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 <u>Seawater Intake</u>

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.

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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

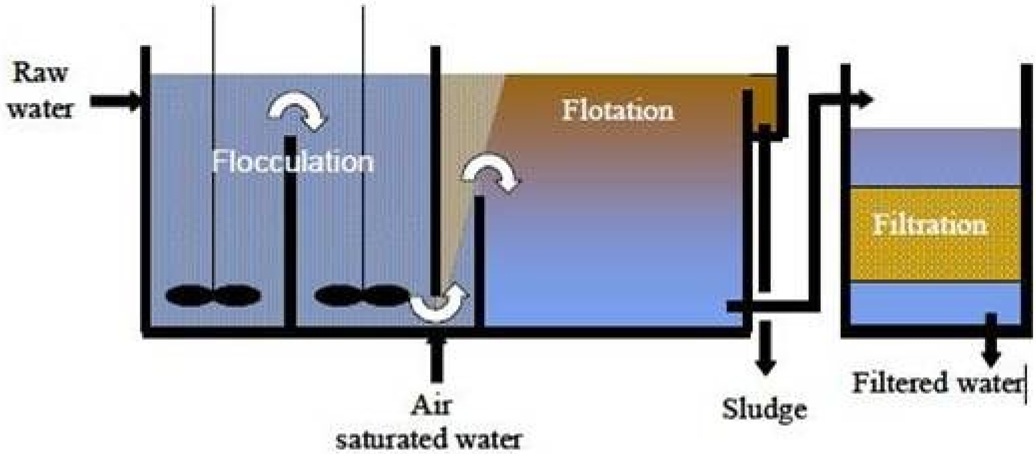
Lamella settlers can quickly remove large amount of relatively coarse material. Coagulation and flocculation are provided prior to the Lamella settlers. 18m x 7.5 m sized lamella settlers have been proposed for this plant with 24 settlers at less than 15 m/hr surface loading rate.

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.