163	5.438	
208.70	0.177	25.534	25.711	25.711	5.516	
208.80	0.177	26.089	26.266	26.266	5.596	
208.90	0.177	26.653	26.830	26.830	5.677	
209.00	0.177	27.225	27.402	27.402	5.756	
209.10	0.177	27.804	27.981	27.981	5.830	
209.20	0.177	28.391	28.568	28.568	5.905	
209.30	0.177	28.985	29.162	29.162	5.984	
209.40	0.177	29.588	29.765	29.765	6.065	
209.50	0.177	30.198	30.375	30.375	6.145	
209.60	0.177	30.817	30.994	30.994	6.227	
209.70	0.177	31.444	31.621	31.620	6.309	
209.80	0.177	32.079	32.256	32.255	6.390	
209.90	0.177	32.722	32.899	32.899	6.471	
210.00	0.177	33.373	33.550	33.550	6.551	
210.10	0.177	34.032	34.209	34.209	6.636	
210.20	0.177	34.700	34.877	34.877	6.718	
210.30	0.177	35.375	35.553	35.552	6.793	
210.40	0.177	36.058	36.235	36.235	6.861	
210.50	0.177	36.748	36.925	36.924	6.928	
210.60	0.177	37.444	37.621	37.620	6.994	
210.70	0.177	38.146	38.324	38.323	7.060	
210.80	0.177	38.856	39.033	39.033	7.128	
210.90	0.177	39.572	39.749	39.749	7.199	
211.00	0.177	40.296	40.473	40.473	7.274	
211.10	0.177	41.027	41.204	41.204	7.352	
211.20	0.177	41.766	41.944	41.943	7.449	
211.30	0.177	42.522	42.699	42.697	7.619	
211.40	0.177	43.288	43.465	43.463	7.709	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
211.50	0.177	44.063	44.241	44.239	7.801	
211.60	0.177	44.848	45.025	45.023	7.887	
211.70	0.177	45.641	45.818	45.816	7.970	
211.80	0.177	46.442	46.619	46.617	8.050	
211.90	0.177	47.251	47.428	47.426	8.129	
212.00	0.177	48.067	48.245	48.243	8.206	
212.10	0.177	48.892	49.069	49.067	8.282	
212.20	0.177	49.724	49.901	49.899	8.360	
212.30	0.177	50.564	50.741	50.739	8.440	
212.40	0.177	51.412	51.589	51.587	8.523	
212.50	0.177	52.269	52.446	52.444	8.609	
212.60	0.177	53.134	53.311	53.309	8.696	
212.70	0.177	54.008	54.185	54.183	8.781	
212.80	0.177	54.890	55.067	55.065	8.866	
212.90	0.177	55.781	55.958	55.956	8.949	
213.00	0.177	56.680	56.857	56.855	9.030	
213.10	0.177	57.587	57.764	57.762	9.110	
213.20	0.177	58.502	58.679	58.677	9.192	
213.30	0.177	59.425	59.603	59.601	9.276	
213.40	0.177	60.357	60.534	60.532	9.361	
213.50	0.177	61.298	61.475	61.473	9.448	
213.60	0.177	62.247	62.424	62.422	9.538	
213.70	0.177	63.205	63.382	63.381	9.630	
213.80	0.177	64.173	64.350	64.348	9.727	
213.90	0.177	65.151	65.328	65.326	9.825	
214.00	0.177	66.138	66.315	66.313	9.922	
214.10	0.177	67.135	67.312	67.311	10.022	
214.20	0.177	68.143	68.320	68.318	10.137	
214.30	0.177	69.163	69.340	69.338	10.264	
214.40	0.177	70.196	70.373	70.371	10.392	
214.50	0.177	71.241	71.418	71.416	10.508	
214.59	**0.177**	**72.191**	**72.368**	**72.366**	**10.595**	**FRL**
214.60	0.177	72.297	72.474	72.472	10.602	
214.70	0.177	73.361	73.538	73.536	10.672	
214.80	0.177	74.432	74.609	74.607	10.750	
214.90	0.177	75.511	75.688	75.686	10.842	
215.00	0.177	76.600	76.778	76.776	10.945	
215.10	0.177	77.700	77.877	77.875	11.046	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
215.20	0.177	78.809	78.986	78.984	11.126	
215.30	0.177	79.925	80.102	80.100	11.188	
215.40	0.177	81.046	81.223	81.221	11.244	
215.50	0.177	82.173	82.351	82.348	11.296	
215.60	0.177	83.305	83.483	83.480	11.346	
215.70	0.177	84.442	84.620	84.617	11.394	
215.80	0.177	85.584	85.761	85.759	11.441	
215.90	0.177	86.731	86.908	86.905	11.486	
216.00	0.177	87.882	88.059	88.056	11.531	
216.10	0.177	89.037	89.214	89.212	11.576	
216.20	0.177	90.197	90.374	90.372	11.621	
216.30	0.177	91.361	91.538	91.536	11.666	
216.40	0.177	92.530	92.707	92.705	11.711	
216.50	0.177	93.703	93.880	93.878	11.755	
216.60	0.177	94.881	95.058	95.056	11.799	
216.70	0.177	96.063	96.240	96.238	11.842	
216.80	0.177	97.249	97.427	97.424	11.885	
216.90	0.177	98.440	98.617	98.615	11.929	
217.00	0.177	99.635	99.812	99.810	11.971	
217.10	0.177	100.834	101.012	101.009	12.015	
217.20	0.177	102.038	102.215	102.213	12.058	
217.30	0.177	103.246	103.423	103.421	12.104	
217.40	0.177	104.459	104.636	104.634	12.149	
217.50	0.177	105.676	105.853	105.851	12.194	
217.60	0.177	106.898	107.075	107.072	12.239	
217.70	0.177	108.124	108.301	108.299	12.284	
217.80	0.177	109.354	109.532	109.529	12.329	
217.90	0.177	110.590	110.767	110.764	12.376	
218.00	0.177	111.830	112.007	112.004	12.423	
218.10	0.177	113.074	113.251	113.249	12.469	
218.20	0.177	114.323	114.501	114.498	12.517	
218.30	0.177	115.578	115.755	115.752	12.565	
218.40	0.177	116.837	117.014	117.011	12.615	
218.50	0.177	118.101	118.278	118.275	12.666	
218.60	0.177	119.370	119.547	119.545	12.719	
218.70	0.177	120.644	120.822	120.819	12.772	
218.80	0.177	121.924	122.102	122.099	12.828	
218.90	0.177	123.210	123.387	123.385	12.883	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
219.00	0.177	124.501	124.678	124.676	12.941	
219.10	0.177	125.798	125.975	125.973	13.000	
219.16	**0.177**	**126.579**	**126.757**	**126.754**	**13.036**	**HFL**

Table 6.2-1 Capacity and Area

6.3 Comparative Statement of Meshwo Reservoir

RL in m	As per 1997 survey		As per 2021 survey		Remarks
	Gross Capacity in M Cu. m	Area in Sq. Km	Gross Capacity in M Cu. m	Area in Sq. Km	
197.82	**0.060**	**-**	**0.177**	**0.321**	**MDDL**
199.55	0.426	0.757	1.263	0.897	
200.55	1.070	1.072	2.273	1.127	
201.55	1.984	1.432	3.519	1.38	
202.55	3.404	1.862	5.075	1.755	
203.55	5.314	2.443	7.066	2.191	
204.55	7.607	2.820	9.475	2.632	
205.55	10.212	3.393	12.362	3.152	
206.55	13.157	4.030	15.802	3.751	
207.55	16.675	4.600	19.914	4.538	
208.55	20.438	5.477	24.892	5.399	
209.55	24.815	5.985	30.684	6.186	
210.55	29.762	7.000	37.272	6.961	
211.55	35.199	7.826	44.632	7.845	
212.55	40.911	9.067	52.877	8.653	
213.55	46.758	10.122	61.948	9.492	
214.59	**53.132**	**11.112**	**72.368**	**10.595**	**FRL**

