CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD

TENDER NO:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/019/2021-22

LOAN AGREEMENT NO. ID-P267

JICA FUNDED PROJECT

BIDDING DOCUMENT

FOR

PROJECT FOR CONSTRUCTION OF CHENNAI SEAWATER DESALINATION PLANT (I)

PART-II (VOLUME 5 OF 5)

(EMPLOYER'S REQUIREMENTS)

PROCUREMENT OF DESIGN/ENGINEERING, CONSTRUCTION, COMMISSIONING OF 400 MLD SEAWATER REVERSE OSMOSIS (SWRO) DESALINATION PLANT AT PERUR, CHENNAI WITH 20 YEARS OF OPERATION AND MAINTENANCE (DBO BASIS)

INTERNATIONAL COMPETITIVE BIDDING

PROJECT MANAGEMENT CONSULTANTS
SMEC International Pty Ltd.
NJS Engineers India Pvt. Ltd.
Tata Consulting Engineers Ltd.
SMEC India Pvt. Ltd.

SUPERINTENDING ENGINEER
(CONTRACTS & MONITORING)
CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD

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Process	P
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சென்னைக் குடிநீர் வாரியம்

CHENNAI METRO WATER

EIA REPORT

For

Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamilnadu, India

AECOM

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EXECUTIVE SUMMARY

BACKGROUND

Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) is presently operating one 100 MLD R.O. desalination plant at Nemmeli, south of Chennai. It has now proposed to set up additional seawater desalination plant of 400 MLD & 150 MLD.

PROJECT DESCRIPTION

For the proposed Phase II plant, the seawater of 47791.66 m^3/hour will be drawn from the sea and about 31125 m^3/hour of brine reject will be released into the sea. The seawater intake head will be located at a distance of about 1150 m from the shoreline at 10 m depth. The outfall diffuser will be located at 750 m distance from the shoreline at 8 m water depth. The diffuser will have the multiple ports of 18 nos. x 600 mm diameter. This project involves construction of the following activities:

- *Laying of seawater intake pipeline*
- *Laying of outfall pipeline*
- *Construction of seawater intake head*
- *Construction of outfall diffuser*
- *Construction of seawater sump with pump house.*

This report deals with the investigations carried out, prediction of possible impact on the environment arising out of the provision of the above facilities and the proposed mitigation measures adopting the standards and norms prescribed by the Government and other authorities. The objective is to provide a facility having minimum environment impact in terms of temperature, salinity, and chlorine dosage, which are the vital parameters having influence on marine life. The sequence of task modules associated with the development pertaining to marine environment, are discussed in this report in detail and this section highlights the main aspects in a nutshell.

BASELINE DATA

To start with, baseline data of the existing environment needs to be established so as to determine the impact of additional facilities that are to be created, on the existing environment. For this purpose, the marine environment of the project region covering the open sea at 10 km radius has been studied as per the norms stipulated by MOEF. The baseline data required for chemical and biological parameters were collected in open sea in July 2013. The parameters studied pertain to:

i) *Physical parameters: Meteorological and oceanographic parameters such as wind, storms, waves, tides, currents, salinity and temperature, littoral drift, bathymetry, seismic survey, side scan survey, Advection - Diffusion modelling etc.*

ii) *Water quality parameters: Temperature, pH, TDS, Salinity, Dissolved Oxygen, BOD, COD, Ammonia-N, Nitrite-N, Nitrate-N, Total nitrogen, Inorganic phosphate, Total phosphorus, Turbidity, Total suspended solids, Cadmium, Lead, Mercury, Total Chromium, Phenolic Compounds, Total Petroleum Hydrocarbons, and Oil and grease.*

iii) *Sediment quality parameters: Sediment structure, Total Nitrogen, Total Phosphorous, Total organic carbon, Calcium carbonate, Cadmium, Lead, Mercury, Total Chromium and Total Petroleum Hydrocarbons.*

iv) *Biological parameters: Primary productivity, phytoplankton, zooplankton, macro benthos and their respective biomass and diversity, mangroves and seaweeds, flora and fauna, fisheries etc.*

The results of detailed analysis carried out are shown in Tables and Plates which are attached with the report. Only the important and vital parameters are discussed in this section to provide an overall insight into various sections included in the report.

I) Physical parameters

Wind: *The wind speed varies between 7 to 11 knots throughout the year and during April, May, June and December the wind speed varies around 10-11 knots and during the remaining months wind speeds varies between 7 and 9 knots. During April to September, the morning wind mostly prevailed from SW and W, and during November to February, it mostly prevailed from NW.*

Storm: *In total 58 storms had crossed within 300 km off the project region and occurrence of storms in this region are more frequent in October and in November.*

Tide: *MHWS-1.15 m, MLWS-0.14 m, MSL-0.65 m.*

Current: *During the measurement period, the maximum current speed recorded was 0.33 m/s. The current direction was shifting with tides showing the variation within the sector of 330° – 90°.*

Waves: *The significant wave height varies between 0.5 m and 1.0 m during February to April and it varies between 1 and 3.0 m during May to September and it varies between 1 and 2 m during rest of the year. The zero crossing period of the waves varied between 5 and 8 s.*

Salinity: *It varies between 32 to 34.5 ppt throughout the year.*

Temperature: *It varies between 27 and 30°C throughout the year.*

Littoral drift: *The sediment transport rates were high in May and December and it was low in March. The littoral drift was towards north from April to October and towards south during the remaining months of the year.*

Bathymetry: *At offshore, the seabed shows a steep gradient of 1:70 till 7 m depth, and the water depth is 4 m at 225 m, 5 m at 340 m, 7 m at 520 m, 8 m at 66 m, 9 m at 83 m, 10 m at 1040 m, 11 m at 1360 m, 12 m at 1890 m, 13 m at 2160 m, 14 m at 2460 m, 15 m at 2720 m and 16 m at 2950 m.*

Seismic survey: *The shallow seismic study reveals that the sub-seabed consists of sedimentary layer such as sand and clay up to few meters below seabed. The submerged and buried rocks are also noticed within the study region.*

Side scan survey: *The analyzed records reveal that the seabed is generally covered by sandy clay, clayey sand, coarse sand with scattered rocky outcrops.*

Ambient Air Quality : Predominant winds from W, WSW and E directions were observed during study period. Present major source of air pollution in the region is due to road traffic emission, domestic activities and rural conditions. The PM10 and PM2.5 are observed to vary from 32.7 to 52.5 µg/m3 and 11.0 to 19.5 µg/m3 respectively. The SO2 and NOx are observed to vary from 7.5 to 10.8 µg/m3 and 9.7 to 14.8 µg/m3 respectively. The CO values are observed to vary from 365 to 536 µg/m3 . The results of the monitored data indicate that the ambient air quality of the region in general is in conformity with respect to norms of the National Ambient Air Quality (NAAQ) Standards of Central Pollution Control Board (CPCB), with present level of activities and also it infers that the air quality levels in the study area are of fairly good quality.

Soil Characteristics :The soil samples were tested at 8 locations covering various land uses. It was observed that the soil in the study area is predominantly of sandy clay type. The pH of the soil samples ranged from 7.8 to 8.1. The Electrical Conductance of the soil samples varied from 144 to 280 µmhos/cm. The phosphorus values ranged between 28.2 kg/ha – 78.0 kg/ha. The nitrogen values ranged between 38.0 kg/ha – 65.0 kg/ha. The potassium values ranged between 0.06 kg/ha -0.20 kg/ha.

Noise Level Survey: The noise monitoring has been conducted at 8 locations in the study area. The Day Night Noise Level (Ldn) near plant site was observed as 45.7 dB(A). The noise levels in general found within the acceptable levels as per standards prescribed by Central Pollution Control Board (CPCB).

Landuse Studies: The land use pattern within 10 km radius around the proposed project area has been studied by analyzing the available primary census data. The study area falls in Chengalpattu taluk in Kancheepuram district of Tamil Nadu. The study area of 10 km zone around project area covers about 21 villages within. Altogether, the study area covers about 5663 ha of cultivated land, which works out to about 46.78 % of the total study area. The irrigated and un-irrigated land is about 25.09 % and 21.69 % of the study area respectively. Cultivable waste land and area not available for cultivation are about 14.70 % and 25.79 % respectively. Forest land is about 12.73% of the total study area.

Socio-Economic Details : The information on socio-economic aspects of the study area has been compiled from secondary sources, which mainly include census data of 2011. As per the 2011 census, the study area consists of a total population of 73245 persons residing in 17961 households. The configuration of male and female indicates that the males constitute about 50.51 % and females 49.49 % of the total population. About 34.19 % of the population in the study area belongs to Scheduled Castes (SC) and 1.04 % to Scheduled Tribes (ST). The study area experiences a literacy rate of 72.65% and has 38.83% of the total population as working population.

ii) Water Quality

pH:	*This is the most important parameter having impact on rearing of fishes and aquatic life. During the study period, it was noticed that the pH varied between 8.19 and 8.22 at all the 10 locations.*
TDS:	*TDS values varied from 34.97 to 35.27 g/l at all 10 locations.*
Salinity:	*The estimated salinity of the collected water samples varied between 34.55 to 34.79 ppt at all 10 locations.*
DO:	*The range of DO was observed at 4.51 to 6.74 mg/l. These are considered within normal range as anything below 2 mg/l will alone cause respiratory impacts on marine fauna.*
BOD:	*BOD varies from 1.09 to 4.55 mg/l. The BOD values indicate that the oxidisable organic matter brought to nearshore is effectively assimilated in coastal water and the narrow range of variation in BOD indicates that the water column is well mixed in the project area.*
COD:	*The COD values varied from 12.6 to 79.0 mg/l at all 10 locations.*
Nitrite-Nitrogen:	*Nitrite is an important element, which occurs in seawater as an intermediate compound in the microbial reduction of nitrate or in the oxidation of ammonia. Nitrite concentration ranged from 0.11 to 1.96 µmol/l at all 10 stations.*

Nitrate-Nitrogen: *Nitrate is considered to be the micronutrient, which controls primary production in the euphotic surface layer. Nitrate concentration ranged from 1.17 to 4.32 µmol/l.*

Total nitrogen: *Total nitrogen ranged from 6.20 to 18.60 µmol/l.*

Turbidity: *This is the measure to understand the level of suspended particulate matter load which controls the photosynthesis in the water column. It varies from 0.8 to 90.2 NTU*

The turbidity of nearshore waters in the surface region was found to be within the normal ranges, whereas in the bottom it was high, possibly due to presence of underwater currents.

Ammonia-Nitrogen: *The values of ammonia - Nitrogen are in normal range and indicate a healthy environment as detailed in tables attached with the report.*

Phosphate (PO4-P): *Phosphate concentration ranged from 0.20 to 1.78 µmol/l.*

Total phosphorous: *Total phosphorous ranged from 0.52 to 1.92 µmol/l.*

TSS: *Total Suspended Solids varies from 16 to 84 mg/l. The results are similar to turbidity values and appear to be within normal range.*

Metal: *Very important from the point of view of their possible adverse effects on marine biota. Cadmium concentration in the study area was < 0.01 mg/l*

Mercury concentration remained <0.002 mg/l in open sea area as revealed during the study period.

Lead concentration was < 0.02 mg/l in the open sea.

Chromium concentration was very low i.e., <0.05 mg/l in the open sea.

Phenol was found below detectable level (BDL) < 0.1 mg/l in the open sea.

Petroleum hydrocarbons were found below detectable level 0.1 µg/l in the open sea.

Oil and grease in the study area was found to be <2.0 mg/l in the open sea.

iii) Sediment Characteristics

Sediment: *Predominantly, it was medium and fine sand. Other characteristics:*

TOC	*0.37 to 1.55%.*
Total Nitrogen	*0.14 to 0.23 mg/g*
Total phosphorus	*0.15 to 0.22 mg/g*
Calcium carbonate	*25.35 to 42.90%*
Lead	*3.43 to 32.50 mg/kg*
Cadmium	*0.42 to 1.14mg/kg*
Mercury	*<2.0 mg/kg*
Chromium	*12.05 to 78.71 mg/kg*
Phenol	*<0.1 mg/kg*
Total petroleum hydrocarbons	*<0.5 mg/kg*

Oil and grease *<2.0 mg/kg*

These are low values indicating clean sediments devoid of any contamination.

iv) Biological parameters

Primary productivity:	*323 to 780 mgC/m^3/day* *Area is highly productive.*
Floral diversity	*Varies from 21 to 29 species. Most dominant species are: Bacilleriophyceae (Diatoms) formed the major group followed by Dinophyceae (Dianoflagellates) and Cyanophyceae (blue green algae). Phytoplankton population analyzed at various stations showed that their numerical abundance varied from 68 to 103 nos./ml. As many as 55 species of phytoplankton (net and unit samples put together) represented by 3 diverse groups namely, diatoms (43 species consisting of 34 centrales and 9 pennales), dinophyceans (11) and chlorophyceae (1). There were relatively fewer (46) species in the unit samples*
Zooplankton	*Fluctuates from 38 to 44 species. Zooplankton mostly consists of Coryceas danae (13.5% to 8.7%), Paracalanus parvus (7.2% to 2.0%), Oithona brevicornis (6.8% to 0.6%), Coryceas catus (6.8% to 1.8%) and Copepod stages (5.6% to 1.9%).*
Benthos	*Benthic faunal population in an environment depends on the nature of the substratum and the organic matter content of the substratum.* *Sediment characteristics is of coarse to medium sand, the numerical abundance of benthic fauna varied between 80 and 170 nos/m^2 mainly consisting of amphipods, polychaetes, bivalves and mysids.* *Intertidal benthos: Numerical abundance varied between 30 to75 nos/m^2. Generally, in a project area without pollution/stress/disturbance, the Shannon diversity values and Margalef richeness indices are higher in the range of 2.5 to 3.5, whereas it is low in the project area-which can be attributed to nature of sediment-which is sand in the area.*
Microbiology	*The study indicated that there is no microbiological pollution. Bacterial densities were higher in the sediment samples than those in the water samples which can be attributed to rich organic content in sediment and lesser residence time of microorganism in the water than the sediments.*
Mangroves	*Study area is devoid of presence of mangroves.*
Turtles	*Observed during February and March 2012, and devoid of nesting during the Survey period (July 2013).*
Fishery	*Based on the information collected on fisheries data, it can be concluded that the area is highly productive and has very good potential fishing grounds.*

A. General conclusions of biological parameters

The present study has revealed the following:

- *The diversity values of phytoplankton and zooplankton are in the range of 3.1 to 4 indicating that the region is moderately polluted and its status can be classified as 'Moderate'.*

- Continuous post monitoring of the environment would indicate the possible changes in the ecological status.
- The diversity index of sand is low because of the sandy nature of the seabed and the low organic content,
- Region is known to support good fishery indicating a healthy status of environment in general.

B. Environmental parameters and modelling study

i) Environmental impact study

Having established the baseline data on the above basis, the next important task is to assess the impact arising out of i) the quality aspects of return water let into the sea on marine life and ii) construction of the marine facilities required for the seawater intake and outfall.

ii) Modelling technique

The main objective of the study is to ensure that the rejected water does not unduly alter the marine ecosystem by way of changes in salinity levels, chlorine effects and above all temperature variation exceeding the admissible levels. These are studied by simulating the situation in numerical models developed by various institutions, the most popular one being CORMIX model and MIKE 21.

The boundary conditions are:

Quantity	31125 m^3/hour
Ambient temperature of the receiving body:	28 deg C,
Salinity level of reject water;	71 ppt i.e. 33 ppt > ambient value (38 ppt).

The study has conclusively shown that a diffuser outfall located at 750 m distance into the sea at 8 m depth, with 18 ports of 600 mm dia. each, projecting above the bed by 1.5 m with orientation of 30 deg horizontal is adequate to ensure proper mixing and dilution which will not induct any major alteration to the existing marine ecosystem and consequently on marine life. The study on CORMIX model shows the mixing zone will extend for 75 m to achieve 57 times and extending further till 200 m distance to achieve to dilution of 65 times from the disposal location.

iii) Identification of Impacts

Generally, construction of approach trestle, seawater intake and the brine discharge outfall may have some marginal magnitude of impact on seawater, marine ecology, land use and community at large on some occasions. The brine in the initial mixing zone would cause migration of fish communities. Fishes also may undergo a kind of shock and physical damages and may become prey to predators. Further, prolonged exposure of aquatic organism to chlorine at concentration as low as 0.01 mg/l (or even less to especially sensitive species) can be toxic.

iv) Prediction of Impacts

Activities which need prediction of impacts are:

- Trenching for burial of intake and outfall pipelines,
- Construction of seawater intake head,
- Construction of outfall diffuser,
- Discharge of brine reject,
- Impact on mangroves,
- Impact on turtles,
- Impact on fisheries and fishermen,

- *Impact due to tsunami and storm surge,*
- *Impact on neighbourhood, and*
- *Impact on shoreline.*

v) Impact Assessment

The baseline data collected from the project region and the review of available information indicate that the water quality parameters are within the acceptable limits for coastal regions. The quality of brine discharged into the sea is within the reference level and they reach ambient level within 500 m. The impact causing activities such as construction of intake head, outfall diffuser and pipelines etc. are purely temporary and they are all light weight structure and the civil works can be completed within a short period of time.

vi) Mitigation measures

The mitigation measures suggested in the report will, among others, include:

- *Design of appropriate structure avoiding heavy duty construction equipment and adopting good engineering practice and latest construction techniques*
- *Use of trash bars and screens in the intake head to avoid entry of fishes*
- *Short construction period*
- *Design of appropriate number of ports, diameter, orientation of ports and protection of the installation against damage by floating and lighted buoys.*
- *Controlled dredging for trenching*

vii) Marine Environmental Management Plan (MEMP)

The MEMP has been prepared with the guidelines on proper locations of marine facilities, appropriate design, control and flow of intake and outfall, prevent damage to marine ecology and social life of the people in the region.

viii) Post Project monitoring

Monitoring programme will be a continuous activity during the construction phase as well as operational phase of the facility in coordination with the power plant. This activity has to be properly organized with qualified and experienced team. Automation in measuring the quantity of discharged water is possible and will be implements.

1. INTRODUCTION

1.1. General

Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) is operating a 100 MLD R.O. desalination plant at Nemmeli, south of Chennai in order to meet the acute drinking water supply of the southern part of the Chennai city. Now CMWSSB has proposed to augment the drinking water supply by setting up additional seawater desalination plant of 400 MLD capacity as Phase II. These plants are proposed in one kilometer vicinity of the existing RO plant, i.e., at Pattipulam Village along ECR Road falling under Kancheepuram District in Tamilnadu. The project location is shown in Fig. 1 and the satellite imagery is shown in Fig. 2. AECOM, Gurgaon has been nominated as Consultant for setting up the desalination plant.

The marine facilities for the proposed desalination plant will consist of: i) laying of seawater intake pipeline on the seabed but buried below seabed to a distance of 1150 m into the sea till 10 m water depth, ii) laying of outfall pipeline on the seabed but buried below the seabed to a distance of 750 m into the sea till 8 m water depth, iii) construction of seawater intake head, iv) construction of outfall diffuser.

AECOM has awarded various oceanographic investigations to Indomer Coastal Hydraulics (P) Ltd., Chennai. Indomer has carried out studies in four parts viz., Part I: Seabed investigations, Part II: Marine EIA study, Part III: Advection Dispersion modelling study and Part IV: CRZ Demarcation by Approved Agency. Separate reports have been submitted under each part.

This report covers Part II - Marine EIA study comprising of baseline data collection on water quality, seabed sediment quality and biological parameters incorporated with modelling study on mixing and seabed investigations on the pipeline corridor. The demarcation of LTL/HTL/CRZ along the project shoreline was carried out by Institute of Remote sensing, Anna University Chennai which is one of the approved institutions by MoEF.

Coastal Regulation Zone

The Central Government has declared the following areas as Coastal Regulation Zones (CRZ),

i. The land between the High Tide Line (HTL) to 500 metres on the landward side along the sea front;
ii. Land associated with tidal influenced water bodies such as tidal creeks;
iii. The land area falling between the hazard line as defined by the Ministry of Environment and Forestry (MoEF), and 500 metres from HTL on the landward side;
iv. The land area between the HTL and the Low Tide Line (LTL), which is referred to as the intertidal zone;
v. The water and the bed area between the LTL to the territorial water limit, 12 nautical

miles offshore.

Central Government has prohibited certain activities within the CRZ, and has declared certain activities permissible with clearance from the MoEF. Desalination plants are permissible activities with permission from the MoEF, refer Section 4 (ii) (h) of the Coastal Regulation Zone Notification.

CRZ-I, II, III and IV areas are defined in the notification. CRZ zones III and IV are relevant at Perur:

- ✓ CRZ-III: Are areas that are relatively undisturbed.
- ✓ CRZ-IV: Is the water area from the Low Tide Line to twelve nautical miles on the seaward side.

Within CRZ-III there are two designated zones, a "No Development Zone" and the "200 m to 500 m zone". Within both these zones, 'Foreshore activities for desalination plants and associated facilities' are permitted activities, refer Section III, CRZ-III, A (iii)(h), and CRZ-III, B (v). In CRZ-IV areas, the activities impugning on the sea and tidal influenced water bodies are regulated. The construction of intake and outfall conduits, and intake and outfall structures, are regulated in this area.

All calendar dates are referred in Indian style as dd.mm.yy. (eg. 05.07.14 for 5th July 2014). The WGS84 spheroid with UTM coordinates in Zone 44 is followed for the surveys and for the presentation in this report.

1.2. Plant description

The seawater Reverse Osmosis Desalination Plant is planned for 400 MLD under this Phase II plan. The proposed plant will be located at Perur (Nemmeli village) at a latitude of 12° 42' 44" N and longitude of 80° 14' 26" E adjacent to the existing 100 MLD Seawater Desalination plant at Nemmeli, Kancheepuram . The nearest railway station is Othivakkam which is at a distance of 21 km from the site and the nearest airport is located at Chennai at a distance of 33 km.

The prime purpose of desalination system is to remove most of the dissolved solids from filtered seawater to make it potable for the south Chennai citizens. The seawater will be drawn from the adjacent Bay of Bengal and will be carried to the sump located inside the desalination plant. The brine reject coming out from the desalination plant will be routed by pipeline to back into the sea. Desalination Plant will have a pre treatment plant, filtration plant, reverse osmosis chambers including high pressure pump, energy recovery system and pumps for discharging the outfall.

In the SWRO unit the water is boosted upto the desired pressure by high pressure pumps and is supplied to the unit, where majority of total dissolved solids are arrested by the membranes and rejected along with the water.

The backwash and sludge generated at periodic intervals from various treatment units would be discharged into the sea along with brine.

1.3. Project Location

The plant boundary for phase II development is shown in Fig. 3. The site is located at eastern side of East Coast Road (ECR) at 12° 42' 44" N, 80°14' 26" E. The proposed 400 MLD Sea Water Reverse Osmosis (SWRO) Plant will be located at Perur near Nemmeli village, Kancheepuram District approximately 40 km south of Chennai city.

The plant site is mainly barren land, which is in the process of being acquired for the Project. East side of the site towards the sea face is fully planted with Casuarina Plantations, whereas ECR road is bordering the west side of the proposed side.

1.4. Project region

Morphology: The coastline is comprised of long and straight sandy beach exposed to open sea with elevated backshore and dune vegetations as shown in Plate 1. The coastal region is backed up with wide sand dunes upto 500 m distance inland. ECR is running immediately adjoining this shore. The strip of coastal stretch between ECR and sea is more urbanized developed with tourist resorts, hotels, cottages, farm houses and intermittent pockets of fishing hamlets. The stretches under the possession of Government remain as a plain and barren land with thorny bushes and at places protected with Casuarina farms. The nearshore remains relatively steeper due to the action of high waves during monsoon season. The seabed at nearshore primarily comprises of sand and silty clay with the spread of submerged rocky patches.

The plant situated inland will have an effluent land fall point at shore near New Kalpakkam). The coastline in this region consists of long open beaches with Casuarina plantations. The beach predominantly consists of fine sand to medium sand.

The coastline between Thiruvanmiyur and Madras port shows accretional trend due to the construction of breakwaters at Chennai port. The widest part of the beach, having horizontal spread of 600 m is seen at Marina beach. Between Thiruvanmiyur and Uthandi, beach is stable and not much subjected to human activities. This stretch showed urbanized development with an average width of 100 m foreshore and sand dunes reaching a height of 2 m. From Uthandi to Mahabalipuram towards the south, rocky outcrops are prominent in the nearshore waters. The stretch between Covelong and Mahabalipuram, is widely used for recreation. Due to the construction of semi-circular breakwater around the Mahabalipuram Shore temple, the shoreline over a stretch of 3 km towards the north is exposed to erosion. Many beach resorts are situated in this region. At 1 km north of the Mahabalipuram temple, the beach is narrow with only 50 m width with steep foreshore.

The oceanographic parameters suggest that the nearshore waters between Madras and Mahabalipuram is rich in biological resources. It was further supported from the fish catch data that the area under investigation is potentially rich in fish production.

Oceanography: The oceanography of this region is influenced by 3 climatic conditions viz., southwest monsoon (June – September), northeast monsoon (Mid October to Mid March) and fair weather period (Mid March to May). The coast is more influenced by the northeast monsoon than other two seasons. Wave action prevails high during northeast monsoon and cyclonic period. The coastal current within 5 km distance from the shore is greatly influenced by wind and tides. The nearshore remains more dynamic and turbulent due to persistent action of seasonal wind, high waves and coastal currents. The distribution of temperature and salinity indicates that the nearshore water is well mixed without stratification. The influence of littoral drift is significant and the annual net drift takes place in northerly direction.

1.5. Ecology & Economy

The fishery potential of the region is relatively good. The nearshore supports certain type of demersal fisheries with moderate bottom animal community. Tourism and beach resorts are developing in this region. The Metro water is operating 100 MLD desalination plant nearby.

2. DETAILS OF MARINE FACILITIES

2.1. Basis for selection of marine facilities

For the desalination plant, it is essential to draw the water from the sea and release brine outfall into the sea at the appropriate locations. The locations of the seawater intake and outfall are decided based on the nearshore topography, geological composition of the seabed, the dynamics of the ocean including waves and currents, the mixing characteristics of the nearshore water, the restriction imposed on the recirculation of discharged water into the intake. The various parameters relevant to all these aspects were studied during the data collection and mathematical modeling and accordingly, the appropriate locations are identified.

In the present case, the intake has been located at 1150 m distance offshore in order to draw clean seawater without the interference of the outfall. The outfall diffuser located at 750 m distance from the shoreline. Since the nearshore currents in this region are predominantly directed towards north, it is preferred to locate the outfall on the northern side, so that the plume spread will be mostly oriented towards north and there will not be any re-circuit to the intake. The various concepts and the relevant calculations are shown in detail in forthcoming chapters. The summary of the various facilities are described below.

2.2. Seawater intake

The seawater will be drawn by laying two submarine pipelines (intake I and intake II). The details are given below:

Location	Geographical Co-ordinates		UTM	
	Latitude, N	Longitude, E	X (m)	Y (m)
LFP – Intake I	12°42'48.50"	80°13'44.80"	416345	1405575
LFP – Intake II	12°42'47.85"	80°13'44.50"	416335	1405551
Intake head I Depth= 10 m	12°42'39"	80°14'20.69"	417447	1405280
Intake head II Depth= 10 m	12°42'30.24"	80°14'17.10"	417339	1405010

Intake volume: The seawater requirement for the RO (Reverse Osmosis) plant will be 10833 m^3/hour (260 MLD) initially during the present stage and it will be 47791.66 m^3/hour (1147 MLD) finally after phase II development.

Intake description: The both seawater intake head will be located at a distance about 1150 m from the shoreline at 10 m CD (Chart Datum) water depth. The water from the intake head will be drawn by gravity flow through the submarine pipeline buried 1 m below the seafloor.

2.3. Marine outfall

Brine outfall quality: The salinity of the return water released into the sea will be 71 ppt, which will have the salinity difference of 33 ppt higher than the seawater ambient salinity of 38 ppt. A chlorine dosage of 3 ppm will be given to the drawn seawater and the return water discharged into the sea will have the concentration of around 0.2 ppm. The water quality of the return water disposed into the sea will conform to the standards stipulated by Tamilnadu Pollution Control Board. There will not be any change in other water quality parameters compared to the ambient values.

Brine outfall volume: The brine discharge into the sea will be 6667 m^3/hour (160 MLD) initially during the present stage and it will be 31125 m^3/hour (747 MLD) after phase II development.

Outfall location: The outfall diffuser will be located at 750 m distance from the shoreline at the water depth of 8 m CD. The outfall will have a multiple port diffuser arrangement system.

Location	Geographical Co-ordinates		UTM	
	Latitude, N	Longitude, E	X (m)	Y (m)
LFP -Outfall	12°42'48.90'	80°13'44.95"	416349	1405588
Outfall diffuser Depth = 8 m	12°42'48.83"	80°14'08.05"	417066	1405582

3. SCREENING AND SCOPING

The project region primarily comprises of dry and barren land without much inhabitation. The proposed expansion of desalination plant will improve the drinking water supply to the southern part of Chennai city. The project related activities are concerned with the marine environment and thus a marine EIA study will be essential in order to identify the impacts, mitigation and to draw an Environmental Management Plan.

4. BASELINE DATA

The marine environment of the project region at open sea has been studied for the evaluation of baseline information as per the norms stipulated by the Ministry of Environment and Forests, Govt. of India. The baseline data were collected during July 2013. The chemical and biological samples were collected at ten locations in the open sea covering 10 km radius. In addition, water samples were also collected from six more location around the proposed intake and outfall locations for detailed analysis. The details of the sampling locations are presented in Table 1 and also shown in Fig. 4. The details of the studies carried out in the coastal region on physical, chemical and biological aspects are presented below.

Physical parameters

Wind
Storm
Waves
Tides
Currents
Salinity and Temperature,
Littoral Drift
Computer modelling on mixing and
Bathymetry, shallow seismic and side scan surveys

Water quality parameters

Temperature
pH
TDS
Salinity
Dissolved Oxygen
BOD
COD
Ammonia-N
Nitrite-N
Nitrate-N,
Total nitrogen
Inorganic phosphate

Total phosphorus
Turbidity
Total suspended solids
Cadmium
Lead
Mercury
Total Chromium
Phenolic Compounds
Total Petroleum Hydrocarbons
Oil and grease

Sediment quality parameters

Sediment structure
Total Nitrogen
Total Phosphorous
Total organic carbon
Calcium carbonate
Cadmium
Lead
Mercury
Total Chromium and
Total Petroleum Hydrocarbons.

Biological parameters

Primary Productivity
Phytoplankton, its biomass and diversity
Zooplankton, its biomass and diversity
Macro benthos, its biomass and diversity
Microbial population in water and sediments
Mangroves
Biological status of floral and faunal communities and
Fisheries.

Environmental study

Assessment of fishery resources in the area,
Assessment of coastal and marine ecosystem,
Assessment of impact on laying of intake/outfall pipelines,
Assessment of impact on construction of seawater intake head,
Assessment of impact on construction of outfall diffuser,
Assessment on the impact of the discharge of brine,
Recommendation on mitigation measures and
Preparation of Environment Management Plan.

4.1. Plan of work

The data collection was carried out during July 2013 in order to prepare the Marine EIA report.

4.2. Methods of data collection and analysis

4.2.1. Physical

Wind: To understand the wind pattern prevailing in the project region, the data on daily variation of wind speed and direction at 0830 hours and 1730 hours available for Chennai region were compiled from the *Bay of Bengal Pilot (1978)*.

Storm: The information on cyclonic storm is essential for the environmental assessment. Occasional occurrence of severe cyclonic storm is found to occur in this region. Based on the IMD data on the Tracks of Storms and Depressions in the Bay of Bengal and the Arabian Sea, (1979), and the Addendum (1996) published by IMD, the details on the storms occurred between 1877 and 1990 were compiled.

Waves: The ship reported visual observations documented in Indian Daily Weather Reports (IDWR) published by the India Meteorological Department, Pune, compiled over the period from 1968 to 1986 were used for the base line data. The data reported for the region between the latitude 10°N - 15°N, and longitude 80°E - 85°E were considered for the present project (Chandramohan, et.al., 1990).

Tides: Tide measurement was carried at Fishing harbor using Aanderaa WTR9 Wave and Tide Recorder for a period of 19 days from 27.07.2013 to 15.08.2013. The tide data were recorded at 30 min interval. The Tides are measured at site. The details of measurements are:

Location	Geographical Co-ordinates		UTM - Zone 44		Duration	
	Latitude, N	Longitude, E	X (m)	Y (m)	From	To
Stn. T1	13°07'33"	80°17'53"	0423938	1451168	27.07.13	15.08.13

Aanderaa WTR9 Wave and Tide Recorder: It is manufactured by Aanderaa Instruments, Norway. It has a pressure sensor, which is based on a high precision quartz crystal oscillator. The pressure is measured every 0.5 seconds and 1024 samples are taken (512 seconds) and stored in internal RAM for wave analysis. The parameters/ channels are transmitted as Aanderaa standard PDC-4 from the electronic control board to the removable and reusable solid state Data Storage Unit (DSU). The instrument is housed in a pressure case and has the arrangement for shallow and deep water moorings. A mode switch with a test and serial communication setting, a depth-setting switch and a recording interval switch is built into this board. The quartz pressure sensor is also attached to the board by a shock-absorbing bracket. A specially designed bottom mounting frame was used for installing the instrument on the seabed. The sensor is of quartz pressure type based on a pressure-controlled oscillator having frequency of 30 – 45 kHz. It has a range of 0-690 kPa, with an accuracy of 210 Pa and a resolution of 7 Pa. By use of the Deck Unit 3127 interface, the output raw data signals can be read by a PC through the same terminal and converted into engineering units.

Currents: Variations of current speed and direction were measured at one location off the project region using Aanderaa Seaguard SW RCM current meter (Stn. C1). The measurements were carried out in 15 minutes interval from 10.08.13 to 25.08.13. The measurement location is shown in Fig. 5. The details of measurement location, depth and duration are:

Location	Geographical Co-ordinates		UTM - Zone 44		Distance offshore (km)	Water depth (m)	Duration	
	Latitude, N	Longitude, E	X (m)	Y (m)			From	To
Stn.C1	12°37'30"	80°12'31"	0414063	1395804	1.5	8.5	10.08.13	25.08.13

Aanderaa Seaguard RCM SW Current Meter: The SEAGUARD RCM manufactured by Aanderaa Data Instruments (AADI), Norway, comes standard with the ZPulse™ multi frequency Doppler current sensor. The new current sensor comprises acoustic pulses of several frequency components to lower the statistical variance in the Doppler shift estimate. The advantage of this is reduced statistical error with fewer pings, providing increased sampling speed and lower power consumption. The new Doppler Current Sensor also incorporates a robust fully electronic compass and a tilt sensor.

The Seaguard architecture is based on a general data logger unit and a set of autonomous smart sensors. The data logger and the smart sensors are interfaced by means of a reliable CAN bus interface (AiCaP), using XML for plug and play capabilities. The autonomous sensor topology also gives the sensor designer flexibility and opportunities where each sensor type may be optimized with regard to its operation; each sensor may now provide several parameters without increasing the total system load. Data storage takes place on a Secure Digital (SD) card. The current capacity for this card type is up to 4GB, which is more than adequate for most applications.

Littoral Drift: Based on the ship reported wave data, the longshore sediment transport rate at the study region was estimated using the following equation (Shore Protection Manual, CERC, US Army, 1975).

$$Q = 1290(\frac{\rho g^2}{64\pi})T(H_o K_r)^2 \sin 2\alpha_b$$

Where,

Q	=	longshore sediment transport rate in m^3/year,
ρ	=	mass density of the sea water in kg/m^3,
g	=	acceleration due to gravity,
H_o	=	deepwater wave height in m,
T	=	wave period in seconds,
K_r	=	refraction coefficient, and
α_b	=	wave breaking angle.

4.2.2. Water quality

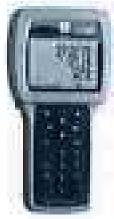
Water samples were collected at 10 locations in open sea and also collected six more locations (A1 to A6), as indicated in Table 1. and Fig. 4. Samples were collected at surface, mid depth and bottom. Van Dorn water sampler was used for collection.

Samples for Dissolved Oxygen was collected in DO bottles (125 ml capacity) soon after the sampler was retrieved. One end of the nozzle tube was inserted into the sample bottle bottom and filled till 100 ml and the water was allowed to overflow from the bottle to ensure that no bubble is trapped or carried out in the bottle. To the brimful DO bottles 1 ml of Winkler A (manganese chloride) and 1 ml Winkler B (alkaline KI) were added. The stopper is then inserted and the bottle is shaken vigorously for about 1 minute to bring each molecule of dissolved oxygen in contact with manganese (II) hydroxide. After fixation of oxygen, the precipitate was allowed to settle. The DO bottles were kept in dark and transported to the laboratory for analysis. Samples for Biochemical Oxygen Demand (BOD) was also collected in the similar fashion as described for DO in 300 ml glass BOD bottles. All the samples were transported to the laboratory in portable ice box. The samples were incubated at 27°C for 3 days. After incubation, the samples were fixed with Winkler A and Winkler B and later the BOD was analyzed in the laboratory.

Water samples for salinity, total suspended solids, turbidity, nutrients, trace metals and phenolic compounds were collected from the sampling locations using clean polyethylene bottles and were transported to the laboratory by keeping them in a portable ice box. Water samples for total petroleum hydrocarbons were collected separately in 5 litre glass bottles. The sample for Phenol estimation was collected in a pre cleaned 1 litre plastic container.

Method of analysis

YSI 6600 V2 Multiparameter Water Quality Sondes: For the current project we have also used one of the latest equipment, YSI Multiparameter Water Quality measurement and data collection system. The main advantage of this system is its ability to collect data on several parameters continuously and simultaneously while the instrument is deployed into the water column from the surface.



This type of measurement would help us to see the presence of any stratification in the water column and if needed, measurements at a given location can be undertaken even for a number of days. This instrument is also accompanied by a hand held monitor for real time recording on board the survey vessel. The unit which we have used measured the following parameters:

- Depth
- Temperature
- Salinity
- Total Dissolved Solids
- pH
- ROX Optical Dissolved Oxygen
- DO Saturation

Method of analysis

Temperature: The sondes utilize a thermistor of sintered metallic oxide that changes predictably in resistance with temperature variation. The algorithm for conversion of resistance to temperature is built into the sonde software, and accurate temperature reading in degrees Celsius, or Fahrenheit is provided automatically. The measurable temperature range is -5 to 50 $^{\circ}$C with an accuracy of $\pm$ 0.15 $^{\circ}$C. The temperature is measured with a resolution of 0.01°C

pH: The sonde employ a field replaceable pH electrode for the determination of hydrogen ion concentration. The probe is a combination electrode consisting of a proton selective glass reservoir filled with buffer at approximately pH 7 and a Ag/AgCl reference electrode that utilize electrolyte that is gelled. A silver wire coated with AgCl is immersed in the buffer reservoir. Protons (H^+ ions) on both sides of the glass (media and buffer reservoir) selectively interact with the glass, setting up a potential gradient across the membrane. Since the hydrogen ion concentration in the internal buffer solution is invariant, this potential difference, determined relative to the Ag/AgCl reference electrode, is proportional to the pH of the media. The sonde was calibrated using standard pH buffer. The measurable pH range is 0 to 14 units with an accuracy of $\pm$ 0.2 units. The pH is measured with a resolution of 0.01 units.

Salinity: Salinity is determined automatically from the sonde based on conductivity and temperature readings according to algorithms found in *Standard Methods for the Examination of water and wastewater* (1989). The measurable Salinity range is 0 to 70 ppt with an accuracy of $\pm$ 1.0% of reading or 0.1ppt. The Salinity is measured with a resolution of 0.01 ppt

Total Dissolved Solids: The electrical conductivity of environmental water is due to the presence of dissolved ionic species. Thus, the magnitude of the conductivity (or specific conductance) value can be used as a rough estimate of amount (in g/L) of these ionic compounds which are present. The 6-series software provides a conversion from specific conductance to total dissolved solids (TDS) by the use of a simple multiplier. However, this multiplier is highly dependent on the nature of the ionic species present.

Dissolved Oxygen (DO): Dissolved Oxygen sensors from a variety of manufacturers are based on the well-documented principle that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with carefully-chosen chemical dyes. The sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into disk about 0.5 inches in diameter. This dye-containing disk will be evident on inspection of the sensor face. The blue light causes the immobilized dye to luminance and the lifetime of this dye luminescence is measured via a photodiode in the probe. The measurable Dissolved Oxygen range is 0 to 50 mg/l with an accuracy of $\pm$ 0.01 mg/l. The Dissolved Oxygen is measured with a resolution of 0.01 mg/l.

Biochemical Oxygen Demand (BOD): BOD was determined by the same procedure (Winkler method) as that for DO, after 3 days of incubation at 27°C in a BOD incubator. The difference in the amount of oxygen on the 1st and 3rd day give the measure of Biochemical Oxygen Demand.

Chemical Oxygen Demand (COD): Chemical oxygen demand (COD) determines the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The organic matter gets oxidized completely by potassium dichromate ($K_2Cr_2O_7$) in the presence of H_2SO_4 to produce CO_2 plus H_2O. The excess $K_2Cr_2O_7$ remaining after the reaction was titrated with ferrous ammonium sulphate [$Fe(NH_4)_2(SO_4)_2 . 6H_2O$] using ferroin as indicator. The volume of dichromate consumed gives the oxygen required for oxidation of the organic matter.

Turbidity: Turbidity was measured by the Nephelometric method after calibrating the Nephelometer using known dilutions of standard prepared from hydrazine sulfate and hexamethylene tetramine in distilled water.

Nitrite-Nitrogen (NO_2-N): The nitrite was estimated by following method of Parsons et al. (1984). The nitrite from known volume of sea water (25 ml) was allowed to react with sulfanilamide in an acid solution. The resulting diazo compound was allowed to react with N-(1-naphthyl)-ethylenediamine to form a coloured azo dye which was spectrophotometrically measured at 543 nm.

Nitrate-Nitrogen (NO_3-N): It was determined using the method given by Parson *et al.* (1984). Nitrate in the sea water was quantitatively reduced to nitrite by running the sample through a column containing cadmium filings coated with metallic copper. The nitrite produced is diazotised with sulfanilamide and coupled with N-(1-naphthyl)-ethylenediamine to form a pink coloured azo dye, which was measured spectrophotometrically at 543 nm. Nitrate values were corrected for nitrite in the sample.

Total Nitrogen: This nutrient was estimated by following method suggested by Grasshoff *et al.* (1983). Total nitrogen represents all forms of dissolved inorganic and organic compounds of nitrogen in seawater. Organically bound nitrogen is oxidized to nitrate during alkaline persulphate digestion. The nitrate content of the sample is determined after reduction to nitrite running the sample through a column containing cadmium filings coated with metallic copper. The nitrite produced is diazotised with sulfanilamide and coupled with N-(1-naphthyl)-ethylenediamine to form a pink coloured azo dye, which was measured spectrophotometrically at 543 nm.

Inorganic Phosphate (PO_4-P): It was determined by following the procedure of Parsons *et al.* (1984). In this method the seawater sample was allowed to react with a composite reagent containing molybdic acid, ascorbic acid and trivalent antimony. The resulting phosphomolybdate complex is reduced to give a blue colour solution, which was measured using in spectrophotometer at 880 nm.

Total phosphorous: This nutrient was estimated by following method suggested by Grasshoff *et al.* (1983). Total phosphorous represents all forms of dissolved inorganic and organic species of phosphorous. Organically bound phosphorous is completely decomposed to phosphate by a strong oxidizing agent (alkaline persulphate). Inorganic forms of phosphorous in lower oxidation state are also oxidized to phosphate. The pH is between 4 and 5. These conditions are obtained by a boric acid-sodium hydroxide system. Phosphate in sea water is allowed to react with ammonium molybdate in acid medium, forming a phosphomolybdate complex, which is reduced by ascorbic acid, in presence of antimony ions (to accelerate the reaction), to a blue coloured complex containing 1:1 atomic ration of phosphorous to antimony. The absorption of the complex is measured at 880 nm.

Ammonia-Nitrogen (NH_3-N): This nutrient was estimated by following method suggested by Grasshoff *et al.* (1983). Ammonia from the seawater sample reacts in moderately alkaline solution with hypochlorite to monochloramine, which in the presence of phenol, trisodium citrate buffer and excess hypochlorite and gives indophenol blue. The reaction temperature of 37 - 40° C was used for the estimation of ammonia-nitrogen. The concentration was measured spectrophotometrically at 640 nm to obtain NH_3-N.

Total Suspended Solids (TSS): The TSS of seawater samples was determined by filtering a known volume (500 ml) of seawater sample through pre-weighed 4.5 cm Whatman GF/C glass microfibre filter paper. Filtration was carried out under controlled vacuum source. The filter papers were then dried (40°C) till a constant weight was obtained. The difference between the final and initial weight of the filter paper resulted in the estimation of TSS from the water samples.

Phenols: Phenols in seawater (500 ml) was converted to yellow coloured antipyrine complex by adding 4 –amino antipyrine. The complex was extracted in chloroform (25 ml) and the absorption was measured at 460 nm using phenols as a standard. The method followed was according to IS: 3025 (P-43) 1992 (RA 2003).

Total Petroleum Hydrocarbons (PHC): The fraction of the PHC was estimated using a Gas chromatography with Flame Ionization Detector (GC/FID) following the method of TNRCC, 1055. The various fractions analyzed were: Decane, Docosane, Dodecane, Eicosane, Hexacosane, Hexadecane, Octacosane, Octadecane, Tetracosane and Tetradecane.

Cadmium, Lead and Chromium: Known volume of sample was acidified to pH 2.0 using HCL. APDC (Ammonium Pyrrolidine Dithiocarbamate) was added and sample shaken well for complete mixing. Known volume of MIBK (Methyl Isobutyl Ketone) was added to the sample followed by thorough mixing. Metals' forming a yellow ring over the sample was separated and this extract was kept for further analysis of trace metals (Cd, Pb, Cr) using AAS (Model- HITACHI-Z-7000, Polarized Zeeman Atomic Absorption Spectrophotometer, Graphite Furnace, Tube type covet). Protocol followed was according to IS: 3025 (P-41) 1992 (RA 2003), IS: 3025 (P-47) 1994 (RA 2003) and IS 3025 (P-52) 2003.

Mercury: Seawater samples for the determination of mercury was transferred from Niskin sampler to acid washed bottles and acidified to a pH below 2 by adding 0.1 N hydrochloric acid which was previously tested for traces of mercury. Pre-concentration of mercury in seawater was achieved by complexing with dithiozone at pH below 2. The complex was extracted in carbon tetrachloride and back extracted in 5 M hydrochloric acid. The acid extract was shaken with sodium nitrite to decompose the dithizone and revert mercury to the aqueous phase. Excess of nitrite was reduced to hydroxylamine hydrochloride. Inorganic mercury compounds in the final solution was reduced to the elemental mercury with stannous chloride and measured by cold vapor Atomic Absorption Spectroscopy (Protocol according to IS: 3025 (P-48) 1994 (RA 2003)).

Oil and Grease: The total oil and grease content of the water samples were estimated according to the method outlined in IS 3025 (P-39) 1991 (RA 2003) and the results are expressed in mg/l.

Meteorology

The meteorological data recorded during the monitoring period is very useful for proper interpretation of the baseline information as well as for input prediction models for air quality dispersion. Historical data on meteorological parameters will also play an important role in identifying the general meteorological regime of the region.

The year may broadly be divided into four seasons:

- Winter season : December to February
- Pre-monsoon season : March to May
- Monsoon season : June to September
- Post-monsoon season : October to November

Methodology

The methodology adopted for monitoring surface observations is as per the standard norms laid down by Bureau of Indian Standards (IS : 8829) and India Meteorological Department (IMD). On-site monitoring was undertaken for various meteorological variables in order to generate the site-specific data. The generated data is then compared with the meteorological data generated by IMD.

Methodology of Data Generation

The automatic meteorological instrument was installed on top of a building near to the project site to record wind speed, direction, relative humidity and temperature. Cloud cover is recorded by visual observation. Rainfall is monitored by rain gauge. Hourly average, maximum, and minimum values of wind speed, direction, temperature, relative humidity and rainfall have been recorded continuously at this station during 1st August 2013 to 31th October 2013.

Sources of Information

Secondary information on meteorological conditions has been collected from the nearest IMD station at Chennai Airport.
India Meteorological Department has been monitoring surface observations at Chennai since 1891. Pressure, temperature, relative humidity, rainfall, wind speed and direction are measured twice a day viz., at 0830 and 1730 hr. The wind speed and direction data of IMD, Chennai has been obtained for the past available 10 years. The data for the remaining parameters has been collected for the last 10 years and processed.

4.2.3. Sediment characteristics

Method of collection

Seabed sediment samples were collected at 10 locations (stns. S1 to S10). Intertidal zone sediment samples were also collected at 3 locations for inter tidal benthos analysis (stns. IB1 to IB3). The sediment sampling locations are shown in Fig. 4. Seabed sediments were collected using van Veen grab, stored in two plastic bags. One fraction was fixed in buffer formaldehyde mixed with rose Bengal solution for sub-tidal benthos analysis and another fraction taken to the laboratory for seabed sediment quality parameters. Inter-tidal benthos samples were collected using a handheld shovel using a quadrant (0.25m²). After collection, the scooped sample was sieved using a handheld sieve (500 micron) and organisms transferred to polythene bags, fixed, labeled and stored for further analyses at the laboratory. On reaching the laboratory the sediment samples were dried and sieved.

Method of analysis

Size distribution: The sediment samples were dried and sieved for fractions: 53 µ, 125 µ 212 µ, 300 µ, 425 µ, 500 µ, 600 µ, 1000 µ and 2000 µ. The fractions retained in each mesh size were weighed and analyzed.

Total Organic Carbon: TOC was determined by wet oxidation method. Potassium dichromate was added to the sample, followed by Sulfuric acid and after cooling distilled water was added. A drop of diphenylamine indicator and pellets of sodium fluoride was added, and sample was titrated against Ferrous ammonium sulfate.

Total nitrogen: Total nitrogen from the sediment sample was estimated by extracting the sediment with an extracting reagent ($CuSO_4$ and silver sulfate) and shaking the experimental flask for 15 minutes. Later $Ca(OH)_2$ and $MgCl_2$ was added and the contents filtered through Whatman 1 filter paper. A known volume (5 ml) of the filtrate was used for total nitrate estimation similar to the process used for water samples (reduction by passing through a cadmium column).

Total Phosphorus: Total Phosphorus of the sediments was estimated by initially digesting the sediment samples in sulfuric acid for 30 minutes to oxidize phosphorus to phosphate. After filtration, a known volume of the filtrate was allowed to react with ammonium molybdate and reduced using ascorbic acid to form a blue coloured complex which was measured at 880 nm using a spectrophotometer.

Calcium Carbonate: Calcium Carbonate from the sediment sample was estimated by treating a specimen of known dry weight (5 g) with dilute hydrochloric acid until all visible reactions are complete. Then the sediment is washed with distilled water and dried in oven at 40°C and weighed again. The initial dry weight and the final dry weight give the carbonate content present in the seabed sediment

Cadmium, Lead and Chromium: Sediment sub-samples were collected and sealed in plastic bags and frozen till the analyses were carried out at the shore laboratory. These were thawed and dried in oven at 40° C. The dried sediment was then finely ground and digested with hydrofluoric acid in a pre cleaned acid washed Teflon beaker. During this process the silica volatized as silicon tetrafluoride. This was followed by treatment with nitric and perchloric acid to destroy the organic matter. The residue after the evaporation of acids was dissolved in dilute hydrochloric acid. The metals were determined on a graphite furnace Atomic Absorption Spectrophotometer, calibrated with suitable standards digested similarly and measured at recommended wavelengths.

Mercury: Sediment samples were oven-dried at 40°C and crushed to fine powder. About 0.5 gm aliquot of the sample was transferred into 300 ml BOD bottles (in duplicate). 5 ml of Milli Q water and 5 ml Aqua Regia were added and mixed with the sample. The samples were heated for 2 minutes in a water bath at 90°C. On cooling 20 ml of Milli Q water and 15 ml of $KMnO_4$ solutions were added to each. After thorough mixing, the samples were again heated in the water bath for 30 minutes at 90°C. On cooling 6 ml of sodium chloride- Hydroxylamine hydrochloride reagent was added to each bottle to reduce the excess permanganate and the final volume was made up to 75 ml. Blanks and standards were also digested similarly. Mercury compounds in the final solution were reduced to elemental mercury with 5 ml of 20% stannous chloride and measured by cold vapor Atomic Absorption Spectrophotometer at 253.7 nm.

Oil and Grease: The total oil and grease content of the sediment samples were estimated according to the method outlined in APHA 22nd edition 2012, 5520-E and the results are expressed as mg/kg.

4.2.4. Biological parameters

Primary Productivity: Primary Production was estimated at 10 locations i.e. stns. S1 to S10 (Fig. 4). From the water sampler, the samples were immediately transferred to 125 ml Dissolved Oxygen (DO) bottles (two light bottles and one dark bottle). One light bottle containing sample was fixed with Winkler A and Winkler B for analysis of initial oxygen content. The other light bottle and dark bottle with sample were kept in a bucket containing same water sample for 6 hours to allow photosynthesis and respiration. After 6 hours the samples were fixed with Winkler A and Winkler B, and later the DO was analyzed in the laboratory. The increase in dissolved oxygen of water as a result of photosynthesis was measured in the light bottle; simultaneously the decrease in oxygen content in the dark bottle was measured to estimate the respiration alone in the same sample of water. From the two DO values the amount of organic carbon synthesized during photosynthesis was calculated.

Flowmeter: Digital flowmeter (model - 2030R) duly calibrated by the company was used for collection of phyto and zooplankton in the current project. The flow meter consists of an impeller and a counter. The impeller is directly connected to the counter which records each revolution of the impeller. The flow meter has to be attached to the mouth region of the plankton net. With the help of the flow meter we can measure and calculate the volume of water filtered to obtain the plankton biomass in a unit area.

Phytoplankton: Phytoplankton samples were collected at 10 locations i.e. S1 to S10 (Fig. 4). Phytoplankton net (60 micron) was towed 0.5 m below the water surface for 5 minutes and the collected samples were immediately preserved in Lugol's iodine solution for identification purpose only. Besides, phytoplankton was also collected from surface waters using 1 lit. clean polyethylene bottles for population estimation and preserved with Lugol's iodine. Total sedimentation time was 72 hours. After sedimentation of phytoplanktons, the supernatant solution was siphoned out to concentrate the volume to about 100-150ml. During the siphoning process, due care was taken to prevent entry of phytoplankton by attaching an appropriate net (mesh size-55micron) at the inlet of the siphoning tube. Moreover, instead of taking the supernatant in one lot out, about 200 to 300ml of the supernatant was removed after every 24 hrs, so that disturbance is kept at minimum during the siphoning process. From the above concentrated aliquot, after homogenizing, 1ml was taken on a Sedge-wick Rafter cell for counting and analyses under a binocular research microscope (Nikon, Eclipse 50i with 400 X magnification). Identification of phytoplankton was carried out using phytoplankton identification manuals (UNESCO, 1978; Subrahmanyam (1946), Parson et al., 1984, Santhanam et al. (1987) and Tomas (1997) and Subba Rao, 2002).

Zooplankton: Zooplankton samples were collected at 10 locations i.e. stns. S1 to S10 (Fig. 4). Zooplankton net (300 micron) was towed 0.5 m below water surface for 5 minutes and the collected samples were immediately preserved in 5% buffer formaldehyde. The biomass values of zooplankton were calculated from the displacement volume method. Based on the zooplankton volume, fractions were taken for analysis using plankton counting chamber for quantitative, qualitative analysis and species diversity. Organisms were identified up to genus level under a binocular microscope using standard identification key and counting chamber.

Macro Benthos: Seabed sediment samples for macro benthos were collected using Van Veen grab sampler at 10 locations, (Fig. 4). The intertidal benthos samples were collected at 3 locations along the beach (stns. IB1, IB2 and IB3) as shown in Fig. 4. The benthic organisms were separated by sieving through 500 micron mesh and preserved using buffer formaldehyde with Rose Bengal. The samples were sorted and identified up to groups/Genera level using stereo zoom microscope. The wet weight was taken to calculate the biomass of benthic organisms.

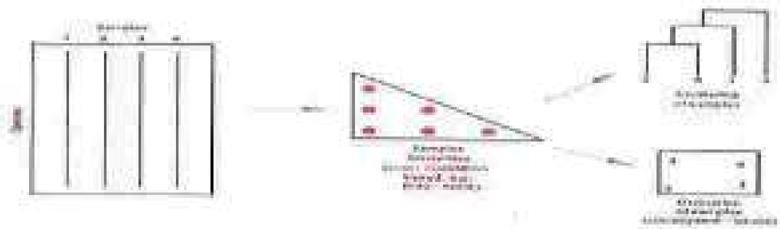
Microbiology: The microbiological samples were collected from 10 locations, i.e. stns. S1 to S10 (Fig. 4). Samples were collected in sterilized bottles and transported for analysis. Spread plate method was used to culture the microorganisms. The agar media used for analysis were: Nutrient agar, MacConkey agar, M-FC agar, Thiosulphate Citrate Bile Sucrose agar, Xylose Lysine Deoxycholate agar, M-Enterococcus agar and Cetrimide agar. Plates were incubated at 37°C for 48 hrs. After incubation, the colonies were counted and identified based on their color characteristics.

Fisheries: The information on fisheries and their potential were collected from the local fishing villages and from Department of fisheries, Government of Tamilnadu.

Coastal vegetation and Seaweeds: The nearshore plants like sand dune plants and seaweeds were collected and herbarium was prepared for further identification in the laboratory.

Statistical Analyses: All statistical calculations and graphs were generated using computer software package PRIMER V.6.1.9 (Plymouth Routines In Multivariate Ecological Research) obtained from Primer –E Ltd., Plymouth, UK (see www.primer-e.com). It's scope is the analysis of data arising in community ecology and environmental science which is multivariate in character (many species, multiple environmental variables).Sample data were compiled into square matrix (species x samples) and square root transformed to counter act the weight of dominant species without severely diminishing their importance. The transformed species – by – sample was then converted into a triangular sample-by-sample similarity matrix by calculating the Bray–Curtis similarity index between all samples – pairs, based on joint species abundance, and presence and absence. Ecological data were then analyzed for similarity of population using agglomerative hierarchical cluster analysis based on the Bray – Curtis similarity index and an average linkage dendrogram were produced.

Further analysis used non-metric multi-dimensional scaling (MDS) which constructs a rank similarity – based sample configuration. On the two dimensional (2D) plots generated from MDS analysis, highly similar samples will appear closer together than samples with lower rank similarities, effectively constructing a two dimensional map of similar samples.



Stages in a multivariate analysis based on similarity coefficients

Diversity measures were calculated from the untransformed data for each sample. Indices calculated were: Margalef's species evenness coefficient (J'), the Shannon – Wiener diversity coefficient (H') and Simpson's diversity index (1- λ). The cumulative dominance plot was also constructed to compare the biodiversity between the samples.

4.3. Results

4.3.1. Physical

Wind: The month wise distribution of wind speed and direction are shown in Table 2. It is observed that during April, May, June and December wind speeds were around 10-11 knots and during the remaining months wind speeds were varying between 7 and 9 knots. During April to September, the morning wind mostly prevailed from SW and W, and during November to February, it mostly prevailed from NW. The wind patterns during morning hours and evening hours show the influence of land-sea breeze system in this region. During the days of depressions and cyclones, the wind speed commonly exceeds 50 kmph.

Storm: The tracks of cyclones which have crossed the coast near Chennai (within 150 km on either side) during 1877 to 1990 are presented in Table 3. It indicates that totally 58 storms had occurred within 300 km off the project region. The occurrence of storms in this region are more frequent in November (23) and in October (19). Among them about 37 number of storms had crossed the coast within 300 km distance during 1877 to 1990.

Tides: The various tide levels with respect to Chart Datum for Chennai as presented in *Indian Tide Table 2013* are shown 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 measured tide levels reduced to chart datum for the period 27.07.2013 to 15.08.2013 are shown in Fig. 6. It showed a spring tidal range of 0.95 m and a neap tidal range of 0.33 m.

Currents: The variation of surface current speed and direction measured at 1500 m offshore (stn. C1) is shown in Fig. 7. The current speed reached upto 0.33 m/s and the current direction was shifting with tides showing the variation within the sector of 330° – 90°.

Waves: The data compiled based on the ship observed deep-water waves over the region between the latitude 10°N - 15°N, and longitude 80°E - 85°E is considered for the present project. It is observed that the significant wave heights varied between 0.5 and 1 m during February to April, 1 and 3.0 m during May to September and, between 1 and 2 m during rest of the year. The zero crossing period of the waves varied between 5 and 8 s. The project region is located on the region which is significantly influenced during the northeast monsoon. The wave climate remains rough from May to November. The occurrence of storms and depressions during northeast monsoon often increase the wave activity in this region.

Tsunami: The occurrence of a Tsunami along the Indian coast is an extremely rare event with a very low frequency of less than once in 500 years. One worst tsunami event was witnessed on 26th December 2004 along the Tamil Nadu coast. From records of tide gauge data during the 2004 tsunami event, the run up due to tsunami at different stretches along the coast was observed to vary between 1 m and 3.5 m. The water level rise due to this Tsunami near the project region was around 2.0 m and the run-up crossed over the highways (ECR). Eye -witness accounts say that each high tsunami wave that approached the coast was like a solitary surging / tidal bore wave, and the rise in water level near the coast due to such surging wave existed for a short duration of nearly 30 minutes.

Salinity and temperature: The available literature (Wyrtki, 1971) on annual variation of surface salinity for this offshore region indicates that the salinity values ranged between 32 ppt and 34.5 ppt over different months of the year (Table 4). The vertical salinity gradient is not relevant in shallow coastal waters off the study region and no density stratification can be expected in this region.

The available literature (Rao, 1995) on annual variation for the offshore region indicates that the temperature varies between 27° C in December and 30° C in May (Table 4). During southwest monsoon period (June-September), no wide fluctuation in temperature was observed.

Ambient Air Quality

Predominant winds from W, WSW and E directions were observed during study period. Present major source of air pollution in the region is due to road traffic emission, domestic activities and rural conditions. To establish the baseline status of the ambient air quality in the study area, the air quality was monitored at 8 locations during the study period. The PM_{10} and $PM_{2.5}$ are observed to vary from 32.7 to 52.5 $\mu g/m^3$ and 11.0 to 19.5 $\mu g/m^3$ respectively. The SO_2 and NOx are observed to vary from 7.5 to 10.8 $\mu g/m^3$ and 9.7 to 14.8 $\mu g/m^3$ respectively. The CO values are observed to vary from 365 to 536 $\mu g/m^3$

The results of the monitored data indicate that the ambient air quality of the region in general is in conformity with respect to norms of the National Ambient Air Quality (NAAQ) Standards of Central Pollution Control Board (CPCB), with present level of activities and also it infers that the air quality levels in the study area are of fairly good quality.

Soil Characteristics

The soil samples were tested at 8 locations covering various land uses. It was observed that the soil in the study area is predominantly of sandy clay type. The pH of the soil samples ranged from 7.8 to 8.1. The Electrical Conductance of the soil samples varied from 144 to 280 µmhos/cm. The phosphorus values ranged between 28.2 kg/ha – 78.0 kg/ha. The nitrogen values ranged between 38.0 kg/ha – 65.0 kg/ha. The potassium values ranged between 0.06 kg/ha -0.20 kg/ha.

Noise Level Survey

The noise monitoring has been conducted at 8 locations in the study area. The Day Night Noise Level (Ldn) near plant site was observed as 45.7 dB(A). The noise levels in general found within the acceptable levels as per standards prescribed by Central Pollution Control Board (CPCB).

Landuse Studies

The land use pattern within 10 km radius around the proposed project area has been studied by analyzing the available primary census data. The study area falls in Chengalpattu taluk in Kancheepuram district of Tamil Nadu. The study area of 10 km zone around project area covers about 21 villages within. Altogether, the study area covers about 5663 ha of cultivated land, which works out to about 46.78 % of the total study area. The irrigated and un-irrigated land is about 25.09 % and 21.69 % of the study area respectively. Cultivable waste land and area not available for cultivation are about 14.70 % and 25.79 % respectively. Forest land is about 12.73% of the total study area.

Socio-Economic Details

The information on socio-economic aspects of the study area has been compiled from secondary sources, which mainly include census data of 2011. As per the 2011 census, the study area consists of a total population of 73245 persons residing in 17961 households. The configuration of male and female indicates that the males constitute about 50.51 % and females 49.49 % of the total population. About 34.19 % of the population in the study area belongs to Scheduled Castes (SC) and 1.04 % to Scheduled Tribes (ST). The study area experiences a literacy rate of 72.65% and has 38.83% of the total population as working population.

Littoral drift: The monthly volume of littoral drift at project region is shown in Table 5. The sediment transport rates were high (>1.98 x 10^6 m^3/month) in May and December. It was lowest (< 0.75 x 10^5 m^3/month) in March. The littoral drift was towards north from April to October and towards south during the remaining months of the year. The annual northerly transport is 0.98 x 10^6 m^3/year and the annual southern transport is 0.51 x 10^6 m^3/year.

<u>Synthesis of Data on Climatic Conditions</u>

Analysis of the Data Recorded at IMD-Chennai

1) <u>Temperature</u>

The winter season starts from December and continues till the end of February. January is the coldest month with the mean daily maximum temperature at 33.3°C with the mean daily minimum temperature at 17.0°C. Both the day and night temperatures increase rapidly during the onset of Pre-monsoon season. During Pre-monsoon the mean maximum temperature (May) is observed at 43.4°C with the mean minimum temperature at 21.6°C. The mean maximum temperature in the Monsoon season was observed to be 42.8°C whereas the mean minimum temperature was observed to be 21.2°C. By end of September with the onset of Northeast monsoon (October), day temperatures decrease slightly with the mean maximum temperature at 35.9°C with the mean minimum temperature at 22.4°C. The monthly variations of temperatures are presented in **Table-1.4.1**.

2) Relative Humidity

The air is generally very humid in the region especially during monsoon when the average relative humidity is observed around 67% with a maximum and minimum of 100% and 35% respectively. In the pre-monsoon period the relative humidity is 63%. During the pre-monsoon season the mean maximum humidity is observed at 100%, with the mean minimum humidity at 39% in the month of May and April respectively. During winter season the humidity is found to be in line with the values recorded during the Pre-monsoon season. The mean maximum humidity recorded during winter season, which is the driest part of year with an average of 66% relative humidity. The mean maximum relative humidity is observed to be 100% with mean minimum humidity at 38%. The monthly mean variations in relative humidity are presented in **Table-1.4.1**.

3) Atmospheric Pressure

The station level maximum and minimum atmospheric pressure levels are recorded during the winter and monsoon seasons. The maximum pressure observed is in the range of 1016.5 to 1003.5-mb, with the maximum pressure (1016.5-Mb) occurring during the winter season, in the month of January. The minimum pressure observed is in the range of 1013.6 to 999.9 Mb, with the minimum pressure (999.9-Mb) occurring during the pre-monsoon season in the month of June. The average pressure levels in all other months are found to be in the range of 1008.5 to 1010.6-mb. The monthly variations in the pressure levels are presented in **Table-1.4.1**.

4) Rainfall

It is observed that the north-east monsoon is more predominant than the south-west monsoon. The southwest monsoon generally sets in during the last week of May. About 30% of the rainfall is received during the southwest monsoon. The rainfall gradually increases after September (and reaches maximum rainfall is recorded in the month of November). The area experiences maximum rainfall (308.0 mm) in the month of November. The Northeast monsoon rain occurs between October to December and contributes to the rainfall by about 60% of the total rainfall. Monthly variations in the rainfall for past available 10 years are given in **Table-1.4.1**.

5) Cloud Cover

Generally light clouds are observed during winter mornings. During pre-monsoon and the post-monsoon evenings the skies are either clear or lightly clouded. But in post-monsoon mornings as well as monsoon morning heavy clouds are commonly observed. Whereas in the evening time the skies are light to moderately clouded through out the year.

6) **Wind Speed/Direction**

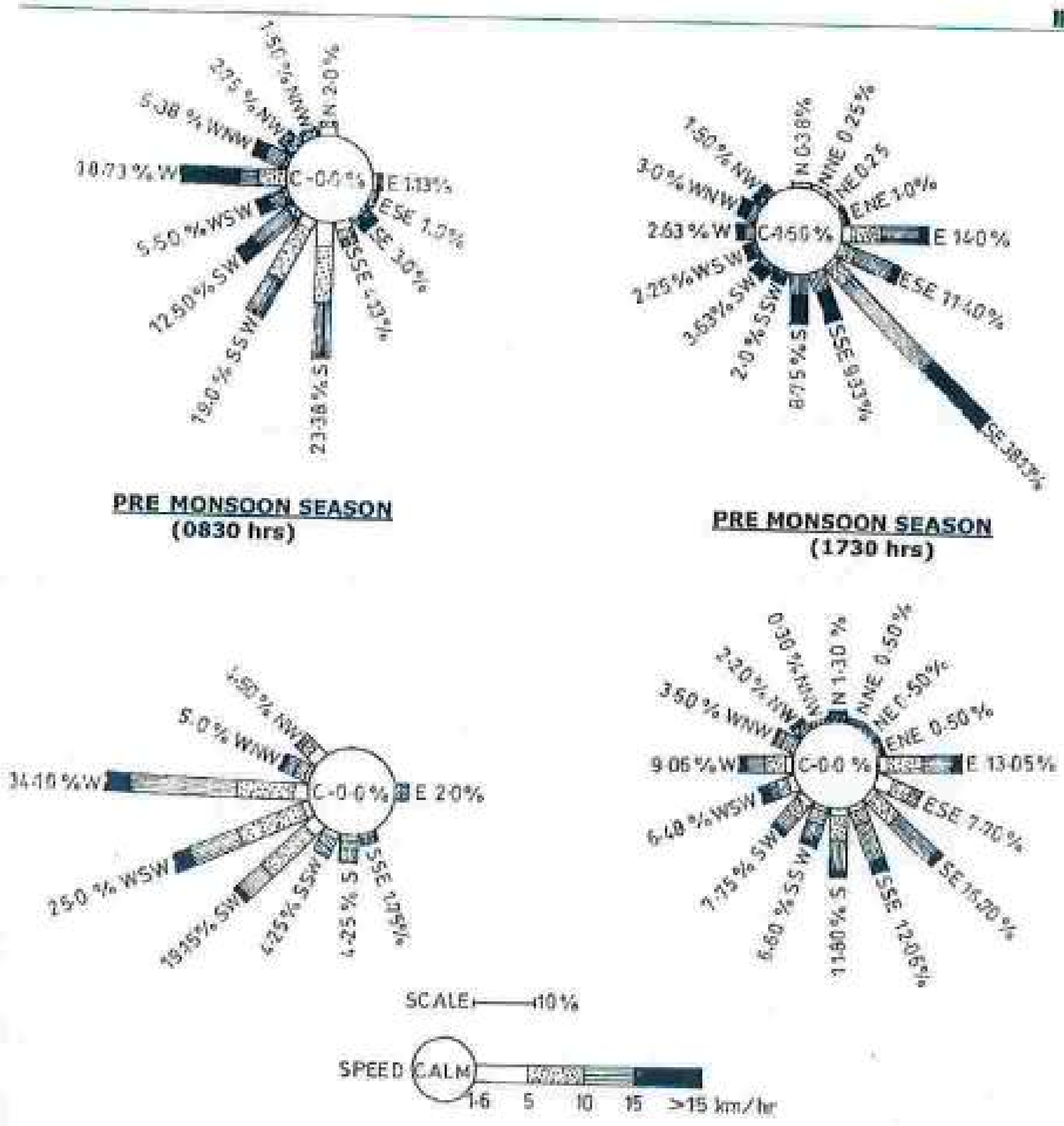
The windrose for the study period representing pre-monsoon, monsoon, post-monsoon and winter season along with annul windrose are shown in **Figure-1.4.1** and presented in **Table-1.4.2.**

TABLE-1.4.1
CLIMATOLOGICAL DATA - IMD, CHENNAI (MINAMBAKAM)

Month	Temperature (^{0}C)			Relative Humidity (%)		Atmospheric Pressure (Mb)		Rainfall (mm)
	Max	Min	Avg.	0830	1730	0830	1730	
January	33.3	17.0	26.1	100	38	1016.5	1013.6	23.8
February	34.9	16.0	25.2	95	31	1012.2	1009.0	6.8
March	38.7	18.2	27.5	91	28	1010.6	1007.1	15.1
April	42.7	21.0	32.0	96	39	1008.4	1004.3	24.7
May	43.4	21.6	32.2	100	15	1004.5	1000.8	51.7
June	42.8	21.2	32.5	100	32	1003.5	999.9	52.6
July	39.5	22.3	31.0	95	35	1004.2	1000.7	83.5
August	39.0	22.0	31.0	98	32	1004.9	1001.1	124.3
September	37.8	21.5	29.5	97	35	1006.3	1002.4	118.0
October	35.9	22.4	28.7	98	46	1008.5	1005.3	267.0
November	34.4	18.0	27.0	99	42	1010.9	1003.1	308.0
December	31.7	17.8	25.0	100	34	1012.9	1010.0	139.1

TABLE-1.4.2
SUMMARY OF WIND PATTERN – IMD, CHENNAI

Season	First predominant winds		Second predominant winds		Calm condition in %	
	0830	1730	0830	1730	0830	1730
Pre-monsoon	S (29.0)	S (37.5)	SSW (17.5)	SSW (24.9)	10.3	1.7
Monsoon	SSW (17.3)	SSW (20.3)	SW (16.9)	S (18.1)	10.5	8.2
Post monsoon	NNE (17.0)	E (15.0)	N (15.5)	NE (14.0)	21.0	25.0
Winter	NE (16.7)	S (14.6)	NNE (14.0)	E (11.6)	31.0	16.7
Annual	SSW (12.9)	S (18.9)	SW (10.0)	SSW (14.2)	15.8	12.9



PRE MONSOON SEASON (0830 hrs)

PRE MONSOON SEASON (1730 hrs)

MONSOON SEASON (0830 hrs)

MONSOON SEASON (1730 hrs)

FIGURE-1.4.1 (A)
WINDROSE FOR PRE MONSOON & MONSOON SEASON-IMD, CHENNAI

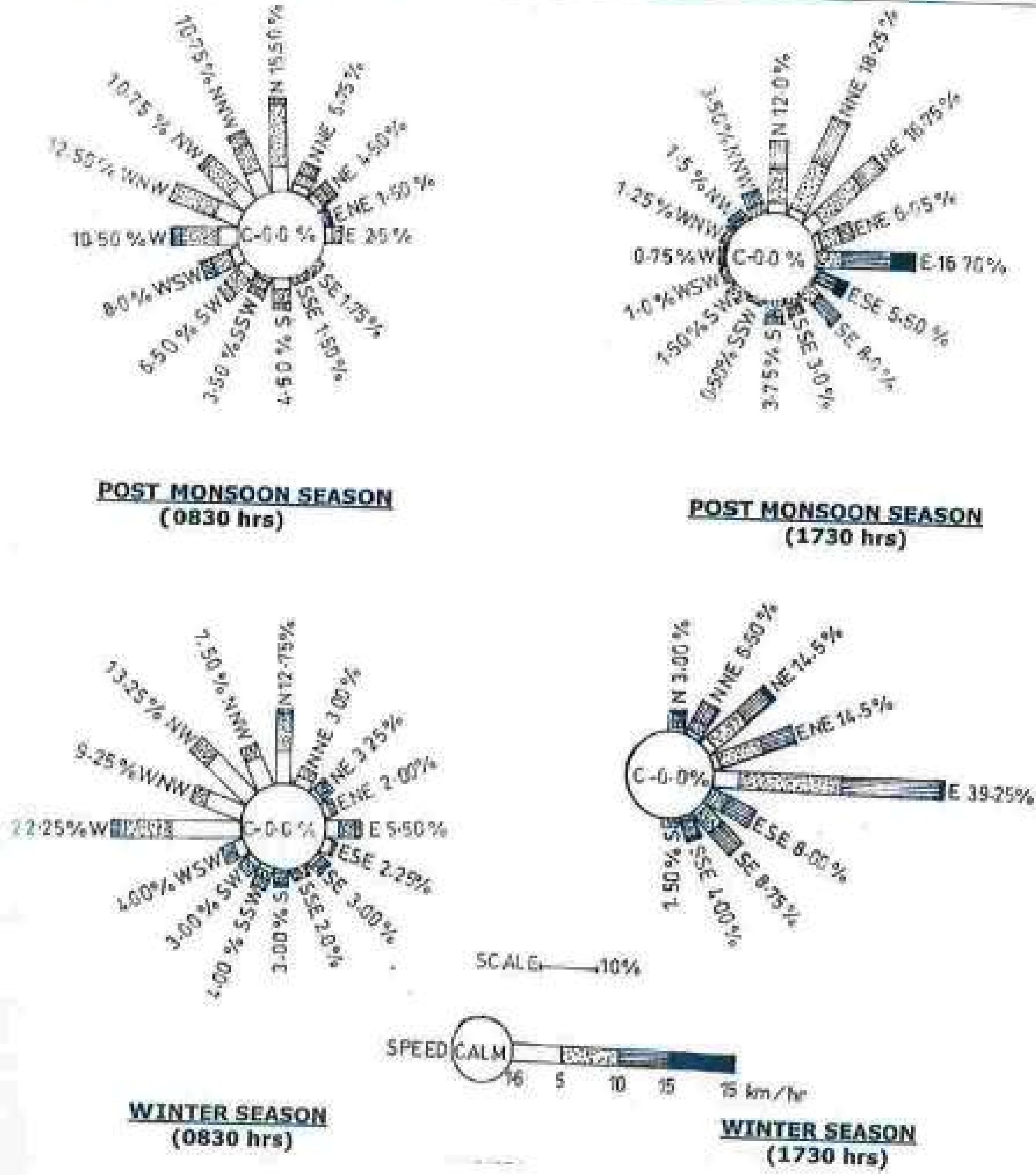


FIGURE-1.4.1 (B)
WINDROSE FOR POST MONSOON & WINTER SEASON-IMD, CHENNAI

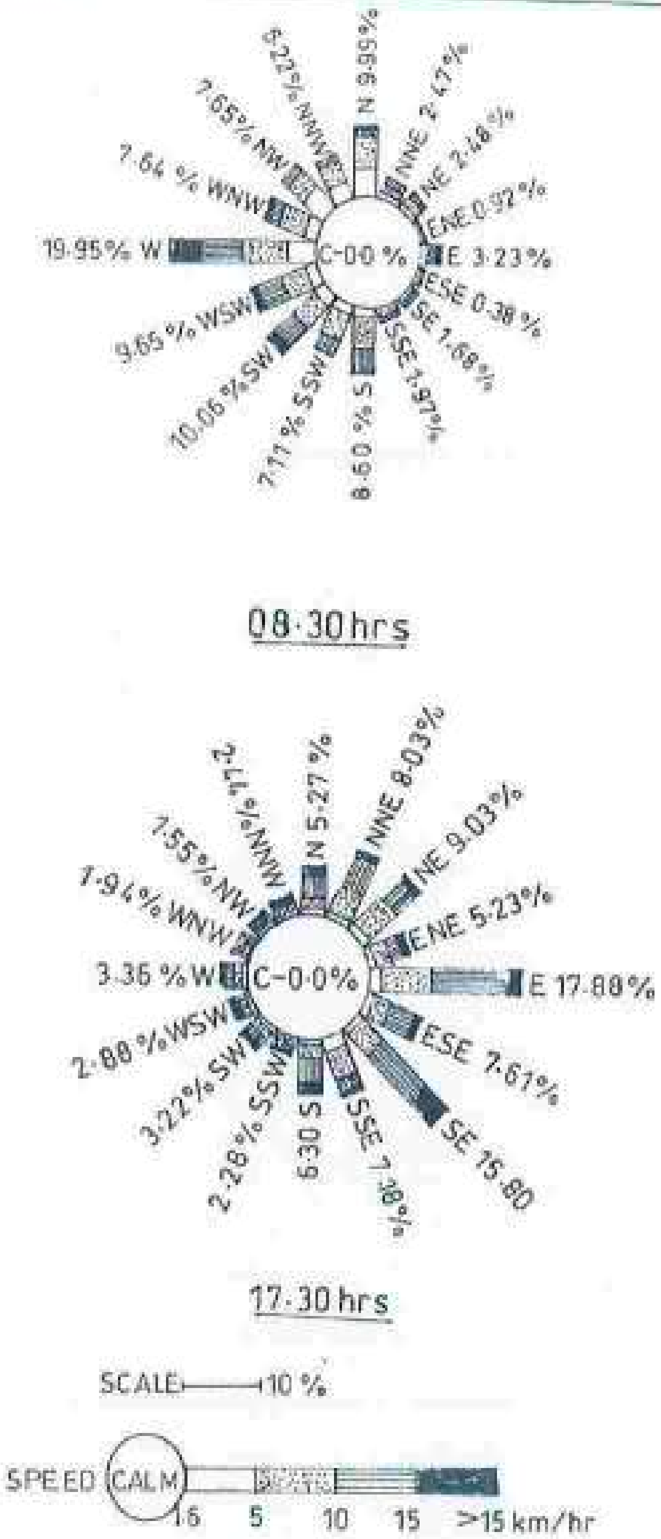


FIGURE-1.4.1 (C)
ANNUAL WINDROSE -IMD, CHENNAI

Analysis of Meteorological Data Recorded at Project Site

The meteorological data recorded at the project site during the study period (1st August, 2013 to 31st October, 2013) is presented in **Table-1.4.3.**

TABLE-1.4.3

SUMMARY OF THE METEOROLOGICAL DATA AT SITE

Month	Temperature (°C)		Humidity (%)		Total Rainfall (mm)
	Max	Min	Max	Min	
August 2013	37.5	23.7	100	28	73
September 2013	36.8	22.9	100	34	89
October 2013	36.3	22.6	100	21	121

1) **Temperature**

It was observed that the temperature at the proposed site during study period ranged from 22.9°C to 37.5°C. The monthly variations in the temperatures are presented in **Table-1.4.3.**

2) **Humidity**

During the period of observation, the humidity ranged from 21.0% to 100.0%. The monthly variations in the humidity are presented in **Table-1.4.3.**

3) **Rainfall**

A total of 283 mm of rainfall was observed during the study period. The maximum rainfall was recorded in the month of October in study period.

4) **Cloud Cover**

Mostly clear skies were observed except rainy days during the study period.

5) **Wind Speed and Direction**

The windrose for the study period representing winter season is shown in **Figure-1.4.2**. A review of the windrose diagram shows that predominant winds are mostly from West (14.4%) and WSW (10.3%) followed by E (8.1%) direction. Calm condition was recorded for 4.5%.

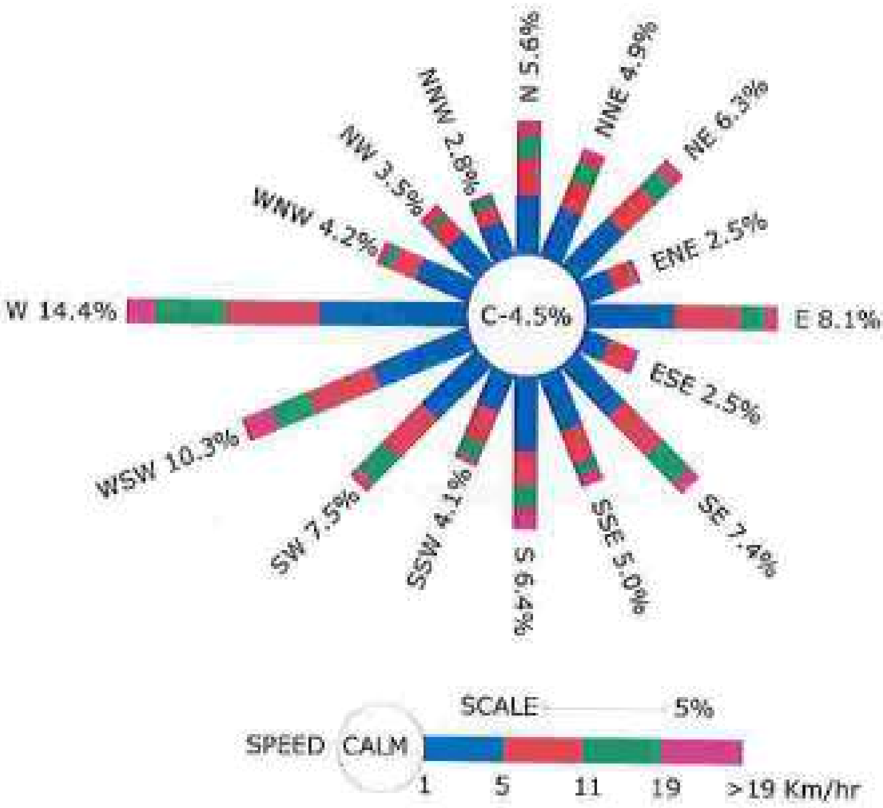


FIGURE-1.4.2

SITE SPECIFIC WINDROSE (AUGUST – OCTOBER 2013)

4.3.2. Water quality

The estimated water quality parameters on temperature, Total dissolved solids, salinity, dissolved oxygen, pH, nitrite-nitrogen, nitrate-nitrogen, total nitrogen, inorganic phosphate, total phosphorous, ammonia-nitrogen, total suspended solids, turbidity, biochemical oxygen demand and chemical oxygen demand are presented in Tables 6. The results of cadmium, lead, mercury, total chromium, oil and grease, phenols and total petroleum hydrocarbons are presented in Table 7.

Temperature: Steep gradients of sea water temperature across the depths bear direct impact on the productivity and animal colony of the region. The temperature varied from 26.58°C (station 10, bottom) to 28.82°C (station 3, surface) among all 10 locations.

Total Dissolved Solids: The electrical conductivity of environmental water is due to the presence of dissolved ionic species. The TDS values varied from 34.97 (station 8, surface) to 35.27 g/l (station 9, bottom) at all 10 locations.

Salinity: The estimated salinity of the collected water samples varied between 34.55 to 34.79 ppt at all 10 locations .The minimum (34.55 ppt) was recorded at S8 surface water while the maximum (34.79 ppt) was observed at S9 in bottom waters.

Dissolved Oxygen (DO): Of all the dissolved gases in water, oxygen is the most important one for the survival of aquatic biota. The amount of oxygen dissolved in the water column at a given time is the balance between consumption and replenishment. In an ideal ecosystem, these two processes should be at equilibrium to keep the water column saturated with DO. Generally, the coastal waters are always found to be saturated and this is so in the present study area also.

Dissolved oxygen content varied from 4.51 to 6.74 mg/l at all 10 locations. The minimum (4.51 mg/l) was recorded at S10 in bottom waters while the maximum (6.74 mg/l) was at S4 in surface water .The principal natural physical factors affecting the concentration of oxygen in the marine environment are temperature and salinity. DO concentrations decrease with increasing temperature and salinity. So it is possible to calculate the theoretical saturation of dissolved oxygen for a given combination of temperature and salinity. Then the observed values can be compared to see whether the system can sustain the biological demand. The dissolved oxygen saturation and a comparison of values with COMAPS (Coastal ocean monitoring and prediction system) data are also given in Table 8 respectively. These values indicate a normal condition which shows good productivity in the project region. Review of literature indicates that the levels below 2 mg/l are only known to cause respiratory impacts on marine fauna.

pH: Variations in pH due to chemical and other industrial discharges render a water column unsuitable for the rearing of fish and other aquatic life. pH is a very sensitive and most important parameter of an environmental study. Primary production, respiration and mineralization are able to alter the redox and pH of aqueous system due to the changes in oxygen and carbonate concentration. Identifying pH for acidic or alkaline disturbances enables one to locate zones of pollution and other quality conditions for the use of seawater.

During the present study, water pH varied between 8.19 and 8.22. The minimum (8.19) was recorded at stations 7 (surface), while the maximum (8.22) was recorded at S1, S3, S4 and S6, in surface, mid depth and bottom waters. More uptake of CO_2 by the photosynthetic organisms especially phytoplankton of the sea during the period could have increased the pH levels. The result shows that the pH values lie within the range of normal sea water.

Nutrients: Nutrients determine the potential fertility of an ecosystem and hence it is important to know their distribution and behavior in different geographical locations and seasons. The fishery potential of an area is in turn, dependent on the availability of primary nutrients like nitrogen and phosphorus. Enrichment of these nutrients by anthropogenic inputs in the coastal waters having limited ventilation may result in water becoming eutrophicated.

The major inorganic species of nitrogen in water are ammonia, nitrite and nitrate of which nitrite is very unstable and ammonia is bio-chemically oxidized to nitrate. Hence, the concentrations of nitrite and ammonia are often very low in natural waters. The utilization of nutrients such as nitrates and phosphates can be taken as a measure of the productivity of the area.

Inorganic phosphate and nitrogen compounds in the sea play a decisive role in the biological production. Normally they occur in low concentrations. Their distribution in the coastal waters is mostly influenced by land run off. Since nutrients form an important index to the primary productivity of an ecosystem, the study of its distribution is important from the point of view of its role in the biological productivity and also as an indicator of pollution. Values of various nutrient parameters analyzed at different stations are presented in Tables 6 and 13.

Nitrite-Nitrogen (NO_2-N): Nitrite is an important element, which occurs in seawater as an intermediate compound in the microbial reduction of nitrate or in the oxidation of ammonia. In addition, nitrite is excreted by phytoplankton especially, during plankton bloom.

Nitrite concentration ranged from 0.11 to 1.96 µmol/l at all 10 stations. The minimum (0.11 µmol/l) was recorded at S4 and S10 mid depth while the maximum (1.96 µmol/l) was noticed at S7 (bottom). The distribution in spatial and vertical direction shows more random.

Nitrate-Nitrogen (NO_3-N): Nitrate values are in general higher as compared to nitrite values. Nitrate is the final oxidation product of nitrogen compounds in seawater and is considered to be the only thermodynamically stable oxidation level of nitrogen in seawater. Nitrate is considered to be the micronutrient, which controls primary production in the euphotic surface layer. The concentration of nitrate is governed by several factors of which microbial oxidation of NH_3 and uptake by primary producers may be important in the present study area.

Nitrate concentration ranged from 1.17 to 4.32 µmol/l. The minimum (1.17 µmol/l) was recorded at S2 (surface) while the maximum (4.32 µmol/l) was noticed at S8 (bottom-). As in the case of nitrate the distribution is random.

Total nitrogen: Total nitrogen ranged from 6.20 to 18.60 µmol/l. The minimum (6.20 µmol/l) was recorded at S2 (mid depth) while the maximum (18.60 µmol/l) was recorded at S8 (bottom).

Ammonia-Nitrogen (NH_3-N): Unpolluted waters are generally devoid of ammonia and nitrite. However, coastal input by sewage and other nitrogenous organic matter and fertilizers can increase these nutrients to higher levels. In addition, ammonia in seawater can also come from various organisms as an excretory product due to the metabolic activity and the decomposition of organic matter by micro-organisms.

Ammonia concentration ranged from 0.09 to 0.27 µmol/l. The minimum (0.09 µmol/l) was recorded at station 2 (mid depth) and station 10 bottom water and maximum (0.27 µmol/l) was recorded at S6 (surface). The values are in normal range and indicate a healthy environment.

Inorganic Phosphate (PO_4-P): Inorganic phosphate is also an important nutrient like nitrogen compound in the primary production of the sea. The concentration of phosphate especially in the coastal waters is influenced by the land run off and domestic sewage.

Phosphate concentration ranged from 0.20 to 1.78 µmol/l. The minimum (0.20 µmol/l) was recorded at S4 and S7 (surface) while the maximum (1.78 µmol/l) was noticed at S1 (bottom).

Total phosphorous: Total phosphorous ranged from 0.52 to 1.92 µmol/l. The minimum (0.52 µmol/l) was recorded at S4 (surface) while the maximum (1.92 µmol/l) was noticed at S1 (bottom).

The water quality parameters observed at open sea do not show much variation and the water remains clean without any contamination or organic load.

Total Suspended Solids (TSS): Total Suspended Solids in seawater originate either from autochthonous (biological life) or allochthonus (derived from terrestrial matter) sources. It varied from 16 to 84 mg/l at all 10 stations. The minimum 16 mg/l was found at S4, S5 and S8 at surface and the maximum 84 mg/l at S1 bottom water.

Turbidity: Turbidity is another measure to understand the suspended particulate matter which controls the photosynthesis in the water column. The measured turbidity varied between 0.5 to 8.5 NTU at all 10 locations. The minimum (0.5 NTU) value was noticed at S8 in surface. The maximum (8.5 NTU) value was noticed at S1 in bottom. The turbidity of the nearshore waters in the surface region was found within normal ranges indicating the existence of unturbid and clean water whereas in the bottom waters the turbidity was high due to movement of underwater currents.

Biochemical Oxygen Demand (BOD): Rate of aerobic utilization of oxygen is a useful tool to evaluate the intensity of deterioration in an aquatic medium. The oxygen taken up for the breakup of organic matter leads to a reducing environment or in the event of release of excess nutrients, it may cause eutrophication.

For the present study the BOD values varied from 1.09 to 4.55 mg/l at all 10 locations. The minimum value was recorded at S8 in mid water and maximum was noticed at S10 in surface water. The low BOD values indicate that oxidisable organic matter brought to the nearshore waters is effectively assimilated in coastal water. The range of variation in BOD values indicate that the water column is well mixed in the project area.

Chemical Oxygen Demand (COD): Chemical oxygen demand (COD) determines the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The organic matter gets oxidized completely by potassium dichromate ($K_2Cr_2O_7$) in the presence of H_2SO_4 to produce CO_2 plus H_2O. The excess $K_2Cr_2O_7$ remaining after the reaction was titrated with ferrous ammonium sulphate [$Fe(NH_4)_2(SO_4)_2$. $6H_2O$] using ferroin as indicator. The volume of dichromate consumed gives the oxygen required for oxidation of the organic matter.

The COD values varied from 12.6 to 79.0 mg/l at all 10 locations in the present study. The minimum (12.6 mg/l) value was recorded at S10 surface waters. The maximum value was (79.0 mg/l) recorded at S2 in middle water. In general the bottom values were higher than the subsurface and surface values.

Trace metal concentration: Concentrations of trace metals in water are often close to the background level due to their efficient removal from the water column through hydrolysis and adsorption by suspended particulate matter. Hence, sediments serve as an ultimate sink for several trace metals and their analyses can serve as a useful index of metal pollution.
Knowledge of the trace metal concentration in seawater is very important from the point of view of their possible adverse effects on marine biota. Oysters by their ability to concentrate some trace metals from the environment are considered to be useful indicators of metal pollution. Many of the trace metals are adsorbed to the particulate matter and are ultimately deposited at the bottom. Bottom sediments are considered to provide a reliable estimate of metal pollution status. The relationship between gross concentration of heavy metal in solution and its ability to cause toxic effects in an organism is a complex one, and is mostly decided by the speciation of metal and the condition of the organism. Whether or not, a trace metal can interact with the biota depends on its "bio-availability" in the medium. Presence of other toxicants or metals can reduce or increase the additive toxicity of each element. In addition to these factors, temperature, total dissolved solids, pH, salinity, turbidity and dissolved oxygen concentration also significantly affect metal-organism interactions.

The nominal presences of trace metals, which occur in seawater, are found to be necessary to promote growth of marine organisms. The concentration levels of Cadmium, Lead, Total Chromium, Mercury, Phenols and Total Petroleum hydrocarbon measured at 10 locations are presented in Table 7.

Cadmium (Cd): The bioavailability and toxicity of trace metals such as Cd, Cu, and Zn are related to the activity of the free metal ion rather than the total metal concentration. For Cd it is the $CdC1_2$ complex that predominates in seawater. Therefore, salinity is the overriding factor which can alter free Cd ion activity (Cd2+), and hence, bioavailability and toxicity in marine systems.

The cadmium concentration of the study region was found below detectable level < 0.01 mg/l at all 10 locations.

Mercury (Hg): Mercury is considered as a non-essential and toxic element for living organisms. Mercury, amongst other heavy metals has attracted global concern due to its extensive use, toxicity, widespread distribution and the biomagnifications. A chemical whose concentration increases along a food chain is said to be biomagnified. The bio-concentrate of mercury in aquatic organisms such as oysters and mussels has been reported to be much greater than those contained in the environment in which they live. Mercury is considered as a non-essential and toxic element for living organisms.

During this period, the concentration of the study region was found below detectable level < 0.002 mg/l at all 10 locations.

Lead (Pb): Lead has been used by man for centuries and is amongst the most widely dispersed environmental contaminant. The considerably greater toxicity of organo-lead compounds compared to inorganic forms has led to studies whether; such compounds may be formed by natural process. Available literature suggests that alkylation of lead is purely a chemical process which may occur in organic-rich anoxic sediment.

The lead concentration for the sea water samples was estimated as lead strongly gets accumulated in fishes especially with shell fish. The lead concentration in the study region was found below detectable level < 0.02 mg/l at all 10 locations.

Chromium (Cr): In dissolved form chromium is present as either anionic trivalent $Cr(OH)_3$ or as hexavalent CrO_4^{2-}. The amount of dissolved Cr^{3+} ions is relatively low, because these form stable complexes. Oxidation ranks from Cr(II) to Cr(VI). In natural waters trivalent chromium is most abundant. Chromium is a dietary requirement for a number of organisms. This however only applies to trivalent chromium. Hexavalent chromium is very toxic to flora and fauna. Chromium water pollution is not regarded as one of the main and most severe environmental problems, although discharging chromium polluted untreated wastewater in rivers have caused environmental disasters in the past. Chromium (III) oxides are only slightly water soluble, therefore concentrations in natural waters are limited. Cr^{3+} ions are rarely present at pH values over 5, because hydrated chromium oxide ($Cr(OH)_3$) is hardly water soluble.

Chromium (VI) compounds are stable under aerobic conditions, but are reduced to chromium (III) compounds under anaerobic conditions. The reverse process is another possibility in an oxidizing environment. Chromium is largely bound to floating particles in water. The LC_{50} value for chromium in sea fish lies between 7 and 400 ppm, and for algae at 0.032-6.4 ppm.

The Chromium concentration in the study region was found below detectable level < 0.05 mg/l at all 10 locations.

Phenol: The main source of phenolic compounds in seawater is through plants. Additionally, they can also be released during humification processes occurring in soil. Higher concentrations occur in industrial wastewaters. Phenols can be toxic to marine organisms and can accumulate in certain cellular components. Chlorination of phenol-containing waters can lead to formation of chlorophenols with unpleasant odour and taste.

The concentration of phenol in the study area was found below detectable level (BDL) < 0.1 mg/l at all 10 locations.

Total Petroleum Hydrocarbons: The coastal waters are susceptible to oil pollution due to various maritime activities like fishing operation, spillage from oil tankers, port activities etc. In the study area, the dissolved and dispersed Petroleum hydrocarbons were found below detectable level 0.1 µg/l at all 10 locations.

Oil and grease: The coastal waters are susceptible to oil pollution due to various maritime activities like fishing operation, spillage from oil tankers, port activities etc. The concentration of oil and grease in the study area was found to be <2.0 mg/l in all the sampling stations.

4.3.3. Sediment characteristics

Sediment size distribution: The sand size distribution and nature of the sediments collected from the seabed at 10 locations are shown in Table 9. The seabed is predominantly composed of coarse to medium and fine sand.

The percentage composition of total organic carbon, calcium carbonate, concentration of total nitrogen and total phosphorus in sediment samples are given in Table 10.

Total Organic Carbon: Total organic carbon content ranged from 0.37 to 1.55% at all 10 locations. The minimum (0.37%) was recorded at S7 while the maximum (1.55%) was recorded at S4.

Calcium Carbonate: The carbonate content in the sediments varied from 25.35 to 42.90% at all 10 locations. The minimum was recorded at S10 while the maximum was recorded at S9.

Total Nitrogen: Total nitrogen concentration ranged from 0.14 to 0.23 mg/g. The minimum (0.14 mg/g) was recorded at S7 while the maximum (0.23 mg/g) was recorded at S4.

Total Phosphorus: Total phosphorus concentration ranged from 0.15 to 0.22 mg/g. The minimum (0.15 mg/g) was recorded at S7 and S9 while the maximum (0.22 mg/g) was recorded at S1.
The concentration of lead, cadmium, mercury, total chromium, oil & grease, phenol and total petroleum hydrocarbons in bottom sediments are presented in Table 11.

Lead (Pb): The lead concentration of the study area varied from 3.43 to 32.50 mg/kg at all 10 locations.

Cadmium (Cd): The concentration of cadmium in the study region varied from 0.42 to 1.14 mg/kg at all 10 locations.

Mercury (Hg): The concentration of mercury in the study area was found below detectable level <2.0 mg/kg at all 10 locations.

Total Chromium (Cr): The concentration of total chromium in the study area varied between 12.05 and 78.71 mg/kg at all 10 locations.

Phenol: The concentration of Phenol in the study region was found below detectable level <0.1 mg/kg at all 10 locations.

Total Petroleum hydrocarbons: Total petroleum hydrocarbons were found below detectable level <0.5 mg/kg at all 10 locations.

Oil & Grease: They were found to be below detectable level <2.0 mg/kg at all 10 stations.

The concentrations of heavy metals, phenols and petroleum hydrocarbons in the sediment samples showed extremely low values in the open sea. It indicates that there is no accumulation of pollutants and there is no contamination in sediment.

4.3.4. Biological parameters

Biological status of an area is an essential prerequisite for environmental impact assessment and can be evolved by selecting a few reliable parameters from a complex ecosystem. Whenever we consider assessment of the implications of environmental pollution, we must be aware of the fact that despite many changes it may cause in the physio-chemical properties of water body and seabed sediment, the ultimate consequences are inevitably of biological nature. The biological parameters considered in the present study are Primary production, phytoplankton biomass and population, zooplankton biomass and population, macro benthic biomass and population, and fishery of the region. The first four reflect the productivity of a water column at primary and secondary levels. Benthic organisms being sedentary animals associated with the seabed, provide information regarding the integrated effects of stress due to disturbances, if any, and hence are good indicators of early warning of potential damage.

Phytoplankton and primary productivity: Phytoplankton is the primary source of food in the marine environment. The concentration and numerical abundance of the phytoplankton indicate the fertility of a region. The plankton population depends primarily upon the nutrients present in the sea water and the sunlight for photosynthesis. This primary production is an importance source of food for the higher organisms in the marine environment. The measured primary productivity results are shown in Table 12. The results indicate that the area is highly productive and the values vary from 323 to 780 mgC/m^3/day. A comparative statement of primary production along the east coast of India is also given in Table 13. The numerical abundance of phytoplankton is shown in Table 14. Various phytoplankton groups were observed and their percentage compositions are shown in Table 15.

The floral diversity fluctuates from 21 to 29 species. Bacilleriophyceae (Diatoms) formed the major group followed by Dinophyceae (Dianoflagellates) and Cyanophyceae (blue green algae). Phytoplankton population analyzed at various stations showed that their numerical abundance varied from 68 to 103 nos./ml^{-1}. As many as 55 species of phytoplankton (net and unit samples put together) represented by 3 diverse groups namely, diatoms (43 species consisting of 34 centrales and 9 pennales), dinophyceans (11) and chlorophyceae (1). There were relatively fewer (46) species in the unit samples. Table. 14 contains a detailed account on species composition and distribution at different stations in the surface waters. Overall, bacillariophyceans remained the largest group (29 species). In general, *Biddulphia heteroceros, Biddulphia mobiiliensis, Ditylum brightwelli, Thalassiosira subtilis, Pleursigma normanii, Ceratium macroceros* and *Trichodesmium erythraeum* and to be found at all stations. Overall, centrales formed the bulk (55%) of the population followed by pennales (15%), dinophyceans (17%) and Cyanophyceans (13%). Highest phytoplankton population (103 nos./ml^{-1}) was observed at stn. S8 and the minimum (68 nos./ml^{-1}) were at stn. S1. The biomass varied between 31.36 to 58.61ml/100m^3 (Table 16). Average phytoplankton biomass value recorded in this region is 42.36ml/100m^3.

The same thing was also reflected in the population numbers. *Biddulphia heteroceros, Biddulphia mobiiliensis, Ditylum brightwelli, Thalassiosira subtilis, Pleurosigma normanii, Ceratium macroceros* nd *Trichodesmium erythraeum* were recorded in good numbers at all the stations. *Ceratium macroceros* and *Pleurosigma normanii* was the dominant species found at all station. *Trichodesmium erythraeum* was observed to be in good numbers at all stations expect at stn. S3 and S8.

Based on the Primer software, the Shannon-Wiener (H') diversity clearly showed the diverse nature of project area (4.216 – 4.738). The similarity in species composition and abundance among stations varied from 43.24 to 75.58% with an average similarity percentage of 61.24%. The dominance plot for all the stations showed sigma shaped curves indicating healthy condition of the environment.

Zooplankton: The zooplankton diversity fluctuated from 38 to 44 species. Various zooplankton groups and their percentage composition observed at various stations are shown in Table 17. The zooplankton data indicated a high standing stock in the area of observation. Zooplankton population analysis at various stations showed that their numerical abundance varied from 309283 to 720187 nos./100 m^3 (Table 18). Highest Zooplankton population was observed at S6 and the minimum was observed at S5. The percentage occurrence of various groups varied from place to place.

The zooplankton biomass at various stations varied from 10.31 to 37.50 ml/100 m^3 (Table 17). The most zooplankton species contributing to the population are given (Table 18). Zooplankton mostly consists of *Coryceas danae* (13.5% to 8.7%), *Paracalanus parvus* (7.2% to 2.0%), *Oithona brevicornis* (6.8% to 0.6%), *Coryceas catus* (6.8% to 1.8%) and Copepod stages (5.6% to 1.9%).

The Shannon-Wiener (H') diversity clearly showed the rich diversity of the project area (4.957-5.144). The similarity in species composition and abundance among stations varied from 73.55 – 90.76% with an average similarity percentage of 84.29%. The dominance plot for all the stations showed sigma shaped curves indicating healthy condition of the environment.

Benthos: Benthic faunal population in an environment depends on the nature of the substratum and the organic matter content.

Subtidal benthos: The sediment characteristics of the study area showed gravel, coarse and medium sand. The numerical abundance of the benthic fauna was moderate and varied from 80 to 170 nos./m^2 (Table 19). The faunal population was mainly dominated by Polychaete worms, followed by Nematodes, Amphipods, Gastropods and Bivalves.

Intertidal benthos: The intertidal faunal population is shown in (Table 19). In the samples collected from this region (IB1, IB2 and IB3) Amhipods were found to be equally dominant followed by polychaetes and cumaceans. The numerical abundance of the inter tidal benthic fauna was low and varied from 30 to 75 nos./m^2.

In general the subtidal benthic population was about 7 to 8 times more than intertidal benthic population. Polycaetes was the dominant group found at the subtidal region with *Perineries* sp. recording the highest number followed by *Eunice* sp. *Owenia* sp. and *Cossura* sp. were found in equal numbers and occupied the third place. The next in abundance was *Nephtys* sp., followed by *Scolelepis* sp. and *Polydora* sp. Polychaetes were collected from almost all the ten subtidal benthic region stations with the maximum number at station 2 followed in equal number from station 3 and station 5. Minimum number of polychaetes were recorded at station 9.

Crustaceans dominated by amphipods were the second abundant group in the subtidal and intertidal benthic population followed by molluscan, nematode and cumacean groups. However, nematodes and molluscan groups were completely absent at the intertidal region. It is interesting to note that all the molluscan forms recorded at the subtidal region were mostly from station 7 to station 10 and were completely absent at station 1 to station 6. On the other hand two third of the polychaetes recorded at the sub-tidal region were all from station 1 to station 6. Overall, the highest number of organisms at the subtidal was region recorded at station 3 and the minimum at station 9. At the intertidal region IB3 recorded the most number of organisms followed by IB1 and IB2. It is concluded that the subtidal area of this region is more diverse and moderately populated than the intertidal region.

Inference: The Shannon-Wiener diversity was low in the project area *(0.918 to 2.873). Similarly the Margalef richness (d) values were also low (0.263 - 1.438). However the evenness was similar in all stations. Generally in a healthy environment, Shannon diversity and Margalef richness indices are higher and in the range of 2.5 – 3.5. Values less than these are normally attributed to some sort of stress or disturbance. However in the project area there is no evidence of such stress or pollution. The only explanation that can be offered to the observed low values is the nature of sediment (dominated by sand) and the low organic carbon content. These factors obviously contributed to low number of species. The similarity in species composition and abundance among stations widely varied from 0 to 78.23% with an average similarity percentage of 36.37%. The dominance plot for all the stations showed steep rise curves possibly because of low number of organisms as there is no apparent disturbance or pollution in the environment.

Phytoplankton diversity indices calculated for stations 1-10

Stations	S	N	d	J'	H'(loge2)	1-Lambda'
S1	23	68	5.214	0.9445	4.272	0.9482
S2	25	84	5.417	0.9676	4.493	0.9624
S3	21	73	4.662	0.96	4.216	0.9524
S4	23	87	4.926	0.9503	4.299	0.9511
S5	24	87	5.150	0.9523	4.366	0.9511
S6	23	94	4.842	0.9390	4.248	0.9460
S7	26	98	5.453	0.9538	4.483	0.9546
S8	29	103	6.041	0.9753	4.738	0.9684
S9	28	102	5.838	0.9600	4.615	0.9608
S10	27	99	5.658	0.9699	4.612	0.9641

Zooplankton diversity indices calculated for stations 1-10

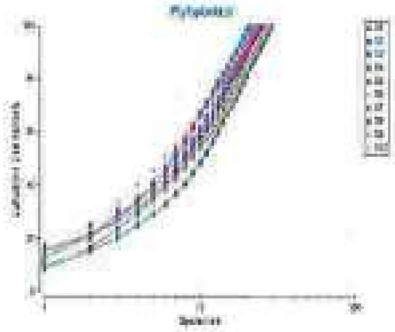
Stations	S	N	D	J'	H'(loge2)	1-Lambda'
S1	44	379232	3.347	0.9308	5.082	0.9596
S2	42	333113	3.224	0.954	5.144	0.9667
S3	40	379246	3.036	0.9488	5.049	0.9637
S4	42	402305	3.177	0.9338	5.036	0.9615
S5	41	309283	3.164	0.9253	4.957	0.956
S6	42	720187	3.040	0.9206	4.964	0.9558
S7	41	589039	3.011	0.9377	5.024	0.9620
S8	38	346190	2.901	0.9583	5.029	0.9647
S9	43	355505	3.286	0.9275	5.033	0.9581
S10	41	373930	3.117	0.9495	5.087	0.9648

Benthic community diversity indices calculated for stations 1-10 & IB1 to IB3

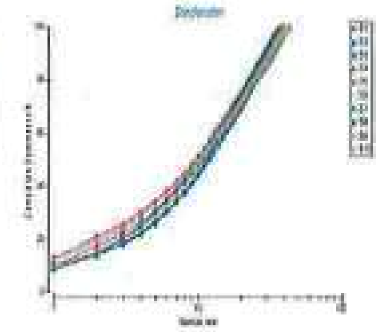
Stations	S	N	d	J'	H'(log2)	1-Lambda'
S1	6	130	1.027	0.9700	2.507	0.8229
S2	5	140	0.809	0.9134	2.121	0.7503
S3	7	170	1.168	0.9476	2.660	0.8354
S4	6	90	1.111	0.9684	2.503	0.8240
S5	5	110	0.851	0.8787	2.040	0.7173
S6	5	80	0.913	0.9690	2.250	0.7911
S7	6	100	1.086	0.9756	2.522	0.8283
S8	8	130	1.438	0.9577	2.873	0.8587
S9	5	80	0.913	0.9284	2.156	0.7595
S10	7	100	1.303	0.9696	2.722	0.8485

Stations	S	N	d	J'	H'(log2)	1-Lambda'
IB1	2	45	0.263	0.9183	0.918	0.4545
IB2	2	30	0.294	1.0000	1.000	0.5172
IB3	4	75	0.695	0.9610	1.922	0.7297

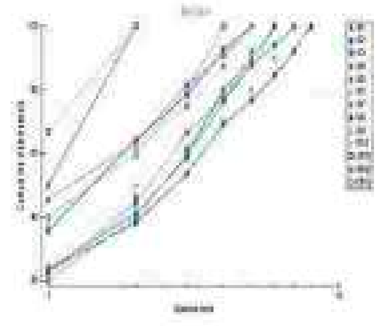
S-Total number species (richness); N- total number of individuals; d- Margalef's richness index; J'- Pielou's evenness index; H'- Shannon-Wiener diversity index; 1- Lambda'- Simpons's diversity index.



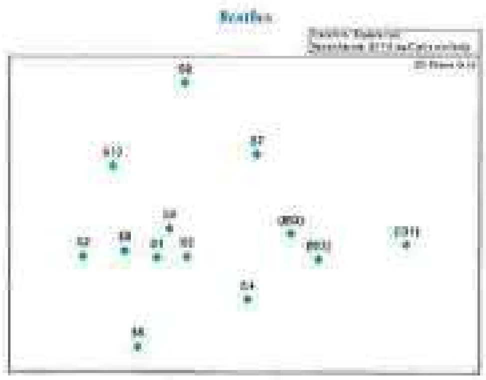
Dominance curve for Phytoplankton



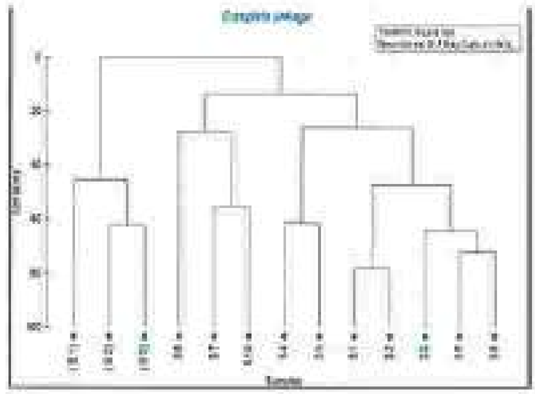
Dominance curve for Zooplankton



Dominance curve for Benthos



MDS plot for Benthic animals recorded in various stations



Dendrogram of Benthic species recorded in various stations

Bray – Curtis similarity for Phytoplankton collection from different stations

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
S1										
S2	72.04									
S3	61.54	60.46								
S4	62.16	63.70	68.21							
S5	57.50	52.17	53.73	60.82						
S6	45.68	50.89	48.85	51.01	43.24					
S7	58.00	54.57	59.38	64.62	54.35	58.88				
S8	59.12	60.70	63.36	70.84	60.99	57.02	75.58			
S9	66.89	63.50	64.20	69.89	73.62	50.07	73.55	69.34		
S10	63.52	66.59	66.70	67.36	57.17	51.04	70.19	68.40	64.45	

Bray – Curtis similarity for Zooplankton collection from different stations

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
S1										
S2	89.97									
S3	87.89	90.76								
S4	85.36	87.96	87.12							
S5	84.12	86.14	84.33	82.86						
S6	80.76	80.19	82.82	82.87	73.55					
S7	82.29	79.14	80.06	78.66	79.69	82.52				
S8	82.06	85.19	84.18	85.03	80.13	77.61	77.96			
S9	88.63	88.23	87.76	86.82	85.36	80.52	82.34	86.95		
S10	89.52	88.44	88.76	89.72	86.09	81.28	82.76	88.85	89.68	

Bray – Curtis similarity for Benthos collection from different stations

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	IB1	IB2	IB 3
S1													
S2	78.23												
S3	67.92	47.27											
S4	42.81	26.13	54.09										
S5	43.30	50.61	49.95	61.71									
S6	70.14	67.50	64.25	29.66	51.31								
S7	34.57	17.99	41.92	51.39	13.59	28.78							
S8	62.40	48.94	69.43	39.66	40.07	71.88	34.03						
S9	26.93	28.15	23.87	29.88	15.14	32.29	49.47	37.22					
S10	40.29	46.95	36.22	25.83	31.54	41.42	55.53	48.46	27.80				
IB1	21.00	0.00	18.05	24.02	0.00	0.00	23.08	15.47	0.00	0.00			
IB2	21.96	0.00	37.51	50.55	25.75	23.01	44.03	35.81	0.00	18.71	45.31		
IB3	41.90	18.18	52.21	41.73	19.64	34.34	55.71	41.93	17.31	32.60	58.58	62.36	

Microbiology: Microorganism distribution in the marine and brackish environment plays an important role in the decomposition of organic matter and mineralization. Since the last two decades, water quality analysis was given more importance in marine pollution monitoring programmes. These pathogenic bacteria invade into marine environment through human and animal excreta, river runoff, land runoff, sewage with organic and inorganic contents, agricultural waste and industrial waste. Hence, the spatial and temporal distribution of the Total fecal coli forms as well as pathogenic bacteria in water and sediment is essential to assess the sanitary. The regular monitoring in the coastal environment is an integral and essential part in predicting the microbial population of coastal waters.

