CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD (CMWSSB)

BATHYMETRY SURVEY REPORT

PMC for Chennai Perur 400 MLD Desalination Plant and Allied Works

Reference No.: Loan ID-P267
Contract No. : CNT/ CON/DESAL /ICB/GoI/016/2018-19
9 December 2020

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The Project Management Consultant (PMC) for the Chennai 400 MLD Desalination Plant project is a consortium led by SMEC International Pty Ltd in partnership with Tata Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI) and SMEC India Pvt Ltd.

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BATHYMETRY SURVEY FOR SETTING UP OF 400 MLD DESALINATION PLANT AT PERUR, CHENNAI, TAMIL NADU

BATHYMETRY REPORT

PROJECT CODE: 696082021

For
SMEC India Pvt Ltd.
Gurugram

September 2020

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Client	SMEC India Pvt Ltd., Gurugram.
Project Title	Bathymetry survey for setting up of 400 MLD desalination plant at Perur, Chennai, Tamil Nadu.
Project Code	696082021
Abstract	CMWSSB has planned to set up a 400 MLD desalination plant at Perur. CMWSSB has nominated SMEC India Pvt Ltd., Gurugram as Project Consultant. SMEC has in turn asked to Indomer Coastal Hydraulics (P) Ltd., Chennai, to carry out the bathymetry survey over the proposed nearshore planned for providing seawater intake and brine reject outfall. Indomer has carried out the survey in August 2020 and this report presents the methodology and the bathymetry map.
Foreword	
Document	Controlled
References	SMEC India Pvt Ltd.- SCA4 Rev00 10051/dt.19th August, 2020

Date	Report Type	Originator	Checked by	Approved by	Approver's sign
16.09.2020	FINAL	J. Vinoth Kumar	Dr. P. Chandramohan	Dr. J. Guru Prasath	
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LIST OF FIGURES

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List of Abbreviations

BM	Bench Mark
CD	Chart Datum
DGPS	Differential Global Position System
GNSS & GLONASS	Global Navigation Satellite System
GPS	Global Position System
GRS	GPS Range Residuals
GSA	Overall Satellite data
GST	GPS Pseudo range Noise Statistics
GSV	Detailed Satellite data
Hz	Hertz
kHz	Kilohertz
km	Kilometer
m	Meter
MSL	Mean Sea Level
RMC	Recommended Minimum Data for GPS
RS	Recommended Standard
RTCM	Radio Technical Commission for Maritime Services
RTK	Real- time Kinematic
SBAS	Satellite Based Augmentation Systems
UTM	Universal Transverse Mercator
VHF	Very High Frequency communication
w.r.t	with respect to
WGS	World Geodetic System

1. INTRODUCTION

Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) has appointed SMEC India Pvt. Ltd., Gurugram for the preparation of Detailed Project Report for the proposed 400 MLD desalination plant Perur, Chennai. In order to prepare the initial plan, SMEC has asked Indomer Coastal Hydraulics (P) Ltd., Chennai to conduct the bathymetry survey at nearshore which has been planned for the selection of seawater intake and brine reject outfall corridor. Accordingly, Indomer has carried out the surveys in August 2020.This report presents the methodology and results of the survey. The location map is shown in **Fig. 1.1.**

All calendar dates are referred in Indian style as dd.mm.yy. (eg. 28.08.20 for 28th August 2020) and the time is referred to Indian Standard Time in 24-hour clock, eg. 3 PM is written as 1500 hrs. SI units are followed for all fundamental and derived units. The depths are referred with respect to Chart Datum. The UTM coordinates are indicated in WGS 84 spheroid - Zone 44N.

2. SCOPE OF WORK

i. to carry out the bathymetry survey for about 1000 m along the coast and 2000 m into the sea (However, Indomer has carried out additional area covering 1650 m along coast and 2500 m into the sea)

ii. to prepare and submit the report.

3. METHADOLOGY

3.1. Reference spheroid

World Geodetic System (WGS84) spheroid – Zone 44N has been followed for entire surveys and for the presentation in the chart.

3.2. Horizontal control

Reference station: The DGPS Beacon Transmitter installed by Department of Lighthouse and Navigation at *Pondicherry* has been taken as reference station. The transmitting frequency of this reference station DGPS Beacon transmitter is 315 kHz.

Mobile station: The horizontal positioning of the mobile unit was carried out using **Hemisphere R100** Series DGPS Beacon Receiver. It combines high-performance GPS reception with a DGPS-capable receiver in a lightweight, durable housing and comes with a separate antenna. It gives the horizontal position to an accuracy of close to 1 m. The GPS receiver also contains technology enabling *WAAS/EGNOS, Omni STAR* or *Beacon* real time differential capabilities. When used with a Real- time Kinematic (RTK) Base station, the GPS receiver provides RTK positioning for high-accuracy, centimeter-level applications. A standard GPS receiver provides the following features:

- 10 Hz (10 positions per second) output rate
- 12 GPS (C/A-code L1, C/A code L2 (for the Omni STAR XP/HP and RTK models)) tracking channels, code carrier channels
- Sub meter differential accuracy (RMS), assuming at least five satellites and a PDOP (Position Dilution of Precision) of less than four (when used with Satellite Based Augmentation Systems (SBAS) correction).

The system configuration is enabled with:

- LED display and keypad

- Outputs a 1 PPS (pulse per second) strobe signal on both ports. This signal enables an external instrument to synchronize its internal time with a time derived from the very accurate GPS system time.
- SBAS such as WAAS (Wide Area Augmentation System) differential correction 1
- Beacon differential correction
- Omni STAR VBS capability
- Omni STAR XP/HP capability in the XP/HP and RTK models
- RTK positioning capability, In the RTK model only
- EVEREST™ multipath rejection technology
- Two connectors that support both CAN 2.0B and RS-232:
- CAN: J1939 and NMEA 2000 messages
- RS 232
- NMEA-0183 output: GGA, GLL, GRS, GST, GSA, GSV, MSS, RMC, VTG, ZDA (the default NMEA messages are GGA, GSA, VTG, and RMC).

3.3. Tide Measurements

The tide measurements were carried out at Kasimedu Fishing Harbour, Chennai using Aanderaa Tide Recorder (WTR 9). The measurements were done for 5 days from 25.08.20 to 29.08.20. The tide data were recorded at 15 minute interval. The measured tide levels were reduced to Chart Datum (CD) and used for tidal correction in the collected bathymetry data. The details of tide measurements are given in below.