Table 6.3-1 COMPARATIVE STATEMENT OF MESHWO RESERVOIR

6.4 Gross Capacity in M Cu. m of the Reservoir - Year 2020:

RL (m)	0	0.1	0.16	0.2	0.3	0.4	0.5	0.59	0.6	0.7	0.8	0.82	0.9
195												0.000	0.000
196	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.004	0.006	0.009	0.010	0.014
197	0.021	0.031	0.038	0.043	0.057	0.073	0.093	0.113	0.115	0.141	0.171	**0.177**	0.204
198	0.241	0.281	0.307	0.324	0.371	0.422	0.477	0.530	0.536	0.600	0.667	0.681	0.737
199	0.810	0.886	0.933	0.965	1.046	1.131	1.218	1.299	1.308	1.400	1.494	1.513	1.590
200	1.688	1.789	1.851	1.893	1.999	2.107	2.217	2.319	2.330	2.445	2.562	2.586	2.682
201	2.803	2.928	3.003	3.054	3.184	3.316	3.451	3.575	3.589	3.730	3.875	3.904	4.023
202	4.175	4.331	4.426	4.490	4.652	4.818	4.988	5.146	5.163	5.345	5.531	5.569	5.722
203	5.918	6.118	6.240	6.322	6.530	6.741	6.957	7.154	7.176	7.399	7.626	7.672	7.857
204	8.093	8.334	8.481	8.580	8.830	9.085	9.344	9.580	9.607	9.875	10.148	10.203	10.426
205	10.709	10.997	11.173	11.291	11.591	11.895	12.205	12.488	12.520	12.841	13.167	13.233	13.498
206	13.835	14.179	14.388	14.528	14.884	15.247	15.615	15.952	15.990	16.373	16.762	16.840	17.158
207	17.561	17.971	18.220	18.388	18.813	19.246	19.688	20.096	20.142	20.605	21.077	21.173	21.558
208	22.047	22.546	22.849	23.053	23.568	24.092	24.623	25.109	25.163	25.711	26.266	26.379	26.830
209	27.402	27.981	28.332	28.568	29.162	29.765	30.375	30.932	30.994	31.621	32.256	32.384	32.899
210	33.550	34.209	34.609	34.877	35.553	36.235	36.925	37.551	37.621	38.324	39.033	39.176	39.749
211	40.473	41.204	41.647	41.944	42.699	43.465	44.241	44.946	45.025	45.818	46.619	46.780	47.428
212	48.245	49.069	49.567	49.901	50.741	51.589	52.446	53.224	53.311	54.185	55.067	55.245	55.958
213	56.857	57.764	58.312	58.679	59.603	60.534	61.475	62.329	62.424	63.382	64.350	64.545	65.328
214	66.315	67.312	67.916	68.320	69.340	70.373	71.418	**72.368**	72.474	73.538	74.609	74.824	75.688
215	76.778	77.877	78.542	78.986	80.102	81.223	82.351	83.369	83.483	84.620	85.761	85.990	86.908
216	88.059	89.214	89.910	90.374	91.539	92.707	93.881	94.941	95.059	96.24	97.427	97.664	98.617
217	99.812	101.012	101.733	102.215	103.423	104.636	105.853	106.952	107.075	108.301	109.532	109.778	110.767
218	112.007	113.251	114.S000	114.501	115.755	117.014	118.278	119.420	119.547	120.822	122.102	122.358	123.387
219	124.678	125.975	**126.757**										

Table 6.4-1 GROSS STORAGE CAPACITY IN M cu. m YEAR -2021

Note: Gross storage capacity for FRL at 214.59 m is 72.366 M Cu. m, dead storage at 197.82 m is 0.177 M Cu. m and HFL at 219.16 m is 126.757 M Cu. m.

6.5 Live Storage Capacity in M Cu. m of the Reservoir - Year 2021:

RL (m)	0	0.1	0.16	0.2	0.3	0.4	0.5	0.59	0.6	0.7	0.8	0.82	0.9
197												0.000	0.027
198	0.064	0.104	0.130	0.147	0.194	0.245	0.300	0.353	0.359	0.423	0.490	0.504	0.560
199	0.633	0.709	0.756	0.788	0.869	0.954	1.041	1.122	1.131	1.223	1.317	1.336	1.413
200	1.511	1.612	1.674	1.716	1.822	1.930	2.040	2.142	2.153	2.268	2.385	2.409	2.504
201	2.626	2.750	2.826	2.877	3.007	3.139	3.274	3.398	3.412	3.553	3.698	3.727	3.846
202	3.998	4.154	4.249	4.313	4.475	4.641	4.811	4.969	4.986	5.168	5.354	5.392	5.545
203	5.741	5.941	6.063	6.145	6.353	6.564	6.780	6.977	6.999	7.222	7.449	7.495	7.680
204	7.916	8.157	8.304	8.403	8.653	8.908	9.167	9.403	9.430	9.698	9.971	10.026	10.249
205	10.532	10.820	10.996	11.114	11.414	11.718	12.028	12.311	12.343	12.664	12.990	13.056	13.321
206	13.658	14.002	14.211	14.351	14.707	15.070	15.438	15.775	15.813	16.196	16.585	16.663	16.981
207	17.384	17.794	18.043	18.211	18.636	19.069	19.511	19.919	19.965	20.428	20.900	20.996	21.381
208	21.870	22.369	22.672	22.876	23.391	23.915	24.446	24.932	24.986	25.534	26.089	26.202	26.653
209	27.225	27.804	28.155	28.391	28.985	29.588	30.198	30.755	30.817	31.444	32.079	32.207	32.722
210	33.373	34.032	34.432	34.700	35.376	36.058	36.748	37.374	37.444	38.147	38.856	38.999	39.572
211	40.296	41.027	41.470	41.766	42.522	43.288	44.063	44.769	44.848	45.641	46.442	46.603	47.251
212	48.067	48.892	49.390	49.724	50.564	51.412	52.269	53.047	53.134	54.008	54.890	55.068	55.781
213	56.680	57.587	58.135	58.502	59.426	60.357	61.298	62.152	62.247	63.205	64.173	64.368	65.151
214	66.138	67.135	67.739	68.143	69.163	70.196	71.241	**72.191**	72.297	73.361	74.432	74.647	75.511
215	76.600	77.700	78.364	78.809	79.925	81.046	82.173	83.192	83.305	84.442	85.584	85.813	86.731
216	87.882	89.037	89.732	90.197	91.361	92.530	93.703	94.763	94.881	96.063	97.249	97.487	98.440
217	99.635	100.834	101.556	102.038	103.246	104.459	105.676	106.775	106.898	108.124	109.354	109.601	110.590
218	111.830	113.074	113.823	114.323	115.578	116.837	118.101	119.243	119.370	120.644	121.924	122.181	123.210
219	124.501	125.798	**126.579**										

Table 6.5-1 LIVE STORAGE CAPACITY IN M cu. m YEAR -2021

Note: Live storage capacity for FRL at 214.59 m is 72.191 M Cu. m and HFL at 219.16 m is 126.579 M Cu. m.

6.6 Spread Area in Sq. Km of the Reservoir - Year 2021:

RL (m)	0	0.1	0.16	0.2	0.3	0.4	0.5	0.59	0.6	0.7	0.8	0.82	0.9
195					0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002
196	0.002	0.002	0.003	0.003	0.004	0.006	0.010	0.015	0.016	0.025	0.039	0.042	0.058
197	0.083	0.108	0.122	0.131	0.153	0.180	0.211	0.237	0.241	0.277	0.314	0.321	0.351
198	0.384	0.418	0.438	0.451	0.486	0.529	0.571	0.613	0.617	0.652	0.687	0.693	0.718
199	0.745	0.773	0.789	0.801	0.832	0.859	0.885	0.906	0.908	0.929	0.950	0.955	0.974
200	0.998	1.022	1.037	1.046	1.070	1.093	1.115	1.136	1.138	1.160	1.183	1.188	1.207
201	1.230	1.255	1.270	1.281	1.307	1.335	1.365	1.393	1.396	1.429	1.466	1.473	1.504
202	1.538	1.571	1.591	1.604	1.639	1.678	1.727	1.778	1.784	1.838	1.888	1.898	1.937
203	1.978	2.021	2.045	2.059	2.097	2.134	2.172	2.206	2.210	2.250	2.294	2.303	2.337
204	2.386	2.434	2.462	2.481	2.523	2.566	2.609	2.651	2.656	2.707	2.755	2.765	2.805
205	2.856	2.911	2.946	2.969	3.020	3.070	3.125	3.174	3.180	3.234	3.287	3.298	3.342
206	3.401	3.463	3.502	3.529	3.592	3.653	3.717	3.780	3.788	3.857	3.926	3.940	3.995
207	4.065	4.136	4.180	4.209	4.287	4.372	4.484	4.578	4.587	4.679	4.761	4.779	4.849
208	4.938	5.027	5.079	5.112	5.195	5.277	5.358	5.430	5.438	5.516	5.596	5.613	5.677
209	5.756	5.830	5.875	5.905	5.984	6.065	6.145	6.219	6.227	6.309	6.390	6.407	6.471
210	6.551	6.636	6.686	6.718	6.793	6.861	6.928	6.987	6.994	7.060	7.128	7.142	7.199
211	7.274	7.352	7.403	7.449	7.619	7.709	7.801	7.879	7.887	7.970	8.050	8.066	8.129
212	8.206	8.282	8.329	8.360	8.440	8.523	8.609	8.688	8.696	8.781	8.866	8.882	8.949
213	9.030	9.110	9.159	9.192	9.276	9.361	9.448	9.529	9.538	9.630	9.727	9.747	9.825
214	9.922	10.022	10.089	10.137	10.264	10.392	10.508	**10.595**	10.602	10.672	10.750	10.767	10.842
215	10.945	11.046	11.097	11.126	11.188	11.244	11.296	11.341	11.346	11.394	11.441	11.450	11.486
216	11.531	11.576	11.603	11.621	11.666	11.711	11.755	11.794	11.799	11.842	11.885	11.894	11.929
217	11.971	12.015	12.041	12.058	12.104	12.149	12.194	12.234	12.239	12.284	12.329	12.338	12.376
218	12.423	12.469	12.498	12.517	12.565	12.615	12.666	12.713	12.719	12.772	12.828	12.839	12.883
219	12.941	13.000	**13.036**										

Table 6.6-1 SPREAD AREA IN SQ. KM YEAR -2021

Note: Spread Area for FRL at 214.59 m is 10.595 Sq. Km and HFL at 219.16 m is 13.036 Sq. Km.