Bacterial counts in the surface water and in sediment samples at all stations were analyzed, and are presented in Tables 20 and 21 respectively. In the water samples, population density enumerated from the all stations varied from 0.01 to 4.91 × 10^3 CFU ml^{-1} with the minimum (0.01 ×10^3 CFU ml^{-1}) at S1 & S3 and the maximum (4.91 × 10^3 CFU ml^{-1}) at S10. In the sediment samples, population density enumerated from the all stations varied from 0.03 to 5.75 ×10^4 CFU g^{-1} with the minimum (0.03 ×10^4 CFU g^{-1}) at S1 and S10. The maximum 5.75 ×10^4 CFU g^{-1}) at S1.

The bacterial colonies were identified up to generic level. Organisms isolated were normally expected in all coastal waters, under moderate human influence. The total count in the water sample at the surface closer to the coastal areas was found to be higher due to terrestrial run off and towards the open sea the count was found to be lesser. *Pseudomonas aerugenosa* and *Shigella* like organisms were found to be present in very low numbers. Other counts indicated lesser populations. This result implies that in this region there is no indication of any microbiological pollution.

Bacterial densities were higher in the sediment samples than the water samples. This could be ascribed to the fact that the coastal and shelf sediments play a significant role in the demineralization of organic matter which supports the growth of microbes. Higher bacterial population in sediments than water is generally due to the rich organic content of the former and the lesser residence time of microorganism in the water than the sediments. The pathogenic organism such as (TVC) *Escherichia coli*, *Vibrio* like organisms, *Shigella*, *Proteus klebsiella*, *Vibrio cholera* and *Vibrio parahaemolyticus*, Total coli forms have been recorded in the study area. The counts indicated lesser population which shows that the environment is healthy and pollution free.

In general the coastal waters are influenced by *Escherichia coli*, *Salmonella* sp., *Klebsiela* sp., *Enterobacter* sp., *Bacillus* sp., and *Staphyloccous* sp., and *Vibrio* like organisms. Estuaries and creeks are influenced by *E.coli*, *Salmonella* sp., *Shigella* sp., *Vibrio cholera*, *Vibrio parahaemolyticus*, *Pseudomonas* sp., and other pathogens like Total Coli forms and Total Viable Counts.

Mangroves: Mangroves are salt-tolerant forest ecosystems found mainly in tropical and sub-tropical inter-tidal regions of the world. They are trees or shrubs that have the common trait of growing in shallow and muddy salt water or brackish waters, especially along quiet shorelines and in estuaries. Mangroves are not common on sandy beaches and rocky shores. A muddy substratum of varying depth and consistency is necessary for their normal growth. The survey conducted in the project area does not indicate any mangrove species.

Turtles: Sea turtles are the key species in marine ecosystem function and helps in sustaining the biodiversity. Five species of sea turtles occur along the coast of India, including Olive Ridley (Lepidochelys olivacea). Out of this five reported species, four species nests along Indian coast. Olive Ridley is the most common and well known for 'arribadas' or annual mass nesting along Indian coast. Tamil Nadu and Andhra Pradesh coasts are considered as the migratory pathways of Olive Ridleys for approaching mass nesting beaches in Odisha.

Tamil Nadu, located at southeast coast of India, has a coastline of 950 km. Interestingly, all five species of the sea turtles have been reported. Olive Ridley nests sporadically along northern Tamil Nadu coast and high nesting was observed along Nagapattinam and Chennai coasts. The other turtle nesting areas are the coasts between Tranquebar and Pazhayaru, Mamallapuram and Chennai and Point Calimere and Nagapattinam. In the Kanyakumari to Trichendur stretch, the earlier reports indicate that the core nesting area existed between Manapad and Periyathalai. The turtle nesting was reported during December to February.




In Tamil Nadu, 36 Olive Ridley nests were recorded during January to March 2004 in the stretch of Mahabalipuram - Pondicherry coastline (100 km). The Chennai beach has been monitored by the Students' Sea Turtle Conservation Network (SSTCN) since 1988. A total of 50 nests were collected for their hatchery during January - April 2004, and 62 nests during 2005.

Observations on the nesting of Olive Ridley turtles is carried out on a regular basis across two beach stretches by the SSTCN team. The observations are made along the 14 km stretch from Neelankarai to Besant Nagar. As part of the conservation initiatives, the SSTCN team move turtle eggs from their natural nests into hatcheries situated at Besant Nagar and Marina beach where they are protected from the natural predators and human disturbances. The hatchlings that emerge are released safely into sea. During their survey, 121 nests were identified in both the beach stretches (76 nests were sighted in Marina beach (7 km); and 45 nests were found between the Besant Nagar and Neelankarai beach area (7 km)). Maximum numbers of nests were observed during February 2012 along both the stretches

Observations by WWF-India Personnel

Nesting survey was carried out fortnightly in the stretch between Neelankarai and Uthandi by WWF-India personnel. The survey was conducted from January to March 2012. A total of 6 Olive Ridley nests were recorded during the survey.

A beach stretch of 50 km from Mahabalipuram to Pondicherry was monitored by WWF-India personnel and a resource person. The nesting survey was carried out on a fortnightly basis and nesting information was recorded.

During the survey conducted by Indomer from February to March 2012, 44 nests of Olive ridley turtles were observed. The maximum number of nests was observed during 2nd week of February and March 2012 and some areas recorded higher nesting activity, ranging between 12 and 17 nests.

Coastal sand Dunes: Vast tracts of India's coast consist of beaches and coastal sand dunes. These natural formations are among the most effective natural defense against storms, cyclones and tsunamis. Fishing communities rely on their presence and most of the coastal tourism industry advertises them as major attractions. What is often not realized is that these are dynamic and complex habitats, many of which are under threat. Coastal sand dunes depend on a constant supply of sand, which is often is obstructed by activities such as construction of sea walls and wind breaks along the coast or damming of rivers and choking off their natural supply of sediment to the coast. Conservation of dunes thus involves both their stabilization as well as ensuring a constant supply of sand.

Coastal sand dunes perform a unique ecological function as a buffering mechanism for coastal erosion and deposition and protection against wave action, wind and tides. They also provide a large range of goods and services to coastal communities. These include sites for boat landing, sales of fish, drying and repairing of nets and motors as well as ground water recharge. Additional uses of coastal sand dune vegetation are fodder, food and medicinal plants. They also serve as a store house of sediments and nutrients and source of beach nourishment, protection from storm surges, hurricanes and erosion. They provide habitats for plants, bird nesting, sea turtle and mammals. Sand dune helps in the arrest of blowing sand and deflect wind upwards assist in the retention of fresh water and obstruct the ingress of saline marine water into the hinterland. Prevent loose sand from advancing inland on the coastal zone. The survey conducted in the project area absence of sand dunes.

Coastal Vegetation: The project area is widely dominated with *Casuarina litorea* trees and sparsely populated with veelikkaruvai (*Prosopis juliflora), Ipomea pes caprae, Pandanus odoratissimus, Catharanus roseus, Thespesia populnea, Cocus nucifera, Borassus flabellifer, Azadirachta indica, Pedalium* sp., *Calotropis gigantea* and *Spinifex littoreus.* In addition, dead shells of gastropod and bivalve molluscs are largely found washed on the shore line. The shore plants were collected and herbaria were prepared for further identification and confirmation in the laboratory. On the coastal front, farm houses, resorts and tourist spots are fast developing due to the internationally famous tourist spot at Mamallapuram.

Prosopis juliflora

Ipomea pes-caprae.

Thespesia populnea

Calotropis gigantea

Pandanus odoratissimus

Catharanthus roseus

Cocos nucifera

Borassus flabellifer

Spinifex littoreus

Azadirachta indica

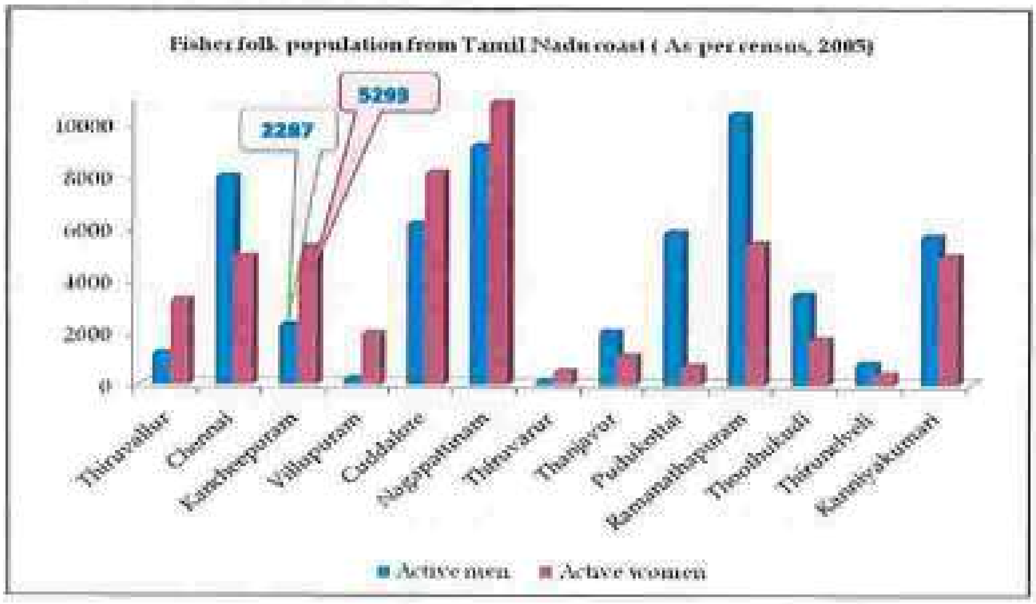
Pedalium sp.

Casuarina litorea

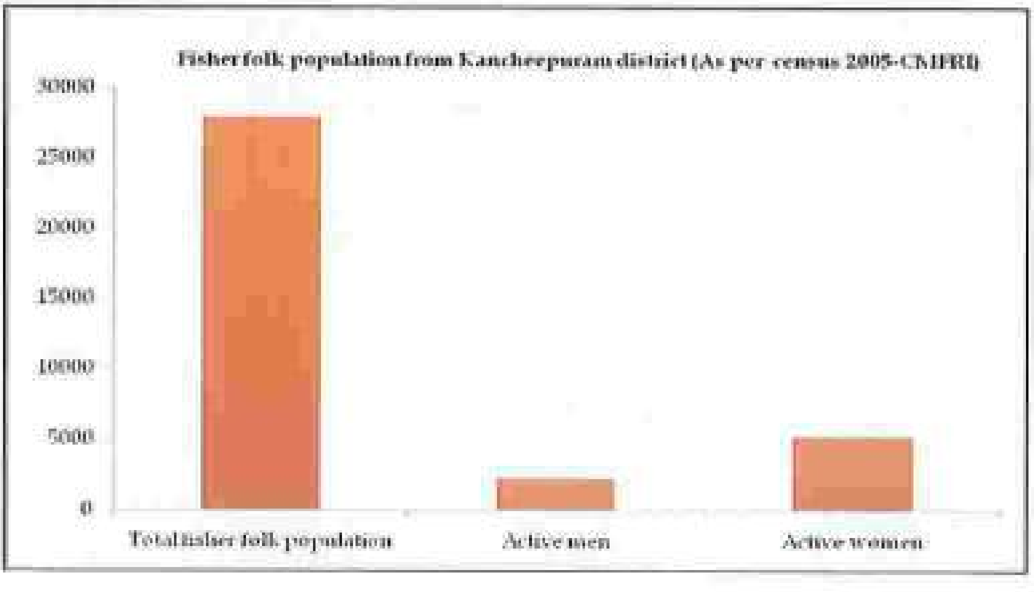
Fishery: Tamil Nadu has got a coastline of 1076 km and the continental shelf area covers 41,400 sq.km extending up to 40-60 km. This coastline is the third longest in India after A&N islands and Gujarat. The coast line of Tamil Nadu covers 14 out of 32 districts and starts from Chennai in the north to Kanyakumari in the south. According to the survey conducted by the CMFRI (2005), there are 7,90,408 fishermen and fisherwomen along the coast and only 1,04,509 are active in the fishing industry.

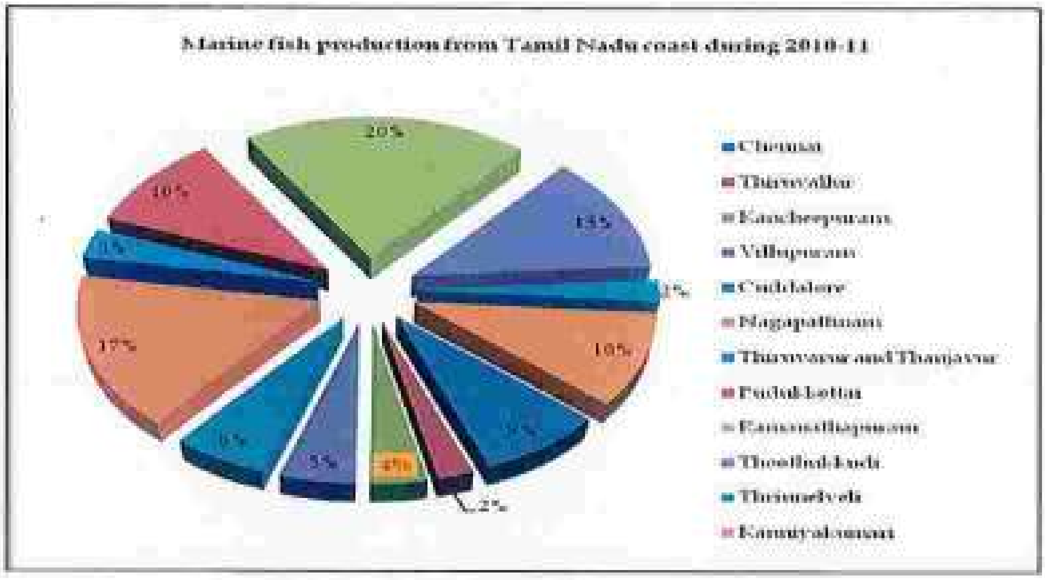
The Kancheepuram district under which the present site comes, has 87 km. of coast line and the fourth longest in the state with 44 fishing villages. There are 2 major and 37 minor fish landing centers.

The total fisher folk population in the district is 27,962 with an active fishermen (2,287) and fisherwomen (5,293) totaling 7,580 (Table 22) as given below.



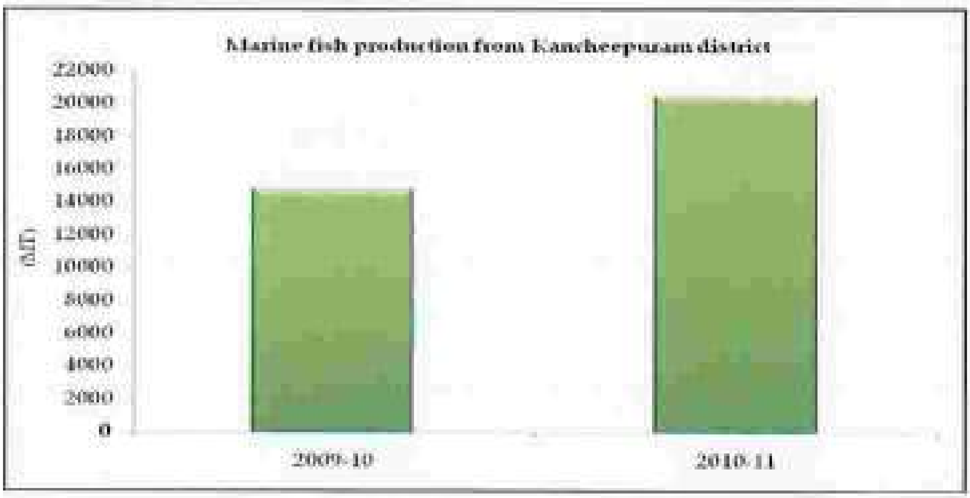
The fishery of the region is assessed based on the data obtained from the Department of Fisheries, Govt. of Tamil Nadu. The marine fish landings for the entire Tamil Nadu coast for the year 2010 - 2011 are presented below.

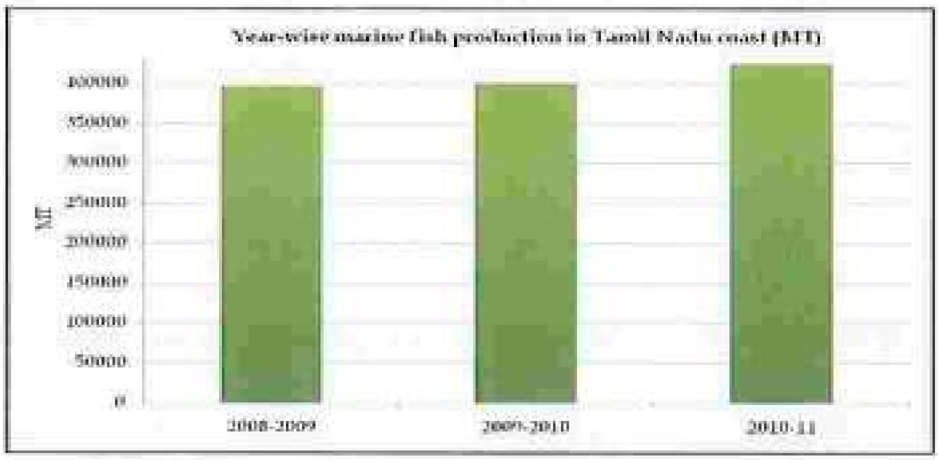




Kancheepuram district contribute as much as 4% to that of total marine fish catch of Tamil Nadu. The available data indicate that the yearly fish landings of the Kancheepuram area are not constant and they fluctuate widely.

An increasing trend in the marine fish catch during the post Tsunami period (2009 – 2011) has been observed in the Kancheepuram district as indicated in the figure below.

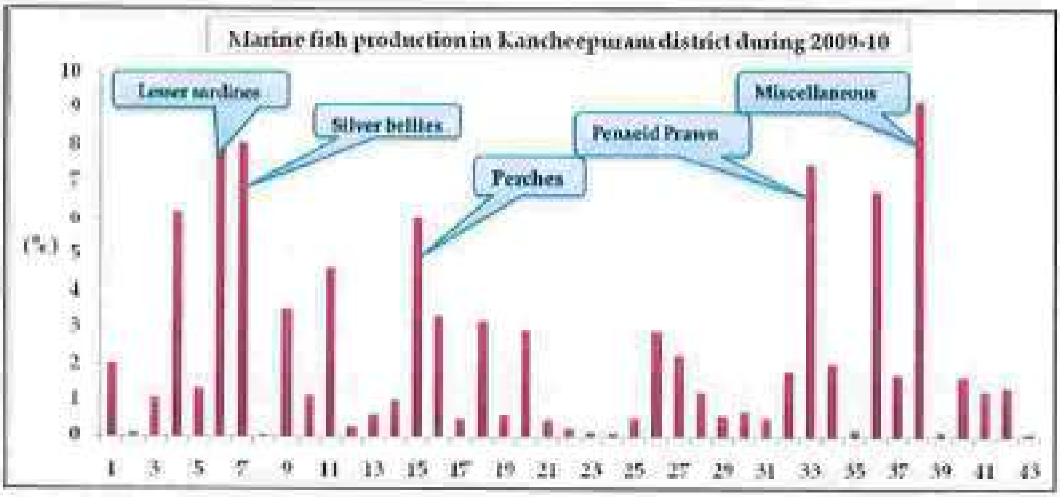


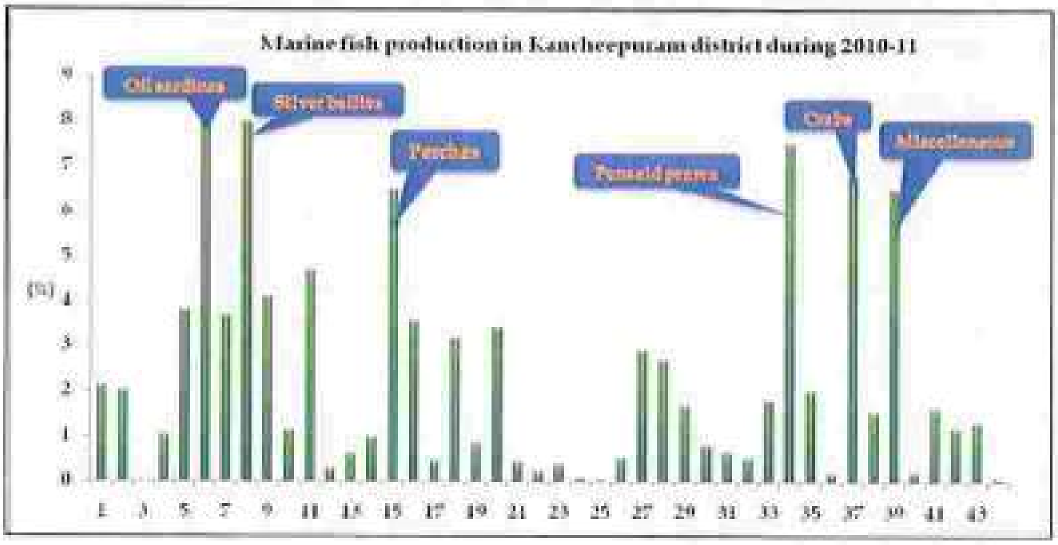


Total fish production during the last three years were 3,97,117.22 MT (2008-09), 4,01,128.37MT (2009-10) and 4,24,833.84 MT (2010-11).

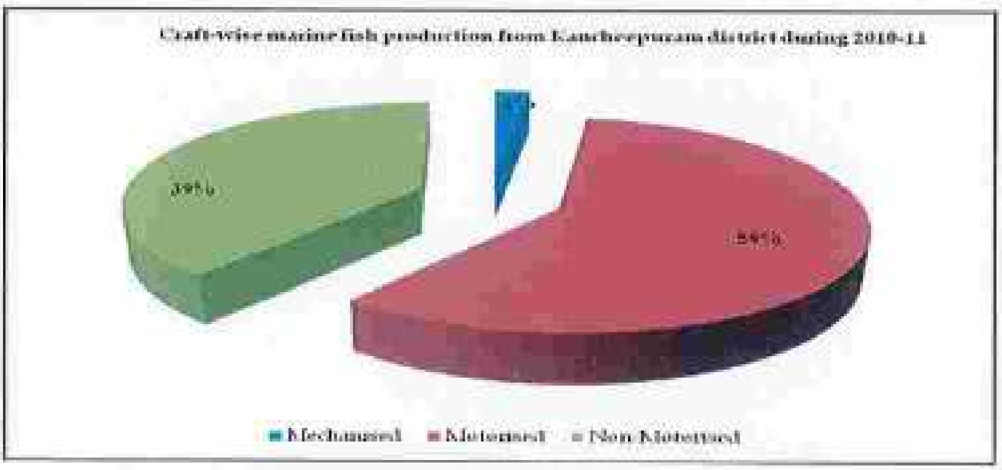
A variety of fishing crafts, like mechanized boats, wooden vallams and FRP Vallams, are used in this region. The total number of such crafts are 4011. However, mechanised boats (8), Wooden vallams (1722) and FRP Vallams (2281) are the most commonly used fishing crafts in this region (Table 23). Among the fishing gears, gill nets, trawl nets, hook nets and bag nets are primarily used for fishing by these communities (Table 24). However gill nets are the most popular among the fishing communities.

In general, the dominant fishes species of the Kancheepuram region are *Dussumieria acuta* (Mothakendi), oil Sardines (Paichalai), lesser Sardines (Keerimeen – Chalai), Anchovies (Nethili), Silver bellies (Kare), Savalai (*Lepturacanthus* sp.), Calawah (*Epinephelus* sp.), Catfish (Keleru), Carangoides (Parah), *Scomberomorus* sp. (Vanjiaram), Mackerels (Kanangeluthi), Changarah, Thullunkendai (*Nemipterus sp.),* Cuttle fish (*Sepia* sp.), Squids (*Loligo* sp.), Crab (*Portunus sanguinolentus, P. Pelagicus*) and Prawns (*Penaeus indicus, P. monodon*). Marine fish production from Kancheepuram district (2009 – 2011) is presented in (Table 25). The available data indicate that the yearly fish landings fluctuate and are not constant. While the total landing was 14,822.87 MT in 2009-2010, it was 20,476.53 MT during 2010-11.





The total marine fish catch in the district from all crafts accounted for 15,822.95 MT during 2010-11, with the following break – up; Mechanized boats (354.48 MT), Non-mechanized boats (6187.39 MT) and Motorized boats (9281.08 MT- Table 26) and their percentage catch is given below.

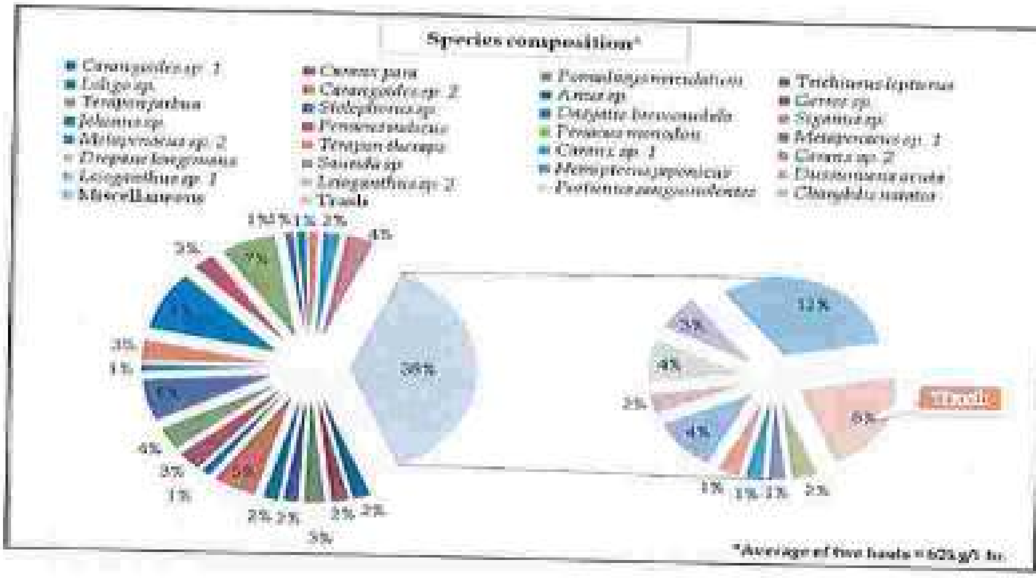


The biological productivity of this region in the open sea is largely influenced by the seasonal coastal circulation. Phytoplankton and zooplankton population is relatively high as seen by the biomass and primary production values. The coastal waters are highly dynamic and show good mixing which minimizes any likely impact of discharges in the region. The fishery is well represented by various groups of pelagic and demersal species. Based on the observations and results obtained, from the study area, it is concluded that the near shore environment is biologically normal and free from pollution.

Experimental trawl surveys: In order to assess the fishery potential of the region, it is necessary to conduct exploratory and experimental fishing. Accordingly, experimental trawl fishing was conducted using a commercial mechanized stern trawler of 46 ft. in length. The area covered is adjacent to the project site and all the trawls were done at 10-25 m depth. Two types of bottom trawls, shrimp trawl with 34 m head-rope with cod end mesh size of 10mm and fish trawl with 40 m head-rope with a cod end mesh size of 20 mm are available. In the present study, we used shrimp trawl nets for the experimental trawling.

Totally two hauls (shrimp trawl nets) were carried out on 27.07.13 during day time. The duration of each haul was approximately 1 hr 30 min and the towing speed varied between 2.5 and 3.5 knots. The catch of each haul was sorted out into various groups/species and weighed. Fish samples including prawns and crabs collected from the trawl survey were also examined for the maturity stages. Using the experimental trawl survey data, both biomass and density of fish stocks, were calculated following swept area method (Sparre *et.al.* 1989). This method assumes that the mean catch in weight per unit area is an index of stock abundance. The area swept by the trawl is: Area = DW (km^2) where D is the distance covered by the trawl during one haul and W is the width of the path swept by the trawl. The Biomass (B) for the given area was estimated following the formula: B=S (mean CPUE/Q) where S is the stratum area, CPUE is the catch per unit effort, and Q is the catch ability coefficient, which is normally taken as 0.5. Then the density of fish stock is calculated: Biomass/Area.

The location of hauls and other details are given in Table 27. The catch rate ranged from 64kg/hr. to 60kg/hr with a mean value of 62kg/hr. The estimated total biomass of the water body area is 157 km^2 (Volume of area πr^2; 22/7 x 10 km X 10 km) and the rest of the area (157km^2) is terrestrial. Based on the experimental trawl survey from the water body, the biomass was calculated to be 19.47 tonnes with an estimated population density of 124kg/km^2. The haul wise composition of catch is given in Table 28. A set of photographs on trawling operations and groups of fishes collected are given in the following pages.



In general, the fish catch was moderate with major portion of both hauls dominated by species belonging to the family Carangidae and Leioganthidae. Among the catch, members of the Family: Carangidae (*Carangoides* sp.1, *Carangoides* sp.2, *Caranx para*, *Caranx* sp.1 and *Caranx* sp. 2) constituted the major portion (15%) followed by other family Leioganthidae. Species like *Leiognathus* sp.1 and *Leiognathus* sp. 2 constituted 6%. Rest of the catch was dominated by miscellaneous groups constituting (12%) representing fish species such as *Rhabdosargus* sp., *Pampus chinensis*, *Plotosus anguillaris*, *Narcine brunnea*, *Narcine* sp., *Ophisthopterus tardoore*, *Aesopia cornuta*, *Aesopia* sp., *Ambassis* sp., *Scomberomorus* sp., *Sphyraena* sp., *Gerres filamentosus*, *Platycephalus* sp., *Nemipterus* sp., *Alectis* sp., *Upeneus* sp., *Alepes* sp., *Lactarius lactarius*, *Cynoglossus* sp., *Pseudorhombus* sp., *Psettodes* sp., *Himantura uarnak* and cephalopod like *Sepiella* sp. etc., Other major family, Sciaenidae was represented by species like *Johnius* sp. formed (9%) of the catch. The rest of the catch comprised by other commercially important species like *Stolephorus* sp. (6%), *Terapon jarbua* (4%), *Siganus* sp. (3%), *Gerres* sp. (3%), *Pomadasys maculatum* sp. (3%), *Trichiurus lepturus* (2%) and *Drepane longimana* (2%). In addition other important species like *Arius* sp. (1%), *Dasyatis brevicaudala* (1%), *Terapon theraps* (1%), *Saurida* sp. (1%), *Nemipterus japonicas* (1%) and *Dussumieria acuta* (1%) were present as shown in figure given below. This was followed by crustacean species like *Penaeus monodon* (7%), *P. indicus* (3%), *Metapenaeus* sp.1 (1%) and *Metapenaeus* sp. 2 (1%) crabs like *Portunus sanguinolentus* (4%), *Charybdis natator* (3%) and cephalopod species such as *Loligo* sp. (2%) were present in the catch. The catch grouped as trash fish constituting (8%) is represented by *Squilla* sp., sea snakes, Gastropods, Bivalves, non edible crabs, small sized *Leiognathus* and Echinoderms. The sea snakes caught in the catch were very large and many.


Shooting of trawl net


Trawl net operation


Opening haul


Assorted fish catch

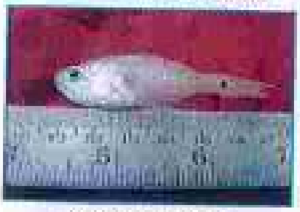

Shorting fish catch


Dasyatis brevicaudala


Himantura uarnak


Narcine sp.


Narcine brunnea


Ambassis sp.


Caranx para


Caranx sp.1


Caranx sp.2


Trichiurus lapturus


Pampus chinensis

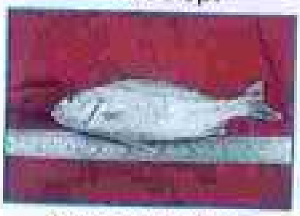

Plotosus anguillaris


Arius sp.


Gerres sp.


Gerres filamentosus


Johnius sp.

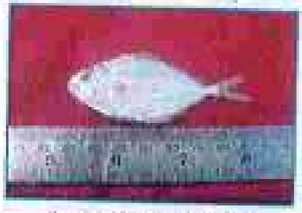

Terapon jarbua


Terapon theraps

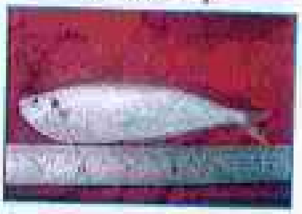

Stolophorus sp.


Siganus sp.


Johnius sp.


Leiognathus sp.


Leiognathus sp.


Opisthopterus tardoore


Aesopia cornuta


Aesopia sp.


Pseudorhambus sp.


Psettodes sp.

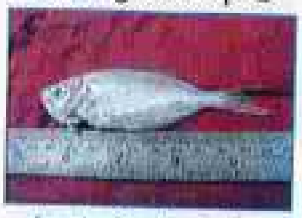

Cynoglossus sp.


Carangoides sp. 1


Carangoides sp. 2


Drepane longimana


Opisthopterus tardoore


Lactarius lactarius


Scomberomorus sp.


Sphyraena sp.


Pomadasys maculatum


Unidentified

Saurida sp.

Alepes sp.

Alectis sp.

Nemipterus japonicus

Nemipterus sp.

Platycephalus sp.

Dussumieria acuta

Unidentified

Upenus sp.

Rhabdosargus sp.

Lagocephalus intermis

Triacanthus biaculeatus

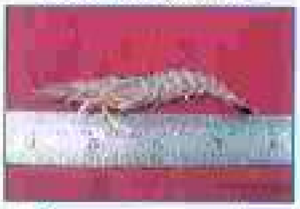
Portunus sanguinolentus

Charybdis nataor

Calappa lophos

Albunea symnista

Penaeus indicus



Penaeus monodon

Metapenaeus sp.1

Metapenaeus sp.2

Panulirus polyphagus

Thenus sp.

Octopus sp.

Loligo sp.

Sepiella sp.

Sepia sp.

Ficus sp.

Lophitoma sp.

Babylonia spirata

Turritella attenuata

Conus sp.

Conus sp.

Olivancellaria sp.

Bursa rana

Murex virgineus

Architectonica sp.

Fusinus sp.

Pleuroploca sp.

Circe sp.

Meretrix sp.

Amusium pleuronectus

Peristeidion sp.

Astropecten sp.

Clypeaster sp.

Squilla sp.

Weighing fish catch

Leiognathus sp.

Shirmp

Stolephorus sp.

Crab

General conclusions on ecological status

It is always advantageous to assess the "Ecological Status" of a region before any major project is initiated so that the baseline status that was recorded can be used as a reference for future assessments. This will help us to monitor the environment systematically and would enable us to take any mitigation measures, whenever necessary. The biodiversity or community structures of flora and fauna of the region react to changes in the environment which ultimately affect the productivity of that region. There are several statistical methods and indices to explain these changes and based on the values people classify the ecological status. One such general method is the classification of Shannon -Weiner diversity Index as given below.

Productivity Status	Species Diversity (Shannon - H')	Explanation
Bad	0.0 – 1.5	Very highly polluted
Poor	1.6 – 3.0	Highly polluted
Moderate	3.1 – 4.0	Moderately polluted
Good	4.1 - 4. 9	Transitional zone (i.e. pristine to polluted)
High	5.0 and above	Normal/Pristine (i.e. can be a reference site)

In the present study, the diversity values (H') for phytoplankton and zooplankton were found to be >5.0 indicating that the region may be classified as "high" which is an indication of normal or pristine zone. Continuous post monitoring of the environment would be necessary to indicate the possible changes in the ecological status. As pointed out earlier, the diversity values were high in this region due to of the sandy nature of the bottom and low organic matter content. However, there could be a direct impact of anthropogenic activities in the region, and these values could be taken for comparison to assess the ecological status subsequently. Based on the statistics available from the Tami Nadu State Fisheries Department, it is evident that the fishery of this region is very good.

5. SEABED INVESTIGATIONS

The seabed investigations consisting of bathymetry survey, shallow seismic survey and side scan sonar survey were carried out in the nearshore of the proposed intake and outfall region. These surveys were carried out to cover 2.5 km distance along the coast and 3 km distance into the sea. The surveys were carried out during July - August 2013.

5.1. Bathymetry

The bathymetry chart of the project region prepared in 1:15000 scale is presented in Annexure-II. The nearshore till 7 m depth remained steep with the gradient of 1:70. The region between 7 m and 15 m water depth showed the gradient of 1:250. The water depth of 16 m appears at a distance of about 3 km from the shore. It has been noticed that the depths near the existing outfall and intake locations have become deeper due to the existence of construction debris, dredging activities, burying of pipelines etc. The offshore beyond 11 m water depth is found to be slightly shallower on the southern side compared to the northern side. The variation of water depth with distance from the shore close to the Phase II development is shown below.

Depth w.r.t. CD (m)	Distance from shore (m)
4	225
5	340
6	440
7	520
8	660
9	835
10	1040
11	1360
12	1890
13	2160
14	2480
15	2720
16	2950

5.2. Shallow seismic survey

Characteristics of sub-seabed

The interpreted isopach map based on seismic data is generated in 1:15000 scale and presented in Annexure-III.

The shallow seismic study reveals that the sub-seabed consists of sedimentary layer such as sand and clay up to few meters below seabed. The submerged and buried rocks are also noticed within the study region.

Submerged Rocks: The seismic records are showing higher amplitude signals at few places which are indicating the rocks submerged above the seabed. The isopach contours less than 1 m are showing the rocky out crops that are located randomly at different elevations.

The submerged rocks are identified on the southern region (nearshore) at a distance of about 850 m from the shore. The nearshore rock spreads o quite large spatial extents on the seabed extent. The offshore seismic records also reveal the presence of the submerged rocky patches beyond 2000 m from the shore. At the northern side, rocks are not seen till 1500 m from the shore. Beyond that, patches of linear rocks are located randomly.

Buried Rocks: The gradual increase in sediment thickness close to the rocky-outcrop indicates the extension of buried rock beneath the seabed. The buried rocks are extending beneath near the submerged rocky patches at various directions. As the limitation of acoustic basement depends on the mask of seismic multiples, the dipping angles and depth of extension of buried rocks are not described further deep.

Sedimentation: Generally, the sediment thickness (till acoustic basement) within the survey boundary varies up to 9 m.

Southern side: The sediment thickness appears slightly lesser than the northern side and varies up to 5 m at the nearshore. The sediment thickness increases towards offshore till the distance of about 2 km from the shore. Further, the isopach values decrease due to the presence of submerged and buried rocks. The sediment thickness of 9 m appears on the southern side at a distance of about 1 km from the shore.

Northern side: At the northern side, the sediment thickness is varying between 3 m and 7 m till the distance of about 1.5 km from the shore. Beyond that, it decreases due to the existence of linear NE-SW rocky patches. The offshore sub-seabed is found to be composed by sand and clay varying the thickness between 7 m to 9 m.

5.3. Side scan sonar survey

The seabed map prepared in 1:15000 scale is presented in Annexure-IV. The analyzed records reveal that the seabed is generally covered by sandy clay, clayey sand, coarse sand with scattered rocky outcrops.
Spread of submerged rocks: The higher amplitude acoustic signals on the sonogram shows the presence of about 20 rocky outcrops on the seabed. The rock-outcrops are scattered on the seafloor at various random locations with different elevations above the seafloor. At some of the places the rock-heads are carpeted by the seashells and coarse sand.

Southern side: Four submerged rocky patches of various spatial extents are seen on the nearshore region till the distance of about 1300 m from the shore. Beyond that, the rocks are not visible from side scan records till 2000 m from the shore. Further, six patches of submerged rocks are demarcated till the end of the survey limit.

Northern side: The nearshore is observed by the absence of rock-outcrops till 1.5 km from the shore. Beyond that, the seabed shows the patches of linear rocky outcrops in NE-SW direction. It has been noticed that the stretch of linear rock is about 1 km long in NE-SW direction. It exists at 2 km offshore.

Existence of pipelines: The intake and outfall pipelines of Phase-I which are partially buried have been observed on the seafloor. The construction debris and trenches are also noticed in the side scan records along the pipeline corridor.

Seabed covered by sediments: The rest of the seabed apart from rock-heads is carpeted by mainly sandy clay and clayey sand. The patches of coarse sand with different grain sizes are noticed to be distributed on the seafloor. The presence of seashells is also illuminating the side scans sonogram at few locations.

6. DISPERSION MODEL

The main objective of the study is to ensure that releasing the brine would not alter the existing marine ecosystem in terms of the water quality and biological characteristics deviating from the prescribed standards. The total volume of AECOM brine to be discharged into the sea after phase II will be 31125 m^3/hour≈8.64 m^3/s).

The distance of outfall diffuser from the bank, water depth, wind, river water density gradient, current speed and direction etc. are some of the primary factors determine the extent of dilution. The dilution of effluent released in the marine environment takes place in 2 stages, viz., i) initial dilution due to jet mixing, and ii) secondary dispersion due to turbulence. The extent of initial dilution is controlled by the engineering design of the diffuser. For a proposed design of the diffuser port the behaviour of the jet plume is designed using CORMIX model. Once the return water rises to the water surface as the water moves away from the outfall location the subsequent dilution takes place by larger scale turbulence in the horizontal direction. This second stage is controlled by the prevailing currents and turbulence that exist in the coastal region. Such secondary dispersion is estimated using DHI-MIKE 21 model.

6.1. CORMIX model and mixing in near field

For a proposed design of the diffuser port the behaviour of the return water jet plume is designed and estimated using **CORMIX** model. The second stage is controlled by the prevailing currents and turbulence that exist in the coastal region. Such secondary dispersion is estimated using **DHI-MIKE 21 - AD** model.

The volume of discharge into the sea in each of the seven outfalls is assumed as 31125 m^3/hour (8.64 m^3/s). The outfall diffuser will have the multi ports of 18 nos. x 600 mm diameter. All the ports will be oriented 30° to the horizontal. The water depth at the disposal location will be 8 m and the diffuser height will be 1.5 m above the seafloor. The various input parameters for the CORMIX models are given below.

Volume of discharge	=	31125 m^3/hour (8.64 m^3/s)
No. of Ports	=	18 nos. x 600 mm dia.
Inclination of ports	=	30° to horizontal

CORMIX SESSION REPORT:

CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 8.0GTH
DYDRO: Version-5.0.0.0 April, 2012

SITE NAME/LABEL	: NEMMELI
DESIGN CASE	: Metro water
FILE NAME	: C:\Program Files \CORMIX 8.0\Nemmeli phase2.prd
Using subsystem BCORMIX2	: Multiport Diffuser Brine Discharges
Start of session	: 1st December, 2014--16:30:00

AMBIENT PARAMETERS:

Cross-section		= unbounded
Average depth	HA	= 8.0 m
Depth at discharge	HD	= 8.0m
Ambient velocity	UA	= 0.15 m/s
Wind velocity	UW	= 2 m/s
Stratification Type	STRCND	= U
Surface density	RHOAS	= 1023.34 kg/m^3
Bottom density	RHOAB	= 1023.34 kg/m^3

DISCHARGE PARAMETERS	:	Submerged Multiport Diffuser Discharge
Diffuser type	DITYPE	= unidirectional perpendicular
Diffuser length	LD	= 54 m
Nearest bank		= left
Diffuser endpoints	YB1	= 696 m; YB2 = 750 m
Number of openings	NOPEN	= 18
Number of Risers	NRISER	= 18
Spacing between risers/openings	SPAC	= 3.18 m
Port/Nozzle diameter	D0	= 0.6 m
Total area of openings	TA0	= 5.0894 m^2
Discharge velocity	U0	= 1.70 m/s
Total discharge flowrate	Q0	= 8.64 m^3/s
Discharge port height	H0	= 1.5 m
Nozzle arrangement	BETYPE	= unidirectional without fanning
Vertical discharge angle	THETA	= 30 deg
Discharge density	RHO0	= 1050 kg/m^3
Density difference	DRHO	= -26.6600 kg/m^3
Discharge concentration	C0	= 31000 mg/l

NON-DIMENSIONAL PARAMETERS:

Port/nozzle Froude number	FRD0	= 4.18

D-CORMIX PREDICTION FILE:

FLOW CLASSIFICATION

X-Y-Z COORDINATE SYSTEM:

ORIGIN is located at the SURFACE and at the diffuser mid-point

X - Axis points downstream
S - Hydrodynamic average dilution

X	S
0.0	1.0
2.5	4.0
5.5	5.5
8.0	6.5
10.5	7.5
13.5	8.0
16.0	8.8
18.5	9.5
21.5	10.0
24.0	10.5
27.0	11.0
75.0	57.0
120.0	60.0
165.0	62.0
200.0	65.0

Cumulative travel time = 2 min

Discussion on Initial dilution

The study on CORMIX model shows the mixing zone will extend for 75 m to achieve 57 times and extending further till 200 m distance to achieve to dilution of 65 times from the disposal location. Thereafter the initial dilution, the secondary dispersion take place due to convection currents and undergoes further dilution. The secondary dispersion characteristics are studied in detail using MIKE 21 model.

6.2. Secondary Dispersion – MIKE 21 model

The tide and wind induced flow field over the project area is determined using the MIKE 21 hydrodynamic module (HD) and the return water diffusion using the Advection-Dispersion module (AD).

The relevant equations and method of solutions are given in detail in the report - "Mathematical modeling study for Phase II seawater desalination plant at Nemmeli, Chennai".

Details of Intake: The existing seawater intake laid for Phase I draws 260 MLD ≈ 10833 m^3/hour of seawater. For the Phase II, i.e., the proposed seawater intake considered in this report will draw 1147 MLD ≈ 47791.66 m^3/hour of seawater.

Details of Outfall: The existing outfall laid for Phase I discharges 160 MLD ≈ 6667 m^3/hour of return water. For the Phase II, i.e., the proposed outfall considered in this report will discharge 747 MLD ≈ 31125 m^3/hour of brine reject.

Salinity of return water: The brine reject will have a salinity of 71 ppt which is 33 ppt higher than the ambient seawater salinity (38 ppt). There will be no change in other water quality parameters compared to the ambient values.

Modelling scenarios: In the present case, for the discharge of Phase II development, the model study has been conducted for the two scenarios as detailed below.

Case 1: Phase I (Existing) + Phase II
Case 2: Phase I (Existing) + Phase II + Phase III (future)

6.3. Simulations

In each simulation the flow field and the mixing pattern were obtained for a period of one lunar month (i.e. 28 days). The total number of simulations carried out is six as detailed below.

Number of simulations = I 1 x I 2 x I 3 = 6
Where,

Number of dispersing substance	I 1= 1
Number of seasons	I 2 =3
Number of scenarios	I 3 = 2

The instantaneous flow and mixing patterns corresponding to flood and ebb phases during spring and neap tide periods are presented in the report.

6.4. Results

Fair weather

The flow simulation and the corresponding secondary dispersion of the return water for fair weather with no wind condition (representing conservative mixing scenario) are presented.

Spring tide

Flow field: The tide induced flow fields under no wind condition during the *flood and ebb phases on a spring tidal day* close to the project region are presented in Fig. 8.1. The magnitude of currents over a major portion of the project region was around 0.12 m/s with the direction of flow towards north during the flood phase and towards south during the ebb phase.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.2. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 2 ppt was observed to occur at 80 m and 250 m from Phase I and Phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.3. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 2 ppt was observed to occur at 80 m, 250 m and 100 m from Phase I, Phase II and Phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Neap tide

Flow field: The tide induced flow field under no wind condition during the *flood and ebb phases on a neap tidal day* close to the project region is presented in Fig. 8.4. The magnitude of currents over a major portion of the project region was around 0.10 m/s with the direction of flow towards north during the flood phase and towards south during the ebb phase.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged at 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.5. The brine discharged in the nearshore water undergoes dilution around the outfall point such that the difference in salinity of 2 ppt was observed to occur at 90 m and 300 m from phase I and phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.6. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 2 ppt was observed to occur at 80 m, 300 m and 120 m from Phase I, Phase II and Phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Southwest monsoon

Spring tide

Flow field: The flow field due to tide and southwest monsoon wind during the *flood and ebb phase on a spring tidal day* for close to the project region in Fig. 8.7. The magnitude of currents over major portion of the project region remains around 0.25 m/s with the direction of flow towards north.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged at 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.8. The brine discharged in the nearshore water undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m and 500 m from phase I and phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.9. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m, 500 m and 90 m from Phase I, Phase II and Phase III outfalls respectively in the shore parallel direction. The modelling result reveals that the there is no merging between the outfalls.

Neap tide

Flow field: The flow field due to tide and southwest monsoon wind during the *flood and ebb phase on a neap tidal day* close to the project region is presented in Fig. 8.10. The magnitude of currents over major portion of the project region remains around 0.20 m/s with the direction of flow towards north.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.11. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the salinity of 1 ppt above the ambient condition was observed to occur within 60 m and 550 m from Phase I and Phase II outfalls respectively in the shore parallel direction. The modelling results reveals the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.12. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 60 m, 550 m and 100 m from Phase I, Phase II and Phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Northeast monsoon

Spring tide

Flow field: The flow field due to tide and northeast monsoon wind during the *flood and ebb phase on a spring tidal day* close to the project region is presented in Fig. 8.13. The magnitude of currents over major portion of the project region remains around 0.19 m/s with the direction of flow towards south.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.14. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m and 180 m from Phase I and Phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.15. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt above was observed to occur at 50 m, 180 m and 70 m from Phase I, Phase II and Phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Neap tide

Flow field: The flow field due to tide and southwest monsoon wind during the *flood and ebb phase on a neap tidal day* close to the project region is presented in Fig. 8.16. The magnitude of currents over major portion of the project region remains around 0.17 m/s with the direction of flow towards south.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.17. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m and 210 m from Phase I and Phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.18. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m, 210 m and 80 m from Phase I, Phase II and Phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

6.5. Discussion and conclusion

The existing seawater intake laid for Phase I draws 260 MLD ≈ 10833 m^3/hour of seawater. For the Phase II, i.e., the proposed seawater intake considered in this report will draw 1147 MLD = 47791.68 m^3/hour of seawater. There is a proposal to establish Phase III unit in future, which will have a separate intake system to draw the seawater of 455 MLD ≈ 18958.33 m^3/hour.

The existing outfall laid for Phase I discharges 160 MLD ≈ 6667 m^3/hour of return water. For the Phase II, i.e., the proposed outfall considered in this report will discharge 747 MLD ≈ 31125 m^3/hour of brine reject. There is a proposal to establish Phase III unit in future, which is expected to discharge 305 MLD ≈12708.33 m^3/hour through a separate outfall.

The brine reject will have the salinity of 71 ppt which will be 33 ppt higher than the ambient seawater salinity (38 ppt). There will be no change in other water quality parameters compared to the ambient values.

The MIKE 21 flow simulation study showed that the tide induced flow in the project region during fair weather is of the order of 0.12m/s. The increase in turbulence due to stronger currents (> 0.25 m/s) induced by monsoon winds and rough seas would enhance the mixing during the southwest and northeast monsoons. The currents during the southwest monsoon are observed to be stronger (> 0.25 m/s) than the remaining period of the year, leading to higher rate of mixing.

Based on the Mike 21 Modelling studies, it is indicated that the brine undergoes dilution to a difference in salinity of 2 ppt above the ambient condition. The plumes of 2 ppt salinity difference spread from different outfalls do not merge with each other and they get diluted with their respective mixing zone. On the other hand the difference in salinity of 1ppt is found to merge with other outfalls. However during the monsoon, the dilution is very high and there is no merging of plumes at all over at < 1ppt.

The study also shows that the brine reject discharged into the shoreline do not reach and there will be no shoreline connection and no contaminations of the water near the coast.

Further it is noticed that there is no recirculation of discharged water into the intake.

7. SCHEME FOR SEAWATER INTAKE & RETURN WATER OUTFALL

Seawater intake: The volume of seawater to be drawn is 47791.66 m^3/hour. It has been proposed to lay a submarine pipeline with intake head and a gravity flow to a land based sump with pump house. The intake head will be located at 1150 m distance offshore at a water depth of 10 m CD. The pipeline will be buried 1 m below the seafloor with reference to the top of the pipeline. The landward end of the intake pipeline has to be connected with the intake sump at (-) 7 m CD on the landward side. There will be trash bars and vertical screens in the sump to avoid the entry of marine organisms.

Outfall: The volume of return water will be 31125 m^3/hour. The return water will be carried by a submarine pipeline with multiple port diffusers at the offshore end. The outfall diffuser will be located at 750 m distance offshore at a water depth of 8 m CD. The entire stretch of the pipeline will be buried 1-1.5 m below the seafloor with reference to the top of the pipeline. The outfall will have a multiple port diffuser arrangement system consisting of 18 nos. x 600 mm dia. ports. In addition 4nos. x 600 mm dia. ports will be provided as standby.

8. DESCRIPTION OF ENVIRONMENT

The schematic presentation of the coastal zone proposed for seawater intake is shown in Plate 1. The morphology of this region is influenced by the 3 climatic conditions, viz., southwest monsoon (June – September), northeast monsoon (Mid October to Mid March) and fair weather period (Mid March to May). The coast is more influenced by the northeast monsoon period followed by southwest monsoon period.

Wave action prevails high during southwest monsoon and cyclonic period in northeast monsoon. The coastal currents within 5 km distance from the shore are greatly influenced by wind. The nearshore remains more dynamic and turbulent due to persistent action of seasonal wind, high waves and coastal currents. The distribution of temperature and salinity indicates that the near shore water is well mixed without stratification. Presently the coastline remains with elevated dunes and wide backshore. The influence of littoral drift is significant and the annual net drift takes place in northerly direction.

Examination of water quality of this region indicated that they are homogeneous across the depth and do not differ in vertical and spatial directions. Absence of marked vertical gradients of the physical parameters indicates that the coastal waters are well mixed. Various results on the chemical and biological parameters indicate that the water is well oxygenated, nutrient rich and biologically productive at primary and secondary levels. The sub-tidal benthic fauna is moderately rich in diversity and numbers compared to the inter tidal benthic fauna.

The marine flora and fauna also indicate the existence of diverse population. The area is rich in fishery both pelagic and demersal. The study on various oceanographic parameters and the information on adjacent region indicate that the coastal water is clean and highly productive.

9. IMPACT ASSESSMENT

9.1. Identification of Impacts

The schematic scenario of various activities in the project region is shown in Plate 2. The construction of seawater intake head and brine discharge will have marginal magnitude of impact on:

- Seawater,
- Marine ecology,
- Land use and
- Community

The magnitude of adverse impact appears to be very minimum. Nevertheless, the proposed project would bring positive impact on land use, people, their living and the economical development of the state.

The impacts due to different activities are analyzed. The construction of a seawater intake head and marine outfall for the release of brine reject into the sea will have impact on the marine environment.

Pipelines for both intake and outfall will be buried in such a way that the top of the pipeline will be 1 m below the seafloor. However it should be more than the scouring depth, say approximately 4 m below storm profile of the seafloor across the surf zone. As the intake point is located in the sea, the problem of entrapment of marine organisms and entrainment of zooplankton and fish eggs and larvae would occur. The impacts due to the construction of outfall diffuser are also analyzed. The discharge of brine would initially cause fall in seawater quality, especially on the ambient salinity. The discharge may affect the primary producers in the vicinity and thereby the productivity of the area. As benthic populations are essentially sessile, they will be the affected more. Fishes in the vicinity will avoid the discharge area and migrate from this region.

The effect of sudden change in salinity will present in a complex manner. Most fishes including shellfishes can tolerate mild increase than the normal range for a period of minutes to hours; however more extended periods may be fatal. Fishes may undergo shock and physical damages, and become prey to predators.

The residual chlorine present in the return water will affect the animal community living in the area. Prolonged exposure of aquatic organism to chlorine at concentration as low as 0.01 mg/l (or even less to especially sensitive species) can be toxic. The coastal installation like pump house and other infrastructure facilities may cause limited air and noise pollution on land. The magnitude of adverse impact for the indicated volume of intake and outfall appears to be low. Any negative impacts on historic/cultural heritage and social economic activities appear to be absent. The expected impacts on climate and soil condition are negligible. Nevertheless, the proposed project would bring positive impact on land use, people, their living and the economical development of the state.

9.2. Prediction of impacts

While the identification of the impacts provides the status of anticipated impact on the environment, the prediction of impact will give the extent to which these conditions can alter or improve the environment. Based on the prediction, mitigation measures can be evaluated to minimize the impact on the environment. The prediction of impacts is enumerated for:

i) Trenching for burial of intake and outfall pipelines,
ii) Construction of seawater intake head,
iii) Construction of outfall diffuser,
iv) Discharge of brine reject,
v) Impact on mangroves,

vi) Impact on turtles,
vii) Impact on fisheries and fishermen, and
viii) Impact due to tsunami and storm surge
ix) Impact on neighbourhood
x) Impact on shoreline

i) Trenching for burial of intake and outfall pipelines

It is proposed to lay submarine pipelines for both the intake and the outfall. The intake head has been proposed to be located at 1150 m distance offshore at 10 m water depth. Similarly the outfall has also been planned at 750 m distance offshore at 8 m water depth. The outfall diffuser will be erected at 600 m distance north of the intake in order to avoid the recirculation. The trench after laying the pipelines will be filled back with native sand. To meet the requirement of the proposed size of the trench, a moderate dredging activity along the entire stretch of the pipeline will have to be carried out. It is estimated that approximately 170,000 m^3 of sediment will be dredged temporarily. The identified effects due to dredging include entrainment and removal of organisms, increased turbidity near the dredging location, organic matter enrichment, fish injury associated with exposure to suspended sediments and decreased dissolved oxygen and fish behavioural effects due to the effects of noise.

Turbidity: Increased turbidity would affect the filter feeding organisms, such as shellfish, through clogging and damaging feeding and breathing equipment (gills). Similarly, young fish will be damaged if suspended sediments become trapped in their gills. Increased fatalities of young fish have been observed in heavily turbid water. Adult fish are likely to move away from or avoid areas of high suspended solids resulting from dredging activities. Increase in turbidity results in decrease of light penetration in water column which would further affect the density of phytoplankton which are the major primary producers in the coastal waters. Various studies show that, in general, the effects of suspended sediments and turbidity are confined to shortterm for less than a week on completion of dredging and limited to a region of less than a kilometer from the dredging location.

Removal of Benthic animals: During all dredging operations, the extraction of bottom sediments simultaneously leads to the removal the benthic animals living on the seabed and in the sediments. With the exception of some deep burrowing animals or mobile surface animals that may survive a dredging event through avoidance, dredging may initially result in the complete removal of animals from the excavation site. The rate of recovery of benthic communities following dredging in various habitats varied from few weeks to several years. Recovery rates are generally more rapid in highly disturbed sediments that are dominated by opportunistic species compared to stable sand habitats that are dominated by long-lived components with complex biological interactions controlling community structure.

Organic matter and nutrients: The release of organic rich sediments during dredging can result in the localized removal of oxygen from the surrounding water. Depending on the location and timing of the dredging, this may lead to the suffocation of marine animals and plants within the localized area or may deter migratory fish or mammals from passing through. However the removal of oxygen from water is only temporary, as tidal exchange would quickly replenish the oxygen supply. Therefore, in most cases where dredging is taking place in open coastal waters, the removal of oxygen has little effect on marine life. *In present project, the dredged channels will be filled with the dredged material after the pipelines are laid which would help to minimize the impact on the hydrodynamic regime and geomorphology.*

ii) Construction of seawater intake head

Improper design of intake head may cause vortex formation on the upper surface of the sea and also cause danger for the boats moving around the vicinity. The presence of intake head may alter or distort the existing current pattern.

Since the early 1970's, seawater intakes have been identified as having a potential adverse impact on aquatic organisms due to impingement/entrapment and entrainment. The cooling water intake structure extends from the point at which water is withdrawn from the surface water source up to, and including, the intake pumps. Entrainment means the incorporation of all early life stages of fish and shellfish with intake water flow entering and passing through a seawater intake structure and into sea water processing system. Impingement means the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during withdrawal of intake water. The larval forms which enter the seawater system are likely to be killed completely and causes recognizable loss to the fishery, depending on the species available at the site. While impingement is also known to affect the fishery to a limited extent, it involves mostly young (juvenile) organisms, in the immediate vicinity of the intake structure. The intake velocity and volume are known to be the major contributory factors for the impingement. The amount of physical damage incurred by fishes at seawater intakes is variable with species, life history stage and size of the fish. The mortality resulting from impingement is highest for small fishes. The extent of physical damage to which a fish is subjected is directly related to the duration of impingement, the technique of handling impinged fishes and the intake water velocities.

Non-scientific design of intake mouth, screens and trash bars will cause such impingement of marine organisms and entrainment of zooplankton and fish larvae. Further, the improper location of intake head might pose danger to the boats and fishermen moving in the vicinity. The pump house may induce the noise pollution.

iii) Construction of outfall diffuser

The presence of outfall diffuser may locally restrict the use of drifting nets. The installation of diffuser in sea and the jet plume discharge of discharge water would locally alter the flow pattern within the initial mixing zone. Improper design of outfall diffuser may reduce the mixing and increase the distance of mixing zone. The presence of discharge ports above the seafloor will prohibit use of gill nets and drift nets. Any ambiguity in the engineering design of the outfall diffuser can cause interference with currents and may become potential danger for the boats moving in the vicinity.

iv) Discharge of Brine reject

The brine discharge into the sea would initially raise the salinity of the seawater in the mixing zone. Effect of salinity changes present in a complex manner depending upon the corresponding changes in temperature and dissolved oxygen content. Most fishes including shellfishes can tolerate salinity outside their normal range for a period of minutes to hours; however the more extended periods may cause impact on fish life. Many shellfishes (Clams, Oysters etc) will be unable to move freely, but they can take protective action by temporarily closing their shells when exposed to abnormal salinities. Several instances of major losses of bivalves have been reported in other parts of the world as a result of larger variations of salinity.

Primary Producers: The phytoplankton is the primary producer that needs optimum salinity conditions for their growth and survival. An increase of salinity in the environment will lead to the death and decay of these primary producers. Therefore, it is advisable that the return brine may be discharged at a location where maximum dilution takes place within a short time of discharge so that the detrimental effect can be kept to a minimum.

Macrophytes: Macrophytes are multicellular plants which are attached to submerged rocks on the seabed in the shallow water region. They are sensitive to salinity changes in the environment.

Zooplankton: Zooplanktons, which are pelagic, move with the water current can be exposed to higher saline conditions resulting in varying degrees of stress due to changes in the osmoregulatory function. The residual chlorine present in the return water would also affect the population.

Benthic animal community: As the benthic community is sedentary in nature they will be affected by environmental changes more than the other communities. Like other animal population, they are also sensitive to the drastic changes in saline conditions, which may affect their body physiology. The noticeable effects are alteration of community structure resulting in the reduction of species.

Inter tidal fauna: The intertidal fauna are resistant to environmental changes to a limited extent, but large variations will affect their metabolism.

Fishes and shellfishes: Besides the effects of salinity changes, the dissolved oxygen content also affect the fish and shellfish lives. Most fish including shellfish can tolerate salinities outside their normal range for a period of minutes to hours, however, extended periods may cause impact in fish life. Many shellfish (Clams, Oyster etc) are unable to move freely, but they can take protective action by temporarily closing their shells when exposed to abnormal salinities. Several instances of major losses of bivalves have been reported as a result of larger variations of salinity.

Residual chlorine: The residual chlorine if present in the return water will affect the marine life living in the area. Prolonged exposure of aquatic organism to chlorine at concentration as low as 0.01 mg/l (or even less to very sensitive species) can be toxic. Besides high saline content affecting the salinity of the seawater, the residual chlorine in return water will also have impact on marine life. The intensity of impact depends on how soon the high saline water and residual chlorine concentration get diluted in the environment.

The freely available chlorine at any point of time should be kept within 0.5 mg/l. Residual chlorine present in the brine reject can have synergistic effects on the flora and fauna of the receiving water. Therefore, the standards stipulated by the Pollution Control Boards should strictly be adhered to in discharging the residual chlorine in the return water.

v) Impact on Fisheries and Fishermen

Kancheepuram district has a coastline of 87 km and is the fourth longest in the state with 44 fishing villages. There are 2 major and 37 minor fish landing centers. The active fisher folk population in the district is 7580 of which 2287 are male and 5293 are female.

The fishing village Perur and Nemmeli is located in the vicinity of the project region. Their fishing is mostly confined to Mahabalipuram region and at offshore. The laying of submarine outfall will have limited bearing on the day to day fishing activities. Entire stretch of the intake and outfall pipelines will be buried below the seafloor. Only the outfall diffuser and seawater intake head will be sitting on the seafloor and projecting above the seafloor. These locations will be marked with a marker buoy with lighted beacon so that the fishermen can avoid fishing in this zone. This will not cause any significant impact to the fishing community.

In general, the dominant fishes species of the Kancheepuram region are *Dussumieria acuta* (Mothakendi), oil Sardines (Paichalai), lesser Sardines (Keerimeen – Chalai), Anchovies (Nethili), Silver bellies (Kare), Savalai (*Lepturacanthus* sp.), Calawah (*Epinephelus* sp.), Catfish (Keleru), Carangoides (Parah), *Scomberomorus* sp. (Vanjiaram), Mackerels (Kanangeluthi), Changarah, Thullunkendai (*Nemipterus* sp.), Cuttle fish (*Sepia* sp.), Squids (*Loligo* sp.), Crab (*Portunus sanguinolentus, P. Pelagicus*) and Prawns (*Penaeus indicus, P. monodon*).

There is no seasonal fluctuation in the fish catch, so no particular trend in the fish catch is followed. The coastal waters are highly dynamic and show good mixing which minimizes any likely impact of discharges in the region. The fishery is well represented by various groups of pelagic and demersal species. The proposed intake and outfall pipeline will be buried below the seafloor with reference to the top of the pipeline. There will be trash bars and vertical screens in the intake sump to avoid the entry of fishes and fish larvae. There will be disturbance to the species during the construction stage and later on the original equilibrium will be retained.

Further be noted that fishing activity takes place minimum 5 km into the sea, whereas the intake and outfall are restricted within 1.2 km offshore, thus having no impact on the activity. Also the outfall point is located at 750 m from the shore hence the discharge of return water into the sea is not expected to cause any threat to the tourists as the brine reject undergoes maximum dilution within 100 m.

vi) Impact on Mangroves

The survey conducted in the project area indicates that the project region is an open coastal stretch with sandy beaches and is devoid of Mangroves. Hence the construction of intake and outfall does not have the question of affecting mangroves.

vii) Impact on Turtles

In Tamil Nadu, 36 Olive Ridley nests were recorded during January to March 2004 in the stretch of Mahabalipuram - Pondicherry coastline (100 km). A total of 50 nests were collected for their hatchery during January - April 2004, and 62 nests during 2005 by the SSTCN.

During the survey conducted by Indomer from February to March 2012 44 nests of olive ridley turtles were observed. The maximum number of nests was observed during 2nd week of February and March 2012 and some areas recorded higher nesting activity, ranging between 12 and 17 nests.

viii) Impact due to tsunami and storm surge

Cyclone: The occurrence of depression and cyclones are common over the project region and keeps the wave climate relatively higher. The coastal currents are greatly influenced by tides directed perpendicular to the coast. Since the pipelines are laid subsea, there will not be any impact on the marine facilities.

Tsunami: The occurrence of a Tsunami along the Indian coast is an extremely rare event with a very low frequency of less than once in 500 years. No reliable historical records of occurrence of Tsunami events and their impact along the Indian coast are available because of its exceedingly rare nature. One worst Tsunami occurred on 26.12.04 along the Tamilnadu coast and the destruction was more near the project region. The project region is located on the notified area of Tsunami impact, as the offshore tectonic plates are alive in Andaman Island. The presence of sand dunes (> 3 m) on the coast may to some extent dissipate the strength of tsunami but cannot totally protect from tsunami run up.

Storm surge: The project location is located wherein the cyclones would generally cross during the northeast monsoon season. The storm surge of 1.3 m height has been predicted for a cyclonic wind speed of 180 kmph for this region. However the project area is elevated and the impact may not be severe.

ix) Impact on neighbourhood

The nearest tourist destination is Mahabalipuram and the strip of coastal stretch between ECR and sea is more urbanized developed with tourist resorts, hotels, cottages, farm houses and intermittent pockets of fishing hamlets. The proposed location of the outfall is located in the relatively remote part of the coastline wherein only two fishing villages are located. The outfall point is located at 750 m from the shore hence the discharge of return water into the sea is not expected to cause any threat to the tourists as the brine reject undergoes maximum dilution within 100 m.

x) Impact on shoreline

The project coastal front is subjected to high littoral drift. In case of the present project, the intake and outfall systems are designed by submarine pipelines which will be buried below the seabed. There will not be any projection above the seabed which can cause interference for the littoral drift. It will continue to allow the littoral drift to move smoothly across the surf zone. Since the littoral drift is not affected by the intake and outfall pipelines, there will not be any change in the neighbouring shoreline.

9.3. Impact assessment

The baseline data collected from the project region and the review of the available information indicate that the water quality parameters are within the acceptable limits for the coastal waters. The coastal waters are well mixed, remain clean and free from any pollution. The quality of return water discharged into the sea is confined to the stipulated standards of the Tamilnadu State Pollution Control Board.

The seawater intake and the marine outfall will result in marginal impacts on marine community viz., coastal fisheries. But such impacts are confined to a limited duration of the period of construction. The analysis on quality of seawater drawn and the quantity of discharge indicate that impact due to such activity is limited to 100 m radius. The discharge at open sea does not cause any impact to the environment.

Despite various initial impacts on the environment, the benefits due to this project outweigh such initial adverse impacts since the project would prove extremely beneficial for the State and the people living in the project region.

10. MITIGATION

Though the proposed activities on construction of installation of seawater intake head and installation of outfall diffuser lead to certain adverse impacts initially on marine environment, there is sufficient scope for mitigations measures.

Trenching for burial intake and outfall pipelines

In order to minimize destruction on sub-tidal benthic community, the dredging may be carried out in controlled manner confined to only pipeline corridor. The turbidity induced during the dredging can be minimized using controlled dredging techniques using appropriate cutter suction dredger. The net enclosures with booms may be placed around the dredging area in order to control the spread of the turbid plume. Regular monitoring on the heavy metals in the water column may be carried out during dredging in order to watch any rise in concentration due to dredging. The dredged materials can be used as back fill after laying the pipeline in the trench.

Construction of seawater intake head

The intake head has to be designed in order to avoid vortex formation. The intake head shall be designed in cylindrical form to avoid interference of currents with velocity less than 0.15 m/sec. It should not cause any hazard to the boats and fishermen sailing in the vicinity. The intake should have appropriate screens and trash bars with small openings to minimize the entry of small marine organisms, fish larvae and fishes (entrapment and impingement). A marker buoy has to be placed close to the intake head as per the norms of Directorate General of Lighthouses and Lightships. This will also help boats to avoid collision while enroute. The route of pipelines laid on the seafloor has to be furnished to Naval Hydrographic Office, Dehradun in order to mark on the Naval Hydrographic Charts as a warning for navigation.

Construction of outfall diffuser

The outfall can be designed with multiple ports, which can enhance the jet mixing of the brine with the seawater. In this case, it has been designed with 18 nos. x 600 mm diameter of ports. This will ensure faster dilution of brine to ambient levels of salinity within short distance and there will not be any impact on marine organisms including fish catch in the nearby zone. The outfall diffuser should not have any sharp projection and should not pose any risk for the boats and fishermen moving around this region. The part of the outfall pipelines before the diffuser port may suitably be placed and buried to avoid hindrance for fishing and the movement of the boat. The diffuser ports should be placed appropriately above the seabed and also below the sea surface, so that they do not cause obstruction to the movements of boats and crafts. A marker buoy has to be placed close to the outfall as per the norms of Directorate General of Lighthouses and Lightships. This will also help boats to avoid collision while enroute. The route of pipelines laid on the seafloor has to be furnished to Naval Hydrographic Office, Dehradun in order to mark on the Naval Hydrographic Charts as a warning for navigation.

Breakage of pipeline

Pipeline can be damaged due to natural hazards like storm, earthquake, extreme waves, scouring on the foreshore and tsunami. It can also get damaged due to manmade causes like fishing, trawling and intentional damage. In case of any damage leading to breakage caused on the outfall pipeline, the brine water will gush out at shorter distance from the shoreline and would affect the marine environment. In such eventuality, the necessary mitigation measures like immediately attending the repair of pipeline has to be taken up. Necessary spares of pipeline segments with bends/Tees and divers with experience in salvation operation irrespective of sea condition have to be kept ready always within the plant.

Construction of intake sump and pump house

The intake sump and pump house should be constructed as per CRZ regulations.

Impacts and mitigations

The list of various impacts and the possible mitigations are summarized below.

Activity	Impact	Duration of Impact	Mitigation
Trenching for intake and outfall pipelines	Trenching will disturb the sea bed resulting in loss of seagrass beds and associated benthic communities.	Temporary	Use of good engineering tools like cutter suction dredger for trenching to be used.
	Increased turbidity affecting the photosynthetic process of the water column.	Temporary	Controlled method of dredging with latest technology which will limit the plume generation.
	Suspended particles will affect the filter feeders and adult fish will migrate from the site of impact.	Temporary	To minimize the spread of suspended particles, silt screens may be deployed.
	Boat movements and fishing activity will be restricted.	Temporary	Complete the operation within shortest duration.

Activity	Impact	Duration of Impact	Mitigation
Laying of submarine pipelines	Boat movements and fishing activity will be restricted	Temporary	Laying operation may be done in shortest duration within a week. Barricading the water along the shoreline has to be avoided. Install proper marker lights indicating if any obstructions.
Seawater intake head	Entrapment of fishes and other organisms. Entrainment of smaller organisms such as fish larvae.	Continuous	Installation of trash bars with < 10 cm opening, subsequently screens with 3mm opening, region covered for 50 m radius with nylon mesh having 1 cm opening to avoid entry of fishes and fish larvae. The entry should be only sideways with a limiting velocity of < 15 cm/s.
Outfall diffuser	Increased salinity Chlorine concentration	Continuous	Faster dilution of moderately high salinity levels to ambient levels Chlorine concentration to be maintained below 0.2 ppm.
Coastal installation	-	-	All installations as per CRZ regulations

11. MARINE ENVIRONMENTAL MANAGEMENT PLAN

11.1. Introduction

Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) has proposed to augment the drinking water supply by setting up additional seawater desalination plant of 400 MLD capacity as Phase II. The marine facilities for the proposed desalination plant will consist of: i) laying of seawater intake pipeline on the seabed but buried below seabed to a distance of 1150 m into the sea till 10 m water depth, ii) laying of outfall pipeline on the seabed but buried below the seabed to a distance of 750 m into the sea till 8 m water depth, iii) construction of seawater intake head, iv) construction of outfall diffuser and v) construction of seawater sump with pump house on the shore.

The salinity of the return water released into the sea will be 71 ppt, which will have the salinity difference of 33 ppt higher than the seawater ambient salinity of 38 ppt. The proposed activities will have the impacts on the marine environment and it is necessary to draw an Environmental Management Plan. The Environmental Management Plan has been prepared with the guidelines on proper locations of the marine facilities, appropriate design, control and flow of intake and outfall, regulation of boats movements, preservation of near shore ecology and protection of social life.

Context and Scope

This Environmental Management Plan addresses the environmental issues associated with the project including potential effects to marine water quality, sediment quality, pelagic and benthic producer habitats and the ecosystem integrity. The Environmental Management Plan has been prepared with the guidelines on proper locations of the marine facilities, appropriate design, control and flow of intake and outfall, regulation of boats movements, preservation of nearshore ecology and protection of social life.

Objectives

The MoEF objectives relevant to Marine Management Plan include:

- To maintain or improve marine water and sediment quality in compliance with sediment and water quality guidelines documented.
- To maintain the integrity, ecological functions and environmental values associated with marine environment both coastal and offshore.
- To maintain the abundance, species diversity, geographic distribution and productivity of marine flora and fauna.

- To ensure that any impacts on locally significant marine communities are avoided, minimized and/or mitigated.
- To ensure that appropriate consideration is given to cumulative impacts so that the proposed activity does not cause considerable damage to the sustainability of the ecosystem.
- To protect Specially Protected (Threatened) Fauna in accordance with the provisions of the Wildlife Conservation Act.
- To monitor the impact of the proposed activity on the productivity of the region.

Potential impacts

The various impacts in any project development can be categorized as mitigable and non-mitigable and it is essential to list the impacts accordingly. Key activities or aspects of the proposal that may potentially affect habitat of flora and fauna and require application management controls include:

Site preparation includes welding of pipelines on shore, storing of marine spreads, pile driving equipments, sheet piling across the surfzone, construction of seawater intake head and marine outfall diffuser, pumping stations etc.

Operation of seawater intake on a continual basis will affect on the occurrence and distribution of marine fauna especially fishes. A detailed marine EIA report enumerating the project development on marine front has been prepared and presented in previous chapters.

11.2. Delineation of Impacts

The various impacts in any project development can be categorized as mitigable and non-mitigable and it is essential to list the impacts accordingly. The proposed activities in marine environment under this project will have impacts on: i) seawater, ii) marine ecology, iii) land use and iv) community.

In a broad sense, the construction of intake and outfall would affect the flow and in turn the sea bottom initially. While the construction of seawater intake head will not have any long term impact, the outfall with the diffuser will have marginal impact at nearshore. The construction of the facilities would affect the flow and in turn the sea bottom initially. It would further interfere with the movement of trawlers and fishing boats along its stretch. The presence of outfall diffuser would restrict the use of drifting nets.

The coastal installation of pump house and other infrastructure facilities would cause limited air and noise pollution on land. The impacts on historic/ cultural heritage and social-economic activities appear to be absent.

11.3. Identified Mitigation and compensation measures

Though the proposed activities on construction of seawater intake head and outfall diffuser lead to certain adverse impacts initially on marine environment, there is sufficient scope for mitigations measures.

a) Activity: Construction of seawater intake head

Mitigation: The seawater water intake head planned at open ocean should have a cylindrical shape with appropriate height. There should be enough clearance from the sea surface and the intake screens may be placed well below the water line to avoid any vortex formation. The location should not cause any hindrance to the divers working in the vicinity. The intake should have screens and trash bars with appropriate openings to minimize the entry of marine organisms, fish larvae and fishes. Marker beacon should be anchored close to intake head to warn the mariners and fisher men.

b) Activity: Construction of outfall diffuser

Mitigation: The outfall can be designed with multiple ports, in this case 18 nos. x 600 mm diameter ports, which can enhance the jet mixed brine. The outfall diffuser should not have any sharp projection and should not pose any danger for the boats and fishermen moving around this region. The diffuser ports should be placed on the seabed and the top of the ports should be well below the sea surface so that they do not cause obstruction to the movements of boats and crafts. A marker buoy placed close to the outfall would help boats to avoid collision while enroute.

c) Activity: Trenching for burial of intake and outfall pipelines

Mitigation: The outfall pipelines are to be placed on the seabed and buried beneath the seafloor, so that it will not cause hindrance for fishing and navigation. The pipelines on the seashore should be buried below the ground so that the movement of men and machinery will not be affected.

Compensation: Like in other cases, only fishermen are the stake holders on such activities and their need on social welfare can be partly taken care.

d) Activity: Coastal installation

Mitigation: All installations along the coast in connection with sump and pump house may be developed as per CRZ regulations.

Compensation: Proper access for the public to the shoreline has to be ensured.

12. POST PROJECT MONITORING

The post project monitoring is an equally important aspect in Environmental Management Plan. In order to verify the outcome on the implemented mitigation measures and also to alter the proposed mitigation, the post project monitoring becomes inevitable. Indomer can follow up its Environmental Assessment study and extend suitably on required parameters as detailed in this chapter.

12.1. Marine water and sediment quality monitoring

Water and sediment samples collected from at least 6 locations around the outfall will have to be analyzed for various physical, chemical and biological parameters (phytoplankton and zooplankton) with required frequency.

12.2. Monitoring of Marine Benthic fauna

The benthic population and community structure around the outfall have to be monitored periodically to assess any change. The collected data have to be statistically analyzed so that the diversity indices can be recorded. This will enable us to develop meaningful management plans in altering the discharge methods, if required.

12.3. Assessing the impact on fisheries

Continuous monitoring of the intake system for impingement and entrapment of marine organisms has to be carried out. The trash bars and screens meant to prevent impingement have to be regularly examined for the type of animal impinged and record the quantity of commercially valuable fish impinged on the screens. Similarly the intake water has to be examined at the pumping location for the entrapped organisms, especially fish eggs and larvae of commercially important species, so that a realistic assessment of possible fisheries loss could be made. This exercise is also necessary to understand the efficacy of the screens and other devices used to minimize the entrapment.

Summary of Monitoring, Review and Reporting

Purpose	Parameter	Frequency
	Seawater & Sediment quality	
To monitor impacts on seawater and sediment quality	Measurements of levels of nutrients and heavy metals in water and sediment samples collected from sites at risk of pollution	Each season April (Fair Weather), July (SW monsoon) and November (NE monsoon)
	Marine Benthic Fauna	
To determine the composition and distribution of major groups of fauna	Benthic faunal composition in the water outfall region.	Each season as indicated above
	Intake	
To determine the incidence of entrapment and mortality of marine fauna	Screens on pump stations and effectiveness of management measure	Each season as indicated above
To determine the impact of entrainment within and external ponds/storage sump/well to assess the loss of fishery.	Record abundance of fauna within the pond/ storage sump/well	Each season as indicated above
	Seawater outfall	
To determine the effect of increased temp/salinity on the plankton.	Monitor abundance and distribution of both phytoplankton and zooplankton near the outfall.	Each season as indicated above
	Monitor abundance and distribution of benthic animal communities near the outfall.	Each season as indicated above

The results of monitoring can be reported to the relevant authority annually or as required which could include:

Ministry of Environment and Forests, New Delhi
State Department of Environment
State Department of Fisheries
State Pollution Control Board

Monitoring program has to be continued during the construction and operational phases of the project. It should be repeated at periodic intervals after the commencement of the project, when the project is fully operational. The monitoring has to be organized with qualified and experienced environmental team. Standard procedure shall be followed in sample collection and analysis.

PROJECT BENEFITS

The primary benefit of the proposed Desalination Plant is that it will assist in securing the supply of drinking water to the metropolitan population well into the future. It can continue to deliver high quality drinking water for consumption, even during periods of drought. It also provides an alternative source of water that will make our overall supply more diverse and less vulnerable to interruption.

The CMA is faced with recurring droughts and an existing shortage of water that will become more severe as populations continue to expand in the region. Since desalination represents the only climate independent water supply option, the proposed Desalination Plant offers considerable benefits in facilitating the ongoing development of metropolitan Chennai and the State in line with Tamil Nadu's Strategic Plan objectives.

In addition, the proposed development presents a number of State, regional and local benefits as follows:

State

- Provision of a climate-independent water source that will supplement Chennai's water supply and reduce the reliance on rainfall;
- Reduction in the State's reliance on the River and other traditional water resources, particularly during periods of severe drought;
- Enabling greater flexibility in water management through diversification of metropolitan Chennai's water sources;
- Enhancing confidence within the local community to both retain and increase investment in housing and business development; and
- It will encourage the investors to invest in Tamil Nadu thereby boost economy of the state.

Local

- The provision of a secure water supply for residents and industry within the Chennai metropolitan area which will assist in maintaining living standards and the amenity of the urban area;
- Primary and secondary employment opportunities during the construction and operation of the proposed Desalination Plant;

- Further impetus to industrial investment and growth across the southern suburbs and metropolitan Chennai more generally; and
- Ongoing opportunities for local community involvement in the operation of the proposed development.

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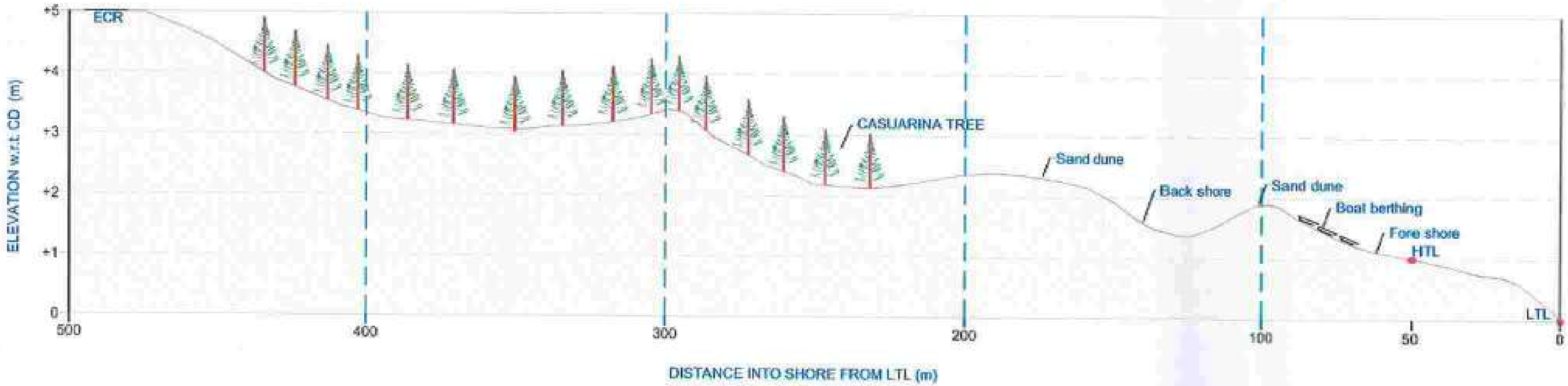


PLATE. 1. TYPICAL CROSS SECTION OF COASTAL FORM

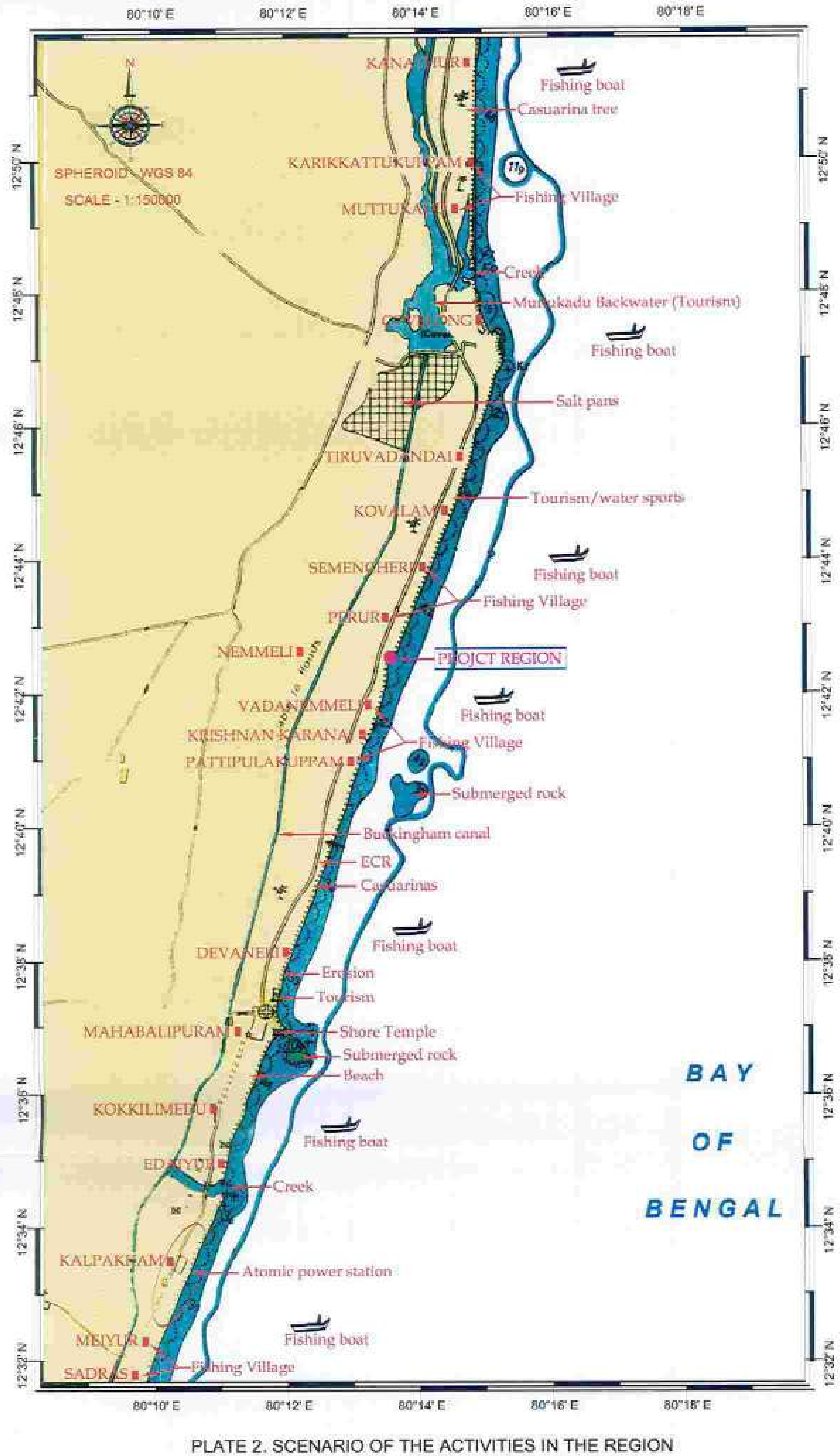


PLATE 2. SCENARIO OF THE ACTIVITIES IN THE REGION

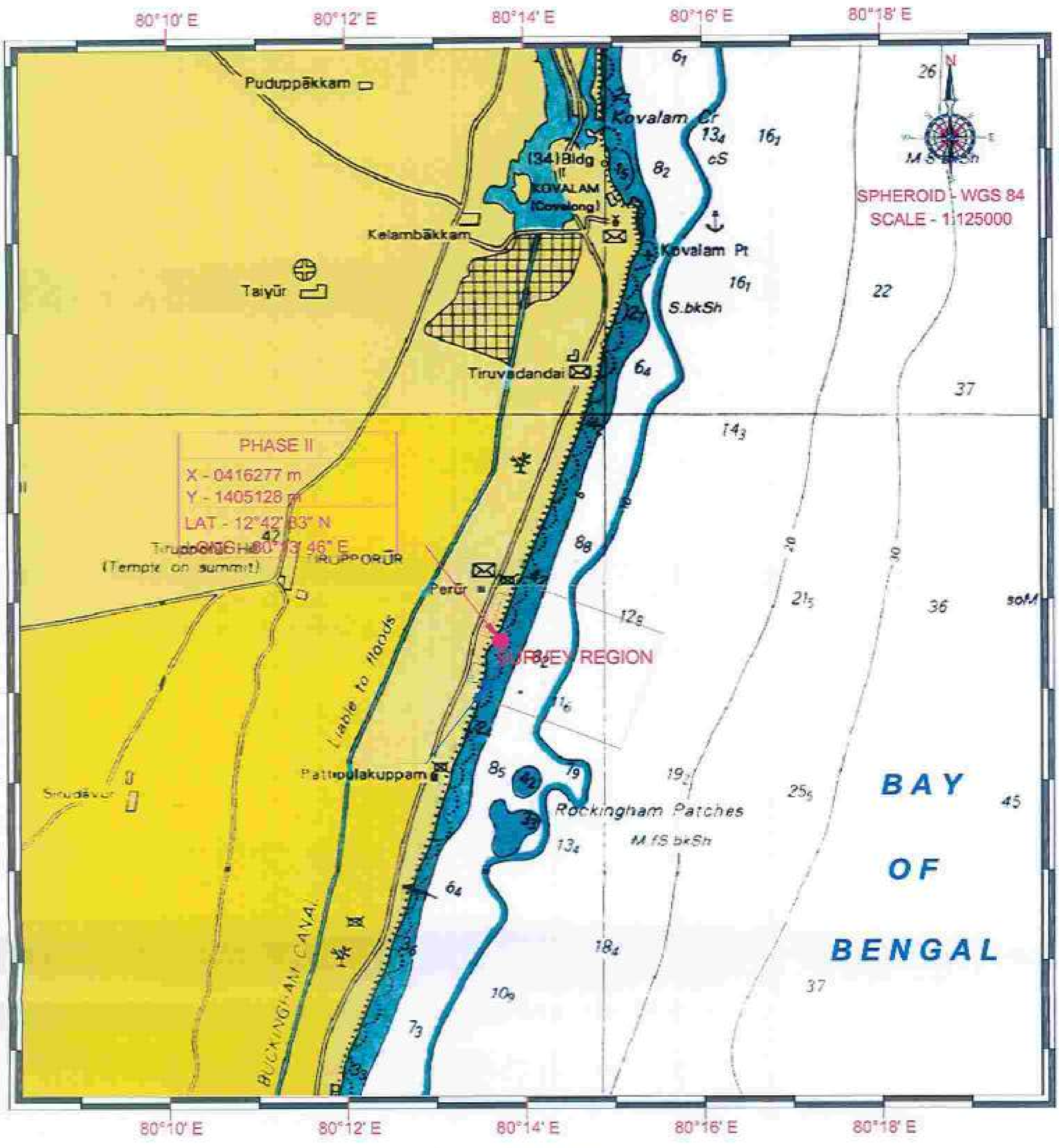


FIG. 1. LOCATION MAP

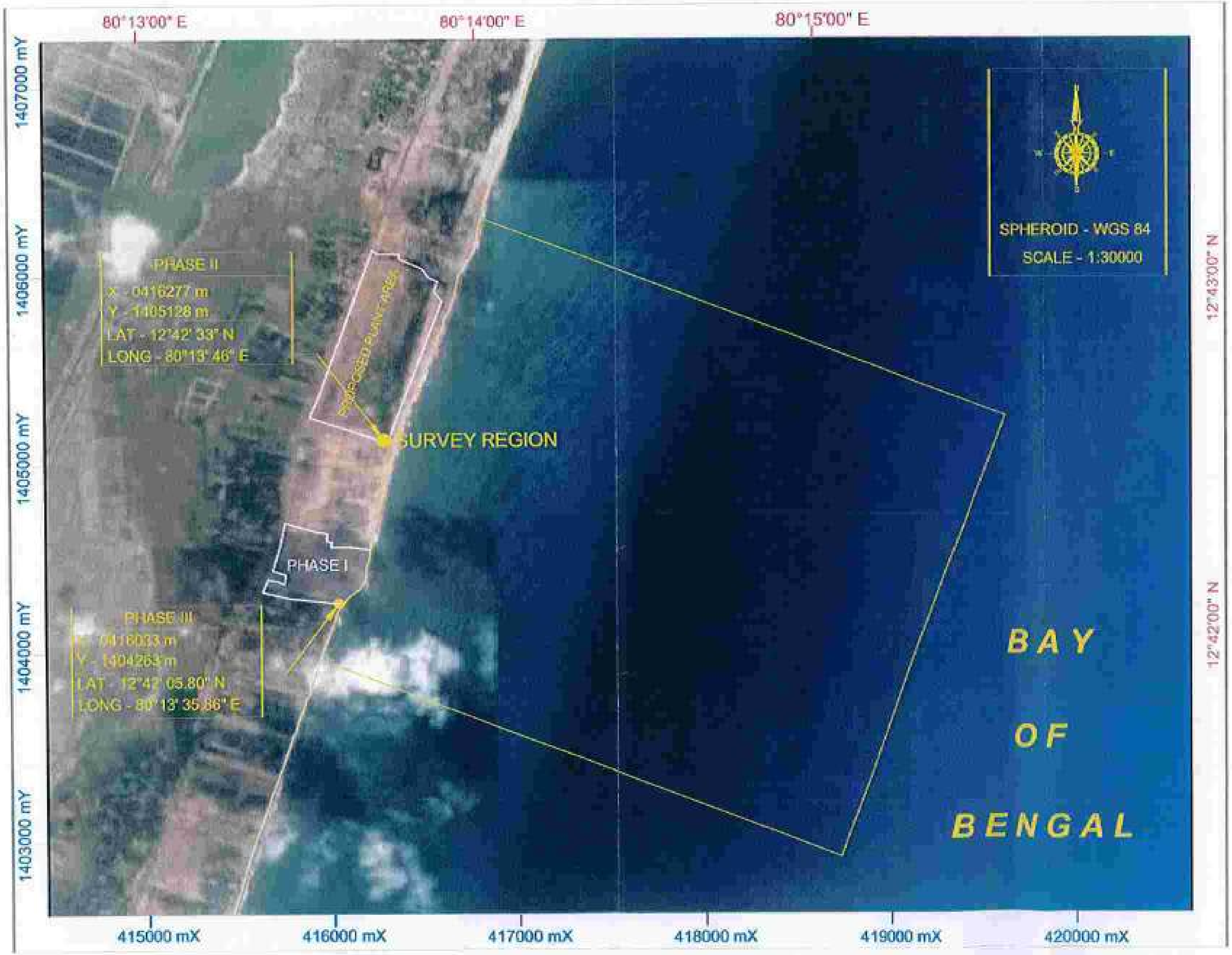


FIG. 2. SATELLITE IMAGERY OF THE SURVEY REGION

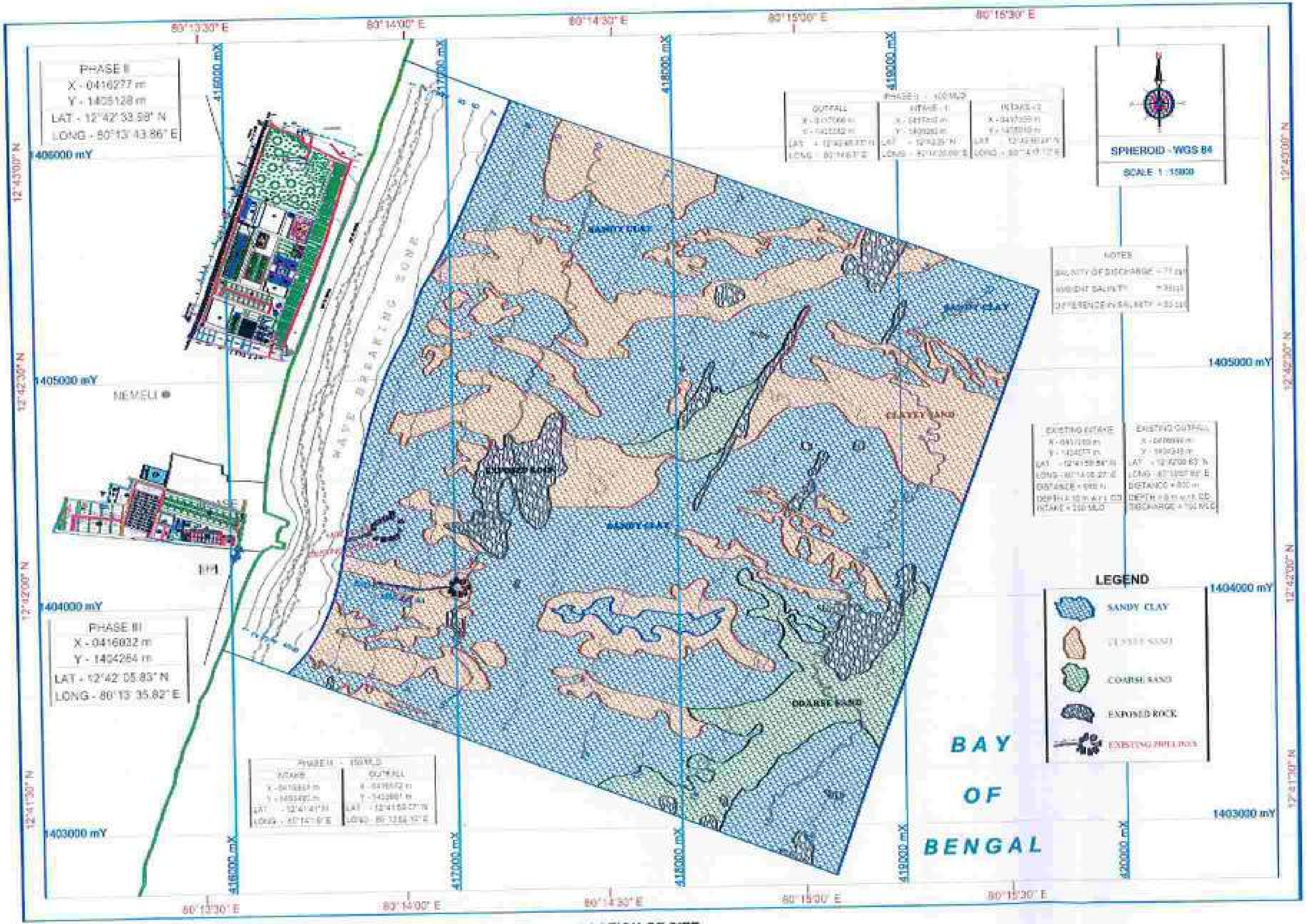


FIG 3 - LOCATION OF SITE

CONSULTANT: AECOM

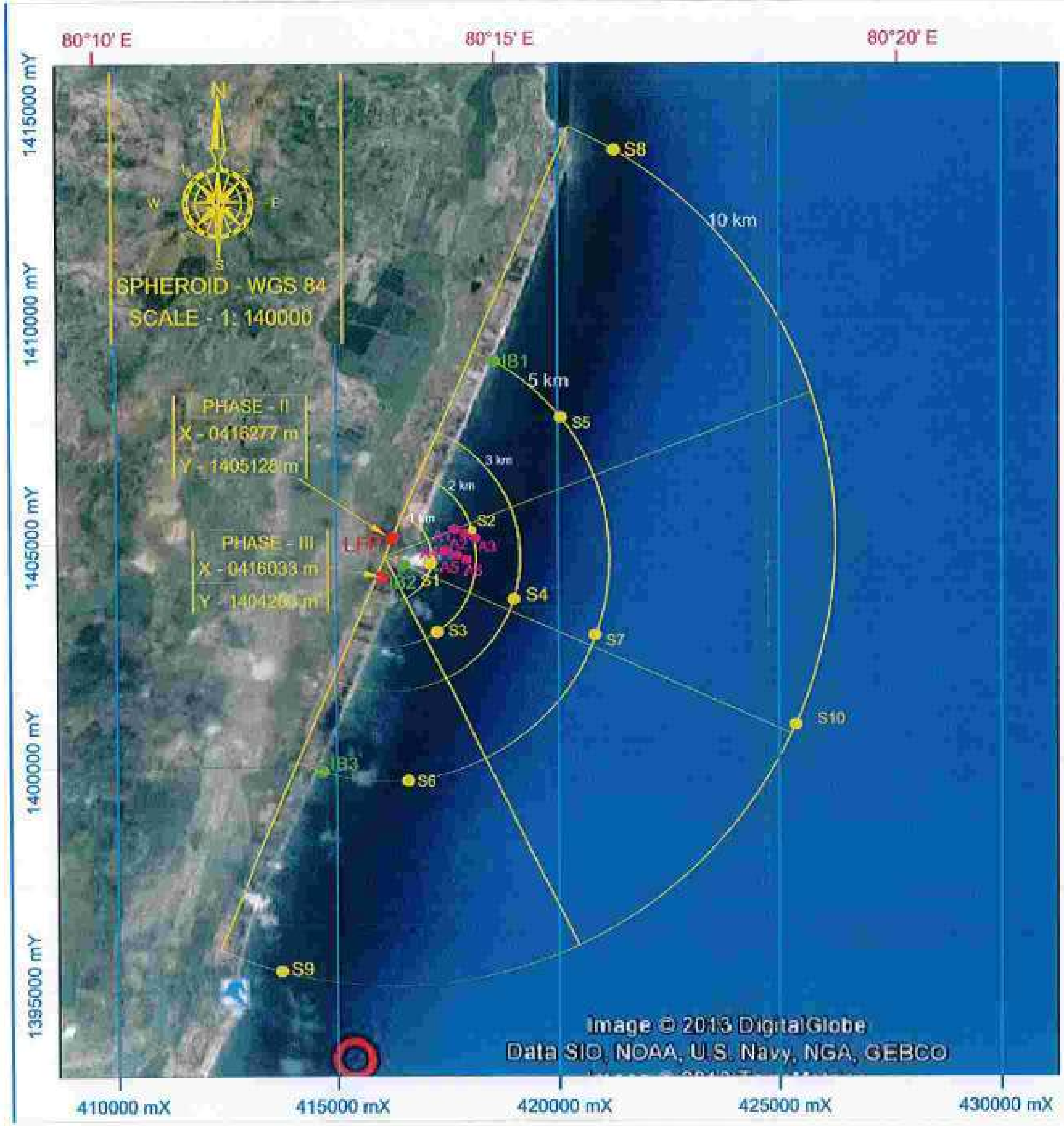
AECOM INDIA Private Limited in

CLIENT: Chennai Metro Water Supply and Sewerage Board

PROJECT TITLE -

DRAWING TITLE - LOCATION OF SITE

SCALE - AS SHOWN



SAMPLING CO - ORDINATES	
LFP	0416277 mX ; 1405128 mY θ = 12°42'33" N ; Ø = 80° 13'46" E
S1	417117 mX ; 1404299 mY
S2	418062 mX ; 1405297mY
S3	417270 mX ; 1402890 mY
S4	419007 mX ; 1403764 mY
S5	420056 mX ; 1407823 mY
S6	416621 mX ; 1399717 mY
S7	420825 mX ; 1402971 mY
S8	421287 mX ; 1413782 mY
S9	413755 mX ; 1395470 mY
S10	425371 mX ; 1400968 mY
A1	417661 mX ; 1405316 mY
A2	417892 mX ; 1405221 mY
A3	418130 mX ; 1405123 mY
A4	417457 mX ; 1404838 mY
A5	417689 mX ; 1404743 mY
A6	417926 mX ; 1404645 mY
INTER TIDAL BENTHOS	
IB 1	418563 mX ; 1409078 mY
IB 2	416532 mX ; 1404533 mY
IB 3	414689 mX ; 1399915 mY

FIG. 4. WATER SAMPLING LOCATIONS (REVISED AS PER AECOM CLARIFICATION)