Location details of Tide recorder

Location	Geographical Coordinates (WGS – 84)		UTM Coordinates (Zone 44N)		Duration	
	Latitude, N	Longitude, E	X (m)	Y (m)	From	To
Kasimedu Fishing Harbour	13° 07 ' 5	8 0 ° 1 7	0423987	1451773	25.08.20	29.08.20

Instrument: The Aanderaa Tide Recorder (WTR 9) manufactured by Aanderaa Data Instruments, Norway. It is a high precision recording instrument for measuring the variation of water level in the sea. The Pressure sensor 4647 is a compact, yet intelligent sensor designed to be used in this measuring systems. The sensor is based on a silicon piezo-resistive bridge sampled and temperature

compensated by an advanced Digital Signal Processor. The tide measurement is an average of the hydrostatic pressure measured over a time period of 10 seconds to 8 minutes (Optional). The recoding interval is selected between 2 seconds and 2 Hrs. The output parameters are Tide pressure, Tide level, Pressure and Temperature. Tide levels are preliminary, internally calculated estimates, based on fixed, selectable values of atmospheric pressure. Tide pressure is an average of hydrostatic pressure over the integration time. The data are stored on DSU. The instrument is housed in a pressure case that is closed by two C-clamps. All external and internal parts are fastened to the top end plate so that the whole instrument can be removed from the pressure case as one unit. In addition to carrying the combined handle and protection ring, the acoustic transducer and sensor inlet, the top end plate is furnished with a watertight receptacle. This terminal permits remote triggering and real-time reading of data by connecting cable.

Technical Specifications:

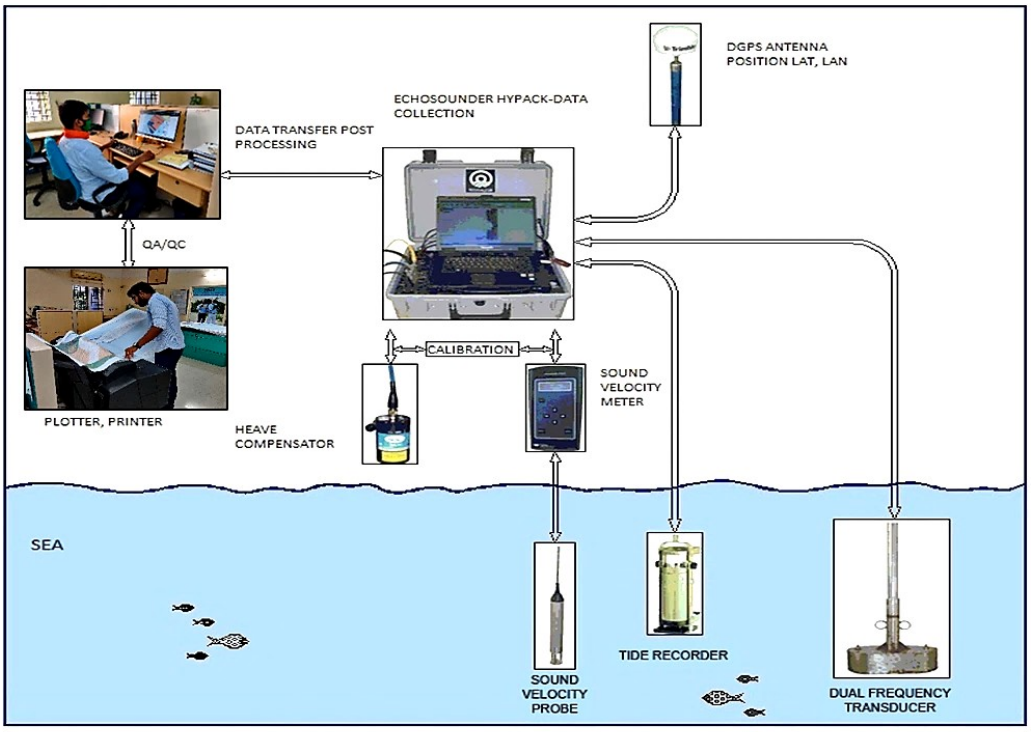
Top-End Plate	:	Multiparameter platform
Recording system	:	Data Storage on DSU
Storage Capacity	:	≤ 2GB
Battery	:	2 batteries inside the instrument
	:	Alkaline 3988 9V, 15Ah (nominal 12.5Ah; 20W down to 6V at 4°C) or Lithium 4002: 7V, 30Ah
Supply voltage	:	6 to 14VDC
	:	Parallel 2 Alkaline battery (each 9.0 VDC)
Operating temperature	:	-5 – + 4 0(23∈1 0 4) ° F
Deployment depth	:	Up to 300 m depending on sensor
Dimensions	:	OD: 139mm; H: 356mm
Weight in air	:	6.3kg
Weight in water	:	1.8kg
Materials	:	PET, Titanium, Stainless Steel 316, Epoxy
Pressure	:	4647B Range: 0 – 700kPa (101 psia) 60 m depth
	:	Resolution: 0.0001% FSO
	:	Accuracy: ±0.04% FSO
	:	Pressure connection: Swagelok™
	:	Inlet port (reference): top of the pressure port
	:	Pressure parameters: Pressure in kPa, Pressure raw data in LSB
Temperature	:	Range: 0 – 36°C (32 – 9 6 . 8 ° F)
	:	Resolution: 0.001°C (0.0018°F)
	:	Accuracy: ±0.4°C (0.72°F)
	:	Response Time (63%): < 2 min
	:	Temperature parameters: Temperature in °C, Temperature raw data in LSB
Tide	:	Integration time: 10s - 8 minutes
	:	Tide parameters: Tide pressure in kPa,
	:	Tide level in meter

3.4. Bathymetry survey

Area of survey: The bathymetry survey covers an area of 1650 m distance along the coast and 2500 m distance into the sea. The survey transects were planned perpendicular to coastline at 50 m spacing. In addition, the shore parallel tie up lines were planned at 250 m spacing. The surveyed bathymetry lines are shown **in Fig.3.1.**

Methodology

Instrument arrangement: The configuration of various devices and arrangements for conducting the bathymetry survey is shown below.



CONFIGURATION OF BATHYMETRY FLOW CHART

The survey vessel ***"MFV SRI DHURGAI"*** was used for the survey. The Echosounder transducer was mounted on the starboard side of the vessel by positioning it at 1.0 m below the sea surface. The DGPS receiver antenna was mounted on the mast vertically in line with the transducer, so that it represents the exact coordinates of the location where the depth is simultaneously measured by the transducer. The Heave Sensor was attached close to transducer stem on the boat deck in order to measure the residual vertical displacement of the boat induced by external disturbances and to carry out the correction.

