GEOSERVICES
MARITIME PVT. LTD.

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

GMPL REPORT NUMBER: P-SUR-BATHY-009-2020-WRD-DANTIWADA
SURVEY PERIOD: 23 JAN TO 27 JAN 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

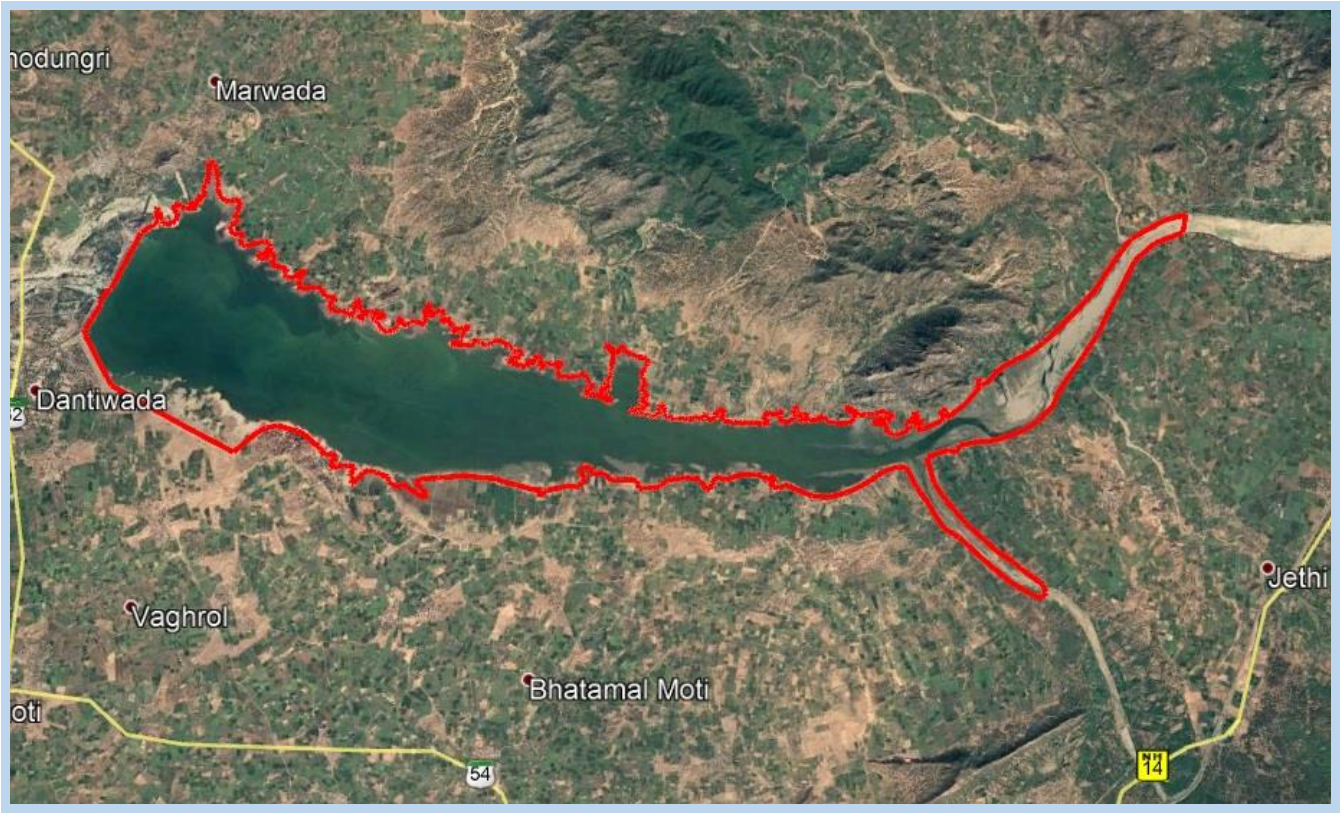

Figure 1.1-1 LOCATION MAP

LOCATION MAP SHOWING SURVEY AREA "DANTIWADA RESERVOIR", GUJARAT, INDIA

DOCUMENT ARRANGEMENT

REPORT OF SURVEY WITH CHART / DRAWING

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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 Dantiwada 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 Dantiwada 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 8 Jan 2021".

1.2 Objective

The client's objectives were:

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 Dantiwada Reservoir.

The detailed scope of work was:

i) To measure the water depth of the Dantiwada 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.

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 0.10 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 DANTIWADA RESERVOIR

The Dantiwada is major irrigation project, constructed on the Banas River near village Dantiwada of Dantiwada taluka in Banaskantha district, Gujarat State. It was impounded in the year 1965. The reservoir is mainly for irrigation and water supply purpose.Total catchment area of Dantiwada reservoir is 2862sq.km. The full reservoir level (FRL) is 184.15m and Minimum Draw Down Level (MDDL) is 161.85m. The gross storage capacity is 464.39 mm^3 including dead storage of 19.68 mm^3 and live storage of 444.71 mm^3.

DANTIWADA IRRIGATION SCHEME		
I	**Location**	
	Coordinates	Latitude 24°20'2" N Longitude 72°21'37" E
	River	Banas
	Village	Dantiwada
	Taluka	Dahenra
	District	Banaskantha
II	**Reservoir Details**	
	Catchment Area	2862 km^2
	Top of Dam	187.2
	HFL/MWL	185.06
	FRL	184.15 m
	MDDL	161.85 m
	Dead Storage Capacity	6.21 mcm
	Live Storage Capacity	387.64 mcm
	Gross Storage Capacity	464.39 mm^3
	Area under submergence at FRL	174.00 Ha
III	**Spillway Details**	
	Length	165 m
	Crest level of Spillway	175.91 m
	Type of Spillway	Ogee
	Maximum Discharge Capacity	7504 m^3/s
	No. of Radial Gates	11
	Size of Radial Gates	12.5 m x 8.23 m
V	**Dam Details**	
	Type of Dam	Earthen and Masonry
	Length of Top of Dam	4832 m
VI	**Canal Details**	
	Length of Canal	48 km
	Capacity	31 m^3/s
	Gross Command Area	80939 ha
	Cultural Command Area	59895 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 Dantiwada Reservoir survey area from 8 Jan to 21 Jan 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 (215 kHz) were utilised to acquire the bathymetric data within the Dantiwada 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 Dantiwada Reservoir area.

Four (4) hours of DGPS observation was carried out at OBS DANT, which was on the top of Reservoir

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

- The Minimum elevation within Dantiwada Reservoir is 155.47 m above MSL and
- The Maximum depth within Dantiwada Reservoir is 19.73 m.
- Area covered by bathymetric survey is 20.813 Sq. Km.
- Area covered by topographic survey is 19.515 Sq. KM

According to recent survey, total area of reservoir at FRL 184.15 m is 38.983 Sq. Km, corresponding storage capacity is 399.066 M Cu. m, and Dead storage at 161.85 m is 5.108 M Cu. m.

The comparison between 1965 and 2021(56 years) data results in a rate of siltation (silt index) of 4.076 Ham/100 Sq. Km/year. Annual percentage loss of gross storage capacity, live storage capacity and dead storage capacity is 0.25%, 0.20% and 1.32% respectively.

The comparison of 2007 and 2021 data with respect to 1965 impounding data at FRL 184.15 m results in silt index of 5.745 Ham/100 Sq. Km/year and 4.076 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
Nikhil Chavan	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 Dantiwada 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	DGPS Trimble DSM 232
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.

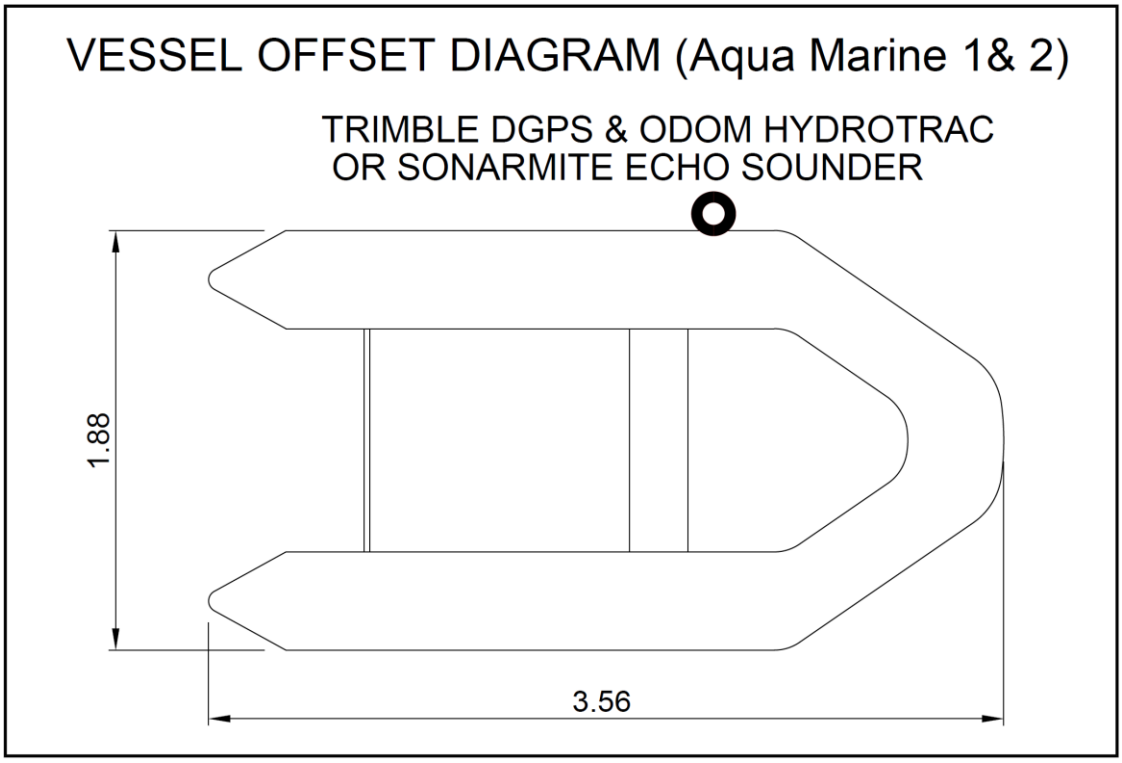

Figure 4.3-1 SURVEY BOAT ' AQUA MARINE' OFFSET DIAGRAM

5 DETAILED METHODOLOGY OF SURVEY

5.1 Mobilisation

The bathymetric survey equipment were mobilised on board "Aqua Marine" on 8 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 "Acqua Marine" as per figure given below.

