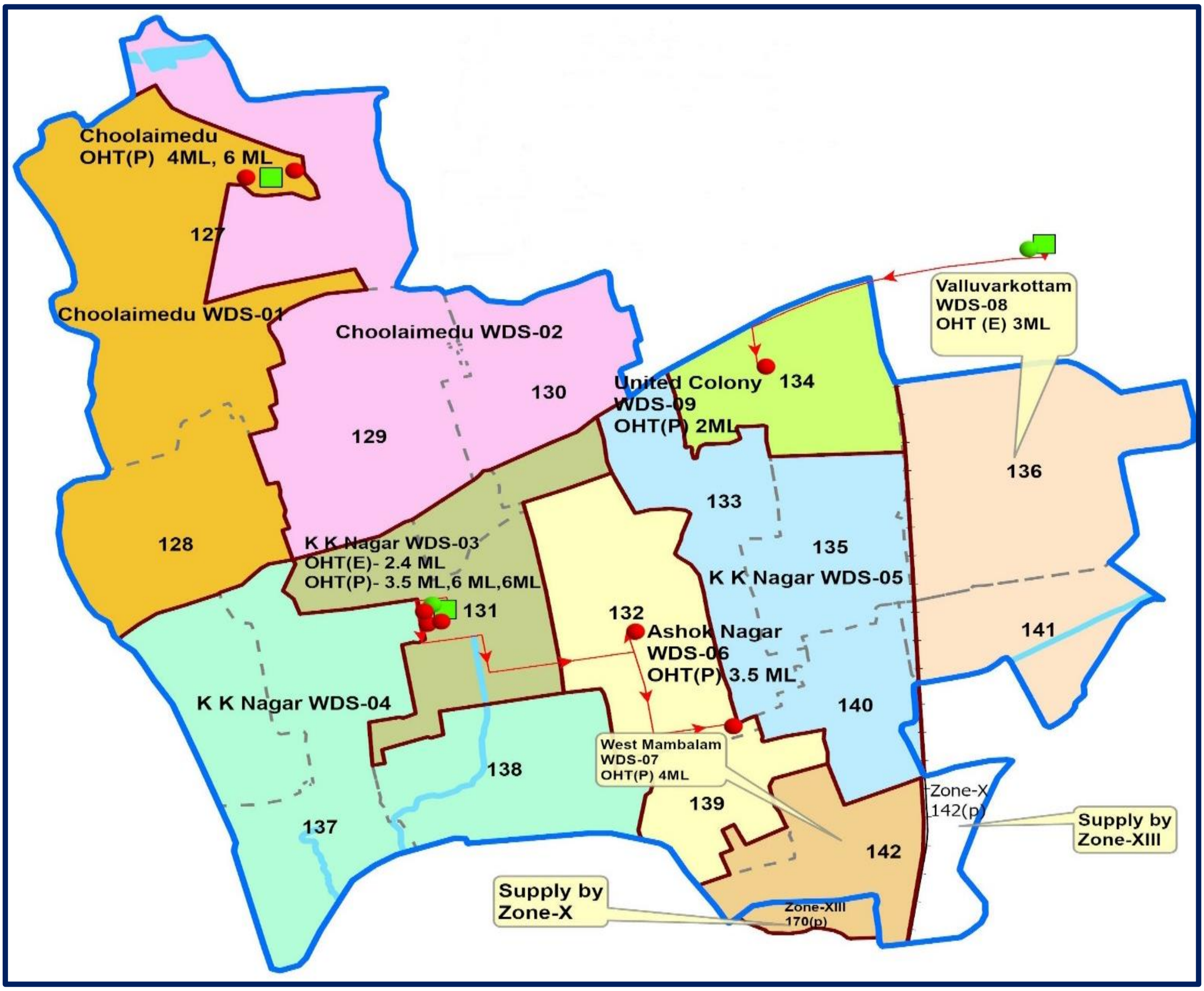
CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD (CMWSSB)

JICA Assisted "Project For Construction of 400 MLD Capacity Seawater Reverse Osmosis Desalination Plant At Perur And Allied Works (JICA Loan Id-P267)

Contract No. : CNT/ CON/DESAL /ICB/GoI/016/2018-19

DRAFT DETAILED DESIGN REPORT FOR AREA X

(Package CP4: Improvement of the Existing Water Distribution Networks- Chennai Core City)
[Volume 1 of 4]- Main Report



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Document Control

Document:	**Draft Detailed Design Report for Area X – Package CP4**
File Location:	-
Project Name:	**JICA Assisted "Project For Construction of 400 MLD Capacity Seawater Reverse Osmosis Desalination Plant At Perur And Allied Works (JICA Loan Id-P267)**
Revision Number:	0 (Draft Submission)

Revision History Revision No.	Date	Prepared by	Reviewed by	Approved for Issue by
0	3 January 2022	CP-4 Team	Mr Siddappaswamy	Dr. P. Dharmabalan

Issue Register

Distribution List	Date Issued	Number of Copies
CMWSSB	3 January 2022	2 Copies

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List of Abbreviation and Acronyms

Acronyms	Abbreviation
AMSL	Above the Mean Sea Level
BOQ	Bill of Quantities
C&M	Contracts and Monitoring
CMA	Chennai Metropolitan Area
CMWSSB	Chennai Metropolitan Water Supply & Sewerage Board
CP	Contract Package
CPCB	Central Pollution Control Board
CRZ	Coastal Regulation Zone
CRZC	Coastal Regulation Zone Clearance
CWDL	Chennai Water Desalination Ltd
CZMA	Coastal Zone Management Authority
CZMP	Coastal Zone Management Plan
DAE	Deputy Area Engineer
DFR	Detailed Final Report
DFR/FR	Draft Final Report/Final Report
DMA	District Metering Area
DP	Distribution Pipe
DPR	Detailed Project Report
DSP	Desalination Plant
ECR	East Coast Road
FR	Final Report
GCC	Greater Chennai Corporation
GER	Gross Enrollment Ratio
GO	Government Order
GOI	Government of India
GOJ	Government of Japan
GOTN	Government of Tamil Nadu
H.W.	Head Works
HO	Head Offices
HP	Horse-Power
HP	High Pressure
HQ	Headquarters
HR&CE	Hindu Religious and Charitable Endowment
HRM	Human Resource Management
HSC	House Service Connection
ICR	Inception Report
IEC	Information Education Communication
IEE	Initial Environmental Examination
IMD	Indian Meteorological Department
IR	Impact Rate
IS	Indian Standards
JICA	Japan International Cooperation Agency
KL	Kilo liter
km	kilometer
KwH	kilowatt-hour
LAP	Land Acquisition and Resettlement Action Plan
m	meter
m/hr	meter per hour
M/P	Master Plan
m/s	meter per second

Acronyms	Abbreviation
MAWS	Municipal Administration Water Supply
MOD	Minute of Discussion
mg/L	milligram per liter
MIS	Management Information System
MLD	Million Liters per Day
mm	millimeter
MORD	Ministry of Rural Development
MSL	Mean Sea Level
NGO	Non-Governmental Organization
NH	National Highway
OHT/OHSR	Over Head Tank/Over Head Service Reservoir
O&M	Operation and Maintenance
S/S	Substation
S.No	Serial Number
SIA	Social Impact Assessment
SIM	Social Impact Management
TCE	Tata Consulting Engineers
TOR	Terms of Reference
TP	Town Panchayat
TP	Transmission Pipelines
UGT	Underground Tank
VP	Village Panchayat
WDS	Water Distribution Station
WDZ	Water Distribution Zone
WHO	World Health Organization
WRD	Water Resource Department
WSS	Water Supply System
WSSB	Water Supply & Sanitation Board
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

Background:

Chennai (Madras, erstwhile) was established in 1639 and became the Capital City of Tamil Nadu State during the re-organization of the states. The population of Chennai Core city as per the 2011 census was 46,46,732, and the area is 176 Sq km. After reorganising administrative boundaries, the city presently has 7 (10 erstwhile) administrative areas, namely IV, V, VI, VIII, IX, X & XIII, accommodating 107 Wards/Depots (155 depots erstwhile). Chennai Metropolitan Water Supply and Sewerage Board ("CMWSSB" or "the Client") is responsible for the administration and operation, and maintenance of Chennai City's water production, treatment, storage, distribution, billing and revenue collection. The present water supply system is intermittent due to various constraints in source, storage facilities and adequacy of the existing distribution system. The Chennai Core city's average per capita water supply is around 101 lpcd. To improve the current water supply situation, the Chennai Metropolitan Water Supply and Sewerage Board ("CMWSSB" or "the Client") has obtained a loan from the Japan International Cooperation Agency ("JICA") through the Tamil Nadu Government to supplement current supplies with a 400 MLD Sea Water Desalination plant at Perur, additional storage facilities and other allied works.

CMWSSB has selected a Project Management PMC ("PMC") through a competitive bidding process to support the CMWSSB Project Implementation Unit ("PIU") for the development of the 400 MLD Seawater Desalination Plant and its components (collectively referred to as the "Project"). A Consultancy Contract agreement was signed dated January 09, 2020, for Consulting Services with the PMC for this Project. The PMC is a Consortium comprising SMEC International Pty Ltd., Australia as the lead member of the consortium, Tata Consulting Engineers Limited (TCE), NJS Engineers India Pvt. Ltd. (NJSEI) and SMEC (India) Private Limited as Associate PMCs to the consortium.

Need for the project:

There is an inequitable supply of drinking water both in quantity and pressure. This is because of the inadequacy in the demand /supply management plan. Therefore, it is imperative to formulate a proposal to improve the existing distribution system to achieve equitable and sustainable 24 X 7 water supply to all the zones of Chennai core city.

However, administrative areas X and XIII are prioritised based on the client's funding allocation and execution purpose. The present report comprises the detailed draft design for improving water distribution networks in admin Area X under construction package CP4. The design includes replacement/strengthening of existing distribution pipes, pumping systems, overhead storage tanks, development of District Metering Areas, campaign for Unaccounted for water and water quality improvement, and the inclusion of supplementary water supply assets ensuring proper efficiency, maintainability, and flexibility for water supply service.

Table- 1 Salient Features Of Admin Area X

Sl.No.	Details	Remarks
1.	Area (sq.km)	22.31
2.	Total Number of Depots	16
3.	Population as per 2011 Census	7,31,530
4.	Base Year Population Adopted 2025	7,79,620
5.	Intermediate Year Population Adopted - 2040	8,36,230
6.	Ultimate Year Population Adopted - 2055	8,94,250
7.	Total number of Assesses (Based on tax paid)	1,47,740
8.	Total number of House service connection	117763
9	No of metered connections	1960
9.	Length of Roads (in Kms)	440 Km

PROJECT HORIZON YEARS:

The ultimate design year is considered 2055, and the project will be commissioned in 2025 (Base year). So the horizon years are considered 2040 (as an intermediate year) and 2055 (the ultimate year).

DETAILS OF DEPOTS UNDER AREA X:

Area X presently covers a total of 16 wards/Depots numbered from 127 to 142

EXISTING WATER SUPPLY SYSTEM IN AREA X:

Sources of Water Supply

Presently all Area X water distribution stations (WDS) are receiving the water mainly from two sources, namely Vadakuthu WTP and Chembarambakkam WTP. However, the details of each WDS under Area X with their source connectivity and beneficiary Depots are shown below.

Table- 2 WDS FEEDING ADMIN AREA X - PRESENTLY

Sl.No.	WDS Name	Beneficiary Depots	Sources
1.	Choolaimedu	127, 128P, 129P, 130P,131P, 132P, 133P, 134P, 135P	Chembrambakkam & Vadakuthu, Puzhal WTPs and Minjur DSP

Sl.No.	WDS Name	Beneficiary Depots	Sources
2.	KK Nagar New	131P, 132P, 133P, 137P, 138P, 139P, 140P, 142P	Chembrambakkam & Vadakuthu WTPs
	KK Nagar Old	128P,131P, 132P, 133P, 135P,137P,138P, 139P	
3	Valluvarkottam	129P,130P,133P,134, 135P	Chembrambakkam & Vadakuthu, Puzhal WTPs and Minjur DSP
4	Southern Headworks	136, 140P, 141, 142	Chembrambakkam & Vadakuthu, Puzhal, Kilpauk and Minjur DSP

Source: As per site information, P- Part of the Depot

Storage Facilities & Pumping details at WDS Location

Various storage and pumping facilities currently serving the Admin Area X- are shown below.

Table- 3 STORAGE AND PUMPING FACILITIES -SERVING ADMIN AREA X PRESENTLY

Sl. No.	WDS Name	Storage facilities (ML)		Pumping Facilities			
		UGT	ELSR	Discharge MLD	Head (m)	No	Type
1.	Choolaimedu	43		90.72	30	4+2	HSC
2.	KK Nagar New	14	2.4	50.98	30	4+2	VT
3.	KK Nagar Old	9	0.9, 0.9	12.10	28.6	4+2	HSC
4.	Valluvarkottam	15	3	65.23	32	2+2	HSC
5.	Southern Headworks	24	4.5	39.31	35	4+2	HSC

Source: Site information collected by PMC team

Existing Distribution Network:

The total lengths of the existing pipelines are about 502 km diameter ranging from 100mm to 1600mm. The CI piping material comprises 88.58% of the total pipe-lengths, while DI and PVC piping material comprises 11.25% and 1.45 %, respectively, with 0.16% only MS piping material. Dia and material-wise Pipe line breakup is shown below Table.

Table- 4: DETAILS OF EXISTING DISTRIBUTION NETWORK- AREA X

Sl.No.	Dia (mm)	Material				Total Length (m)
		CI	PVC	MS	DI	
1.	100	322626.70			27460.42	350087.12
2.	110		728.42			728.42
3.	150	35001.22			12494.40	47495.62
4.	160					0.00
5.	200	19048.66			5187.47	24236.13
6.	225	793.77				793.77
7.	250	14294.81			575.93	14870.74
8.	300	13391.98			2316.24	15708.22
9.	350	3450.26			3358.61	6808.87
10.	400	13830.85			2099.94	15930.79
11.	450	1974.26			11.66	1985.93
12.	500	3496.42			446.88	3943.30
13.	525	5261.86			0.00	5261.86
14.	600	1514.83			481.73	1996.55
15.	700	2196.59			1618.23	3814.82
16.	750	3602.70			0.00	3602.70
17.	800	0.00			463.40	463.40
18.	900	3310.06		29.90	0.00	3339.96
19.	1100	0.00			0.00	0.00
20.	1200	0.00		52.58	0.00	52.58
21.	1600			830.56	0.00	830.56
Total		**443794.97**	**728.42**	**913.04**	**56514.90**	**501951.34**

Source: Site information collected by PMC team

Presently, there are no specific hydraulically delineated zones based on the storage reservoir's capacity topographical features, or population. No isolation of Water Distribution Zones (WDZ) has been made, and interconnections exist between the WDZ, making the system difficult to manage. Further, the operational area and depot offices of CMWSSB are aligned geographically to the depots and not spatially to the hydraulic zones resulting in inefficiency/difficulty of operation and maintenance works.

Population Projections and Water Demand details of Area X:

As per the 2011 census, the total population of Chennai core city is 46,46,732, out of which Zone -X contributes to 7,31,530 as No Census data is available for the year 2021. PMC has collected the population record information available in JICA and master plan reports and proportionately estimated for the year 2055 as defined by the client. Water demand estimation for various horizon years has been worked out accordingly. Table 5 shows the projected population and water demand details at the WDS level for the base, intermediate and ultimate years for the admin Area X.

Table- 5 : POPULATION ESTIMATION DETAILS - AREA X

Sl. No.	Description	2025	2040	2055	Remarks
1	Population	779620	836230	894250	
2	Domestic Demand (MLD)	115.77	124.18	132.80	@ 135 LPCD with 10% distribution losses
3	Commercial Demand (MLD)	5.79	6.21	6.64	5% of domestic water demand
4	Fire Demand (MLD)	10.99	11.38	11.76	As per CPHEEO Manual Fire demand, Clause No 2.2.8.3 (C)
5	Bulk consumer Demand (MLD)	7.20	7.20	7.20	At actual as per data received from CMWSSB
6	**Total (MLD)**	**139.75**	**148.97**	**158.4**	2+3+4+5

Proposed Water Supply infrastructure:

Storage Facilities:

Most of the storage facilities in Area X are in the form of the (UGT) underground storage tanks. It is proposed to build additional storage facilities in the overhead tanks (OHT) for a 24X7 gravity supply. Due to the limited land availability for constructing reservoirs at some locations, reservoirs are designed to the maximum possible capacity based on the site dimension/layout. Based on the proposed overhead storage facilities, command area (Beneficiary depots) details are finalized under each reservoir. Details of various storage facilities proposed and Beneficiary depots under each OHT are as follows.

Table- 6 : PROPOSED STORAGE FACILITIES WITH BENEFICIARY DEPOTS

AREA X - SUMMARY OF STORAGE FACILITIES WITH BENEFICIARY DEPOTS							
S.No	**OHTs location**	**UGT Capacity in ML(existing)**	**OHT Capacity in ML**	**Beneficiary Depot**	**Total Ave. Demand (The year 2055) MLD**	**Type of Supply/OHT Shape**	**Supply to OHTs**
1	Choolaimedu	43	4 ML	127(P),128(P)	14.57	Gravity/ Circular	Choolaimedu WDS
			6 ML	127(P), 129, 130(P)	22.35		
2	KK Nagar WDS	14+9	2.4E+ 3.5P	131,129(P),130 (P)	21.71	Gravity/Circular	KK Nagar WDS
			6P	137,138,128(P)	22.45		
			6P	133, 135, 140	23.95		
3	West Mambalam		4P	142(P)#,139(P), 170 (P)^	13.68	Gravity/ rectangular	KK Nagar Old WDS
4	Ashok Nagar		3.5P	132,139(P)	14.88	Gravity/ rectangular	
5	Valluvar Kottam	15	3E	136, 141	13.42	Gravity/ Circular	ValluvaruKottam WDS
6	United Colony		2 P	134	8.05	Gravity/ rectangular	
	Total	**72**	**40.4**		**155.06**		
P- Proposed, E-Existing, (P)- Part of the depot ^ - 170 of Admin Area XIII, # - Part of Depot served by Admin area XIII							

The table shows that new additional overhead storage facilities of 35 MLD have been proposed other than the existing 5.4 MLD.

Pumping facilities:

The new pumping facilities proposed to lift the water to the overhead reservoirs from the underground storage reservoirs.

Table- 7 -PROPOSED PUMPING FACILITIES

S.No	**WDS location**	**Type of Pump**	**Discharge (MLD)**	**Head**	**No**	**OHT Location**
1	Choolaimedu	HSC	38	32	1W+1S	Choolaimedu-6ML &4ML
2	KK Nagar New WDS	VT	23	34	1W+1S	KK Nagar WDS -3.5 ML& 2.5 ML
		VT	48	32	1W+1S	6 ML- 2 Nos at KK Nagar WDS
	KK Nagar Old WDS	HSC	29	36	1W+1S	Ashok Nagar -3.5 ML and West Mambalam- 4 ML

S.No	WDS location	Type of Pump	Discharge (MLD)	Head	No	OHT Location
3	Valluvar Kottam	HSC	23	30	1W+1S	Vallurukottam- 3 ML and United colony -2 ML

Hydraulic Zones:

A total of 9 no of revised hydraulic zones is proposed based on storage capacities of overhead tanks. Details of hydraulic zones with beneficiary wards are shown in Table 8. Fig 1 shows revised hydraulic zone boundaries of admin area X.

Table- 8 PROPOSED HYDRAULIC ZONES DETAILS

S No	Hydraulic Zone	OHT Capacity	Staging Ht (m)	Benefited Depots	Supply to OHTs
1	Choolaimedu WDS 01	4 ML- N	20	127(P),128(P)	Choolaimedu
2	Choolaimedu WDS 02	6 ML- N	20	127(P), 129, 130(P)	
3	KK Nagar WDS 03	2.4 ML-E, 3.5 ML-N	20,20	131,129(P),130 (P)	KK Nagar New WDS
4	KK Nagar WDS 04	6 ML-N	20	137,138,128(P)	
5	KK Nagar WDS 05	6 ML-N	20	133, 135, 140	
6	Ashok Nagar WDS 06	3.5 ML-N	17	132,139(P)	KK Nagar Old WDS
7	West Mambalam WDS 07	4ML-N	17	142(P)#,139(P), 170 (P)^	
8	Valluvarkottam WDS 08	3 ML-E	20	136, 141	Valluvarkottam
9	United Colony WDS-09	2 ML-N	17	134	

Distribution Network:

Most of the pipeline network in the existing system is of CI material and is a minimum of 20 years old and got encrusted due to the absence of internal protective lining/coating. Based on the site investigations, consumer complaint records, and hydraulic analysis of the existing network for 24X7 supply, it is obvious that the existing system cannot cater to the base year demand requirements. Further, as per the information received from the client, it is understood that house service connections are made on the feeder lines of dia up to 250mm, which is not an acceptable practice for better control and maintenance of the required pressure in the distribution system. Hence, it is discussed and decided to completely replace all CI pipes of dia up to 250mm. Total 8 hydraulic zones are prepared to cover all the depots of Admin area X, excluding a small portion of ward no 142 and including part of ward no 170 of Admin area XIII based on the natural boundaries and storage facilities. The total number of DMAs identified is 67 Nos, with several House service connections in each DMA ranging from 1000-5000.

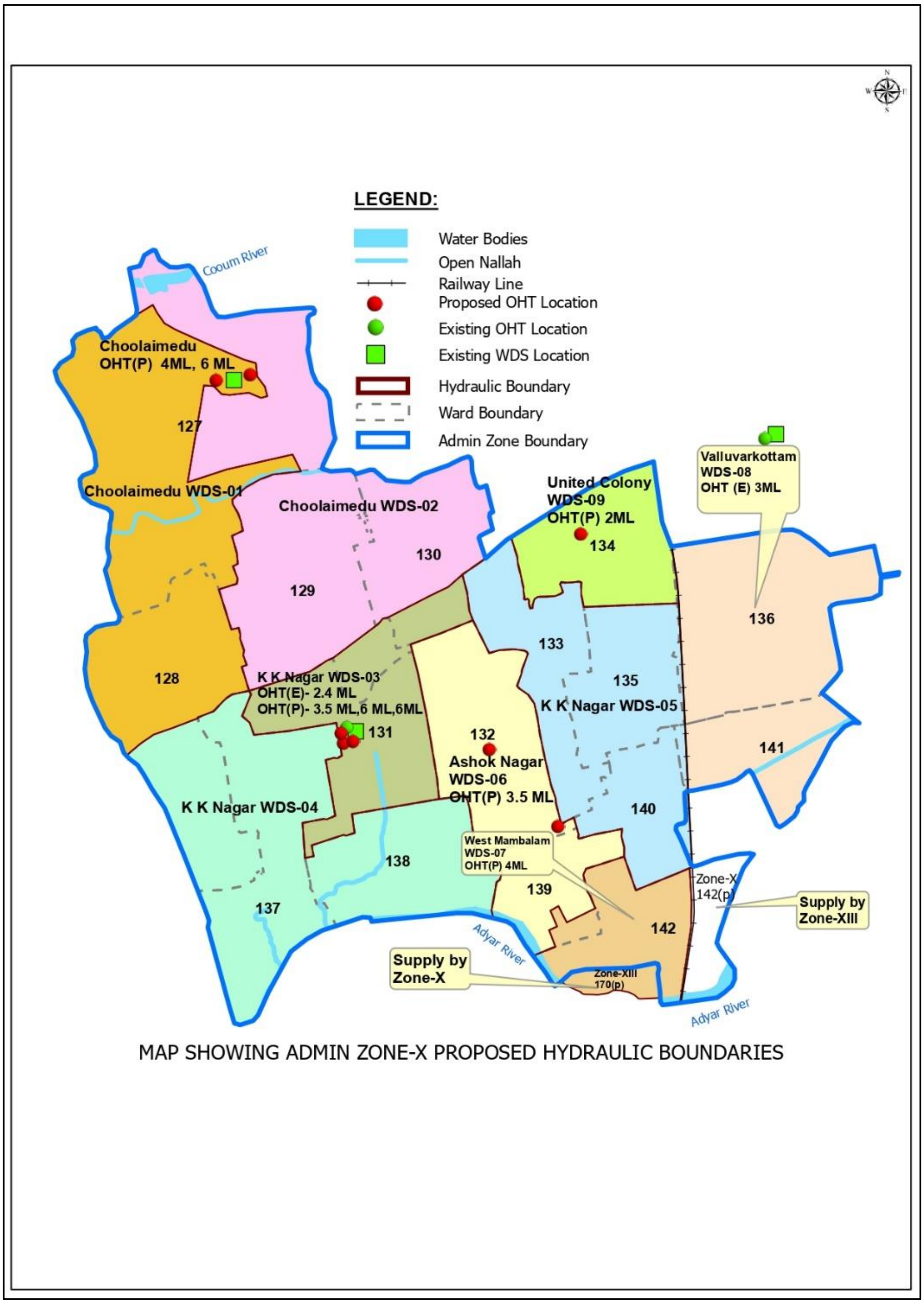


Figure- 1. Map Showing the Proposed Hydraulic Zonal Boundaries of Admin Area X

Summary of details of new pipe proposed and existing pipes retained/replaced are shown in below table 9.

Table- 9 : DISTRIBUTION NETWORK DETAILS – BASED PROPOSED HYDRAULIC ZONES

PIPE LINE SUMMARY DETAILS OF AREA-X- LENGTH in meters						
Diameter (mm)	**CI/E**	**CI/R/DI**	**DI/E**	**DI/P**	**PVC/R/DI**	**MS/E**
100	0	425,136	31,628	20,278	750	0
150	0	1,003	9,115	39,820	0	0
200	0	616	4,508	17,627	0	0
250	0	0	1,272	13,894	0	0
300	6,877	0	3,935	8,787	0	0
350	1,212	0	755	842	0	0
400	7,107	0	2,033	3,612	0	0
450	1,977	416	0	13	0	0
500	2,525	0	491	3,696	0	0
525	1,455	0	0	0	0	0
600	1,522	1,301	461	2,075	0	0
700	0	0	668	1,382	0	0
750	448	0	0	0	0	0
800	0	0	494	75	0	0
900	2,729	0	0	1,731	0	0
1200	0	0	0	0	0	83
1,600	0	0	0	0	0	913.04

Project Cost Estimate:

The detailed cost estimates for the project have been carried out item-wise, based on the schedule of rates (SoR) published by CMWSSB, TWAD Board and CPWD for the year 2021-22. For the items for which rates are not available in SoR, quotations are collected from the reputed vendors, suppliers, and manufacturers. Physical Contingencies @ 2.5% and labour welfare fund @1% on the base cost of work is considered. GST of 18% and provisional sum @ 5% (Breakup is shown in Table-10) is considered on the project's total cost. The total estimated cost for improving the distribution network of the Admin zone is around 1019.58 Crores. The “Summary of Total Cost” is given in Table-10.

Table- 10: General Abstract of draft cost estimate for Admin Area X

S. No	Description of Item	Amount in INR Cr.
1	Providing comprehensive water supply scheme to Area-X of core city (A)	519.12
2	Contingencies and Unforeseen items @ 2.5% of (A)	12.98
	Sub-Total (B)	**532.09**
3	GST @ 18%	95.78
4	Provision for Investigation charges @ 0.5% of (A)	2.60
5	Supervision Charges @ 5% of (B)	26.60
6	Labour Welfare cess @ 1% of (A)	5.19
7	Road Restoration charges	293.16
8	Third party inspection charges @ 1% of (A)	5.19
9	TNEB service connection charges @ 0.25% of (A)	1.30
10	Provision for Dewatering arrangements (LS)	0.10
11	Demolition of existing structures @ 0.15% of (A)	0.78
12	Provision for environmental monitoring charges @ 0.1% of (A) (As applicable)	0.52
13	Provision for social intervention charges @ 0.15% of (A) (As applicable)	0.78
14	Shifting of Underground utilities @ 2% of (B)	10.64
15	Prvision for Rehabilitation of existing PH & UGT 0.1% of (A)	0.52
16	Provision for Trenchless Technology (LS)	0.20
17	Provision for pipe carrying bridge (As applicable)	0.00

S. No	Description of Item	Amount in INR Cr.
18	Provision for price escalation for the First year @ 5% of the Base Cost (A)	25.96
19	Provision for price escalation for the Second year @ 5% of 70% of Base Cost (A)	18.17
	Grand Total	**1,019.58**

Note: Provision for price escalation is considered for 2 years only and for project duration more than 2 years then the provision for further years to be considered.

1 CHAPTER 1: BACKGROUND AND SCOPE OF WORK

1.1 Project Background and its Objective

Chennai (Erstwhile Madras) municipal corporation was established in the year 1688 with an area of around 176 Sqkm (Presently known as Core City covering seven administrative areas, namely IV (Thondiyarpet), V (Royapuram), VI (Thiru.vi.ka. Nagar, VIII (Anna Nagar), IX (Teynampet), X (Kodambakkam) and XIII-Adyar) and became Greater Chennai Corporation (GCC) in the year 2011 after integration of neighbouring 42 local urban bodies (called as expanded area) covering a total area of 426 sqkm. Currently, GCC consists of 15 administrative zones covering 200 wards/depots, out of which the core city covers 107 depots with 7 administrative zones. With its expanded area, Chennai core city has further been extended by adding adjacent and distant urban/rural areas of Thiruvallur and Kanchipuram Districts, which constitutes the Chennai Metropolitan Area (CMA). The Total area covered under Chennai Metropolitan Area (CMA) is 1189 sq. km.

The Chennai municipal corporation was responsible for water supply and sewerage services in their area until CMWSSB was formed in 1978 under CMWSSB Act 28 by the Govt of Tamilnadu. Though CMWSSB is responsible for providing the water to all the people and businesses in the entire CMA, due to shortage in water volume and human resources availability, currently their services are limited to the Chennai Corporation area and some bulk water supply to the Cantonment area in the expanded area and some part of the rest of CMA.

Rapid urbanization and migration to the Chennai Metropolitan Area from other parts of the State have resulted in a significant increase in population, leading to a substantial increase in the demand for water supply and other infrastructure facilities. This growing, dynamic need called for prudent utilization of the existing water supply sources and an urgent need to improve/ augment the existing sources.

The entire Chennai core city is divided into 18 Water distribution Zones (WDZs) based on storage facilities in the area. However, the present system could not provide equitable water supply with adequate pressure at all points due to improper zoning/operational problems.

In 2016, the Government of Tamil Nadu established a Master Plan for Water Supply and Sewerage Sectors (MPWSSS) for Chennai Metropolitan Area (CMA). The aim of MPWSSS was to develop a proper overall long-term plan to satisfy the expected water supply demands and sewerage services over a 30-year horizon starting from 2020 up to 2050.

According to the output of the master plan and based on water demands statistics (2015), the Government of Tamil Nadu noted a 36% deficiency between the supply and demand (686 MLD against 933 MLD) upon which, it was decided an additional new Water Desalination Plant (DSP) of capacity 400MLD would be required to overcome the identified deficiency and to secure reliable water sources for consumers of CMA.

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), upon its role that was authorised By-Act No 28 of 1978, reacted to gain international funding program provided by JICA who developed a detailed project report (DPR). The DPR report included preliminary design for a new proposed 400 MLD DSP, underground storage facilities, pumping station, 65kms transmission pipeline, improvements of existing water distribution networks and electrical express feeder main.

In continuation to achieve the target of supplying adequate, reliable water demands to their consumers, CMWSSB engaged a Consortium of four consultant teams, namely M/s. SMEC International Pty limited, Australia and its consortium (M/s SMEC India Pvt Ltd., M/s NJS Engineers India Pvt Ltd., & M/s Tata Consulting Engineers Ltd (here after known as Project Management Consultant, PMC) to deliver engineering consultancy services that achieve the following objectives:

1. To deliver additional water of 400 MLD to CMA by constructing Seawater Desalination Plant at Perur with storage cum pumping facilities and new transmission main.
2. To Improve the efficiency of the existing water distribution network in the Chennai Core City.

   Accordingly, the entire project is divided into the following five major Packages, namely

   1- Construction and supervision of 400 MLD DSP at Perur (Package - CP1)- mainly includes Sea water intake, pre-treatment, desalination by RO (reverse osmosis), Post-treatment facilities, potable water storage, effluent discharge, substation for power supply and other building such as admin, storage and guard house etc.

   2- Construction and supervision for pumping station and reservoirs at Perur (9 ML) and Porur (10 ML) (Package- CP2)

   3- Installation and supervision Mild Steel product water transmission main of 65km length of dia ranging from 2000mm to 1000mm from Perur to Porur (Package- CP3).

   4- Improvement of the existing water distribution network in Chennai Core city (Package CP4) – Replacement, installation of supplementary and new pipes, reinforcement of storage facilities and installation of house service connections with water meter and formation of DMA (District metered areas).

   5- Installation of external power transmission lines (Package -CP5).

1.2 Scope of the Works

The scope of the work under consultancy services under this project includes “ Conceptual & Detailed Design, Bid Documents & Evaluation of Bids for the Proposed Construction of 400 MLD Capacity Seawater Reverse Osmosis Desalination Plant at Perur along East Cost Road, South of Chennai, Tamilnadu, including Construction of Pumping Station & Reservoirs, Improvement of Existing water Distribution Networks and Construction Management & Supervision for the Proposed Desalination Plant and its Product water

Conveyance Pipe line from the Plant and up to Porur and allied works". The details of services to be provided by the PMC to achieve efficient and proper preparation and implementation of the project are as follows.

1. **Design works for CP-1, CP-2 and CP-4**

   Conceptual design for CP-1 includes the works, i.e. review of technical information, implementation of necessary surveys, conceptual design including brine diffusion analysis, preparation of conceptual design reports covering all the process, general layout plan, water and material balance sheet, process flow diagram and instrumentation plan, cost estimates.

   Detailed design for CP-2 includes the works, i.e. review of existing technical information, conducting necessary topographical and geotechnical surveys, hydraulic analysis of product water transmission main to determine required pump head and counter measure of water hammer, detail design of pumping station and reservoirs covering all civil, structural, electro-mechanical and architectural works, preparation of construction plan, detailed design drawings and cost estimates

   Detailed design for CP-4 includes the works, i.e. review of existing technical information, collection, review and conducting the topographical survey for Chennai core city, review of pipe line inventory, preparation of hydraulic modelling of the existing water distribution network, hydraulic analysis of the existing network, improvement to the existing network by establishing the District Metered area (DMAs), preparation of detailed design report and drawings and cost estimates.

2. **Bid documents preparation and Tender assistance for CP-1, CP-2 and CP-4**

   Preparation of Bid document for CP-1 and CP2 for international competitive bidding includes Pre-qualification (PQ) document, preparation of addendum/corrigendum and clarification to the bidders, PQ evaluation and report preparation, Technical specifications, Bill of Quantities (BOQ), Bid documents comply to FIDIC Gold Book (2008) and JICA Guidelines for environmental and social consideration (April 2010)

   Preparation of bid documents for CP-4 with local competitive bidding includes Bid documents with Technical specifications and BOQ

   Tender assistance includes assistance in the tender call, addendum/corrigendum, clarification to the bid documents, conducting pre-bid conferences, evaluation of bids, preparation of bid evaluation reports, contract negotiation, preparation of draft and final contract agreement

3. **Construction and Supervision including defect liability period for CP-1, CP-2, CP-3 and CP-4**

   Execute the construction, supervision and contract administration services in accordance with the power and authority to be delegated by the client, Providing assistance to the client in variations and claims, advise the client on resolution of any dispute with contractor, issuing instruction, approvals and notices as appropriate, recommendations for accepting of the contractor's performance security , advance payment and required insurances, adequacy check of all the materials, labour and equipment provided by contractor, check and approval of the contractor's work methodology, site organization, programme of performance, quality assurance system, safety plan, Environmental Monitoring Plan (EMoP), monitoring physical and financial progress of the work, explain and/or adjust and/or discrepancies in the contract documents, issue of necessary clarifications, review and approval of contractor's design, working drawings, shop drawings , liaise with concern authorities, field inspections in relations to original points. Lines and levels of reference specified in the contract documents, organize necessary meetings with contractor to review of the arrangements of future works, preparation and delivery of minutes of meeting, supervise field test, samplings and laboratory tests carried by contractor, inspection of construction method, equipment and workman ship, attend the shop inspections and manufacturing tests as per the client's requirement, verification of statement submitted by the contractor, issue of payment certificates, modify the employer's requirement as may be necessary in accordance with the actual site conditions and issue of variation orders .timely reporting to the client for any inconsistency/ cause of delays , suggesting appropriate corrective measures to be applied, supervise testing and commissioning works, perform inspection of the works and issue relevant certificates of performance, taking -over etc, check and certify the as-built drawings, operation and manuals prepared by the contractor, assist in obtaining necessary permissions from the concern authorities, assist the client to report to JICA in case of any accidents in a manner reasonably requested by JICA, prepare and submit all the reports as specified in terms of reference of contract agreement in relation to the implementation of the project.

4. **Facilitation of implementation of Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP) for CP-1, CP-2, CP-3, CP-4 and CP-5**

   Assist Client in environmental management and monitoring through review and update EMP according to the actual site conditions, designs and technical specifications and contract documents, review and update of EMoP, identification of environmental responsibilities during bid document preparation, review of contractor's Environmental programme in accordance with EMP, relevant plans, JICA Environmental Guidelines and make recommendations to client in case of any necessary amendments for approvals, supervision of EMP implementation, implement measures identified in EMP, Monitoring the effects of EMP and negative impacts on environment by the construction works, provide technical advice including feasible solution to improve the situation, assist client in the preparation of the answer to the JICA's advisory committee for environmental and social considerations, assist the client in the capacity building of their staff on environmental management through on-the-job training so that EMoP shall be carried out appropriately during O & M period of the desalination plant

5. **Capacity development, organization improvement and public awareness activities.**

   Assist client in developing digital pipeline inventory database using Geo-graphical information system (GIS) through OJT (On Job Training), in development of capability of maintenance of the database, in preparation of water loss reduction plan.

   Analysis on obstacles preventing the expansion of installation of house service connections, assist the client in preparing the proposal of CMWSSB to GoTN on the acceleration of service connections, water meter installation, and maintenance.

   Assist in improving customer information database, planning and implementing customer satisfaction survey, a publication for appreciation, improvement plan for water tariff payment, and enhancing tariff collection in preparation of public awareness activities like water tariff payment, sanitization, and water-saving.

   Assist in preparing the financial plan to simulate appropriate future water rate, organizational improvement plan for effective business operations, the training program of technical and administrative staff and business plan based results of accomplishment of the activities.

According to the above scope of the works, the PMC team shall discharge the detailed designs for the CP4 - Package along with a detailed design report, drawings and cost estimate for the entire core city area of Chennai, as shown in Figure 1.1. The detailed design phase shall include the following disciplines: Hydraulic analysis, optimum, pipeline selection, structural design, Mechanical & Electrical, SCADA, EIA, Social Studies, Topographic Survey, Geotechnical Survey and Architectural.

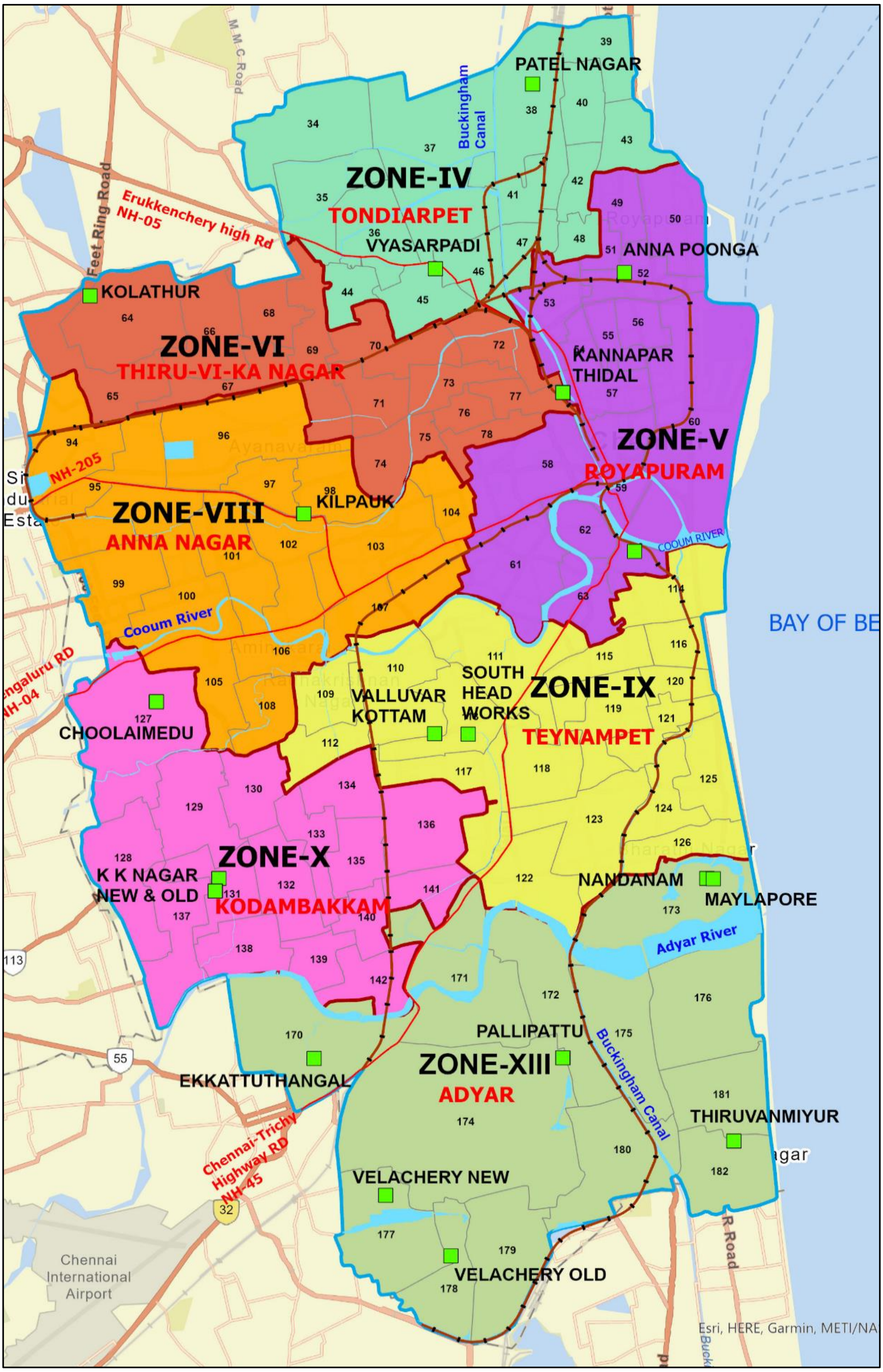


Figure 1.1 Chennai Core City Map with Depots and WDS locations

Based on the client's requirement, Area X and XIII are prioritised for improving the distribution network. The present report covers improvement proposals made for the existing distribution network in area X, as shown in Fig 1.2, including strengthening storage facilities.

1.3 Report Objectives & Design Philosophy

To achieve the specific client needs for package CP4, the design team referred to the following documents:

1- CMWSSB request for proposal and its terms of reference (ToR).
2- JICA final design report February 2017.
3- Guidelines were established by Central Public Health and Environmental Engineering Organization (CPHEEO).
4- Master Plan(M/P) for Water Supply and Sewerage Sectors in Chennai Corporation and the rest of Chennai Metropolitan Area.
5- Minutes of Discussion (MoD)between CMWSSB and JICA on 19th. January 2018
6- The site visits are recorded, and the design team collects relevant information.
7- The Topographical survey reports/drawings conducted by the PMC
8- Environmental and Social studies conducted by the PMC.
9- CMWSSB requirements are recorded during the regular meetings with the design team in verbal discussion and written correspondences.

Based on the above, the PMC design team established the following design objectives:

1- Ensure continuous water supply on a 24/7 basis.
2- Achieve client's operational needs to satisfy minimum residual pressure 12m during peak supply hours.
3- Achieve client's operational needs in terms of changing the operational philosophy from pumping supply to gravitational supply.
4- Establish district metering areas within each zone to be hydraulically monitored, locally controlled, and capable of future tie-in central control.
5- Provide a control strategy for UFW (unaccounted for water) based on leak detection devices locally controlled and capable for future tie-in central control.
6- Implement water quality monitoring points locally controlled and capable for future tie-in central control.
7- Maximise the benefits of the existing assets by applying optimisation techniques based on rehabilitation, strengthening, renovation, and replacement of the existing water distribution networks.
8- Design for the houses/services connection and ensure a proper metering strategy are established with associated economic remuneration.
9- Implement proper operational strategies that are necessary for providing efficient water supply services and maximizing the assets' lifetime

10- Apply hydraulic analysis scenarios to simulate the daily water demand pattern covering average, maximum-daily, peak-hourly, and minimum water demand durations along a typical day.

The PMC design team has adopted a design philosophy that ensured the application of modern technologies, problem-solving techniques, and engineering sustainability concepts. The design approach will include optimization and reliability-based engineering solutions that are flexible and readily available. The proposed solutions and alternatives also considered possible risks as a function of supply, demand, and operational processes, supported by evidence-based hydraulic analysis simulations using WaterGems hydraulic modelling software Connect Edition, update 3, 10.03.01.08, 21-05-2020 developed by BENTLEY.

1.4 Contents of the Draft Design Report- Area X

This report is the draft design report (DDR) for Area X (refer to the location map in **Error! Reference source not found.**). The DDR shall comprise the following topics:

1- Background of the project, scope of work and detailed objectives
2- Overview of the existing water supply system
3- System Design Criteria
4- Population and water demand
5- Assessment of the existing system
6- Proposed water supply system
7- Basis of Cost estimates
8- Project implementation plan
9- Operation and maintenance
10- Capacity building and training
11- Social Safeguard situation and impact analysis
12- Environmental Management Plan

This report is the second deliverable (First deliverable- Inception Report) of the CP-4 component, i.e., detailed design, tender documents, and construction supervision to improve the existing water distribution in Chennai Core City, covering detailed design and cost estimates only for Zone -X at presently.

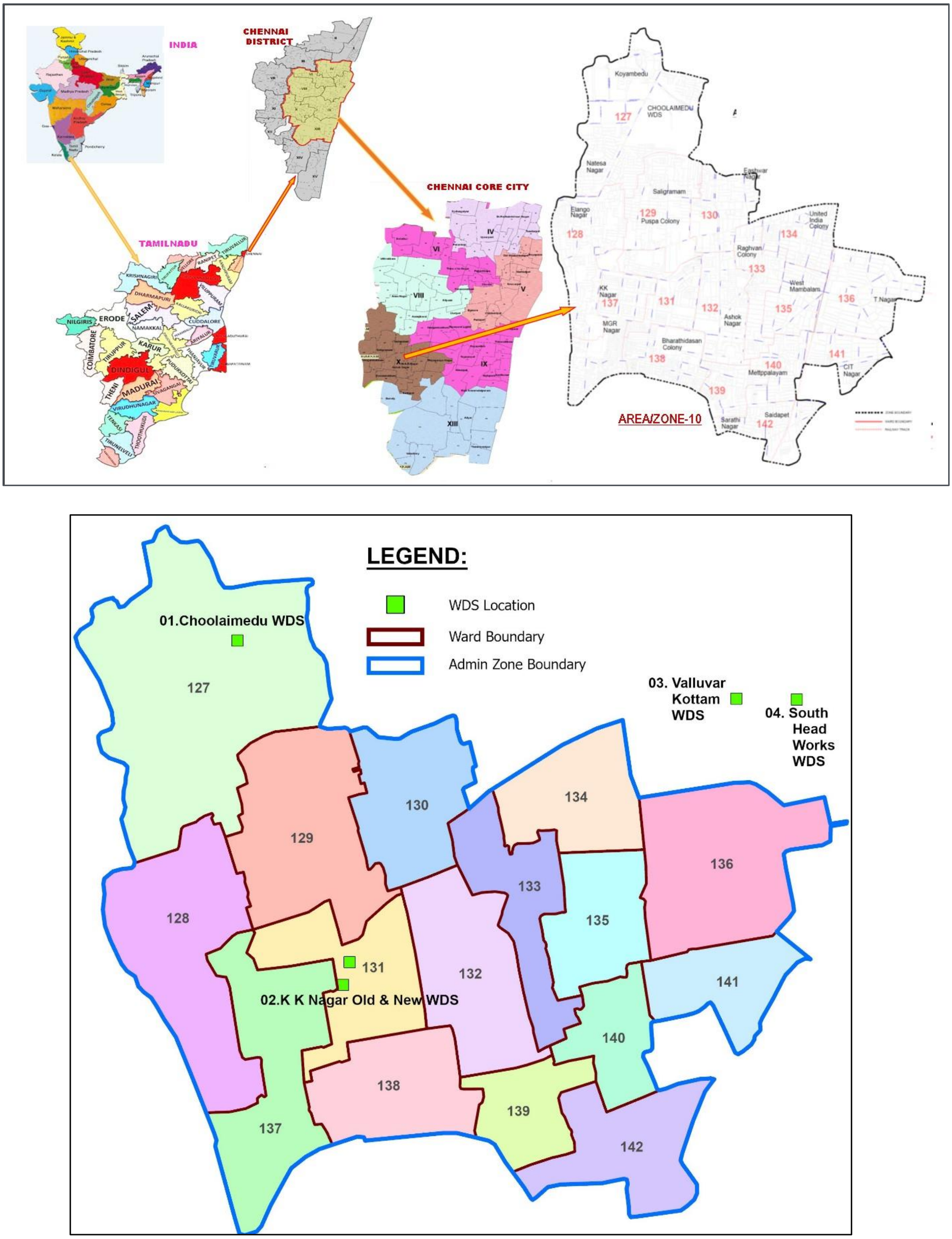


Figure 1.2 Area X Location Map and Its Corresponding Administrative Wards

2 CHAPTER 2: OVER VIEW OF THE EXISTING WATER SUPPLY SYSTEM

2.1 Introduction

This Chapter mainly describes the overview of the existing water supply system of Chennai Core City with the details of Water Sources, WTP, Transmission mains, pumping stations, zone wise water distribution stations, service reservoirs and distribution systems serving the zones and specific existing water supply infrastructure of Admin Area X.

2.2 Existing Water Sources

Presently, Chennai city has four different water sources, i.e. surface water, ground water, sea water desalination plants, and waste water recycling plants. The details of the sources with their proposed capacity, maximum yield is given in Table 2.1

Table 2.1: Details of Existing Water Supply Sources

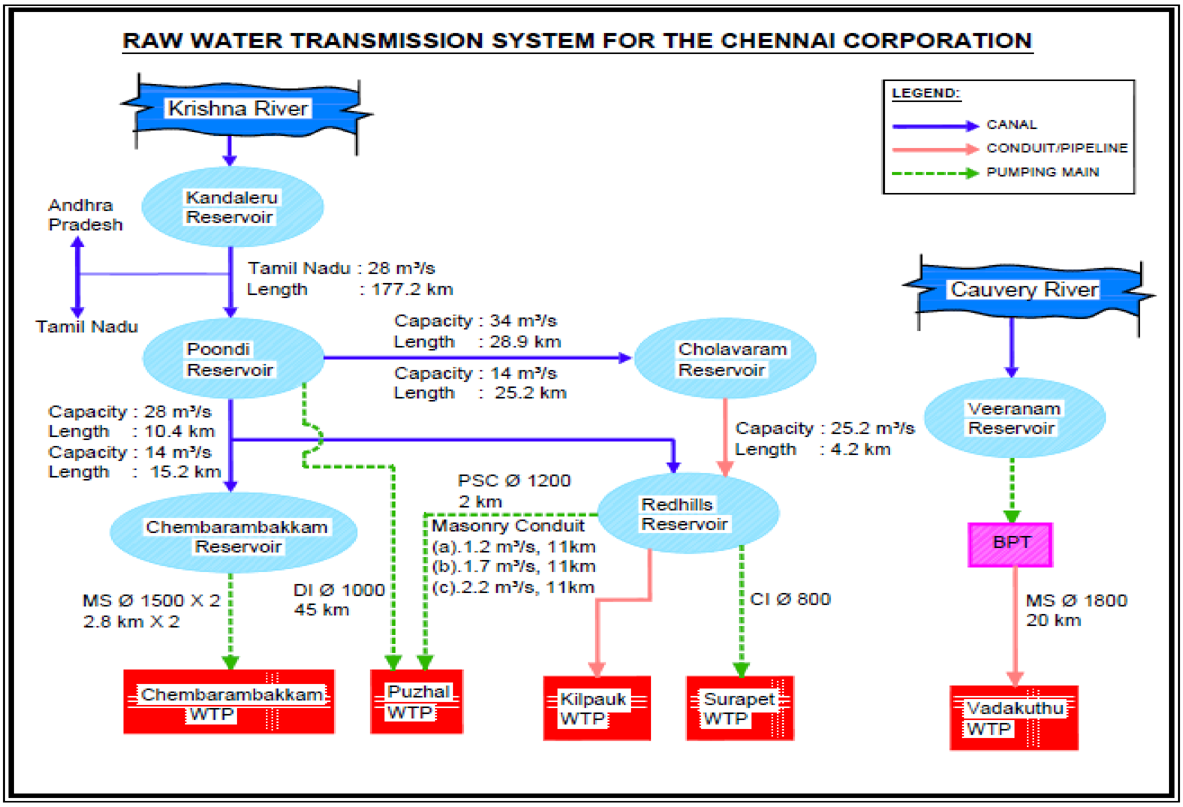
Sl. No	Particulars	Potential Expected Yield During Planning Stage (MLD)	Particulars Potential Yield after Construction (MLD)	Present availability (as of October 2015) (MLD)
1	Surface Water Sources			
a)	Poondi, Red hills, Cholavaram &Chembarambakkam lakes (surface sources)	200	125	75
b)	Telugu-Ganga Project	930	400	200
c)	Veeranam Lake Source	180	100	100
2	Ground Water/Sub Surface water			
a)	Northern well field /Southern Coastal aquifer	100	25	25
b)	Sub Surface water sources in the Rest of CMA	32	32	32
3	Sea Water Desalination			
a)	Minjur DSP	100	100	100
b)	Nemmeli DSP	100	100	100

Sl. No	Particulars	Potential Expected Yield During Planning Stage (MLD)	Particulars Potential Yield after Construction (MLD)	Present availability (as of October 2015) (MLD)
4	Water Recycle System- TTRO			
a)	Kodungaiyur TTRO	45	45	45
b)	Koyambedu TTRO	45	45	45
		1732	**972**	**722**

Source: Master Plan/JICA Report

2.3 Existing Raw Transmission mains/ Canals

The raw water from sources is transmitted by either canal or conduit/pipe line. The details of raw water transmissions mains with their size /capacity are shown in Fig 2.1.



Source: Master Plan/JICA Report

Figure 2.1 Raw water transmission network details of Chennai water supply system

2.4 Existing Treatment Facilities

Details of Existing water treatment plants with their capacity and their production is given in below Table 2.2

Table 2.2: Details of Existing Water Treatment Facilities

Sl. No	Production facilities	Capacity (MLD)	Production (MLD)		Source of water
			The year 2015	The year 2016	
1	Kilpauk WTP, Surapet WTP, Puzhal WTP, Chembarambakkam WTP	1114	159	551	Poondi, Red hills, Cholavaram &Chembarambakkam lakes and Telugu Ganga Project
2	Vadakuthu WTP	180	177	76	Cauvery River (Veeranam Reservoir)
3	Minjur DSP	100	88	89	Sea water
4	Nemelli DSP	100	74	53	
5	Ground water	128	98	42	Northern well fields and Extended area well fields
6	Tertiary Reverse Osmosis Plants at Koyambedu and Kodungaiyur	90			Sewage water Commissioned in the year 2019
		1712			

Source: Master Plan/JICA Report

2.5 Clear water transmission main

Treated water from the WTP/ Desalination plants will be conveyed to 18 Water distribution stations (WDS) located in the core city. The total length of clear water transmission main is around 490km, with Dia ranging from 225mm to 2000mm of material Cast Iron (CI), Pre-stressed Concrete (PSC), Ductile Iron (DI) and Mild steel (MS). In addition to the above, additional product water transmission main of MS pipe dia ranging from 1200-1400km for 40km and DI pipe of 300km for 9km is under construction under 150 MLD Nemelli Desalination Project. The schematic layout of existing clear water transmission network mains is shown in Fig 2.2

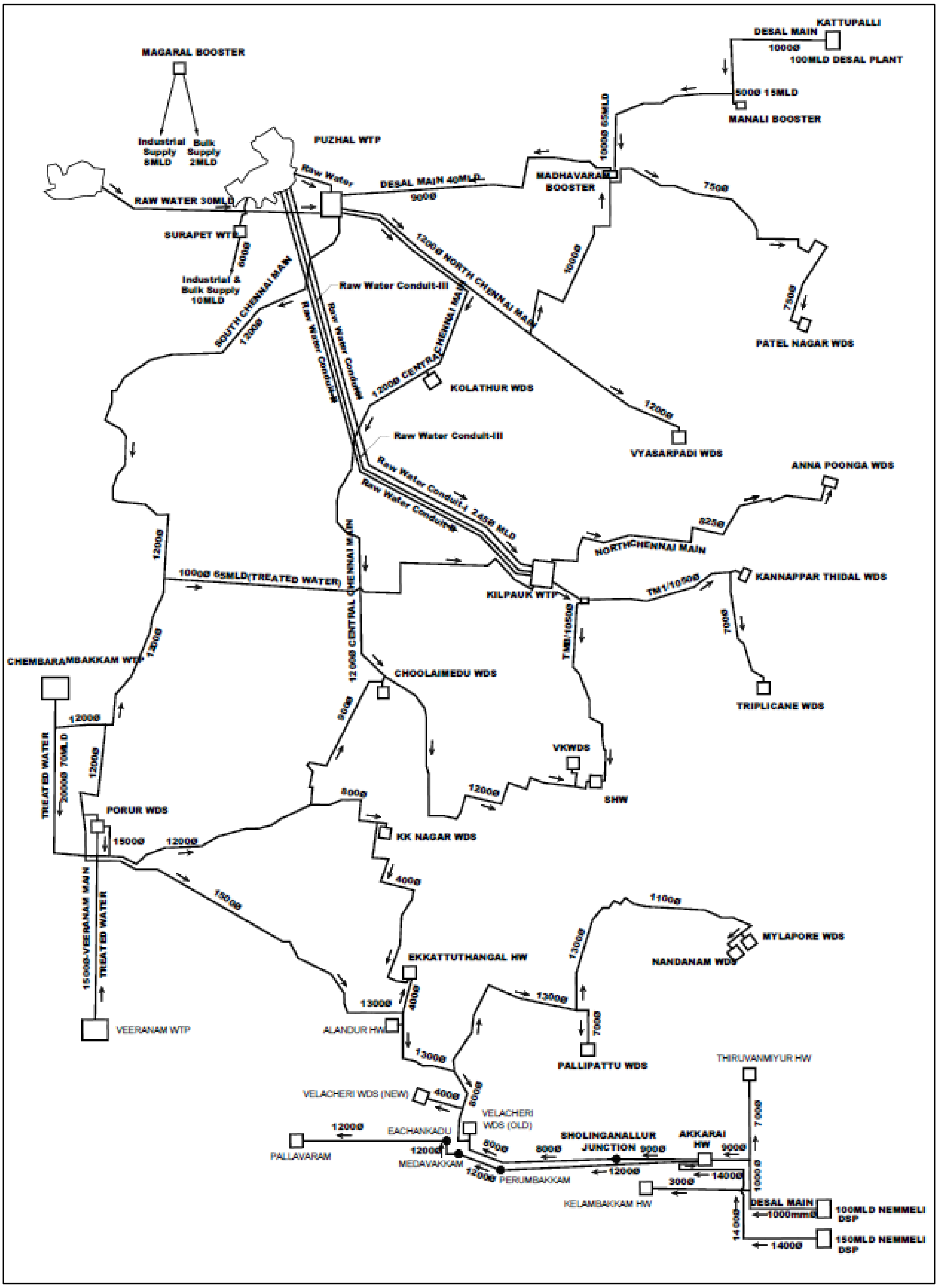


Figure 2.2 Clear water transmission main layout diagram of Chennai Core city

2.6 Water Distribution stations

There are around 18 Existing Water Distribution Stations (WDS) in Chennai Core City. Though initially, these were formulated as isolated hydraulic zones, over time, many interconnections were made in their distribution network, which is a major cause of concern for better demand-supply management and from an operation and maintenance point of view. Each WDS have its storage facilities. Details of WDS with their storage capacities are given in Table 2.3.