FIG. 5. LOCATIONS OF CURRENT MEASUREMENT

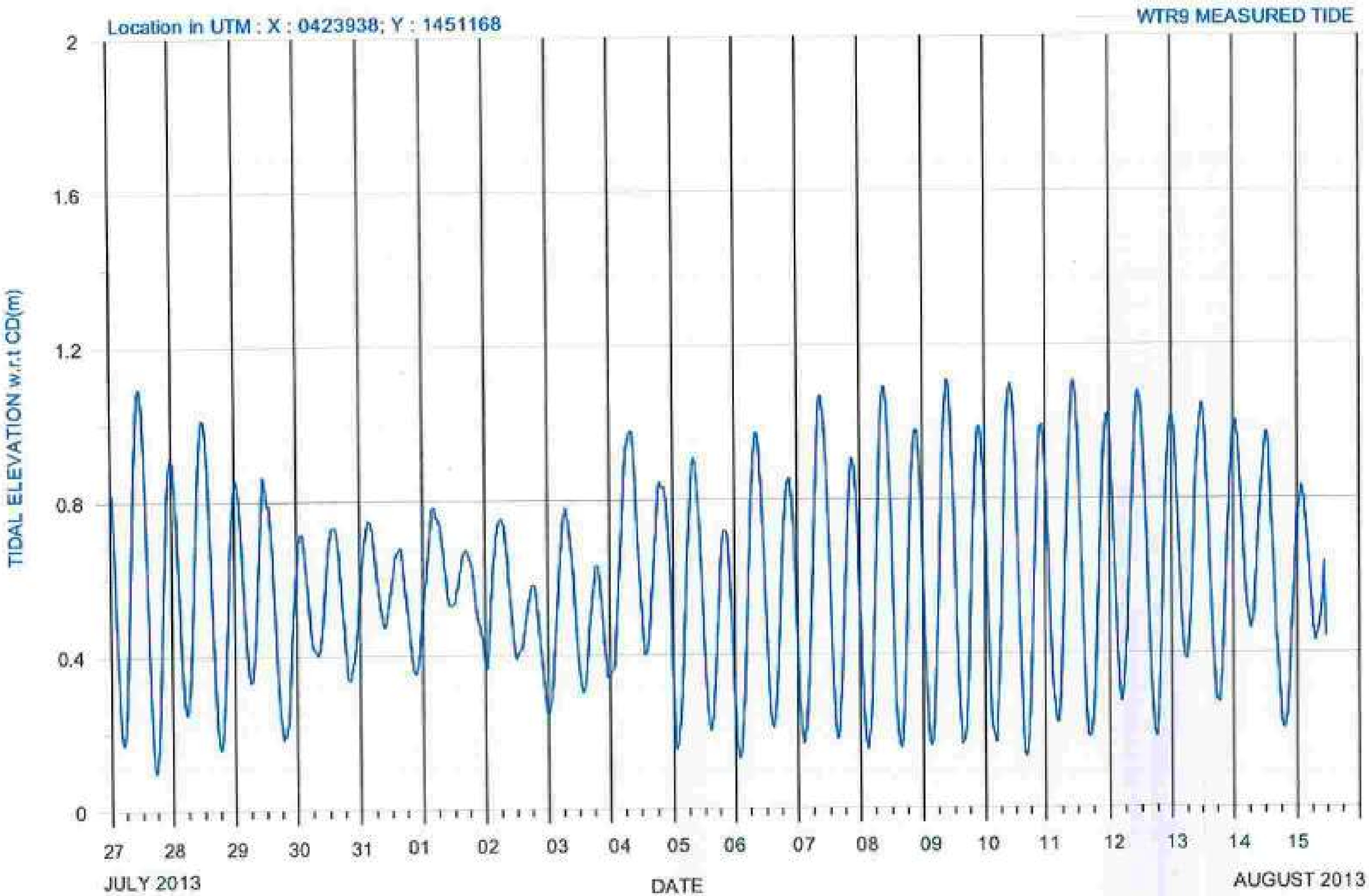


FIG. 6. VARIATION OF MEASURED TIDE

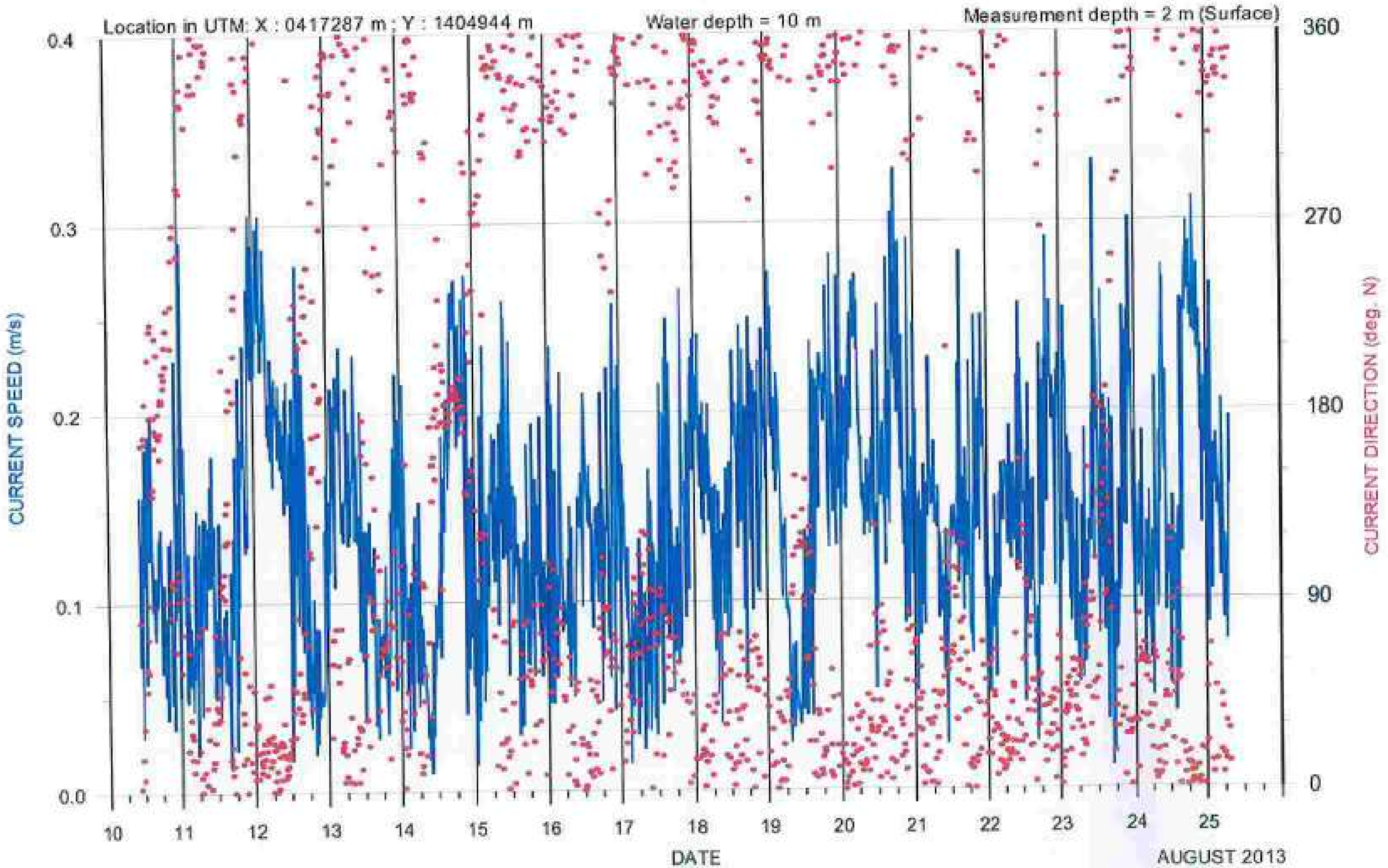


FIG. 7. VARIATION OF CURRENT SPEED AND DIRECTION OFF NEMELI

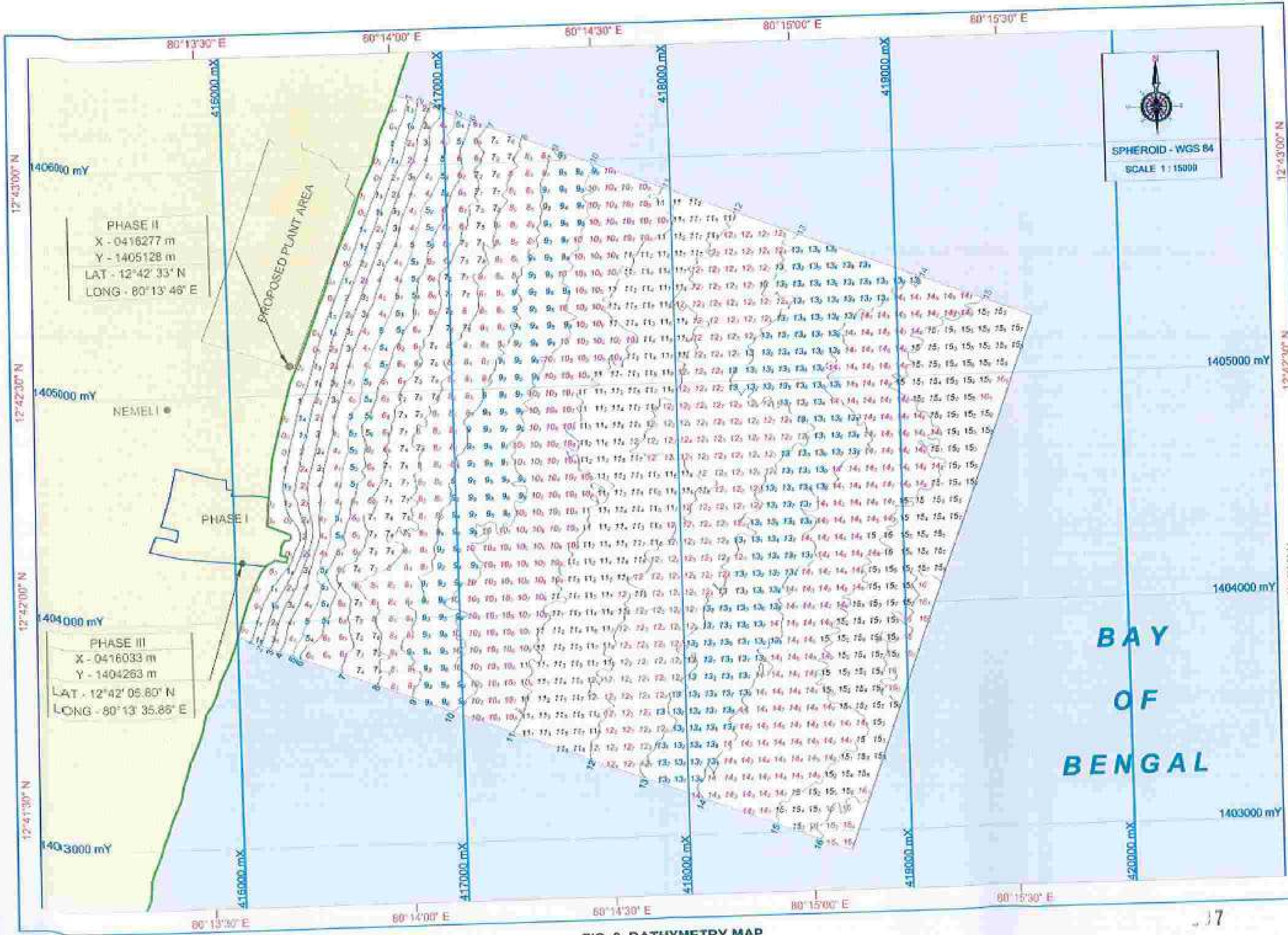


FIG. 8. BATHYMETRY MAP

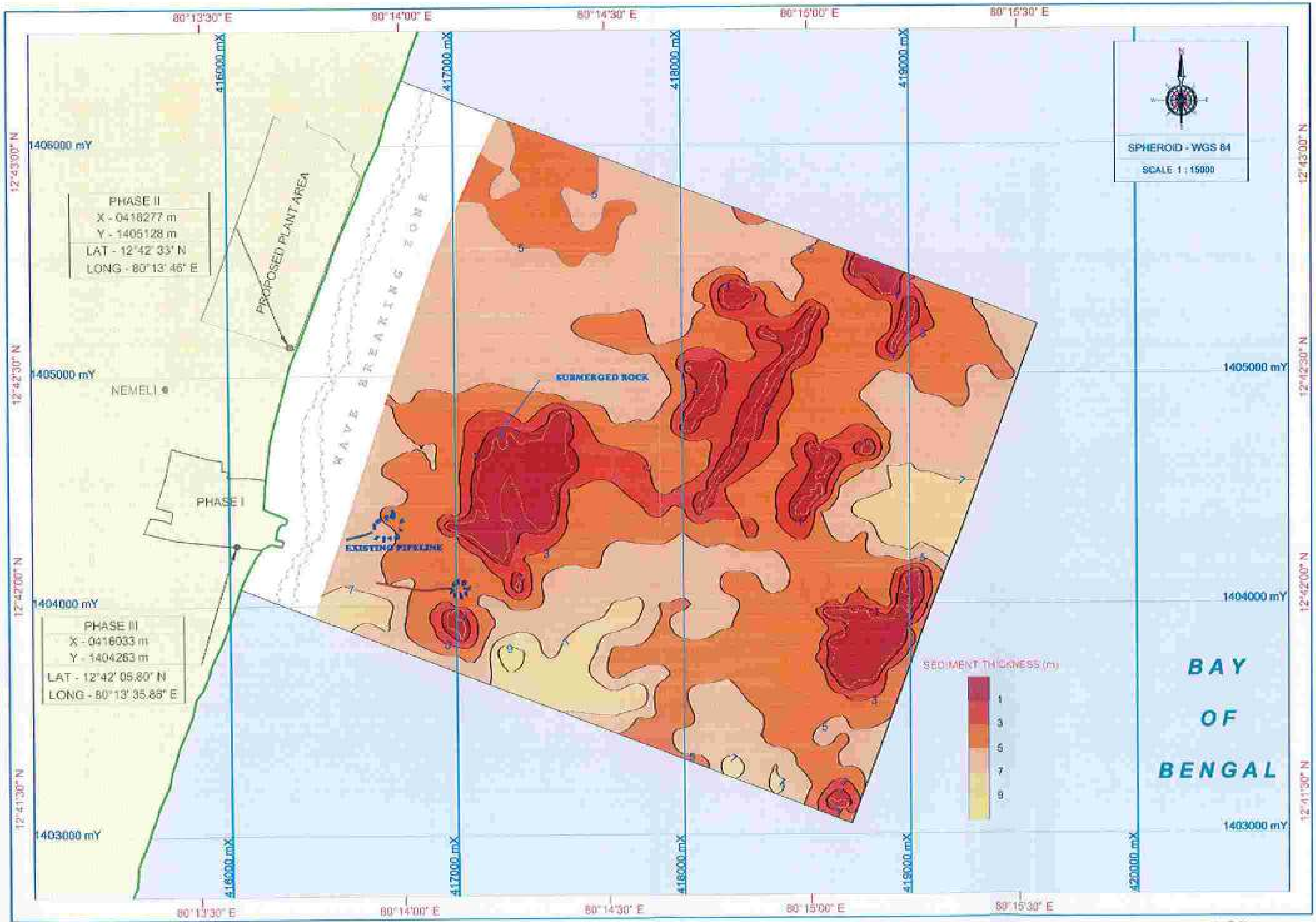


FIG. 9. ISOPACH MAP

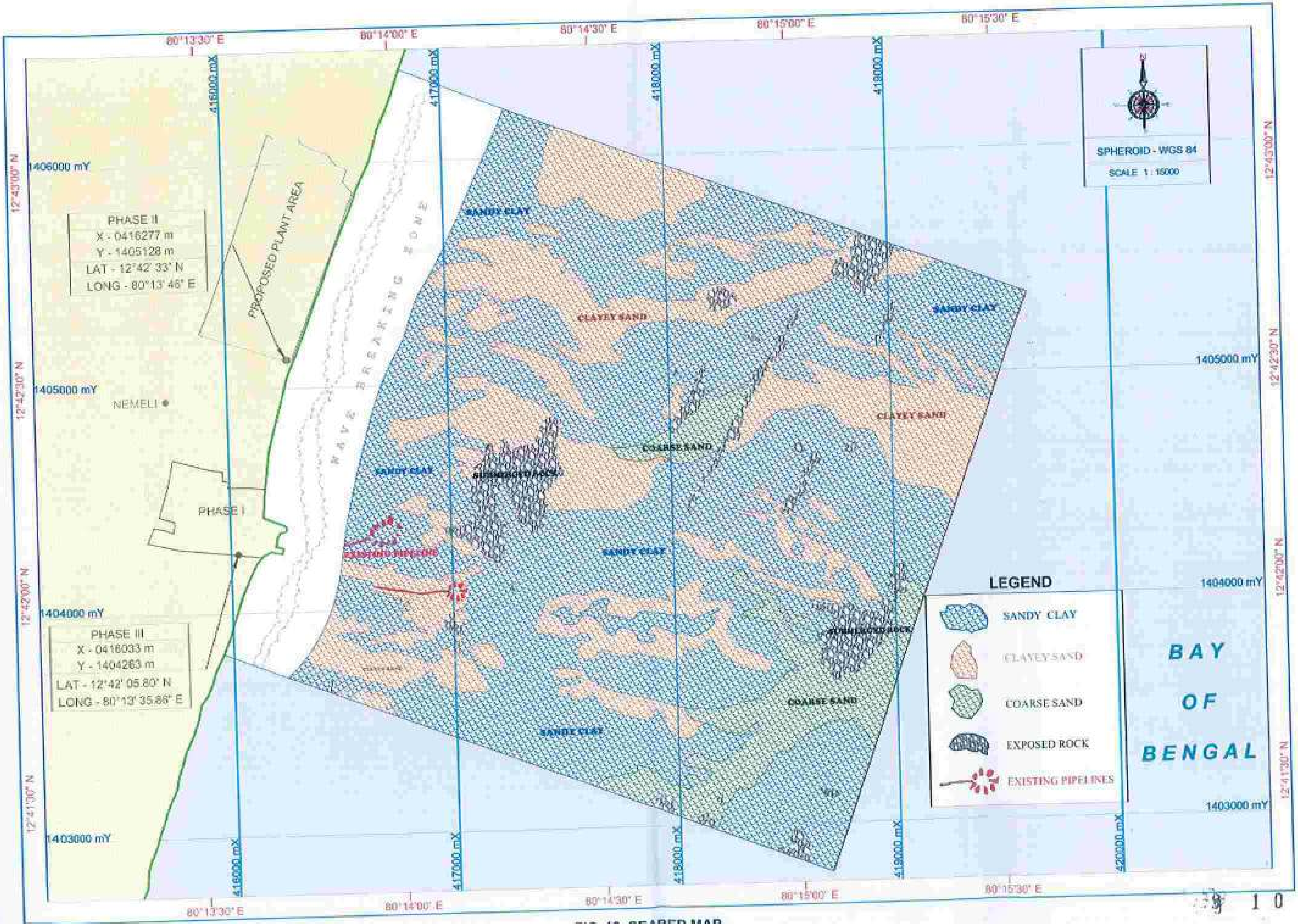


FIG. 10. SEABED MAP

ALL TABLES

Table 1. Measurement locations and details

Stn. No	Distance from LFP (m)	Locations	UTM Coordinates (WGS 84) X (m)	UTM Coordinates (WGS 84) Y (m)	Water depth (m)	Measurement depth from surface (m)
CURRENT MEASUREMENTS						
C1		Open sea	0414063	1395804	8.5	1500
TIDE MEASUREMENTS						
T1		Open sea	0423938	1451168	-	
WATER SAMPLING						
S1	1014	Open sea	417117	1404299	10	*S, M, B*
S2	1794		418062	1405297	12	*S, M, B*
S3	2318		417271	1402880	11	*S, M, B*
S4	3051		419007	1403764	17	*S, M, B*
S5	4641		420056	1407823	14	*S, M, B*
S6	5421		416621	1399717	12	*S, M, B*
S7	5033		420825	1402973	22	*S, M, B*
S8	10000		421287	1413782	15	*S, M, B*
S9	10000		413755	1395470	10	*S, M, B*
S10	10000		425371	1400968	42	*S, M, B*
A1	1396		417661	1405316	11	*S & B*
A2	1617		417892	1405221	11	*S & B*
A3	1852		418130	1405123	12	*S & B*
A4	1215		417457	1404838	11	*S & B*
A5	1462		417689	1404743	12	*S & B*
A6	1718		417926	1404645	12	*S & B*
INTERTIDAL BENTHOS						
IB1	North		418563	1409078	-	
IB2	Middle		416532	1404533	-	
IB3	South		414689	1399915	-	

S = Surface, M = Mid depth, B = Bottom

Table 2. Monthwise distribution of wind speed and direction

Month	Speed (knots)	Predominant direction from	
		0830 hrs	1730 hrs
January	8	NW	NE
February	8	W-NW	E-SE
March	9	SW-W	SE
April	10	S-SW	SE
May	11	S-SW	SE
June	10	SW-W	SE-S
July	9	SW-W	SE-S
August	8	SW-W	SE-S
September	7	SW-W	SE
October	7	SW-NW	N-SE
November	9	NW	N-SE
December	10	NW	N-SE

Table 3. Tracks of cyclones passed Chennai region - 1877 to 1990

Month	Occurred in the vicinity	Crossed in the vicinity
January	3	--
February	-	
March	-	-
April	2	1
May	7	3
June	-	-
July	-	-
August	-	-
September	-	-
October	19	13
November	23	19
December	4	1

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Table 4. Monthly distribution of salinity and sea surface temperature

Month	Temperature (°C)	Salinity (ppt)
January	27.0	32.0
February	27.0	32.0
March	27.5	34.0
April	29.0	34.0
May	30.0	34.0
June	29.0	34.0
July	28.0	34.5
August	28.0	34.5
September	28.0	33.5
October	28.0	33.5
November	28.0	33.0
December	27.0	33.0

Table 5. Longshore sediment transport rate along Chennai coast

Month	Quantity (m^3 / month)
January	155790
February	84199
March	7376
April	-91894
May	-198016
June	-178516
July	-125861
August	-149160
September	-157813
October	-76053
November	68486
December	196906
(-) Transport in northerly direction	

Table 7. Concentration of Heavy Metals, Phenol, Total Petroleum Hydrocarbons and Oil and grease in sea water

Stations	Heavy metals (mg/l)				Phenols (mg/l) C_6H_5OH	PHC	Oil and Grease (mg/l)
	Cadmium as Cd	Mercury as Hg	Lead as Pb	Total Chromium as Cr			
S1	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S2	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S3	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S4	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S5	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S6	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S7	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S8	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S9	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0
S10	<0.01	<0.002	<0.02	<0.05	<0.1	<0.1	<2.0

Table 10. Seabed sediment quality parameters

Station	Total Organic Carbon (%)	Calcium Carbonate (%)	Total Nitrogen (mg/g)	Total Phosphorus (mg/g)
S1	0.52	28.60	0.21	0.22
S2	0.77	32.50	0.22	0.19
S3	0.64	34.45	0.17	0.17
S4	1.55	39.00	0.23	0.18
S5	0.98	30.55	0.19	0.18
S6	0.52	29.25	0.17	0.17
S7	0.37	36.40	0.14	0.15
S8	0.46	31.85	0.15	0.21
S9	1.27	42.90	0.17	0.15
S10	0.75	25.35	0.22	0.17

Table 11. Concentration of heavy metals, phenol and total petroleum hydrocarbons in seabed sediments

Stations	Heavy metals (mg/kg)				Oil & Grease (mg/kg)	Phenols (mg/kg) C_6H_5OH	Total Petroleum Hydrocarbons (mg/kg)
	Cadmium as Cd	Mercury as Hg	Lead as Pb	Total Chromium as Cr			
S1	0.75	<2.0	9.80	25.80	<2.0	<0.1	<0.5
S2	0.84	<2.0	13.50	19.80	<2.0	<0.1	<0.5
S3	0.96	<2.0	16.50	21.50	<2.0	<0.1	<0.5
S4	1.14	<2.0	32.50	78.71	<2.0	<0.1	<0.5
S5	0.64	<2.0	3.43	19.63	<2.0	<0.1	<0.5
S6	0.55	<2.0	14.10	20.00	<2.0	<0.1	<0.5
S7	0.42	<2.0	8.80	12.05	<2.0	<0.1	<0.5
S8	0.68	<2.0	3.80	31.90	<2.0	<0.1	<0.5
S9	0.80	<2.0	12.80	43.20	<2.0	<0.1	<0.5
S10	0.98	<2.0	19.87	61.94	<2.0	<0.1	<0.5

Table 12: Primary productivity in coastal waters

Station	Gross Photosynthetic activity	Net Photosynthetic activity	Photosynthetic quotient (PQ)	Primary production (mgC/m³/day)
S1	1.0	0.5	1.0	338
S2	1.0	0.5	1.0	353
S3	1.3	0.7	1.0	555
S4	1.6	0.9	1.0	705
S5	1.0	0.4	1.0	323
S6	1.3	0.5	1.0	375
S7	1.0	0.6	1.0	480
S8	1.3	1.0	1.0	780
S9	1.6	0.6	1.0	473
S10	1.3	1.0	1.0	758
Average				**514**

Table 13.Comparative statement of primary production along the East coast of India

Sl. No	Location	Date	Average PP mgC/m³/day
1	Hooghly River (21°58'04"N 88°06'23"E)	5.06.2011	413
2	Paradip (Orissa) (20°16'07"N 86°40'57"E)	19.01.2010	465
3	Gopalpur (Orissa) (19°17'28"N 84°58'37"E)	30.11.2006	797
4	Sompet (A.P) (18°53'31"N 84°17'46"E)	25.10.2008	591
5	Bhavanapadu (A.P) (18°29'31"N 84°17'46"E)	02.10.2007	666
6	Machilipatnam (A.P) (16°07'16"N 81°12'39"E)	23.07.2008	592
7	Krishnapatnam (A.P) (14°10'47"N 80°07'38"E)	21.01.2009	516
8	Krishnapatnam (A.P) (14°10'47"N 80°07'38"E)	25.03.2009	537
9	Agaramperuthottam(T.N) (11°11'37"N 79°51'15"E)	06.02.2010	518
10	Thirukuvalai (T.N) (10°34'07"N 79°52'53"E)	26.02.2008	775
11	Thondi (T.N) (09°3'51"N; 78°55'34"E)	15.07.2011	468
12	Kulasekarapatnam (T.N) (08°23'34"N 78°03'28"E)	19.07.2012	513
13	Tuticorin (T.N) (10°34'07"N 79°52'53"E)	02.10.2012	664
14	**Nemmeli (T.N) (12°42'33"N 80°13'46"E)**	**26.07.2013**	**514**

Table 16. Phytoplankton biomass in different sampling stations

Sl.No	No. of genera or species (nos./ml^{-1})	Population (nos./ml^{-1})	Biomass (nos./ml^{-1})
S1	23	68	40.29
S2	25	84	44.20
S3	21	73	41.37
S4	23	87	31.36
S5	24	87	42.80
S6	23	94	58.61
S7	26	98	44.20
S8	29	103	41.01
S9	28	102	39.61
S10	27	99	40.14

Table 17. Zooplankton biomass in different sampling stations

Sl. No	No of genera or species	Population (nos./100 m^3)	Biomass (ml/100 m^3)	Most common species	%
S1	44	379232	14.22	*Coryceas danae*	12.5
				Favella sp.	5.6
				Coryceas catus	5.6
				Eutintinnus tenuis	5.0
				Euterpina acutifrons	5.0
S2	42	333113	11.18	*Coryceas danae*	8.7
				Favella sp.	5.4
				Eutintinnus tenuis	4.0
				Oithona brevicornis	4.0
				Crustacean larvae	4.0
S3	40	379246	26.34	*Coryceas danae*	9.0
				Copepodid stages	5.6
				Favella sp.	5.6
				Paracalanus parvus	5.6
				Tintinnopsis sp.	4.9
S4	42	402305	12.05	*Coryceas danae*	10.2
				Paracalanus parvus	7.2
				Oithona rigida	4.8
				Copepodid stages	4.8
				Favella sp.	4.2
S5	41	309283	10.31	Barnacle napulii	12.7
				Coryceas danae	8.7
				Favella sp.	4.7
				Paracalanus parvus	4.7
				Tintinnopsis sp.	4.0
S6	42	720187	37.50	*Coryceas danae*	13.5
				Oithona brevicornis	6.8
				Copepod nauplii	4.7
				Oithona rigida	4.7
				Coryceas catus	4.2
S7	41	589039	30.83	*Coryceas danae*	9.9
				Paracalanus parvus	5.2
				Oithona similis	5.2
				Copepodid stages	4.7
				Oikopleura larvae	4.7

S8	38	346190	13.94	*Coryceas danae*	8.7
				Paracalanus parvus	5.4
				Copepodid stages	4.7
				Acartia erythraea	4.0
				Oithona similis	4.0
S9	43	355505	24.02	*Coryceas danae*	12.8
				Coryceas catus	6.8
				Copepodid stages	5.4
				Favella sp.	4.7
				Tintinnopsis sp.	4.1
S10	41	373930	22.74	*Coryceas danae*	8.8
				Paracalanus parvus	6.1
				Copepodid stages	5.4
				Favella sp.	4.1
				Oikopleura larvae	4.1

Table 22. Fisherfolk population from Kancheepuram district (As per census, 2005)

Sl. No	Fisherfolk population	Total*
1	Total fishermen population	27962
2	Active men	2287
3	Active women	5293

Source: CMFRI

Table 23. Number of crafts operated from Kancheepuram district during 2007-08

Sl. No	Type crafts	Nos.*
1	Mechanised Boats	8
2	Wooden Vallams	1722
3	FRP Vallams	2281
Total		**4011**

Table 24. Gear wise catch from Kancheepuram district during 2007-08

Sl. No	Type of Gear	Quantity *(MT)	%
1	Trawl net	530.18	5.02
2	Gill net	7425.31	7025
3	Hook net	1568.96	14.84
4	Bag nets	261.49	2.47
5	Falling gears	784.48	7.42
Total		**10570.42**	**100**

Table 25. Marine fish production from Kancheepuram district (MT)

Sl. No	Species	2009-10	2010-11
1	Sharks	316.13	436.15
2	Skates & Rays	299.8	413.63
3	Eels	16.33	1.20
4	Cat fishes	154.35	212.96
5	*Chirocentrus* sp.	914.25	779.35
6	Oil Sardines	197.4	1638.12
7	Lesser Sardines	1184.37	752.29
8	Silver bellies	1196.25	1634.03
9	Hilsa ilisha	4.38	0.60
10	Other ilisha	0.39	0
11	Anchoviella	519.46	840.39
12	Thrissocles sp.	167.71	233.43
13	Clupeids	690.14	956.25
14	Saurida & Saurus sp.	43.04	57.33
15	Hemiramphus & Belone sp.	90.53	124.91

16	Flying fish	145.45	200.67
17	Perches	890.31	1327.04
18	Red Mullets	491.26	728.02
19	Polynemids	71.24	96.24
20	Sciaenids	470.48	651.15
21	Ribbon fish	92.03	173.11
22	Caranx sp.	436.35	698.41
23	Chironemus sp.	66.79	90.10
24	Trachinotus sp.	37.10	49.14
25	Cyprinoides sp.	0.25	0
26	Elacate sp.	20.78	74.82
27	Gazza sp.	0	16.38
28	*Lactarius* sp.	13.36	9.64
29	Pomfrets	77.18	106.48
30	Mackerel	431.89	595.87
31	Seer fish	333.94	557.12
32	Tunnies	181.07	346.21
33	Sphyraena sp.	84.60	162.87
34	Mullets	106.86	131.05
35	Bregmaceros sp.	78.66	106.48
36	Soles	265.67	366.53
37	Penaeid Prawns	1113.13	1539.83
38	N.P. Prawns	298.32	411.58
39	Lobsters	26.72	32.76
40	Crabs	1001.82	1386.26
41	Cephalo pods	252.31	315.34
42	Drepane sp.	20.78	38.60
43	Lethrinus sp.	244.89	333.77
44	*Sillago* sp.	187.01	239.58
45	Balistes sp.	200.36	268.24
46	Ora	14.84	12.29
47	Miscellaneous	1371.89	1330.31
Total		**14821.87**	**20476.53**

*(*Data source from Department of Fisheries in Tamil Nadu)*

Table 26. Craft wise catch from Kancheepuram district during 2010-11

Sl. No	Type of crafts	Quantity *(MT)	%
1	Mechanised Boats	354.48	2.24
2	Non-mechanised Boats	6187.39	58.66
3	Motorised Boats	9281.08	39.10
Total		**15822.95**	**100**

*(*Data source from Department of Fisheries Govt of Tamil Nadu)*

Table 27. Details of Bottom trawl survey

No.	Location of Hauls		Haul-1	Haul-2
1	Date		27.07.2013	27.07.2013
2	Gear		Shrimp net	Shrimp net
3	Starting time		8.30	11.00
4	Closing time		10.00	12.30
5	Duration haul		1.5 hrs.	1.5 hrs.
6	Started	Latitude	12° 41' 48.50"N	12° 38' 16.26"N
		Longitude	80° 17' 23.72"E	80° 13' 7.28"E
7	Finished	Latitude	12° 39' 7.60"N	12° 39' 41.69"N
		Longitude	80° 17'48.70"E	80° 15' 28.37"E
8	Distance (m)		5000	5000
9	Depth(m)		10	25
10	Water Temp. (°C)		30	30
11	Salinity(ppt)		35	35
12	Total catch (kg)		95	90

Table 6. Water quality parameters

Station	Temp. (°C)		TDS (g/l)	Salinity (ppt)	pH	DO (mg/l)	NO_2-N (µmol/l)	NO_3-N (µmol/l)	Total Nitrogen (µmol/l)	PO_4-P (µmol/l)	Total phosphorus (µmol/l)	NH_3-N (µmol/l)	Total Suspended Solid (mg/l)	Turbidity (NTU)	BOD (mg/l)	COD (mg/l)
S1	S	28.71	35.15	34.69	8.21	6.59	0.37	1.60	8.70	0.88	1.41	0.11	28	3.0	4.03	23.4
	M	27.99	35.15	34.69	8.21	6.39	0.65	2.46	9.70	1.04	1.73	0.10	38	5.1	2.55	50.6
	B	27.87	35.23	34.76	8.22	5.98	0.65	2.72	11.90	1.78	1.92	0.11	84	8.5	3.74	60.0
S2	S	28.31	35.12	34.65	8.20	6.57	0.31	1.17	9.00	0.84	0.89	0.10	18	0.8	3.69	53.7
	M	27.95	35.10	34.67	8.21	6.34	0.34	1.56	6.20	1.08	1.36	0.09	24	1.4	3.46	79.0
	B	27.87	35.20	34.73	8.21	5.92	0.54	2.38	10.40	1.00	1.10	0.14	48	3.2	2.40	72.0
S3	S	28.82	35.13	34.70	8.22	6.62	0.48	1.73	11.60	0.88	1.84	0.19	18	1.9	3.10	34.8
	M	27.94	35.16	34.70	8.22	6.12	0.82	1.30	13.20	1.24	1.46	0.11	20	3.5	3.88	37.9
	B	27.86	35.22	34.75	8.22	5.63	1.02	2.03	14.00	1.12	1.15	0.12	22	5.9	2.11	53.7
S4	S	28.71	35.09	34.64	8.22	6.74	0.14	2.46	6.80	0.20	0.52	0.16	16	0.6	1.94	28.4
	M	27.85	35.10	34.66	8.22	6.26	0.11	2.55	8.50	0.44	0.68	0.19	32	0.7	1.78	34.8
	B	27.75	35.12	34.66	8.22	5.98	0.51	2.51	9.40	0.36	1.15	0.21	42	1.0	1.50	37.3
S5	S	28.23	35.03	34.59	8.21	6.61	0.34	2.20	6.80	0.88	0.94	0.10	16	1.2	3.09	25.3
	M	27.75	35.05	34.60	8.21	6.17	0.34	2.33	8.10	0.36	0.99	0.11	38	2.0	2.65	33.5
	B	27.74	35.05	34.60	8.21	6.09	0.65	2.68	11.70	1.68	1.78	0.13	40	3.4	2.89	47.4
S6	S	28.68	35.05	34.62	8.21	6.54	0.54	1.94	9.20	0.24	1.20	0.27	26	0.5	3.98	29.1
	M	28.06	35.09	34.65	8.21	6.35	0.34	2.46	10.40	0.48	1.26	0.26	34	1.5	2.51	20.9
	B	27.99	35.11	34.66	8.22	6.14	0.68	2.81	12.30	0.60	1.10	0.09	56	1.5	2.62	27.2
S7	S	28.80	35.04	34.60	8.19	6.40	0.65	2.64	7.20	0.20	1.05	0.11	18	0.8	3.52	20.9
	M	27.89	35.05	34.62	8.20	6.16	1.31	3.07	10.70	0.24	1.15	0.13	26	0.9	2.64	32.9
	B	27.82	35.05	34.62	8.21	6.09	1.96	3.59	12.20	0.84	1.26	0.14	42	1.2	2.57	25.3
S8	S	28.46	34.97	34.55	8.21	6.32	0.54	3.15	13.40	0.28	0.94	0.10	16	0.7	2.80	23.4
	M	27.84	35.01	34.57	8.21	5.89	0.45	4.06	14.30	0.64	1.20	0.14	18	2.1	1.09	28.4
	B	27.73	35.03	34.58	8.21	5.75	0.48	4.32	18.60	0.68	1.62	0.14	36	2.8	1.59	28.4
S9	S	28.06	35.20	34.71	8.21	6.41	0.40	1.64	9.80	0.76	0.99	0.11	24	1.7	3.21	19.0
	M	27.97	35.17	34.74	8.21	6.24	0.63	2.12	10.10	1.04	0.99	0.26	28	2.6	2.72	22.1
	B	27.82	35.27	34.79	8.21	5.23	0.51	2.46	11.80	1.20	1.20	0.13	34	3.6	2.99	23.4
S10	S	28.31	35.04	34.61	8.21	6.15	0.23	1.86	12.20	0.60	1.15	0.11	44	1.5	4.55	12.6
	M	28.00	35.07	34.62	8.21	5.34	0.11	1.73	13.20	0.28	1.73	0.09	54	2.9	4.38	15.8
	B	26.58	35.14	34.65	8.21	4.51	0.20	1.56	14.30	0.76	1.78	0.14	60	4.2	3.55	17.1

= Surface, M=Middle, B = Bottom

Table 8. Comparison of pH, salinity, DOES and nutrient levels with COMAPS data

Sl. No	Parameters	Near Shore Cuddalore (COMAPS Data) *	Andaman Offshore (COMAPS Data) *	CPCB Standard	Observed Values (Present Study)	Remarks
1	pH	8-8.4[†] (8.13)[$]	8.0	6.5-8.5	8.19 - 8.22 (8.21)[$]	Normal
2	Salinity (ppt)	28.0-35.0 (32.3)[$]	35.0	-	34.55 - 34.79 (34.66)	Normal
3	Dissolved Oxygen (mg/l)	4.06-5.56 (4.82)[$]	5.8	4.0	4.51 - 6.74 (6.12)	Normal
4	Nitrite (µmol/l)	0.17 -0.94 (0.46)[$]	0.4	-	0.11 - 1.96 (0.54)	Normal
5	Nitrate (µmol/l)	2.59-11.07 (4.71)[$]	1.3	-	1.17 - 4.32 (2.37)	Normal
6	Phosphate (µmol/l)	0.008-0.16 (0.09)[$]	0.02	-	0.2 - 1.78 (0.75)	Normal
7	Ammonia(µmol/l)	0.25-1.04 (0.53)[$]	0.002	-	0.09 - 0.27 (0.14)	Normal

** Data from Jan – Dec 2009. † Range $ Average*

COMAPS – Coastal ocean monitoring and prediction system, MoES

Table 9. Sediment size distribution

Station No.	Water Depth (m)	D_{50} mm	Sand (%)				Silt & Clay (%)	Description of Soil
			Gravels	Coarse sand	Medium Sand	Fine Sand		
S1	10	0.26	-	4.42	77.47	17.40	0.71	Medium with fine sand
S2	12	0.19	-	2.47	27.36	70.12	0.05	Fine with medium sand
S3	11	0.58	-	52.43	42.06	4.85	0.66	Medium with Fine sand
S4	17	0.17	-	-	37.48	57.52	5.0	Fine with Medium sand
S5	14	0.34	-	10.37	88.38	1.25	-	Medium sand
S6	12	0.59	-	49.70	47.91	2.38	0.01	Coarse with Medium sand
S7	22	0.50	-	27.47	72.37	0.16	-	Medium with Coarse sand
S8	15	0.80	-	71.28	27.50	1.02	0.20	Coarse with Medium sand
S9	10	0.14	-	27.04	68.44	4.52	-	Medium with Coarse sand
S10	42	0.12	-	-	24.00	69.00	7.00	Fine with Medium sand

Table 14. Phytoplankton numerical abundance (nos.*ml^{-1})

Sl. No.	Genus / Species	Stn.1	Stn.2	Stn.3	Stn.4	Stn.5	Stn.6	Stn.7	Stn.8	Stn.9	Stn.10	Total	(%)
PHYLUM: Heterokontophyta													
Class: Bacillariophyceae (Diatoms)													
Order: Centrales													
1	*Aulacodiscus orbiculatus*	0	3	2	2	4	5	0	3	2	0	21	2.35
2	*Bellerochea malleus*	3	5	4	0	0	0	3	4	4	3	26	2.91
3	*Biddulphia heteroceros*	3	4	3	2	4	2	5	2	4	4	33	3.69
4	*Biddulphia mobiliensis*	2	2	4	2	2	5	4	3	3	5	32	3.58
5	*Biddulphia sinensis*	3	2	3	6	0	0	3	5	3	2	27	3.02
6	*Chaetoceros affinis*	0	0	0	0	3	0	3	0	2	2	10	1.12
7	*Chaetoceros diversum*	2	0	0	0	0	2	0	0	0	0	4	0.45
8	*Chaetoceros laciniosus*	0	0	0	0	4	2	3	4	3	0	16	1.79
9	*Climacodium frauenfeldianum*	0	0	0	0	3	0	0	0	4	2	9	1.01
10	*Coscinodiscus centralis*	0	0	0	0	5	0	0	5	3	0	13	1.45
11	*Coscinodiscus excentricus*	0	0	0	0	0	4	0	0	0	3	7	0.78
12	*Coscinodiscus lineatus*	0	3	0	3	0	0	0	0	0	3	9	1.01
13	*Coscinodiscus marginatus*	0	0	0	0	0	3	0	0	0	0	3	0.34
14	*Coscinodiscus radiatus*	2	0	0	3	4	0	3	2	3	0	17	1.90
15	*Ditylum brightwellii*	3	2	4	2	2	3	4	3	4	4	31	3.46
16	*Eupodiscus argus*	0	3	0	0	0	3	2	4	0	0	12	1.34
17	*Leptocylindrus danicus*	0	0	0	0	4	0	0	2	0	0	6	0.67
18	*Leptocylindrus minimus*	0	2	0	0	0	0	2	0	0	2	6	0.67
19	*Lithodesmium undulatum*	0	0	0	0	2	0	0	0	0	0	2	0.22
20	*Planktoniella sol*	2	2	2	2	3	0	3	4	4	3	25	2.79
21	*Rhizosolenia robusta*	3	2	3	0	2	0	0	0	3	3	16	1.79
22	*Rhizosolenia styliformis*	0	0	4	5	3	2	6	7	2	5	34	3.80
23	*Skeletonema costatum*	1	0	2	0	0	0	0	0	0	0	3	0.34
24	*Stephanophyxix palmeriana*	3	4	0	0	2	0	0	0	2	0	11	1.23
25	*Suriella* sp.	3	4	0	0	0	2	0	2	0	0	11	1.23
26	*Thalassiosira decipiens*	3	3	2	5	4	0	0	0	3	4	24	2.68
27	*Thalassiosira subtilis*	5	6	7	6	5	3	3	4	2	6	47	5.25
28	*Triceratium favus*	3	3	2	4	5	0	0	4	3	6	30	3.35
29	*Triceratium reticulatum*	1	0	0	2	0	0	0	2	0	2	7	0.78
Order: Pennales													
30	*Asterionella japonica*	2	0	0	0	0	0	4	2	0	3	11	1.23
31	*Navicula henneydii*	2	3	0	4	2	0	2	3	7	2	25	2.79
32	Nitzschia closterium	0	0	2	0	0	4	0	0	0	0	6	0.67
33	Nitzschia longissima	0	0	0	2	2	0	3	2	2	0	11	1.23
34	*Pleurosigma normanii*	2	1	4	6	3	6	4	3	6	3	38	4.25

35	*Thalassionema nitzschioides*	0	6	5	2	0	0	0	4	0	3	20	2.23
36	*Thalassiothrix frauenfeldii*	4	5	0	4	0	4	3	0	3	0	23	2.57
Class: Dinophyceae (Dinoflagellates)													
37	*Ceratium furca*	0	2	0	2	0	3	4	4	3	4	22	2.46
38	*Ceratium fusus*	0	3	0	0	0	2	0	0	0	0	5	0.56
39	*Ceratium macroceros*	2	2	4	6	3	11	4	4	6	3	45	5.03
40	*Ceratocorys horrida*	0	0	0	0	0	2	2	2	0	2	8	0.89
41	*Dinophysis caudate*	0	0	4	3	0	9	5	4	0	6	31	3.46
42	*Dinophysis puncata*	0	0	2	2	0	0	4	3	3	0	14	1.56
43	*Peridinium depressum*	2	4	0	0	0	3	3	3	3	4	22	2.46
44	*Peridinium divergens*	0	0	0	0	2	2	0	0	0	0	4	0.45
45	*Prorocentrum micans*	0	0	1	0	0	0	1	0	2	0	4	0.45
Class: Cyanophyceae (Blue-greens)													
46	*Trichodesmium erythraeum*	12	8	9	12	14	12	15	9	13	10	114	12.74
Total		**68**	**84**	**73**	**87**	**87**	**94**	**98**	**103**	**102**	**99**	**895**	**100**

Table 15. Phytoplankton species composition

Sl. No.	Genus / Species	Stn.1	Stn.2	Stn.3	Stn.4	Stn.5	Stn.6	Stn.7	Stn.8	Stn.9	Stn.10
PHYLUM: Heterokontophyta											
Class: Bacillariophyceae (Diatoms)											
Order: Centrales											
1	*Aulacodiscus orbiculatus*	+	-	-	+	-	+	+	-	-	-
2	*Bacteriastrum hyalinum*	+	-	-	+	+	-	-	-	-	-
3	*Bellerochea malleus*	+	+	+	+	+	+	+	+	+	+
4	*Biddulphia heteroceros*	+	+	+	+	+	+	+	+	+	+
5	*Biddulphia mobiliensis*	+	+	+	+	+	+	+	+	+	+
6	*Biddulphia sinensis*	+	+	+	+	+	+	+	+	+	+
7	*Cerataulina bergonii*	+	-	+	+	-	+	-	-	-	-
8	*Chaetoceros affinis*	-	-	+	-	-	+	+	-	+	-
9	*Chaetoceros diversum*	-	-	+	-	-	-	-	+	-	-
10	*Chaetoceros laciniosus*	+	+	+	+	-	+	-	+	-	-
11	*Climacodium frauenfeldianum*	+	+	+	+	+	+	+	+	+	+
12	*Coscinodiscus centralis*	+	+	+	+	+	+	+	+	+	+
13	*Coscinodiscus concinnus*	-	-	-	+	-	+	-	-	+	-
14	*Coscinodiscus excentricus*	-	+	+	+	-	+	-	+	-	-
15	*Coscinodiscus marginatus*	-	-	-	+	+	+	-	+	-	-

16	*Coscinodiscus radiatus*	+	+	+	+	+	+	+	+	-	+
17	*Cyclotella striata*	-	-	-	-	-	-	+	-	+	-
18	*Ditylum brightwellii*	+	+	+	+	-	+	+	+	+	+
19	*Eupodiscus argus*	+	+	+	+	-	+	-	+	+	-
20	*Lauderia glacialis*	-	-	+	-	+	-	+	-	-	-
21	*Leptocylindrus danicus*	+	+	-	+	-	-	-	+	-	-
22	*Leptocylindrus minimus*	-	+	-	+	-	+	-	+		+
23	*Lithodesmium undulatum*	+	-	-	-	-	-	-	-	+	+
24	*Planktoniella sol*	+	+	-	+	+	+	+	+	+	+
25	*Rhizosolenia alata*	+	-	+	-	+	-	+	-	+	+
26	*Rhizosolenia robusta*	+	+	+	+		+	+	+	+	+
27	*Rhizosolenia styliformis*	+	+	+	+	+	+	+	+	+	+
28	*Skeletonema costatum*	-	+	+	+	+	-	+	-	+	-
29	*Stephanophyxix palmeriana*	+	-	-	+	-	+	+	+	+	-
30	*Suriella* sp.	+	+	+	+	+	-	-	+	+	-
31	*Thalassiosira decipiens*	-	+	+	+	+	+	+	+	+	+
32	*Thalassiosira subtilis*	+	+	+	+	-	+	+	+	+	+
33	*Triceratium favus*	+	+	+	+	+	+	+	+	+	+
34	*Triceratium reticulatum*	+	+	+	+	+	+	+	+	+	+
Order: Pennales											
35	*Amphora* sp.	+	+	+	+	+	+	-	-	+	+
36	*Asterionella japonica*		+	+	+	+	+	+	+	+	+
37	*Bacillaria paxillfera*	+	+	+	+	+	+	-	-	+	+
38	*Navicula henneydii*	+	+	+	+	+	+	+	+	+	+
39	Nitzschia closterium	-	-	+	+	-	+	-	+	-	-
40	Nitzschia longissima	+	+	+	-	-	-	+	+	+	+
41	*Pleurosigma normanii*	-	+	+	+	+	+	+	+	+	+
42	*Thalassionema nitzschioides*	+	+	+	+	+	+	+	+	+	+
43	*Thalassiothrix frauenfeldii*	+	+	+	+	+	+	+	+	+	+
Class: Dinophyceae (Dinoflagellates)											
44	*Ceratium fusus*	+	+	+	-	+	+	+	+	-	-
45	*Ceratium furca*	+	+	+	+	+	+	+	+	+	+
46	*Ceratium macroceros*	+	+	+	+	+	+	+	+	+	+
47	*Ceratium bucephalum*	+	+	+	+	+	+	+	+	+	+
48	*Dinophysis caudate*	+	+	+	+	+	+	+	+	+	+
49	*Dinophysis puncata*	+	+	+	+	+	+	+	+	+	+

50	*Peridinium depressum*	+	+	+	+	+	+	+	+	+	+
51	*Peridinium divergens*	-	+	-	-	-	+	-	+	+	-
52	*Peridinium pallidum*	+	+	+	+	+	+	+	+	-	-
53	*Prorocentrum micans*	-	+	-	+	+	+	-	+	+	+
54	*Ceratocorys horrida*	+	+	+	+	+	+	+	+	+	+
Class:	**Cyanophyceae (Blue-greens)**										
55	*Trichodesmium erythraeum*	+	+	+	+	+	+	+	+	+	+
Total		**40**	**42**	**43**	**46**	**36**	**45**	**38**	**43**	**41**	**35**

Table 18. Zooplankton population

Sl. No.	Genus / Species	Population (nos./100 m^3)																			
		St-1		St-2		St-3		St-4		St-5		St-6		St-7		St-8		St-9		St-10	
		Nos.	(%)	Nos.	(%)	Nos.	(%)	Nos.	(%)	Nos.	(%)	Nos.	(%)	Nos.	(%)	Nos.	(%)	Nos.	(%)	Nos.	(%)
PHYLUM: PROTOZOA																					
Order: Tintinnids (Ciliate groups)																					
1	*Eutintinnus tenuis*	18962	5.0	13414	4.0	13168	3.5	9636	2.4	10309	3.3	15004	2.1	13699	2.3	9294	2.7	9608	2.7	10106	2.7
2	*Favella* sp.	21332	5.6	17885	5.4	21069	5.6	16863	4.2	14433	4.7	26257	3.6	23973	4.1	11617	3.4	16815	4.7	15159	4.1
3	*Tintinnopsis* sp.	14221	3.7	13414	4.0	18436	4.9	14454	3.6	12371	4.0	18755	2.6	17123	2.9	6970	2.0	14413	4.1	12633	3.4
PHYLUM: RHIZARIA																					
	Class: Foraminifera																				
	Order: Globigerinidae																				
4	Globigerina	4740	1.2	2236	0.7	5267	1.4	2409	0.6	4124	1.3	7502	1.0	6849	1.2	4647	1.3	4804	1.4	5053	1.4
PHYLUM: CHAETOGNATHA																					
5	*Sagitta* sp.	7111	1.9	8943	2.7	10535	2.8	7227	1.8	10309	3.3	15004	2.1	13699	2.3	9294	2.7	9608	2.7	10106	2.7
PHYLUM: CNIDARIA																					
6	*Diphyes* sp.	7111	1.9	8943	2.7	10535	2.8	12045	3.0	8247	2.7	11253	1.6	10274	1.7	4647	1.3	7206	2.0	5053	1.4
7	*Obelia* sp.	4740	1.2	2236	0.7	2634	0.7	2409	0.6	2062	0.7	3751	0.5	3425	0.6	-	-	2402	0.7	2527	0.7
PHYLUM: ANNELIDA																					
	Class: Polychaeta																				
8	Polychaete larvae	4740	1.2	4471	1.3	5267	1.4	4818	1.2	4124	1.3	7502	1.0	6849	1.2	6970	2.0	4804	1.4	5053	1.4
PHYLUM: MOLLUSCA																					
9	Bivalve veliger larvae	7111	1.9	6707	2.0	5267	1.4	7227	1.8	6186	2.0	3751	0.5	10274	1.7	6970	2.0	4804	1.4	7580	2.0
10	Gastropod veliger larvae	9481	2.5	4471	1.3	7901	2.1	4818	1.2	4124	1.3	7502	1.0	6849	1.2	4647	1.3	7206	2.0	5053	1.4
11	*Creseis* sp.	4740	1.2	2236	0.7	2634	0.7	2409	0.6	2062	0.7	3751	0.5	3425	0.6	2323	0.7	2402	0.7	2527	0.7
PHYLUM: ARTHROPODA																					
	Class: Crustacea																				
	Order: Copepoda																				
	Sub- order: Calanoida																				
12	*Acartia clausi*	4740	1.2	6707	2.0	7901	2.1	16863	4.2	6186	2.0	11253	1.6	13699	2.3	-	-	7206	2.0	5053	1.4
13	*Acartia danae*	4740	1.2	6707	2.0	10535	2.8	-	-	8247	2.7	7502	1.0	6849	1.2	-	-	4804	1.4	-	-
14	*Acartia discaudata*	4740	1.2	6707	2.0	13168	3.5	7227	1.8	-	-	18755	2.6	-	-	9294	2.7	7206	2.0	10106	2.7
15	*Acartia erythraea*	7111	1.9	11178	3.4	10535	2.8	9636	2.4	4124	1.3	22506	3.1	10274	1.7	13941	4.0	9608	2.7	5053	1.4
16	*Acartia spinicauda*	4740	1.2	4471	1.3	5267	1.4	2409	0.6	-	-	7502	1.0	-	-	-	-	-	-	-	-
17	*Acrocalanus gracilis*	4740	1.2	8943	2.7	7901	2.1	16863	4.2	6186	2.0	26257	3.6	6849	1.2	9294	2.7	4804	1.4	7580	2.0
18	*Centropages hamatus*	7111	1.9	4471	1.3	5267	1.4	7227	1.8	4124	1.3	15004	2.1	10274	1.7	4647	1.3	4804	1.4	7580	2.0
19	*Centropages typicus*	4740	1.2	6707	2.0	5267	1.4	7227	1.8	-	-	11253	1.6	-	-	6970	2.0	7206	2.0	5053	1.4
20	*Eucalanus elongatus*	4740	1.2	4471	1.3	-	-	-	-	-	-	-	-	6849	1.2	-	-	-	-	-	-

21	*Labidocera wollastani*	2370	0.6	-	-	-	-	4818	1.2	2062	0.7	7502	1.0	6849	1.2	4647	1.3	4804	1.4	5053	1.4
22	*Paracalanus parvus*	11851	3.1	11178	3.4	21069	5.6	28909	7.2	14433	4.7	18755	2.6	30822	5.2	18587	5.4	7206	2.0	22739	6.1
23	*Parapontella brevicornis*	4740	1.2	6707	2.0	5267	1.4	9636	2.4	6186	2.0	22506	3.1	23973	4.1	11617	3.4	7206	2.0	7580	2.0
24	*Pseudocalanus elongatus*	7111	1.9	6707	2.0	10535	2.8	9636	2.4	6186	2.0	15004	2.1	6849	1.2	13941	4.0	9608	2.7	7580	2.0
25	*Temora discaudata*	4740	1.2	4471	1.3	5267	1.4	4818	1.2	6186	2.0	11253	1.6	10274	1.7	4647	1.3	7206	2.0	5053	1.4
26	*Temora longicorins*	7111	1.9	-	-	-	-	-	-	4124	1.3	-	-	6849	1.2	-	-	2402	0.7	5053	1.4
27	*Temora turbinata*	7111	1.9	6707	2.0	5267	1.4	7227	1.8	6186	2.0	7502	1.0	6849	1.2	6970	2.0	4804	1.4	7580	2.0
28	Copepod nauplii	14221	3.7	8943	2.7	7901	2.1	16863	4.2	4124	1.3	33758	4.7	27397	4.7	11617	3.4	14413	4.1	15159	4.1
29	Copepodid stages	7111	1.9	13414	4.0	21069	5.6	19272	4.8	10309	3.3	26257	3.6	27397	4.7	16264	4.7	19217	5.4	20212	5.4
Sub- order: Cyclopoida																					
30	*Coryceas catus*	21332	5.6	13414	4.0	10535	2.8	7227	1.8	8247	2.7	30008	4.2	20548	3.5	11617	3.4	24021	6.8	15159	4.1
31	*Coryceas danae*	47405	12.5	29063	8.7	34238	9.0	40954	10.2	26804	8.7	97524	13.5	58219	9.9	30204	8.7	45640	12.8	32845	8.8
32	*Oithona brevicornis*	2370	0.6	4471	4.0	5267	1.4	12045	3.0	8247	2.7	48762	6.8	6849	1.2	-	-	4804	1.4	5053	1.4
33	*Oithona rigida*	7111	1.9	6707	1.3	2634	0.7	19272	4.8	4124	1.3	33758	4.7	-	-	4647	1.3	2402	0.7	7580	2.0
34	*Oithona similis*	-	-	-	-	-	-	-	-	-	-	-	-	30822	5.2	13941	4.0	4804	1.4	-	-
Sub- order: Harpacticoida																					
35	*Euterpina acutifrons*	18962	5.0	6707	2.0	15802	4.2	7227	1.8	6186	2.0	22506	3.1	20548	3.5	11617	3.4	7206	2.0	15159	4.1
36	*Macrosetella gracilis*	4740	1.2	2236	0.7	5267	1.4	4818	1.2	4124	1.3	7502	1.0	6849	1.2	4647	1.3	4804	1.4	5053	1.4
37	*Microsetella* sp.	-	-	-	-	-	-	2409	0.6	2062	0.7	-	-	-		-	-	-	-	-	-
Other Crustaceans																					
38	Barnacle napulii	9481	2.5	11178	3.4	13168	3.5	9636	2.4	39175	12.7	11253	1.6	27397	4.7	9294	2.7	4804	1.4	10106	2.7
39	Brachyuran zoea	7111	1.9	8943	2.7	7901	2.1	7227	1.8	6186	2.0	11253	1.6	13699	2.3	11617	3.4	12011	3.4	7580	2.0
40	Crustacean larvae	9481	2.5	13414	4.0	7901	2.1	4818	1.2	12371	4.0	22506	3.1	20548	3.5	13941	4.0	12011	3.4	15159	4.1
41	*Lucifer* sp.	9481	2.5	6707	2.0	10535	2.8	7227	1.8	8247	2.7	15004	2.1	10274	1.7	11617	3.4	7206	2.0	10106	2.7
42	Mysis larvae	4740	1.2	4471	1.3	5267	1.4	4818	1.2	4124	1.3	3751	0.5	6849	1.2	4647	1.3	2402	0.7	5053	1.4
PHYLUM: ECHINODERMATA																					
43	Echinoderm larvae	2370	0.6	2236	0.7	2634	0.7	2409	0.6	2062	0.7	3751	0.5	6849	1.2	2323	0.7	2402	0.7	2527	0.7
PHYLUM: CHORDATA																					
44	*Oikopleura* larvae	9481	2.5	11178	3.4	7901	2.1	9636	2.4	4124	1.3	11253	1.6	27397	4.7	6970	2.0	7206	2.0	15159	4.1
45	Fish eggs	4740	1.2	6707	2.0	5267	1.4	7227	1.8	4124	1.3	11253	1.6	10274	1.7	6970	2.0	4804	1.4	7580	2.0
46	Fish larvae	2370	0.6	2236	0.7	-	-	2409	0.6	2062	0.7	7502	1.0	3425	0.6	2323	0.7	2402	0.7	2527	0.7
Total		**379232**	**100**	**333113**	**100**	**379246**	**100**	**402305**	**100**	**309283**	**100**	**720187**	**100**	**589039**	**100**	**346190**	**100**	**355505**	**100**	**373930**	**100**

Table 19. Sub tidal and Inter tidal benthic population

Sl. No.	Groups	Subtidal benthos (nos./m^2)										Intertidal benthos (nos./m^2)		
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	IB1	IB2	IB3
Phylum: ANNELIDA **Class: Polychaeta**														
1	**Family: Oweniidae** *Owenia* sp.	20	50	10	-		20	-	20	-	10	-	-	-
2	**Family: Spionidae** *Scolelepis* sp.	-	-	30	10	10	-	-	-	-	-	-	-	-
3	*Polydora* sp.	-	-	-	20	-	-	20	-	10	-	-	-	-
4	**Family: Nereidae** *Perineris* sp.	30	40	20	-	-	10	20	10	10	20	-	-	15
5	**Family: Eunicidae** *Eunice* sp.	20	20	10	10	50	20	-	10	10	-	-	-	-
6	**Family: Cossuridae** *Cossura* sp.	-	-	30	20	20	10	10	30	-	10	-	15	15
7	**Family: Nephtyidae** *Nephtys* sp.	10	20	-	10	20	-	-	-	-	20	-	-	-
Phylum: NEMATODA **Class: Nematoida**														
8	Nematodes	20	10	30	-	10	20	-	20	-	-	-	-	-
Phylum: ARTHROPODA **Class: Crustacea**														
9	Amphipods	30	-	40	20	-	-	20	10	-	-	15	15	30
10	Cumacea	-	-	-	-	-	-	-	-	-	-	30	-	15
Phylum: MOLLUSCA **Class: Gastropoda**														
11	**Family: Turritellidae** *Turritella* sp.	-	-	-	-	-	-	20	-	30	10	-	-	-
12	**Family: Nassaridae** *Nassarius* sp.	-	-	-	-	-	-	-	10	20	-	-	-	-
13	**Family: Marginellidae** *Marginella* sp.	-	-	-	-	-	-	-	20	-	20	-	-	-
Class: Bivalvia														

14	**Family: Tellinidae** *Tellina* sp.	-	-	-	-	-	-	10	-	-	10	-	-	-
Total		**130**	**140**	**170**	**90**	**110**	**80**	**100**	**130**	**80**	**100**	**45**	**30**	**75**
Total sub tidal benthic fauna (nos./m^2)		**1130**			**Total intertidal benthic fauna (nos. /m^2)**							**150**		

Table 20. Bacterial population in coastal waters (nosx10^3/ml)

Media	Type of Bacteria	Stations									
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Nut Agar	TVC	4.28	4.56	4.28	4.42	4.31	4.42	4.52	4.68	4.52	4.91
Mac Agar	TC	0.94	0.51	1.03	0.74	0.32	0.47	0.75	0.62	1.55	0.55
Mac Agar	ECLO	0.41	0.24	0.67	0.55	0.39	0.23	0.29	0.36	0.35	0.25
XLD Agar	SHLO	0.04	0.06	0.05	0.05	0.11	0.07	0.07	0.07	0.10	0.13
XLD Agar	PKLO	0.01	0.02	0.01	0.02	0.02	0.05	0.02	0.02	0.02	0.02
TCBS Agar	VLO	0.18	0.31	0.37	0.30	0.29	0.27	0.23	0.21	0.19	0.22
TCBS Agar	VPLO	0.16	0.23	0.22	0.21	0.17	0.22	0.17	0.16	0.16	0.18
TCBS Agar	VCLO	0.02	0.08	0.15	0.09	0.12	0.05	0.06	0.05	0.03	0.04
CET Agar	PALO	0.05	0.04	0.04	0.06	0.05	0.05	0.06	0.05	0.07	0.05

- Not Detectable

TVC -Total Viable Counts; TC- Total Coliforms; ECLO-*Escherichia coli* like organisms; SHLO-*Shigella* like organisms; SLO-*Salmonella* like organisms; PKLO-*Proteus klebsiella*; VLO-*Vibrio* like organisms; VPLO- *Vibrio parahaemolyticus* like organisms; VCLO-*Vibrio cholera* like organisms; PALO- *Pseudomonas aerugenosa* like organism

Table 21. Bacterial population in seabed sediments (x10^4 nos./g)

Media	Type of Bacteria	Stations									
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Nut Agar	TVC	5.75	5.56	5.42	5.52	5.46	5.43	5.40	5.23	5.38	5.54
Mac Agar	TC	1.03	0.89	0.71	0.85	0.69	0.78	0.76	0.86	0.68	0.65
Mac Agar	ECLO	0.48	0.45	0.35	0.38	0.45	0.29	0.34	0.45	0.42	0.46
XLD Agar	SHLO	0.25	0.29	0.22	0.25	0.27	0.22	0.17	0.36	0.22	0.39
XLD Agar	PKLO	0.20	0.09	0.13	0.13	0.07	0.12	0.12	0.09	0.10	0.11
TCBS Agar	VLO	0.37	0.31	0.48	0.29	0.36	0.42	0.39	0.30	0.42	0.30
TCBS Agar	VPLO	0.31	0.27	0.42	0.22	0.31	0.37	0.32	0.26	0.37	0.23
TCBS Agar	VCLO	0.06	0.04	0.06	0.07	0.05	0.05	0.07	0.04	0.05	0.07
CET Agar	PALO	0.03	0.06	0.05	0.04	0.04	0.06	0.06	0.07	0.06	0.03

- Not Detectable

TVC -Total Viable Counts; TC- Total Coliforms; ECLO-*Escherichia coli* like organisms; SHLO-*Shigella* like organisms; SLO-*Salmonella* like organisms; PKLO-*Proteus klebsiella*; VLO-*Vibrio* like organisms; VPLO- *Vibrio parahaemolyticus* like organisms; VCLO-*Vibrio cholera* like organisms; PALO- *Pseudomonas aerugenosa* like organisms.

Table 28. Classification of experimental bottom trawl fishes

Phylum	Class	Order	Family	Species	Haul-1 (kg)/90 mint.	Haul-2 (kg)/ 90 mint
Chordata	Chondrichthyes	Rajiformes	Trygonidae	*Himantura uarnak*	-	1
			Dasyatidae	*Dasyatis brevicaudala*	2	-
			Torpedinidae	*Narcine brunnea*	1	-
	Teleostomi	Clupeiformes	Dussumieridae	*Dussumieria acuta*	-	2.5
			Engraulidae	*Stolephorus* sp.	8	4
				Ophisthopterus tardoore	1	0.5
		Myctoohiformes	Synodontidae	*Saurida* sp.	-	2
		Mugiliformes	Sphyraenidae	*Sphyraena* sp.	-	1.5
		Siluriformes	Plotosidae	*Plotosus anguillaris*	1	0.5
			Tachysuridae	*Arius* sp.	1	1
		Scopaeniformes	Platycephalidae	*Platycephalus* sp.	-	1
		Perciformes	Teraponidae	*Terapon jarbua*	3.5	3
				Terapon theraps	2.5	-
			Ambassidae	*Ambassis* sp.	0.5	-
			Carangidae	*Carangoides* sp.1	3	1
				Carangoides sp.2	3.5	6.5
				Caranx para	3	1
				Caranx sp. 1	3	1
				Caranx sp. 2	4	2.5
				Alectis sp.	-	1.5
			Gerreidae	*Gerres filamentosus*	-	1
				Gerres sp.	3	2.5
			Leiognathidae	*Leiognathus* sp.1	4	3.5
				Leiognathus sp.2	-	3
			Scombridae	*Scomberomorus sp.*	-	1
			Sciaenidae	*Johnius* sp.	11	6
			Ephippidae	*Drepane longimana*	2	1
			Mullidae	*Upeneus* sp.	-	1
			Sparidae	*Rhabdosargus* sp.	1	-
			Stromatidae	*Pampus chinensis*	1	0.5
			Pomadasyidae	*Pomadasys maculatus*	3	2
			Trichiuridae	*Trichiurus savala*	2	1.5

			Nemipteridae	*Nemipterus japonicus*	-	2
				Nemipterus sp.	-	1.5
			Siganidae	*Siganus* sp.	4	2
			Lactariidae	*Lactarius lactarius*	-	0.5
		Pleuronectiformes	Cynoglossidae	*Cynoglossus* sp.	1	-
			Soleidae	*Aesopia cornuta*	0.5	-
				Aesopia sp.	-	1
			Psettodidae	*Psettodes* sp.	-	1
			Bothidae	*Pseudorhombus* sp.	-	1
Mollusca	Cephalopoda		Sepiidae	*Sepiella* sp.	0.5	-
			Loliginidae	*Loligo* sp.	1.5	2
Arthropoda	Crustacea	Decapoda	Penaeidae	*Penaeus indicus*	3	2
				P. monodon	6	7
				Metapenaeus sp. 1	1	1
				Metapenaeus sp. 2	1	1
			Palinuridae	*Panulirus polyphagus*	0.5	-
			Portunidae	*Charybdis natator*	2	3
				Portunus sanguinolentus	3	3.5
Trash					**7**	**8**
			Calappidae	*Calappa lophos*		
			Squillidae	*Squilla* sp.		
			Tetraodontidae	*Lagocephalus lunaris*		
			Triacanthidae	*Triacanthus* sp.		
Echinodermata	Asteroidea		Astropectinidae	*Astropecten* sp.		
	Echinoidea		Clypeasteridae	*Clypeaster* sp.		
Total					**95**	**90**

Annexure-I

Project and Plant Brief

1.0 PROJECT DESCRIPTION

1.1 Introduction

The Desalination Plant will produce fresh drinking water from seawater by separating salts and other impurities from the seawater. It is the centerpiece of the Desalination Project and will contribute up to 400 MLD of potable water to Chennai's water supply.

2.2 Type of the Project

CMWSSB has proposed 400 MLD Sea Water Reverse Osmosis (SWRO) Plant (Desalination Plant) located at Perur along the East Coast Road (ECR), Kancheepuram District, Tamil Nadu State. This project is proposed to meet the future water demand of Chennai Metropolitan Area (CMA).

2.3 Need of the project

The population of Chennai city as per 2011 census was 6.727 Million and Chennai Urban agglomeration was 8.497 Million with projection of 7.924 Million for city and 10.530 Million for Chennai Urban agglomeration for the year 2021. The population projected for Chennai City for 2016 shall be 7.312 Million and for complete Chennai Urban agglomeration shall be 9.435 million. The water Demand for 2016 with 155 LPCD (including 15% losses) shall be 1133 MLD for Chennai city and 1462 MLD for Chennai Urban Agglomeration. With this the total water demand in 2016 shall be 1462 MLD with supply of approx. 840 MLD including 200 MLD from existing two SWRO one in north and the other in south of the city.

The main sources of water supply to the Chennai city is from surface water sources such as Poondi, Cholavaram and Redhills reservoirs and also from ground water sources from Araniar and Korataliar basin. The water supply source has been augmented with distant sources such as Krishna Water Supply scheme with supply from the State of Andhra Pradesh and by Chennai Water Supply Augmentation Project with supply from Veeranam Tank. A desalination plant of capacity 100 MLD has been commissioned in July 2010 near Kattupalli village, Minjur in North Chennai and is in successful operation. Another 100 MLD capacity Desalination plant with Central Government funds is operational at Nemmeli at the southern outskirts of Chennai. The demand has been calculated with base year 2018, since most of the associated water supply projects are due for completion in 2018.

Population (in lakh)	Year	Chennai City	Chennai City and Chennai Urban Agglomeration
	2011	67.27 Lakh	84.97 lakh
	2016	73.12 Lakh	94.35 Lakh
	2018	77.38 Lakh	98.10 Lakh
	2019	79.37 Lakh	100.60 Lakh
	2034	97.87 Lakh	138.40 Lakh
	2049	149.77 Lakh	190.30 Lakh
Water Demand (in MLD)	Year	Chennai City	Chennai City and Chennai Urban Agglomeration
	2016	1133 MLD	1462 MLD
	2018	1199 MLD	1520 MLD
	2019	1230 MLD	1560 MLD

	2034	1517 MLD	2145 MLD
	2049	2321 MLD	2950 MLD

Drinking water supply sources in Chennai city are monsoon dependent and the city experiences water scarcity frequently. The drinking water demand for Chennai and Chennai Urban Agglomeration has been estimated at 1462 MLD in the year 2016 and 1560 MLD in the year 2019.
As against the total projected water demand for the Chennai city and CUA is 1560 MLD for the year 2019, the water supply is 840 MLD, thus having a supply demand gap of 720MLD. Therefore, there is need to setup a 400 MLD Sea Water Reverse Osmosis (SWRO) Plant at Peruralong the East Coast Road (ECR), Chennai.

2.4 Salient Features of the Project

The key components of the proposal are:

- seawater intake structure, and offshore pipeline to the plant;
- Onshore Intake pumping station
- reverse osmosis desalination plant;
- discharge pipeline through a diffuser array, 750 m offshore;
- Product Water Transfer Pipeline to city approx. 60 km;

The main characteristics of the proposal are summarized in **Table-2.1** below.

TABLE 2.1
SALIENT FEATURES OF PROPOSED EXPANSION

Element	Description
General	
Capacity	400 MLD
Power requirement	85 MWe
Power Source	TNEB Substation
Seawater intake	
Length (indicative)	1150 m
Number	2 pipes
Diameter	Each 2500 mm OD HDPE 6.4 bar
Concentrated seawater discharge	
Salinity	32,500mg/l -33,000mg/l above ambient.
Temperature	Not more than 1°C above or below ambient seawater
pH	6-8
Pipeline Length (indicative)	Extending up to 750 meters offshore
Number	1 pipe
Diameter	2500 mm OD HDPE 6.4 bar
Sludge	
Sludge production	approximately 60-75 t/per day; depended on suspended solid concentration in sea water inlet
Water Transfer Pipeline	
Length	60 km
Diameter	2000 mm upto 42 km ; rest 18 km 1600 mm
Destination	Part of Chennai City- South and West

2.5 Project Location and Layout

The proposed site for 400 MLD desalination Plant is located at Perur (Nemmeli Village) quite adjacent to the existing 100 MLD Sea Water Desalination Plant at Nemmeli along East Coast Road, Kancheepuram District, Tamilnadu, India. The site is located at eastern side of East Coast Road (ECR) at 12° 42' 44" North, 80° 14' 26" East and is approximately 40 km of south of Chennai city.

The contours are generally varying from 3.5-4.0m from the shore to 7-7.5 m towards the East Coast Road. There are two numbers of burial ground one on the southern side on the sae cost and other on the northern side towards the East Coast Road. The total area of the proposed site is 87.915 acre out of which the two burial grounds have a combined area of 2.01 acre, therefore net area available is 85.90 acre. The burial grounds have been left undisturbed and shall be protected by compound wall all across and proper drainage shall be made draining towards the sea.

The proposed plant shall be spread over approx. 50 acre and rest of the area has been left for future expansion.

SITE LOCATION

2.5.1 Site features

Area requirement for the proposed plant has been optimized considering the space requirements of all the equipment, systems, buildings and structures and chemical storage area etc for the proposed plant.

Necessary plant drainage system would be provided at the plant site.

2.6 Infrastructure and Resources Requirement

2.6.1 Land Requirement

The total land requirement for the proposed project is estimated at about 50 acres (20.25 ha).

2.6.2 Power

The total power requirement of the proposed desalination plant is about 85 MWe, which is being met from **TNEB**. D.G sets are proposed to meet the power requirement **for lighting only** during power failure.

2.6.3 Health and Sanitation

To ensure optimum hygienic conditions in the plant area, proper drainage network will be provided to avoid water logging and outflow. Adequate health related measures and a well equipped safety and environment department will be provided to ensure clean and healthy environment.

2.6.4 Internal Roads

All internal roads within the proposed plant area will be minimum 4.5 m wide for proper movement.

2.6.5 Lightning Protection System

Adequate lightning protection facilities will be provided as per the applicable Indian codes of practice.

2.6.6 Fire Protection System

For protection of the plant against fire, all yards and plant will be protected by any one or a combination of the following system:

a) Hydrant system;
b) Automatic high velocity and medium velocity sprinkler system;
c) Water spray (emulsifier system);
d) Automatic fixed foam system; and
e) Portable and mobile chemical extinguisher.

The system will be designed as per the recommendation of Tariff Advisory Committee (TAC) of Insurance Association of India. Applicable codes and standards of National Fire Prevention Association (NFPA), USA would also be followed.

2.7 Brief Description of Project

Desalination Process

Desalination refers to a water treatment process whereby salts are removed from saline water to produce fresh water. The proposed desalination process will make use of Reverse Osmosis (RO) technology to remove salt from sea water, thereby producing fresh product water as well as high salinity brine. The flow of Desalination plant process is attached herewith. The main elements in the desalination process are:

- **Seawater intake**;
- **Pre-treatment of feed water**, which would include screening, clarification, floatation and filtration to remove suspended solids;
- **Desalination**, making use of RO technology, in which pressurized feed water passes through a series of membranes which allow only water (low saline permeate) to pass through and salts and organic matter to accumulate in brine;
- **Post-treatment** (remineralisation and disinfection) of process water; and
- **Discharge of brine** from the desalination process.

2.7.1 Seawater Intake

Primary Flows

Two intake conduits of 2500 mm OD HDPE have been proposed for the plant to produce 400 MLD permeate capacity.

Intake structure with Screen offshore

A 100 mm screen in GRP construction will be provided at the intake to exclude larger marine life. The approach velocity will be <0.15 m/s to minimize the entrapment of marine species. A fish net with will be provided to minimize the ingress of jelly fish to the intake. The fish net will be required to be inspected and replaced from time to time, as the same is likely to be damaged by marine lives. The head loss through the intake system will also be monitored, and in any increase in system losses indicating fouling at the intake, or the growth of biomass within the intake conduit, the same shall be cleaned through divers.

Active Screens before the Sea Water Pumps

Travelling Band Screens shall be provided before the Pumps on shore and shall be the first level of defence to the plant against all foreign matter like floating, sea shells, diatoms etc.

Travelling Band Screens

Band screens have been in service for screening sea water for many years. They provide efficient removal with relatively low maintenance costs. Through-flow band screens have been proposed herewith. Typically mesh sizes vary from 2 mm to 10 mm, and, in view of the marine biomass problems at Nemmeli, a mesh size of 3 mm has been selected.

Sea Water Pumping Station

Vertical shaft pumps in a wet well are particularly suitable for sites with a low tidal range, such as is experienced at Chennai. Vertical shaft pumps in a wet well have been selected.

- There shall be 6 pumps in operation each pump must be capable of delivering 7042 m3/hr, at a head of around 23 meters.
- Pair of three pumps shall form one manifold to a module of 12 Settlers. The diameter of each manifold 2,400 mm (2.4 m), with a velocity of 1.33 m/sec.
- These pumps are Vertical Turbine pumps with large clear passages. The intake screen and net at the intake will prevent the ingress of material like to cause a blockage.
- Isolation valves along with flow meters shall be installed main and branch manifolds.

These pumps are Vertical Turbine pumps with large clear passages. The intake screen and net at the intake will prevent the ingress of material like to cause a blockage.

Shock chlorination system

A shock chlorination system is proposed to minimize marine growth in the inlet pump station and pressure main. It will be done using chlorine gas through vacuum chlorinate, the range of dose will be 1-10 mg/l at the rate of 1-2 hour per day in off shore inlet well.

2.7.2 Pretreatment System

The pre-treatment process has been sized assuming that there are 16 membrane trains in operation to produce 400 MLD of Permeate water.

pH Correction

The seawater will be dosed with Sulphuric acid to achieve the optimum pH for coagulation. The dosing system will consist of dosing pumps into each pretreatment train.

Coagulation and Flocculation

Coagulation is important to reduce the turbidity to an acceptable level in order to avoid the fouling on RO membrane. Ferric chloride will be used as a coagulant.

Flocculation will be provided at the head of each Lamella. It will be achieved in two flocculation tanks in series with each tank consisting of one or two vertical mixers so as to have the mixing energy tapered.

Lamella Settlers

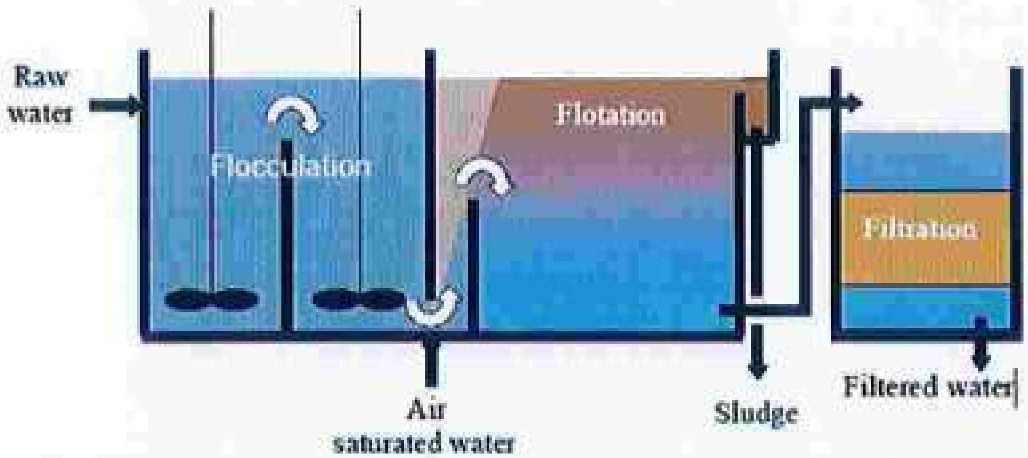
Lamella settlers can quickly remove large amount of relatively coarse material. Coagulation and flocculation are provided prior to the Lamella settlers. 18m x 7.5 m sized lamella settlers have been proposed for this plant with 24 settlers at less than 15 m/hr surface loading rate.

Dissolved Air Flotation (DAF)

Dissolved air floatation (DAF) is a high rate process using micro-bubbles to float coagulated and flocculated particles to the surface of a clarification basin. DAF is a form of physical treatment that involves coagulating impurities then removing those solids by using dissolved air to float them to the surface of the water. Residual fine particles that are not floated off are removed by the filters downstream. A cross sectional schematic is shown in the Figure-below.

DAF would be effective in the removal of algae, and should be reasonably effective in the removal of other marine biomass, such as larvae and jelly fish particulate matter. DAF would be effective in the removal of oils and greases.

The loading rate will be 15-20 m/hr with recycle rate 10-15%. Air dose rate will be 10 mg/l and the air saturation pressure around 800kPa.



SECTIONAL SCHEMATIC OF DISSOLVED AIR FLOTATION

Dual Media Gravity Sand Filters & water storage

Clarified water from the DAF outlet shall feed to the inlet channel of the gravity filters. Dual-media filters shall have two layers of filtration media. An upper layer of coarse material with low density typically is anthracite of 0.5 m -1.0 m depth. Sand will be placed as a bottom layer of fine material with higher density for refinement. The depth of sand will be 0.8-1.5 m. The above filtration medium shall be typically supported by a layer of gravel bed. The gravel bed is graded in three to six layers and is located on the top of a filter under drain system.

Filtered water storage will be located immediately downstream of the Gravity Dual Media filtration system. This will serve as control storage between the filtration system and the RO plant. It will ensure that the flow to the RO trains will be constant while the production from the pre-treatment system fluctuates due to backwashing. The tanks have been sized to provide twenty minutes storage.

2.7.3 Desalination Plant - Reverse Osmosis

Overview of RO Plant

The RO plant will be a single stage/single pass design with an overall recovery of 46%. The 400 MLD modules will be configured as Seventeen individual trains. Each of the Seventeen (17) RO trains will consist of one RO rack each, with dedicated pumping system and Energy Recover Devices (ERDs). The plant is to be designed such that full production can be achieved through Sixteen (16) trains.

The trains will be configured to allow for each individual train to be isolated for cleaning, maintenance, or membrane replacement. SWRO membrane elements of 8-inch diameter have been selected. Each pressure vessel will house eight membrane elements. The design treated water TDS for the RO plant is 300 mg/L. No allowance has been made in the RO plant layout for a second pass RO system.

In sizing the RO plant an average membrane flux of approximately 13.5 L/m2/hour (LMH) has been selected. The provision of 8% spare space for more membranes provides the flexibility to reduce the flux if advantageous for reducing cleaning frequency or reducing power consumption.

Ancillary system

To protect the RO membranes and the smooth process of reverse osmosis system the following methods are provided,

Cartridge filtration - It will be provided for each RO train downstream of the filtered water transfer pumps to protect the RO membrane

Oxidant control - Sodium bisulphite (SBS) dosing is included in the design to neutralize residual oxidants present in the feed water due to intake shock dosing.

Scale Control - Provision for scale control by means of antiscalant dosing is included in the design. The sulphuric acid addition as part of the pre-treatment system will also assist with prevention of scaling.

Reverse Osmosis Pumping and Energy Recovery System - The energy recovery devices will be an isobaric design. Either the Energy Recovery International (ERI) or Calder DWEER technology could be used.

RO Clean In Place System

A RO clean in place (CIP) system is included in the design. This includes a chemical cleaning preparation tank, chemical cleaning buffering tank, a heat exchanger, pumps, cartridge filters, cleaning chemical storage tanks, cleaning network and cleaning recirculation loop piping and a neutralization system.

Provision has been made in the design for storage and dosing of the following cleaning and preservation chemicals:

- Caustic soda
- Sodium Bisulphite
- Hydrochloric Acid
- Phosphoric Acid
- Citric acid
- Detergents (surfactant)
- Ammonia solution

Cleaning occurs intermittently and all of these chemicals would not be used at the same time. The amount and type of cleaning chemical required would vary depending upon the degree of membrane fouling and the nature of the fouling. Depending on the membrane selected, the system may be designed to enable cleaning of the RO system from both directions, i.e. from the front to the back and from the back to the front. This would allow employing specific cleaning procedures for a particular type of fouling / scaling. The CIP system will be sized to clean each individual RO rack separately. The system, including the chemicals for the CIP will be located in a dedicated building located next to the main RO building.

All wastes from the CIP process will be neutralized prior to being directed to the outfall and for the same a Neutralization Tank has been provided. After chemical cleaning and prior shutdown of membrane trains, the brine and spent cleaning solution will be flushed out of the RO and ERD racks using RO permeate. Flushing prior train shutdown will reduce potential for scale build up and corrosion, and will also reduce fouling and the amount of high TDS water produced on start up. The flushing system would consist of flushing pumps and pipe work allowing each RO train to be flushed individually.

Permeate Storage

Two permeate storage tanks will be located immediately downstream of the RO plant. Each tank has been sized for at least 0.5 hours storage at the maximum permeate flow.

2.7.4 Post Treatment

Post treatment of permeate is required to meet the statutory product water quality requirements. Post treatment will consist of remineralisation/stabilization and disinfection of the water.

Re-mineralization/Stabilization

Requirement for Stabilization

Water produced by a reverse osmosis process has very low residual hardness and alkalinity, which renders it very aggressive to most materials including steel and concrete thus causing corrosion and premature aging of assets. The lack of carbonate alkalinity as well as the low content of calcium and magnesium (i.e., very low hardness) causes desalinated water to be unstable and prone to wide variations in pH due to its low buffering capacity and its inability to form protective calcium carbonate films on pipe walls, which makes it corrosive. Therefore, before the permeate from reverse osmosis be supplied to customers, it needs stabilization also known as remineralisation or conditioning to prevent this from happening.

Water shall be stabilized by the addition of carbon dioxide and lime (calcium hydroxide). The calcium is dosed via limewater, which is produced by mixing powdered hydrated lime with reverse osmosis permeate using a clarifier. Carbon dioxide gas is added to the water. It reacts with the dosed lime to form calcium bicarbonate, which buffers the water and increases the resistance to changes in pH and thus reduces the corrosivity of the water.

Disinfection

Chlorine based disinfection (i.e. chlorination) has been considered for this project. Chlorine kills the micro-organisms by immobilizing their metabolism rendering them harmless. Chlorine is a slow stable reaction thus its main advantage of chlorine is the formation of residuals which remain in the water for longer periods of time protecting the system from bacterial contamination.

2.7.5 Water Storage and Transfer

Process water storage

Treated process water will be stored on site prior to being transferred to the city for consumption. Total usable storage volume will be 35,000 m^3 with 2 hour storage time for average flow.

Process water transfer pump station

The design criteria adopted for design of the pump station is therefore as follows;

- Type of pumps : centrifugal variable speed drive,
- Number of units : 6 duty, 2 standby
- Nominal pump station duty : 2800 m3/hr @ 60 m head,
- Pump control : by level in the receiving tank,
- Positive suction at all times.

2.7.6 Seawater Outfall

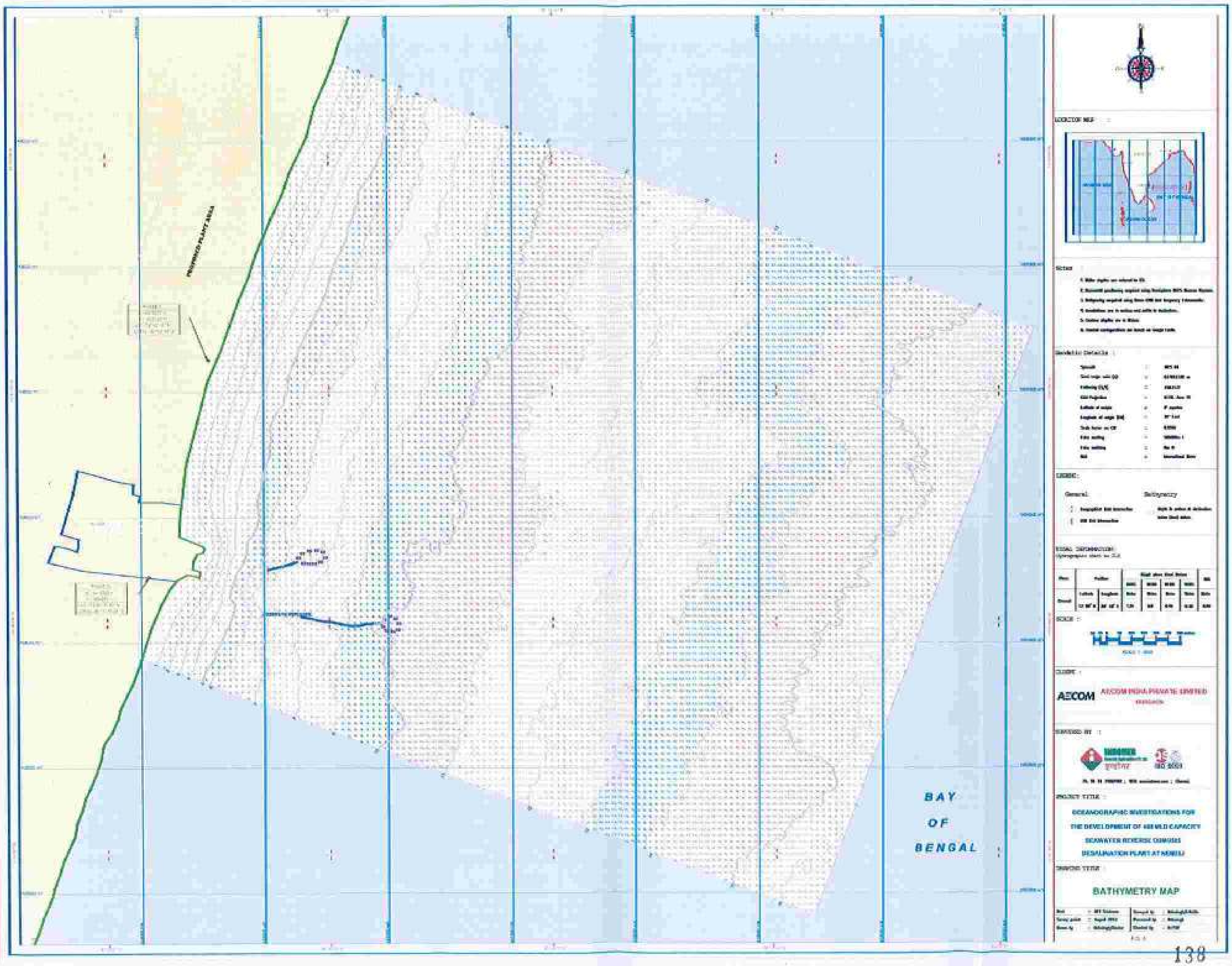
Outfall Pipeline

The desalination plant will discharge rejected seawater concentrate and other waste streams into the ocean via an outlet pipeline.

Coastal currents flow from south to north from August to October and from north to south from November to March each year. The currents from the south to the north are stronger than the currents from the north to the south. For this reason the outfall will be located to the north of the intake, as at Nemmeli.

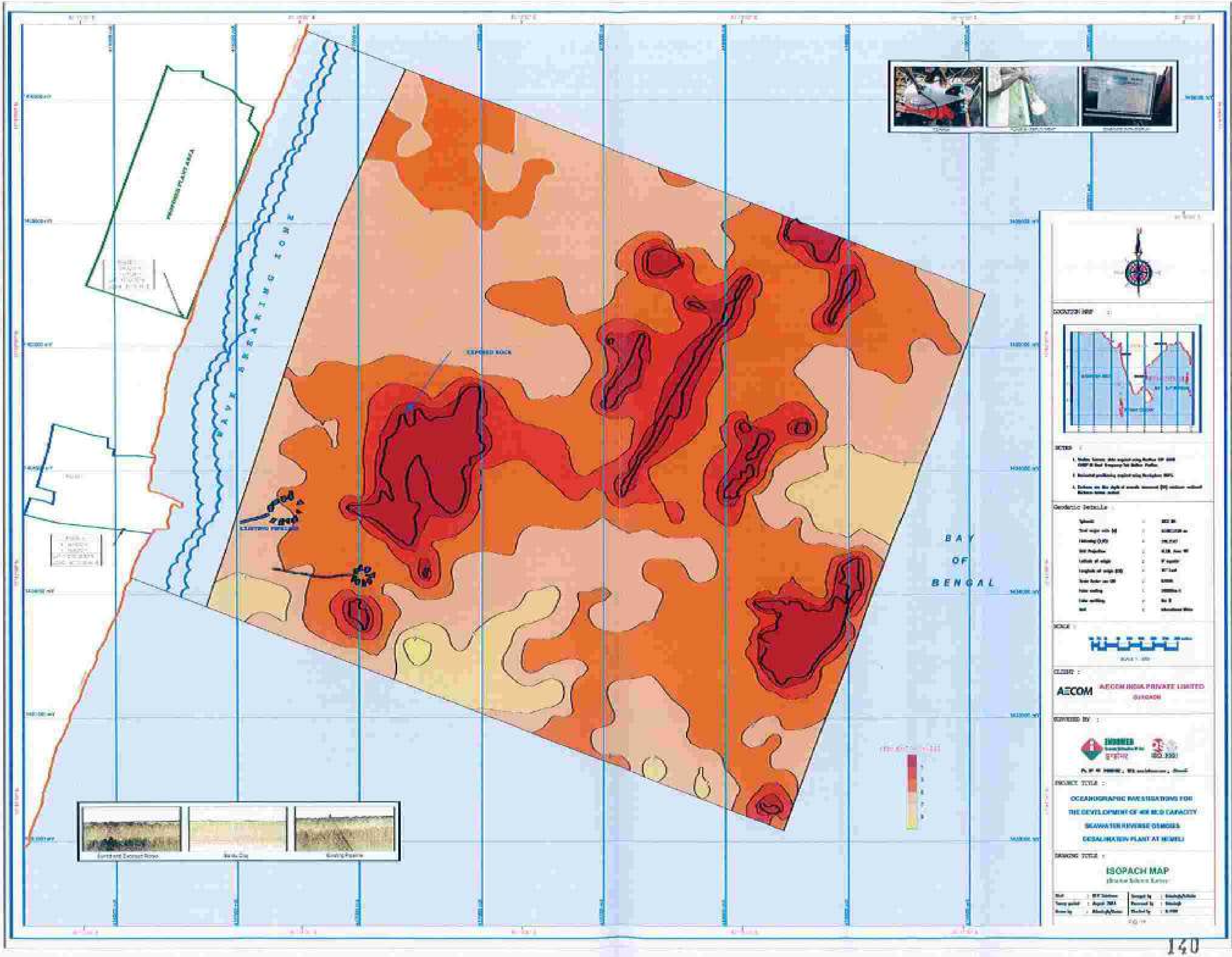
Annexure-II

Bathymetric Survey


PROPOSED PLANT AREA
BAY
OF
BENGAL
AECOM
AECOM INDIA PRIVATE LIMITED
OCEANOGRAPHIC INVESTIGATIONS FOR
THE DEVELOPMENT OF 400 MLD CAPACITY
SEAWATER REVERSE OSMOSIS
DESALINATION PLANT AT NEMELI
BATHYMETRY MAP

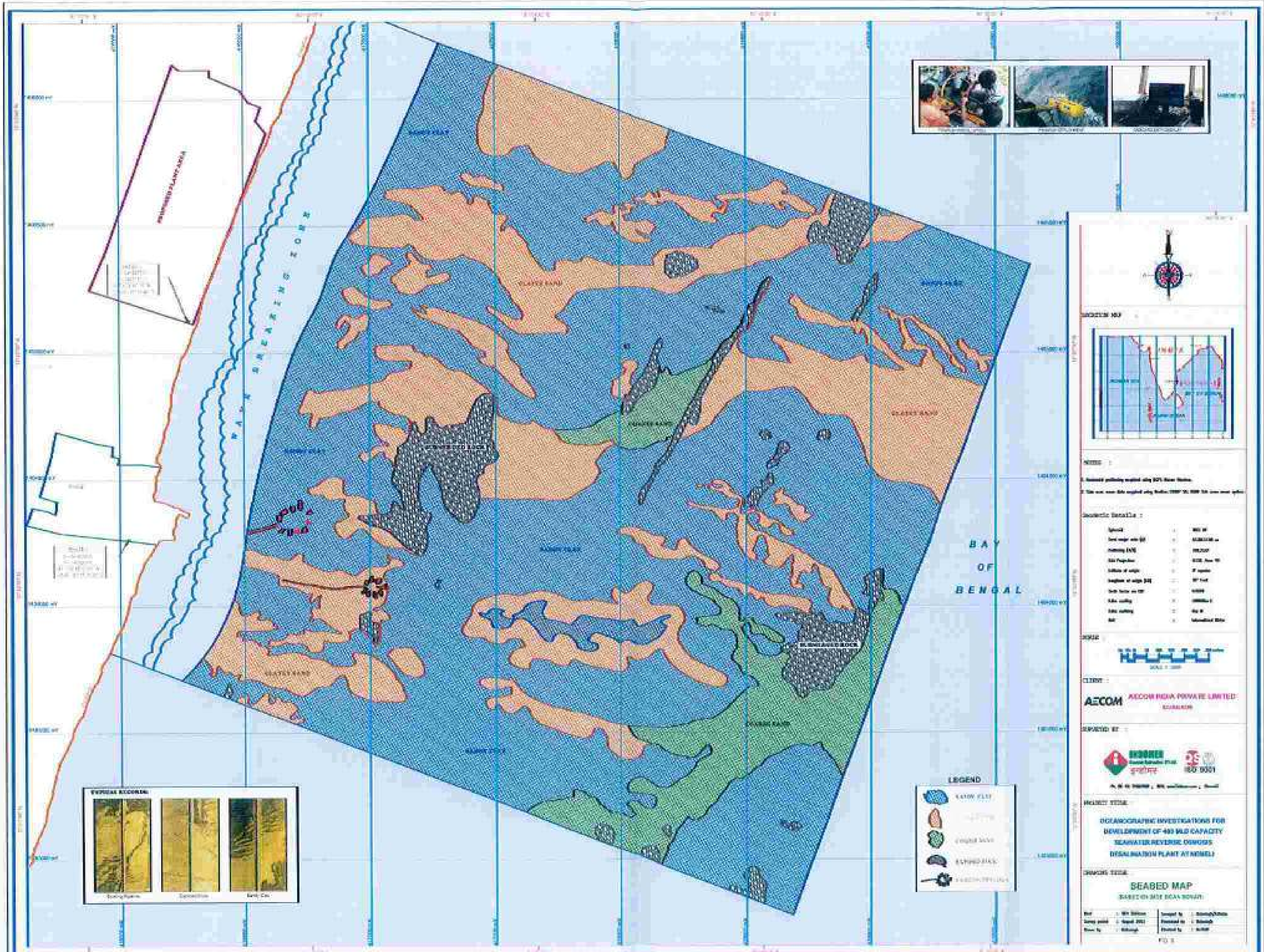
Annexure-III

Isoptach Map


PROPOSED PLANT AREA
WAVE BREAKING ZONE
EXPOSED ROCK
EXISTING PIPELINE
BAY OF BENGAL
LOCATION MAP :
NOTES :
Geodetic Details :
SCALE :
CLIENT :
AECOM
AECOM INDIA PRIVATE LIMITED
GURGAON
SURVEYED BY :
PROJECT TITLE :
OCEANOGRAPHIC INVESTIGATIONS FOR
THE DEVELOPMENT OF 400 MLD CAPACITY
SEAWATER REVERSE OSMOSIS
DESALINATION PLANT AT NEMELI
DRAWING TITLE :
ISOPACH MAP
Sand and Exposed Rocks
Sandy Clay
Existing Pipeline

Annexure-IV

Sea Bed Map


WAVE BREAKING ZONE
CLAYEY SAND
SANDY CLAY
COARSE SAND
SUBMERGED ROCK
BAY
OF
BENGAL
LEGEND
LOCATION MAP
INDIA
NOTES :
Geodetic Details :
SCALE :
CLIENT :
AECOM
AECOM INDIA PRIVATE LIMITED
SURVEYED BY :
ISO 9001
PROJECT TITLE :
OCEANOGRAPHIC INVESTIGATIONS FOR
DEVELOPMENT OF 400 MLD CAPACITY
SEAWATER REVERSE OSMOSIS
DESALINATION PLANT AT NEMELI
DRAWING TITLE :
SEABED MAP
(BASED ON SIDE SCAN SONAR)
TYPICAL RECORDS
PROPOSED PLANT AREA

Annexure-V

Dispersion Modelling

EXECUTIVE SUMMARY

Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) is presently operating one 100 MLD R.O. desalination plant at Nemmeli, south of Chennai. It has now proposed to set up additional seawater desalination plant of 400 MLD capacity as Phase II. The existing seawater intake laid for Phase I draws 260 MLD = 10833 m^3/hour of seawater. For the Phase II, i.e., the proposed seawater intake considered in this report will draw 1147 MLD = 47791.66 m^3/hour of seawater. There is a proposal to establish Phase III unit in future, which will have a separate intake system to draw the seawater of 455 MLD = 18958.33 m^3/hour. The existing outfall laid for Phase I discharges 160 MLD = 6667 m^3/hour of brine reject. For the Phase II, i.e., the proposed outfall considered in this report will discharge 747 MLD = 31125 m^3/hour of brine reject. There is a proposal to establish Phase III unit in future, which is expected to discharge 305 MLD =12708 m^3/hour through a separate outfall.

Phase	Intake head	Intake volume (m^3/hour)	Outfall diffuser	Discharge volume (m^3/hour)
Phase I (Existing)	Dist.= 915 m Depth= 10 m	10833	Dist.= 600 m Depth = 8 m	6667
Phase II (Proposed)	Dist.= 1150 m Depth= 10 m	47791.66	Dist.= 750 m Depth = 8 m	31125
Phase III (Future)	Dist.= 1050 m Depth= 10 m	18958.33	Dist.= 650 m Depth = 7.5 m	12708

CORMIX model: For the proposed phase II operation, the outfall diffuser will have the multiple ports of 18 nos. x 600 mm diameter placed at 750 m into the sea. All the ports will be oriented 30° to the horizontal. The water depth at the disposal location will be 8 m and the diffuser will be placed 1.5 m above the seafloor. The study on CORMIX model shows that the mixing zone will extend for 75 m to achieve dilution of 57 times and it will extend further till 200 m distance to achieve dilution of 65 times from the disposal location.

MIKE 21 HD-AD MODEL: The model study presented in this report covers the following two scenarios:

i) Phase I (existing) + Phase II (proposed) and
ii) Phase I (existing) + Phase II (proposed) + Phase III (future).

Model Input

Salinity of return water: The brine reject will have the salinity of 71 ppt which will be 33 ppt higher than the ambient seawater salinity (38 ppt). There will be no change in other water quality parameters compared to the ambient values.

Simulation: In each simulation the flow field and the mixing pattern were obtained for a period of one lunar month (i.e. 28 days).

The secondary dispersion is estimated using DHI-MIKE 21-FLOW-AD model. The MIKE 21 flow simulation study showed that the tide induced flow in the project region during fair weather is of the order of 0.12 m/s. The increase in turbulence due to stronger currents (> 0.25 m/s) induced by monsoon winds and rough seas would enhance the mixing during the southwest and northeast monsoons. The currents during the southwest monsoon are observed to be stronger (> 0.25 m/s) than the remaining period of the year, leading to higher rate of mixing. The plumes of 2 ppt salinity difference spread from different outfalls do not merge with each other and they get diluted with their respective mixing zone. On the other hand the plumes having difference in salinity of 1 ppt is found to *merge with other outfalls. However during the monsoon, the dilution is very high and there is no merging of plumes at all over at < 1 ppt. The study also shows that the brine reject discharged into the shoreline do not reach the shore and there will be no shoreline connection and no contaminations of the water near the coast.*

6. DIFFUSER DESIGN – CORMIX MODEL

The dilution of any return water released in a natural water body takes place in 2 stages, viz., i) initial dilution due to jet mixing, and ii) secondary dispersion due to turbulence. The extent of initial dilution is controlled by the engineering design of the diffuser. For a proposed design of the diffuser port the behaviour of the return water jet plume is designed and estimated using **CORMIX** model. Once the return water rises to the water surface as the water moves away from the outfall location the subsequent dilution takes place by larger scale turbulence in the horizontal direction. This second stage is controlled by the prevailing currents and turbulence that exist in the coastal region. Such secondary dispersion is estimated using **DHI-MIKE 21- FLOW -AD** model.

The Cornell Mixing Zone Expert System (CORMIX) is a software module for the analysis, prediction, and design of aqueous toxic or conventional pollutant discharges into diverse water bodies. It is a widely accepted and recommended analysis tool in US on granting permission for industrial, municipal, thermal, and other point source discharges to receiving waters. It is used to predict the geometry and dilution characteristics of the initial mixing zone and also the behaviour of the discharge plume at larger distances.

6.1. Methodology

The highly user-interactive CORMIX system is organized with three subsystems: (i) CORMIX1- for the analysis of submerged single port discharges, (ii) CORMIX2- for the analysis of submerged multiport diffuser discharges and (iii) CORMIX3- for the analysis of buoyant surface discharges. Several post-processing options are available like, CORJET (the Cornell Buoyant Jet Integral Model) for the detailed analysis of the near-field behaviour of buoyant jets, FFLOCATR (the Far-Field Plume

Locator) for the far-field delineation of discharge plumes in non-uniform river or estuary environments, and CMXGRAPH, a graphics package for plume plotting.

Hydrodynamic Mixing Processes: The mixing behaviour of any effluent discharge is governed by the interplay of ambient conditions in the receiving water body and by the discharge characteristics. The **ambient conditions** in the receiving water body are described by the water body's geometric and dynamic characteristics such as: plan shape, vertical cross-sections, and bathymetry, especially in the discharge vicinity. Dynamic characteristics are given by the velocity and density distribution in the water body, again primarily in the discharge vicinity. The **discharge conditions** relate to the geometric and flux characteristics of the submerged outfall installation. For a single port discharge the port diameter, its elevation above the bottom and its orientation provide the geometry; for multiport diffuser installations the arrangement of the individual ports along the diffuser line, the orientation of the diffuser line, and construction details represent additional geometric features; and for surface discharges the cross-section and orientation of the flow entering the ambient watercourse are important. *The distinction between near-field and far-field is made purely on hydrodynamic grounds and it is unrelated to any regulatory mixing zone definitions.*

6.2. Design details

The total volume of return water that would be discharged into the sea during Phase II is 747 MLD (31125 m^3/hour = 8.64 m^3/s). The outfall diffuser will have the multi ports of 18 nos.x 600 mm diameter placed at 750 m distance in to the sea. All the ports will be oriented 30° to the horizontal. The water depth at the disposal location will be 8 m and the diffuser height will be 1.5 m above the seafloor. In addition 4 nos. x 600 mm dia. ports will be provided as standby. The design outfall discharge volume is taken as 31125 m^3/hour (8.64 m^3/s). The various input parameters for the CORMIX models are given below.

Volume of discharge	=	31125 m^3/hour (8.64 m^3/s)
No. of Ports	=	18 nos. x 600 mm dia.
Inclination of ports	=	30° to horizontal

CORMIX SESSION REPORT:

CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 8.0GTH
DYDRO: Version-5.0.0.0 April, 2012

SITE NAME/LABEL	: NEMMELI
DESIGN CASE	: Metro water
FILE NAME	: C:\Program Files \CORMIX 8.0\Nemmeli phase2.prd
Using subsystem BCORMIX2	: Multiport Diffuser Brine Discharges
Start of session	: 1st December, 2014--16:30:00

AMBIENT PARAMETERS:

Cross-section		= unbounded
Average depth	HA	= 8.0 m
Depth at discharge	HD	= 8.0m
Ambient velocity	UA	= 0.15 m/s
Wind velocity	UW	= 2 m/s
Stratification Type	STRCND	= U
Surface density	RHOAS	= 1023.34 kg/m^3
Bottom density	RHOAB	= 1023.34 kg/m^3

DISCHARGE PARAMETERS :	Submerged Multiport Diffuser Discharge	
Diffuser type	DITYPE	= unidirectional perpendicular
Diffuser length	LD	= 54 m
Nearest bank		= left
Diffuser endpoints	YB1	= 696 m; YB2 = 750 m
Number of openings	NOPEN	= 18
Number of Risers	NRISER	= 18
Spacing between risers/openings	SPAC	= 3.18 m
Port/Nozzle diameter	D0	= 0.6 m
Total area of openings	TA0	= 5.0894 m^2
Discharge velocity	U0	= 1.70 m/s
Total discharge flowrate	Q0	= 8.64 m^3/s
Discharge port height	H0	= 1.5 m
Nozzle arrangement	BETYPE	= unidirectional without fanning
Vertical discharge angle	THETA	= 30 deg
Discharge density	RHO0	= 1050 kg/m^3
Density difference	DRHO	= -26.6600 kg/m^3

Discharge concentration CO = 31000 mg/l

NON-DIMENSIONAL PARAMETERS:
Port/nozzle Froude number FRDO = 4.18

D-CORMIX PREDICTION FILE:

FLOW CLASSIFICATION

X-Y-Z COORDINATE SYSTEM:

ORIGIN is located at the SURFACE and at the diffuser mid-point

X - Axis points downstream
S - Hydrodynamic average dilution

X	S
0.0	1.0
2.5	4.0
5.5	5.5
8.0	6.5
10.5	7.5
13.5	8.0
16.0	8.8
18.5	9.5
21.5	10.0
24.0	10.5
27.0	11.0
75.0	57.0
120.0	60.0
165.0	62.0
200.0	65.0

Cumulative travel time = 2 min

Discussion on Initial dilution

The study on CORMIX model shows the mixing zone will extend for 75 m to achieve 57 times and extending further till 200 m distance to achieve to dilution of 65 times from the disposal location. Thereafter the initial dilution, the secondary dispersion take place due to convection currents and undergoes further dilution. The secondary dispersion characteristics are studied in detail using MIKE 21 model.

7. SECONDARY DISPERSION – MIKE 21 MODEL

The tide and wind induced flow field over the project area is determined using the MIKE 21 hydrodynamic module (HD) and the return water diffusion using the Advection-Dispersion module (AD). These models have been developed by Danish Hydraulic Institute (DHI), Denmark and are being used worldwide for many coastal engineering applications.

7.1. Methodology

Mike 21 Flow Module (HD): The MIKE 21-Flow module is a multi-dimensional 2D or 3D (present case 2D), hydrodynamic flow simulation model, which solves shallow-water equations for given boundary conditions to compute non-steady flow fields in response to a variety of environmental forcing and processes in natural water bodies. The environmental forcing and processes include: *bottom shear stress, wind shear stress, barometric pressure gradients, Coriolis force, momentum dispersion, sources and sinks, evaporation, flooding and drying and wave radiation stresses.*

This model uses an Alternate Direction Implicit (ADI) Finite Difference Method on staggered orthogonal grids and also has the option to use Finite Element Method. The basic shallow-water equations in the Cartesian co-ordinate system used in the MIKE 21 HD flow module are:

Continuity equation:

$$\frac{\partial \zeta}{\partial t} + \frac{\partial p}{\partial X} + \frac{\partial q}{\partial Y} = S - e$$

Momentum equations in x- and y- directions:

$$\frac{\partial p}{\partial t}+\frac{\partial}{\partial X}\left[\frac{p^2}{h}\right]+\frac{\partial}{\partial Y}\left[\frac{p\,q}{h}\right]+gh\frac{\partial \zeta}{\partial X}+F_{bx}-K_aWW_x-\frac{h}{\rho_w}\frac{\partial p_a}{\partial X}-\Omega\,q-F_{EX}=S_{ix}$$

$$\frac{\partial q}{\partial t}+\frac{\partial}{\partial X}\left[\frac{p\,q}{h}\right]+\frac{\partial}{\partial Y}\left[\frac{q^2}{h}\right]+gh\frac{\partial \zeta}{\partial Y}+F_{by}-K_aWW_y-\frac{h}{\rho_w}\frac{\partial p_a}{\partial Y}+\Omega p-F_{EY}=S_{iy}$$

Symbol list

$$F_{EX}=\left[\frac{\partial}{\partial X}\left[\varepsilon_x h\frac{\partial u}{\partial X}\right]+\frac{\partial}{\partial Y}\left[\varepsilon_y h\frac{\partial u}{\partial Y}\right]\right]$$

$$F_{EY}=\left[\frac{\partial}{\partial X}\left[\varepsilon_x h\frac{\partial u}{\partial X}\right]+\frac{\partial}{\partial Y}\left[\varepsilon_y h\frac{\partial u}{\partial Y}\right]\right]$$

$$F_{bx}=\frac{g}{C^2}\sqrt{\frac{p^2}{h^2}+\frac{q^2}{h^2}}\frac{p}{h}$$

$$F_{by}=\frac{g}{C^2}\sqrt{\frac{p^2}{h^2}+\frac{q^2}{h^2}}\frac{q}{h}$$

ζ (x, y, t)	-	Water surface level above datum (m)
p(x, y, t)	-	flux density in the x-direction (m^3/s/m)
q(x, y, t)	-	flux density in the y-direction (m^3/s/m)
h(x, y, t)	-	water depth (m)
S	-	source magnitude per unit horizontal area ($m^3/s/m^2$)
S_{ix}, S_{iy}	-	source impulse in x and y-directions ($m^3/s/m^2$.m/s)
e	-	evaporation rate (m/s)
g	-	gravitational acceleration (m/s^2)
C	-	Chezy resistance No. ($m^{1/2}$/s)
K_a	-	$C_w \frac{\rho_{air}}{\rho_{Water}}$
C_w	-	wind friction factor
W, W_X, W_Y(x, y, t)	-	wind speed and components in x- and y-directions (m/s)
p_a (x, y, t)	-	barometric pressure (Kg/m/s^2)
ρ_w	-	density of water (kg/m^3)
Ω	-	Coriolis coefficient (latitude dependent) (s^{-1})
ε(x, y)	-	eddy or momentum dispersion coefficient (m^2/s)
x, y	-	space coordinates (m)
t	-	time (s)

Advection and dispersion model

The advection-dispersion module (AD) of the MIKE 21 model suite simulates the spreading of return water in an aquatic environment under the influence of the fluid transport and associated natural dispersion process. The dispersing substance may be conservative or non-conservative, inorganic or organic: e.g. salt, heat, dissolved oxygen, inorganic phosphorus, nitrogen and other such water quality parameters. Applications of the MIKE 21 AD module are in principle essential for two types of investigations, viz., i) cooling water recirculation studies for power plants and salt recirculation studies for desalination plants, and ii) water quality studies connected with sewage outfalls and non-point pollution sources.

This module determines the concentration of the dispersing substance by solving the equation of conservation of mass for a dissolved or suspended substance. The concentration of the substance is calculated at each point of a rectangular grid covering the area of interest using a two-dimensional finite difference scheme. Information on the transport, i.e. currents and water depths at each point of the grid, are provided by the MIKE 21 HD module. Other data required in the model include effluent volume discharged, the concentration of the pollutant, initial and the boundary conditions.

Governing equation

The MIKE 21 AD module solves the advection-dispersion equation for dissolved or suspended substances in two dimensions. This is in reality the mass-conservation equation to which quantities of substances discharged and their concentrations at source and sink points are included together with their decay rate.

$$\frac{\partial}{\partial t}(hc)+\frac{\partial}{\partial x}(uhc)+\frac{\partial}{\partial y}(vhc) = \frac{\partial}{\partial x}\left[hD_x\frac{\partial C}{\partial x}\right]+\frac{\partial}{\partial y}\left[hD_y\frac{\partial C}{\partial y}\right]-Fhc+S$$

Symbol List

C	-	compound concentration (arbitrary units)
u, v	-	horizontal velocity components in the x, y directions (m/s)
h	-	water depth (m)
D_x, D_y	-	dispersion coefficients in the x, y directions (m^2/s)
F	-	linear decay coefficient (1/s)
S	-	$Q_s \cdot (C_s - C)$
Q_s	-	Source / sink discharge per unit horizontal area ($m^3/s/m^2$)
C_s	-	concentration of compound in the source / sink discharge.

Information on u, v and h at each time step is provided by the MIKE 21 HD module.

7.2. Units and Conventions used

Units: Units of all parameters and variables in the model study are according to international SI conventions. Coordinate system: The coordinate system used for model grid generation and other horizontal positioning was UTM based on WGS 84 spheroid. Vertical reference level: The depth information used in the tidal flow models is relative to Mean Sea Level (MSL); depths below MSL are defined negative.

Directions: Current – Ocean current directions refer to the direction **towards** which the flow is taking place. Directions of the flow are always given clockwise with respect to North. The Unit is degrees, where 360 degrees cover the circle. Wind - Wind directions refer to the direction **from** which the wind is approaching. Directions of the wind are always given clockwise with respect to North. The Unit is degrees, where 360 degrees cover the circle.

7.3. Model setup

The model domain in the study area stretches between the longitudes 80° 12' 13.08" E to 80° 19' 44.06" E and latitudes 12° 39' 15.06" N to

12° 45'49.05" N and an area of approximately 12 km x 13.5 km (Fig. 7.1). The grid spacing is 50 m in both directions. A rectilinear grid system was used for the simulation of flow field in the study region. In these region, the tide and wind induced flow fields over the study area for two lunar tidal cycles (28 days) were simulated for different monsoons, Viz. Fair weather (April), SW monsoon (July) and NE monsoon (November).

Depth Schematization: For the schematization of depths in the flow model, the depths of the sea were extracted from different sources viz., i) DHI - MIKE 21 – *C Map* data base, ii) Indian Naval Hydrographic Charts corresponding to this region and iii) the bathymetry measured at the site by Indomer in 2013.

Depth schematization or setting up bathymetries at model grid points has always been one of the most tedious, expensive and yet crucial part of any coastal modelling problem. It is now possible to greatly reduce the time and effort required to this task with the MIKE C-MAP's worldwide electronic chart database. This database and the program to extract the bathymetric data over the selected area with as much detail as possible have been developed jointly by DHI and C-MAP, Norway.

Boundary conditions: The coarse resolution model is forced by the tidal water level variations along the open sea boundaries. For the generation of these boundary conditions, the MIKE 21 *C-Map* data base can be used. These boundary conditions for the coarse resolution model are prescribed as time series of tidal water level variations along the open boundaries of the model.

If the tidal constituents along the boundaries of the coarse resolution model are available, then the boundary conditions are represented by:

$$h_t = A_0 + \sum_{i=1}^{n} f_i A_i \cos(\omega_i t + (v_0 + u)_i - g_i)$$

With:

h_t	=	water level at time = t
A_0	=	mean value of the signal
A_i	=	amplitude of component i
f_i	=	nodal amplitude factor of component i
ω_i	=	angular frequency of component i
$(v_0+u)_i$	=	astronomic argument of component i
g_i	=	phase lag of component i

For the modelling domain, the MIKE 21 *C-Map* tides derived for Pondicherry have been applied along the southern boundary and Chennai for the northern boundary. Along the eastern boundary the tide levels linearly interpolated between Pondicherry at south and Chennai at north have been assigned.

Calibration: The model is calibrated using the tides measured from 27.07.13 to 15.08.13. Good agreement is observed among the simulated and the measured data.

Seasons: The flow simulations were done for **fair weather**, i.e. when there is no wind and it leads to minimum mixing condition ('*conservative scenario*') with the prevalence of larger mixing zone having difference in salinity into the sea. The simulations were also carried out with wind forcing representing **southwest monsoon** and **northeast monsoon** conditions. In the presence of wind, the sea becomes more turbulent with high waves and the flow becomes stronger which then leads to good mixing with less mixing zone.

The tidal effects on currents in the nearshore region particularly in the study area are small and the currents are generally dominated by wind. By the onset of southwest monsoon, the coastal currents turn gradually and tend to prevail consistently towards north. Consequently, on the commencement of northeast monsoon, the nearshore currents tend to be consistently northward. Hence during monsoons, the discharge released through the diffuser tends to travel in coast parallel direction, towards south in NE monsoon and north during SW monsoon.