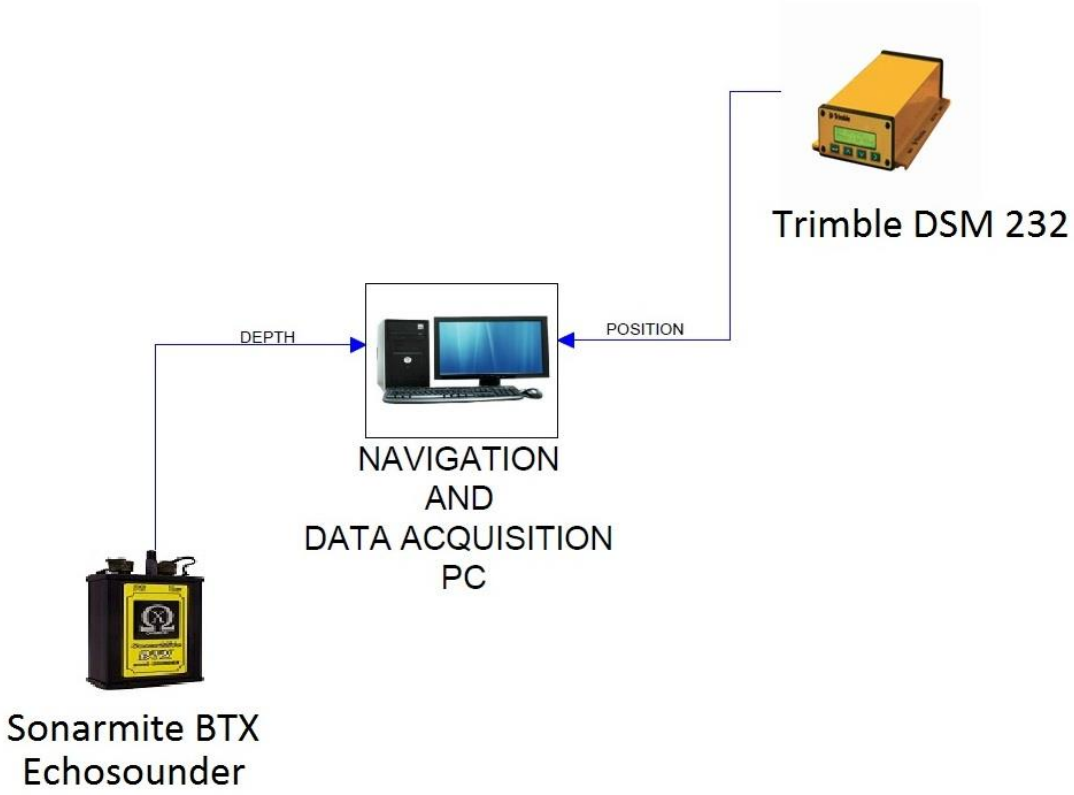

Figure 5.1-1 SBES SURVEY EQUIPMENT CONFIGURATION DIAGRAM ON BOARD

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

Four (4) hours of DGPS observation was carried out at OBS DANT (Next to CH-1230 old marking), which was on the top of Reservoir. Two (2) Temporary Bench Marks were marked, locations are easily accessible via Table given below.

The details of Bench Marks are presented in the table below:

T.BM. Information - DANTIWADAReservoir, South Gujarat					
Location	**Latitude (N)**	**Longitude (E)**	**Easting (m)**	**Northing (m)**	**Elevation (m) W.r.t MSL**
OBS DANT	24°20'12.6924"	72°20'19.255"	229959.146	2694108.144	187.2
T.B.M. 1	24°20'25.9188"	72°20'25.919"	230154.894	2694511.532	188.698
T.B.M. 2	24°20'41.8236"	72°20'32.86"	230359.929	2694997.335	188.831

Table 5.3-1 BENCH MARK DETAILS

Figure 5.3-1 RTK BASE SET UP

5.3.2 Topographic and Bathymetric Survey

For topographic survey, Pentax RTK base was used for DGPS observation on top of dam, near spillway. Four Hrs. of DGPS observation was carried out on OBS DANT. RTK DGPS Base station was set up at OBS DANT, 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, installed, operated and maintained 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 has deployed and in principle, higher frequency of 215 kHz has operated. Echo Sounder equipment has 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.
- Pentax RTK Base station was set up at the OBS DANT and configured to transmit the corrections.
- Pentax RTK Rover was used for Topographic survey and two TBM were established to cover whole area.

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.

Navigation

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

Echo Sounder

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 Dantiwada Reservoir with due, consent from Client Representative, the survey equipment on board were demobilised on 27 Jan 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.
- The depth sounding obtained from SBES were reduced to MSL with the help of observed water level in the reservoir.
- 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)
08/01/2021	1000	175.73
	1900	175.73
09/01/2021	0800	175.66
	19:00	175.61
10/01/2021	0800	175.56
	1900	175.52
11/01/2021	0800	175.49
	1900	175.46
12/01/2021	0800	175.40
	2000	175.35
13/01/2021	0800	175.31
	1900	175.27
14/01/2021	0800	175.21
	1900	175.18
15/01/2021	0800	175.14
	1900	175.09
17/01/2021	0800	174.97
	1900	174.94

Date	Time	Water Level (meters)
18/01/2021	0800	174.89
	1900	174.85
19/01/2021	0800	174.80
	1900	174.76
20/01/2021	0800	174.71
	1900	174.68
21/01/2021	0800	174.65
	1900	174.62

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

Ten drawings have been prepared for DANTIWADA 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-004-DANTIWADA-BATHY-01	Bathy part 1	Paper size A0 (1:5000)	PDF & CAD
2	P-SUR-004-DANTIWADA-BATHY-01	Bathy part 2	Paper size A0 (1:5000)	PDF & CAD
3	P-SUR-004-DANTIWADA-BATHY-01	Bathy part 3	Paper size A0 (1:5000)	PDF & CAD
4	P-SUR-004-DANTIWADA-BATHY-01	Bathy part 4	Paper size A0 (1:5000)	PDF & CAD
5	P-SUR-004-DANTIWADA-BATHY-01	Bathy part 5	Paper size A0 (1:5000)	PDF & CAD
6	P-SUR-004-DANTIWADA-BATHY-01	Bathy part 6	Paper size A0 (1:20000)	PDF & CAD
7	P-SUR-004-DANTIWADA-OVERVIEW-01	Overview Map of Reservoir	Paper size A3	PDF & CAD
8	Area Capacity Curve DANTIWADA -2021	Area Capacity curve of Reservoir	Paper size A3	PDF & CAD
9	DANTIWADA Cross Sections	37 Cross Section at 100 m interval	Only soft copy	CAD
10	DANTIWADA L-Section	L-Section of Reservoir	Only soft copy	CAD

Table 5.8-2 LIST OF CHARTS

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 Dantiwada reservoir.

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

- The Minimum elevation within Dantiwada Reservoir is 155.47 m above MSL and
- The Maximum depth within Dantiwada Reservoir is 19.73 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:

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

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
155.00	0.000	0.000	0.000	0.000	0.000	
155.10	0.000	0.000	0.000	0.000	0.000	
155.20	0.000	0.000	0.000	0.000	0.000	
155.30	0.000	0.000	0.000	0.000	0.000	
155.40	0.000	0.000	0.000	0.000	0.000	
155.50	0.000	0.000	0.000	0.000	0.001	
155.60	0.001	0.000	0.001	0.001	0.020	
155.70	0.004	0.000	0.004	0.004	0.041	
155.80	0.010	0.000	0.010	0.010	0.081	
155.90	0.021	0.000	0.021	0.021	0.132	
156.00	0.037	0.000	0.037	0.036	0.177	
156.10	0.056	0.000	0.056	0.056	0.218	
156.20	0.081	0.000	0.081	0.080	0.265	

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
156.30	0.108	0.000	0.108	0.107	0.286	
156.40	0.138	0.000	0.138	0.137	0.301	
156.50	0.169	0.000	0.169	0.168	0.322	
156.60	0.202	0.000	0.202	0.201	0.343	
156.70	0.237	0.000	0.237	0.237	0.364	
156.80	0.275	0.000	0.275	0.274	0.381	
156.90	0.314	0.000	0.314	0.313	0.401	
157.00	0.355	0.000	0.355	0.354	0.423	
157.10	0.398	0.000	0.398	0.397	0.444	
157.20	0.444	0.000	0.444	0.443	0.466	
157.30	0.492	0.000	0.492	0.491	0.492	
157.40	0.542	0.000	0.542	0.541	0.515	
157.50	0.595	0.000	0.595	0.594	0.539	
157.60	0.650	0.000	0.650	0.649	0.561	
157.70	0.707	0.000	0.707	0.706	0.585	
157.80	0.767	0.000	0.767	0.766	0.605	
157.90	0.828	0.000	0.828	0.827	0.625	
158.00	0.891	0.000	0.891	0.891	0.642	
158.10	0.957	0.000	0.957	0.956	0.661	
158.20	1.024	0.000	1.024	1.023	0.677	
158.30	1.092	0.000	1.092	1.091	0.692	
158.40	1.162	0.000	1.162	1.161	0.709	
158.50	1.234	0.000	1.234	1.233	0.726	
158.60	1.307	0.000	1.307	1.306	0.742	
158.70	1.382	0.000	1.382	1.381	0.759	
158.80	1.459	0.000	1.459	1.458	0.777	
158.90	1.538	0.000	1.538	1.537	0.797	
159.00	1.618	0.000	1.618	1.617	0.818	
159.10	1.701	0.000	1.701	1.700	0.837	
159.20	1.786	0.000	1.786	1.785	0.857	
159.30	1.873	0.000	1.873	1.872	0.878	
159.40	1.961	0.000	1.961	1.961	0.900	
159.50	2.053	0.000	2.053	2.052	0.923	
159.60	2.146	0.000	2.146	2.145	0.944	
159.70	2.242	0.000	2.242	2.241	0.969	
159.80	2.340	0.000	2.340	2.339	0.995	
159.90	2.441	0.000	2.441	2.440	1.021	