Table 2.3 Details of Existing WDS with their storage details

DETAILS EXISITING WDS LOCATIONS IN CHENNAI CORE CITY						
WDS Zone	**Name of WDS**	**Underground Tank (UGT) (ML)**	**Elevated Service Reservoir (ESR) (ML)**	**Water Source**	**Planned Supply Volume (MLD)**	**Supplied by**
1	Kilpauk	81.32	15.80	Kilpauk WTP + Chembarambakkam WTP & Vadakuthu WTP	94	Pump and ESR
2	Anna poonga	22.50	2.50	Kilpauk WTP	20	Pump and ESR
3	Kannaparthidal	16.00	-	Kilpauk WTP	18	Pump
4	Triplicane	10.00	2.40	Kilpauk WTP	10	Pump and ESR
5	KK nagar	14.00	2.40	Chembarabakkam WTP Vadakuthu WTP	28	Pump & ESR
6	Velachery	6.00	-	Chembarabakkam WTP Vadakuthu WTP + Nemmeli DSP	25	Pump
6A	Velachery(New)	2.00	-	Chembarabakkam WTP Vadakuthu WTP + Nemmeli DSP	5	Pump
7	Ekkatuthangal	4.50	-	Chembarabakkam WTP Vadakuthu WTP	5	Pump
8	Choolaimedu	43.00	-	Chembarabakkam WTP Vadakuthu WTP + Redhills WTP & Minjur DSP	35	Pump
9	Kolathur	20.00	-	Redhills WTP & Minjur DSP	30	Pump
10	Vysarpadi	22.00	-	Redhills WTP & Minjur DSP	30	Pump
11	Patel nagar	14.00	-	Redhills WTP & Minjur DSP	20	Pump
12	Pallipattu	17.00	0.75	Chembarabakkam WTP Vadakuthu WTP + Nemmeli DSP	29	Pump & ESR
12A	Thiruvanmiyur	3.00	0.75	Nemeli DSP	5	Pump & ESR
13	Nandanam	11.00	-	Chembarabakkam WTP Vadakuthu WTP + Nemmeli DSP	15	Pump
14	Mylapore	11.50	-	Chembarabakkam WTP Vadakuthu WTP + Nemmeli DSP	25	Pump
15	Southern HW	24.00	4.50	Kilpauk WTP & Redhills WTP Minjur DSP + Chembarabakkam WTP Vadakuthu WTP	55	Pump & ESR
16	Valluvarkottam	15.00	3.00	Redhills WTP & Minjur DSP + Chembarabakkam WTP Vadakuthu WTP	15	Pump & ESR
Other area(Industries,Expanded areas,bulk supply,tank lorries etc.)		-	-		366	Various
Total		**336.82**	**32.10**		**830**	-
		368.92		-		

Source: Site information collected by PMC Team / JICA Report

2.7 Water Distribution Network

As per the data available with CMWSSB, the total length of the water distribution network in the core city is around 2,381 km. Most of the water distribution network in the core city has been redeveloped based on DPR entitled "Detailed Engineering Design of water Distribution System for Chennai City" in Sep 2018 prepared by M/s Kriloskar Consultant. As per the JICA report prepared in the year 2017, the total length of the distribution network based on field data book is around 2,303 km comprising of CI (91.62%), uPVC (6.17%), DI(1.80%), GI (0.38%) and AC (0.03%) diameter ranging from 40mm to 750mm. However, as the CMWSSB does not have any consolidated database for pipeline inventory, the PMC team has visited all the Area/Depot offices and collected the available data and drawings. The PMC team has digitalized the pipeline inventory data based on available information. The total distribution network length in all 7 zones (Entire Core city) is based on preliminary information received from the CMWSSB (except for Area X and XIII data for which details are scrutinized and authenticated by respective area/depot engineers) is around 3079.20km. Details are given in Table 2.4

Table 2.4: Details of Existing Distribution Network- Chennai Core City

S.NO	PIPE DIAMETER (mm)	PIPE MATERIAL with (Length in m)						TOTAL LENGTH (m)
		PSC	AC	CI	PVC	MS	DI	
1	100			1900530.70	121.00	0.00	177058.22	2077709.92
2	110				23490.42			23490.42
3	125			4140.82				4140.82
4	140				215.00			215.00
5	150			300164.92	23442.00		41681.45	365288.37
6	160				4798.00			4798.00
7	175			4266.57				4266.57
8	200		1770.00	152975.86	1270.00		18420.58	174436.44
9	225			22409.07				22409.07
10	250			58387.10			5908.70	64295.80
11	300			90414.44			11683.63	102098.07
12	350			24149.79			9763.72	33913.51
13	400			27203.72			3490.94	30694.66
14	450			39323.12			11.66	39334.79
15	500			6933.42			3558.93	10492.35
16	525			12214.17				12214.17
17	575			1272.00				1272.00
18	600			21772.76			6229.73	28002.48
19	675			8668.62				8668.62
20	700			19514.59			3093.71	22608.30
21	750			6591.58			244.00	6835.58
22	800			4694.00			2279.40	6973.40
23	825			9332.38				9332.38
24	900			13730.06		29.90		13759.96

S.NO	PIPE DIAMETER (mm)	PIPE MATERIAL with (Length in m)						TOTAL LENGTH (m)
		PSC	AC	CI	PVC	MS	DI	
25	1000			301.84			1602.00	1903.84
26	1050			3494.00				3494.00
27	1100							0.00
28	1200	724.00				4985.58		5709.58
29	1300							0.00
30	1600			830.56				830.56
TOTAL LENGTH		**724.00**	**1770.00**	**2733316.09**	**53336.42**	**5015.48**	**285026.66**	**3079188.66***

Source: Data and drawings collected by PMC from all area/ depot offices of the Chennai core city

* *Subject to change, based on the scrutiny, finalization and authentication of Area IV, V, VI, VIII and IX area/depot offices.*

Further, as per the latest information available with CMWSSB, the total number of house service connections in the core city are 559158 and out of which 22619 are metered, and the rest will be charged on a flat rate basis. Breakup details of house service connection are given below Table 2.5

Table 2.5: Breakup of Service connections in Chennai Core city

Area	Total Number of Tax payers	Service Connections (SCs)			Metered rate	Assesses/SC
		Metered	Unmetered	Total		
Area-IV	75284	1708	57157	58865	2.9%	1.28
Area - V	69902	9572	35390	44962	21.3%	1.55
Area - VI*	87314	1032	67666	68698	1.5%	1.27
Area - VIII	108800	2152	81603	83755	2.6%	1.30
Area - IX	114435	4159	89803	93962	4.4%	1.22
Area - X*	147740	1960	113843	115803	1.7%	1.28
Area - XIII*	127469	2036	91077	93113	2.2%	1.37
Total Core City	**730944**	**22619**	**536539**	**559158**	**4%**	**1.31**
* Updated data based on latest information collected from Area offices						

Source: Data collected by PMC/ JICA Report.

2.8 Existing water supply system scenario in Area X (Kodambakkam)

2.8.1 Water Distribution Stations and Pumping facilities

Area X (Kodambakkam) is part of the project area containing the 7 administrative areas of Chennai Core City (CCC) covering 16 wards, i.e. from 127 to 142 with an area of 22.31 Sq km a road network of 440 Km. The total population of this area as per the 2011 census is 7,31,530. Presently, this area is being served by Four existing WDS located within (i.e. Choolaimedu and KK Nagar WDS) Area X or in neighbour WDS (i.e. Valluvarkottam and Southern Head works WDS in Area IX) admin areas. In addition to the above WDS, some OHT tanks are located within area X but not serving presently due to their condition, lesser capacity, and smaller staging ht. The detailed configuration of the existing WDSs located within Area X is listed in Table 2.6

Table 2.6: Configuration of Existing WDS serving Area X Presently

S No	Existing Storage Facilties(ML)				Existing Pumps Configuration			Type of pumps	Beneficiary Depots Present
	WDS Location	UGR (ML)	OHT (ML)	Staging ht (m)	Discharge (MLD)	Head (m)	No (W+S)		
1	Chooliamedu	43			90.72	30	4+2	HSC	127, 128P, 129P, 130P,131P, 132P, 133P, 134P, 135P
2	KK Nagar- New	14	2.4	20	50.98	30	4+2	VT	131P, 132P, 133P, 137P, 138P, 139P, 140P, 142P
	KK Nagar- Old	9	0.91	10	12.10	28.6	3+3	VT	128P,131P, 132P, 133P, 135P,137P,138P, 139P
			0.91	10					
3	Valluvarkottam	15	3	20	65.23	32	2+2	HSC	129P,130P,133P,134, 135P
4	Southren Head works	24	4.5	14	39.31	35	4+2	HSC	136, 140P, 141, 142
5	Other OHTs outside WDS premises								
(a)	Pammal , 128 ward		0.3	12					Not in use due to their condition, capacity or staging ht
(b)	Ashok Nagar, 132 Ward		0.7	12					
(c)	West Mambalam, 132 Ward								
(d)	L&T Colony, ward no 128								

Source: Site information collected by PMC Team

From the above table, it is clear that none of the command areas under WDS is isolated; multiple interconnections were made in the distribution network between the command areas. There is no knowledge of these interconnections at the organization level due to improper data management, lack of documentation work and data transfer by individuals leads to major concerns in operation and maintenance of the network. Further, the operational areas and depots of CMWSSB are aligned geographically to the depots but not spatially to the water distribution stations. Due to this misalignment, interface issues across the areas are always in place, resulting in the inefficiency of O & M Works.

2.8.2 Inventory of Area X Piping System

As per the latest site information, drawings and data collected and digitalized by PMC, the total length of the existing pipeline in the area is about 502 Km with dia meter ranging from 100 to 1600 mm for a total road network length of around 440 km. The CI piping material comprises 88.58% of the total pipe-lengths with DI 11.25%, and MS and PVC piping material comprises 1.45 % and 0.16%, respectively.

69.8% (around 350 km) of the total piping lengths have 100/110mm diameter, 9.5% of the total piping length have 150/160mm diameter, while the rest of 20.7% has diameters range from 200 mm to 1600mm. From the above information, nearly 20.5% of the road network is not covered by 100mm where HSC connections need to be made. Presently CMWSSB is giving HSC connections on all the pipes of diameter ranging from 100mm to 250mm, which is not desirable for better management of the system. Dia and material-wise existing distribution network breakup of Area X is mentioned in Table 2.7.

Table 2.7: Pipe line inventory data of area X

Sl.No.	Dia (mm)	Material				Total Length (m)
		CI	PVC	MS	DI	
1.	100	322626.70			27460.42	350087.12
2.	110		728.42			728.42
3.	150	35001.22			12494.40	47495.62
4.	160					0.00
5.	200	19048.66			5187.47	24236.13
6.	225	793.77				793.77
7.	250	14294.81			575.93	14870.74
8.	300	13391.98			2316.24	15708.22
9.	350	3450.26			3358.61	6808.87
10.	400	13830.85			2099.94	15930.79
11.	450	1974.26			11.66	1985.93
12.	500	3496.42			446.88	3943.30
13.	525	5261.86			0.00	5261.86
14.	600	1514.83			481.73	1996.55
15.	700	2196.59			1618.23	3814.82

Sl.No.	Dia (mm)	Material				Total Length (m)
		CI	PVC	MS	DI	
16.	750	3602.70			0.00	3602.70
17.	800	0.00			463.40	463.40
18.	900	3310.06		29.90	0.00	3339.96
19.	1100	0.00			0.00	0.00
20.	1200	0.00		52.58	0.00	52.58
21.	1600	830.56			0.00	830.56
Total		**444625.53**	**728.42**	**82.48**	**56514.90**	**501951.34**

Present water supply is intermittent with a duration ranging from 3 to 4 hours.

Individual Ward wise break up an existing distribution network of area X is listed in ***Annexure 2.1***

2.8.3 House Service Connections

As per the latest CMWSSB records, the total number of House Service Connections existing in area X is 115503. Of the 1960 (i.e. 1.7%) are metered and rest all unmetered. Of 1960 metered connections, 1736 are AMR metered, and the rest are non-AR. Ward wise Details of HSC connection with meters in area X are shown in Table 2.8

Table 2.8: House service connection details in Area X

AREA X - DETAILS OF AS ON 01-07-2021									
Depot	***Old meter Total***	***AMR meter Total***	***Meter consumer Total***	***Number of consumer metered***			***Number of consumer unmetered***		
				Water Intensive	***Non Water Intensive***	***Partially Commercial & Multistoreyed Building***	***Water Intensive***	***Non Water Intensive***	***Partially Commercial & Multistoreyed Building***
127	23	127	150	49	11	90	31	80	6764
128	3	77	80	20	13	47	21	163	12362
129	8	102	110	35	*43*	32	48	237	9669
130	8	107	115	45	53	17	40	218	6668
131	4	30	34	6	16	12	16	61	4258
132	21	173	194	47	124	23	55	512	7007
133	9	133	142	25	70	47	20	165	6079
134	9	93	102	32	44	26	48	357	7850
135	31	109	140	55	42	43	24	270	9061
136	60	415	475	203	144	128	125	1075	6878
137	1	124	125	12	8	104	22	121	8240
138	0	66	66	22	6	38	24	83	5838
139	0	10	10	2	0	8	9	37	3889
140	3	35	38	26	6	6	23	33	5076
141	35	75	110	19	54	37	26	182	4159
142	9	60	69	38	19	13	62	92	5765
	224	**1736**	**1960**	**636**	**653**	**671**	**594**	**3686**	**109563**
Total				**115803**					

2.8.4 Bulk Water Consumers in Area X

List of the bulk water consumers information and their consumption details received from CMWSSB are given in Table 2.9

Table 2.9: Bulk Water Consumer Details in Area X

S No	Depot	Name of the consumer	Consumption per month in ML
1	127	SAF	12.515
2	127	Food Grains-market	0.752
3	127	CMDA	0.600
4	127	CMRL	1.173
5	127	Rail nagar	1.000
6	127	BASHYAM FLATS-2000flats	
7	127	RADIANCE FLATS-1000flats	
8	128	IAS QUARTERS	1.000
9	130	GREEN PARK-HOTEL	2.130
10	131	TNSCB - Rani annanagar(1744 units)	
11	131	TNSCB - Sivalingapuram(488 units)	
12	131	CPWD Quarters - 1298 flats	7.800
13	131	AVM Asta - 660 Flats	
14	132	TNSCB - (80 units) - Sector 10,Sivalingapuram	
15	132	TNSCB - (200 units) - Ashoka colony	
16	132	TNSCB - (350 units) - Sector 15,Ottagapalayam	
17	132	TNHB - (1150 Units) under construction - Bharathiyar colony	
18	133	TNSCB - (80 units) - Sector 10,Sivalingapuram	
19	133	nagar	
20	135	TNSCB - (402 units) - Gokulam colony	
21	136	Hotel Residency Towers- 176 rooms	1.8
22	138	TNHB Quarters- (562 Units) - Brindavan towers	3.6
23	138	ESIC College & Hospitals - 470 Beds	
24	139	Jafferkanpet Tenenment TNSCB - 666Units	
25	140	TNSCB - (64 units) - Perumal koil thottam	
26	140	TNSCB - (544 units) - Reddykuppam	
27	140	Appasamy flats - Reddykuppam road	
28	140	West Hilss Flats - Reddykuppam	
29	141	TNSCB - (176Units)-Kamaraj colony ,Kannamapettai	
30	142	Sunshine Apartments - 1200 flats	
31	142	Indus Amber Apartments - 260 flats	
32	142	Dhobicana TNSCB - 112 units	
33	142	Ghodhamedu TNSCB - 672 units	

3 CHAPTER 3: SYSTEM DESIGN CRITERIA

3.1 Introduction

In general, the Water supply system design will be done based on the parameters and guidelines of CPHEEO norms.

The water supply component in the DPR is framed as per guide lines laid down in the Manual on Water Supply & Treatment -1999 published by the Ministry of Urban Development Government of India and as per provisions laid down in the relevant I.S. codes published by the Bureau of Indian Standards.

This chapter describes the various design criteria's used –in the design of the water supply -system.

3.2 Design Period

Considering the recommendations given in Guidelines and Manual, the Project Horizon and Design Periods/years adopted for various water supply system components are as follows.

1.	Base year for evaluation of the existing system	=	2025
2.	Project Horizon/Design Year	=	2055
3.	Intermediate Design Year	=	2040
4.	For the Design of Water Supply distribution Network	=	2055
5.	Pumping stations	=	2055
6.	Civil Works of Service Reservoirs/OHT	=	2040
7.	Mech./Elect/I & C-Equipment's & Machineries	=	2040
8.	Pumping Mains/Rising Mains	=	2055

Note: In case of insignificant difference between intermediate and ultimate years storage requirement and land availability constraints, OHT/ reservoirs are designed for the ultimate year.

3.3 Water Demand Estimation

According to the CPHEEO Manual for water supply and treatment 1999, the water supply schemes are designed for 135 lpcd for Corporations and Urban Local Body (ULBs) having Underground Sewerage Scheme (UGSS). Provisions are also made for fire fighting demands as per CPHEEO Manual. Commercial demands are considered as per the JICA Report. No industrial demand is anticipated in the core city as all industries have been shifted to outside. Bulk water demand is considered based on the monthly average consumption details received from

CMWSSB. The details of per capita water demands considered for Chennai Core City (CCC) is as presented in Table 3.1

Table 3.1: Water Demand Norms Considered for CHENNAI CORE CITY

Sl. No.	Description	Units	Demand Norms	Remarks
1.	Per Capita Water Supply (Domestic water Demand)	LPCD	135	As per CPHEEO norms with 15% Losses (5% Transmission and process losses and 10% distribution losses), 135*1.15= 155.25 lpcd≈155 lpcd
2.	Fire Fighting Demand	KL/Day	$100\sqrt{P}$ P = Population in Thousands	As per CPHEEO Guidelines
3.	Bulk water Demand	MLD	At actual	Based on information received from CMWSSB
4	Commercial water demand	MLD	5% of domestic water demand	As per the JICA Report recommendation.

3.4 Water Losses in the System

As per the CPHEEO manual, 15% of total losses in the system (5% as process and transmission losses and 10% as distribution losses) shall be considered by increasing the per capita water demand by a factor of 1.15.

3.5 The capacity of Overhead Tanks/Demand Pattern

CPHEEO recommends providing 1/3 of the daily demand of intermediate water demand as storage facilities for intermittent water supply systems. As the system is proposed to design for 24X7 supply and due to land constraints, the reservoir capacity is finalized based on the mass curve technique considering hour demand variations.

The capacity of service storage that is feeding a water distribution network connected directly to consumers' service connections should cover the gaps between the peak demand hours and average demand hours. Accordingly, the service storage, in this case, has to be calculated using the formula:

The variable water demand pattern over 24-hours reflects consumers' domestic activities for one day of water consumption. The volume of the overhead tank has a specific role in substituting the water demand that exceeds the average consumption.

A 24-hours water demand pattern is applied during the hydraulic analysis of the water distribution network. Figure 3.1 and Figure 3.2 represent the daily water demand pattern curve and bar-chart, respectively. The hourly water demand' factors were driven by the PMC design team based on the general consumption pattern during 24 hrs.

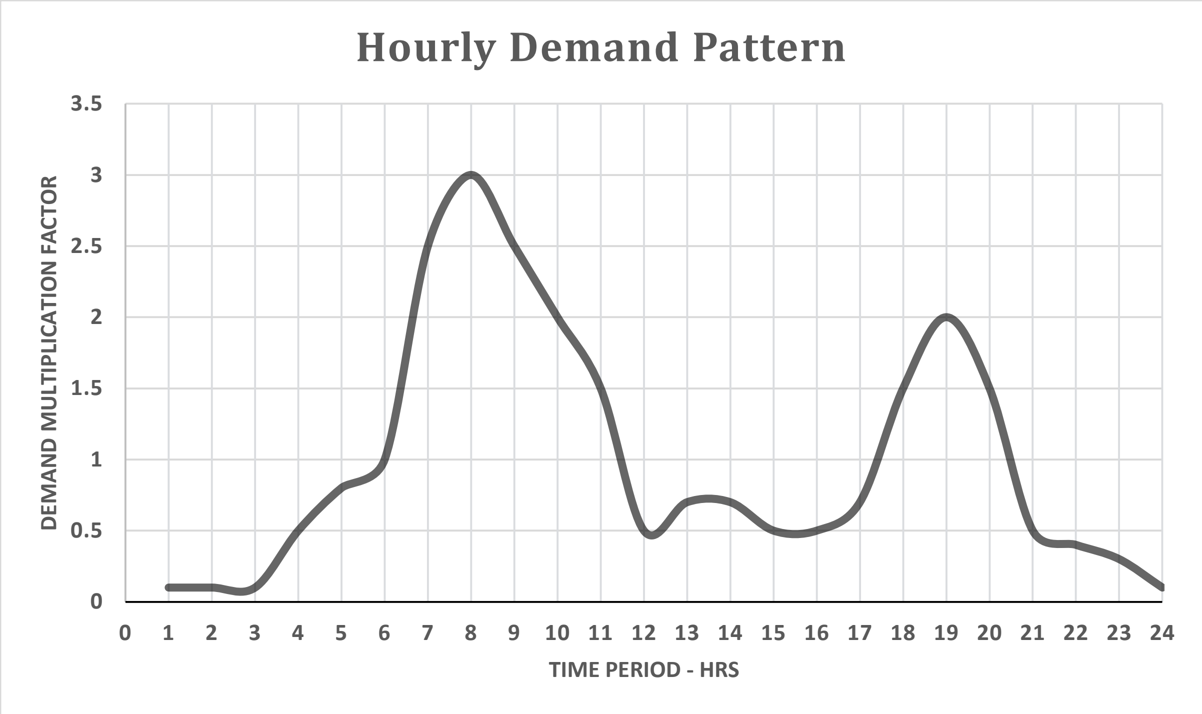


Figure 3.1 Diurnal Hourly Water Demand Pattern Curve

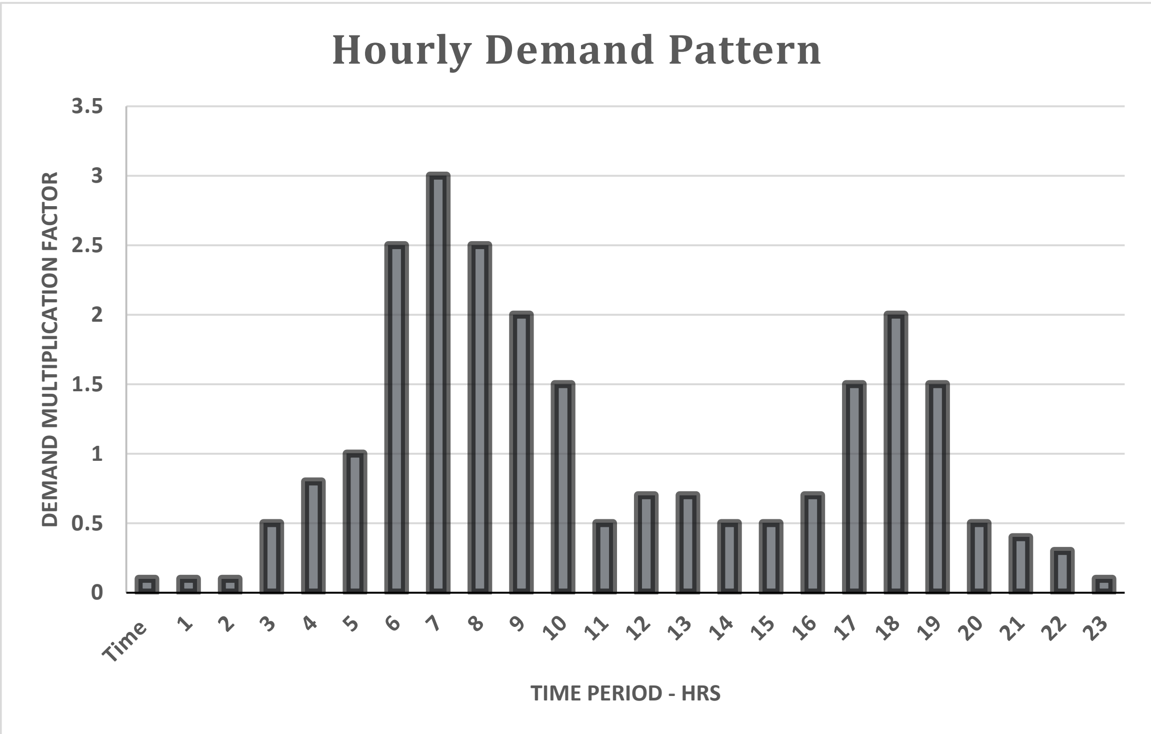


Figure 3.2 Hourly Water Demand Pattern - Bar Chart

3.6 Water Distribution System Planning

A gridiron/looped skeleton for distribution network planning is proposed to minimize the dead ends within the networks. The piping layout shall follow the planning of the existing roads/streets. A minimum of 1m clear cover is proposed for the buried pipelines. To avoid cross-cutting of the major roads, especially for house connections and the regular maintenance activities, parallel pipes have been suggested for roads greater than 10m separated by medians.

3.7 Pipe Materials

Pipe materials are selected based on discussion with CMWSSB and following the norms adopted by the TWAD Board for urban areas. For all pipe diameters starting from 100 mm to 1000 mm, ductile iron (D.I.) pipes are considered while pipes diameter larger than 1000mm MS Pipe material is considered. All consumers services connections shall be MDPE pipes. Wherever MDPE pipeline crosses drains while giving service connections, HDPE pipe encasements are recommended.

3.8 Minimum Pipe Diameter

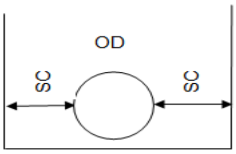
As per CPHEEO norms, the minimum pipe diameter shall be 100 mm; therefore, recommended minimum pipe diameter is 100 mm.

3.9 Pipe Trench Width

The trench width and depth are to be adopted for excavation shall be based on standard practice. A minimum cover of 1.00 m from the ground level to the crown of the pipe is proposed to distribute the load acting on the pipe material. The width of the trench as per Table 3.2

Table 3.2- Details of Trench Width and Depth.

Sl. No.	Pipe Diameter (mm)	Trench Width (m)	Side Clearance (SC), mm
1	100 to 250 mm	(SC+OD+SC)	200 * 2
2	250 to 450 mm	(SC+OD+SC)	300 * 2
3	> 450mm	(SC+OD+SC)	350 * 2

OD 

= Outer Diameter

SC = Side Clearance

Figure 3.3 ***Typical Trench Width Details***

3.10 Friction Losses Calculations

Based on the CPHEEO guideline, Hazen-William's formula for calculating the frictional losses in the pipe is to be used.

Hazen Willam's Formula: $V = 0.849\ C\ R^{0.63}\ S^{0.54}$

Where, V = Velocity of flow (m/sec)

R = Hydraulic Radius = D/4

S = hf = Hydraulic loss per m length

C = Hazen William Co-efficient

Hazen William Roughness Coefficient recommended by CPHEEO is presented in **Error! Reference source not found.**3.3 represents Hazen William's roughness coefficients (C) values considered for various pipelines for designs of the distribution system.

Table 3.3- Hazen William's C Values for Design Purposes

Sl.	Pipe Material	New Pipes	Old Pipes
1	Metal pipes (MS) unlined, Galvanized Iron	100	70
2	Steel pipes (MS, CI, DI) with centrifugally lined with Cement mortar lining	140	80
3	Plastic pipes (PVC, HDPE)	145	130

For DI pipelines recently laid under I & A Works (By CMWSSB), a C-Value of 130 is being adopted.

3.11 Residual Pressure

Manual on Water Supply and Treatment by CPHEEO recommends following residual pressures at ferrule points as shown in Table 3.4

Table 3.4- MINIMUM RESIDUAL PRESSURE FOR DIFFERENT BUILDING HEIGHTS

Building Type	Minimum Residual Pressure (MCW)
Single storey	7
Double-storey	12
Three storeys	17

In general, a residual pressure of 7m (for single storey buildings as suggested in CPHEEO) above the ferrule point is designed for the peak flow period. The present distribution network is designed for a minimum residual pressure of 12m per the CMWSSB requirement.

3.12 Peak Factor

The per capita water supply indicates only the average water consumption per day per person over a year. As far as distribution network is considered, the hourly variation matters; this fluctuation is accounted for considering the peak rate of consumption, which is the average rate multiplied by the peak factor.

As per the CPHEEO guideline, the peak factors considered for the hydraulic design is provided in Table 3.5.

Table 3.5- PEAK FACTORS CONSIDERED FOR ANALYSIS OF DISTRIBUTION SYSTEM

Population	Peak Factors
< 50,000	3.0
50,000 – 2,00,000	2.5
> 2,00,000	2.0

The present distribution system is designed for the peak factor of 3.0 to accommodate both intermediate and 24X7 water supply.

3.13 Operational-Supply Hours

The client CMWSSB seeks to provide continuous water supply services to all consumers within the project area of scope. Accordingly, the proposed solution accommodated 24/7 continuous water supply services. However, changing the operational philosophy from its current intermittent services to continuous water supply services would not be achieved on an immediate basis. Rather, it will take a period to adapt the overall water supply systems.

Due to the holistic improvements to the overall water supply system (that starts from the desalination plants, transmission mains, boosting pumping stations), a transition plan would be recommended that will include the construction of the new system assets within the project area of scope and also a strategy for improving the operational/maintenance management.

3.14 Water Supply Philosophy

Downstream of the storage reservoirs/facilities, the water supply service will be delivered by gravity via existing and newly proposed Over Head Tanks (OHT). According to specific operational scenarios, the existing/ New pumping units shall pump the water to the OHT. In case of the non-availability of existing OHT and/or space to construct new OHT assets, the water supply service will be delivered directly by pumping units. Each isolated hydraulic zone will be examined against the factual inputs at each zone and the valid/available possible solutions.

3.15 Isolation Valves & Air Valves

For the operation and maintenance of the distribution system, isolation valves are necessary to facilitate operational activities. Ideally, every branch should have a valve for isolation purposes. In the case of intermittent supply, the maintenance can be provided during non-supply hours; hence every branch need not have a valve.

Isolation valves are also necessary to isolate two reaches of pipelines and/or two areas if an elevation difference exists. In this case, an isolation valve in addition to a wash-out valve will be provided.

Another case where installing isolation valves is necessary is where hydraulic isolation is required with the possibility of providing water maneuvering and/or by-pass as per operational emergencies.

Air valves are required at peak points to release entrapped air, admission of air when draining the system and slow release of air during normal operation. Scour valves are provided in a pipeline system at low points, facilitating draining of the pipeline. The discharge generally will be disposed of into a nearby natural stream/valley.

The distribution system is designed considering the DMA formation, and isolation valves will be recommended wherever isolation is required for hydraulic discreteness of the DMA. In addition, valves will be recommended to create sub-zones for step tests to identify the leak-prone area. PRV might be proposed in specific scenarios where the difference in the residual heads (normally more than 22mm) is critical in terms of operation.

3.16 Water Distribution Hydraulic Zones & DMAs

The proposed design approach of the water distribution systems incorporated the formation of District Metering Areas (DMAs) for better control and audit of water supply against consumption. Applying zoning via the DMA concept would facilitate monitoring and controlling of the distribution systems in terms of quantities (i.e. water demands), quality (i.e. water quality and residual pressure) and finally, economic return on investment (financial returns, billing systems and unaccounted for water due to leakage).

The following criteria for establishing zoning/sectionalization of water distribution system were adopted:

a) **Topography:** The elevation difference between any two points in zones would not be more than 15 m to 25 m. And also, the zone boundary would not cross any physical features like Nallah's, Railway lines, Major Roads etc.,(generally, these features would form the zonal boundary).

b) **The Density of the Population:** The greater the density, the less the area of the zone and Vice-Versa. For instance, a zone in the core area of the town will cover less area than the zone at the outskirts or near municipal limits. A maximum of. 3000 service connections (with a 15000 population) are selected for a DMA**.**

c) **Operation and Maintenance:** The zones were formed in such a way to facilitate the operation and maintenance department's resources, tools, equipment and the adopted SCADA technology. Another criterion adopted was the governmental rules relevant to the administrative boundaries (i.e., ward boundaries).

d) **Type of the Locality/Topographical impact:** such cases can be represented by land-use patterns, existing natural water streams/drains, railways/metro routes, existing structures, etc.

e) **Types of ancillaries/devices** required to create isolation and monitor pressure, water quality and leakage detection.

f) **The capacity of the storage facilities:** The Capacity of the existing reservoir also governs the zoning of the water distribution system. Each zone will be served by the separate reservoir(s). Suppose an existing reservoir is not sufficient to cater to a particular zone's demand. In that case, a new reservoir is proposed, and both the reservoirs (existing and new) will be used for future demand. If the existing are not structurally fit to serve up to the ultimate year, then a new tank must be proposed, which governs the system's zoning.

g) **Neighbourhood zones** may be interconnected if required to provide emergency supplies as per client needs/requirements.

h) One DMA (Sub Zone) would be proposed for every 500-3000 House service connections (i.e., 15,000 capita) considering land use pattern, physical features and topography.

i) Every administrative zone shall be divided into one or more hydraulic zones, and each hydraulic zone shall be divided into one or more DMAs.

3.17 The Problem of Water Losses & Control Approach

The loss of treated water is a major concern in quantity, quality, and revenue loss. In addition, the drastic increase in the requirement due to urbanisation makes it difficult for the service provider to manage the system with adequate supply to the consumers. Therefore, the first stage would be to know the water loss in the system, and for that, it is essential to create the facilities/infrastructure required for the same.

The components of UFW are divided into physical and Non-physical losses. Physical losses are the system's real losses, including leakages in reservoirs, trunk mains, and distribution systems. Non-physical losses are apparent losses in the system, including bulk-meter errors, consumer-meter errors, unauthorized consumption due to illegal connections, and administration errors (rough estimation, meter reading error, etc.).

As mentioned above, it is essential to create the infrastructure for the estimation of UFW while improving the distribution system. As a practice worldwide, the concept of District Metering Areas (DMAs) will be considered while carrying out the design of the distribution system. A DMA means a water administration zone with defined inlets, outlets and hydraulically discrete with a known number of consumer connections. All the inlets and outlets of the DMA shall be metered with an EMF meter. The calculation of UFW in terms of % is as given below:

UFW= (Water Supplied in DMA – (Water billed Authorised Consumption))*100 Water Supplied into DMA

Active leak detection programs on control of water loss are the crucial approach for reducing the water loss and improving the financial revenue of the water board in addition to conserving the water resource.

3.18 Types of Water Losses

The effective control of Unaccounted for Water (UFW) is an important program for improving financial revenue against the water supply service provided to the consumer. It is also an important parameter that positively conserves water resources and combat water scarcity. The approach of controlling the UFW includes a set of programmes and activities aimed at achieving an optimized water supply management system (OWSMS) through improved operation & maintenance and sound management practices.

Before considering any leak detection method, it is essential to estimate the amount of water loss by various means to adopt the appropriate methods. Therefore, it is essential to measure the physical and non-physical losses in the system.

Physical losses:

A physical loss (leakage) in the distribution system measures the actual leakage in a District Meter Area (DMA). This may be measured using the Minimum Night Flow (MNF) method. Leakage shall be evaluated from flow measurements taken at the DMA supply flow meters when demand in the DMA is minimum. This will generally be between the hours of 01.00 and 04.00. From this Minimum Night Flow (MNF), deductions shall be made for metered consumption by large water users during the evaluation period and legitimate use by the remaining consumers to make allowance for toilet flushing, etc., to obtain the Net Night Flow (NNF). To this net night flow, a diurnal pressure factor needs to be applied to correct pressure variation in the system to obtain the actual physical loss of water.

Non-physical losses:

Non-physical losses (commercial losses) result from metering errors and illegal connections. An accredited test bench shall test a few percentages of consumer meters for the accuracy of the meters. This will yield loss through the consumer meter errors. For bulk meters provided at the inlet and outlet of the system, calibration should be provided to make sure that the quantity supplied is accurately measured. In addition, losses through illegal connections must be identified and rectified to reduce the losses.

3.19 Methodology for Reducing Water Losses

After understanding the physical and non-physical losses, for reduction of physical losses, various methods using equipment can be adopted for the reduction of water loss. To reduce commercial losses, it is essential to ensure that accurate meters are installed at the consumer end and all inlets and outlets of the supply system. Moreover, routine maintenance and checking of the accuracy meters with prior planning are essential for reducing and controlling water losses.

Reduction of Physical Water Loss:

Reduction of UFW and leakage is greatly assisted by dividing the distribution network into smaller hydraulically isolated areas within which the characteristics of each district metered area can be monitored and assessed. The impact of any remedial work (for instance, leak repairs or pipe replacement) is quantified and compared against the initial system characteristics to measure the benefits achieved. Inflow and outflow across the boundaries of such small areas are normally metered, hence the name District Meter Area (DMA). DMAs may be further sub-divided and be designed to be progressively reduced in size to undertake step tests to identify the worst leak-prone area so that priority can be given in identifying leaks in the system. The strategy for UFW control is to focus on the worst components progressively. As distribution system leakage is typically the largest contributor to UFW, resources would be focused on DMAs with high UFW to identify the problematic pipe lengths within them, avoiding unnecessary work on pipe lengths that do not require attention. Ultimately the whole distribution network is divided into DMAs.

Reduction of Commercial losses:

Routine maintenance and accuracy tests of all the meters, including consumer meters, shall be carried out. Replacement of inaccurate, defective, and non-working meters shall be carried regularly to avoid commercial losses. Identification and regularisation of illegal connections shall be carried out to reduce water loss. By implementing the SCADA system, the human calculation can be eliminated.

3.20 The Concept of District Metering Areas (DMAs)

Distribution zones are divided into several DMA's to monitor and control UFW. In general, about 500-3000 connections are considered during the formation of DMA. Each DMA area would have a well-defined boundary with DMA meters and isolation valves on both upstream and downstream of the DMA for easy maintenance. Boundary valves are planned on the boundary of each DMA area where pipes are interlinked. These boundary valves are generally kept in the closed position and are operated only during an emergency to allow water flow from one zone to another. These DMA's shall be divided into sub-zones for step test purposes with valves for monitoring and reducing UFW per water supply industry practice. These subzones also help isolate the sections during repairing leaks or maintenance without interrupting the total supply to the DMA.

3.21 Leak Detection Monitoring

Using acoustic rod or digital sound detector:

When a pipe has leakage, a leak sound spreads through the pipe. Wherever the pipe appurtenance is exposed, an acoustic rod or digital sound detector will be placed to detect the sound. Further investigation shall be carried out based on the sound generated using other equipment such as a leak noise correlator.

Detection of leaks by Leak Detector;

The leak detector will identify the locations of the leaking points. Experienced staff shall carry their equipment along the pipe route investigating for leak sounds. Wherever a leak is identified, it will be marked and prepared for further investigation via the excavation process for immediate repair.

Use of Leak Sound Correlator to PinPoint the Leak Point:

Leak Sound Correlator shall be used to confirm the leaking point when leak sound is detected at two points or if they are not sure due to poor signal. This equipment identifies the leak location by intercepting leak noise between two sensors mounted directly on pipes, valves or hydrants. Thus, it pinpoints the leaking point.

3.22 Water Quality Monitoring

Each hydraulically isolated zone shall be provided with water quality monitoring devices at the inlet connection feeding such a hydraulic zone. This monitoring point will relate to another farthest point within the hydraulic zone via a pre-defined information transfer system (Fiber-Optic, GPRS, Radio Frequency, etc.). The main water quality parameters such as concentration level of Chlorine Residual, trihalomethanes, bacterial contamination, pH value. All information shall be connected to a local monitor/control point located at the water source of the hydraulic zone. A decision support framework should be established by operators based on hourly, daily and weekly information. CPHEEO identifies standard Water Quality Parameters for India.

3.23 DESIGN OF ELEVATED SERVICE RESERVOIRS/OVERHEAD TANKS (OHTs)

The OHTs are the elevated structures used for the storage and distribution of water. These OHTs are designed by using the following parameters:

Capacity and Location

The capacity and staging of the service reservoir or overhead tank are arrived at based on the command area, which can be supplied by maintaining the minimum required pressure in the system. Sometimes, separate storage reservoirs at different elevations cater to high-level and low-level zones separately. Depending upon the pumping hours, rate of pumping, hours of supply and supply quantity, the capacity of the storage reservoir is decided. However, as per the norms adopted by TWAD Board, service reservoir capacity shall be 1/3 rd of total demand rounded off next higher 10000 litres.

Staging Height

The staging height of the tank shall be such that a minimum residual pressure of 12 m of water is maintained at the farthest / highest point in the distribution system. To minimise the staging height, it is desirable to locate the reservoir at the highest point in the specific zone. As per the client's requirement, the staging height for the proposed OHT shall be decided so that the minimum residual pressure shall be achieved at 12 m in that particular zone.

3.23.1 Design Basis for Civil Structures

This section outlines the guidelines for the design aspects of civil and structural works briefly

3.23.2 Design Loadings

All Buildings and Structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include Dead Load, Live Load, Wind Load, Seismic Load, Dynamic Load, Vehicular Load and Monorail/EOT Crane Load and Stresses due to temperature changes, shrinkage and creep in materials, etc.

Dead Load

This shall comprise all permanent construction, including walls, floors, roofs, partitions, stairways, fixed service equipment, and other machinery items. All fixtures, attached piping, etc., shall be considered in estimating loads of process equipment.

Dead Loads shall be in general as per IS 875 (Part 1). However, the following minimum loads are to be considered for the design of structures:

Weight of water	10 kN / m^3
Weight of soil (irrespective of strata available at site and type of soil used for filling etc.). However, for checking stability against uplift, the actual weight of soil as determined by field test shall be considered	20.00 kN / m^3
Weight of Concrete	24.00 kN / m^3
Weight of Reinforced Concrete	25.00 kN / m^3
Weight of Brickwork (exclusive of plaster)	20.00 kN / m^3
Weight of Solid Concrete Blockwork (exclusive of plaster)	22.00 kN / m^3
Weight of plaster to the masonry surface	18.00 kN / m^3
Weight of sand	20.00 kN / m^3
Weight of alum blocks	24.20 kN / m^3
Weight of MS chequered plates	78.5 N/m^2 per mm thickness of plates

Live Load

Live Load shall include the superimposed loads due to the structure/building's use/occupancy of the structure/building, not including Dead, Wind or Earthquake Load.

Live Loads shall be in general as per IS 875 (Part 2). However, the following minimum Live Loads shall be considered in the design of structures:

Live Load on roofs	For Accessible Roof- 1.50 kN/m^2 For Non-Accessible Roof- 0.75 kN/m^2
Live Load on floors supporting Equipment such as pumps, valves, Blowers, Compressors and Equipment etc. (Subject to verification of vendor's requirement)	10.00 kN/m^2
Live Load on all other floors, Walkways, stairways and Platforms	5.00 kN/m^2
Live Load on Toilet areas	2.00 kN/m^2
Live Load Surcharge for Structures	1.2m x Density of Soil (Equivalent load as per IRC 6)

In the absence of any suitable provisions for Live Loads in BIS Codes or as given above for any particular type of floor or structure, assumptions made must receive the Engineer's approval before starting the design work. Apart from the specified Live Loads or any other load due to material stored, any other equipment load or possible overloading during maintenance or erection/construction shall be considered partial or full, whichever causes the most critical condition.

Wind Load

Wind Loads shall be as per IS 875 (Part 3).
Parameters:

Design Wind Speed at any height Vz =(Vb x k1 x k2 x k3) m/sec Clause 5.3

Basic wind speed (Vb) Appendix -A

k1 - Probability factor or Risk Coefficient Table -1

k2 - Terrain height & structure size factor Table - 2

k3-Topography factor Clause 5.3.3

Design Wind Pressure at any height : Pz =(0.6 x Vz^2) N/m^2 Clause 5.4

Earthquake Load

This shall be computed as per IS 1893 (Part 1) for Buildings, IS 1893 (Part 4) –for Industrial Structures and IS 1893for Liquid Retaining structures. An important factor appropriate to the type of structure shall be considered for the design of all the structures.

Dynamic Load

Dynamic loads due to the working of plant items such as Pumps, Blowers, Compressors, Switch Gears, Travelling Cranes, etc., shall be considered in the design of structures.

Dynamic Loads due to the working of Machines / Equipment- Foundation weight shall be sized to 3 times the dynamic weight of rotating equipment.

Monorail / EOT Crane Load

(i)For Hoists and Monorails - For manually operated - Lifted load, Impact factor 10%, Lateral surge 10% & Longitudinal surge 5 % of Crab

(ii) For EOT cranes - Lifted load, Impact factor of 25%, Lateral surge 10% and longitudinal surge 5 % of Crab

Vehicular Load

For any structure surcharge load or pipeline below the roads, Class A loading of IRC 6 shall be considered.

3.23.3 Design Life Period

The design depreciation period of all structures and buildings shall be 50 years as a minimum, anticipating that no major repair will be required in the depreciation period

3.23.4 Design Criteria for Underground or Partly Underground Liquid Retaining Structures

All Underground or partly Underground Liquid Retaining structures shall be designed for the following conditions:

(a) Liquid depth up to the full height of the wall; no relief due to soil pressure from outside to be considered.

(b) Structure empty (i.e., empty of liquid, any material, etc.); full earth pressure and surcharge pressure wherever applicable to be considered.

(c) According to the geotechnical report recommendations, if a Water table exists, Earth Pressure should be considered for submerged soil conditions.

(d) The partition wall between the dry sump and wet sump is designed for full liquid depth up to the full height of the wall.

(e) The partition wall between two compartments will be designed to be empty and the other full.

(f) Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads (Hydrodynamic Impulsive pressure).

(g) If a water table exists, Underground or partially Underground structures shall be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures beneath the base slab concerning geotechnical report recommendations. The Structures shall be designed for uplift in empty conditions and ensure a minimum safety factor of 1.2 against uplift with an appropriate safety factor to the characteristic dead load.

(h) The equilibrium and safety of the structure and parts of it against sliding and overturning, especially when the structure is founded on the side of long or sloping ground, shall be checked.

(i) For General retaining walls, both overturning and sliding checks shall be performed with appropriate safety factors for Characteristic Dead Loads as per codal provisions.

(j) For Large-sized tanks where the walls are designed as retaining walls, an overturning check shall be performed with appropriate safety factors for Characteristic Dead Loads as per codal provisions.

(k) All the Liquid Retaining structures shall be designed for maximum design crack widths of 0.1mm for direct tension and flexure.

(l) Overturning: The Stability of a structure as a whole against overturning shall be ensured so that the restoring moment shall be not less than the sum of 1.2 times the maximum overturning moment due to the characteristic dead load and 1.4 times the maximum overturning moment due to the characteristic imposed loads. In cases where dead load provides the restoring moment, only 0.9 times the characteristic dead load shall be considered. Restoring moment due to imposed loads shall be ignored.

(m) Sliding: The Structure shall have a factor against sliding of not less than 1.4 under the most adverse combination of the applied characteristic forces. Only 0.9 times the characteristic dead load shall be considered in this case.

Foundations

(a) The minimum depth of foundations for all structures, buildings and frame foundations and load-bearing walls shall be as per IS 1904, but in any case, this shall not be less than 1.0 meter in the original soil.

(b) All related parameters of design and Safe Bearing Capacity of the soil strata shall be considered per Geotechnical report recommendations.

(c) Care shall be taken to avoid adjacent buildings or structure foundations without destabilizing them. Suitable adjustments in-depth, location and sizes may have to be made depending on site conditions.

(d) Special attention is drawn to the danger of uplift caused by the groundwater table. If Water Table exists, all related underground structural slabs shall be designed for uplift forces due to groundwater pressure concerning the Geotechnical report recommendations.

(e) EGL (Existing ground level) and FGL (Finished ground level) shall be marked on all drawings showing foundation/sub-structure details and related design documents. Machine/static equipment foundations shall be separated from adjoining parts of buildings, other foundations and floor/pavement slabs. Joints at floor/pavement slabs shall be suitably sealed.

(f) Foundations and structures for machines subject to vibrations shall be so proportioned that the amplitude and frequency of the foundation/structure are within the permissible limits as per relevant BIS codes (or as required by the machine vendor).

(g) Machine foundations shall be designed and detailed as per IS 2974. All appendages to such foundations shall be Reinforced suitably to ensure integral action.

(h) Machine / Static equipment foundations shall be separated from the adjoining parts of the Buildings, other foundations and floor pavement slabs. Joints at floor/pavement slabs shall be suitably sealed.

Design Requirements

The following are the design requirements for all Reinforced or plain concrete structures:

(a) All Blinding and levelling concrete shall be 150 mm thick in concrete grade M15.

(b) All Liquid Retaining Reinforced concrete structures shall be of a minimum M30 grade with a maximum 20 mm aggregate size for all structural members. For Buildings, Reinforced concrete shall be of a minimum M25 grade (Footings, Plinth Beams, Columns, Slab and Beams, etc., i.e. which are other than Liquid Retaining structures) with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural members. Further, if any Liquid Retaining RCC tanks are coming up with in the buildings, concrete shall be of minimum M30 grade for such RCC tanks.

(c) The Reinforced concrete for all structures shall have a minimum cement content of 375 kg/m^3 with a maximum 20 mm size aggregate and 350 kg/m^3 with a maximum 40 mm size aggregate. Reinforced concrete shall have a maximum slump of 100mm with a maximum water-cement ratio of 0.48.

(d) All Liquid Retaining Structures shall be analysed & designed concerning their aspect ratios and respective boundary conditions as per the provisions of relevant codes and standard specialist literature, etc.
The design of all structural members of all Liquid Retaining Structural members shall conform to 'Controlled cracked design criteria' as per the provisions of IS 3370 (Part-1 &2) specifications by adopting the 'Limit State Design approach' with a serviceability crack width of 0.10 mm and other limit state requirements also to ensure an adequate degree of safety and serviceability.

(e) All Building Structures shall be idealized & analysed as RC structural framing systems. The design of all structural members of all buildings shall conform to 'Limit State Design' as per the provisions of IS 456-2000 for strength, serviceability and durability criteria requirements with a structural concrete grade of M25 (minimum).

(f) All external walls for Buildings shall be in Brickwork/Solid Cement Concrete blocks of concrete grade M15 and shall be provided as per IS: 2185 and shall be 230/200 mm thick, respectively.

(g) All Internal partition walls shall be in Brickwork/solid cement concrete blocks of concrete grade M15 and provided as per IS: 2185. All internal walls shall be 230/200mm thick except for toilets. Toilet partition walls shall be 100 mm thick solid concrete block or 115mm Brickwork.

(h) The minimum clear cover to the main reinforcing bars for different members:

<u>Non–Liquid Retaining structures</u> <u>shall be as follows unless stated otherwise:</u>

(i)	Slab (Floor, Roof, Canopy, Chajja and Staircase)		30 mm
(ii)	Beams (Sides, Bottom & Top)		40 mm
(iii)	Lintels (all around)		30 mm
(iv)	Columns		
	(a)	For Columns width 200 mm	40 mm
	(b)	For Column width 230 mm & above	50 mm
(v)	Pedestals (in contact with earth)		50 mm
(vi)	Basement wall, Retaining walls		
	(a)	Face in contact with earth	50 mm
	(b)	Interior face	50 mm
(vii)	Foundations (Top, Bottom and sides)		50 mm

<u>Liquid Retaining structures shall be as follows unless stated otherwise:</u>

(i)	Walls - Face in contact with earth	60 mm
(ii)	Walls - Face in contact with Water	60 mm
(iii)	Base Slab in contact with Water	60 mm
(iv)	Base Slab in contact with Soil	60 mm
(v)	Launders/Gutter Slabs	45 mm

(i) Reinforcement for all Liquid Retaining structural units and those connected with these systems shall be HYSD –CRS (Corrosion Resistant Steel) bars of Fe-500, and for buildings & other structural units (i.e. for those structures other than the Liquid Retaining structures) shall be HYSD bars of Fe-500 grade. All physical and chemical properties of this Fe, 500-grade steel, shall conform to IS 1786. Welded wire fabric shall conform to IS 1566 as shown or specified on the drawing. The CRS (corrosion-resistant steel) index shall be at least 1.35 when tested for the Salt Spray test as per ASTM B 117 test procedure for 120 hours compared with the Fe 500 normal reinforcement bars and the same bar diameter.

All test results (including physical and chemical properties and salt spray tests) have to be produced for the respective bar diameter for each consignment of steel delivered at the site and a frequency of every 20 Metric Tons. Reinforcement bars and structural steel to be procured only from Primary steel producers/Integrated Steel Plants such as TATA/SAIL/RINL/JSW/SHYAM STEEL using iron ore as the basic raw material and having in-house iron-making facilities followed by the production of liquid steel and crude steel with in-house rolling, adopting BF-BOF route or DRI-EAF technology as per Ministry of Steel guidelines. No Re-rolled material/secondary steel will be accepted or allowed for any structural works.

The steel manufacturing company should have the latest ISO accreditation for Quality Management System

(j) All Buildings shall have a minimum of 1 meter wide, 100 mm thick plinth protection paving in M15 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well-compacted strata.

(k) All pipes and ducts laid below the structural plinth and road crossings shall be surrounded with concrete of grade M15 having a minimum of 150 mm thick concrete or D/4 (D = outer dia. of pipe) thickness, whichever is more.

(l) Use of pressure relief valves to reduce uplift pressure due to the ground water table shall not be allowed.

(m) The reinforcement's details shall be considered per the latest Indian code of practices and special publications as applicable.

(n) Sliding Layer or Slip Layer shall be provided between sub-base and structural slab (Raft). Polythene sheets of 500 microns shall be provided as a sliding layer per IS specification.

(o) Water tightness testing of water retaining structures shall be conducted; following IS 3370, (Part I) - 2009. The depth of water for testing shall be up to the soffit of the covering slab.

(p) The following minimum thicknesses shall be adopted for main structural Reinforced Concrete components, irrespective of design requirements:

(i)	Walls for Liquid Retaining structures	:	300 mm
(ii)	Foundations for Walls of Liquid Retaining Structures	:	300 mm
(iii)	Roof slabs for Liquid Retaining structures (Other than flat slabs)	:	150 mm
(iv)	Bottom slabs for Liquid Retaining structures (Other than wall foundations)	:	250 mm
(v)	Floor slabs, Roof slabs, Walkways & Canopy slabs, etc.	:	125 mm
(vi)	Walls of cables / pipe trenches &		

	Underground pits, etc.	:	200 mm
(vii)	Column footings	:	300 mm
(viii)	Parapets, chajja and all fascias	:	100 mm
(ix)	Precast trench cover	:	75 mm
(x)	Column Dimensions		
	(a) To match with Block Masonry wall width:200 mm		
	(b) To match with Brick Masonry wall width: 230 mm		
	(c) In general case	:	300 mm
(xi)	Beam Dimensions		
	(a) To match with Block Masonry wall width	:	200 mm
	(b) To match with Brick Masonry wall width	:	230 mm
	(c) In general case	:	300 mm
(xii)	Launder Base Slab	:	200 mm
(xiii)	Launder Vertical Wall, Baffle Wall & Gutter Slab, etc.	:	150 mm
(xiv)	Grade Slabs	:	150 mm
(xv)	Elevated Service Reservoirs (ELSRs)		
	(a) Top Dome	:	125 mm
	(b) Cylindrical wall	:	200 mm
	(c) Bottom Dome	:	150 mm
	(d) Conical wall	:	250 mm
	(e) Raft Slab	:	300 mm

Joints:

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall suit the structure. However, contraction joints shall be provided at specified locations, not more than 7.5 m in both right-angle directions for walls and rafts.

Expansion joints of the suitable gap at suitable intervals not more than 30 m shall be provided in walls, floors and roof slabs of water retaining structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on the convenience of construction.

To avoid concrete segregation in walls, horizontal construction joints are normally provided at every 2 m height. PVC water stops of 150 mm width shall be used for walls and 230 mm width for base slabs.

3.23.5 Design and Detailing Standards:

All designs shall be based on the latest Indian Standard Specifications or Codes of Practice. The design standards adopted shall follow the best modern engineering practice in the field based on any other international standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Engineer.

All Reinforced concrete structural design shall generally conform to the following publications by the Bureau of Indian Standards (BIS):

(a) IS 875 : Code of Practice for design loads for buildings and structures (Part 1 to 5)

(b) IS 456 : Code of Practice for Plain and Reinforced concrete

(c) IS 3370 : Code of Practice for concrete structures for the storage of liquids (Part 1 to 4)

(d) IS 1893 : Criteria for earthquake resistant design of structures.

(e) IS 1904 : Code of Practice for Design and Construction of Foundation in Soils: General Requirements.

(f) IS 2974 : Code of Practice for design and construction of machine foundations (Part 1 to 5)

(g) IS 3414 : Code of practice for Design and Installation of Joints in Buildings.

(h) IS 4326 : Code of practice for earthquake resistant design and construction of buildings

(i) IRC 6 : Standard Specification and code of practice for roads and bridges : Loads and Stresses.

(j) SP 16 : Design Aids for Reinforced Concrete to IS 456.

(k) SP 34 : Handbook on Concrete Reinforcement and Detailing.

All Structural steel design shall generally conform to the following publications by the Bureau of Indian Standards:

i) IS 800 : Code of Practice for general construction in steel
ii) IS 806 : Code of Practice for use of steel tubes in general building construction
iii) SP 38 : Handbook of Typified Design of Structures with Steel Roof trusses.

3.24 DESIGN CONSIDERATIONS OR MECHANICAL WORKS

3.24.1 Types of Pumps

Two types of pumps are considered for comparison for the selection of pumps. For dry pit Horizontal Split Case Centrifugal Pumps and Wet Pit Vertical Turbine Pumps. For dry pit, Horizontal Split Case Centrifugal Pumps viz. pumps have horizontal shafts connected to horizontal shaft motors and Vertical Turbine Pump sets connected with vertical solid or hollow shafts motors. The horizontal shaft dry pit configuration is the most conventional type of installation in India for pumping water from above-ground reservoirs with flooded suction. The vertical turbine pumps are used in pumping water from a high depth sump or river/sea/intake/canal. The Horizontal Split Case Centrifugal Pumps are relatively quite easy to erect. There are fewer shaft alignment problems as one would come across compared to vertical shaft pump installations. Horizontal shaft pumps are normally designed with side suction & side discharge nozzle with flooded suction. This feature is essential to avoid priming before starting the pump.

The vertical shaft pumps have one distinct advantage over the horizontal shaft pump; the motor is at a higher level making it safe during the flooding of the dry well due to any unforeseen reason. Moreover, the width of the dry well reduces with vertical shaft pumps, thereby reducing the dry well area, which could be advantageous if there are site constraints.

Vertical Turbine Pumps are widely used abroad and in many installations in India. The installations involve a suction well, circular or rectangular, in which the pumps are installed. The civil cost is relatively low, and construction is relatively simple. The only disadvantage is that these pumps are relatively expensive compared to conventional pumps.

Vertical Turbine Pumps are selected for the application, as the civil cost is also substantially low and area requirement is also less, Pump Efficiency is also better, and suction side valves and pipes would be eliminated.

Pump Construction

To ensure reasonable life for the pump sets, the following materials are proposed for the major pump parts:

S. No.	Component	Material
(i)	Impeller	Bronze, Grade LTB 2, IS 318
(ii)	Casing	Cast Iron to IS:210 Gr FG 200
(iii)	Mechanical seal (Motor side and Pump side)	Water-lubricated with tungsten carbide or silicon-carbide faces
(iv)	Shaft	Stainless Steel: AISI SS 410
(v)	Bush	Bronze IS 318 Gr. LT B2
(vi)	Fasteners and Foundation Bolts	Stainless Steel AISI 304

Pump Capacity

Given a choice, it is always attractive to select as far as possible equal capacity-equal head pumps. The advantages are less inventory of spare parts, relatively lesser capital cost and simplicity of operation. Moreover, keeping the minimum velocity in the pumping main within the normally acceptable value. The other alternative would be to adopt unequal capacity pumps. The advantages are more combinations of pumping rate making it possible to better match the inflow rate with the pumping rate and reduced retention period, especially during minimum flow conditions. Weighing the pros and cons of the different types of pumps, adopting equal capacity pumps is proposed.