To represent monsoon seasons, the normal wind conditions expected during the southwest and northeast monsoons, i.e. 10 m/s, corresponding to 25% exceedence was used in the model. For the flow simulation during the fair weather, no wind was introduced in the model. In the secondary dispersion studies, the discharge of return water introduced at any grid cell is assumed to be uniformly dispersed over the entire volume of water in this grid cell.

Input to AD Model

Details of intakes: The existing seawater intake laid for Phase I draws 260 MLD ≈ 10833 m^3/hour of seawater. For the Phase II, i.e., the proposed seawater intake considered in this report will draw 1147 MLD ≈ 47791.66 m^3/hour of seawater. There is a proposal to establish Phase III unit in future, which will have a separate intake system to draw the seawater of 455 MLD ≈ 18958.33 m^3/hour.

Details of Outfall: The existing outfall laid for Phase I discharges 160 MLD ≈ 6667 m^3/hour of return water. For the Phase II, i.e., the proposed outfall considered in this report will discharge 747 MLD ≈ 31125 m^3/hour of brine reject. There is a proposal to establish Phase III unit in future, which is expected to discharge 305 MLD =12708.33 m^3/hour through a separate outfall.

Distance between outfalls: The outfalls distance from the Phase II to Phase I ≈ 1260 m and Phase III to Phase I ≈ 550 m.

Salinity of return water: The brine reject will have the salinity of 71 ppt which will be 33 ppt higher than the ambient seawater salinity (38 ppt). There will be no change in other water quality parameters compared to the ambient values.

Modelling scenarios: In the present case, for the discharge of Phase II development, the model study has been conducted for the two scenarios as detailed below.

Case 1: Phase I (Existing) + Phase II

Case 2: Phase I (Existing) + Phase II + Phase III (future)

7.4. Simulations

In each simulation the flow field and the mixing pattern were obtained for a period of one lunar month (i.e. 28 days). The total number of simulations carried out is six as detailed below.

Number of simulations = I1 x I 2 x I 3 = 6

Where,

Number of dispersing substance	I 1 = 1
Number of seasons	I 2 = 3
Number of scenarios	I 3 = 2

The instantaneous flow and mixing patterns corresponding to flood and ebb phases during spring and neap tide periods are presented in the report.

8. RESULTS

Fair weather

The flow simulation and the corresponding secondary dispersion of the return water for fair weather with no wind condition (representing conservative mixing scenario) are presented.

Spring tide

Flow field: The tide induced flow fields under no wind condition during the *flood and ebb phases on a spring tidal day* close to the project region are presented in Fig. 8.1. The magnitude of currents over a major portion of the project region was around 0.12 m/s with the direction of flow towards north during the flood phase and towards south during the ebb phase.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.2. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 2 ppt was observed to occur at 80 m and 250 m from phase I and phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.3. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 2 ppt was observed to occur at 80 m, 250 m and 100 m from phase I, phase II and phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Neap tide

Flow field: The tide induced flow field under no wind condition during the *flood and ebb phases on a neap tidal day* close to the project region is presented in Fig. 8.4. The magnitude of currents over a major portion of the project region was around 0.10 m/s with the direction of flow towards north during the flood phase and towards south during the ebb phase.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged at 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.5. The brine discharged in the nearshore water undergoes dilution around the outfall point such that the difference in salinity of 2 ppt was observed to occur at 90 m and 300 m from phase I and phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.6. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 2 ppt was observed to occur at 80 m, 300 m and 120 m from phase I, phase II and phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Southwest monsoon

Spring tide

Flow field: The flow field due to tide and southwest monsoon wind during the *flood and ebb phase on a spring tidal day* for close to the project region in Fig. 8.7. The magnitude of currents over major portion of the project region remains around 0.25 m/s with the direction of flow towards north.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged at 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.8. The brine discharged in the nearshore water undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m and 500 m from phase I and phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.9. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m, 500 m and 90 m from phase I, phase II and phase III outfalls respectively in the shore parallel direction. The modelling result reveals that the there is no merging between the outfalls.

Neap tide

Flow field: The flow field due to tide and southwest monsoon wind during the *flood and ebb phase on a neap tidal day* close to the project region is presented in Fig.

8.10. The magnitude of currents over major portion of the project region remains around 0.20 m/s with the direction of flow towards north.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.11. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the salinity of 1 ppt above the ambient condition was observed to occur within 60 m and 550 m from phase I and phase II outfalls respectively in the shore parallel direction. The modelling results reveals the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.12. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 60 m, 550 m and 100 m from phase I, phase II and phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Northeast monsoon

Spring tide

Flow field: The flow field due to tide and northeast monsoon wind during the *flood and ebb phase on a spring tidal day* close to the project region is presented in Fig. 8.13. The magnitude of currents over major portion of the project region remains around 0.19 m/s with the direction of flow towards south.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged 600 m and 750 m offshore in Phase I and

Phase II respectively is shown in Fig. 8.14. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m and 180 m from phase I and phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.15. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt above was observed to occur at 50 m, 180 m and 70 m from phase I, phase II and phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Neap tide

Flow field: The flow field due to tide and southwest monsoon wind during the *flood and ebb phase on a neap tidal day* close to the project region is presented in Fig. 8.16. The magnitude of currents over major portion of the project region remains around 0.17 m/s with the direction of flow towards south.

Dispersion due to Phase I and Phase II outfalls: The mixing pattern of the brine reject in the nearshore water discharged 600 m and 750 m offshore in Phase I and Phase II respectively is shown in Fig. 8.17. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m and 210 m from phase I and phase II outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

Dispersion due to Phase I, Phase II and Phase III outfalls: The mixing pattern of the brine reject in the nearshore water discharged from phase I, phase II and phase III is shown in Fig. 8.18. The brine discharged in the nearshore waters undergoes dilution around the outfall point such that the difference in salinity of 1 ppt was observed to occur at 50 m, 210 m and 80 m from phase I, phase II and phase III outfalls respectively in the shore parallel direction. The modelling results reveal that the there is no merging between the outfalls.

9. DISCUSSION AND CONCLUSION

The existing seawater intake laid for Phase I draws 260 MLD ≈ 10833 m^3/hour of seawater. For the Phase II, i.e., the proposed seawater intake considered in this report will draw 1147 MLD ≈ 47791.66 m^3/hour of seawater. There is a proposal to establish Phase III unit in future, which will have a separate intake system to draw the seawater of 455 MLD ≈ 18958.33 m^3/hour.

The existing outfall laid for Phase I discharges 160 MLD ≈ 6667 m^3/hour of return water. For the Phase II, i.e., the proposed outfall considered in this report will discharge 747 MLD ≈ 31125 m^3/hour of brine reject. There is a proposal to establish Phase III unit in future, which is expected to discharge 305 MLD ≈12708.33 m^3/hour through a separate outfall.

The brine reject will have the salinity of 71 ppt which will be 33 ppt higher than the ambient seawater salinity (38 ppt). There will be no change in other water quality parameters compared to the ambient values.

The MIKE 21 flow simulation study showed that the tide induced flow in the project region during fair weather is of the order of 0.12 m/s. The increase in turbulence due to stronger currents (> 0.25 m/s) induced by monsoon winds and rough seas would enhance the mixing during the southwest and northeast monsoons. The currents during the southwest monsoon are observed to be stronger (> 0.25 m/s) than the remaining period of the year leading to higher rate of mixing.

Based on the Mike 21 Modelling studies, it is indicated that the brine undergoes dilution to a difference in salinity of 2 ppt above the ambient condition. The plumes of 2 ppt salinity difference spread from different outfalls do not merge with each other and they get diluted with their respective mixing zone. On the other hand the difference in salinity of 1 ppt is found to merge with other outfalls. However during the monsoon, the dilution is very high and there is no merging of plumes at all over at < 1ppt.

The study also shows that the brine reject discharged into the shoreline do not reach the shore and there will be no shoreline connection and no contaminations of the water near the coast.

Further it is noticed that there is no recirculation of discharged water into the intake.

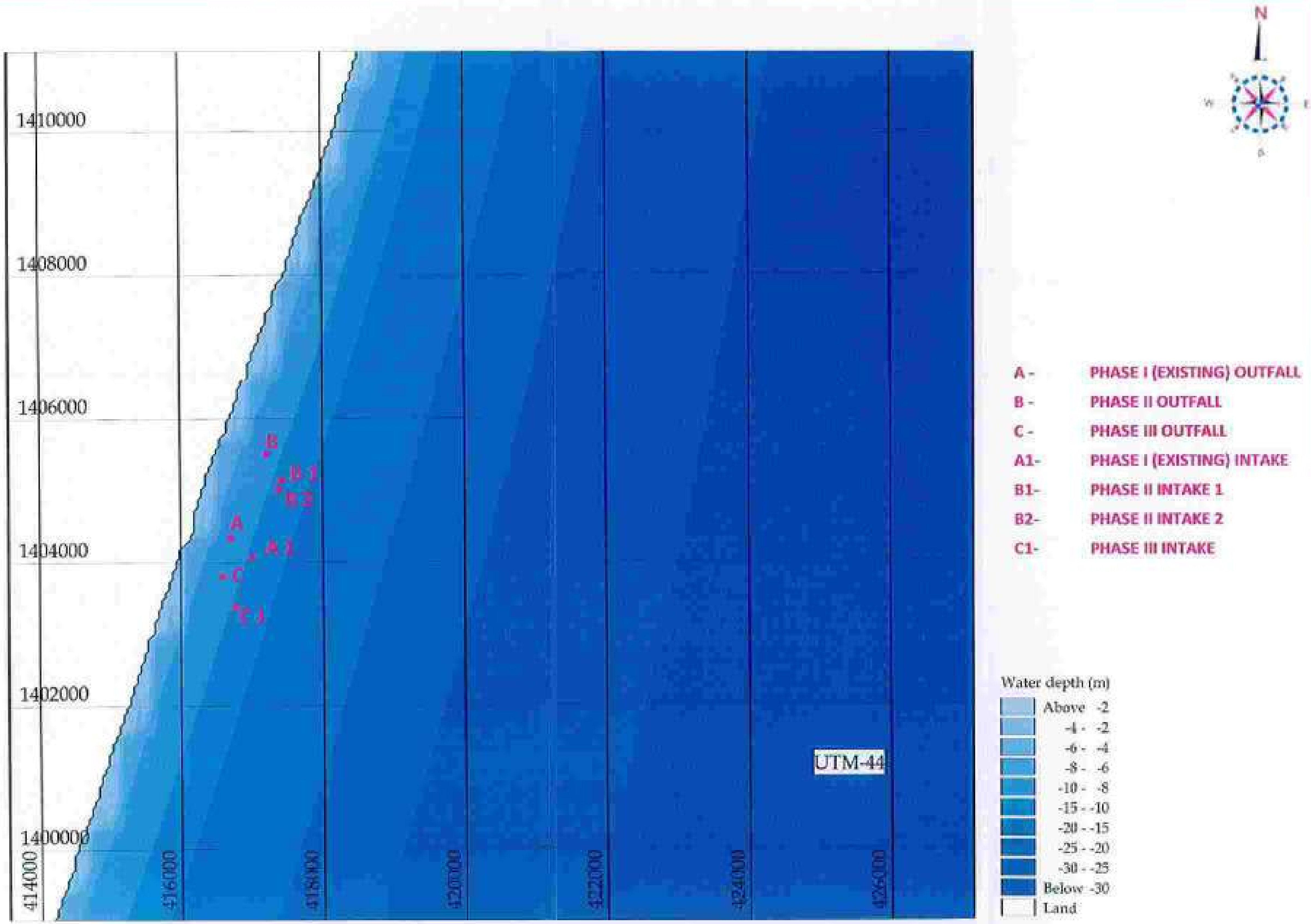
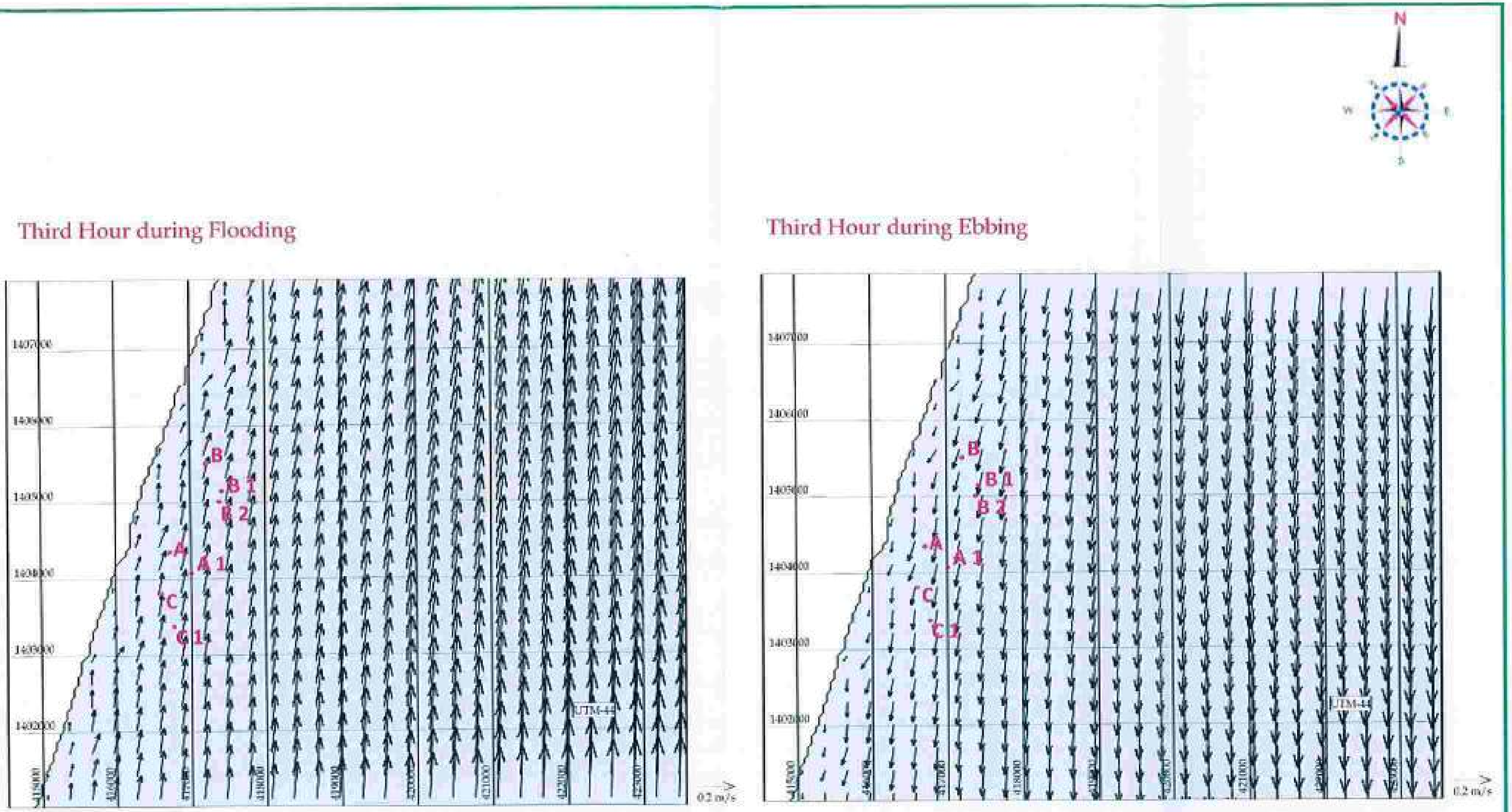
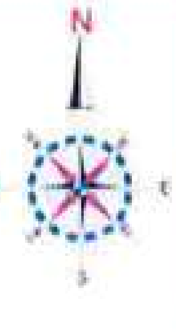


Fig. 7.1. Bathymetry for Mike 21 HD & AD Module



A -	PHASE I (EXISTING) OUTFALL
B -	PHASE II OUTFALL
C -	PHASE III OUTFALL
A1-	PHASE I (EXISTING) INTAKE
B1-	PHASE II INTAKE 1
B2-	PHASE II INTAKE 2
C1-	PHASE III INTAKE

Fig. 8.1. Flow field - Spring tide –Fair weather



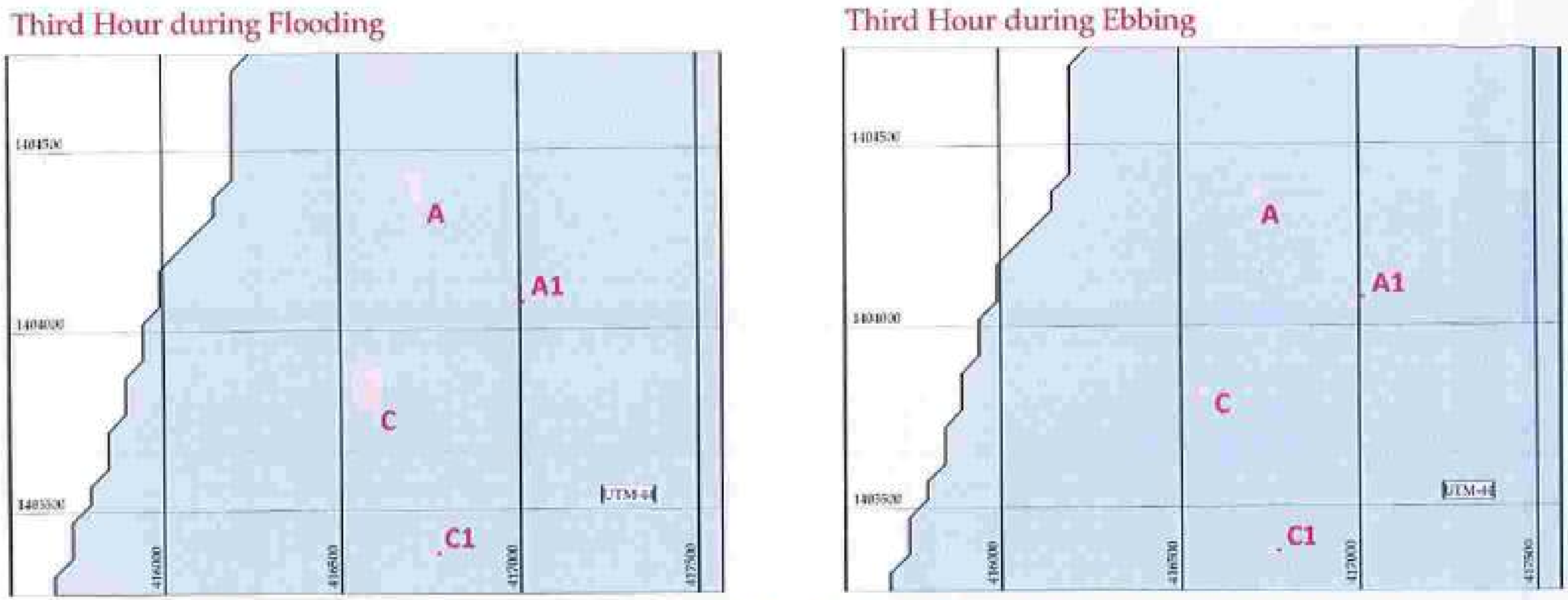


Fig. 8.2. Secondary Dispersion – Spring tide - Fair weather – Phase I (Existing) & Phase III

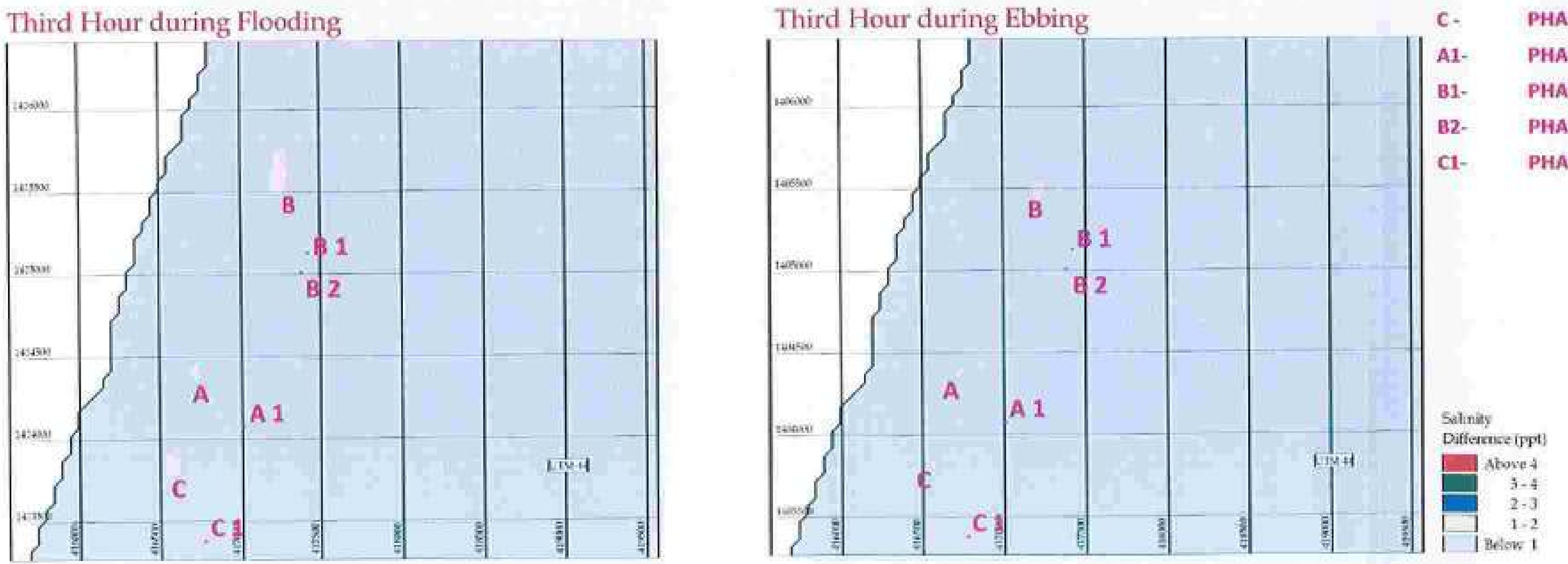
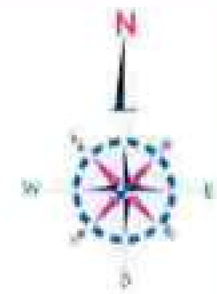


Fig. 8.3. Secondary Dispersion – Spring tide - Fair weather – Phase I (Existing), Phase II & Phase III



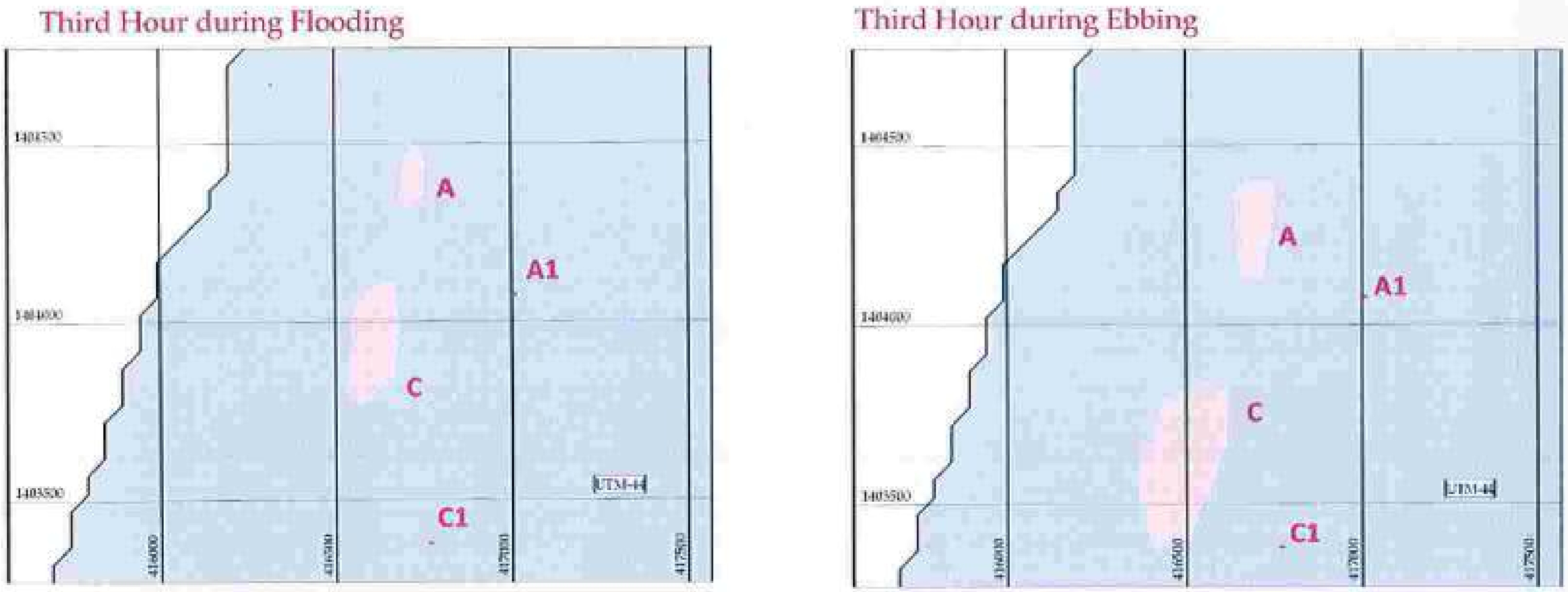


Fig. 8.5. Secondary Dispersion – Neap - Fair weather – Phase I (Existing) & Phase III

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

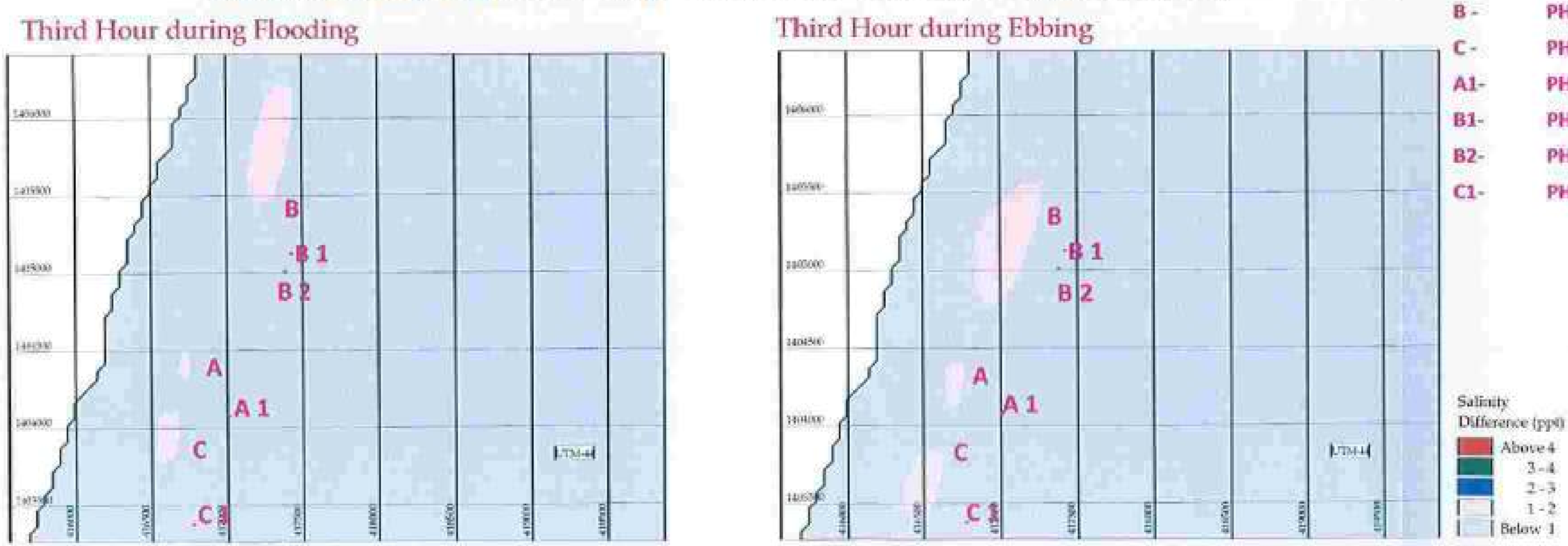
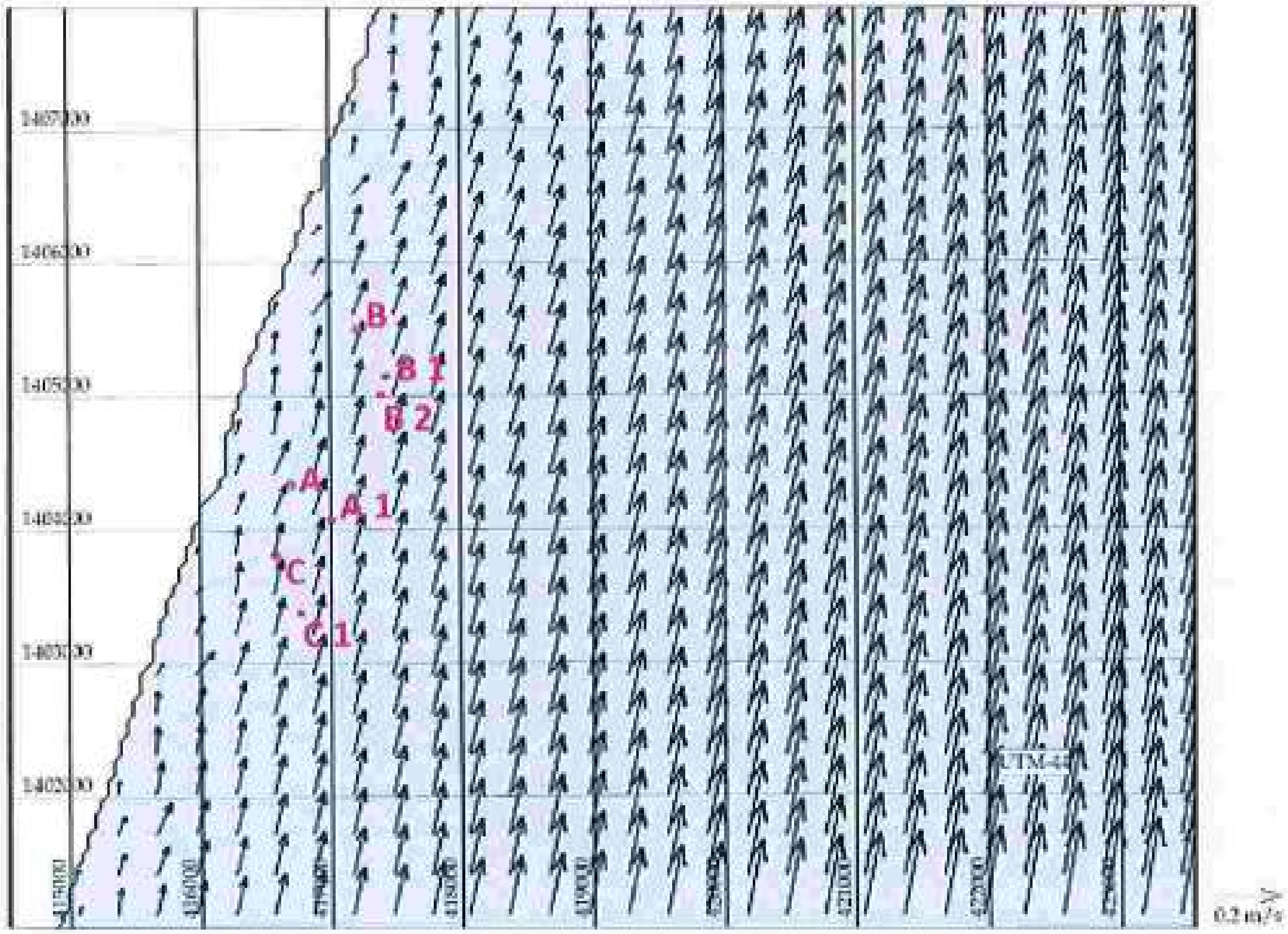
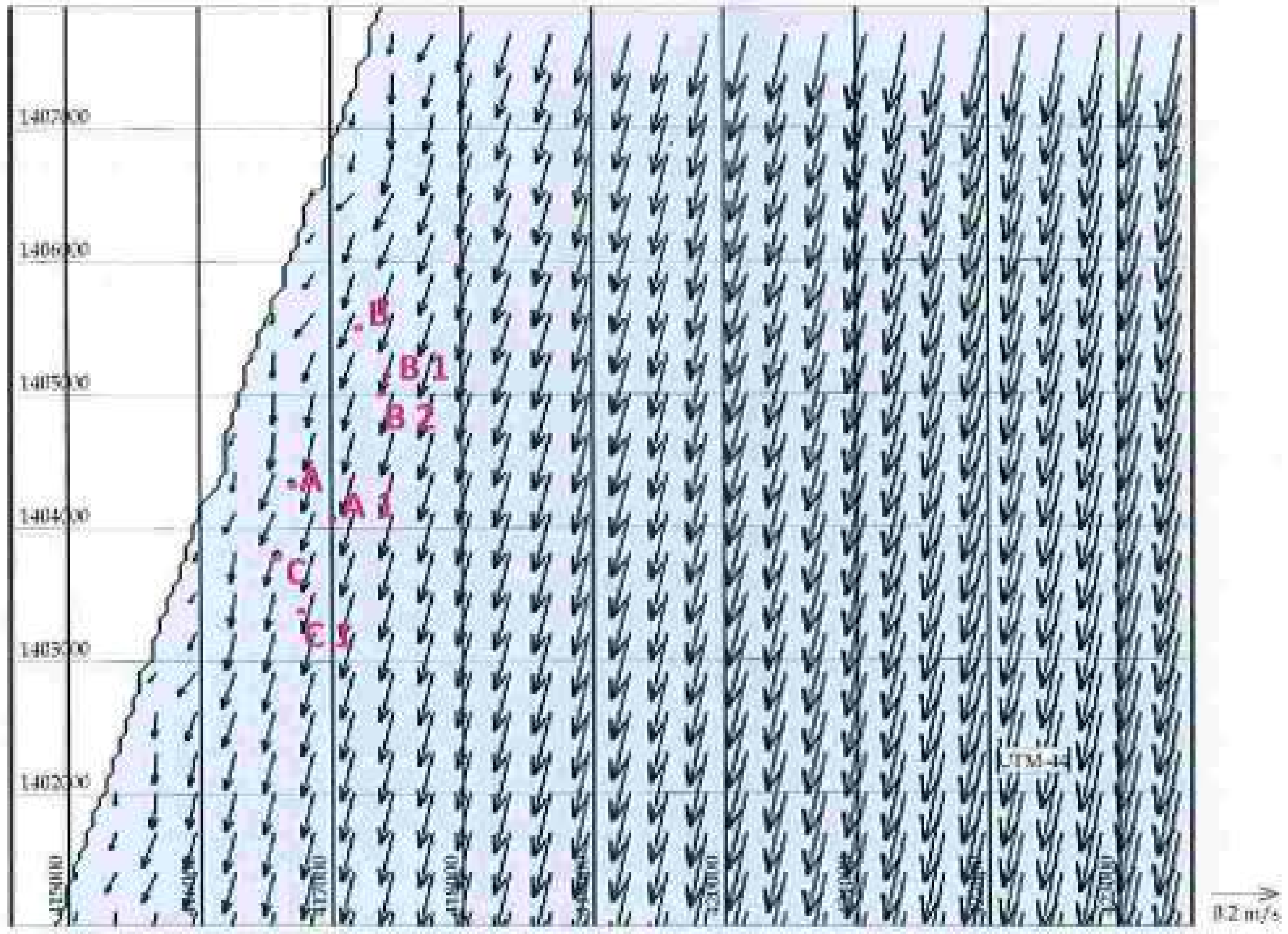


Fig. 8.6. Secondary Dispersion – Neap tide - Fair weather – Phase I (Existing), Phase II & Phase III

Third Hour during Flooding



Third Hour during Ebbing



A -	PHASE I (EXISTING) OUTFALL
B -	PHASE II OUTFALL
C -	PHASE III OUTFALL
A1-	PHASE I (EXISTING) INTAKE
B1-	PHASE II INTAKE 1
B2-	PHASE II INTAKE 2
C1-	PHASE III INTAKE

Fig. 8.4. Flow field - Neap tide – Fair weather

Third Hour during Flooding

Third Hour during Ebbing

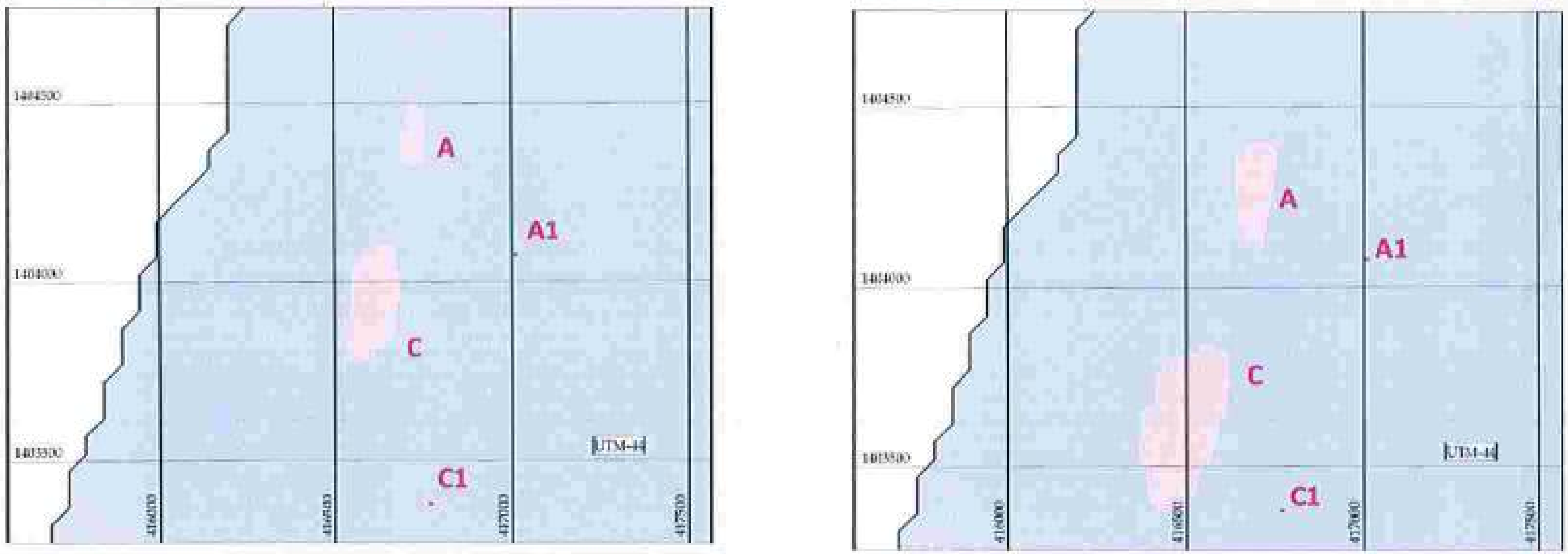


Fig. 8.5. Secondary Dispersion – Neap - Fair weather – Phase I (Existing) & Phase III

A -	PHASE I (EXISTING) OUTFALL
B -	PHASE II OUTFALL
C -	PHASE III OUTFALL
A1-	PHASE I (EXISTING) INTAKE
B1-	PHASE II INTAKE 1
B2-	PHASE II INTAKE 2
C1-	PHASE III INTAKE

Third Hour during Flooding

Third Hour during Ebbing

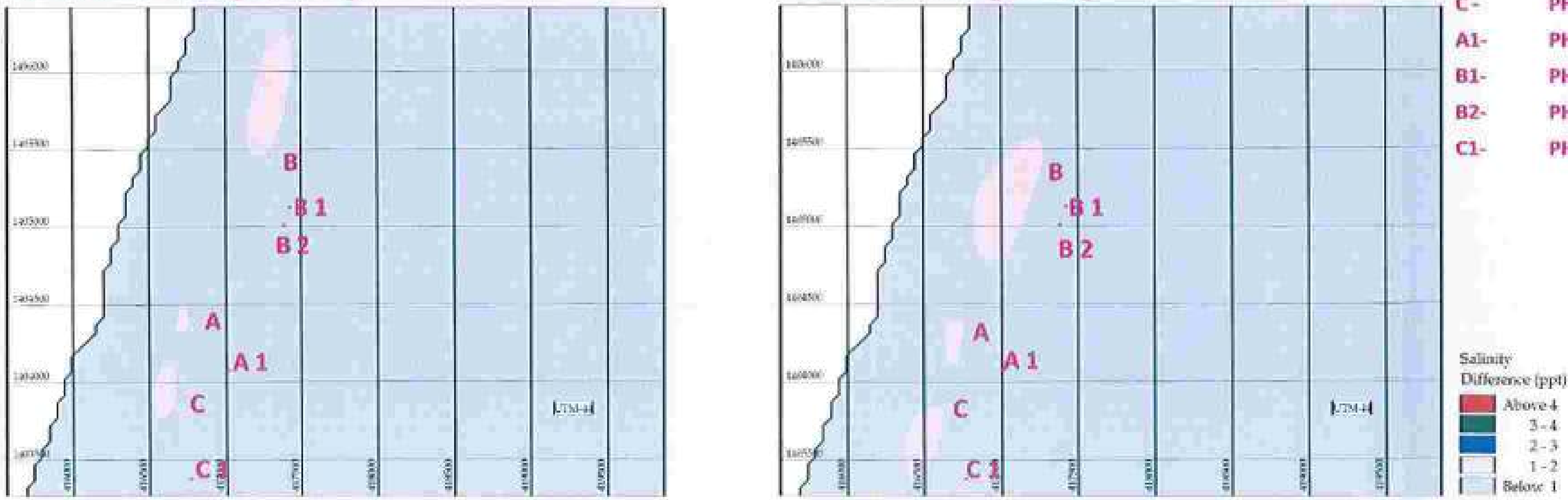
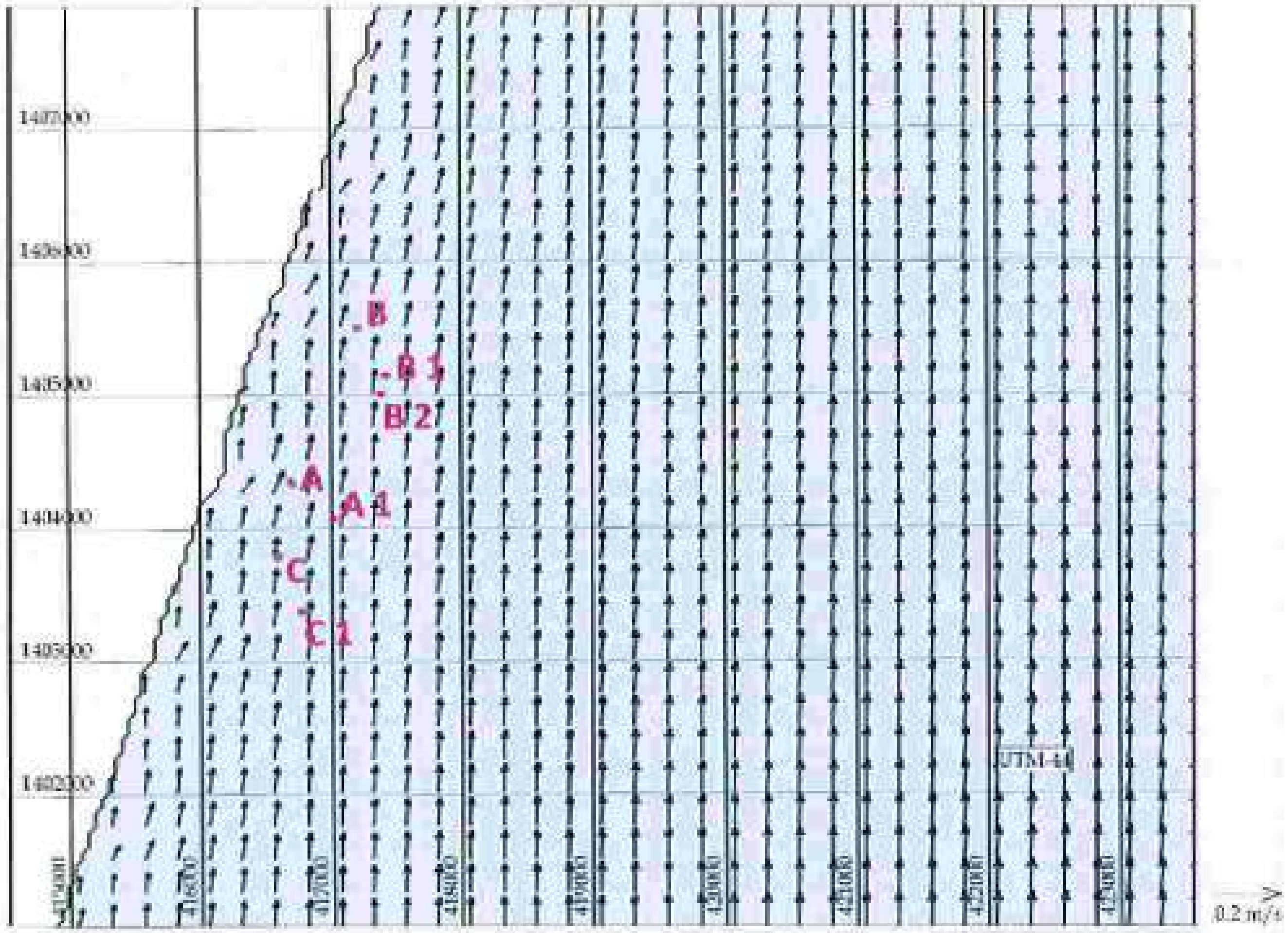
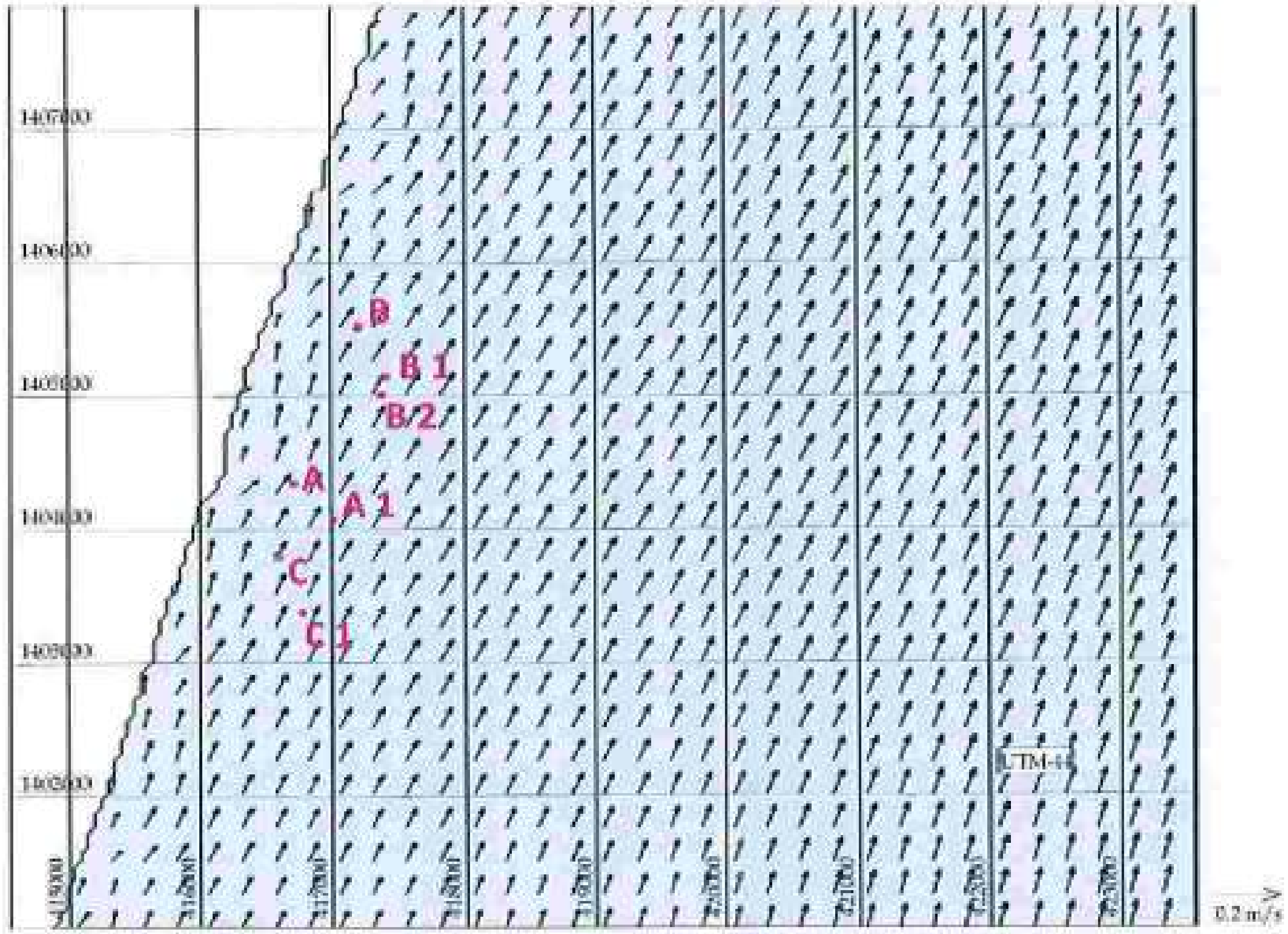


Fig. 8.6. Secondary Dispersion – Neap tide - Fair weather – Phase I (Existing), Phase II & Phase III

Third Hour during Flooding



Third Hour during Ebbing



A -	PHASE I (EXISTING) OUTFALL
B -	PHASE II OUTFALL
C -	PHASE III OUTFALL
A1-	PHASE I (EXISTING) INTAKE
B1-	PHASE II INTAKE 1
B2-	PHASE II INTAKE 2
C1-	PHASE III INTAKE

Fig. 8.7. Flow field - Spring tide – SW Monsoon

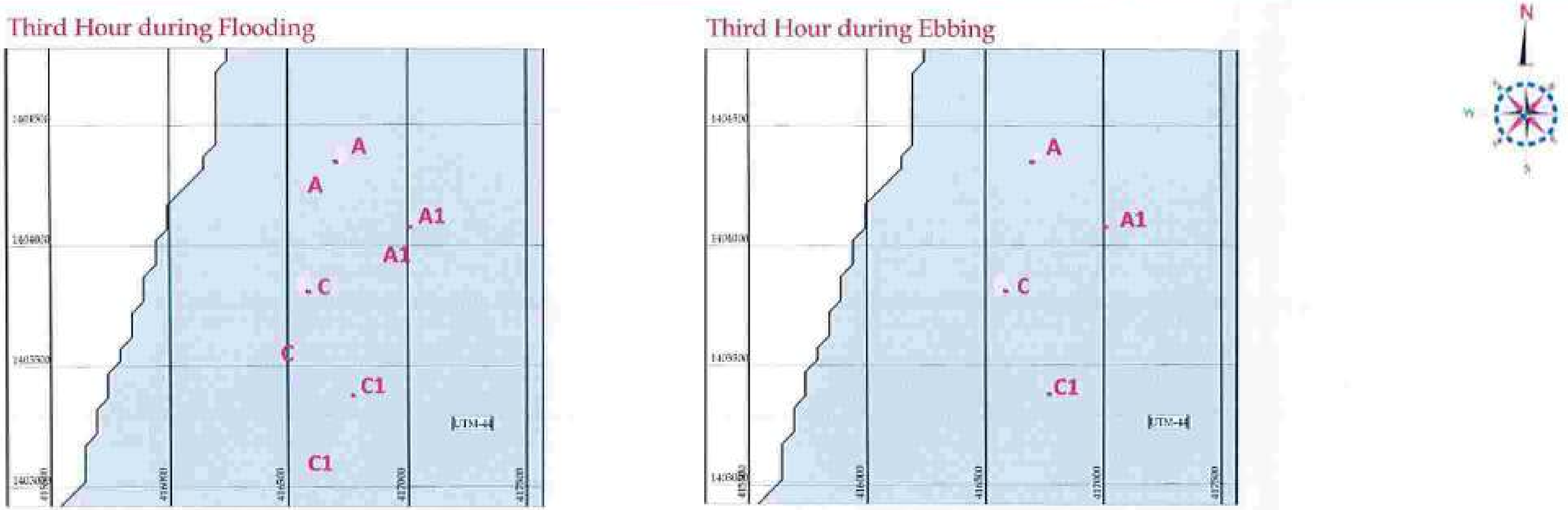


Fig. 8.8. Secondary Dispersion – Spring tide – SW Monsoon – Phase I (Existing) & Phase III

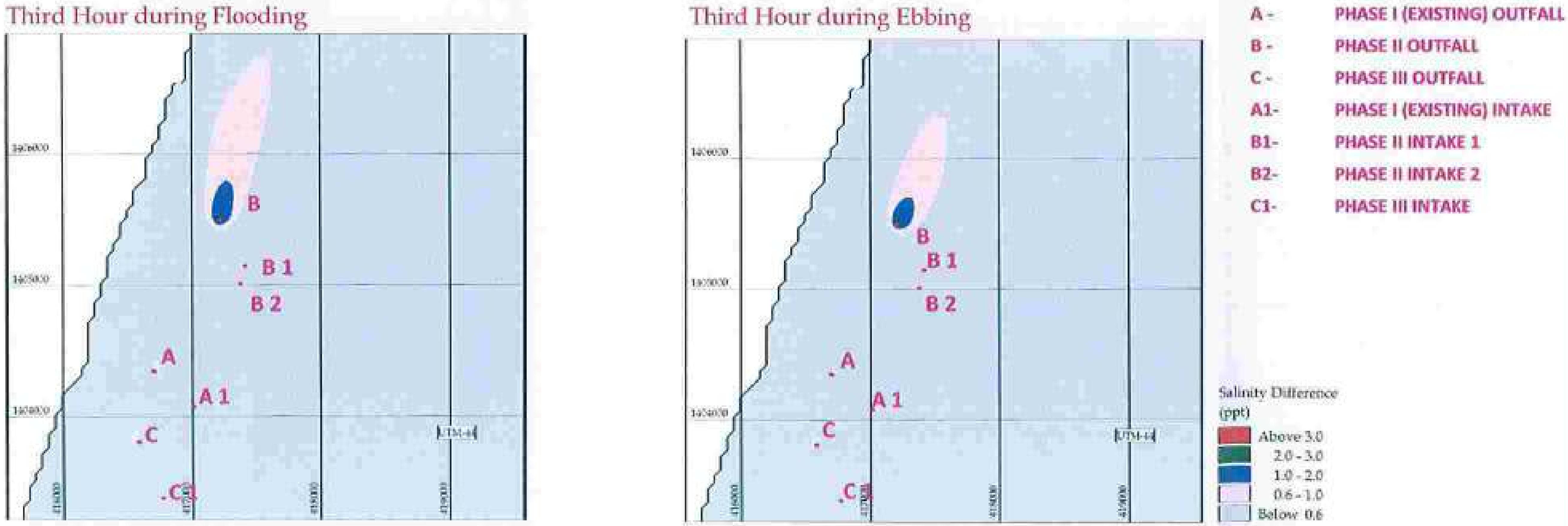
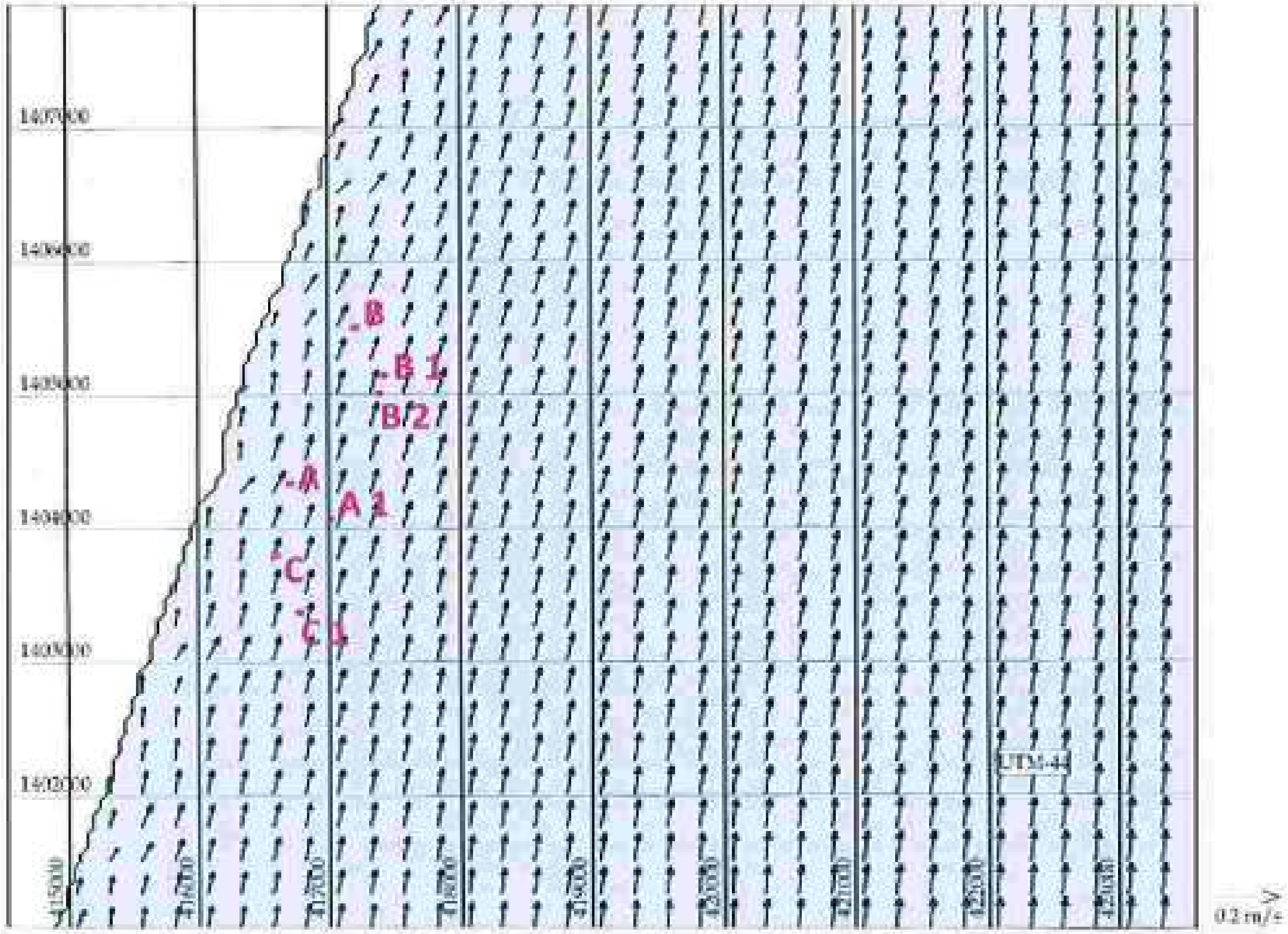


Fig. 8.9. Secondary Dispersion – Spring tide – SW Monsoon – Phase I (Existing), Phase II & Phase III

Third Hour during Flooding



Third Hour during Ebbing

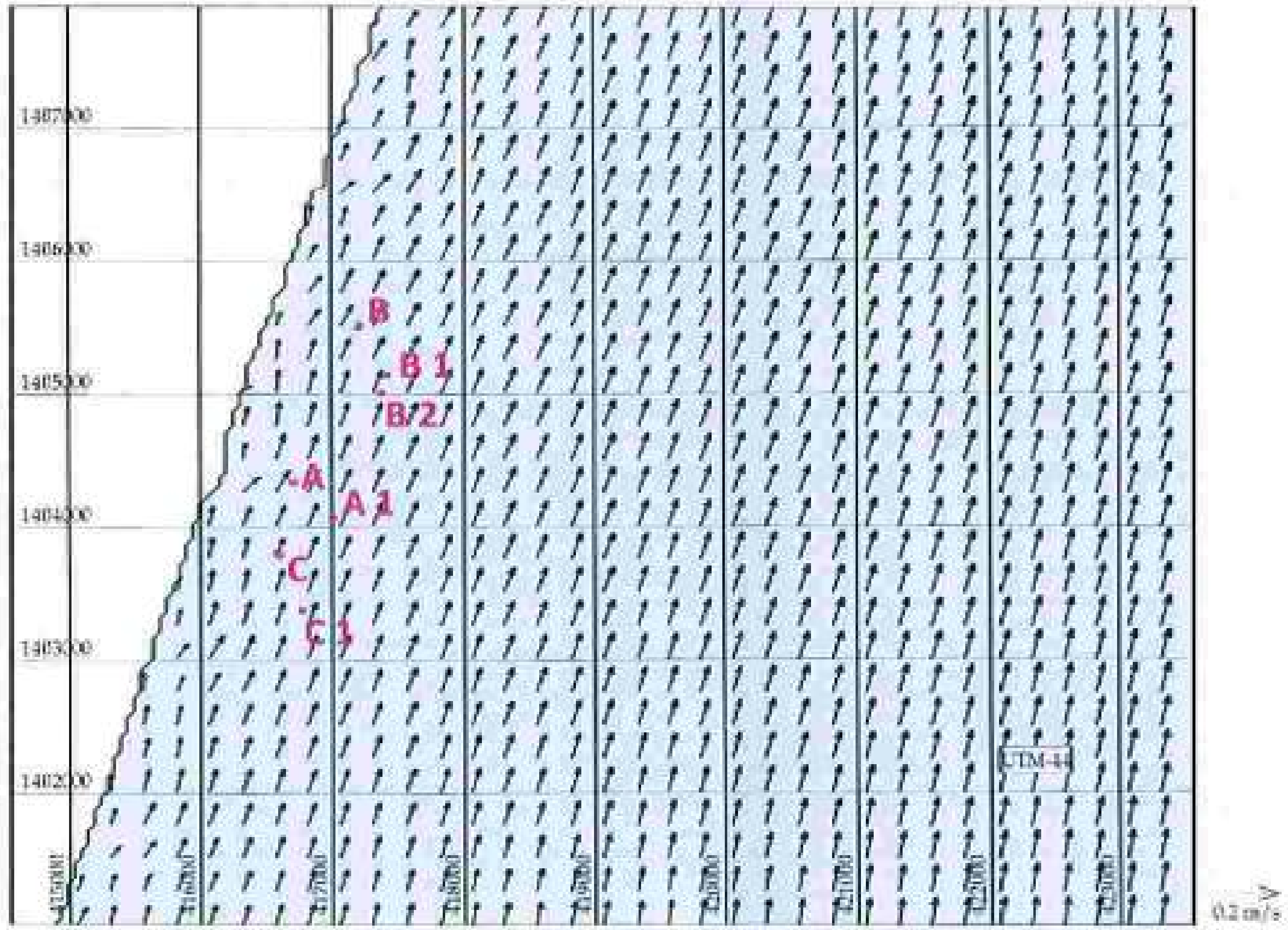


Fig. 8.10. Flow field - Neap tide – SW Monsoon

A -	PHASE I (EXISTING) OUTFALL
B -	PHASE II OUTFALL
C -	PHASE III OUTFALL
A1-	PHASE I (EXISTING) INTAKE
B1-	PHASE II INTAKE 1
B2-	PHASE II INTAKE 2
C1-	PHASE III INTAKE

Third Hour during Flooding　　Third Hour during Ebbing

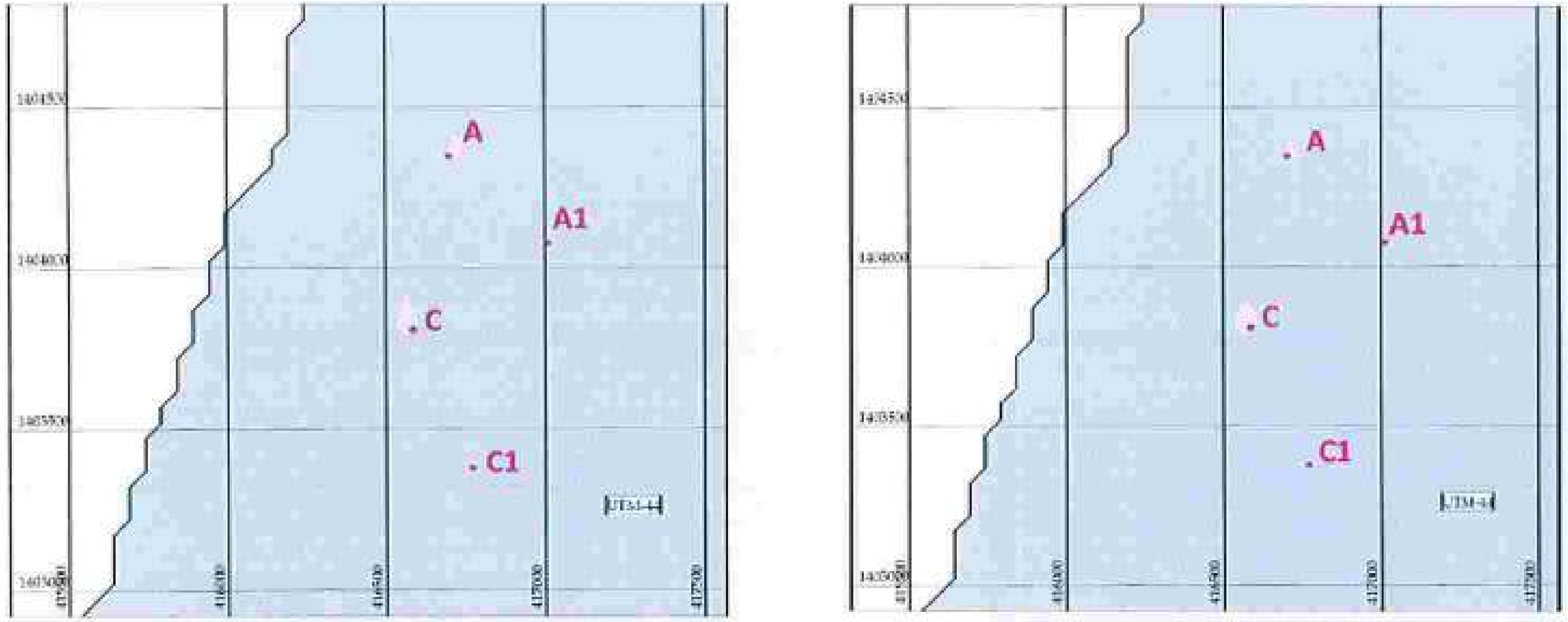


Fig. 8.11. Secondary Dispersion – Neap tide – SW Monsoon – Phase I (Existing) & Phase III

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding　　Third Hour during Ebbing

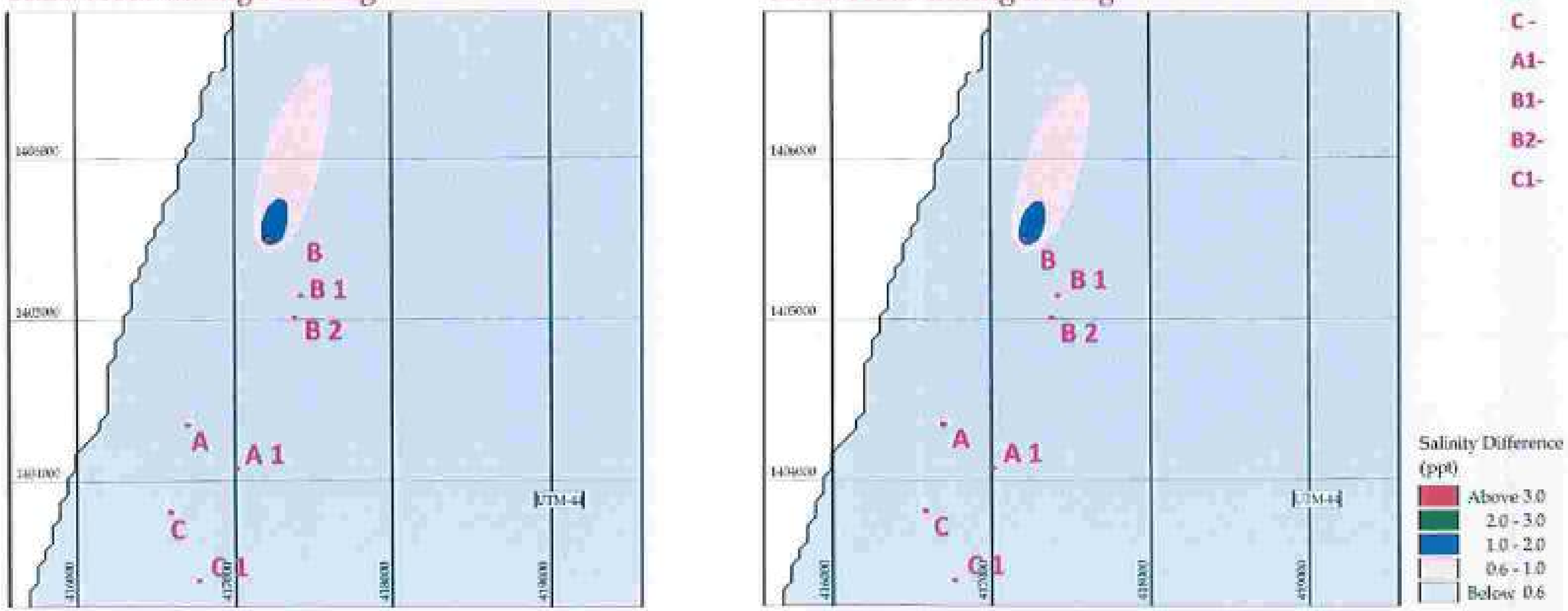
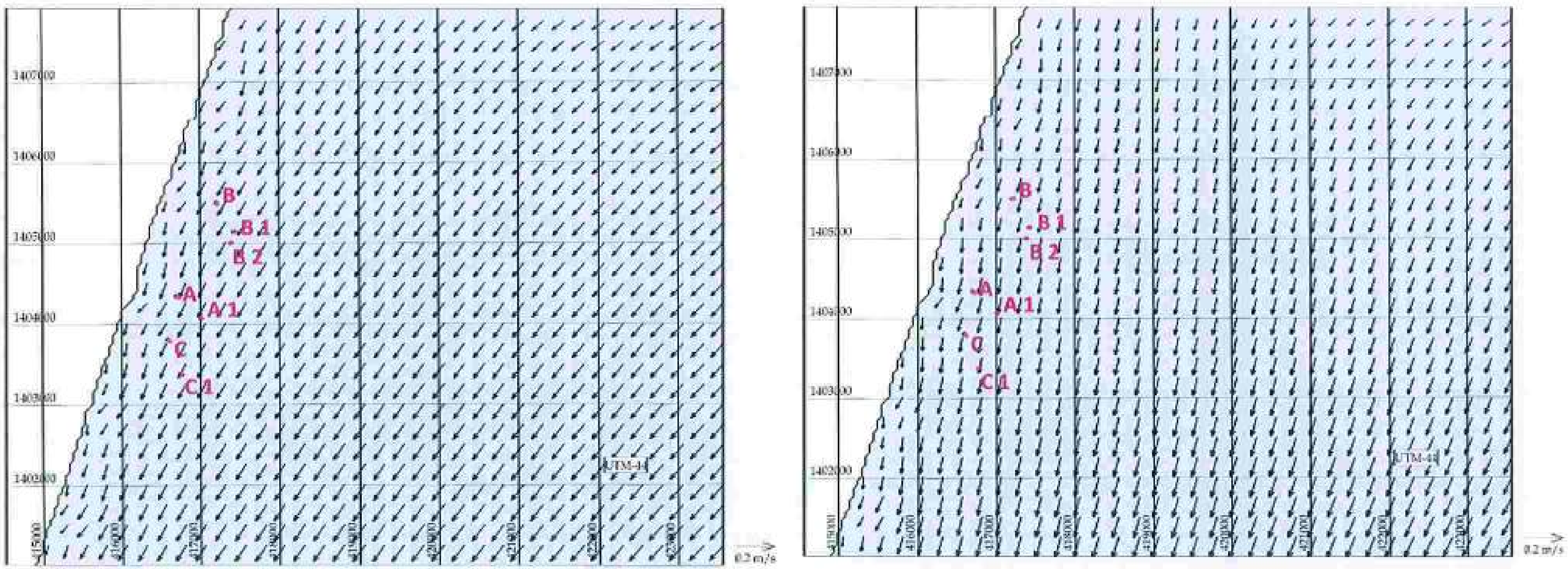


Fig. 8.12. Secondary Dispersion – Neap tide – SW Monsoon – Phase I (Existing), Phase II & Phase III

Third Hour during Flooding

Third Hour during Ebbing



A - PHASE I (EXISTING) OUTFALL

B - PHASE II OUTFALL

C - PHASE III OUTFALL

A1- PHASE I (EXISTING) INTAKE

B1- PHASE II INTAKE 1

B2- PHASE II INTAKE 2

C1- PHASE III INTAKE

Fig. 8.13. Flow field - Spring tide - NE Monsoon

Third Hour during Flooding

Third Hour during Ebbing

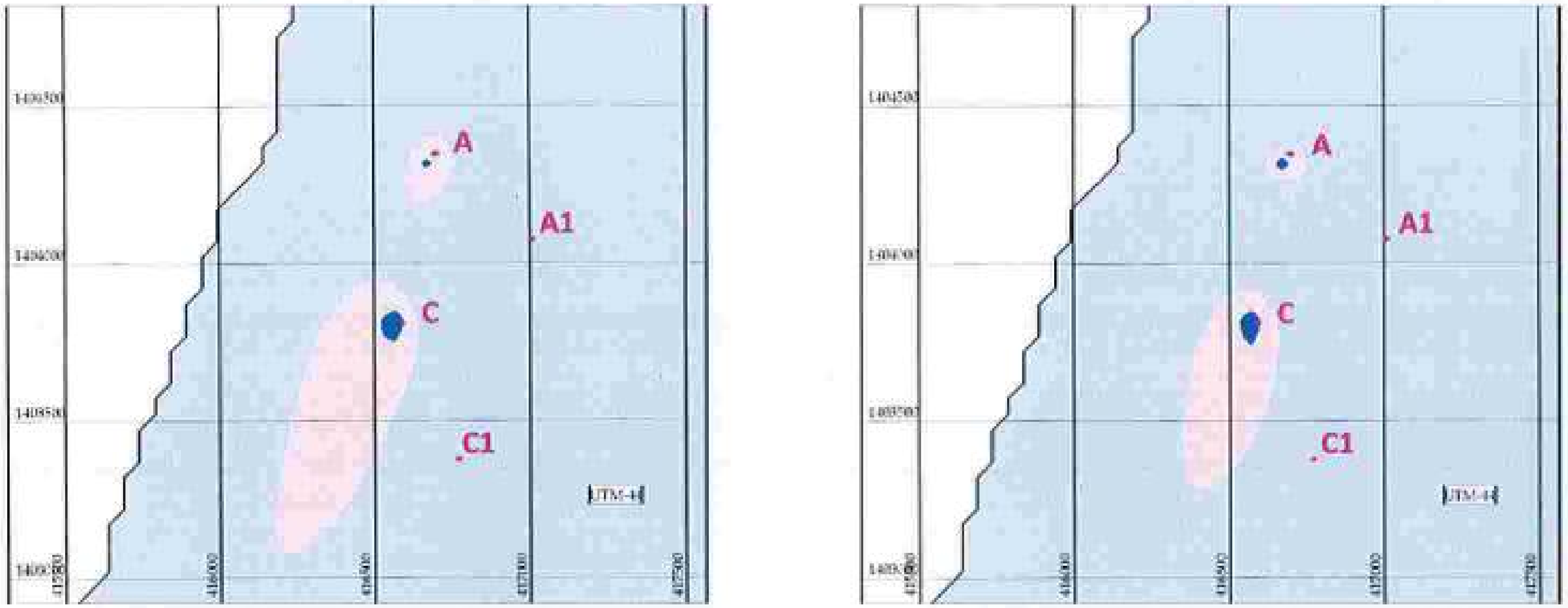


Fig. 8.14. Secondary Dispersion - Spring tide - NE Monsoon - Phase I (Existing) & Phase II

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding

Third Hour during Ebbing

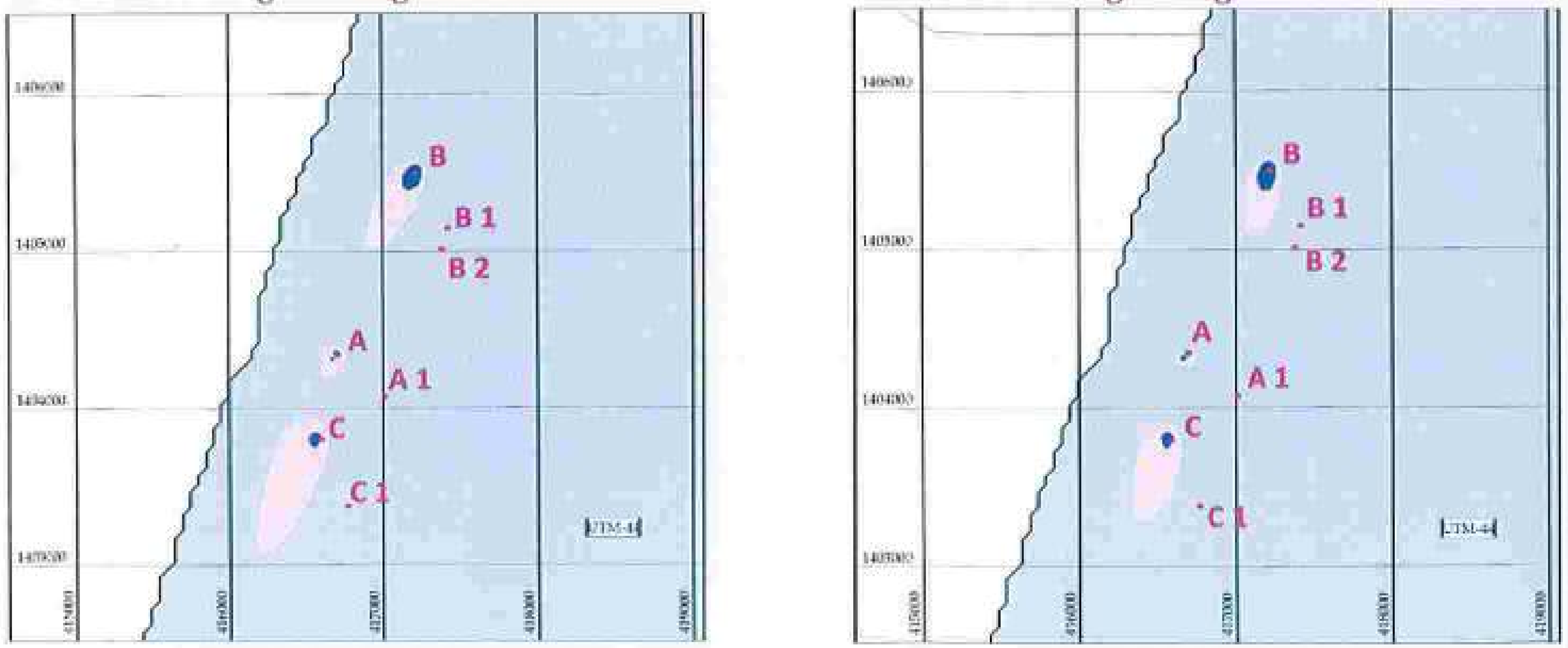
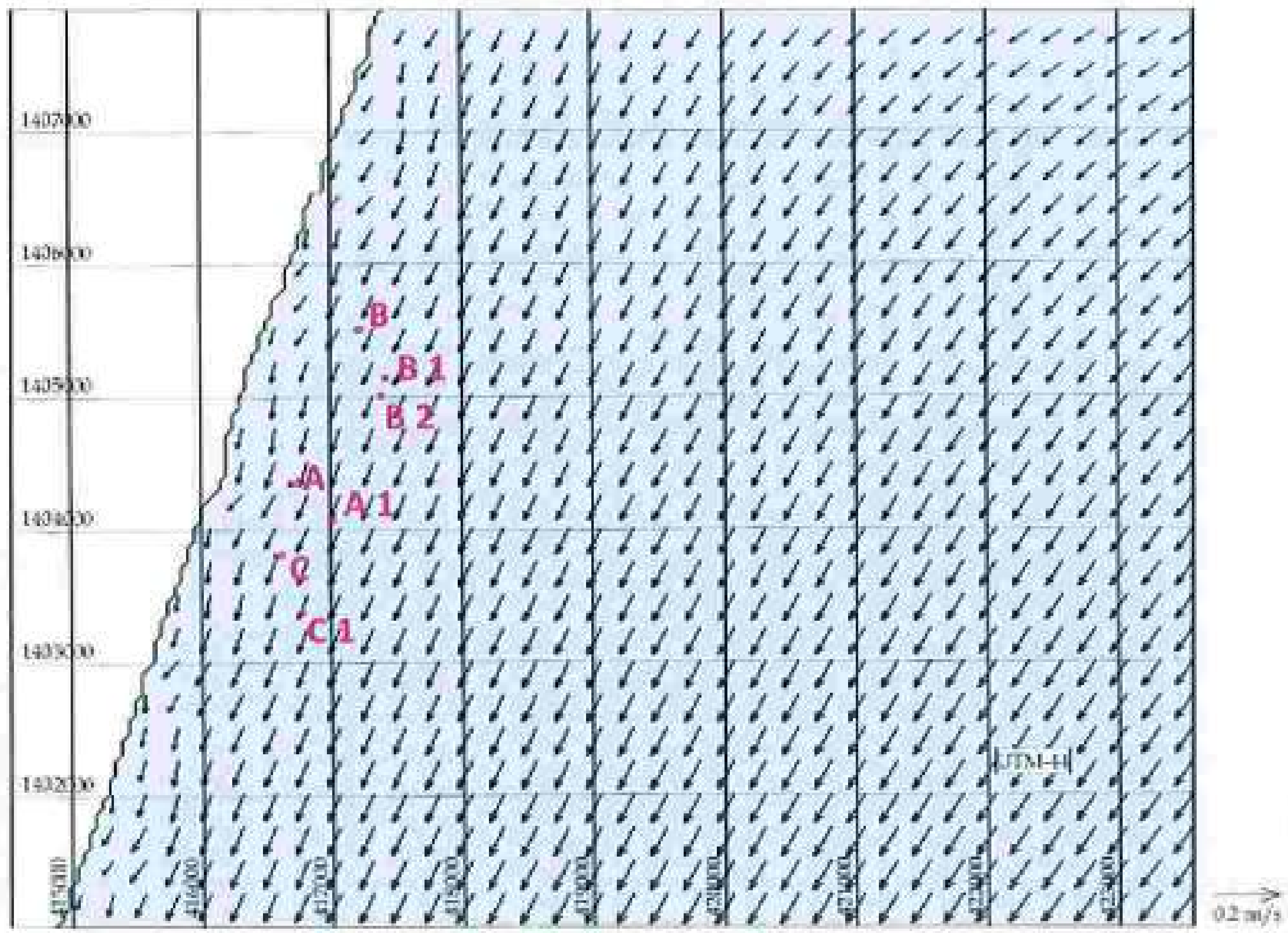
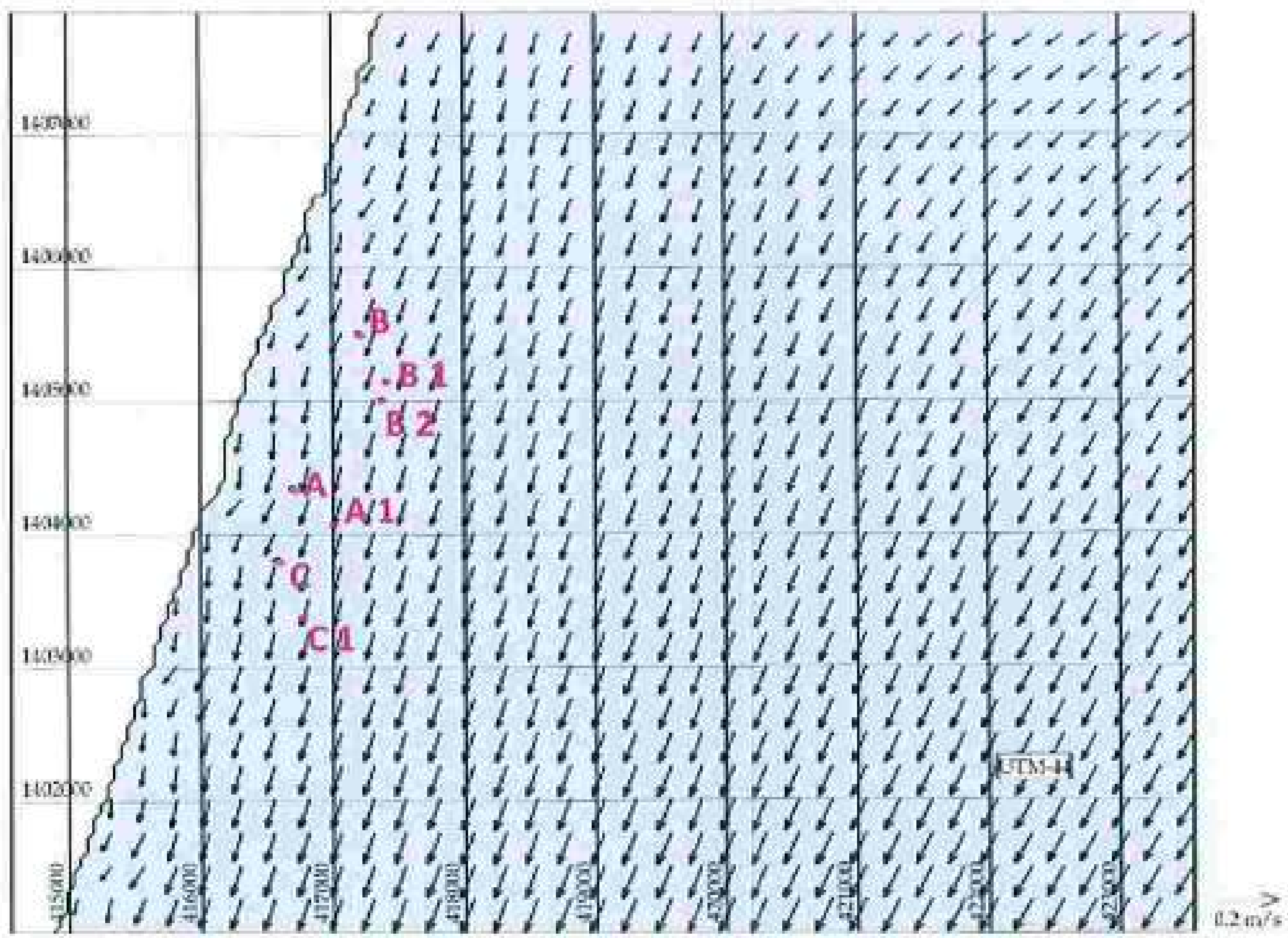


Fig. 8.15. Secondary Dispersion - Spring tide - NE Monsoon - Phase I (Existing), Phase II & Phase III

Third Hour during Flooding



Third Hour during Ebbing



A -	PHASE I (EXISTING) OUTFALL
B -	PHASE II OUTFALL
C -	PHASE III OUTFALL
A1-	PHASE I (EXISTING) INTAKE
B1-	PHASE II INTAKE 1
B2-	PHASE II INTAKE 2
C1-	PHASE III INTAKE

Fig. 8.16. Flow field - Neap tide - NE Monsoon

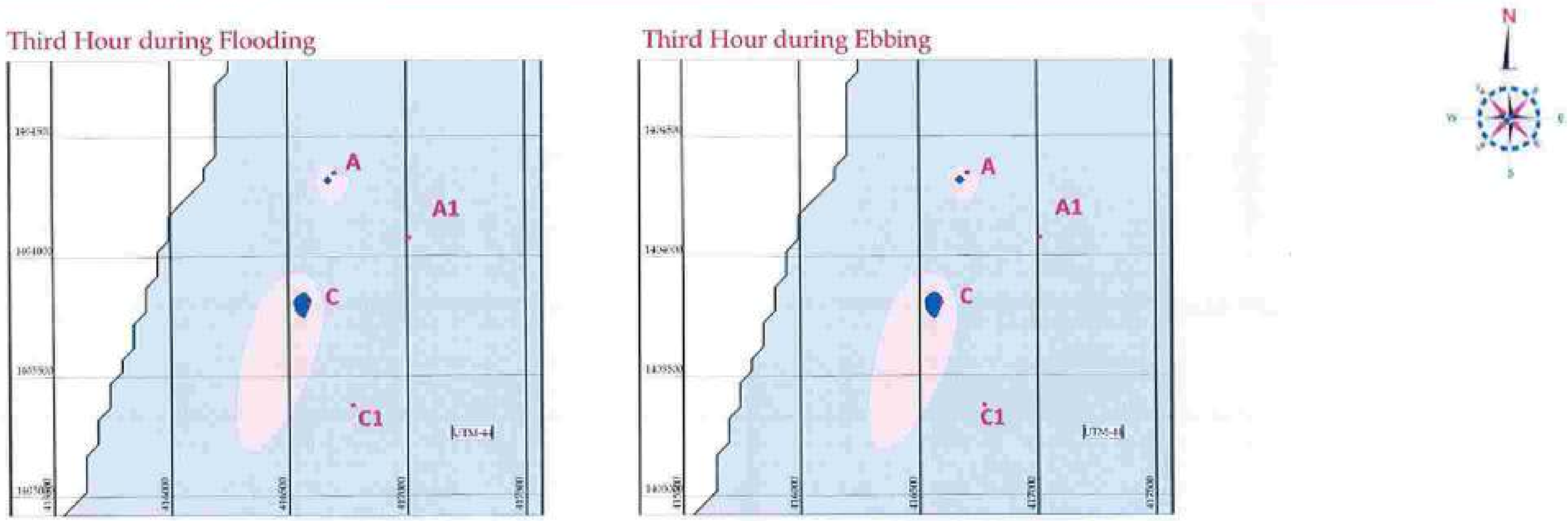


Fig. 8.17. Secondary Dispersion - Neap tide - NE Monsoon - Phase I (Existing) & Phase II

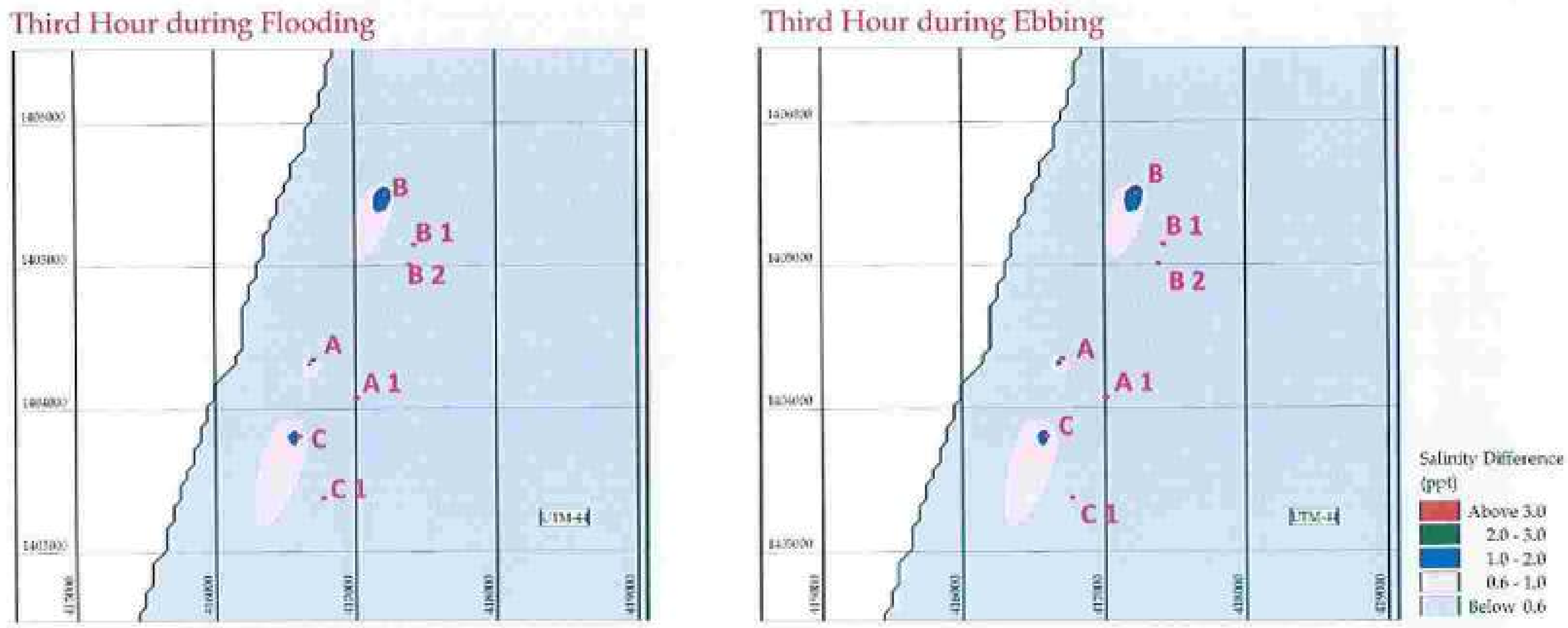


Fig. 8.18. Secondary Dispersion - Neap tide - NE Monsoon - Phase I (Existing), Phase II & Phase III

Annexure-VI

Base Line Collection Data

BASELINE ENVIRONMENTAL STATUS REPORT

FOR

PROPOSED METRO WATER DESALINATION PLANT IN NEMMELI, KANCHEEPURAM DISTRICT, TAMIL NADU

Submitted to:

Indomer Coastal Hydraulics (P) Limited

Chennai – 600 087 for AECOM INDIA P. LTD

Report Prepared by:

Vimta

Driven by Quality. Inspired by Science.

VIMTA Labs Ltd., 142, IDA, Phase-II
Cherlapally, Hyderabad – 500 051, India
www.vimta.com

December 2013

1.0 BASELINE ENVIRONMENTAL STATUS

1.1 Introduction

This chapter illustrates the description of the existing environmental status of the study area with reference to the prominent environmental attributes. The study area covers the area falling within 10 km radius from the center of the proposed project site.

The existing environmental setting is considered to adjudge the baseline environmental conditions, which are described with respect to climate, hydro-geological aspects, atmospheric conditions, water quality, soil quality, vegetation pattern, ecology and socio-economic profiles of people and land use. The objective of this section is to define the present environmental status, which would help in assessing the environmental impacts due to the proposed project.

This report incorporates the baseline data generated through primary surveys for three months from 1st August 2013 to 31st October 2013 representing summer season.

1.1.1 Methodology

Appropriate methodologies have been followed in developing the EIA/EMP report. The methodology adopted for the study is outlined below:

- Conducting reconnaissance surveys for knowing the study area; and
- Selecting sampling locations for conducting various environment baseline studies.

The sampling locations have been selected on the basis of the following:

- Predominant wind directions recorded by the India Meteorological Department (IMD) Meenambakkam, Chennai observatory;
- Existing topography;
- Drainage pattern and location of existing surface water bodies like lakes/ponds, rivers and streams;
- Location of villages/towns/sensitive areas; and
- Areas, which represent baseline conditions.

The field observations have been used to:

- Assess the positive and negative impacts due to the proposed project; and
- Suggest appropriate mitigation measures for negating the adverse environmental impacts, if any; and
- Suggesting post-project monitoring requirements and suitable mechanism for it.

1.2 Geology and Hydrogeology

The Geographical area of the Kancheepuram district is 4470.25 (Sq. km). The elevation of the area ranges from 100 m amsl in the west to a sea level in the east. The major part of the area is characterized by an undulating topography with innumerable depressions, which are used as irrigation tanks. Three beach terraces ranging in elevation between 4m mark the coastal tract and 12 m with broad inter terrace depressions. The coastal plain displays a fairly low level or gently rolling surface and only lightly elevated above the local water surfaces on rivers. The straight trend of the coastline is a result of development of a vast alluvial plain. There are a number of sand dunes in the coastal tract. The coastal landforms include estuarine tidal, mud flats or lagoons and salt marsh etc.

1.2.1 Drainage

The drainage pattern in the area is developed by River Palar and Cheyyar and its tributories. The drainage pattern in general is sub-dendritic and radial. All the rivers are seasonal and carry substantial flows during monsoon period. River Palar, a major river course, which drains this district originates from Western Ghats in Karnataka state, and discharges in Bay of Bengal near Pudupattinam. The Cheyyar, a tributary of Palar originates from the Jawadu Hills of Tiruvannamalai district. It has a northeasterly flow in Kancheepuram district and confluences with the Palar near Pazhaiyaseevaram. Other seasonal river like Korattalaiar and Tandiar drain this district partly on the northern and southern part respectively.

1.2.2 Geology

Geologically the Tamilnadu state is comprises of Crystalline rocks of Archaean to late Proterozoic age occupy over 80% of the area of the state, while the rest is covered by Phanerozoic sedimentary rocks mainly along the coastal belt and in a few inland River valleys. The hard rock terrain comprises predominantly of Charnockite and Khondalite groups and their migmatitic derivatives, supracrustal sequences of Sathyamangalam and Kolar groups and Peninsular Gneissic Complex (Bhavani Group), intruded by ultramafic-mafic complexes, basic dykes, granites and syenites. The sedimentary rocks of the coastal belt include fluviatile, fluvio-marine and marine sequences, such as Gondwana Supergroup (Carboniferous to Permian and Upper Jurassic to Lower Cretaceous), marine sediments of Cauvery basin (Lower Cretaceous to Paleogene), Cuddalore/ Panambarai Formation (Mio-Pliocene) and sediments of Quaternary and Recent age.

Geologically the study area comes under Charnokite gneiss and Pyroxene granulites and also Coastal sediments and Alluvium.

1.2.3 Hydrogeology

Hydro geologically the district is underlain by both sedimentary and fissured formations. The important aquifer system in the district are constituted by 1) unconsolidated and semi consolidated formations and 2) weathered, fissured and fractured crystalline rocks.

Hydro geologically the study area underlain by Sedimentary and fissured formations. The important aquifer system in the study are constituted by consolidated and semi consolidated formations of Granite, Gneisses, Charnokite and Sandstones, conglomerate, Clay, shale types of rocks. Ground water occurs under unconfined to semiconfied and Discontinuous, Restricted to weathered residuum and fracture zones.

CGWB was determined by recording the water levels in the Tamilnadu state of Kancheepuram District during pre and post-monsoon periods. The depth to water levels in the study area were observed ranges from 2 to 5 m bgl during premonsoon may-2006 and 0-5 m bgl during post monsoon January-2007. The specific yield ranges from <1 to 2 lps and yield restricted to shallow depth (50 m bgl) and 50 cu.m/d near weathered divides and high grounds 50-200 cu.m/d near third order steams and low grounds.

1.2.4 Present Status Of Ground Water Development

The state ground water organizations jointly with Central Ground Water Board (CGWB) determine the status of ground water development for each tehsil every year and publish the findings once in four years after monitoring the key wells.

The findings of the CGWB have been released in the Ground Water report-2007. The status of ground water development as on March 2004 of Thiruporur black, Kancheepuram District, Tamil Nadu state as 81% of long term ground water recharge have been declared as semi critical area for future ground water development.

1.3 Land Use Studies

Studies on land use aspects of eco-system play important roles for identifying sensitive issues, if any, and taking appropriate actions for maintaining the ecological balance in the development of the region.

1.3.1 Objectives

The objectives of land use studies are

- To determine the present land use pattern;
- To analyze the impacts on land use due to plant activities in the study area; and
- To give recommendations for optimizing the future land use pattern vis-a-vis growth of plant activities in the study area and its associated impacts.

1.3.2 Methodology

For the study of land use, literature review of various secondary sources such as District Census Handbooks, regional maps regarding topography, zoning settlement, industry, forest etc., were taken. The data was collected from various sources like District Census Handbook, Revenue records, state and central government offices and Survey of India (SOI) Top sheets and also through primary field surveys.

1.3.3 Land use Based on Secondary Data

Based on the census report, 10-km radial distance around this Plant Centre has been considered in the study. These areas were studied in detail to get the idea of land use pattern in the study area. The land use census data 2011 is not available and the land use pattern of the study area as per 2001 Census is presented in **Table-1.3.1.** The village wise land use data is presented in **Annexure-X.**

TABLE-1.3.1
LAND USE PATTERN IN THE STUDY AREA

S .No	Particulars of Land use	0-3 km	3-7 km	7-10 km	0-10 km	%
1	Forest Land (ha)	0	390	1151	1541	12.73
2	Land under Cultivation					
	a) Irrigation Land (ha)	238	1188	1611	3037	25.09
	b) Un Irrigated Land (ha)	164	1389	1073	2626	21.69
3	Cultivable Waste Land (ha)	208	1016	554	1779	14.70
4	Area not Available for Cultivation (ha)	528	1244	1350	3122	25.79
	Total Area	**1138**	**5228**	**5740**	**12105**	**100.00**

Source: District Census Hand Book -2001

- ***Forest***

The revenue forestland under the study area consists 1541 ha (12.73%) of the total geographic area.

- ***Land under Cultivation***

Altogether 5663 ha cultivable land (irrigated and un-irrigated) was observed in the study area. The irrigated land admeasures to about 3037 ha in the study area which works out to be 25.09 % of total study area. The un-irrigated land admeasures about 2626 ha and works out to about 21.69 % of the total study area.

- ***Cultivable Waste***

This land includes that land, which was cultivated sometime back and left vacant during the past 5 years in succession. Such lands may either be fallows or covered with shrubs, which are not put to any use. Lands under thatching grass, bamboo bushes, other grooves useful for fuel etc., and all grazing lands and village common lands are also included in this category. The study area comprises about 14.70% cultivable wastelands.

- ***Land not available for Cultivation***

The land not available for cultivation is 25.79 % of the total study area.

1.4 Soil Characteristics

It is essential to determine the potentiality of soil in the area and to identify the impacts of urbanization on soil quality. Accordingly, the soil quality assessment has been carried out.

1.4.1 Data Generation

The sampling locations have been identified with the following objectives:

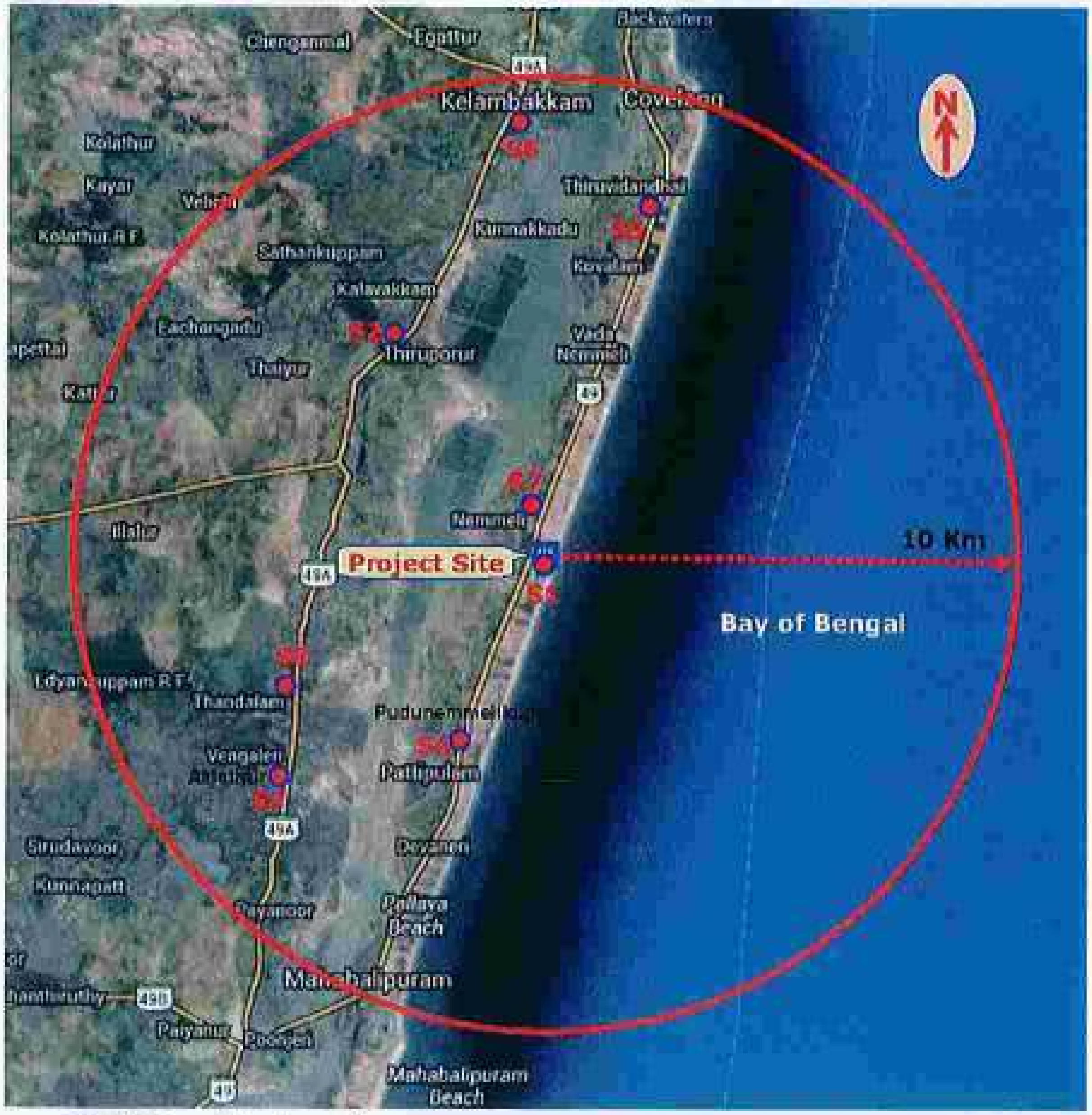
- To determine the baseline soil characteristics of the study area;
- To determine the impact of proposed project on soil characteristics; and
- To determine the impact on soils more importantly from agricultural productivity point of view.

For studying soil characteristics of the region, soil sampling locations were selected to assess the existing soil conditions in and around the project area representing various land use types. The physical, chemical and heavy metal concentrations were determined. The samples were collected using ramming a core cutter into the soil up to a depth of 90 cm.

The present study on the soil profile establishes the baseline characteristics. Eight soil samples were collected from the study area. At each location, soil samples were collected from three different depths viz. 30 cm, 60 cm and 90 cm below the surface and homogenized. The homogenized samples were analyzed for physical and chemical characteristics.
The details of the soil sampling locations are given in **Table-1.4.1** and shown in **Figure-1.4.1.**

TABLE-1.4.1
DETAILS OF SOIL SAMPLING LOCATIONS

Code No.	Location	Distance w.r.t. Proposed Site (Km)	Direction w.r.t Proposed Site
S1	Near-Plant Site	--	--
S2	Thiruporur	4.7	NW
S3	Aalathur	5.0	SW
S4	Pudunellikuppam	1.9	SSW
S5	Thiruvidanthai	6.9	NNE
S6	Kelambakkam	9.2	NNW
S7	Nemmeli	1.2	NW
S8	Thandalam	3.2	W



Soil Sampling Locations

FIGURE-1.4.1
SOIL SAMPLING LOCATIONS

1.4.2 Baseline Soil Status

The soil characteristics are shown in **Table-1.4.2**.The results are compared with standard soil classification given in **Table-1.4.3.**

TABLE-1.4.2
SOIL ANALYSIS RESULTS

Sr. No.	Parameter	UOM	S1	S2	S3	S4
1	pH (1:5 Aq. Extract)	----	7.9	8.0	8.1	7.9
2	Conductivity (1:5 Aq. Extract)	mS/cm	245	192	280	144
3	Texture	----	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay
4	Sand	%	45	48	46	45
5	Silt	%	15	10	09	13
6	Clay	%	40	42	45	42
7	Bulk Density	mg/cc	1.1	1.1	1.2	1.1
8	Exchangeable Calcium as Ca	mg/kg	4387	2924	2276	3217
9	Exchangeable Magnesium as Mg	mg/kg	296	592	608	279
10	Exchangeable Sodium as Na	mg/kg	97.5	69.2	91.9	90.4
11	Available Potassium as K	Kg/ha	0.17	0.13	0.20	0.19
12	Available Phosphorous as P	Kg/ha	56.0	52.0	56.0	52.0
13	Available Nitrogen as N	Kg/ha	46	58	52	46
14	Organic Matter	%	180	186	320	250
15	Organic Carbon	%	0.086	0.100	0.028	0.085
16	Water Soluble Chloride as Cl	mg/kg	0.148	0.172	0.049	0.147
17	Water Soluble Sulphate as SO_4	mg/kg	320	260	320	275
18	Sodium Absorption Ratio	----	128	98	120	106
19	Aluminum	%	0.86	1.02	0.48	0.68
20	Total Iron	%	1.24	0.96	0.64	0.97
21	Manganese	mg/kg	280	240	360	260
22	Boron	mg/kg	14	28	19	36
23	Zinc	mg/kg	74	82	87	68

TABLE-1.4.2 (Conti...)
SOIL ANALYSIS RESULTS

Sr. No.	Parameter	UOM	S5	S6	S7	S8
1	pH (1:5 Aq. Extract)	----	7.8	8.1	8.0	7.9
2	Conductivity (1:5 Aq. Extract)	mS/cm	158	168	220	236
3	Texture	----	Sandy Clay	Sandy Clay	Sandy Clay loam	Sandy Clay loam
4	Sand	%	65	63	54	55
5	Silt	%	20	22	12	13
6	Clay	%	15	15	34	32
7	Bulk Density	mg/cc	1.3	1.3	1.1	1.1
8	Exchangeable Calcium as Ca	mg/kg	2437	1889	3284	2925
9	Exchangeable Magnesium as Mg	mg/kg	652	918	627	711
10	Exchangeable Sodium as Na	mg/kg	35.1	29.3	57.2	66.3
11	Available Potassium as K	Kg/ha	0.07	0.06	0.11	0.12
12	Available Phosphorous as P	Kg/ha	42.0	28.2	78	72
13	Available Nitrogen as N	Kg/ha	38	42.0	72	65
14	Organic Matter	%	280	198	360	380
15	Organic Carbon	%	0.014	0.028	0.513	0.357
16	Water Soluble Chloride as Cl	mg/kg	0.024	0.049	0.885	0.617
17	Water Soluble Sulphate as SO_4	mg/kg	214	196	216	218
18	Sodium Absorption Ratio	----	82	76	78	82
19	Aluminum	%	0.76	0.96	0.88	0.74
20	Total Iron	%	1.06	1.06	1.16	0.98
21	Manganese	mg/kg	384	410	380	270
22	Boron	mg/kg	44	48	32	26
23	Zinc	mg/kg	74	62	56	58

1.4.2.1 Observations

- It has been observed that the pH of the soil in the study area varied from 7.8 to 8.1. The maximum pH value of 8.1 was observed at S3 and S6 where as the minimum value of 7.8 was observed at S5.
- The electrical conductivity was observed to range from 144 μmhos/cm to 280 μmhos/cm, with the maximum observed at S3 with the minimum observed in S4.
- The nitrogen value varies from 28.2-78.0 kg/ha. The nitrogen content in the study area falls in very less to less category.
- The phosphorus values varies from 38.0 to 72.0 kg/ha, indicating that the phosphorus content in the study area falls in medium to sufficient category.
- The potassium values varies from 180 to 380 kg/ha. The potassium content in the study area falls in less to more than sufficient category.
- The organic carbon value varies from 0.014 % to 0.513 %. The organic carbon content in the study area falls in very less to on an average sufficient category.

TABLE-1.4.3
STANDARD SOIL CLASSIFICATION

Sr. No.	Soil Test	Classification
1	pH	<4.5 Extremely acidic 4.51- 5.50 Very strongly acidic 5.51-6.0 moderately acidic 6.01-6.50 slightly acidic 6.51-7.30 Neutral 7.31-7.80 slightly alkaline 7.81-8.50 moderately alkaline 8.51-9.0 strongly alkaline 9.01 very strongly alkaline
2	Salinity Electrical Conductivity (mmhos/cm) (1 ppm = 640 mmho/cm)	Upto 1.00 Average 1.01-2.00 harmful to germination 2.01-3.00 harmful to crops (sensitive to salts)
3	Organic Carbon	Upto 0.2: very less 0.21-0.4: less 0.41-0.5 medium, 0.51-0.8: on an average sufficient 0.81-1.00: sufficient >1.0 more than sufficient
4	Nitrogen (Kg/ha)	Upto 50 very less 51-100 less 101-150 good 151-300 Better >300 sufficient

Sr. No.	Soil Test	Classification
5	Phosphorus (Kg/ha)	Upto 15 very less 16-30 less 31-50 medium, 51-65 on an average sufficient 66-80 sufficient >80 more than sufficient
6	Potash (Kg/ha)	0 -120 very less 120-180 less 181-240 medium 241-300 average 301-360 better >360 more than sufficient

Source: Handbook of Agriculture

1.5 Meteorology

The meteorological data recorded during the monitoring period is very useful for proper interpretation of the baseline information as well as for input prediction models for air quality dispersion. Historical data on meteorological parameters will also play an important role in identifying the general meteorological regime of the region.

The year may broadly be divided into four seasons:

- Winter season : December to February
- Pre-monsoon season : March to May
- Monsoon season : June to September
- Post-monsoon season : October to November

1.5.1 Methodology

The methodology adopted for monitoring surface observations is as per the standard norms laid down by Bureau of Indian Standards (IS : 8829) and India Meteorological Department (IMD). On-site monitoring was undertaken for various meteorological variables in order to generate the site-specific data. The generated data is then compared with the meteorological data generated by IMD.

1.5.1.1Methodology of Data Generation

The automatic meteorological instrument was installed on top of a building near to the project site to record wind speed, direction, relative humidity and temperature. Cloud cover is recorded by visual observation. Rainfall is monitored by rain gauge. Hourly average, maximum, and minimum values of wind speed, direction, temperature, relative humidity and rainfall have been recorded continuously at this station during 1st August 2013 to 31th October 2013.

1.5.1.2 Sources of Information

Secondary information on meteorological conditions has been collected from the nearest IMD station at Chennai Airport.

India Meteorological Department has been monitoring surface observations at Chennai since 1891. Pressure, temperature, relative humidity, rainfall, wind speed and direction are measured twice a day viz., at 0830 and 1730 hr. The wind speed and direction data of IMD, Chennai has been obtained for the past available 10 years. The data for the remaining parameters has been collected for the last 10 years and processed.

1.5.2 Synthesis of Data on Climatic Conditions

1.5.2.1 Analysis of the Data Recorded at IMD-Chennai

1) Temperature

The winter season starts from December and continues till the end of February. January is the coldest month with the mean daily maximum temperature at 33.3°C with the mean daily minimum temperature at 17.0°C. Both the day and night temperatures increase rapidly during the onset of Pre-monsoon season. During Pre-monsoon the mean maximum temperature (May) is observed at 43.4°C with the mean minimum temperature at 21.6°C. The mean maximum temperature in the Monsoon season was observed to be 42.8°C whereas the mean minimum temperature was observed to be 21.2°C. By end of September with the onset of Northeast monsoon (October), day temperatures decrease slightly with the mean maximum temperature at 35.9°C with the mean minimum temperature at 22.4°C. The monthly variations of temperatures are presented in **Table-1.5.1**.