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
160.00	2.544	0.000	2.544	2.543	1.049	
160.10	2.650	0.000	2.650	2.649	1.077	
160.20	2.759	0.000	2.759	2.759	1.105	
160.30	2.871	0.000	2.871	2.871	1.136	
160.40	2.987	0.000	2.987	2.986	1.167	
160.50	3.105	0.000	3.105	3.104	1.200	
160.60	3.227	0.000	3.227	3.226	1.235	
160.70	3.352	0.000	3.352	3.351	1.273	
160.80	3.481	0.000	3.481	3.481	1.312	
160.90	3.614	0.000	3.614	3.614	1.351	
161.00	3.752	0.000	3.752	3.751	1.391	
161.10	3.893	0.000	3.893	3.892	1.433	
161.20	4.038	0.000	4.038	4.037	1.476	
161.30	4.188	0.000	4.188	4.187	1.524	
161.40	4.343	0.000	4.343	4.342	1.575	
161.50	4.503	0.000	4.503	4.503	1.627	
161.60	4.669	0.000	4.669	4.668	1.685	
161.70	4.840	0.000	4.840	4.839	1.742	
161.80	5.017	0.000	5.017	5.017	1.801	
161.85	**5.108**	**0.000**	**5.108**	**5.107**	**1.831**	**MDDL**
161.90	5.108	0.092	5.200	5.200	1.862	
162.00	5.108	0.282	5.390	5.389	1.926	
162.10	5.108	0.478	5.586	5.585	1.996	
162.20	5.108	0.681	5.789	5.788	2.065	
162.30	5.108	0.891	5.999	5.998	2.131	
162.40	5.108	1.107	6.215	6.214	2.194	
162.50	5.108	1.329	6.437	6.437	2.258	
162.60	5.108	1.559	6.667	6.666	2.324	
162.70	5.108	1.794	6.902	6.901	2.387	
162.80	5.108	2.036	7.144	7.143	2.451	
162.90	5.108	2.284	7.392	7.392	2.513	
163.00	5.108	2.539	7.647	7.646	2.572	
163.10	5.108	2.799	7.907	7.906	2.636	
163.20	5.108	3.066	8.174	8.173	2.697	
163.30	5.108	3.338	8.446	8.446	2.757	
163.40	5.108	3.617	8.725	8.725	2.823	
163.50	5.108	3.903	9.011	9.010	2.888	

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
163.60	5.108	4.195	9.303	9.302	2.953	
163.70	5.108	4.493	9.601	9.601	3.016	
163.80	5.108	4.798	9.906	9.905	3.079	
163.90	5.108	5.109	10.217	10.216	3.143	
164.00	5.108	5.427	10.535	10.534	3.206	
164.10	5.108	5.750	10.859	10.858	3.271	
164.20	5.108	6.081	11.189	11.188	3.341	
164.30	5.108	6.419	11.527	11.526	3.416	
164.40	5.108	6.764	11.872	11.871	3.489	
164.50	5.108	7.117	12.225	12.224	3.568	
164.60	5.108	7.478	12.586	12.585	3.650	
164.70	5.108	7.847	12.955	12.954	3.729	
164.80	5.108	8.223	13.331	13.331	3.804	
164.90	5.108	8.607	13.716	13.715	3.878	
165.00	5.108	8.999	14.107	14.106	3.954	
165.10	5.108	9.399	14.507	14.506	4.039	
165.20	5.108	9.807	14.915	14.914	4.117	
165.30	5.108	10.222	15.331	15.330	4.202	
165.40	5.108	10.647	15.755	15.755	4.290	
165.50	5.108	11.081	16.189	16.188	4.383	
165.60	5.108	11.523	16.632	16.631	4.475	
165.70	5.108	11.976	17.084	17.083	4.566	
165.80	5.108	12.437	17.545	17.544	4.656	
165.90	5.108	12.907	18.015	18.014	4.748	
166.00	5.108	13.386	18.495	18.494	4.846	
166.10	5.108	13.876	18.984	18.984	4.944	
166.20	5.108	14.376	19.484	19.483	5.050	
166.30	5.108	14.886	19.994	19.993	5.151	
166.40	5.108	15.406	20.514	20.514	5.255	
166.50	5.108	15.937	21.045	21.044	5.359	
166.60	5.108	16.478	21.586	21.585	5.465	
166.70	5.108	17.030	22.138	22.137	5.569	
166.80	5.108	17.592	22.700	22.699	5.674	
166.90	5.108	18.165	23.273	23.272	5.781	
167.00	5.108	18.748	23.856	23.855	5.885	
167.10	5.108	19.342	24.450	24.449	5.995	
167.20	5.108	19.947	25.055	25.055	6.111	

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
167.30	5.108	20.564	25.672	25.672	6.230	
167.40	5.108	21.194	26.302	26.301	6.362	
167.50	5.108	21.837	26.945	26.944	6.501	
167.60	5.108	22.494	27.602	27.602	6.645	
167.70	5.108	23.166	28.274	28.274	6.799	
167.80	5.108	23.854	28.962	28.962	6.957	
167.90	5.108	24.558	29.666	29.666	7.123	
168.00	5.108	25.279	30.387	30.387	7.300	
168.10	5.108	26.017	31.125	31.125	7.459	
168.20	5.108	26.771	31.879	31.879	7.622	
168.30	5.108	27.541	32.649	32.649	7.781	
168.40	5.108	28.328	33.436	33.435	7.949	
168.50	5.108	29.131	34.239	34.238	8.109	
168.60	5.108	29.949	35.057	35.057	8.266	
168.70	5.108	30.784	35.892	35.891	8.426	
168.80	5.108	31.635	36.743	36.742	8.586	
168.90	5.108	32.501	37.609	37.609	8.744	
169.00	5.108	33.383	38.491	38.490	8.893	
169.10	5.108	34.279	39.387	39.387	9.032	
169.20	5.108	35.189	40.298	40.297	9.173	
169.30	5.108	36.114	41.222	41.222	9.329	
169.40	5.108	37.056	42.164	42.163	9.497	
169.50	5.108	38.014	43.122	43.121	9.665	
169.60	5.108	38.989	44.097	44.096	9.830	
169.70	5.108	39.980	45.088	45.087	9.990	
169.80	5.108	40.987	46.095	46.094	10.153	
169.90	5.108	42.010	47.118	47.117	10.315	
170.00	5.108	43.050	48.158	48.157	10.484	
170.10	5.108	44.107	49.215	49.214	10.656	
170.20	5.108	45.181	50.289	50.289	10.828	
170.30	5.108	46.272	51.380	51.380	10.996	
170.40	5.108	47.380	52.488	52.488	11.162	
170.50	5.108	48.505	53.613	53.612	11.332	
170.60	5.108	49.647	54.755	54.754	11.507	
170.70	5.108	50.807	55.915	55.915	11.709	
170.80	5.108	51.989	57.097	57.097	11.930	
170.90	5.108	53.193	58.302	58.302	12.162	

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
171.00	5.108	54.421	59.529	59.528	12.377	
171.10	5.108	55.668	60.776	60.776	12.574	
171.20	5.108	56.936	62.044	62.043	12.773	
171.30	5.108	58.223	63.331	63.331	12.970	
171.40	5.108	59.530	64.638	64.637	13.166	
171.50	5.108	60.857	65.965	65.964	13.376	
171.60	5.108	62.205	67.313	67.313	13.594	
171.70	5.108	63.575	68.683	68.683	13.809	
171.80	5.108	64.966	70.075	70.074	14.014	
171.90	5.108	66.379	71.487	71.487	14.240	
172.00	5.108	67.814	72.922	72.922	14.462	
172.10	5.108	69.271	74.379	74.379	14.680	
172.20	5.108	70.750	75.858	75.858	14.900	
172.30	5.108	72.252	77.360	77.359	15.128	
172.40	5.108	73.775	78.883	78.883	15.338	
172.50	5.108	75.319	80.427	80.426	15.541	
172.60	5.108	76.883	81.992	81.991	15.752	
172.70	5.108	78.470	83.578	83.578	15.981	
172.80	5.108	80.081	85.189	85.189	16.240	
172.90	5.108	81.718	86.826	86.826	16.500	
173.00	5.108	83.381	88.489	88.489	16.757	
173.10	5.108	85.070	90.178	90.178	17.028	
173.20	5.108	86.786	91.894	91.894	17.286	
173.30	5.108	88.526	93.634	93.634	17.516	
173.40	5.108	90.288	95.396	95.396	17.722	
173.50	5.108	92.070	97.178	97.177	17.910	
173.60	5.108	93.870	98.978	98.977	18.085	
173.70	5.108	95.687	100.795	100.794	18.255	
173.80	5.108	97.521	102.629	102.628	18.422	
173.90	5.108	99.371	104.479	104.478	18.587	
174.00	5.108	101.238	106.346	106.345	18.751	
174.10	5.108	103.121	108.229	108.228	18.911	
174.20	5.108	105.020	110.128	110.127	19.072	
174.30	5.108	106.935	112.043	112.042	19.232	
174.40	5.108	108.866	113.975	113.974	19.389	
174.50	5.108	110.813	115.921	115.920	19.547	
174.60	5.108	112.776	117.884	117.883	19.706	

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
174.70	5.108	114.754	119.862	119.862	19.865	
174.80	5.108	116.749	121.857	121.856	20.033	
174.90	5.108	118.761	123.870	123.869	20.215	
175.00	5.108	120.792	125.900	125.900	20.402	
175.10	5.108	122.843	127.951	127.950	20.610	
175.20	5.108	124.914	130.022	130.021	20.813	
175.30	5.108	127.005	132.113	132.113	21.018	
175.40	5.108	129.117	134.225	134.224	21.214	
175.50	5.108	131.248	136.356	136.355	21.408	
175.60	5.108	133.399	138.507	138.506	21.603	
175.70	5.108	135.569	140.677	140.676	21.800	
175.80	5.108	137.759	142.867	142.866	22.002	
175.90	5.108	139.969	145.077	145.077	22.208	
176.00	5.108	142.200	147.308	147.308	22.411	
176.10	5.108	144.451	149.559	149.558	22.604	
176.20	5.108	146.721	151.829	151.829	22.800	
176.30	5.108	149.011	154.119	154.118	22.996	
176.40	5.108	151.320	156.429	156.428	23.191	
176.50	5.108	153.649	158.757	158.756	23.381	
176.60	5.108	155.997	161.105	161.104	23.573	
176.70	5.108	158.364	163.472	163.471	23.769	
176.80	5.108	160.751	165.859	165.858	23.971	
176.90	5.108	163.158	168.266	168.265	24.174	
177.00	5.108	165.585	170.694	170.693	24.376	
177.10	5.108	168.033	173.141	173.141	24.581	
177.20	5.108	170.501	175.610	175.609	24.785	
177.30	5.108	172.991	178.099	178.098	25.008	
177.40	5.108	175.503	180.611	180.610	25.229	
177.50	5.108	178.037	183.145	183.145	25.459	
177.60	5.108	180.594	185.703	185.702	25.689	
177.70	5.108	183.175	188.283	188.283	25.921	
177.80	5.108	185.779	190.887	190.887	26.160	
177.90	5.108	188.407	193.515	193.515	26.399	
178.00	5.108	191.059	196.167	196.166	26.634	
178.10	5.108	193.734	198.842	198.842	26.872	
178.20	5.108	196.433	201.541	201.541	27.109	
178.30	5.108	199.156	204.264	204.264	27.355	