Number of Pumps

The selection of the number of pumps depends significantly, in addition to other factors, upon the retention time and the space available. The lesser the number of pumps, the larger the capacity of each pump and the greater the retention time. A lesser number of high-capacity pumps also increases the depth of the pumping station since there is an increase in the wet well volume along with an increase in submergence that each pump demands. This is an important factor at sites where deep excavation poses a problem. The number of pumps has been selected to balance the above two aspects.

The number of standby pumps is selected to have 50% standby.

The pump configurations will be selected based on minimum power consumption, less inventory.

3.24.2 Pumping Main

A single pumping main is proposed to be installed considering the aggregate peak flows. The diameter of the pumping main is selected based on the minimum and maximum velocity considerations of 0.6 m/sec and 2.0 m/sec, respectively. The minimum velocity is selected to prevent the settlement of grit, and the maximum velocity is selected to minimize erosion of the pipe.

Although in some cases, the minimum velocity consideration may not be possible during single pump operation, a greater number of pumps operate during peak flow, thereby achieving a flushing velocity of 1.2 m/sec, which keeps the pumping main free of settlements.

3.24.3 Positive Suction

One of the problems at the pumping stations stems from the improper design incorporating negative suction. This problem does not exist in vertical turbine pumps since the pumps always work under submerged conditions. In the case of dry pit pumps, positive suction shall be provided by locating the pumps below the minimum starting level so that the pump casing is filled with water before starting.

If a Vertical Turbine/Submersible pump is selected for the application, positive suction will be maintained by pump submergence condition.

3.24.4 Pumping House Configuration – Wet /Suction Well Design

Pumping Stations with Vertical Turbine/submersible pumps are proposed with circular suction wells considering the ease of construction. If necessary, rectangular suction wells may also be considered depending on site constraints.

Pumping stations with Horizontal Shaft Split Case Centrifugal Pumps are rectangular.

3.24.5 Dewatering System & Sump drainage arrangement.

Submersible centrifugal sewage non-clog pumps having discharge 20 M3/hour at 15 m head to be provided for above. The pump should be vertical spindle type, wear resistance with submersible motor for the various duty conditions. The pump shall handle min 100 mm solid size with sewage specific gravity of up to 1.05. The pump shall be of robust construction. Liquid passages shall be finished smooth and designed to allow free passage to solids. Pump Impeller should be of non-clog semi-open type, single vane / multi-vane preferably vortex impeller design. A double mechanical seal with silicon carbide faces should be provided to protect the motor from sewage ingress along the shaft.

Drain Pump:

For dewatering the stuffing box & piping leakage, one number portable horizontal submersible mono set is to be provided with an impeller of cast Iron. It shall be with double mechanical seals to prevent moisture ingress into the motor. It shall be complete with an automatic level switch, common pipe of 40 mm steel pipe for the pump to connect it to the nearest drain. The discharge capacity of the drain pump shall be 10 m3/hr against 10 Mtrs head

3.24.6 Forced ventilation system:

A fresh air circulation system is to be provided for the pump house for circulation of fresh air to limit the increase in temperature and avoid stale air presence. The complete system and all associated required air supply fans, exhaust fans, ducts, grills, galvanized bird screens, hoods, and all necessary accessories shall be provided. Suitable arrangements to prevent rainwater ingress into the building shall also be provided.

All ductwork shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending of fabrication of ducts.

3.24.7 Material Handling:

For erection and maintenance of pump sets and other equipment, an Electrically Operated crane is proposed for a crane capacity of 5 Tons and above. An electrically Operated Hoist is proposed to provide a crane capacity of 2 Tons and above. Hand operated hoists are proposed for a capacity of fewer than 2 Tons.

3.24.8 Piping and Valves:

All pipework will be manufactured out of Ductile iron (K9) for all pump delivery piping and common header. The delivery pipework will be rated based on the respective maximum working pressures. The Individual delivery pipe velocity shall be about 2.4 m/sec. All pipework within the pumping station will be flanged. After installation, all pipe work will be tested to 1.5 times the working pressure.

All Valves inside the pumping station shall be made of Ductile Iron.

Motorized Sluice/Butterfly shall be used on the suction side of each horizontal centrifugal pump. On the delivery side of each pump, one Swing check valve and one electrically operated sluice valve are to be provided with metallic expansion joints. For suction/discharge pipe size up to 900 mm electrically operated sluice valve to be considered. An electrically operated butterfly valve should be considered for a suction/discharge pipe size of more than 900 mm.

When Wet pit pumps are installed, only the delivery side valves with metallic expansion joints are required; one Swing check valve and one electrically operated sluice/butterfly valve may be considered as per the above condition.

The common header will provide one Swing check valve and one electrically operated sluice valve with metallic expansion joints. Expansion joints shall be provided for easy erection and dismantling of the pumps and valves. One Air valve with an isolation valve and one scour valve to be provided within the pump house campus. All valves in the common header shall be installed in valve chambers.

3.24.9 Flow Measuring Devices:

Flow measuring devices of electromagnetic type are recommended to be provided at all the major water distribution stations with peak flow greater than or equal to 40 MLD as they are considered reliable and accurate measurements. As these devices are expensive, portable ultrasonic flow meters could be provided at smaller pumping stations.

Portable flow meters offer a non-intensive method of flow measurement. In this method, the flow measurement is done liquid flow in a pipeline is measured by clamping or inserting the flow transducers on the outer wall of the pipeline. The flow totalizer/ computer receives and processes the signal from the transducers. It provides facilities for entering process data connected to the flow measurement and computes and displays the flow. The data such as pipe diameter, pipe material, wall thickness, liquid details, etc., is entered in the flow computer and is stored in its memory. The flow totalizer/ computer displays the flow rate, integrates the flow over a period and stores the flow trend in its memory. It is possible to achieve less than ±2% accuracy in the flow measurement.

3.25 DESIGN CONSIDERATIONS FOR ELECTRICAL WORKS

3.25.1 General Design Criteria

a) All electrical equipment shall be rated for 45°C design ambient temperature.

b) The design standards described herein generally comply with the latest IEC, Indian Standards, and code of practices established in the country.

c) All electrical installations shall conform to the latest Indian Electricity Acts and Rules.

The following aspects were considered while designing the electrical system for this package:

1. Safety of life and property
2. Reliability of power supply to the extent possible
3. Automatic protection of all electrical equipment through selective protection system
4. Simplicity of operation
5. Flexibility of system
6. Initial Cost
7. Power Factor Improvement

3.25.2 System Voltage Details

Table 3.6: MV & LV System Voltage details:

Sr. No	Description	Unit	MV System		LV System
1	Nominal Voltage	kV	3.3	11	0.415
2	Highest System Voltage/No-load Transformer Voltage for LT System	kV	3.6	12	0.433
3	Frequency	Hz	50	50	50
4	Connection		3 Wire	3 Wire	4 Wire
5	System Earthing		Solidly Earthed	Solidly Earthed	Solidly Earthed
6	Fault Level	MVA	180	500	36
7	Fault Current	kA	31.5	26.2	50

Unless otherwise specified, the Water Distribution Station's all-new installations shall be capable of continuous operation at a voltage level in the range of 90% to 110% of the relevant nominal voltage and a frequency variation of plus 5% minus 5% with a maximum combined tolerance of 10%.

AC Control, Lighting and Space Heating

a)	Voltage	:	240 V
b)	Phases	:	1
c)	Frequency	:	50 Hz
d)	Connection	:	2 wire (Phase & Neutral)

DC Control, Protection and Alarm

a)	Voltage	:	110 V
b)	Phases	:	1
c)	Connection	:	2 Wire (unearthed)

3.25.3 Lighting

All internal and external areas shall be provided with LED lightings. The required illumination levels must be achieved on the working plane per different areas/ locations.

3.25.4 Illumination System

The latest version of related IS standards, NBC, and National Lighting Code (NLC), shall be referred for designing Illumination for different areas in all the Pumping Stations or Water Distribution Stations.

3.25.5 System Earthing

An earthing system comprising earth electrodes and conductors shall be established for Water Distribution Stations.

The earthing system shall be designed to give a combined earth resistance value of not greater than 1 ohm. To obtain suitable final values, soil resistivity shall be measured at the various sites during the detailed design phase of the work.

3.25.6 FIRE FIGHTING DEMAND & FIRE HYDRANTS

CPHEEO guidelines 1999 and IS 9668:1980 recommended that the fire demand be considered 100*square root of (0.001*population) (kilolitres per day). Considering 50,000 capita upon the equation provided will lead to 9 l/s fire flow. Fire hydrants shall be provided in spacing around 800 feet (244 meters) as per NFPA Fire Code 2015 Edition.

Fire hydrants are considered during the design and construction of the distribution systems within Chennai Core City under this project. It is always recommended that the design include fire hydrants even via extra spacing rather than omitting and discarding from the water distribution system. Typical Fire hydrant drawing is shown in 701563/PMC400MLD/CP-4/PW/SD/018.

4 CHAPTER 4: POPULATION AND WATER DEMAND

4.1 Population Projection Background

Projection of future population for the service area is one of the important tasks which influences the estimation of the future water demand. Population projections play a vital role in the planning of any developmental activities. Therefore, it is the primary goal to understand the present population and trend of future development to plan the water supply components for the design years. CPHEEO manual specifies various methods of population projection like Arithmetic Increase Method, Incremental Increase Method, Geometrical Progression Method, Line Of Best Fit Method, Exponential Method, Population Forecast By Semilog graphical Method etc. All the design for reservoirs, pumping stations, and distribution systems depends on the population's correctness and demand estimation. Hence it is essential to finalise the service area and population details for the project design horizon.

Chennai Metropolitan Authority developed the entire Chennai Metropolitan area (CMA) population forecast in "Second Master Plan for Chennai Metropolitan Area, 2026 " (hereinafter CMDA-MP) in the year 2008 before the 2011 census. Further, the new comprehensive Master plan report for the water and sewerage system has been prepared and submitted by M/s Shah Technical PMCs in 2016 (will be called M/P during the upcoming sections).

Upon comparing the Chennai Core city forecast population for 2011 (49.32 lakhs) in CMDA-MP with the actual census results in 2011 (46.37 lakhs), M/P concluded that the forecast in CMDA-MP was an overestimation for the Chennai Core city and subsequently carried out its estimate to incorporate the latest population trend found in the census 2011. M/P has considered the base year, intermediate year, and ultimate stage year 2020, 2035 and 2050. The population projection used in this report shall be developed to match CMWSSB requirements for the base year 2025, the intermediate year 2045 and the ultimate stage year 2055.

4.2 Project Area

Chennai Core City:

The main project area of the CP-4 package covers Chennai Core City, presently comprising 107 divisions/ wards (earlier 155 divisions/wards) with a total area of about 176 sq km. The details of Chennai Core City are given in Table 4.1

Table 4.1: General Details of Chennai Core City

a.	Area of the Chennai Core city	176 sq km
b	Population (2011 Census)	46,46,732
c	Number of Wards/divisions	107 (155 erstwhile)
d	Number of Admin Zones	7 (10 erstwhile)

4.3 Population and Water Demand for Area X

As 2021 census data is not available to carry out the new estimate by incorporating the latest trends in population, the PMC team has collected information related to historical population records; studies carried out in the approved master plan 2016. JICA PDR 2016 from the year 2020 to 2050 and an estimate developed to come up with an acceptable projection for population estimates up to the horizon year 2055 as defined by the client CMWSSB.

The details of population estimation with water demand projection details for the entire project area are provided in Annexure 4.1. However, admin area wise summary details are given in Table 4.2.

Table 4.2: Population Estimation and Demand Projection

Admin Area	Population (in Thousands)					Water Demand (MLD)* with 10% distribution including Commercial and firewater demand			
	2011	2025	2040	2050	2055	2025	2040	2050	2055
Area IV	697.27	741.74	780.65	809.20	823.89	126.07	132.41	137.05	139.44
Area V	619.44	639.44	659.52	671.87	678.12	109.45	112.73	114.74	115.75
Area VI	647.58	684.41	723.83	750.66	765.70	116.80	123.23	127.60	130.04
Area VIII	664.72	718.67	772.84	809.27	827.84	122.30	131.13	137.05	140.07
Area IX	736.43	766.46	803.79	823.16	836.99	131.18	137.27	140.42	142.67
Area X	731.53	779.62	836.23	871.98	894.25	132.55	141.77	147.58	151.20
Area XIII	549.76	608.27	662.45	700.76	719.41	103.66	112.50	118.73	121.77
Total	**4646.73**	**4938.61**	**5239.30**	**5436.90**	**5546.19**	**842.02**	**891.02**	**923.17**	**940.95**

**Excluding bulk water demand which varies from area to area based on actual consumers*

Table 4.3 shows ward wise population and water demand projection details for Area X. for various design horizon years. The total population estimated for the ultimate year is around 8,94,250, with a water demand of 151.2 MLD. An amount of 7.2 MLD bulk water demand (according to the client record) presented in Table 4.4 is added to the water demand of Area X makes the total water demand equal to 158.4 MLD.

Table 4.3: Depot wise Population Estimation and Demand Projections- Admin Area X

Admin Area-X Depots	Population (in Thousands)					Water Demand (MLD)* with 10% distribution including Commercial and firewater demand excl. Bulk water demand			
	2011	2025	2040	2050	2055	2025	2040	2050	2055
127	31.86	32.58	36.94	38.63	39.47	5.95	6.37	6.64	6.78
128	60.86	61.96	68.94	71.63	73.40	10.86	11.58	12.01	12.30
129	61.52	62.63	69.66	72.38	74.17	10.97	11.70	12.14	12.43
130	44.83	45.41	49.46	51.01	52.44	7.93	8.42	8.67	8.90
131	86.79	88.66	100.50	105.24	107.90	15.53	16.67	17.43	17.86
132	23.74	24.05	26.19	27.01	27.77	4.33	4.60	4.73	4.86
133	49.47	50.11	54.59	56.29	57.87	8.71	9.25	9.53	9.78
134	40.33	40.85	44.49	45.89	47.17	7.17	7.60	7.83	8.04
135	31.87	32.28	35.16	36.26	37.28	5.73	6.08	6.26	6.42
136	30.02	30.41	33.12	34.16	35.12	5.41	5.74	5.91	6.07
137	56.89	58.00	65.09	67.90	69.66	10.24	10.96	11.41	11.70
138	29.23	30.00	34.68	36.58	37.46	5.56	6.00	6.31	6.45
139	49.42	50.71	58.63	61.84	63.32	9.18	9.91	10.43	10.67
140	33.48	34.35	39.72	41.89	42.90	6.33	6.82	7.18	7.34
141	34.32	35.06	39.70	41.55	42.61	6.36	6.82	7.12	7.30
142	66.91	68.65	79.37	83.72	85.72	12.29	13.27	13.97	14.29
Total	**731.53**	**779.62**	**836.23**	**871.98**	**894.25**	**132.55**	**141.77**	**147.58**	**151.20**

Table 4.4: Bulk Water demand Projections for Area X.

Sl.no	Depot no	Location	Demand in MLD
1	127	SAF	0.417
2	127	FOOD GRAINS MARKET	0.025
3	127	CMDA	0.020
4	127	CMRL	0.039
5	127	RAIL NAGAR	0.033
6	127	BASHYAM FLATS-2000Nos	1.485
7	127	RADIANCE FLATS-1000Nos	0.743
8	128	IAS QUARTERS	0.033
9	130	GREEN PARK-HOTEL	0.071
10	131	CPWD QUARTERS-1298Nos	0.964
11	131	AVM ASTA-660Nos	0.490
12	132	TNSCB -ASHOKA CLNY-200Nos	0.149
13	132	TNHB FLATS (Under cons.)-1150Nos	0.854
14	136	HOTEL RESIDENCY TOWERS	0.060
15	138	TNHB QUARTERS	0.120
16	138	ESIC COLLEGE & HOSPITAL (470beds*450lit)	0.212
17	140	TNSCB FLATS-REDDIKUPPAM-544 Nos	0.404
18	142	SUN SHINE APPARTMENTS-1200 Nos	0.891
19	142	INDUS AMBER FLATS-260 NOs	0.193
			7.202

5 CHAPTER 5: ASSESSMENT OF THE EXISTING SYSTEM

5.1 General

Water supply to consumers with the required quantity and quality can be achieved only when the system is maintained and improved by strengthening it to meet future requirements. It is necessary to assess the status of the present water supply infrastructures and present service levels by identifying the intervention required in the present system. Because of that, the condition assessment of water supply components has been carried out, and field data has been collected.

Water supply distribution pipes form a major part of the capital investments in any water supply project. Thorough knowledge of the existing pipes regarding their carrying capacity and physical condition is required to be known for better pipeline maintenance. This information can be correlated to arrive at logical conclusions for retaining the pipes for future use.

The present distribution networks in Chennai Core City consist of CI, DI, MS, and PVC pipelines. Most of these pipes are fall in different age groups from 20 years to more than 50 years.

The pipe samples excavated or replaced during routine Operation and Maintenance have been examined for their condition. The condition assessment is carried out based on visual observations/ inspection. The details are as follows.

5.2 Pipeline Condition assessment in Area X

5.2.1 Assessment based on physical samples

The distribution system (Pipeline) of area X consists of CI, DI, MS and PVC pipe dia ranging from 100mm to 1600mm. Photos of various pipe samples collected depot wise of Area X are listed in Annexure 5.1. Figure 5.1 represents photos of the existing water pipeline samples collected during the site visits.

Figure 5.1: Photographs showing Condition of the distribution network in Area X

From the above observation, it is clear that regardless of the pipe aging and dia, the current condition of pipes shows dramatic deterioration resulting from pipe scaling, tuberculation, biofilms formation, and obvious reduction in the net cross-sectional area of the pipes. This might be due to Lead joints used for CI pipe joints in the olden days, which are susceptible to yield due to deflection during uneven soil settlement. Due to this, it is prone to leak at joints & also, in the olden days, CI pipes were manufactured without internal lining. The pipes are encrusted, reducing the C value and its carrying capacity. Even disturbance caused to the existing pipeline joints during excavation and laying of other utilities will also lead to pipeline susceptible to leakages. Due to the present adopted intermittent supply system, the distribution system often becomes empty during non-supply hrs. It causes negative pressure at some locations, which causes contamination due to the entrapment of foreign objects into the water supply.

Condition. Most of the above samples are taken in the problematic stretches identified by the Operation staff during their regular operation and maintenance works. However, the PMC team recommends the excavation and condition assessment of some pipeline samples in non-problematic areas to better understand the pipeline.

5.2.2 Assessment based on Consumer Complaints records

In addition to the above analysis, the PMC team has collected the Consumer complaint logbooks (O& M records) records from the respective depot/area office to assess the status of the existing distribution system. These records are related.

1- Customer's complaints with its relevant reasons category (Already collected)
2- Repair history (implicit in customers' complaints)
3- Number of recurrent pipes' breaks (implicit in customers' complaints)
4- Records related to water leakage (implicit in customers' complaints)
5- Records related to water quality problems (implicit in customers' complaints)
6- Records related to meantime to failure, mean time to recover (not available)

Summary of the online and offline customers' complaints records are collected during the site visits conducted by the PMC design team (Refer to Table 5.1 and Table 5.2). The customers' complaints records are considered effective key performance indicators in judging the service level. Hence, as per the records, Four main categories of complaints were captured:

- No water or shortage of water (2613 complaints)
- Water quality deterioration/Polluted water (800 complaints)
- Pipe leakage (184 Complaints).
- Others (119 complaints)

According to the above records, there is a lack of quantity, quality, environmental impact, sustainability, sociology, and economic revenue.

Table 5.1: Summary of Online Customers' Complaints on Area X (Period Jan 21 to Aug 21)

Abstract of online water complaints in Zone-X from 1-1-21 to 31-8-21																		
S. No.	*Complaint Type*	Ward																Total
		127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	
1	*Water short supply*	23	34	38	5	5	3	11	12	5	3	17	5	1	0	3	15	**180**
2	*Water Pollution*	31	93	58	65	39	60	16	11	27	51	26	19	12	21	17	12	**558**
3	*Water leakage in Distribution Main*	7	3	10	2	6	1	0	7	0	1	1	2	0	1	3	2	**46**
4	*Water leakage in Service Line*	7	7	7	4	4	5	0	5	1	5	9	5	1	4	12	4	**80**
5	*No water supply*	228	315	292	88	66	46	82	57	45	55	179	169	21	23	34	26	**1726**
6	*Water leakage*	4	2	0	2	0	2	0	0	0	0	2	1	1	0	2	0	**16**
7	*Public Fountain repair*	1	1	0	2	3	1	0	1	0	0	1	1	0	0	1	2	**14**
8	*Other Complaint -*	9	12	18	8	10	9	7	7	4	7	3	6	3	4	2	10	**119**

Table 5.2: Summary of Offline Customers' Complaints on Area X (Period Nov 20 to Aug 21)

Abstract of offline water complaints in Zone-X													
Sl. No.	Ward	Type of complain	Month										Total
			Nov '20	Dec '20	Jan '21	Feb '21	Mar '21	Apr '21	May '21	Jun '21	Jul '21	Aug '21	
1	128	No water Supply	27	11	12	45	46	67	89	58			**355**
2		Water Pollution	22	30	8	10	11	12	9	42			**144**
3		Water main/service leakage	5	5	0	3	1	6	0	3			**23**
1	129	No water Supply						52	46	56	103		**257**
2		Water Pollution						6	8	3	23		**40**
3		Water main/service leakage						1	0	0	0		**1**
1	136	No water Supply			4	3	10	3	2	12	18	13	**65**
2		Water Pollution			2	4	1	5	3	8	8	16	**47**
3		Water main/service leakage			0	1	1	0	1	1	0	0	**4**
1	142	No water Supply			3	8	7	0	0	1	6	5	**30**
2		Water Pollution			1	2	2	1	0	1	2	2	**11**
3		Water main/service leakage			0	0	0	0	0	0	0	0	**0**

5.2.3 Assessment based on Hydraulic Analysis

In addition to the visual and consumer complaints assessment, the PMC team performed a hydraulic assessment of the existing network to check the adequacy of the system for the present and future requirements. However, It is worth mentioning that there are no clear boundaries for the hydraulic zones in the existing distribution system. Many interconnections were made, and most are not on record. PMC team made multiple site visits and discussions with O&M staff to understand the ground scenario. But all efforts are failed as these connectivity details are neither in the drawings nor in records. Hence, the PMC team discussed with O&M staff and identified the depots with a major area currently benefiting from each WDS. Accordingly, We made five separate hydraulic zones using 5 WDS for hydraulic adequacy check. The details of zones considered for hydraulic assessment are shown in Fig 5.2

The Hydraulic Analysis was undertaken for the existing network considering the following provisions.

1- The existing WDS has been utilised with existing pumping units, underground storage reservoirs, and overhead tanks.
2- All existing pipelines have been utilized according to the data collected from the client and digitalized.
3- The allocated water demands are based on the 2025 population (Base year demand)
4- Diurnal Demand pattern is considered with for hourly variation with a peak factor of 3 as described in Chapter-3
5- Hazen William factor of 130 was adopted for recently laid DI pipes with Internal lining, and for all other pipes, 80 was adopted except PVC pipe where 140 is adopted.
6- A 40% reduction in the net cross-sectional area is considered for pipes with diameters up to 250mm except for newly laid DI pipes with internal lining.
7- 10% reduction in the net cross-sectional area is considered for all other pipes

The full hydraulic analysis report output existing distribution network is provided in Vol II- Design outputs with resulting residual pressures at each junction node. The demand patterns for Area X over 24 hours are illustrated in Figure 5.3

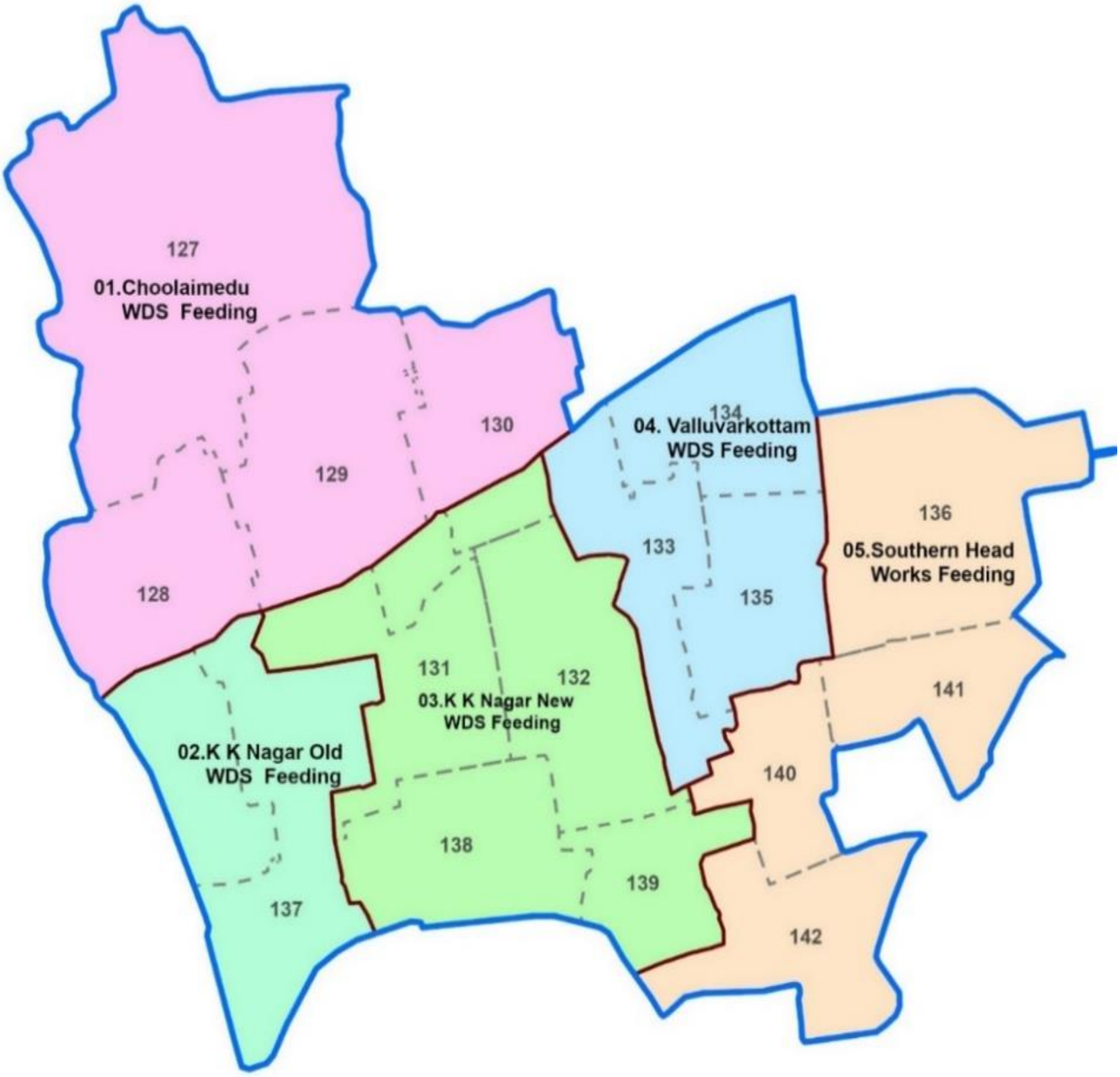


Figure 5.2 : Details of isolated Hydraulic zones lineated for Adequacy Check

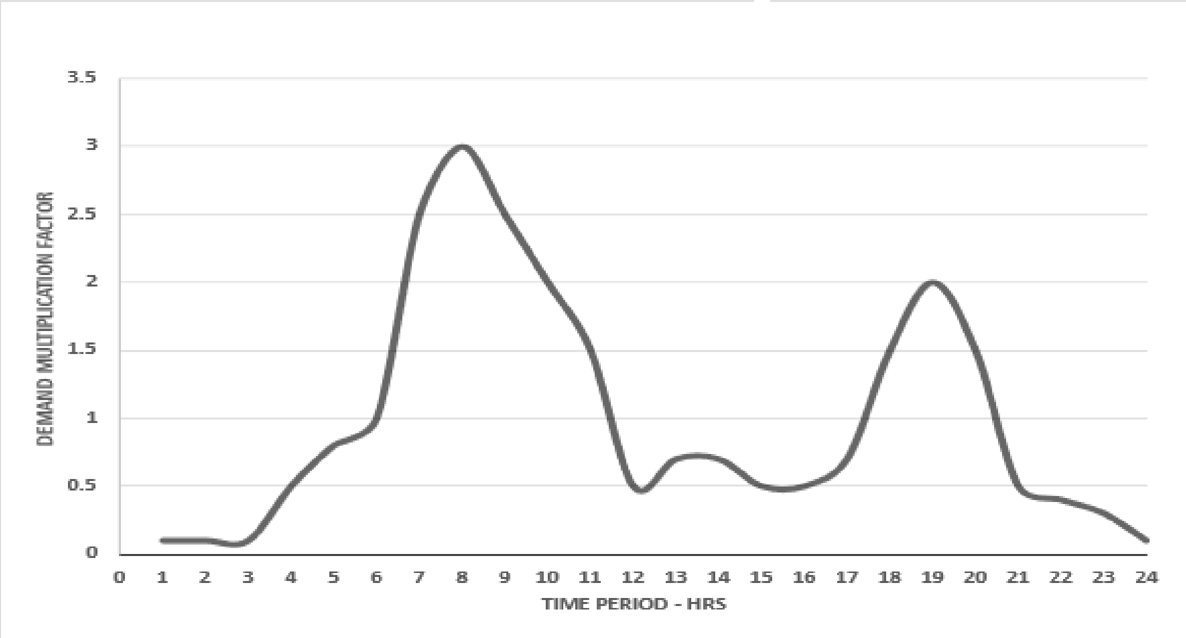


Figure 5.3 : Water Demand Patten for the Hydraulic Analysis of the Existing Systems

5.2.3.1 Assessment of Choolaimedu WDS Area

The outputs of the EPS hydraulic run at 6:00 am (Average demand of the year 2025), and 8.00 am (Peak Demand of the year 2025) showed negative pressures occurred at most of the locations, as illustrated in **Error! Reference source not found.** & Figure 5.5. It is concluded that the existing distribution network system failed to deliver the average demand of the year 2025 to the part of the area.

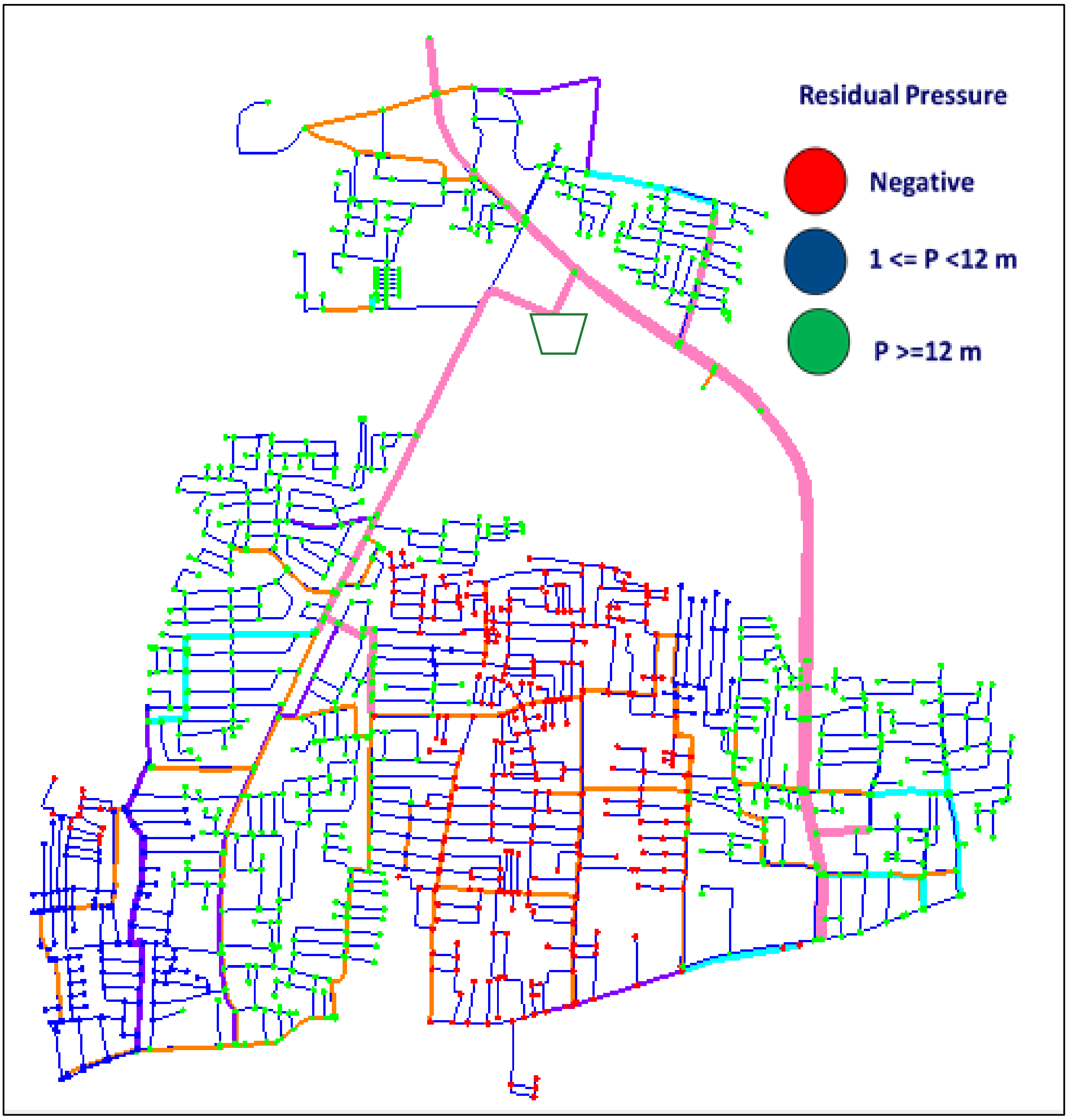


Figure 5.4 : Residual Pressure distribution of Choolaimedu WDS for year 2025 average water demand

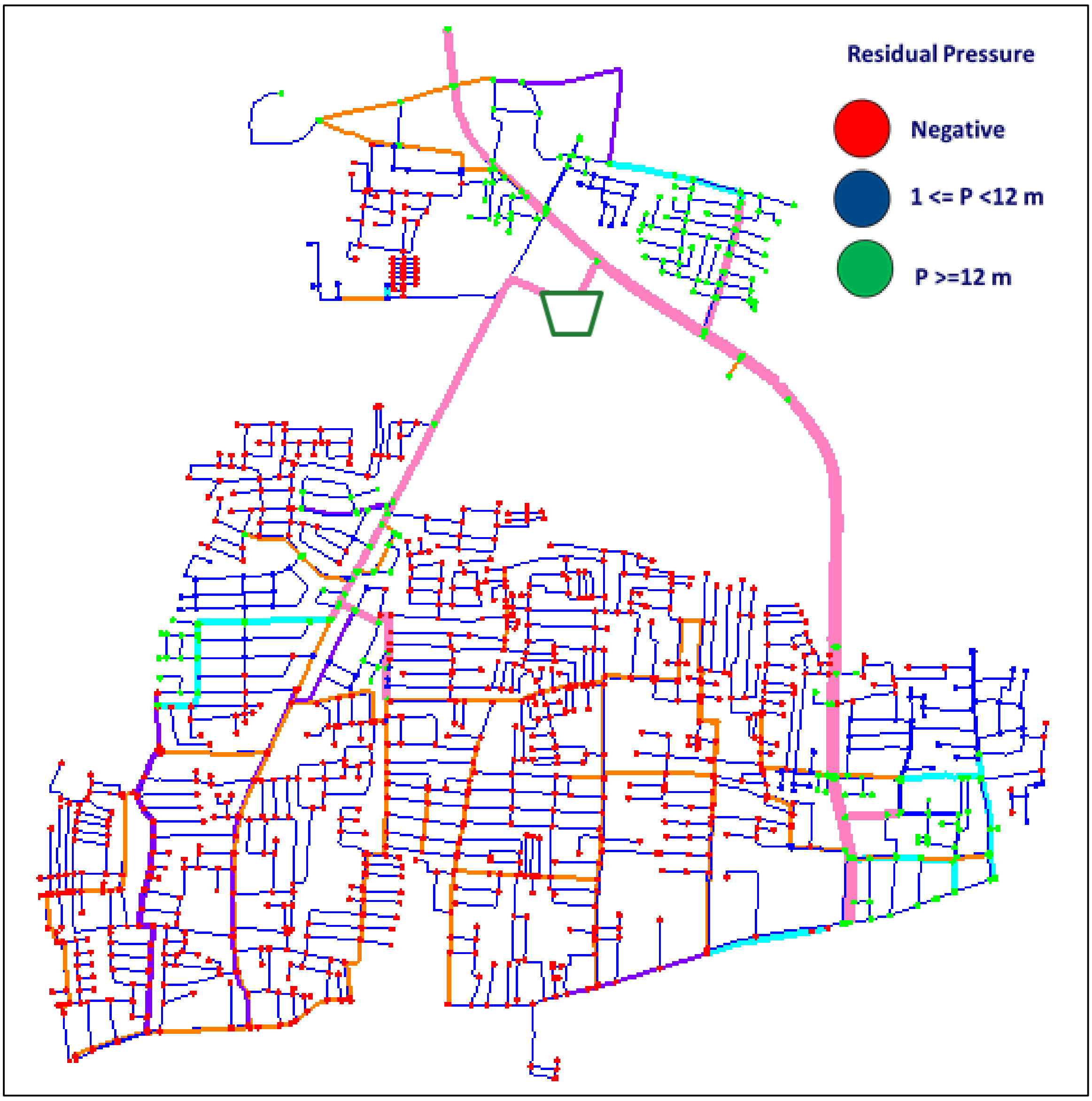


Figure 5.5 : Residual Pressure distribution of Choolaimedu WDS for year 2025 peak water demand

5.2.3.2 Assessment of KK Nagar Old WDS Area

The outputs of the EPS hydraulic run at 6:00 am (Average demand of the year 2025), and 8.00 am (Peak Demand of the year 2025) showed negative pressures occurred at most of the locations, as illustrated in Figure 5.6 & Figure 5.7. It is concluded that the existing distribution network system failed to deliver the average demand for the year 2025.

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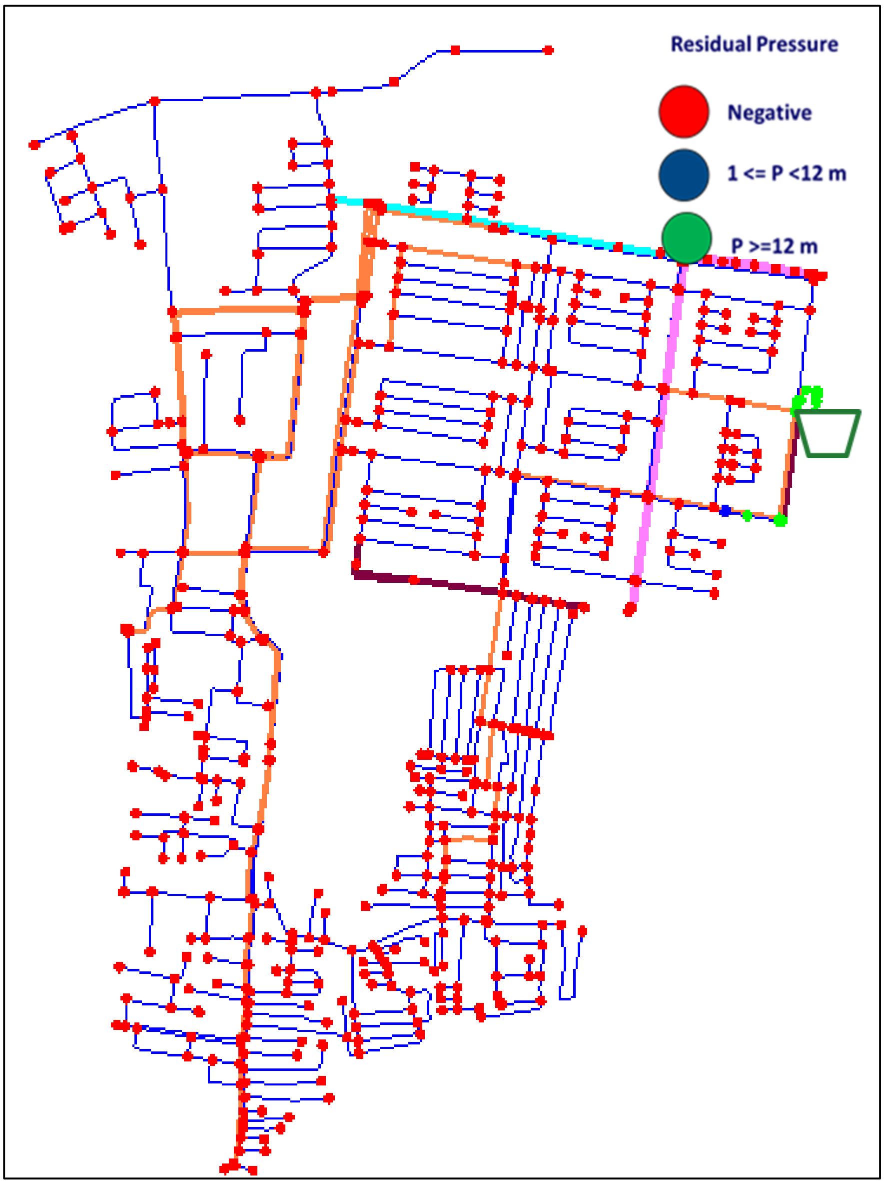


Figure 5.6 : Residual Pressure distribution of KK Nagar Old WDS for year 2025 average water demand

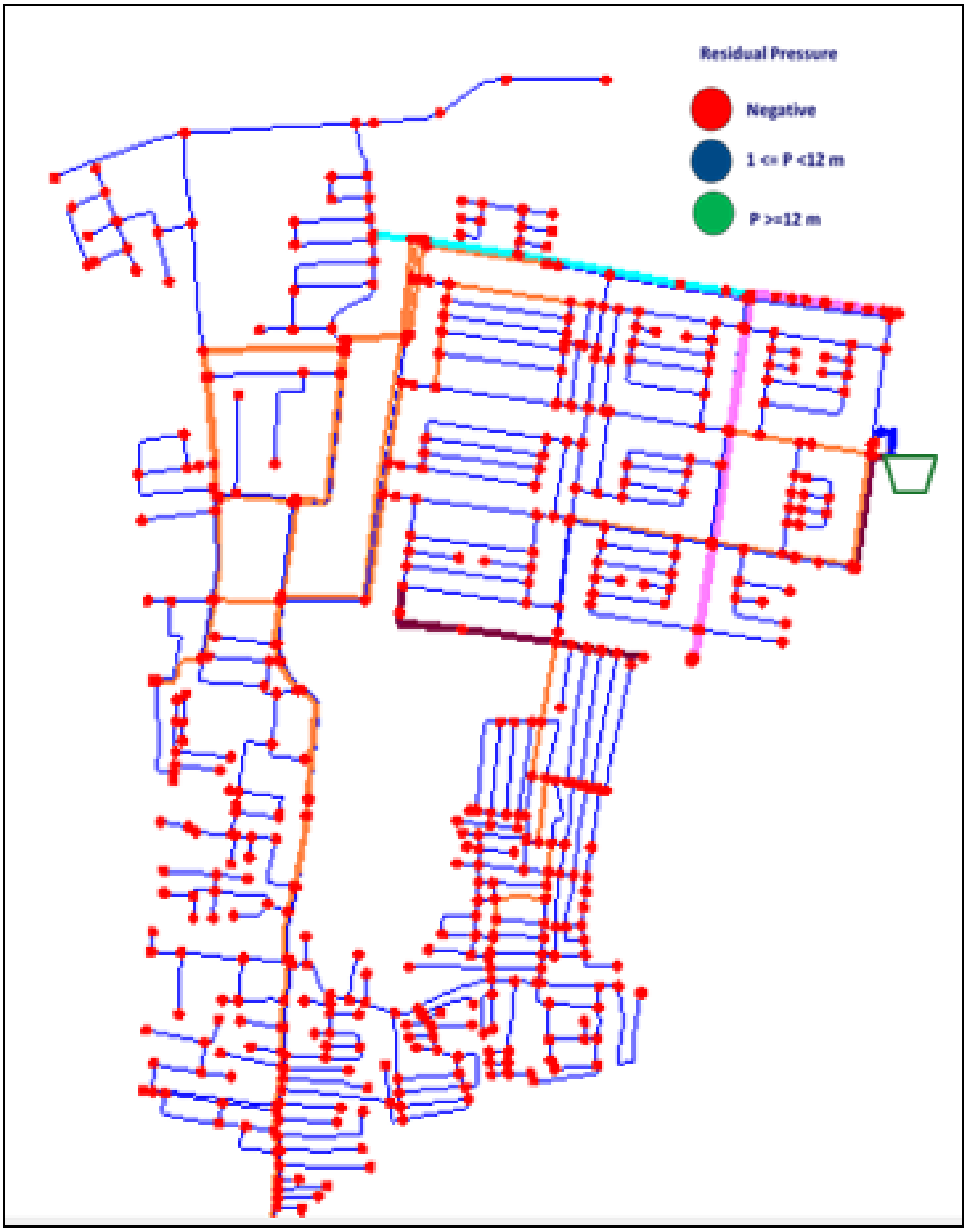


Figure 5.7: Residual Pressure distribution of KK Nagar Old WDS for year 2025 peak water demand

5.2.3.3 Assessment of KK Nagar New WDS Area

The outputs of the EPS hydraulic run at 6:00 am (Average demand of the year 2025), and 8.00 am (Peak Demand of the year 2025) showed negative pressures occurred at most of the locations, as illustrated in Figure 5.8 & Figure 5.9. It is concluded that the existing distribution network system failed to deliver the average demand of the year 2025 to some of the peripheral areas.

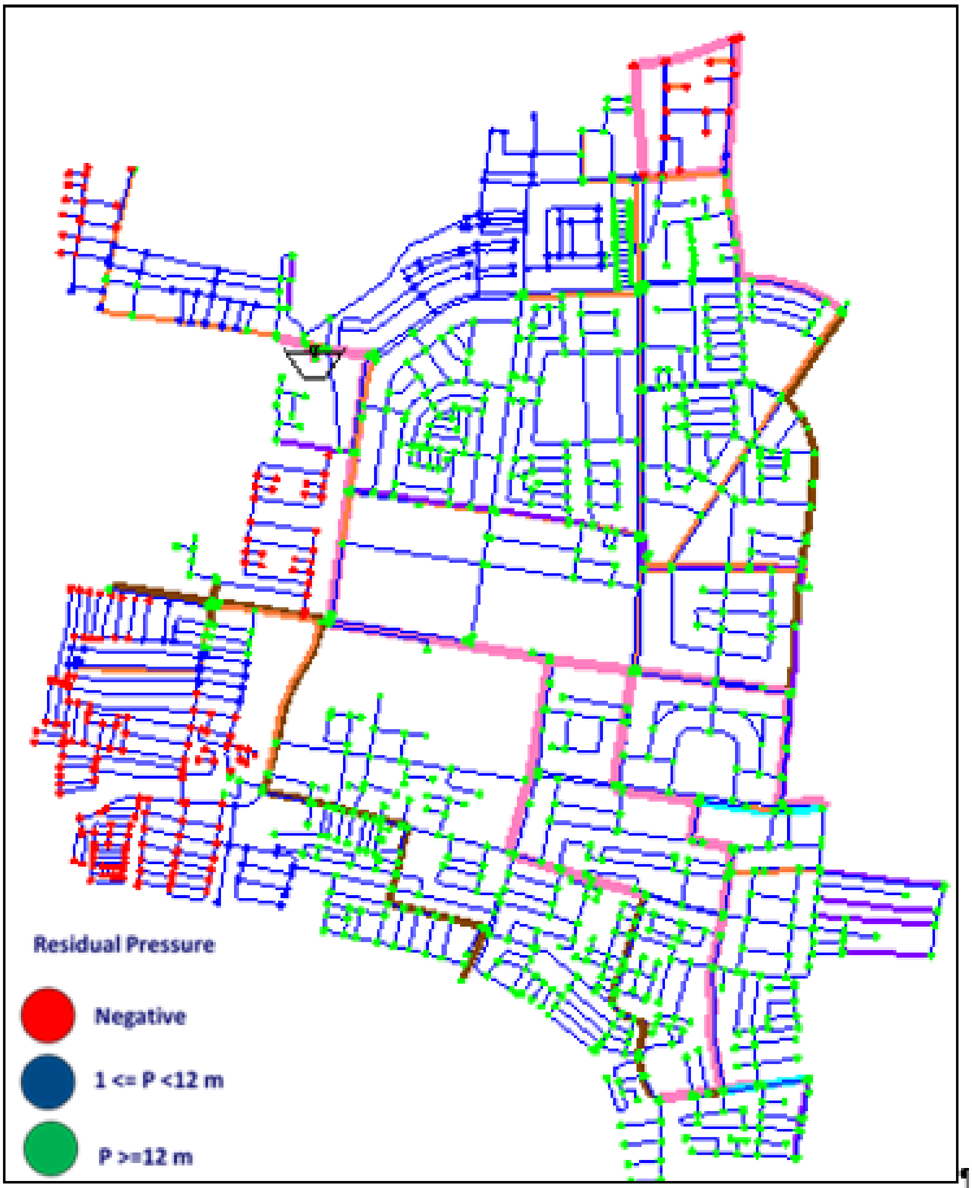


Figure 5.8 : Residual Pressure distribution of KK Nagar New WDS for year 2025 average water demand

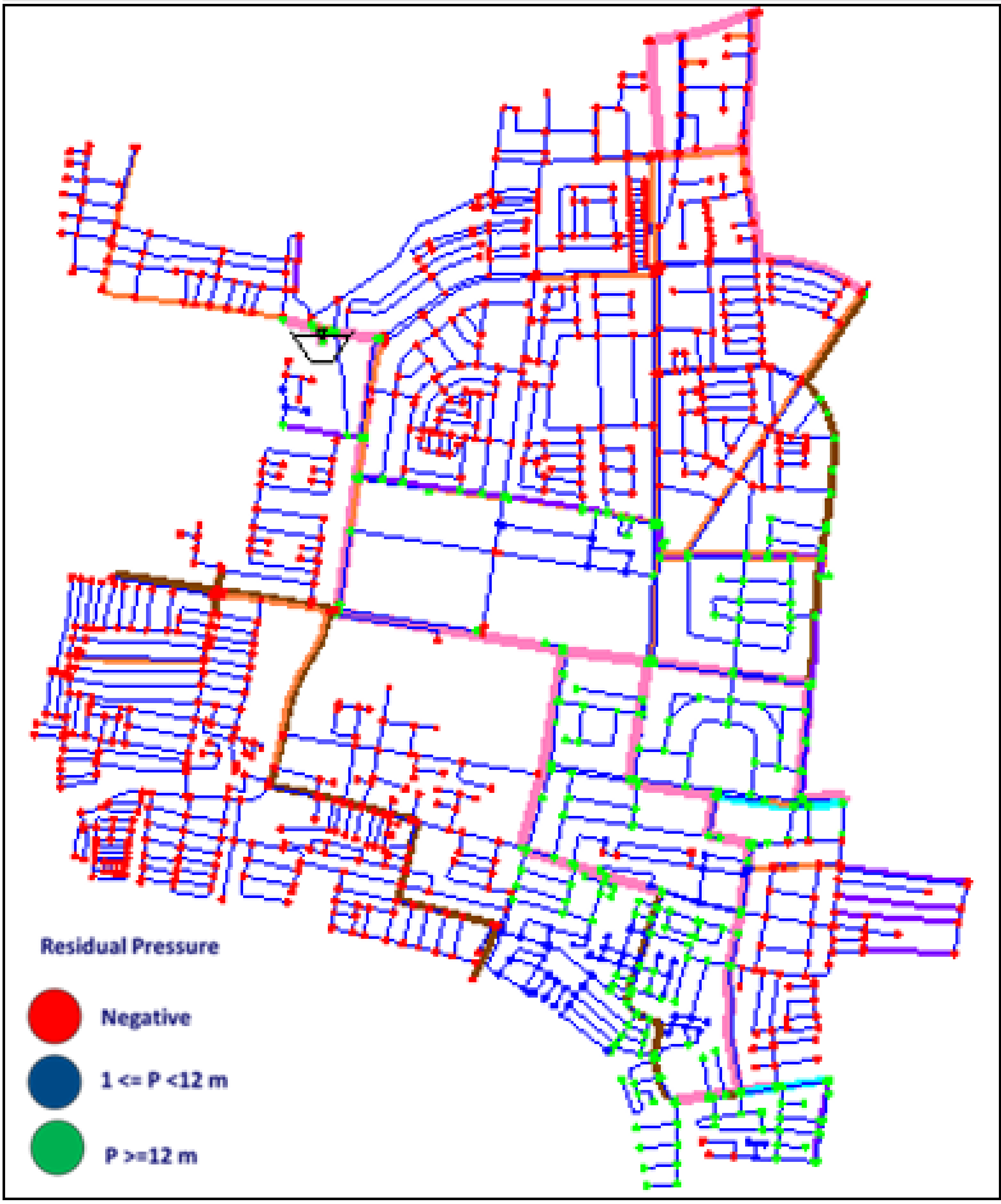


Figure 5.9: Residual Pressure distribution of KK Nagar New WDS for year 2025 peak water demand

5.2.3.4 Assessment of Valluvarkottam WDS Area

The outputs of the EPS hydraulic run at 6:00 am (Average demand of the year 2025) and 8.00 am (Peak Demand of the year 2025) showed negative pressures occurred at most of the locations, as illustrated in Figure 5.10 & Figure 5.11. It is concluded that the existing distribution network system failed to deliver the average demand of the year 2025 to a small part of the peripheral area.

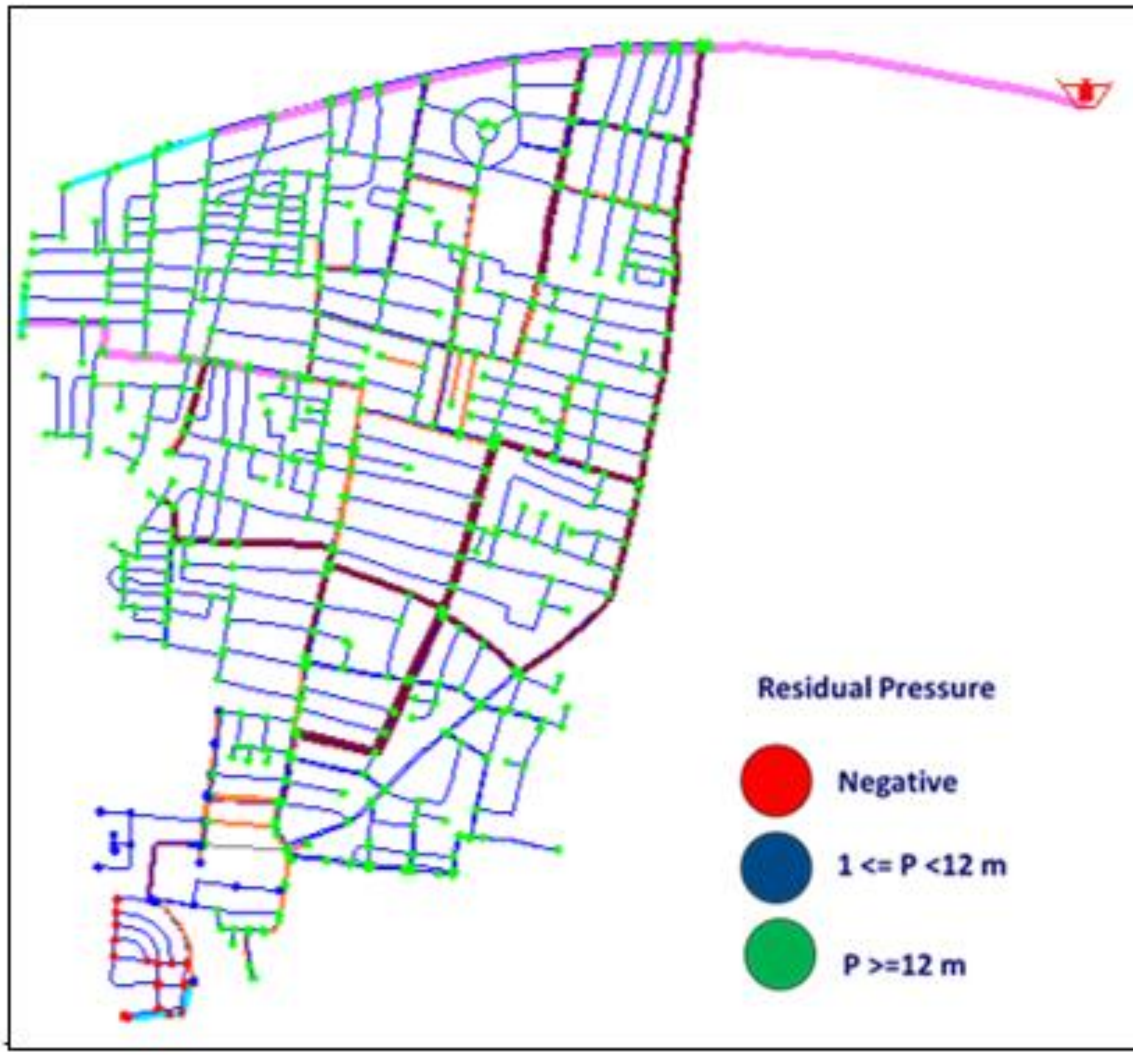


Figure 5.10: Residual Pressure distribution of Valluvarkottam WDS for year 2025 average water demand

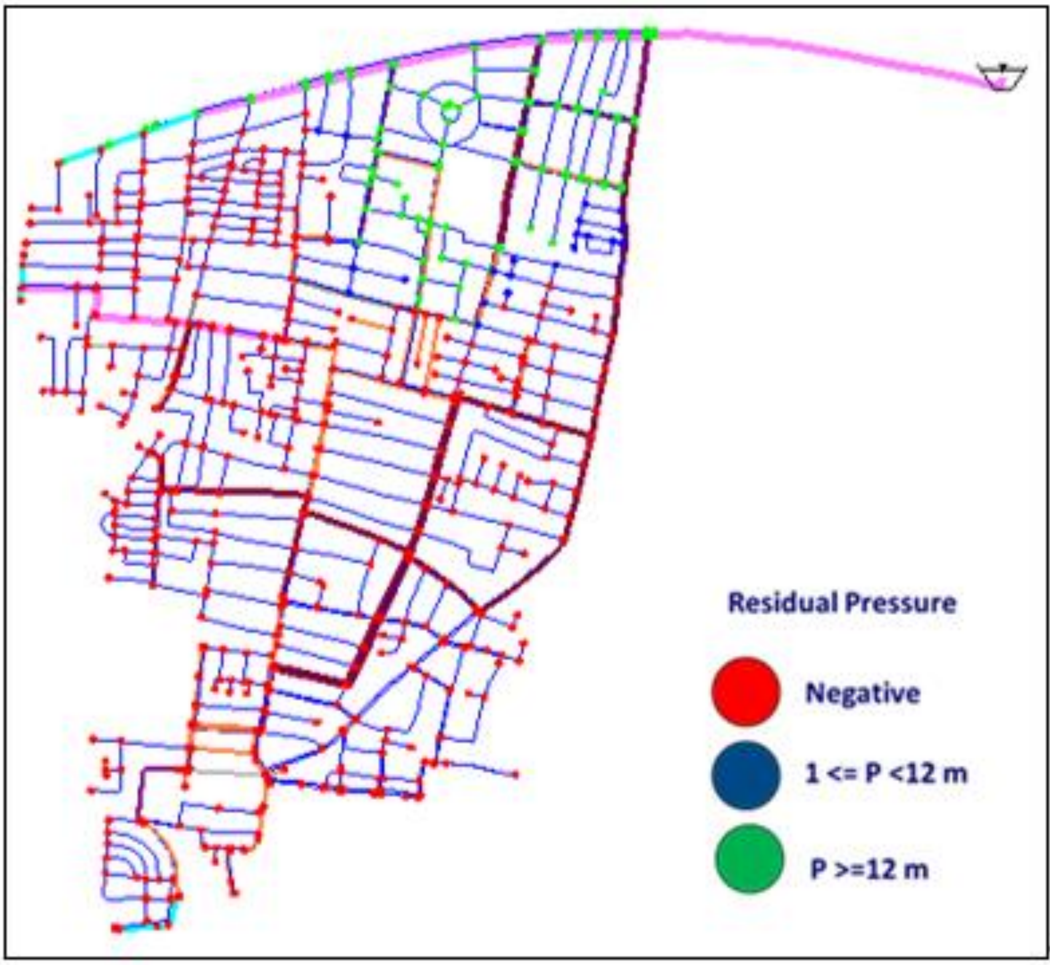


Figure 5.11: Residual Pressure distribution of Valluvarkottam WDS for year 2025 Peak water demand

5.2.3.5 Assessment of Southern Headworks WDS Area

The outputs of the EPS hydraulic run at 6:00 am (Average demand of the year 2025) and 8.00 am (Peak Demand of the year 2025) showed negative pressures occurred at most of the locations, as illustrated in Figure 5.12 & Figure 5.13. It is concluded that the existing distribution network system failed to deliver the average demand of the year 2025 to some parts of the area.