6.7 Sediment Analysis:

6.7.1 Observed Rate of Sedimentation

The reservoir was impounded during the year 1968. As per survey total area of reservoir at FRL 214.59 m was 11.16 Sq. Km, corresponding storage capacity was 82.12 M Cu. m, and Dead storage at 197.82 m was 4.87 M Cu. m.

The reservoir was surveyed in the year 1998. As per survey of the year total area of reservoir at FRL 214.59 m was 11.112 Sq. Km, corresponding gross storage capacity at FRL 214.59 m was 53.132 M Cu m and Dead storage at 197.82 m was 0.06 M Cu. m.

The reservoir was recently surveyed by means of integrated bathymetric and topographic survey in year 2021. As per recent survey, total area of reservoir at FRL 214.59 m is 10.595 Sq. Km, corresponding storage capacity is 72.368 M Cu. m and Dead storage at 197.82 m is 0.177 M Cu. m.

The rate of siltation in the reservoir (up to FRL 214.59 m) during the last 53 years (1968-2021), was found to be 0.184 M Cu. m / year.

Original Reservoir data:

Year of Impounding	: 1968
Catchment Area	: 259 Sq. Km
Surface area at 214.59 m	: 11.16 Sq. Km
Live storage at 214.59m	: 77.25 M Cu. m
Dead storage at 197.82m	: 4.87 M Cu. m
Gross storage at 214.59m	: 82.12 M Cu. m

Rate of Sedimentation (at FRL 214.59) with respect to impounding year 1968													
Sr. No	**Year of Survey**	**Capacity in M Cu. m**			**Period in years**	**Silt Deposited in M Cu. m**	**Silt Rate in M Cu. m/year**	**Loss in Capacity in M Cu. m and percentage**			**Silt Index ham/100 Sq. Km/Yr.**	**Annual % loss**	**Remarks**
		Dead	**Live**	**Gross**				**Dead**	**Live**	**Gross**			
1	1968	4.87	77.25	82.12	-	-	-	-	-	-	-	-	
2	1998(Hydrographic survey)	0.06	53.072	53.132	30	28.988	0.966	4.81 98.77%	24.178 31.30%	28.988 35.30%	37.308	1.18%	**Serious Category**
3	2021 (Hydrographic survey)	0.177	72.191	72.368	53	9.752	0.184	4.693 96.37%	5.059 6.55%	9.752 11.87%	7.104	0.22%	**Significant Category**

Table 6.7-1 RATE OF SEDIMENTATION

<u>According to IS -12182 (1987)</u>

Annual % loss	-	**Class of Reservoir**
Up to 0.1	-	Insignificant
0.1 to 0.5	-	Significant
Above 0.5	-	Serious

Rate of Silt = Loss in Gross Capacity in M Cu. m/No of Years
Silt Index = (Silt Rate/Catchment area) x 10000
Annual % Loss = Loss in % of Gross Capacity/No of years

6.8 Conclusion

- By above table we can conclude that the capacity of reservoir is decreased significantly due to deposition of sediments in the reservoir. The annual percentage loss from survey of the year 1998 and 2021 is 1.18% and 0.22% respectively for FRL 214.59 m.
- The decrease in annual percentage loss from 1.18% (1998 survey) to 0.22% (2021 survey) for FRL 214.59 m may be because at initial stage after dam construction sedimentation takes place at higher rate compare to later on.
- The increase in storage capacity (19.236 M Cu. m increased in Gross Storage capacity) in 2021 survey data compared to 1998 survey data is due to difference in method used to acquire survey data of the reservoir during 1998 and 2021.

6.9 Methods for controlling the sedimentation

According to IS-6518:2017 there are several factors involved in controlling sedimentation in reservoirs and they relate to aspects on,

a) Design of reservoir.
b) Control of sediment inflow.
c) Control of sediment deposition.
d) Removal of sediments.

All these aspects are to be simultaneously taken note of and appropriate measures be adopted.

6.9.1 Design of Reservoirs

The capacity of reservoirs is governed by a number of factors which are covered in IS 5477 (Parts 1 to 4). From the point of view of sediment deposition, the following points may be given due consideration:

a) The sediment yield which depends on the topographical, geological and geomorphological set up, meteorological factors, land use/land cover, intercepting tanks, etc.;
b) Sediment delivery characteristics of the channel system;
c) The efficiency of the reservoir as sediment trap;
d) The ratio of capacity of reservoir to the inflow;
e) Configuration of reservoir;
f) Method of operation of reservoir; and
g) Provisions for silt exclusion.

- The rate of sediment delivery increases with the quantum of discharge.
- The percentage of sediment trapped by a reservoir with a given drainage area increases with the increased capacity. In some cases an increased capacity will however, result in greater loss of water due to evaporation. However, with the progress of sedimentation, there is decrease of storage capacity which in turn lowers the trap efficiency of the reservoir.

- The capacity of the reservoir and the size and characteristics of the reservoir and its drainage area are the most important factors governing the annual rate of accumulation of sediment. Periodical reservoir sedimentation surveys provide guidance on the rate of sedimentation. In the absence of observed data for the reservoir concerned, data from other reservoirs of similar capacity and catchment characteristics may be adopted.
- Sedimentation takes place not only in the dead storage but also in the live storage space in the reservoir. The practice for design of reservoir is to use the observed suspended sediment data available from key hydrologica1 networks and also the data available from hydrographic surveys of other reservoirs in the same region.

This data may be used to simulate sedimentation status over a period of reservoir life as mentioned in IS 12182.

- Raising the Dam at Periodic Intervals:

Engineering economic analysis of some reservoir projects probably would show that it is cheaper to build a substantially lower dam initially, and to raise it at intervals unti1 its ultimate height for the given original capacity so that long useful life may result. Stage-wise construction also provides lower trapping efficiency and less evaporation in the initial stages.

However, this method may not be feasible in all the existing dams. Wherever this method is contemplated, proper consideration should be given on the strength.

6.9.2 Control of Sediment Inflow

There are many methods for controlling sediment inflows and they can be divided as follows:

1. Watershed management/soil conservation measures to check production and transport of sediment in the catchment area

1.1. The engineering methods

1.1.1. Check Dams

a) They help to arrest degradation of stream bed thereby arresting the slope failure; and

b) They reduce the velocity of stream flow, thereby causing the deposition of the sediment load.

Check dams become necessary, where the channel gradients are steep and there is a heavy inflow of sediment from the watershed. They are constructed of local material like earth, rock, timber, etc. These are suitable for small catchment varying in size from 40 to 400 hectares. It is necessary to provide small check dams on the subsidiary streams flowing into the main streams besides the check dams in the main stream. Proper consideration should be given to the number and location of check dams required. It is preferable to minimize the height of the check dams. If the stream has, a very-steep slope, it is desirable to start with a smaller height for the check dams than may ultimately be necessary.

Check dams may generally cost more per unit of storage than the reservoirs they protect. Therefore, it may not always be possible to adopt them as a primary method of sediment control in new reservoirs. However, feasibility of providing check dams at later date should not be overlooked while planning the construction of a new reservoir

1.1.2. Contour Bunding and Trenching

These are important methods of controlling soil erosion on the hills and sloping lands, where gradients of cultivated fields or terraces are flatter, say up to 10 percent. By these methods the hill side is split up into small compartments on which the rain is retained and surface run-off is modified with prevention of soil erosion. In addition to contour bunding, side trenching is also provided as per requirement.

1.1.3. Gully Plugging

This is done by small rock fill dams. These dams will be effective in filling up the gullies with sediment coming from the upstream of the catchment and also prevent further widening of the gully.

1.1.4. Bank Protection

This is achieved by terracing, revetment, retaining walls, gabions and spurs.

1.2. Agronomy

The agronomic measures include establishment of vegetative screen, contour farming, strip cropping and crop rotation.

1.3. Forestry

Forestry measures include forest conservancy, control on grazing, lumbering, operations and forest fires along with management and protection of forest plantations.

2. Preventive measures to check inflow of sediment into the reservoir

2.1. Restricting the waste/sediment entering into the reservoirs due to agricultural and infrastructural activities surrounding the submergence.