The DIGIBAR-PRO sound velocity meter was used to measure the sound velocity across the vertical and entered as input for calibrating the transmitting part of the instrument. The bar check was also carried out by lowering the rigid plate at different depths and comparing with the displayed depth. The necessary inputs were given in HYPACK data collection software before the commencement of the survey. The planned track lines were displayed on the monitor at wheel for navigation. Watch guards were positioned at bow, transducer/antenna, and heave compensator at rear end. The data were continuously collected at onboard PC along each transect. After that day data collection was made, entire data were downloaded to external hard disc and stored. The recorded the data included: date, time, latitude, longitude, X coordinate, Y coordinate and heave. The depth data was recorded at 0.2 sec interval

Echosounder: ODOM Echotrac CVM Digital Dual Frequency Echo sounder manufactured by ODOM Hydrographic Systems; USA was used for the survey. This Echosounder has incorporated the cutting-edge technology, features and reliability of the Echotrac MKIII, plus the ease and flexibility of operation of a networked Windows interface. It operates in dual frequency consisting of 200 kHz on higher band and 33 kHz in lower band. It can be operated from 0.2 m to 1500 m water depth with 0.01 m accuracy. The Echotrac CVM transceiver units are compact rack mount package that is ideally suited to survey vessel installations. It supports Chart-functionality in one optional format and a laptop with a full size colour LCD as an electronic chart. The optional color LCD laptop offers internal data storage (in .XTF format) and playback of the analog return signal digitized to full 16-bit resolution. It contains a dual channel board. All channels feature a robust design and frequency agility enabling the operator to precisely match the transceiver to almost any existing transducer. Operator selectable TVG curves serve to optimize the Echotrac for both shallow and Deepwater bottom detection tasks and for Sonar imaging. The Echotrac CVM features unsurpassed interfacing flexibility, offering 2 serial ports that can be configured to interface with computers and motion reference units. It has an Ethernet port that outputs the 16-bit samples of the acoustic data for further processing and supports a number of output formats that are compatible with most common Echo Sounder strings.

Technical specifications

Frequency	:	High Band: 200 kHz Low Band: 33 kHz
Input Power	:	110 or 220 V AC or 24 VDC 50 watts

Resolution	:	0.01m / 0.1 ft.
Accuracy	:	m / 0.10 ft. +/-0.1% of depth @ 200 kHz 0.01 m / 0.30 ft. +/- 0.1% of depth @ 33 kHz
Depth range	:	0.2 – 200 m / 0.5 – 600 ft. @ 200 kHz 0.5 – 1500 m / 1.5 – 4500 ft. @ 33 kHz
Sound Velocity	:	1370 – 1700 m/s
Resolution	:	1 m/s
Depth Display	:	On control PC
Clock	:	Internal battery backed time, elapsed time, and date clock
Annotation	:	Internal – date, time, GPS position External – from RS232 Port or Ethernet
Interfaces	:	2 x RS232 serial ports, baud rate selectable 4800-19200. Input from external computer, motion sensor, and sound velocity. Outputs to external computer. Ethernet interface. Heave – TSS1 and sounder sentence
Software	:	Echotrac Control supplied. Chart View display and logging software.

Heave Compensator: TSS HS-50 Dynamic Motion Heave Sensor manufactured by TSS (UK) Ltd., UK was installed onboard. This will measure the component of the heave induced at echosounder transducer. The measured heave is then corrected from the depth values and the true depth was recorded in computer. The system is connected via. RS232 communication to the computer onboard enabled through HYPACK data collection software.

Hydrographic Survey Software: HYPACK survey software was used for data collection and processing. It is integrated, first generation hydrographic survey software developed by Coastal Oceanographical INC., USA. It works in MS Windows operating environment. The HYPACK's design program allows importing background map in CAD's DFX or Microsoft's DGN format. It enables to quickly create planned survey lines, plotting sheets and bottom coverage grids in a graphical environment. It gives the flexibility to support multiple navigational systems (GPS, range/range, range/azimuth), echo sounders (single and dual frequency, multiple transducer and multi-beam), magnetometers, ROV-tracking systems, telemetry tide systems and many other devices. It contains the post processing module to analyse and prepare the chart. The survey tracks were planned using this software for accurate manoeuvring of the vessel and to keep the accuracy of the track. The post processing of the survey data and preparation of map were carried out using this software.

Data recording: The Echo sounder, heave compensator and Beacon DGPS receiver was interfaced through HYPACK software with onboard PC. The entire system was supported by AC Power

Generator installed onboard. The position and depth were recorded along the pre-planned transect at 200 millisecond intervals continuously.

Calibration for Sound Velocity: ODOM DIGIPRO SVM has been used to measure the velocity of sound across the vertical and the mean value was fed in the echo sounder during calibration before the commencement of survey on each day.