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
178.40	5.108	201.904	207.012	207.012	27.607	
178.50	5.108	204.678	209.786	209.786	27.867	
178.60	5.108	207.477	212.585	212.585	28.122	
178.70	5.108	210.302	215.410	215.410	28.375	
178.80	5.108	213.152	218.260	218.260	28.621	
178.90	5.108	216.025	221.133	221.133	28.843	
179.00	5.108	218.920	224.028	224.028	29.062	
179.10	5.108	221.838	226.946	226.946	29.287	
179.20	5.108	224.778	229.886	229.885	29.507	
179.30	5.108	227.738	232.847	232.846	29.705	
179.40	5.108	230.718	235.826	235.826	29.889	
179.50	5.108	233.716	238.824	238.824	30.076	
179.60	5.108	236.733	241.841	241.841	30.266	
179.70	5.108	239.770	244.878	244.877	30.460	
179.80	5.108	242.826	247.934	247.933	30.660	
179.90	5.108	245.901	251.009	251.009	30.847	
180.00	5.108	248.995	254.103	254.102	31.028	
180.10	5.108	252.107	257.215	257.215	31.214	
180.20	5.108	255.237	260.346	260.345	31.399	
180.30	5.108	258.387	263.495	263.494	31.584	
180.40	5.108	261.554	266.662	266.662	31.766	
180.50	5.108	264.740	269.848	269.847	31.940	
180.60	5.108	267.942	273.050	273.050	32.115	
180.70	5.108	271.162	276.271	276.270	32.290	
180.80	5.108	274.400	279.508	279.508	32.465	
180.90	5.108	277.655	282.764	282.763	32.637	
181.00	5.108	280.928	286.036	286.036	32.813	
181.10	5.108	284.218	289.327	289.326	32.999	
181.20	5.108	287.528	292.636	292.635	33.185	
181.30	5.108	290.856	295.964	295.963	33.375	
181.40	5.108	294.203	299.311	299.310	33.563	
181.50	5.108	297.568	302.676	302.676	33.747	
181.60	5.108	300.952	306.060	306.060	33.933	
181.70	5.108	304.355	309.463	309.462	34.120	
181.80	5.108	307.776	312.884	312.884	34.309	
181.90	5.108	311.217	316.325	316.324	34.499	
182.00	5.108	314.676	319.784	319.784	34.694	

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
182.10	5.108	318.155	323.264	323.263	34.893	
182.20	5.108	321.655	326.763	326.763	35.105	
182.30	5.108	325.176	330.284	330.284	35.314	
182.40	5.108	328.718	333.826	333.826	35.521	
182.50	5.108	332.280	337.388	337.388	35.725	
182.60	5.108	335.863	340.971	340.971	35.928	
182.70	5.108	339.466	344.574	344.574	36.132	
182.80	5.108	343.089	348.197	348.197	36.328	
182.90	5.108	346.732	351.840	351.839	36.523	
183.00	5.108	350.394	355.502	355.501	36.719	
183.10	5.108	354.076	359.184	359.183	36.921	
183.20	5.108	357.778	362.886	362.885	37.121	
183.30	5.108	361.500	366.608	366.607	37.320	
183.40	5.108	365.242	370.350	370.350	37.527	
183.50	5.108	369.005	374.113	374.113	37.736	
183.60	5.108	372.789	377.897	377.897	37.943	
183.70	5.108	376.594	381.702	381.701	38.148	
183.80	5.108	380.419	385.527	385.526	38.349	
183.90	5.108	384.264	389.372	389.371	38.551	
184.00	5.108	388.128	393.236	393.236	38.738	
184.10	5.108	392.011	397.119	397.118	38.906	
184.15	**5.108**	**393.958**	**399.066**	**399.065**	**38.983**	**FRL**
184.20	5.108	395.909	401.017	401.016	39.054	
184.30	5.108	399.821	404.929	404.928	39.189	
184.40	5.108	403.747	408.855	408.854	39.322	
184.50	5.108	407.685	412.794	412.793	39.455	
184.60	5.108	411.638	416.746	416.745	39.594	
184.70	5.108	415.605	420.713	420.712	39.742	
184.80	5.108	419.587	424.695	424.695	39.913	
184.90	5.108	423.588	428.696	428.696	40.106	
185.00	5.108	427.608	432.716	432.716	40.307	
185.01	**5.108**	**428.012**	**433.120**	**433.119**	**40.328**	**HFL**

Table 6.2-1 Capacity and Area

6.3 Comparative Statement of Dantiwada Reservoir

RL in m	As per original survey		As per 2007 survey		As per 2020 survey		Remarks
	Gross Capacity in M Cu. m	Area in Sq. Km	Gross Capacity in M Cu. m	Area in Sq. Km	Gross Capacity in M Cu. m	Area in Sq. Km	
146.60	0.000	0.000	0.000	0.000	0.000	0.000	
149.65	0.230	0.190	0.000	0.000	0.000	0.000	
152.70	1.760	0.810	0.000	0.000	0.000	0.000	
152.90	2.550	0.840	0.000	0.000	0.000	0.000	
155.75	5.150	1.380	0.140	0.254	0.006	0.063	
159.11	10.540	2.190	2.182	0.950	1.710	0.839	
161.85	**19.680**	**3.920**	**6.207**	**2.093**	**5.108**	**1.831**	**MDDL**
164.90	35.400	6.510	15.880	4.382	13.716	3.878	
167.94	60.940	10.410	34.020	7.842	29.952	7.197	
170.99	99.740	15.150	65.255	12.750	59.405	12.357	
174.04	154.120	20.630	114.266	19.354	107.097	18.815	
177.09	228.600	28.440	183.366	25.394	172.896	24.560	
180.13	323.360	33.920	266.805	29.218	258.152	31.270	
183.18	447.970	39.400	362.007	33.170	362.144	37.082	
184.15	**464.390**	**40.470**	**395.330**	**35.630**	**399.066**	**38.983**	**FRL**

Table 6.3-1 COMPARATIVE STATEMENT OF DANTIWADA RESERVOIR

6.4 Gross Storage Capacity in M Cu. m of the Reservoir - Year 2021:

RL in m	0	0.06	0.1	0.15	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85	0.9
155	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.010	0.015	0.021
156	0.037	0.048	0.056	0.068	0.081	0.108	0.138	0.169	0.202	0.237	0.275	0.294	0.314
157	0.355	0.381	0.398	0.421	0.444	0.492	0.542	0.595	0.650	0.707	0.767	0.797	0.828
158	0.891	0.930	0.957	0.990	1.024	1.092	1.162	1.234	1.307	1.382	1.459	1.498	1.538
159	1.618	1.668	1.701	1.743	1.786	1.873	1.961	2.053	2.146	2.242	2.340	2.390	2.441
160	2.544	2.607	2.650	2.705	2.759	2.871	2.987	3.105	3.227	3.352	3.481	3.547	3.614
161	3.752	3.836	3.893	3.965	4.038	4.188	4.343	4.503	4.669	4.840	5.017	**5.108**	5.200
162	5.390	5.507	5.586	5.686	5.789	5.999	6.215	6.437	6.667	6.902	7.144	7.267	7.392
163	7.647	7.802	7.907	8.040	8.174	8.446	8.725	9.011	9.303	9.601	9.906	10.061	10.217
164	10.535	10.728	10.859	11.023	11.189	11.527	11.872	12.225	12.586	12.955	13.331	13.523	13.716
165	14.107	14.346	14.507	14.710	14.915	15.331	15.755	16.189	16.632	17.084	17.545	17.779	18.015
166	18.495	18.787	18.984	19.233	19.484	19.994	20.514	21.045	21.586	22.138	22.700	22.985	23.273
167	23.856	24.211	24.450	24.751	25.055	25.672	26.302	26.945	27.602	28.274	28.962	29.312	29.666
168	30.387	30.828	31.125	31.500	31.879	32.649	33.436	34.239	35.057	35.892	36.743	37.174	37.609
169	38.491	39.027	39.387	39.841	40.298	41.222	42.164	43.122	44.097	45.088	46.095	46.604	47.118
170	48.158	48.790	49.215	49.750	50.289	51.380	52.488	53.613	54.755	55.915	57.097	57.696	58.302
171	59.529	60.275	60.776	61.408	62.044	63.331	64.638	65.965	67.313	68.683	70.075	70.778	71.487
172	72.922	73.794	74.379	75.116	75.858	77.360	78.883	80.427	81.992	83.578	85.189	86.004	86.826
173	88.489	89.499	90.178	91.033	91.894	93.634	95.396	97.178	98.978	100.795	102.629	103.552	104.479
174	106.346	107.474	108.229	109.177	110.128	112.043	113.975	115.921	117.884	119.862	121.857	122.861	123.870
175	125.900	127.128	127.951	128.984	130.022	132.113	134.225	136.356	138.507	140.677	142.867	143.969	145.077
176	147.308	148.657	149.559	150.692	151.829	154.119	156.429	158.757	161.105	163.472	165.859	167.060	168.266

RL in m	0	0.06	0.1	0.15	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85	0.9
177	170.694	172.160	173.141	174.373	175.610	178.099	180.611	183.145	185.703	188.283	190.887	192.198	193.515
178	196.167	197.769	198.842	200.189	201.541	204.264	207.012	209.786	212.585	215.410	218.260	219.694	221.133
179	224.028	225.776	226.946	228.413	229.886	232.847	235.826	238.824	241.841	244.878	247.934	249.469	251.009
180	254.103	255.968	257.215	258.778	260.346	263.495	266.662	269.848	273.050	276.271	279.508	281.134	282.764
181	286.036	288.008	289.327	290.979	292.636	295.964	299.311	302.676	306.060	309.463	312.884	314.602	316.325
182	319.784	321.869	323.264	325.011	326.763	330.284	333.826	337.388	340.971	344.574	348.197	350.016	351.840
183	355.502	357.709	359.184	361.032	362.886	366.608	370.350	374.113	377.897	381.702	385.527	387.447	389.372
184	393.236	395.564	397.119	**399.066**	401.017	404.929	408.855	412.794	416.746	420.713	424.695	426.693	428.696
185	432.716	**435.139**											

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

Note: Gross storage capacity for FRL at 184.15 m is 399.066 M Cu. m, dead storage at 161.85 m is 5.108 M Cu. m and HFL at 185.06 m is 435.139 M Cu. m.