2) Relative Humidity

The air is generally very humid in the region especially during monsoon when the average relative humidity is observed around 67% with a maximum and minimum of 100% and 35% respectively. In the pre-monsoon period the relative humidity is 63%. During the pre-monsoon season the mean maximum humidity is observed at 100%, with the mean minimum humidity at 39% in the month of May and April respectively. During winter season the humidity is found to be in line with the values recorded during the Pre-monsoon season. The mean maximum humidity recorded during winter season, which is the driest part of year with an average of 66% relative humidity. The mean maximum relative humidity is observed to be 100% with mean minimum humidity at 38%. The monthly mean variations in relative humidity are presented in **Table-1.5.1**.

3) Atmospheric Pressure

The station level maximum and minimum atmospheric pressure levels are recorded during the winter and monsoon seasons. The maximum pressure observed is in the range of 1016.5 to 1003.5-mb, with the maximum pressure (1016.5-Mb) occurring during the winter season, in the month of January. The minimum pressure observed is in the range of 1013.6 to 999.9 Mb, with the minimum pressure (999.9-Mb) occurring during the pre-monsoon season in the month of June. The average pressure levels in all other months are found to be in the range of 1008.5 to 1010.6-mb. The monthly variations in the pressure levels are presented in **Table-1.5.1**.

4) Rainfall

It is observed that the north-east monsoon is more predominant than the south-west monsoon. The southwest monsoon generally sets in during the last week of May. About 30% of the rainfall is received during the southwest monsoon. The rainfall gradually increases after September (and reaches maximum rainfall is recorded in the month of November). The area experiences maximum rainfall (308.0 mm) in the month of November. The Northeast monsoon rain occurs between October to December and contributes to the rainfall by about 60% of the total rainfall. Monthly variations in the rainfall for past available 10 years are given in **Table-1.5.1**.

5) Cloud Cover

Generally light clouds are observed during winter mornings. During pre-monsoon and the post-monsoon evenings the skies are either clear or lightly clouded. But in post-monsoon mornings as well as monsoon morning heavy clouds are commonly observed. Whereas in the evening time the skies are light to moderately clouded through out the year.

6) Wind Speed/Direction

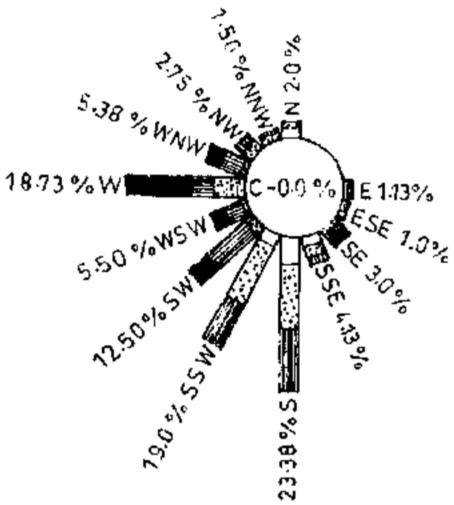
The windrose for the study period representing pre-monsoon, monsoon, post-monsoon and winter season along with annul windrose are shown in **Figure-1.5.1** and presented **in Table-1.5.2**.

TABLE-1.5.1
CLIMATOLOGICAL DATA - IMD, CHENNAI (MINAMBAKAM)

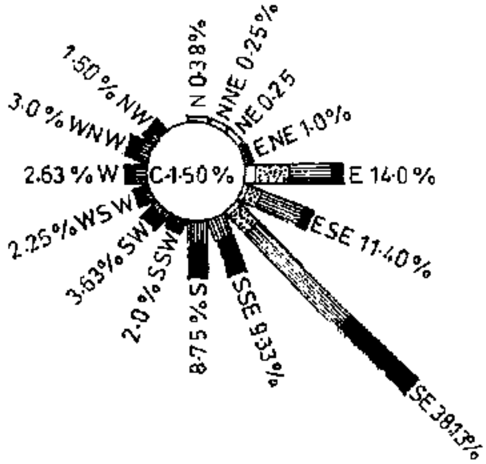
Month	Temperature (^{0}C)			Relative Humidity (%)		Atmospheric Pressure (Mb)		Rainfall (mm)
	Max	Min	Avg.	0830	1730	0830	1730	
January	33.3	17.0	26.1	100	38	1016.5	1013.6	23.8
February	34.9	16.0	25.2	95	31	1012.2	1009.0	6.8
March	38.7	18.2	27.5	91	28	1010.6	1007.1	15.1
April	42.7	21.0	32.0	96	39	1008.4	1004.3	24.7
May	43.4	21.6	32.2	100	15	1004.5	1000.8	51.7
June	42.8	21.2	32.5	100	32	1003.5	999.9	52.6
July	39.5	22.3	31.0	95	35	1004.2	1000.7	83.5
August	39.0	22.0	31.0	98	32	1004.9	1001.1	124.3
September	37.8	21.5	29.5	97	35	1006.3	1002.4	118.0
October	35.9	22.4	28.7	98	46	1008.5	1005.3	267.0
November	34.4	18.0	27.0	99	42	1010.9	1003.1	308.0
December	31.7	17.8	25.0	100	34	1012.9	1010.0	139.1

TABLE-1.5.2
SUMMARY OF WIND PATTERN – IMD, CHENNAI

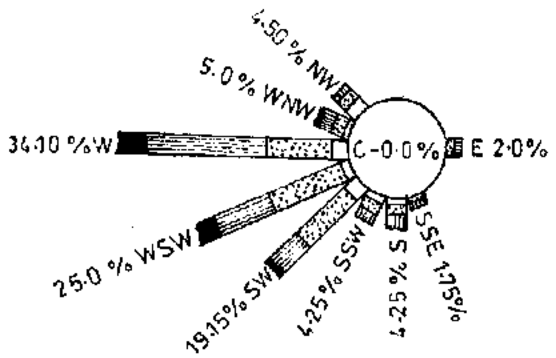
Season	First predominant winds		Second predominant winds		Calm condition in %	
	0830	1730	0830	1730	0830	1730
Pre-monsoon	S (29.0)	S (37.5)	SSW (17.5)	SSW (24.9)	10.3	1.7
Monsoon	SSW (17.3)	SSW (20.3)	SW (16.9)	S (18.1)	10.5	8.2
Post monsoon	NNE (17.0)	E (15.0)	N (15.5)	NE (14.0)	21.0	25.0
Winter	NE (16.7)	S (14.6)	NNE (14.0)	E (11.6)	31.0	16.7
Annual	SSW (12.9)	S (18.9)	SW (10.0)	SSW (14.2)	15.8	12.9

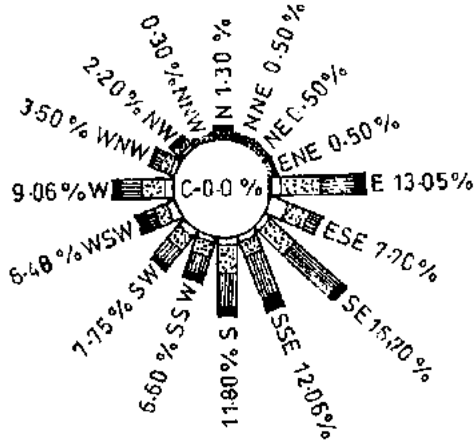


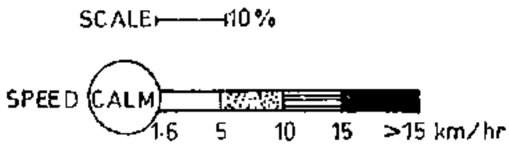
PRE MONSOON SEASON
(0830 hrs)



PRE MONSOON SEASON
(1730 hrs)



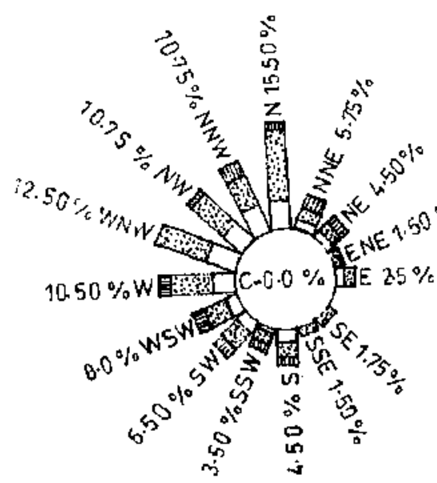




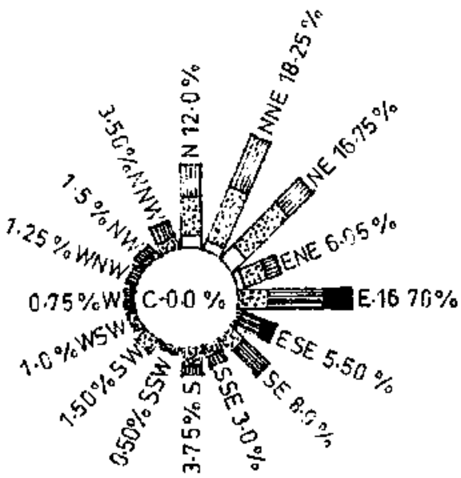
MONSOON SEASON
(0830 hrs)

MONSOON SEASON
(1730 hrs)

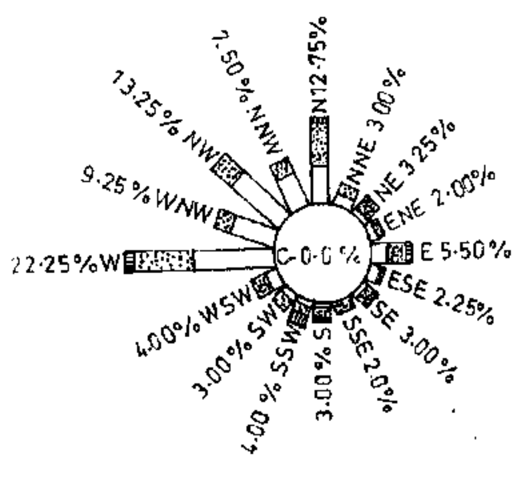
FIGURE-1.5.1 (A)
WINDROSE FOR PRE MONSOON & MONSOON SEASON-IMD, CHENNAI

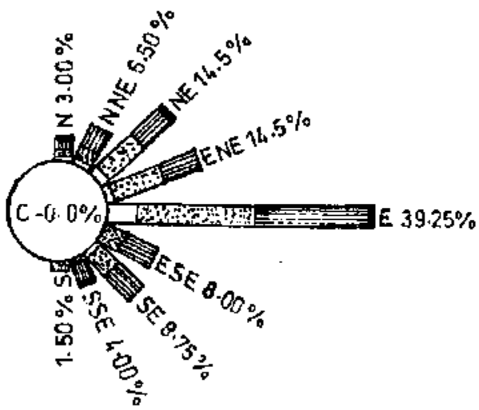


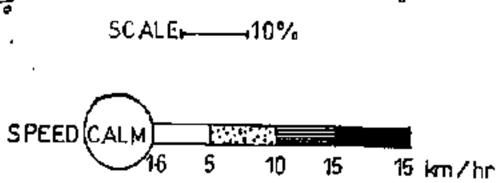
POST MONSOON SEASON
(0830 hrs)



POST MONSOON SEASON
(1730 hrs)







WINTER SEASON
(0830 hrs)

WINTER SEASON
(1730 hrs)

FIGURE-1.5.1 (B)
WINDROSE FOR POST MONSOON & WINTER SEASON-IMD, CHENNAI

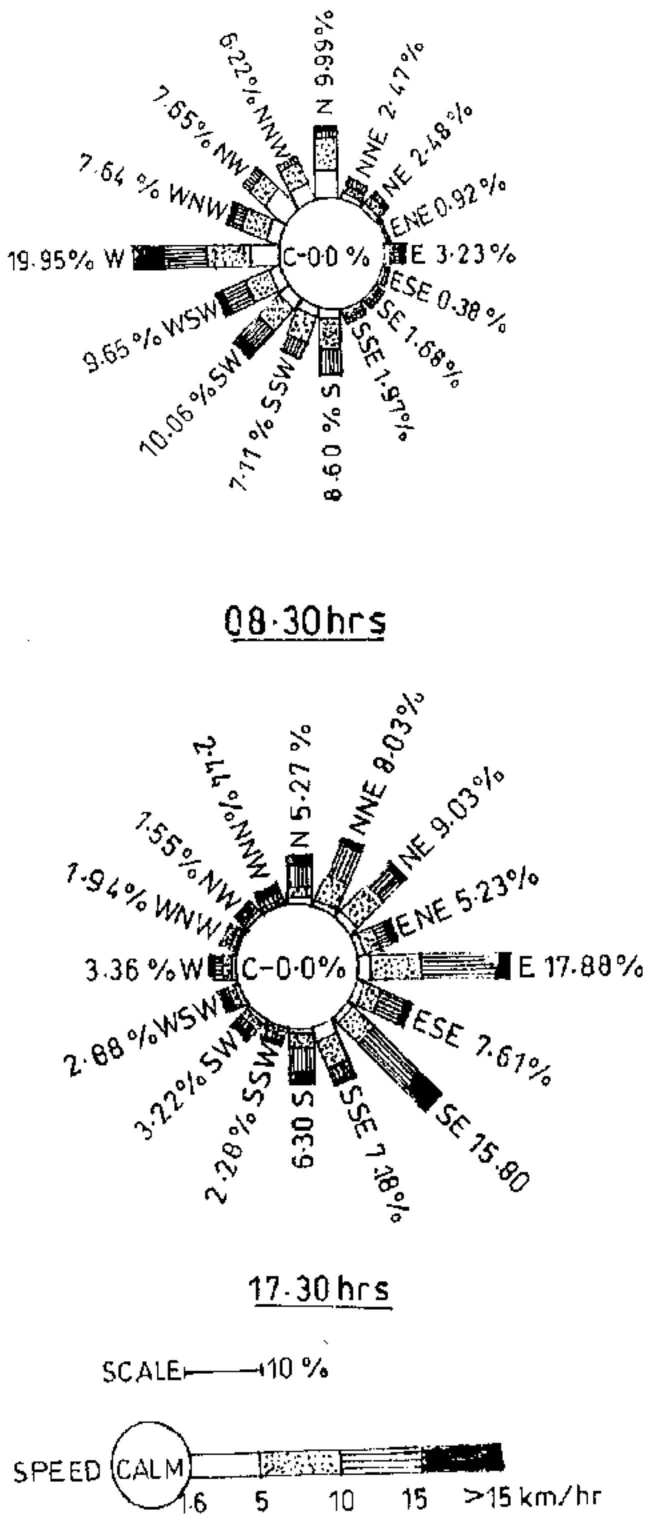


FIGURE-1.5.1 (C)
ANNUAL WINDROSE -IMD, CHENNAI

1.5.2.2Analysis of Meteorological Data Recorded at Project Site

The meteorological data recorded at the project site during the study period (1st August, 2013 to 31st October, 2013) is presented in **Table-1.5.3.**

TABLE-1.5.3
SUMMARY OF THE METEOROLOGICAL DATA AT SITE

Month	Temperature (°C)		Humidity (%)		Total Rainfall (mm)
	Max	Min	Max	Min	
August 2013	37.5	23.7	100	28	73
September 2013	36.8	22.9	100	34	89
October 2013	36.3	22.6	100	21	121

1) Temperature

It was observed that the temperature at the proposed site during study period ranged from 22.9°C to 37.5°C. The monthly variations in the temperatures are presented in **Table-1.5.3.**

2) Humidity

During the period of observation, the humidity ranged from 21.0% to 100.0%. The monthly variations in the humidity are presented in **Table-1.5.3.**

3) Rainfall

A total of 283 mm of rainfall was observed during the study period. The maximum rainfall was recorded in the month of October in study period.

4) Cloud Cover

Mostly clear skies were observed except rainy days during the study period.

5) Wind Speed and Direction

The windrose for the study period representing winter season is shown in **Figure-1.5.2**. A review of the windrose diagram shows that predominant winds are mostly from West (14.4%) and WSW (10.3%) followed by E (8.1%) direction. Calm condition was recorded for 4.5%.

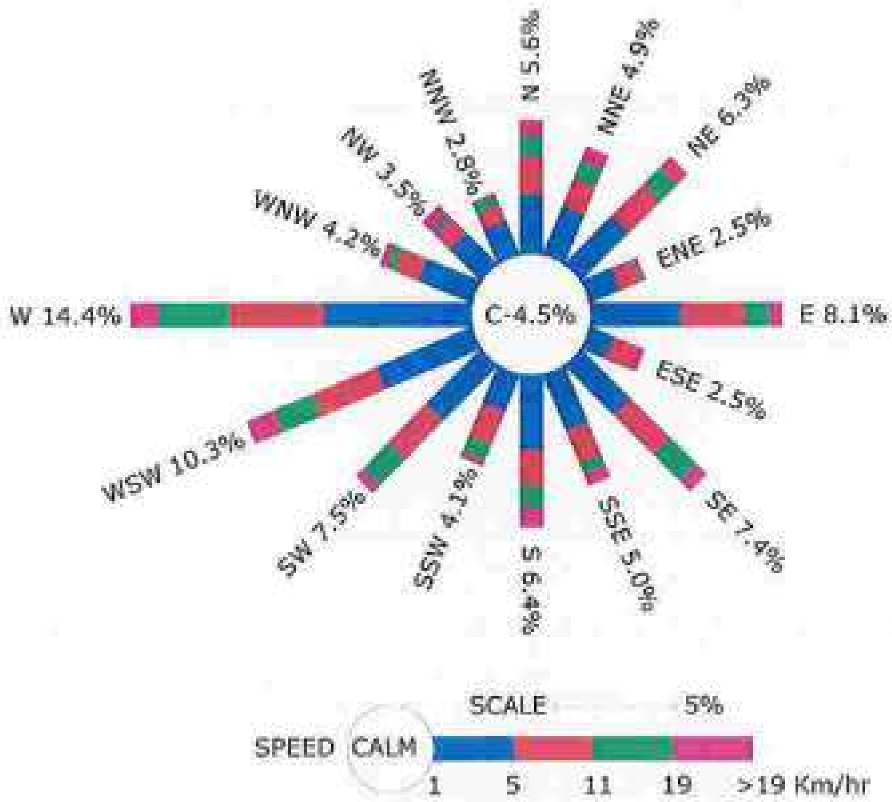


FIGURE-1.5.2
SITE SPECIFIC WINDROSE (AUGUST – OCTOBER 2013)

1.6 Air Quality

The ambient air quality with respect to the study zone of 10-km radius around the project site forms the baseline information. The various sources of air pollution in the region are industries and vehicular traffic. The prime objective of the baseline air quality study was to assess the existing air quality of the area. The study area represents mostly rural environment.

This section describes the selection of sampling locations, methodology adopted for sampling, analytical techniques and frequency of sampling.

1.6.1 Methodology adopted for Air Quality Survey

1.6.1.1 Selection of Sampling Locations

The baseline status of the ambient air quality has been assessed through a scientifically designed ambient air quality-monitoring network. The design of monitoring network in the air quality surveillance program has been based on the following considerations:

- Meteorological conditions on synoptic scale;
- Topography of the study area;
- Representatives of regional background air quality for obtaining baseline status;
- Representatives of likely impact areas.

Ambient Air Quality Monitoring (AAQM) stations were set up at **eight** locations with due consideration to the above mentioned points. **Table-1.6.1** gives the details of environmental setting around each monitoring station. The location of the selected stations with reference to the project site is given in the same table and shown in **Figure-1.6.1**.

TABLE-1.6.1
DETAILS OF AMBIENT AIR QUALITY MONITORING LOCATIONS

Station Code	Name of the Station	Distance w.r.t Project Site (km)	Direction w.r.t Project Site
AAQ1	Near-Plant site	--	--
AAQ2	Thiruporur	4.7	NW
AAQ3	Aalathur	5.0	SW
AAQ4	Pudunemmelikuppam	1.9	SSW
AAQ5	Thiruvidanthai	6.9	NNE
AAQ6	Kelambakkam	9.2	NNW
AAQ7	Nemmeli	1.2	NW
AAQ8	Thandalam	3.2	W

1.6.1.2 Frequency and Parameters for Sampling

The following frequency has been adopted for sampling:

Ambient air quality monitoring has been carried out with a frequency of two days per week at all locations for study period from 1st March 2012 to 31st May 2012. The baseline data of air environment is generated for the following parameters:

- Particulate Matter (PM_{10});
- Particulate Matter ($PM_{2.5}$);

- Sulphur dioxide (SO_2);
- Nitrogen dioxide (NO_2);
- Carbon monoxide (CO);

1.6.1.3 Duration of Sampling

The sampling duration for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 was twenty-four hourly continuous samples per day and CO was sampled for 8-hrs continuous thrice a day. This is to allow a comparison with the present revised standards mentioned in the latest Gazette notification of the Central Pollution Control Board (CPCB) (November 16, 2009).

TABLE-1.6.2
MONITORED PARAMETERS AND FREQUENCY OF SAMPLING

Parameters	Sampling Frequency
PM_{10}	24 hourly sample twice a week for three months
$PM_{2.5}$	24 hourly sample twice a week for three months
Sulphur dioxide (SO_2)	24 hourly sample twice a week for three months
Oxides of Nitrogen (NO_x)	24 hourly sample twice a week for three months
Carbon Monoxide (CO)	08 hourly sample twice a week for three months

1.6.1.4 Method of Analysis

The air samples were analyzed as per standard methods specified by Central Pollution Control Board (CPCB), IS: 5184 and American Public Health Association (APHA).

1.6.2 Instruments used for Sampling

Dust Samplers of Pollutech instruments were used for monitoring PM_{10} (<10 microns), $PM_{2.5}$ and gaseous pollutants like SO_2 and NO_2. Glass tubes were deployed for collection of grab samples of Carbon monoxide. Gas Chromatography techniques have been used for the estimation of CO.

1.6.3 Sampling and Analytical Techniques

The techniques used for ambient air quality monitoring and minimum detectable levels are given in **Table-1.6.3.**

TABLE-1.6.3
TECHNIQUES USED FOR AMBIENT AIR QUALITY MONITORING

Sr. No.	Parameter	Technique	Technical Protocol	Minimum Detectable Limit ($\mu g/m^3$)
1	PM_{10}	Fine Particulate Sampler (Gravimetric Method)	IS-5182 (Part-IV)	5.0
2	$PM_{2.5}$	Fine Particulate Sampler (Gravimetric Method)	IS-5182 (Part-IV)	2.0
3	Sulphur dioxide	Modified West and Gaeke Method	IS-5182 (Part-II)	4.0
4	Oxides of Nitrogen	Jacob & Hochheiser Method	IS-5182 (Part-VI)	9.0
5	Carbon Monoxide (CO)	Gas Chromatography Method	IS:5182 (Part-X)	12.5

●Ambient Air Quality Monitoring Locations

FIGURE-1.6.1
AIR QUALITY SAMPLING LOCATIONS

1.6.4 Presentation of Primary Data

Various statistical parameters like 98th percentile, average, maximum and minimum values have been computed from the observed raw data for all the AAQ monitoring stations. The summary of these results for summer season is presented in **Table-1.6.4.**

TABLE-1.6.4
SUMMARY OF AMBIENT AIR QUALITY RESULTS

Location	PM_{10} ($\mu g/m^3$)				$PM_{2.5}$ ($\mu g/m^3$)				SO_2 ($\mu g/m^3$)			
	Max	Min	Avg	98%	Max	Min	Avg	98%	Max	Min	Avg	98%
Near-Plant Site	49.9	40.9	45.7	49.6	18.5	12.8	15.7	18.0	10.7	8.6	9.5	10.6
Thiruporur	51.5	42.4	47.3	51.2	19.5	13.8	16.3	19.1	10.8	8.2	9.1	10.5
Aalathur	47.3	41.4	44.0	47.1	17.3	13.9	15.1	17.2	9.8	8.3	9.0	9.7
Pudunemmelikuppam	46.0	37.8	42.1	45.7	17.4	12.9	14.5	16.7	9.6	7.5	8.7	9.6
Thiruvidanthai	44.7	36.7	41.0	44.5	16.1	12.4	14.1	15.9	10.2	7.9	8.8	9.8
Kelambakkam	52.5	45.2	49.1	52.2	19.5	15.1	16.9	19.4	10.4	8.6	9.5	10.4
Nemmeli	40.0	32.7	36.7	39.8	14.6	11.0	12.7	14.3	9.9	8.2	9.0	9.8
Thandalam	43.6	36.3	40.2	43.3	15.4	11.8	13.8	15.3	9.8	8.2	8.9	9.8
Range	**32.7-52.5**				**11.0-19.5**				**7.5-10.8**			
Standards	**100**				**60**				**80**			

TABLE-1.6.4 (Cont...)
SUMMARY OF AMBIENT AIR QUALITY RESULTS

Location	NO_2 ($\mu g/m^3$)				CO ($\mu g/m^3$)			
	Max	Min	Avg	98%	Max	Min	Avg	98%
Near-Plant Site	14.2	10.7	12.4	14.0	514	383	448	509
Thiruporur	13.6	11.0	12.1	13.6	527	390	451	520
Aalathur	13.3	10.4	11.9	13.2	481	373	429	477
Pudunemmelikuppam	13.7	9.7	11.5	13.4	495	365	424	480
Thiruvidanthai	13.5	10.0	11.6	13.5	486	371	428	483
Kelambakkam	14.8	11.4	12.6	14.8	536	394	462	521
Nemmeli	13.8	10.2	11.9	13.5	489	368	429	485
Thandalam	13.1	10.4	11.8	13.0	497	377	436	494
Range	**9.7-14.8**				**365-536**			
Standards	**80**				**2000**			

1.6.5 Observations of Primary Data

The three months Ambient Air Quality data is given as **Annexure-3.**

PM_{10}: The maximum and minimum concentrations for PM_{10} were recorded as 52.5 $\mu g/m^3$ and 32.7 $\mu g/m^3$ respectively. The maximum concentration was recorded at Kelambakkam and the minimum concentration was recorded at Nemmeli. The average values were observed to be in the range of 36.7 and 49.1 $\mu g/m^3$.

$PM_{2.5}$: The maximum and minimum concentrations for $PM_{2.5}$ were recorded as 19.5 $\mu g/m^3$ and 11.0 $\mu g/m^3$ respectively. The maximum concentration was recorded at Kelambakkam and the minimum concentration was recorded at Nemmeli. The average values were observed to be in the range of 12.7 and 16.9 $\mu g/m^3$.

SO_2: The maximum and minimum SO_2 concentrations were recorded as 10.8 $\mu g/m^3$ and 7.5 $\mu g/m^3$. The maximum concentration was recorded at Thiruporur and the minimum concentration was recorded at Pudunemmelikuppam. The average values were observed to be in the range of 8.7 and 9.5 $\mu g/m^3$.

NO_2: The maximum concentration of 14.8 $\mu g/m^3$ for NO_2 was recorded at Kelambakkam and minimum of 9.7 $\mu g/m^3$ observed at Pudunemmelikuppam. The average concentrations were ranged between 11.5 and 12.6 $\mu g/m^3$.

CO: The maximum concentration of 536 $\mu g/m^3$ was recorded at Kelambakkam and minimum of 365 $\mu g/m^3$ observed at Pudunemmelikuppam. The average concentrations were ranged between 424 and 462 $\mu g/m^3$.

The concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_X, CO and O_3 are observed to be well within the standards prescribed by Central Pollution Control Board (CPCB) for Industrial, Rural, Residential and Other area.

1.7 Water Quality

Selected water quality parameters of ground water and surface water resources within the study area has been studied for assessing the water environment and evaluate anticipated impact of the proposed project. Understanding the water quality is essential in preparation of Environmental Impact Assessment and to identify critical issues with a view to suggest appropriate mitigation measures for implementation.

The purpose of this study is to:

- Assess the water quality characteristics for critical parameters;
- Evaluate the impacts on agricultural productivity, habitat conditions, recreational resources and aesthetics in the vicinity; and
- Prediction of impact on water quality by this project and related activities.

The information required has been collected through primary surveys and secondary sources.

1.7.1 Methodology

Reconnaissance survey was undertaken and monitoring locations were finalized based on:

- Drainage pattern;
- Location of residential areas representing different activities/likely impact areas; and
- Likely areas, which can represent baseline conditions.

Water sources covering 10-km radial distance were examined for physico-chemical, heavy metals and bacteriological parameters in order to assess the effect of industrial and other activities on water. The samples were collected and analyzed as per the procedures specified in 'Standard Methods for the Examination of Water and wastewater' published by American Public Health Association (APHA).

Samples for chemical analysis were collected in polyethylene carboys. Samples collected for metal content were acidified with 1 ml HNO_3. Samples for bacteriological analysis were collected in sterilized glass bottles. Selected physico-chemical and bacteriological parameters have been analyzed for projecting the existing water quality status in the study area. Parameters like temperature, Dissolved Oxygen (DO), free Chlorine and pH were analyzed at the time of sample collection.

1.7.2 Water Sampling Locations

Water samples were collected from 4 ground water and 2 surface water-sampling locations. These samples were taken as grab samples and were analyzed for various parameters to be compared with the standards for drinking water as per IS:10500. The water sampling locations are listed below in **Table-1.7.1** and are depicted in **Figure-1.7.1.**

TABLE-1.7.1
DETAILS OF WATER SAMPLING LOCATIONS

Code	Location	Distance w.r.t. Project Site (km)	Direction w.r.t. Project Site
Ground Water			
GW1	Alathur	5.0	SW
GW2	Thiruporur	4.7	NW
GW3	Pudunemmelikuppam	1.9	SSW
GW4	Thiruvidanthai	6.9	NNE
Surface Water			
SW1	Pattipulam	2.7	SSW
SW2	Vada Nemmeli	4.6	NNE

1.7.3 Presentation of Results

Four ground water and two surface water samples representing water environment have been considered around the proposed plant within the periphery of 10 km taking in to account the various uses. The results of surface water samples and the ground water quality are presented in **Table-1.7.2 and Table-1.7.3.**

FIGURE-1.7.1
WATER SAMPLING LOCATIONS

TABLE 1.7.2
GROUND WATER QUALITY

Sr. No	Parameters	Unit	IS: 10500 Limits	GW1	GW2	GW3	GW4
1	pH	-	6.5 – 8.5 (NR)	7.4	7.5	7.3	7.6
2	Colour	Hazen	5(25)	2	3	2	2
3	Taste	-	Agreeable	Ag	Ag	Ag	Ag
4	Odour	-	U.O	U.O	U.O	U.O	U.O
5	Conductivity	µS/cm	$	1601.0	1676.0	104.0	1568
6	Turbidity	NTU	5(10)	1	2	1	1
7	TDS	mg/l	500(2000)	1040	1080	65	1015
8	Total Hardness as $CaCO_3$	mg/l	300(600)	473	497	39	640
9	Total Alkalinity	mg/l	200(600)	485.0	350.0	22.0	510.0
10	Calcium as Ca	mg/l	75(200)	160.5	165.0	10.2	85.0
11	Magnesium as Mg	mg/l	30(100)	17.5	20.5	5.3	40.0
12	Residual Chlorine	mg/l	0.2 Min	<0.2	<0.2	<0.2	<0.2
13	Boron	mg/l	1	0.01	0.02	<0.01	0.02
14	Chlorides as Cl	mg/l	250(1000)	140.2	235.0	10.2	85.0
15	Sulphates as SO_4	mg/l	200(400)	86.5	112.2	6.1	120.0
16	Fluorides as F	mg/l	1.0(1.5)	0.9	0.8	0.5	0.7
17	Nitrates as NO_3	mg/l	45(NR)	30.2	35.0	11.2	36.0
18	Sodium as Na	mg/l	$	145.0	150.0	6.2	65.0
19	Potassium as K	mg/l	$	15.6	16.0	0.6	14.0
20	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001	<0.001	<0.001
21	Cyanides	mg/l	0.05 (NR)	<0.02	<0.02	<0.02	<0.02
22	Anionic Detergents	mg/l	0.2 (1.0)	<0.1	<0.1	<0.1	<0.1
23	Mineral Oil	mg/l	0.01 (0.03)	<0.01	<0.01	<0.01	<0.01
24	Cadmium as Cd	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01
25	Arsenic as As	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01
26	Copper as Cu	mg/l	0.05 (1.5)	<0.01	<0.01	<0.01	<0.01
27	Lead as Pb	mg/l	0.05 (NR)	<0.01	<0.01	<0.01	<0.01
28	Manganese as Mn	mg/l	0.1 (0.3)	0.01	0.04	<0.01	0.02
29	Iron as Fe	mg/l	0.3(1.0)	0.06	0.04	0.02	0.05
30	Chromium as Cr^{+6}	mg/l	0.05(NR)	<0.05	<0.05	<0.05	<0.05
31	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01
32	Zinc as Zn	mg/l	5(15)	<0.01	<0.01	<0.01	<0.01
33	Aluminum as Al	mg/l	0.03(0.2)	<0.01	<0.01	<0.01	<0.01
34	Mercury as Hg	mg/l	0.001(NR)	<0.001	<0.001	<0.001	<0.001
35	Pesticides	mg/l	Absent	Absent	Absent	Absent	Absent
36	E. Coli	-	Absent	Absent	Absent	Absent	Absent
37	Total Coliforms	MPN/100	10	<2	<2	<2	<2

Note: Values in paranthesis are 'Permissible limit in the absence of Alternate source'. NR: No relaxation, *$: Limits not specified, UO: Un-Objectionable,* Agr-Agreeable

IS: 10500 (the standard prescribes the requirements for the essential and desirable characteristics required to be tested for ascertaining the suitability of water for drinking purpose).

TABLE 1.7.3
SURFACE WATER QUALITY

Sr. No	Parameters	Unit	IS: 10500 Limits	SW1	SW2
1	pH	-	6.5 – 8.5 (NR)	7.9	7.9
2	Colour	Hazen	5(25)	2	2
3	Conductivity	µS/cm	$	51600	51800
4	TDS	mg/l	500(2000)	33540	33670
5	DO	mg/l	$	5.5	5.6
6	BOD	mg/l	$	<3	<3
7	COD	mg/l	$	<5	<5
8	Total Hardness as $CaCO_3$	mg/l	300(600)	7013	7059
9	Total Alkalinity as $CaCO_3$	mg/l	200(600)	145.0	150.0
10	Calcium as Ca	mg/l	75(200)	690.0	700.0
11	Magnesium as Mg	mg/l	30(100)	1285.0	1290.0
12	Chlorides as Cl	mg/l	250(1000)	17359.0	17458.0
13	Residual free Chlorine	mg/l	0.2 Min	<0.2	<0.2
14	Phosphates as PO_4	mg/l	$	0.1	0.1
15	Sulphates as SO_4	mg/l	200(400)	0.1	650.0
16	Fluorides as F	mg/l	1.0(1.5)	620.0	2.0
17	Nitrates as NO_3	mg/l	45(NR)	2.0	3.5
18	Sodium as Na	mg/l	$	3.0	8524.0
19	Potassium as K	mg/l	$	8500.0	350.0
20	Total Boron as B	mg/l	1	0.04	0.05
21	Cyanides	mg/l	0.05 (NR)	<0.02	<0.02
22	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001
23	Oil and Grease	mg/l	$	<1	<1
24	Cadmium as Cd	mg/l	0.01 (NR)	<0.01	<0.01
25	Arsenic as As	mg/l	0.01 (NR)	<0.01	<0.01
26	Copper as Cu	mg/l	0.05 (1.5)	<0.01	<0.01
27	Lead as Pb	mg/l	0.05 (NR)	<0.01	<0.01
28	Iron as Fe	mg/l	0.3(1.0)	0.03	0.03
29	Chromium as Cr^{+6}	mg/l	0.05(NR)	<0.05	<0.05
30	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01
31	Zinc as Zn	mg/l	5(15)	<0.01	<0.01
32	Aluminum as Al	mg/l	0.03(0.2)	<0.01	<0.01
33	Mercury as Hg	mg/l	0.001(NR)	<0.001	<0.001
34	SAR	-	$	44.17	44.15
35	Pesticides	mg/l	Absent	Absent	Absent
36	Anionic Detergents	mg/l	0.2 (1.0)	Absent	Absent
37	Total Coliforms	MPN/100	10	<2	<2

Note: Values in paranthesis are 'Permissible limit in the absence of Alternate source'. NR: No relaxation, $: *Limits not specified, UO: Un-Objectionable,* Agr-Agreeable

IS: 10500 (the standard prescribes the requirements for the essential and desirable characteristics required to be tested for ascertaining the suitability of water for drinking purpose).

1.7.4 Observations

Ground Water Quality

- The analysis results indicate that the pH ranges in between 7.3 to 7.6, which is well within the specified standard of 6.5 to 8.5. The minimum pH of 7.3 was observed at GW3 and the maximum pH of 7.6 was observed at GW4.
- Total hardness was observed to be ranging from 39 to 640 mg/l. The minimum hardness (39 mg/l) was recorded at GW3 and the maximum (640 mg/l) was recorded at GW4.
- Chlorides were found to be in the range of 10.2 mg/l to 235.0 mg/l, the minimum concentration of chlorides (10.2 mg/l) was observed at GW3, whereas the maximum value of 235.0 mg/l was observed at GW2.
- Sulphates were found to be in the range of 6.1 mg/l to 120.0 mg/l. The minimum value observed at GW3 (6.1 mg/l) whereas the maximum value observed at GW4 (120.0 mg/l).
- The Total Dissolved Solids (TDS) concentrations were found to be ranging in between 65 to 1080 mg/l, the minimum TDS observed at GW3 (65 mg/l) and maximum concentration of TDS observed at GW2 (1080 mg/l).
- Iron is found in between 0.02 mg/l to 0.06 mg/l and Zinc found <0.01 mg/l.
- The ground water quality in the study area does indicate slightly sea water characteristics influence.

Surface Water Quality

- The analysis results indicate that the pH values were found 7.9, for both the station.
- DO was observed to be in the range of 5.5 to 5.6 mg/l. The TDS was observed in the range of 33540 mg/l to 33670 mg/l, the minimum TDS value was observed at SW1, and where as maximum value was observed at SW2.
- The chlorides and Sulphates were found to be in the range of 17359.0 to 17458.0 mg/l and 620.0 to 650.0 mg/l, respectively.
- Total hardness expressed as $CaCO_3$ ranges between 7013 to 7059 mg/l. The concentration of nitrate fluctuates between 3.0 to 3.5 mg/l.
- The calcium & magnesium were found to be in the range of 690.0 to 700.0 mg/l and 1285.0 to 1290.0 mg/l, respectively. Iron values are found 0.03 mg/l and zinc is found <0.01 mg/l.

1.8 Noise Level Survey

The physical description of sound concerns its loudness as a function of frequency. Noise in general is sound which is composed of many frequency components of various loudness distributed over the audible frequency range. Various noise scales have been introduced to describe, in a single number, the response of an average human to a complex sound made up of various frequencies at different loudness levels. The most common and universally accepted scale is the A weighted Scale which is measured as dB (A). This is more suitable for audible range of 20 Hz to 20,000 Hz. The scale has been designed to weigh various components of noise according to the response of a human ear.

The impact of noise sources on surrounding community depends on:

- Characteristics of noise sources (instantaneous, intermittent or continuous in nature). It can be observed that steady noise is not as annoying as one which is continuously varying in loudness;
- The time of day at which noise occurs, for example high noise levels at night in residential areas are not acceptable because of sleep disturbance; and
- The location of the noise source, with respect to noise sensitive land use, which determines the loudness and period of exposure.

The environmental impact of noise can have several effects varying from Noise Induced Hearing Loss (NIHL) to annoyance depending on loudness of noise. The environmental impact assessment of noise due to construction activity, and vehicular traffic can be undertaken by taking into consideration various factors like potential damage to hearing, physiological responses, annoyance and general community responses. Noise monitoring has been undertaken for 24-hr duration at each location.

1.8.1 Identification of Sampling Locations

A preliminary reconnaissance survey has been undertaken to identify the major noise generating sources in the area. Noise at different noise generating sources has been identified based on the activities in the village area, ambient noise due to industries and traffic and the noise at sensitive areas like hospitals and schools. The noise monitoring has been conducted for determination of noise levels at eight locations in the study area. The environmental settings of each noise monitoring location is given in **Table-1.8.1** and depicted in **Figure-1.8.1**.

1.8.2 Method of Monitoring

Sound Pressure Level (SPL) measurements were measured at all locations; one reading for every hour was taken for 24 hours. The day noise levels have been monitored during 6 am to 10 pm and night levels during 10 pm to 6 am at all the monitoring locations within the study area.

TABLE-1.8.1
DETAILS OF NOISE MONITORING LOCATIONS

Location Code	Location (Village)	Distance w.r.t Project Site (km)	Direction w.r.t Project Site	Zone
N1	Near-Plant site	--	--	Residential
N2	Thiruporur	4.7	NW	Residential
N3	Aalathur	5.0	SW	Residential
N4	Pudunellikuppam	1.9	SSW	Residential
N5	Thiruvidanthai	6.9	NNE	Residential
N6	Kelambakkam	9.2	NNW	Commercial
N7	Nemmeli	1.2	NW	Residential
N8	Thandalam	3.2	W	Residential

1.8.3 Parameters Measured During Monitoring

For noise levels measured over a given period of time interval, it is possible to describe important features of noise using statistical quantities. This is calculated using the percent of the time certain noise levels are exceeding the time interval. The notation for the statistical quantities of noise levels are described below:

- L_{10} is the noise level exceeded 10 per cent of the time;
- L_{50} is the noise level exceeded 50 per cent of the time ; and
- L_{90} is the noise level exceeded 90 per cent of the time.

Equivalent Sound Pressure Level (L_{eq}):

The Leq is the equivalent continuous sound level which is equivalent to the same sound energy as the actual fluctuating sound measured in the same period. This is necessary because sound from noise source often fluctuates widely during a given period of time.

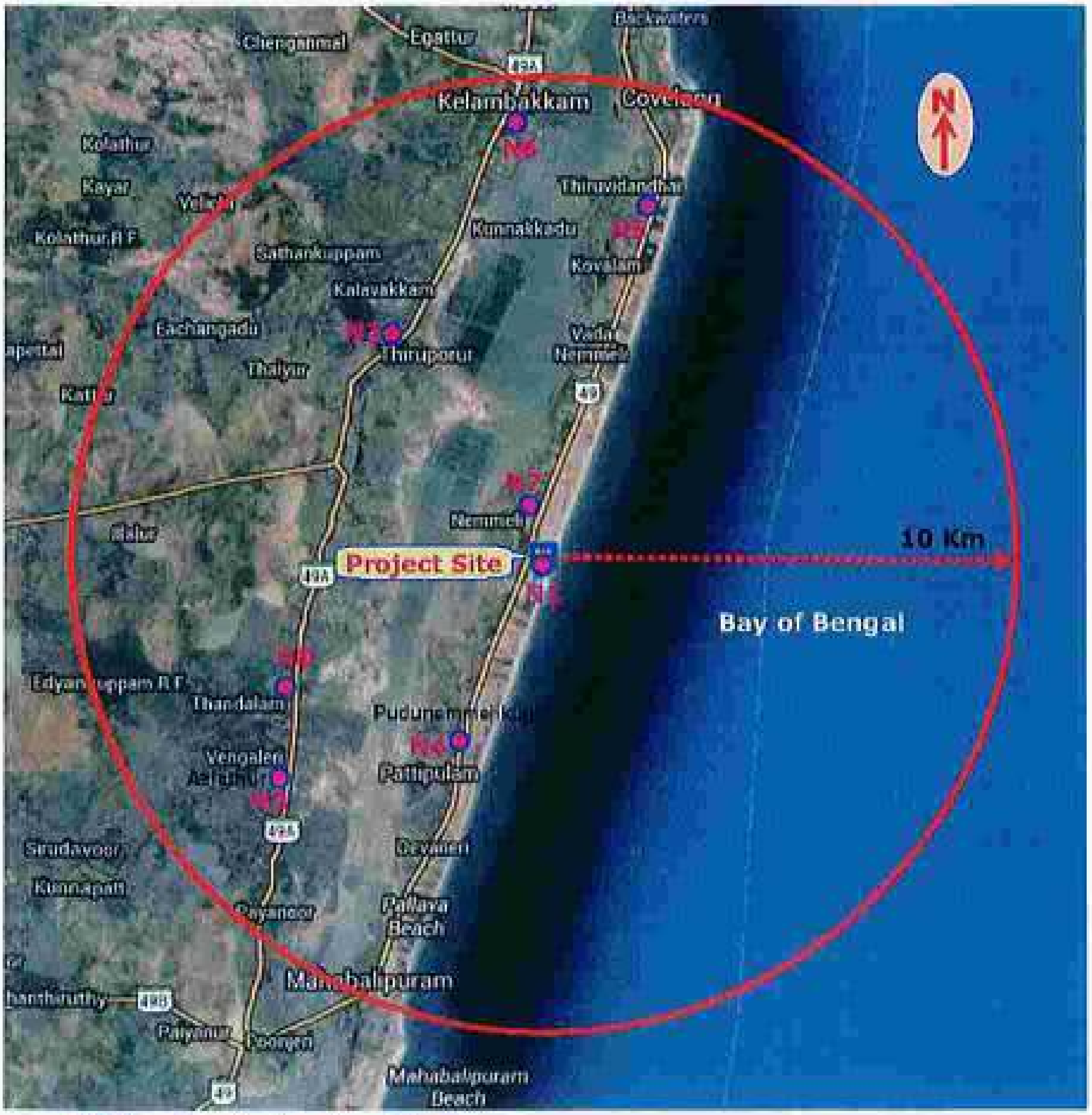
This is calculated from the following equation:

$$L_{eq} = L_{50} + \frac{(L_{10} - L_{90})^2}{60}$$

L_{day} is defined as the equivalent noise level measured over a period of time during day (6 am to 10 pm).

L_{night} is defined as the equivalent noise level measured over a period of time during night (10 pm to 6 am).

A noise rating developed by Environmental protection Agency (EPA) for specification of community noise from all the sources is the Day-Night Sound Level, (L_{dn}).



Noise Monitoring Locations

FIGURE-1.8.1
NOISE MONITORING LOCATIONS

Day-Night Sound Level (L_{dn}):

The noise rating developed for community noise from all sources is the Day-Night Sound Level (L_{dn}). It is similar to a 24 hr equivalent sound level except that during night time period (10 pm to 6 am) a 10 dB (A) weighting penalty is added to the instantaneous sound level before computing the 24 hr average.

This night time penalty is added to account for the fact that noise during night when people usually sleep is judged as more annoying than the same noise during the day time.
The L_{dn} for a given location in a community may be calculated from the hourly L_{eq}'s, by the following equation.

$$L_{dn} = 10 \log \{1/24[16(10^{Ld/10}) + 8 (10^{(Ln+10)/10})]\}$$

Where L_d is the equivalent sound level during the daytime (6 am to 10 pm) and L_n is the equivalent sound level during the nighttime (10 pm to 6 am).

1.8.4 Presentation of Results

The statistical analysis is done for measured noise levels at eight locations for once during study period. The parameters are analyzed for L_{day}, L_{night}, and L_{dn}. These results are tabulated in **Table-1.8.2.**

TABLE-1.8.2
NOISE LEVELS IN THE STUDY AREA

Code	Location	L_{10}	L_{50}	L_{90}	L_{eq}	L_{day}	L_{night}	L_{dn}
N1	Near-Plant site (R)	44.3	40.4	36.7	41.4	42.2	38.6	45.7
N2	Thiruporur (C)	47.7	43.8	40.1	44.8	45.6	42.0	49.1
N3	Aalathur (R)	45.8	41.9	38.2	42.9	43.7	40.1	47.2
N4	Pudunellikuppam (R)	45.1	41.2	37.5	42.2	43.0	39.4	46.5
N5	Thiruvidanthai (R)	46.2	42.3	38.6	43.3	44.1	40.5	47.6
N6	Kelambakkam (C)	48.3	44.4	40.7	45.4	46.2	42.6	49.7
N7	Nemmeli (R)	45.5	41.6	37.9	42.6	43.4	39.8	46.9
N8	Thandalam (R)	44.9	41.0	37.3	42.0	42.8	39.2	46.3

Note: *R- Residential, C- Commercial*

a) Daytime Noise Levels (L_{day})

The daytime noise levels at all the locations are observed to be within the prescribed limits for various zones. The minimum noise level is observed 42.2 dBA at Near-Plant site (N1) and maximum noise level observed 46.2 dB (A) at Kelambakkam (N6).

It is observed that the day time noise levels are in broadly in accordance to the prescribed limit of 55 dB (A) for rural / residential areas and 65 dB (A) for commercial zones.

b) Night time Noise Levels (L_{night})

The night time noise levels at all the locations were found to be within the prescribed limits for various zones. The maximum noise level observed 44.7 dB (A) at Vayor village (N6).

It is observed that the night time noise levels are in broadly in accordance to the prescribed limit of 45 dB (A) for rural / residential areas and 55 dB (A) for commercial zones.

1.9 Flora and Fauna

1.9.1 Introduction

Ecological evaluation aims at developing and applying methodologies to assess the relevance of an area for nature conservation. As such, it is to support the assessment of the impact of a proposed development by providing guidance on how to describe the ecological features within the area affected, how to value them, and how to predict the value losses caused by the development. The evaluation of the ecological significance of an area can be undertaken from different perspectives and consequently with different objectives. One of such perspectives focuses on the conservation of the biological diversity or biodiversity. Among the human activities that pose the highest threat to the conservation of biodiversity are the developmental projects in particular. Such projects represent artificial elements that cut through the landscape and interfere with the natural habitat and its conditions by emissions that may be solid, liquid and or gaseous. This in turn influences the abundance and distribution of plant and animal species, i.e., the biodiversity of the areas impacted.

Most of the data are usually already existing and obtainable from the governmental agencies or the scientific literature. This information is typically complemented by field visit, site surveys and sample collection. The description of the actual ecological assessment provided by the ecological baseline study serves to set a reference for the subsequent impact analysis. Moreover, it helps decision-makers and EIA reviewers to become familiar with the environmental features and the needs of the study area.

1.9.2 Objectives

The present study was undertaken with the following objectives to assess both terrestrial and aquatic habitats of the study area:

- To assess the nature and distribution of vegetation in and around the existing project site.
- To assess the fauna in the study area.
- To understand the ecology of the water bodies.
- To identify and quantify the ethno botanical importance of the plant species.
- To ascertain the migratory routes of fauna, presence of breeding grounds and sensitive habitats in the study area, if any.
- To assess the presence of protected areas in the study area.

- To review the information from secondary sources and discuss the issues of concern with the relevant authority and stakeholders.
- Impact prediction based on primary and secondary data sources to formulate mitigation measures.

1.9.3 Methodology

To achieve the above objectives a detailed study of the area was undertaken with the existing plant as its centre. The different methods adopted were as follows:

- Generation of primary data by undertaking systematic ecological studies in the study area;
- Primary data collection for flora through random sampling method for trees, shrubs and herbs from the selected locations to know the vegetation cover qualitatively.
- Faunal studies by taking transect in the study area to spot the fauna and also to know the fauna through secondary indictors such as pugmarks, scats, fecal pallets, calls and other signs.
- For ecological information, the secondary sources such as local officials, villagers and other stakeholders were interviewed.
- Sourcing secondary data with respect to the study area from published literature.

The locations for terrestrial and aquatic ecological studies are shown in **Figure 1.9.1** and the details are given in **Table 1.9.1.**

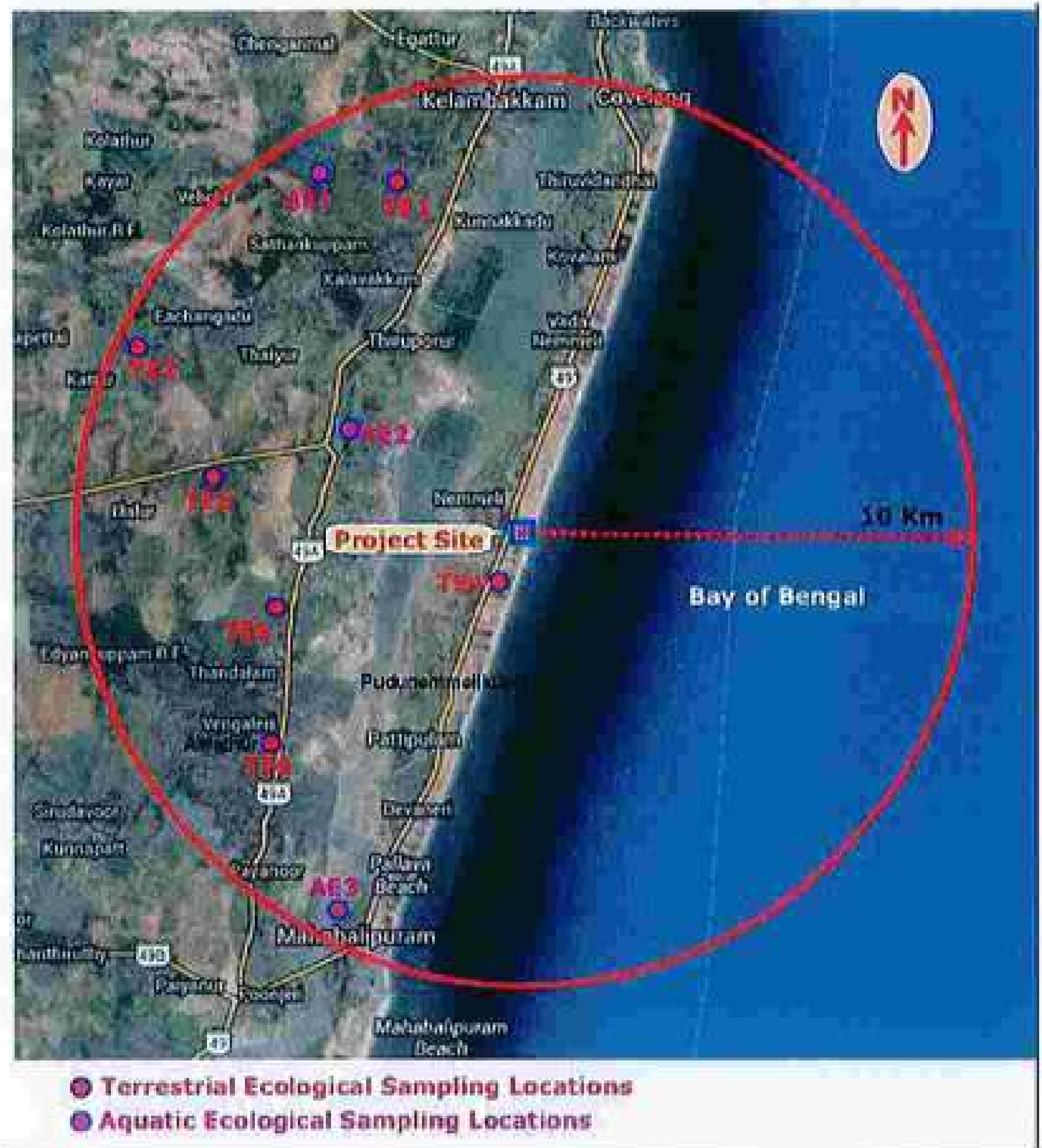


FIGURE-1.9.1
ECOLOGICAL SAMPLING LOCATIONS

TABLE-1.9.1
DETAILS OF SAMPLING LOCATIONS

Code	Location	Distance w.r.t. Project Site (km)	Direction w.r.t. Project Site
Terrestrial			
TE1	Near OMR (North)	8.2	NNW
TE2	Near Kattur	9.5	NW
TE3	Near Illalur	7.0	WNW
TE4	Near Pattipullam	1.2	SSW
TE5	Near OMR (South)	5.8	WSW
TE6	Near Vengaleri	7.3	SW
Aquatic			
AE1	Near Pudupakkam	9.1	NNW
AE2	Kandhaswamy Temple Tank	4.5	NW
AE3	Near Mahabalipuram	9.2	SSW

1.9.4 Type of Habitats in the Study Area

The study area falls in the southern east coast of the subcontinent which receives considerable rainfall in the monsoon. Being a coastal region and intrusion of marine water on the landwards side, the habitat is dominated by backwaters and salt pans. The eastern half of the study area (10km radius) falls under marine subtidal region, coastal habitats comprising of beaches, marshes and estuaries. Towards the west of the coast (landward side) the habitat is mainly represented by dense *Casurina* plantations on the coast and salt pans intermixed with backwaters.

The area in general is well developed with good road network, infrastructure along with many beach resorts and places of interest for tourism and pilgrimage. The two main roads which connect the villages in the region to the major towns and the capital city are East Coast Road (ECR) and Old Mahabalipuram Road (OMR). The other habitats in the study area are mostly represented by pasture lands, grazing lands, agriculture lands, farms and plantations. There are reserve forests (RFs) in the study area which have secondary mixed dry deciduous forest. The study area also has many ephemeral water bodies and manmade water bodies. There are no large rivers flowing through the study region. The land between the ECR and OMR has marine water intrusion (about 50%) hence most of the area is being used as salt pans. The list of reserve forest are given in **Table-1.9.2.**

1.9.5 Terrestrial Flora

The study area is located near the capital city and there are two major roads crossing through the study area which connect Chennai with a major tourist destination that is Mahabalipuram. Owing to this the buffer zone of the study area has very less natural forests remaining which are catagorised as Reserve Forests. Most of the vegetation is in the form of plantation along the bunds of agricultural lands, grazing lands and road side vegetation. The coastal areas in the buffer zone have been planted with *Casurina* which acts as shoreline protection.

There is very little natural vegetation within the study area. The RFs in the buffer zone have low dense mixed scrub forest. The RFs have a well grown under storey with many shrubs and grasses. Few areas have bamboo and other areas are dominated by *Prosopis juliflora* on uncultivable waste land. *Azadirachta indica* and *Borassus flabelliform* have better adaptability among naturally growing species. The villages in study area have sometimes cashew tree & coconut plantation. Plantation of fruit trees & decorative plants like Guava, Papaya, Banana, China rose, Coconut etc. are seen. Paddy is the main crop but pulses, sugarcane & groundnut are also grown is this area. Many locally available plants are used in traditional medicine. The area along the coast and two major roads have been occupied by many commercial establishments which consist of resorts and hotels. These establishments have maintained and developed good vegetation and green belt which comprise of trees with canopy and ornamental and flowering shrubs.

Significant amount of area in the buffer zone is maintained as grassland which acts as fodder source for cattle **(Figure 1.9.2).** The plantations along the roads are mostly of *Eucaliptus, Azadiracta indica, Casurina* and *Cassia sp.* Many patchy areas have exclusive plantations of *Eucaliptus, Azadirachta indica, Casurina, Cocos nucifera, Tectona grandis* and Palm. Some of the areas have developed dense vegetation of *Prosopis juliflora*. Trees like *Lepisanthes tetraphylla, Buchanania axillaris, Santalum album* and *Manilkara hexandra*, once known to be common are now found only in the protected forests of the region. *Ziziphus xylopyrus, Acacia planifrons, Atalantia monophylla, Canthium parviflorum, Catunaregam spinosa, Scutia myrtina, Benkara malabarica* and *Ziziphus oenoplia* have now started to dominate amongst the vegetation. High anthropogenic pressure, browsing and lopping are the presumable reasons for the occurrence of more number of these thorny species. The genera with high occurrence include *Cassia*, *Crotalaria*, *Erogrostis*, *Phyllanthus* and *Hedyotis*.

The area shows many algae, fungi, bryophytes and ferns. Algae are present in aquatic bodies and in marshy places. Fungi, particularly from ascomycetes and basidiomycetes are located either on ground or epiphytically. Lichens of crustose, foliose and fruticose types are present on different substrates. Bryophytes occur in wet areas and occasionally on barks of trees and old walls of houses and other structures.

1.9.6 Terrestrial Fauna

No wild lives of Schedule 1 are found in the core zone. The terrestrial fauna consist mostly of avifauna and there are no major animals of conservation importance. Jungle cat, Rhesus macaque, Indian fox etc. are found amongst mammals. The mammals occasionally observed such as Jackal and rodents which stray from the nearby RFs.

The avifauna recorded during the field survey are; Cattle Egret, Pond Heron, Grey Heron, Pale Harrier, Common Babblers, Leaf Warblers, White Throated Kingfisher, Black Drongo, Red Whiskered Bulbul, Indian Roller and House Crow etc. The area is also known to harbour species of Storks, Ibis, Stilt, Plovers, Jacanas along with other wader.

As the region has good rainfall, many common species of herpetofauna occur in the region along with many arthropods. Due to presence of many lentic and lotic water bodies interspersed with small hillocks with rocky habitats the area shows a good representation of reptiles and amphibians viz; Common Indian toad

(*Duttaphrynus melanostictus*), Common tree frog (*Polypedates maculates*), Indian skipper frog (*Euphlyctis cyanophlyctis*), Indian flapshell turtle (*Lissemys punctata*), Southern house gecko (*Hemidactylus frenatus*), Common garden lizard (*Calotes versicolor*), Common skink (*Eutropis macularia*), Indian rat snake (*Ptyas mucosus*), Common bronzeback (*Dendrelaphis tristis*), Bengal monitor (*Varanus bengalensis*).

TABLE-1.9.2
DETAILS OF RESERVE FOREST IN THE STUDY AREA

Sr.No.	Forests	Distance (Km)	Direction
1	Talayur RF	7.6	NW
2	Illalur RF	5.2	NW
3	Madayattur RF	5.7	WNW
4	Kattur RF	8.9	WNW
5	Alattur RF	4.4	W
6	Kulattur RF	10	NW
7	Kayar RF	11.6	NW
8	Sirukunram RF	14.8	WNW
9	Sonallur RF	12.6	NNW
10	Mambakkam RF	14.4	NW

1.9.7 Aquatic Biodiversity

The buffer zone has many freshwater bodies which are mostly ephemeral. There is a canal crossing across the study area which runs parallel to the coast covering large stretch of land from Chennai to Pondicherry. Many water bodies in the study area have submerged and floating hydrophytes such as lotus and water lily (*Nelumbo* sp.), *Ipomea aquatic* and *Hydrilla* sp..

The micro-algae represented by Chlorophyceae and Bacillariophyceae that include *Pediastrum* sp, *Actinastrum* sp, *Synedra* sp, *Navicula* sp, *Pinnularia* sp., *Nitzschia* sp. and *Cymbella* sp., *Chlorella vulgaris, Dunaliella tertiolecta, Tetraselmis suecica.*

The freshwater zooplanktons were significantly represented by Cladocerans, Rotifers, Copepods, Sarcodines and Euglinids. The community composition included *Keratella* sp., *Diaptomus* sp., *Pseudodioptomus* sp., *Branchionus* sp., *Diaphanosoma* sp., *Macrothrix* sp. along with Amoeba and Euglina.

Freshwater benthic fauna was represented by larval and sub adult stages of terrestrial and aquatic arthropods along with molluscs and crustaceans such as aquatic gastropods, crabs other decapods and Oligochaetes. The arthropods were represented by Ephemeroptera, Diptera, Trichoptera, Coleoptera, Odonata and Hemiptera.

Freshwater fishes found in the study area are mostly the result of traditional fishery practices, modern aquacultures and exploitation of fish resources. The species which usually occur are introduced in the region for commercial and economic growth. The species may have sporadic and seasonal occurrence depending on the availability of water in the water bodies across the seasons. The species include *Cirrhina mrigala, Hypophthalmichthys molitrix, Ctenophyaryngodon idella, Cyprinus carpio, Labeo rohita, Catla catla,* *Heteropneustes fossilis, Rita rita, Mystus pseudutropius, Ompok sp., Clarias sp., Wallago sp.*

1.9.8 Conclusions

The baseline survey reveals that the study area harbours biodiversity which is mostly aggregated in the reserve forests and plantations and near the water bodies. There are no schedule-I species as per the Wildlife (Protection) Act 1972. There are no Wildlife Sanctuaries, National Parks, Tiger Reserves or Biosphere Reserves in the study area. There are no corridors and routes of migratory fauna. The study core zone of the study area has no flora and fauna and does not involve any tree cutting. The buffer zone has few reserve forests which have secondary grown forest and shows signs of heavy anthropogenic pressure that has resulted in stunted growth, dominance of weeds and more thorny species of shrubs and trees.

FIGURE 1.9.2
(A) CASURINA PLANTATION NEAR THE COAST
(B) PALM IN THE CULTIVATED GRASSLANDS
(C) CATTLE GRAZING IN THE GRASSLANDS AND
(D) KANDHASWAMY TEMPLE TANK

1.10 Demography and Socio-Economics

In this section, the prevailing socio-economic aspects of people in the study area around the proposed project boundary, which would form the basis for making planning efforts for the socio-economic development of people of the study area, have been described.

1.10.1 Methodology Adopted for the Study

The methodology adopted for the study mainly includes review of latest published secondary data (District Census Statistical Handbooks-2011 and Primary Census Abstract of Census-2011) with respect to population, Social structure, literacy levels and occupational structure available for 10-km radius study area.

1.10.2 Review of Demographic and Socio-Economic Profile-2011

The village wise demographic data for the census year 2011 is given in **Annexure-IX**. The salient features of the demographic and socio-economic details are described in the following sections.

1.10.3 Demography

Almost all villages in the study area are experiencing a rapid growth of population, which may be due to the process of industrialization.

Distribution of Population

As per 2011 census the study area consisted of 73245 souls inhabited in study area. The distribution of population in the study area is shown in **Table-1.10.1.**

TABLE-1.10.1
DISTRIBUTION OF POPULATION

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
No. of Households	1009	9190	7762	17961
Male Population	1974	18994	16031	36999
Female Population	1848	18470	15928	36246
Total Population	3822	37464	31959	73245
Male Population (0-6 years)	250	2179	1871	4300
Female Population (0-6 years)	226	2178	1831	4235
Total Population (0-6 years)	476	4357	3702	8535
Average Household Size	3.79	4.08	4.12	4.08
% of males to the total population	51.65	50.70	50.16	50.51
% of females to the total population	48.35	49.30	49.84	49.49
Sex Ratio (no of females per 1000 males)	936	972	994	980
Density	336	717	557	605

Source: District Census Hand Book -2011

Average Household Size

The study area has a family size of 4.08 as per 2011 census.

Population Density

The density of population reveals that the study area has an overall density of 605 persons per km2 (PP km2) as per 2011 census reports.

Sex Ratio

The configuration of male and female indicates that the males constitute to about 50.51% and females to 49.49% of the total population as per 2011 census records. The sex ratio i.e. the number of females per 1000 males indirectly reveals certain sociological aspects in relation with female births, infant mortality among female children and single person family structure, a resultant of migration of industrial workers. The study area on an average has 980 females per 1000 males as per 2011 census reports.

1.10.4 Social Structure

In the study area, as per 2011 census, 34.19 % of the population belongs to Scheduled Castes (SC) and 1.04 % to Scheduled Tribes (ST). The distribution of population by social structure is shown in **Table-1.10.2**.

TABLE-1.10.2
DISTRIBUTION OF POPULATION BY SOCIAL STRUCTURE

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Schedule caste	203	14864	9973	25040
% To the total population	5.31	39.68	31.21	34.19
Schedule Tribes	124	398	240	762
% To the total population	3.24	1.06	0.75	1.04
Total SC and ST population	327	15262	10213	25802
% To total population	8.56	40.74	31.96	35.23
Total population	3822	37464	31959	73245

Source: District Census Hand Book -2011

1.10.5 Literacy Levels

The study area experiences a literacy rate of 72.65 % (2011). The distribution of literate and literacy rate in the study area is given in **Table-1.10.3.**

TABLE-1.10.3

DISTRIBUTION OF LITERATE AND LITERACY RATES

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Male Population	1974	18994	16031	36999
Female Population	1848	18470	15928	36246
Total Population	3822	37464	31959	73245
Male Population (0-6 years)	250	2179	1871	4300
Female Population (0-6 years)	226	2178	1831	4235
Total Population (0-6 years)	476	4357	3702	8535
Male literates	1546	15125	12489	29160
Female literates	1206	12357	10487	24050
Total literates	2752	27482	22976	53210
Male literacy rate (%)	56.18	55.04	54.36	54.80
Female literacy rate (%)	43.82	44.96	45.64	45.20
Average Male Literacy to the total population (%)	40.45	40.37	39.08	39.81
Average female Literacy to the total population (%)	31.55	32.98	32.81	32.84
Total Literacy rate (%)	72.00	73.36	71.89	72.65

Source: District Census Hand Book -2011

The male literacy i.e. the percentage of literate males to the total males of the study area works out to be 54.80 %. The female literacy rate, which is an important indicator for social change, is observed to be 45.20 % in the study area as per 2011 census records.

1.10.6 Occupational Structure

The occupational structure of residents in the study area is studied with reference to main workers, marginal workers and non-workers. The main workers include 10 categories of workers defined by the Census Department consisting of cultivators, agricultural laborers, those engaged in live-stock, forestry, fishing, mining and quarrying; manufacturing, processing and repairs in household industry; and other than household industry, construction, trade and commerce, transport and communication and other services.

The marginal workers are those workers engaged in some work for a period of less than six months during the reference year prior to the census survey. The non-workers include those engaged in unpaid household duties, students, retired persons, dependents, beggars, vagrants etc.; institutional inmates or all other non-workers who do not fall under the above categories.

As per 2011 census records altogether the main workers works out to be 30.51% of the total population. The marginal workers and non-workers constitute to 8.32 % and 61.17 % of the total population respectively. The distribution of workers by occupation indicates that the non-workers are the predominant population. The occupational structure of the study area is shown in **Table-1.10.4.**

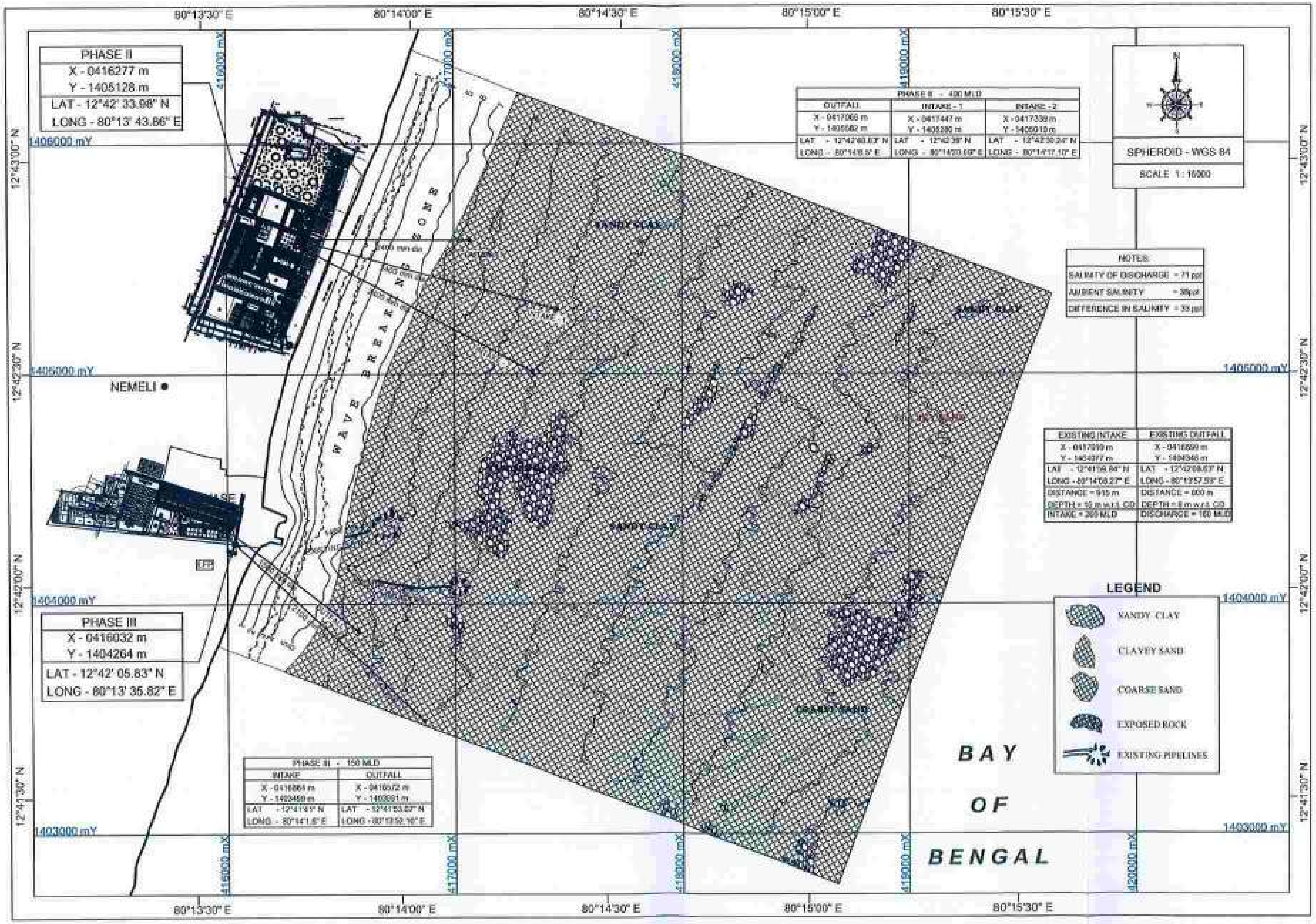
TABLE-1.10.4
OCCUPATIONAL STRUCTURE

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Total Population	3822	37464	31959	73245
Total workers	1402	14378	12660	28440
Work participation rate (%)	36.68	38.38	39.61	38.83
Total main workers	1319	10588	10440	22347
% of main workers to total population	34.51	28.26	32.67	30.51
Marginal workers	83	3790	2220	6093
% of marginal workers to total population	2.17	10.12	6.95	8.32
Non-workers	2420	23086	19299	44805
% of non-workers to total population	63.32	61.62	60.39	61.17

Source: District Census Hand Book-2011

Annexure-VII

Marine Facilities



DETAILS OF INTAKES & OUTFALLS

CONSULTANT:	AECOM INDIA Private Limited in Association with GHD Pty Limited and WATER Engineering
CLIENT:	Chennai Metro Water Supply and Sewerage Board
PROJECT TITLE:	CONSULTANCY TO CONDUCTING PREFEASIBILITY STUDIES/PREPARATION OF DETAILED PROJECT REPORT, BID DOCUMENTS, EVALUATION OF BIDS (BID PROCESSING) AND FINANCIAL VIABILITY FOR SETTING UP OF A 400 MLD CAPACITY SEA WATER REVERSE OSMOSIS DESALINATION PLANT FOR CHENNAI CITY AT PERUR ALONG ECR ROAD, CHENNAI, TAMILNADU, INDIA
DRAWING TITLE:	DETAILS OF INTAKES AND OUTFALLS
SCALE:	AS SHOWN
SIZE	A1
SHEET	1

REV NO.	DATE	DETAILS	BY	CHKD	APPD	PROJ MGR
0		FOR APPROVAL	MKC	A.R.	P.G.	U.K.

Annexure-VIII

HTL /LTL Line Demarcation by Anna University

DEMARCATION OF HIGH TIDE LINE, LOW TIDE LINE AND PREPARATION OF COASTAL LANDUSE MAP FOR THE PROPOSED DESALINATION PLANT IN NEMMELI VILLAGE, CHENGALPATTU TALUK, KANCHEEPURAM DISTRICT, TAMILNADU

SPONSORED BY

M/s AECOM INDIA PRIVATE LIMITED
Building No. 10
DLF Cyber City, DLF Phase-II
Gurgaon, Haryana, India

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY, CHENNAI-25

FEBRUARY 2014

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DEMARCATION OF HIGH TIDE LINE, LOW TIDE LINE AND PREPARATION OF COASTAL LANDUSE MAP FOR THE PROPOSED DESALINATION PLANT IN NEMMELI VILLAGE, CHENGALPATTU TALUK, KANCHEEPURAM DISTRICT, TAMILNADU

ABSTRACT

At the request of the M/s AECOM India Private Limited, Gurgaon, Haryana, India a survey was carried out to demarcate the High Tide Line (HTL), Low Tide Line (LTL) and Preparation of Coastal Landuse Map for 7Km radius around proposed desalination plant in survey no. 208 Part of Nemmeli Village, Chengalpattu Taluk, Kancheepuram District of Tamil Nadu. The satellite data of the study area were interpreted for landuse and geomorphic features. A landuse map for an area of 7 Km radius around proposed desalination plant was prepared at 1:25,000. The proposed site has predominantly flat topography. Bay of Bengal lies along eastern boundary and Buckingham canal runs away from western boundary of site. The cadastral map of the Nemmeli Village provided by Survey and Land Records was used as the Base Map. Based on the topography, HTL, LTL has been identified and traced in the field by Kinematic GPS survey. The HTL, LTL was superimposed on to georeferenced cadastral map to prepare a local level HTL map. 200m, 500m buffer lines for HTL of Bay of Bengal and 100m buffer, buffer for creek width for HTL of creek were drawn in the vicinity of project site. The proposed project boundary as provided by the client were superimposed on to local level HTL map and enclosed. The spherical co-ordinates of the High Tide Line in WGS84 system are presented in the Annexure.

DEMARCATION OF HIGH TIDE LINE, LOW TIDE LINE AND PREPARATION OF COASTAL LANDUSE MAP FOR THE PROPOSED DESALINATION PLANT IN NEMMELI VILLAGE, CHENGALPATTU TALUK, KANCHEEPURAM DISTRICT, TAMILNADU

1. INTRODUCTION

The coastal zone is the area of interaction between land and sea. The coastal Zone in Tamil Nadu has a very high concentration of population along with ecologically sensitive areas like mangroves, fish culture zones. There is a spurt of developmental activities arising from new industries and tourism centres along the coast and in coastal zone. There is a need to protect the coastal environment while ensuring continuing production and development. This zone is extremely vulnerable and has to be managed judiciously striking a balance between ecological and developmental needs.

The Ministry of Environment and Forest in the CRZ Notification, 2011 declared the following areas as CRZ and imposed with effect from the date of the notification the restrictions on the setting up and expansion of industries, operations or processes and the like in the CRZ. The areas that are defined as CRZ as per CRZ Notification, 2011 are

(i) The land area from High Tide Line (HTL) to 500mts on the landward side along the sea front.

(ii) CRZ shall apply to the land area between HTL to 100 meters or width of the creek whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea and the distance upto which development along such tidal influenced water bodies is to be regulated shall be governed by the distance upto which the tidal effects are experienced which shall be determined based on salinity concentration of 5 parts per thousand (ppt) measured during the driest period of the year and distance upto which tidal effects are experienced shall be clearly identified and demarcated accordingly in the Coastal Zone Management Plans.

(iii) The land area falling between the hazard line and 500mts from HTL on the landward side, in case of seafront and between the hazard line and 100mts line in case of tidal influenced water body the word 'hazard line' denotes the line demarcated by Ministry of Environment and through the Survey of India taking into account tides, waves, sea level rise and shoreline changes.

(iv) Land area between HTL and Low Tide Line (LTL) which will be termed as the intertidal zone.

(v) The water and the bed area between the LTL to the territorial water limit (12 Nm) in case of sea and the water and the bed area between LTL at the bank to the LTL on the opposite side of the bank, of tidal influenced water bodies.

The Classification of the CRZ is also modified for the purpose of conserving and protecting the coastal areas and marine waters as CRZ – I, CRZ – II, CRZ – III and CRZ – IV. The CRZ – I include the areas that are ecologically sensitive and the geomorphological features which play a role in the maintaining the integrity of the coast like (a) Mangroves(b) Corals and coral reefs and associated biodiversity (c) Sand Dunes (d) Mudflats which are biologically active (e) National parks, marine parks, sanctuaries, reserve forests, wildlife habitats and other protected areas (f) Salt Marshes (g) Turtle nesting grounds (h) Horse shoe crabs habitats (i) Sea grass beds (j) Nesting grounds of birds (k) Areas or structures of archaeological importance and heritage sites and the area between Low Tide Line and High Tide Line. The CRZ-II includes areas that have been developed upto or close to the shoreline. The CRZ-III includes areas that are relatively undisturbed and those do not belong to either CRZ-I or II, which include coastal zone in the rural areas (developed and undeveloped) and also areas within municipal limits or in other legally designated urban areas, which are not substantially built up. The CRZ-IV includes the water area from the Low Tide Line to twelve nautical miles on the seaward side and the water area of the tidal influenced water body from the mouth of the water body at the sea upto the influence of tide which is measured as five parts per thousand during the driest season of the year.

The Ministry of Environment and Forest has also provided guidelines for demarcation of High Tide Line in the CRZ Notification, 2011. As per the guidelines, Cadastral (village) maps in 1:3960 or the nearest scale shall be used as the base maps. HTL and LTL will be demarcated in the cadastral map based on detailed physical verification using coastal geomorphological signatures or features in accordance with the CZM Maps approved by the Central Government. 500metre and 200metre lines shall be demarcated with respect to the HTL.

In order to facilitate classification of Coastal Regulation Zones Government of India has approved few agencies/institutions across the Country vide Lr. No. J17011/8/92-1A III, dated 10.05.1999 of Ministry of Environment and Forests. Institute of Remote Sensing, Anna University being one of them, has been carrying out HTL and LTL mapping following the guidelines issued by Ministry of Environment and Forests, Government of India.

2. BACKGROUND OF THE STUDY

M/s M/s AECOM India Private Limited, Gurgaon, Haryana has requested Institute of Remote Sensing, Anna University for demarcation of HTL, LTL and landuse map for an area with 7Km radius around proposed desalination plant in Nemmeli Village, Chengalpattu Taluk, Kancheepuram District. The Project site is located near Bay of Bengal and Buckingham canal which carry tidal water; hence this study was carried out to demarcate the HTL for Bay of Bengal and Buckingham canal in the vicinity of the project site.

3. STUDY AREA AND EXTENT

The site falls inside the Coastal Regulation Zone of Bay of Bengal in Nemmeli Village. The project area is covered in survey no. 208 of Nemmeli Village, Chengalpattu Taluk, Kancheepuram District. The study area has flat topography with vegetation. The project site lies between East Coast Road and Bay of Bengal.

4. NEED FOR THE STUDY

The proposed site has proximity to Bay of Bengal and Buckingham Canal. It is in this context, the proposed site needs to be evaluated to assess whether the proposed project site is affected under provisions of CRZ Notification, 2011. The objective of the present study is to examine the site with reference to Coastal Regulation Zone Notification, 2011. Keeping in view of the requirements of notification, Institute of Remote Sensing, Anna University under took the project with following agreed scope of work:

- To demarcate HTL for Bay of Bengal and Buckingham Canal within the vicinity of proposed site as per the procedures defined by Ministry of Environment and Forest, Government of India
- To demarcate 200m, 500m buffer lines from HTL for Bay of Bengal 100m buffer line from HTL for Buckingham Canal and Creeks for identification of Coastal Regulation Zone as per the provisions of CRZ Notification, 2011

5. DEMARCATION OF HTL ON THE LOCAL LEVEL MAP

5.1 Methodology adopted

The cadastral map of Nemmeli Village has been used as the base map. The Geomorphology of the Coastal Zone has been studied from the temporal medium resolution satellite data. In order to prepare the local level map on 1:5,000 scale, the site has been inspected by IRS Scientists. Based on the geomorphic units, the high tide line has been identified in the field and traced by field survey.

The tide level observations were collected from the Tide Tables. The highest high tide level and lowest low tide level for the past 19 years was determined from these tide tables.

As per the definition of high tide line, "The High Tide Line means the line on the land up to which the highest water line reaches during the spring tide". There is a clear boundary between the areal spread of mudflats and vegetation usually very much apparent. This boundary line coincides with the HTL line interpreted from the satellite imagery.

In case of inland waters such as creeks and backwaters, the CRZ guidelines indicates that the development along rivers, creeks and backwaters has to be regulated up to a distance where the tidal effects are experienced which has to be determined based on salinity concentration of 5 parts per thousand (ppt). Insitu observations of the salinity were used to delineate the HTL for backwaters.

Landuse features were also interpreted from Satellite Imagery as per the guidelines provided by National Remote Sensing Agency, Hyderabad covering an area of 7Km around proposed desalination plant.

6. GPS SURVEYING

The Trimble 5700 and 4000 SSE (Geodetic Surveyor Series) GPS receivers were used to conduct the surveying at the project site. The survey involves three components namely, 1. Establishing Base Station, 2. Control Survey for Village Maps and 3. Real Time Kinematic Survey for HTL Demarcation.

6.1 Establishing Base Station

The survey involves establishing one base station for each project site using Static Survey. The base stations were identified on stable locations with clear view of sky for uninterrupted access to GPS satellite signals. The control point with known elevation was used as initial reference station. The base station for the project site was established on a culvert and observed with static GPS survey from the known coordinates of the control point. The observations times were fixed based on the length of base lines to obtain highest possible accuracies.

6.2 Static Survey

The conduct of Static Survey using GPS requires two GPS receivers, one to be setup over the control point (with known co-ordinate) and another one over a reference station whose coordinates and distance from the control point are to be determined. Both these receivers must record data simultaneously. These known co-ordinates of the control point were fed and fixed for processing of the logged data to accurately determine the co-ordinates of the base stations.

6.3 Control Survey for Georeferencing Village Maps

The village map pertaining to the project sites provided by the client were obtained from Tamilnadu Survey and Land Records Office. These hard copy village map were scanned and need to be georeferenced for the preparation of local level HTL Maps. In order to georeference these village maps, control points (village bi-junction and tri-junction points) are acquired from the field.

The control points were acquired using Static Survey with Trimble 5700 receivers. Required numbers of control points were obtained and the village maps were georeferenced in WGS 84 datum using the control points for mapping purposes.

6.4 Real Kinematic Survey for HTL Demarcation

Kinematic Surveying enables a very rapid survey of a number of base lines in areas where there is good satellite visibility. At least, two GPS receivers are required to perform a kinematic survey. One receiver is designated as the reference receiver and is set up over the Base Station. All baselines are measured relative to this station. The other receivers, called rovers, are moved in succession to trace and record the HTL on ground through ground profiling.

7. DEMARCATION OF HTL

Surrogate data such as Coastal Geomorphologic features identified from the satellite imagery, indicators available on the ground and Tidal data obtained from Survey of India were used to verify the HTL demarcated by Kinematic Survey. Kinematic GPS receivers used for determination of High Tide Line on the ground was integrated with base station observations to result in baselines.

8. OUTPUT

The observed baselines were processed using TGO software. The same were plotted at large scale using the ArcGIS 9.3 software and the same was superimposed in the georeferenced cadastral map. In the cadastral map of 1:4,000 scale, the HTL for Bay of Bengal and Buckingham Canal, Creeks and buffer lines for 200m and 500m from HTL for Bay of Bengal, 100m from HTL for Buckingham Canal, Creeks are marked (Map enclosed). A landuse map at 1:25,000 was prepared with standard colour codes defined by NRSC, Hyderabad (Map Enclosed). The processed HTL co-ordinates in WGS 84 system are presented in annexure. The satellite imagery of project site is presented below for reference.

DEMARCATION OF HIGH TIDE LINE / LOW TIDE LINE FOR THE PROPOSED DESALINATION PLANT IN NEMMELI VILLAGE, CHENGALPATTU TALUK, KANCHEEPURAM DISTRICT

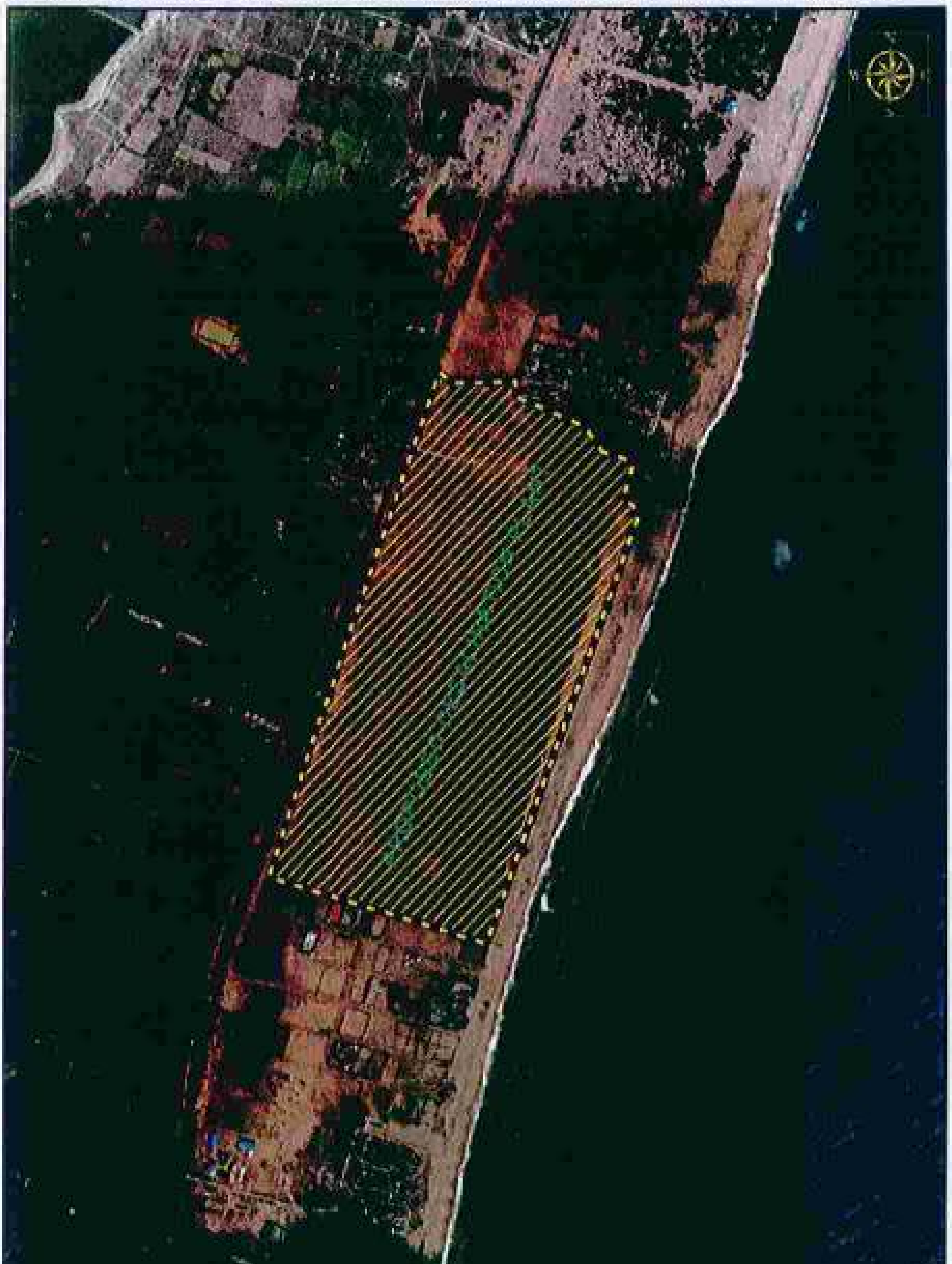


Photo 1 Beach South of Proposed Desalination Project

Photo 2 Eroded and Accreted coast near existing desalination plant

ANNEXURE I

DEMARCATION OF HIGH TIDE LINE, LOW TIDE LINE AND PREPARATION OF COASTAL LANDUSE MAP FOR THE PROPOSED DESALINATION PLANT IN NEMMELI VILLAGE, CHENGALPATTU TALUK, KANCHEEPURAM DISTRICT, TAMILNADU

COORDINATES OF HTL POINTS

Point No	Latitude	Longitude
C1310	12° 42' 14.826" N	80° 13' 00.927" E
C1311	12° 42' 15.689" N	80° 12' 56.098" E
C1312	12° 42' 21.644" N	80° 12' 52.881" E
C1317	12° 42' 49.466" N	80° 12' 53.089" E
C1318	12° 42' 53.120" N	80° 12' 56.922" E
C1319	12° 42' 54.778" N	80° 13' 01.252" E
C1320	12° 43' 01.566" N	80° 13' 04.404" E
C1321	12° 43' 05.745" N	80° 13' 07.766" E
C1322	12° 43' 10.694" N	80° 13' 12.355" E
C1323	12° 43' 13.307" N	80° 13' 13.017" E
C1324	12° 43' 16.854" N	80° 13' 17.923" E
C1325	12° 43' 20.260" N	80° 13' 19.790" E
C1427	12° 43' 08.912" N	80° 13' 56.280" E
C1428	12° 43' 07.614" N	80° 13' 56.274" E
C1429	12° 43' 00.635" N	80° 13' 53.292" E
C1430	12° 42' 59.214" N	80° 13' 52.903" E
H138	12° 43' 19.891" N	80° 14' 02.531" E
H139	12° 43' 14.205" N	80° 14' 00.214" E
H140	12° 43' 09.387" N	80° 13' 58.251" E
H141	12° 43' 07.464" N	80° 13' 57.471" E
H142A	12° 43' 03.652" N	80° 13' 56.148" E
H143A	12° 43' 00.348" N	80° 13' 54.897" E
H144A	12° 42' 58.191" N	80° 13' 53.841" E
H145A	12° 42' 51.975" N	80° 13' 50.910" E
H146A	12° 42' 46.701" N	80° 13' 48.701" E
H147A	12° 42' 43.759" N	80° 13' 47.488" E
H148A	12° 42' 38.211" N	80° 13' 44.751" E
H149A	12° 42' 33.935" N	80° 13' 43.235" E
H149B	12° 42' 31.025" N	80° 13' 43.665" E
H150	12° 42' 26.101" N	80° 13' 42.268" E
H151	12° 42' 21.049" N	80° 13' 40.141" E
H152	12° 42' 17.800" N	80° 13' 39.750" E
H153	12° 42' 15.877" N	80° 13' 38.646" E

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University, Chennai-600 025

AECOM

AECOM Asia Company Limited
8/F, Grand Central Plaza, Tower 2
138 Shatin Rural Committee Road
Shatin N.T. Hong Kong
www.aecom.com

27 March 2014

The Chief Engineer, PMC, RRWS, & FMP (Nagaur),
PHED, Qtr. No. AW 1/1, PHED Colony,
Vaishali Nagar, Ajmer-305004,
Rajasthan, India.

Sub. : Project undertaken by AECOM Asia Company Limited.

Project Name : Project Monitoring and Supervision Consultants for Rajasthan Rural Water Supply and Fluorosis Mitigation Project (Nagaur)

Dear Sir,

This has reference to the above project. We hereby submit that AECOM Asia Company Limited is registered in Hong Kong. Its registered office address is 8/F, Grand Central Plaza, Tower 2, Grand Shatin Rural Committee Road, Shatin, N.T. Hong Kong. The Company is doing the above project in Nagaur, Rajasthan (India) from its registered branch office in India at 9th Floor, Infinity Tower C, DLF Cyber City, DLF Phase II, Gurgaon-122002. The Company's Gurgaon office will deploy its staff, makes all expenditures for the execution of the Project and will receive all its payment in Indian component and Foreign component in its Current Account No. 054-393244-002 maintained in Indian currency with The Hongkong & Shanghai Banking Corporation Ltd., JMD Regent Square, DLF Phase II, Mehrauli-Gurgaon Road, Gurgaon-122002 branch in Haryana (India).

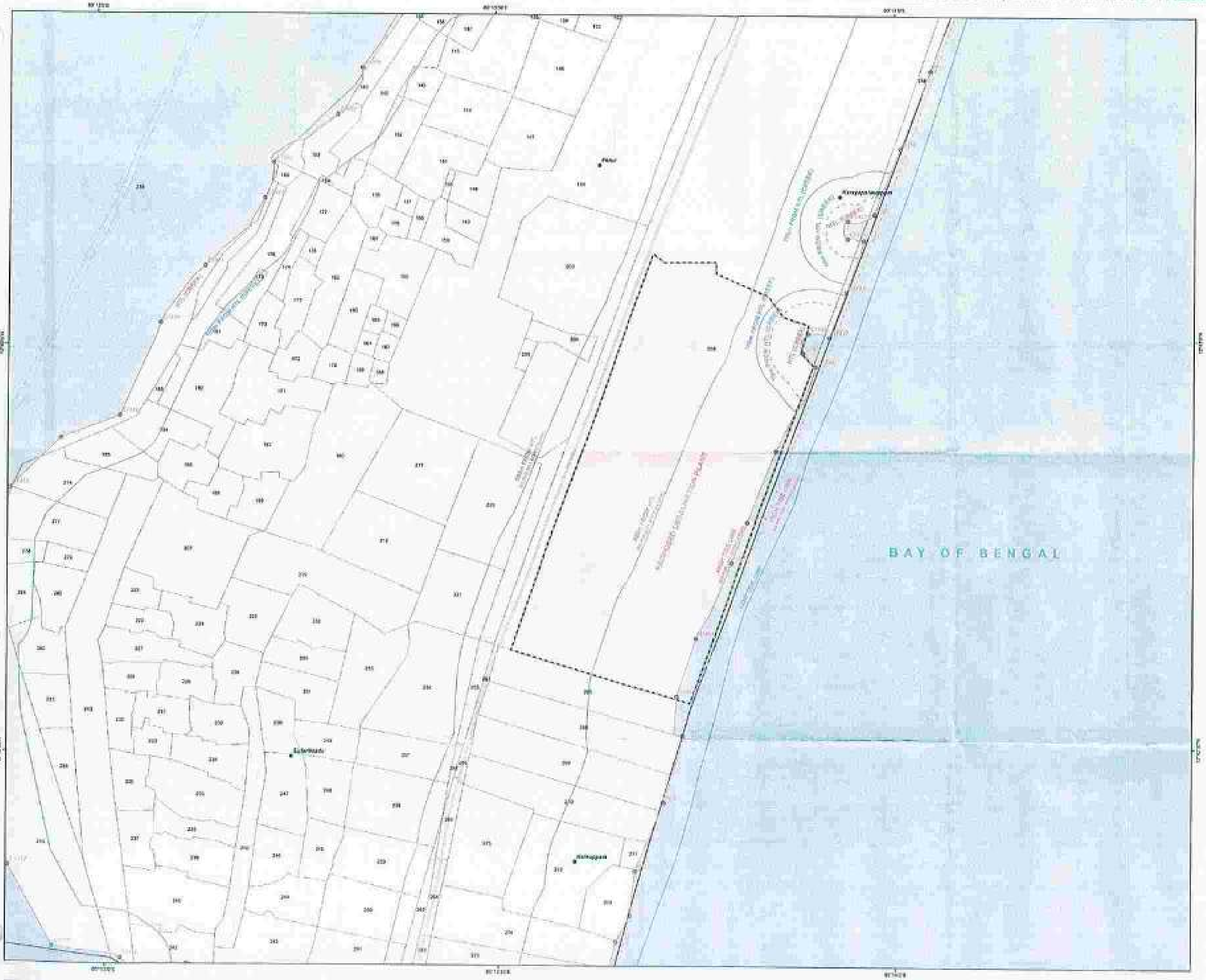
This is for your information and records.

Thanking you,
Yours sincerely,
For **AECOM Asia Company Limited**

AECOM Asia Company Limited

(Authorised Signatory)

DEMARCATION OF HIGH TIDE LINE / LOW TIDE LINE FOR THE PROPOSED DESALINATION PLANT IN NEMMELI VILLAGE, CHENGALPATTU TALUK, KANCHEEPURAM DISTRICT



N

LEGEND

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL) / HTL (CREEK)
- HIGH TIDE LINE (CHIEF HYDROGRAPHER)
- CREEK WIDTH FROM HTL
- 100m FROM HTL (CREEK)
- 200m FROM HTL
- 500m FROM HTL
- EARTHERN ROAD
- EAST COAST ROAD (ECR)
- STREAM / TANK
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- WATER BODIES
- HAMLET
- HTL REFERENCE POINTS

SOURCE : CLIENT

PROPOSED DESALINATION PLANT

SCALE 1 : 4,000

0 50 100 200 300 400 M

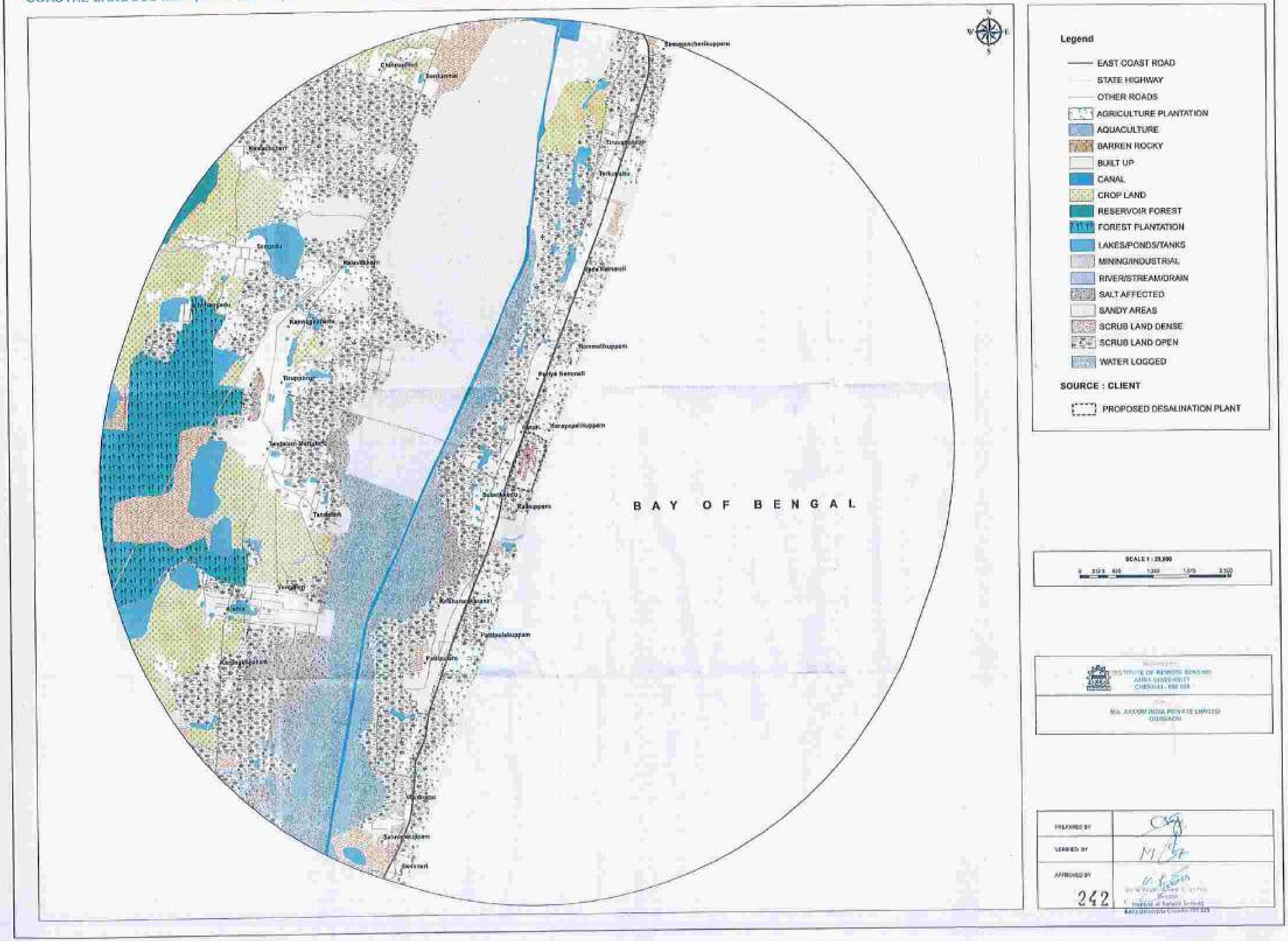
INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

M/s. ACCOM INDIA PRIVATE LIMITED
GURGAON

PREPARED BY	
VERIFIED BY	
APPROVED BY	

Institute of Remote Sensing
Anna University Chennai 600 025

COASTAL LANDUSE MAP (7KM RADIUS) IN 1 : 25000 SCALE FOR THE PROPOSED DESALINATION PLANT IN NEMMELI VILLAGE, CHENGALPATTU TALUK, KANCHEEPURAM DISTRICT



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DEMARCATION OF HIGH TIDE LINE / LOW TIDE LINE FOR THE PROPOSED DESALINATION PLANT IN NEMMELI VILLAGE, CHENGALPATTU TALUK, KANCHEEPURAM DISTRICT

Date 31.10.18
No. 952

F.No. 11-37/2016-IA-III
Government of India
Ministry of Environment, Forest and Climate Change

31 OCT 2018
1292

Indira Paryavaran Bhawan,
Jor Bagh Road, New Delhi - 110003
Dated: 25.10.2018

01 NOV 2018

To,

Chennai Metropolitan Water Supply & Sewerage Board
No.1, Pumping Station Road,
Chintadripet, Chennai-600 002

Sub: CRZ Clearance for setting up of 400 MLD capacity desalination Plant at Perur, East Coast Road, Chennai, Tamil Nadu - reg.

Sir,

This has reference to your proposal No. IA/TN/MIS/59770/2016, received in this Ministry seeking CRZ Clearance for setting up of 400 MLD capacity desalination Plant at Perur, East Coast Road, Chennai, Tamil Nadu, *in* accordance with the provisions of the Coastal Regulation Zone (CRZ) Notification, 2011 issued under the Environment (Protection) Act, 1986.

2. The proposal was considered in the 165th meeting held on 16-17 January, 2017; 175th meeting held on 28th November, 2017; and 190th Meeting held on 08.05.2018 respectively. The project has been recommended for CRZ clearance by the Expert Appraisal Committee (EAC) - Infrastructure Development, Coastal Regulation Zone, Building/Construction and Miscellaneous projects in its 190th meeting held on 08.05.2018. The details of the project, as per the documents submitted by you and as informed to the EAC are noted as under:

i) The proposed project is for setting up of a 400 MLD Desalination plant involving laying of sea water intake pipeline, outfall pipeline, construction of seawater intake head and outfall diffuser along with intake sump and a pump house.
ii) The proposed project is aimed at augmentation of drinking water supply in the southern and western parts of Chennai city with no perennial source of surface water.
iii) The site is located at Eastern side of East Coast Road (ECR) at 120 42' 44" N, 800 14' 26" E is approximately 40 km south from the city.
iv) Two intake structure at 10 m depth and two intake pipe each of 2500 mm dia. of HDPE will be set up. The sea water intake head will be located at a distance of about 1150m from the shoreline at 10 m depth.
v) The outfall will be a single pipeline of 2500 mm dia HDPE. The outfall diffuser will be located at 750 m distance from the shoreline at 8 m water depth.
vi) For Reverse osmosis two permeate storage tanks will be used.
vii) The seawater of 47791.66 m3 /hour will be drawn from the sea and about 31125 m3 /hour of brine reject will be released into the sea.
viii) The proposed project site is located in CRZ- III and CRZ- IV as per CZMP.

SE / DESAL

EE (Nemmeli)

AEE

31/X/18

SE (Desal) 1/11/18

01/11/18

ix) CRZ map indicating HTL, LTL demarcation in 1:4000 scale with the proposed desalination plant route superimposed on the map has been prepared by IRS, Anna University.
x) The total power requirement for running the plant will be sourced from the grid supply of TNEB.
xi) The total cost of the project will be Rs 3912.16 crores.
xii) The TNCZMA has recommended the project for CRZ clearance vide its letter Nos. 844/EC.3/2016-1, dated 14.01.2016 and No. 24117/EC.3/2017-1, dated 09.01.2018, respectively.

3. Based on the information submitted by you as at para no. 2 above and presentation made before the EAC (Infrastructure Development, Coastal Regulation Zone, Building / Construction and Miscellaneous projects) in its 190th meeting held on 08.05.2018, and in acceptance of the recommendation of the EAC, the Ministry of Environment, Forest and Climate Change hereby accords CRZ Clearance to the above project viz *'Setting up of 400 MLD capacity desalination Plant based on Sea Water Reverse Osmosis at Perur, East Coast road, Chennai, Tamil Nadu,* subject to the following specific and general conditions:

PART A - SPECIFIC CONDITIONS:

(i) The project proponent shall implement the shoreline erosion control and management plan framed by the State government, as may be applicable in the area.

(ii) The project proponent shall submit an undertaking to the TNCZMA before commencement of work of the proposed plant stating that it shall bear full cost of environmental damage and restitution arising due to setting up of the proposed 400 MLD desalination plant.

(iii) All conditions/recommendations stipulated by the Tamil Nadu Coastal Zone Management Authority (TNCZMA) vide its letter no. 844/EC.3/2016-1, dated 14.01.2016 and letter No. 24117/EC.3/2017-1, dated 09.01.2018 respectively, shall strictly be complied with.

(iv) 'NOC' from Tamil Nadu Pollution Control Board for discharge of brine water into the sea after necessary safeguards shall be obtained prior to commencement of operation.

(v) 'Consent to Establish' shall be obtained from State Pollution Control Board under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974, as may be applicable, prior to commencement of work.

(vi) The project proponent shall ensure that the temporary structures installed for laying of pipe lines are removed within three months of accomplishment of the work.

(vii) The project proponent shall ensure that the structure proposed to be set up is Tsunami resistant.

(viii) The construction in CRZ areas shall be done strictly in accordance with the provisions of CRZ Notification, 2011 and as amended from time to time.

(ix) Solid waste shall be collected, treated and disposed of in accordance with the Solid Waste Management Rules, 2016.

(x) There shall be no dressing or alteration of the sand dunes, natural features including landscape changes for beautification, recreation and other such purpose.

(xi) Soil and ground water samples in and around the SWRO Desalination Plant shall be tested regularly to ascertain that there is no threat to ground water quality through ingress/leaching of sea water.

PART B - GENERAL CONDITIONS:

(i) A copy of the clearance letter shall be uploaded on the websites of the Company/Proponent and concerned State Pollution Control Board. The Clearance letter shall also be displayed at the Regional Office, District Industries centre and Collector's Office/ Tehsildar's office for 30 days.

(ii) The funds earmarked for environmental protection measures shall be kept in a separate account and shall not be diverted for other purpose. Year-wise expenditure shall be reported to this Ministry and its concerned Regional Office.

(iii) Concealing factual data or submission of false/fabricated data and failure to comply with any of the conditions mentioned above may result in withdrawal of this clearance and attract action under the provisions of Environment (Protection) Act, 1986.

(iv) Adequate provision for infrastructure facilities including water supply, fuel and sanitation must be ensured for construction workers during the construction phase of the project to avoid any damage to the environment.

(v) A six-monthly monitoring report shall need to be submitted by the project proponent to the concerned regional Office of this Ministry regarding the implementation of the stipulated conditions.

(vi) The Ministry of Environment, Forest & Climate Change or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary in the interest of environment and the same shall be complied with.

(vii) Concealing factual data or submission of false/fabricated data and failure to comply with any of the conditions mentioned above may result in withdrawal of this clearance and attract action under the provisions of Environment (Protection) Act, 1986.

(viii) The above stipulations would be enforced among others under the provisions of the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and control of Pollution) Act, 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991, the EIA Notification, 2006 and the CRZ Notification, 2011.

(ix) Full co-operation shall be extended to the officials from the Regional Office of MoEF&CC, during monitoring of implementation of environmental safeguards stipulated. It shall be ensured that documents/data sought pertinent is made available to the monitoring team. A complete set of all the documents submitted to MoEF&CC shall be forwarded to the concerned Regional Office of MoEF&CC.

(x) In the case of any change(s) in the scope of the project, the project would require a fresh appraisal by this Ministry.

(xi) The Ministry reserves the right to add additional safeguard measures subsequently, if considered necessary, and to take action to ensure effective implementation of the suggested safeguard measures in a time bound and satisfactory manner, including revoking of the environment clearance under the provisions of the Environmental (Protection) Act, 1986, for non compliance.

(xii) All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponent from the respective competent authorities.

(xiii) The project proponent should advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board (SPCB) and may also be seen on the website of the Ministry of Environment, Forest and Climate Change at http://www.envfor.nic.in. The advertisement should be made within Seven days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the concerned Regional Office of this Ministry.

4. This Clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this project.

5. Any appeal against this clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.

6. A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parisad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/ representations, if any, were received while processing the proposal.

7. The proponent shall upload the status of compliance of the stipulated conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF&CC, the respective Zonal Office of CPCB and the SPCB.

8. The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of clearance conditions and shall also be sent to the respective Regional Office of the Ministry by e-mail.

(W. Bharat Singh)
Director/ Sc 'F'

Copy to:

1. The Secretary, Environment & Forests Department, Govt of Tamil Nadu, Saint George Port, Chennai.
2. The Chairman, Central Pollution Control Board, Parivesh Bhavan, CBD- cum-Office Complex, East Arjun Nagar, Delhi - 110032.
3. The Chairman, Tamil Nadu State Pollution Control Board, 76, Mount Salai, Guindly, Chennai – 600032.
4. The Member Secretary, Tamil Nadu Coastal Zone Management Authority, Department of Environment and Forests, Government of Tamil Nadu, First Panaqal Building, Saidapet, Chennai 600015.
5. The APCCF (C), MoEF&CC, RO, 1st Floor, Handloom Export Promotion Council, 34, Cathedral Garden Road, Nungambakkam, Chennai-600034.
6. Guard File.
7. Monitoring File

(W. Bharat Singh)
Director/ Sc 'F'

Environment & Forests (EC-3)
Department,
Secretariat, Chennai – 600 009

Letter No. 844/EC.3/2016-1, Dated 14.01.2016

From
Thiru Hans Raj Verma, I.A.S.,
Principal Secretary to Government

To
The Chairman,
National Coastal Zone Management Authority,
Government of India,
Ministry of Environment and Forests and Climate Change,
New Delhi – 110 003. (w.e.)

Sir,

Sub.: Proposed Construction of 400 MLD sea water reverse osmosis desalination plant at Perur village, Thiruporur taluk, Kancheepuram distict proposed by Chennai Metropolitan Water Supply & Sewerage Board, Chennai – Clearance under CRZ Notification 2011 requested – reg.

Ref.: From the Director of Environment Letter No. P1/790/2014, dated 14.1.2016.

I am to enclose a copy of the proposal received from the Director of Environment together with its enclosures and to state that the Member Secretary, Tamil Nadu State Coastal Zone Management Authority / Director of Environment has sent the proposal Proposed Construction of 400 MLD sea water reverse osmosis desalination plant at Perur village, Thiruporur taluk, Kancheepuram distict proposed by Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB), Chennai and he has furnished the following details in this regard:

- M/s Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) has proposed to establish a 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Village, Thiruporur Taluk, Kancheepuram District at a distance of 600 m in the northern side of the existing 100 MLD Seawater Desalination Plant at Nemmeli Village, Thiruporur Taluk, Kancheepuram district. The prime purpose of desalination plant is to remove most of the dissolved solids from filtered seawater to make it potable for supplying the Chennai City. The proposed project involves construction of the following activities:

  a) Laying of seawater intake two pipeline

  b) Laying of outfall pipeline

  c) Construction of seawater intake head (offshore construction)

  d) Construction of outfall diffuser (offshore construction)

  e) Construction of seawater sump with pump house

  f) Installation of pretreatment & reverse osmosis system.

- The sea water requirement for the proposed plant will be 47791.66 cu.m/hr (1147 MLD). The sea water will be drawn by laying two submarine pipelines. Both the seawater intake heads will be located at a distance of about 1150 m from the shoreline at 10m CD (Chart Datum) water depth. The water from the intake head will be drawn by gravity flow through the submarine pipeline buried 1 m below the sea floor.

- The proposed Desalination plant will have an offshore screen, offshore intake and outfall pipe, onshore screen, lamella clarifier, dissolved air floatation, gravity dual media filter, reverse osmosis system, post treatment, administration building, workshop building, chemicals storage building, product water storage & distribution.