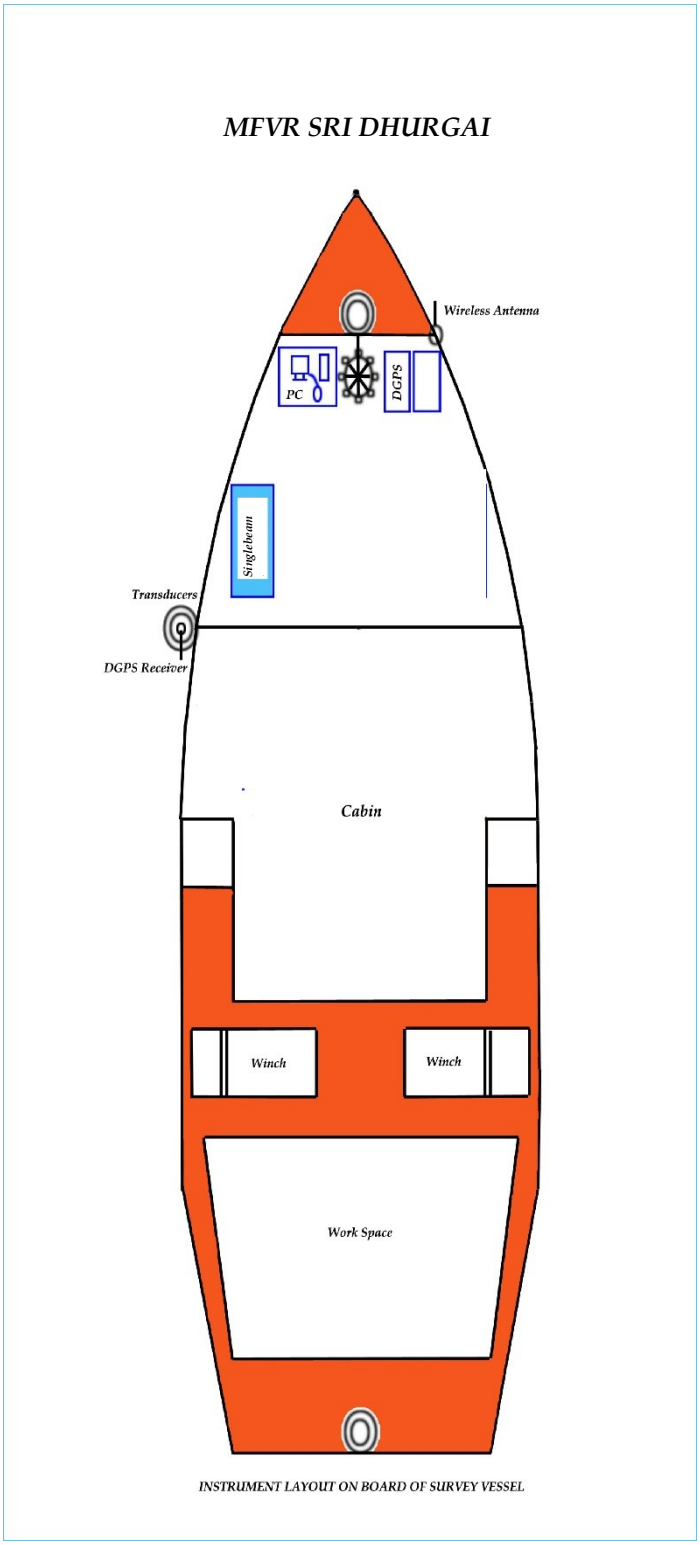
Calibration by Bar Check: Bar check was performed before starting of the surveys every day. It was done by lowering a bar plate at known depth below the transducer. The correction coefficients for known depth were noted and entered on the data collection software.

Tidal correction: The collected data were processed in the laboratory by applying corrections for tides and immersion depth of the transducer.

3.5. Survey boat and instrument arrangements

The bathymetry surveys were carried out using the survey vessel ***'MFV SRI DHURGA'I*** fitted with Multi-channel VHFR/T, Ship-to-Shore R/T, Gyro compass, Marine radar, Loud hailer, additional hull mounted Echo sounder, GPS positioning system and the VHF communication system. In addition, a smaller surf landing cum life boat was also put in place throughout the survey period for the safety and to transport surveyors to and for the survey vessel anchored at offshore.

SURVEY VESSEL - SRI DHURGAI



Survey vessel and Instruments arrangement

4. RESULTS

4.1. Tides

The variation of design tide levels with respect to Chart Datum for Chennai as presented in Indian Tide Table 2020, published by Survey of India are given below:

Mean High Water Spring	+ 1.15 m
Mean High Water Neap	+ 0.84 m
Mean Sea Level	*+ 0.65 m*
Mean Low Water Neap	+ 0.43 m
Mean Low Water Spring	+ 0.14 m

The variation of measured tide levels are reduced to chart datum for the period 25.08.20 to 29.08.20. is shown in **Fig. 4.1**.

Deployment of tide recorder

4.2. Bathymetry

The bathymetry map was prepared in WGS84 spheroid with UTM (Zone 44N) coordinates supplemented by Geographical coordinates indicating the latitude and longitude. The bathymetry map is prepared in 1:4000 scale and is presented in **Fig. 4.2** (see Pouch)**.** The depths w.r.t. chart datum is presented in 20 m x 20 m grid. Another bathymetry map was prepared in 1:12000 scale and presented in **Fig. 4.3.** The depths are presented in 60 m x 60 m grid. The tentative intake and outfall corridors and their locations as suggested by SMEC are shown in these charts.

The variation of water depth with distance from shore is shown below.

Water depth vs Distance

Depth w.r.t. CD (m)	Distance from shore (m)
wave breaking zone	
1	170
2	220
3	270
4	330
5	380
6	460
7	520
8	715
9	880
10	1050
11	1270
12	1560
13	1980
14	2150

The digital values (X,Y,Z) of bathymetry data are given in excel format and enclosed separately in DVD.