2.2. Construction of by-pass channels or conduits.

The various methods in this category require the construction of some type of diversion dam or weir at the head of the reservoir basin, and a canal, tunnel or conduit leading around the reservoir to a point below the dam where the flow may re-enter the main channels. In such cases the flood flows of sediment laden water are by-passed to the downstream of the dam. In some cases where topography permits construction of new off channel reservoirs can be considered. These reservoirs will invariably have a forebay and check dam on the upstream for trapping the sediment. The stored water in the fore bay is led to the reservoir and the sediment trapped is flushed through by by-pass channel/ conduit/tunnel to the main channel downstream of the dam.

6.9.3 Control of Sediment Deposition

The deposition of sediment in a reservoir may be controlled to a certain extent by designing and operating gates or other outlets in the dam in such a manner as to permit selective withdrawals of water having a higher than average sediment content. The suspended sediment content of the water in reservoirs is higher during and just after flood flow. Thus, more the water wasted at such times, the smaller will be the percentage of the total sediment load to settle into permanent deposits. There are generally three methods:

- **Density current**

Water at various levels of a reservoir often contains radically different concentrations of suspended sediment particularly during and after flood flows. If all wastewater could be withdrawn at those levels where the concentration is highest, a significant amount of sediment might be removed from the reservoir. Because a submerged outlet draws water towards it from all directions, the vertical dimension of the opening should be small with respect to the thickness of the layer and the rate of withdrawal also should be low.

- **Waste-water release**

Controlling the sedimentation by controlling waste- water release is obviously possible only when water can be or should be wasted. This method is applicable only when a reservoir is of such size that a small part of large flood flows will fill it.

In the design of the dam, sediment may be passed through or over it as an effective method of silt control by placing a series of outlets at various elevations. The percentage of total sediment load that might be ejected from the reservoir through proper gate control will differ greatly with different locations. It is probable that as much as 20 percent of the sediment inflow could be passed through many reservoirs by venting through outlets designed and controlled.

- **Scouring Sluicing**

This method is somewhat similar to both the control of waste-water release and the draining and flushing methods

The distinctions amongst them are the following:

a) The waste-water release method ejects sediment laden flood flows through deep spillway gates or large under-sluices at the rate of discharge that prevents sedimentation.
b) Drainage and flushing method involves the slow release of stored water from the reservoir through small gates or valves making use of normal or low flow to entrain and carry the sediment, and
c) Scouring sluicing depends for its efficiency on either the scouring action exerted by the sudden rush of impounded water under a high head through under-sluices or on the scouring action of high flood discharge coming into the reservoir

Scouring sluicing method can be used in the following:

i. Small power dams that depend to a great extent on pondage but not on storage;
ii. Small irrigation reservoirs, where only a small fraction of the total annual flow can be stored;
iii. Any reservoir in narrow channels, gorges, etc, where water wastage can be afforded; and

iv. When the particular reservoir under treatment is a unit in an interconnected system so that the other reservoirs can supply the water needed.

6.9.4 Removal of Sediment Deposit

The most practical means of maintaining the storage capacity are those designed to prevent accumulation of permanent deposits as the removal operations are extremely expensive, unless the material removed is usable. Therefore, the redemption of lost storage by removal should be adopted as a last resort. The removal of sediment deposit implies in general, that the deposits are sufficiently compacted or consolidated to act as a solid and, therefore, are unable to flow along with the water. The removal of sediment deposits may be accomplished by a variety of mechanical and hydraulic or methods, such as excavation, dredging, siphoning, draining, flushing, flood sluicing, and sluicing aided by such measures as hydraulic or mechanical agitation or blasting of the sediment. The excavated sediments may be suitably disposed off so that, these do not find the way again in the reservoir.

1. Excavation

The method involves draining most of or all the water in the basin and removing the sediment by hand or power operated shovel, dragline scraper or other mechanical means.

The excavation of silt and clay, which constitute most of the material in larger reservoirs, is more difficult than the excavation of sand and gravel. Fine-textured sediment cannot be excavated easily from larger reservoirs unless it is relatively fluid or relatively compact.

2. Dredging

This involves the removal of deposits from the bottom of a reservoir and their conveyance to some other point by mechanical or hydraulic means, while water storage is being maintained.

Dredging practices are grouped as:

a) Mechanical dredging by bucket, ladder, etc;
b) Suction dredging with floating pipeline and a pump usually mounted on a barge; and
c) Siphon dredging with a floating pipe extending over the dam or connected to an opening in the dam and usually with a pump on a barge.

NOTES

1) Practicality of the two methods, namely, excavation and dredging, requires to be carefully considered in any particular case.
2) Suitable measures to prevent deposition of the dredged silt in the natural channel where it is discharged need to be adopted.

3. Draining and Flushing

The method involves relatively slow release of all stored water in a reservoir through gates or valves located near bottom of the dam and the maintenance thereafter of open outlets for a shorter or longer period during which normal stream flow cuts into or directed against the sediment deposits. Therefore, this method may be adopted in flood control reservoirs.

4. Sluicing with Controlled Water

This method differs from the flood sluicing in that the controlled water supply permits choosing the time of sluicing more advantageously and that the water may be directed more effectively against the sediment deposits. While the flood sluicing depends either on the occurrence of flood or on being able to release rapidly all of a full or nearly full supply of water in the main reservoir is empty. The advantage of this method is that generally more sediment can be removed per unit of water used than in flood scouring or draining and flushing.

5. Sluicing with Hydraulic and Mechanical Agitation

Methods that stir up break up or move deposits of sediment into a stream current flowing through a drained reservoir basin or into a lake current moving through and out of a full reservoir will tend to make the removal of sediment from the reservoir more complete. Wherever draining, flushing or sluicing appear to be warranted, the additional use of hydraulic means for stirring up the sediment deposits, or sloughing them off, into a stream flowing through the reservoir basin should be considered. It has, however, limited application.