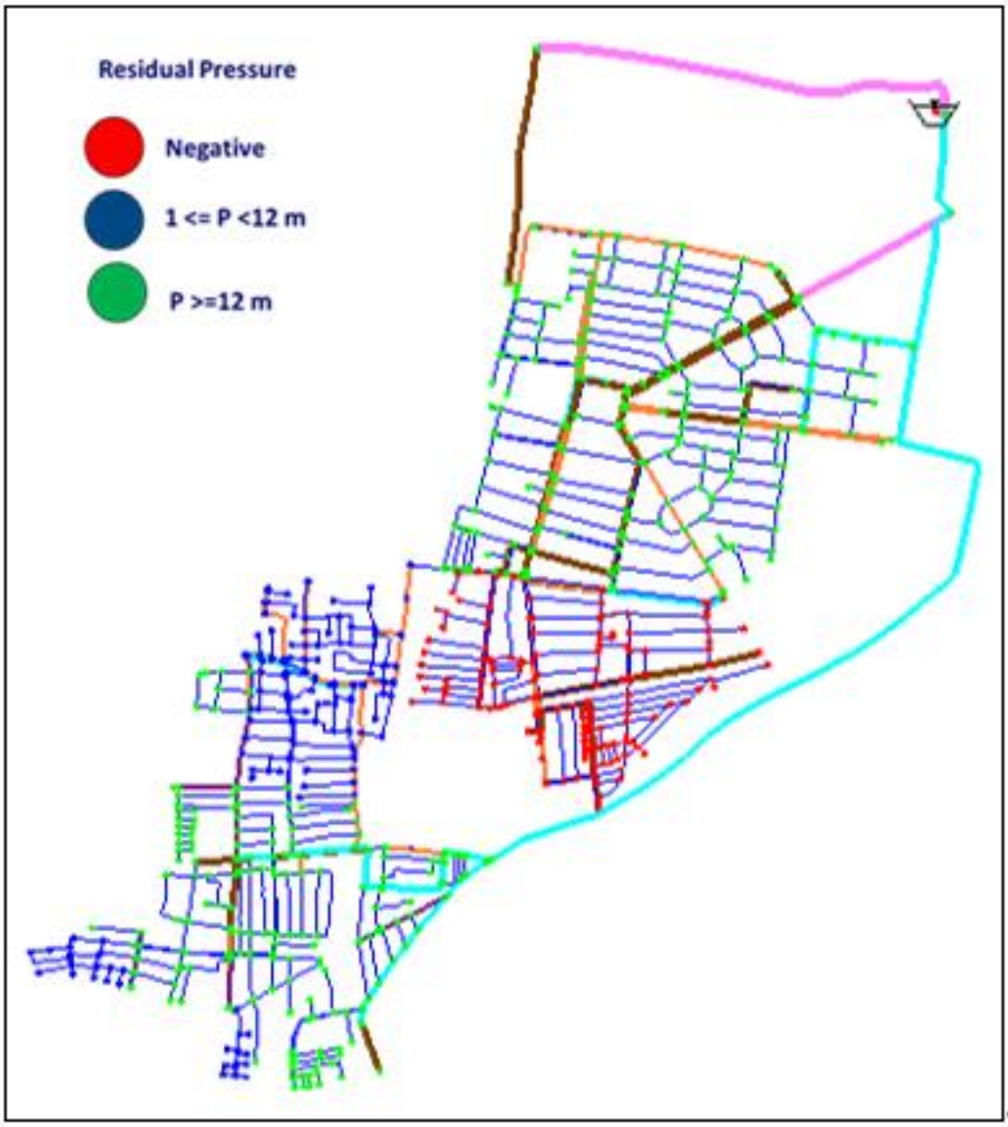


Figure 5.12 : Residual Pressure distribution of Southern Headworks WDS for year 2025 average water demand

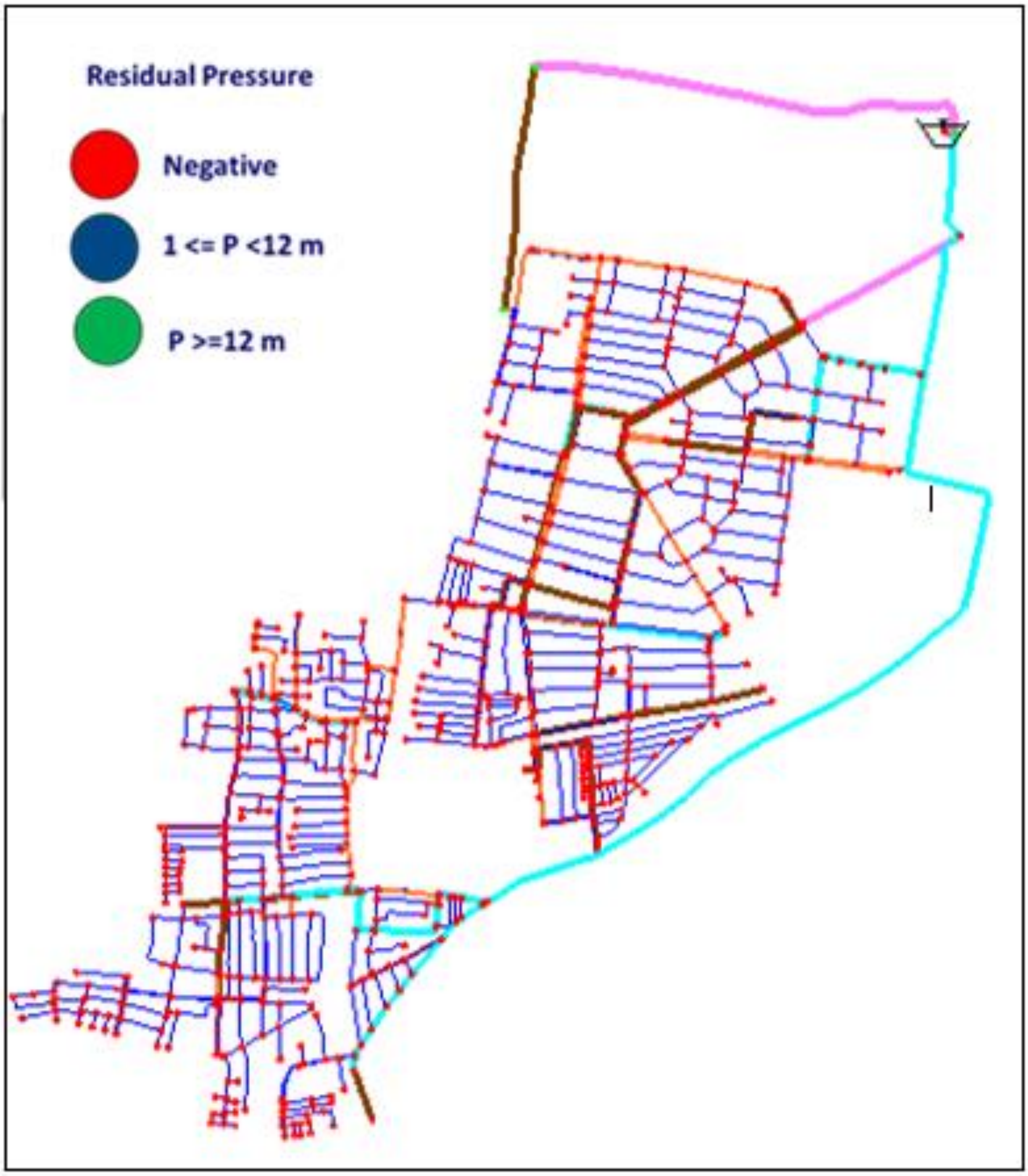


Figure 5.13: Residual Pressure distribution of Southern Headworks WDS for year 2025 peak water demand

The adequate results of the existing distribution network from Water Gem files are given in Volume-II of the report.

5.3 CONDITION ASSESSMENT OF CIVIL STRUCTURES

5.3.1 Introduction

The existing WDS consists of Ground-level Reservoirs & Elevated reservoirs of various capacities with Pumping stations and other necessary components. This report was prepared based on the visual inspection carried out by the PMC team during September 2021. The scope of this evaluation did not include in-depth structural or civil evaluations, calculations, or investigations. The observations on civil works during the visit are listed below with recommendations.

5.3.2 Assessment Findings of the Existing WDS Locations:

5.3.2.1 Choolaimedu WDS

Salient Features:

Period of Construction	:	1996 to 2001
Name of the Component	:	UGT-43ML & Pumping station
Type of Structure	:	RCC frame structure
Location	:	Choolaimedu

Visual Observations:

- The ground reservoir is in good condition. No visual leakages and structural damages are observed.
- Wire mesh is not provided for the UGT Roof ventilator
- The condition of the Pumping station building appears structurally satisfactory, but minor observations are noted as listed below
  - ✓ The diagonal cracks are observed in brick masonry walls at many places of the Pumping station
  - ✓ Cracks observed at the joint of masonry and structural element
  - ✓ Damp patches were observed in the ceiling and walls at various locations in the Pumping station and Chlorine building
  - ✓ External MS staircase corroded and damaged severely
  - ✓ Pumping station Floor level is same as Finished Ground level
- No proper stacking facilities for Chlorine tonners

Photographs:

Pumping station

Ground Level Reservoir

Pump Room

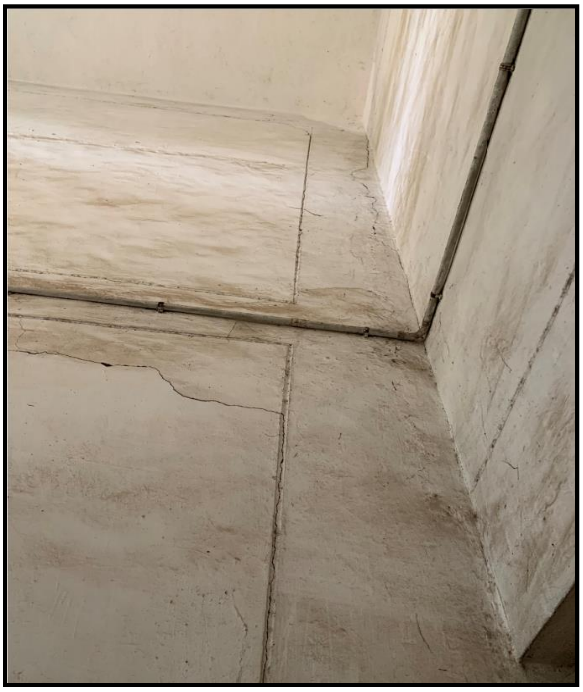
Diagonal Crack (Inner Surface of Room)

Diagonal Crack above Corbel (Inside)

Diagonal Crack above Corbel (Outside)

Water stagnant on Chlorine Room Terrace

Damp Patches on Chlorine Room Ceiling



Cracks at Various Places in Pumping Stations

MS Staircase corroded and damaged

Damaged MS Platform

Recommendations:

- Treatment for locally damaged regions of masonry wall
- Wire mesh shall be provided to all roof ventilators of UGT
- Damaged MS Staircase shall be replaced
- Damaged MS platform at pump area shall be repaired.
- Periodic maintenance is required to increase the life span of the structure
- Chlorine tonners shall be stacked inappropriate places.
- Flood protection arrangement shall be provided to avoid water entry into the Pumping station during flood

- All trenches shall be cleaned and covered with a chequered plate/precast slab.
- Painting shall be carried out to the pumping station, including steel structures, by removing the patches/rust

5.3.2.2 K.K. Nagar new WDS

Salient Features:

Period of Construction: 2014

Name of the Components	:	UGT-9ML, OHT-2.4ML & Pumping station
Type of Structure	:	RCC structure
Location	:	K.K. Nagar New

Visual Observations:

- The Ground level reservoir is in good condition. No visual leakages and structural damages are observed.
- Wire mesh is not provided for the UGT Roof ventilator
- The condition of the Pumping station building appears structurally satisfactory
- No Chlorine Building and proper stacking facilities for Chlorine tonners

Photographs:

Pumping Station

Overhead Tank

Pump Room

Chlorine tonners stacked in an open area

Recommendations:

- The existing OHT staging height is 18m and 2.4ML capacity hence;, it is recommended to accommodate the proposed distribution system.
- Chlorine Building shall be constructed with stacking facilities
- Periodic maintenance is required to increase the life span of the structure
- Wire mesh shall be provided to all roof ventilators of UGT

5.3.2.3 K.K Nagar Old WDS

Salient Features:

Period of Construction: 1992

Name of the Components	:	OHT-0.9ML (2 Nos), UGT-9.0ML Pumping station & Chlorine Building
Type of Structure	:	RCC structure
Location	:	K.K. Nagar Old

Visual Observations:

- The OHT's & Pumping station are in good condition. No visual leakages and structural damages are observed.
- The condition of the Pumping station building appears structurally satisfactory
- Building not in use in front of DG Room

Photographs:

Pump Room

Chlorine Building

Overhead Tank

Recommendations:

- Overhead tank staging is 10m and capacity 0.9ML each, hence not recommended for the proposed system.
- Periodic maintenance is required to increase the life span of the structure
- Painting shall be carried out to the pumping station, including steel structures, by removing the patches/rust
- Unused buildings shall be demolished.

5.3.2.4 Valluvarkottam Headworks WDS

Salient Features:

Period of Construction	:	1998
Name of the Components	:	OHT-3ML, UGT-15ML & Pumping station
Type of Structure	:	RCC structure
Location	:	Valluvarkottam Headworks

Visual Observations:

- The OHT's, UGT & Pumping stations are in good condition. No visual leakages and structural damages are observed.
- The condition of the Pumping station and Reservoirs appears structurally satisfactory

Recommendations:

- The existing OHT staging height is 20m, and 3ML capacity is recommended to accommodate the proposed distribution system.
- Periodic maintenance is required to increase the life span of the structure

Photographs:

Pump Room

Ground Level Reservoir

Overhead Tank

5.3.2.5 Southern Headworks WDS

Salient Features:

Period of Construction: 1973

Name of the Components : UGT-24ML, OHT-4.5ML & Pumping station

Type of Structure : RCC structure

Location : Southern Headworks

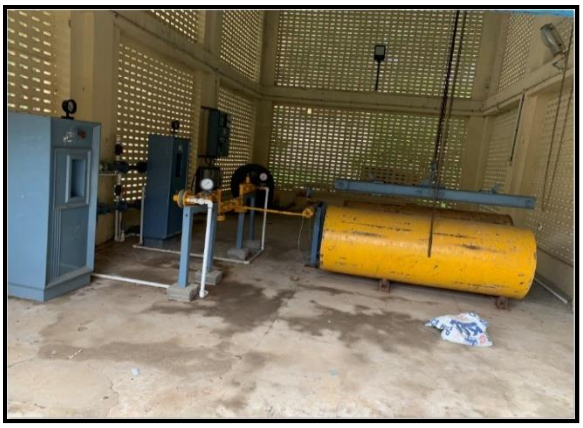
Visual Observations:

- The UGT, OHT & Pumping station are in good condition. No visual leakages and structural damages are observed.
- OHT Roof dome/slab dilapidated
- Minor repair works done to the OHT and pumping stations
- OHT staircase tread and Handrails are damaged

Photographs:

Pumping Station

Pump Room



Chlorine Room

Chlorine Room Roof

Overhead tank

Damaged Staircase

Damaged OHT Bottom Slab

OHT Bottom Slab

<u>Recommendations:</u>

- OHT Roof slab needs to be replaced and recommended to accommodate the proposed distribution system after the Non-destructive test.
- Pumphouse and Reservoirs reached their life span, hence recommended for NDT test to check the strength of the structure to use further.

- OHT staircase shall be demolished and recommended to construct based on NDT test recommendations.

5.4 CONDITION ASSESSMENT OF MECHANICAL SYSTEM

The PMC design team conducted several site visits for all WDS within zone X. The following sections shall provide detailed findings for each WDS.

5.4.1 Choolaimedu WDS (date of visit 07.09.2021):

Table 5.3: Existing Mechanical system details – Choolaimedu WDS

S. No.	Investigated Items	Findings/Details
1	Type of pump	HSCF
2	Make of Pump	Mather & Platt
3	Number of pumps	Six (4W+2S)
4	Capacity(cum/hour)	3780
5	Head (mwc)	30
6	Motor rating	500 KW, 3.3 KV
7	Speed	960 rpm
8	Suction x discharge size	1000 MM x 900 MM
9	Crane	10 TON
10	Valves	Suction & discharge valves are corroded
11	Year of installation	2001
12	Material of construction	
	Pump casing	Cast iron
	Impeller	Bronze
	Shaft	Stainless steel, AISI SS 410
One Pump set is not working due to the damaged condition of one electrically operated discharge sluice valve. The time of operation: morning 5 am to 9 am, evening: 3 pm to 6 pm		
Recommendation:		

1. Since all pump sets crossed a design life of 15 years, it is recommended to use new pumps, replacing existing pumps. 2. Priming pumps are provided for all pumps because they run with suction lift / negative suction. Negative suction may increase cavitation & reduce pump life. So, running pumps in negative suction is not recommended.

5.4.2 K.K. Nagar New WDS (date of visit 07.09.2021):

Table 5.4: Existing Mechanical system details – KK Nagar New WDS

S. No.	Investigated Items	Findings/Details
1	Type of pump	Vertical Turbine
2	Make of Pump	Flowmore
3	Number of pumps	Six (4W+2S)
4	Capacity(cum/hour)	2124
5	Head (mwc)	30
6	Motor rating	250 KW, 0.415 KV
7	Speed	960 rpm
8	Suction x discharge size	Not applicable
9	Crane	EOT – 7.5 Ton
10	Valve /piping	Discharge valves and pipings are corroded
11	Year of installation	2014
12	Material of construction	
	Pump casing	Cast iron
	Impeller	Bronze
	Shaft	Stainless steel, AISI SS 410
All Pump sets are working fine as of date. The time of operation: morning 12 am to 6.30 am, evening: 5 pm to 7.30 pm		
Recommendations: 1. Since all pump sets are within a design life of 15 years, it is recommended to use them.		

5.4.3 K.K. Nagar Old Head Works (date of visit 07.09.2021):

Table 5.5: Existing Mechanical system details – KK Nagar Old WDS

S. No.	DETAILS	OLD (1996) INSTALLATION	NEW (1999) INSTALLATION
1	Type of pump	HSCF	HSCF
2	Make of Pump	KIRLOSKAR	KIRLOSKAR
3	Number of pumps	THREE(2W+1S)	THREE(2W+1S)
4	Capacity(cum/hour)	504	504
5	Head (mwc)	28.6	28.6
6	Motor rating	75 HP, 0.415 KV	75 HP, 0.415 KV
7	Speed	1450 rpm	1450 rpm
8	Suction x discharge size	250MM X 250MM	250MM X 250MM
9	Crane	EOT 5 Ton	Manual hoist 5 Ton
10	Valve /piping	Suction & discharge valves and pipings are corroded	Suction & discharge valves and pipings are corroded
11	Year of installation	2014	2014
12	Material of construction		
	Pump casing	Cast iron	Cast iron
	Impeller	Bronze	Bronze
	Shaft	Stainless steel, AISI SS 410	Stainless steel, AISI SS 410
All Pump sets are working fine. The time of operation: morning 5 am to 9 am, evening: 3 pm to 6 pm			
Recommendation: 2. Three pump sets are within a design life of 15 years for new installations, so it is recommended to use these pumps. We may replace old Pump sets which were installed in the year 1992.			

3. Priming pumps are provided for all pumps because they run with suction lift / negative suction. Negative suction may cause cavitation & reduce pump life. So, running pumps in negative suction is not recommended.

5.4.4 Valluvarkottam Head Works (date of visit 08.09.2021):

Table 5.6: Existing Mechanical system details – Valluvarkottam WDS

S. No.	Investigated Items	Findings/Details
1	Type of pump	HSCF
2	Make of Pump	JYOTI
3	Number of pumps	FOUR(2W+2S)
4	Capacity(cum/hour)	2718
5	Head (mwc)	32
6	Motor rating	300 KW, 3.3 KV
7	Speed	985 rpm
8	Suction x discharge size	500 MM X 450MM
9	Crane	5 TON
10	Valve /piping	Suction & discharge valves and pipings are corroded
11	Year of installation	1998
12	Material of construction	
	Pump casing	Cast iron
	Impeller	Bronze
	Shaft	Stainless steel, AISI SS 410
All pump sets are working fine. may work for another few years The time of operation: 3 pm one pump, 3.30 pm 2 pumps started		
Recommendations: 1. Since all pumps are exceeded their design life, they may run satisfactorily for another few years. So, we should replace all Pump sets with new Pump sets.		

2. Priming pumps are provided for all pumps because they run with suction lift / negative suction. Negative suction may cause cavitation and reduce the pump lifetime. Keeping the pump sets running in negative suction status is not recommended.

5.4.5 Southern Head Works (date of visit 08.09.2021):

Table 5.7: Existing Mechanical system details – Southern Headworks WDS

S. No.	Investigated Items	Findings/Details
1	Type of pump	HSCF
2	Make of Pump	JYOTI
3	Number of pumps	SIX(4W+2S)
4	Capacity(cum/hour)	1638
5	Head (mwc)	35
6	Motor rating	200 KW, 0.415 KV
7	Speed	985 rpm
8	Suction x discharge size	400 MM X 350MM
9	Crane	5 TON
10	Valve /piping	Suction & discharge valves and pipings are corroded
11	Year of installation	1985
12	Material of construction	
	Pump casing	Cast iron
	Impeller	Bronze
	Shaft	Stainless steel, AISI SS 410
13	Vacuum Pump set details	
	Make	Kirloskar
	Rating	10 hp
	Speed	1440 rpm
	Size	50 mm X 50 mm
14	Drain Pump Sets details	

	Make	Kirloskar
	Rating	5 hp
	Speed	1440 rpm
	Discharge	45 cum
	Head	14 meters
	Size	80 mm X 80 mm
All pump sets are working fine and may be used for another few years satisfactorily. time of operation: 6 pm to 6 am		
Recommendations: 1. All pumps exceeded their operational lifetime; however, the pumps may run in an acceptable condition for some more few years (i.e., maximum 4 years). It is recommended to replace all Pump sets after 4 years. 2. Priming pumps are provided for all pumps because they run with suction lift / negative suction. Negative suction may cause cavitation & reduce pump life. So, running pumps in negative suction is not recommended.		

5.5 CONDITION ASSESSMENT OF ELECTRICAL SYSTEM

This section covers the conditional assessment and general recommendations based on standard engineering practices for electrical systems at water distribution stations in Zone-X, which comprises Power Supply arrangement, Power distribution scheme, various electrical equipment details, and data collection of the equipments. The two major parts in this section, namely a) Electrical Conditional assessment and b) Recommendations, basically describes the site observations with suitable recommendations w.r.t. latest standards and guidelines to refurbish or renovate an old electrical system for Water Distribution Station. However, implementation of these recommendations (fully or partially) depends on individual WDS hydraulic/ mechanical design requirement only. Hence the electrical scope of works and upgradation required for each WDS, shall be solely based on the new electrical design change part only and not for full electrical system refurbishment. The new electrical arrangement and proposed design change for each WDS are detailed in chapter-6 of this report.

5.5.1 General

The details and particulars provided in this report are observed and assessed to the best possible extent in the brief inspection of various locations, including the proposed OHT location on 07-09-21 and 08-09-21. However, most of the information provided is based on visual inspection & feedback given by operators or other staff at respective existing WDS.

The List of existing Water Distribution Stations (WDS) for Zone-X are mentioned below:

1. Choolaimedu WDS
2. KK Nagar- New WDS
3. KK Nagar- Old WDS
4. Valluvarkottam WDS
5. Southern Headworks WDS

5.5.2 Power Supply Situation

Based on the discussion with available WDS operation staff, it was understood that power supply reliability has significantly improved over the past few years. There were only a few major power shutdowns and/or low voltage problems in the electrical power supply system. Hence, the duration of the Diesel Generator's operation has been reduced, but the requirement for the DG set cannot be avoided. The electricity authority for the Zone-X area is TNEB/ TANGEDCO (Tamil Nadu Generation and Distribution Corporation Limited).

5.5.3 CHOOLAIMEDU WDS:

5.5.3.1 EXISTING ELECTRICAL SYSTEM (Choolaimedu)

The Clear Water Pumping Station consists of SIX (6) Nos. of 3.3 kV, 500 kW motors (4W+2S). The starting of these motors is through Auto-Transformer Type Starters (ATS). The motors are connected to the 3.3 kV ATS Panels, wherein the starters are fed from the 3.3 kV main bus in the composite panel. Capacitor banks installed and connected across each motor feeder is fed through the respective Switching Unit.

In addition to the main 500 KW pump motors, various auxiliary pumps and motors are there in this pumping station. The LV load is fed through the LV PCC panel for all auxiliary loads and lightings.

5.5.3.2 Power Supply Arrangement (Choolaimedu)

1. The power supply for this pumping station is derived through an Indoor Substation with one 11 kV incoming from the nearby TNEB substation. The TNEB metering and RMG panels are kept in separate rooms and further feeds to 11 kV VCB Switchboard. The outgoing of VCBs is connected to the primary of two 4 MVA, 11/3.3 kV transformers (1W+1S), which feed to main 3.3 kV Starters through 3.3 kV switchgear. Each transformer can take care of the 100% Load of the Pumping Station.
2. In case of power failure, one no. 2 MVA, 3.3 kV Diesel generator is there for emergency backup supply.
3. The LV supply for auxiliary load is taken from a 200 kVA separate auxiliary transformer, feeding to the LV PCC panel. Also, one small DG set of 62.5 kVA capacity is there for lighting and critical loads in a power failure.

Table 5.8: Existing Electrical System Summary details – Choolaimedu WDS

Sr. No.	Item	Details	Status/ Observations
1	Year of Installation/ Commissioning	2001	More than 20 years old.
2	EB Incoming Supply	11 kV, Nearby TNEB Substation	
3	Main Transformers	2 x 4 MVA, 11/ 3.3 kV, Oil Immersed type, Dyn11 with OLTC Make- Indo Tech	To be refurbished.
4	Auxiliary Transformers	1 x 200 kVA, 11/ 0.433 kV, Oil Immersed type, Dyn11 with OFTC	To be refurbished.
5	Pump-Motor Rating	500 kW, 3.3 kV, 960 rpm Make- Crompton Greaves Pump Make- Mather & Platt (HSFC)	To be replaced.
6	Motor Operation	6 Nos. (4W+2S)	
7	Motor Starters	Auto-Transformer Starter (ATS) type	To be replaced with new Soft starters.
8	MV Switchgears	11 kV Switchboard 3.3 kV Switchboard	To be replaced.
9	MV Capacitor Bank	3.3 kV, 2 x 350 kVAR,	To be replaced.
10	LV Switchgears	0.415 kV, ACB Switchboard	To be replaced.
11	DG Set for Pumping	1 No. 2 MVA, 3.3 kV Make - Caterpillar	To be completely overhauled.
12	DG set for Auxiliary load	1 No. 62.5 kVA, 0.415 kV	To be completely overhauled.
13	EOT- Pump House	10 Tons	Complete oiling and greasing required.
14	HOT- DG Room	15 Tons	Complete oiling and greasing required.
15	MOV Actuators	2.2 kW, with external DOL starter, at the discharge of each pump. Make- Auma India	One of the actuators is dismantled for repair.

5.5.3.3 Condition Assessment (Choolaimedu)

- One complete pump-motor set, sluice valve, actuator & LPBS are not working and are under repair.
- The 2 nos. 4 MVA Power Transformers are still operational but requires complete refurbishment, a lot of maintenance, oil-filtration and test procedures as per IEC and IS standards to assess whether they are required to be replaced or not.
- The Main 3.3 kV DG set and auxiliary 415 V DG set are old designed and are in poor condition. Initially, 3.3 kV, 2 MVA DG set came with Air pressure cranking type arrangement, but in the recent past, it was changed to Battery starter cranking for starting.
- All the major switchgear and panels like 11 kV Switchgears, 3.3 kV Switchgears, LV switchgear, ATS starter Panels, Capacitor banks are very old designed and are in poor condition. They have crossed more than 20 years of operation and requires a lot of maintenance. The test procedures as per IEC and IS standards must be conducted.
- The motors' power and control cables will be assessed after conducting Insulation Resistance and other necessary tests. All the glands and lugs either are in very poor condition or not at all there.
- All the small distribution boards like LDBs, PDBs, Indoor & outdoor CJBs and other DBs are in poor condition, mostly without door locks, door gasket and deteriorated cable termination.
- Some motorized Valves are still operational to date but require calibration, re-painting, and heavy maintenance.
- The Local push button stations (LPBS) are also in bad condition without an Emergency Push-button.
- All relays and protection units are mostly old-fashioned and mechanical types and need to be tested and repaired.
- Only 30% of the plant lighting is functional. Some of the lights are replaced with LED type but only a few.
- The plant's main PLC panel is faulty and non-functional. All the operations are carried out on a manual basis only.
- The Level and flow meter totalizer panel with data-logger works satisfactorily, transmitting periodical readings to concerned authorities through GSM/ GPRS mode.
- Chlorination Building: Main 200 A Switchboard panel needs to be completely replaced. 7.5 HP Gas blower is out of order, and motor needs to be replaced.

2 x 4 MVA Power Transformer

2 MVA, 3.3 kV DG SET

200 kVA AUX. TRANSFORMER

11 kV PANEL

11 kV Switchboard

3.3 kV Switchboard

ATS Starter

ATS Starter Panel

3.3 kV PANEL

LV SWITCHBOARD

LPBS & MOV Starter

MOV

3.3 kV/ 500 KW | LDBs & JBs

5.5.3.4 Recommendations (Choolaimedu)

- Since this WDS was commissioned 20 years back and most of the electrical switchgear and electrical equipment have exhausted their lifespan, it is recommended to replace all such electro-mechanical items viz. Pump-Motor set, Switchgears etc., considering system design improvement for the minimum year 2040.
- If Power and Auxiliary transformers pass the test procedures required per IEC and IS standards, a replacement for the old and defective parts shall be provided, and re-painting, oil-filtration of the whole Transformer with corrosion proof paint shall be executed. If the transformers do not pass the test procedures required, the new transformers shall be provided.
- The 3.3kV, 2000 kVA Diesel generator should be tested as per IS & IEC standards. The availability of spare parts to be checked with the DG manufacturer and further assessment about replacement or refurbishment. If the DG sets do not pass the test procedures required, the new DG set shall be provided.
- All power cables shall be tested for insulation resistance per IEC and IS standards. The power cable that has failed the insulation resistance test shall be replaced. All glands and lugs are to be replaced.
- All the major switchgear and panels like 11 kV Switchgears, 3.3 kV Switchgears, LV switchgear, ATS starters Panels, Capacitor banks are to be replaced with new one, complying with the latest IS & IEC standards.
- All measuring and protection units will be upgraded as per the latest IS and IEC standards and communication protocols.
- All the small distribution boards like LDBs, PDBs, Indoor & outdoor CJBs and other DBs will be replaced with a new one with suitable IP protection and sealing.

- All Motorized Valves shall be replaced with new ones with corrosion proof paint and cables protected by PVC coated liquid-tight flexible conduits with brass glands.
- The Local push button stations (LPBS) will be replaced with new ones, having a Mushroom type lockable Emergency push button.
- The earthing system must be tested thoroughly as per IS/ IEC procedures and assessed for replacements of no. electrodes and conductors. All corroded earthing conductors must be replaced with associated hardware. The cable carrier systems are to be fully replaced with a new system.
- All indoor and outdoor lighting should be replaced with new LED type suitable sized luminaires.

5.5.4 K.K. NAGAR- NEW WDS:

5.5.4.1 Existing Electrical System (K.K. Nagar-New)

This Clear Water Pumping Station consists of SIX (6) Nos. of 0.415 kV, 250 kW motors (4W+2S). The starting of these motors is through FCMA type Soft-Starters (SS). The motors are connected to the 415 V SS Panels, wherein the starters are fed from the 415 V main PCC panel. Capacitor banks installed and connected across each motor feeder is fed through the respective switching unit.

In addition to the main 250 kW pump motors, various auxiliary pumps and motors are there in this pumping station which are fed through the LV PCC panel or other LDB panels.

5.5.4.2 Power Supply Arrangement (K.K. Nagar-New)

1. The power supply for this pumping station is derived through an Indoor Substation with one 11 kV incoming from the nearby TNEB substation. The TNEB metering and RMG panels are kept in separate rooms and further feeds to 11 kV VCB Panels. The outgoing VCBs are connected to the primary of two 1600 kVA 11/0.433 kV transformers (1W+1S), feeding to the main 0.415 kV LV PCC panel. This Main LV PCC panel feeds directly to each Soft-Starter panel through the respective feeder. Each transformer can take care of the 100% Load of the Pumping Station.
2. In case of power failure, one no. 1010 kVA, 0.415 kV Diesel generator is there for emergency backup supply connected through a long AL bus-duct to Main LV PCC panel.

Table 5.9: Existing Electrical System Summary details – KK Nagar new WDS

Sr. No.	Item	Details	Status/ Observations
1	Year of Installation/ Commissioning	2014	Relatively new WDS
2	EB Incoming Supply	11 kV, Nearby TNEB Substation	

Sr. No.	Item	Details	Status/ Observations
3	Main Transformers	2 x 1600 kVA, 11/0.433 kV, Oil Immersed type, Dyn11 with OLTC	Re-filtration to be done.
4	Pump-Motor Rating	250 kW, 0.415 kV, 960 rpm Make- Marathan Electric Pump Make- Flowmore (VT)	To be checked.
5	Motor Operation	6 Nos. (4W+2S)	
6	Motor Starters	FCMA type Soft-starters	To be tested.
7	MV Switchgears	11 kV, VCB Switchboard	Badly corroded. To be cleaned, tested. Double epoxy coated paint is required.
8	LV Capacitor Bank	450 kVAR, 0.415 kV	To be tested.
9	LV Switchgears	0.415 kV, MDO ACB Switchboard	To be tested.
10	DG Set for Pumping	1 No. 1010 kVA, 0.415 kV Make – Powerica Limited	To be tested.
11	DG set for Auxiliary load	NA	NA
12	EOT- Pump House	7.5 Tons	Complete oiling and greasing required.
13	MOV Actuators	1.1 kW, with an inbuilt DOL starter, at the discharge of each pump. Make- Rotork	

5.5.4.3 Condition Assessment (K.K. Nagar):

- All Pumps sets are operational.
- Both 1600 kVA transformers need to be tested, filtration and double-coated epoxy painting is required
- The backup DG set should also be overhauled and tested for normal operation. DG bus duct from GCB panel to Incomer panel is very lengthy.
- All relays, breakers and protection units are tested for settings and calibration.
- Only 50% of the plant lighting is functional. Some of the lights are replaced with LED type but only a few.
- The plant's main PLC panel is faulty and non-functional. All the operations are carried out on a manual basis only.

- The Level and flow meter totalizer panel with data-logger works satisfactorily, transmitting periodical readings to concerned authorities through GSM/ GPRS mode.
- Chlorination: There is no chlorination system in place. Manual chlorination mixing is done.

FCMA Soft Starter Panel

LV Distribution Panel

11 kV Switchboard

450 kVAR APFCR Panel

1010 kVA DG Set

250 kW VT Motors

5.5.4.4 Recommendations (K.K. Nagar)

- Since this WDS was commissioned 7 years back and most of the electrical switchgear and electrical equipment is working satisfactorily. Only testing, recalibration of protective devices and electrical equipment is required. Highly corroded Panels should be repainted with double coated epoxy painting.
- An automatic chlorination system should be in place to avoid unsafe manual chlorine mixing in the tank.
- All indoor and outdoor lighting should be replaced with new LED type suitable sized luminaires.

5.5.5 K.K. NAGAR- OLD WDS:

5.5.5.1 Existing Electrical system (K.K. Nagar- Old)

This Clear Water Pumping Station has two different pumping units inside the main pump house and another external Pump House. Each installation consists of three (3) Nos. of 0.415 kV, 55 kW motors (2W+1S). The starting of these motors is through Auto Transformer Starter (ATS) type starters. The inside and outside unit motors are connected to each standalone ATS starter, fed by a PCC panel through an individual external switch.

In addition to the main 55 kW pump motors, other auxiliary loads are also fed through LV PCC and other LDB panels.

5.5.5.2 Power Supply Arrangement (K.K. Nagar- Old)

1. The power supply for this pumping station is derived through one 11 kV incoming from a nearby TNEB substation. The RMG panel is kept at Old abandoned WTP Premises, from where a long 11 kV XLPE underground cable is laid to Pump-House HT OCB Panel. The 11 kV supply is stepped down by 400 kVA, 11/0.433 kV transformers (1W+1S), feeding to the main 0.415 kV LV PCC panel. This Main LV PCC panel feeds directly to each Starter panel through the respective feeder or switch unit. Each transformer can take care of the 100% load of the Pumping Station.
2. In case of power failure, one no. 250 kVA, 0.415 kV Diesel generator is there for emergency backup supply.

Table 5.10: Existing Electrical System Summary details – KK Nagar Old WDS

Sr. No.	Item	New Installation	Old Installation	Status/ Observations
1	Year of Installation/ Commissioning	1999	1996	More than 20 years old
2	EB Incoming Supply	11 kV Connection Supply, Nearby TNEB Substation		Common supply for both Pump House

Sr. No.	Item	New Installation	Old Installation	Status/ Observations
3	Main Transformers	2 x 400 kVA, 11/0.433 kV, Oil Immersed type, Dyn11 with OFTC		BDV testing, Re-filtration and epoxy paint to be applied.
4	Pump-Motor Rating	55 kW, 0.415 kV, 1450 rpm Make- Kirloskar Electric Pump Make- Kirloskar (HSCF)	55 kW, 0.415 kV, 1450 rpm Make- Kirloskar Electric Pump Make- Kirloskar (HSCF)	To be checked.
5	Motor Operation	3 Nos. (2W+1S)	3 Nos. (2W+1S)	
6	Motor Starters	ATS Starters	ATS Starters	The operation is to be checked.
7	MV Switchgears	11 kV, OCB Switchboard		Badly corroded. To be cleaned, tested. Double epoxy coated paint is required.
8	LV Capacitor Bank	90 kVAR, 0.415 kV	90 kVAR, 0.415 kV	To be tested.
9	LV Switchgears	0.415 kV, ACB Switchboard	0.415 kV, ACB Switchboard	To be tested.
10	DG Set for Pumping	1 No. 250 kVA, 0.415 kV Make – Caterpillar		To be tested. Overhauled completely.
11	DG set for Auxiliary load	NA	NA	
12	EOT- Pump House	5 Tons	Mechanical Chain block	At least Electrical Hoist to be provided at outside Pump Hose
13	MOV Actuators	Manual Valves	Manual Valves	To be replaced with MOVs

5.5.5.3 Condition Assessment:

- The 2 nos. 400 kVA transformers are still operational but require complete refurbishment, a lot of maintenance, oil-filtration, and test procedures as per IEC and IS standards to assess whether they are required to be replaced or not.
- The backup DG set should also be overhauled, refurbished, painted, and tested for normal operation. The test results are to be assessed for replacement.
- All the major switchgear and panels like 11 kV Switchgears, LV switchgear, ATS Starters Panels, Capacitor banks are very old designed and are in poor condition. They have crossed more than 20 years

of operation and requires a lot of maintenance. The test procedures as per IEC and IS standards must be made to assess whether they are required to be replaced or not.

- The motors' power and control cables will be assessed after conducting insulation resistance and other tests. All the glands and lugs either are in very poor condition or not at all there.
- All the small distribution boards like LDBs, PDBs, Indoor & outdoor CJBs and other DBs are in poor condition, mostly without door locks, door gasket and improper cable termination.
- The Local push button stations (LPBS) are also in bad condition without an Emergency Push-button.
- All relays and protection units are mostly old-fashioned and mechanical types and need to be tested and repaired.
- Earthing conductors and electrodes are corroded at most places. At some locations, there are only single point earthing provided.
- Only a few of the plant lighting is functional. Some of the lights are replaced with LED type but only a few.
- The plant’s PLC control panel is faulty and non-functional. All the operations are carried out on a manual basis only.
- The Level and flow meter totalizer are not showing readings, and even the data-logger is not working satisfactorily.
- Chlorination Building: Main Switchboard panel needs to be completely replaced. 5HP Gas blower is out of order, and the motor needs to be replaced.

11 kV Switchgears Panel

Inside Pump House- Pump Motor Set

55 kW Star-Delta Starter

Outside Pump House- Pump Motor

Chlorine Gas Blower

DG Set

5.5.5.4 Recommendations:

- Since this WDS was commissioned 20 years back and most of the electrical switchgear and electrical equipment have exhausted their lifespan, it is recommended to replace all such electro-mechanical items viz. Pump-Motor set, Switchgears etc., considering system design improvement for the minimum year 2040.
- If Power transformers pass the test procedures required as per IEC and IS standards, a replacement for the old and defective parts shall be provided, and re-painting, oil-filtration of the whole transformer with corrosion proof paint shall be executed. If the transformers do not pass the test procedures required, the new transformers shall be provided.

- The 250 kVA/ 0.415 kV Diesel generator should be tested as per IS & IEC standards. The availability of spare parts to be checked with the DG manufacturer and further assessment about replacement or refurbishment. If the DG sets do not pass the test procedures required, the new DG set shall be provided.
- All power cables shall be tested for insulation resistance per IEC and IS standards. The power cable that has failed the insulation resistance test shall be replaced. All glands and lugs are to be replaced.
- All the major switchgear and panels like 11 kV Switchgears, LV switchgear, ATS starter Panels (except SD starters), Capacitor banks are to be replaced with a new one, complying with the latest IS & IEC standards.
- All measuring and protection units will be upgraded as per the latest IS and IEC standards and communication protocols.
- All the small distribution boards like LDBs, PDBs, Indoor & outdoor CJBs and other DBs will be replaced with a new one with suitable IP protection and sealing.
- The Local push button stations (LPBS) will be replaced with new ones, having a Mushroom type lockable Emergency push button.
- The earthing system must be tested thoroughly as per IS/ IEC procedures and assessed for replacements of no. electrodes and conductors. All corroded earthing conductors must be replaced with associated hardware. The cable carrier systems are to be fully replaced with a new system.
- All indoor and outdoor lighting should be replaced with new LED type suitable sized luminaires.

5.5.6 VALLUVARKOTTAM WDS:

5.5.6.1 Existing Electrical System (Valluvarkottam)

The Clear Water Pumping Station consists of FOUR (4) Nos. of 3.3 kV, 300 KW motors (2W+2S). The starting of these motors is through Auto-Transformer type Starters (ATS). The motors are connected to the 3.3 kV ATS Panels, wherein the starters are fed from the 3.3 kV main bus in the composite panel. Capacitor banks installed and connected across each motor feeder are fed through the respective Switching Unit.

In addition to the main 300 kW pump motors, various auxiliary pumps and motors are there in this pumping station. The LV load is fed through the LT PCC panel for all auxiliary loads and lightings.

5.5.6.2 Power Supply Arrangement (Valluvarkottam)

1. The power supply for this pumping station is derived through an Indoor Substation with one 11 kV incoming from the nearby TNEB substation. The TNEB metering and RMG panels are kept in separate

rooms and further feeds to 11 kV VCB Panels. The outgoing VCB is connected to the primary of two 3 MVA 11/ 3.3 kV transformers (1W+1S), which feed to the main 3.3 kV VCB panel and feed to each Starter panel through 3.3 kV switchgear. Each transformer is capable of taking care of the 100% Load of the Pumping Station.

2. There is no backup Diesel generator here; in case of any power failure or EB shut down, the water supply to respective areas is not possible.
3. The LV supply for auxiliary load is taken from a 200 kVA separate auxiliary transformer, feeding to the LT PCC panel. There is no small LV DG set for lightings and other critical loads.

Table 5.11: Existing Electrical System Summary details – Valluvarkottam WDS

Sr. No.	Item	Details	Status/ Observations
1	Year of Installation/ Commissioning	1997	More than 20 years old.
2	EB Incoming Supply	11 kV, Nearby TNEB KDM 33/11 kV Substation	
3	Main Transformers	2 x 3 MVA, 11/ 3.3 kV, Oil Immersed type, Dyn11 with OLTC	To be refurbished.
4	Auxiliary Transformers	1 x 200 kVA, 11/ 3.3 kV, Oil Immersed type, Dyn11 with OFTC	To be refurbished.
5	Pump-Motor Rating	300 kW, 3.3 kV, 985 rpm Make- Jyoti Electric/ 1 no. - Kirloskar Pump Make- Jyoti (HSFC)	To be replaced.
6	Motor Operation	4 Nos. (2W+2S)	
7	Motor Starters	Auto-transformer type	To be replaced with new FCMA Soft starters.
8	MV Switchgears	11 kV, VCB Switchgears 3.3 kV, VCB Switchgears	To be replaced.
9	MV Capacitor Bank	3.3 kV, 3x120 kVAR	To be replaced.
10	LV Switchgears	0.415 kV, ACB Switchgear	To be replaced.
11	DG Set for Pumping	No DG Set Back-up	To be provided.
12	DG set for Auxiliary load	No DG Set	To be provided.
13	EOT- Pump House	10 Tons Make- High-Tech Industries.	Complete lubrication & overhaul required.
14	EOT- DG Room	NA	

Sr. No.	Item	Details	Status/ Observations
15	MOV Actuators	1.1 KW, with an in-built RDOL starter, at the discharge of each pump. Make- Auma	One of the actuators is dismantled for repair.

5.5.6.3 Condition Assessment (Valluvarkottam):

- The 2 nos. 3 MVA Power Transformers are still operational but require complete refurbishment, a lot of maintenance, oil-filtration and test procedures as per IEC and IS standards to assess whether they are required to be replaced or not.
- There is no backup DG set installed at this WDS location. Even a small DG set for lighting loads etc., is also not there.
- All the major switchgear and panels like 11 kV Switchgears, 3.3 kV Switchgears, LV switchgear, ATS starters Panels, Capacitor banks are very old designed and are in poor condition. They have crossed more than 20 years of operation and requires a lot of maintenance. The test procedures as per IEC and IS standards must be made to assess whether it is required to be replaced or not.
- The motors' power and control cables will be assessed after conducting insulation resistance and other tests. All the glands and lugs either are in very poor condition or not at all there.
- All the small distribution boards like LDBs, PDBs, Indoor & outdoor CJBs and other DBs are in poor condition, mostly without door locks, door gasket and improper cable termination.
- Some motorized Valves are still operational to date but require calibration, re-painting, and heavy maintenance.
- The Local push button stations (LPBS) are also in bad condition without an Emergency Push-button.
- All relays and protection are mostly old-fashioned mechanical type only, needs to be tested and extensive maintenance.
- Only 30% of the plant lighting is functional. Some of the lights are replaced with LED type but only a few.
- The plant's main PLC panel is faulty and non-functional. All the operations are carried out on a manual basis only.
- The Level and flow meter totalizer panel with data-logger works satisfactorily, transmitting periodical readings to concerned authorities through GSM/ GPRS mode.
- Chlorination Building: Main Switchboard panel needs to be completely replaced. 5HP Gas blower is out of order, and the motor needs to be replaced.

3.3 kV/ 300 kW Motor

3 MVA Transformer

11 kV VCB Switch Board

3.3 kV VCB Switchboard

3.3 kV Auto-transformer Starter (ATS) Panel

3.3 kV Capacitor Banks

MOV with external Starter Unit

Chlorine Gas blower & LDBs

DBs & Corroded Earthing

LV Switchboard

5.5.6.4 Recommendations (Valluvarkottam)

- Since this WDS was commissioned 20 years back and most of the electrical switchgear and electrical equipment have exhausted their lifespan, it is recommended to replace all such electro-mechanical items considering system design improvement for the minimum year 2040.
- If Power and Auxiliary transformers pass the test procedures required per IEC and IS standards, a replacement for the old and defective parts shall be provided, and re-painting, oil-filtration of the whole Transformer with corrosion proof paint shall be executed. If the transformers do not pass the test procedures required, the new transformers shall be provided.
- The 3.3kV Suitable Rated Diesel generator should be provided at this WDS to cater to emergency or power failure situations, especially considering the 24x7 water supply scheme. Also, a small 0.415 kV DG set should be provided here for lighting and other LV critical loads.
- All power cables shall be tested for insulation resistance per IEC and are standards. The power cable that has failed the insulation resistance test shall be replaced. All glands and lugs are to be replaced.

- All the major switchgear and panels like 11 kV Switchgears, 3.3 kV Switchgears, LV switchgear, ATS starters Panels, Capacitor banks are to be replaced with new one, complying with the latest IS & IEC standards.
- All measuring and protection units will be upgraded as per the latest IS and IEC standards and communication protocols.
- All the small distribution boards like LDBs, PDBs, Indoor & outdoor CJBs and other DBs will be replaced with a new one with suitable IP protection and sealing.
- All Motorized Valves shall be replaced with a new one with corrosion proof paint and cables to be protected by PVC coated liquid-tight flexible conduits with brass glands.
- The Local push button stations (LPBS) will be replaced with new ones, having a Mushroom type lockable Emergency push button.
- The earthing system must be tested thoroughly as per IS/ IEC procedures and assessed for replacements of no. electrodes and conductors. All corroded earthing conductors must be replaced with associated hardware. The cable carrier systems are to be fully replaced with the new system.
- All indoor and outdoor lightings should be replaced with new LED type suitable sized luminaires.

5.5.7 SOUTHERN HEADWORKS

5.5.7.1 Existing Electrical System (SHW)

This Clear Water Pumping Station consists of SIX (6) Nos. of 0.415 kV, 200 kW motors (4W+2S). Out of a total of six motors, the starting of three (3) motors is through Auto-transformer type Starters (ATS) and the rest three (3) motors with newly replaced VFD control starters. The motors are connected to the 415 V ATS/ VFD Panels; wherein the starters are fed from the 415 V main PCC panel. A new 200 kVAR capacitor bank is installed and connected for power factor correction along with old small capacitor banks. Capacitor bank switching is done manual only.

In addition to the main 200 kW pump motors, various auxiliary pumps and motors are in this pumping station fed through LT PCC panels or other LDB panels.

5.5.7.2 Power Supply Arrangement (SHW)

1. The power supply for this pumping station is derived through an Indoor Substation with one 11 kV incoming from the nearby TNEB substation. The TNEB metering and RMG panels are kept in separate rooms and further feeds to 11 kV VCB Panels. The outgoing VCBs are connected to the primary of two 1250 kVA 11/0.433 kV transformers (1W+1S), feeding to the main 0.415 kV LV PCC panel. This Main LV PCC panel feeds directly to each Starter panel (ATS or VFD) through the respective feeder. Each transformer is capable of satisfying 100% Load of the Pumping Station.

2. In case of power failure, one no. 625 kVA, 0.415 kV Diesel generator is there for emergency backup supply.

Table 5.12: Existing Electrical System Summary details – Southern head works WDS

Sr. No.	Item	Details	Status/ Observations
1	Year of Installation/ Commissioning	1997	More than 20 years old.
2	EB Incoming Supply	11 kV, Nearby TNEB Substation	
3	Main Transformers	2x1250 kVA, 11/0.433 kV, Oil Immersed type, Dyn11 with OLTC	To be refurbished.
4	Auxiliary Transformers	NA	
5	Pump-Motor Rating	200 kW, 0.415 kV, 990 rpm Make- Jyoti Limited Pump Make- Jyoti (HSFC)	To be replaced.
6	Motor Operation	6 Nos. (4W+2S)	
7	Motor Starters	ATS type Starters for 3 Motors New VFD starters for other 3 Motors (replaced in 2020)	ATS to be replaced with new Soft starters. VFDs can be retained.
8	MV Switchgears	11 kV, VCB Switchboard	To be replaced.
9	LV Capacitor Bank	2 x 200 kVAR capacitor bank (1 no. new one replaced a few years)	To be replaced.
10	LV Switchgears	0.415 kV, ACB switchboard	To be replaced.
11	DG Set for Pumping	1 No. 625 kVA, 0.415 kV Make – Powerica Limited	To be completely overhauled.
12	DG set for Auxiliary load	NA	NA
13	EOT- Pump House	5 Tons	Complete oiling and greasing required.
14	HOT- DG Room	10 Tons	Complete oiling and greasing required.
15	MOV Actuators	1.1 KW, with an in-built RDOL starter, at the discharge of each pump. Make- Auma India	One of the actuators is dismantled for repair.

5.5.7.3 Condition Assessment (SHW)

- The 2 nos. 1250 kVA Main Transformers are still operational but requires complete refurbishment, a lot of maintenance, oil-filtration and test procedures as per IEC and IS standards to assess whether they are required to be replaced or not.
- The backup DG set should also be overhauled, refurbished, painted, and tested for normal operation. The test results are to be assessed for replacement.
- All the major switchgear and panels like 11 kV Switchgears, LV switchgear, ATS starters Panels, Capacitor banks are very old designed and are in poor condition. They have crossed more than 20 years of operation and requires a lot of maintenance. The test procedures as per IEC and IS standards must be made to assess whether it is required to be replaced or not.
- The motors' power and control cables will be assessed after conducting insulation resistance and other tests. All the glands and lugs either are in very poor condition or not at all there.
- All the small distribution boards like LDBs, PDBs, Indoor & outdoor CJBs and other DBs are in poor condition, mostly without door locks, door gasket and improper cable termination.
- Some motorized Valves are still operational to date but require calibration, re-painting, and heavy maintenance.
- The Local push button stations (LPBS) are also in bad condition, even without an Emergency Push-button.
- All relays and protection units are mostly old-fashioned and mechanical types and need to be tested and repaired.
- Earthing conductors and electrodes are corroded at most places. At some locations, there are only single-point earthing provided.
- Around 50% of the plant lighting is functional. The Pump house lights are recently replaced with LED type high bay lights. Some of the outdoor lights are also under replacement.
- PLC and automation system is not in place.
- The Level and flow meter totalizer panel with the data-logger unit works satisfactorily.
- Chlorination Building: Main chlorination Switchboard panel needs to be completely replaced. 5HP Gas blower is out of order, and the motor needs to be replaced.

1250 kVA transformer

11 kV Switch Board

LV Switchboard

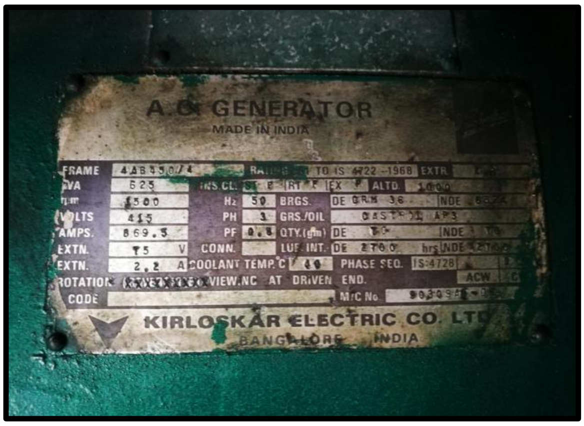
APFC Panel

Old Capacitor Banks

New VFD Starter Panel

LV Motor & MOV

LDBs



DG Set

5.5.7.4 Recommendations (SHW)

- Since this WDS was commissioned 20 years back and most of the electrical switchgear and electrical equipment have exhausted their lifespan, it is recommended to replace all such electro-mechanical items viz. Pump-Motor set, Switchgears etc., considering system design improvement for the minimum year 2040.
- If Power transformers pass the test procedures required as per IEC and IS standards, a replacement for the old and defective parts shall be provided, and re-painting, oil-filtration of the whole transformer with corrosion proof paint shall be executed. If the transformers do not pass the test procedures required, the new transformers shall be provided.
- The 625 kVA/ 0.415 kV Diesel generator should be tested as per IS & IEC standards. The availability of spare parts to be checked with the DG manufacturer and further assessment about replacement or refurbishment. If the DG sets do not pass the test procedures required, the new DG set shall be provided.
- All power cables shall be tested for insulation resistance per IEC and IS standards. The power cable that has failed the insulation resistance test shall be replaced. All glands and lugs are to be replaced.
- All the major switchgear and panels like 11 kV Switchgears, LV switchgear, ATS starters Panels (except VFD starters), Capacitor banks are to be replaced with a new one, complying with the latest IS & IEC standards.
- All measuring and protection units will be upgraded as per the latest IS and IEC standards and communication protocols.
- All the small distribution boards like LDBs, PDBs, Indoor & outdoor CJBs and other DBs will be replaced with a new one with suitable IP protection and sealing.

- All Motorized Valves shall be replaced with a new one with corrosion proof paint and cables to be protected by PVC coated liquid-tight flexible conduits with brass glands.
- The Local push button stations (LPBS) will be replaced with new ones, having a Mushroom type lockable Emergency push button.
- The earthing system will be tested for resistivity, and conductors and electrodes to be replaced upon the test assessment. Everywhere double point earthing to be ensured.
- All cable carrier systems with associated hardware will be completely replaced with a new system.
- All remaining old indoor and outdoor lighting should be replaced with new LED type suitable sized luminaires.

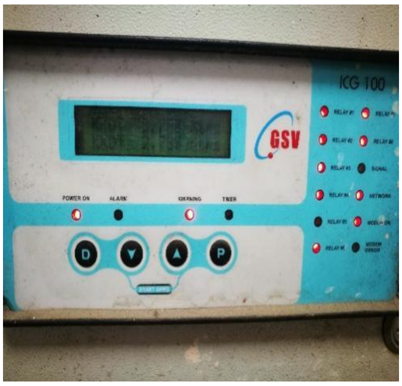
5.6 CONDITION ASSESSMENT OF INSTRUMENTATION AND CONTROL SYSTEM

5.6.1 INTRODUCTION:

Improving the existing water distribution networks in the Chennai Core City improves the reliability, efficiency and monitoring of the existing pump stations. In addition, it is required to establish hydraulic zones and district metered areas in the Core City to obtain better control over the water distribution network within the zones. Hence, a site visit on the existing Water Distribution Networks has been done to evaluate the present condition of the Civil, Mechanical, Electrical, Instrumentation and Control Systems of the pump stations to give recommendations for improving the same.

This report shall discuss the site observation and recommendation for improving the Instrumentation and Control System of Zone X Water Pumping Stations, namely KK Nagar Old WDS, KK Nagar New WDS, Choolaimedu Valluvarkottam WDS, and Southern Headworks WDS.

5.6.2 K.K. Nagar Old WDS



5.6.2.1 Site Observation (K.K. Nagar Old)

1- An inlet flow meter (800 mm) is not available.

2- Outlet flow meter at Pump Station - 1 (600 mm) is not available.

3- Outlet flow meter at Pump station -2 (300 mm) is not available.

4- Pressure switches and pressure gauges at pumping stations 1& 2 are unavailable.

5- Motorized valves are not available; instead, manual valves were used.

6- UGT manual level meter is available but not working.

7- UGT ultrasonic level transmitter is available and working.

8- OHT-1 manual level meter is available and working.

9- OHT-1 ultrasonic level transmitter is available and working.

10- OHT-2 manual level meter is available and working.

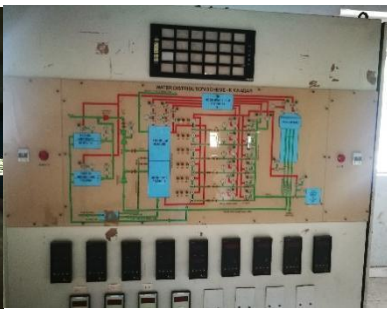
11- OHT-2 ultrasonic level transmitter is available and working.

12- Chlorine Analyzer is not available. 20 kgs/hr Chlorinator is available.

13- PLC is not available.

14- Existing WDS depends on digital displays and data loggers for recording the levels and volumes of the UGT and OHT.