Heave compensator

Bar Check

Sound Velocity Meter

Onboard data collection

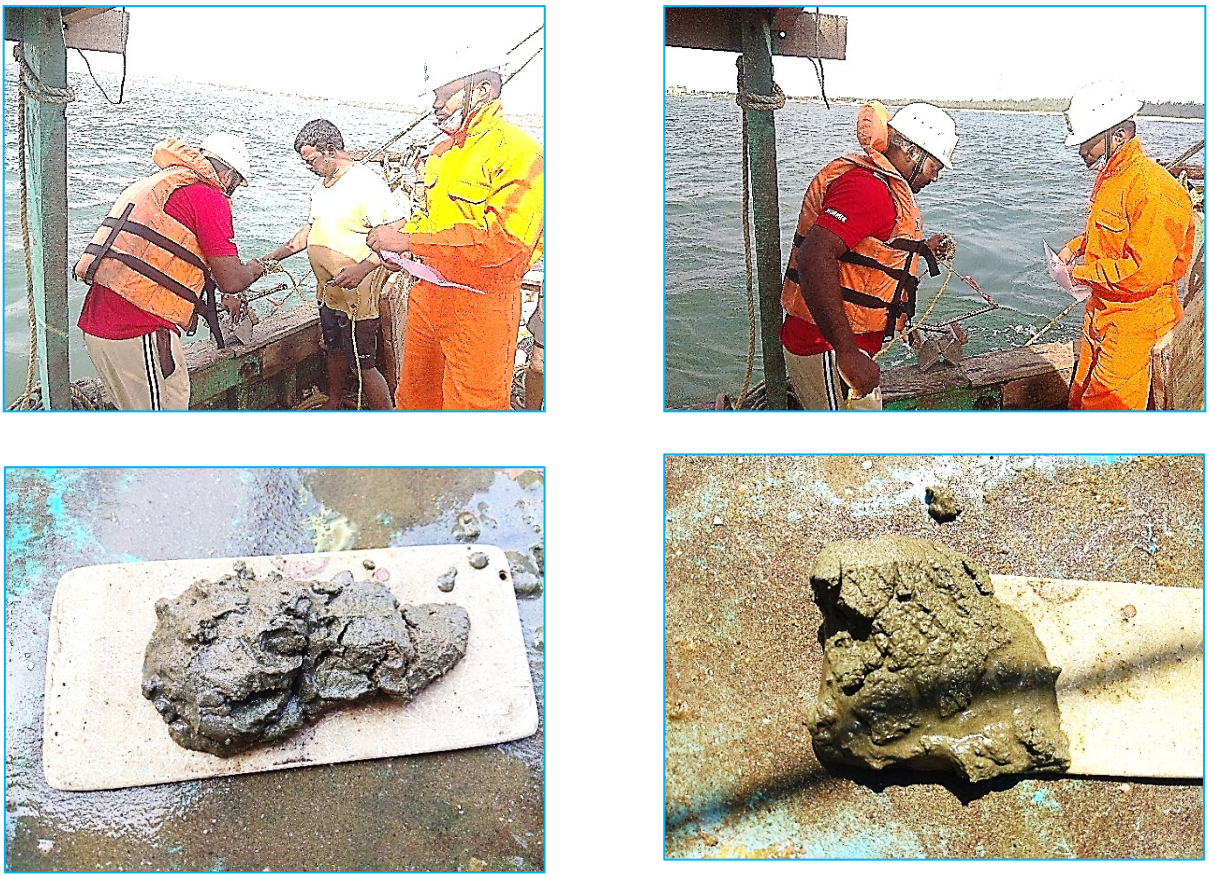
5. ADDITIONAL STUDIES

5.1. Collection of sediment sample

Seabed samples were collected using Van veen grab, in order to understand the nature of the geology of the seabed. The locations of sediment sample collection are shown in **Fig. 5.1.** The details of sediment sampling locations and sediment size distributions are given in below.

The nearshore in this region consists of scattered terraces of rock outcrops which is evidenced through the earlier survey conducted in the adjacent region. Planning of buried pipelines for intake and outfall needs top 4 m with sand and without any rocks thereupon.

Therefore, it is suggested to carry out shallow seismic survey in conjunction with side scan survey and magnetometer survey to identify the presence of rocks if any and to accordingly delineate a most suitable corridor for laying pipelines.

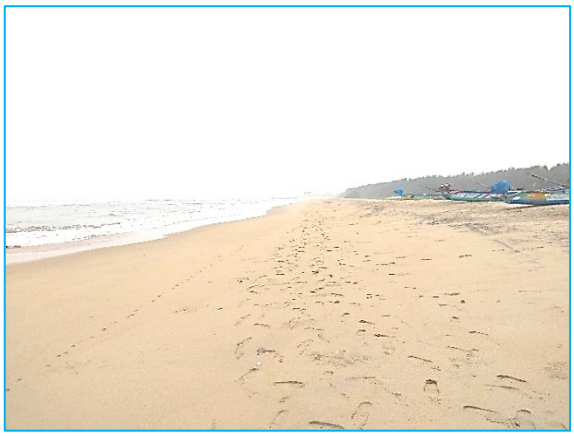


Collection of seabed sediment samples

Sediment size distribution

Stations	UTM Coordinates (WGS 84)		Water depth (m)	Classification of Soil	D_{50} (mm)	Sand			Silt & Clay %
	Easting (m)	Northing (m)				Coarse (%)	Medium (%)	Fine (%)	
SB1	416828	1405667	5.0	Fine sand	0.18	1.2	3.9	94.5	0.4
SB2	417053	1405591	7.5	Fine sand	0.17	1.4	3.9	93.8	0.8
SB3	417431	1405459	10.0	Fine sand	0.17	2.9	3.8	91.8	1.5
SB4	417809	1405328	11.5	Medium sand	0.41	38.3	31.5	30.0	0.2
SB5	418126	1405211	12.4	Medium sand	0.35	32.5	25.4	41.9	0.2
SB6	418452	1405104	13.6	Fine sand	0.14	4.5	4.8	88.1	2.6
SB7	418733	1405008	14.3	Fine sand	0.11	0.7	1.0	96.5	1.8
SB8	416978	1405405	7.7	Fine sand	0.11	2.1	2.5	90.4	5.0
SB9	417546	1405208	10.5	Medium Sand	0.40	28.4	46.4	25.1	0.1
SB10	418113	1405011	12.8	Coarse Sand	0.59	62.3	23.9	13.0	0.8
SB11	418683	1404820	14.0	Coarse Sand	0.55	63.6	26.5	9.5	0.5
SB12	417127	1405776	7.7	Medium Sand	0.37	35.1	25.3	39.3	0.3
SB13	417695	1405580	11.0	Medium Sand	0.44	37.1	44.5	18.2	0.2
SB14	418262	1405383	13.0	Medium Sand	0.35	31.2	27.7	40.3	0.7
SB15	418825	1405187	14.5	Medium Sand	0.45	26.8	62.3	10.6	0.3