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

RL in m	0	0.06	0.1	0.15	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85	0.9
161	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.092
162	0.282	0.398	0.478	0.578	0.681	0.891	1.107	1.329	1.559	1.794	2.036	2.159	2.284
163	2.539	2.694	2.799	2.931	3.066	3.338	3.617	3.903	4.195	4.493	4.798	4.953	5.109
164	5.427	5.620	5.750	5.915	6.081	6.419	6.764	7.117	7.478	7.847	8.223	8.415	8.607
165	8.999	9.238	9.399	9.602	9.807	10.222	10.647	11.081	11.523	11.976	12.437	12.671	12.907
166	13.386	13.679	13.876	14.125	14.376	14.886	15.406	15.937	16.478	17.030	17.592	17.877	18.165
167	18.748	19.103	19.342	19.643	19.947	20.564	21.194	21.837	22.494	23.166	23.854	24.204	24.558

RL in m	0	0.06	0.1	0.15	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85	0.9
168	25.279	25.720	26.017	26.392	26.771	27.541	28.328	29.131	29.949	30.784	31.635	32.066	32.501
169	33.383	33.919	34.279	34.733	35.189	36.114	37.056	38.014	38.989	39.980	40.987	41.496	42.010
170	43.050	43.682	44.107	44.642	45.181	46.272	47.380	48.505	49.647	50.807	51.989	52.588	53.193
171	54.421	55.167	55.668	56.299	56.936	58.223	59.530	60.857	62.205	63.575	64.966	65.670	66.379
172	67.814	68.686	69.271	70.008	70.750	72.252	73.775	75.319	76.883	78.470	80.081	80.896	81.718
173	83.381	84.391	85.070	85.925	86.786	88.526	90.288	92.070	93.870	95.687	97.521	98.444	99.371
174	101.238	102.366	103.121	104.069	105.020	106.935	108.866	110.813	112.776	114.754	116.749	117.753	118.761
175	120.792	122.020	122.843	123.876	124.914	127.005	129.117	131.248	133.399	135.569	137.759	138.861	139.969
176	142.200	143.548	144.451	145.584	146.721	149.011	151.320	153.649	155.997	158.364	160.751	161.952	163.158
177	165.585	167.052	168.033	169.265	170.501	172.991	175.503	178.037	180.594	183.175	185.779	187.090	188.407
178	191.059	192.661	193.734	195.080	196.433	199.156	201.904	204.678	207.477	210.302	213.152	214.586	216.025
179	218.920	220.668	221.838	223.305	224.778	227.738	230.718	233.716	236.733	239.770	242.826	244.361	245.901
180	248.995	250.860	252.107	253.670	255.237	258.387	261.554	264.740	267.942	271.162	274.400	276.026	277.655
181	280.928	282.900	284.218	285.871	287.528	290.856	294.203	297.568	300.952	304.355	307.776	309.494	311.217
182	314.676	316.761	318.155	319.903	321.655	325.176	328.718	332.280	335.863	339.466	343.089	344.908	346.732
183	350.394	352.600	354.076	355.924	357.778	361.500	365.242	369.005	372.789	376.594	380.419	382.339	384.264
184	388.128	390.456	392.011	**393.958**	395.909	399.821	403.747	407.685	411.638	415.605	419.587	421.585	423.588
185	427.608	**430.031**											

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

Note: Live storage capacity for FRL at 183.15 m 393.958 M Cu. m and HFL at 185.06 m is 430.031 M Cu. m.

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

RL in m	0	0.06	0.1	0.15	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85	0.9
155	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.020	0.041	0.081	0.109	0.132
156	0.177	0.204	0.218	0.241	0.265	0.286	0.301	0.322	0.343	0.364	0.381	0.391	0.401
157	0.423	0.435	0.444	0.456	0.466	0.492	0.515	0.539	0.561	0.585	0.605	0.615	0.625
158	0.642	0.654	0.661	0.669	0.677	0.692	0.709	0.726	0.742	0.759	0.777	0.786	0.797
159	0.818	0.830	0.837	0.847	0.857	0.878	0.900	0.923	0.944	0.969	0.995	1.008	1.021
160	1.049	1.066	1.077	1.091	1.105	1.136	1.167	1.200	1.235	1.273	1.312	1.332	1.351
161	1.391	1.417	1.433	1.454	1.476	1.524	1.575	1.627	1.685	1.742	1.801	**1.831**	1.862
162	1.926	1.968	1.996	2.031	2.065	2.131	2.194	2.258	2.324	2.387	2.451	2.483	2.513
163	2.572	2.610	2.636	2.667	2.697	2.757	2.823	2.888	2.953	3.016	3.079	3.111	3.143
164	3.206	3.244	3.271	3.305	3.341	3.416	3.489	3.568	3.650	3.729	3.804	3.841	3.878
165	3.954	4.004	4.039	4.079	4.117	4.202	4.290	4.383	4.475	4.566	4.656	4.701	4.748
166	4.846	4.906	4.944	4.998	5.050	5.151	5.255	5.359	5.465	5.569	5.674	5.729	5.781
167	5.885	5.950	5.995	6.053	6.111	6.230	6.362	6.501	6.645	6.799	6.957	7.037	7.123
168	7.300	7.396	7.459	7.540	7.622	7.781	7.949	8.109	8.266	8.426	8.586	8.665	8.744
169	8.893	8.976	9.032	9.101	9.173	9.329	9.497	9.665	9.830	9.990	10.153	10.233	10.315
170	10.484	10.586	10.656	10.742	10.828	10.996	11.162	11.332	11.507	11.709	11.930	12.044	12.162
171	12.377	12.495	12.574	12.673	12.773	12.970	13.166	13.376	13.594	13.809	14.014	14.124	14.240
172	14.462	14.592	14.680	14.790	14.900	15.128	15.338	15.541	15.752	15.981	16.240	16.369	16.500
173	16.757	16.919	17.028	17.161	17.286	17.516	17.722	17.910	18.085	18.255	18.422	18.504	18.587
174	18.751	18.847	18.911	18.991	19.072	19.232	19.389	19.547	19.706	19.865	20.033	20.122	20.215
175	20.402	20.523	20.610	20.711	20.813	21.018	21.214	21.408	21.603	21.800	22.002	22.105	22.208

RL in m	0	0.06	0.1	0.15	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85	0.9
176	22.411	22.527	22.604	22.701	22.800	22.996	23.191	23.381	23.573	23.769	23.971	24.072	24.174
177	24.376	24.499	24.581	24.682	24.785	25.008	25.229	25.459	25.689	25.921	26.160	26.280	26.399
178	26.634	26.778	26.872	26.990	27.109	27.355	27.607	27.867	28.122	28.375	28.621	28.733	28.843
179	29.062	29.195	29.287	29.399	29.507	29.705	29.889	30.076	30.266	30.460	30.660	30.755	30.847
180	31.028	31.139	31.214	31.307	31.399	31.584	31.766	31.940	32.115	32.290	32.465	32.552	32.637
181	32.813	32.924	32.999	33.092	33.185	33.375	33.563	33.747	33.933	34.120	34.309	34.404	34.499
182	34.694	34.812	34.893	34.999	35.105	35.314	35.521	35.725	35.928	36.132	36.328	36.426	36.523
183	36.719	36.839	36.921	37.022	37.121	37.320	37.527	37.736	37.943	38.148	38.349	38.451	38.551
184	38.738	38.841	38.906	**38.983**	39.054	39.189	39.322	39.455	39.594	39.742	39.913	40.008	40.106
185	40.307	**40.436**											

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

Note: Spread Area for FRL at 184.15 m is 38.983 Sq. Km and HFL at 185.06 m is 40.436 Sq. Km.

6.7 Sediment Analysis:

6.7.1 Observed Rate of Sedimentation

The reservoir was impounded during the year 1965. As per report of the year 1965, total area of reservoir at FRL 184.15 was 40.47 Sq. Km, corresponding storage capacity was 464.39 M Cu. m, and Dead storage at 161.85m was 19.68 M Cu. m.

The reservoir was surveyed in the year 2007. As per survey of the year 2007, total area of reservoir at FRL 184.15 m was 35.63 Sq. Km, corresponding storage capacity was 395.33 M Cu. m, and Dead storage at 161.85 m was 6.207 M Cu. m.

The reservoir was recently surveyed by means of integrated bathymetric and topographic survey in year 2021. As per survey recent survey, total area of reservoir at FRL 184.15 m is 38.983 Sq. Km, corresponding storage capacity is 399.066 M Cu. m and Dead storage at 161.85 m is 5.108 M Cu. m.

The rate of siltation in the reservoir (up to FRL 184.15 m) during the last 56 years (1965-2021), was found to be 1.167 M Cu. m / year.