5.6.3 K.K. Nagar New



5.6.3.1 Site Observation (K.K. Nagar New)

1. The inlet flow meter (750 mm) is available and functional.
2. An outlet flow meter (1200 mm) is not available.
3. Pressure gauges and pressure switches at pump stations 1&2 are available but not working.

4. UGT ultrasonic level transmitter is available and working.
5. UGT Manual level meter is available but not working.
6. OHT ultrasonic level transmitter is available and working.
7. OHT Manual level meter is available and working.
8. A chlorine analyzer is not available.
9. The chlorination system is not available and uses manual dosing.
10. PLC is available but not working.
11. Existing WDS depends on digital displays and data loggers for recording the levels and volumes of the UGT and OHT.

5.6.4 Choolaimedu WDS














5.6.4.1 Site Observations (Choolaimedu)

1. An inlet flow meter is available and working.
2. An outlet flow meter is available and working.
3. Pressure switches and pressure gauges are available in the pump station.
4. UGT ultrasonic level transmitter is available and working.
5. UGT manual level meter is available and working.
6. The chlorine analyzer is available and working.
7. Chlorinator with 20 kgs/hr chlorinator is available.
8. PLC is available but not working.
9. Motorized Valves are still working but need replacement.
10. Local Control Push Buttons are still working but need replacement.
11. Existing WDS depends on digital displays and a data logger for recording the levels and volumes of the UGT.

5.6.5 Southern Headworks WDS



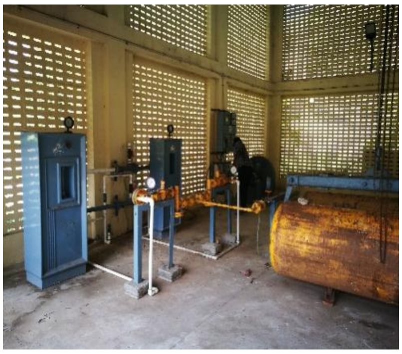














5.6.5.1 Site Observations (Southern H.W.)

1. Incoming flow meter (900 mm) not available.
2. The outgoing flow meter (900 mm) is available but not working.
3. Pressure gauges are available, but pressure switches at the pumping station are unavailable.

4. UGT ultrasonic level transmitter is available and working.
5. UGT Manual level meter is available and working.
6. OHT ultrasonic level transmitter is available and working.
7. OHT manual level meter is available and not working.
8. The chlorine analyzer is available but not working.
9. 20 kgs/hr chlorinator is available.
10. PLC is available but not working.
11. Existing WDS depends on digital displays and a data logger for recording the levels and volumes of the UGT and OHT.

5.6.6 Valluvarkottam WDS







5.6.6.1 Site Observations (Valluvarkottam)

1. Incoming flow meter (700 mm) not available.
2. Outgoing flow meter (1200 mm) available but not working.
3. Pressure switches at the pumping station are not available.
4. UGT ultrasonic level transmitter is available and working.
5. UGT manual level meter is available but not working.
6. OHT ultrasonic level transmitter is available and working.
7. A chlorine analyzer is not available.
8. 20 kgs/hr chlorinator is available.
9. PLC is available but not working.
10. Existing WDS depends on digital displays and a data logger for recording the levels and volumes of the UGT and OHT.

6 CHAPTER 6: PROPOSED WATER SUPPLY SYSTEM

6.1 General

This section describes the proposed water supply distribution system and its different features in detail. Area -X presently is served by only Two major Over Head major tanks, i.e. one is at KK Nagar WDS (2.4 ML), and another is at Valluvarkottam (3.0ML) WDS. Most area-x is presently served by direct pumping or a combination of both OHT and pumping. The sizes of the existing distribution pipe network vary from 100mm to 1600mm and cover the major part of the area, which is insufficient to cater to the consumers' required pressure. Hence, it is necessary to improve the system to provide equitable water to all parts with desired water pressure. Keeping this vision, the proposed water supply distribution system is designed for continuous 24X7 supply for the horizon year 2055. To arrive at a perfect techno-economical design of water supply distribution system, various steps are adopted viz. (a) population projection (b) demand estimation (c) Distribution zoning or selection of command area (d) distribution network analysis with hydraulic modelling software (e) design of overhead tanks with desired capacities etc. The design approach aligns with the CMWSSB/TWAD Board Guideline and CPHEEO norms. This chapter describes proposed distribution zones, details of overhead tanks and distribution networks.

6.2 Planning of the system

The distribution system is planed considering the location of existing OHTs and their present command area. During the rezoning of the system, care has been taken to ensure that the available capacities of the OHTs are fully utilized. However, wherever the existing reservoir capacities are insufficient, a reservoir is proposed at appropriate locations considering the land availability, elevation etc. Thrust has been given for the land availability. The zonal demands are calculated considering the area served from the particular service reservoirs.

The primary aim of the system planning is to utilize the advantage of the city's topography and existing facilities to the maximum extent. The zonal boundary is marked based on the capacity of existing reservoirs concerning projected population, demand and areas it can be served, topography and the location of proposed reservoirs based on land availability

6.3 Details of Existing WDS considered for the proposed system

Currently, 4 WDS are being utilized to feed Area X. However, based on rezoning and availability of land for the construction OHTs, future requirements of other adjacent Areas, 3 WDS are proposed to be utilized for Area X, i.e. Choolaimedu, KK Nagar and Valluvarkottam. Southern Headworks is proposed to be disconnected from the present system and utilized for Area IX requirement, adjacent to Area X.

6.4 Transmission network for newly proposed OHTs outside the WDS premises

Based on the land availability, three new overhead tanks are proposed outside the present WDS premises, namely Ashok Nagar- 3.5 ML- 1 No, West Mambalam 4.0 ML-1 No and United colony 2 ML-1 No. A schematic diagram of proposed transmissions for these OHTs is shown in Fig 6.1

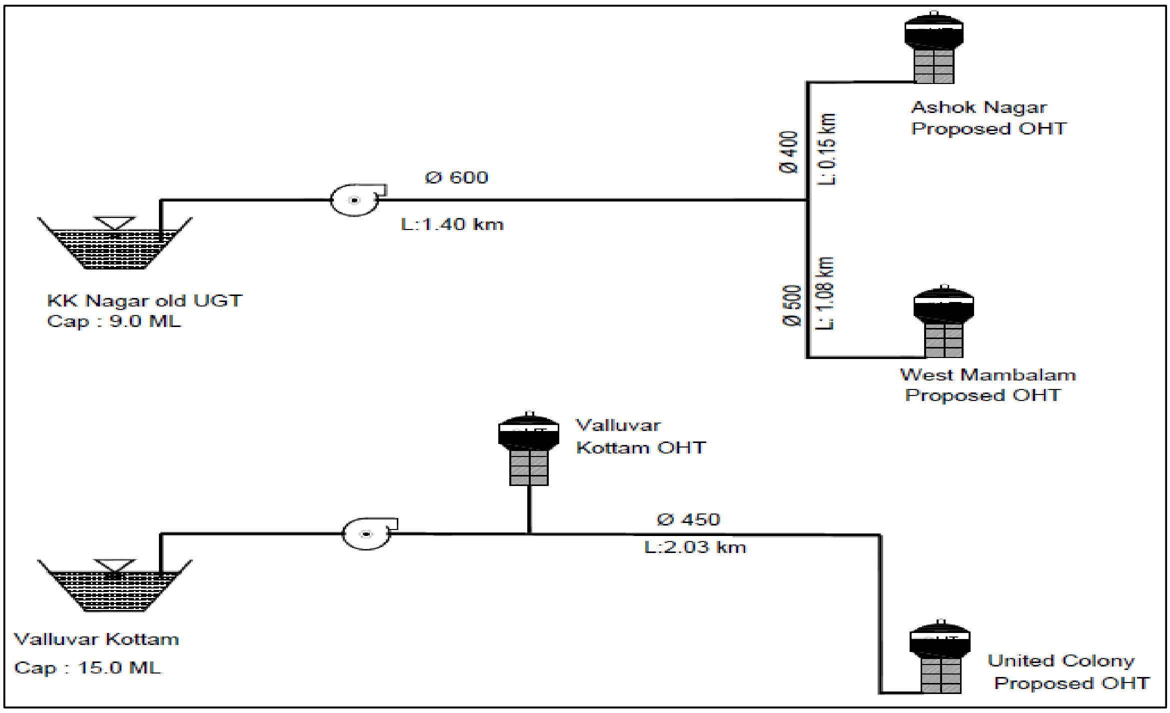


Figure 6.1: Proposed Transmission mains details for newly proposed OHTS outside the WDS premises

6.5 Elevated Service reservoir requirement

Presently, Area X is served by only 2 OHTs, and their total capacity is 5.4 ML. However, the intermediate and ultimate demand requirements are 50 ML (demand of 149MLD) and 53 ML (demand of 158.4 MLD), respectively, considering CPHEEO guidelines, i.e. 1/3 of the daily requirement. However, if the reservoirs requirement is calculated based on the mass curve as per the CHPEEO manual, the requirement will be reduced to 25% for a 24 X 7 supply system. As there is no considerable difference between the storage requirements of intermediate and ultimate years considering the land constraints in future for additional storage, storage facilities are provided for the ultimate design year.

Details of storage requirement based on mass curve calculations for each hydraulic zones proposed are given in Annexure 6.1 Summary of new OHTs proposed with their capacities, and staging details are shown in Table 6.1

Table 6.1– Details of New Proposed OHTs in Area-x

S No	Location	OHT Capacity (ML)	Staging Ht (m)	Land available (sqm)	Shape	Supply to OHT
1	Choolaimedu WDS	4	20	17150	Circular	Choolaimedu
2	Choolaimedu WDS	6	20			
3	KK Nagar WDS	3.5	20	7500		KK Nagar New WDS
4	KK Nagar WDS	6	20			
5	KK Nagar WDS	6	20			
6	Ashok Nagar Ward no 132 Depot office	3.5	17	1240	Rectangular	KK Nagar Old WDS
7	West Mambalam Park, 7th Avenue, Corporation park. Ward no 132	4	17	1468		
8	United Colony Ward no 134, Depot office	2	17	931		Valluvarkottam

Details description of OHTs proposed at different locations are as follows.

6.5.1 Choolaiemdu WDS

OHT Capacity	:	6.0ML & 4.0ML(Each 1 No.) with 20m staging
Source to OHT	:	From Choolaimedu WDS
Area Available	:	17150.00 sqm
Area required for tank	:	3600.00 sqm
Size of Tank	:	40m dia for 6.0ML and 33m dia for 4.0ML 5.0m- water depth
Site Information	:	• The site is located between Chennai Mofussil Bus terminus and Metro station at Koyambedu inward no.127 • The site is covered with bushes and trees
Natural Ground level (NGL)	:	EL:10.00 (Avg)
Maximum Flood level (MFL)	:	EL: 9.75
Existing Structures	:	NIL
Existing Pipelines	:	Along the WDS compound wall
Nearby drain	:	500 km away from the site

Reference Dwg	:	7061563/PMC400MLD/CP4/CV/WDS01/01-02

6.5.2 KK Nagar WDS

OHT Capacity	:	6.0ML (2 Nos) & 3.5ML(1No.) with 20m staging
Source to OHT	:	From KK Nagar WDS
Area Available	:	7500.00 sqm
Area required	:	5500.00 sqm
Size of Tank	:	40m dia for 6.0ML and 31m dia for 3.5ML 5.0m- water depth
Site Information	:	• The site is located at KK Nagar old WDS inward no.131 • The site has minor trees and bushes • Compound wall- RR masonry of 2.5m height
Natural Ground level (NGL)	:	EL:9.50 (Avg)
Maximum Flood level (MFL)	:	EL: 10.10
Existing Structures	:	Well – 11.60m dia & 13.30m dia and Building 8.0 x 7.3m size – Not in use Existing DG room size (9.2m X 7m X 4.5m) and Transformer room size (4.25m X 4m X 4.5m) has to be revised to 12m X 8m X 6.5m for DG and 6m X 5.5m X 4.5m for Transformer as per Electrical design requirement at Old WDS location *All existing structures have to be demolished
Existing Pipelines	:	NIL
Nearby drain	:	Near boundary wall towards the roadside
Reference Dwg	:	7061563/PMC400MLD/CP4/CV/WDS02/01-02

6.5.3 Ashok Nagar

OHT Capacity	:	3.5ML-17.0m staging

Source to OHT	:	From KK Nagar WDS
Area Available	:	1240.00 sqm
Area required	:	1240.00 sqm
Size of Tank	:	34 x 21 x 6m (5.0m water depth)
Site Information	:	• The site is located inward at 132 Depot office. • The site has minor trees near the boundary • Compound wall- RR masonry and Brickwork of 1.5m height
Natural Ground level (NGL)	:	NA
Maximum Flood level (MFL)	:	NA
Existing Structures	:	Ward office - 16.5 x 10.0m and 15.5 x 5.0 m size OHT – 0.7ML (Not in service) *All existing structures have to be demolished
Existing Pipelines	:	Pipelines connected to existing OHT
Nearby drain	:	Near boundary wall towards the roadside
Reference Dwg	:	7061563/PMC400MLD/CP4/CV/WDS06/01-02

6.5.4 West Mambalam

OHT Capacity	:	4.0ML-17.0m staging
Source to OHT	:	From KK Nagar WDS
Area Available	:	1468.00 sqm
Area required	:	1344.00 sqm
Size of Tank	:	35 x 24 x 6m (5.0m water depth)
Site Information	:	• The site is located inward no.139 • The site has trees and bushes

- Compound wall- RR masonry of 2.5m height

Natural Ground level (NGL)	:	NA
Maximum Flood level (MFL)	:	NA
Existing Structures	:	Steel OHT, UGT, Pumping station with Generator room and Well – Not in use *All existing structures have to be demolished
Existing Pipelines	:	Connected to existing reservoirs – Not in use
Nearby drain	:	Near boundary wall towards the roadside
Reference Dwg	:	7061563/PMC400MLD/CP4/CV/WDS05/01-02

6.5.5 United Colony

OHT Capacity	:	2.0ML-17m staging
Source to OHT	:	From Valluvarkottam WDS
Area Available	:	931.00 sqm
Area required	:	931.00 sqm
Size of Tank	:	36.6 x 12 x 6m (5.0m water depth)
Site Information	:	• The site is located inward no 34 Depot office. • The site has minor trees near the boundary • Compound wall- RR masonry and Brickwork of 1.5m height
Natural Ground level (NGL)	:	NA
Maximum Flood level (MFL)	:	NA
Existing Structures	:	14.5 x 8.65m size of depot office - to be demolished
Existing Pipelines	:	NIL

Nearby drain	:	Near boundary wall towards the roadside
Reference Dwg	:	7061563/PMC400MLD/CP4/CV/WDS08/01-02

6.6 Design Approach for Distribution System

Chapter 5 described how the existing water supply system within Area X hydraulically fails to satisfy the average water demand for 2025. Hence, significant modifications are required for replacement, rehabilitation, renovation, strengthening, and upgrading the existing water supply system to recover its proper performance to meet the future demand of the horizon year 2055.

To design the City water supply system, the following approach is followed:

(i) The number of water supply zones are formed based on area, population, demand, topography etc., as mentioned in design criteria. It is considered that the individual tank will serve each zone.

(ii) While designing the distribution system, the formation of DMAs shall be considered. It may be difficult to identify the number of connections exactly, but it is intended to form DMAs with their area around 0.5 to 0.75 Sq. Km. The approximate number of connections may vary between 500 to 4000. However, it may vary based on field requirement/constraints in unavoidable circumstances.

(iii) The capacity of new OHTs is proposed concerning the zonal demand; wherever possible, the existing OHTs are considered for proposed distribution zones based on the capacities and physical conditions of the existing tanks.

(iv) The capacity of new tanks is considered based on the standard size of 2 ML, 3.5 ML, 4ML and 6ML. The staging of all the OHTs ranges from 17-20m based on the topography and minimum residual head requirement of 12m at the consumer end.

(v) Various alternative alternatives have been studied by PMC for gravity supply to the possible extent as per the client requirement.by utilizing the existing or proposed OHT at different locations based on land availability. The details of various alternatives analysed as follows.

a) Alternative (1): the existing WDS within the selected hydraulic zone, which may comprise more than 1 DMA, will be utilized as a water source for the selected isolated zone in addition to new proposed OHTs shall be installed within every WDS providing that sufficient space is available. If there is no space available for this option (a), then alternative (2) will be examined.

b) Alternative (2): New location with available space within the relevant hydraulic zone will be selected to install the new proposed source containing ground storage reservoirs, pumping station, and OHTs. If this option has no availability, then alternative (3) will be examined. The acceptant criterion for this alternative is that the land acquisition approval would be provided by the client CMWSSB if it was not under the client’s ownership.

c) Alternative (3): New location to install only OHTs; hence, the nearest existing pumping station will be utilized to convey water and fill the OHTs via the new proposed pipeline. Its diameter will be based on hydraulic analysis/design. If this option is unavailable, then the client request to feed the water distribution networks by gravity shall not have room to apply and completely be discarded. Accordingly, alternative (4) shall compulsory prevail.

d) Alternative (4): The existing WDS will be utilized to discharge water by pumping to the water distribution networks even 24/7 in case the client decides to apply continuous/non-disturbed feeding along the daily hours. Refer to **Error! Reference source not found.** for a schematic diagram showing the decision approach in selecting the type of water source within each isolated hydraulic zone. On the other hand, **Error! Reference source not found.** illustrates a systematic, logical problem-solving flow chart to decide which water source types suit each hydraulic zone.

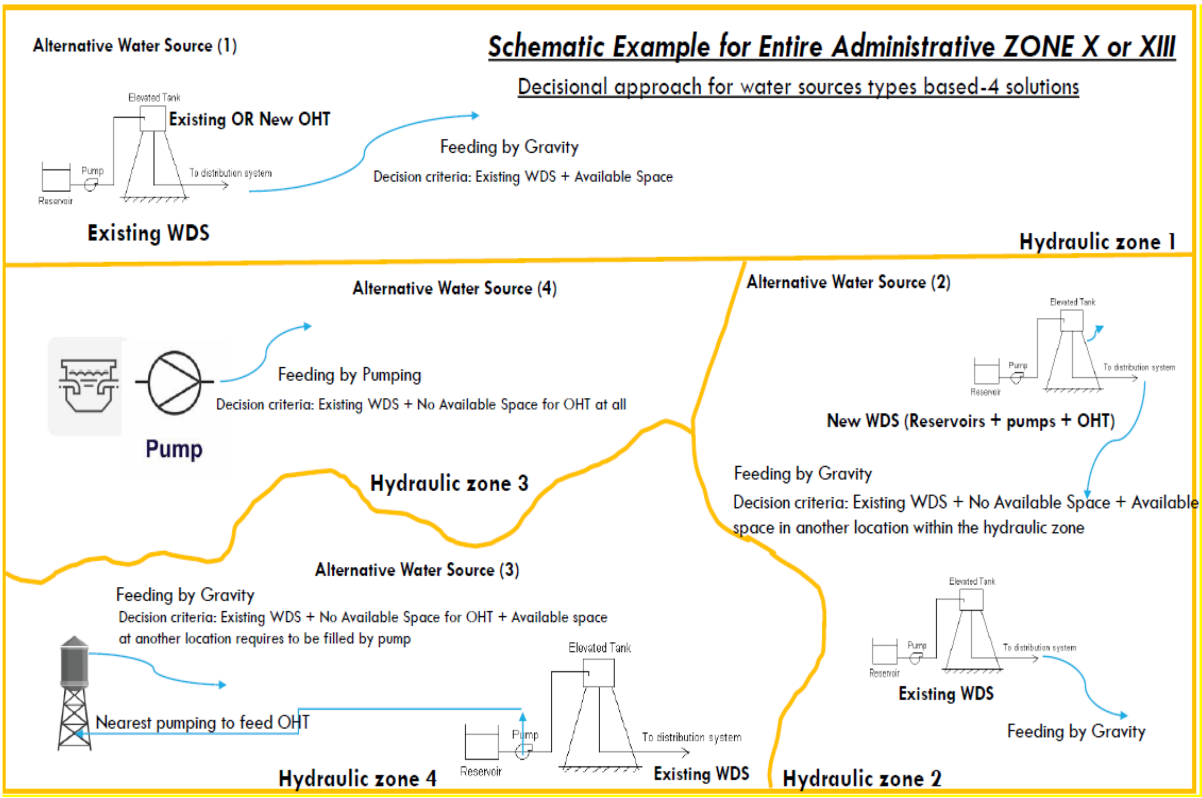


Figure 6.2 Proposed Water Source: Problem-Solving Schematic Diagram

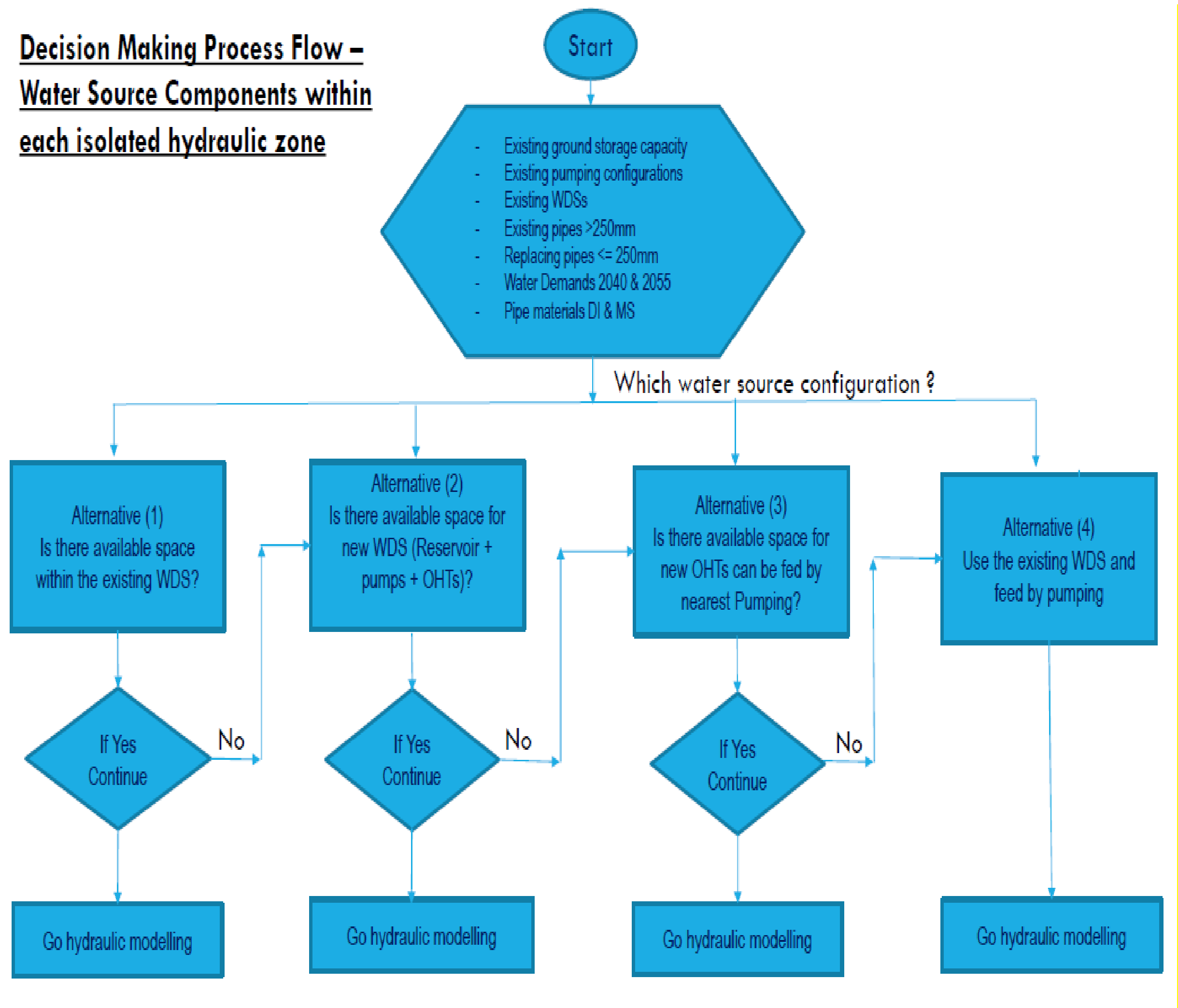


Figure 6.3 Systematic Problem-Solving Flow Chart - Water Recourse Type-Selection

The PMC design team has developed (4) hydraulic scenarios for each isolated hydraulic zone. The four hydraulic scenarios include average, maximum daily, peak hourly, and minimum daily demand. Once a specific scenario satisfies all required criteria relevant to the required level of service (i.e., minimum 12 m residual pressure corresponding to peak hourly demand), an optimized scenario shall be developed to achieve the least cost economic design with the level of hydraulic performance is required. Water quality analysis for each isolated zone shall be provided in the final revision as still client approval is required to proceed further in the details design. No water quality analysis shall be provided in this draft report.

(vi) The distribution network is designed using the following steps

- Initially, the demand for the ultimate horizon year 2055 is calculated separately for each zone. Total water demand is (Excluding bulk water demands) distributed to the 100mm dia network using the unit line method.
- The AutoCAD survey drawings with road network and elevation are imported into the hydraulic modelling software background. Then network drawing with pipes, nodes and reservoir (OHT) are created in the software interface.
- An individual distribution network model is prepared for each zone. The nodal demand is calculated based on pipe length.
- Input data for a network is given as per Table 6.2

Table 6.2- Input Data for Network design

Sl. No.	Component	Input Data	Remarks
01	Pipe	Diameter, Length, "C" Value	C = 140 for New DI, 130 for Old DI pipes and 80 for all other pipes MS, CI
02	Junction or Node	Elevation, Demand	Elevation as per survey drawing
03	Underground Reservoir	Elevation	Minimum water/suction level of the tank
04	OHTs	Depth/shape	5m Water dept/ Circular or Rectangular based on space availability

The network is analyzed in hydraulic modelling software, and the pressures at the endpoints/nodes/junctions are reviewed. The sizes of pipelines/mains are suitably adjusted and optimized using the trial and error method to achieve the desired tail end / residual pressures of the network.

6.7 Zone Wise Details of Proposed Distribution System

The detailed design and analysis of the distribution system are carried out for the Area-X for the projected demand of the horizon year 2055. The water distribution zoning is carried out based on the design criteria outlined in Chapter III. The command areas were reviewed, and new zones were formed based on the existing capacity or proposed additional OHTs. The details of the proposed hydraulic zones are shown in Fig 6.4. The pressure varies between min 12m and 22m in the newly proposed zones as per the design. The details of service reservoirs and water distribution zones are presented in Table 6.3. Proposed distribution zones drawings with pipeline details are shown in drawing no 701563/PMC400MLD/CP4/PW/LM/009(42 sheets).

For each zone, the details of service reservoir, command area, water demand, pipe network drawing, junction report, pipe report, a summary of pipe length, etc., are furnished separately.

The proposed pipeline for the distribution network is as per design criteria indicated in Chapter III. The total pipeline length with diameter and material is presented in Table 6.4. All the existing DI, MS and CI pipes >250mm dia pipelines are retained in the system. The Design outputs from Water Gem are given in Volume-II of the report.

The proposed design improves the residual pressures from the current/existing residual pressure range 0-5 mts to 12 and above.

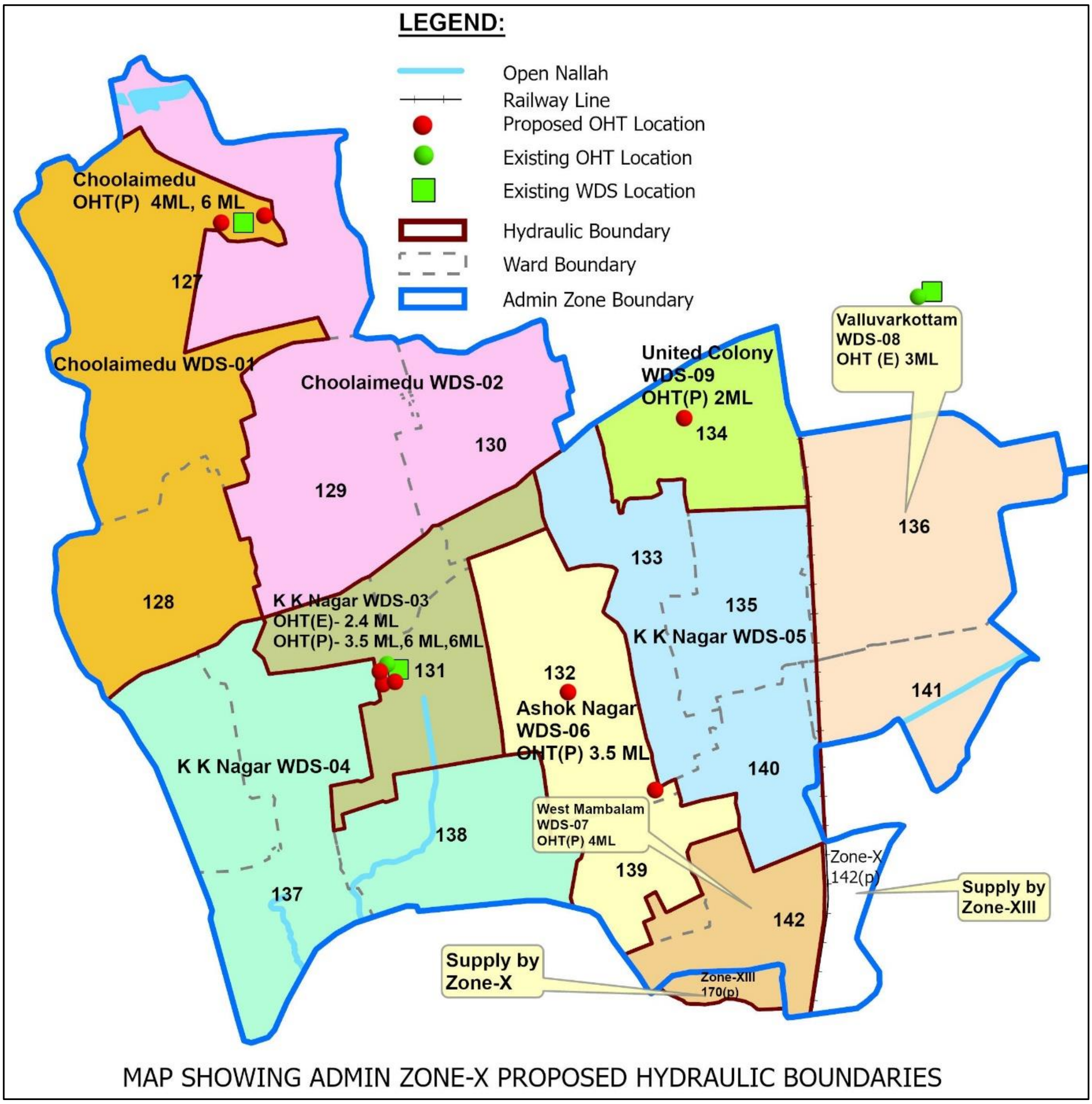


Figure 6.4 : Map showing the Proposed Hydraulic Zones of Area X

Table 6.3– Details of distribution Zones with Proposed and Existing OHTs

S No	Hydraulic Zone	OHT Capacity	Staging Ht (m)	2055 demand (MLD)	Benefited Depots	No of DMA	Supply to OHTs
1	Choolaimedu WDS 01	4 ML- N	20	14.57	127(P),128(P)	8	Choolaimedu
2	Choolaimedu WDS 02	6 ML- N	20	22.35	127(P), 129, 130(P)	8	
3	KK Nagar WDS 03	2.4 ML-E, 3.5 ML-N	20,20	21.71	131,129(P),130 (P)	9	KK Nagar New WDS
4	KK Nagar WDS 04	6 ML-N	20	22.45	137,138,128 (P)	9	
5	KK Nagar WDS 05	6 ML-N	20	23.95	133, 135, 140	10	
6	Ashok Nagar WDS 06	3.5 ML-N	17	14.88	132,139(P)	8	KK Nagar Old WDS
7	West Mambalam WDS 07	4ML-N	17	13.68	142(P)#,139(P), 170 (P)^	6	
8	Valluvarkottam WDS 08	3 ML-E	20	13.42	136, 141	6	Valluvarkottam
9	United Colony WDS-09	2 ML-N	17	8.04	134	3	

Table 6.4– Total length of pipeline with material and diameter in Area-x

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	425,136	31,628	20,278	750	0
150	0	1,003	9,115	39,820	0	0
200	0	616	4,508	17,627	0	0
250	0	0	1,272	13,894	0	0
300	6,877	0	3,935	8,787	0	0
350	1,212	0	755	842	0	0
400	7,107	0	2,033	3,612	0	0
450	1,977	416	0	13	0	0
500	2,525	0	491	3,696	0	0
525	1,455	0	0	0	0	0
600	1,522	1,301	461	2,075	0	0
700	0	0	668	1,382	0	0
750	448	0	0	0	0	0
800	0	0	494	75	0	0
900	2,729	0	0	1,731	0	0
1200	0	0	0	13	0	83
1,600	0	0	0	0	0	830.56

6.8 Salient Features of Proposed Distribution Zones

Based on the number of existing and proposed Over Head Tanks, the entire area X is divided into 9 individual isolated hydraulic zones. The salient features of each hydraulic zone are as follows.

6.8.1 Choolaiemdu WDS-01

This zone comprises wards 127 Part and 128 Part. The total estimated water demand for Intermediate (2040) and ultimate (2055) years is 14.27MLD and 14.57 MLD, respectively. 4ML Capacity of new OHT is proposed in Choolaimedu WDS Premises to serve this zone. Both OHT and Distribution networks are designed for the ultimate demand of 14.57 MLD. The total no of DMAs has been proposed 8 nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.5

Table 6.5– Details of pipeline network in Choolaimedu WDS-01

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- Choolaimedu WDS 01						
Diameter (mm)	**CI/E**	**CI/R/DI**	**DI/E**	**DI/P**	**PVC/R/DI**	**MS/E**
100	0	70949	5865	5	0	0
150	0	92	2025	2776	0	0
200	0	5	2038	1187	0	0
250	0	0	8	878	0	0
300	883	0	3187	788	0	0
350	0	0	0	0	0	0
400	0	0	0	70	0	0
450	0	0	0	0	0	0
500	913	0	0	0	0	0
525	0	0	0	0	0	0
600	503	0	0	8	0	0
700	0	0	0	0	0	0
750	448	0	0	0	0	0
800	0	0	0	0	0	0
900	1084	0	0	20	0	0
1200	0	0	0	0	0	0
1,600	0	0	0	0	0	0

6.8.2 Choolaiemdu WDS-02

This zone comprises wards 127 Part, 129 and 130 Part. The total estimated water demand for Intermediate (2040) and ultimate (2055) years is 21.89 MLD and 22.39 MLD, respectively. 6ML capacity of new OHT is proposed in Choolaimedu WDS Premises to serve this zone. Both OHT and Distribution networks are designed for the ultimate demand of 22.39 MLD. The total no of DMAs proposed are 8 nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.6

Table 6.6– Details of pipeline network in Choolaimedu WDS-02

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- Choolaimedu WDS 02						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	49650	18696	413	0	0
150	0	146	589	4765	0	0
200	0	408	678	1850	0	0
250	0	0	0	2310	0	0
300	0	0	748	2789	0	0
350	0	0	0	221	0	0
400	0	0	0	326	0	0
450	1216	0	0	0	0	0
500	527	0	0	633	0	0
525	139	0	0	0	0	0
600	0	0	461	236	0	0
700	0	0	0	6	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
900	1645	0	0	0	0	0
1200	0	0	0	0	0	0
1,600	0	0	0	0	0	830.56

6.8.3 KK Nagar WDS-03

This zone comprises wards 129 Part, 130 Part and 131. The total estimated water demand for Intermediate (2040) and ultimate (2055) years is 20.46 MLD and 21.71 MLD, respectively. The existing 2.4 ML capacity is not sufficient to feed this zone completely; hence, a new OHT 3.5 ML capacity is proposed in addition to the existing one in KK Nagar new WDS Premises to serve this zone. Both OHT and Distribution networks are designed for the ultimate demand of 21.71 MLD. The total no of DMAs proposed are 9 Nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.7

Table 6.7– Details of pipeline network in KK Nagar WDS -03

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- KK Nagar WDS03						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	33111	331	1168	127	0
150	0	6	0	5118	0	0
200	0	5	0	3104	0	0
250	0	0	0	2492	0	0
300	1226	0	0	817	0	0
350	0	0	0	102	0	0
400	478	0	0	296	0	0
450	0	416	0	0	0	0
500	0	0	0	294	0	0

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- KK Nagar WDS03						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
525	0	0	0	0	0	0
600	0	0	0	11	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	494	10	0	0
900	0	0	0	0	0	0
1200	0	0	0	0	0	52
1,600	0	0	0	0	0	0

6.8.4 KK Nagar WDS-04

This zone comprises wards 128 Part, 137 and 138. The total estimated water demand for Intermediate (2040) and ultimate (2055) years is 21.06 MLD and 22.45 MLD, respectively. 6ML Capacity of new OHT is proposed in KK Nagar new WDS Premises to serve this zone. Both OHT and Distribution networks are designed for the ultimate demand of 22.45 MLD. The total no of DMAs proposed are 9 nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.8

Table 6.8– Details of pipeline network in KK Nagar WDS -04

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- KK Nagar WDS04						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	83872	529	5056	0	0
150	0	16	4186	6383	0	0
200	0	198	685	3523	0	0
250	0	0	0	2019	0	0
300	0	0	0	1447	0	0
350	0	0	0	14	0	0
400	2419	0	296	954	0	0
450	761	0	0	0	0	0
500	0	0	0	538	0	0
525	0	0	0	0	0	0
600	750	0	0	284	0	0
700	0	0	0	538	0	0
750	0	0	0	0	0	0
800	0	0	0	52	0	0
900	0	0	0	0	0	0
1200	0	0	0	0	0	0
1,600	0	0	0	0	0	0

6.8.5 KK Nagar WDS-05

This zone comprises wards 133,135, and 140. The total estimated water demand for Intermediate (2040) and ultimate (2055) years is 22.55 MLD and 23.95 MLD, respectively. 6ML Capacity of new OHT is proposed in KK Nagar new WDS Premises to serve this zone. Both OHT and Distribution networks are designed for the ultimate demand of 23.95 MLD. The total no of DMAs proposed are 10nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.9

Table 6.9– Details of pipeline network in KK Nagar WDS -05

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- KK Nagar WDS05						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	56018	2080	2488	358	0
150	0	24	0	7278	0	0
200	0	0	673	1847	0	0
250	0	0	0	1638	0	0
300	1273	0	0	777	0	0
350	287	0	0	0	0	0
400	2846	0	0	1264	0	0
450	0	0	0	0	0	0
500	724	0	0	244	0	0
525	974	0	0	0	0	0
600	269	1301	0	0	0	0
700	0	0	0	34	0	0
750	0	0	0	0	0	0
800	0	0	0	13	0	0
900	0	0	0	1711	0	0
1200	0	0	0	0	0	0
1,600	0	0	0	0	0	0

6.8.6 Ashok Nagar WDS-06

This zone comprises wards 132 and 139(P). The estimated water demand for Intermediate (2040) and ultimate (2055) years is 13.96 MLD and 14.88 MLD, respectively. 3.5 ML capacity of new OHT is proposed in Ashok Nagar ward no 132 Depot office Premises to serve this zone. KK Nagar Old WDS GLR is used to pump the water to this OHT. Both OHT and Distribution networks are designed for the ultimate demand of 14.88 MLD. The total no of DMAs proposed are 8 nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.10

Table 6.10– Details of pipeline network in Ashok Nagar WDS -06

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- Ashok Nagar WDS06						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	44493	1064	1356	0	0
150	0	144	0	4541	0	0
200	0	0	434	2090	0	0
250	0	0	0	1002	0	0
300	727	0	0	285	0	0
350	0	0	0	0	0	0
400	360	0	0	0	0	0
450	0	0	0	0	0	0
500	361	0	0	438	0	0
525	0	0	0	0	0	0
600	0	0	0	392	0	0
700	0	0	668	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
1200	0	0	0	0	0	0
1,600	0	0	0	0	0	0

6.8.7 West Mambalam WDS-07

This zone comprises wards 139 part, 142 part and 170 part (Area XIII). Total estimated water demand for Intermediate (2040) and ultimate (2055) years is 12.77 MLD and 13.68 MLD, respectively. 4 ML capacity of new OHT is proposed in Ashok Nagar ward no 132 Depot office Premises to serve this zone. KK Nagar Old WDS GLR is used to pump the water to this OHT. Both OHT and Distribution networks are designed for the ultimate demand of 13.68 MLD. The total no of DMAs proposed are 6 nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.11

Table 6.11– Details of pipeline network in West Mambalam WDS -07

PIPE LINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- West Mamblam WDS07						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	18475	2324	2643	0	0
150	0	6	0	3086	0	0
200	0	0	0	1596	0	0
250	0	0	0	1134	0	0
300	1110	0	0	292	0	0
350	0	0	0	50	0	0
400	177	0	1057	0	0	0
450	0	0	0	0	0	0
500	0	0	0	0	0	0
525	342	0	0	0	0	0
600	0	0	0	1144	0	0

PIPE LINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- West Mamblam WDS07						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
1200	0	0	0	0	0	0
1,600	0	0	0	0	0	0

6.8.8 Valluvar Kottam WDS-08

This zone comprises wards 136 and 141. The estimated water demand for Intermediate (2040) and ultimate (2055) years is 12.62 MLD and 13.42 MLD, respectively. The existing 3 ML capacity in Valluvarkottam WDS serves this zone. A distribution network is designed for the ultimate demand of 13.42 MLD. The total no of DMAs proposed are 6 nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.12

Table 6.12– Details of pipe line network in Valluvar Kottam WDS -08

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- ValluvarKottam WDS08						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	44672	0	6893	0	0
150	0	407	2315	4397	0	0
200	0	0	0	1774	0	0
250	0	0	1264	1418	0	0
300	0	0	0	524	0	0
350	925	0	755	455	0	0
400	0	0	680	0	0	0
450	0	0	0	0	0	0
500	0	0	491	1549	0	0
525	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	804	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
1200	0	0	0	0	0	31
1,600	0	0	0	0	0	0

6.8.9 United Colony WDS-09

This zone comprises ward no 134. Total estimated water demand for Intermediate (2040) and ultimate (2055) year is 7.04 MLD and 8.04 MLD, respectively. 2 ML capacity of new OHT is proposed in united colony ward no 134 Depot office Premises to serve this zone. Valluvarkottam is used to pump the water to this OHT. Both OHT and

Distribution networks are designed for the ultimate demand of 8.04 MLD. The total no of DMAs has been proposed 3 nos. Details of Proposed as well as existing network details in this zone are shown in below table Table 6.13

Table 6.13– Details of pipeline network in United Colony WDS -09

PIPELINE SUMMARY DETAILS OF AREA-X- LENGTH in meters- United Colony WDS09						
Diameter (mm)	CI/E	CI/R/DI	DI/E	DI/P	PVC/R/DI	MS/E
100	0	23,896	739	256	265	0
150	0	162	0	1,476	0	0
200	0	0	0	656	0	0
250	0	0	0	1,003	0	0
300	1,658	0	0	1,068	0	0
350	0	0	0	0	0	0
400	827	0	0	702	0	0
450	0	0	0	13	0	0
500	0	0	0	0	0	0
525	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
1200	0	0	0	0	0	0
1,600	0	0	0	0	0	0

6.9 House Service Connection

The number of properties existing in the area-x is collected from CMWSSB. The total number of existing residential, commercial, Institutional and Industrial data is mainly used to arrive at the number of service connections required. House service connections shall be provided from the secondary networks only, i.e. on100mm dia pipes. Wherever primary pipes (higher than 150mm) runs, a parallel pipe of 100 mm dia. shall be laid along with the primary network. It is interconnected at sufficient intervals to minimize the dead ends. The same is considered while calculating the total length of the pipe.

Pipe material for House service connections shall be MDPE. Depending upon the requirements, the size of connections shall be 15mm, 20mm, 25 mm and 40mm. It is proposed to provide 1,48,000 house service connections based on assessments. The general arrangement of HSC is shown in Drawing 701563/PMC400MLD/CP-4/PW/SD/019.

6.10 Valves in the distribution system

The proposed distribution system provides different types of valves as per the design criteria (Chapter III). Isolation valves are proposed/provided in such a way that these valves will isolate small areas considering possible factors, which may occur during the operation and maintenance of the system. Air valves and Scour valves are also provided as per the design criteria. The general arrangement of Sluice Valve & Scour Valve chambers is shown in Drawing 701563/PMC400MLD/CP-4/PW/SD/014 and 701563/PMC400MLD/CP-4/PW/SD/015 respectively. Motorized/Diaphragm/Pilot operated flow control valves are proposed for installation at the inlet to DMA, controlled by the SCADA system. The typical flow control valve with isolation valve is shown in Drawing 701563/PMC400MLD/CP-4/PW/SD/016.

6.11 Flow Meter, Pressure Reducing Valve and Pressure transmitter with data logger FOR OHTS/DMA's inlet/outlet

It is proposed to consider flow meters, pressure measuring instruments with data loggers, and motorised valves to monitor the system at the inlet and entry to DMAs. An outlet of every OHT is an entry to a DMA; therefore, all the outlets of OHTs are fixed with flow meters for better water accountability. All these devices can transmit the real-time flow and pressure data to the central server to be set under the main SCADA system and implemented under a separate package.

All proposed devices for OHTs and DMAs shall be interfaced with the proposed SCADA system located at Central SCADA Room. The necessary flow meters and pressure measuring instruments with data loggers to monitor the flow and pressure in the distribution system are considered. The cost for the same is included in this report. The general arrangement of the Electro Magnetic Flow meter chamber is shown in Drawing no.701563/PMC400MLD/CP4/PW/SD/17

6.11.1 Proposed MOTORIZED VALVES & FLOW METERS for OHTs & DMAs

There are 9 OHTs supplying water to cater to the needs of Area-10, and for that only, the requirement of instruments (Flowmeters, Pressure Transmitters, Level Transmitters) are considered in the system.

Following details are observed and shall be proposed for a typical Single Compartment OHT:

- A single compartment OHT has an inlet pipeline going into the tank, an outlet/delivery line coming from the tank, a Scour line, and an overflow line.
- On top of the OHT, air vent nozzles are provided, and it is proposed to install an Ultrasonic Level Transmitter.
- It was proposed to install a Pressure Transmitter, Magnetic Flowmeter with transmitter and motorized isolation valve (Sluice Type) at the inlet horizontal pipeline going into the tank.
- At the horizontal delivery line, it is proposed to install a motorized Isolation valve (Sluice Type).

Each OHT shall be equipped with an independent PLC-based monitoring and control system comprised of panel-mounted PLC, HMI and PLC hardware along with a UPS battery and battery charger. All the instruments and valve signals shall be interfaced with the PLC panel. All the signals shall be transmitted to the proposed remote SCADA control room location through wireless communication (GSM / GPRS) for monitoring and control purposes.

At each DMA, installing a Magnetic Flow Transmitter and a Pressure Transmitter at the tail end of the pipe is proposed. Also proposed to install a Pressure Transmitter at Average Zonal Point(AZP) and Critical Pressure Point(CPP). These transmitters shall be communicated to the main plant PLC via GSM / GPRS modem.

All the Instruments signals present in the Main header of DMA shall be interfaced to the Proposed SCADA system through GSM / GPRS based wireless communication.

During detailed engineering, the contractor shall provide a detailed PLC I/O list for each OHTs (including the proposed one) and DMAs' (signals to be interfaced to main SCADA).

6.12 Proposed Mechanical System

Based on the revised hydraulic zone requirements, new pumps are proposed at various WDS locations. Details are as follows.

6.12.1 Choolaimedu WDS

To supply 35 mld of water in 24 hours for Choolaimedu WDS 01 and 02 together, pump sets will operate approximately 22 hours per day. So designed flow of each pump is 35*24/22 = 38.18 mld

It is recommended to install 2 sets (1w+1s) new Horizontal pump sets having capacity of each pump 1591 cum/hour (38.18 MLD), 32-meter head with 210 KW, 3.3 KV, 1500 rpm electric motor replacing 2 numbers of old pump sets. The remaining existing four pump sets out of six pump sets will work as usual. So, no additional space is required to install two numbers of new pump sets.

6.12.2 KK Nagar New WDS

For supply of 21 mld of water in 24 hours to KK Nagar WDS 03, pump sets will operate approximately 22 hours per day. So designed flow for each pump is 21*24/22 = 23 mld.

For supply of 44 mld of water in 24 hours to KK Nagar WDS 04 and 05 together, pump sets will operate approximately 22 hours per day. So, the designed flow for each pump is 44*24/22 = 48 mld

It is recommended to add two numbers (1w+1s) new vertical turbine pump sets of capacity each 2000 cum/hour (48 MLD) at the 32-meter head with 250 KW, 1500 rpm, 415 volts, 3 phase LT Motor replacing two numbers existing vertical turbine pump sets in the same space. We also propose to add another two numbers (1w+1s) of new vertical turbine pump sets of the capacity of each 450 cum/hour (23 MLD) at the 34-meter head with 132 KW, 1500 RPM, 415 Volt, 3 Phase, 50HZ Motor replacing two numbers of existing vertical turbine pump' sets.

Hence, four new vertical turbine pump' sets will be installed by dismantling the four existing vertical pump sets. Out of six pump sets, two pump sets will remain as it is. No additional space is required to install four new pump sets.

6.12.3 KK Nagar Old WDS

For supply of 27 mld of water in 24 hours to Ashok Nagar WDS 06 and West Mambalam 07 together, pump sets will operate approximately 22 hours per day. So designed flow for each pump is 27*24/22 = 29.45 mld

It is recommended to replace all three numbers of existing horizontal centrifugal pump sets of outside pump house (Shed) installation with two numbers (1w+1s) new pump sets having capacity of each pump sets 1227 cum/hour (29.45 MLD) at the 36-meter head, with 180 KW, 1500 RPM, 415 Volt, 3 Phase, 50 HZ LT Motor.

No modification will be proposed inside the Pumphouse of KK Nagar old WDS.

6.12.4 Valluvarkottam WDS

For supply of 21 mld of water in 24 hours to Valluvarkottam WDS 08 and United Colony WDS 09, pump sets will operate approximately 22 hours per day. So designed flow for each pump is 21*24/22 = 23 mld

It is recommended to replace two numbers of existing horizontal centrifugal pump sets with two numbers (1w+1s) new pump sets with a capacity of each pump set is 955 cum/hour (23 MLD) at the 30-meter head with 120 KW, 1500 RPM, 3.3 KV, 3 Phase LT Motor. Out of four pump sets, two pump sets shall be replaced; the remaining two will be as it is. No additional space is required to install two new pump sets.

P&I diagrams for proposed of various WDS under Area X are shown in Drawings no. 7061563/PMC400MLD/CP4/PW/PD/010 to 013

6.13 PROPOSED ELECTRICAL SYSTEM

6.13.1 Introduction:

The above section no. 5.5 of this report has described the major assessment and recommendation as per standard engineering practices and guidelines. However, the scope of electrical works is dependent on zone wise hydraulics requirements and subsequent mechanical pumping design change for Zone-X.

This section describes the electrical design change, and electrical scope works for WDS locations in zone-X considering mechanical and hydraulic inputs for upgrading pumps' sizes and relevant auxiliaries. The proposed hydraulic system is introduced to feed all areas in zone X, which comprises new Overhead tanks proposed in different areas of this Zone. Accordingly, pumping requirements and pump sizes are altered in existing WDS for enabling 24x7 water feeding to all areas.

6.13.2 General Design Criteria

The electrical demand and equipment sizing must be re-affirmed as per the changes in mechanical pumps and auxiliaries for each WDS. The hydraulic design and subsequently revised pump requirements are based zone-wise only, and Plant (WDS) based design finalization is not possible at this stage. So complete WDS refurbishment or replacement of electrical system cannot be planned unless all other zones' hydraulic requirements to be fed from each WDS are finalized.

So, the improvement and upgrading of the electrical system are considered with minimum required changes to envisage for revised new pumping load with remaining old pumps. This preliminary engineering with subsequent budgeting is based on various assumptions and design considerations that are subject to change as per other zones' hydraulic and mechanical design requirements.

All electrical equipment shall be rated for 45°C design ambient temperature. The installation, testing & commissioning shall generally conform to IS / IEC standards.

The power factor correction has added advantages in that it reduces the overall demand to the Incoming Supply Authority, thereby adding to the overall economy. Besides the proposed changes in electrical system and design, the Tamil Nadu Electricity Board (TNEB) requirement for improving the power factor and maintaining demand must be met. The power factor shall be maintained complying with TNEB guidelines minimum of 0.98.

6.13.3 Upgrading of WDS

Out of the above-mentioned existing WDS in Zone-X, the recommendation for revised pumping requirements as per hydraulic design is for four WDS only, which are enlisted in Table 6.14. The new pumping requirements for Southern headworks WDS, which is currently feeding Zone-X, will be finalized based on the command area served under WDS, so no improvement or refurbishment is considered.

Table 6.14– Revised Pumping requirement with load details					
WDS	**Existing Pumps arrangement**	**Proposed Pumps arrangement**	**Old WDS Load (Rated)**	**Revised WDS Load (Rated)**	**Remarks**
Choolaimedu	500 kW, HSCF Pumps (4W+2S)	New- 210 kW, HSCF Pumps (1W+1S) Old- 500 kW, HSCF Pumps (3W+1S)	2300 kW (including 15% auxiliary load)	1967 kW (including 15% auxiliary load)	Since the Revised load is less than the old load, the Major Electrical equipment, viz. transformers and DG sets, shall work normally.
KK Nagar-New	250 kW, VT Pumps (4W+2S)	i) New- 132 kW, VT Pumps (1W+1S) ii) New- 250 kW, VT Pumps (1W+1S) Old- 250 kW, VT Pumps (1W+1S)	1150 kW (including 15% auxiliary load)	723 kW (including 15% auxiliary load)	Since the Revised load is less than the old load, the Major Electrical equipment, viz. transformers and DG sets, shall work normally.

Table 6.14– Revised Pumping requirement with load details					
WDS	**Existing Pumps arrangement**	**Proposed Pumps arrangement**	**Old WDS Load (Rated)**	**Revised WDS Load (Rated)**	**Remarks**
KK Nagar-OLD	55 kW, HSCF Pumps, (2W+1S & 2W+1S)	New- 180 kW, HSCF Pumps, (1W+1S) Old- 55 kW, HSCF Pumps (2W+1S)	253 kW (including 15% auxiliary load)	334 kW (including 15% auxiliary load)	Here the Revised load is higher than the old load, and the difference is significant. So, both transformer and DG sets need to be replaced with suitable sized switchgear and equipment.
Valluvarkottam	300 kW, HSCF Pumps (2W+2S)	New- 120 kW, HSCF Pumps (1W+1S) Old- 300 kW, HSCF Pumps (1W+1S)	690 kW (including 15% auxiliary load)	483 kW (including 15% auxiliary load)	Since the Revised load is less than the old load, the Major Electrical equipment, viz. transformers and DG sets, shall work normally.

No change envisaged for Southern Headworks WDS in Zone-X report.

6.13.4 WDS wise Proposed electrical system details

6.13.4.1 Choolaimedu WDS

The existing electrical distribution scheme for Choolaimedu WDS is shown in the drawing no. 7061563/PMC400MLD/CP4/EL/001A and proposed revised electrical distribution scheme is described in Single Line Diagram no. 7061563/PMC400MLD/CP4/EL/001B.

- The two new pump motors shall be fed through two new 3.3 kV FCMA soft starters with a suitable isolating switch. The old 2 nos. Leftover ATS can be discarded, and their feeder SFUs shall feed to new starter panels individually through separate cables.
- The necessary provision for cable termination is to be made in the existing 3.3 kV panel bus bar chamber or termination chamber.
- The two new local push button stations (LPBS) will be placed for both new pump-motors sets.
- All power and control cables must be laid with new cable carrier systems and hardware. New earthing arrangements for both new motors, panels and LPBS shall be installed with two-point earthing requirements as per IS 3043. All these earthing conductors shall be properly connected to the main earthing grid of the plant.
- Complete indoor and outdoor lighting systems shall be replaced with LED luminaires and fittings at this stage itself since that will optimize the power consumption of the WDS.
- Until design for the whole WDS capacity is finalized, at least minimum required maintenance, calibration and repair are envisaged for the major electrical equipment and switchgear.

6.13.4.2 K.K. Nagar-New WDS

- The existing electrical distribution scheme for KK Nagar- New WDS is shown in the drawing no. 7061563/PMC400MLD/CP4/EL/002A and proposed revised electrical distribution scheme is described in Single Line Diagram no. 7061563/PMC400MLD/CP4/EL/002B.Here 4 nos. of new pump motors shall be replaced with 2 nos. 132 kW motors and two nos. 250 kW motors. These motors shall be fed through 2 nos. of new 0.415 kV FCMA LT soft starters (132 kW) and other two from existing FCMA soft starters (250 kW) with suitable isolating switches. The old 2 nos. leftover FCMA starters can be kept as spare remaining 250 kW starters. The feeders to these discarded starters shall now feed to new 132 kW FCMA soft starters.
- The necessary provision for cable termination is to be made in the existing 0.415kV panel bus bar chamber or termination chamber.
- The four nos. of new local push button stations (LPBS) to be placed for all new pump-motors sets.
- All-new power and control cables are to be laid with new cable carrier systems and hardware.

- The earthing arrangement for both new motors, panels and LPBS shall be installed with two-point earthing requirements as per IS 3043. All these earthing conductors shall be properly connected to the main earthing grid of the plant.
- Complete indoor and outdoor lighting systems shall be replaced with LED luminaires and fittings at this stage itself since that will optimize the power consumption of the WDS.
- Until design for the whole WDS capacity is finalized, at least minimum required maintenance, calibration and repair are envisaged for the major electrical equipment and switchgear.

6.13.4.3 K.K. Nagar-Old WDS

- The existing electrical distribution scheme for KK Nagar- Old WDS is shown in the drawing no. 7061563/PMC400MLD/CP4/EL/003A and proposed revised electrical distribution scheme is described in Single Line Diagram no. 7061563/PMC400MLD/CP4/EL/003B.Here 2 nos. new pump-motor set of 180 kW (1W+1S) shall be installed in place of 3 nos. 55 kW existing pump-motor sets in the outside pump house. These new motors shall be fed through 2 nos. of new 0.415 kV FCMA LT soft starters (180 kW) with suitable isolating switch. The old 3 nos. Leftover ATS starters can be kept as a spare for existing 55 kW motors inside Pumphouse.
- Since the old feeders are underrated for new higher size motors and even complete Main PCC panel is Underrated and old, a new PCC panel shall be installed incorporating all small and large motor feeders with other required feeders for WDS.
- Since the total revised load is significantly higher, the new suitable sized transformer and DG set shall be installed for this WDS.
- All associated higher-rated MV, LV switchgear and distribution boards to be replaced with new ones.
- The newly designed cable carrier system for MV and LV must be installed, tested and commissioned for new installations.
- The two nos. New local push button stations (LPBS) to be placed for new pump-motors sets.
- The earthing arrangement for both new motors, panels and LPBS shall be installed with two-point earthing requirements as per IS 3043. All these earthing conductors shall be properly connected to the main earthing grid of the plant.
- Complete indoor and outdoor lighting systems shall be replaced with LED luminaires and fittings at this stage itself since that will optimize the power consumption of the WDS.
- Until design for the whole WDS capacity is finalized, at least minimum required maintenance, calibration and repair are envisaged for the major electrical equipment and switchgear.

6.13.4.4 Valluvarkottam WDS

- The existing electrical distribution scheme for Valluvarkottam WDS is shown in the drawing no. 7061563/PMC400MLD/CP4/EL/004A and proposed revised electrical distribution scheme is described in Single Line Diagram no. 7061563/PMC400MLD/CP4/EL/004B.The two new pump motors shall be fed through two new 3.3 kV FCMA soft starters with a suitable isolating switch. The old 2 nos. leftover ATS starters can be discarded, and their feeder SFUs shall feed to new starter panels individually through separate cables.
- The necessary provision for cable termination is to be made in the existing 3.3 kV panel bus bar chamber or termination chamber.
- The two new local push button stations (LPBS) will be placed for both new pump-motors sets.
- All-new power and control cables are to be laid with respective new cable carrier system, tagging and hardware for all the new installations.
- The earthing arrangement for both new motors, panels and LPBS shall be installed with two-point earthing requirements as per IS 3043. All these earthing conductors shall be properly connected to the main earthing grid of the plant.
- Complete indoor and outdoor lighting systems shall be replaced with LED luminaires and fittings at this stage itself to optimize the power consumption of the WDS.
- Until design for the whole WDS capacity is finalized, at least minimum required maintenance, calibration and repair are envisaged for the major electrical equipment and switchgear.