GALLERY



Perur coastal front

crossing surfzone

Client inspection on board the vessel

Installation of Transducer

Client inspecting bathymetry data collection

SMEC officials with Indomer team

Discussing with CMWSSB Officals

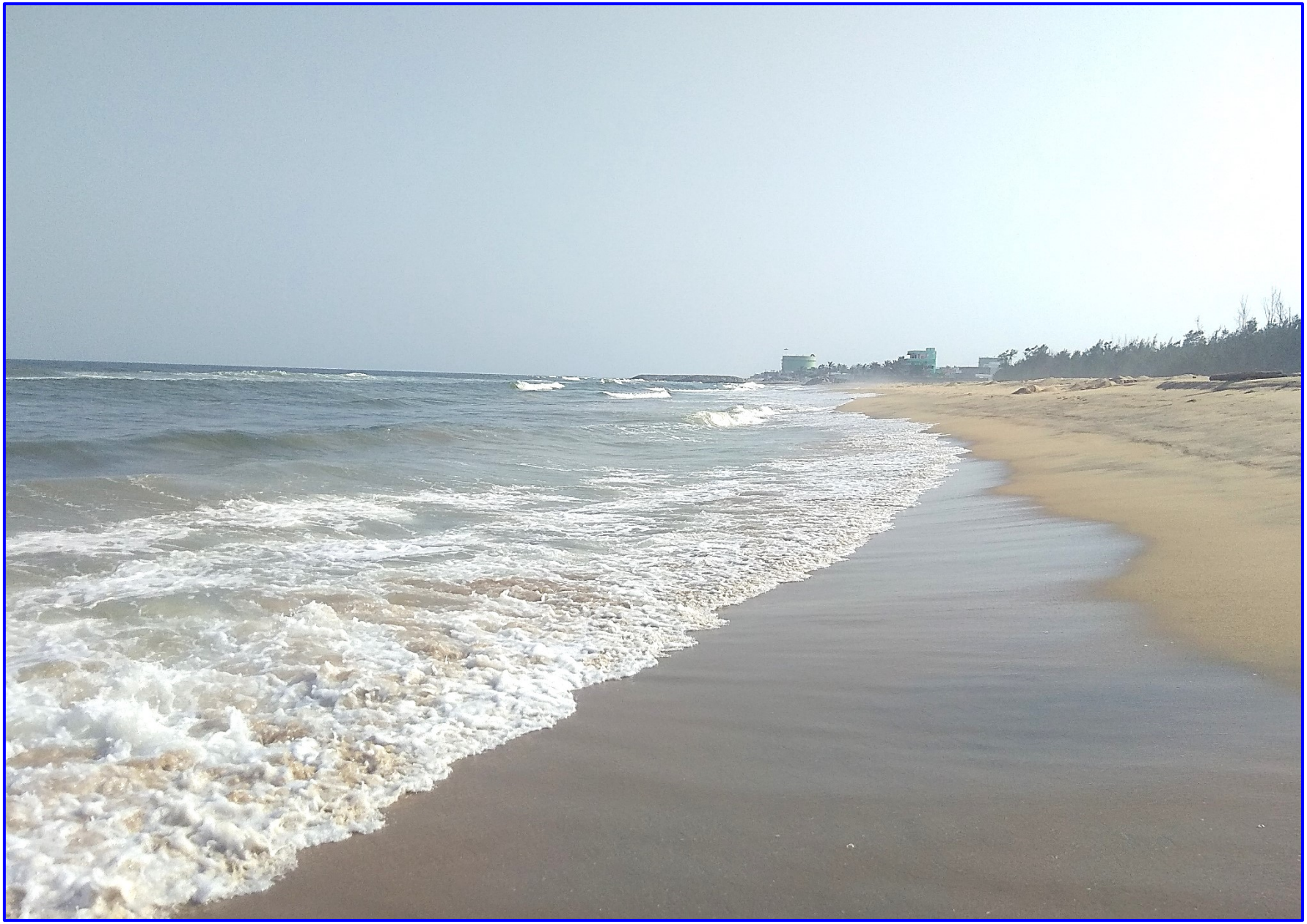


FIG. 1.1. LOCATION MAP

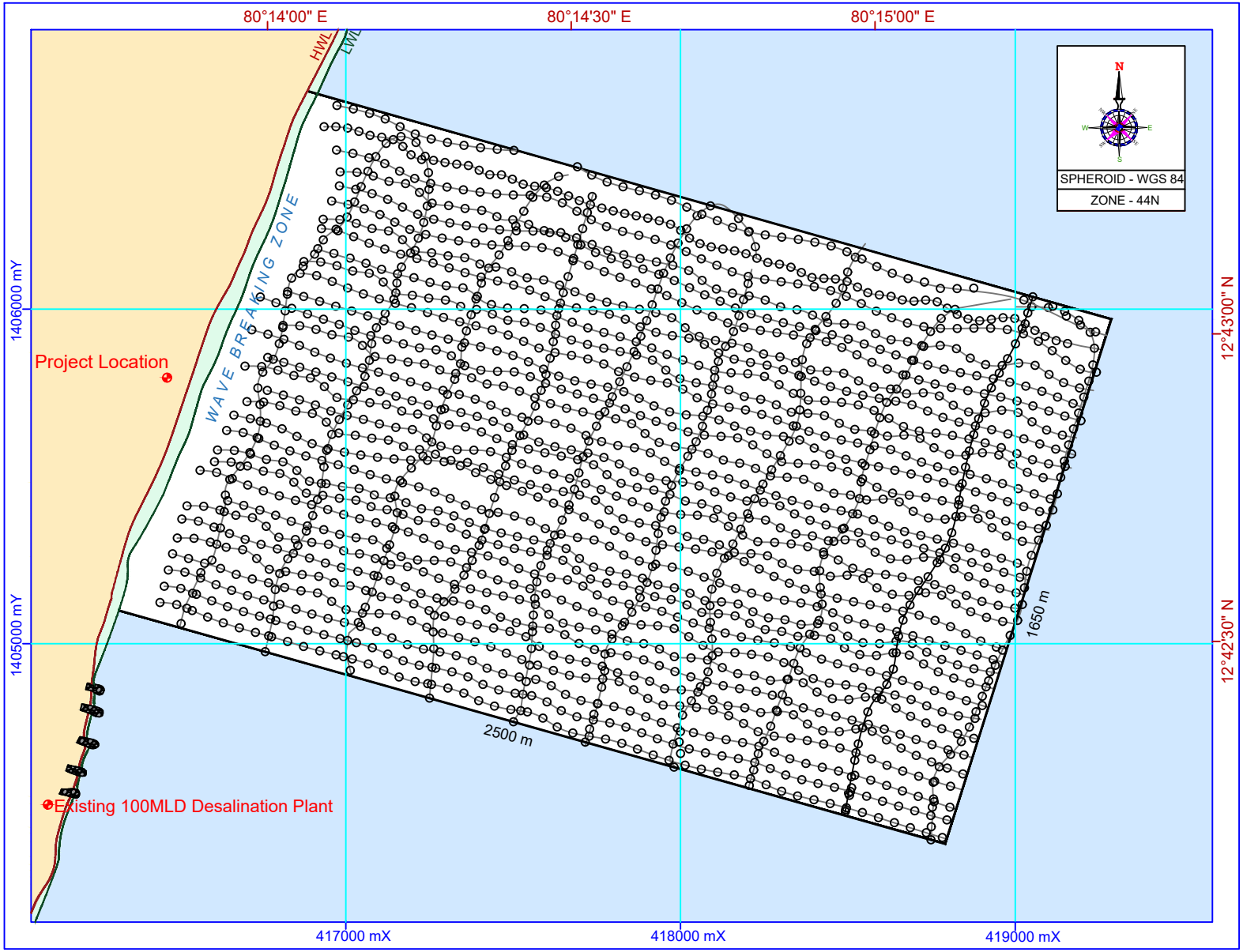


FIG.3.1. SURVEYED BATHYMETRY LINES

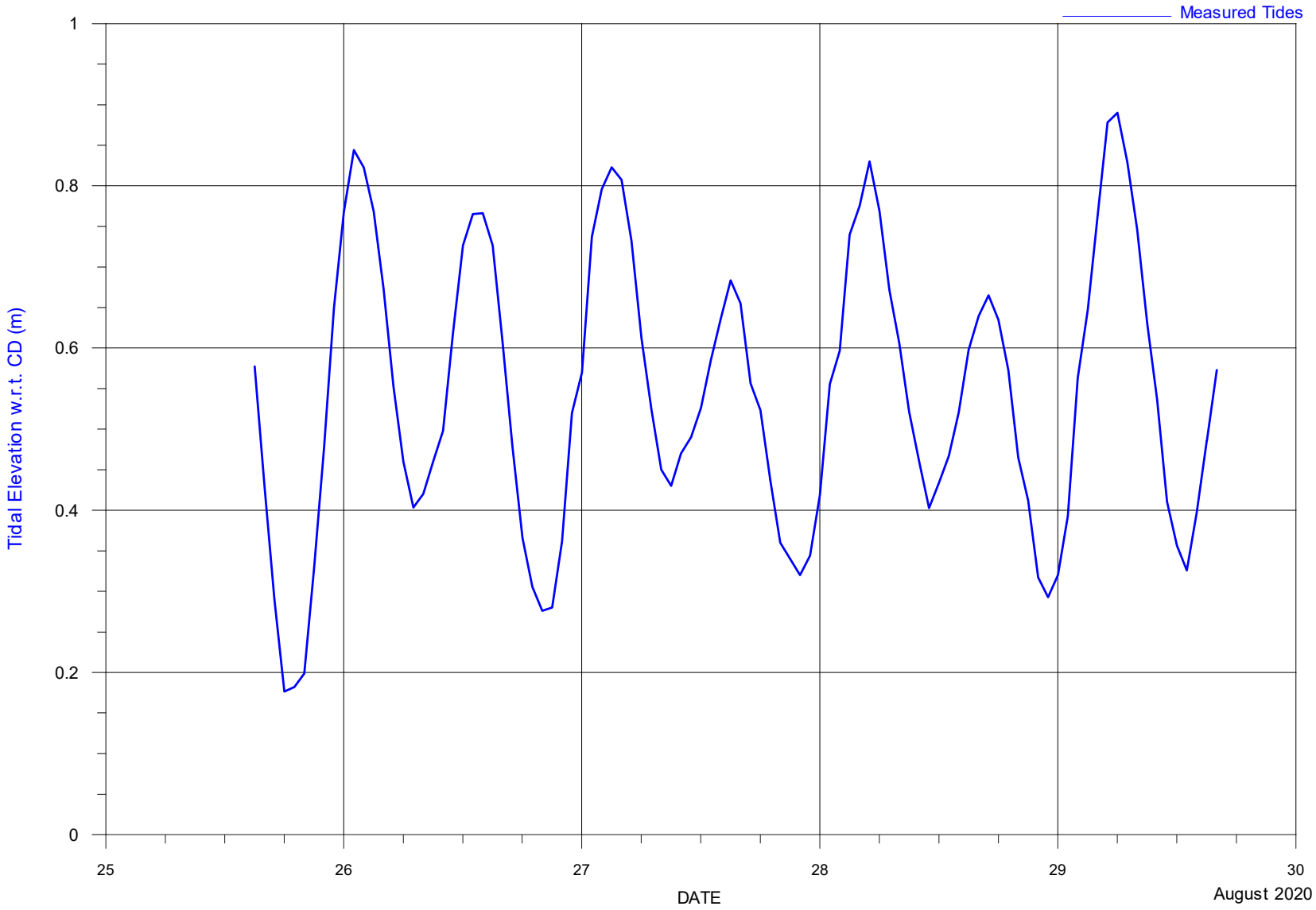


FIG.4.1. VARATION OF MEASURED TIDES

80°13'30" E | 80°14'00" E | 80°14'30" E | 80°15'00" E | 80°15'30" E

12°43'30" N

1406800 mY | 1406400 mY | 1406000 mY | 1405600 mY | 1405200 mY | 1404800 mY | 1404400 mY

415600 mX | 416000 mX | 416400 mX | 416800 mX | 417200 mX | 417600 mX | 418000 mX | 418400 mX | 418800 mX | 419200 mX | 419600 mX

12°42'30" N

Benchmark (Given by client)	Easting X(m)	Northing Y(m)	Level w.r.t MSL
TS 1	416126.9	1405923.9	11.941 m
TS 2	146025.9	1405956.7	4.752 m

EAST COAST ROAD

HTL

LWL

Nemmili kuppam

Temple

TS 2

TS 1

Discharge pit

WAVE BREAKING ZONE