6.10 Area – Capacity – Curve of Meshwo Reservoir:

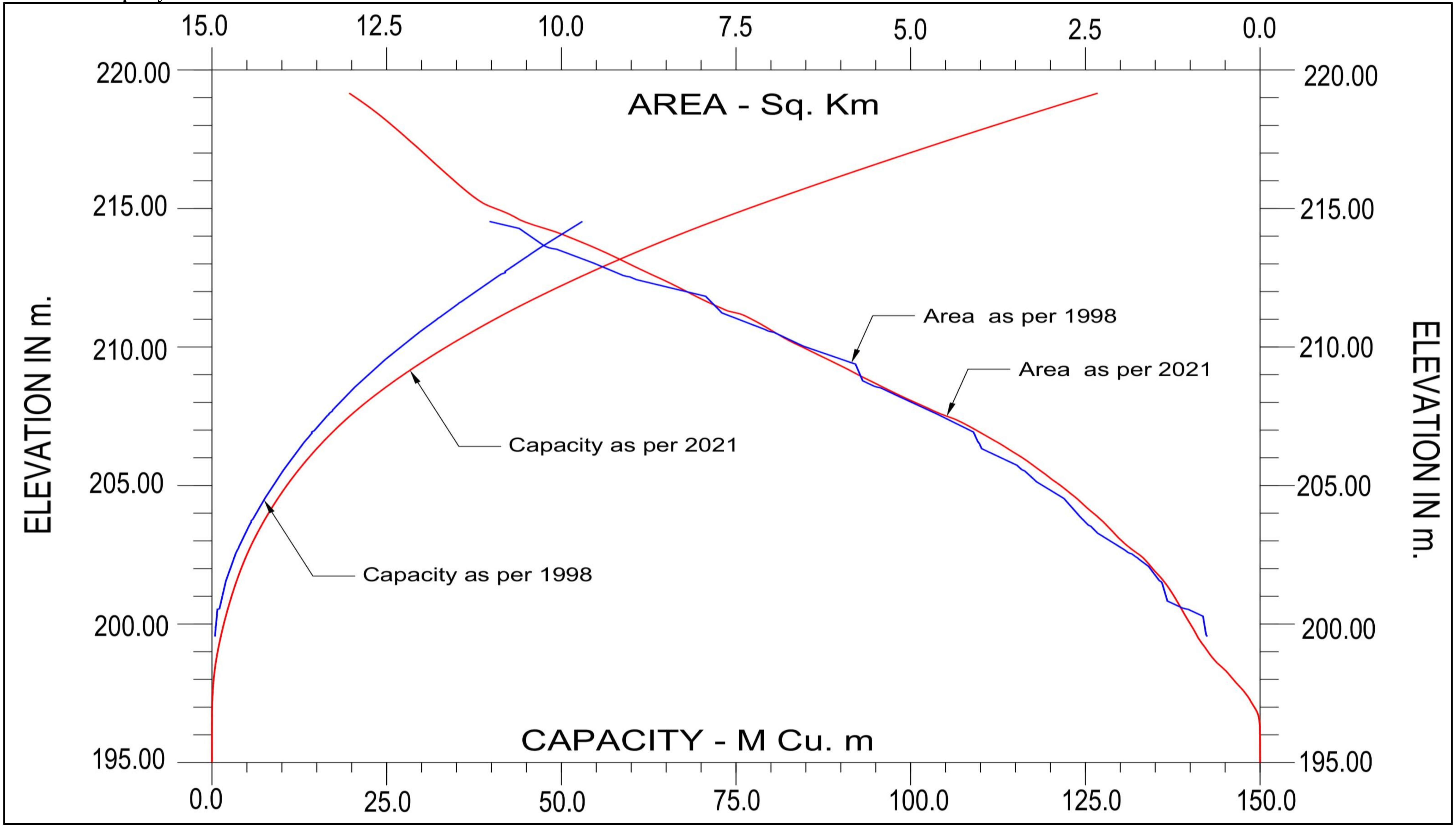


Figure 6.10-1 AREA – CAPACITY - CURVE

6.11 Segment, Contour, Wire Frame Map and L Section:

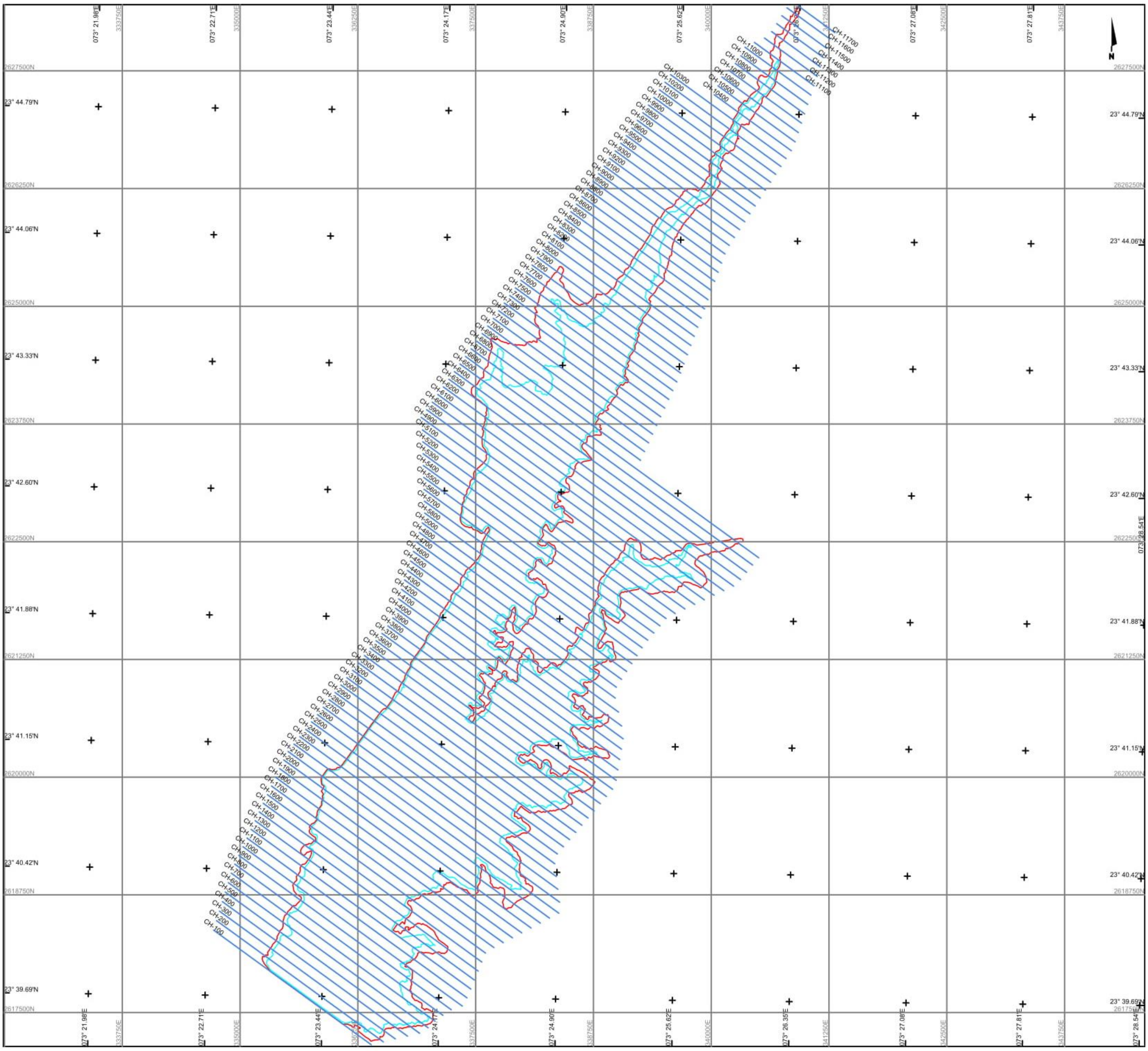


Figure 6.11-1 SEGMENT MAP FOR CROSS SECTION

Cross sections showing bed profile at 100m interval were prepared and are provided as soft copy in CD/Hard Disc. Total 117 cross section profiles were prepared.