6.13.5 Design Considerations/ Assumptions of Cost Estimates

Since hydraulic design and subsequently revised pump requirements are based on zone X only, WDS design finalization is not possible; the cost estimate is considered based upon minimum changes required in the electrical system to incorporate new pumps in place of old ones in existing WDS. The proposals for complete replacement of old electrical equipment & switchgear as per conditional assessment report must be kept on hold unless other/ all zone requirements are finalized.

6.13.6 Assumptions & Considerations:

- Apart from the pumps that shall be replaced, the remaining pumps will run, as usual, feeding only to the existing area.
- In the near future these old retained pumps may also be replaced or upgraded to feed other areas upon theirdesign finalization. Subsequent total electrical loads/ requirements for the WDS will be identified accordingly.

- Since hydraulic design is only based on zone X, WDS based design finalization is not possible; final proposals for complete replacement of electrical equipment & switchgear must be kept on hold until other zones' requirements are clarified.
- The Cost Estimates are considered based on the required changes in the electrical system to incorporate new pumps in place of old ones at the existing WDS.
- Upgrading the existing lighting system is considered wherever changes in a particular WDS are required.
- A minimum lumpsum amount is considered for maintenance and repair with spares of the existing electrical system to run.
- Other WDS where there is no recommendation of a change in pump sizes, no upgrading BOQ or cost estimates are prepared since their revised pumping requirement may be decided at a later stage.
- The cost estimates are tentative and may change upon the assumptions mentioned above and hydraulic/ pumping requirements considerations.
- The relevant civil and mechanical works requirement may also subject to change upon revision in WDS's electrical loads and equipment sizing on finalization of other dependent area's hydraulic design.

6.13.7 Electrical Works at Proposed OHTs & DMAs

This section details the Electrical Scope of works at Proposed Water storage facilities or Overhead Tanks (OHT) and District Metering Areas (DMA) for Zone-X.

6.13.7.1 OVERHEAD TANKS (OHT):

To improve the water distribution system, various capacities of OHTs are Proposed in different locations in Zone-X. Details of capacities and location are listed below:

1. Choolaimedu OHT (4 ML-1 No and 6 ML-1 No)
2. KK Nagar WDS OHT (3.5 ML-1 No)
3. KK Nagar WDS OHT (6 ML-2 No)
4. West Mambalam OHT (4 ML-1 No)
5. Ashok Nagar OHT (3.5 ML-1 No)
6. United Colony OHT (2.0 ML-1 No)

Since there is no pumping or process requirement at these new OHT locations, only limited electrical works are required at each OHT. The electrical scope includes attaining a power supply connection of 5 kVA to 10 kVA. Maximum demand from TNEB/ TANGEDCO at each location, Indoor and outdoor lightings, lightning arrester with aviation lamp and earthing system. The quantity and type of lighting shall be finalized as per the road plan and plot plan layout of the individual OHT location.

If the proposed OHT is coming at the existing WDS location, the power supply can be taken from WDS Switchboard.

The field Instrumentation load shall be considered while calculating the Maximum demand for individual OHT locations power supply connection.

6.13.7.2 DISTRICT METERING AREAS (DMA):

Apart from proposed works at WDS and OHTs, the improved hydraulic system includes different District Metering Areas (DMA) and respective critical/ average pressure monitoring points as per the typical P&ID drawing nos. 701563/PMC400/CP4/IC/001 and 701563/PMC400/CP4/IC/002. There shall be an individual power supply connection at each of these critical monitoring point locations as per Instrumentation loads burden and other requirements if any. The single-phase power supply connection is to be attained from TNEB/ TANGEDCO for such locations with suitable metering arrangements.

6.14 PROPOSED INSTRUMENTION AND CONTROL SYSTEM

6.14.1 K.K. Nagar Old

1. Electromagnetic flow meter, pressure transmitters, pressure gauge and motorized isolation valve in a valve chamber shall be provided at the inlet.
2. Electromagnetic flow meter, pressure transmitters, pressure gauge and motorized isolation valve in a valve chamber shall be provided at Pump Station 1 outlet.
3. Electromagnetic flow meter, pressure transmitters, pressure gauge and motorized isolation valve in a valve chamber shall be provided at Pump Station 2 outlet.
4. Pressure transmitters and pressure gauges should be provided at pumping stations 1 & 2 piping works.
5. Motorized valves shall be used instead of manual valves.
6. UGT manual level meter shall be replaced with new and latest models.
7. UGT ultrasonic level transmitter shall be replaced with new and latest models.
8. OHT-1 manual level meter shall be replaced with new and latest models.
9. OHT-1 ultrasonic level transmitter shall be replaced with new and latest models. Afloat switch shall also be provided as a backup if the ultrasonic level transmitter fails.
10. OHT-2 manual level meter shall be replaced with new and latest models.
11. OHT-2 ultrasonic level transmitter shall be replaced with new and latest models. Afloat switch shall also be provided as a backup if the ultrasonic level transmitter fails.
12. The existing chlorination system shall be replaced with an automatic chlorine dosing system, leak detection system and Neutralization Tower / Scrubber Tower. The building shall be enclosed in concrete with a motorized roller shutter door, extract fans, chlorine tonners storage rack, overhead electric travelling crane, emergency eye bath/shower and concrete pit for the Neutralization Tower / Scrubber Tower’s FRP air ducts.

13. Existing PLC system, digital displays and data loggers shall be replaced with SCADA System, PLC with SCADA system hardware and software, SCADA workstation, server and UPS System. The SCADA system shall provide a centralized monitoring and control system overall equipment and operation.
14. Motorized Valves shall be replaced with new and latest models.
15. Local Control Push Buttons shall be replaced with new ones.
16. CCTV System shall be provided.
17. Fire Alarm System shall be provided.
18. Water truck filling station's flow meters shall be integrated with SCADA System.

6.14.2 K.K. Nagar New

1. An inlet pipe shall provide an electromagnetic flow meter, pressure transmitters, pressure gauge, and motorized isolation valve in a valve chamber.
2. An electromagnetic flow meter, pressure transmitters, pressure gauge and motorized isolation valve in a valve chamber shall be provided at the outlet pipe.
3. Pressure gauges shall be replaced with new ones, and pressure switches shall be replaced with pressure transmitters at pump stations 1 & 2.
4. UGT ultrasonic level transmitter shall be replaced with the new and latest model.
5. UGT Manual level meter shall be replaced with the new and latest model.
6. OHT ultrasonic level transmitter shall be replaced with the new and latest model. Afloat switch shall also be provided as a backup if the ultrasonic level transmitter fails.
7. OHT Manual level meter shall be replaced with the new and latest model.
8. The existing chlorination system shall be replaced with an automatic chlorine dosing system, leak detection system and Neutralization Tower / Scrubber Tower. A building shall be enclosed in concrete with a motorized roller shutter door, extract fans, chlorine tonners storage rack, overhead electric travelling crane and emergency eye bath/shower.
9. Existing PLC system, digital displays and data loggers shall be replaced with SCADA System, PLC with SCADA system hardware and software, SCADA workstation, server and UPS System. The SCADA system shall provide a centralized monitoring and control system overall equipment and operation.
10. Motorized Valves shall be replaced with new and latest models.
11. Local Control Push Buttons shall be replaced with new ones.
12. CCTV System shall be provided.
13. Fire Alarm System shall be provided.
14. Water tank filling station's flow meters shall be integrated with SCADA System.

6.14.2.1 Choolaimedu WDS

1. An inlet pipe shall provide an electromagnetic flow meter, pressure transmitters, pressure gauge, and motorized isolation valve in a valve chamber.
2. An electromagnetic flow meter, pressure transmitters, pressure gauge and motorized isolation valve in a valve chamber shall be provided at the outlet pipe.
3. Pressure gauges shall be replaced with new ones, and pressure switches shall be replaced with pressure transmitters at pump stations 1 & 2.
4. UGT ultrasonic level transmitter shall be replaced with the new and latest model.
5. UGT Manual level meter shall be replaced with the new and latest model.
6. The existing chlorination system shall be replaced with an automatic chlorine dosing system, leak detection system and Neutralization Tower / Scrubber Tower. A building shall be enclosed in concrete with a motorized roller shutter door, extract fans, chlorine tonners storage rack, overhead electric travelling crane and emergency eye bath/shower.
7. Existing PLC system, digital displays and data loggers shall be replaced with SCADA System, PLC with SCADA system hardware and software, SCADA workstation, server and UPS System. The SCADA system shall provide a centralized monitoring and control system overall equipment and operation.
8. Motorized Valves shall be replaced with new and latest models.
9. Local Control Push Buttons shall be replaced with new ones.
10. CCTV System shall be provided.
11. Fire Alarm System shall be provided.
12. Filling station's flow meters to be integrated with SCADA System.

6.14.2.2 Southern Headworks WDS

1. An inlet pipe shall provide an electromagnetic flow meter, pressure transmitters, pressure gauge, and motorized isolation valve in a valve chamber.
2. An electromagnetic flow meter, pressure transmitters, pressure gauge and motorized isolation valve in a valve chamber shall be provided at the outlet pipe.
3. Pressure gauges shall be replaced with new ones, and pressure transmitters shall be provided.
4. UGT ultrasonic level transmitter shall be replaced with the new and latest model.
5. UGT Manual level meter shall be replaced with the new and latest model.
6. OHT ultrasonic level transmitter shall be replaced with the new and latest model. If the ultrasonic level transmitter fails, the afloat switch shall also be provided as a backup.
7. OHT Manual level meter shall be replaced with the new and latest model.
8. The existing chlorination system shall be replaced with an automatic chlorine dosing system, leak detection system and Neutralization Tower / Scrubber Tower. A building shall be enclosed in concrete with a motorized

roller shutter door, extract fans, chlorine tonners storage rack, overhead electric travelling crane and emergency eye bath/shower.

9. CCTV System shall be provided.
10. Fire Alarm System shall be provided.
11. Existing PLC system, digital displays and data loggers shall be replaced with SCADA System, PLC with SCADA system hardware and software, SCADA workstation, server and UPS System. The SCADA system shall provide a centralized monitoring and control system overall equipment and operation.
12. Motorized Valves shall be replaced with new and latest models.
13. Local Control Push Buttons shall be replaced with new ones.
14. CCTV System shall be provided.
15. Fire Alarm System shall be provided.
16. Filling station's flow meters to be integrated with SCADA System.

6.14.2.3 Valluvar Kottam WDS

1. An inlet pipe shall provide an electromagnetic flow meter, pressure transmitters, pressure gauge, and motorized isolation valve in a valve chamber.
2. An electromagnetic flow meter, pressure transmitters, pressure gauge and motorized isolation valve in a valve chamber shall be provided at the outlet pipe.
3. A pressure Transmitter shall be provided instead of pressure switches.
4. UGT ultrasonic level transmitter shall be replaced with the new and latest model.
5. UGT Manual level meter shall be replaced with the new and latest model.
6. OHT ultrasonic level transmitter shall be replaced with the new and latest model. If the ultrasonic level transmitter fails, the afloat switch shall also be provided as a backup.
7. The existing chlorination system shall be replaced with an automatic chlorine dosing system, leak detection system and Neutralization Tower / Scrubber Tower. A building shall be enclosed in concrete with a motorized roller shutter door, extract fans, chlorine tonners storage rack, overhead electric travelling crane and emergency eye bath/shower.
8. Existing PLC system, digital displays and data loggers shall be replaced with SCADA System, PLC with SCADA system hardware and software, SCADA workstation, server and UPS System. The SCADA system shall provide a centralized monitoring and control system overall equipment and operation.
9. Motorized Valves shall be replaced with new and latest models.
10. Local Control Push Buttons shall be replaced with new ones.
11. CCTV System shall be provided.
12. Fire Alarm System shall be provided.
13. Water Tank Filling station's flow meters shall be replaced with new one and shall be integrated with the new SCADA System.

6.14.3 Direct Pumping To Water Transmission Line

For Direct Pumping to water transmission line, the DMA Entry Point shall have a throttling valve which is a globe valve attached to a motorized actuator that can vary the opening of the valve as per the flow meter reading and pressure transmitter reading.at the DMA entry point, at the average and critical pressure point and at the farthest DMA point.

Water Quallity Sensors like chlorine analyzer, ph and temperature analyzer and turbidity analyzer are also installed at the DMA Entry Point, at the average and critical pressure point at the DMA and at the farthest DMA point.

Automatic meter reading (AMR) are also installed in the households where in it automatically collects and transfers metering data to a central database for analysis and billing purpose.

All the data or readings coming from the pressure transmitter, flow meter, water quality sensors and automatic meter readers in the households of each DMAs shall be sent to the pump station's SCADA system and to the CMWSSB SCADA system at Chintadripet through the GPRS network communication system.

A username ID and password shall be provided only to authorized personnel to access all the data or readings coming out from all the DMAs to monitor and control the non water revenue.

Zone 10 Typical SCADA/Instrumentation and Control P&ID for Direct Pumping to Water Transmission Line are shown on Drawing No. 701563/PMC400MLD/CP4/IC/002.

Zone 10 WDS Network Communication System are shown on Drawing No. 701563/PMC400MLD/CP4/IC/005.

6.14.4 Existing and Proposed Overhead Tank

For Existing and Proposed Overhead Tanks supplying water by gravity to water transmission lines, a motorized valve shall be installed at the inlet pipe of the overhead tank for isolation purposes which shall close when the OHT water level reaches the maximum level. In addition, a motorized valve along with pressure transmitter, flow meter and water quality sensors like chlorine analyzer, ph and temperature analyzer and turbidity analyzer are installed in a valve chamber within the WDS compound.

In the DMA Entry Point, the valve chamber shall have a throttling valve which is a globe valve attached to a motorized actuator that can vary the opening of the valve as per the flow meter reading and pressure transmitter reading.at the DMA entry point, at the average and critical pressure point and at the farthest DMA point.

Water Quallity Sensors like chlorine analyzer, ph and temperature analyzer and turbidity analyzer are also installed at the DMA Entry Point, at the average and critical pressure point at the DMA and at the farthest DMA point.

Automatic meter reading (AMR) are also installed in the households where in it automatically collects and transfers metering data to a central database for analysis and billing purpose.

All the data or readings coming from the pressure transmitter, flow meter, water quality sensors and automatic meter readers in the households of each DMAs shall be sent to the pump station's SCADA system and to the CMWSSB SCADA system at Chintadripet through the GPRS network communication system.

A username ID and password shall be provided only to authorized personnel to access all the data or readings coming out from all the DMAs to monitor and control the non water revenue.

Zone 10 Typical SCADA/Instrumentation and Control P&ID for Existing and Proposed Over Head Tank to supply water by gravity to water transmission lines are shown on Drawing No. 701563/PMC400MLD/CP4/IC/001.

Zone 10 WDS Network Communication System are shown on Drawing No. 701563/PMC400MLD/CP4/IC/005.

7 CHAPTER 7: BASIS OF COST ESTIMATE

While working on developing a cost estimate for water supply distribution systems, the following aspects should be considered:

- Capital investment costs for supply, install, construction and capacity building are called CAPEX (Capital Expenditures).
- Operational and maintenance costs are required to maintain and keep the systems working efficiently. That is called OPEX (Operational Expenditures).
- Possible sources of funding (Governmental, International aid programs, Donors, Public-Private Partnership PPP, etc.)
- Expected returns on investment (revenues).
- Life Cycle Costing (LCC)
- Cost of energy

Accordingly, a separate report under the title "Cost Estimate for package CP4 Project'' shall be developed to address all the above main aspects pertain financial analysis and cost estimate.

7.1 The basis for Cost Estimate

The cost estimates are prepared based on the schedule of rates published by TWAD Board (2020-21), CMWSSB (2020-21) and PWD (2020-21). Budgetary quotations are also collected for various materials/equipment and works from the reputed suppliers/vendors. The total cost presented here might have some variation at a later stage based on actual Geotechnical investigations and site surveys

The Present cost estimate basis shall be considered:

- The cost estimate shall be a rough estimate of magnitude +/- 10%
- Bills of quantities shall include:
  1- Pipes/fittings materials supply/installation/testing/commissioning/spare parts
  2- Earthworks (excavation/backfilling)
  3- Valves of all types, flowmeters, monitoring devices.
  4- Ancillaries' valves/flow meter chambers
  5- Overhead tanks
  6- Electro-mechanical equipment supply/install
  7- SCADA and instrumentation supply/install.
  8- Environmental Monitoring cost
  9- Social intervention provisional cost
  10- Provision sums for permissions and deposits

11- Physical contingencies

12- Labour welfare fund cost

13- GST@18%

7.2 Earthwork excavation

The unit rate for earthwork excavation considered for trenches in all kinds of soils includes hard stiff clay, black cotton, hard red earth, shales, murals, gravel and Stoney earth, earth mixed with small size boulders and hard gravelly soil, refilling / backfilling of pipeline trenches and foundation, with watering and ramming to consolidation etc. are taken from TWAD Board/ CMWSSB standard schedule of rates for the year 2020-21.

7.3 Concrete and allied works

The concrete work involves providing and laying reinforced cement concrete to construct Over Head Tanks, Ground level service reservoirs, Pumping stations, valve chambers, etc. Formwork and steel reinforcement for RCC work is also included in this section. The unit rates for all the items are considered from CMWSSB/TWAD/ PWD SOR 2020-21

7.4 Pipeline and ancillary works

This work involves providing, laying, jointing, testing, commissioning pipelines of different materials, sizes, valves and specials, bulk flow meter, house service connection, etc. Most of the unit rates are taken from the TWAD Board/ CMWSSB standard rate schedule for 2020-21. The average length of the MDPE pipeline considered for the cost estimate of each House Service Connection is 7m. Road restoration works are considered for the trench width + 200mm.

7.5 Service reservoirs

Construction of OHT/ GLSR/Pumping stations consists of different types of works viz. earthwork excavation below ground level, PCC work, RCC work, Formwork, Plastering, Painting, Piping work etc. The unit rates are taken from PWD, TWAD/ CMWSSB 2020-21 schedule of rates (SOR) and rate analysis.

7.6 Pumps, Motors, Valves and electro-magnetic flow meters, electrical items, instrumentation and DMAs

The items available is TWAD/ CMWSSB/ PWD 2020-21/ AP Building/ KPWD SoR; the same rates have been adopted. For items not available in SOR, budgetary quotations have been collected from the Market, and the lowest of the cost of these vendors was taken for arriving at the cost of the components.

7.7 Other Assumptions and Considerations

- For the costing of civil items, quantities are based on PMC's draft detailed design.
- Anticipating the equipment to be in the warranty period during the commissioning, no R&M cost has been considered.

- Excise duty is taken as zero, in accordance with S.No.233, condition no. 23 of Excise notification no. 12/2012, exempting 'water supply projects producing potable water' from excise duty.
- GST at 18% (compound rate) is considered the final estimated sum.
- In the near future, these old pumps may be replaced or upgraded to feed other areas upon another zone's design finalization. Subsequently, the total electrical requirement for the WDS can be updated.
- Since hydraulic design is carried out based on zones of priority and not as a whole in a holistic approach for the entire Chennai core city, the final designs for WDSs might be updated after completing the hydraulic design of all the seven zones project area. The final cost estimate will be updated accordingly to the terms of requirement of pumping configuration, electrical equipment, switchgear, instrumentation, and other relevant civil works or other implications.
- The Cost Estimate is based on the assumption of replacing the new equipment in the same space as the existing WDS.
- Upgrading of the existing lighting system will be updated after completing the design of all seven zones.
- The minimum lump-sump amount is considered for maintenance and repair with spares of the existing electrical system to run.
- Other WDS where there is no recommendation of a change in pump sizes, no upgrading BOQ or cost estimates are prepared as of today since their revised pumping requirement may be decided at a later stage.
- The cost estimate for Area X is based on the above assumptions and might be updated upon completing the final detailed design.

The "Summary of Total Cost" is given in Table 7.1. Detailed cost estimates are furnished in a separate volume.

Table 7.1: General Abstract of Draft Cost estimate for area X

S. No	Description of Item	Amount in INR Cr.
1	Providing comprehensive water supply scheme to Area-X of core city (A)	519.12
2	Contingencies and Unforeseen items @ 2.5% of (A)	12.98
	Sub-Total (B)	**532.09**
3	GST @ 18%	95.78
4	Provision for Investigation charges @ 0.5% of (A)	2.60

S. No	Description of Item	Amount in INR Cr.
5	Supervision Charges @ 5% of (B)	26.60
6	Labour Welfare cess @ 1% of (A)	5.19
7	Road Restoration charges	293.16
8	Third party inspection charges @ 1% of (A)	5.19
9	TNEB service connection charges @ 0.25% of (A)	1.30
10	Provision for Dewatering arrangements (LS)	0.10
11	Demolition of existing structures @ 0.15% of (A)	0.78
12	Provision for environmental monitoring charges @ 0.1% of (A) (As applicable)	0.52
13	Provision for social intervention charges @ 0.15% of (A) (As applicable)	0.78
14	Shifting of Underground utilities @ 2% of (B)	10.64
15	Prvision for Rehabilitation of existing PH & UGT 0.1% of (A)	0.52
16	Provision for Trenchless Technology (LS)	0.20
17	Provision for pipe carrying bridge (As applicable)	0.00
18	Provision for price escalation for the First year @ 5% of the Base Cost (A)	25.96
19	Provision for price escalation for the Second year @ 5% of 70% of Base Cost (A)	18.17
	Grand Total	**1,019.58**

Note: Provision for price escalation is considered for 2 years only and for project duration more than 2 years then the provision for further years to be considered.

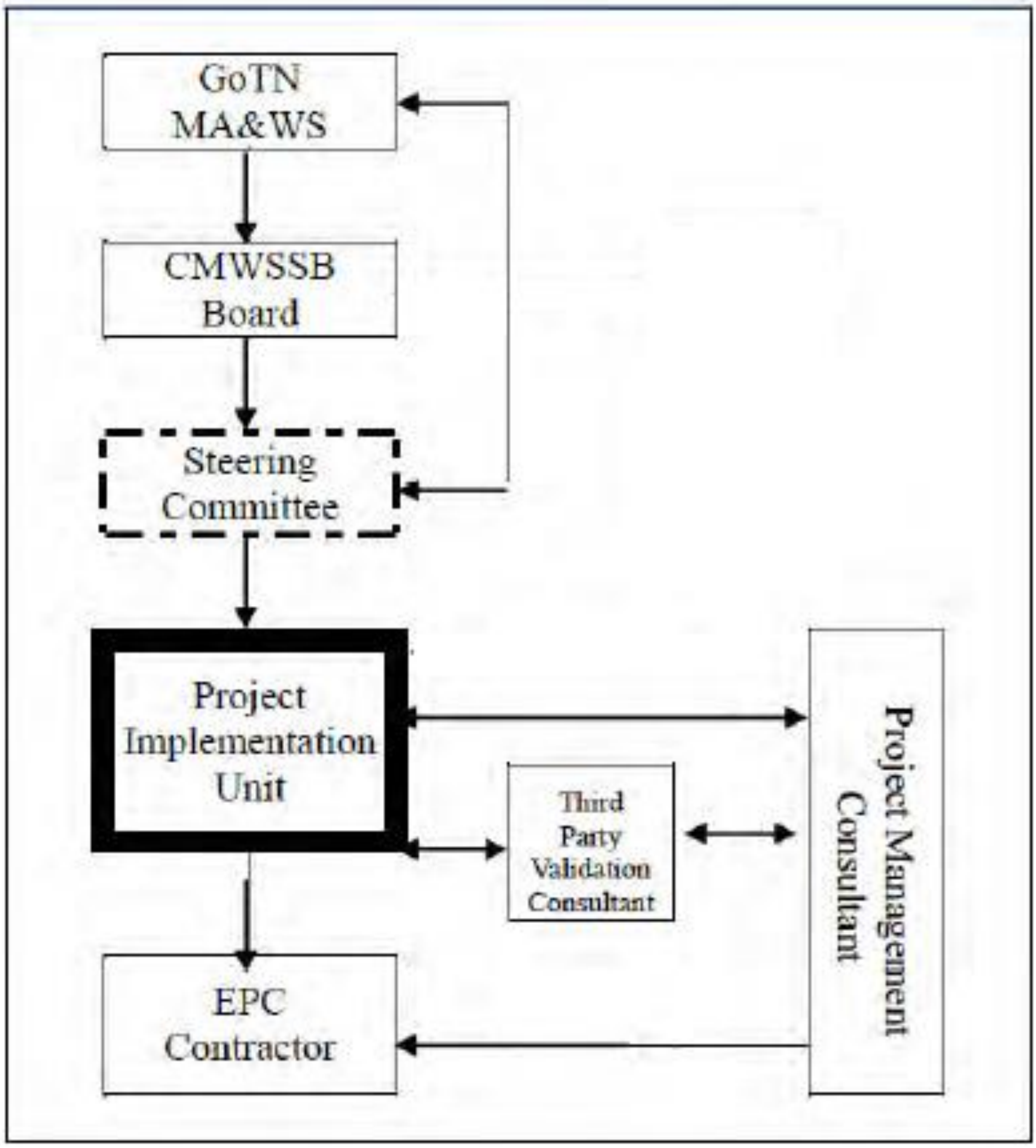
8 CHAPTER 8: PROJECT IMPLEMENTATION PLAN

8.1 Implementation Structure:

The contract package, CP-04 of Perur Desalination Water Plant Project for Improvement of the existing water distribution system shall be executed and implemented with financing from the State Government of Tamil Nadu. Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) is a statutory board of the Government of Tamil Nadu and has the mandate for providing water supply and sewerage treatment for the city of Chennai and areas around it, shall be the Executing Agency (EA) for the project.

A Project Implementation Unit (PIU) headed by a Project Director, of the rank of a Chief Engineer of CMWSSB, is in place for smooth implementation the progress of the work for the Board and the PIU is assisted by a Project Management Consultant (PMC), which is staffed with internationally competent experts in the field of desalination and water supply. A Coordination Committee under the Managing Director, CMWSSB, has been constituted for coordination with the stakeholders within the Government and overall project monitoring progress. Also, a Steering Committee under the chairmanship of the Principal Secretary, MAWS, will provide overall strategic guidance to the project. All these arms will work in tandem to deliver the proposed output for the project.

The process flow diagram is presented in **Error! Reference source not found.**, showing how the relevant parties interact, communicate, and cooperate during the execution process of the implementation plan.



Source: JICA Study Team

Figure 8.1 Implementation Structure Framework

Involvement of Relevant Authorities:Error! Reference source not found. represents the list of relevant authorities involved with the Seawater Desalination Plant Project, Perur and their respective roles, including the estimated processing time for their respective actions.

Table 8.1 Roles of Agencies in Government of Tamil Nadu (Source: JICA Study Team)

Agency	Role
Chennai Metropolitan Water Supply and Sewerage Board, GOTN	• Project Executing Agency
Municipal Administration and Water Supply Department, GOTN	• Issue Government Order (GO) granting Administrative and Financial approval for the project.
Department of Finance, GOTN	• Grant 'Financial approval' for the project. • Sanction Annual Budget, route finances during the project construction phase • Annually monitor, audit and report expenditure to GOTN.
Highways and Minor Ports Department, GOTN	• Grant approval for cutting State Highway and Road to lay Trunk main: part-by-part/section. • Prepare a budget estimate for repair of road and collect charges from CMWSSB: part-by-part/section
Department of Municipalities, GOTN	• Grant permission to cut open the roads and their restoration in areas under their jurisdiction
Department of Town Panchayat, GOTN	• Grant permission to cut open the roads and their restoration in areas under their jurisdiction
Tamil Nadu Road Development Corporation, GOTN	• Grant approval for cutting roads falling under their jurisdiction for laying part of Trunk main. • Prepare a budget estimate for repair of road and collect charges from CMWSSB
Public Works Department, GOTN	• Grant approval for construction and laying of Trunk main across water bodies (rivers, streams, lakes).
Chennai City Police Commissioner (Traffic)	• Grant 'In principle' approval for 'Traffic Management Plan' for constructing and laying of Trunk main through city streets • Position Traffic Controllers on Trunk main route to marshal vehicular traffic: part-by-part/section

Agency	Role
Department of Telecommunication, GOTN	• Grant approval for shifting of optic fibre telephone cables as & when required
Tamil Nadu Industrial Explosives Limited, GOTN	• Grant approval for the purchase and use of explosive (gelatine) to blast rocks for laying part of Trunk main
Ministry of Road Transport & Highways - NHAI, GoI	• Grant approval for cutting of road falling under their jurisdiction for laying part of Trunk main; part-by-part/location
Ministry of Railways - Southern Railways, GoI	• Grant approval for laying/constructing part of Trunk main under the rail line; part-by-part/location.

8.2 Financial Plan:

The project's cost, including all the taxes, contingencies, and the provisional sum, is 1019.58 cr. The CP-04 component of this project will be implemented through the fund from the Government of Tamil Nadu or external funding agency.

8.3 Procurement Plan

Generally, for all the projects under National Competitive Bidding (NCB) Process, CMWSSB applies a prescribed procurement process as stipulated by The Tamil Nadu Transparency in Tender Act (1998) and The Tamil Nadu Transparency in Tenders Rules (2000). The procedure and documents prescribed by the funding agency are utilised for externally funded projects.

The procurement method for the contractor procurement for the CP04 component would be item rate type employing a Single-Stage Two-Envelopes Bidding procedure wherein the bidders' technical capability, and the financial standing will be evaluated simultaneously. The bidders quoting the lowest price for the project will be awarded.

8.4 Construction Plan

Items	Duration (Months)	
Preparatory Work	1	**Mobilization, permits, settlement etc.**

Excavation	**16**	**Narrow roads require defined precautions**
Installation of Pipes	**10**	**Bedding, partial/full backfilling, testing**
Cleaning, swabbing, flushing, scraping of the existing pipes	**5**	**Before integrating with the new proposed pipes, existing pipes must have extensive cleaning, scraping, flushing, swabbing, and disinfection process.**
Commissioning	**4**	**Performance testing and putting into operation before handing over to the client.**

9 CHAPTER 9: OPERATION & MAINTENANCE

9.1 GENERAL

The success of any project depends on how the operation and maintenance of the system are planned to ensure that the project objective is achieved throughout its life span. An efficient operation and maintenance are needed to maintain the water supply system to provide safe drinking water to all the consumers with adequate quantity and quality with sufficient pressure at a convenient location and time and as economically as possible on a sustainable basis.

The operation refers to the timely and daily operation of the various components of the water supply system, including service reservoirs, pumps, DMA meters, pressure transmitters, control valves etc., effectively by various technical and skilled personnel. It is essential to ensure that a 24X7 water supply is provided and that all the equipment transmits the data to the central SCADA system.

Maintenance is defined as the art of keeping the structures, plants, machinery and equipment and other facilities in optimum working order. Maintenance includes preventive or corrective maintenance, mechanical adjustments, repairs, corrective action and planned maintenance. However, replacements, correction of defects etc., are considered as actions excluded from preventive maintenance. The O&M Manual is required to encompass various issues pertaining to an effective O&M such as technical, managerial, administrative, HRD, financial & social aspects etc.

This chapter addresses the O & M of the water supply distribution system by improving the distribution system and strengthening storage facilities in Chennai core city.

9.2 EXISTING O & M SYSTEM

Presently the O & M staff of the Area/Depot Offices of CMWSSB are maintaining the water supply distribution system within that particular Area. The existing network/layouts drawings are important for better O & M of the system. But unfortunately, in most of the locations, the latest existing distribution network drawings are not available. The record of extension of new distribution mains with all appurtenances and accessories and service connections shall also be updated to maintain the system efficiently. In the absence of such necessary information and procedure, it becomes very difficult to operate the system, and a problem arises for the consumers. Moreover, regular training is required to train the O & M staff to manage the problems in the distribution system.

9.3 STRATEGY OF EFFICIENT OPERATION AND MAINTENANCE (O & M)

The minimum requirements for good operation and maintenance are:

(a) Preparation of a plan for operation and maintenance

(b) Providing required personnel to operate and maintain the system

(c) Providing Capacity building programmes for the O&M personnel

(d) Availability of spares and tools for ensuring maintenance

(e) Preparation of GIS-based maps for distribution system

(f) Preparation of a water audit and leakage control plan

(g) Maintaining MIS records on the system, including the history of the equipment, costs, life etc.

(h) Action Plan for an energy audit for saving on energy

(i) Establishing a sound financial management system.

9.4 PROPOSED O & M PLAN FOR WATER SUPPLY DISTRIBUTION SYSTEM

9.4.1 OPERATION PLAN

The following plans shall be adopted for the efficient operation of the water supply distribution system.

I) MAPPING AND INVENTORY OF PIPES AND FITTINGS IN DISTRIBUTION SYSTEM

The first requirement for the preparation of the operation schedule is the availability of updated distribution system maps with contours, valves, flow meters and pressure gauges or taping points. CMWSSB should set up routine procedures for preparing and updating the maps and inventory of pipes, valves, flow meters and consumer connections. The activities involved in mapping are:

- Maintain distribution network maps, i.e. layout plan of distribution system with the representation of pipes, valves, flow meters, connections etc. and easy access to O & M staff.
- Establishment of procedures for storage and retrieval & updation of maps and inventory information.
- Setting up procedures for collecting map information in the field, including verifying the as-built drawings with the design.
- Setting up procedures for updating maps when any changes are made in the distribution system.

II) ROUTINE OPERATION OF DISTRIBUTION SYSTEM

The efficiency and effectiveness of a water supply system depend on the operating personnel's knowledge of the variables that affect the continuity, reliability, and quantity of water supplied to consumers. The operational staff should be able to carry out changes in the hydraulic status of the system as required depending on those variables promptly and effectively. Routine operations shall be specified, which are activities for adjusting the valves and operation of pumps to match the prevailing conditions (flows, pressures, levels and operation of pumps). Valve and pump operations will have to be controlled as per schedule. The schedule shall contain procedures for operating the distribution system. It should contain procedures to obtain, process, and analyze the variables related to water flows, pressures and levels, and the consequences of manipulating control devices, such as valves and or pumps, so that the hydraulic status of the system can match the water demand. When operators change their shifts, information on valve closure and opening must be exchanged.

III) MEASUREMENT OF FLOW, PRESSURE AND LEVEL

It is necessary to monitor regularly operational data concerning flows, pressures and levels to assess whether the system is functioning as per requirements. Data analysis may explore over supply and under supply water to some reservoirs and consumers. Appropriate flow control devices may be introduced to limit the supplies to the required quantity. A list of priority points in the water supply system has to be identified, such as installing meters to measure flows, pressures, and levels. A detailed map showing the location for each measuring point also has to be prepared. The degree of sophistication of the devices used at each measuring point concerning indication, integration, recording, transmission and reception of data depends mainly on the skills of the O&M personnel available with the CMWSSB and affordability of the agency. All the inlets and outlets of OHTs are provided with EMF meters that transmit the real-time flow and pressure data to the central SCADA system. In addition, a level indicator is fixed in all the OHTs to monitor the water level in the tanks.

IV) CHECKING OF DRINKING WATER QUALITY

Ensuring the supply of the desired water quality to the consumer is a vital responsibility of CMWSSB. To achieve the quality, it is necessary that the physical, chemical and bacteriological tests are to be carried out at frequent intervals. The minimum number of samples to be collected from the distribution system should be as prescribed in CPHEEO Manual on “Water Supply & Treatment”. Samples should be taken at different points on each occasion to enable overall assessment. More frequent sampling may be required in an epidemic or danger of pollution, especially for bacteriological quality. For each distribution system, a monitoring programme has to be prepared showing the location of sampling points. Based on historic records of a system, it will be possible to decide locations for bacteriological sampling and residual chlorine testing.

9.4.2 PREVENTIVE MAINTENANCE

The Preventive Maintenance of a water supply distribution system includes the following tasks viz. set priorities, issue of work orders for tasks to be performed, list of scheduled tasks not completed, a record of when the tasks are completed and maintaining a record of tools, materials, labour and costs required to complete each task. Preventive maintenance may increase the initial cost to the CMWSSB marginally. Still, it will increase the sustainability of the water distribution system, which in turn will assure regular and uninterrupted water supply to consumers. The following points shall be considered for the preventive maintenance of the city's water distribution system.

- **Inspect the distribution system for trouble-free operation and optimum performance, inspection and periodical servicing of pumps, valves, public taps, flow meters and pressure gauges, etc**. Corrosion and leakage of valves are the main problems in the distribution system, and the same can be prevented by using good quality material. Preventive measures against corrosion shall be performed.

- **The manufacturer's catalogues** shall be referred, and comprehensive servicing procedures shall be prepared for periodical servicing. These procedures shall contain the manufacturer's name, address, telephone number etc. and the technical information furnished by the manufacturer of the equipment used in the distribution system, such as sluice valves, air valves, pressure gauges, flow meters etc. The test certificates, inspection reports and warranty certificates of this equipment shall also be kept along with the manual.

- **A list of spares** required for the distribution system shall be prepared, and the same shall be procured and kept for use. The list should indicate the minimum level at which replenishments should be initiated. The list of probable spares to be kept in stock may include the following:

Spare check nuts and spindle rods and bolts, nuts and washers for the flanged joints, gaskets for flanged joints for all sizes of sluice valves installed in the distribution system and consumables like the gland rope, grease, cotton waste, spun yarn etc.

- **The necessary tools** to properly repair and correct the routine problems and facilitate repairs and replacements in a distribution system must be identified and provided to the maintenance staff. Some of the tools for the maintenance work in a distribution system are: Key rods for the operation of all sluice valves, hooks for lifting manhole covers, pipe wrench of appropriate sizes, Screw Drivers, Pliers, Hammers, Chisels, caulking tools for lead and spun yarn, excavation tools such as crow bars, spades, iron baskets, buckets, pipe cutting machine, de-watering pumps, leak detectors, lighting sets etc.

- **Maintenance** of pipeline valves chambers to ensure all pipelines, valves and other appurtenances are working properly. Covers of valve chambers are stolen or broken up by vandalism or by accident resulting in damage to the valves or the accidental fall of a person into the open valve chamber. Such situations must be corrected on priority.

- **A leak detection programme** shall be performed to reduce UFW.

- **An emergency work team** shall be formed in the CMWSSB to attend an emergency call from the consumers.

- **Proper training** on distribution system maintenance shall be conducted for the CMWSSB staff.

9.4.3 Maintenance of Valves & Appurtenances

The purpose of installing valves and appurtenances in the distribution system is to control water supply, protect pipelines and assist with periodical cleaning and servicing. The pipe appurtenances in the distribution system are described below.

9.4.3.1 Sluice Valves for Isolation

Sluice valves are installed in the distribution main to control and regulate water supply and shall be provided at regular intervals. The following defects are normally observed on the sluice valves.

- Gland leaks can be rectified by replacing the hemp packing at specified intervals or visual observation.
- Spindle damage: Unequal application of pressure damages the spindle, which training valve operators can avoid operating the valve according to manufacturer recommendations on tightening pressure. It is necessary to have spare spindles for the full range to ensure replacement in the shortest possible time frame.
- Partial valve closure: Debris accumulated in the valve seat and around spindle heads causes this problem and can be removed by opening the top cover of the sluice valves. Round out of spindle heads are a direct consequence of wear and tear, and this can be reduced by using specially prepared caps.

The sluice valve shall be provided with a name plate near the edge of the footpath where details of sluice valves with location, size, and opening direction shall be specified. This will reduce the complaint regarding sluice valves getting buried during road construction and trench backfill. Wherever possible, sluice valves shall be installed along pavements. Sluice valves in roads where extreme traffic shall be provided with heavy-duty CI or pre-cast concrete cover slabs to avoid accidental damage.

9.4.3.2 Scour Valves

Scour valves are provided at the low points at the bottom of pipelines and operated to drain the water mains during maintenance completely. This is also a kind of sluice valve used for scouring purposes. Inspection and maintenance of these valves shall be required to ensure they are working properly and there is no mixing of sewerage or polluted water in the drinking water main.

9.4.3.3 Air Valves

Air valves are installed in the pipeline at the peak points for the entry and release of air automatically when emptying and filling the pipeline, respectively.

When a pipeline is filled with water, air could be entrapped at peaks along with the pipeline profile, increasing head losses and reducing pipeline capacity. It is also not desirable to have air pockets in the pipeline as they may cause water hammers, damaging the pipeline. Regular inspection and maintenance of all the air valves shall ensure proper working to maintain the pipeline's safety.

9.4.4 Maintenance of Service Reservoir/OHT

The maintenance of the service reservoir shall cover every component used in the service reservoir, viz. valves, flow meters etc. The following maintenance aspects shall be adopted to ensure efficient use of the Service Reservoir.

- **Valves**: All valves shall be inspected and operated regularly. Also, ensure that they are in good working conditions.
- **Flow Measurement**: The inlet and outlet flows shall be measured to ensure equal supply and discharge. The flow meter should be inspected regularly to ensure that the meter is functioning properly.
- **Level Indicator**: Inspection shall be made to check the water level indicators are in working condition.
- **Structural Damage**: All structural damages and leakage through the structures shall be checked, and if there is any damage or leakage, it should be promptly repaired.
- **Contamination:** Manhole openings, ventilation shafts and pipes shall be adequately protected and checked periodically to prevent contaminant infiltration.
- **Cleaning of Reservoir**: Routine reservoir inspection for cleaning and disinfection shall be carried out. A visual inspection can be made from the roof manhole with the water level lowered to about half full or less. Alternatively, a detailed inspection can be made after draining the tank and then cleaning or washing. The best time of the year to clean the service reservoir is during the period of lowest water consumption.

The following activities are normally involved in the cleaning of an overhead tank or service reservoir:

(a) Make alternate arrangements for water supply to consumers served by the SR.

(b) Close the inlet line before commencing cleaning of SR.

(c) Draw the water from the SR until 200-300 mm water is left.

(d) Close the outlet valve so that no water will be used while the tank is cleaned.

(e) Collect a sample of water and silt/mud accumulated in the Tank and get the biological analysis and snails and worms' presence. If snails and worms are found, find the source and eliminate it.

(f) Drain and dispose of the remaining water and silt.

(g) Wash the interior of tank walls and floor with a water hose and brushes.

(h) Inspect the interior of the walls and ceiling of the tank for signs of peeling off or deterioration.

(i) Apply disinfectant (Supernatant of Bleaching powder) to the walls and floor before the start of filling the tank/SR.

- **Cleanliness:** General cleanliness in and around the Service Reservoir should be maintained, and a garden around the Service Reservoir structure can be provided for aesthetic reasons.

- **Safety:** Appropriate safety measures to prevent the entry of unauthorised persons shall be provided. All guide and hand railings shall be maintained safely and infirm condition.

9.4.5 Maintenance of Pumps and Motors

Operation and Maintenance of Pumping Machinery:

Operation and Maintenance of Pumping machinery are subjected to wear & tear, erosion, and corrosion due to its nature of functioning, and therefore it is vulnerable to failures. Generally, failures or interruptions are mostly attributed to pumping machinery rather than any other component. Therefore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery. Sudden failures can be avoided by timely inspection, follow-up actions on inspection observations, and planned periodical maintenance. Downtime can be reduced by maintaining an inventory of fast-moving spare parts. Due attention needs to be paid to all such aspects for efficient and reliable functioning of pumping machinery

Operation of the Pump sets

The following points should be observed while operating the pumps.

A. Dry running of the pumps should be avoided.

B. Centrifugal pumps, if installed with negative suction, should be primed before starting.

C. Pumps should be operated only within the recommended range of the head-discharge characteristics of the pump. • If the pump is operated at a point away from the duty point, the pump efficiency normally reduces. • Operation near the shut-off point should be avoided. It causes substantial recirculation within the pump, resulting in overheating sewage in the casing and, consequently, overheating the pump.

D. As far as possible positive suction is to be provided to avoid priming during design itself.

E. Voltage during operation of the pump-motor set should be within ±10 % of the rated voltage. Similarly, the current should be below the rated current shown on the motor's name plate.

F. When parallel pumps are to be operated, the pumps should be started and stopped with a time lag between two pumps to restrict change of flow velocity to a minimum and restrict the dip in voltage in the incoming feeder and should be adequate to allow the pump head to stabilise.

G. When the pumps are to be operated in series, they should be started and stopped sequentially, but with a minimum time lag. Any pump next in the sequence should be started immediately after the delivery valve of the previous pump is even partly opened. Due care should be taken to keep open the air vent of the pump next in sequence before starting that pump.

H. The stuffing box should allow a drip of leakage to ensure that no air passes into the pump and that the packing gets adequate wetness for cooling and lubrication. When the stuffing box is sealed with grease, an adequate refill of the grease should be maintained.

I. The running of duty pumps and standby pumps should be scheduled so that no pump remains idle for a long period and all pumps are in ready-to-run condition. Similarly, the running schedules should be ensured that all pumps do not wear equally, needing a simultaneous overhaul.

J. If any undue vibration or noise is noticed, the pump should be stopped immediately, and the cause for vibration or noise should be checked and rectified.

K. Generally, the number of starts per hour shall not exceed four. Frequent starting and stopping should be avoided as each start causes overloading of motor, starter, contactor and contacts. Although overloading lasts only for a few seconds, it reduces the life of the equipment.

Undesirable Operations:

The following undesirable operations should be avoided:

A. Operation at higher head: A pump should never be operated at a **head** higher than the maximum recommended head; otherwise, such operation may result in excessive recirculation in the pump and overheating of the sewage and the pump. Efficiency at a higher head is normally low, and such an operation is also inefficient. Another problem that arises if a pump is operated at a head higher than the recommended maximum head is that the radial reaction on the pump shaft increases, causing excessive unbalanced forces on the shaft, which may cause the failure of the pump shaft. Appropriate marking should be made on the pressure gauge as a useful guide.

B. Operation at lower head: If a pump is operated at a lower head than the recommended minimum head, the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft, which may cause premature wear of bearings and possibly shaft failure if persisted. Efficiency at a lower head is normally low; hence such an operation is inefficient. In such cases, it is advisable to throttle the delivery side valve to create more heads to work within a safe head. This will also reduce the power. If this is a design flaw additional head has to be created at the tail end by elevating the delivery. However, these are not energy-efficient solutions: change of impeller to suit the actual head is the solution. Appropriate marking should be made on both pressure gauge and ammeter as a useful guide.

C.Operation on the higher suction lift: If a pump is operated on a suction lift higher than the permissible value, pressures at the eye of the impeller and the suction side fall below vapour pressure. This results in the flashing of water into vapour. These vapour bubbles collapse during the passage, resulting in cavitation in the pump, causing pitting on the suction side of the impeller and casing and excessive vibrations. In addition to mechanical damage due to pitting, pump discharge also reduces drastically.

D. Operation of the pump with low submergence: Minimum submergence above the bell-mouth or foot-valve is necessary to prevent air entry into the pump's suction, which gives rise to the vortex phenomenon, causing excessive vibration overloading bearings, reduction in discharge and efficiency. The lowest permissible sewage level should be marked as a useful guide on the water level indicator. Usually, the pump manufacturer indicates the minimum height of submergence. In the case of submersible pumps, the minimum depth is needed to ensure the motor's cooling while running.

E. Operation with the occurrence of vortices: If vibration continues even after taking all precautions, a vortex may be the cause. Vortex should be stopped by using anti-vortex fittings

Table 9.1: Typical main check-up activities - Mechanical

Activity	**Frequency**
General - Mechanical	
Analysis of operating parameters (pumps, blowers, rotating machines etc.)	Daily
Analysis of operating incidents and rapid correction to ensure uninterrupted operations.	Daily
Read out elapsed time meters of rotating machinery	Daily
Consumption of various consumables	Daily
Lockout and restoration of Equipment under maintenance	Daily
Monitoring, follow-up, and adjustment of automated control devices.	Daily
Monitoring of temperature (Bearings, delivers etc.)	Daily
Inspection of No. of starts of Equipment and delivers	Daily
Check for leakages in the pipeline, delivers and water retaining structures	Daily
Logbook recording of details of the Plant	Daily
Specific - Mechanical	
Check for abnormal Noise	Daily
Check for Motor/Drive/Engine temperature	Daily
Check for operating pressure	Daily
Check for abnormal vibration	Daily
Lubrication: - Checking of Levels and top-up oil - Manual Greasing - Change Oil (Compressors, gears, pumps) - Lubricate IC Engines	Weekly Weekly Based on running time
Checking of functioning of valves, gates	Weekly
Check the functioning of moving parts of all Equipment.	Weekly
Tightening of Belts and repack stuffing boxes	Monthly

Checking alignment of couplings, pulleys, shaft sets, shear pins, torque limiters, etc.	Monthly
Service and replace wear parts (bearings, belts, impellers etc.)	Monthly
Remove air service screens and accessories	Monthly
Test and, if necessary, remove or service valves and sluice gates and their control devices.	Monthly
Check water/air tightness of Equipment	Monthly
Dust off Mechanical Equipment.	Monthly
Check for Vibrations with vibration damping	3 months
Calibrate the motor speed	3 months
Adjust play, deliver impeller couplings etc.	6 months
Service and replace wear parts of delivers, compressors, blowers, pumps, etc.	6 months
Test and service air compressor sets	Yearly
Technical inspection of pressurized tanks by an approved body	Yearly
Dust of ventilation outlets and ducts	Yearly
Attending breakdowns	As and when it occurs
Preparation of list of spares for satisfactory operation	Half-yearly
IR and PI values of motors	Monthly
Condition of silica gel in breather and replacement (if required)	Monthly
Replacement of bearings	Within a day of breakdown
Transformer oil sample checking	Half-yearly
Inspect switchboard, cable box, etc.(i.e. visual inspection, tightness of nuts and bolts, IR values, earthing contacts, checking the tightness of terminal block, etc.)	Halt-yearly
Measurement of earth resistance	Yearly
Checking of relays/ alarm (through secondary injection)	Yearly
Condition of gasket and replacement (if required)	Yearly

a) Typical tasks for plant operation

1) Operate water pumping equipment, machinery, and pipeline, including valves, gate, stop-logs, pumps, surge protection system, reading water meter; regulate the water flow through the water system.
2) Emergency operation and troubleshooting procedure.
3) Adding specified amounts of chorine solution to the water system, if necessary, during an emergency:
4) Making minor repairs and adjustments to machinery, equipment, pipes and other materials pertinent to the operation of the plant.
5) Upkeeping maintenance and operational records.

6) Cleaning of Pumping machinery and equipment and structural tanks, inside and outside of the building, unloads and stores properly.
7) Doing general maintenance of the plant, including, but not limited to, painting, general custodial work, maintenance of equipment, etc.;
8) Assistance in repairing water meter and pipeline including valves, vessels, the compressor in inactive time.
9) And shall assist in inspecting all necessary equipment, water sampling & of the pipeline, or new ones as they are installed.

b) Detail of typical tasks

i) Operation and maintenance of all the water Pumping facilities from the inlet valve to clear water reservoir, pumps, Motors, Electrical System, anti-Surge system, Safety and protection system complete.

ii) Providing required manpower for routine operation of centrifugal pump house, GLRs, compressor room, HV/LV switchgear room, Outdoor Substations and Control rooms, PLC control, all motors and valves in the system, and Electrical substations.

iii) Maintaining the PLC, including the hardware, software and all instruments, in good working condition. The downtime of the entire control system shall not exceed 2 hours. During the downtime, the Contractor shall continue to operate the water pumping station in manual mode using the local panel controls and the readings from local instruments.

iv) Per the manufacturer's recommendations, routine and periodic maintenance of the entire control system and instruments.

v) Replacement of damaged controls, communication cables and power supply cables.

vi) Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, online pH meters, other instruments, along with all other equipment. The downtime of any individual instrument as referred above shall not exceed 24 hours.

vii) Periodic site calibration of all measuring/metering equipment or as recommended by the manufacturer. The calibration at the manufacturer's works shall be done only in case of major failure/ repairs of the instruments.

viii) The local SCADA system prepares and submits daily and monthly customized reports.

ix) Provision and maintenance of all consumables for printing without additional costs to the Employer.

x) Weekly lubrication of all gears of reduction motors, motorized valves, gates, and other system parts.

xi) Periodic operating and checking of all valves and gates for manual and electric operation. The operation of valves must be checked from the local control console, switchgear and through the PLC system. Any defect observed must be made good.

xii) Operation and maintenance of all circuits and buildings associated with the treatment works.

xiii) Breakdown maintenance of all electrical, mechanical and instrumentation equipment.

xiv) Routine monitoring of substation equipment and taking preventive measures (as required)

xv) Routine operation & maintenance works of the lighting system.

xvi) Routine maintenance works of earthing system.

xvii) Re-painting the exposed mild steel components of pipeline, ladders, railings, Electro-Mechanical Equipment etc., in the Plant in the 3rd, 5th and 7th year of O&M to keep them in good shape.

xviii) Maintaining the surrounding areas of the Pumping station free from shrubs, weeds, grass, and other unwanted vegetation.

xix) Annual cleaning and disinfection of the clear water reservoir. The raw water shall be used for watering plants and washing.

xx) Providing safety accessories, e.g., gloves, shoes, first aid box, etc.

xxi) Ensuring proper functioning of fire and safety equipment.

9.4.6 MAINTENANCE OF ELECTRICAL EQUIPMENT

General Routine Maintenance

General routine preventive maintenance schedule for various electrical equipment shall be adopted from O&M Manual. However, the general routine maintenance to be carried out by the Contractor's personnel will include but not limited to the following:

i) If it is observed that power consumption per MLD of water pumped is increased, the contractor must trace out the fault and rectify the same to bring to the standard Value.

ii) De-weeding and cleaning of the Transformer yard and other places.

iii) Drying and refilling of silica gel in the breather of the transformer

iv) Regular watering on the earth- pits.

v) Check for any oil leak in the transformer and inform and repair the same.

vi) Air blowing/ cooling of motors, H.T. & L.T. panels etc.

vii) Check for any loose connections in all electrical equipment, switchboards, and rectification of the same.

viii) General cleaning of all equipment and building.

ix) Checking and replacing bulbs, tubes, chokes, starters, switches, control etc., throughout the plant, including street and head lights.

Preventive Maintenance Checks

The contractor shall adopt a preventive maintenance check's schedule as per the original equipment manufacturer O & M schedule under intimation to the Employer. The preventive maintenance checks and their tasks frequencies will not be limited to the following:

Checks to be performed daily:

a) Vibration in the pump-motor sets, moving assemblies etc.

b) Tightness

c) Check the condition of oil & grease & replace if necessary

d) Rise in temperature of motor bearings, moving parts and other units, etc.

e) Working of gauges and other measuring devices.

f) Observations on water quality.

Checks to be performed weekly:

a) Tightness of all electrical connections
b) Tightness of all cable connections
c) Temperature rises due to loose connections
d) Watering of earthling pits
e) Current and voltages in all electrical equipment.

Checks to be performed monthly:

a) Wear and tear of moving parts.
b) Adoption of electrical energy conservation consumption methods.
c) Electrical contacts
d) Motors
e) Metering of electrical equipment

Checks to be Performed Quarterly:

a) Relay testing and calibration, if possible, of MFMs
b) Speed of motors

Checks to be performed bi- annually:

a) Cleaning, checking/ tightening of HT and LT circuit/ panel
b) Tightening of PMCC
c) Auxiliary DB, Capacitor bank
d) Battery and Battery charger

Checks to be performed annually:

a) Overhauling requirement of all equipment
b) Improvement required, if any, in the operation of the plant
d) 11 kV and 3.3 kV VCB cleaning and testing.
e) Transformer cleaning, checking silica gel, oil checking filtering/ replacing.

Minor Electrical Repair Generally Encountered in the WDS

a) For H.T. Installations (Outdoor Switchyard)

i. Replacement of jumpers
ii. Replacement of insulator (Porcelain or other)
iii. Replacement of Air-Break Switch

b) For Both H.T. & L.T. Installations

i. Replacement of no-volt coil for VCB

ii. Replacement of Cable lugs, including terminations
iii. Replacement of burnt out HRC fuses
iv. Replacement of moving and fixed contacts or contractors
v. Repairs to isolators and switch fuse units and replace it and fuse base units.

The typical brief activities and checks for Electrical equipment are enlisted in the below table:

Table 9.2: Typical Electrical Items & Maintenance Requirements:

Equipment	Daily	Periodic	
	Description	Frequency	Description
Transformers	▪ Verification of kVA, V, A, ▪ Abnormal sound, current protection, oil temperature, winding temperature.	Every Six Months	▪ Verification of general performance ▪ Verification of oil levels, silica gel in breather, OLTC, OTI, WTI, Buchholz relay, CTs etc., ▪ Testing of oil, verification of earth connections, IR measurement.
11 kV Switchboard and Switchgears	▪ Verification of kVA, kW, kWh, V, A, PF, Hz, ▪ The healthiness of protections, indications. ▪ Alarms, abnormal sound, heating or burning. ▪ Smell.	Every Six Months	▪ Verification of condition of breakers, switches, relays, protective devices, earthing, wiring and connections.
3.3 kV Switchboard and Switchgears	▪ Verification of kVA, kW, kWh, V, A, PF, Hz. ▪ Healthiness of protections, indications. ▪ Alarms, abnormal sound, heating or burning. ▪ Smell.	Every Six Months	▪ Verification of condition of breakers, switches, relays, protective devices, earthing, wiring and connections.
PCC/ PMCC/ MCCs/ MLDB	▪ Verification of V, A, the healthiness of protections, lamps, abnormal sound, burning smell		▪ Verification of condition of breakers, switches, pushbuttons, relays, protective devices, earthing, wiring and connections
Soft Starters/ SD Starters/ DOL Starters	▪ Verification of Input & output voltage, current, frequency. ▪ Verification of Indications, alarms & protections.	Every Six Months	▪ Verification of condition of breakers, switches, pushbuttons, relays, protective devices, earthing, wiring and connections.

Equipment	Daily	Periodic	
	Description	Frequency	Description
			▪ Verification of working of FCMA Module, Contactors, Timers, Contacts, Electronic module etc.
Variable Frequency Drives	▪ Verification of Input & output voltage, current, frequency. ▪ Verification of Indications, alarms & protections.	Every Six Months	▪ Verification of condition of breakers, switches, pushbuttons, relays, protective devices, earthing, wiring and connections. ▪ Verification of working of converter, inverter, DC Link. ▪ Verification of Harmonic Distortion.
Lighting panels	▪ Verification of lamps, abnormal sound, burning smell.	Every Six Months	▪ Verification of condition of breakers, switches, earthing, wiring and connections.
Meters reading	▪ Verification of V, Am, overload protection	Every Six Months	▪ Verification of overload protection indication, switch On/ Off, accuracy, damage.
Diesel Generator Set	▪ Verification of Engine oil level, Engine oil leakage, air & oil filters, cooling fans, fuel level, water level etc. ▪ Verification of battery voltage charging & self-start. ▪ Verification of abnormal sound, vibrations etc. ▪ Verification of Voltage, current, frequency, RPM, Indications, Alarms & Protections. ▪ Verification of Oil leakage, fuel leakage. ▪ Verification of Interconnecting Cable, earthing, loose connections etc.	Every 250 hours/ Six Months	▪ Verification of Conditions of filters. ▪ Verification of Condition of the cooling fan. ▪ Verification of Condition of battery & charger. ▪ Verification of self-start system ▪ Verification of engine condition, alternator & accessories, doors of the acoustic enclosure, exhaust system etc. ▪ Verification of conditions of Breakers, Switches, Push Buttons, Relays etc. ▪ Verification of Auto / Manual operation, all interlocks, synchronizing. ▪ Verification of Indications, Alarms & Protections. ▪ Verification of Condition of Interconnecting Cables, Connection & earthing, including

Equipment	Daily	Periodic	
	Description	Frequency	Description
			Neutral Earthing of AC Generator.
Cable system	▪ Verification of short circuit, burning smell, loose connections, local heating.	Every Six Months	▪ Verification of voltage drop, damage, insulation resistance
Lighting Fixtures	▪ Verification of working of lamps & ballasts.	Every Six Months	▪ Verification of illumination level ▪ Verification of condition of lamps & ballasts. ▪ Cleaning of lighting fixtures. ▪ Verification of wiring.
Switch board	▪ Verification of operation of switches, sockets.	Every Six Months	▪ Verification of condition of switches, sockets & fan regulators. ▪ Verification of wiring.
Switch Socket	▪ Verification of operation of Switch & Socket.	Every Six Months	▪ Verification of condition of Switch & Sockets
Ceiling Fan	▪ Verification of operation of Fan.	Every Six Months	▪ Verification of condition of a ceiling fan. ▪ Verification of condition of bearing, abnormal sound /noise.
Power sockets	▪ Verification of operation of MCB, Plug & Socket.	Every Six Months	▪ Verification of condition of MCB, Socket & Wiring.
General	▪ Inspection of General appearance of various Electrical equipment /items. ▪ Verification of Cable System for Short circuit, smell, damage etc.	Every Six Months	▪ Verification of condition of cables, wires& connections. ▪ Verification of Insulation resistance of individual equipment, cables and total system. ▪ Verification of Condition of Earth Connections.