- The backwash and sludge generated at periodic intervals from various treatment units would be discharged into the sea along with brine. The salinity of the return water released into the sea will be 71 ppt, which will have the salinity of the difference of 33 ppt higher than the seawater ambient salinity of 38 ppt. A chlorine dosage of 3ppm will be given to the drawn seawater and the return water discharged into the sea will have the concentration of around 0.2 ppm. The brine water discharged into the sea will be 31125 cu.m/hr (747 MLD). The outfall diffuser will be located at 750 m from the shoreline at the water depth of 8 m CD. The outfall will have a multiple port diffuser arrangemtn system with 18 Nos. x 600mm diameter. Limited excavation work will be carried out for construction of Civil structures. Some amount of leveling / grading through cut and fill is required to make the land suitable for construction. The domestic solid waste will be suitably disposed and the sewage generated will be treated and the treated sewage will be used for green belt development.

- The District Coastal Zone Management Authority, Kancheepuram district has recommended the project.

- The subject was placed before the 86th Tamil Nadu State Coastal Zone Authority (TNSCZMA) meeting held on 30.09.2015 and the TNSCZMA has requested the following details.

a) A detailed turtle nesting conservation plan in and around the project areas.

b) A report on the impact of eco system (flora and fauna) due to the intake and outfall pipelines shall be furnished and the mitigation measures taken on the adverse impacts shall be furnished.

c) As CMWSSB has already constructed a desalination plant at Nemmeli a report on the functioning of the said plant with reference to the conditions imposed in the Environmental Clearance should be furnished.

d) Baseline data of the Nemmeli plant, details of the 600MLD plant being constructed by Reliance in Rann of Kutch and other relevant baseline study reports shall be furnished to enable a comparison and obtain learning.

- The project site is falling in CRZ III, CRZ – I (inter tidal zone) and CRZ-IV (sea water area). The total project cost is Rs. 2891.70 crores. As per CRZ Notification 2011, vide para 4 (i) (a)., para 8 I CRZ I (i) (b) and 8 III CRZ III A (h) & B(v) the above activities are permissible activities. However the project requires clearance from the Ministry of Environment and Forests, Government of India vide para 4 (ii) (h) of Coastal Regulation Zone Notification 2011.

- The subject along with the above details are placed before the 87th meeting of the State Coastal Zone Management Authority held on 14.01.2016 and the Authority resolved to recommend the proposal to the Ministry of Environment Forests & Climate Change, Government of India, subject to the following conditions:-

a) The proposed activities should not cause coastal erosion and alter the beach configuration.

b) Untreated chemical waste generated due to membrane protection activity and the sewage generated should not be discharged into the sea.

c) The project activity should not affect the coastal ecosystem including marine flora and fauna.

d) It may be ensured that mercury concentration is not present in the end product.

e) The proponent should ensure that the saline water shall not gain access into ground while conveying or processing the sea water.

f) Marine water quality should be monitored at the outfall area every quarter and results sent to Tamil Nadu State Coastal Zone Management Authority.

g) A system shall be evolved for a close and continuous monitoring during the construction and post construction phases through reputed institutions such as National Center for Sustainable Coastal Management (NCSCM), Anna University, Chennai/NIOT, Chennai / IIT Chennai. Periodical report shall be furnished to the Tamil Nadu State Coastal Zone Management Authority on the site conditions every year so as to take mitigation measures on the event of any adverse impacts on the coast.

h) The impact on the corals, marine organisms, Turtle nesting etc., due to the above constructions, in long run, should be evaluated and monitored through experts, in which, ecologists should be included.

i) The activities such as intake pipeline and outfall line and intake arrangement in sea and the pipeline should not cause hindrance to fishing activities and to boat movement.

j) Marking the intake and outfall pipelines adequately such that fishing vessels and fishermen are made aware of its presence.

k) No blasting or drilling activities in CRZ is permissible.

l) The proponent should not prevent public from easy access to the beach

m) The proponent shall implement the Green Belt as envisaged in EIA report.

2. The Member Secretary, Tamil Nadu State Coastal Zone Management Authority / Director of Environment has sent copy of proposal along with the reports, additional details, HTL map and minutes of the 87th meeting of Tamil Nadu State Coastal Zone Management Authority held on 14.01.2016 and requested that the proposals may be recommended to the Ministry of Environment and Forests and Climate Change, Government of India for clearance under Coastal Regulation Zone Notification, 2011.

3. In line with the recommendation of the Tamil Nadu State Coastal Zone Management Authority, this Government recommend the proposal of The Member Secretary, Tamil Nadu State Coastal Zone Management Authority / Director of Environment for the Proposed Construction of 400 MLD sea water reverse osmosis desalination plant at Perur village, Thiruporur taluk, Kancheepuram distict as proposed by Chennai Metropolitan Water Supply & Sewerage Board to the Chairman, National Coastal Zone Management Authority, Government of India, Ministry of Environment, Forests and Climate Change for clearance under Coastal Regulation Zone notification 2011, subject to the conditions mentioned at para-1 above.

Yours faithfully,

for Principal Secretary to Government

Copy to:
The Member Secretary,
Tamil Nadu State Coastal Zone Management Authority /
Director of Environment, Chennai-15
(with a request to furnish 20 copies of the
proposal of Government of India,
Ministry of Environment, Forests & Climate Change,
New Delhi)
SF/SC

CE (O & M)-II OFFICE
2234
18 JAN 2018
CMWSS BOARD

778
19 JAN 2018

Office of the Managing Director, C.M.W.S.S. Board, CH-2
17 JAN 2018
1434

Immediate/

By Speed Post

Environment & Forests (EC-3)
Department, Secretariat,
Chennai – 600 009

Letter No. 24117/EC.3/2017- 1 ,dated: 09/01/2018

From
Thiru. Md. Nasimuddin, I.A.S.
Principal Secretary to Government.

To
The Chairman,
National Coastal Zone Management Authority,
Government of India,
Ministry of Environment,Forests & Climate Change,
Agni Wing, 5th Floor,
Indira Paryavaran Bhawan,
Jor Bag Road, Aliganj,
New Delhi – 110 003. (w.e.)

S.E.

19/1/18
C.E.

Sir,

Sub: CRZ – Application for CRZ clearance – Setting up of 400 MLD SWRO Desalination Plant at Perur along ECR, Chennai – Fresh Recommendation requested as per EAC meeting proposed by CMWSSB –Clearance requested under CRZ Notification 2011 - requested – Regarding.

Ref: From the Member Secretary, Tamil Nadu State Coastal Zone Management Authority/ Director of Environment letter No R.C/P1/2410/2017, dated 08.12.2017

I am to enclose a copy of the proposal received from the Member Secretary, Tamil Nadu State Coastal Zone Management Authority/Director of Environment together with its enclosures and to state that the Member Secretary, Tamil Nadu State Coastal Zone Management Authority/ Director of Environment has sent the proposal to establish a 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Village, Thiruporur Taluk, Kancheepuram District at a distance of 600 m in the northern side of the existing 100 MLD Seawater Desalination Plant at Nemmeli Village, Thiruporur Taluk, Kancheepuram district, proposed by M/s.Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) and he has furnished following details:-

A. M/s Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) has proposed to establish a 400 MLD Sea Water Reverse Osmosis Desalination

AEE/Desal
20/1/18
EE/Desal

EE (Desal)
20/1/18
SE (Desal)

Plant at Perur Village, Thiruporur Taluk, Kancheepuram District at a distance of 600 m in the northern side of the existing 100 MLD Seawater Desalination Plant at Nemmeli Village, Thiruporur Taluk, Kancheepuram district. The prime purpose of desalination plant is to remove most of the dissolved solids from filtered seawater to make it potable for supplying the Chennai City. The proposed project involves construction of the following activities:

i. Laying of seawater intake two pipeline
ii. Laying of outfall pipeline
iii. Construction of seawater intake head (offshore construction)
iv. Construction of outfall diffuser (offshore construction)
v. Construction of seawater sump with pump house
vi. Installation of pretreatment & reverse osmosis system.

B. The sea water requirement for the proposed plant will be 47791.66 cu.m/hr (1147 MLD). The sea water will be drawn by laying two submarine pipelines. Both the seawater intake heads will be located at a distance of about 1150 m from the shoreline at 10m CD (Chart Datum) water depth. The water from the intake head will be drawn by gravity flow through the submarine pipeline buried 1 m below the sea floor.

C. The proposed Desalination plant will have an offshore screen, offshore intake and outfall pipe, onshore screen, lamella clarifier, dissolved air floatation, gravity dual media filter, reverse osmosis system, post treatment, administration building, workshop building, chemicals storage building, product water storage & distribution.

D. The backwash and sludge generated at periodic intervals from various treatment units would be discharged into the sea along with brine. The salinity of the return water released into the sea will be 71 ppt, which will have the salinity of the difference of 33 ppt higher than the seawater ambient salinity of 38 ppt. A chlorine dosage of 3ppm will be given to the drawn seawater and the return water discharged into the sea will have the concentration of around 0.2 ppm. The brine water discharged into the sea will be 31125 cu.m/hr (747 MLD). The outfall diffuser will be located at 750 m from the shoreline at the water depth of 8 m CD. The outfall will have a multiple port diffuser arrangement system with 18 Nos. x 600mm diameter. Limited excavation work will be carried out for construction of Civil structures. Some amount of leveling / grading through cut and fill is required to make the land suitable for construction. The domestic solid waste will be suitably disposed and the sewage generated will be treated and the treated sewage will be used for green belt development.

E. The project site is falling in CRZ III, CRZ – I (inter tidal zone) and CRZ-IV (sea water area). The total project cost is Rs. 2891.70 crores. As per CRZ Notification 2011, vide para 4 (i) (a)., para 8 I CRZ I (i) (b) and 8 III CRZ III A (h) & B(v) the above activities are permissible activities. However the project requires clearance from the MOEF., GoI vide para 4 (ii) (h) of CRZ Notification 2011.

F. The District Coastal Zone Management Authority, Kancheepuram district has recommended the project subject to certain conditions.

G. The proposal was placed before the 87th TNSCZMA meeting held on 14.01.2016 and the authority has resolved to recommend the proposal to the Ministry of Environment, Forests and Climate Change, Government of India subject to the certain specific conditions.

H. The above proposal was recommended to the Chairman, National Coastal Zone Management Authority, Government of India, Ministry of Environment, Forests and Climate Change, New Delhi vide Government letter No.844/EC.3/2016-1, dated 14.01.2016.

I. The proposal was placed before the 165th Expert Appraisal Committee on 16.01.2017 and the committee had deferred the projects for the want of the following information.

i. As stated by the Project Proponent (PP), both the desalination plants of 150 MLD and 400 MLD are situated at a distance of 600 m. EAC has raised a query why the both plants cannot be installed at the same location. The Committee also wanted to know financial as well as environment implications of two separate units against one single unit with 600 MLD capacity.

ii. Impact of shoreline change needs to be performed.

iii. Fresh recommendations from the TNSCZMA after examining all the documents as mentioned para 4.2 of CRZ Notification 2011 including NOC from concerned State Pollution Control Board.

J. The CMWSSB has submitted in letter dated 12.10.2017, the followings details with reference to the 400 MLD Desalination Plant and requested fresh recommendation from TNSCZMA to Ministry of Environment, Forests and Climate Change, Govt. of India as indicated in the 165th EAC meeting of MoEF & CC, Govt. of India.

i) Financial as well as environmental implications of two separate units. (i.e. proposed 150 MLD & 400 MLD) against one single unit with 600 MLD capacity.

ii) Impact of shoreline change have been prepared towards setting up of the 400 MLD SWRO Desalination Plant at Perur.

iii) The NOC received from Tamil Nadu Pollution Control Board.

iv) Details on Mathematical Model Study done for the impact of soil erosion due implementation of 150 MLD and 400 MLD plants.

K. The subject was placed before the 97th meeting of the Tamil Nadu State Coastal Zone Management Authority held on 29.11.2017 and the Authority resolved to recommend the proposal to the Ministry of Environment, Forests and Climate Change, Government of India.

3. The Member Secretary, Tamil Nadu State Coastal Zone Management Authority/Director of Environment has sent a copy of proposal along with its enclosures and minutes of the 97th meeting of TNSCZMA held on 29.11.2017 and requested that the proposals may be recommended to the Ministry of Environment, Forests and Climate Change, Government of India, subject to the following specific conditions:

a) The proposed activities should not cause coastal erosion and alter the beach configuration.

b) Untreated chemical waste generated due to membrane protection activity and the sewage generated should not be discharged into the sea.

c) The project activity should not affect the coastal ecosystem including marine flora and fauna.

d) It may be ensured that mercury concentration is not present in the end product.

e) The proponent should ensure that the saline water shall not gain access into ground while conveying or processing the sea water.

f) Marine water quality should be monitored at the outfall area every quarter and results sent to Tamil Nadu State Coastal Zone Management Authority..

g) A system shall be evolved for a close and continuous monitoring during the construction and post construction phases through reputed institutions such as National Center for Sustainable Coastal Management (NCSCM), Anna University, Chennai/NIOT, Chennai / IIT Chennai. Periodical report shall be furnished to the Tamil Nadu State Coastal Zone Management Authority on the site conditions every year so as to take mitigation measures on the event of any adverse impacts on the coast.

h) The impact on the corals, marine organisms, Turtle nesting etc., due to the above constructions, in long run, should be evaluated and monitored through experts, in which, ecologists should be included.

i) The activities such as intake pipeline and outfall line and intake arrangement in sea and the pipeline should not cause hindrance to fishing activities and to boat movement.

j) Marking the intake and outfall pipelines adequately such that fishing vessels and fishermen are made aware of its presence.

k) No blasting or drilling activities in CRZ is permissible.

l) The proponent should not prevent public from easy access to the beach.

m) The proponent shall implement the Green Belt as envisaged in EIA report.

n) Turtle conservation plan shall be prepared and implemented during the project period.

4. In line with the recommendation of the Tamil Nadu State Coastal Zone Management Authority, this Government recommend the proposal of Member Secretary, TNSCZMA/DOE, Chennai to setting up of 400 MLD SWRO Desalination Plant at Perur along ECR, Chennai proposed by M/s. Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) to the Chairman, National Coastal Zone Management Authority, Government of India, Ministry of Environment, Forests and Climate Change, New Delhi, for clearance under CRZ Notification,2011, subject to the specific conditions mentioned at para 3 above.

H. [signature] 12.1.18

For Principal Secretary to Government

[signature] 12.1.18

Copy to:-

The Member Secretary, TNSCZMA/DOE, Chennai – 15.

Managing Director, Chennai Metropolitan Water Supply & Sewerage Board, Chennai – 2.

(with a request to furnish 20 copies of the proposal of GoI, MoEF&CC, New Delhi)

~~SF/SC~~.

CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD (CMWSSB)

BATHYMETRY SURVEY REPORT

PMC for Chennai Perur 400 MLD Desalination Plant and Allied Works

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

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

SMEC International Pty. Ltd., Australia in consortium with
NJS Engineers India Private Limited, Pune
Tata Consulting Engineers Limited, Mumbai
SMEC (India) Private Limited, Haryana

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PMC DETAILS

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IMPORTANT NOTICE

This report is confidential and is provided solely to report the Bathymetry Survey of the Project Management Consultant (“PMC”) on the Consulting Services to be delivered under the Chennai Perur 400 MLD Desalination Plant and Allied Works project]. This report is provided according to a Contract Agreement between SMEC International Pty Limited (“SMEC”), as lead consultant in the PMC, and CMWSSB, under which SMEC undertook to perform a specific and limited task for CMWSSB.

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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	The materials presented in this report carry the copyright of SMEC and INDOMER. The data presented in the report should not be altered or distorted or copied or presented in different manner by anyone without the written consent from SMEC or INDOMER. The violation in any form is punishable and liable for prosecution under the copy right act.
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	
	Project Code	696082021		Text pages	22
	File Location	F:/2020 Projects/Aug -20/Perur 400MLD		Figures	6

TEAM

Name	Qualification
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Mr. A. Baskaran	B.Tech. (Civil Engineering)
Mr. J. Vinoth Kumar	B.E. (Civil Engineering)
Mr. M. Sharath	B. E. (Electronics and Instrumentation Engineering)
Mr. S. Vijay	B.E. (Civil Engineering)

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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	80° 17	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:

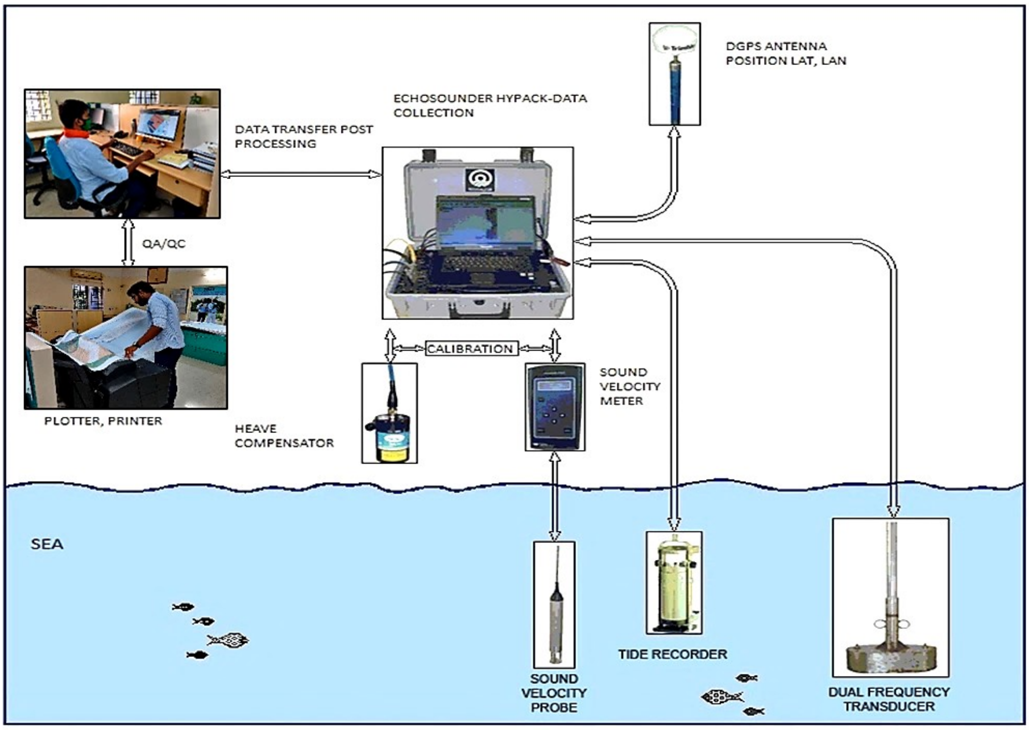
Top-End Plate	:	Multiparameter platform
Recording system	:	Data Storage on DSU
Storage Capacity	:	≤ 2GB
Battery	:	2 batteries inside the instrument
	:	Alkaline 3988 9V, 15Ah (nominal 12.5Ah; 20W down to 6V at 4°C) or Lithium 4002: 7V, 30Ah
Supply voltage	:	6 to 14VDC
	:	Parallel 2 Alkaline battery (each 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 – 96.8 °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.

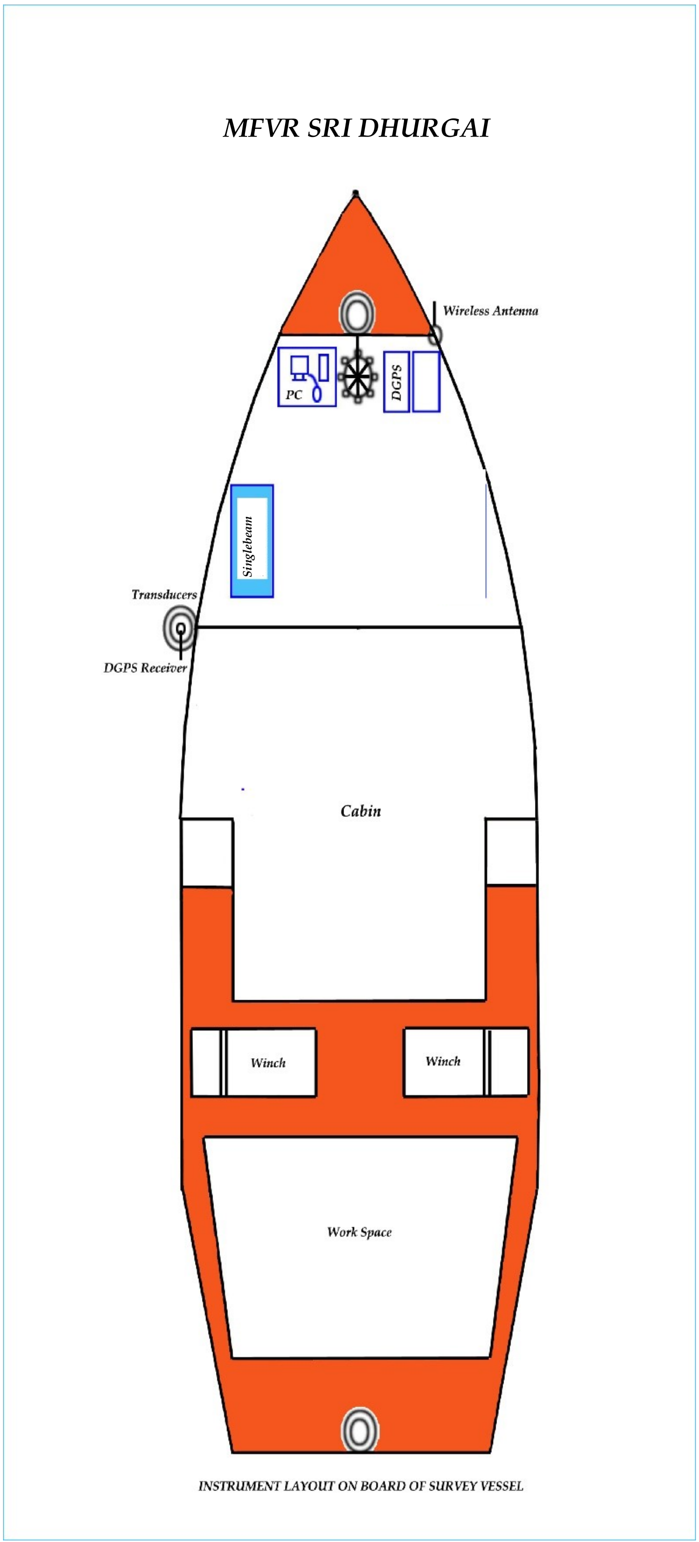
Calibration by Bar Check: Bar check was performed before starting of the surveys every day. It was done by lowering a bar plate at known depth below the transducer. The correction coefficients for known depth were noted and entered on the data collection software.

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

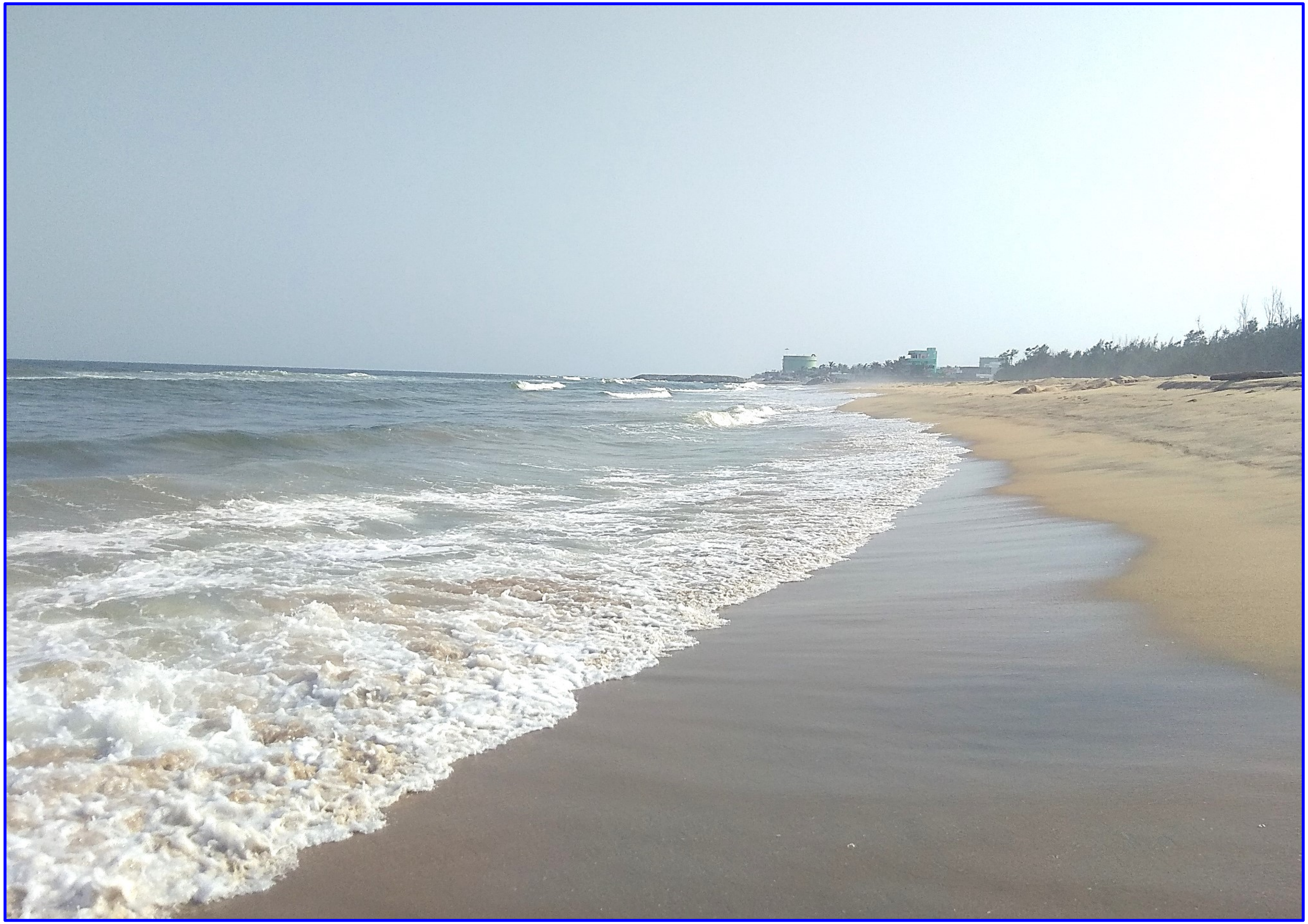


FIG. 1.1. LOCATION MAP

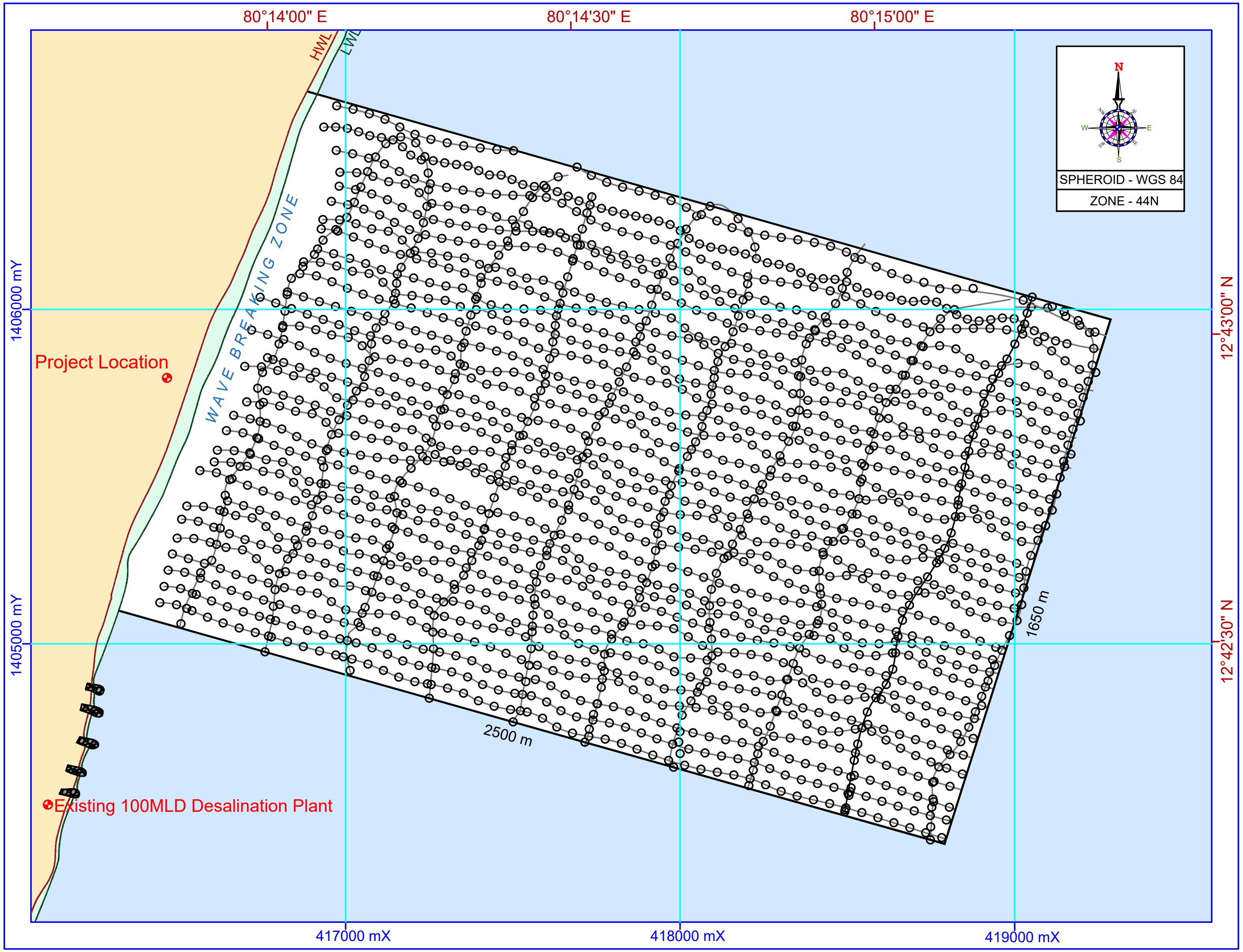


FIG.3.1. SURVEYED BATHYMETRY LINES

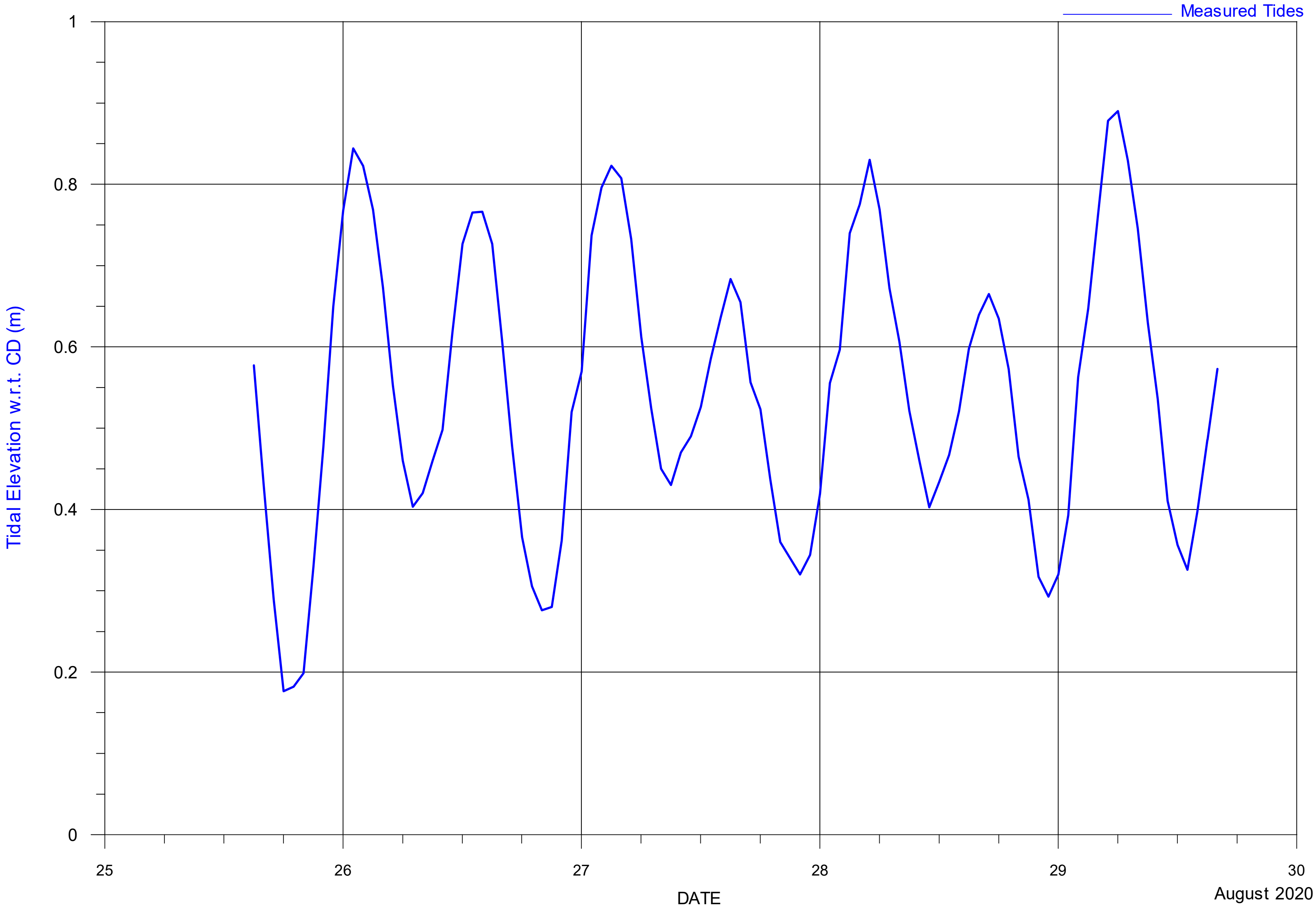


FIG.4.1. VARATION OF MEASURED TIDES

80°13'30" E
80°14'00" E
80°14'30" E
80°15'00" E
80°15'30" E
12°43'30" N
12°43'00" N
12°42'30" 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
EAST COAST ROAD
HTL
LWL
Nemmili kuppam
Temple
TS 2
TS 1
Discharge pit
400MLD Desalination Plant Area
WAVE BREAKING ZONE
Sullerikattukuppam
100MLD Desalination Plant
150MLD Plant Area
2500 m
1650 m
Outfall
Intake
BAY OF BENGAL
Bar check calibration
CVM Echotrac unit
Onboard data collection
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
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
N
S
E
W
LOCATION MAP :
INDIA
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
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 Latitude | Longitude | HEIGHT ABOVE CHART DATUM MHWS Metre | MHWN Metre | MLWN Metre | MLWS Metre | MSL (m)
CHENNAI | 12° 52' N | 80°41' E | 1.15 | 0.84 | 0.43 | 0.14 | 0.65
CLIENT :
SMEC
Member of the Surbana Jurong Group
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. Sharath/S. Vijay
Processed by : J. Vinothkumar/S. Vijay
Drawn by : J. Vinothkumar/S. Vijay
Checked by : Dr. P. Chandramohan

FIG. 4.2.

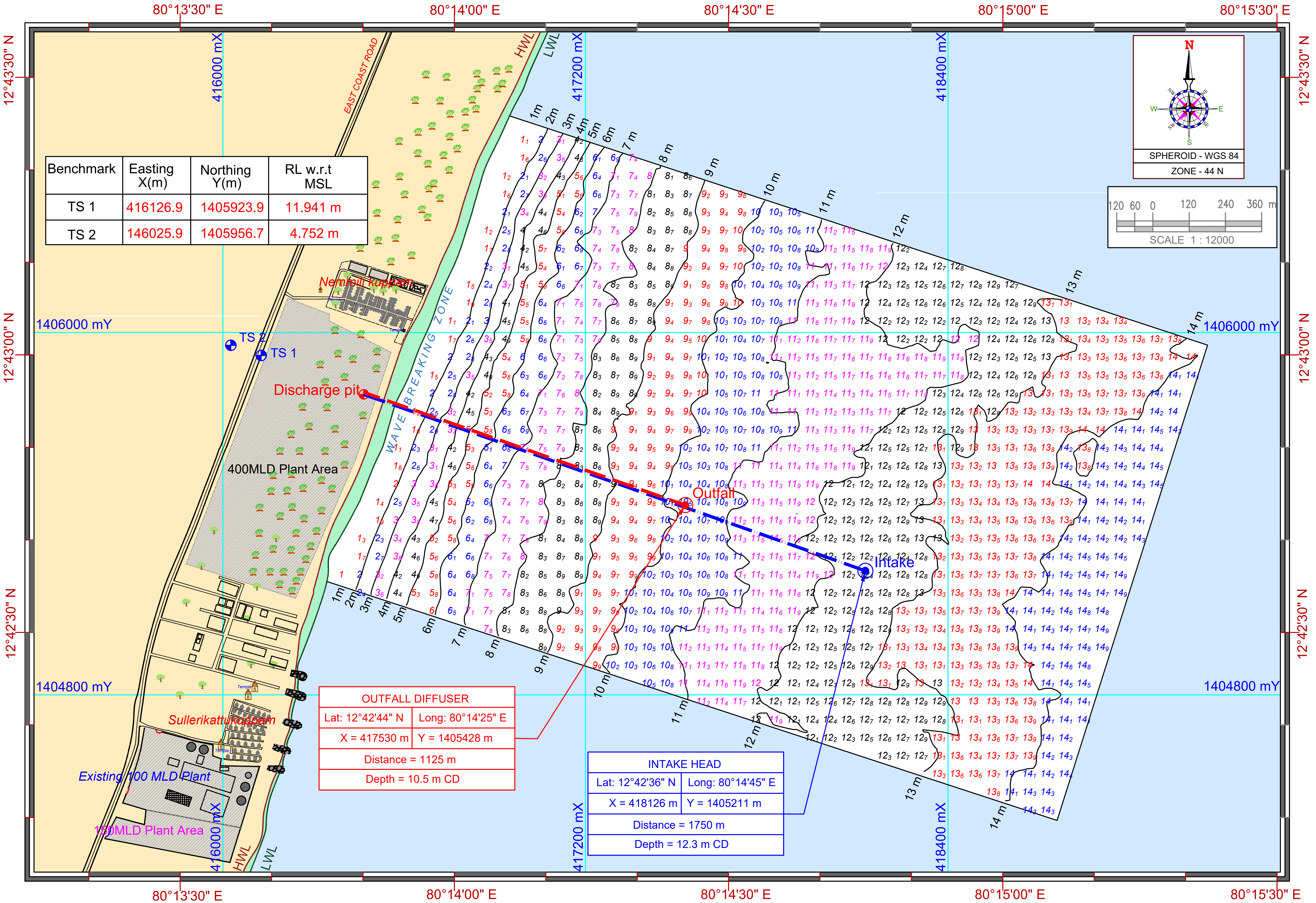


FIG. 4.3. BATHYMETRY MAP (1:12000 SCALE)

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

The CHENNAI 400 MLD DESALINATION PLANT is a Project being delivered by the Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) with the assistance of an Official Development Assistance (ODA) loan from the Japan International Cooperation Agency (JICA).

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.

Member of the Surbana Jurong Group

Part-II

Geotechnical Investigation Report

Annexure-3

Geotechnical Report

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Chennai Metropolitan Water Supply &
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Chennai - 600 002.

Division of Soil Mechanics and Foundation Engineering
Department of Civil Engineering,
College of Engineering Guindy Campus,
Anna University, Chennai – 600 025.
Ph: 044 22357549

GEOTECHNICAL INVESTIGATION REPORT

NAME OF WORK : **REPORT ON THE RECOMMENDATION OF FOUNDATION FOR THE PROPOSED CONSTRUCTION OF 400 MLD CAPACITY REVERSE OSMOSIS DESALINATION PLANT AT PERUR ON ECR, CHENNAI**

CLIENT : **M/s AECOM India Pvt. Ltd., Gurgaon,**
9th Floor, Infinity Tower, 'C',
DLF Cyber City, DLF Phase II,
Gurgaon - 122002, Haryana

Executive Engineer (Desal)
Chennai Metropolitan Water Supply &
Sewerage Board
Chennai - 600 002.

JOB NO : SM&FE / 059 / Consultancy / MERIDIAN / 2014

DATE : 14th November 2014

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Division of Soil Mechanics and Foundation Engineering
Department of Civil Engineering,
College of Engineering Guindy Campus,
Anna University, Chennai – 600 025.
Ph: 044 22357549

Division of Soil Mech. & Foundation Engg. CEGC Anna University Chennai-25

REPORT ON THE RECOMMENDATION OF FOUNDATION FOR THE PROPOSED CONSTRUCTION OF 400 MLD CAPACITY REVERSE OSMOSIS DESALINATION PLANT AT PERUR ON ECR, CHENNAI

JOB NO: SM&FE / 059 / Consultancy / MERIDIAN / 2014

CLIENT:

M/s AECOM India Pvt. Ltd., Gurgaon,
9th Floor, Infinity Tower, 'C',
DLF Cyber City, DLF Phase II,
Gurgaon - 122002, Haryana

Ref: The Team Leader Lr. No. PMS / AU / LR / 053 Dated, 10.10.2014, From M/s Prime Meridian Surveys Pvt. Ltd

1. INTRODUCTION

The CMWSSB, Government of Tamilnadu has proposed to construct a 400 MLD capacity Reverse Osmosis Desalination Plant at Perur on ECR, Chennai. The CMWSSB has appointed M/s AECOM India Pvt. Ltd, Gurgaon, Haryana as consultant for this project. The officials of M/s AECOM India Pvt. Ltd, Gurgaon, Haryana and Engineers of CMWSSB, Chennai have approached the Division of Soil Mechanics and Foundation Engineering, Department of Civil Engineering, Anna University, Chennai - 25 to carryout soil investigation in the proposed site and recommend the most suitable foundation system for the proposed construction of 400 MLD capacity Reverse Osmosis Desalination Plant. Accordingly, the work

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Chennai - 600 0

Division of Soil Mech. & Foundation Engg. CEGC Anna University Chennai-25

was taken up and Field Investigation was carried out by M/s VRR Engineering Consultancy, Chennai - 103 under the supervision of Professor, Division of Soil Mechanics and Foundation Engineering, Department of Civil Engineering, Anna University, Chennai - 25. The soil investigation work was carried out during 28th of October 2014 to 5th of November 2014. This report comprises the details of soil investigation, analysis of field and laboratory test results and recommendation of most suitable foundation system.

2. SITE CONDITION AND EXPERIMENTAL PROGRAM

The proposed site is located at Perur, ECR, Chennai. The site is having ECR road to its western side and 200 m from bay of bengal sea shore to its eastern side. The site is covered with lot of trees. The water table was located within 1.5 m to 2.0 m as can be seen from many small ditches found in the site, because of nearness of seashore. The total number of borehole locations has been decided as 5 numbers as agreed by the client and the Professor & Project Co-ordinator, Division of Soil Mechanics and Foundation Engineering, Department of Civil Engineering, Anna University, Chennai - 25. The location of bore hole is shown in figure 1. The nature of field tests includes standard penetration tests, disturbed soil sampling through split spoon sampler, identification of different soil layers, location of ground water table, complete logging of the borehole etc, Laboratory investigation consists of classification tests such as grain size distribution, Atterberg limits, specific gravity and free swell index of soil samples and point load strength index and geological classification of rock core samples.

After removing the top 0.25 m soil, the boreholes were advanced from the existing ground level using rotary boring technique supplemented by Bentonite mud circulation. Mud circulation was used to stabilize the sides and bottom of the boreholes and then to bring the soil

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3. REVIEW OF FIELD AND LABORATORY TEST RESULTS OF SOIL PROFILE

3.1 Borehole Number 1 (BH 1)

Brown sand layer was encountered at top 7.5 m depths with 'N' values of 11, 18, 28, 24, 27, 36 and 14 respectively for 1 m, 2 m, 3 m, 4 m, 5 m, 6 m and 7.5 m depths. The sand and fine content (silt and clay) of this sand layer is 91% - 98% and 2% - 9% respectively (Table 1). In 9 m and 10.5 m depths, brown sand layer was observed with 'N' values of 28 and 21 respectively. The sand and fine content (silt and clay) of this sand layer is 81% and 19% respectively. Grayish silty sand layer was found at 12 m depth with 'N' = 23 whose sand and fine (silt & clay) content values are 75% and 25% respectively. Grayish clayey sand (CI) of 'N' value 24 was found in 13.5 m depth. The sand and fine content (silt and clay) of this clayey sand layer is 43% and 57% respectively. This clayey sand (CI type) is having liquid limit of 42%, plastic limit of 22% and free swell index of 60% (Table 1). In 15 m depth, grayish silty clay (CH) layer was observed with 'N' value of 38 whose sand and fine content (silt and clay) value is 48% and 52%. This silty clay (CH type) is having liquid limit of 51% and plastic limit of 24%. Grayish clayey sand (SC-CH) of 'N' value > 100 (Hammer was Rebound for 55 blows with 13 cm penetration) was found in 16.5 m depth with sand and fine content (silt and clay) of 73% and 27% respectively. This clayey sand (SC - CI type) is having liquid limit of 41%, plastic limit of 22% and free swell index of 140%(Table 1). The high swelling nature and plasticity characteristics of this clayey sand is may be attributed to the presence of degraded Feldspar rock minerals of the underlying weathered rock layer. Grayish weathered rock was encountered in the depth range of 18 m to 20 m with SPT 'N' > 100 (Hammer was Rebound for 54 blows with 2 cm penetration at 18 m depth and 54 blows with 1 cm penetration at 19.5 m

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depth). The NX size double tube core barrel was used to drill and retrieve the rocky stratum from 20 m to 21.5 m depth. The observed rock layer is Pinkish Granite with more Feldspar mineral (Plate 5 and 9 of Annexure - 1). The weathering grade of this rock is II (slightly weathered and moderately strong) as per the ISI scale of weathering grade of rock mass. The Point Load Strength Index this pinkish granite is 1.18 MPa. The borehole was terminated at 21.5 m depth from the existing ground level. The index and shear strength properties of soils and rock samples collected at BH 1 in different depths are listed in table 1. The ground water table is located at a depth of 1.60 m from the existing ground level. Figure (a) shows the variation of SPT 'N' value of different soil layers with respect to depth in BH 1 location.

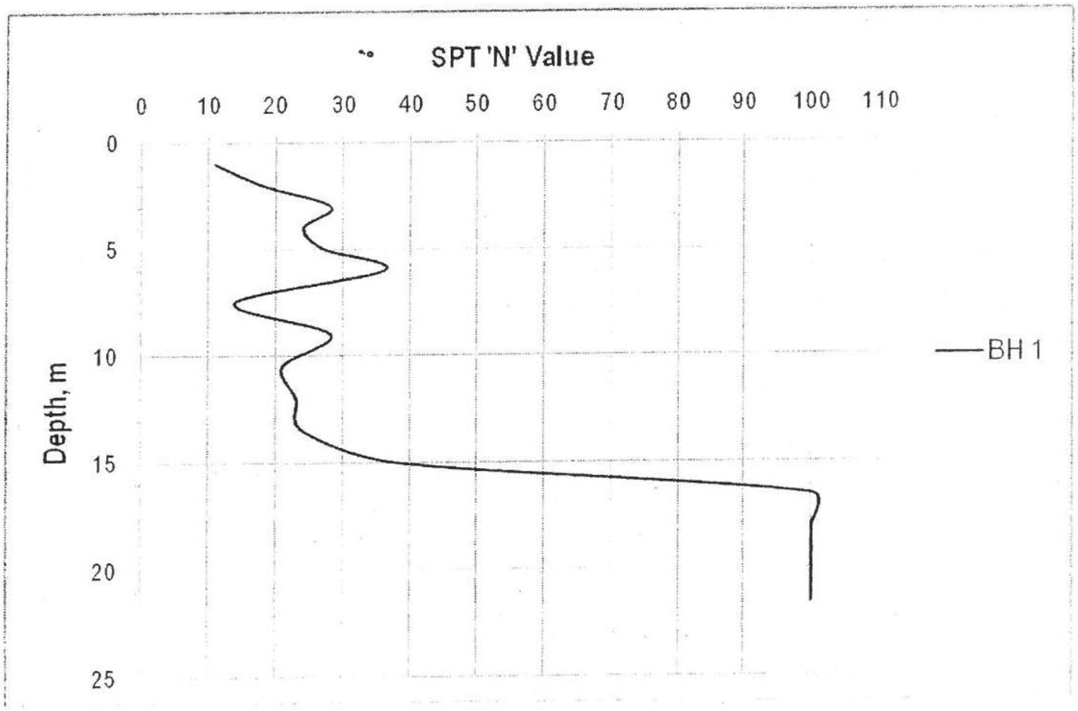

Figure (a) Variation of SPT 'N' value of different soil layers with respect to depth in BH 1

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3.2 Borehole Number 2 (BH 2)

In the top 9 m depth, brown sand layer was observed with 'N' values of 12, 18, 12, 33, 36, 40, 33 and 24 respectively for 1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7.5 m and 9 m depths. The sand and fine content (silt and clay) of this sand layer is 96% - 99% and 1% - 4% respectively. Grayish brown clayey sand (SC) of 'N' value 27 and 21 was found in 10.5 m and 12 m depths with sand and fine content (silt and clay) of 58%-65% and 35%-42% respectively. This clayey sand (SC type) is having liquid limit of 37%, plastic limit of 17% and free swell index of 40%(Table 2). Grayish silty clay (CI) of 'N' value 22 was encountered in 13.5 m depth. The sand and fine content (silt and clay) of this silty clay layer is 23% and 77% respectively. This silty sand (CI type) is having liquid limit of 44%, plastic limit of 25% and free swell index of 55%. In 15 m depth, grayish silty clay (CH) layer was observed with 'N' value of 36 whose sand and fine content (silt and clay) value is 23% and 77%. This silty clay (CH type) is having liquid limit of 57%, plastic limit of 24% and free swell index of 120% (Table 2). Grayish brown clayey sand (SC-CI) of 'N' = 38 was observed in 16.5 m depth with sand and fine content (silt and clay) of 54% and 46% respectively. This clayey sand (SC - CI type) is having liquid limit of 41%, plastic limit of 22% and free swell index of 100%(Table 2). The high swelling nature and plasticity characteristics of this clayey sand is may be due the presence of degraded rock minerals of the underlying weathered rock layer. Grayish weathered rock was encountered at 17.9 m with SPT 'N' > 100 (Hammer was Rebound for 54 blows with 2 cm penetration). The borehole was terminated at 17.9 m depth from the existing ground level. The index and shear strength properties of soils and rock samples collected at BH 2 in different depths are listed in table 2. The ground water table is located at a depth of 1.70 m from the existing ground level. Figure (b)

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shows the variation of SPT 'N' value of different soil layers with respect to depth in BH 2 location.

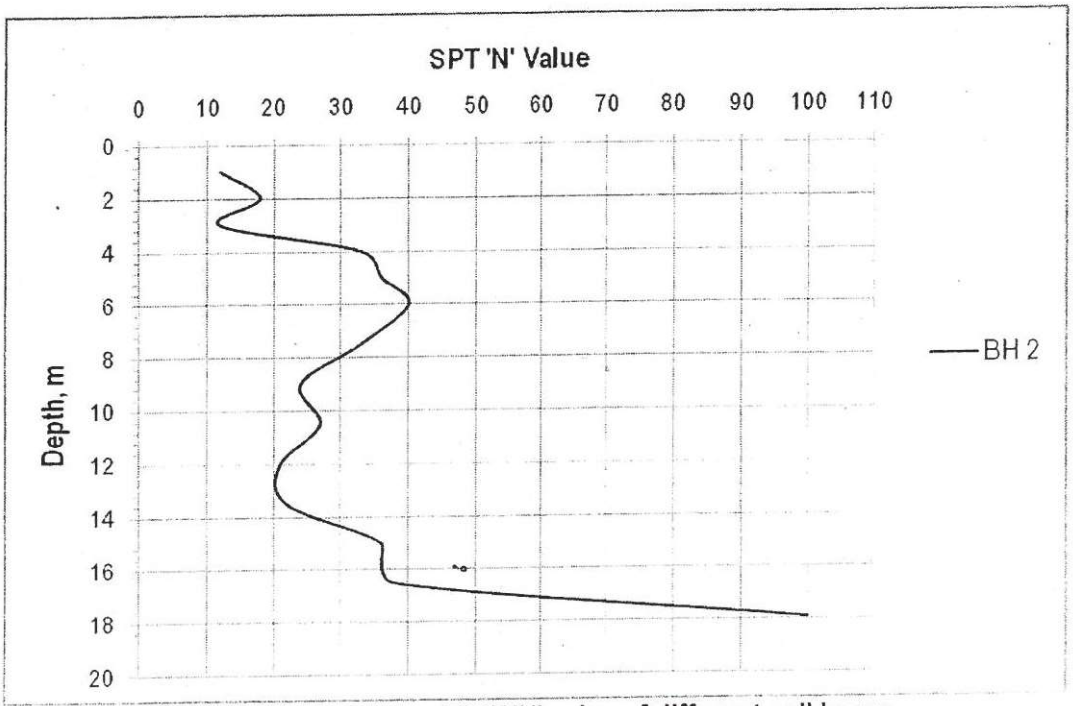

Figure (b) Variation of SPT 'N' value of different soil layers with respect to depth in BH 2

3.3 Borehole Number 3 (BH 3)

Brown sand layer was observed in top 6 m depths with 'N' values of 11, 12, 15, 18, 18 and 34 respectively for 1 m, 2 m, 3 m, 4 m, 5 m and 6 m depths. The sand and fine content (silt and clay) of this sand layer is 93% - 96% and 4% - 7% respectively (Table 3). In 7.5 m depth, grayish brown sand layer was observed with 'N' = 15. The sand and fine content (silt and clay) of this sand layer is 82% and 18% respectively. Grayish brown clayey sand (SC) of 'N' = 22 was found in 9 m depth with sand and fine content (silt and clay) of 67% and 33% respectively. This clayey sand (SC) is having liquid limit of 34%, plastic limit of 17% and free swell index of 40%(Table 3). At 10.5 m depth, grayish silty clay (CI) of 'N' value 23 was found with sand and

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fine content (silt and clay) of 43% and 57% respectively. This silty clay (CI type) is having liquid limit of 39%, plastic limit of 19% and free swell index of 45% (Table 3). In 12 m depth, grayish silty clay (CH) layer was observed with 'N' value of 22 whose sand and fine content (silt and clay) value is 26% and 74%. This silty clay (CH type) is having liquid limit of 47%, plastic limit of 23% and free swell index of 50%. Grayish clayey sand (SC-CI) of 'N' value 27 and 42 was found in 13.5 m and 15 m depths respectively with sand and fine content (silt and clay) of 62% and 38% respectively. This clayey sand (SC - CI type) is having liquid limit of 42%, plastic limit of 22% and free swell index of 50% (Table 3). The high swelling nature and plasticity characteristics of this clayey sand is may be attributed to the presence of degraded Feldspar rock minerals of the underlying weathered rock layer. Grayish weathered rock was encountered in the depth range of 16.5 m to 17 m with SPT 'N' > 100 (Hammer was Rebound for 57 blows with 8 cm penetration at 16.5 m depth and 55 blows with 3 cm penetration at 17 m depth). The NX size double tube core barrel was used to drill and retrieve the rocky stratum from 17 m to 18.5 m depth. The observed rock layer is Fresh Granite with more Hypersthene mineral (Plate 6 and 10 of Annexure - 1). The weathering grade of this rock is I (Fresh, no visible sign of weathering and very strong) as per the ISI scale of weathering grade of rock mass. The Point Load Strength Index this grayish granite is 2.20 MPa. The borehole was terminated at 18.5 m depth from the existing ground level. The index and shear strength properties of soils and rock samples collected at BH 3 in different depths are listed in table 3. The ground water table is located at a depth of 1.54 m from the existing ground level. Figure (c) shows the variation of SPT 'N' value of different soil layers with respect to depth in BH 3 location.

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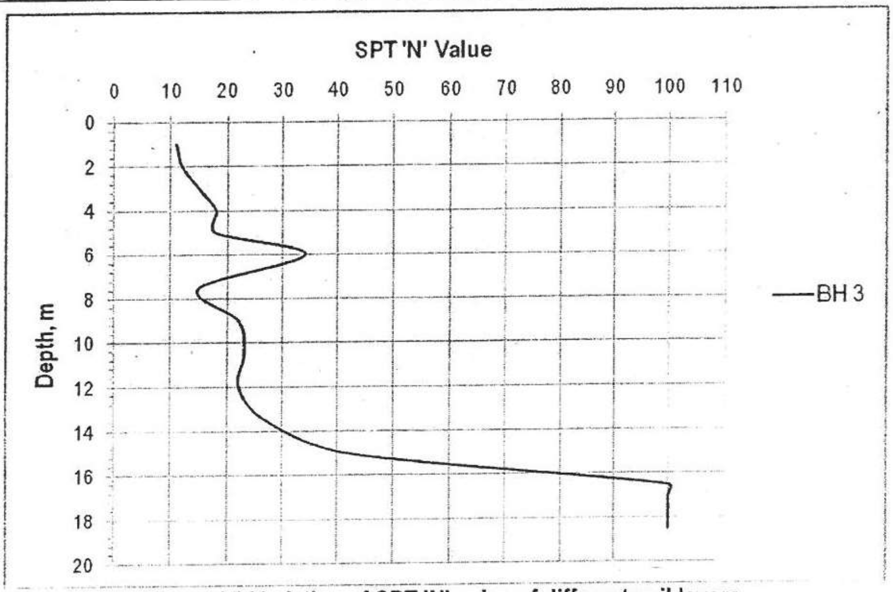

Figure (c) Variation of SPT 'N' value of different soil layers with respect to depth in BH 3

At 5 m, 6 m and 7.5 m depths, grayish brown sand layer was observed with 'N' values of 33, 36 and 18 respectively. The sand and fine content (silt and clay) of this sand layer is 83% - 89% and 11 - 17% respectively. Grayish brown clayey sand (SC) of 'N' = 24 was found in 9 m and 10.5 m depths with sand and fine content (silt and clay) of 70% and 30% respectively. This clayey sand (SC) is having liquid limit of 30%, plastic limit of 16% and free swell index of 30%(Table 4). In 12 m, 13.5 m and 15 m depths, grayish brown clayey sand (SC) of 'N' values 28, 58 and 67 was observed with sand and fine content (silt and clay) of 64% - 70% and 30% - 36% respectively. This clayey sand (SC type) is having liquid limit of 33%, plastic limit of 17% and free swell index of 40% (Table 4). Grayish weathered rock was encountered in the depth range of 16.5 m to 17 m with SPT 'N' > 100 (Hammer was Rebound for 55 blows with 5 cm penetration at 16.5 m depth and 53 blows with 2 cm penetration at 17 m depth). The NX size double tube core barrel was used to drill and retrieve the rocky stratum from 17 m to 18.5 m depth. The observed rock layer is Fresh Granite with more Hypersthene mineral (Plate 7 and 11 of Annexure - 1). The weathering grade of this rock is I to II (slightly weathering and moderately strong) as per the ISI scale of weathering grade of rock mass. The Point Load Strength Index this grayish granite is 1.10 MPa. The borehole was terminated at 18.5 m depth from the existing ground level. The index and shear strength properties of soils and rock samples collected at BH 4 in different depths are listed in table 4. The ground water table is located at a depth of 1.65 m from the existing ground level. Figure (d) shows the variation of SPT 'N' value of different soil layers with respect to depth in BH 4 location.

3.5 Borehole Number 5 (BH 5)

Brown sand layer was found in top 7.5 m depths with 'N' values of 14, 18, 35, 33, 36, 35 and 20 respectively for 1 m, 2 m, 3 m, 4 m, 5 m, 6 m and 7.5 m depths. The sand and fine content (silt and clay) of this sand layer is 86% - 96% and 4% - 14% respectively (Table 5). In 9 m and 10.5 m depths, brown clayey sand (SC) layer was observed with 'N' values of 27 and 22 respectively. The sand and fine content (silt and clay) of this clayey sand layer is 67% and 33% respectively. This clayey sand (SC) is having liquid limit of 30%, plastic limit of 16% and free swell index of 30% (Table 5). Grayish brown silty sand of 'N' = 54 and 72 was found in 12 m and 13.5 m depths with sand and fine content (silt and clay) of 85% and 15% respectively. In 15 m depth, grayish brown clayey sand (SC) of 'N' = 63 was observed with sand and fine content (silt and clay) of 60% and 40% respectively. This clayey sand (SC type) is having liquid limit of 34%, plastic limit of 17% and free swell index of 40% (Table 5). Grayish weathered rock was encountered in the depth range of 16.5 m to 19.6 m with SPT 'N' > 100 (Hammer was Rebound for 54 blows with 1 cm penetration at 16.5 m depth, 58 blows with 1 cm penetration at 18 m depth and 54 blows with 0 cm penetration at 19.6 m depth).

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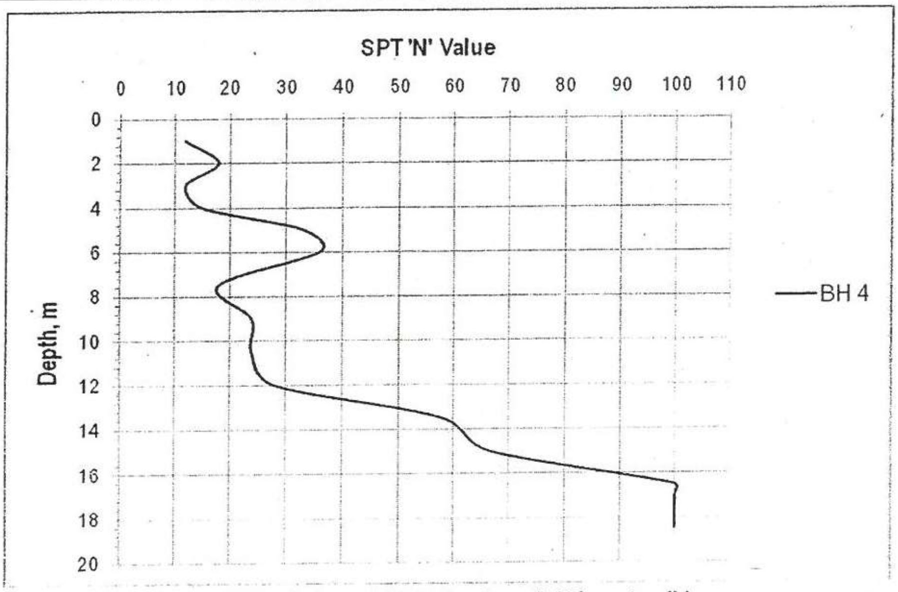

Figure (d) Variation of SPT 'N' value of different soil layers with respect to depth in BH 4

The NX size double tube core barrel was used to drill and retrieve the rocky stratum from 19.6 m to 21.1 m depth. The observed rock layer is Fresh Granite with more Hypersthene mineral (Plate 8 and 12 of Annexure - 1). The weathering grade of this rock is I (Fresh, no visible sign of weathering and very strong) as per the ISI scale of weathering grade of rock mass. The Point Load Strength Index this grayish granite is 1.78 MPa. The borehole was terminated at 18.5 m depth from the existing ground level. The index and shear strength properties of soils and rock samples collected at BH 5 in different depths are listed in table 5. The ground water table is located at a depth of 1.72 m from the existing ground level. Figure (e) shows the variation of SPT 'N' value of different soil layers with respect to depth in BH 5 location.

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Figure (f) shows the variation of SPT 'N' value of different soil layers with respect to depth in BH 1 to BH 5 of the proposed site. It is learnt that ground water level might raise to as high as 0.5 m to 1.5 m to 2 m normal water table fluctuation, especially during winter season.

4.0 COMPUTATION OF BEARING CAPACITY AND SETTLEMENT

In order to determine the bearing capacity and settlement of the *'shallow open foundation system'* at various depths of 2.0 m and 3.0 m depths, the location of ground water table is assumed at ground surface (submerged condition). Table I to Table V show the SPT'N' value, Correlated CPT 'q_c' value (IS 2911, Part 1, Sec.1), Correlated Elastic Modulus 'E_s' value (Schmertmann 1970) and Shear strength parameters of the borehole 1 to 5 of the proposed site. The geotechnical design parameters of engineering properties of soil layers which are required to determine bearing capacity and settlement are taken from Table I to Table V by considering the worst soil condition and least shear strength parameters below the foundation depth. The least 'N' values of soil layers were observed in BH - 3. Hence, safe bearing capacity and settlement computations were made for BH-3 data. The Safe Bearing Capacity is computed using Bureau of Indian Standard IS 6403-1981 equation. The Settlement of foundation is arrived based De Beer Method (IS 8009 (Part I) 1976 Sec. 9.1.2) using the correlated CPT 'q_c' value (IS 2911, Part 1, Sec.1), of the borehole number 3 of the proposed site.

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Figure (f) shows the variation of SPT 'N' value of different soil layers with respect to depth in BH 1 to BH 5 of the proposed site. It is learnt that ground water level might raise to as high as 0.5 m to 1.5 m to 2 m normal water table fluctuation, especially during winter season.

4.0 COMPUTATION OF BEARING CAPACITY AND SETTLEMENT

In order to determine the bearing capacity and settlement of the *'shallow open foundation system'* at various depths of 2.0 m and 3.0 m depths, the location of ground water table is assumed at ground surface (submerged condition). Table I to Table V show the SPT'N' value, Correlated CPT 'q_c' value (IS 2911, Part 1, Sec.1), Correlated Elastic Modulus 'E_s' value (Schmertmann 1970) and Shear strength parameters of the borehole 1 to 5 of the proposed site. The geotechnical design parameters of engineering properties of soil layers which are required to determine bearing capacity and settlement are taken from Table I to Table V by considering the worst soil condition and least shear strength parameters below the foundation depth. The least 'N' values of soil layers were observed in BH - 3. Hence, safe bearing capacity and settlement computations were made for BH-3 data. The Safe Bearing Capacity is computed using Bureau of Indian Standard IS 6403-1981 equation. The Settlement of foundation is arrived based De Beer Method (IS 8009 (Part I) 1976 Sec. 9.1.2) using the correlated CPT 'q_c' value (IS 2911, Part 1, Sec.1), of the borehole number 3 of the proposed site.

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TABLE I SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 1 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m²)	Elastic Modulus 'E_s' Value (kN/m²)	Shear Strength Parameters	
				'c' (kN/m²)	Φ in Degrees
1.0	11	4400	8426	0	29⁰
2.0	18	7200	13788	0	33⁰
3.0	28	11200	21448	0	37⁰
4.0	24	9600	18384	0	35⁰
5.0	27	10800	20682	0	37⁰
6.0	36	14400	27576	0	40⁰
7.5	14	5600	10724	0	30⁰
9.0	28	11200	21448	0	37⁰
10.5	21	8400	16086	0	34⁰
12.0	23	6900	17618	0	35⁰
13.5	24	4800	18384	150	0⁰
15.0	38	7600	29108	237	0⁰
16.5	> 100	40000	76600	0	45⁰
18.0	> 100	100000	76600	0	45⁰
19.5	> 100	100000	76600	0	45⁰
20 - 21.5	> 100	Point Load Strength Index = 1.18 MPa			

TABLE II SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 2 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m²)	Elastic Modulus 'E_s' Value (kN/m²)	Shear Strength Parameters	
				'c' (kN/m²)	Φ in Degrees
1.0	12	4800	9192	0	29⁰
2.0	18	7200	13788	0	33⁰
3.0	12	4800	9192	0	29⁰
4.0	33	13200	25278	0	39⁰
5.0	36	14400	27576	0	40⁰
6.0	40	16000	30640	0	42⁰
7.5	33	13200	25278	0	39⁰
9.0	24	9600	18384	0	35⁰

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TABLE I SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 1 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m^2)	Elastic Modulus 'E_s' Value (kN/m^2)	Shear Strength Parameters	
				'c' (kN/m^2)	Φ in Degrees
1.0	11	4400	8426	0	29^0
2.0	18	7200	13788	0	33^0
3.0	28	11200	21448	0	37^0
4.0	24	9600	18384	0	35^0
5.0	27	10800	20682	0	37^0
6.0	36	14400	27576	0	40^0
7.5	14	5600	10724	0	30^0
9.0	28	11200	21448	0	37^0
10.5	21	8400	16086	0	34^0
12.0	23	6900	17618	0	35^0
13.5	24	4800	18384	150	0^0
15.0	38	7600	29108	237	0^0
16.5	> 100	40000	76600	0	45^0
18.0	> 100	100000	76600	0	45^0
19.5	> 100	100000	76600	0	45^0
20 - 21.5	> 100	Point Load Strength Index = 1.18 MPa			

TABLE II SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 2 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m^2)	Elastic Modulus 'E_s' Value (kN/m^2)	Shear Strength Parameters	
				'c' (kN/m^2)	Φ in Degrees
1.0	12	4800	9192	0	29^0
2.0	18	7200	13788	0	33^0
3.0	12	4800	9192	0	29^0
4.0	33	13200	25278	0	39^0
5.0	36	14400	27576	0	40^0
6.0	40	16000	30640	0	42^0
7.5	33	13200	25278	0	39^0
9.0	24	9600	18384	0	35^0

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10.5	27	8100	20682	0	37^{0}
12.0	21	6300	16086	0	34^{0}
13.5	22	4400	16852	137	0^{0}
15.0	36	7200	27576	225	0^{0}
16.5	38	15200	29108	0	41^{0}
17.9	> 100	100000	76600	0	45^{0}

TABLE III SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 3 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m^2)	Elastic Modulus 'E_s' Value (kN/m^2)	Shear Strength Parameters	
				'c' (kN/m^2)	Φ in Degrees
1.0	11	4400	8426	0	29^{0}
2.0	12	4800	9192	0	29^{0}
3.0	15	6000	11490	0	31^{0}
4.0	18	7200	13788	0	33^{0}
5.0	18	7200	13788	0	33^{0}
6.0	34	13600	26044	0	39^{0}
7.5	15	6000	11490	0	31^{0}
9.0	22	6600	16852	0	35^{0}
10.5	23	4600	17618	143	0^{0}
12.0	22	4400	16852	137	0^{0}
13.5	27	8100	20682	0	37^{0}
15.0	42	12600	32172	0	42^{0}
16.5	> 100	100000	76600	0	45^{0}
17.0	> 100	100000	76600	0	45^{0}
17 - 18.5	> 100	Point Load Strength Index = 2.20 MPa			

TABLE IV SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 4 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m^2)	Elastic Modulus 'E_s' Value (kN/m^2)	Shear Strength Parameters	
				'c' (kN/m^2)	Φ in Degrees
1.0	12	4800	9192	0	29^{0}
2.0	18	7200	13788	0	33^{0}
3.0	12	4800	9192	0	29^{0}

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10.5	27	8100	20682	0	37^0
12.0	21	6300	16086	0	34^0
13.5	22	4400	16852	137	0^0
15.0	36	7200	27576	225	0^0
16.5	38	15200	29108	0	41^0
17.9	> 100	100000	76600	0	45^0

TABLE III SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 3 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m^2)	Elastic Modulus 'E_s' Value (kN/m^2)	Shear Strength Parameters	
				'c' (kN/m^2)	Φ in Degrees
1.0	11	4400	8426	0	29^0
2.0	12	4800	9192	0	29^0
3.0	15	6000	11490	0	31^0
4.0	18	7200	13788	0	33^0
5.0	18	7200	13788	0	33^0
6.0	34	13600	26044	0	39^0
7.5	15	6000	11490	0	31^0
9.0	22	6600	16852	0	35^0
10.5	23	4600	17618	143	0^0
12.0	22	4400	16852	137	0^0
13.5	27	8100	20682	0	37^0
15.0	42	12600	32172	0	42^0
16.5	> 100	100000	76600	0	45^0
17.0	> 100	100000	76600	0	45^0
17 - 18.5	> 100	Point Load Strength Index = 2.20 MPa			

TABLE IV SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 4 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m^2)	Elastic Modulus 'E_s' Value (kN/m^2)	Shear Strength Parameters	
				'c' (kN/m^2)	Φ in Degrees
1.0	12	4800	9192	0	29^0
2.0	18	7200	13788	0	33^0
3.0	12	4800	9192	0	29^0

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4.0	15	6000	11490	0	31^{0}
5.0	33	13200	25278	0	39^{0}
6.0	36	14400	27576	0	40^{0}
7.5	18	7200	13788	0	33^{0}
9.0	24	7200	18384	0	35^{0}
10.5	24	7200	18384	0	35^{0}
12.0	28	8400	21448	0	37^{0}
13.5	58	17400	44428	0	45^{0}
15.0	67	20100	51322	0	45^{0}
16.5	> 100	100000	76600	0	45^{0}
17.0	> 100	100000	76600	0	45^{0}
17 - 18.5	> 100	Point Load Strength Index = 1.10 MPa			

TABLE V SPT "N' values, Correlated CPT q_c Values, Shear Strength Parameters, Elastic Modulus (E_s) for BH 5 Location

Depth (m)	SPT 'N' Value	CPT 'q_c' Value (kN/m²)	Elastic Modulus 'E_s' Value (kN/m²)	Shear Strength Parameters	
				'c' (kN/m²)	Φ in Degrees
1.0	14	5600	10724	0	30^{0}
2.0	18	7200	13788	0	33^{0}
3.0	35	14000	26810	0	40^{0}
4.0	33	13200	25278	0	39^{0}
5.0	36	14400	27576	0	40^{0}
6.0	35	14000	26810	0	40^{0}
7.5	20	8000	15320	0	34^{0}
9.0	27	8100	20682	0	37^{0}
10.5	22	6600	16852	0	35^{0}
12.0	54	16200	41364	0	45^{0}
13.5	72	28800	55152	0	45^{0}
15.0	63	18900	48258	0	45^{0}
16.5	> 100	100000	76600	0	45^{0}
18.0	> 100	100000	76600	0	45^{0}
19.6	> 100	100000	76600	0	45^{0}
19.6 - 21.1	> 100	Point Load Strength Index = 1.78 MPa			

4.1 Allowable Bearing Capacity

The average design 'N' value and shear strength parameters below foundation level up to the influence depth of 1B is used to determine the Safe Bearing Capacity. The Safe Bearing Capacity is computed using Bureau of Indian Standard IS 6403-1981 equation. The width of foundation is assumed as 2.5 m to determine the Safe Bearing Capacity for varying depth of foundation. The computed Safe Bearing Capacity for the proposed site is shown in Table VI.

TABLE VI Safe Bearing Capacity of the proposed Site at Perur, ECR, Chennai for 2.5 m width of Foundation

Depth of Foundation (m)	Design Shear Strength Parameters		Safe Bearing Capacity (kN/m^2) IS 6403-1981 Equation
	'c' (kN/m^2)	Φ in Degrees	
2.0	0	30^0	158
2.5	0	31^0	209
3.0	0	32^0	274

4.2 Settlement of Soil Layer

One of the important aspects of any foundation systems is to satisfy the settlement criteria apart from bearing capacity criteria. The total settlement of foundation is becoming very critical, especially if the foundation is located on clays, because the clay layer is expected to undergo excessive consolidation settlement over a period of time under sustained loadings which of course depends on the state of clay (initial water content / void ratio), whereas in the

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case of loose sand layer, elastic or immediate settlement plays a crucial role. The Table VII shows the settlement of foundation computed based on De Beer Method (S 8009 (Part I) 1976 Sec. 9.1.2) with respect to safe bearing capacity of the 2.5 m x 2.5 m foundation at various depths. The settlement is computed up to the influence depth of "2B" below the foundation. ***The allowable settlement as per IS 1904 Table I 1986 is 50 mm.***

TABLE VII Settlement Values computed with Respect to the Safe Bearing Capacity of 2.5 m x 2.5 m Size Foundation

Size of Foundation	Depth of Foundation	Safe Bearing Capacity (kN/m^2)	Settlement as per De Beer Method - IS 8009 (Part I) 1976 Sec. 9.1.2 (mm)
2.5 m x 2.5 m	2.0 m	158	17.99
	2.5 m	209	20.99
	3.0 m	274	26.62

5.0 DETERMINATION OF SAFE PILE CARRYING CAPACITY

As the exact total structural load of the super structure has not been made available to this office of Division of Soil Mechanics and Foundation Engineering, CEG, Anna University, Chennai - 25, attempts are also made to suggest pile foundation for varying pile diameter apart from recommendation of shallow foundation. For computing the load carrying capacity of pile, Indian Standard IS 2911 (Part 1/Sec. 2) 2010 method and Meyerhof 1959 formula (Based on SPT 'N' Value) is used. The diameters of piles are assumed as 400 mm, 500 mm, 600 mm and 750 mm and the length of the pile is taken as 17 m to 20 m. The least shear strength parameters and least 'N' values were taken as the criteria from Table I to Table V out of the five

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borehole locations for the design of pile foundation for the proposed site. Accordingly, the least shear strength parameters and least 'N' values of soil layers were observed in BH - 3. Hence, safe pile carrying capacity computations were made for BH-3 borehole data. The Indian Standard IS 2911 (2010) specifies that the base resistance should not exceed 1000 to 1100 t/m^2 for bored cast-in-situ piles and 1500 t/m^2 for precast driven piles. The end bearing capacity is also computed based on Cole and Stroud (1977) approach by providing 0.5 D in Granite Rock Strata as pile socketing (D is pile diameter in mm). The shear strength of rocky stratum (point bearing shear strength) is the point load strength index of the rock samples which is used to determine the ultimate end bearing resistance of the pile.

For calculating the skin friction along the pile length of 17 m to 20 m, the design 'N' values and shear strength parameters for respective depths were used. As seen from section 3.5, the water table may fluctuate significantly varying from 0.5 m to 2 m because of nearness of seashore. This instant fluctuations may induce settlement of surrounding soil which in turn may cause negative skin friction. Hence, the safe frictional capacity were computed beyond 2 m depth. The safe end bearing capacity and safe skin frictional capacity are together added for different pile diameter and the total safe load carrying capacity of pile thus computed is shown in Table VIII. The factor of safety of 3 has been used for determining safe end bearing and also frictional capacity of bored cast-in-situ piles.

The uplift capacity of a pile is given by sum of the frictional resistance and the weight of the pile (buoyant or total as relevant) as per Section 6.3.2 of IS 2911 (Part 1/Sec. 2) 2010. The recommended factor of safety is 3.0 in the absence of any pull out test results and 2.0 with pullout test results. Uplift capacity can be obtained from static formula by ignoring end-bearing

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but adding weight of the pile (buoyant or total as relevant). The safe uplift capacity of pile varying diameter is given in Table IX.

TABLE VIII Safe Load Carrying Capacity of Pile for varying Diameter for the Length of 17 m to 20 m

Pile Diameter	Safe Pile Capacity (Tons) Meyerhof 1959	Safe Pile Capacity (Tons) (IS 2911 Part-I 2010 Static Formula)	Safe Pile Capacity (Tons) Cole and Stroud (1977) Formula) - 0.5 D Socketed into Granite Rock Strata
400 mm	79	87	90
500 mm	95	104	107
600 mm	129	140	145
750 mm	191	204	213

TABLE IX Safe Uplift Capacity of Pile for varying Diameter for the Length of 17 m to 20 m(IS 2911 (Part 1/Sec. 2) 2010

Pile Diameter	Safe Uplift Capacity (Tons) IS 2911 (Part 1/Sec. 2) 2010
400 mm	41
500 mm	47
600 mm	58
750 mm	76

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6. CONCLUSIONS

Upon Consideration and closer examination of the discussions of section 4 and 5, the following conclusions are made for the proposed construction of 400 MLD capacity Reverse Osmosis Desalination Plant at Perur on ECR, Chennai.

- ✓ The recommended safe bearing capacity of the proposed site for '*shallow foundation*' is shown in Table X for varying depth. The minimum width of foundation shall be 2.5 m.

Table X Recommended Safe Bearing Capacity of the proposed site at Perur, ECR, Chennai

Size of Foundation	Depth of Foundation	Safe Bearing Capacity (kN/m^2)	Settlement as per De Beer Method - IS 8009 (Part I) 1976 Sec. 9.1.2 (mm)
2.5 m x 2.5 m	2.0 m	158	17.99
	2.5 m	209	20.99
	3.0 m	274	26.62

- ✓ As an alternative to the shallow foundation, the recommended safe vertical pile carrying capacity and uplift capacity of the 17 m to 20 m length of 'bored cast in-situ pile' for varying diameter is shown in Table XI.

- ✓ The bored cast in-situ pile shall be terminated at about 17 m to 20 m depth on the rocky stratum.

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Table XI Recommended Safe Load Carrying Capacity and Uplift Capacity of Pile for varying Diameter for the Length of 17 m at Perur, ECR, Chennai

Pile Diameter	Pile Capacity (Tons)	Uplift Capacity (Tons)
400 mm	86	41
500 mm	102	47
600 mm	138	58
750 mm	203	76

- ✓ Pile load test has to be conducted to ensure the designed pile carrying capacity. The minimum grade of concrete for pile foundation is M25.

- ✓ Because of the proximity of seashore to the proposed site, there is every possibility for sea water intrusion during open excavation, if shallow foundation is proposed. Enough care may be taken to design a suitable dewatering system while construction of foundation is in progress.

14/11/14

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[3] IS 6403-1981 (Reaffirmed 1997), "Code of Practice for Determination of Bearing Capacity of Shallow Foundations", Bureau of Indian Standards.

[4] IS 8009 (Part I) (Reaffirmed 1998), "Code of Practice for Calculation of Settlements of Foundations", Bureau of Indian Standards.

[5] IS 2911, Part 1 (2010),"Code of Practice for Design and Construction of Pile Foundations", Bureau of Indian Standards.

[6] IS 1904 - 1986 (Reaffirmed 1995)," Code of Practice for Design and Construction of Foundations in Soils : General Requirements", Bureau of Indian Standards.

[7] Schmertmann, J.H. 1970. "Static cone to compute static settlement over sand", Journal of the Soil Mechanics and Foundations Division, ASCE, 96(3): 1011-1043.

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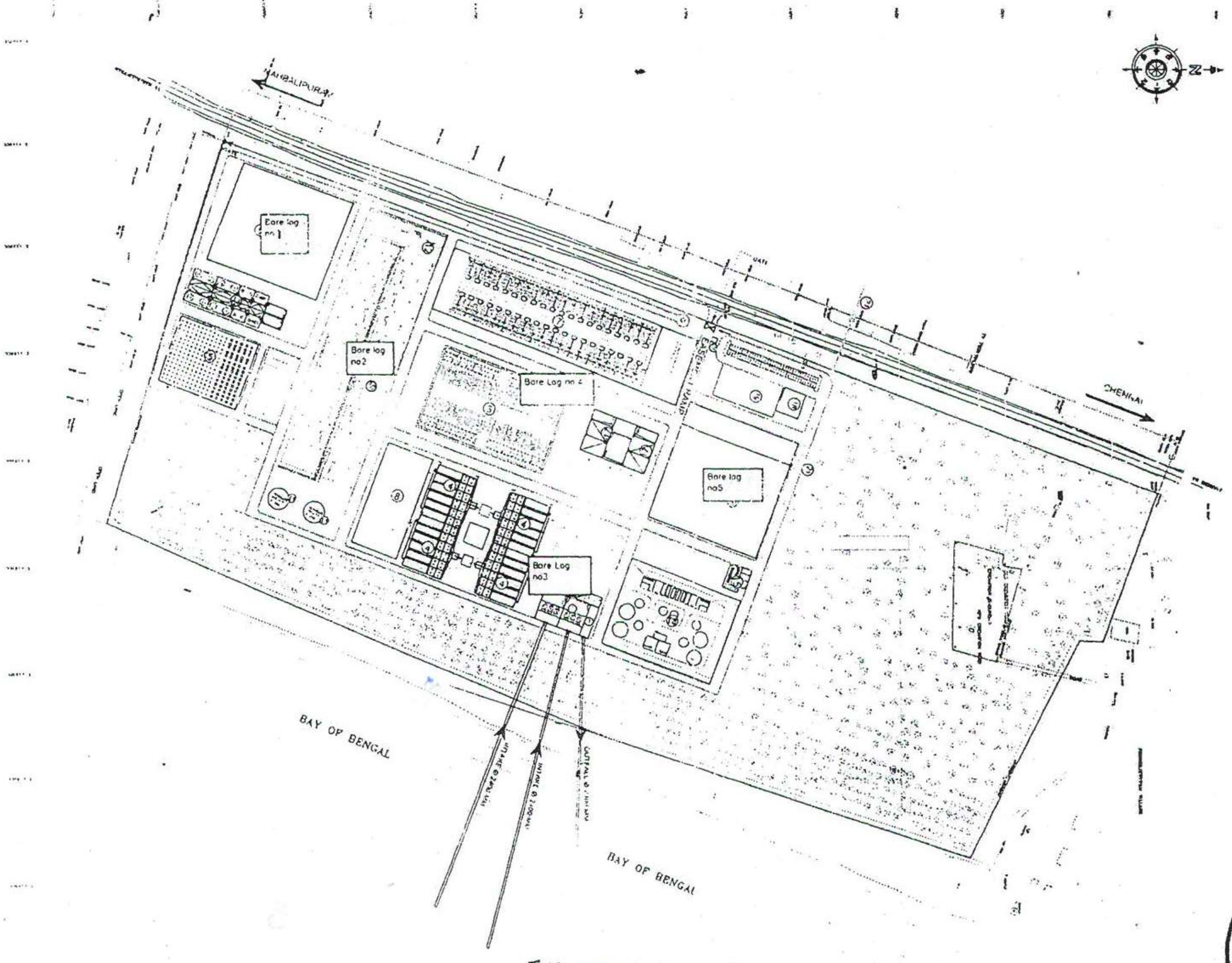

Figure 1 Location of Boreholes

LIST OF UNITS

1. INLET ONSHORE SCREENS
2. INTAKE PUMP STATION
3. OUTFALL CHAMBER
4. LAMELLA CLARIFIER
5. PRE TREATMENT STORAGE
6. DISSOLVED AIR FLOATATION
7. DUAL MEDIA GRAVITY FILTER
8. RO FEED TANK
9. ELECTRICAL SUBSTATION
10. RO BUILDING
11. RO PERMEATE TANK
12. CIP
13. CHEMICAL STORAGE FOR RO
14. POTABILIZATION
15. POST-CHLORINATION BUILDING
16. PRODUCT WATER TANK
17. FILTER BW HOLDING TANK
18. ADMINISTRATION BUILDING
19. MAINTENANCE WORKSHOP
20. GUARD HOUSE
21. PRODUCT WATER MAIN

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CONSULTANT	CLIENT	PROJECT TITLE -	CONSULTANCY TO CONDUCT PREFEASIBILITY STUDIES INCLUDING FINANCIAL VIABILITY PREPARATION OF DETAILED PROJECT REPORT, BID SETTING UP OF ... CAPACITY SEA WATER REVERSE OSMOSIS DESALINATION PLANT E FOR CHENNAI CITY ALONG ECR ROAD, CHENNAI, TAMILNADU, INDIA
AECOM WATEK AECOM INDIA Private Limited in Association with GHD Pty Limited and WATEK Engineering	Chennai Metro Water Supply and Sewerage Board	DRAWING TITLE -	LAYOUT
		SCALE - AS SHOWN	DWG. NO. 12138/CHN/SS8/SWRO/001 — SIZE A3

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FIELD BORE LOG PROFILE

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH NO	1	DATE OF START	03.11.2014
SITE	Perur	DATE OF COMPLETION	04.11.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.60 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	3	5	6	11	Medium Dense
2.00		Brown Sand	6	7	11	18	Medium Dense
3.00		Brown Sand	10	10	18	28	Medium Dense
4.00		Brown Sand	9	10	14	24	Medium Dense
5.00		Brown Sand	10	12	15	27	Medium Dense
6.00		Brown Sand	12	18	18	36	Medium Dense
7.50		Brown Sand	9	7	7	14	Medium Dense
9.00		Brown Sand	11	13	15	28	Medium Dense
10.5		Brown Sand	8	10	11	21	Medium Dense
12.0		Grayish Silty Sand	9	11	12	23	Medium Dense
13.5		Grayish Clayey Sand	8	12	12	24	Medium Dense
15.0		Brown Silty Clay	11	18	20	38	Hard
16.5		Grayish Brown Clayey Sand	21	55 (13 cm) Rebound		> 100	Hard
18.0		Grayish Brown Weathered Rock	54 (2 cm) Hammer Rebound			> 100	Hard
19.5		Grayish Brown Weathered Rock	54 (1 cm) Hammer Rebound			> 100	Hard
20 - 21.5		Pinkish Gray Granite Rock	CR = 60%, RQD = 20%			> 100	Hard
Borehole Termination Depth is 21.5 m from the Existing Ground Level							

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Figure 2

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FIELD BORE LOG PROFILE

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR			
BH NO	2	DATE OF START	01.11.2014
SITE	Perur	DATE OF COMPLETION	02.11.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.70 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling 15	30	45	N	Relative Density/ Consistency
1.00		Brown Sand	4	6	6	12	Medium Dense
2.00		Brown Sand	6	8	10	18	Medium Dense
3.00		Brown Sand	3	6	6	12	Medium Dense
4.00		Brown Sand	6	15	18	33	Dense
5.00		Brown Sand	15	18	18	36	Dense
6.00		Brown Sand	17	18	22	40	Dense
7.50		Brown Sand	13	15	18	33	Dense
9.00		Brown Sand	11	11	13	24	Medium Dense
10.5		Grayish Brown Clayey Sand	12	13	14	27	Medium Dense
12.0		Grayish Brown Clayey Sand	9	10	11	21	Medium Dense
13.5		Grayish Silty Clay	10	11	11	22	Very Stiff
15.0		Grayish Silty Clay	9	18	18	36	Very Stiff
16.5		Grayish Brown Clayey Sand	11	15	23	38	Dense
17.9		Grayish Brown Weathered Rock	54 (2 cm) Hammer Rebound			> 100	Hard
Borehole Termination Depth is 17.9 m from the Existing Ground Level							

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Figure 3

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FIELD BORE LOG PROFILE

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH NO	3	DATE OF START	05.11.2014
SITE	Perur	DATE OF COMPLETION	05.11.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.54 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	2	5	6	11	Medium Dense
2.00		Brown Sand	3	6	6	12	Medium Dense
3.00		Brown Sand	4	7	8	15	Medium Dense
4.00		Brown Sand	5	8	10	18	Medium Dense
5.00		Brown Sand	6	8	10	18	Medium Dense
6.00		Brown Sand	11	15	19	34	Dense
7.50		Grayish Brown Sand	7	7	8	15	Medium Dense
9.00		Grayish Brown Clayey Sand	7	11	11	22	Medium Dense
10.5		Grayish Silty Clay	7	11	12	23	Very Stiff
12.0		Grayish Silty Clay	8	10	12	22	Very Stiff
13.5		Grayish Brown Clayey Sand	9	10	17	27	Medium Dense
15.0		Grayish Brown Clayey Sand	11	18	24	42	Dense
16.5		Grayish Brown Weathered Rock	57 (8 cm) Hammer Rebound			> 100	Hard
17.0		Grayish Brown Weathered Rock	55 (3 cm) Hammer Rebound			> 100	Hard
18.5		Grayish Granite Rock	CR = 25%, RQD = 7%			> 100	Hard
Borehole Termination Depth is 18.5 m from the Existing Ground Level							

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Figure 4

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PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH NO	4	DATE OF START	30.10.2014
SITE	Perur	DATE OF COMPLETION	31.10.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.65 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	5	5	7	12	Medium Dense
2.00		Brown Sand	6	9	9	18	Medium Dense
3.00		Brown Sand	4	6	6	12	Medium Dense
4.00		Brown Sand	6	7	8	15	Medium Dense
5.00		Grayish Brown Sand	8	12	21	33	Medium Dense
6.00		Grayish Brown Sand	9	16	20	36	Dense
7.50		Grayish Brown Sand	6	8	10	18	Medium Dense
9.00		Grayish Brown Clayey Sand	8	11	13	24	Medium Dense
10.5		Grayish Brown Clayey Sand	9	12	12	24	Very Stiff
12.0		Grayish Brown Clayey Sand	10	12	16	28	Very Stiff
13.5		Grayish Brown Clayey Sand	16	25	33	58	Very Dense
15.0		Grayish Brown Clayey Sand	17	33	34	67	Very Dense
16.5		Grayish Brown Weathered Rock	55 (5 cm) Hammer Rebound			> 100	Hard
17.0		Grayish Brown Weathered Rock	53 (2 cm) Hammer Rebound			> 100	Hard
18.5		Grayish Granite Rock	CR = 20%, RQD = 7%			> 100	Hard
Borehole Termination Depth is 18.5 m from the Existing Ground Level							

Figure 5

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FIELD BORE LOG PROFILE

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH NO	5	DATE OF START	28.10.2014
SITE	Perur	DATE OF COMPLETION	30.10.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.72 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	4	7	7	14	Medium Dense
2.00		Brown Sand	5	8	10	18	Medium Dense
3.00		Brown Sand	10	14	21	35	Dense
4.00		Brown Sand	11	15	18	33	Dense
5.00		Brown Sand	12	18	18	36	Dense
6.00		Brown Sand	12	15	20	35	Dense
7.50		Brown Sand	6	10	10	20	Medium Dense
9.00		Brown Clayey Sand	9	12	15	27	Medium Dense
10.5		Brown Clayey Sand	8	10	12	22	Medium Dense
12.0		Grayish Brown Silty Sand	18	23	31	54	Very Dense
13.5		Grayish Brown Silty Sand	20	30	42	72	Very Dense
15.0		Grayish Brown Clayey Sand	21	30	33	63	Very Dense
16.5		Grayish Brown Weathered Rock	54 (1 cm) Hammer Rebound			> 100	Hard
18.0		Grayish Brown Weathered Rock	58 (1 cm) Hammer Rebound			> 100	Hard
19.6		Grayish Brown Weathered Rock	54 (0 cm) Hammer Rebound			> 100	Hard
19.6 - 21.1		Grayish Granite Rock	CR = 20%, RQD = 0%			> 100	Hard
Borehole Termination Depth is 21.1 m from the Existing Ground Level							

Figure 6

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Table 1

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR																			
BH 1															Ground Water Level		1.60 m from EGL		
LABORATORY TEST RESULTS																			
SPT 'N' Value	Depth (m)	Soil Description / Classification	Index Properties						Specific Gravity	Grain Size Analysis (%)						~~Triaxial Shear / UCC Test / Direct Shear Test Results~~ / Correlated Values*		Consolidation Test Results	
			Natural Moisture Content (NMC), %	Bulk Density (kN/m^3)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index		Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines		Cohesion (c) kN/m^2	Angle of Friction (Φ)	Co-efficient of Consolidation (C_v) x 10^{-3} cm^2/sec	Compressibility Index, (C_c)
														Silt	Clay				
11	1.00	Brown Sand	19	18	Non Plastic				2.63	0	3	40	55	2		0	29^0	-	-
18	2.00	Brown Sand	15	19	Non Plastic				2.63	0	4	34	56	6		0	33^0	-	-
28	3.00	Brown Sand	13	21	Non Plastic				2.64	0	3	31	62	4		0	37^0	-	-
24	4.00	Brown Sand	19	20	Non Plastic				2.63	0	2	21	72	5		0	35^0	-	-
27	5.00	Brown Sand	19	21	Non Plastic				2.64	0	2	22	71	5		0	37^0	-	-
36	6.00	Brown Sand	20	22	Non Plastic				2.62	0	3	14	80	3		0	40^0	-	-
14	7.50	Brown Sand	14	18	Non Plastic				2.63	0	15	39	37	9		0	30^0	-	-
28	9.00	Brown Sand	12	21	Non Plastic				2.62	0	42	24	15	19		0	37^0	-	-
21	10.5	Brown Sand	17	20	Non Plastic				2.62	0	12	14	55	19		0	34^0	-	-
23	12.0	Grayish Silty Sand	20	20	Non Plastic				2.66	0	0	4	71	25		0	35^0	-	-
24	13.5	Grayish Clayey Sand (CI)	15	20	42	22	20	45	2.60	0	4	11	28	57		150	0^0	-	-
38	15.0	Brown Silty Clay (CH)	17	22	51	24	27	60	2.60	0	7	11	30	52		237	0^0	-	-
> 100	16.5	Grayish Clayey Sand (SC - CI)	14	22	41	22	19	140	2.67	2	21	23	27	27		0	45^0	-	-
> 100	18.0	Grayish Brown Weathered Rock	Washed Sample													0	45^0	-	-
> 100	19.5	Grayish Brown Weathered Rock	Washed Sample													0	45^0		

Note: * Shear strength parameters were derived as per Terzaghi and Peck Correlation (1974).

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Table 2

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH 2 | **Ground Water Level** | **1.70 m from EGL**

LABORATORY TEST RESULTS

SPT 'N' Value	Depth (m)	Soil Description / Classification	Index Properties: Natural Moisture Content (NMC), %	Bulk Density (kN/m³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index	Specific Gravity	Grain Size Analysis (%): Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines (Silt, Clay)	~~Triaxial Shear / UCC Test / Direct Shear Test Results~~ / Correlated Values*: Cohesion (c) kN/m²	Angle of Friction (Φ)	Consolidation Test Results: Co-efficient of Consolidation (C_v) x 10^{-3} cm²/sec	Compressibility Index, (C_c)
12	1.00	Brown Sand	16	18	Non Plastic				2.64	0	5	44	49	2	0	29^0	-	-
18	2.00	Brown Sand	16	19	Non Plastic				2.64	0	3	48	47	2	0	33^0	-	-
12	3.00	Brown Sand	17	18	Non Plastic				2.63	0	0	25	73	2	0	29^0	-	-
33	4.00	Brown Sand	17	22	Non Plastic				2.64	0	7	18	71	4	0	39^0	-	-
36	5.00	Brown Sand	18	22	Non Plastic				2.63	0	30	39	27	4	0	40^0	-	-
40	6.00	Brown Sand	18	22	Non Plastic				2.63	0	31	40	28	1	0	42^0	-	-
33	7.50	Brown Sand	17	22	Non Plastic				2.62	0	28	41	30	1	0	39^0	-	-
24	9.00	Brown Sand	13	20	Non Plastic				2.61	0	20	29	34	17	0	35^0	-	-
27	10.5	Grayish Brown Clayey Sand (SC)	12	21	37	17	20	40	2.60	0	17	18	30	35	0	37^0	-	-
21	12.0	Grayish Brown Clayey Sand (SC)	21	20	37	17	20	40	2.60	0	9	8	41	42	0	34^0	-	-
22	13.5	Grayish Silty Clay (CI)	21	20	44	25	19	55	2.66	0	0	2	21	77	137	0^0	-	-
36	15.0	Grayish Silty Clay (CH)	19	22	57	24	33	120	2.66	0	0	2	21	77	225	0^0	-	-
38	16.5	Grayish Brown Clayey Sand (SC - CI)	17	22	41	22	19	100	2.67	0	10	11	33	46	0	41^0		
> 100	17.9	Grayish Brown Weathered Rock	Washed Sample												0	45^0		

Note: * Shear strength parameters were derived as per Terzaghi and Peck Correlation (1974).

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Table 3

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH 3 | **Ground Water Level** | **1.54 m from EGL**

LABORATORY TEST RESULTS

SPT 'N' Value	Depth (m)	Soil Description / Classification	Index Properties						Specific Gravity	Grain Size Analysis (%)						~~Triaxial Shear / UCC Test / Direct Shear Test Results~~ / Correlated Values*		Consolidation Test Results	
			Natural Moisture Content (NMC), %	Bulk Density (kN/m^3)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index		Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines		Cohesion (c) kN/m^2	Angle of Friction (Φ)	Co-efficient of Consolidation (C_v) x 10^{-3} cm^2/sec	Compressibility Index, (C_c)
														Silt	Clay				
11	1.00	Brown Sand	20	18	Non Plastic				2.62	0	3	45	46	6		0	29^0	-	-
12	2.00	Brown Sand	23	18	Non Plastic				2.62	0	2	36	58	4		0	29^0	-	-
15	3.00	Brown Sand	22	19	Non Plastic				2.63	0	2	35	58	5		0	31^0	-	-
18	4.00	Brown Sand	19	19	Non Plastic				2.63	0	0	47	49	4		0	33^0	-	-
18	5.00	Brown Sand	19	19	Non Plastic				2.64	0	2	43	48	7		0	33^0	-	-
34	6.00	Brown Sand	19	22	Non Plastic				2.62	0	47	13	35	5		0	39^0	-	-
15	7.50	Grayish Brown Sand	12	19	Non Plastic				2.64	0	29	23	30	18		0	31^0	-	-
22	9.00	Grayish Brown Clayey Sand (SC)	12	20	34	17	17	40	2.63	0	7	22	38	33		0	35^0	-	-
23	10.5	Grayish Silty Clay (CI)	19	20	39	19	20	45	2.61	0	0	0	43	57		143	0^0	-	-
22	12.0	Grayish Silty Clay (CH)	19	20	47	23	24	50	2.61	0	0	0	26	74		137	0^0	-	-
27	13.5	Grayish Brown Clayey Sand (SC - CI)	13	21	42	22	20	50	2.65	0	23	14	25	38		0	37^0	-	-
42	15.0	Grayish Brown Clayey Sand (SC - CI)	15	22	42	22	20	50	2.65	0	32	8	22	38		0	42^0	-	-
> 100	16.5	Grayish Brown Weathered Rock	Washed Sample													0	45^0	-	-
> 100	17.0	Grayish Brown Weathered Rock	Washed Sample													0	45^0	-	-

Note: * Shear strength parameters were derived as per Terzaghi and Peck Correlation (1974).

Table 4

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH 4 | **Ground Water Level** | **1.65 m from EGL**

LABORATORY TEST RESULTS

SPT 'N' Value	Depth (m)	Soil Description / Classification	Index Properties: Natural Moisture Content (NMC), %	Bulk Density (kN/m³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index	Specific Gravity	Grain Size Analysis (%): Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines: Silt	Clay	~~Triaxial Shear / UCC Test / Direct Shear Test Results~~ / Correlated Values*: Cohesion (c) kN/m²	Angle of Friction (Φ)	Consolidation Test Results: Co-efficient of Consolidation (C_v) x 10^{-3} cm²/sec	Compressibility Index, (C_c)
12	1.00	Brown Sand	15	18	Non Plastic				2.63	0	0	32	59	9		0	29^0	-	-
18	2.00	Brown Sand	16	19	Non Plastic				2.64	0	0	25	64	11		0	33^0	-	-
12	3.00	Brown Sand	18	18	Non Plastic				2.64	0	0	18	71	11		0	29^0	-	-
15	4.00	Brown Sand	16	19	Non Plastic				2.64	0	3	28	58	11		0	31^0	-	-
33	5.00	Grayish Brown Sand	14	22	Non Plastic				2.63	0	3	28	58	11		0	39^0	-	-
36	6.00	Grayish Brown Sand	16	22	Non Plastic				2.63	0	5	25	59	11		0	40^0	-	-
18	7.50	Grayish Brown Sand	11	19	Non Plastic				2.63	0	2	39	42	17		0	33^0	-	-
24	9.00	Grayish Brown Clayey Sand (SC)	11	20	30	16	14	30	2.66	0	0	7	63	30		0	35^0	-	-
24	10.5	Grayish Brown Clayey Sand (SC)	11	20	30	16	14	30	2.66	0	0	10	60	30		0	35^0	-	-
28	12.0	Grayish Brown Clayey Sand (SC)	12	21	33	17	16	40	2.66	0	0	9	61	30		0	37^0	-	-
58	13.5	Grayish Brown Clayey Sand (SC)	12	22	33	17	16	40	2.68	0	2	14	51	33		0	45^0	-	-
67	15.0	Grayish Brown Clayey Sand (SC)	12	22	33	17	16	40	2.68	0	1	20	43	36		0	45^0	-	-
> 100	16.5	Grayish Brown Weathered Rock	Washed Sample													0	45^0	-	-
> 100	17.0	Grayish Brown Weathered Rock	Washed Sample													0	45^0	-	-

Note: * Shear strength parameters were derived as per Terzaghi and Peck Correlation (1974).

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Table 5

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH 5 — Ground Water Level: 1.72 m from EGL

LABORATORY TEST RESULTS

SPT 'N' Value	Depth (m)	Soil Description / Classification	Index Properties: Natural Moisture Content (NMC), %	Bulk Density (kN/m^3)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index	Specific Gravity	Grain Size Analysis (%): Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines: Silt	Clay	~~Triaxial Shear / UCC Test / Direct Shear Test Results~~ / Correlated Values*: Cohesion (c) kN/m^2	Angle of Friction (Φ)	Consolidation Test Results: Co-efficient of Consolidation (C_v) x 10^{-3} cm²/sec	Compressibility Index, (C_c)
14	1.00	Brown Sand	15	18	Non Plastic				2.64	0	0	7	84	9		0	30^0	-	-
18	2.00	Brown Sand	15	19	Non Plastic				2.63	0	0	23	68	9		0	33^0	-	-
35	3.00	Brown Sand	18	22	Non Plastic				2.63	0	11	30	50	9		0	40^0	-	-
33	4.00	Brown Sand	18	22	Non Plastic				2.64	0	0	4	90	6		0	39^0	-	-
36	5.00	Brown Sand	18	22	Non Plastic				2.64	0	0	9	87	4		0	40^0	-	-
35	6.00	Brown Sand	13	22	Non Plastic				2.64	0	0	11	85	4		0	40^0	-	-
20	7.50	Brown Sand	13	20	Non Plastic				2.64	0	6	26	54	14		0	34^0	-	-
27	9.00	Brown Clayey Sand (SC)	14	21	30	16	14	30	2.62	0	7	28	42	33		0	37^0	-	-
22	10.5	Brown Clayey Sand (SC)	14	20	30	16	14	30	2.62	0	7	28	42	33		0	35^0	-	-
54	12.0	Grayish Brown Silty Sand	14	22	Non Plastic				2.66	0	1	30	54	15		0	45^0	-	-
72	13.5	Grayish Brown Silty Sand	14	22	Non Plastic				2.66	0	1	30	54	15		0	45^0	-	-
63	15.0	Grayish Brown Clayey Sand (SC)	12	22	34	17	17	40	2.60	0	2	21	37	40		0	45^0	-	-
> 100	16.5	Grayish Brown Weathered Rock	Washed Sample													0	45^0	-	-
> 100	18.0	Grayish Brown Weathered Rock	Washed Sample													0	45^0		
> 100	19.6	Grayish Brown Weathered Rock	Washed Sample													0	45^0		

Note: * Shear strength parameters were derived as per Terzaghi and Peck Correlation (1974).

Executive Engineer (Desal)
Chennai Metropolitan Water Supply & Sewerage Board
Chennai - 600 002.

Division of Soil Mech. & Foundation Engg.
CEGC
Anna University
Chennai-25

Annexure - 1 (Site Photographs)

CEGC
Division of Soil Mech. & Foundation Engg.
Anna University
Chennai-25

Plate 1 View of SPT in Progress at the proposed Site

Executive Engineer (Desal)
Chennai Metropolitan Water Supply &
Sewerage Board
Chennai - 600 002.

Division of Soil Mech. & Foundation Engg.
CEGC
Anna University
Chennai-25

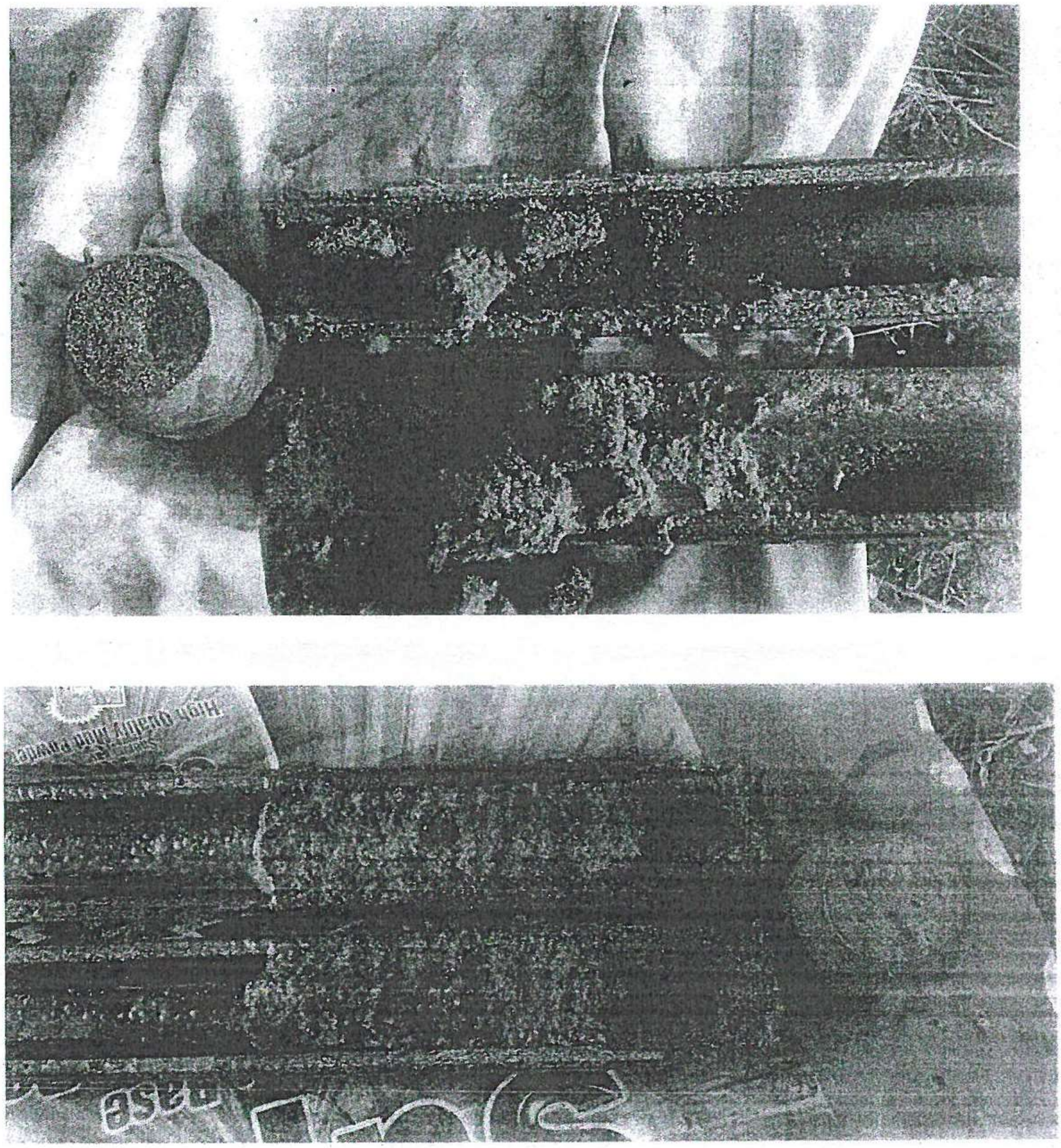


Plate 2 View of Soil Sampling through Split Spoon Sampler at the proposed Site

Executive Engineer (Desal)
Chennai Metropolitan Water Supply &
Sewerage Board
Chennai - 600 002.

Division of Soil Mech. & Foundation Engg.
CEGC
Anna University
Chennai-25

Plate 3 Inspection by the Faculty Member of Department of Civil Engineering, CEG, Anna University, Chennai - 25 on 01.11.2014 at proposed Site

Executive Engineer (Desal)
Chennai Metropolitan Water Supply &
Sewerage Board
Chennai - 600 002.