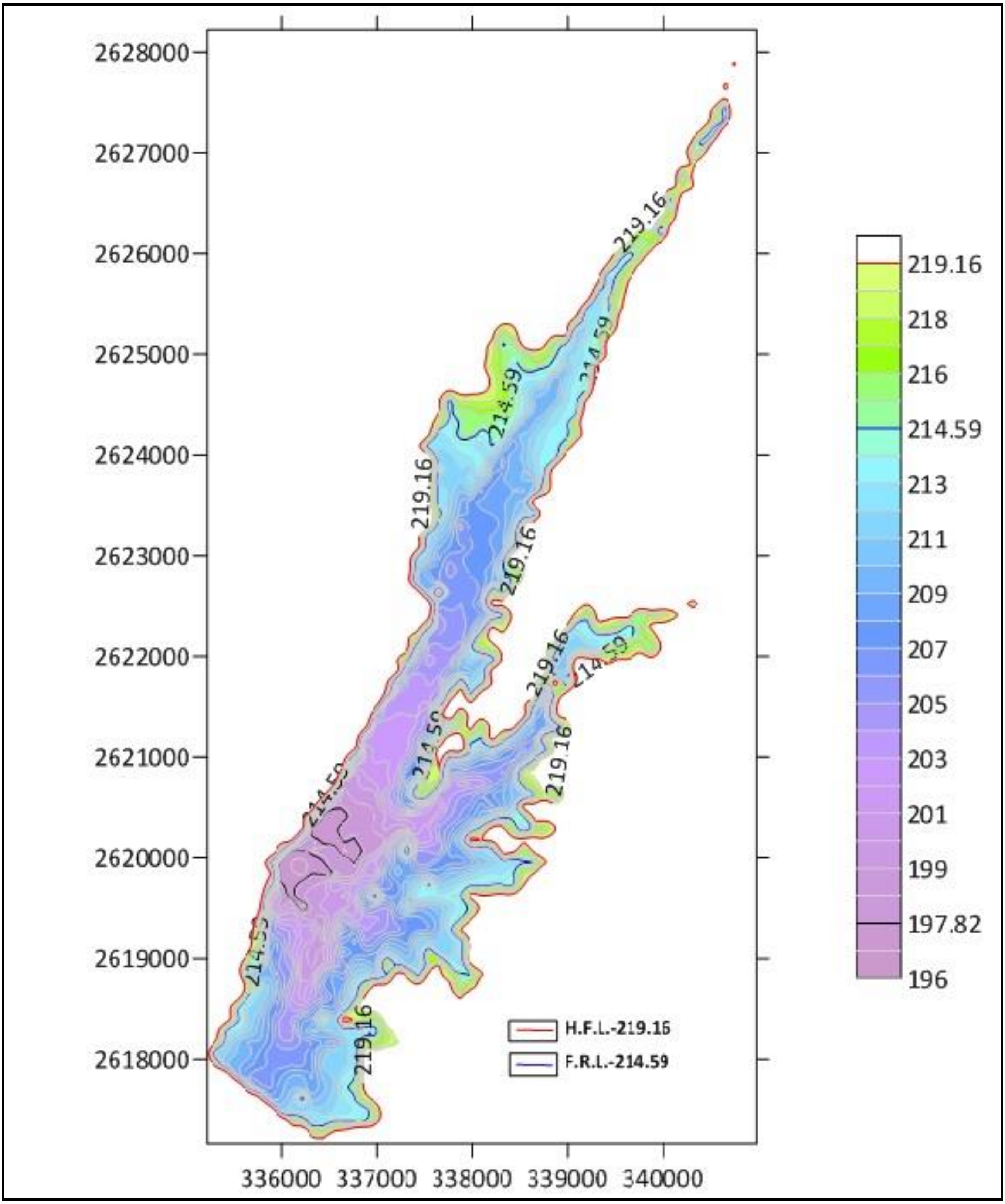


Figure 6.11-2 CONTOUR MAP

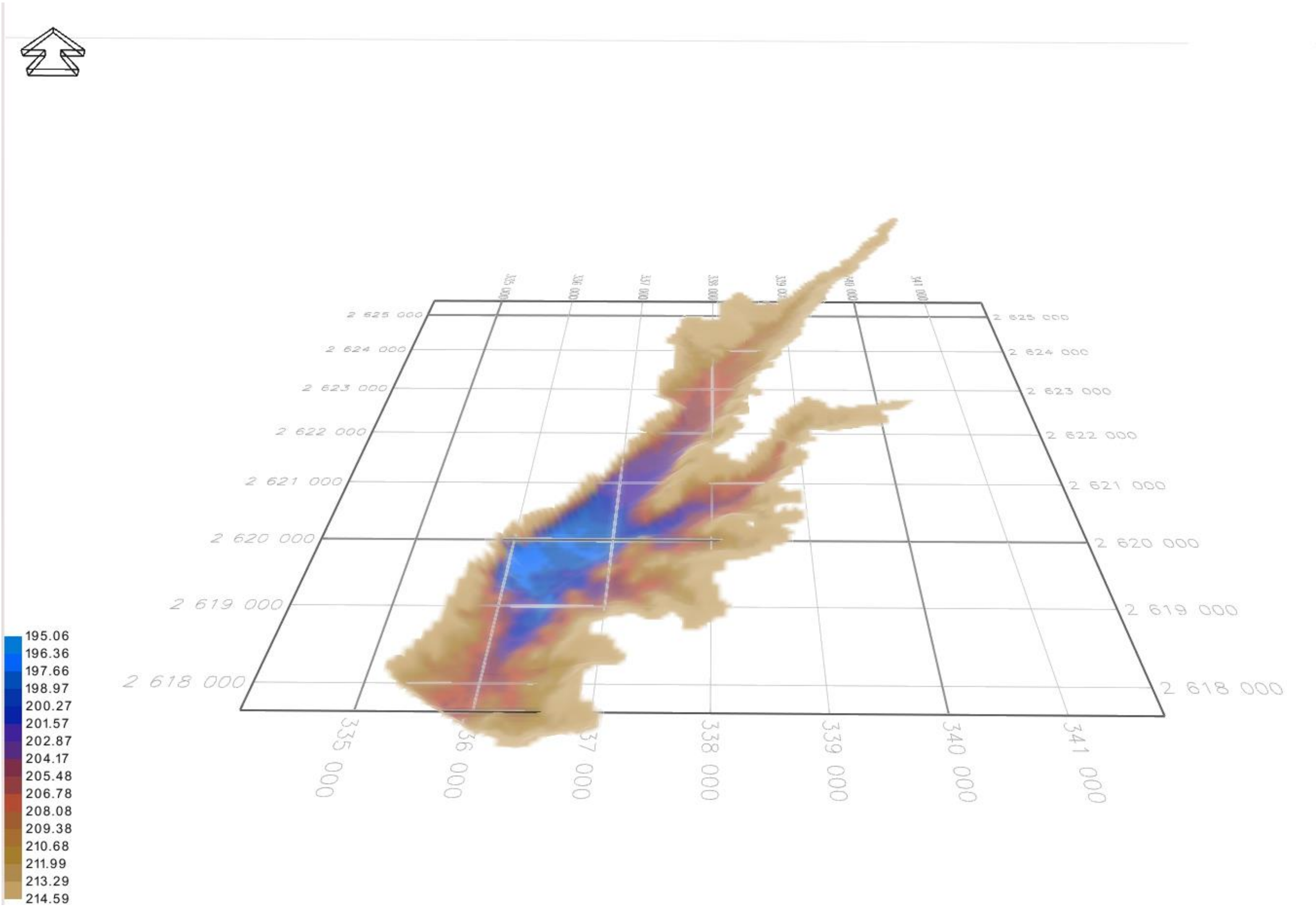


Figure 6.11-3 WIRE FRAME MAP

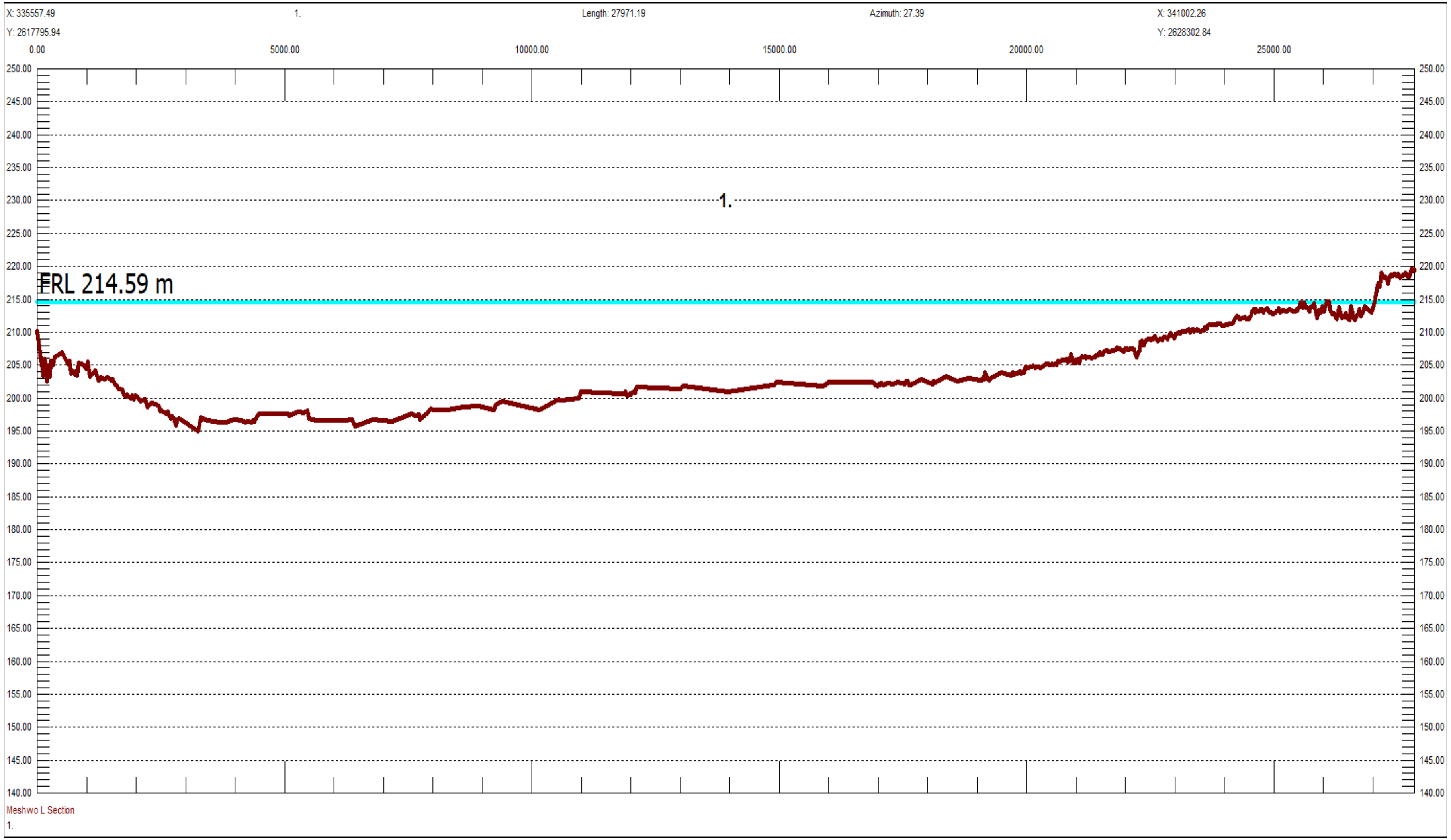


Figure 6.11-4 L SECTION

7 DGPS OBSERVATION REPORT

AUSPOS GPS Processing Report

February 1, 2021

This document is a report of the GPS data processing undertaken by the AUSPOS Online GPS Processing Service (version: AUSPOS 2.4) . The AUSPOS Online GPS Processing Service uses International GNSS Service (IGS) products (final, rapid, ultra-rapid depending on availability) to compute precise coordinates in International Terrestrial Reference Frame (ITRF) anywhere on Earth and Geocentric Datum of Australia (GDA) within Australia. The Service is designed to process only dual frequency GPS phase data.

An overview of the GPS processing strategy is included in this report.