Electrical System Operation Practices

All the electrical equipment shall be handled and operated by trained and authorized personnel only. All the equipment shall be checked for its proper earthing and loose connections before starting the equipment. Naked wire, loose connections and faulty connections shall be repaired immediately before the operation. Electrical sockets and switch shall not be touched by bare or wet hands. If there is any live wire found naked or on wet ground, the main switch shall be turned off first then the wire shall be repaired or moved. For any electrical works proper, insulated tools shall be used. Do not use tools made for other purposes; it may be hazardous.

9.4.7 Maintenance of SCADA

General Maintenance

A comprehensive maintenance program is critical to attaining long-term reliable performance of SCADA systems. Periodic device calibration, preventive maintenance and testing allow potential problems to be identified before they can cause mission failure. Prompt corrective maintenance assures reliability by minimizing downtime of redundant components.

Preventive Maintenance

The SCADA system should be part of the overall preventive maintenance (PM) program for the Pump Stations and their Distribution Networks. Table 9.3 lists recommended maintenance activities and frequencies for SCADA systems and their components. Preventive maintenance schedules for SCADA components and subsystems should be coordinated with those for the Mechanical / Electrical systems they serve to minimize overall scheduled downtime.

Table 9.3- Recommended Maintenance Activities

Activity	Frequency
Pneumatic Systems/Components	
Check Regulators and Filters	Monthly
Inspect Tubing and Piping	Monthly
Actuate Pressure Switches	6 Months
Actuate (Stroke) Valves and Actuators	6 Months
Calibrate Switches and Sensors	Yearly
Calibrate Pressure Gauges	Yearly
Calibrate Thermometers	Yearly
Electrical/Electronic Systems	
Lamp Test/Verify Indicators	Monthly
Inspect Enclosures for Dirt, Water, Heat	Monthly

Actuate (Stroke) Valves and Actuators	6 Months
Actuate Switches	6 Months
Run PLC Diagnostics	6 Months
Calibrate Sensors and Transmitters	Yearly
Calibrate Meters	Yearly
Calibrate Actuators	Yearly
Test Batteries	6 Months
Test Automatic Control Sequences	Yearly
Verify Alarms	Yearly
Software Maintenance and Patching	2 Months
Anti-virus Definition Updates	Monthly
Inspect Wire, Cable and Connections	Monthly

Many components of SCADA systems, such as dead-bus relays, are not required to function under normal system operating modes. For this reason, the system should be tested periodically under actual or simulated contingency conditions. These tests should approach as closely as possible the actual off-normal conditions in which the system must operate. For example, SCADA for standby diesel generator set should be tested by interrupting the utility source as far upstream of the normal service as possible.

The SCADA software maintenance should include timely updates of any new versions from the supplier and testing to verify proper installation on the SCADA computer. In addition, software anti-virus updates should be maintained. This should be performed after the computer is connected to the Internet. Normal operation requires that the SCADA computer not be connected to the Internet.

Concurrent Maintenance

Where SCADA components are associated with redundancy equipment and therefore are not themselves redundant, their maintenance should occur during maintenance of the associated equipment. Concurrent maintenance is defined as testing, troubleshooting, repairing, or replacing a component or subsystem while redundant component(s) or subsystem(s) are serving the load. The ability to perform concurrent maintenance is critical to attaining the specified reliability/availability criteria for the fa- cilities and must be designed into the SCADA system. SCADA components and controllers that are redundant must be capable of being taken out of service, repaired or replaced and tested without interfering with the operation of the redundant component.

Reliability Centered Maintenance

Reliability-Centred Maintenance (RCM) is an approach for developing an effective and efficient mainte- nance program based on the reliability characteristics of the constituent parts and subsystems, economics, and safety. RCM provides a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the operational reliability of systems and equipment while ensuring their safe and economical operation and support. RCM has changed the approach to preventive maintenance and can be considered the "next step" in moving from a trial and error based approach to establishing PM frequencies to an intelligent approach to maintenance planning. A significant byproduct of the application of SCADA systems to the control of pump station facilities is the large amount of operational data made available through the trending and data storage features of the SCADA. This operational data can be used for automated performance monitoring of mechanical and electrical systems to support an RCM approach.

Operations and Maintenance Documentation

The Contractor should perform an O&M analysis to determine the O&M data required to support the maintenance of the SCADA system. This analysis should be coordinated with the maintenance team to determine the available maintenance parameters and O&M data. Typical O&M data requirements include the following items:

1. System documentation
2. Minimum spare parts list
3. Recommended spare parts list
4. Recommended onsite test equipment
5. Recommended O&M training
6. Recommended O&M to be performed by contract

Spare Parts Stocking

The adequate on-site stock of spare parts is essential to ensure the high continuity of SCADA systems.

Minimum recommended stocking levels include the following as a minimum :

1. Manufacturer's recommended spare parts list.
2. One each of all line replaceable boards or modules.
3. Six numbers of each power and control fuse used in the system.
4. Tools required to terminate coaxial on fibre optic cables.

Specifications should also require that the following be furnished with each system:

1. Laptop computer loaded with software required to access controllers.
2. Licenses for all software installed on the system.
3. Permission to modify program code.
4. Spare cables for connecting a computer to controllers.

9.4.8 Maintenance of Water Distribution Pipeline

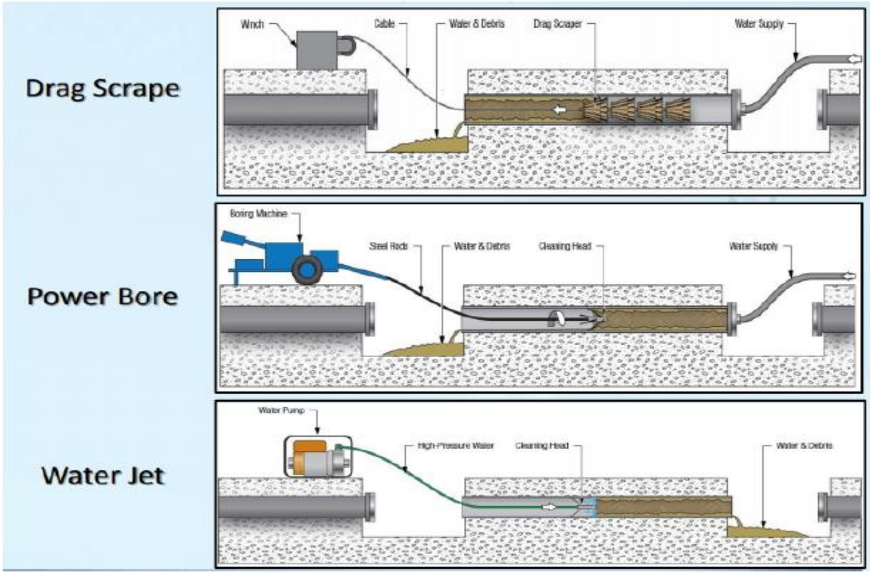
Efficient maintenance of the water distribution system shall be looked after by the authorized official of the controlling authority to receive and deal with complaints. Appropriate maintenance registers shall be maintained to record consumer complaints, and action must be taken to ensure that the complaint is attended to. Regular observation shall be made by the O & M staff to rectify problems before getting complaints from the consumers. The following maintenance shall be conducted for better service of distribution pipeline.

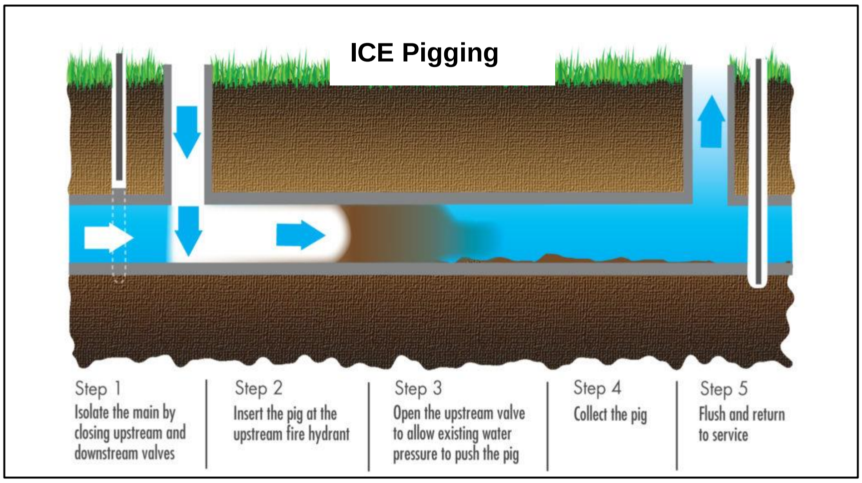
(a) **Pipe Breaks**: Pipeline bursts/main breaks can occur at any time, and the utility shall have a plan to attend such events. This plan must be written down to all concerned, and the CMWSSB must always be in readiness to implement the plan immediately after the pipe break is reported. After a pipe break is located, a decision is to be taken as to which valve is to be closed to isolate the section where the break has occurred. Every consumer should be notified about the break and informed about the probable interruption in water supply and the estimated time of resumption of water supply. After every pipe break, a report shall be prepared regarding the cause of such break, the resources required for rectification and the time and cost required for repairing etc. so that the agency can follow up with measures for avoiding such breaks and also modify their plan to address such breaks in future.

(b) **Flushing of Pipeline:** Flushing is done to clean the distribution lines by removing impurities or sediment that may be present in the pipe. Routine flushing of terminal pipelines is often necessary to avoid taste and odour complaints from consumers. It is advisable that a programme for flushing is prepared and followed so that water mains are flushed before consumers start complaining. Flushing is usually done during low water demand.

(c) **Cleaning of Pipeline**: Mechanical cleaning devices such as swabs and pigs are sometimes used if flushing does not improve the water quality. Scrapers or brushes are used in pipelines with hardened scales or extensive tuberculation. Sometimes scrapers and brushes are used before taking up lining works.

The site visits show that the existing water supply distribution pipes in Chennai Core City suffer dramatic physical deformation caused by scaling, tuberculation, biofilms, and sedimentation. According to American Water Works Association (AWWA) Manual M28, ''Pipeline Renewal Methods'' the following methods are recommended to be implemented as per of the maintenance programs by the client. Those are illustrated in **Error! Reference source not found.**: water jet, power bore, and drag scrape, respectively, according to the level of difficulties from easy to hard. Ice pigging is a newer technology that uses an ice slurry instead of solid pigs to clean common pipeline issues, such as sediment, deposits, and biofilms especially for diameter pipes ranging from 100mm to 600mm. it has high scouring power than flushing of water alone. This cleaning system uses a slurry of ice, called a pig, that travels through underground pipes, scraping the sides and pushing sediments ahead and out of an exit point normally down stream of the fire hydrant. A mixture of ice and salt lowers the freezing point so the pig doesn't become rock hard and can conform to the shape and diameter of the pipe. Traditional pigs are usually made of metal, are inflexible and can get caught in complex pipe networks, while ice pigs simply melt in place if stuck





(d) **Corrosion in Pipeline:** Pipes deteriorate on the inside due to corrosion and encrustation and on the outside due to aggressive soil and water/moisture corrosion. Depending on the material of pipes, these are subjected to some deterioration, loss of water carrying capacity, leaks, corrosion and pitting, tuberculation, deposition of sediment and slime growth. Some preventive measures include detection and prevention of wastage of water from pipelines through leaks, maintaining pipelines' capacity, cleaning pipelines, and relining. The application of cement mortar lining and guniting in the pipes (metallic) inner and the outer surface is very important for preventing corrosion.

9.4.9 Leak Detection and Control in Distribution System

Wastage of water in the system and distribution network occurs through leakage from pipes, joints & fittings, reservoirs and overflow from reservoirs & sumps. The objective of the leakage control programme is to reduce the wastage to a minimum and minimize the time that elapses between the occurrence of a leak and its repair. Generally, in most of the cities in India, water loss is about 30 to 40% which is due to leakage in the distribution system. The leakages in the distribution system are caused due to the following reasons.

- There are leaks from service reservoirs due to cracks in the structural components, leaky joints, and valves.
- Due to defective joints, corroded and damaged pipes and valves, leaks in water distribution mains.
- High pressure in the distribution system intensifies existing leakage.
- Leaks in house service connection piping and fittings due to faulty joints, corrosion etc.
- Leakage in the distribution main due to uncontrolled unauthorized connections.
- Leakage in the water distribution system can be significantly controlled and reduced through systematic detection and damage control procedures. A program of Leak Detection shall be established for the entire water distribution system to ensure minimum leakage.

9.4.10 EMF Meters

The EMF meters are fixed at the inlets and outlets of the OHTs. DMA entry and exit points should be thoroughly maintained by checking the correctness of flow and pressure data concerning previous data, battery condition, and display units by a frequent routine visit to the locations. It can be monitored through the central SCADA system proposed to be built under the main project.

9.4.11 Motorized Valves

Motorised valves are proposed to be fixed under this project to control water through automation using the SCADA system. In addition, these valves will be monitored through the central SCADA system. Routine checks should be carried out at the locations to check the working conditions and transmitter that transmit the valve condition data regarding opening and closure.

9.4.12 Level Indicators at Service Reservoirs/OHTs

Level indicators are proposed to be fixed under this project to monitor water levels in the reservoirs, which will be used to control water in and out of the reservoir through automation using the SCADA system. Routine checks should be carried out at the locations to check the working conditions and transmitter that transmit the water level data in the reservoir. In addition, these level indicators will be monitored through the central SCADA system.

9.4.13 General Maintenance of Instrumentation System, DMA meters inclusive of associated accessories

- Periodic device inspection. calibration, preventive maintenance, repair/replace, testing of all installed equipment inclusive of accessories

- DMA meters, Flow & pressure transmitters, Electronic Systems, Software Maintenance and Patching, etc., to carry out preventive maintenance, testing, calibration, repair/replace etc.
- Inspect Wire, Cable and Connections etc
- Replacement and/or repair of batteries, faulty sets and all other non-functional equipment to ensure trouble-free communication

9.4.14 O & M Staffing

For operation and maintenance of the system is executed is planned with UFW reduction, control and monitoring. The team will be headed by an Executive Engineer level staff supported by additional Engineers and other support team members. The proposed Organization chart for Area X is shown in Fig 9.2.

The team will be responsible for routine maintenance of the water supply, collection and distribution of bills. There will be a separate team to maintain the SCADA under the Manager. Engineers and the other technicians shall support the SCADA expert who heads the team.

UFW/NRW: Under the Manager, the Leak detection team headed by the UFW/NRW expert will be responsible for reducing, controlling, and monitoring the UFW/ levels in the DMAs. The UFW/NRW expert shall do a periodic review of the water losses by following best international practices with the help of the facilities such as District Meters fixed at all the inlets of the DMAs. Leak detection experts shall do periodic leak detection with the help of technicians and other staff to locate visible and non-visible leaks. All the identified leaks are to be repaired permanently using leak arrest clamps

9.5 Developing Maintenance Program for the Overall System

There are three main strategies to consider when a maintenance program needs to be decided: reactive (i.e., corrective) maintenance, active (i.e., planned or predictive) maintenance, and proactive maintenance. Reactive maintenance can be called corrective maintenance as it is going to be applied in case a failure event occurs, meaning that the default status is set to ''no action until a failure occurs'.'

Active maintenance means that there are current actions in place that is going on based on a specific plan or predicted failures by the maintenance team for the system they maintain. It can be time-based maintenance (i.e., daily, weekly, monthly, etc.) with specifically developed checklists valid for regular updates according to the failures' risk magnitude. Active maintenance, as explained, comprises actions being in place to prevent failures from occurring so that it can be called preventive maintenance.

Proactive maintenance is ahead of planned actions called preventive maintenance. It is based on calculating the probability of probable before it may occur and taking necessary proactive actions in advance to prevent the failure from occurring.

Achieving proactive maintenance status is considered one step behind achieving strategic level maintenance, known as reliability center maintenance (RCM). RCM or strategic maintenance level is the highest maturity recognition level for an organization that can be reached

9.6 Maintenance Program versus Cost Implications

The reactive maintenance has the least cost budgetary implication as it is based on action in the request, which requires the minimum resources being in place. Conversely, the proactive maintenance requires higher cost implications due to the required technology that needs to be adopted (i.e., Supervisory Control and Data Acquisition SCADA and Advanced Metering Infrastructures AMI). On the other hand, a structured and systematic examination of complex systems should be developed before implementing an effective proactive maintenance program. Such systematic examination of complex systems requires high investment in hiring experts/professionals and conducting many training sessions followed by several workshops to develop a hazardous operational parameters identification process (HAZOP).

Maintenance costs comprise labour costs, energy costs, replacement costs, materials costs, devices monitoring/control costs, loss of revenue costs during failure times until repair/system recovery, training costs, rehabilitation/renovation costs and any other relevant expenditures such as buying a maintenance service from a provider or sub-contractor. The PMC will provide detailed financial analysis, including O&M costs, to enable a decision.

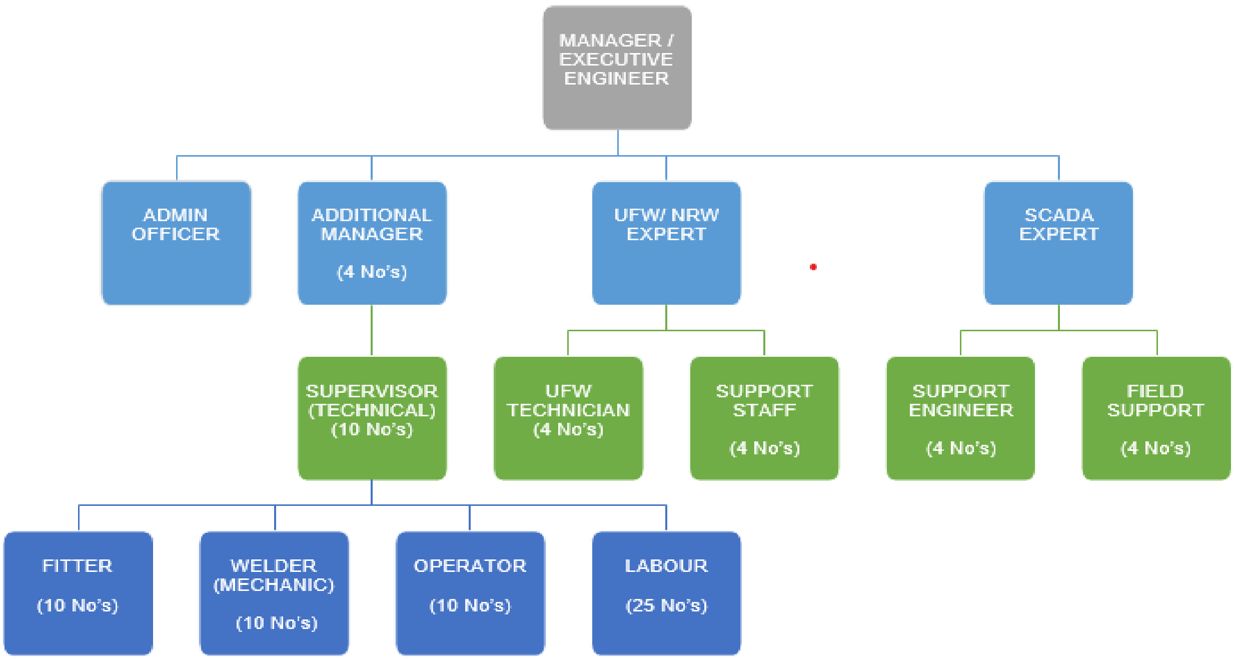


Figure 9.2 : PROPOSED ORGANIZATION CHART FOR AREA X WATER SUPPLY WORKS CITY

10 CHAPTER 10: CAPACITY BUILDING & TRAINING

10.1 General

An efficient operation and maintenance of the water supply distribution system in any City/ULB requires good organisational structure and distinct tasks assignment to its employees. CMWSSB are presently looking after water supply systems and other utilities. It is recommended to introduce a dedicated water supply team to maintain the supply and distribution components in the Chennai core city, and it may be formulated Water distribution zone/ division wise for the ease of O & M. CMWSSB shall have a proper training plan to strengthen the skills and capabilities of their staff members. At the time of recruitment, the staff can be put in on-job training or professional education can be given along with the employment of such personnel. The engineers already employed in the ULB shall obtain additional training to continue effectively performing technical duties.

10.2 Need of Training

The staff members responsible for water supply works are a valuable resource of the CMWSSB, and their efficiency directly influences the quality of service and the overall economy. Well-trained, skilful and hard-working employees are capable of achieving high standards of performance in their professional work, and this results in (a) increased efficiency of operation and maintenance practice, (b) improved efficiency of the water supply system and quality of drinking water (c) improved public health (d) enhance public relationship (e) Improves financial strengthening of CMWSSB. Training is a planned process to modify attitude, knowledge or skill through learning experience to achieve effective performance inactivity and develop the individual's abilities to satisfy the organisation's current and future needs.

The PMC professional team shall provide capacity building program based on technical on-job training for the client's staff members who will be appointed and selected by the client and shall include the following areas of focus:

- The design aspect of the system, including the design deliverables
- Preparation and updating of the data bank on new installations for future reference
- Maintaining the records of breakdown history for preventive maintenance shortly.
- Interaction with consumers
- Sensitising Stakeholders to the prevalent ongoing water crisis
- Need for providing potable water supply
- Description and application details of instruments and other accessories required for maintenance work
- Need for proper maintenance of the same and how each activity shall be operated upon / performed.

- During emergency break down, system restoration in a minimum breakdown period.
- Training shall include field visits to project sites on maintenance procedures
- Redefine roles and responsibilities in changing situations
- Maintain records and necessary field documents about Operation and Maintenance (O&M) of various units in the water supply scheme and periodical interaction with the higher authorities for effective follow-up action.
- Overview of UFW reduction and control activities
- Capacity building of staff on environmental management through on-the-job training
- Built organizational pride through individual behaviour change
- Transform Technical engineering into Social engineering.

10.3 Training requirements

Though most of them are qualified by the education required for the O&M of the water supply scheme, they are not trained to handle and properly operate and maintain the electrical and mechanical equipment in the pumping system. This results in frequent starters and other electrical equipment failures like switches and control panels. Premature failure of both motors and pumps is predicted due to water hammer on account of improper operation of valves during operation. The staffs need training for proper O&M of the equipment and the water supply scheme.

Training Plan

The operating staff shall be trained in the following:

- Basic principle of Pump working
- Basic Knowledge in the working of motor, starters, circuit breakers & switches.
- Purpose of various types of valves – Sluice valve and Scour valve etc.
- Valve operations within pump room and in the pumping mains
- Preventive maintenance of electrical and mechanical equipment
- Attending to minor repairs, major repairs – procedure to be followed
- Various types of pipes and pipe materials – pressure ratings
- Log books – maintenance & upkeep of records
- Importance of keeping good health and hygiene
- Management crises in the operation & Maintenance
- SCADA training shall be provided to O & M staff to better control and monitor the water supply system.
- Centre of Excellence for Change Tamilnadu

- CSE recognized as the Centre of Excellence (COE) by the Indian government. Ministry of Housing and Urban Affairs of the Government of India has recognized CSE as a Centre of Excellence (COE) in sustainable water management.
- Highlight the urgency of many water-related challenges faced by the state
- Severe water scarcity and drought in many places; a dramatic reduction in ground water tables; reduction in storage capacity of tanks; growing conflicts between water user groups; and pollution threats
- Bring community engagement into the whole process from decision-making, executing and sustaining village water and environment development
- Detailing department-wise government schemes and action plans
- Making all stakeholders across the spectrum well informed about the projects
- Recommend Training for selected stakeholders from CMWSSB and WARD members for the CEC 'Blue-Green Movement' training

The overall framework of the capacity building and training program is technical on-job training (i.e., implementation program). The training curriculum shall include the following

Upon completing the capacity-building technical implementation program, the outcomes shall ensure that all attendees will gain the required knowledge, skills, and capabilities of hydraulic analysis techniques relevant to water supply distributions systems.

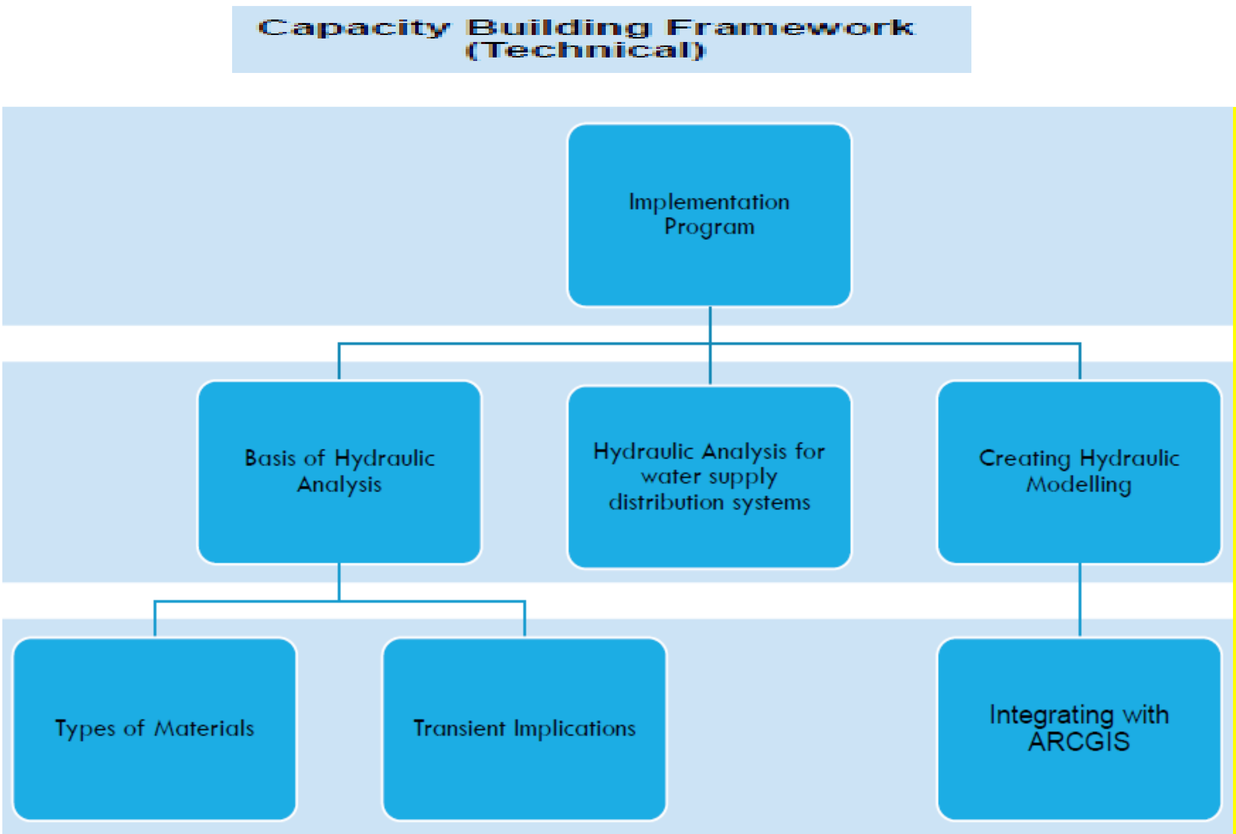


Figure 10.1 Capacity Building Implementation Program (Technical on-job Training)

11 CHAPTER 11: SOCIAL SAFEGUARD SITUATION REVIEW & IMPACT ANALYSIS

Summary

Under the reporting obligations of the Contract, social safeguard aspects are expected to chip in Contract Package-4 (CP-4) of the project. Social communication is required to build understanding and support for the smooth implementation of the network improvement proposals. Further coordination with stakeholders will be necessary for the successful implementation of the project. Thus, working closely with the key stakeholders will be critical, mainly with CMWSSB, Community Leaders/Citizen Charter and District Administration representatives.

A high-level assessment of the current scenario was undertaken to understand water users' perspectives better. The assessment observed that the mere presence of infrastructure did not indicate the availability of potable water. As such, there is incomplete coverage by public supply, coupled with service delivery and adequate water, which remains a critical issue, often for which non-availability of water or water scarcity is cited as a reason. Problems of depletion and deterioration of quantity and quality respectively result in suboptimal or non-functioning drinking water supply systems, ultimately crippling the process of providing adequate safe drinking water to people.

The basic agony among the consumers/users is paying water tax without getting proper water. Consequently, the households are engaged in a range of coping mechanisms, viz.; Dependence either on small-scale private players like tankers or on self-provisioning, typically through tube-wells (bore wells), open wells or hand-pumps. During the field interaction with CMWSSB users/consumers, they appreciated faster grievance redressal in Sewerage-related complaints than water-related.

The infrastructure development for process improvements raises eyebrows on adverse social impact and the mitigation measures as part of social safeguarding. The proposed water supply distribution pipelines are well within the road and free from any incumbency to claim against land loss or involuntary resettlement. Also, the pipeline works will not affect any roadside shrines. The expected hindrances to access to premises/buildings during pipeline laying work will be marginalised through prior information notice, complete the work within the stipulated time, leaving required space for accessibility and, if possible, execution in the nighttime. However, there are two basic concerns viz; Street vendor presence and road traffic issues. The final pipeline design will bring more clarity, and a quick check will be conducted during the laying down of the pipeline design.

Some of the appropriate strategic decisions, viz.; exploring the possibility of location-specific daytime and night-time pipeline works, may marginalise the adverse impact. There will be an influx of labour during the construction, which requires preventive measures and appropriate action, particularly the COVID-19 pandemic, HIV/AIDS, working conditions, and safety.

Secondly, understanding the current low metering rate compared to the connection rate, water users, and potential water users will be strategically communicated to implement water meter installation to utilise potable water

properly. However, in the absence of an appropriate response from the responsible citizens, the government might need proper legislation for the fair utilisation of scarce resources like water.

11.1 Background

Demographic, social, and economic developments are the factors that increase pressure on water resources. Water availability, management and wastewater disposal are three major issues related to water supply in urban settlements. Chennai in 2005 faced severe drought, so a large amount of underground water was extracted to cope with their urban area water demands, so the water table fell 8 to 10 metres (Veena Srinivasan et al., 2010). The fall in the groundwater table has been recorded for the pumping location on seasonal and perennial rivers, is also going down speedily due to intensive use in supply for urban areas. Due to climatic variation, there is a change in rainfall pattern, and rainfall availability is reducing.[i]

Chennai is more dependent on the annual rains of the monsoon season to replenish water reservoirs as there are no major water resources or perennial rivers to serve the city. The average annual rainfall is 1,400 mm, and the average rainfall in a year is 60 days. The city gets most of its seasonal rainfall from the northeast monsoon from middle October to middle December. From July to September, the rainfall is greater than the other months except for the northeast monsoon, and this period is defined as the southwest monsoon.

However, it was learnt that the distribution pipelines are very old, and, in some areas, it is 40 years old. As a result, the replacement is felt inevitable. However, social perspectives have been conducted considering administrative zone to align with data/information related to past, present, and future administrative setup.

Social safeguard aspects deal with the probable social impact expected to occur due to the infrastructure development/improvement and appropriateness suggested/adopted to address/mitigate the adverse social impact. Here the appropriateness resembles/align with the social safeguards policy outlined by various national and international agencies. Hence, the basic objective of the social safeguards policy is to mitigate the adverse social impact on the population affected by the implementation of upgraded water networks and assets. The social safeguard review and analysis has been conducted by social communication specialists/Social unit of the PMC.

11.1.1 Demography and Socio economic details

11.1.1.1 Area/Zone-X: Kodambakkam

About **the Area/Zone**

Kodambakkam is situated at 13.0481 N latitude and 80.2214 E longitude. It is one of the westerly located neighbourhoods of Chennai city. It is bounded by the neighbourhoods of Nungambakkam to the east and West Mambalam and T. Nagar to the south. Vadapalani bounds it to the west and K. K. Nagar and Ashok Nagar to the south-west. Late in 2011, after the reorganisation of Chennai City, Kodambakkam (Area/Zone-X) comprised 16 wards. A brief about the zone is presented in the following table.

Table 11.1: Demographic details of Area-X: Kodambakkam (Census-2011)

Number of Wards	Households	Gender	Population	Population: <6 Years	Schedule Caste	Schedule Tribe	Literacy	Illiteracy
16	191,003	Male	368,620	36,338	40,583	593	316,902	51,718
		Female	362,902	34,638	39,688	562	292,178	70,724
		Total	731,522	70,975	80,271	1,155	609,080	122,442

Kodambakkam (Area/Zone –X) is spread over 22.31 square kilometres, almost 13% of the Chennai Core City spread out area of 172.55 square kilometres. The population density of Kodambakkam is 32,789 thousand per square kilometre. As per Census-2011, the area has 191 thousand households (16.5% of the Chennai core city) and 731.522 thousand population (15.7% of the Chennai core city). The male and the female proportion is 50.4:49.6. SC and ST populations are 11% and 0.16%, respectively. The literacy rate of Kodambakkam stands at 92.21%, which is almost 2% higher than the Chennai core city. However, Tamilnadu State has another class category called MBC (Most Backward Class), which has not been separated from General Caste in 2011. Hence, information regarding MBC could not be analysed in this report.

Table 11.2 Distribution of Workforce in Area-X: Kodambakkam (Census-2011)

Gender	Total Work Population	Total Main Work Population	Total Marginal Work Population	Total Marginal Worker (3-6 months) or Non-Work Population	Total Population
Male	219,525	204,988	14,537	12,558	368,620
Female	75,322	63,582	11,740	10,300	362,902
Total	294,847	268,570	26,277	22,858	731,522

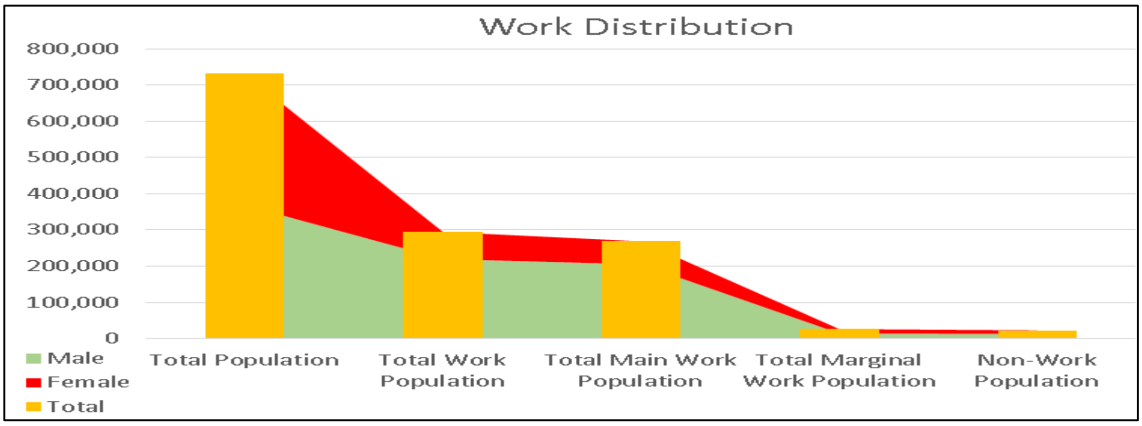


Figure 11.1 Workforce Distribution in Kodambakkam (Area/Zone-X)

According to Census 2011, the total workforce of Area/Zone-X counts 40.3% of the total population comprising almost 91% main worker is higher, and 9% marginal worker is lower than the Chennai core city average of 89.12%

and 10.88% respectively. Female participation in the workforce is almost 25% compared to the core city average of 24.65%. Nearly 2.29% of the workforce of Area/Zone-X comprises the industrial worker, a worker in service industries, etc. The non-worker population is 7.75%, 45% are under the female category, while in the core city, the non-worker population is 9.67%, and 43.46% are under the female category.

11.1.2 Water supply and distribution

Demographic, social, and economic developments are the factors that increase pressure on water resources. Water availability, management and wastewater disposal are three major issues related to water supply in urban settlements. Chennai in 2005 faced severe drought, so a large amount of underground water was extracted to cope with their urban area water demands, which resulted in the water table falling by 8 to 10 metres (Veena Srinivasan et al., 2010). The fall in the groundwater table recorded at the pumping locations on seasonal and perennial rivers is also going down speedily due to intensive use in supply for urban areas. Due to climatic variation, there is a change in rainfall pattern, and rainfall availability is reducing.[ii]

Chennai is more dependent on the annual rains of the monsoon season to replenish water reservoirs as there are no major water resources or perennial rivers to serve the city. The average annual rainfall is 1,400 mm, and the average rainfall in a year is 60 days. The city gets most of its seasonal rainfall from the northeast monsoon from middle October to middle December. From July to September, the rainfall is greater than the other months except for the northeast monsoon, and this period is defined as the southwest monsoon.

The current focus of CMWSSB is the supply of potable water to Chennai core city (7 administrative zones), which is divided into 18 water distribution zones (WDZs). Each WDZ has a water distribution station (WDS), a reservoir and pumps to distribute the water to the WDZ. At present, the interconnections among the WDZs are usually used. Therefore, the WDS are not physically independent of each other.

However, it was learnt that the distribution pipelines are very old, and, in some areas, it is 40 years old. As a result, the replacement is felt inevitable. However, social perspectives have been conducted considering administrative zone to align with data/information related to past, present, and future administrative setup.

Table 11.3 Water Supply Status in Area X: Kodambakkam (Census 2011)

Area/Zone	**Number. of Households**	**Number of Assesses**	**Metered**	**Un-Metered**	**Number of Connection**	**Metered Rate**	**Assesses per Connection**	**Household coverage**
Area/Area X: Kodambakkam	191,003	140,404	1,455	107,832	109,287	1.3%	1.3	57.22%
Chennai Core City	1,154,982	712,304	22,618	522,246	544,864	4.15%	9.3	47.18%
Sources: JICA Study Report								

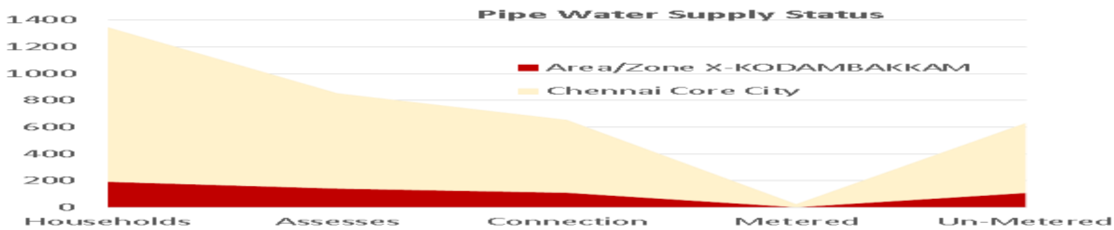


Figure 11.2 Water Supply Service Connection, Meter and Un-meter level in Kodambakkam (Area/Zone-X)

CMWSSB has 109,287 service connections (77.8%) as of July 2016 in Kodambakkam (Area/Zone-X). The remaining 23.5% either access potable water through water supply by lorries from CMWSSB or private sources or access ground water through bore-well. Metered ratio of the service connections is only 1.3%, which is substantially lower than the overall Chennai core city of 4.2%. However, the household coverage rate regarding the water supply service connection is higher (57.22%) in the Kodambakkam area than in the Chennai core city (47.18%).

11.2 Salient Feature of CP4

Improvement of the existing water distribution networks in Chennai City:

- Replacement of the existing distribution pipes,
- Installation of supplementary distribution pipes to strengthen the capacity of the existing distribution networks,
- Installation of new water distribution pipes in un-covered streets in Core city.
- Reinforcement of the storage capacity of Under Ground Tank (UGT) and Elevated Storage Tanks (ESRs)
- Installation of service connections and water meters
- Setup of district metered areas (DMA)

11.3 Objective

The social interventions will form a major role in bringing understanding and harmony among the stakeholders while addressing statutory compliance towards minimising the adverse impact of infrastructure development in improving the water supply distribution pipeline across Kodambakkam (Zone–X).

i. Assess whether the proposed improvements have any adverse effect on the settlements in terms of displacement.

ii. Understand the extent of land, public and private, houses, settlement, and other common properties likely affected by the proposed improvements.

iii. Study the probable social impacts and the nature of impacts.

11.4 Scope of Social Communication in CP4

Under the reporting obligations of the Contract, social communication aspects are required to be delivered in Contract Packages (CPs) of the project by Social Communication Specialists/Expert's Advisor including:

I. Assistance to CMWSSB for the capacity development in the acceleration of service connections and water meters and improvement of customer care and publication with Organizational Expert.
II. Develop the requirements for bid documents preparation for the contractors from the viewpoint of social communication/consideration complied with JICA's Guidelines (April 2010) and international practice.
III. Supervising the contractors from the viewpoint of social communication for smooth implementation of the construction works

11.5 Approach and Methodology

Communication with stakeholders must be strategic, intensive and consultative to build awareness and minimise resistance. Hence, the basic strategy is to address stakeholders' concerns, perceptions, and motivations.

Based on a quick assessment of the current scenario with the constraints of available time and manpower, four wards (Ward number: 127, 131, 136 and 137) out of sixteen wards from Area/Zone: X were selected based on population density viz.; median, above the median, lower to the median. Further, three households from each sampled ward, totalling 12 households, were randomly selected from EWS (Economically Weaker Section) houses/slum dwellers, single-owned houses and a few multi-storeyed apartments.

The Social Safeguard Review report is based on various reference documents, site visits, discussions with government officials and interaction at the community level. The following documents we referred to while preparing this report.

- Terms of Reference (TOR) of the Consultancy Services.
- JICA Final Report on Preparatory Survey on Chennai Seawater Desalination Plant Project.
- JICA Safeguard Guideline (2010); the World Bank and Asian Development Bank Safeguard Policies and National and Tamil Nadu Rehabilitation and Resettlement Policies.
- Census 2011 and District Websites.

11.6 Ground Situations of Water Supply and Its Satisfaction

Figure 11.3 Multiple Sources to Access Potable Water

The mere presence of infrastructure does not indicate the availability of potable water. As such, incomplete coverage by the public supply, coupled with the service delivery and the adequate water, remains a critical issue, often for which non-availability of water or water scarcity is cited as a reason. In the pipeline supply system, the consumers near the water source get very good pressure, but the consumers at the far end. Consequently, the households are engaged in a range of coping mechanisms. The biggest one of these coping mechanisms is dependent on multiple sources of water. Households depend on small-scale private players like tankers or self-provisioning, typically through tube-wells (bore wells), open-wells or hand-pumps.

11.6.1.1 Area/Zone-X: Kodambakkam

Access to Potable Water

There is a massive presence of bore wells at the household level, and water provisioning through tankers happens to be a more reliable source for access to potable water. In the absence of continuous supply/availability of potable water, the households invest in various storage devices to cater to the need, viz.; jerrycans, small tanks, underground and/or overhead tanks, sumps to pump water to overhead tanks, etc. according to space availability as well as affordability. Thus, households have considerable investment to ensure an adequate water supply. Apart from investing in portable water, the purchase of drinking water is also widely practised. The increasing dependence on groundwater by households and private and public utilities involves excessive groundwater extraction, leading to depletion. As a result, the risk of seawater intrusion in aquifers has increased.

> Case-1: Mrs.Sumathi, Rani Anna Nagar in KK Nagar
>
> Mrs Sumathi, a resident of Rani Anna Nagar in KK Nagar, resides in a multi-storeyed housing board tenements is accessible to the water supplied to each house for a few minutes through pipes in a day, which is also not assured. Hence, she has set up a poly water storage tank near her house block, which she fills up by collecting CMWSSB supplied water through a hand pump system available in the street. Also, sometimes the storage tank is filled by the CMWSSB tanker lorries. Each house has individual plastic tanks kept near their blocks, collected water stored in their tanks, and pumped to their tanks on the terrace.
>
> Mrs Sumathi expressed her displeasure that since water collection work is generally considered a women folk responsibility, it is very difficult for them to pump water from the street pumps and fill their big plastic barrels, which is time-consuming, involving a lot of effort and also pain some. She wished that water should be supplied to their houses directly through pipes daily, saving their time, effort, and money.

Quality of Water

Water supplied by public sources is expected to be less contaminated, as the water is treated before distribution, and the utilities carry out periodic checks. Problems of depletion and deterioration of quantity and quality respectively result in suboptimal or non-functioning drinking water supply systems, ultimately crippling the process of providing adequate safe drinking water to people. Area/Zone-X households are mostly dependent on CMWSSB supplied lorry water, which is considered good quality. Otherwise, there is an opinion that the pipeline water supply contaminates. Generally, the pipe used for house connection gets rusted and leaks. When the suction pump is is operated on non-supply times, it sucks the foreign liquid. Accordingly, water availability for drinking purposes is less prioritised by most people; rather, drinking water in jars is purchased for the purpose. However, there are cases like Mrs Sumathi, who is fully dependent on the water supplied through hand pumps and tanker lorries, finds no problem with the water quality for drinking purposes.

Tariff systems

CMWSSB sets the tariff for metered and unmetered customers. The metered customers are billed according to their consumption, but unmetered customers pay the flat rates. Accordingly, the metered ratio of the service connections is only 1.3%, which is substantially lower than the overall Chennai core city of 4.2%. However, the CMWSSB claim has different connotations at ground level, where most consumers are paying a flat tariff rate in the form of "Water Tax". Some of the users earlier interacted said that the meters were connected many years back, and those meters became non-functional after a few days and due to which water supply flow was affected. Hence, the meter was disconnected. These metered households are paying water charges in the form of a water tax half-yearly basis. Also, the tariff has been revised in the year 2019/2020. However, the basic agony among the consumers/users is that they have to pay water tax without getting proper water.

11.7 Expected Social Impact/Considerations

The upcoming CMWSSB effort towards improving water supply is expected to generate positive impacts that would increase access to water services in outreach and water quality and quantity. Key benefits include (i) employment opportunities leading socio-economic development, (ii) educational enrolment and attendance for children, (iii) household health status, (iv) time savings to engage in other productive activities. However, the infrastructure development for process improvements raises eyebrows on adverse social impact and the mitigation measures as part of social safeguarding.

> Social Impacts are assessed as per: Utilisation of Land and local resources, Involuntary resettlement, Livelihood loss, Existing social infrastructure services, Vulnerable social groups, Indigenous people, Gender equality & Children's Rights, Cultural Heritage, Local conflict of interest, Occupational Safety and Unforeseen impacts if any. Since, improvement of water supply through laying down pipeline does not require land acquisition, involuntary resettlement and rehabilitation; falls under Category – 'C' as per JICA's E&S policy

The statement above clarifies that the proposed water supply distribution pipelines are well within the road and free from any incumbency to claim against land loss or involuntary resettlement. Also, the pipeline works will not affect any roadside shrines. The expected hindrances to access to premises/buildings during pipeline laying work will be marginalised through prior information notice, complete the work within the stipulated time, leaving required space for accessibility and, if possible, execution in the nighttime. However, there are two basic concerns, viz.; Street vendor presence and road traffic, which have been analysed further for appropriate decision making.

11.7.1.1 Impact on Street vendors:

Urban street vending is a popular channel for selling goods, from fruits, vegetables, ice creams and beverages to clothing, toys, books, household utilities and decorative items. Area/Zone-X of the Chennai core city is in no way different from any other urban street across India.

Area/Zone-X: Kodambakkam

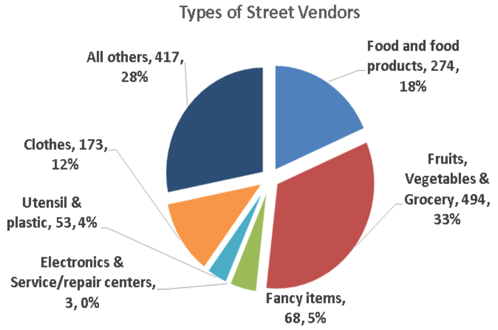


Figure 11.4 Types of Street Vendors (Zone-X)

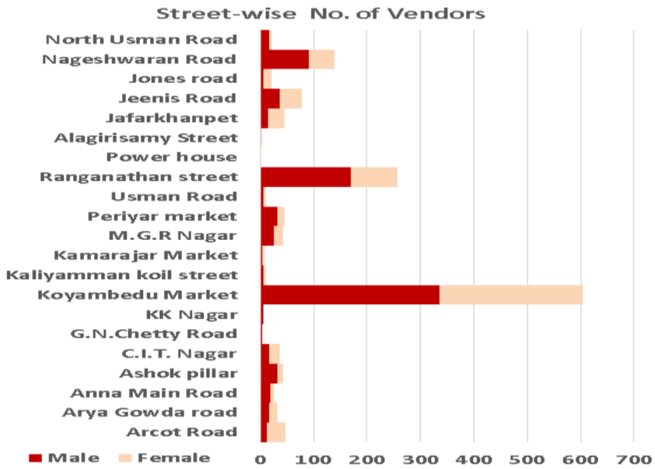


Figure 11.5 Street wise Vendors (Zone-X)

In Kodambakkam Area/Zone, 33% of the street vendors belong to Fruits, vegetables and grocery business which is highest followed by All other/Miscellaneous businesses (28%), food and food products (18%), clothes (12%), Fancy items (5%), utensils & plastic (4%) and only three electronics & service/repair centres. However, 41% of the street vendors are in Koyambedu Market, followed by Ranganathan Street (17%), Nageswaran Road (9%), Jeenis Road (5%), and all other streets/roads have street vendors within 3%.

During the visit to Koyambedu Area/Zone, vending activities on the road portions were not witnessed. Since the pipelines are expected to be within the road portion, adverse impacts on the street vendors are not envisaged.

However, the final approved pipeline design will bring more clarity, and a detailed check will be conducted during the laying down of the pipeline design. Secondly, location-specific day-time and night-time pipeline works can marginalise the adverse impact. If any certified street vendor of the local authority's town vending committee is affected, it will be duly compensated as per “Tamil Nadu Street Vendors Rules 2015”.

11.7.2 Traffic Issues:

11.7.2.1 Width of the road

Kodambakkam Area/Zone has roads of different widths, which have been consolidated into seven categories as per the table below. Since the pipeline will be laying down within the road portion, the width of the road is more of an initial indication to understand probable congestion might occur in the traffic movement.

Area/Zone-X: Kodambakkam

Table 11.4 Road width wise distance covers

Sl.No.	Road Width in feet.	Distance in KM.
1	0-15	0.117
2	16-20	0.597
3	21-30	115.243

Sl.No.	Road Width in feet.	Distance in KM.
4	31-40	300.632
5	41-60	16.297
6	61-80	30.316
7	80 & above	6.706
	Total	**469.908**
Note: Distance is almost closer to the actual		

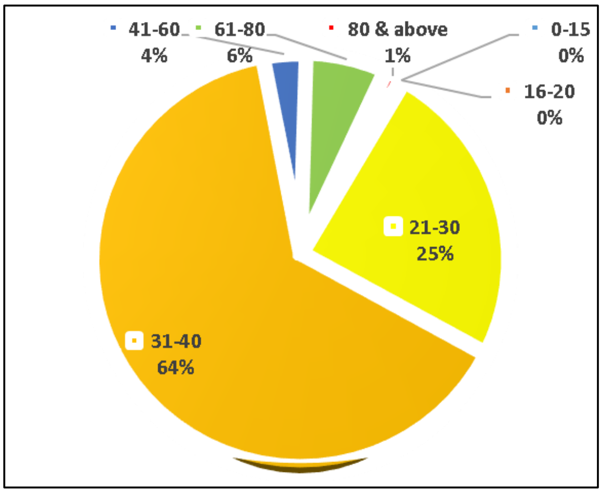


Figure 11.6 Percentage wise road width – Area X

The above table and the graph show that the roads in the range of 31-40 feet cover 64% of the Area/Zone-X, followed by 25% coverage by the road in 21-30 feet. However, higher width road, i.e. 41-60 feet, 61-80 feet and 80 & above feet, represents 4%, 6%, and 1%, respectively. If the workspace at the construction site is considered taking 5 feet of the width of the road, the remaining part will be available for traffic movement. Under such circumstances, the possibilities of slower traffic movement may not be ignored, particularly in the market areas.

Road dividers were observed mostly above 60 feet roads (in some cases between 40ft-60ft wide road); there might be laying down of water pipelines on both sides. Considering the traffic rate, phase manner pipelines may be laid down. However, encroachment of pedestrian facilities on both sides by commercial activities, absence of footpaths in internal roads that house the residential population and on-street parking, and commercial streets causing traffic congestion seems to be another point of concern. Moreover, the temporary congestion due to laying water pipeline for noble cause should not be a major public concern compared to the regular congestions created due to other reasons.

11.7.2.2 Traffic Movement

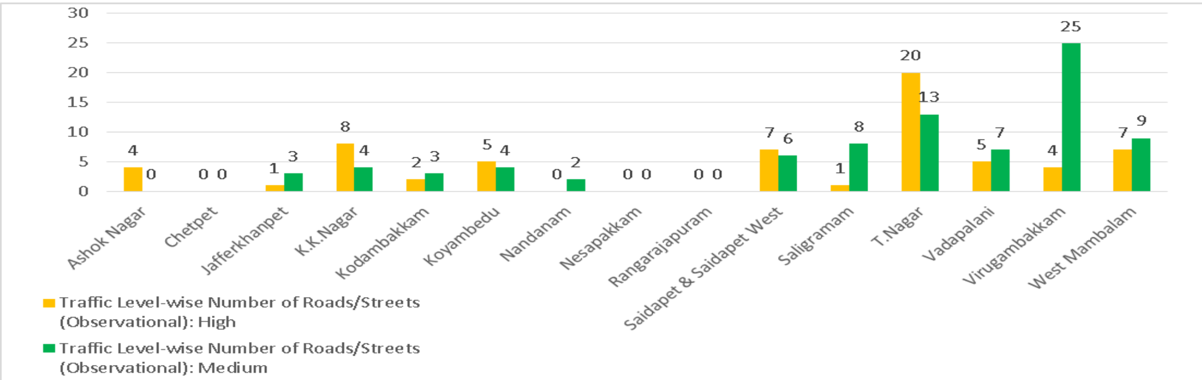
In the city, inbound traffic is high in the morning, and outbound traffic increases in the evening. On the other hand, traffic tends to increase in the suburbs from evening to midnight. It is observed that two-wheeled/motorcycles movements are more in the city centre as the city road is used for commuting in the morning and evening. In contrast, the suburban road is used for large vehicles such as heavy trucks from evening to midnight. Similarly, intra-city bus commuting in the city is more frequent during the morning and evening. The traffic movements in Area/Zone X is analysed below.

Area/Zone-X: Kodambakkam

Table 11.5 Locality wise traffic situation in Bus Transited Routes

Sl. No.	Locality	Bus Traffic Level-wise Number of Roads/Streets (Observational)			Total
		High	Medium	Low	
1.	Ashok Nagar	4	-	173	**177**
2.	Chetpet	-	-	1	**1**
3.	Jafferkhanpet	1	3	196	**200**
4.	K.K.Nagar	8	4	279	**191**
5.	Kodambakkam	2	3	137	**142**
6.	Koyambedu	5	4	212	**221**
7.	Nandanam	-	2	27	**29**
8.	Nesapakkam	-	-	104	**104**
9.	Rangarajapuram	-	-	1	**1**
10.	Saidapet & Saidapet West	7	6	175	**188**
11.	Saligramam	1	8	261	**270**
12.	T.Nagar	20	13	103	**136**
13.	Vadapalani	5	7	170	**182**
14.	Virugambakkam	4	25	410	**439**
15	West Mambalam	7	9	178	**194**
Total		**64**	**84**	**2427**	**2575**

Figure 11.7 Bus Transited Route-wise Traffic Level (Area/Zone-X)



The table and the graph above show that in T.Nagar there are 20 bus routes with high traffic, followed by KK Nagar (8 bus routes) and Saidapet (7 bus routes). Virugambakkam locality has 25 medium traffic roads/streets followed by T.Nagar (13 roads/streets). Since T.Nagar represents both high and medium traffic, congestion is expected during water pipeline laying. Although, Koyambedu locality represents comparatively less number of high and medium traffic roads/streets; some spots like Koyambedu Wholesale Market Complex is one of Asia's largest perishable goods market complex have movements of lorries, and two bus terminals are catering to inter-state, and within the state, transits make the peripheral and connecting roads to Koyambedu market, as well as bus terminuses, make more traffic movement. Hence, as per the water pipeline design network and implementation plan, micro-level traffic situations need to be assessed to manage traffic congestion issues appropriately.

11.7.2.3 Issues, Concerns and Risk matrix

Table 11.6 Issues, Concerns and Risk Analysis on Improvement of water distribution System

Issues	Concerns	Risk Rating (Low /Medium /High)
Utilisation of Land	No (Pipelines will be laid on the roadside)	Low
Local resources/ common resources	Not of major concern if utmost precautions are followed. However, community facilities – including public water stand posts, public utility posts, etc. may be affected in rare cases.	Low
Roadside/ Pavement Shrines	Less Likely	Low
Involuntary resettlement	No	Low
Livelihood loss	Temporary disruption of livelihood	Low
Residences – Hindrance to accessibility	Minimal/No	Low
Commercial Establishments – Loss/Hindrance to Business	Minimal/No	Low
Street vendors	Yes (Temporary and minimal loss of livelihood for the street vendors/ hawkers, if any along the route is envisaged). The risk of social sensitivity might arise if not properly addressed	Low
Bus route roads – Traffic problem and route diversion	The possibility of route diversion for the general public may occur in some routes considering traffic movement. However, it is less likely that the bus route will be diverted.	Low
Closure of Excavated pit	Minimal impact: The contractor immediately closed the Excavated pit after laying the pipeline and verification as per the stipulated guidelines. However, as per the present practice/ stipulated guideline on laying bitumen and bringing back the road/street to	Low

Issues	Concerns	Risk Rating (Low /Medium /High)
	its original shape is the responsibility of the Greater Chennai Corporation, which is expected to consume time following various procedures and compliances. During such a period, the smooth traffic flow might affect certain pockets.	

Table 11.7 Issues, Concerns and Risk Analysis on Proposed Over Head Tank (OHT)

Sl.No.	Proposed Location[1]	Land Acquisition	R&R [2]	Livelihood Loss
Area/Zone-X: Kodambakkam				
1.	Inside Choolaimedu WDS at Koyambedu	No	No	No
2.	Inside the New WDS at K.K Nagar.	No	No	No
3.	West Mambalam: New OHT is proposed instead of old, dilapidated Steel OHT Located in 11th Avenue adjoining 7th avenue at Ashok Nagar[3]	No	No	No
4.	Ashok Nagar: New OHT is proposed instead of the existing OHT located next to 132 Depot office on Inner Ring Road[4]	No	No	No
5.	United India Colony: inside the CMWSSB vacant land next to Depot 134 office at 5th cross street.	No	No	No

11.8 Suggestive Measures

The suggestions to mitigate negative social impacts of land acquisition for construction of water supply project at Chennai Core City according to "Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act (Act 2013) governed by the Ministry of Rural Development (MORD) and Tamil Nadu Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2017; are basic ingredients of the Social Impact Management (SIM). The Social Impact Management

[1] The proposed OHT sites are surrounded either by residential flats or institutions or both. Hence, to avoid traffic problems and hindrances to the public, construction material can be transported in the night time and construction work should be carried out only in the day time.

[2] R&R: Rehabilitation and Resettlement

[3] Since the site is near to Residential area, construction work should be carried out only in the day time.

[4] Since the site location is on the arterial road, Construction materials can be transported only during night time and construction work should be carried out only in the day time

Plan (SIMP) consists of a set of mitigation, monitoring, and institutional measures during the project's design, construction, and operational phases to eliminate adverse social impacts or reduce them to acceptable levels. The main aim of the SIMP is to ensure that the various adverse impacts are mitigated and the positive impacts are enhanced. The SIMP shall be implemented during the various stages of the project, viz. pre-construction stage, construction stage and operational stage. Ass specified below, a description of the various management measures is suggested during different project stages.