Plate 4 Inspection by the Faculty Member of Department of Civil Engineering, CEG, Anna University, Chennai - 25 on 01.11.2014 at proposed Site

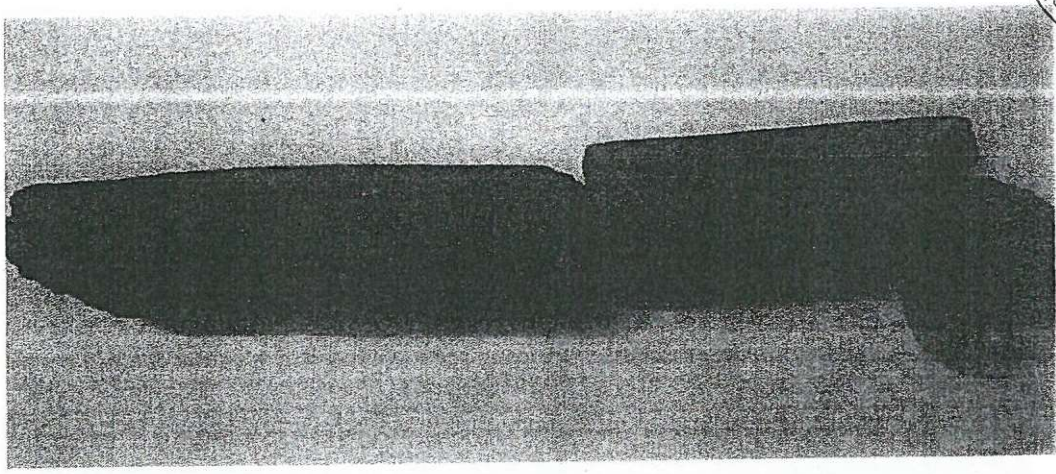


Plate 5 View of Pinkish Granite Core Sample found at BH 1 in 20.0 to 21.5 m Depth

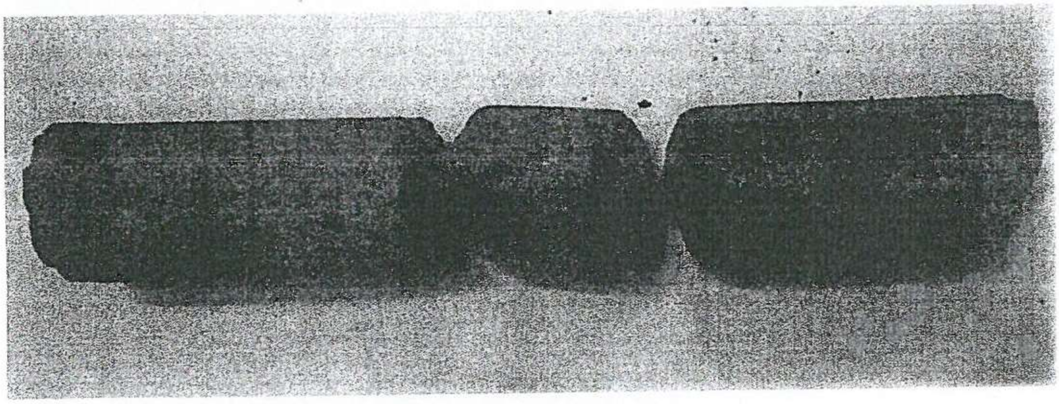


Plate 6 View of Grayish Granite Core Sample found at BH 3 in 17.0 to 18.5 m Depth

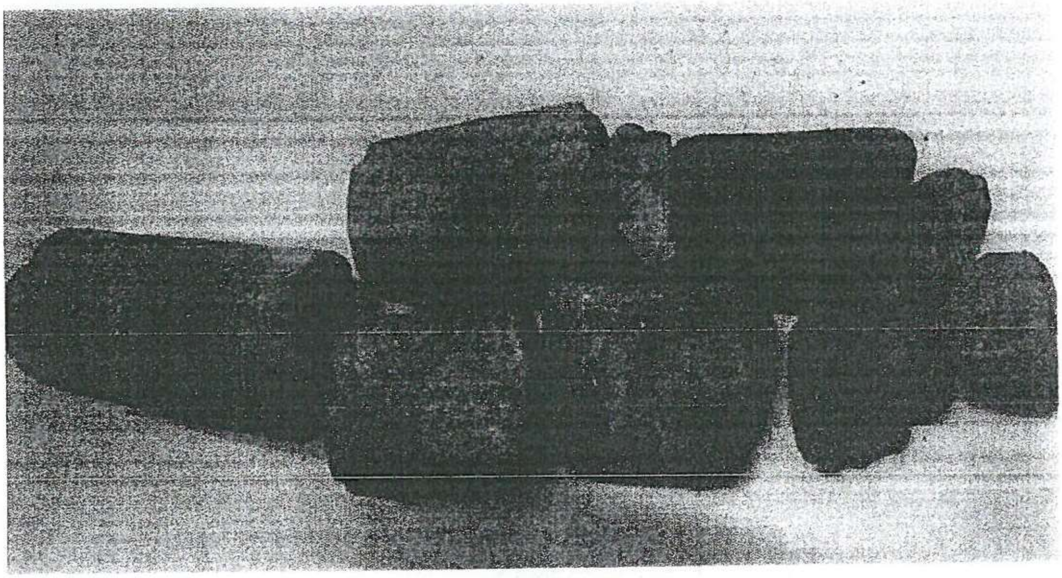


Plate 7 View of Grayish Granite Core Sample found at BH 4 in 17.0 to 18.5 m Depth

Division of Soil Mech. & Foundation Engg.
CEGC
Anna University
Chennai-25

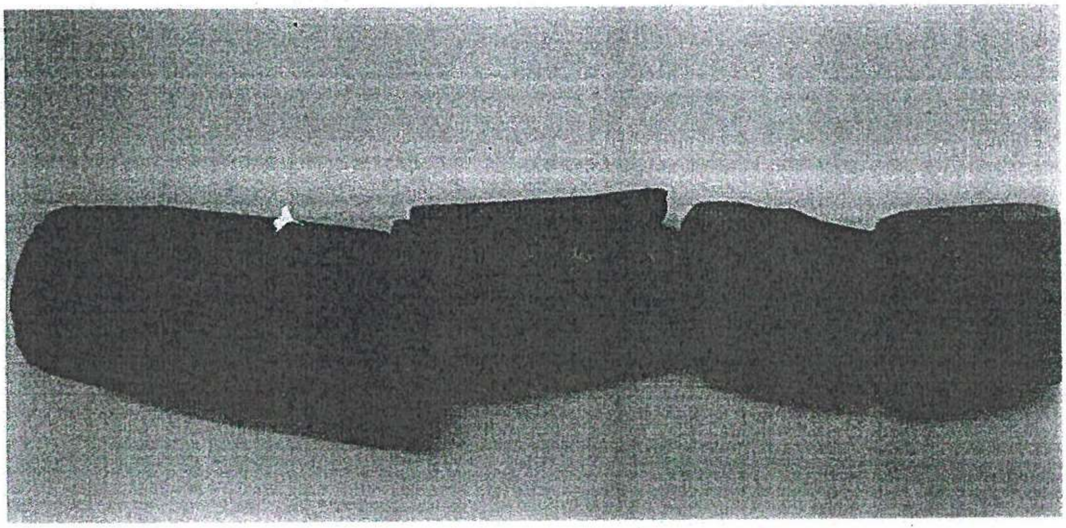


Plate 8 View of Grayish Granite Core Sample found at BH 5 in 19.6 to 21.1 m Depth

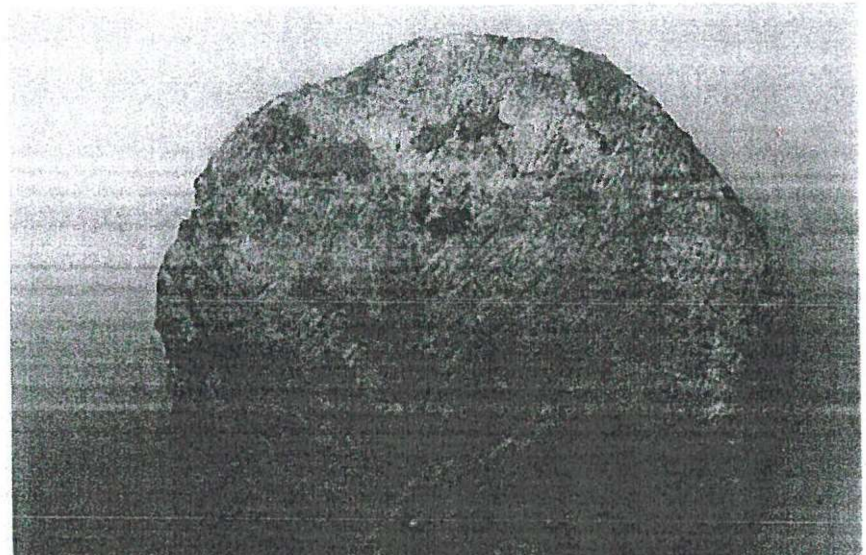


Plate 9 Texture of Pinkish Granite core sample at BH 1 in 20.0 to 21.5 m Depth

Executive Engineer (Desal)
Chennai Metropolitan Water Supply &
Sewerage Board
Chennai - 600 002.

Plate 10 Texture of Grayish Granite core sample at BH 3 in 17.0 to 18.5 m Depth

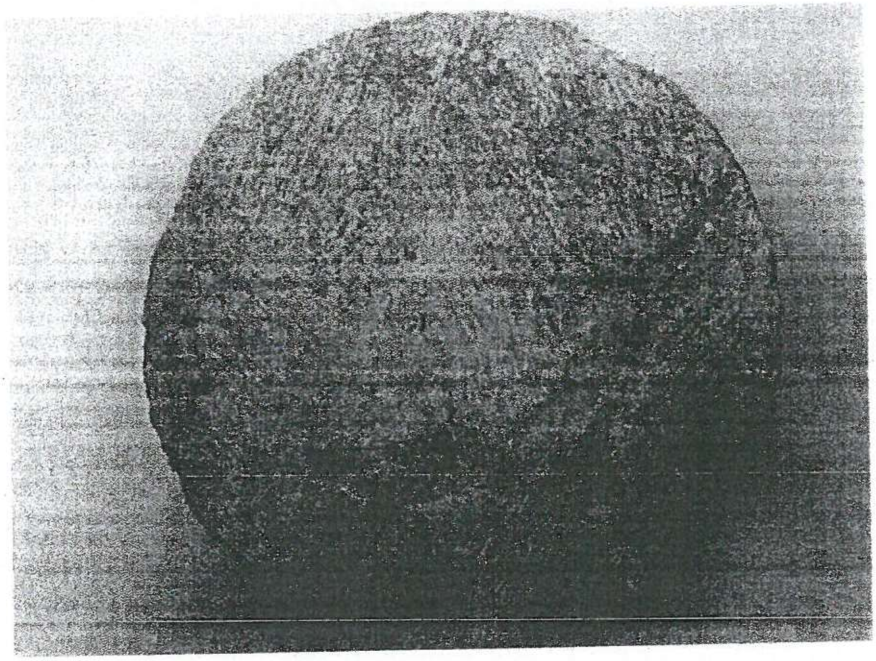


Plate 11 Texture of Grayish Granite core sample at BH 4 in 17.0 to 18.5 m Depth

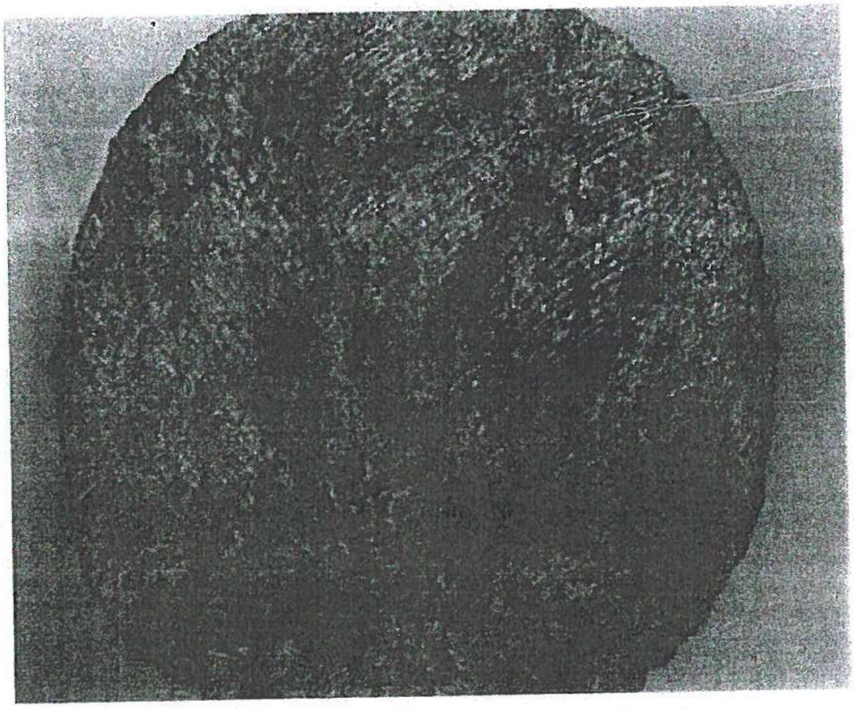


Plate 12 Texture of Grayish Granite at BH 5 core sample in 19.6 to 21.1 m Depth

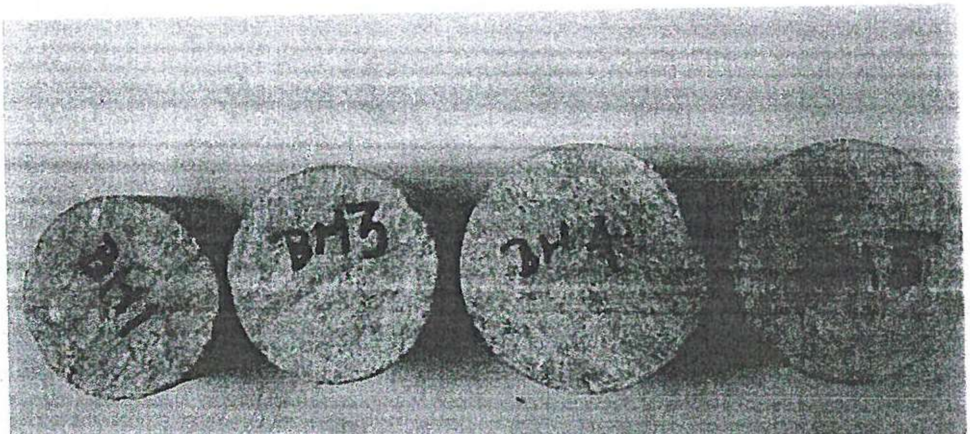
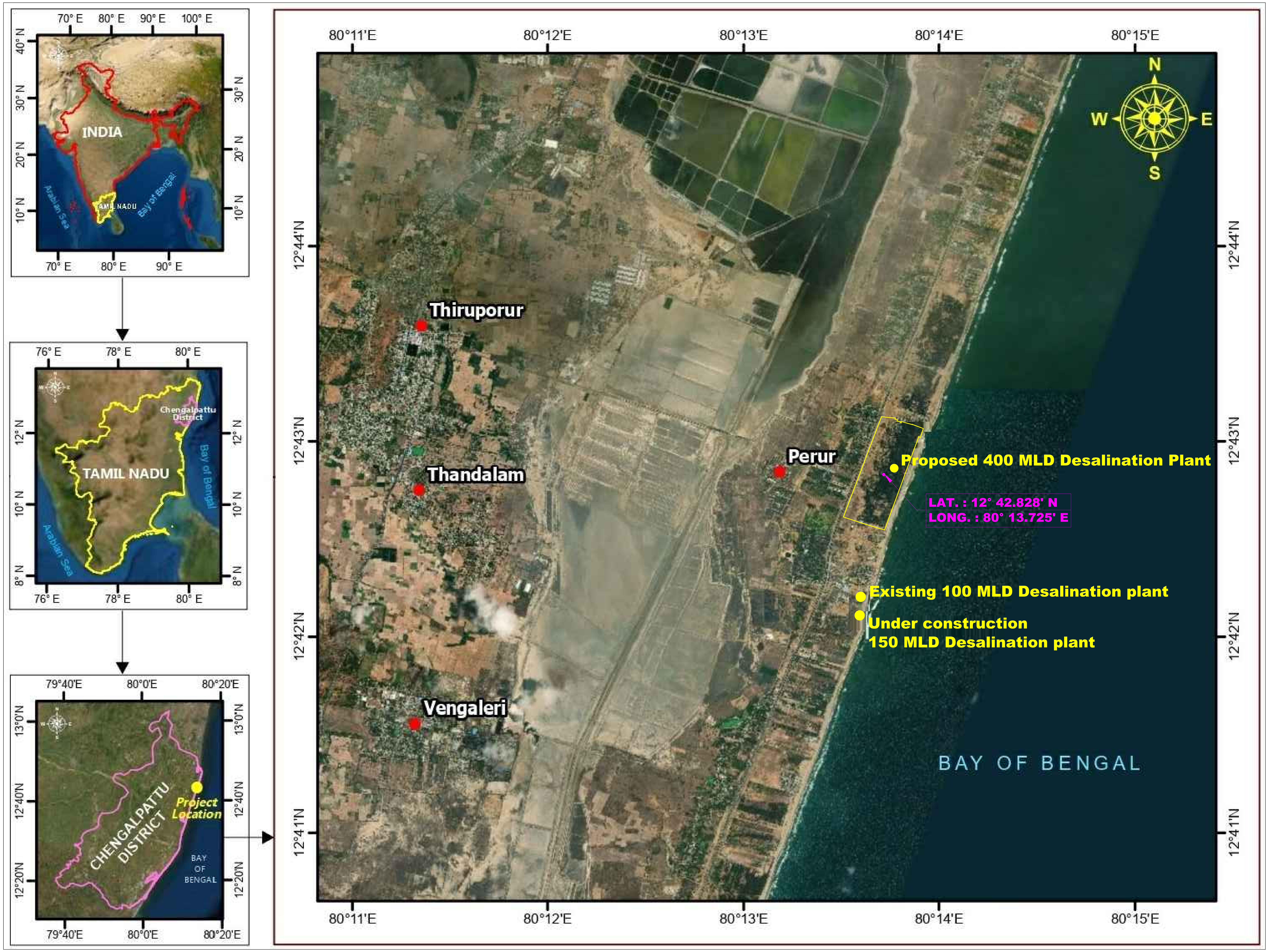


Plate 13 View of Rock Core Samples prepared for conducting Point Load Strength Index Test in Department of Civil Engineering, CEG, Anna University, Chennai - 25



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM		

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title:

LOCATION MAP OF PERUR DESALINATION PLANT

Drawn : NGM	Checked :
Designed :	Approved :
Date : APRIL 2021	Scale : A1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/G/LOC/001	1 OF 1	R0

1.VIEW OF PROJECT SITE FROM
EAST COAST ROAD -1

2.VIEW OF PROJECT SITE FROM
EAST COAST ROAD -2

3.VIEW OF PROJECT SITE FROM
EAST COAST ROAD -3

4.VIEW OF PROJECT SITE

5.BOAT BERTHING AREA ON
NORTHEAST AREA OF PLOT

6.VIEW OF CREMATORIES ON
THE NORTHWEST AREA OF PLOT

7.VIEW OF BURIAL GROUND ON
THE NORTHWEST AREA OF PLOT

8.VIEW OF BURIAL GROUNDS ON
THE SOUTHEAST AREA SIDE OF PLOT

9.SIGN BOARD INDICATING LAND OWNERSHIP DETAILS –
M/S. ARULMIGU ALAVANDAR NAYAKKAR TRUST

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM		

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

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SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
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Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

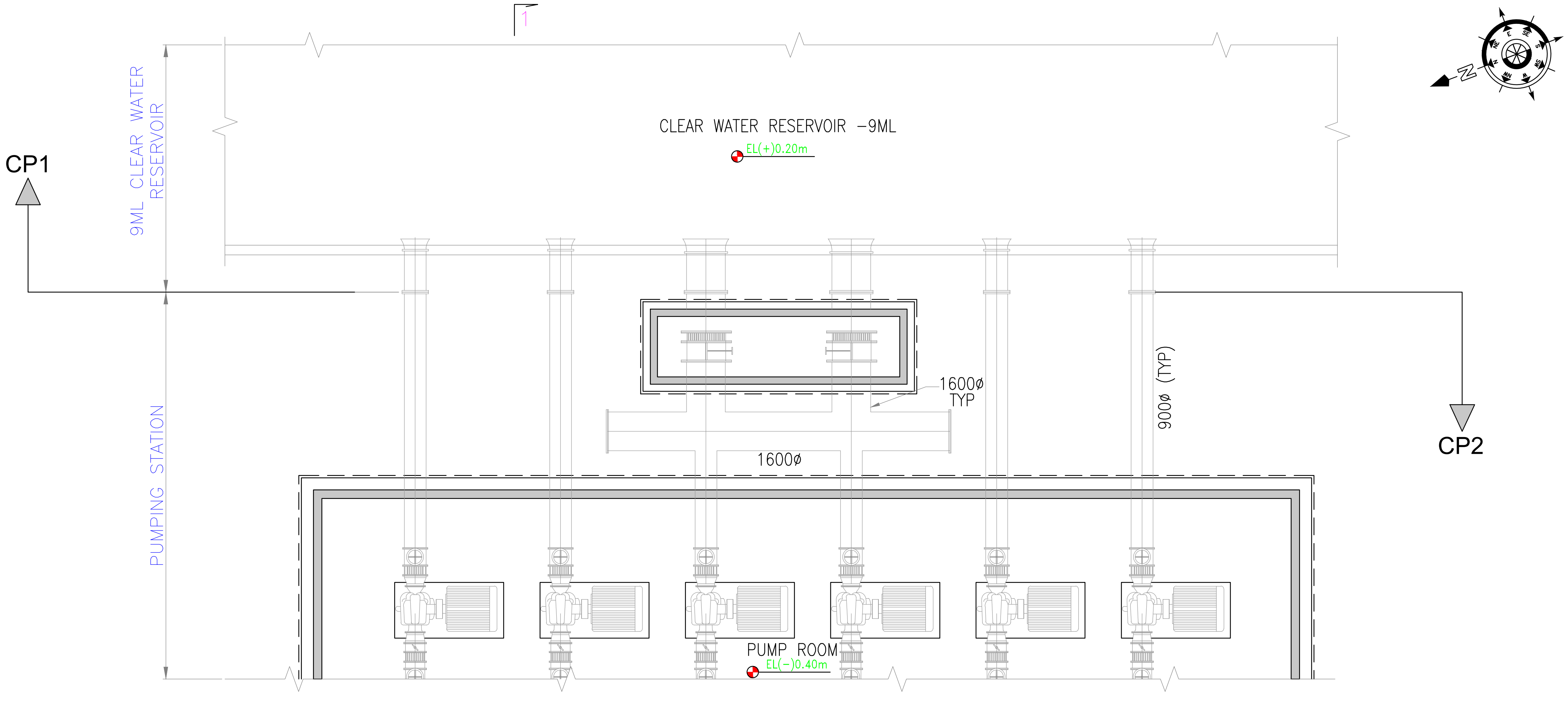
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

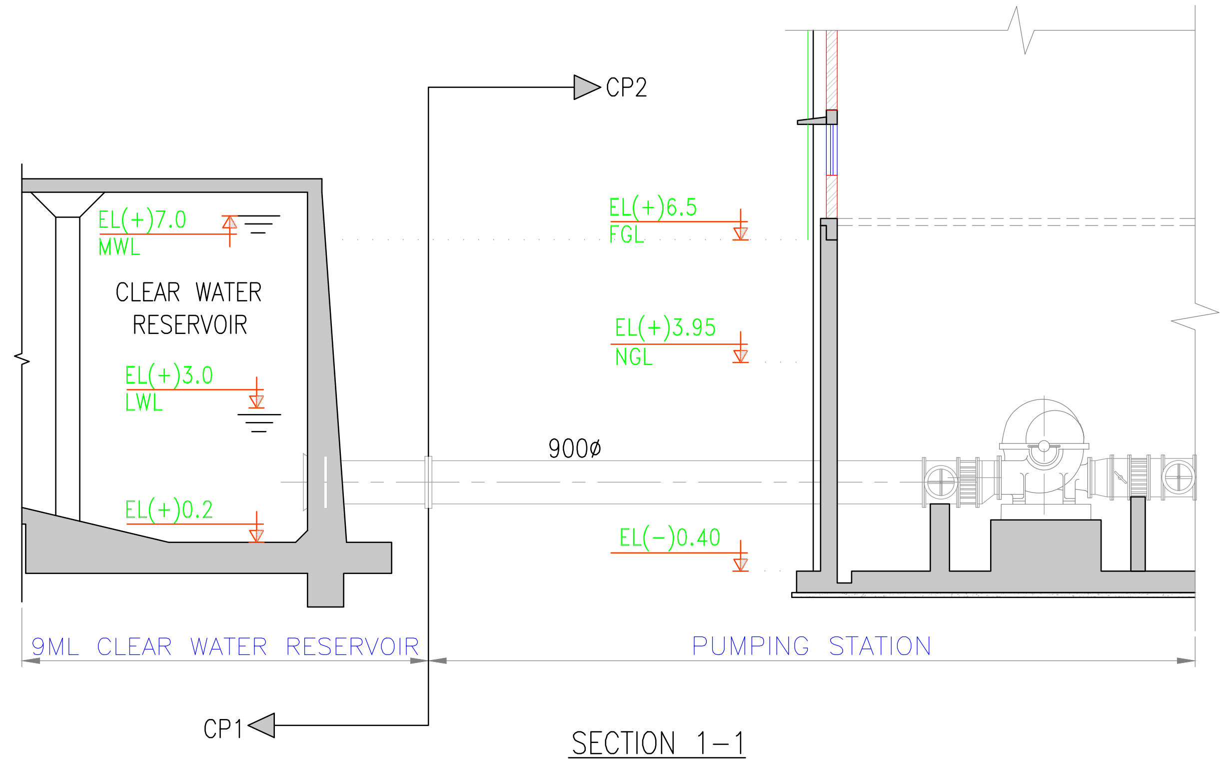
Drawing Title:
SITE PHOTOGRAPHS AT PERUR

Drawn : NGM	Checked :
Designed :	Approved :
Date : APRIL 2021	Scale : A1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/G/PHO/004	1 OF 1	R0



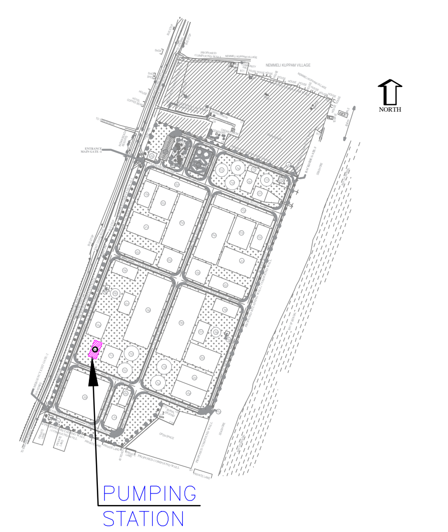
PLAN AT EL(–).0.40m
(SCALE 1:200)



SECTION 1–1
(SCALE 1:150)

NOTES:

1. CP1 SCOPE IS UPTO FIXING 900/1600MM BLANK FLANGES FOR SUCTION PIPES
2. CP2 SCOPE STARTS FROM FIXING 900/1600MM SUCTION PIPE BY REPLACING BLANK FLANGE.
   CP2 SCOPE IS UPTO PROVIDING 1800MM FLANGED PIPE WITH BLANK FLANGE IN TRANSMISSION MAIN UPTO ---M LENGTH



KEY PLAN

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	SSS	PD/SSS

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
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Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

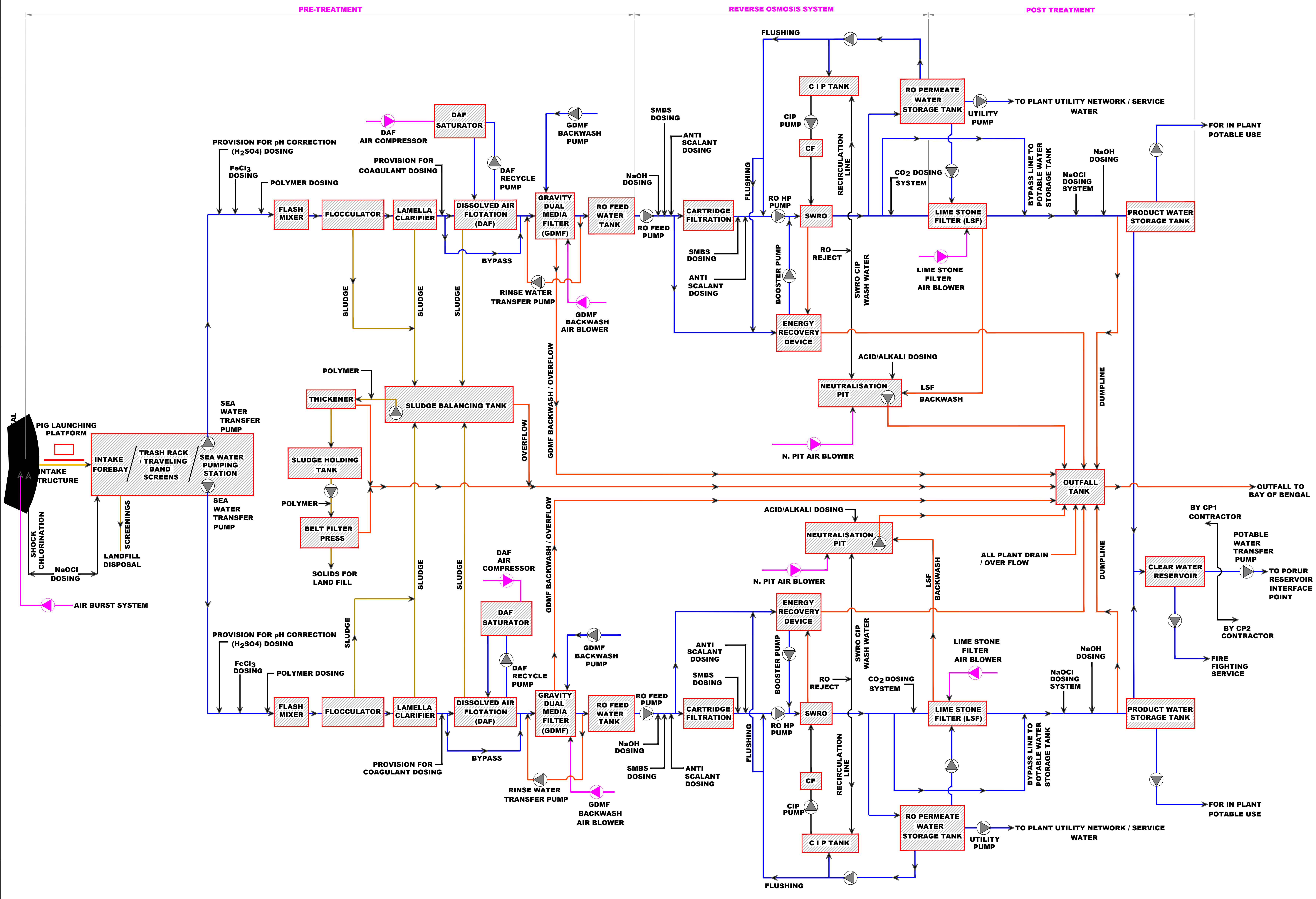
Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title:
INTERFACE DRAWING BETWEEN CP1 & CP2

Drawn : NGM	Checked : SSS		
Designed : SJ / OM / MG	Approved : PD / SSS		
Date : APRIL 2021	Scale : A3 /1:1		
Drawing Number: 7061563/PMC400MLD/CP1/G/INF/006		Sh.No 1 OF 1	Revision: R0



PROCESS FLOW DIAGRAM FOR PROPOSED 400 MLD PERUR DSP

NOTES:

1. TWO (2) STREAMS EACH OF 200 MLD CAPACITY PROPOSED.
2. SEAWATER PUMPING STATION, PRODUCT WATER STORAGE TANK, SLUDGE BALANCING TANK, THICKENER, SLUDGE HOLDING TANK, BELT FILTER PRESS BUILDING ARE COMMON UNITS FOR BOTH STREAMS.
3. RO FEED WATER BACKWASH TANKS (ONE NO.IN EACH STREAM) ARE PROVIDED WITH PARTITION WALLS IN EACH STREAM.

LEGEND:

- INCOMING RAW SEA WATER
- WATER LINE
- REJECT/ BACKWASH/ DRAIN/ BELT FILTER FILTRATE,SUPERNATANT/ RINSE/ DUMPLINE
- AIR FOR BACKWASH/ MIXING
- CHEMICAL DOSING
- SLUDGE / SCREENINGS
- BLOWER / COMPRESSOR
- PUMP
- INTERFACE POINT

SWRO	SEAWATER REVERSE OSMOSIS
CF	CARTRIDGE FILTER
CIP	CLEAN IN PLACE
HP	HIGH PRESSURE
SMBS	SODIUM META BI SULPHATE

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R2	APRIL 2021	TENDER PURPOSE	NGM	GM/MM/GV	PD
R1	24.06.2020	CONCEPTUAL DESIGN REPORT FOR CP1	NGM	GM/MM/GV	PD
R0	17.04.2020	PRELIMINARY DRAFT CONCEPTUAL DESIGN REPORT FOR CP1	VK	GM	PD

Client: Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant : SMEC International Pty Ltd, TATA Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI), SMEC India Pvt Ltd.

Project Name: Project for Construction of Seawater Desalination Plant (I)

Contract Name: Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

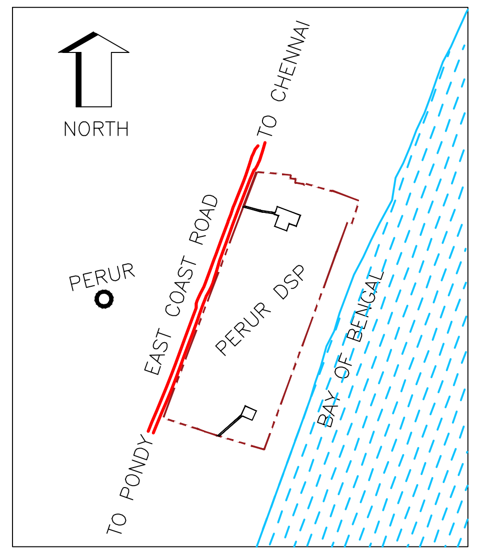
JICA Loan No.: ID-P267

Drawing Title: PROCESS FLOW DIAGRAM FOR PROPOSED 400 MLD PERUR DSP

Drawn :	NGM	Checked :	GM / MM / GV
Designed :	SMK	Approved :	PD
Date :	APRIL 2021	Scale :	NTS

Drawing Number: 7061563/PMC/400MLD/CP1/P/PFD/001 | Sh.No 1 OF 1 | Revision: R2

NORTH



K E Y P L A N

LEGEND :

- SEA WATER
- REJECT PIPE TO SEA
- PROPOSED ROAD
- PROPOSED UNITS
- RETAINING WALL
- COMPOUND WALL
- STORM WATER DRAIN
- CP2 CONTRACTOR'S SCOPE

NOTES :

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. TOTAL AREA OF PROPOSED DESALINATION PLANT LAYOUT = 66.70 Acres (269932.00 SQ.M).
3. TOTAL ALLOTTED AREA (EXCLUDING BURIAL GROUNDS) = 86.69 Acres (3,50,852.00 SQ.M).
4. NORTH SIDE BURIAL GROUND AREA (INCLUDING ROAD) = 1.32 Acres (5361.9 SQ.M).
5. SOUTH SIDE BURIAL GROUND AREA (INCLUDING ROAD) = 0.53 Acres (2163.5 SQ.M).
6. THE BENCHMARK HAS BEEN TAKEN AT CHENNAI,MOUNT ROAD, MUNRO STATUTE PEDESTAL RL:5.398M
7. THE BIDDER NEEDS TO OPTIMIZE THE FOOTPRINT OF THE PLANT TO MINIMIZE THE LAND USAGE AND OBTAIN APPROVAL FROM ENGINEER.

TEMPORARY BENCHMARK:

NO	CO-ORDINATE EAST	CO-ORDINATE NORTH
TS1	416126.939	1405923.993
TS2	416025.996	1405956.785

FOR TENDER PURPOSE ONLY

BOUNDARY DETAILS

B.NO	BOUNDARY CO-ORDINATE EASTING	BOUNDARY CO-ORDINATE NORTHING
B1	416541.576	1405939.606
B2	416239.814	1405118.287
B3	416070.785	1405169.213
B7	415878.897	1405231.554
B14	416061.741	1405709.521
B19	416214.734	1406113.546
B21	416356.857	1406078.315
B22	416581.07	1406009.73
B23	416554.9	1405930.23

400 MLD SEA WATER DESALINATION PLANT AT PERUR
COMPONENT LIST (CP1)

SI NO.	COMPONENT NAME	NO. OF UNITS	MATERIAL OF CONSTRUCTION (MOC)
01	INTAKE PUMPING STATION	1	RCC EPOXY
02	LAMELLA SETTLERS	36	RCC EPOXY
03	DAF-DISSOLVED AIR FLOTATION UNITS	12	RCC EPOXY
04	GDMF-GRAVITY DUAL MEDIA FILTER	80	RCC EPOXY
05	RO FEED TANK	2	RCC EPOXY
06	RO BUILDING	2	PEB SHED
07	LIME STONE FILTER	28	RCC EPOXY
08	RO PERMEATE TANK	2	METALLIC TANK/ RCC EPOXY
09	CO2 STORAGE AREA	2	–
10	PRODUCT WATER TANKS (7.5ML EACH)	4	METALLIC TANK/ RCC EPOXY
11	CLEAR WATER RESERVOIR (9ML)	1	RCC EPOXY
13	SLUDGE BALANCING TANK	1	RCC EPOXY
14	THICKENED SLUDGE THICKENERS	2	RCC EPOXY
15	SLUDGE HOLDING TANK	1	RCC EPOXY
16	BELT FILTER PRESS BUILDING	1	RCC
17	OUTFALL TANK	1	RCC EPOXY
18	CHEMICAL BUILDING-RO	2	RCC WITH CHEMICAL RESISTANT LINING
19	CHEMICAL BUILDING PRE-TREATMENT	2	RCC WITH CHEMICAL RESISTANT LINING
20	POWER RECEIVING STATION/CONTROL BUILDING	1	RCC
21	ELECTRICAL BUILDING FOR INTAKE PUMP STATION & PRE-TREATMENT	2	RCC
22	ELECTRICAL BUILDING FOR RO BUILDING	2	RCC
23	WAREHOUSE	1	PEB SHED
24	WORKSHOP	1	PEB SHED
25	PACKAGE STP	1	–
26	FIRE FIGHTING STATION	1	RCC
27	ADMINISTRATION BUILDING (OFFICER'S ROOM/ CONFERENCE/CANTEEN)(G+2 FLOORS)	1	RCC
27a	ADMINISTRATION BUILDING (LABORATORY CUM MEETING/ TRAINING ROOM)(G+1 FLOORS)	1	RCC
28	PARKING AREA	1	PEB SHED
29	SECURITY ROOM	1	RCC
29a	ADDITIONAL SECURITY ROOM	1	RCC
30	LAY DOWN AREA	1	–
31	LAY DOWN AREA	1	–
32	LANDSCAPE & PARK AREA	1	–
33	WATCH TOWERS	2	–

POTABLE WATER PUMPING STATION AT PERUR
COMPONENT LIST (CP2-1)

12	POTABLE WATER TRANSFER PUMPING STATION	1	RCC
12a	SPACE FOR SURGE VESSELS	1	–

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	GM	PD

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title:

PLANT LAYOUT FOR 400 MLD PERUR DSP

Drawn :	NGM	Checked :	GM
Designed :	SMK ,ELAN,GG,GV.	Approved :	PD
Date :	APRIL 2021	Scale :	1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/P/LAY/002	1 OF 1	R0

NOTE:

1. All Dimensions Are In Meter
2. Survey Work Carried Out During September 2020 & December 2020
3. Total Trees 10801 Nos
4. Drawing Is Based On WGS84 And UTM44 Projection.
5. The Benchmark has been taken at Chennai, Mount Road,Munro Statute Pedestal RL:5.398m
6. The Contours are Drawn at an interval of 0.20m

ALLOTTED AREA BOUNDARY DETAILS

B.NO	BOUNDARY CO-ORDINATE	
	EAST	NORTH
B1	416541.576	1405939.606
B2	416239.814	1405118.287
B3	416070.785	1405169.213
B4	416027.095	1405183.206
B5	416000.492	1405192.689
B6	415895.831	1405226.141
B7	415878.897	1405231.554
B8	415885.064	1405246.286
B9	415903.892	1405289.759
B10	415937.553	1405373.505
B11	415966.450	1405451.569
B12	415996.135	1405532.050
B13	416033.732	1405633.822
B14	416061.741	1405709.521
B15	416092.671	1405793.041
B16	416119.511	1405865.617
B17	416142.397	1405927.222
B18	416171.293	1406004.998
B19	416214.734	1406113.546
B20	416360.513	1406100.000
B21	416356.857	1406078.315

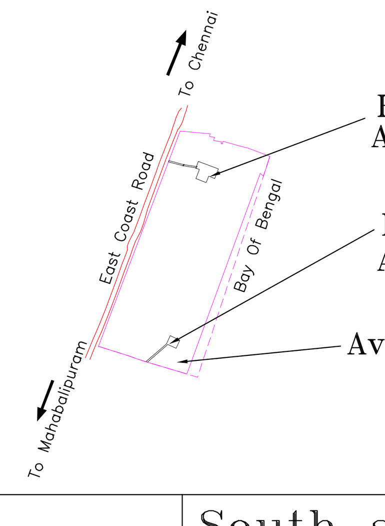
FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R1	DEC-2020	TENDER PURPOSE	B.RAJESH	G.N.KUMARAN	
R0	SEP-2020		B.RAJESH	G.N.KUMARAN	

LEGEND

SITE BOUNDARY		NAME BOARD		ROAD LEVELS	5.575
ROAD BT		TREES		GROUND LEVELS	2.97
CEMENT ROAD		TRAFFIC SIGN BOARD		BENCHMARK	
FENCE		TRAFFIC SIGNAL POLE		TEMPLE	
TREES BOUNDARY		ELECTRICAL LINE		ENCROACHMENT	
CCTV CAMERA		GATE		VODAFONE MANHOLE	
BORE WELL		SURVEY STONE		LAMP POST	
ELECTRICAL POST					
ELECTRICAL TRANSFORMER					
HECTOMETRE STONE					
KILOMETRE STONE					
HAND PUMP					

Surveyed Area Details: North Side



Burial Ground-1 Area:1.32 Acres

Burial Ground-2 Area:0.53 Acre

Available Land =86.69 Acres

North side Burial Ground Co-Ordinate						South side Burial Ground Co-Ordinate		
P.Id	Easting	Northing	P.Id	Easting	Northing	P.Id	Easting	Northing
C1	416369.681	1405957.891	C5	416277.378	1405918.883	C9	416211.861	1405256.896
C2	416354.627	1405918.681	C6	416291.787	1405956.197	C10	416196.478	1405223.245
C3	416329.887	1405928.179	C7	416276.861	1405961.961	C11	416156.916	1405241.331
C4	416319.855	1405902.574	C8	416287.580	1405989.445	C12	416172.299	1405274.981

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

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Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Project Survey Consultant :

PRIME MERIDIAN SURVEYS PVT. LTD (PMSPL), INDIA.
29,First Floor, Dharamaraja Kovil Street,
SAIDAPET, CHENNAI-600 015.
PH No : 044 -24353669/24343663,
Mobile: -94440 20824

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

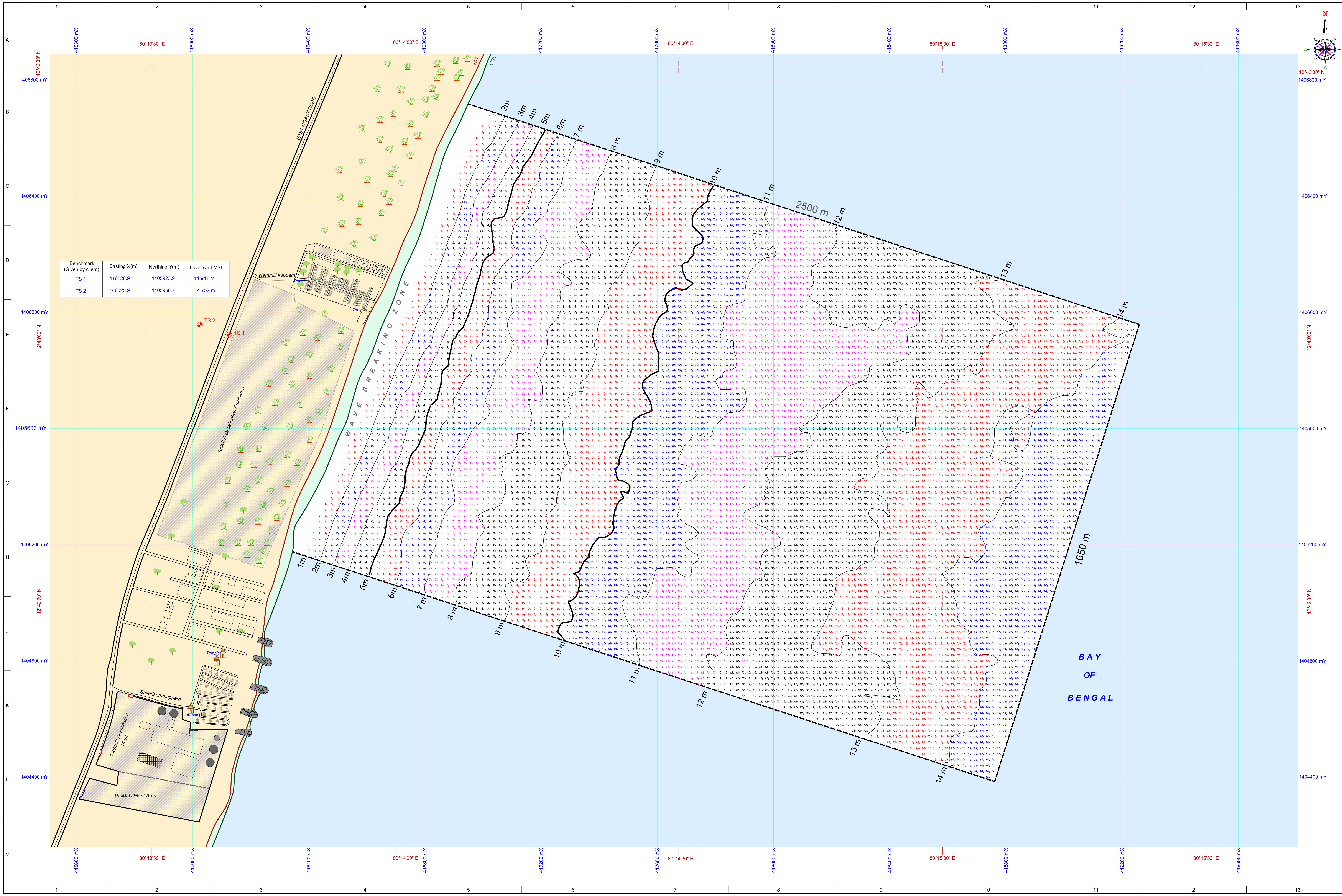
JICA Loan No.: ID-P267

Drawing Title:

TOPO SURVEY - SPOT LEVELS & CONTOURS

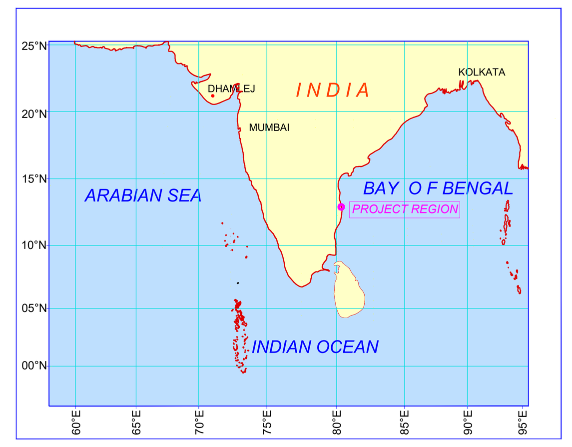
Drawn :	B.RAJESH	Checked :	G.N.KUMARAN
SURVEYED :	SARAVANAN	Approved :	
Date :	DECEMBER-2020	Scale :	A1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/TOP/002	1 OF 1	R1



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

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

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				
	LATITUDE	LONGITUDE	MHWS METRE	MHWN METRE	MLWN METRE	MLWS METRE	MSL (m)
CHENNAI	12° 52' N	80°41' E	1.15	0.84	0.43	0.14	0.65

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	VJ/SV	PC	PD

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title:

BATHYMETRY MAP - PERUR

Drawn : J.VINOTHKUMAR / S.VIJAY	Checked : DR. P. CHANDRAMOHAN
Designed : J.VINOTHKUMAR/M.SHARATH /S.VIJAY	Approved : PD
Date : APRIL 2021	Scale :

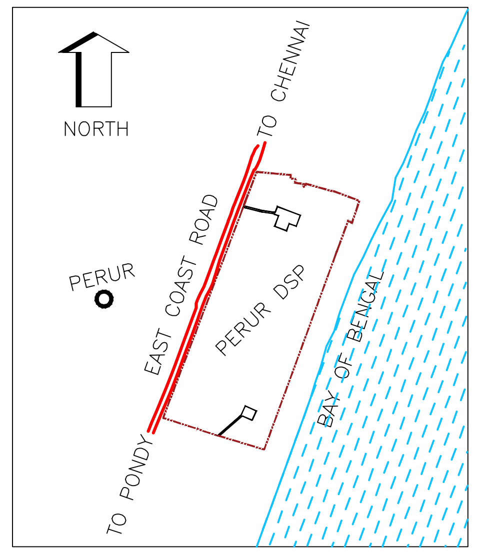
Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/BAT/003	1 OF 1	R0

NORTH SIDE BURIAL GROUND CO-ORDINATES		
P.ID	EASTING	NORTHING
C1	416369.681	1405957.891
C2	416354.627	1405918.681
C3	416329.887	1405928.179
C4	416319.855	1405902.574
C5	416277.378	1405918.883
C6	416291.787	1405956.197
C7	416276.861	1405961.961
C8	416287.580	1405989.445

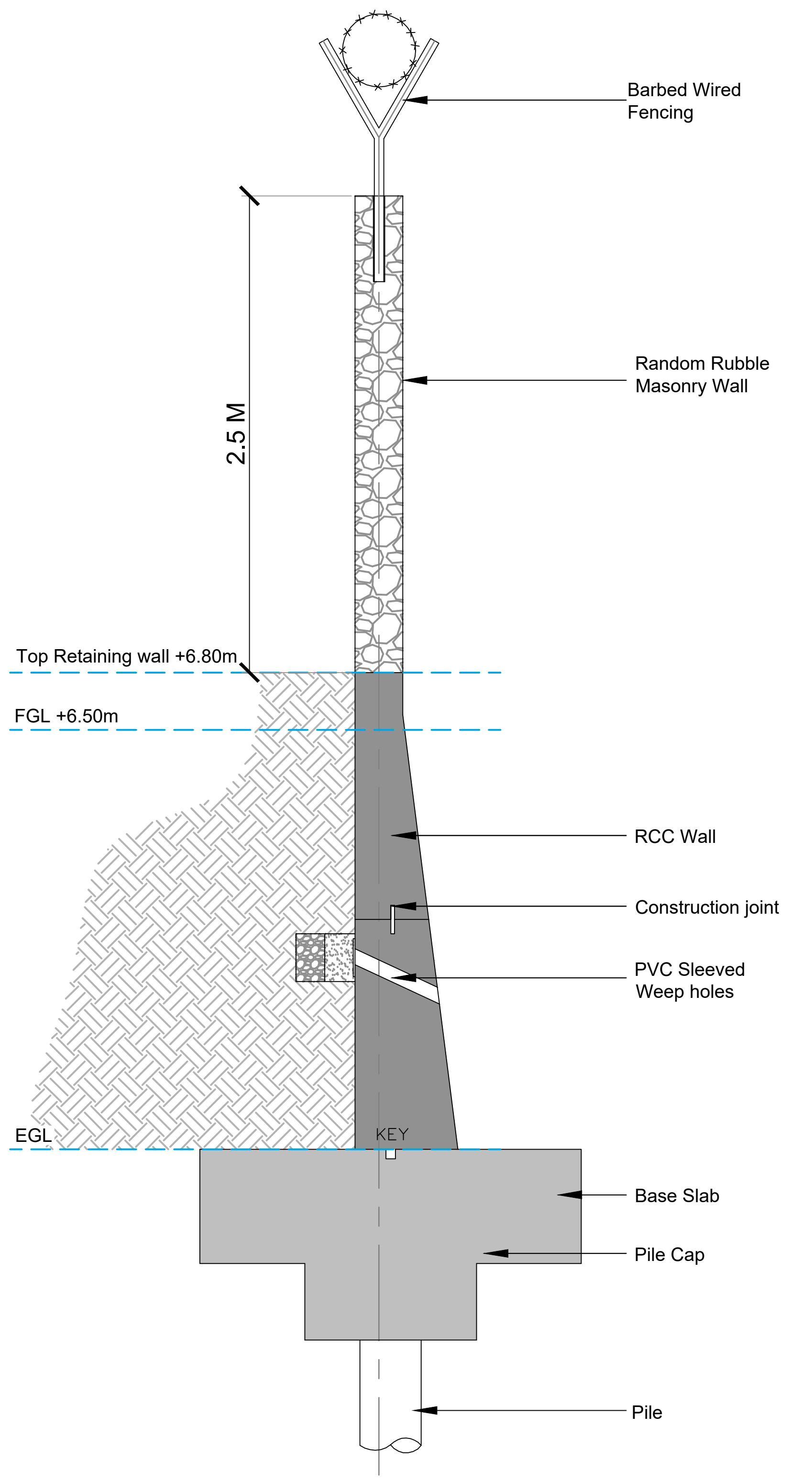
SOUTH SIDE BURIAL GROUND CO-ORDINATES		
P.ID	EASTING	NORTHING
C9	416211.861	1405256.896
C10	416196.478	1405223.245
C11	416156.916	1405241.331
C12	416172.299	1405274.981

BOUNDARY DETAILS

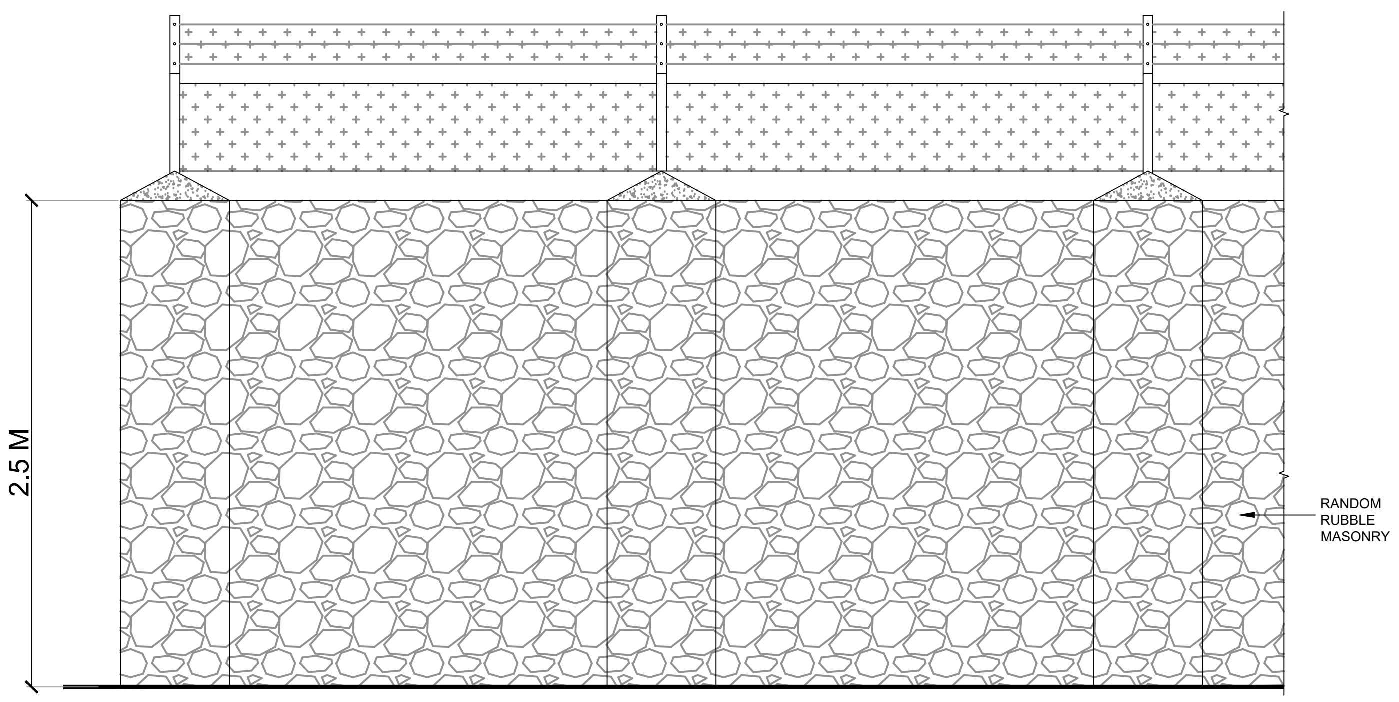
B.NO	BOUNDARY CO-ORDINATE	
	EASTING	NORTHING
B1	416541.576	1405939.606
B3	416070.785	1405169.213
B7	415878.897	1405231.554
B14	416061.741	1405709.521
B19	416214.734	1406113.546
B21	416356.857	1406078.315



KEY PLAN



TYPICAL CROSS SECTION OF RETAINING WALL WITH COMPOUND WALL



TYPICAL COMPOUND WALL ELEVATION

NOTES :

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. TOTAL ALLOTTED AREA (EXCLUDING BURIAL GROUNDS) = 86.69 Acres (3,50,852.00 SQ.M).
3. NORTH SIDE BURIAL GROUND AREA (INCLUDING ROAD) = 1.32 Acres (5361.9 SQ.M).
4. SOUTH SIDE BURIAL GROUND AREA (INCLUDING ROAD) = 0.53 Acres (2163.5 SQ.M).
5. THE BENCHMARK HAS BEEN TAKEN AT CHENNAI,MOUNT ROAD, MUNRO STATUTE PEDESTAL RL:5.398M

LEGEND :

- RETAINING WALL
- COMPOUND WALL
- AREA RESERVED FOR CONSTRUCTION

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	SSS	PD

Client: Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant : SMEC International Pty Ltd, TATA Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI), SMEC India Pvt Ltd.

Project Name: Project for Construction of Seawater Desalination Plant (I)

Contract Name: Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title: RETAINING WALL / COMPOUND WALL LAYOUT FOR 400 MLD PERUR DSP

Drawn :	JN	Checked :	SSS
Designed :	SJ	Approved :	PD
Date :	APRIL 2021	Scale :	1:1

Drawing Number: 7061563/PMC400MLD/CP1/C/RET/005 Sh.No 1 OF 1 Revision: R0

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	GM	PD

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

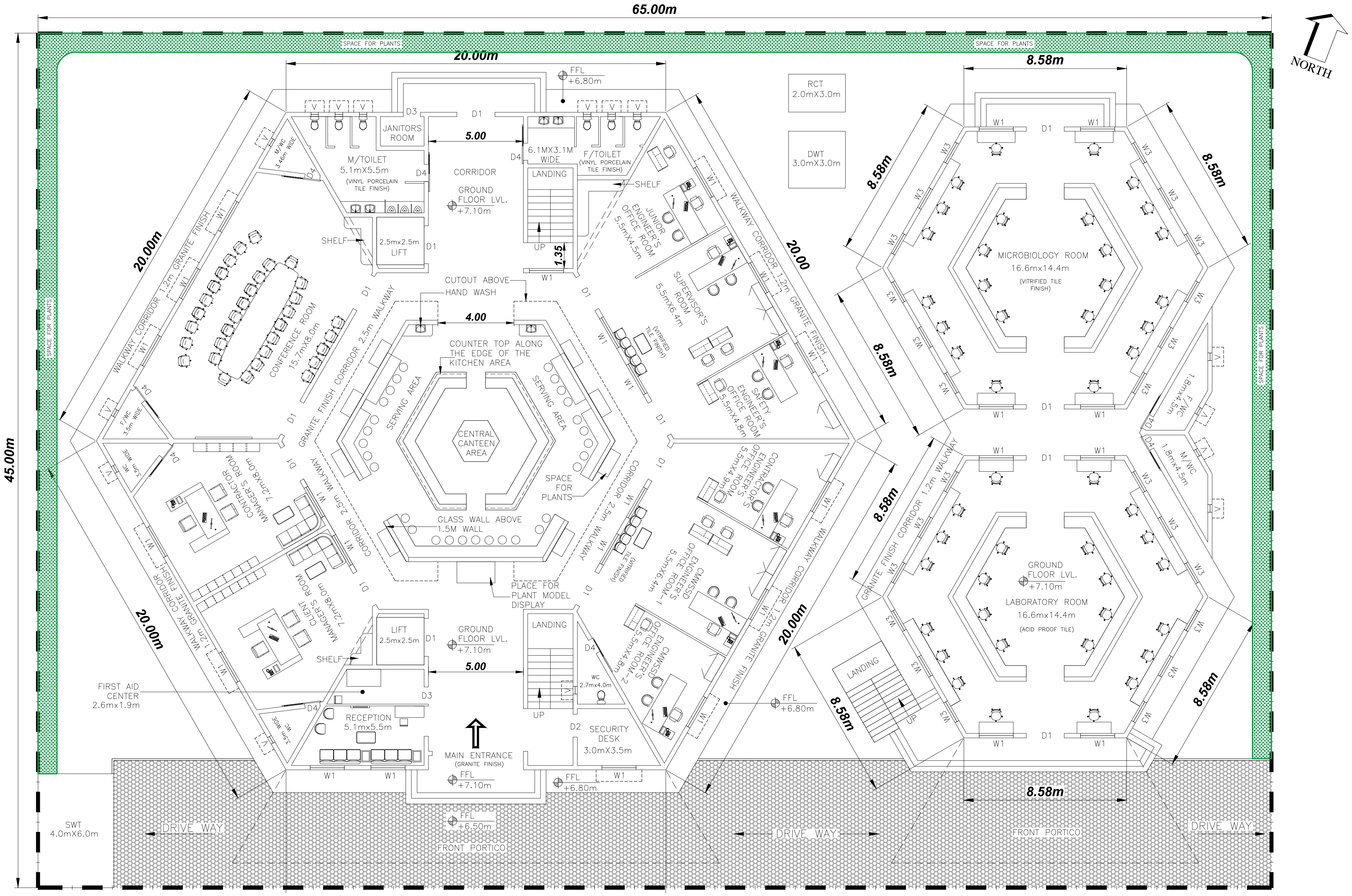
JICA Loan No.: ID-P267

Drawing Title:

ARCHITECTURAL VIEW OF GATEWAY TO
400 MLD PERUR DSP

Drawn :	NGM	Checked :	GM
Designed :	RS	Approved :	PD
Date :	APRIL 2021	Scale :	A2 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ARC/007	1 OF 1	R0



PROPOSED GROUND FLOOR ADMINISTRATION BUILDING
(OFFICER'S ROOM/CONFERENCE/CANTEEN)-(1200Sq,M)

PROPOSED GROUND FLOOR
MICROBIOLOGY & LABORATORY BUILDING-(564Sq,M)

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2925SqM) FOR ADMIN & MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)6.5m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

LEGEND:

1. D1-2.0mx2.0m
2. D2-1.2mx2.0m
3. D3-0.9mx2.0m
4. D4-0.8mx1.8m
5. W1-1.8mx1.2m
6. W2-2.5mx2.5m
7. W3-1.2mx1.2m
8. V -0.4mx0.5m
9. RCT-RAIN WATER COLLECTION TANK
10. SWT-SEWAGE WATER TANK
11. DWT-DRINKING WATER TANK

FLOOR FINISH

1.VITRIFIED TILE,CERAMIC
2.GRANITE
3.VINYL PORCELAIN TILE FINISH

LEGEND:

SMALL PLANT

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	PD	GM

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project Management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

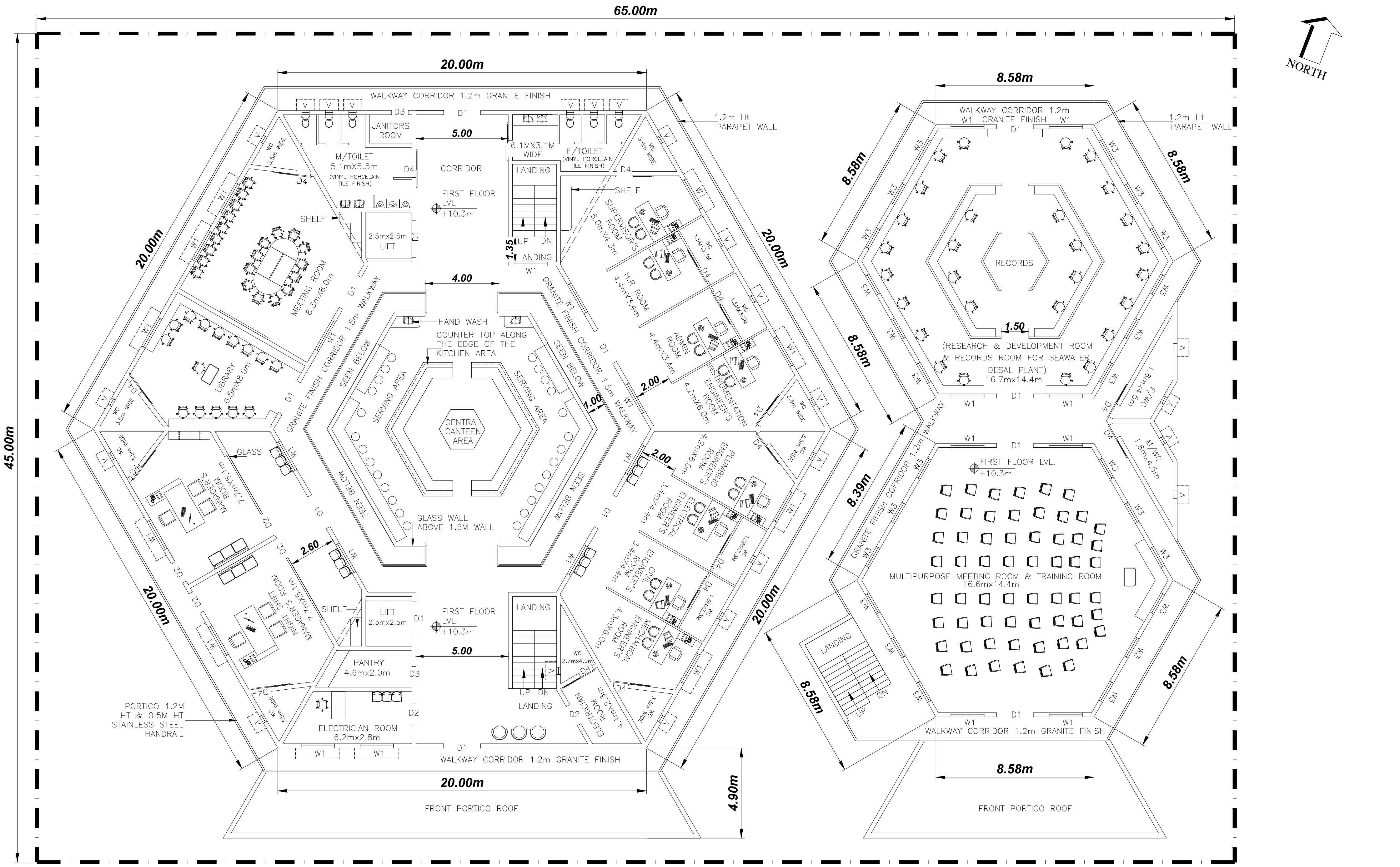
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn : NGM		Checked : PD	
Designed : Dr.ELAN		Approved : GM	
Date : APRIL 2021		Scale : A4 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ABD/001	1 OF 10	R0



PROPOSED FIRST FLOOR ADMINISTRATION BUILDING
(ENGINEERS/SUPPORTING STAFFS/MEETING/PLANT MANAGERS ROOM)-(1200 Sq,M)

PROPOSED FIRST FLOOR R&D RECORDS ROOM,
& MULTIPURPOSE MEETING ROOM -(564Sq,M)

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2925SqM) FOR ADMIN & MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)7.0m ALL LEVEL'S TO BE CONFIRMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

LEGEND:

1. D1-2.0mx2.0m
2. D2-1.2mx2.0m
3. D3-0.9mx2.0m
4. D4-0.8mx1.8m
5. W1-1.8mx1.2m
6. W2-2.5mx2.5m
7. W3-1.2mx1.2m
8. V -0.4mx0.5m

FLOOR FINISH

1.VITRIFIED TILE,CERAMIC,ACID PROOF
2.GRANITE
3.VINYL PORCELAIN TILE FINISH

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	PD	GM

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project Management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

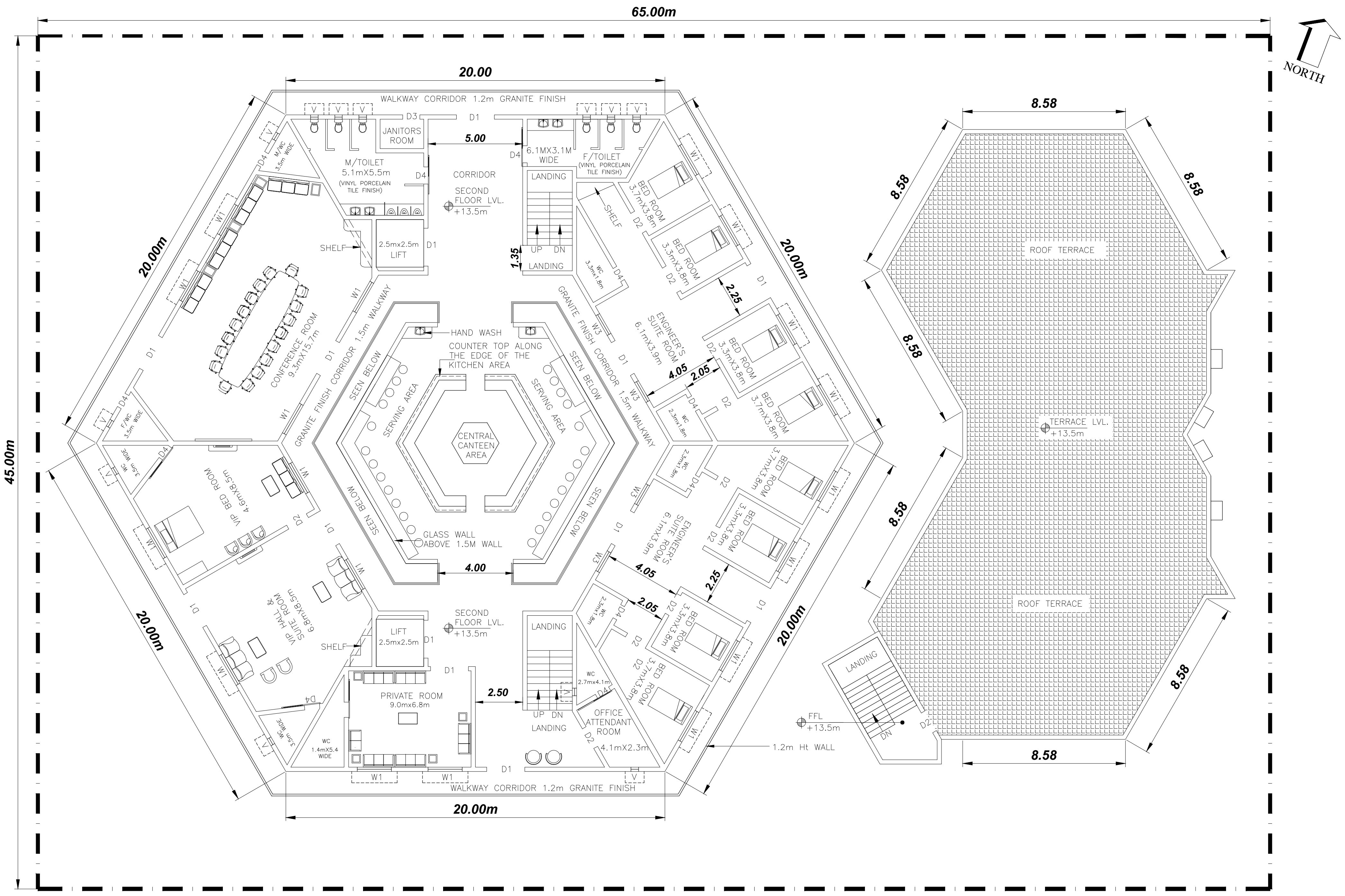
Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn : NGM		Checked : PD	
Designed : Dr.ELAN		Approved : GM	
Date : APRIL 2021		Scale : A4 /1:1	
Drawing Number: 7061563/PMC400MLD/CP1/C/ABD/001		Sh.No 2 OF 10	Revision: R0



PROPOSED SECOND FLOOR ADMINISTRATION BUILDING
(GUEST HOUSE-VIP,PLANT HEAD O&M,
MANAGER'S OFFICE ROOM-(1200Sq,M)

PROPOSED ROOF TERRACE FOR R&D,TRAINING ROOM
& MULTIPURPOSE MEETING ROOM -(477Sq,M)

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2925SqM) FOR ADMIN & MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)7.0m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

LEGEND:

1. D1-2.0mx2.0m
2. D2-1.2mx2.0m
3. D3-0.9mx2.0m
4. D4-0.8mx1.8m
5. W1-1.8mx1.2m
6. W2-2.5mx2.5m
7. W3-1.2mx1.2m
8. V -0.4mx0.5m

FLOOR FINISH

1.VITRIFIED TILE,CERAMIC
2.GRANITE
3.VINYL PORCELAIN TILE FINISH

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	PD	GM

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project Management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

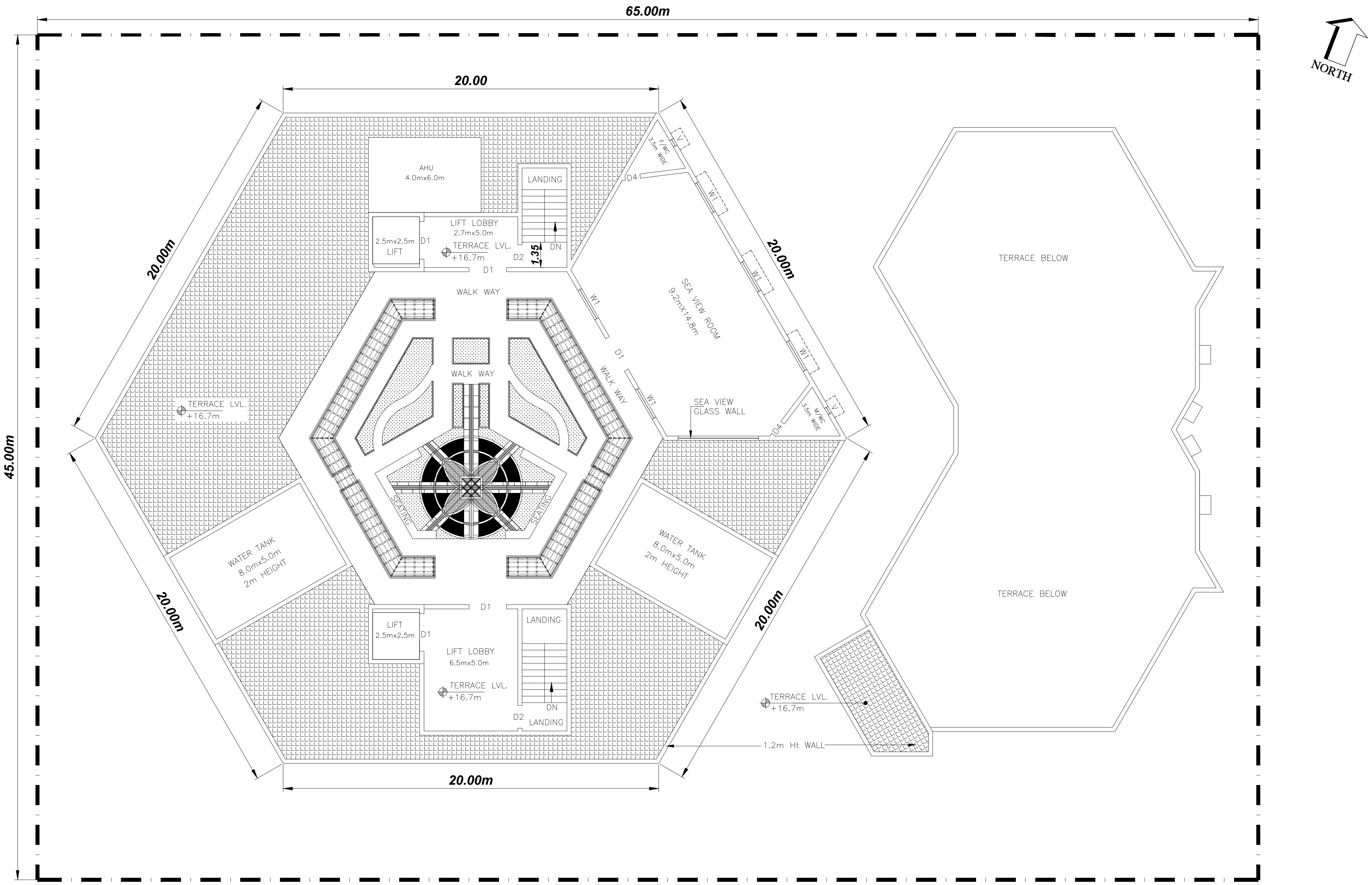
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn : NGM		Checked : PD	
Designed : Dr.ELAN		Approved : GM	
Date : APRIL 2021		Scale : A4 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ABD/001	3 OF 10	R0



PROPOSED ADMINISTRATION BUILDING–ROOF TERRACE &
SEA VIEW ROOM

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2925SqM) FOR ADMIN & CONTROL ROOM IS 60mX40m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)7.0m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

LEGEND:

1. D1–2.0mx2.0m
2. D2–1.2mx2.0m
3. D3–0.9mx2.0m
4. D4–0.8mx1.8m
5. W1–1.8mx1.2m
6. W2–2.5mx2.5m
7. W3–1.2mx1.2m
8. V –0.4mx0.5m

FLOOR FINISH

1.VITRIFIED TILE
2.GRANITE
3.VINYL PORCELAIN TILE FINISH

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	PD	GM

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project Management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

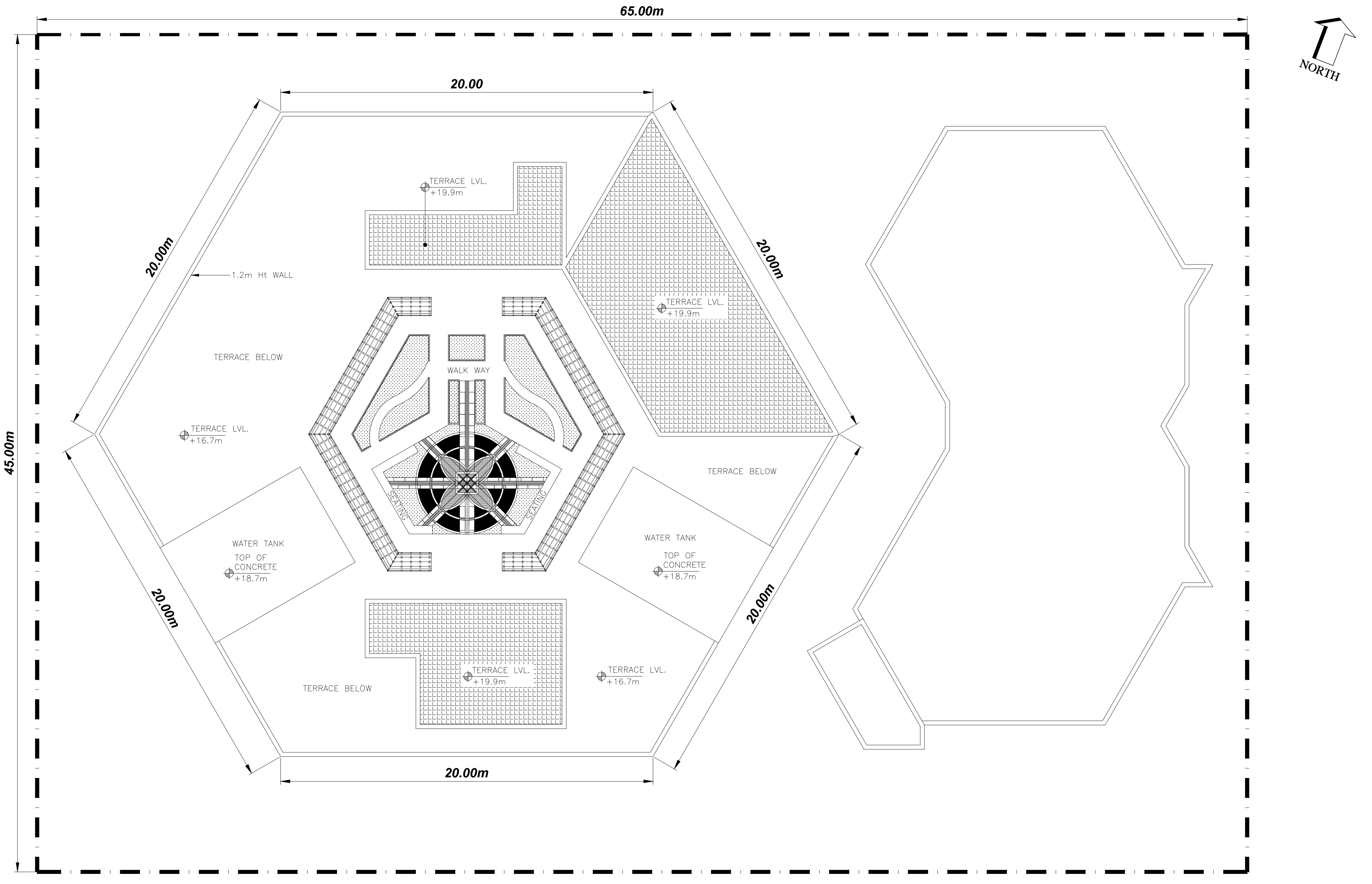
ID-P267

Drawing Title:

PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn :	NGM	Checked :	PD
Designed :	Dr.ELAN	Approved :	GM
Date :	APRIL 2021	Scale :	A4 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ABD/001	4 OF 10	R0



PROPOSED ADMINISTRATION BUILDING—ROOF PLAN

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2925SqM) FOR ADMIN & CONTROL ROOM IS 60mX40m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)7.0m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

LEGEND:

1. D1–2.0mx2.0m
2. D2–1.2mx2.0m
3. D3–0.9mx2.0m
4. D4–0.8mx1.8m
5. W1–1.8mx1.2m
6. W2–2.5mx2.5m
7. W3–1.2mx1.2m
8. V –0.4mx0.5m

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	PD	GM

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project Management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

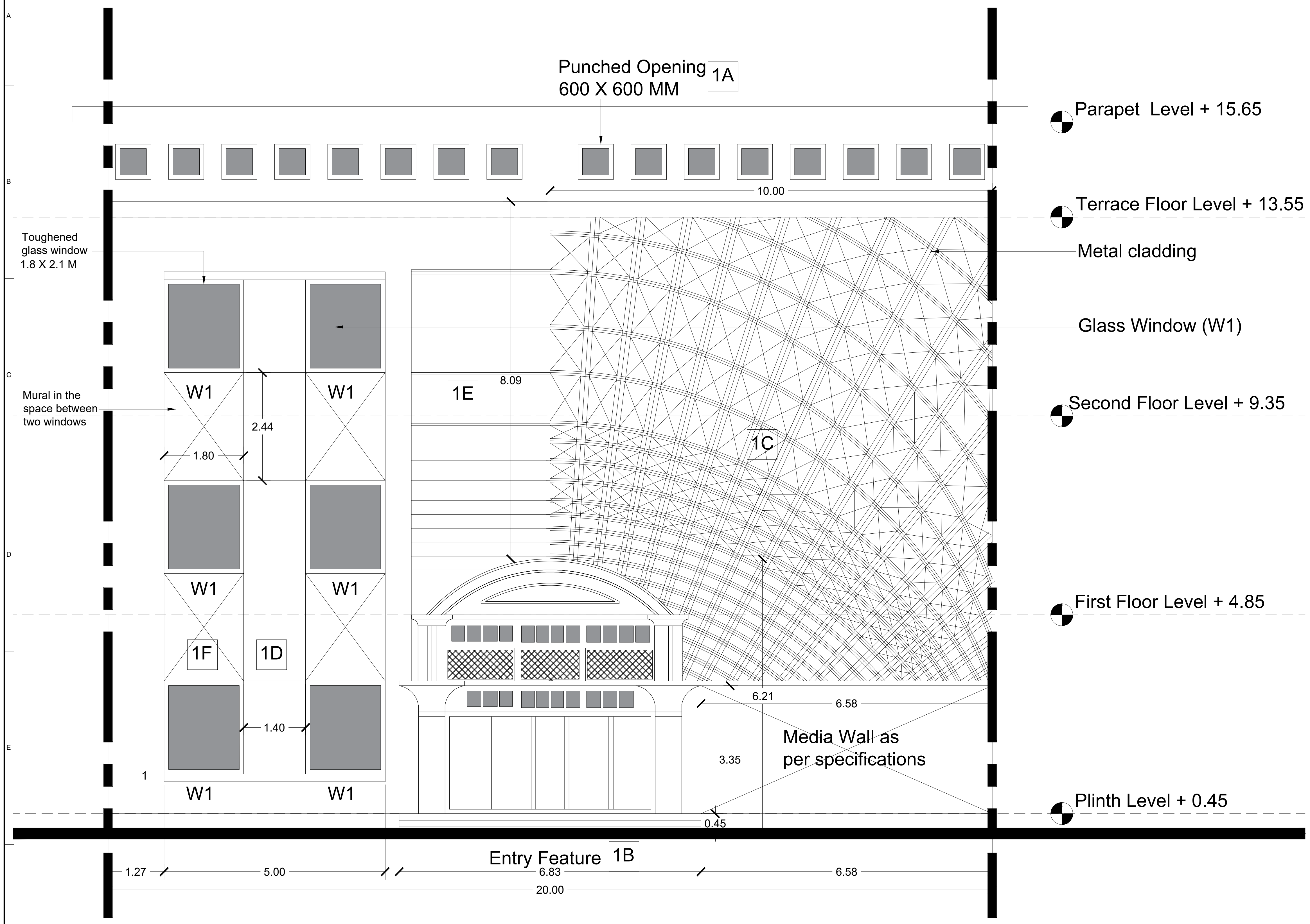
Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn : NGM		Checked : PD	
Designed : Dr.ELAN		Approved : GM	
Date : APRIL 2021		Scale : A4 /1:1	
Drawing Number: 7061563/PMC400MLD/CP1/C/ABD/001		Sh.No 5 OF 10	Revision: R0



FRONT (TRUE) ELEVATION @ 1

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2400SqM) FOR ADMIN & MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)6.5m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

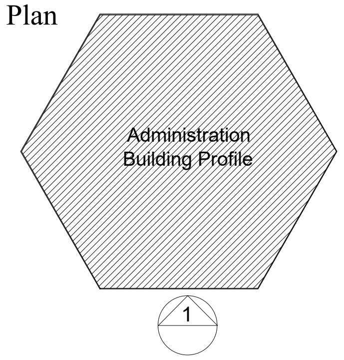
LEGEND:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED ELEVATION IS 15.65 M HIGH MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)6.5m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.
6. ALL FINISHES TO BE CONFIRMED BY CMWSSB.

SCHEDULE OF FINISHES:

1A. PUNCHED OPENING IN PARAPET WALL
1B. Prefabricated, ENTRANCE PORTICO
1C. Meshwork Cladding on the facade
1D. EXTERIOR PAINT
1E. ARCHITECTURAL FEATURE

Key Plan



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	PD	GM

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

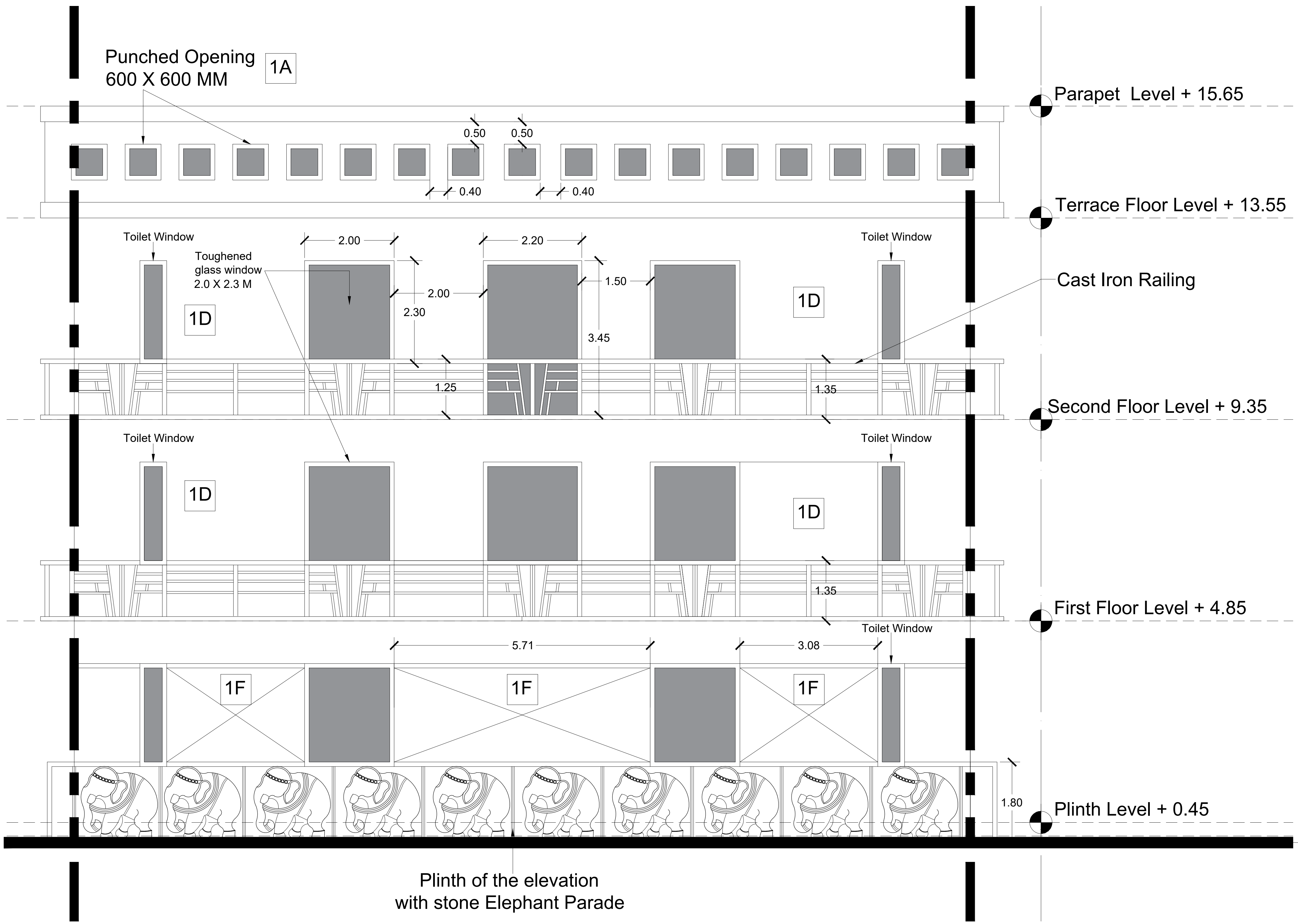
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn : JN		Checked : PD	
Designed : KAS		Approved : GM	
Date : APRIL 2021		Scale : A4 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ABD/001	6 OF 10	R0



LHS (TRUE) ELEVATION @ 2/3

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2400SqM) FOR ADMIN & MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)6.5m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

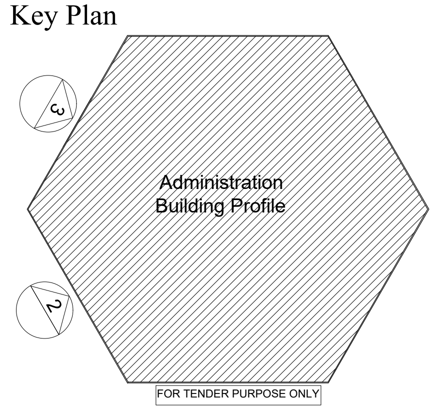
LEGEND:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED ELEVATION IS 15.65 M HIGH MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)6.5m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.
6. ALL FINISHES TO BE CONFIRMED BY CMWSSB.

SCHEDULE OF FINISHES:

1A. PUNCHED OPENING IN PARAPET WALL
1B. Prefabricated, ENTRANCE PORTICO
1C. Meshwork Cladding on the facade
1D. EXTERIOR PAINT
1E. ARCHITECTURAL FEATURE

Key Plan



Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	PD	GM

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

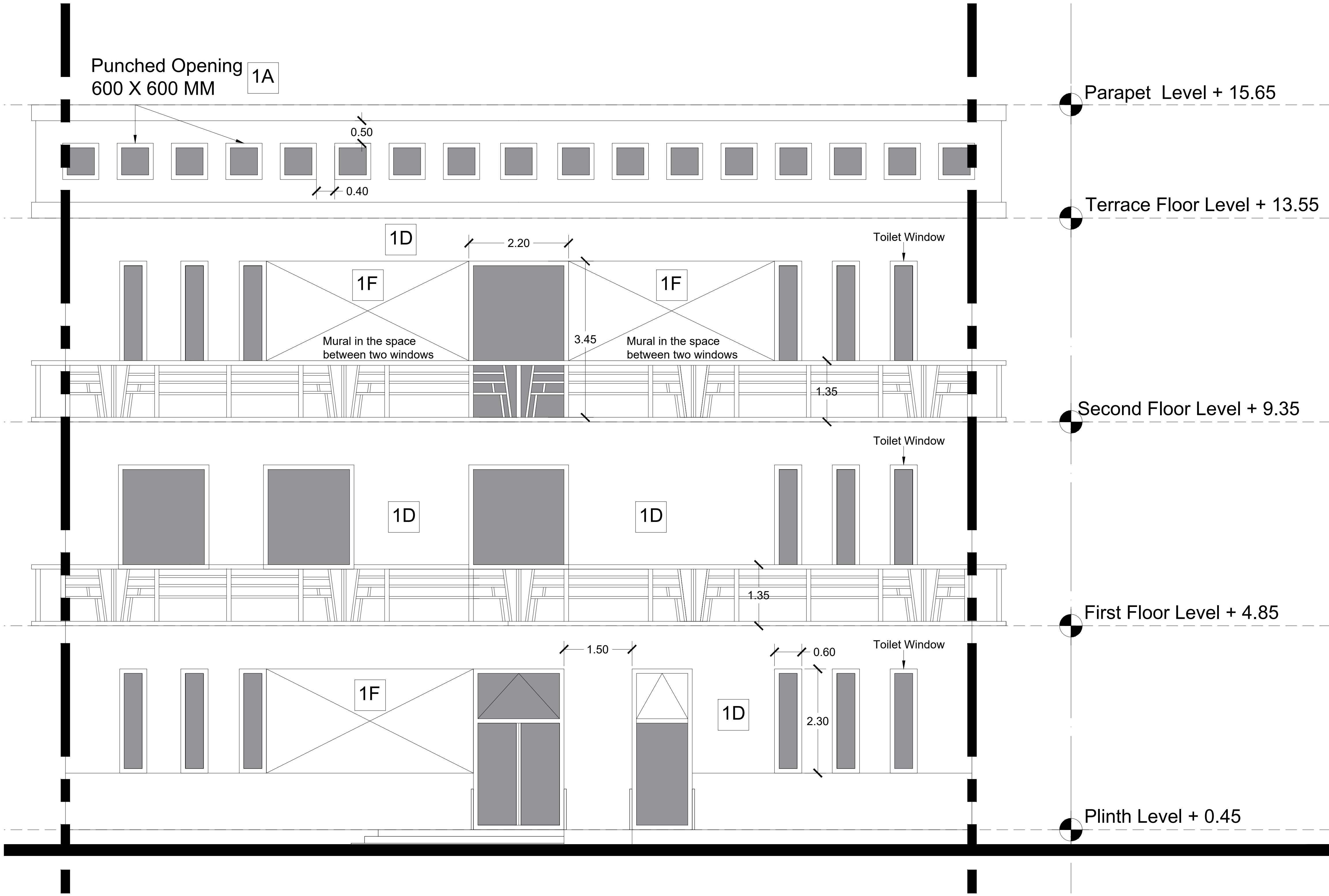
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn	:	JN	Checked	:	PD
Designed	:	KAS	Approved	:	GM
Date	:	APRIL 2021	Scale	:	A4 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ABD/001	7 OF 10	R0



REAR ELEVATION @ 4

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2400SqM) FOR ADMIN & MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)6.5m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

LEGEND:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED ELEVATION IS 15.65 M HIGH MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
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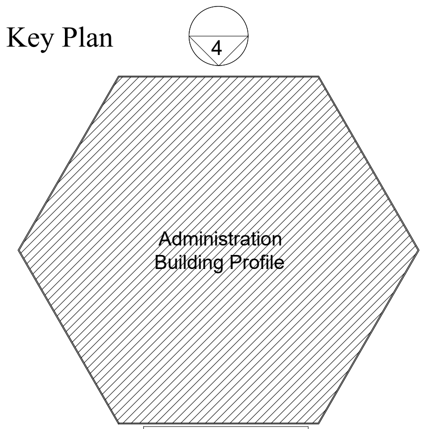
5. ALL FFL TO BE CONFIRMED BY CMWSSB.
6. ALL FINISHES TO BE CONFIRMED BY CMWSSB.

SCHEDULE OF FINISHES:

1A. PUNCHED OPENING IN PARAPET WALL
1B. Prefabricated, ENTRANCE PORTICO
1C. Meshwork Cladding on the facade
1D. EXTERIOR PAINT
1E. ARCHITECTURAL FEATURE

Key Plan



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	PD	GM

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
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Contract Name:
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Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

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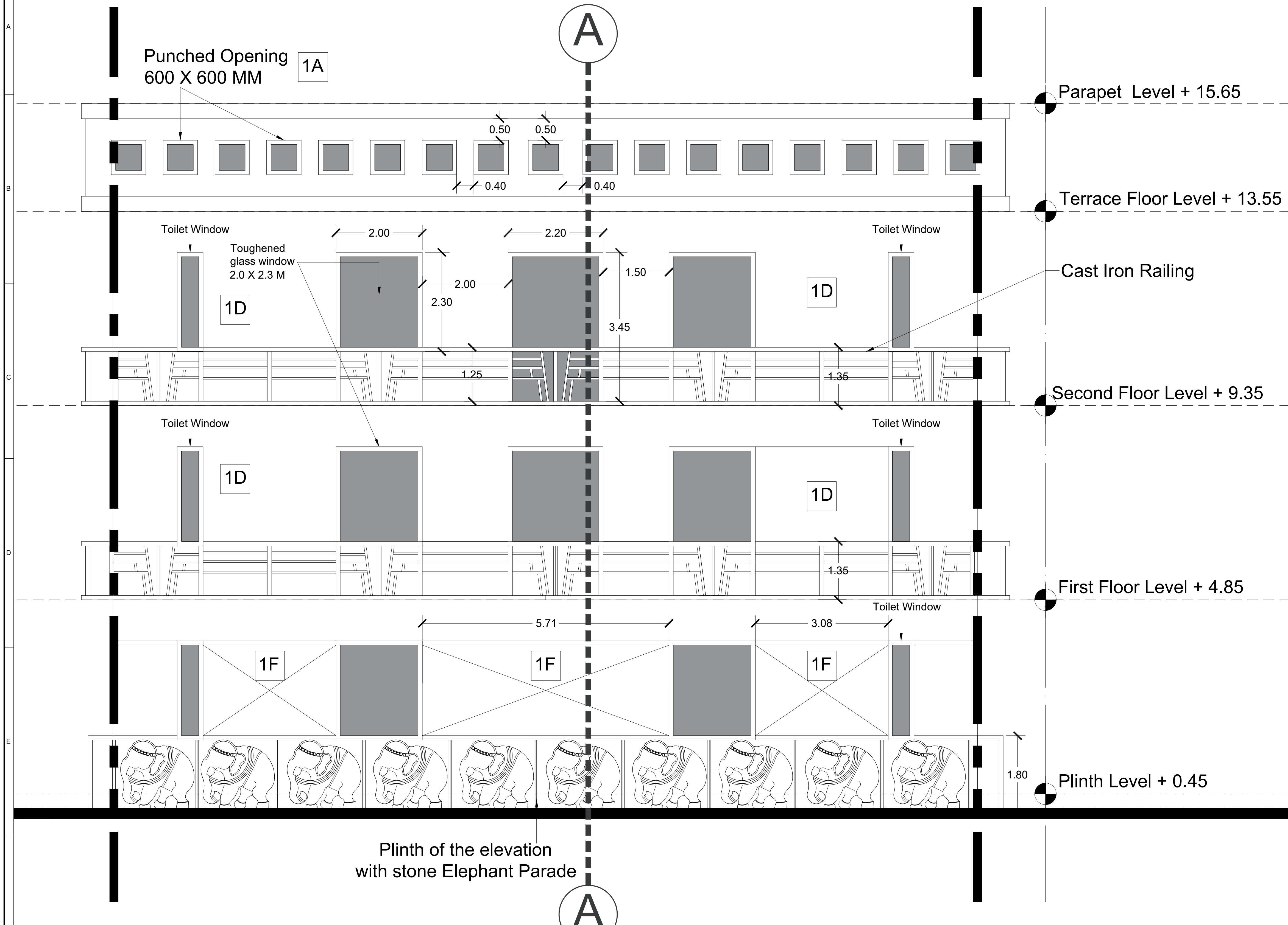
Drawn : JN		Checked : PD	
Designed : KAS		Approved : GM	
Date : APRIL 2021		Scale : A4 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ABD/001	8 OF 10	R0



RHS ELEVATION (5&6)

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED AREA (2400SqM) FOR ADMIN & MICROBIOLOGY IS 65mX45m.
3. JICA RL(+)6.5m.(TO BE APPROVED FROM CMWSSB.)
4. REFERENCE LEVEL(RL) IS ASSUMED TO BE (+)6.5m ALL LEVEL'S TO BE CONFORMED FROM CMWSSB.
5. ALL FFL TO BE CONFIRMED BY CMWSSB.

LEGEND:

1. ALL DIMENSIONS ARE IN METRES UNLESS SPECIFIED.
2. PROPOSED ELEVATION IS 15.65 M HIGH MICROBIOLOGY IS 65mX45m.
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6. ALL FINISHES TO BE CONFIRMED BY CMWSSB.

SCHEDULE OF FINISHES:

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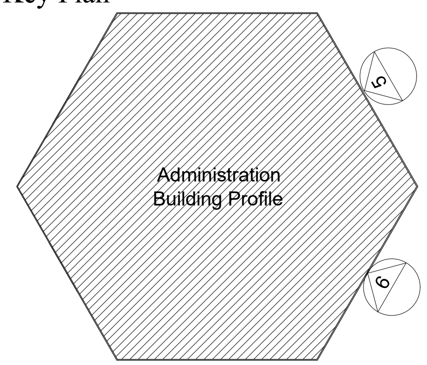
1B. Prefabricated, ENTRANCE PORTICO
1C. Meshwork Cladding on the facade
1D. EXTERIOR PAINT
1E. ARCHITECTURAL FEATURE

Key Plan



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	PD	GM

Client: Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant : SMEC International Pty Ltd, TATA Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI), SMEC India Pvt Ltd.

Project Name: Project for Construction of Seawater Desalination Plant (I)

Contract Name: Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

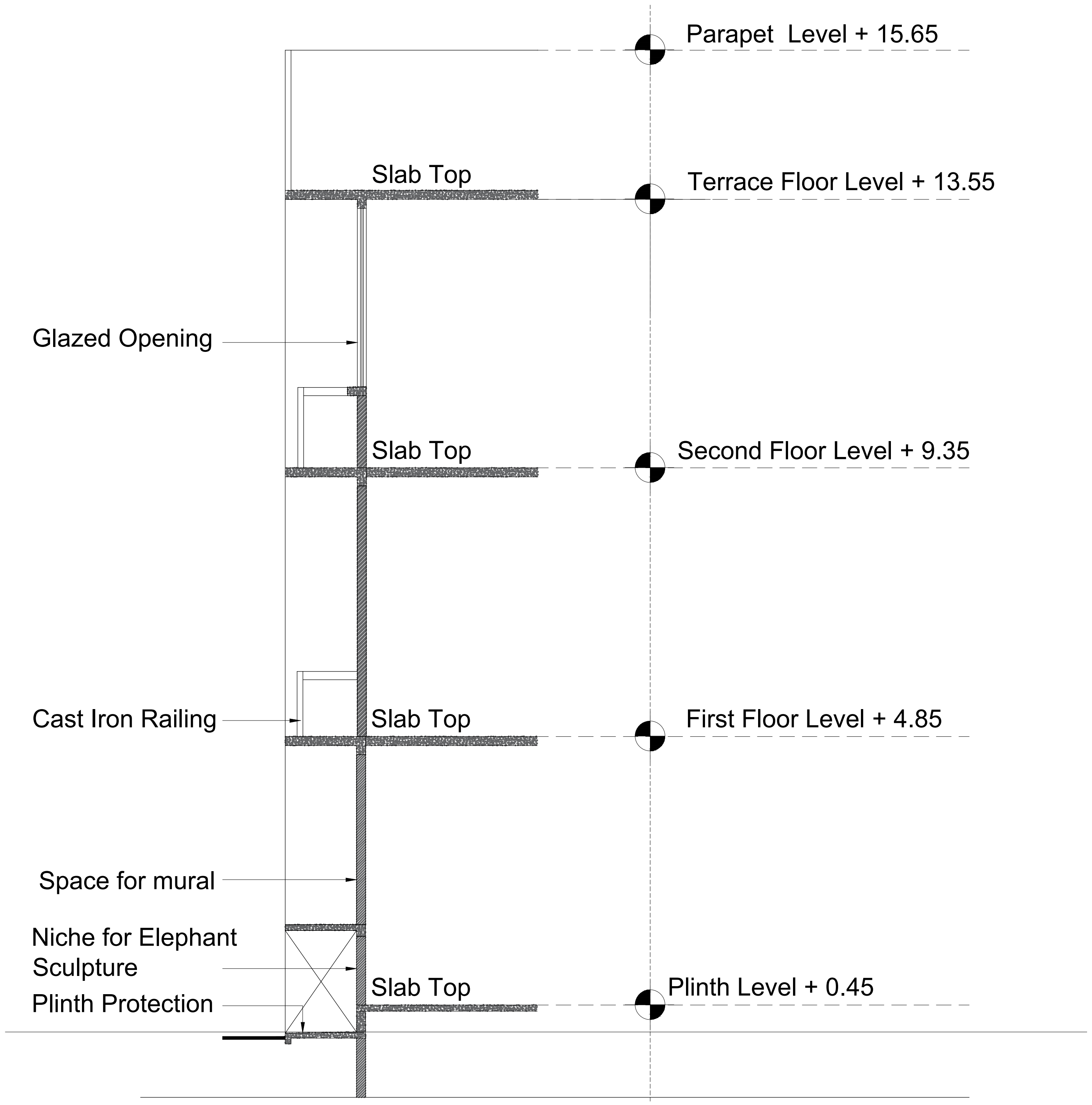
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title: PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn : JN		Checked : PD	
Designed : KAS		Approved : GM	
Date : APRIL 2021		Scale A4 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ABD/001	9 OF 10	R0



CROSS SECTION @ A_A

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	PD	GM

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
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TATA Consulting Engineers Limited (TCE),
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Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

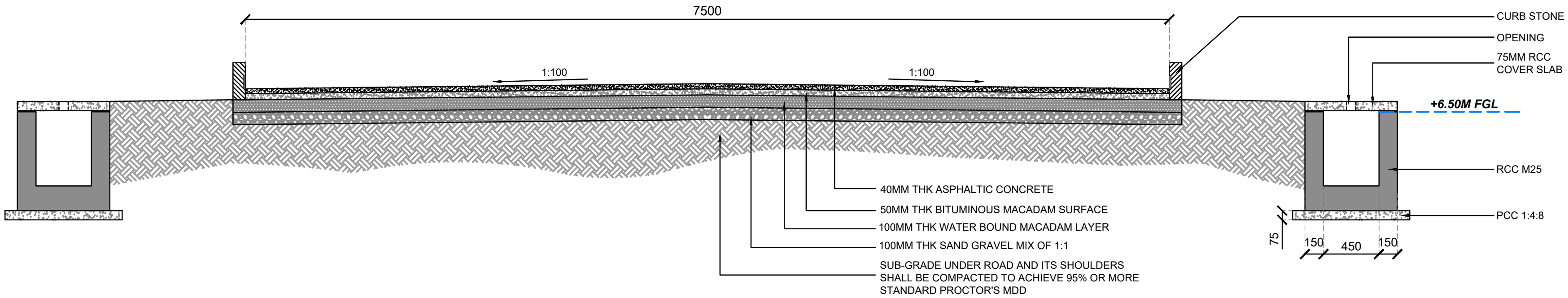
Contract Package No.: Contract Package -1 (CP1)

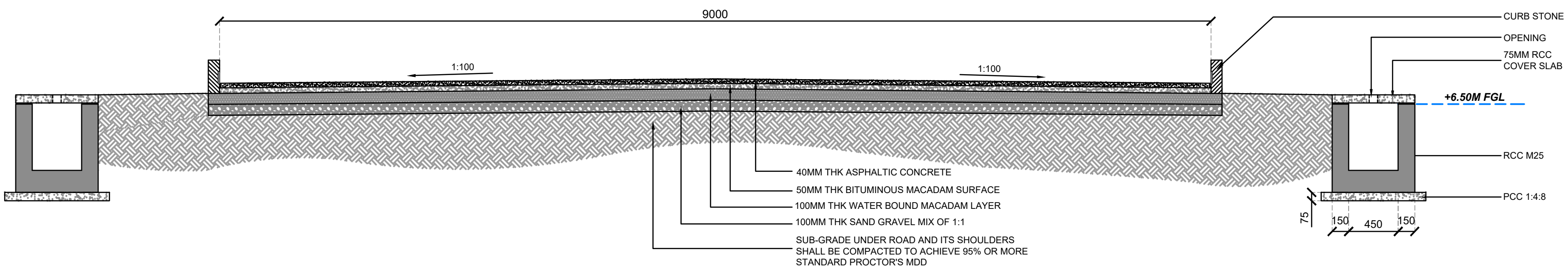
JICA Loan No.:
ID-P267

Drawing Title:
PROPOSED GROUND FLOOR DRAWING FOR ADMINISTRATION BUILDING,(CANTEEN, CONFERENCE ROOM,GUEST HOUSE)& MICROBIOLOGY, LABORATORY BUILDING 400 MLD PERUR DSP.

Drawn :	JN	Checked :	PD
Designed :	KAS	Approved :	GM
Date :	APRIL 2021	Scale :	A4 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/ABD/001	10 OF 10	R0





CROSS SECTION OF STORM DRAIN & ROAD

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN		PD

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
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Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
TYPICAL DRAWING - CONSTRUCTION OF ROADS & STORM WATER DRAINS FOR 400 MLD PERUR DSP

Drawn :	JN	Approved :	PD
Date :	APRIL 2021	Scale :	A4 /1:1

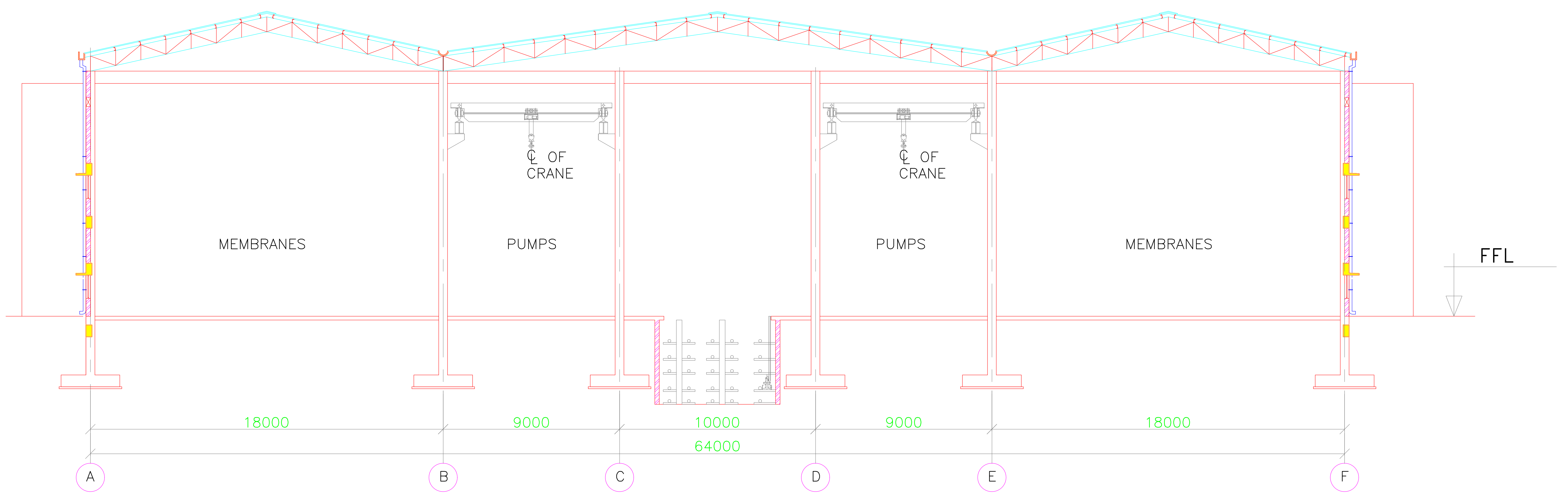
Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/C/R&D/008	1 OF 1	R0

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETER AND LEVELS IN METER UNLESS SPECIFIED.
2. PEB STEEL STRUCTURE PROPOSED.
3. 2 NOS OF RO BUILDING FOR EACH 200MLD STREAM PROPOSED.
4. EACH 200MLD STREAM HAS 9 TRAINS INCLUDING 1 STAND – BY (25MLD/UNITS).

RO BUILDING PIPE & CABLE TRENCHES

SCALE (1:400)



RO BUILDING CROSS SECTION 1–1

SCALE (1:200)

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	GM/MM	PD

Client: Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant : SMEC International Pty Ltd, TATA Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI), SMEC India Pvt Ltd.