Original Reservoir data:

Year of Impounding : 1965
Catchment Area : 2862 Sq. Km
Surface area at 184.15 m : 40.47 Sq. Km
Live storage at 184.15 m : 46 M Cu. m
Dead storage at 161.85 m : 19.68 M Cu. m
Gross storage at 184.15 m : 444.71 M Cu. m

Rate of Sedimentation (at FRL 184.15 m) with respect to impounding year 1965													
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	1976	19.68	444.71	464.39	-	-	-	-	-	-	3.61	-	
2	2007 (Hydrographic Survey)	6.207	389.123	395.33	42	69.06	1.644	13.473 68.46%	55.587 12.50%	69.06 14.87%	5.545	0.35%	**Significant Category**
3	2021(Hydrographic Survey)	5.108	383.958	399.066	56	65.324	1.167	14.572 74.04%	50.752 11.41%	65.324 14.07%	4.076	0.25%	**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 2007 and 2021 is observed to be 0.35% and 0.25% respectively.
- The decrease in annual percentage loss from 0.35%(2007 survey) to 0.25%(2021 survey) is because at initial stage after dam construction sedimentation takes place at higher rate compare to later on.
- The increase in storage capacity (3.736 M Cu. m increased in gross storage capacity) in 2021 survey data compared to 2007 survey data may be due to difference in method used to acquire survey data of the reservoir during 2007 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 DANTIWADA Reservoir:

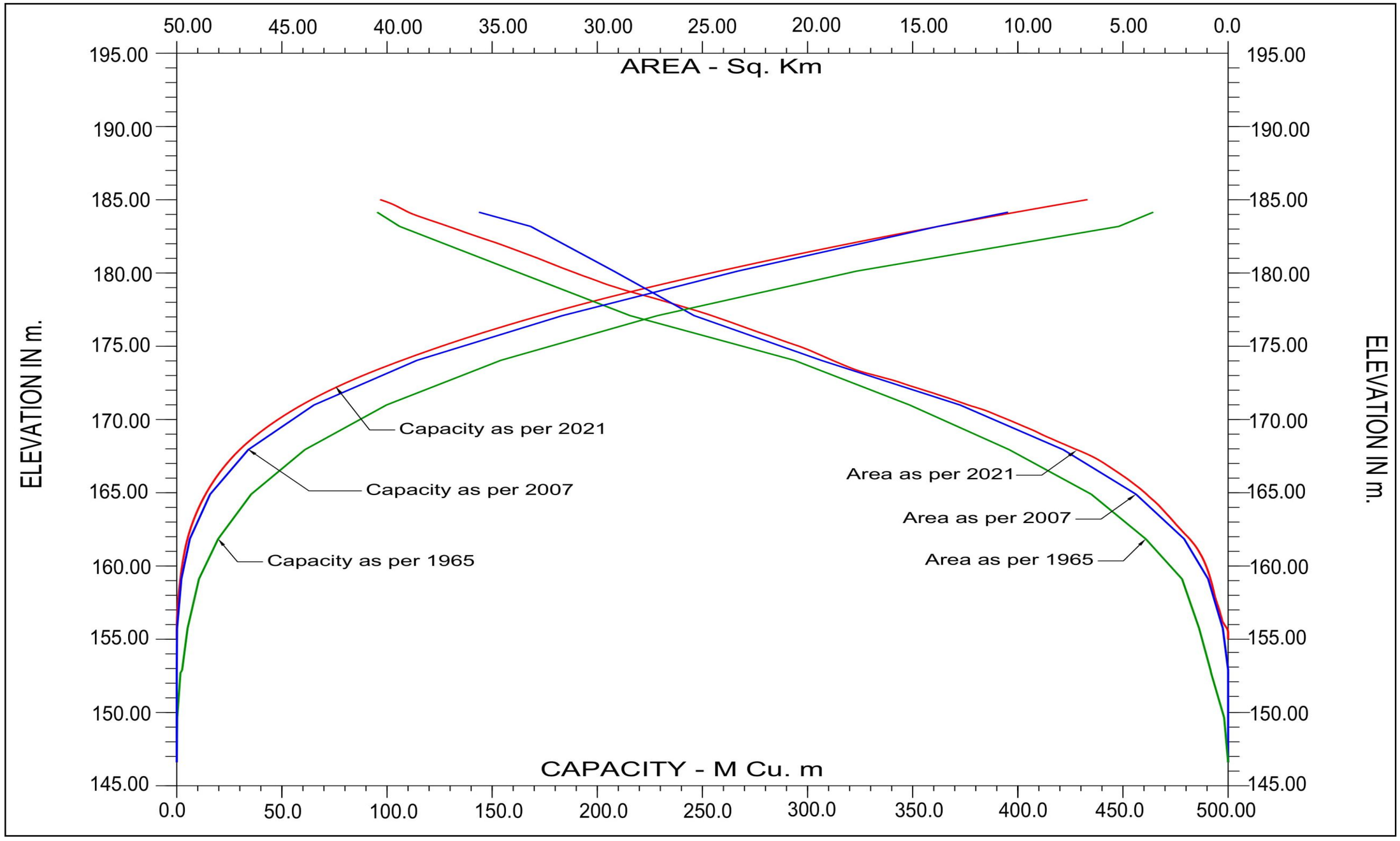

Figure 6.10-1 AREA – CAPACITY - CURVE

6.11 Segment map, Contour map, 3D Image and L-section:

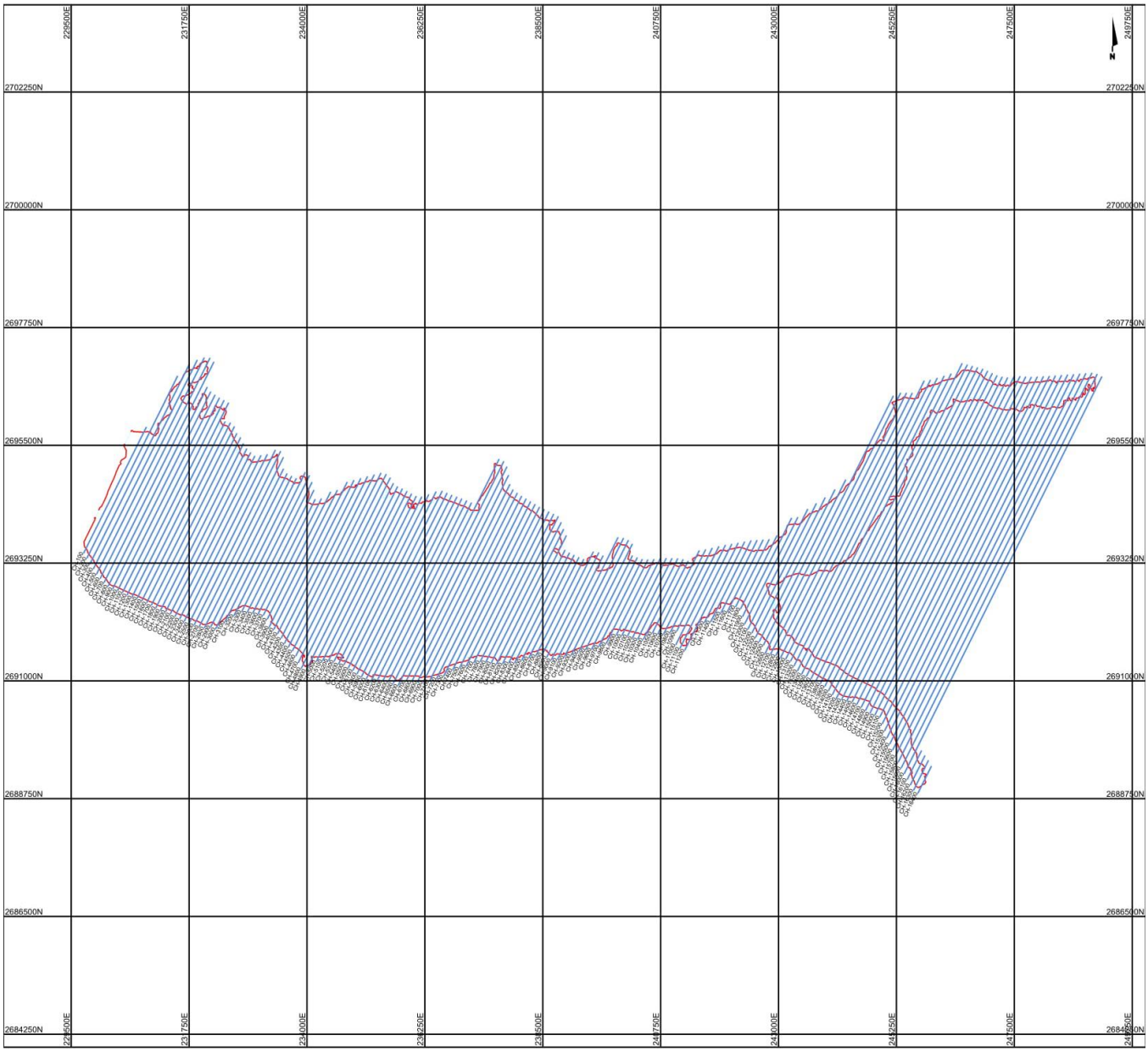

Figure 6.11-1 SEGMENT MAP FOR CROSS SECTION

Cross sections showing bed profile at 100m interval were prepared and are provided as soft copy in CD/Hard Disc. Total 164 cross section profiles were prepared.