400MLD Desalination Plant Area

Outfall

Intake

1m 2m 3m 4m 5m 6m 7m 8m 9m 10m 11m 12m 13m 14m

2500 m

1650 m

Temple

Sullerikattukuppam

Temple

100MLD Desalination Plant

150MLD Plant Area

BAY OF BENGAL

OUTFALL DIFFUSER	
Lat: 12°42'44" N	Long: 80°14'25" E
X = 417530 m	Y = 1405428 m
Distance = 1125 m	
Depth = 10.5 m CD	

INTAKE HEAD	
Lat: 12°42'36" N	Long: 80°14'45" E
X = 418126 m	Y = 1405211 m
Distance = 1750 m	
Depth = 12.3 m CD	


Bar check calibration


CVM Echotrac unit

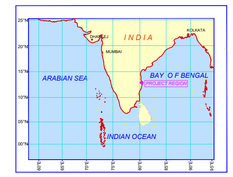

Onboard data collection

N

W E

S

LOCATION MAP :



Notes :

1. Water depths are reduced to CD using measured tides.
2. Horizontal positioning acquired using Hemisphere DGPS Beacon Receiver.
3. Bathymetry acquired using Odom Echotrac CVM Dual frequency Echosounder.
4. Annotations are in metres and suffix in decimetres.
5. Contours depths are in Metres.
6. Soundings Intervals 20 m x 20m.
7. Coastal configuration based on Hemisphere DGPS Beacon Receiver.