Project Name: Project for Construction of Seawater Desalination Plant (I)

Contract Name: Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

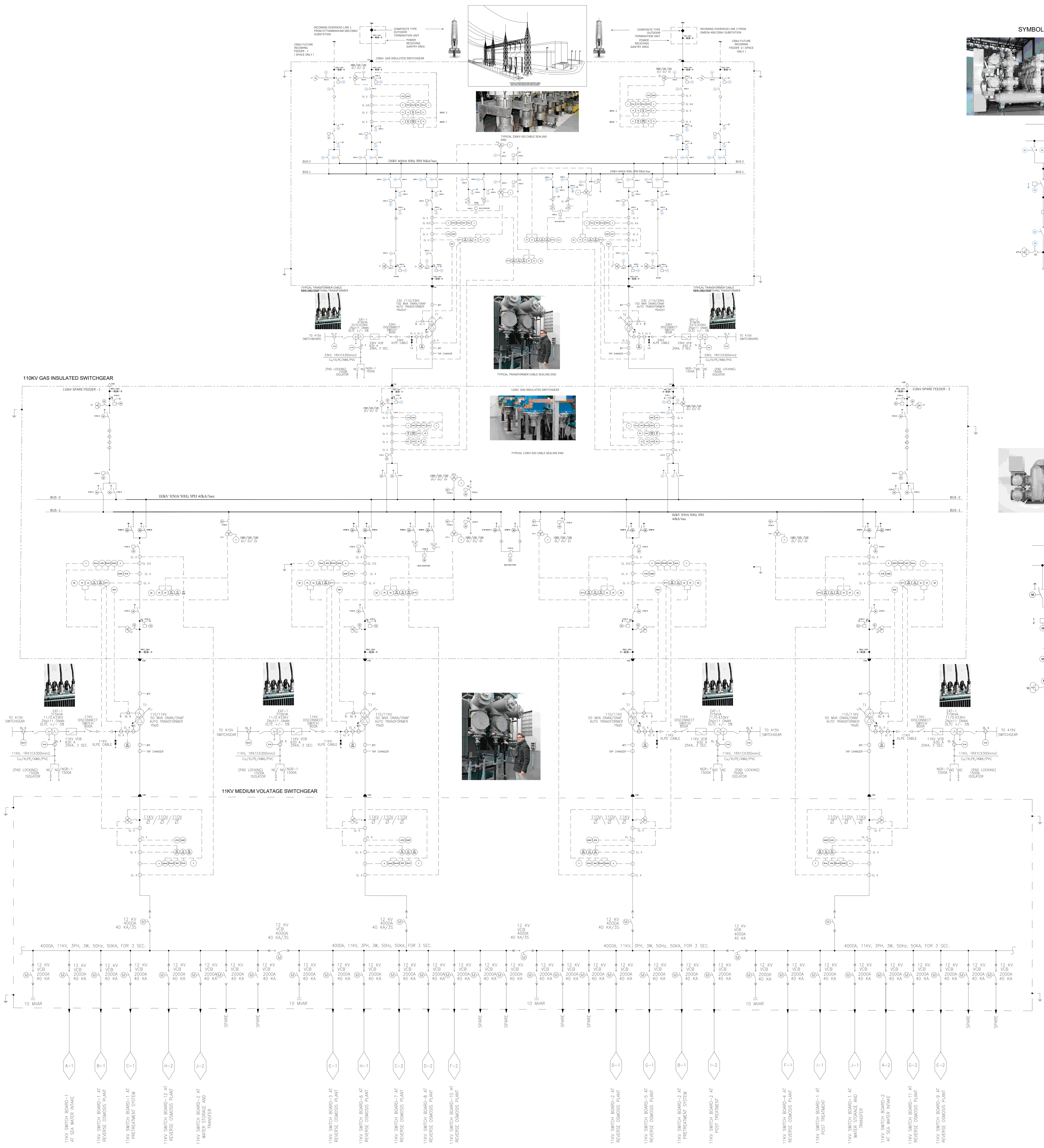
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title: GENERAL ARRANGEMENT DRAWING FOR RO BUILDING

Drawn : NGM		Checked : GM / MM	
Designed : GV		Approved : PD	
Date : APRIL 2021		Scale : 1:1	

Drawing Number: 7061563/PMC400MLD/CP1/M/ROB/002 — Sh.No 1 OF 1 — Revision: R0



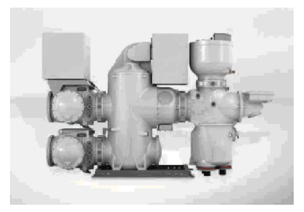
SYMBOLS & LEGENDS :

230 KV GAS INSULATED SWITCHGEAR

1. CIRCUIT BREAKER INTERRUPTER UNIT
2. STORED ENERGY SPRING MECHANISM WITH CIRCUIT BREAKER CONTROL UNIT
3. BUS BAR I
4. BUS BAR DISCONNECTOR I
5. BUS BAR II
6. BUS BAR DISCONNECTOR II
7. WORK IN PROGRESS EARTHING SWITCH
8. WORK IN PROGRESS EARTHING SWITCH
9. OUTGOING FEEDER DISCONNECTOR
10. MAKE PROOF EARTHING SWITCH (HIGH SPEED)
11. CURRENT TRANSFORMER
12. VOLTAGE TRANSFORMER
13. CABLE SEALING END

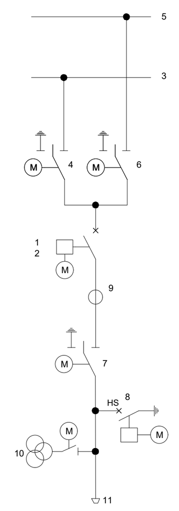
METERING & PROTECTION RELAYS

- A AMMETER
- V VOLTMETER
- MWh MEGAWATTHOUR METER
- Mvarh MEGAVARHOUR METER
- MW MEGAWATT METER
- Mvar MEGAVAR METER
- 87B BUSBAR DIFFERENTIAL PROTECTION RELAY
- 50BF BREAKER FAILURE RELAY
- 21 DISTANCE PROTECTION RELAY
- 50/51 INSTANTANEOUS OVERCURRENT RELAY / AC INVERSE TIME OVERCURRENT RELAY
- 50N/51N INSTANTANEOUS EARTH FAULT RELAY / AC INVERSE TIME EARTH FAULT RELAY
- 25 SYNCHRONIZING CHECK RELAY
- 79 AC RECLOSING RELAY
- REF RESTRICTED EARTH FAULT RELAY
- 87T1 DIFFERENTIAL PROTECTION RELAY
- 24 VOLTS PER HERTZ RELAY / FREQUENCY RELAY
- 86 LOCK OUT RELAY
- 27/59 UNDERVOLTAGE / OVER VOLATGE RELAY
- 67N AC DIRECTIONAL OVERCURRENT RELAY



110 KV GAS INSULATED SWITCHGEAR

1. CIRCUIT BREAKER INTERRUPTER UNIT
2. STORED ENERGY SPRING MECHANISM WITH CIRCUIT BREAKER CONTROL UNIT
3. BUS BAR I
4. BUS BAR I WITH DISCONNECTOR & EARTH SWITCH
5. BUS BAR II
6. BUS BAR II WITH DISCONNECTOR & EARTH SWITCH
7. OUTGOING FEEDER DISCONNECTOR WITH EARTH SWITCH
8. HIGH SPEED EARTHING SWITCH
9. CURRENT TRANSFORMER
10. VOLTAGE TRANSFORMER
11. CABLE SEALING END



METERING & PROTECTION RELAYS

- A AMMETER
- V VOLTMETER
- MWh MEGAWATTHOUR METER
- Mvarh MEGAVARHOUR METER
- MW MEGAWATT METER
- Mvar MEGAVAR METER
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- 50BF BREAKER FAILURE RELAY
- 21 DISTANCE PROTECTION RELAY
- 50/51 INSTANTANEOUS OVERCURRENT RELAY / AC INVERSE TIME OVERCURRENT RELAY
- 50N/51N INSTANTANEOUS EARTH FAULT RELAY / AC INVERSE TIME EARTH FAULT RELAY
- 25 SYNCHRONIZING CHECK RELAY
- 79 AC RECLOSING RELAY
- REF RESTRICTED EARTH FAULT RELAY
- 87T1 DIFFERENTIAL PROTECTION RELAY
- 24 VOLTS PER HERTZ RELAY / FREQUENCY RELAY
- 86 LOCK OUT RELAY
- 27/59 UNDERVOLTAGE / OVER VOLATGE RELAY
- 67N AC DIRECTIONAL OVERCURRENT RELAY

NOTES:

1. CONTRACTOR SHALL USE COMPOSITE TYPE OUTDOOR CABLE TERMINATION FROM REPUTABLE MANUFACTURERS AS PER IEC62067 AND IEC60815 TO TERMINATE THE 230kV INCOMING OVERHEAD LINES (FROM 230kV TNEB SUBSTATIONS) AT THE POWER RECEIVING GANTRY AREA.
2. CU/XLPE/AWA/HDPE CABLE COMPLYING TO IEC 62271-209 ALONG WITH CABLE SEALING ENDS, CABLE PLUG-IN, OUTDOOR CABLE TERMINATION ACCESSORIES, AND EARTH LINK BOXES FROM REPUTABLE MANUFACTURERS SHALL BE USED TO CONNECT THE FOLLOWING :

   (A) OUTDOOR TYPE CABLE TERMINATION LOCATED AT GANTRY AREA TO INCOMING FEEDER BAY OF THE GAS INSULATED SWITCHGEAR WITH CABLE TERMINATION MODULES AND INSPECTION HOLES.

   (B) GAS INSULATED SWITCHGEAR OUTGOING FEEDER BAY CABLE TO AUTO POWER TRANSFORMER HV TERMINALS WITH TRANSFORMER TUBE TERMINATION MODULES.

   TRANSFORMER TUBE TERMINATION MODULES SHALL BE USED TO CONNECT THE GAS INSULATED SWITCHGEAR OUTGOING FEEDER BAY CABLES TO THE OIL INSULATED TRANSFORMER'S PRIMARY & SECONDARY TERMINALS.

   TRANSFORMER TERMINATION MODULES SHALL BE OIL TIGHT, GAS TIGHT, AND PRESSURE RESISTANT.
3. CONTRACTOR SHALL COORDINATE THE CABLE PLUG AND SEALING END CONNECTIONS WITH THE TRANSFORMER AND GAS INSULATED SWITCHGEAR MANUFACTURERS DURING DETAILED DESIGN, PROCUREMENT, FACTORY ACCEPTANCE TEST, AND SITE ACCEPTANCE TEST.

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
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CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

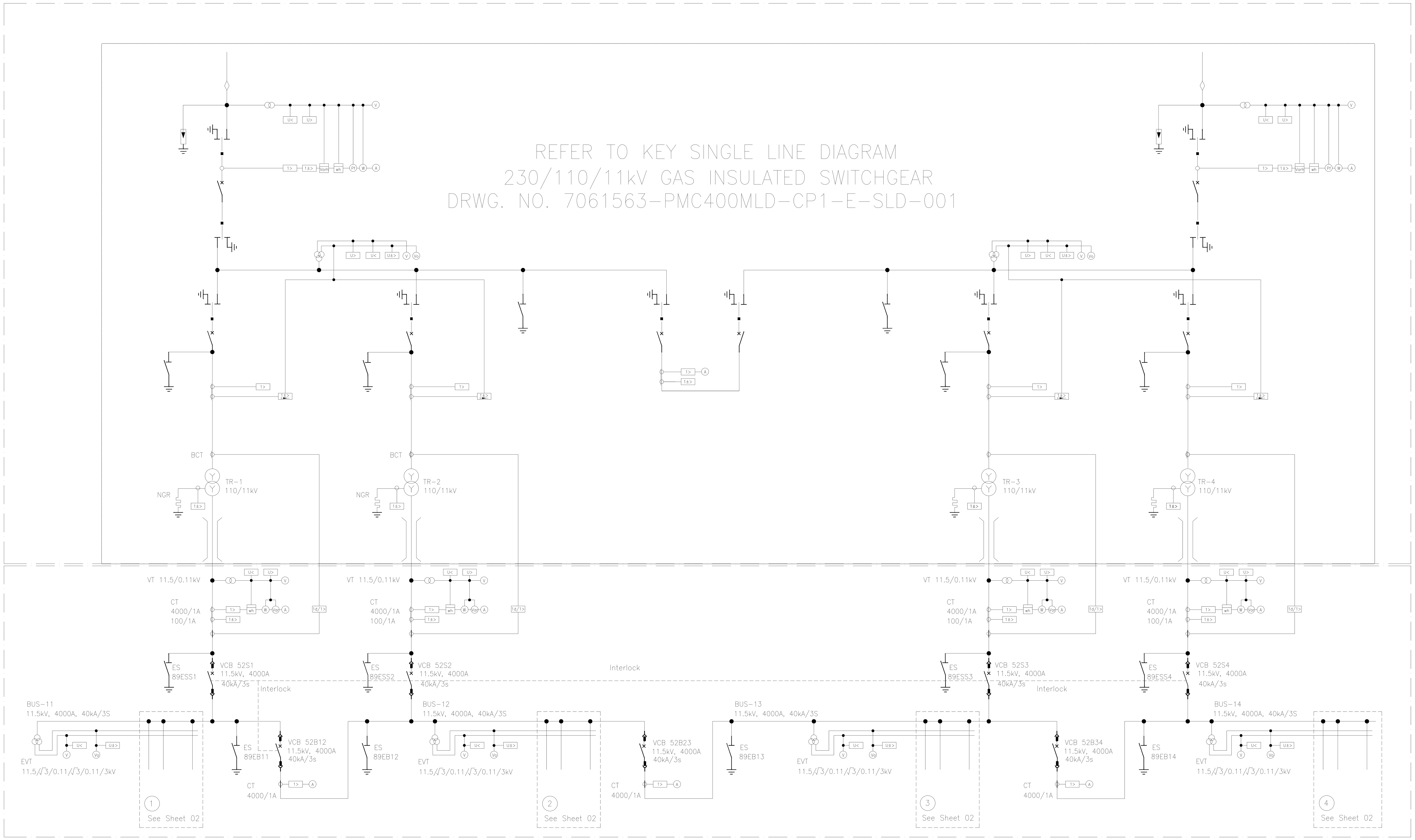
ID-P267

Drawing Title:

KEY SINGLE LINE DIAGRAM
230/110KV GAS INSULATED SUBSTATION

Drawn :	NY	Checked :	OM
Designed :	GG	Approved :	GG
Date :	APRIL 2021	Scale :	A1 / 1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/001	1 OF 1	R0



FOR TENDER PURPOSE ONLY

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CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

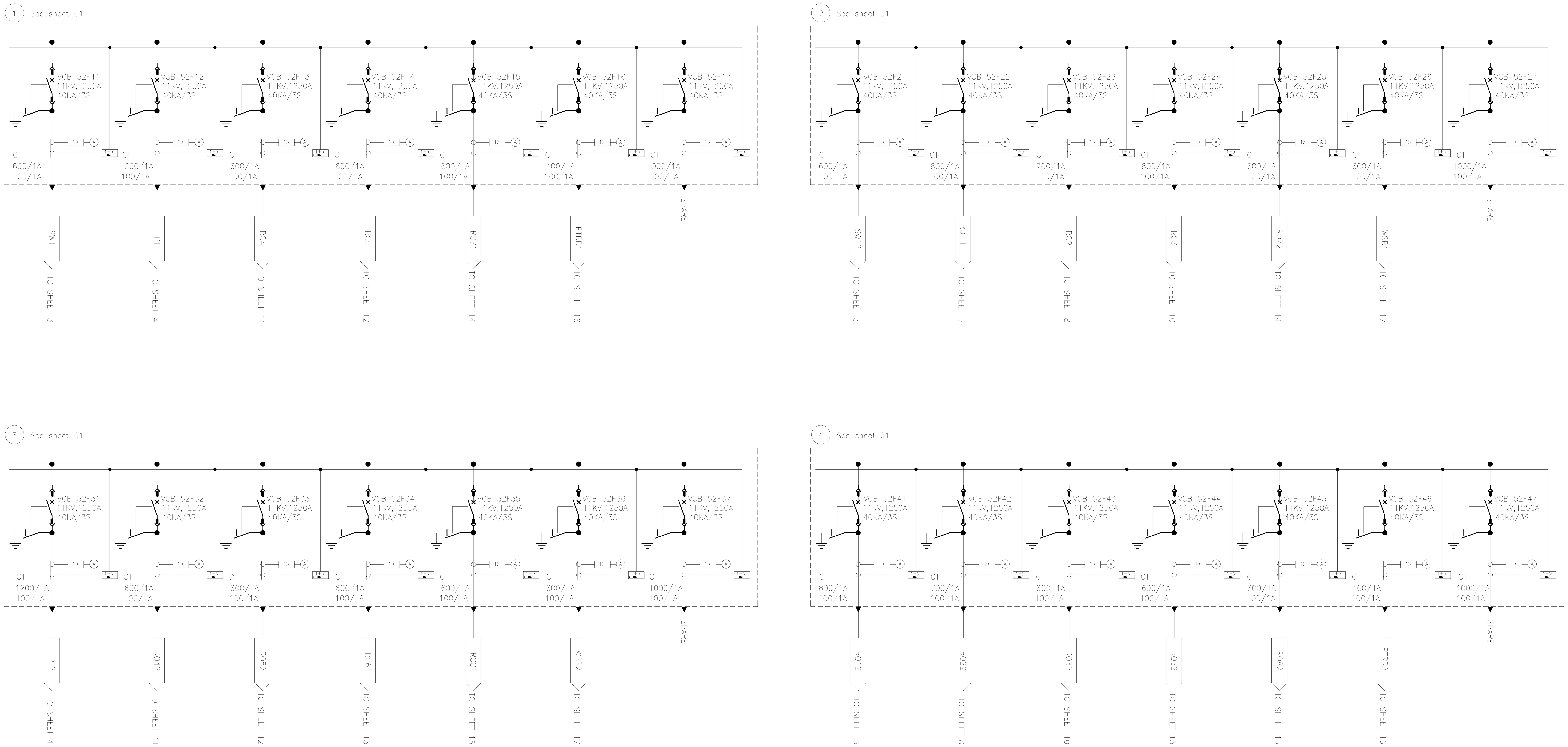
JICA Loan No.: ID-P267

Drawing Title:

110kV INTAKE & 11kV MAIN SWGR FOR 400 MLD PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/002	1 OF 1	R0



FOR TENDER PURPOSE ONLY

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Tender Number:

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Contract Package No.: Contract Package -1 (CP1)

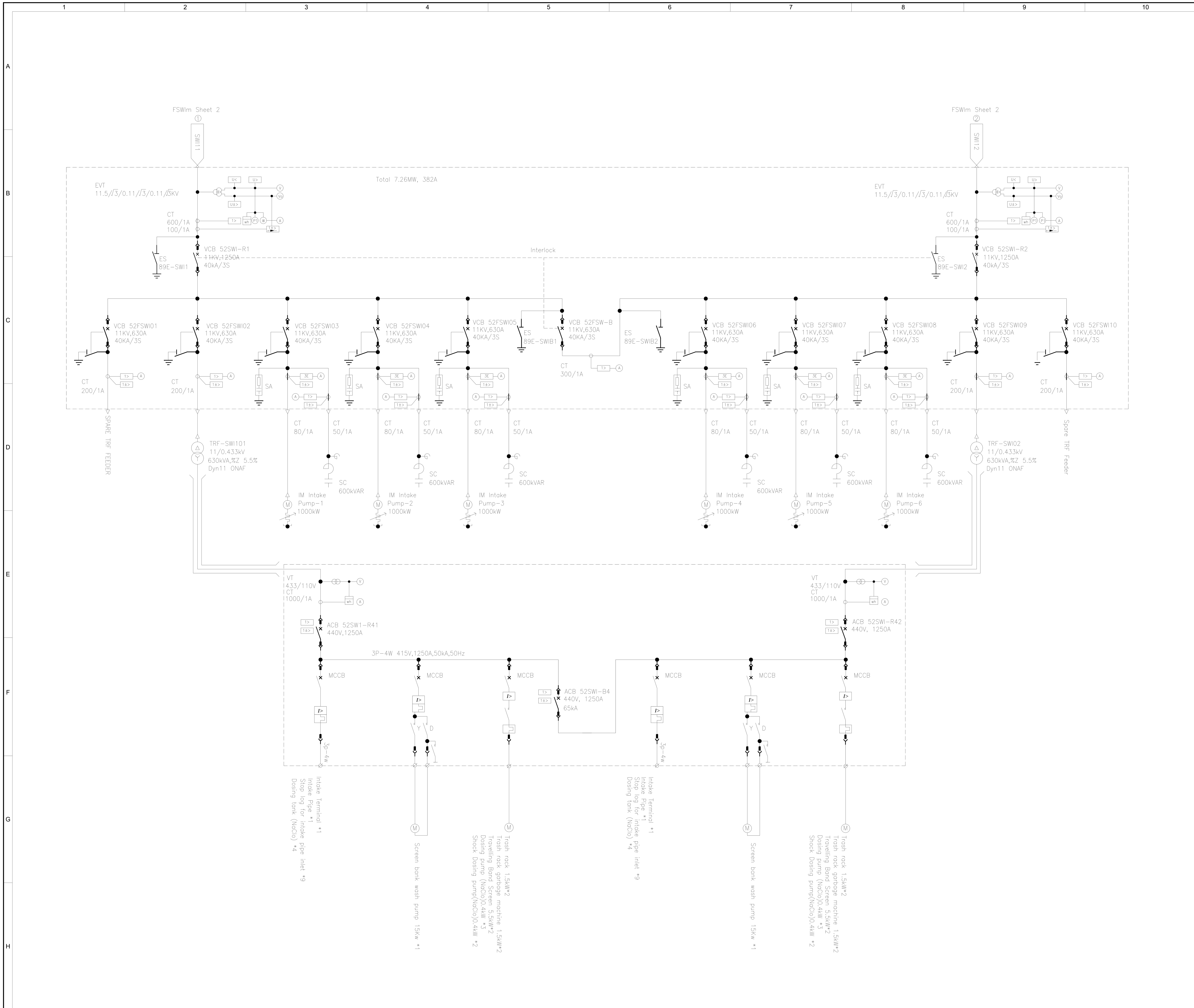
JICA Loan No.: ID-P267

Drawing Title:

11kV MAIN SWGR FEEDER DETAILS FOR 400 MLD PERUR DESALINATION PLANT

Drawn : JN		Checked : OM	
Designed : GG		Approved : GG	
Date : APRIL 2021		Scale : A1 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/003	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

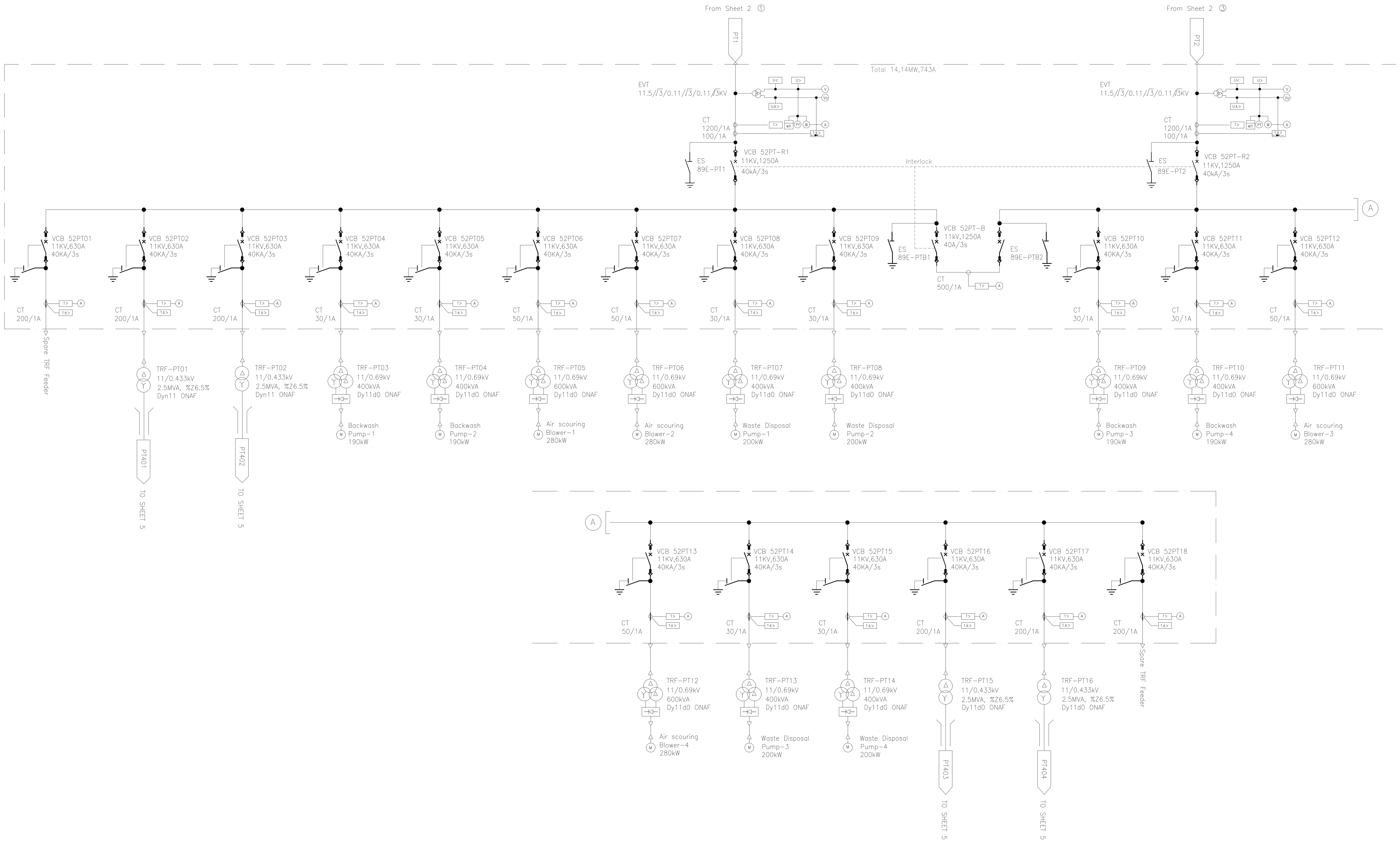
ID-P267

Drawing Title:

SEA WATER INTAKE SINGLE LINE DIAGRAM
FOR 400 MLD PERUR DESALINATION PLANT

Drawn : JN		Checked : OM	
Designed : GG		Approved : GG	
Date : APRIL 2021		Scale : A1 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/004	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

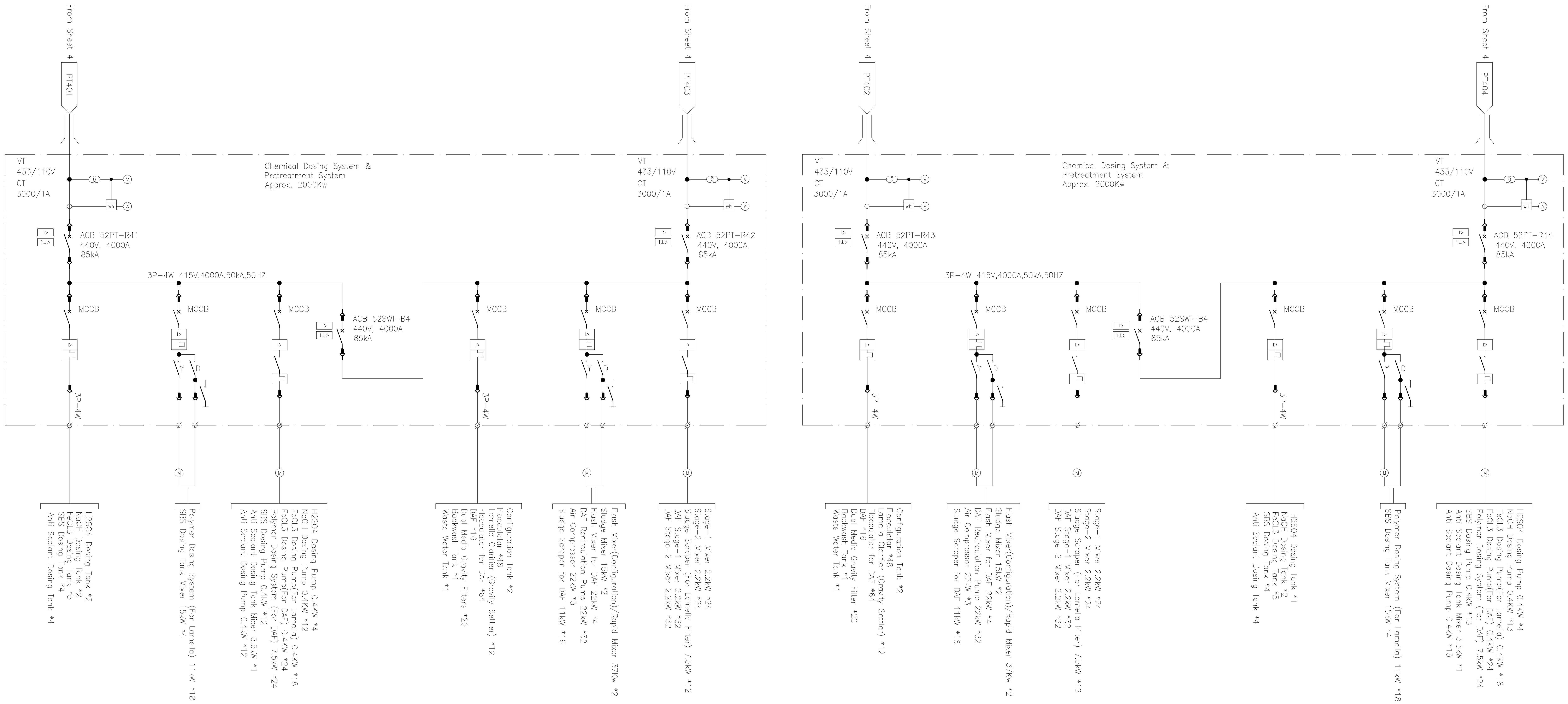
ID-P267

Drawing Title:

PRE TREATMENT SYSTEM 11 AND 0.69kV CIRCUIT SINGLE LINE DIAGRAM FOR 400 MLD PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/005	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

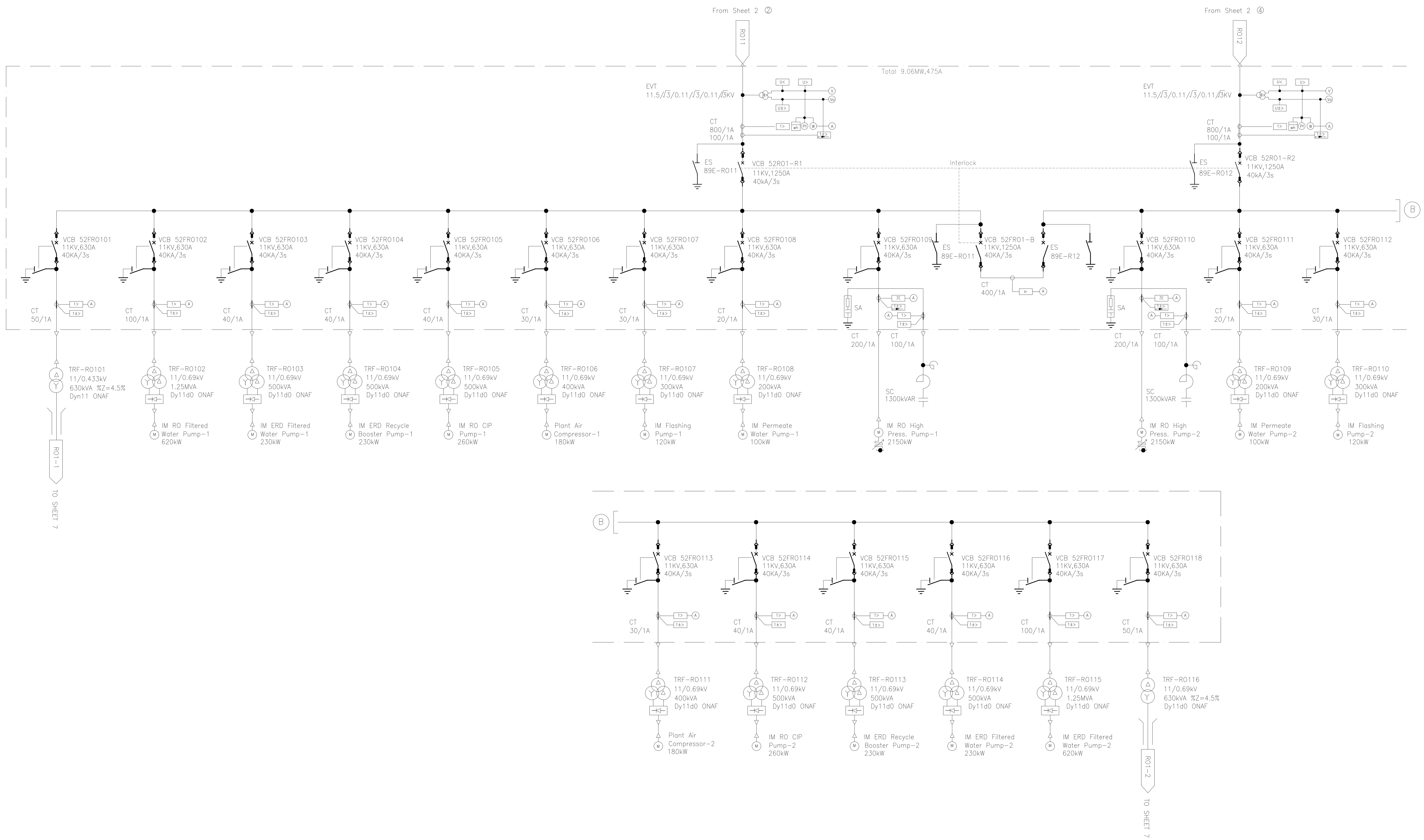
ID-P267

Drawing Title:

PRE TREATMENT SYSTEM 415V CIRCUIT SINGLE LINE DIAGRAM FOR 400 MLD PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/006	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

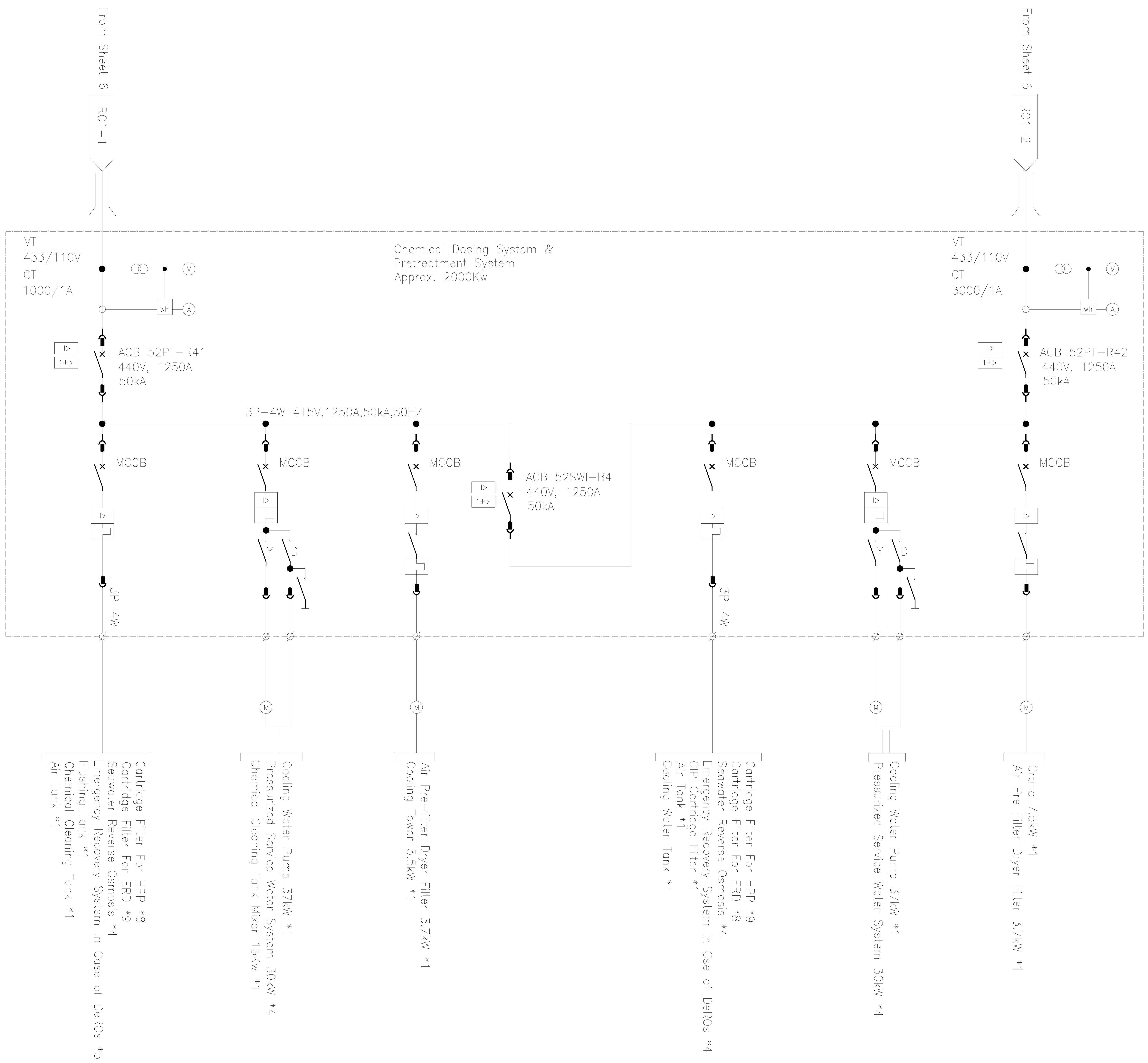
ID-P267

Drawing Title:

REVERSE OSMOSIS PLANT 11kV SWGR-1
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/007	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client: Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant: SMEC International Pty Ltd, TATA Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI), SMEC India Pvt Ltd.

Project Name: Project for Construction of Seawater Desalination Plant (I)

Contract Name: Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

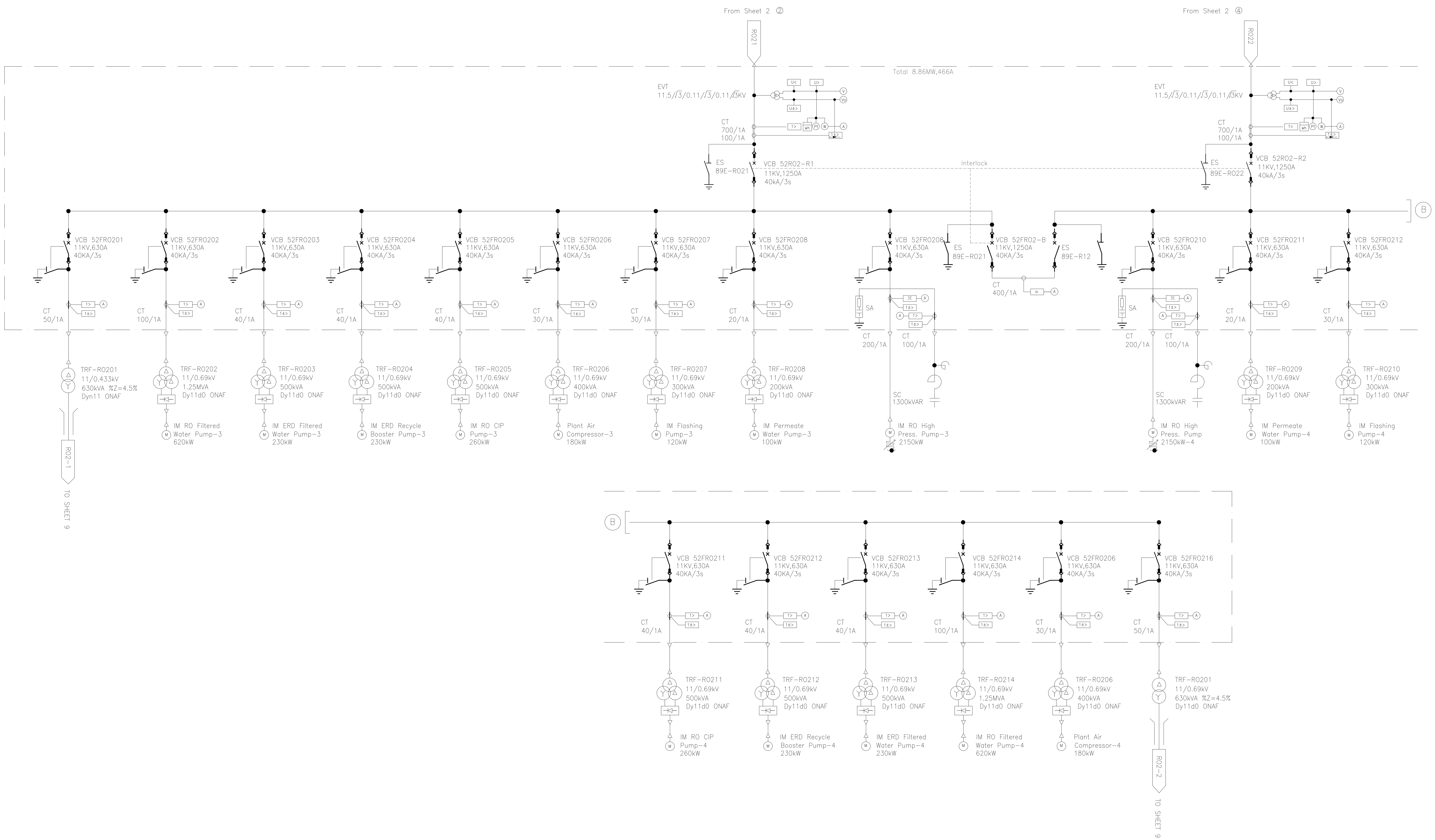
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title: REVERSE OSMOSIS PLANT 415V MCC-1 SINGLE LINE DIAGRAM FOR 400 MLD PERUR DESALINATION PLANT

Drawn : JN		Checked : OM	
Designed : GG		Approved : GG	
Date : APRIL 2021		Scale : A1 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/008	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

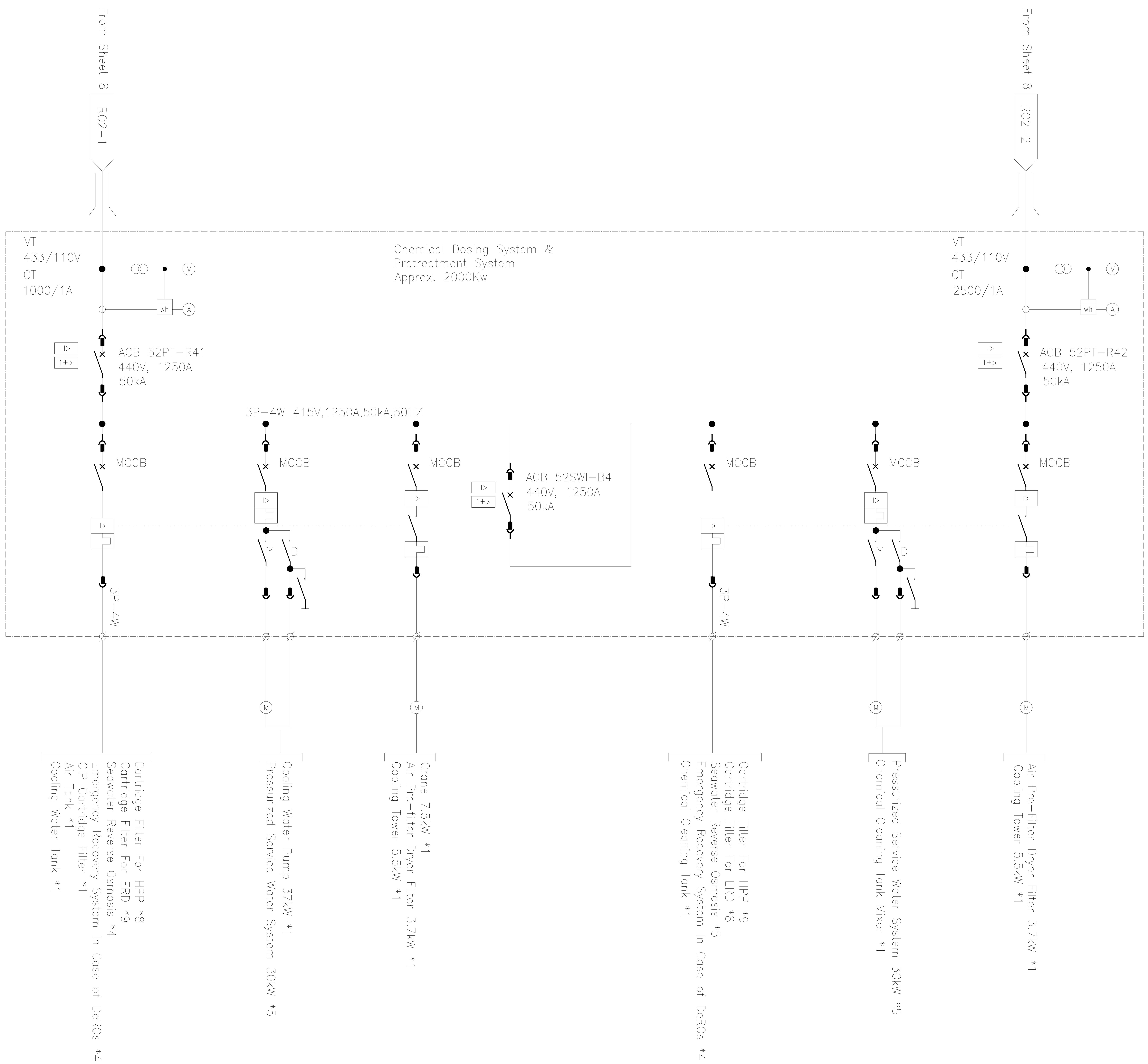
ID-P267

Drawing Title:

REVERSE OSMOSIS PLANT 11kV SWGR-2
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn :	JN	Checked :	OM
Designed :	GG	Approved :	GG
Date :	APRIL 2021	Scale :	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/009	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

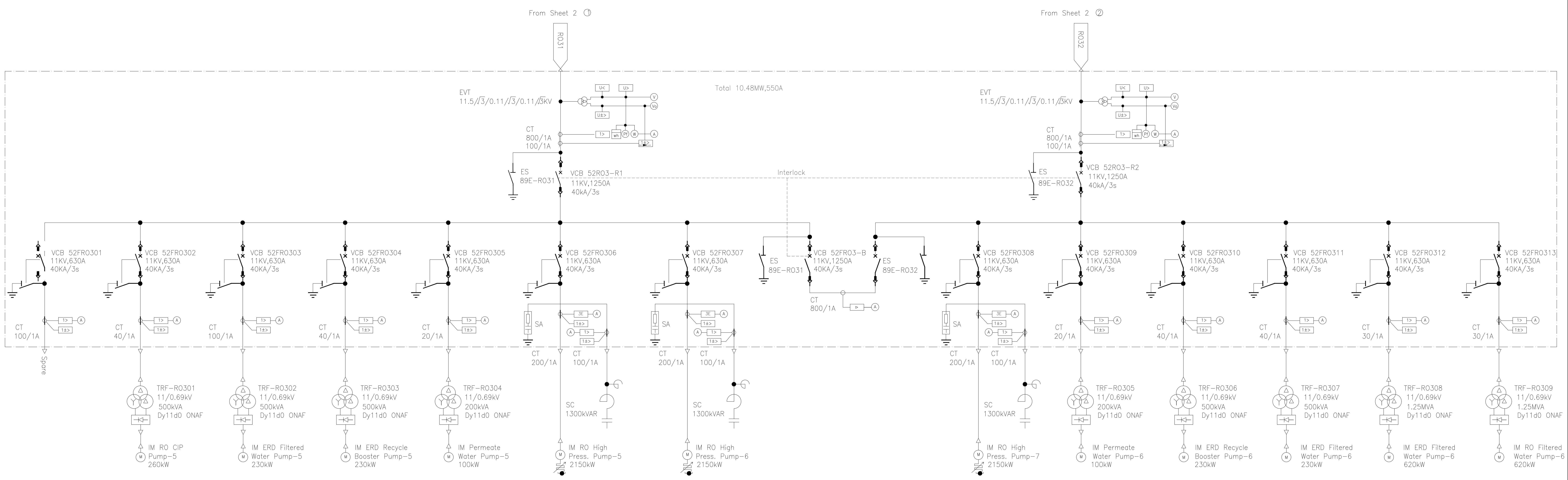
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
REVERSE OSMOSIS PLANT 415V MCC-2
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn :	JN	Checked :	OM
Designed :	GG	Approved :	GG
Date :	APRIL 2021	Scale :	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/010	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

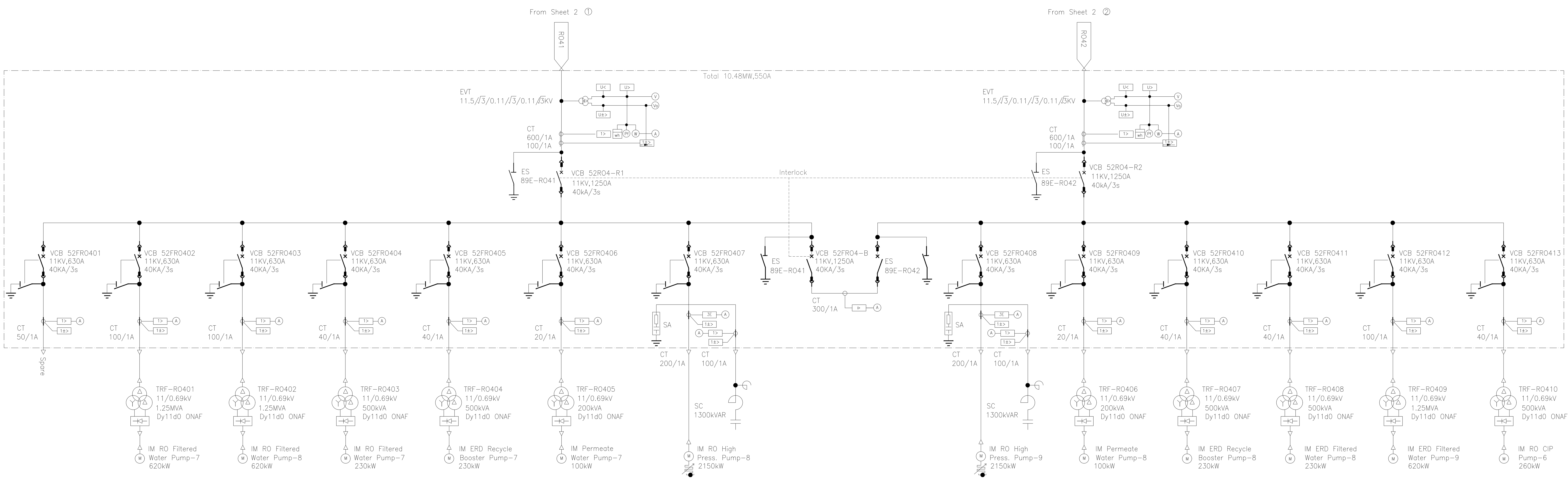
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
REVERSE OSMOSIS PLANT 11kV SWGR-3
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/011	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

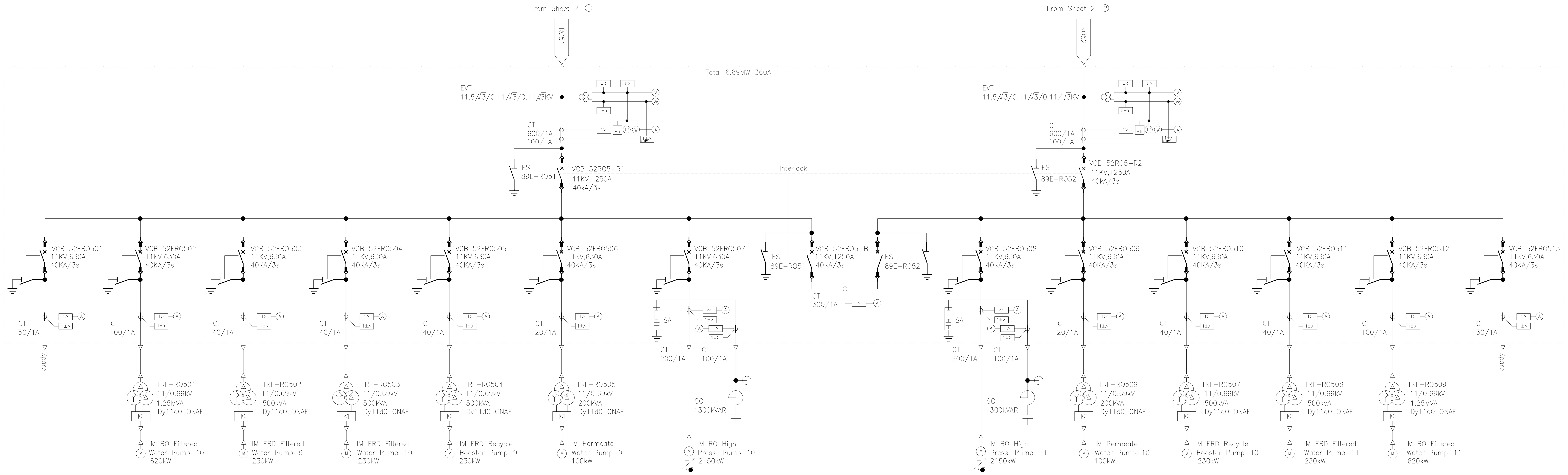
ID-P267

Drawing Title:

REVERSE OSMOSIS PLANT 11kV SWGR-4
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn :	JN	Checked :	OM
Designed :	GG	Approved :	GG
Date :	APRIL 2021	Scale :	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/012	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

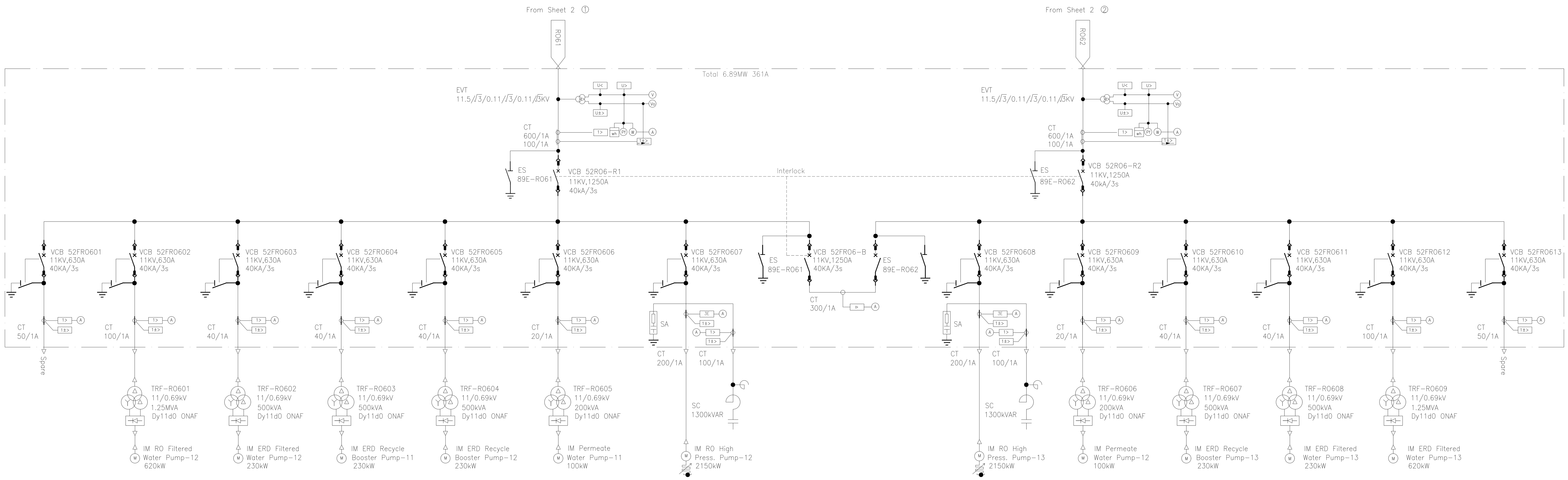
JICA Loan No.: ID-P267

Drawing Title:

REVERSE OSMOSIS PLANT 11kV SWGR-5
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn :	JN	Checked :	OM
Designed :	GG	Approved :	GG
Date :	APRIL 2021	Scale :	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/013	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

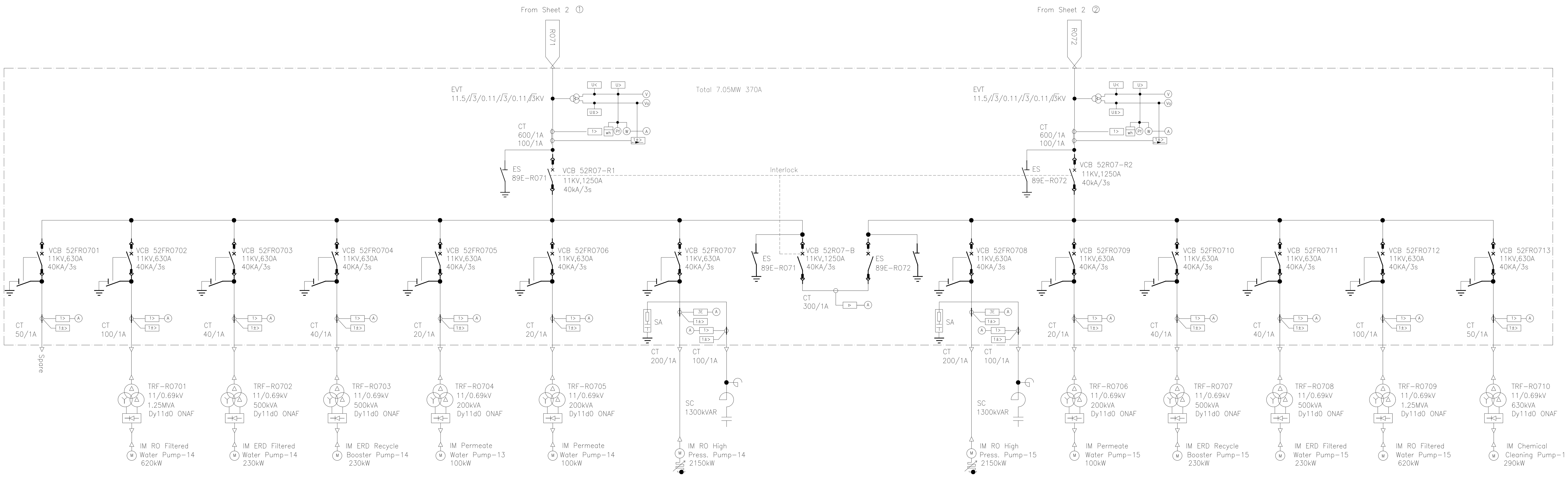
ID-P267

Drawing Title:

REVERSE OSMOSIS PLANT 11kV SWGR-6
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn :	JN	Checked :	OM
Designed :	GG	Approved :	GG
Date :	APRIL 2021	Scale :	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/014	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

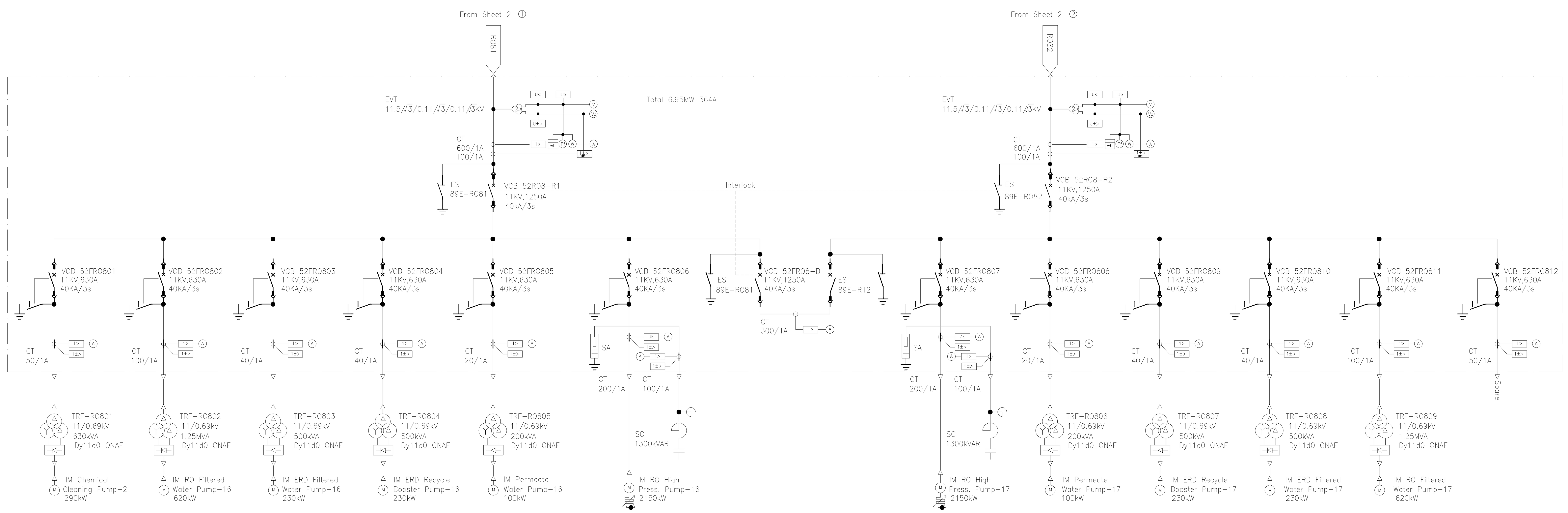
ID-P267

Drawing Title:

REVERSE OSMOSIS PLANT 11kV SWGR-7
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn : JN		Checked : OM	
Designed : GG		Approved : GG	
Date : APRIL 2021		Scale : A1 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/015	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

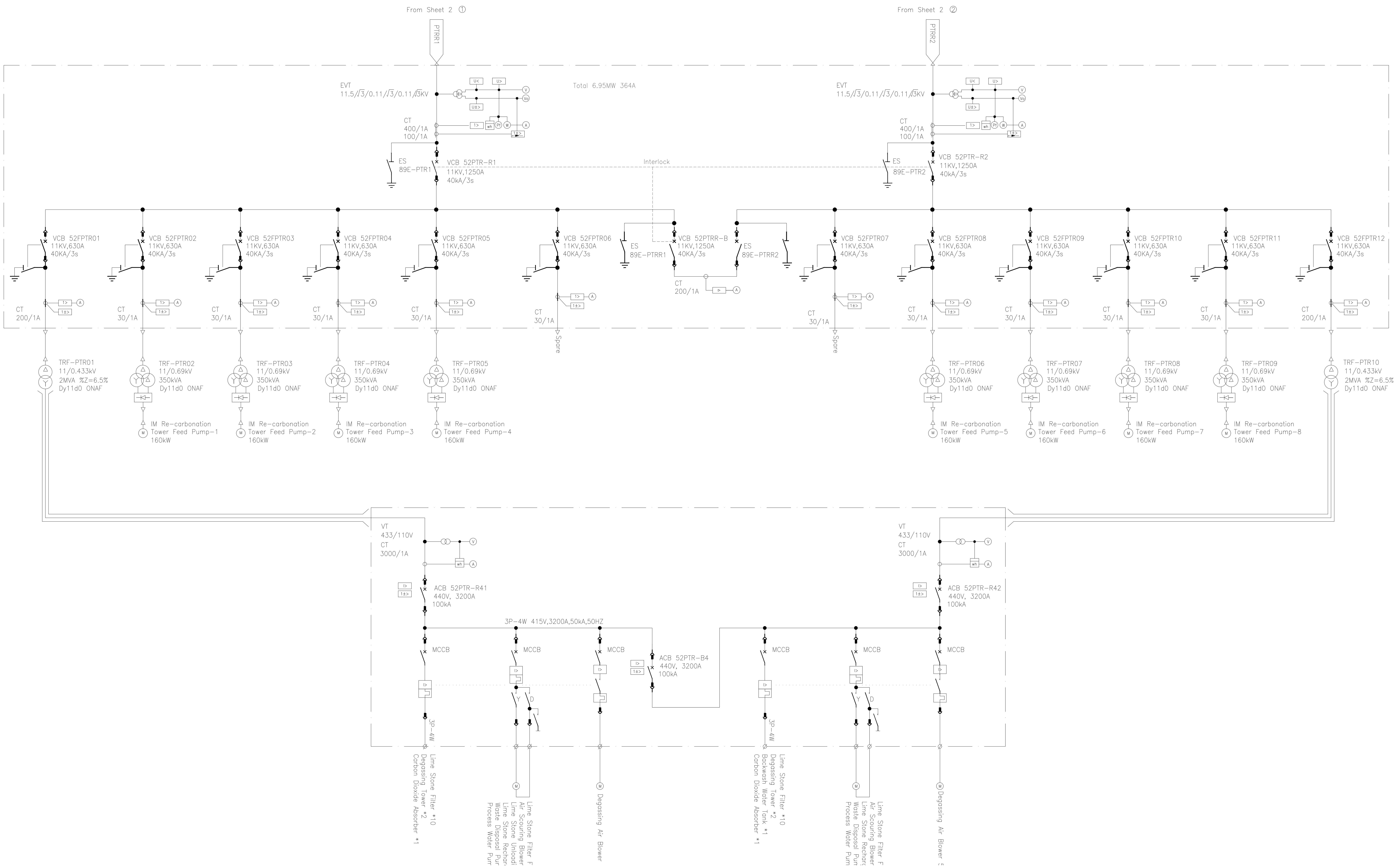
ID-P267

Drawing Title:

REVERSE OSMOSIS PLANT 11kV SWGR-8
SINGLE LINE DIAGRAM FOR 400 MLD
PERUR DESALINATION PLANT

Drawn : JN		Checked : OM	
Designed : GG		Approved : GG	
Date : APRIL 2021		Scale : A1 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/016	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

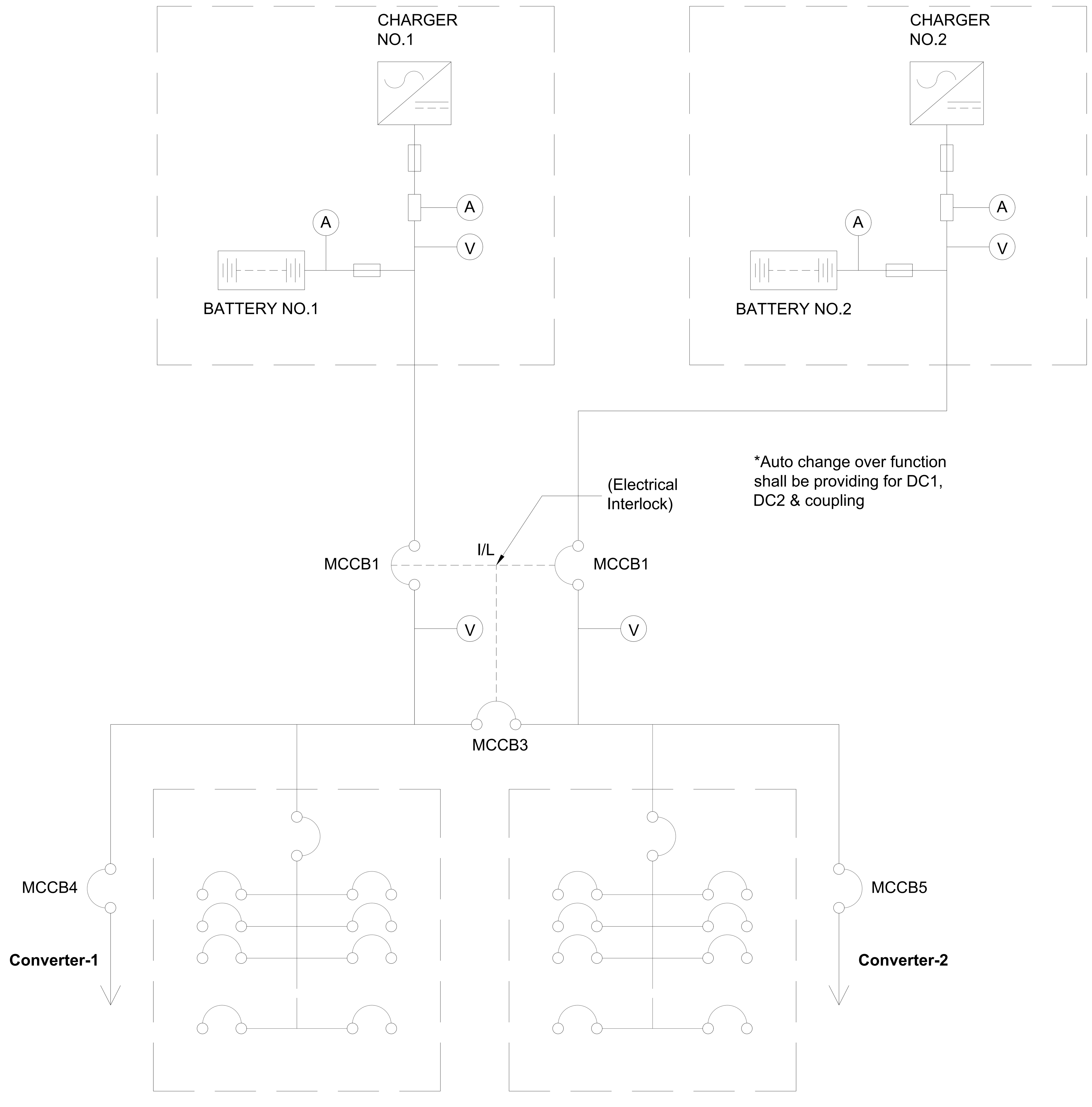
ID-P267

Drawing Title:

POST TREATMENT 11kV ,690V, 433V
CIRCUIT SINGLE LINE DIAGRAM FOR
400 MLD PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/017	1 OF 1	R0



110V DC DISTRIBUTION SCHEME

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

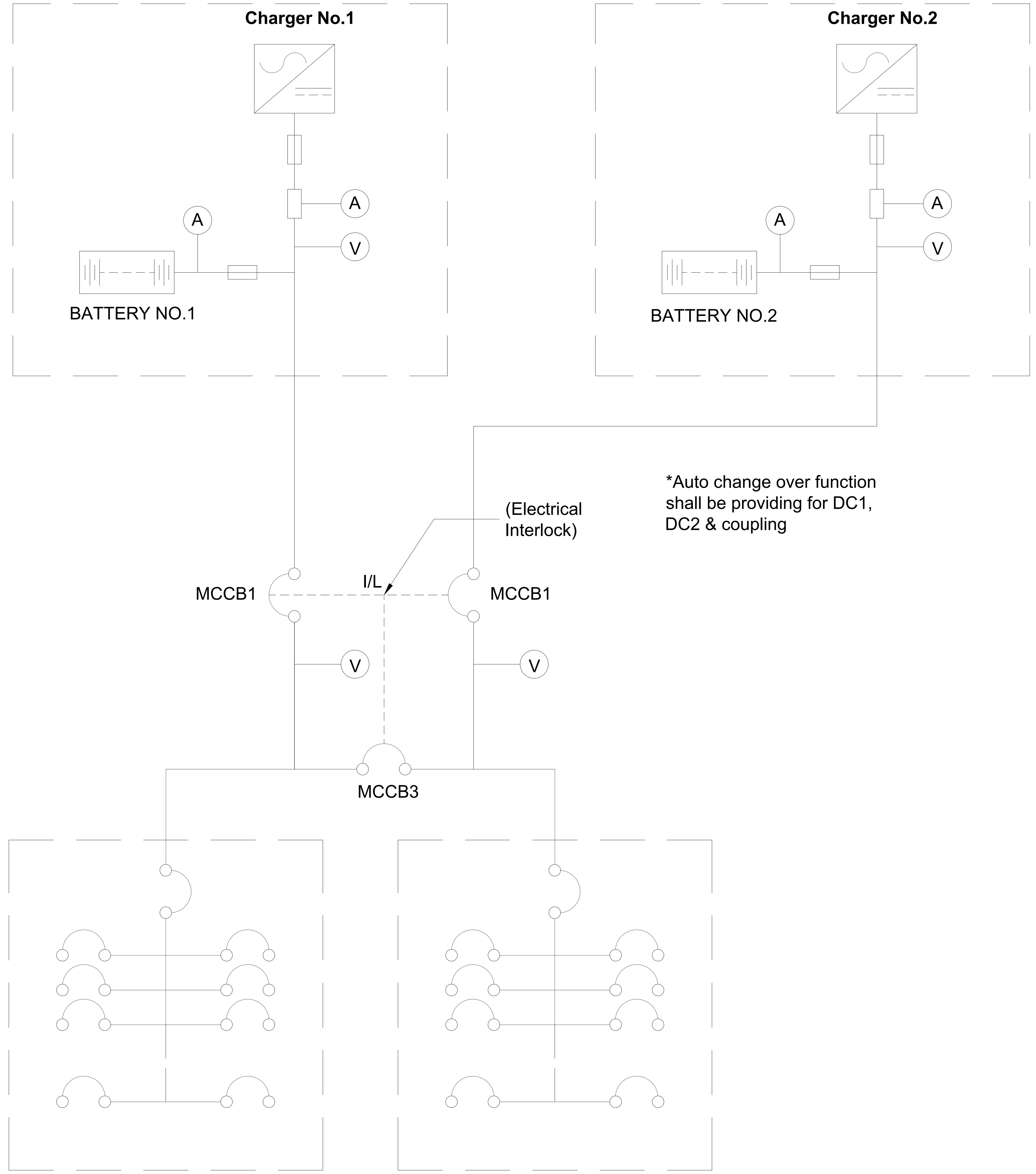
ID-P267

Drawing Title:

110V DC DISTRIBUTION SCHEME FOR
400 MLD PERUR DESALINATION PLANT

Drawn :	JN	Checked :	OM
Designed :	GG	Approved :	GG
Date :	APRIL 2021	Scale :	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/018	1 OF 1	R0



48V DC DISTRIBUTION SCHEME

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

Project for Construction of Seawater Desalination Plant (I)

Contract Name:

Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

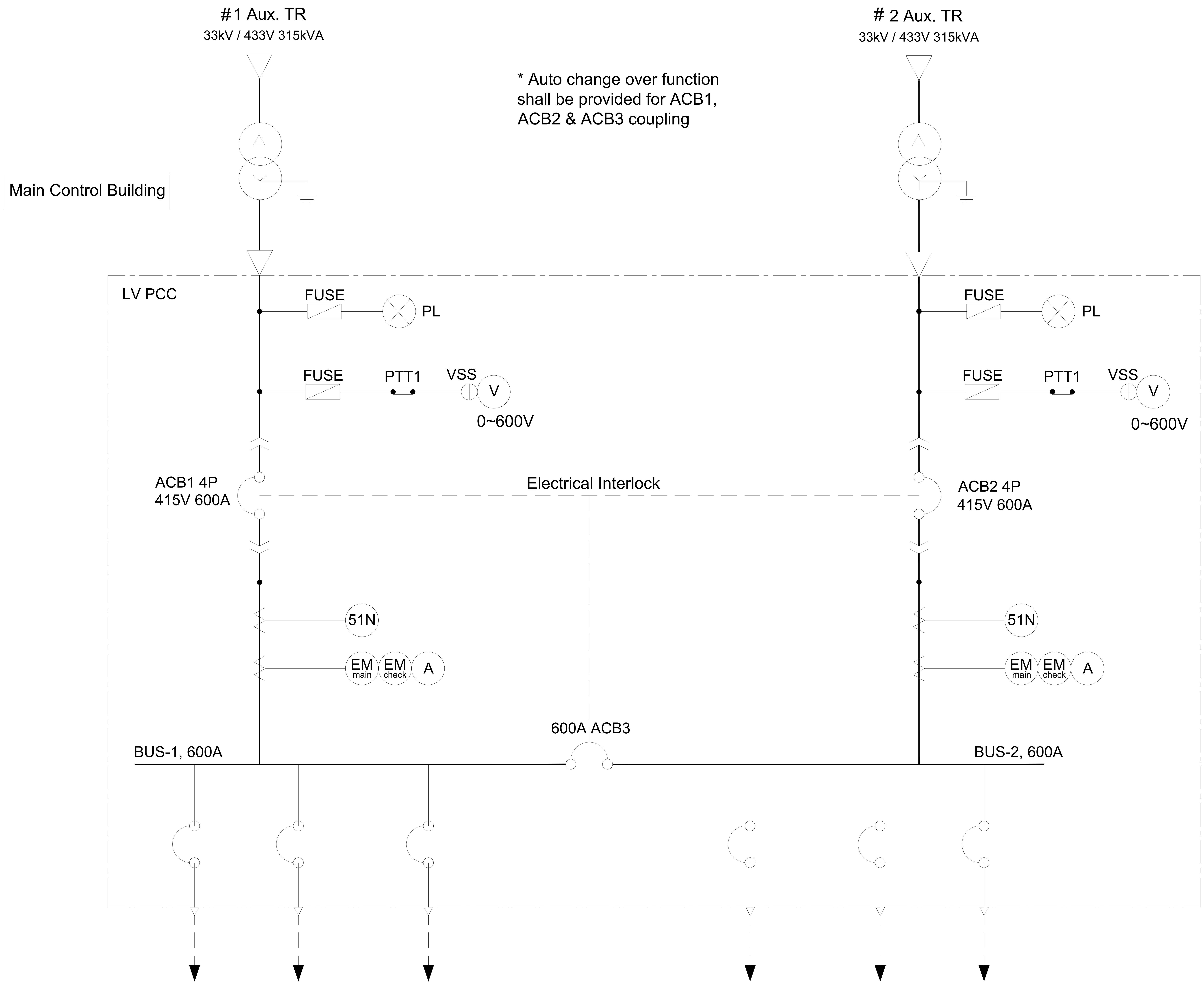
ID-P267

Drawing Title:

48V DC DISTRIBUTION SCHEME FOR
400 MLD PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/019	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

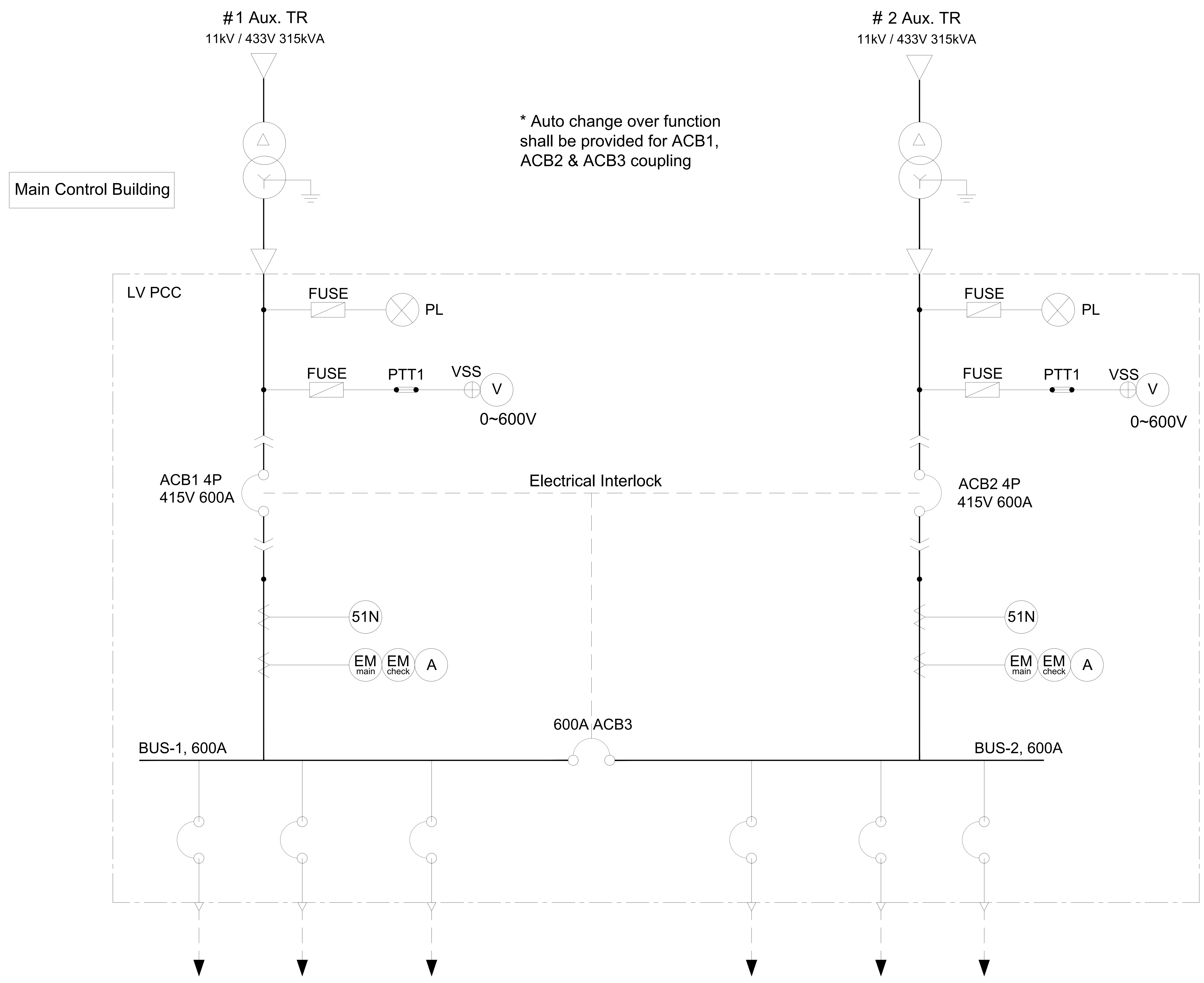
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
33 / 0.433kV SWITCHBOARD SINGLE LINE DIAGRAM FOR 400 MLD PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/020	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :

SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:

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Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:

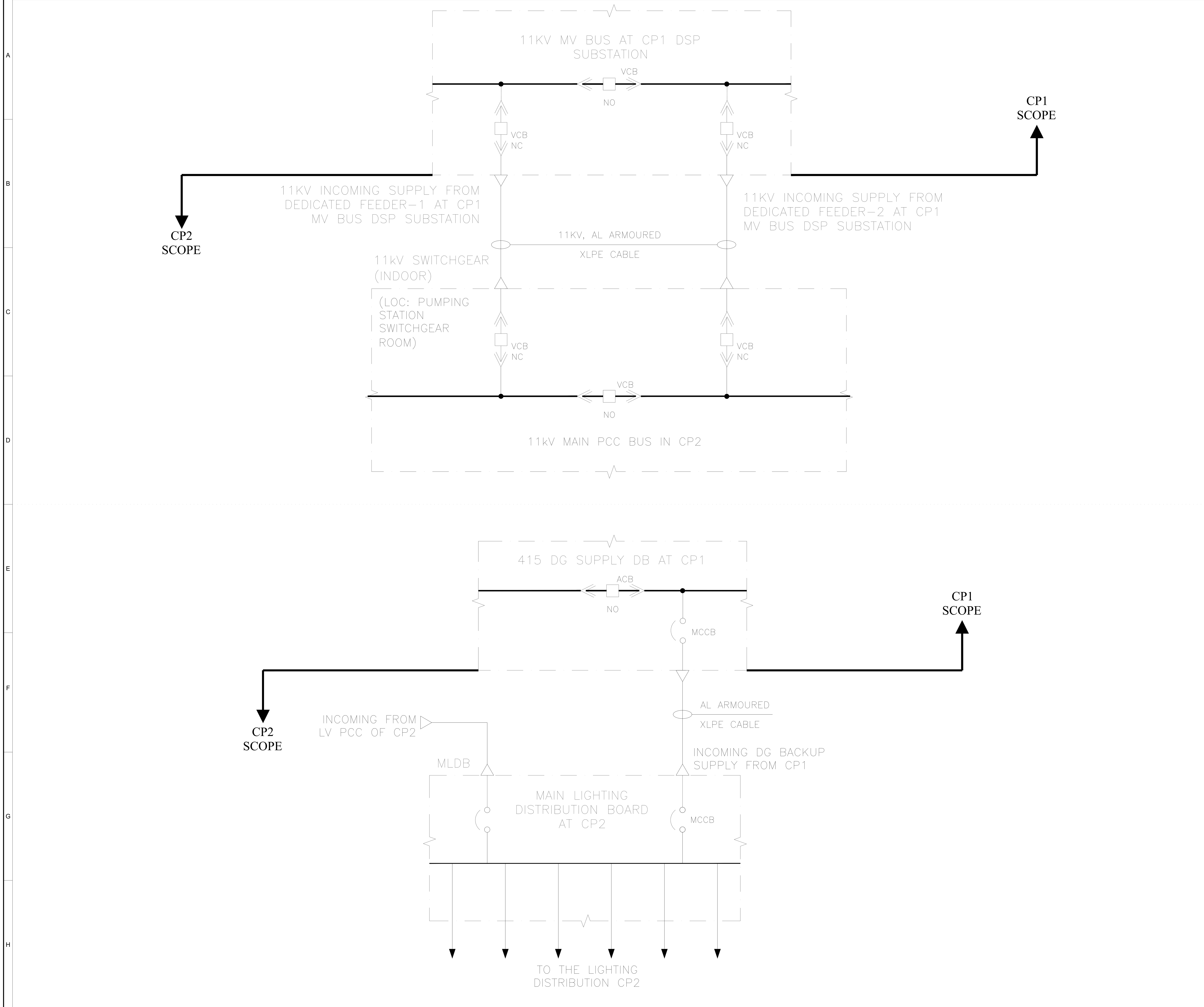
ID-P267

Drawing Title:

11 / 0.433kV SWITCHBOARD SINGLE LINE DIAGRAM FOR 400 MLD PERUR DESALINATION PLANT

Drawn	:	JN	Checked	:	OM
Designed	:	GG	Approved	:	GG
Date	:	APRIL 2021	Scale	:	A1 /1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/021	1 OF 1	R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
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Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

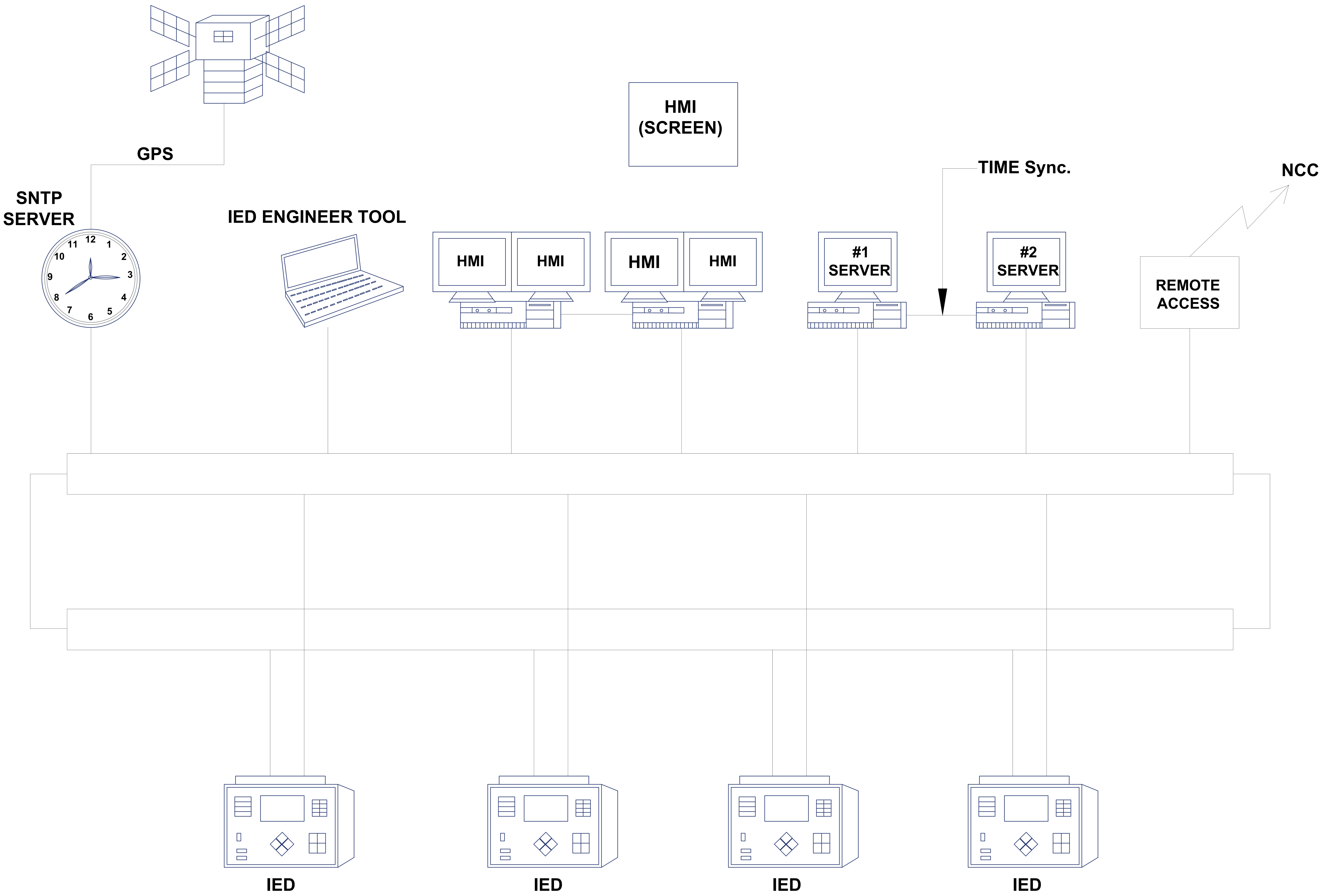
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
ELECTRICAL INTERFACE DIAGRAM BETWEEN CP1 & CP2 FOR 400 MLD PERUR DESALINATION PLANT

Drawn : JN		Checked : OM	
Designed : GG		Approved : GG	
Date : APRIL 2021		Scale : A1 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/022	1 OF 1	R0



SUBSTATION AUTOMATION SYSTEM ARCHITECTURE

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
SMEC India Pvt Ltd.

Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

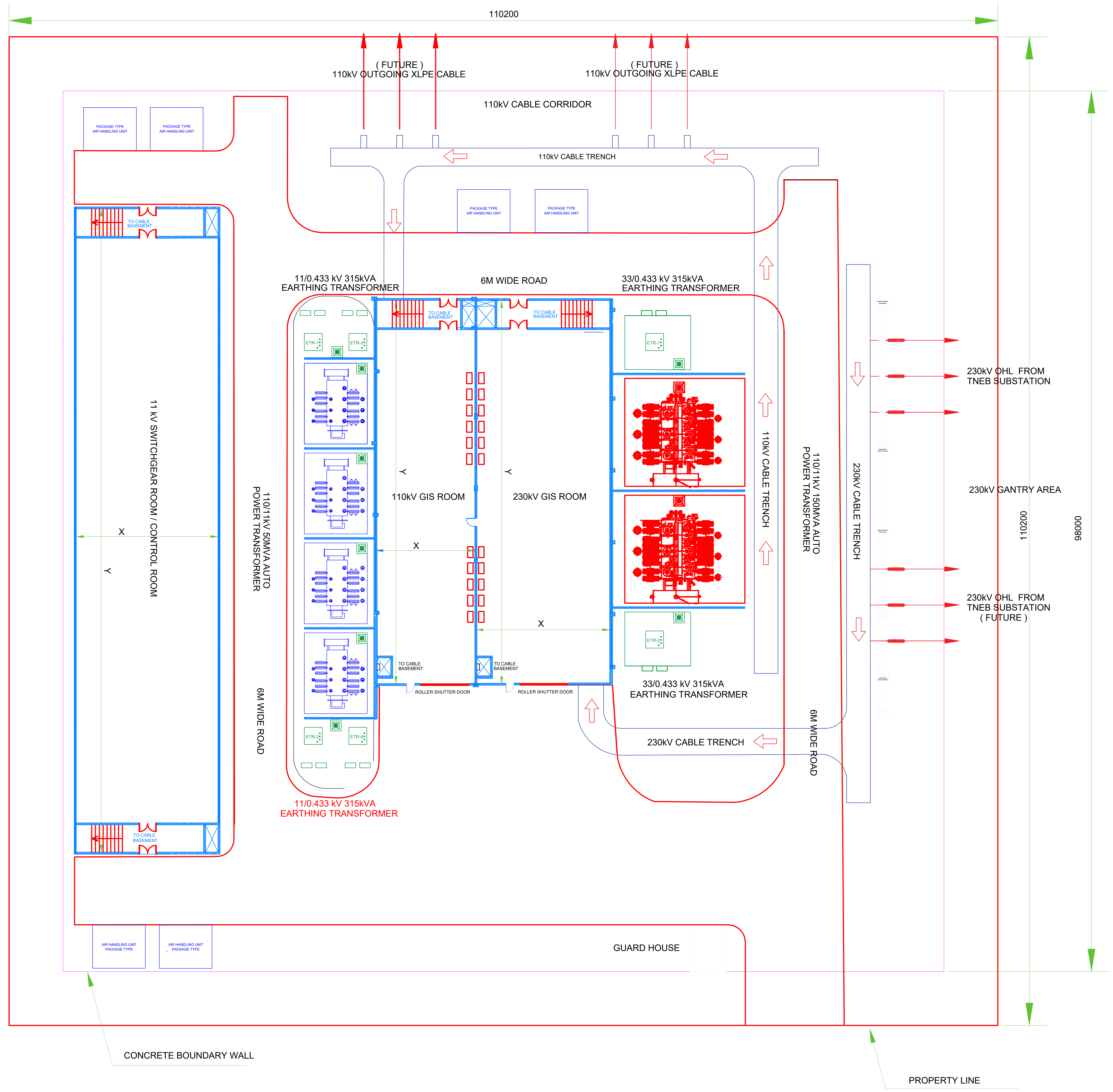
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.:
ID-P267

Drawing Title:
SUBSTATION AUTOMATION SYSTEM ARCHITECTURE

Drawn : JN		Checked : OM	
Designed : GG		Approved : GG	
Date : APRIL 2021		Scale : A1 /1:1	

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/SLD/023	1 OF 1	R0



NOTES :

1. CONTRACTOR SHALL USE COMPOSITE TYPE OUTDOOR CABLE TERMINATION FROM REPUTABLE MANUFACTURERS AS PER IEC62067 AND IEC60815 TO TERMINATE THE 230kV INCOMING OVERHEAD LINES (FROM 230kV TNEB SUBSTATIONS) AT THE POWER RECEIVING GANTRY AREA.
2. CU/XLPE/AWA/HDPE CABLE COMPLYING TO IEC 62271-209 ALONG WITH CABLE SEALING ENDS, CABLE PLUG-IN, OUTDOOR CABLE TERMINATION ACCESSORIES, AND EARTH LINK BOXES FROM REPUTABLE MANUFACTURERS SHALL BE USED TO CONNECT THE FOLLOWING :

   (A) OUTDOOR TYPE CABLE TERMINATION LOCATED AT GANTRY AREA TO INCOMING FEEDER BAY OF THE GAS INSULATED SWITCHGEAR WITH CABLE TERMINATION MODULES AND INSPECTION HOLES.
   (B) GAS INSULATED SWITCHGEAR OUTGOING FEEDER BAY CABLE TO AUTO POWER TRANSFORMER HV TERMINALS WITH TRANSFORMER TUBE TERMINATION MODULES.

   TRANSFORMER TUBE TERMINATION MODULES SHALL BE USED TO CONNECT THE GAS INSULATED SWITCHGEAR OUTGOING FEEDER BAY CABLES TO THE OIL INSULATED TRANSFORMER'S PRIMARY & SECONDARY TERMINALS.

   TRANSFORMER TERMINATION MODULES SHALL BE OIL TIGHT, GAS TIGHT, AND PRESSURE RESISTANT.

3. CONTRACTOR SHALL COORDINATE THE CABLE PLUG AND SEALING END CONNECTIONS WITH THE TRANSFORMER AND GAS INSULATED SWITCHGEAR MANUFACTURERS DURING DETAILED DESIGN, PROCUREMENT, FACTORY ACCEPTANCE TEST, AND SITE ACCEPTANCE TEST.
4. CONTRACTOR SHALL DESIGN AND PROVIDE THE WIDTH AND LENGTH OF THE 230kV and 110kV GIS ROOMS, POWER TRANSFORMER BAYS, EARTHING TRANSFORMER BAYS, 11KV SWITCHGEAR ROOM, CONTROL ROOM, BATTERY CHARGER & UPS ROOM, BATTERY ROOM, DIESEL GENERATOR SET ROOM, CABLE BASEMENTS, ETC. DURING THE BID AND DETAILED DESIGN STAGE.
5. CONTRACTOR SHALL DESIGN AND PROVIDE THE ELECTRIC OVERHEAD TRAVELLING CRANE SIZE AND CAPACITY FOR THE 230kV and 130kV GIS ROOMS.

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	OM	GG

Client: Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant : SMEC International Pty Ltd, TATA Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI), SMEC India Pvt Ltd.

Project Name: Project for Construction of Seawater Desalination Plant (I)

Contract Name: Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

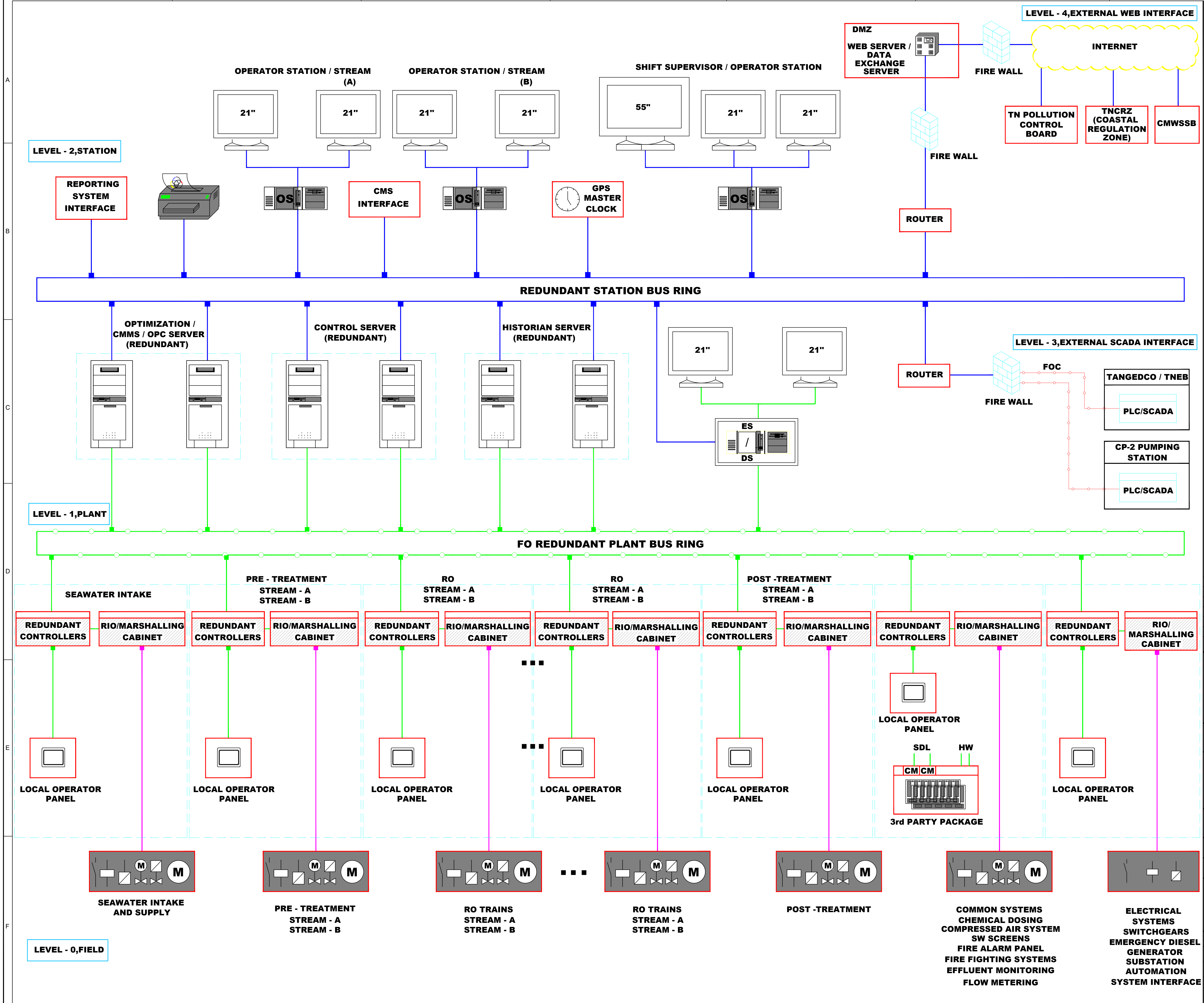
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title: GENERAL ARRANGEMENT PLAN 230/110KV GAS INSULATED SUBSTATION

Drawn :	JN	Checked :	OM
Designed :	GG	Approved :	GG
Date :	APRIL 2021	Scale :	A1 / 1:1

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/E/GAD/001	1 OF 1	R0



NOTES:

1. THE INDICATED DCS ARCHITECTURE IS TENTATIVE ONLY AND HAS TO BE ADJUSTED TO BIDDERS DESIGN.
2. THE INDICATED NUMBER AND PLANT CONFIGURATION ARE PRELIMINARY.FINAL DESIGN SHALL BE DEFINED BY THA BIDDER.
3. COMMUNICATION WITH TANDEGCO/TNEB AND CP-2 PUMPING STATION SHALL BE BY MODBUS TCP/IP OR OPC.
4. FIELD CONTROLLERS ARE TO BE DEDICATED FOR EACH STREAM.
5. DEDICATED WORKSTATION HAS TO BE PROVIDED FOR EACH 200MLD STREAM.
6. ALL INTERFACES TO INCLUDE FIREWALL AND TO COMPLY WITH CYBER SECURITY.

LEGEND:

1. AMR – AUTOMATIC METER READING SYSTEM
2. CMMS – COMPUTERIZED MAINTENNACE MANAGEMENT SYSTEM
3. DMZ – DEMILITARIZED ZONE
4. DS – DIAGNOSTIC STATION
5. ES – ENGINEERING STATION
6. GPS – GLOBAL POSITIONING SYSTEM
7. HW – HARDWIRED
8. OS – OPERATOR STATION
9. SDL – SERIAL DATA LINK
10. TNCRZ – TAMIL NADU COASTAL REGULATION ZONE
11. TANGEDCO– TAMIL NADU GENERATION AND DISTRIBUTIO
12. TNEB – TAMIL NADU ELECTRICITY BOARD
13. FOC – FIBRE OPTICAL CABLE

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R2	APRIL 2021	TENDER PURPOSE	NGM	AAL/GM	PD
R1	10.09.2020	CONCEPTUAL DESIGN REPORT FOR CP1	NGM	AAL/GM	PD
R0	02.09.2020	CONCEPTUAL DESIGN REPORT FOR CP1	NGM	AAL/GM	PD

Client:
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant :
SMEC International Pty Ltd,
TATA Consulting Engineers Limited (TCE),
NJS Engineers India Pvt Ltd (NJSEI),
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Project Name:
Project for Construction of Seawater Desalination Plant (I)

Contract Name:
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Tender Number:
CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

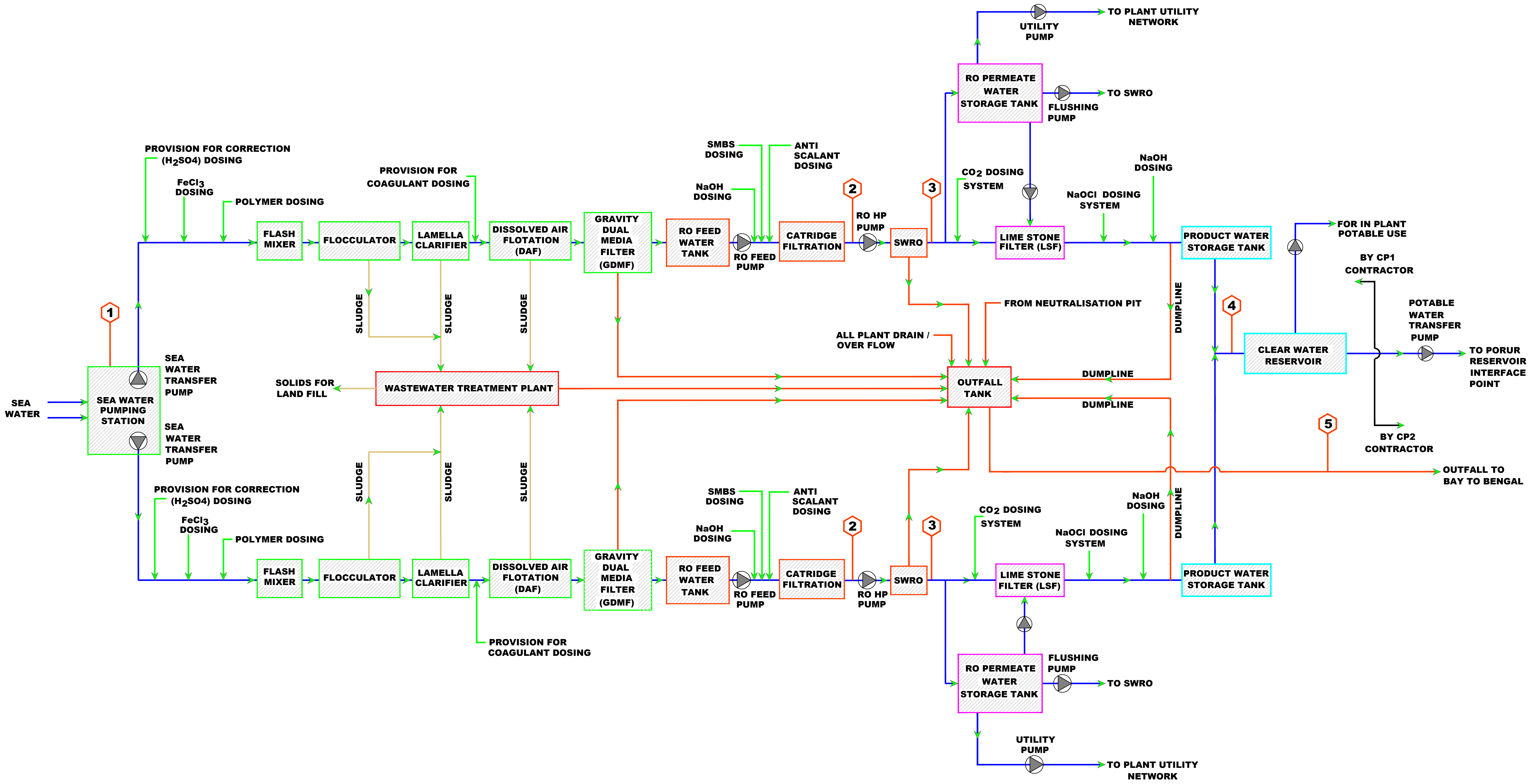
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title:
TENTATIVE DCS ARCHITECTURE & INTERFACES FOR 400 MLD PERUR DSP

Drawn :	NGM	Checked :	AAL/ GM
Designed :	AAL	Approved :	PD
Date :	APRIL 2021	Scale :	A3

Drawing Number: 7061563/PMC400MLD/CP1/I/DCS/001 | Sh.No 1 OF 1 | Revision: R2



NOTES:

1. TWO (2) STREAMS EACH OF 200 MLD CAPACITY PROPOSED

LEGEND:

- INCOMING RAW SEA WATER
- WATER LINE
- REJECT/ BACKWASH/ DRAIN/ BELT FILTER FILTRATE,SUPERNATANT/ RINSE/ DUMPLINE
- AIR FOR BACKWASH/ MIXING
- CHEMICAL DOSING
- SLUDGE / SCREENINGS
- BLOWER / COMPRESSOR
- PUMP
- INTERFACE POINT

SWRO	SEAWATER REVERSE OSMOSIS
CF	CARTRIDGE FILTER
CIP	CLEAN IN PLACE
HP	HIGH PRESSURE
SMBS	SODIUM META BI SULPHATE

FOR TENDER PURPOSE ONLY

NOTE:-

(i) CRITICAL CONTROL POINTS

(ii) TWO STREAMS OF EACH 200 MLD.

1 CRITICAL CONTROL POINTS FOR OIL / TURBIDITY
2 CRITICAL CONTROL POINTS FOR ORP / SDI / BOREN
3 CRITICAL CONTROL POINTS FOR TDS
4 CRITICAL CONTROL POINTS FOR PRODUCT WATER QUALITY / QUANTITY
5 CRITICAL CONTROL POINTS FOR OUTFALL WATER QUALITY

CRITICAL CONTROL POINTS FLOW DIAGRAM FOR PROPOSED 400 MLD PERUR DSP

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	NGM	GM/MM	PD

Client: Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant : SMEC International Pty Ltd, TATA Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI), SMEC India Pvt Ltd.

Project Name: Project for Construction of Seawater Desalination Plant (I)

Contract Name: Procurement of design/Engineering,Construction,Commission of 400 MLD Seawater Reverse Osmosis (SWRO) Desalination Plant at Perur, Chennai with 20 Years of Operation and Maintenance (DBO Basis)

Tender Number: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

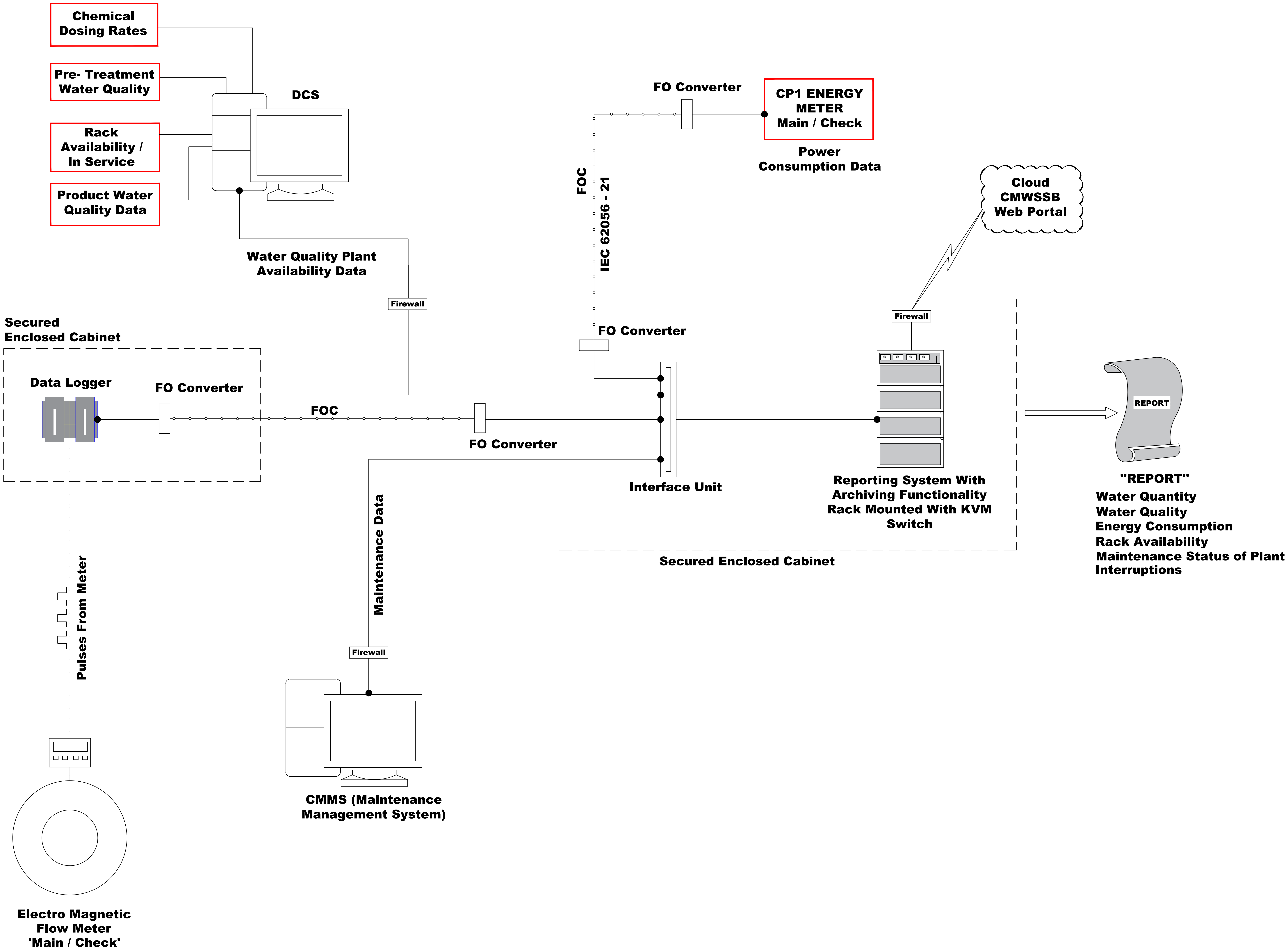
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title: CRITICAL CONTROL POINTS (CCP) FLOW DIAGRAM FOR PROPOSED 400 MLD PERUR DSP

Drawn: NGM	Checked: GM / MM		
Designed: SMK	Approved: PD		
Date: APRIL 2021	Scale: NTS		
Drawing Number: 7061563/PMC400MLD/CP1/I/CCP/002	Sh.No 1 OF 1	Revision: R0	

REPORTING SYSTEM



Notes:

1. Reporting Resolution Available Monthly / Daily / Hourly.
2. All External Interfaces From (or) To The System Should Be Through Firewall.
3. Chemical Dosing Rates Calculated From Dosing Pumps Operation.
4. Rack Availability / Rack In Service Data Provides Capacity Data Of The Plant.
5. Energy Meter Data Provides Power Consumption Of The Plant.
6. DCS Interface To Provide The GPS Time To The Reporting System.
7. Pre-Treatment Water Quality To Include SDI / and TDS.

Legend:

	Fibre Optic Communication
	Communication Interface Hard Wired
	Pulse Interface
	Pulse Output From The Flow Meter
KVM	Keyboard, Video, Mouse
CMMS	Computerized Maintenance Management System
FOC	Fiber Optic Cable

FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	AAL/GM	PD

Client: Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

Project management Consultant : SMEC International Pty Ltd, TATA Consulting Engineers Limited (TCE), NJS Engineers India Pvt Ltd (NJSEI), SMEC India Pvt Ltd.

Project Name: Project for Construction of Seawater Desalination Plant (I)

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Tender Number: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

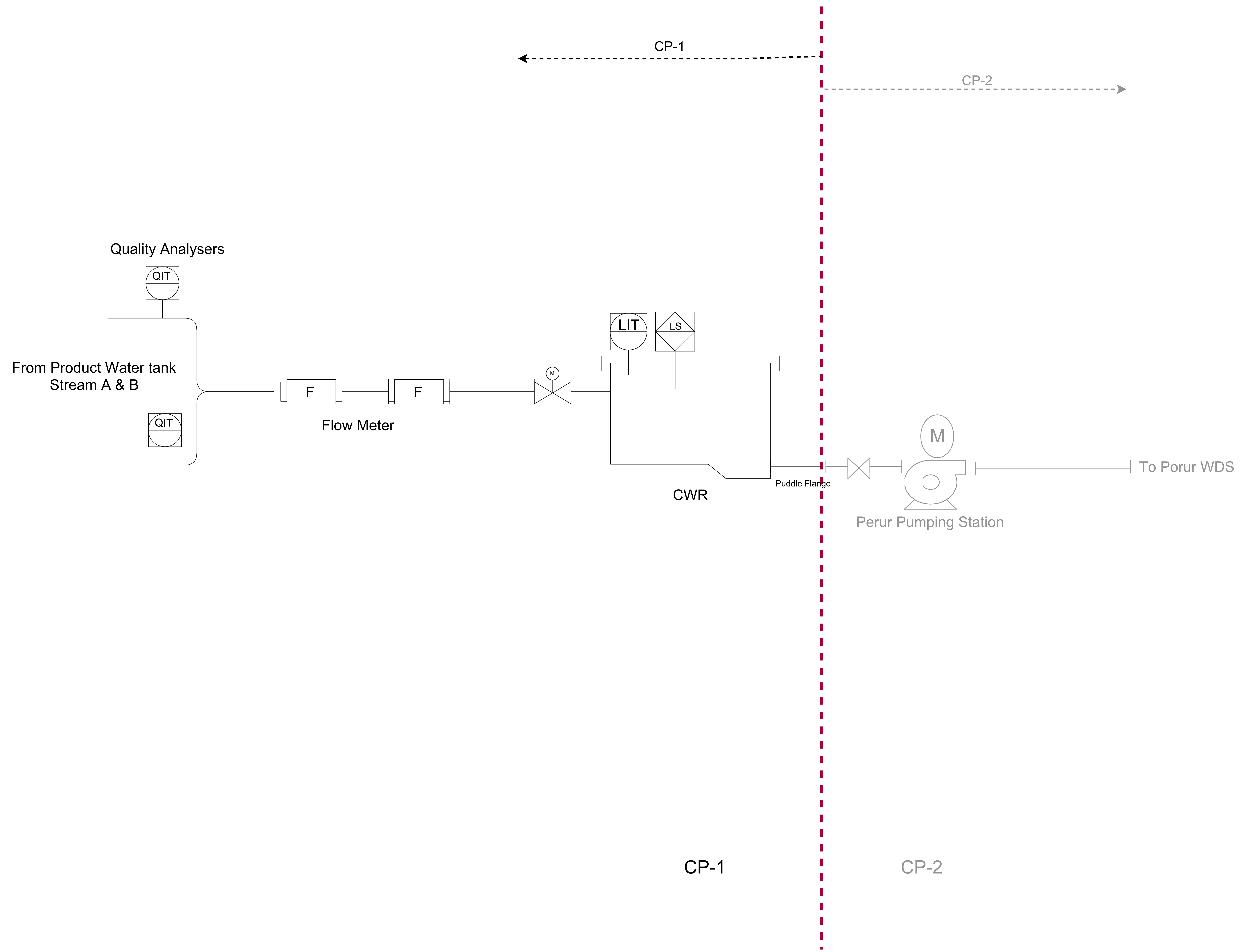
Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title: TENTATIVE REPORTING SYSTEM ARCHITECTURE

Drawn :	JN	Checked :	AAL/ GM
Designed :	AAL	Approved :	PD
Date :	APRIL 2021	Scale :	A3

Drawing Number: 7061563/PMC400MLD/CP1/I/RPS/003 | Sh.No 1 OF 1 | Revision: R0



FOR TENDER PURPOSE ONLY

Rev	Date	Description	Drawn	Chkd	Appd
R0	APRIL 2021	TENDER PURPOSE	JN	AAL/GM	PD

Client:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

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SMEC International Pty Ltd,
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Tender Number:

CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/018/2020-21

Contract Package No.: Contract Package -1 (CP1)

JICA Loan No.: ID-P267

Drawing Title:

CP1-ICA-DEMARCATION DRAWING

Drawn :	JN	Checked :	AAL/ GM
Designed :	AAL	Approved :	PD
Date :	APRIL 2021	Scale :	A3

Drawing Number:	Sh.No	Revision:
7061563/PMC400MLD/CP1/I/DEM/004	1 OF 1	R0