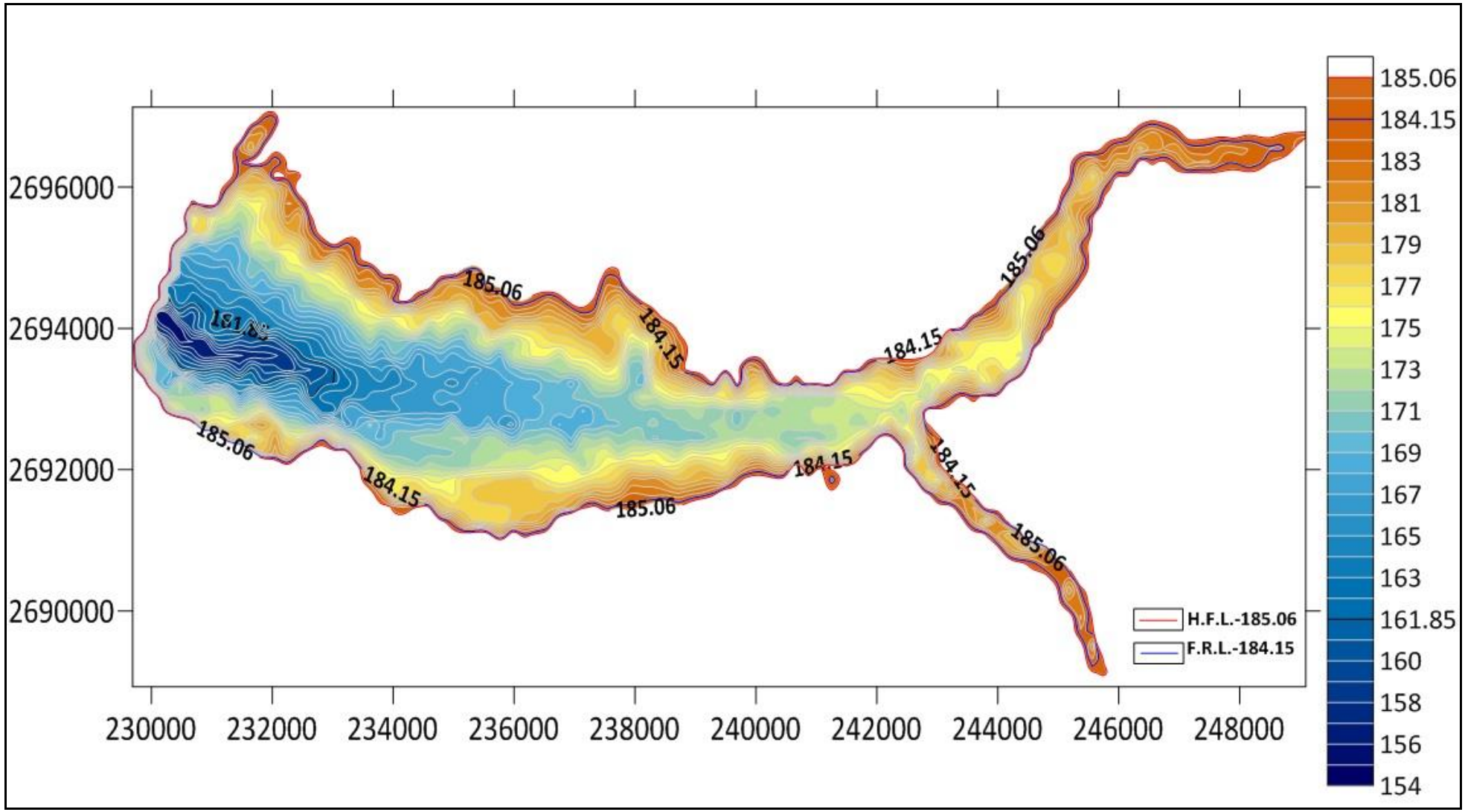

Figure 6.11-2 CONTOUR MAP

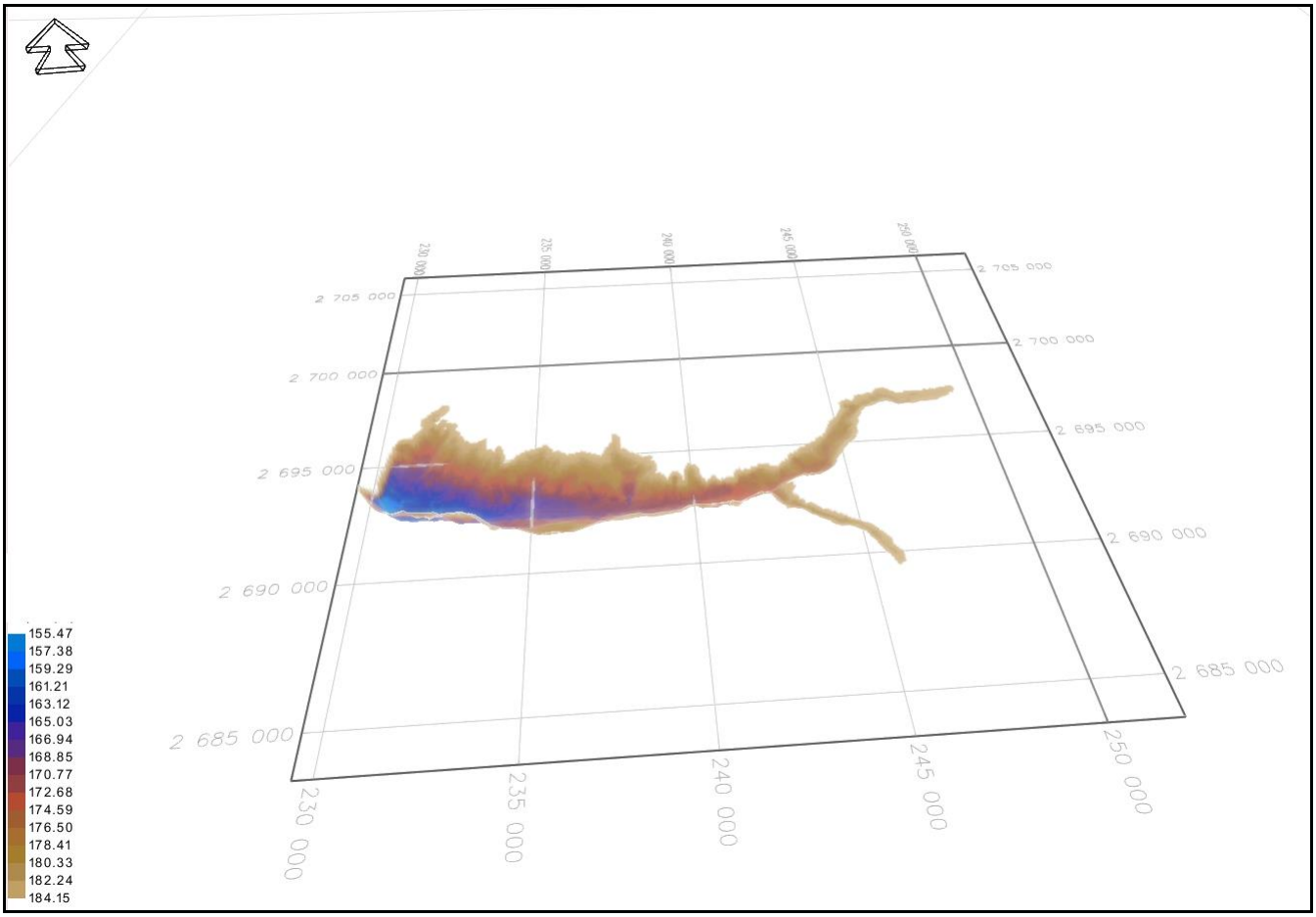

Figure 6.11-3 3D IMAGE

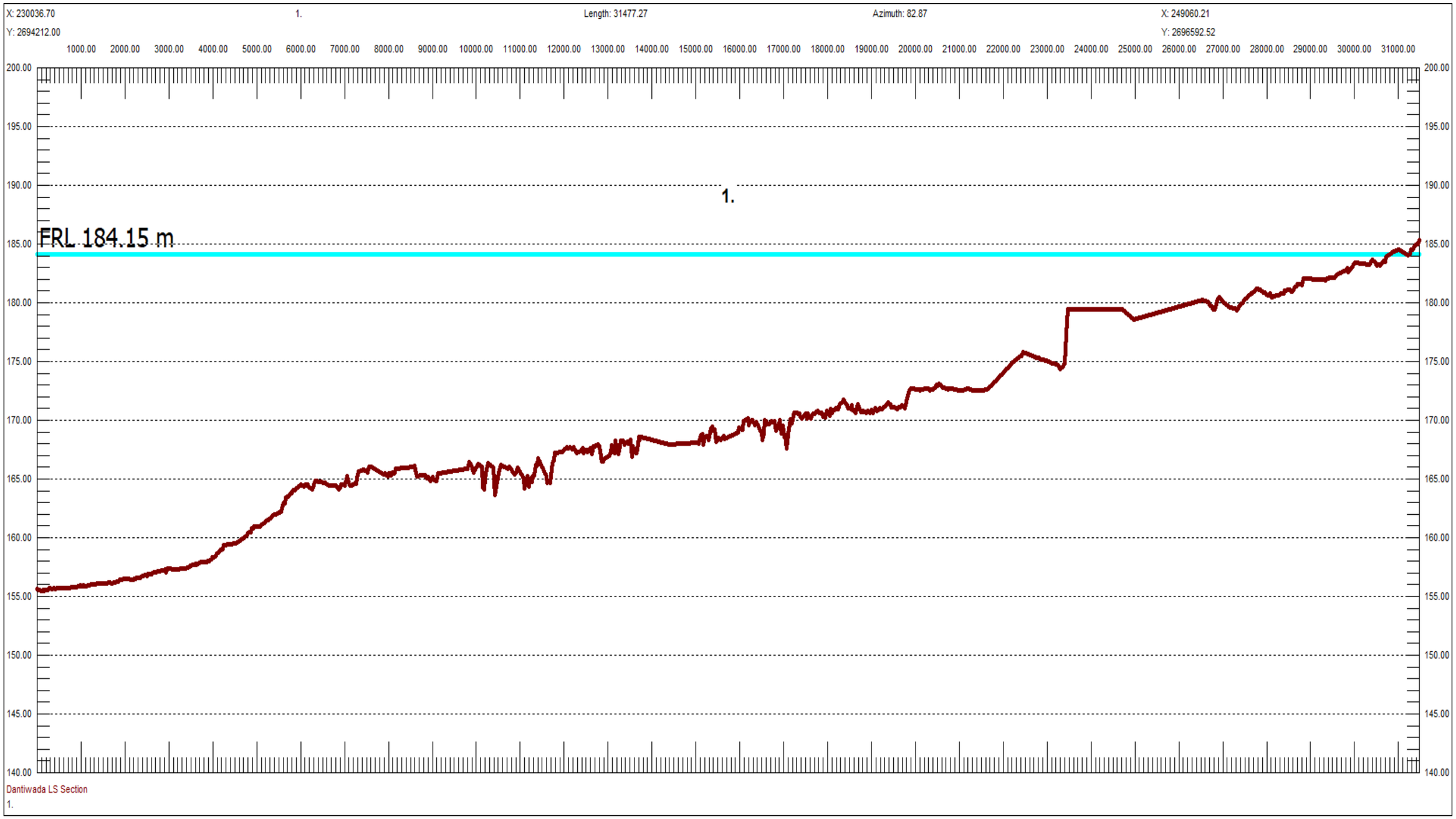

Figure 6.11-4 L-Section

7 DGPS OBSERVATION REPORT

AUSPOS GPS Processing Report

March 18, 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.