Please direct any correspondence to geodesy@ga.gov.au

Geoscience Australia
Cnr Jerrabomberra and Hindmarsh Drive
GPO Box 378, Canberra, ACT 2601, Australia
Freecall (Within Australia): 1800 800 173
Tel: +61 2 6249 9111. Fax +61 2 6249 9929
Geoscience Australia
Home Page: http://www.ga.gov.au

AUSPOS 2.4 Job Number: # 1584
User: samrajdwivedi@gmail.com

1

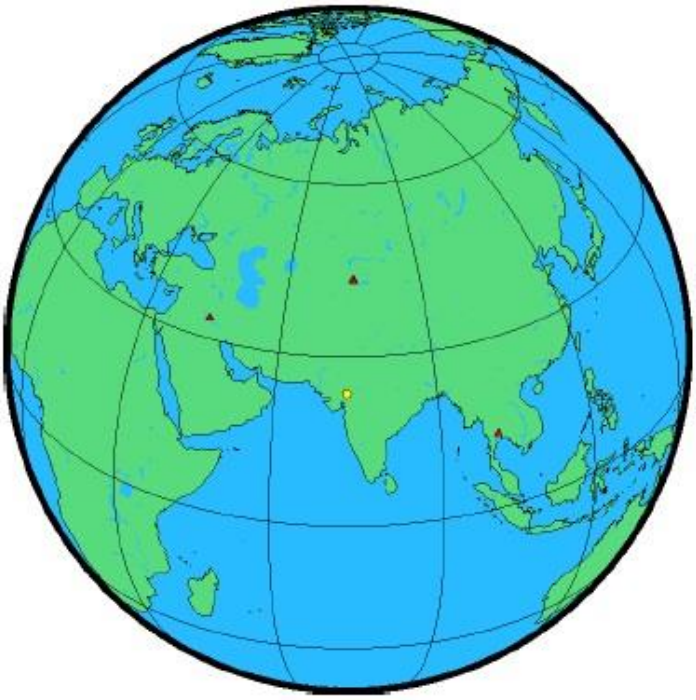
Australian Government
Geoscience Australia

1 User Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP).

Station (s)	Submitted File	Antenna Type	Antenna Height (m)	Start Time	End Time
MESH	MESH_31012021_164313.210	TIAPENG6 NONE	1.770	2021/01/31 08:44:00	2021/01/31 12:28:00

2 Processing Summary



Date	User Stations	Reference Stations	Orbit Type
2021/01/31 08:44:00	MESH	CHUM CUSV ISBA POL2	IGS ultra rapid

Australian Government
Geoscience Australia

3 Computed Coordinates, ITRF2014

All coordinates are based on the IGS realisation of the ITRF2014 reference frame. All the given ITRF2014 coordinates refer to a mean epoch of the site observation data. All coordinates refer to the Ground Mark.

3.1 Cartesian, ITRF2014

Station	X (m)	Y (m)	Z (m)	ITRF2014 @
MESH	1670548.173	5600470.058	2546260.689	31/01/2021
CHUM	1228950.351	4508080.005	4327868.539	31/01/2021
CUSV	-1132915.006	6092528.532	1504633.161	31/01/2021
ISBA	3808364.512	3734430.222	3485693.755	31/01/2021
POL2	1239970.930	4530790.163	4302578.878	31/01/2021

3.2 Geodetic, GRS80 Ellipsoid, ITRF2014

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/.

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
MESH	23 40 59.22865	73 23 27.00511	196.117	249.813
CHUM	42 59 54.60559	74 45 03.97462	716.338	759.328
CUSV	13 44 09.28917	100 32 02.12530	74.253	105.602
ISBA	33 20 29.10596	44 26 18.26215	72.361	73.968
POL2	42 40 47.17469	74 41 39.37351	1714.213	1754.279

3.3 UTM Grid, GRS80 Ellipsoid, ITRF2014

Station	East (m)	North (m)	Zone	Ellipsoidal Height (m)	Derived Above Geoid Height(m)
MESH	335917.097	2620069.824	43	196.117	249.813
CHUM	479712.405	4760678.448	43	716.338	759.328
CUSV	665854.724	1519047.240	47	74.253	105.602
ISBA	447740.895	3689278.419	38	72.361	73.968
POL2	474951.457	4725300.184	43	1714.213	1754.279

Australian Government
Geoscience Australia

3.4 Positional Uncertainty (95% C.L.) - Geodetic, ITRF2014

Station	Longitude(East) (m)	Latitude(North) (m)	Ellipsoidal Height(Up) (m)
MESH	34.701	17.628	21.697
CHUM	0.010	0.006	0.014
CUSV	0.011	0.008	0.015
ISBA	0.011	0.008	0.016
POL2	0.010	0.006	0.014

AUSPOS 2.4 Job Number: # 1584
User: samrajdwivedi@gmail.com

4

Australian Government
Geoscience Australia

4 Ambiguity Resolution - Per Baseline

Baseline	Ambiguities Resolved	Baseline Length (km)
CHUM - MESH	0.0 %	2135.992
CHUM - POL2	61.2 %	35.732
CHUM - ISBA	33.3 %	2821.554
CHUM - CUSV	15.0 %	4007.436
AVERAGE	27.4%	2250.178

Please note for a regional solution, such as used by AUSPOS, ambiguity resolution success rate of 50% or better for a baseline formed by a user site indicates a reliable solution.

5 Computation Standards

5.1 Computation System

Software	Bernese GNSS Software Version 5.2.
GNSS system(s)	GPS only.

5.2 Data Preprocessing and Measurement Modelling

Data preprocessing	Phase preprocessing is undertaken in a baseline by baseline mode using triple-differences. In most cases, cycle slips are fixed by the simultaneous analysis of different linear combinations of L1 and L2. If a cycle slip cannot be fixed reliably, bad data points are removed or new ambiguities are set up A data screening step on the basis of weighted postfit residuals is also performed, and outliers are removed.
Basic observable	Carrier phase with an elevation angle cutoff of 7° and a sampling rate of 3 minutes. However, data cleaning is performed a sampling rate of 30 seconds. Elevation dependent weighting is applied according to $1/\sin(e)^2$ where e is the satellite elevation.
Modelled observable	Double differences of the ionosphere-free linear combination.
Ground antenna phase centre calibrations	IGS14 absolute phase-centre variation model is applied.
Tropospheric Model	A priori model is the GMF mapped with the DRY-GMF.
Tropospheric Estimation	Zenith delay corrections are estimated relying on the WET-GMF mapping function in intervals of 2 hour. N-S and E-W horizontal delay parameters are solved for every 24 hours.
Tropospheric Mapping Function	GMF
Ionosphere	First-order effect eliminated by forming the ionosphere-free linear combination of L1 and L2. Second and third effect applied.
Tidal displacements	Solid earth tidal displacements are derived from the complete model from the IERS Conventions 2010, but ocean tide loading is not applied.
Atmospheric loading	Applied
Satellite centre of mass correction	IGS14 phase-centre variation model applied
Satellite phase centre calibration	IGS14 phase-centre variation model applied
Satellite trajectories	Best available IGS products.
Earth Orientation	Best available IGS products.

Australian Government
Geoscience Australia

5.3 Estimation Process

Adjustment	Weighted least-squares algorithm.
Station coordinates	Coordinate constraints are applied at the Reference sites with standard deviation of 1mm and 2mm for horizontal and vertical components respectively.
Troposphere	Zenith delay parameters and pairs of horizontal delay gradient parameters are estimated for each station in intervals of 2 hours and 24 hours.
Ionospheric correction	An ionospheric map derived from the contributing reference stations is used to aid ambiguity resolution.
Ambiguity	Ambiguities are resolved in a baseline-by-baseline mode using the Code-Based strategy for 180-6000km baselines, the Phase-Based L5/L3 strategy for 18-200km baselines, the Quasi-Ionosphere-Free (QIF) strategy for 18-2000km baselines and the Direct L1/L2 strategy for 0-20km baselines.

5.4 Reference Frame and Coordinate Uncertainty

Terrestrial reference frame	IGS14 station coordinates and velocities mapped to the mean epoch of observation.
Australian datums	GDA2020 and GDA94.
Derived AHD	For stations within Australia, AUSGeoid2020 (V20180201) is used to compute AHD. AUSGeoid2020 is the Australia-wide gravimetric quasigeoid model that has been a posteriori fitted to the AHD. For reference, derived AHD is always determined from the GDA2020 coordinates. In the GDA94 section of the report, AHD values are assumed to be identical to those derived from GDA2020.
Above-geoid heights	Earth Gravitational Model EGM2008 released by the National Geospatial-Intelligence Agency (NGA) EGM Development Team is used to compute above-geoid heights. This gravitational model is complete to spherical harmonic degree and order 2159, and contains additional coefficients extending to degree 2190 and order 2159.
Coordinate uncertainty	Coordinate uncertainty is expressed in terms of the 95% confidence level for GDA94, GDA2020 and ITRF2014. Uncertainties are scaled using an empirically derived model which is a function of data span, quality and geographical location.