LEGEND:

General

Geographical Grid Intersection

UTM Grid Intersection

Bathymetry

13 .14 Depth in metres & decimetres below Chart Datum

GEODETIC DETAILS :

Spheroid	:	WGS 84
Semi major axis (a)	:	6378137.00 m
Inversed Flattening (1/f)	:	298.2572
Grid Projection	:	U.T.M. Zone 44 N
Latitude of origin	:	0° equator
Longitude of origin (CM)	:	81° East
Scale factor on CM	:	0.9996
False easting	:	500000m E
False northing	:	0m N
Unit	:	International Metre

DEPTHS IN METRES

SCALE :

40 20 0 40 80 120 160 200metres

SCALE 1 : 4000

Survey Period : 26.08.2020 to 28.08.2020

TIDAL INFORMATION :

PLACE	POSITION		HEIGHT ABOVE CHART DATUM				
			MHWS	MHWN	MLWN	MLWS	MSL
	Latitude	Longitude	Metre	Metre	Metre	Metre	(m)
CHENNAI	13° 52' N	80°41' E	1.15	0.84	0.43	0.14	0.65

CLIENT :

SMEC

SMEC INDIA, CHENNAI.

SURVEYED BY :

ISO 9001

NABET

Ph. 91-44-24862482 ; WEB: www.indomer.com, Chennai.

PROJECT TITLE :

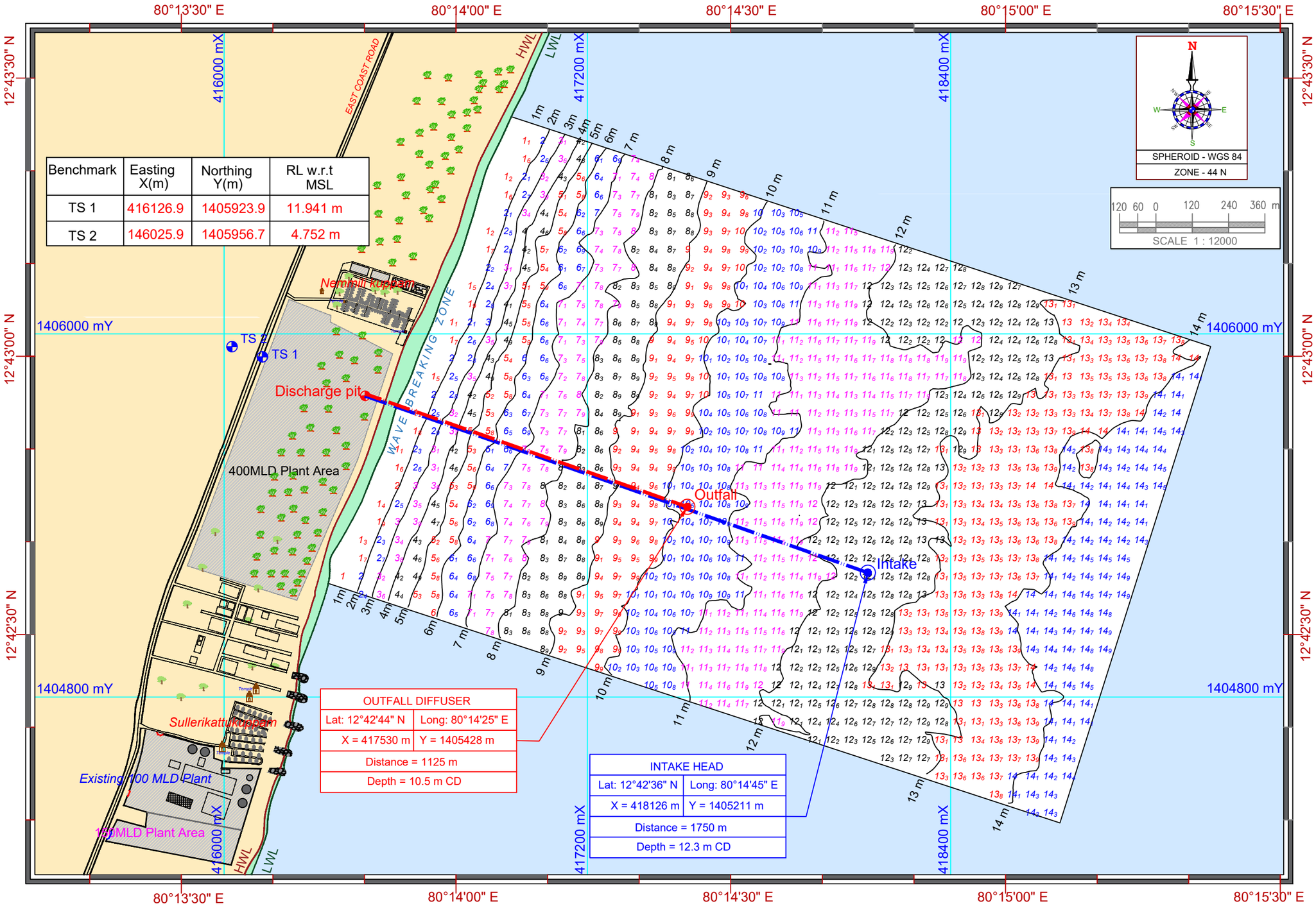
BATHYMETRY SURVEY, SEAWATER SAMPLE COLLECTION, TESTING, ANALYSIS AND BRINE DIFFUSION MODELING STUDY FOR SETTING UP 400 MLD DESALINATION PLANT AT PERUR, TAMILNADU

DRAWING TITLE :

BATHYMETRY MAP - PERUR

Surveyed by	:	J. Vinothkumar/M. Sharathi/S. Vijay
Processed by	:	J. Vinothkumar/S. Vijay
Drawn by	:	J. Vinothkumar/S. Vijay
Checked by	:	Dr. P. Chandramohan

FIG. 4.2.



Benchmark	Easting X(m)	Northing Y(m)	RL w.r.t MSL
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OUTFALL DIFFUSER	
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X = 417530 m	Y = 1405428 m
Distance = 1125 m	
Depth = 10.5 m CD	

INTAKE HEAD	
Lat: 12°42'36" N	Long: 80°14'45" E
X = 418126 m	Y = 1405211 m
Distance = 1750 m	
Depth = 12.3 m CD	

FIG. 4.3. BATHYMETRY MAP (1:12000 SCALE)

SAMPLING LOCATIONS

Stations	UTM Coordinates (Zone 44N)	
	Easting (Xm)	Northing (Ym)
SB1	416828	1405667
SB2	417053	1405591
SB3	417431	1405459
SB4	417809	1405328
SB5	418126	1405211
SB6	418452	1405104
SB7	418733	1405008
SB8	416978	1405405
SB9	417546	1405208
SB10	418113	1405011
SB11	418683	1404820
SB12	417127	1405776
SB13	417695	1405580
SB14	418262	1405383
SB15	418825	1405187

FIG.5.1. LOCATIONS OF SEABED SEDIMENT SAMPLE COLLECTION