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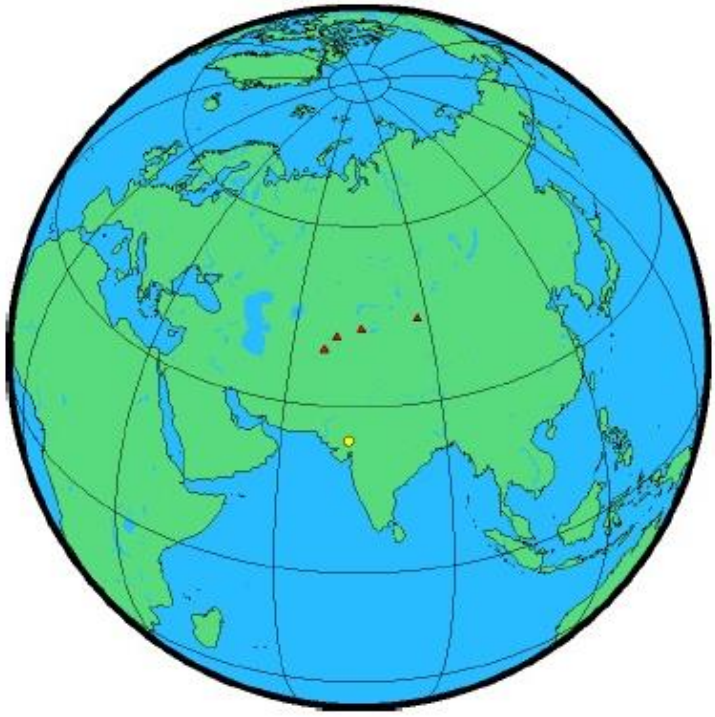
1 User Data

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
DANT	DANT_17032021_155333.210	TIAPENG6 NONE	1.684	2021/03/17 07:54:00	2021/03/17 12:00:30

2 Processing Summary



Date	User Stations	Reference Stations	Orbit Type
2021/03/17 07:54:00	DANT	KIT3 POL2 TASH URUM	IGS ultra rapid

AUSPOS 2.4 Job Number: # 2141
User: samrajdwivedi@gmail.com

2

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 @
DANT	1764150.489	5540726.114	2612380.807	17/03/2021
KIT3	1944944.697	4556652.353	4004326.058	17/03/2021
POL2	1239970.924	4530790.159	4302578.872	17/03/2021
TASH	1695944.769	4487138.671	4190140.756	17/03/2021
URUM	193030.122	4606851.262	4393311.499	17/03/2021

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)
DANT	24 20 12.69403	72 20 19.25406	138.567	187.598
KIT3	39 08 05.16362	66 53 07.62185	622.474	659.571
POL2	42 40 47.17467	74 41 39.37370	1714.205	1754.271
TASH	41 19 40.97918	69 17 44.05717	439.698	483.268
URUM	43 48 28.61965	87 36 02.42041	858.827	922.206

3.3 UTM Grid, GRS80 Ellipsoid, ITRF2014

Station	East (m)	North (m)	Zone	Ellipsoidal Height (m)	Derived Above Geoid Height(m)
DANT	229959.146	2694108.144	43	138.567	187.598
KIT3	317236.778	4333861.159	42	622.474	659.571
POL2	474951.462	4725300.184	43	1714.205	1754.271
TASH	524734.367	4575216.870	42	439.698	483.268
URUM	548313.478	4850717.935	45	858.827	922.206

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

Station	Longitude(East) (m)	Latitude(North) (m)	Ellipsoidal Height(Up) (m)
DANT	0.014	0.011	0.046
KIT3	0.010	0.007	0.016
POL2	0.009	0.006	0.015
TASH	0.009	0.006	0.015
URUM	0.013	0.010	0.031

AUSPOS 2.4 Job Number: # 2141
User: samrajdwivedi@gmail.com

4

4 Ambiguity Resolution - Per Baseline

Baseline	Ambiguities Resolved	Baseline Length (km)
KIT3 - TASH	73.3 %	318.371
DANT - TASH	84.6 %	1898.427
POL2 - URUM	60.9 %	1053.614
POL2 - TASH	80.0 %	471.657
AVERAGE	74.7%	935.517

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 $1/\sin(\epsilon)^2$ where ϵ 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.

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:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**Dantiwada Dam**
Date:	Time:		
8-Jan-21	**15:00HRS**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**19**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4				1500	10
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.04 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	10.02	-0.02
4	3.98	0.02	8	7.98	0.02
6	5.99	0.01	6	5.99	0.01
8	8.02	-0.02	4	4.01	-0.01
10	9.98	0.02	2	1.98	0.02

Average	0.0040	Average	0.0040
Std. Dev	0.0182	Std. Deviation	0.0182
		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**	**Dantiwada Dam**
Date:	Time:		
9-Jan-21	**10:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**19**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.04 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	0	8	8.02	-0.02
4	4.01	-0.01	6	5.98	0.02
6	5.98	0.02	4	3.99	0.01
8	7.99	0.01	2	2.01	-0.01

	Average	0.0050		Average	0.0000
	Std. Dev	0.0129		Std. Deviation	0.0183
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0038

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**	**Dantiwada Dam**
Date:	Time:		
10-Jan-21	**9:22**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**19**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.04 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
4	4.01	-0.01	10	10.01	-0.01
6	5.99	0.01	8	7.98	0.02
8	8.01	-0.01	6	6.01	-0.01
10	9.98	0.02	4	4	0

	Average	0.0025		Average	0.0000
	Std. Dev	0.0150		Std. Deviation	0.0141
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0006

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**	**Dantiwada Dam**
Date:	Time:		
11-Jan-21	**8:55**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**18**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.04 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
4	4.01	-0.01	10	9.98	0.02
6	5.99	0.01	8	8.01	-0.01
8	7.98	0.02	6	5.99	0.01
10	10.1	-0.1	4	4.01	-0.01

	Average	-0.0200		Average	0.0025
	Std. Dev	0.0548		Std. Deviation	0.0150
				Cumulative Average	-0.01
				Cumulative Std. Deviation	0.0281

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**	**Dantiwada Dam**
Date:	Time:		
12-Jan-21	**12:15**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**17**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4				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)
4	4.01	-0.01	10	9.99	0.01
6	5.99	0.01	8	7.98	0.02
8	7.98	0.02	6	6.02	-0.02
10	10.02	-0.02	4	4.01	-0.01

	Average	0.0000		Average	0.0000
	Std. Dev	0.0183		Std. Deviation	0.0183
				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**	**Dantiwada Dam**
Date:	Time:		
13-Jan-21	**10:55**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**15**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**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)
4	4.02	-0.02	10	10.01	-0.01
6	5.99	0.01	8	8.01	-0.01
8	7.98	0.02	6	5.99	0.01
10	9.98	0.02	4	3.98	0.02

	Average	0.0075	Average	0.0025
	Std. Dev	0.0189	Std. Deviation	0.0150
			Cumulative Average	0.00
			Cumulative Std. Deviation	0.0028

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**	**Dantiwada Dam**
Date:	Time:		
14-Jan-21	**9:15**		
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**
0.4				**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

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**Dantiwada Dam**
Date:	Time:		
15-Jan-21	**10:20**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**15**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**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)
4	4.01	-0.01	10	10.02	-0.02
6	5.99	0.01	8	7.98	0.02
8	8.01	-0.01	6	5.99	0.01
10	9.98	0.02	4	3.98	0.02

	Average	0.0025		Average	0.0075
	Std. Dev	0.0150		Std. Deviation	0.0189
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0028

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**	**Dantiwada Dam**
Date:	Time:		
17-Jan-21	**9:55**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**9**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**1500**	**5**
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	0	5	4.98	0.02
3	2.99	0.01	4	4	0
4	4.02	-0.02	3	2.98	0.02
5	5.01	-0.01	2	2.01	-0.01

	Average	-0.0050		Average	0.0075
	Std. Dev	0.0129		Std. Deviation	0.0150
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0015

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**	**Dantiwada Dam**
Date:	Time:		
18-Jan-21	**9:15**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**8**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4				1500	5
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	2.02	-0.02	5	4.98	0.02
3	3.01	-0.01	4	4	0
4	3.99	0.01	3	2.99	0.01
5	5.01	-0.01	2	2	0

	Average	-0.0075		Average	0.0075
	Std. Dev	0.0126		Std. Deviation	0.0096
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0021

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**	**Dantiwada Dam**
Date:	Time:		
19-Jan-21	**9:25**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**7**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**1500**	**5**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 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	5	5.01	-0.01
3	2.99	0.01	4	3.99	0.01
4	3.98	0.02	3	3.02	-0.02
5	4.98	0.02	2	2	0

	Average	0.0100		Average	-0.0050
	Std. Dev	0.0141		Std. Deviation	0.0129
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0009

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**	**Dantiwada Dam**
Date:	Time:		
20-Jan-21	**9:40**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**5**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**1500**	**4**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 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	4	3.99	0.01
3	2.99	0.01	3	3	0
4	4.02	-0.02	2	2	0

	Average	-0.0067		Average	0.0033
	Std. Dev	0.0153		Std. Deviation	0.0058
				Cumulative Average	0.00
				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**	**Dantiwada Dam**
Date:	Time:		
21-Jan-21	**11:25**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**4**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4				**1500**	**3**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 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	0	3	3.01	-0.01
3	2.98	0.02	2	2	0

	Average	0.0100	Average	-0.0050
	Std. Dev	0.0141	Std. Deviation	0.0071
			Cumulative Average	0.00
			Cumulative Std. Deviation	0.0050

The Echosounder Barcheck Values are Accepted for Processing

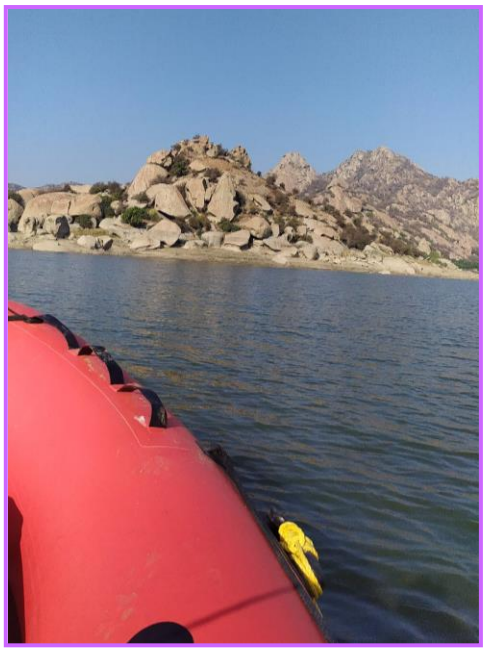
GMPL Party Chief

Approved By: Survey Manager

9 PHOTOGRAPHS

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

Survey Area



Survey in progress

Base Observation

Reservoir Area

Pump House

Bathy Team

TBM 4

END OF REPORT