8 SINGLE BEAM ECHOSOUNDER BAR CHECK RESULTS

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title: Bathymetric Survey		Vessel: Inflatable Boat		Place: Meshwo Dam
Date: 28-Jan-21	Time: 12:45				
Observed By: Amit Singh			Echosounder Model and SL. No. Sonarmite		Area Depth 15

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0				1500	10
Barcheck Frequency selected		Survey Frequency:		Manufacturer's Accuracy	
210		210		0.20 % of Depth	0.03 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.02	-0.02	10	10	0
4	3.99	0.01	8	8.01	-0.01
6	5.98	0.02	6	6.01	-0.01
8	8.01	-0.01	4	3.99	0.01
10	9.99	0.01	2	2	0
	Average	0.0020		Average	-0.0020
	Std. Dev	0.0164		Std. Deviation	0.0084
			Cumulative Average		0.00
			Cumulative Std. Deviation		0.0057

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**Meshwo Dam**
Date:	Time:		
29-Jan-21	**9:05**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**12**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			**Observations while hoisting**		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.01	-0.01	10	10.01	-0.01
4	4.02	-0.02	8	7.99	0.01
6	5.98	0.02	6	6.01	-0.01
8	7.98	0.02	4	3.99	0.01
10	9.99	0.01	2	2.01	-0.01

Average	0.0040	Average	-0.0020
Std. Dev	0.0182	Std. Deviation	0.0110
		Cumulative Average	0.00
		Cumulative Std. Deviation	0.0051

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title: **Bathymetric Survey**		Vessel: **Inflatable Boat**		Place: **Meshwo Dam**
Date: **30-Jan-21**	Time: **9:15**				
Observed By: **Amit Singh**			Echosounder Model and SL. No. **Sonarmite**		Area Depth **9**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0				1500	6
Barcheck Frequency selected		Survey Frequency:		Manufacturer's Accuracy	
210		210		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.01	-0.01	6	6.01	-0.01
4	3.99	0.01	4	4.01	-0.01
6	6.02	-0.02	2	2	0
	Average	-0.0067		Average	-0.0067
	Std. Dev	0.0153		Std. Deviation	0.0058
				Cumulative Average	-0.01
				Cumulative Std. Deviation	0.0067

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**Meshwo Dam**
Date: **31-Jan-21**	Time: **9:05**		
Observed By: **Amit Singh**		Echosounder Model and SL. No. **Sonarmite**	Area Depth **14**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0				1500	10
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		210		0.20 % of Depth	0.03 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.02	-0.02	10	9.98	0.02
4	4.01	-0.01	8	7.99	0.01
6	5.99	0.01	6	6.01	-0.01
8	7.98	0.02	4	4.02	-0.02
10	10	0	2	2	0
	Average	0.0000		Average	0.0000
	Std. Dev	0.0158		Std. Deviation	0.0158
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0000

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**Meshwo Dam**
Date: **1-Feb-21**	Time: **9:40**		
Observed By: **Amit Singh**		Echosounder Model and SL. No. **Sonarmite**	Area Depth **10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0				**1500**	**8**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.01	-0.01	8	8.01	-0.01
4	3.99	0.01	6	5.99	0.01
6	6.02	-0.02	4	3.99	0.01
8	7.99	-0.01	2	2.01	0.01
	Average	-0.0075		Average	0.0050
	Std. Dev	0.0126		Std. Deviation	0.0100
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0018

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title: **Bathymetric Survey**	Vessel: **Inflatable Boat**	Place: **Meshow Dam**
Date: **2-Feb-21**	Time: **9:15**		
Observed By: **Amit Singh**		Echosounder Model and SL. No. **Sonarmite**	Area Depth **10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0				1500	10
Barcheck Frequency selected		Survey Frequency:		Manufacturer's Accuracy	
210		210		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
4	4.02	-0.02	10	10.01	-0.01
6	5.98	0.02	8	7.99	0.01
8	8.01	-0.01	6	5.98	0.02
10	9.98	0.02	4	4.01	-0.01
	Average	0.0025		Average	0.0025
	Std. Dev	0.0206		Std. Deviation	0.0150
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0040

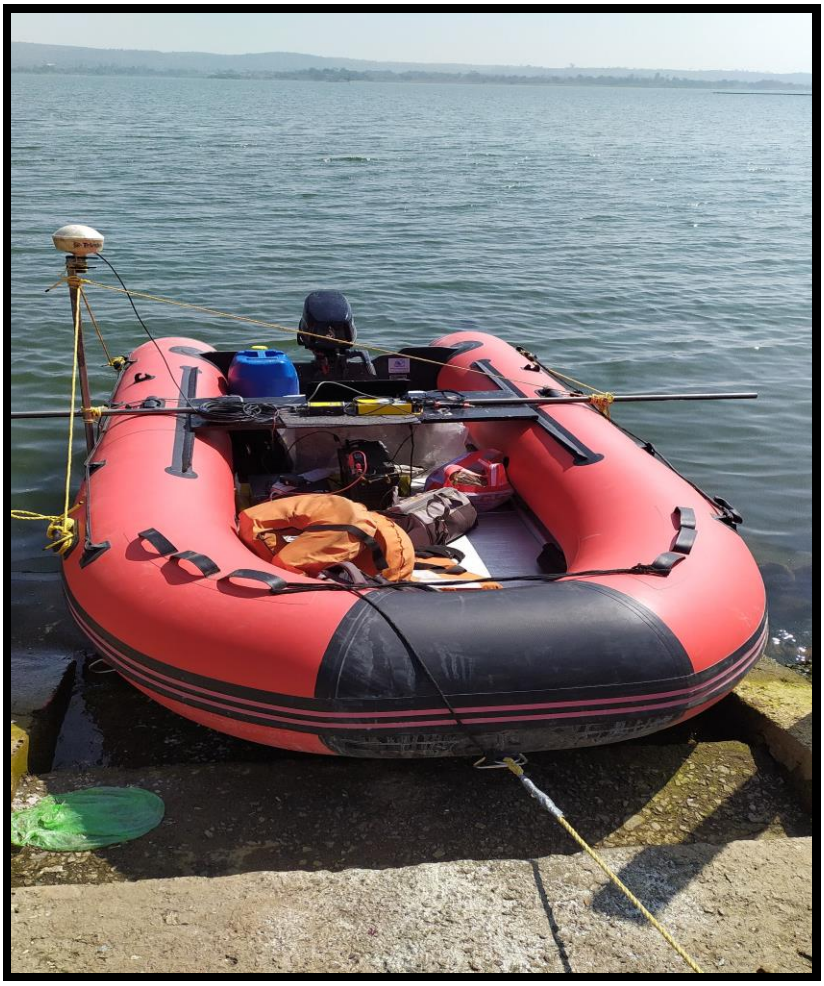
The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

9 PHOTOGRAPHS

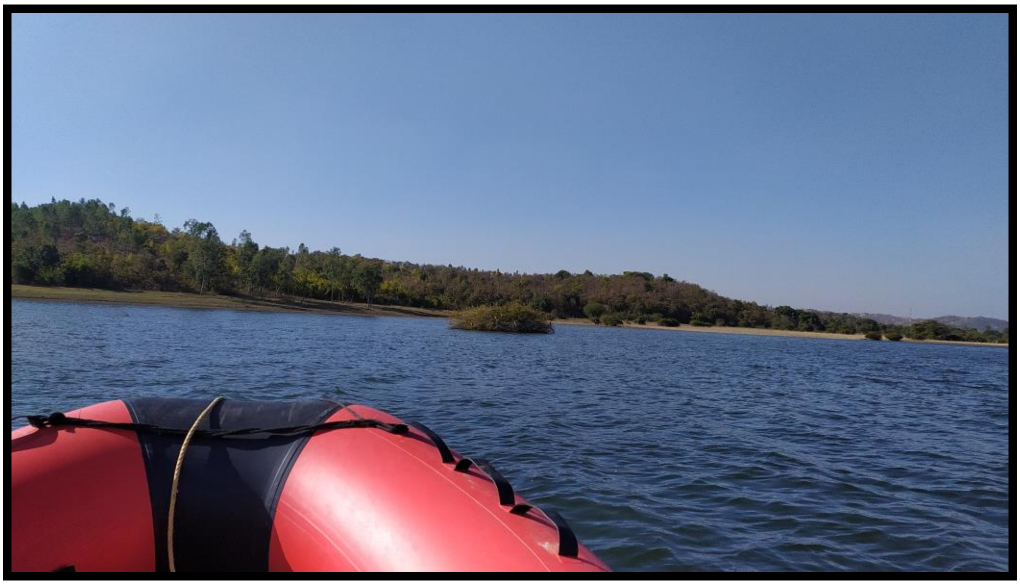
The following Photographs showing the Survey activities and features available at site



Configuration of SBES Equipment

RTK Observation At Dam Top

Water Level



Survey in process

Dam Pillars

Dam Water level Scale

END OF REPORT