- **Ex-post Impact evaluation/measurement**: Baseline Study needs to be conducted by the external agency or by CMWSSB or by PMC or by both as the additional task before execution of water pipeline laying to understand and assess the impact of the project at a later stage or end-tem or few years after completion of the project, which other way can be termed as medium and long-term impact measurement.
- **Capacitating on social safeguard**: CMWSSB engineers responsible for implementing the project activities should be oriented on social safeguard aspects by the social Communication Specialist. Social safeguard aspects can be adhered to during pre-construction, construction and post-construction stages.
- **Improving water meter installation**: Understanding the current low metering rate compared to the connection rate, water users and potential water users will be strategically communicated to adopt water meter installation for proper utilisation of potable water. However, in the absence of an appropriate response from the responsible citizens; the government might need proper legislation to utilise scarce resources like water.
- **Precautionary and safety measures**
  - Prior to the start of construction with the assistance of CMWSSB, (1) information dissemination sessions should be organised at various places and solicit the help of the local community, leaders/ prominent for the project work; (2) focus group meetings should be conducted to discuss and plan of construction work (mainly pipeline work) with local communities to reduce disturbance and other impacts and also regarding the project grievance redress mechanism; (3) constant communication should be established with the affected communities to redress the issues likely to be surfaced during the construction phase; and (4) At the worksites, public information boards should also be provided to disseminate project related information.
  - During laying of pipeline in the narrow and congested road, proper planning should be required during execution time to avoid temporary loss of livelihood, damage to roadside commercial establishment and Common Property Resources etc. While the adverse impact is expected to be negligible, case to case basis, the affected persons should be compensated according to the national and state laws.
  - The excavated pits should be closed and compacted per stipulated guidelines, and after the work is over, bitumen laying will be done. As of now, any repair and the bitumen laying on the city roads/streets comes under the jurisdiction of the Greater Chennai Corporation. However, mutual coordination and cooperation can make the bitumen laying work faster to reduce traffic congestions.

- The traffic control measures need to be in place, which shall mainly consist of providing cautionary signs of "Men at Work" about 500 meters or as appropriate according to the coverage of the roads/streets before the work zone for the approaching vehicles and other cautionary signs of "Road narrows" shall be placed 100 meters or as appropriate ahead of the work area. Regulatory signs of "Keep Left/Right" shall be placed at the commencement point of the work zone and next to the barriers for the approaching vehicles. Movable barriers shall also be placed on both sides of the work area.

➲ **Temporary relocation**: Mobile hawkers and vendors should be assisted by contractors in moving to alternate locations during construction if so desired. Any financial assistance in compensation adhering to applicable rules and regulations should be followed.

➲ **Managing time of Work**: To avoid traffic disturbances, Bus Route Roads are normally laid during the night hours and are opened to traffic the next morning. As a result, traffic problems or route diversion can only be expected to the minimum extent in the inevitable areas and for a shorter period.

Table 11.8 Suggestive Measures for Risk Control/Mitigation

RF[5]. No.	Issues/ Concerns	Control/Mitigation Measures	Responsible Agency
1.	Loss and temporary impacts on local resources/ common resources (Communities and various line departments)	- Ensure community consensus and minimum impact to community utilities like a telephone cable, electric cables and electric poles, water taps. Proper clearance must be obtained from the concerned authorities and sent to the PIA before the commencement of works. - Swift action towards replacing or restoring the affected community facilities includes public water stand posts, utility posts, temples, shrines, etc.	CMWSSB/PMU/Prospective Contractor will be responsible for ascertaining the nature and extent of such loss and resolve.
2.	Temporary disruption of livelihood. (Legal title holders, non-titled displaced	- Vulnerable DPs will be identified based on the final approved design of the water distribution systems and after the Contractor's engagement. - 30 days advance notice regarding construction activities, including duration and type of disruption. - Cash assistance is based on the minimum wage/average earnings per month for the loss of income/livelihood for the period of disruption Contractor's actions to ensure no income/access loss.[6]	CMWSSB/PMU/Contractor verify the extent of impacts through a 100% survey of DPs, determine assistance, verify and identify vulnerable households.

5 Resettlement Framework

6 This includes: leaving spaces for access between mounds of soil, providing walkways and metal sheets to maintain access across trenches for people and vehicles where required, increased workforces to finish work in areas with impacts on access, timing of works to reduce disruption during business hours, phased construction schedule and working one segment at a time and one side of the road at a time

RF[5]. No.	Issues/ Concerns	Control/Mitigation Measures	Responsible Agency
	persons (DPs).)	- Assistance to vendors/hawkers to temporarily shift for continued economic activity as one-time assistance)[7] - Assistance to street vendors/hawkers as per the prevailing Acts/policies, the project affected people should be compensated - For construction activities involving unavoidable livelihood disruption, compensation for lost income or a transitional allowance for the period of disruption, whichever is greater, will be applicable. - Livelihood. Vulnerable households[8] will be given priority in project construction employment and provided with income restoration support. - Vulnerable DPs/businesses will receive subsistence fees as one-time assistance under temporary impacts.	
3.	Bus route roads – Traffic problem and route diversion	- Before taking up construction activity, a Traffic Control Plan should be devised and implemented to the Engineer's satisfaction. - Construction should be taken phase-wise so that sections are available for traffic. - A temporary diversion will be provided with the approval of the engineer. The Detailed traffic control plans prepared and submitted to the engineers for approval one week before commencement of works shall contain details of temporary diversion, details of arrangements for construction under traffic, details of traffic arrangement after cessation of work each day, signages, safety measures for the transport of hazardous materials and arrangement of flagmen. - Special consideration should be given for preparing the traffic control plan for the safety of pedestrians and workers at night. - The contractor will ensure that the diversion/detour is always maintained in running condition, particularly during the monsoon, to avoid disruption to traffic flow. He shall inform the local community of changes to traffic routes, conditions and pedestrian access arrangements.	CMWSSB/ PMU/Prospective Contractor

[7] For example assistance to shift to the other side of the road where there is no construction. These will be however given to only non-movable businesses (which are not on wheels).

[8] Vulnerable households include female-headed households, physically handicapped-headed households, scheduled tribe and schedule caste households, Below Poverty Line households, and households with marginal land holdings, that are the only source of livelihood, and majority of that land is being acquired under the project.

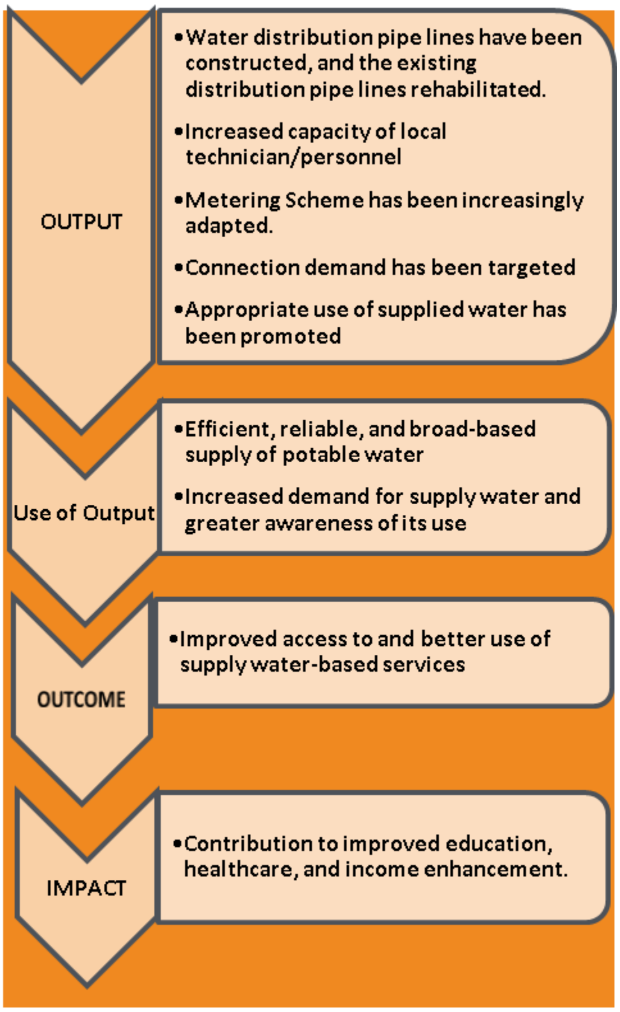
RF[5]. No.	Issues/ Concerns	Control/Mitigation Measures	Responsible Agency
		- This plan will be periodically reviewed concerning site conditions. The temporary traffic detour will be kept.	
4.	Prevention of accidents	During the construction period, the prevention of accidents involving human beings, animals, or vehicles is falling or accidents due to open trenches/manholes. This needs to be ensured with proper signage and barricades. The construction site should be barricaded at all times in a day with adequate marking, flags, reflectors etc., for the safety of general traffic movement and pedestrians. Adequate precautions should be taken to prevent accidents and from the types of machinery. All machines used shall conform to the relevant Indian standards Code and be regularly inspected by the PMU. The contractor shall arrange for: - A readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone - Availability of suitable transport at all times to take an injured or sick person(s) to the nearest hospital	CMWSSB/PMU/ Prospective Contractor
5.	Labour camp & facilities	Setting up of labour camps needs to be done as per the procedures. Adequate potable water facilities, sanitation and drainage, etc., in conformity with the Indian labour laws, shall be ensured. The contractor shall also guarantee each labour camp's location, layout, and basic facility provision will be submitted to the Engineer before their construction.	Prospective Contractor
6.	Laying of distribution pipelines	- Traffic regulation: Adequate actions to direct and regulate traffic shall be taken with PIA, Dept. of Police to prevent jamming of roads during construction. While planning alternative routes, care must be taken to minimize congestion and negative impacts at sensitive receptors such as schools & hospitals. - Adequate precautions should be taken while laying the water distribution lines to avoid the possibility of cross-connection with the sewer lines.	CMWSSB/PMU/ Prospective Contractor
7.	Any other loss not identified	Unanticipated involuntary impacts will be documented and mitigated based on JICA/World Bank/ADB's Safeguard Policy.	CMWSSB/PMU/Contractor will ascertain the nature and extent of such loss.

11.9 Strategic Framework

11.9.1 Mapping programmes result

The results chain through which the programme's success is identified and the potential positive and negative side effects of programme implementation is also identified. Hence, a comprehensive impact map needs to be developed, on which an enhanced results chain to be evolved. The Outcome level embeds the supply of and demand for potable water within the concept of access to water-based potable services.

The Output level is concerned with completing programme activities, such as the rehabilitation and construction of infrastructures and other measures related to the demand for piped water and the awareness of its safe and productive use.



Finally, the Impact level assesses results induced by improved access in the piped water supply areas. An increase of productive and income-enhancement activities and improved educational and health services are all indirect positive results expected from the improvement in the water supply systems. However, these results are only partially attributable to the water supply project because external variables may strongly influence their attainment.

11.9.2 Defining programme indicators

In order to make changes measurable at each of these results levels, indicators have to be designed for all the results identified. Indicators should be precise, provide relevant information, and measure with a justifiable degree of effort. Each indicator comprises several data elements that need to be collected. This section provides an overview and discussion of the core results and their respective indicators, arranged by result level.

RESULTS	INDICATORS
OUTPUT RESULTS	
Efficient, reliable, and broad-based supply of piped water; Increased demand for supply water and greater awareness of its use.	The number of households, businesses, health centres, and schools with a physical connection to the water supply distribution lines.
	The proportion of connections in the area (Wards/Zones/Chennai Core City)
	The proportion of connections for poor households has increased
	Reduced its technical and commercial losses and its collection rate
	Maximum response time for customer complaints has decreased
	The proportion of customers tariff has increased
	Increased awareness of the potential for productive use of water through the use of DMA
OUTCOME RESULTS	
Improved access to and better use of supply water-based services.	The number of beneficiaries who are directly connected to the water distribution systems has increased
	In piped water supply areas, the average number of appliances used in households, businesses, schools and health centres has increased compared to business-as-usual
Contribution to improved education, health care, and income enhancement.	Increase in the school attendance
	Medical centres' information shows a reduction in the various water-borne diseases.
	Opportunities to look forward avenues for income enhancement due to available surplus time.

Table 11.9 Strategic Framework from Social Perspective of Area/Zone: X

SDG-6 (Sustainable Development Goal-6): Ensure availability and sustainable management of water and sanitation for all						
Project Objective: Improve the efficiency of the existing water distribution network in the Chennai Core City, the central area of the CMA						
Verifiable Indicator	**Means of Verification**	**Frequency of Verification**	**Assumptions**	**Target groups**	**Implementation Responsibility**	**Monitoring Responsibility**
Output-1: Improvement of the customer information database						
Finding the subscribers/consumers of the Water Establishment, updating their records	CMWSSB records show updated records	Monthly		Connected, Dis-connected and potential water consumers	CMWSSB	CMWSSB
Output-2: Planning and implementation of the customer satisfaction survey						
customer satisfaction survey planned and implemented	Document related to customer satisfaction	Periodical	No customer satisfaction document is available	Connected and Dis-connected water consumers.	Engaging agency to conduct the survey	Project head / in-charge CMWSSB
Output-3: Build/Enhance the knowledge on development-induced social issues related to the implementation						
Build the capacity of staff to understand the social safeguard mechanisms and application modalities	- Number persons capacitated on social safeguard aspects; - Post-training evaluation.	End of the training programme.	CMWSSB personnel have not been oriented on social safeguard aspects.	- CMWSSB personnel; EE, ADE and JEE - Prospective contractor	CMWSSB / PMC	Project head / in-charge CMWSSB
Output-4: Improvements to Service Connections and Metering (the capacity development in the acceleration of installation of service connections and water meters and improvement of customer care and publication)						
Conduct Stakeholder/Community consultation	Stakeholder/Community consultation process and minutes of meetings.	Monthly	Potential/existing Water users/consumers will be motivated positively for house connection and installing water meter.	Potential and existing water users/consumers.	CMWSSB/PIU / PMC	Project head /in-charge CMWSSB
Output -5: Protection to temporary loss of livelihoods						

SDG-6 (Sustainable Development Goal-6): Ensure availability and sustainable management of water and sanitation for all						
Project Objective: Improve the efficiency of the existing water distribution network in the Chennai Core City, the central area of the CMA						
Verifiable Indicator	**Means of Verification**	**Frequency of Verification**	**Assumptions**	**Target groups**	**Implementation Responsibility**	**Monitoring Responsibility**
The project affected persons were identified, assessed, and compensated per the prevailing Acts/policies.	Field visits, random physical verification, Community consultation process and minutes of meetings.	Bi-monthly		street vendors/hawkers/any other along the distribution pipeline route	CMWSSB / Prospective Contractor	Project head /in-charge CMWSSB
Labour available in the vicinity of the construction site should be given priority according to their skill level.	Labour engagement records	Monthly		Workers of the Chennai core city.	CMWSSB / Prospective Contractor	Project head /in-charge CMWSSB
Output-6: Conducive labour camp management and risk reduction						
Minimisation of pandemic diseases such as COVID-19 through the implementation of guidelines appropriately.	Record verification and visits to the camps	Once/Month	Labourer/workers will be residing at the camp-site	Labourers/workers at the campsite.	CMWSSB / Prospective Contractor	Project head /in-charge CMWSSB
Minimisation of risk of infectious diseases such as HIV/AIDS through Implementation of Health and Sanitation awareness and education camps.		Thrice/Year	Labourer/workers will be residing at the camp-site	Labourers/workers at the campsite.	CMWSSB / Prospective Contractor	Project head /in-charge CMWSSB
Appropriate working Conditions/ Work Safety	Visual inspection on the utilisation of PPE by workers/labours	Daily	Labourer/workers will be residing at the camp-site	Labourers/workers at the campsite.	CMWSSB / Prospective Contractor	Project head /in-charge CMWSSB
Minimised damage in the removal of temporary construction structures and demobilization of construction machinery	Site supervision and review information.	Daily	Labourer/workers will be residing at the camp-site	Labourers/workers at the campsite.	CMWSSB / Prospective Contractor	Project head /in-charge CMWSSB

11.10 Grievance Redressal Mechanism (GRM)

11.10.1 Present Grievance Redressal Mechanism

As part of improving customer services, Chennai Metro Water (CMWSSB) has formulated and established various Grievance Redressal mechanisms to provide services to the citizens. If the Consumer has a service problem either in respect of water supply or wastewater disposal, they can make the complaint with the Board in the following ways:

- In-person or over the phone by dialling 4567 4567 - 24 x 7 at Complaint Cell operating at Chennai Metro Water Head Office.
- Through E-mail complaints - cmwssb@tn.gov.in.
- Open house meetings are conducted on all second Saturdays in all 15 Area Offices from 10.00 am to 1.00 pm.
- One can also reach us for any complaint and suggestion through online complaints through https://chennaimetrowater.tn.gov.in.

The Grievance Cell functions at Head Office, which handles all types of Grievances received through the specified complaint systems. In addition, the petitions received from the Chief Minister's Special Cell, Amma Call Centre Office of the Minister for Municipal Administration, Rural Development and Implementation of Special Programme, Office of the Mayor, MA&WS Dept. (Secretariat), Office of the Managing Director, Senior Officers of the Board, Government of India petitions, E-mail Complaints, through Mail Section of the Board are also registered at Grievance Cell. The petitions received at Grievance Cell are immediately forwarded to the concerned officer/department for redressal, and corrective measures are taken. Follow up action and replies are sent to the petitioner with a copy to Grievance Cell. However, during the field interaction with CMWSSB users/consumers, they appreciated faster grievance redressal in Sewerage-related complaints than water-related. Hence, some suggestive measures have been specified below for further improvement in the grievance redressal.

11.10.2 Proposed Grievance Redressal Mechanism

Grievance Redressal Mechanism (GRM) is a means by which stakeholders can register their concern about real or perceived actions by the project during construction and operation level, to resolve problems before they escalate. Developing an effective grievance mechanism can help achieve the following objectives:

- open channels for effective communication.
- Demonstrate concern about the stakeholders and their well-being.
- Mitigate or prevent adverse impacts of construction and/or operations.
- Improve trust and respect.
- Provide structures for raising, addressing, and resolving issues that reduce imbalances in power.

- Promote productive relationships.
- Build confidence that the existence of a mechanism does not in any way inhibit their access to legal or judicial recourse processes.

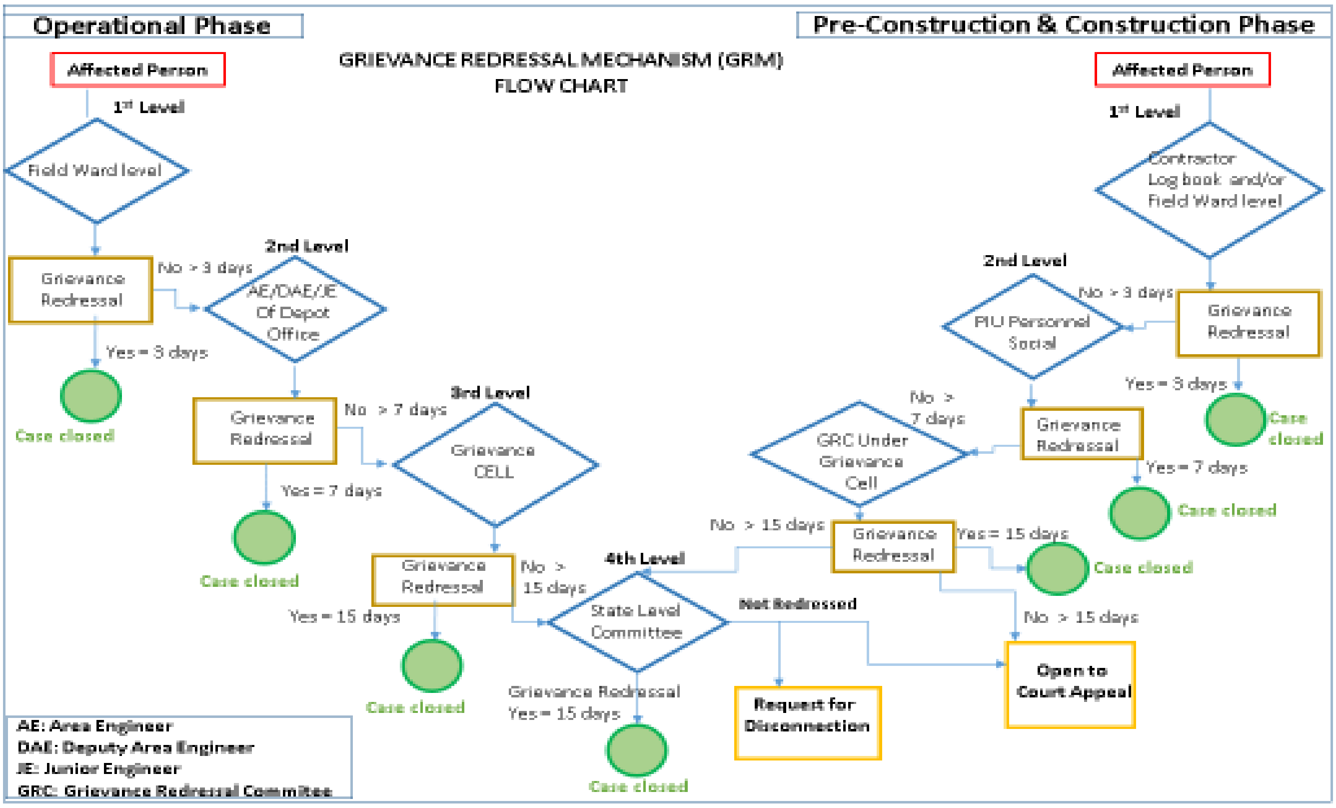


Figure 11.8 Grievance Redressal Mechanism (GRM) Flow Chart

Complementing the current GRM and keeping in view the above objectives, there is some suggestion towards grievance management to ensure that the grievances are dealt with clearly and systematically. Moreover, apart from grievances during the operational stage, grievances are also expected to improve water supply systems. Accordingly, GRM has been bifurcated into “During Construction Period” and “During Operation Period”, including current operation.

METHODICAL STEPS OF GRIEVANCE REDRESSAL MECHANISM (GRM)

Pre-Construction and Construction Phase	Operation Phase

STEP 1: Receive grievance

The staff member receiving the grievance is responsible for documenting and recording the grievance and ensuring that it is entered into the stakeholder engagement database or complaints log.

STEP 2: Preliminary assessment

- Conducting an initial assessment of the grievance and assigning to the relevant person/department.
- Categorisation of Grievance, such as environmental, cultural heritage, land disturbance, recruitment procedures, health and safety, human rights, physical or economic displacement or related to the project.
- Assigning appropriate person/s to deal with the specific details of investigating the grievance.

STEP 3: Respond to grievance

Communicating appropriately to the complainant to acknowledge the grievance and provide information as to expected steps and timing for resolution of the grievance.

STEP 4:Investigate and resolve

- Investigation of the underlying cause(s) and actions needed to prevent recurrence of a similar grievance.
- A grievance resolution report should be completed the earliest. However, the duration may vary between simple examination and complex examination which involves many stakeholders as well as both internal and external factors.
- Containing and resolving actual or potential conflicts and ensure that the complainant is kept informed of the progress of the grievance procedure, especially if a longer period of time is needed to complete the investigation.

STEP 5: Conclusion

- To ensure non-recurrance of grievance, follow the investigation procedure and develop recommendations.
- To ensure complainant/s are satisfied with the proposed resolution, their views about the recommendations should be sought. However, the case load will be the deciding factor in actual engagement of complainant in shoughting views on recommendation.
- If the complainant is satisfied, then sign-off that the grievance has been resolved.

STEP 6: Further action

If the complainant is not satisfied with the proposed solution, initiate further investigation to determine what further action may be taken. In the case that satisfaction cannot be achieved, then the grievance may be referred for third party mediation or external panel review.

STEP 7: Monitoring and evaluation

At various intervals, monthly is ideal, the number of grievances received, resolved and outstanding should be tallied and reported to management and advisers.

Figure 11.9 Methodical Steps of GRM

Citizen-responsive service delivery requires systems and capacities for citizen interface with stakeholders and a responsive and accessible grievance redressal mechanism for resolving the complaints within a stipulated time. Hence, the GRM methodical steps and flow-chart suggest strengthening systems for consumer satisfaction, social audits, and grievance redressal to close the loop for citizen feedback. Accordingly, the complainant's satisfaction should be considered as a precondition for closure

11.10.2.1 During Pre-Construction and Construction Period

Grievances of Affected Persons (APs) will first be brought to the attention of the Contractor, Project personnel, PMC and other implementing partner/s. Their effort should be to immediately resolve the issue on-site in consultation with each other and be required to do so within 3 days of receiving a complaint/grievance. All grievances that cannot be redressed within 3 days at contractor/field/ ward level will be brought to the notice of designated personnel of PIU responsible for social aspects and Social Communication Specialist (SCS) of PMC. PIU personnel coordinating with PMC-SCS should resolve the grievance within 7 days of receipt of complaint/grievance in discussion with the PIU-CMWSSB, the Contractor and other implementing partner/s. All the grievances that PIU does not address within 7 days of receipt will be brought to the Grievance Redressal Committee (GRC) notice under Grievance Cell at CMWSSB. The GRC should be created as a sub-group specifically throughout the project duration for faster response to the grievance; so that disruption to contractor work-in-progress can be avoided. The GRC will resolve the grievance within 15 days of receiving the complaint. An aggrieved person shall *access the country's legal system after the grievance redressal was unsuccessful at GRC. However, appealing to State Level Committee (SLC) for grievance redressal shall have one more level before opting for the country's legal system. The PIU will keep records of all grievances received, including contact details of the complainant*, date of the complaint received, nature of the grievance, agreed corrective actions and the date these were affected, and outcome. The PIU will bear all costs involved in resolving the complaints.

11.10.2.2 Operation/Post Construction Period

Grievances of Affected Persons (APs) will first be brought to the attention at the Ward level of the Contractor, Project personnel, PMC and other implementing partner/s. Their effort should be to immediately resolve the issue on-site in consultation with each other and be required to do so within 3 days of receiving a complaint/grievance. All grievances that cannot be redressed within 3 days at ward level should be brought to the notice of AE/DAE/JE at the respective Zonal level of CMWSSB to resolve the grievance within 7 days of receipt of complaint/grievance. All those grievances which were not addressed within 7 days will be brought to the notice of the Grievance Cell at CMWSSB Head Quarter (HQ). The Grievance Cell will resolve the grievance within 15 days of receiving the complaint; failure to which the complainant/aggrieved person should have the option of appealing to the State Level Committee (SLC) for grievance redressal before opting the country's legal system or request for disconnection of water supply service connection or both.

11.10.2.3 GRM Working Modalities

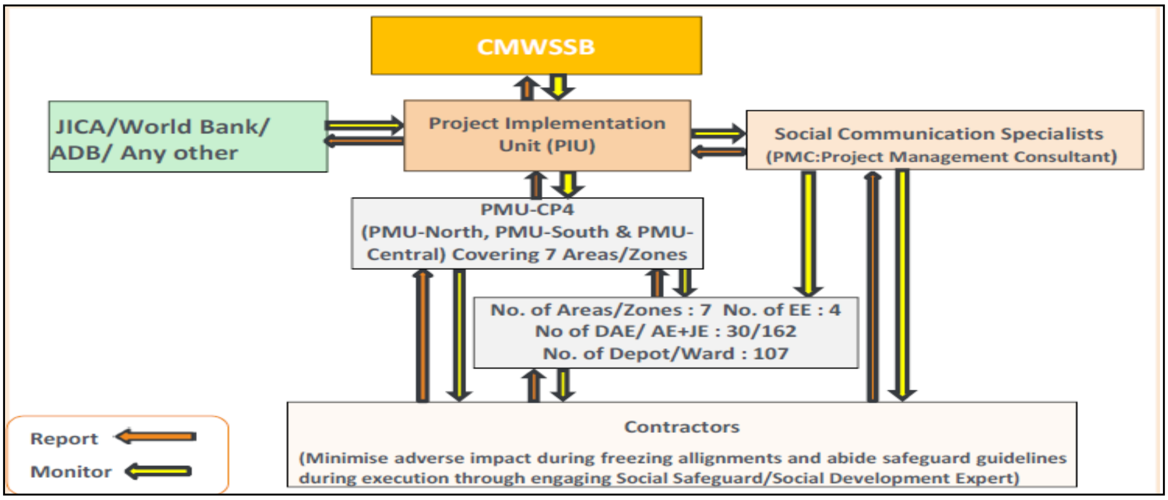
After receiving grievance through telephonic, online and paper-based system/complainant physical visit, are manually forwarded to the concerned offices for redressal. To build up the reliability and confidence level of the consumers on CMWSSB and its operations, the automation in terms of backward and forward linkages for grievance receipt and feedback system should be in place and is desired to be dynamic. Hence, overriding the present manual system of grievance/complaint forwarding, up-gradation in the current Oracle-based platform is expected to be highly beneficial. Accordingly, a four-way complaint receipt system viz.; telephonic, online, paper-based, and mobile app needs to be operative. The mobile app system can be handy for the Chennai city population in the digitalisation era. While telephone calls are operative, adding a toll-free number can be complimentary to the process improvement. Mobile Application "Namma Chennai" launched in 2018 may be considered an additional platform for lodging grievances and feedback.

The GRM should sensibly consider and redress grievances/complaints to facilitate transparency and accountability by communicating its decisions/redress in writing to the complainants within the stipulated period, depending on the nature of complaints. Moreover, when closing the grievance/complaint, the agreement should be made with the complainant on remedy, and both parties sign to their approval/acceptance through mobile app/email/SMS service/Telephonic acceptance through Voice/pressing an assigned number in the keypad.

11.11 Institutional Arrangements

The Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), Government of Tamil Nadu (GoTN) will be the Executing Agency (EA) of the Project and will be responsible for overall strategic approvals, guidance, monitoring the execution of the project. The current Project Implementation Unit (PIU) of CMWSSB will be responsible for the project's overall implementation. PIU will execute and monitor the Component-4 (CP4) implementation through establishing a Project Management Unit (PMU) for CP4. PMU will have direct coordination and support in the implementation and monitoring through the Circle level CMWSSB functionaries majorly comprising of Executive Engineers (EE), Deputy Area Engineers (DAEs), Assistant Engineers (AEs) and Junior Engineers (JEs).

Figure 11.10 Institutional Mechanism for Social Management Plan & Monitoring Guidelines



PIU and PMU-CP4 will be assisted by Project Management Consultant (PMC), who is also an advisor for Design and Supervision comprise of the subject, and sector-specific specialists to provide onsite expert guidance as well as supervise the progress and attainment of drafted specified guidelines by the contractor in compliance to the regulatory mandates. Social Communication Specialists will be interacting regularly with prospective contractors/

contractor's representatives referring to social safeguard compliance and facilitation during a public consultation, particularly house pipe connection and water metering under CP-4.

11.12 Social Policy and Legal Framework

11.12.1 JICA Environmental and Social Framework

JICA requires the consideration of social matters in all aspects of JICA operations and the requirements for social considerations as described in JICA guidelines (April 2010). JICA guidelines endeavour to achieve transparency, predictability, and accountability in supporting and examining social considerations. Also, adherence to International Performance Standards has been suggested.

11.12.2 Screening and Categorisation

The JICA Guidelines' requirement depends on the "project categorization" of the Project, which is stipulated in the JICA Guidelines, as shown in the Table below. However, if the project is likely to have any significant adverse impacts on the environment and society in the Study, the Project may be recategorized as "Category A".

Table 11.10 Project Category in the JICA Guidelines

Category	Description
A	Proposed projects are classified as "Category A" if they are likely to have significant adverse impacts on the environment and society. Projects with complicated or unprecedented impacts that are difficult to assess, or projects with a wide range of impacts or irreversible impacts, are also classified as "Category A". These impacts may affect an area broader than the sites or facilities subject to physical construction. "Category A", in principle, includes projects in sensitive sectors, projects that have characteristics that are liable to cause adverse environmental impacts, and projects located in or near sensitive areas.
B	Proposed projects are classified as "Category B" if their potential adverse impacts on the environment and society are less adverse than those of "Category A" projects. Generally, they are site-specific, few if any are irreversible; and normal mitigation measures can be designed more readily in most cases.
C	Proposed projects are classified as "Category C" if they are likely to have a minimal adverse impact on the environment and society.

Social Impacts are assessed as per: Utilisation of Land and local resources, Involuntary resettlement, Livelihood loss, Existing social infrastructure services, Vulnerable social groups, Indigenous people, Gender equality & Children's Rights, Cultural Heritage, Local conflict of interest, Occupational Safety and Unforeseen impacts if any. Since improving water supply through laying down pipeline does not require land acquisition, involuntary resettlement and rehabilitation fall under Category – 'C' as per JICA's E&S policy. Details of categorisation are available on the JICA website:

https://www.jica.go.jp/english/our_work/social_environmental/id/asia/south/india/c8h0vm0000ahdaf4.html

11.12.3 Regulations, Laws and Permitting

Various acts, rules, policies, and regulations in India deal with social issues that could apply to infrastructure development. Some of the specific regulatory compliance requirements of the sub-project are presented below.

11.12.3.1 Tamil Nadu Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2017

The Act provides transparent and acceptable fair and enhanced compensation and assistance measures. It stipulates a more consultative and participatory approach in dealing with the Project Affected Persons. It emphasizes the rehabilitation and resettlement of the PAPs before implementing the actual project.

11.12.3.2 The Street Vendors (Protection of Livelihood and Regulation of Street Vending) Act, 2014

This act specifically protects urban street vendors' rights and regulates street vending activities. It provides for Survey of street vendors and protection from eviction or relocation; issuance of a certificate for vending; provides for rights and obligations of street vendors; development of street vending plans; organizing capacity building programmes to enable the street vendors to exercise the rights contemplated under this Act; undertake research, education and training programmes to advance knowledge and understanding the role of the informal sector in the economy, in general, and the street vendors, in particular, and to raise awareness.

11.12.3.3 The Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

An Act to recognise and vest the forest rights and occupation in forest land in forest-dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights could not be recorded; to provide for a framework for documenting the rights of the forest so vested and the nature of evidence required for such recognition and vesting in respect of forest land.

11.12.3.4 Right to Information (RTI) Act, 2005

The basic object of the Right to Information Act is to empower the citizens, promote transparency and accountability in the working of the Government, contain corruption, and make our democracy work for the people in a real sense. It says that an informed citizen is better equipped to keep necessary vigil on the instruments of governance and make the government more accountable to the citizens.

11.12.3.5 The operational policy of the World Bank on Social Safeguard

- Indigenous People: This policy applies to positive and negative impacts on the tribal population wherever the project activities are undertaken. Accordingly, the policy creates scope to study whether the project will impact any individual or cluster of tribal people during any project phase.
- Involuntary Resettlement: Involuntary resettlement should be avoided where feasible or minimized, exploring all viable alternative project designs. Where it is not feasible to avoid resettlement, resettlement activities

should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the displaced persons to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to plan and implement resettlement programs. Displaced persons should be assisted in their efforts to improve their livelihoods and living standards or at least restore them, in real terms, to pre-displacement levels or to levels prevailing before the beginning of project implementation, whichever is higher.

- Policy on Access to Information and Disclosure: World Bank safeguards policy requires consultation with PAPs during planning and implementation of resettlement action plan and tribal development plan and public disclosure of drafts. RTFCTLARR, 2017 also requires disclosure of draft SIA and RAP and other project reports followed by mandatory Public hearings. Once the draft is prepared, it is to be made available at a place accessible to, and in a form, manner and language understandable to the displaced or affected people and local NGOs. Consultations with PAPs or interested people, people in the vicinity of the project area are to be done. Public disclosure on the project details, positive/negative social impacts, and feedback must be carried out at appropriate intervals of the project period.

11.12.3.6 ADB's Safeguard Policy

Safeguard policy statements (SPS) are generally operational policies that seek to avoid, minimize, or mitigate adverse environmental and social impacts, including protecting the rights of those likely to be affected or marginalized by the development process. ADB's safeguard policy framework consists of three operational policies on the Environment, Indigenous Peoples, and involuntary resettlement and brings them into a consolidated policy framework that enhances effectiveness and relevance. Accordingly,

i. impacts are to be identified and assessed early in the project cycle;
ii. plans to avoid, minimize, mitigate, or compensate for the potential adverse impacts are developed and implemented; and
iii. affected people are informed and consulted during project preparation and implementation.

11.12.3.7 Salient Features of Key Applicable Labour Laws

1. Payment of Wages Act, 1936: It lays down as to what date the wages are to be paid, when it will be paid, and what deductions can be made from the workers' wages.
2. Minimum Wages Act, 1948: The employer is supposed to pay not less than the Minimum Wages fixed by the appropriate Government as per provisions of the Act if the employee has scheduled employment. Construction of buildings, roads, runways etc., are scheduled employments.
3. The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Cess Act of 1996: All the establishments that carry on any building or other construction work and employ 10 or more workers are covered under this Act. All such establishments are required to pay less at the

rate not exceeding 2% of the construction cost as may be modified by the Government. The Employer to whom the Act applies has to obtain a registration certificate from the Registering Officer appointed by the Government.

4. Inter-State Migrant Workmen's (Regulation of Employment & Conditions of Service) Act, 1979: The Act applies to an establishment that employs 5 or more inter-state migrant workers through an intermediary (who has recruited workers in one state for employment in the establishment situated in another state). The Inter-State migrant workmen, in an establishment to which this Act becomes applicable, are required to be provided certain facilities such as housing, medical aid, travelling expenses from home up to the establishment and back, etc.
5. Employees P.F. and Miscellaneous Provision Act, 1952: The Act provides monthly contribution by the employer plus workers @ 10% or 8.33%. The benefits payable under the Act are:
6. Pension or family pension on retirement or death, as the case may be.
7. Deposit linked insurance on the death in the harness of the worker.
8. Payment of P.F. accumulation on retirement/death etc.
9. Employees Compensation Act, 1923: The Act provides compensation in case of injury, disease or death arising out of and during employment by certain employers to their employees for injury caused to them by accident. It enables an employee, and in case of death of an employee, his dependents, to get, at the cost of his employer, compensation for employment injury if an employee contracts an occupational disease. In contrast, it is also treated under the Act as injury caused by accident in employment.
10. The Personal Injuries (Compensation Insurance) Act, 1963: This Act provides for the employer's liability and responsibility to pay compensation to employees where workers sustain personal injuries in the course of employment. The employer has to give the workers' insurance against the liability. The Act describes the term of major importance under the Act called partial disablement and total disablement.
11. Employer's Liability Act, 1938: This Act protects workers who bring suits for damages against employers in case of injuries endured in the course of employment. Such injuries could be on account of negligence on the employer or persons employed by them in the maintenance of all machinery, equipment etc., in healthy and sound condition.
12. Employee's State Insurance Act, 1948: The Act provides certain benefits to insured employees and their families in case of sickness, maternity, and disablement arising from an employment injury. The Act applies to all employees in factories (as defined) or establishments that the appropriate government may notify. The Act provides for the setting up an Employees' State Insurance Fund, which is to be administered by the Employees State Insurance Corporation. Contributions to the Fund are paid by the employer and the employee at rates prescribed by the Central Government. The Act also provides benefits to dependents of insured persons in case of death due to an employment injury.
13. Payment of Bonus Act, 1965: The Act applies to all establishments employing 20 or more employees. The Act provides for annual bonus payments subject to a minimum of 8.33% of the wages drawn in the relevant year. It applies to skilled or unskilled manual, supervisory, managerial, administrative and technical or clerical work

to hire or reward employees who draw a salary of Rs. 10,000/- per month or less. The employee should have worked in the establishment for not less than 30 working days in the relevant year to be eligible for the bonus. The Act does not apply to certain establishments. The newly set-up establishments are exempted for five years in certain circumstances. Some State Governments have reduced the employment size from 20 to 10 for applicability of this Act.

14. Payment of Gratuity Act, 1972: Gratuity is payable to an employee under the Act on the satisfaction of certain conditions - on separation if an employee has completed 5 years of service or more or on death, the rate of 15 days wages for every completed year of service. The Act applies to all establishments employing 10 or more employees.

15. Labour (Regulation and Abolition) Act, 1970: The Act provides for certain welfare measures to be provided by the contractor to contract labour, and in case the Contractor fails to provide, the same is required to be provided by the Principal Employer by Law. The Principal Employer is required to take a Certificate of Registration, and the Contractor is required to take a license from the designated Officer. The Act applies to the establishments or Contractor of Principal Employer if they employ 20 or more contract labour.

16. Equal Remuneration Act, 1979: The Act provides that no employer shall pay to any worker employed by him in an establishment or employment, remuneration whether payable in cash or in-kind at the rates less favourable than those at which he pays compensation to the workers of the opposite sex in such establishment or employment. The Act further provides that no discrimination should be made against women at the time of recruitment. The Act also does not discriminate against female employees in transfers, training and promotions etc.

17. Maternity Benefit Act, 1951: An Act to regulate women's employment in certain establishments for certain periods before and after childbirth and to provide for maternity benefit and certain other benefits. It provides maternity benefits, including leave, wages, bonuses, nursing breaks etc.

18. Sexual Harassment of Women at the Workplace (Prevention, Prohibition and Redressal) Act, 2013: This Act defines sexual harassment in the workplace, provides for an enquiry procedure in case of complaints and mandates the setting up of an Internal Complaints Committee or a Local Complaints Committee.

19. Child and Adolescent Labour (Prohibition and Regulation) Act, 1986-Amended in 2016: The Act prohibits employment of children and adolescents below 14 and 18 years of age respectively in certain occupations and processes and provides for employment regulation children and adolescents in all other occupations and processes. Employment of child and adolescent labour is prohibited in the Building and Construction Industry.

20. Bonded Labour System (Abolition) Act, 1976: The Act provides for the abolition of the bonded labour system to prevent the economic and physical exploitation of weaker sections of society. Bonded labour covers all forms of forced labour, including arising out of a loan, debt, or advance.

11.13 Social intervention related provisional cost estimation

Considering the expected social interventions specified in earlier sections to improve water distribution and overhead tanks, the following provisional cost is summarised.

Table 11.11 Social Intervention Provisional Cost Estimate

Sl. No.	Items	Unit	Total Units	Cost / unit in INR	Amount in INR. (Construction Period of 2 years)
1	Baseline Study	LS			10,00,000.00
2	Engagement of Social specialist to implement and address related issues	No.	2	25,000.00	18,00,000.00
3	Loss and temporary impacts on local resources/ common resources (Communities and various line departments) (Provisional)	LS			20,00,000.00
4	Public Consultation	No.	12 / year	20,000.00	7,20,000.00
5	Capacity building of executing agency	LS			10,00,000.00
6	Contingency	5%			3,26,000.00
Total (Rupees Sixty Eight Lakh Forty-Six Thousand only)					**68,46,000.00**

12 CHAPTER 12: ENVIRONMENT MANAGEMENT PLAN

12.1 Introduction

In this Chapter, potential impacts on the environment from the proposed Contract Package (CP4) at Area X of Chennai Core city are identified based on the nature and extent of various activities associated during construction and after completion of the Project. The proposed expansion activities will vary on environmental components, both beneficial (positive) and adverse (negative) impacts. These (positive) and adverse (negative) impacts are considered for the impact prediction studies. The details of impact prediction and assessment are given in this Chapter.

12.2 Environmental Setting

1- Weather, Climate and Climate Change

Based on the Indian Meteorological Department (IMD) data, the average and the recorded (maximum and minimum) values are presented in Table 12.1

Chennai has a tropical wet and dry climate. The city lies on the thermal equator and is also on the coast, preventing extreme variation in seasonal temperature. The hottest part of the year is late May to early June, known regionally as *Agni Nakshatram*, with a mean maximum temperature in the Pre-monsoon season (May) was observed at 41.4 °C and mean minimum temperature observed at 24.4 °C. The mean maximum temperature in the monsoon season (June) was 40.2 °C, whereas the mean minimum temperature was observed at 23.8 °C. By the end of September, with the onset of Northeast monsoon (October), day temperatures decrease slightly with the mean maximum temperature at 35.4 °C with the mean minimum temperature at 22.3 °C.

Table 12.1 Climatological Data -IMD, Chennai (Nungambakkam ,1981 -2010)

Month	Mean Temperature		Relative Humidity (%)		Atmospheric pressure (hPa)		Rainfall (mm)
	Min.	Max.	08:30	17:30	08:30	17:30	
January	31.4	18.7	81	67	1014.3	1011.2	25.9
February	33.3	19.5	80	66	1013.1	1009.8	3.4
March	35.5	21.6	78	67	1011.4	1007.7	3.5
April	38.1	23.7	74	70	1009.0	1005.1	14.4

Month	Mean Temperature		Relative Humidity (%)		Atmospheric pressure (hPa)		Rainfall (mm)
	Min.	Max.	08:30	17:30	08:30	17:30	
May	41.4	24.4	67	68	1005.8	1002.2	34.2
June	40.2	23.8	64	63	1004.5	1001.1	55.8
July	38.5	23	70	65	1005.2	1001.9	103.8
August	37.4	23	73	66	1006.0	1002.5	126.8
September	36.9	22.6	77	71	1007.4	1003.9	147.7
October	35.4	22.3	82	76	1009.5	1006.3	315.6
November	32.6	20.3	83	76	1011.8	1008.9	374.4
December	30.7	19.1	81	71	1013.9	1011.0	177.4

2- Relative Humidity

The air is generally very humid in the region, especially during monsoon, when the average relative humidity is around 72 %, with the maximum and minimum of 77% and 71%, respectively. During the pre-monsoon season, the mean maximum humidity is observed at 78%, with the mean minimum humidity at 70% in April. During the winter season, the humidity is in line with the values recorded during the Pre-monsoon season. The mean maximum relative humidity during the winter season is 83%, with the mean minimum humidity at 76% in October and November, respectively. The monthly variation in relative humidity is furnished in Table *12.1*

3- Atmospheric Pressure

Based on the maximum and minimum atmospheric pressure levels recorded from 1981 – 2010 at Nungambakkam station, the maximum pressure was observed in 1014.3 to 1004.5 hPa, with the maximum pressure (1014.3 hPa) occurring during the winter season in January. The minimum pressure observed is in the range of 1011.2 to 1001.1 hPa, with the minimum pressure (1001.1 hPa) occurring during the winter season in June. The monthly variation in pressure levels is furnished in Table *12.1.*

4- Rainfall

It is observed that the northeast monsoon is more predominant than the southwest monsoon. The southwest monsoon sets in the last week of May. About 31% of rainfall is received during the southwest monsoon. The rainfall gradually increases after September (and reaches maximum rainfall in November). The area experienced maximum rainfall (374.4 mm) in November. The northeast monsoon rain occurs between October and December and contributes to 63 % of the total rainfall. Monthly variations in the rainfall for the past 10 years are given in Table *12.1.*

5- Windspeed/ Direction

The wind rose diagrams of the nearest IMD station Nungambakkam – Annual, Pre-monsoon, Monsoon, Post monsoon, and winter seasons have been reproduced from the Wind Rose Atlas published by India Meteorological Department. The annual wind rose prepared from the daily surface wind data recorded at 1200 UTC from 1971 to 2000 from Nungambakkam metrological station indicates that the most frequently occurring direction is from the southeast (SE) followed by winds from east (E) northeast (NE), and south (S). The frequency of winds from the southeast (SE), east (E), northeast (NE) and south (S). The frequency of winds from the southeast (SE), east (E), northeast (NE) and south (S) is 20 %, 13 %, 12 % and 10 %, respectively. The winds rarely blow from a northwesterly direction. The average wind speed of > 4.5 m/s is observed in many directions.

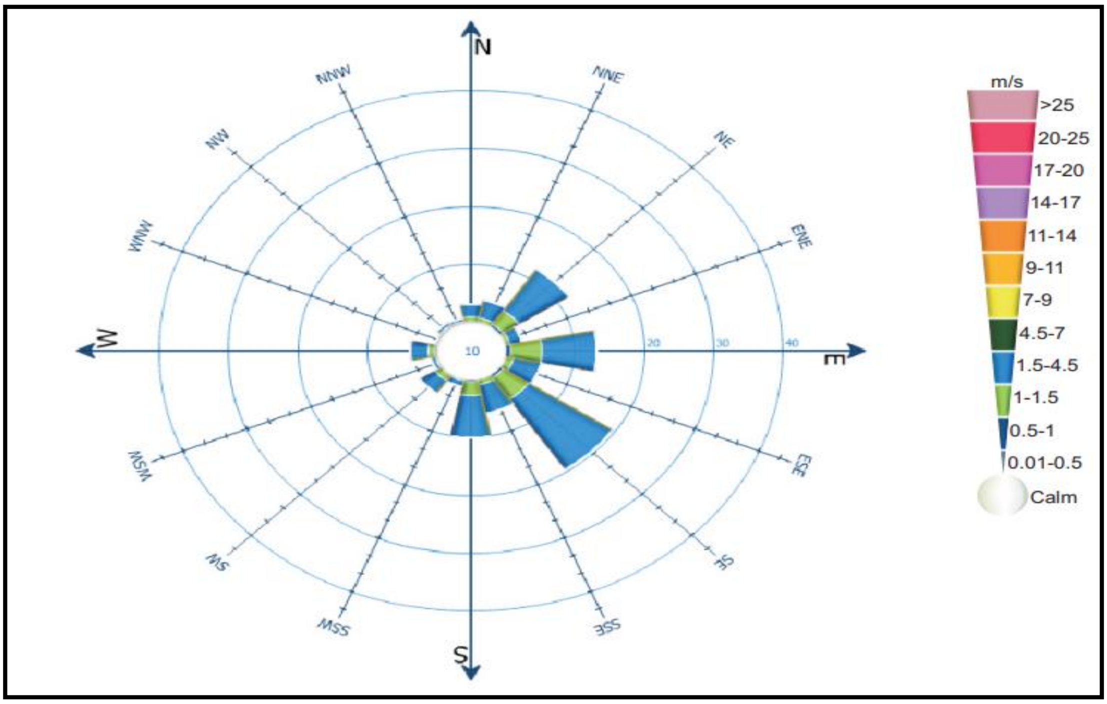


Figure 12.1 Annual Wind Rose IMD Nungambakkam (1971-2000)

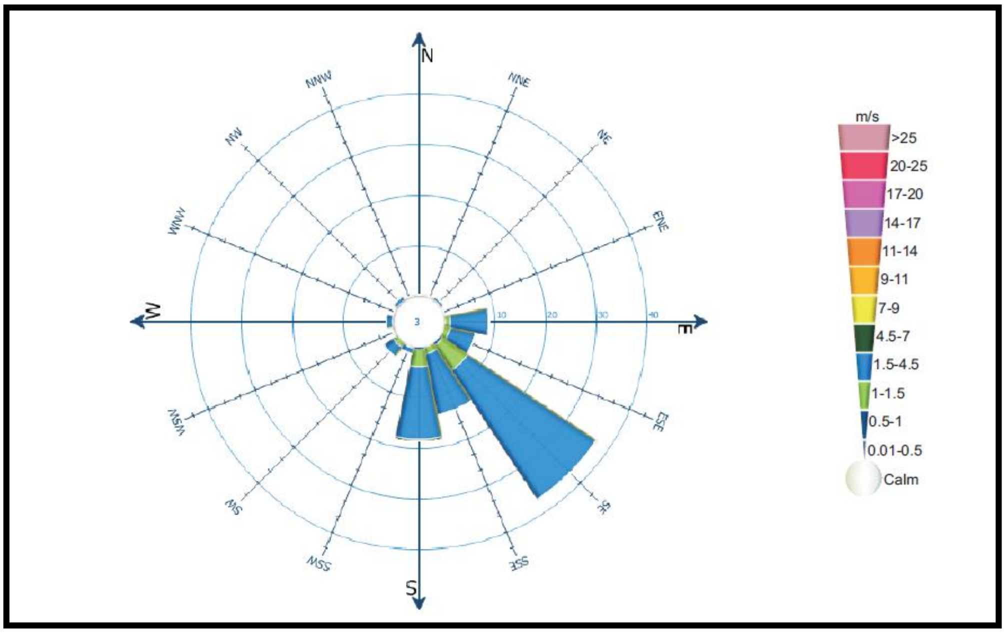


Figure 12.2 IMD Wind rose for Nungambakkam for Pre-monsoon season – May (1971-2000)

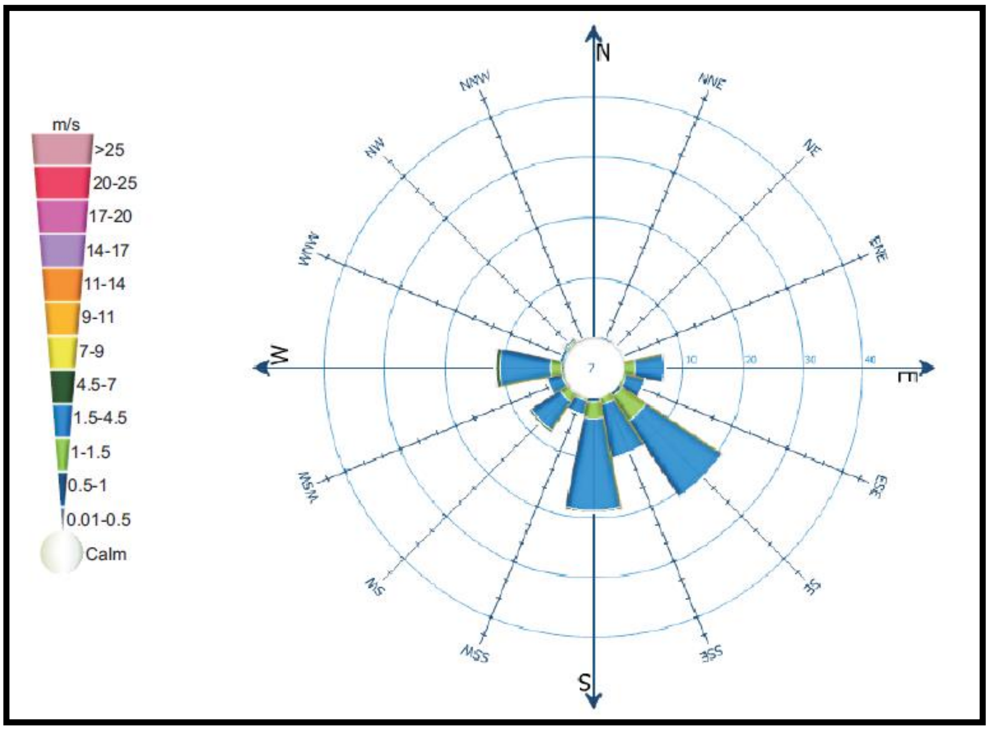


Figure 12.3 IMD Wind rose for Nungambakkam for Monsoon season – June (1971-2000)

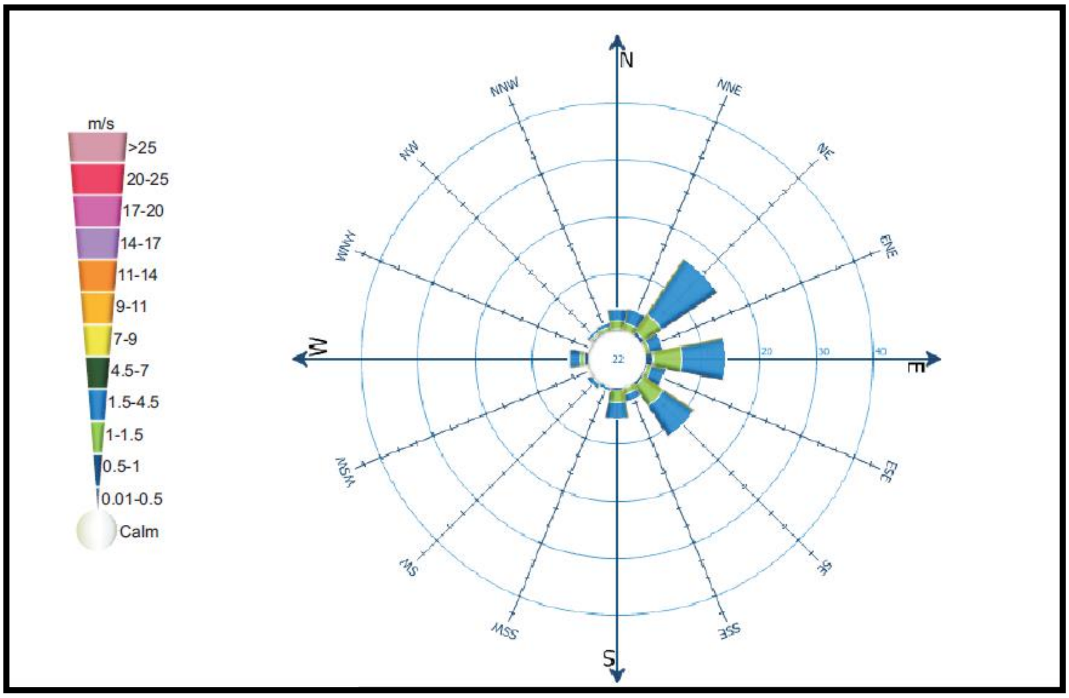


Figure 12.4 IMD Wind rose for Nungambakkam for Post-monsoon season – Oct. (1971-2000)

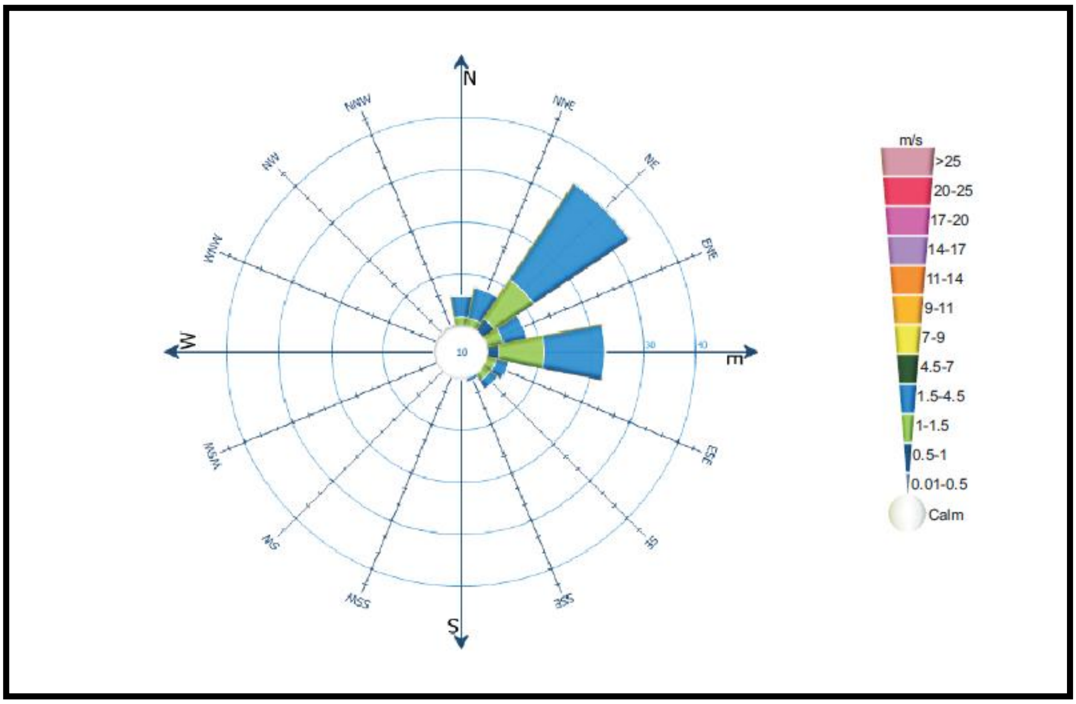


Figure 12.5 IMD Wind rose for Nungambakkam for Winter season – January (1971-2000)

6- Geology

The Chennai Corporation is classified into three regions based on its geological features, i.e., sandy, clayey, and hard-rock areas. The geology of Chennai also comprises clay, shale, and sandstone. Sandy areas are found along the riverbanks and coasts, whereas the clayey regions cover most city areas. Hard rock areas are Guindy, Velachery, Adambakkam, and Saidapet. Rainwater run-off percolates very quickly in sandy areas such as Thiruvanmayur, Adyar, Kottivakkam, Santhome, George Town, Tondiarpet, and the rest of the coastal areas of Chennai. Though the rainwater percolates slowly in the clayey and hard rock areas, it is held by the soil for a longer time. Under the clayey areas, T.Nagar, West Mambalam, Anna Nagar, Perambur and Virugambakkam are enlisted.

As for the water supply improvement subproject in Area X- Kodambakkam is concerned the geology is Sandy and Sandy clay, as shown in Figure *12.6*

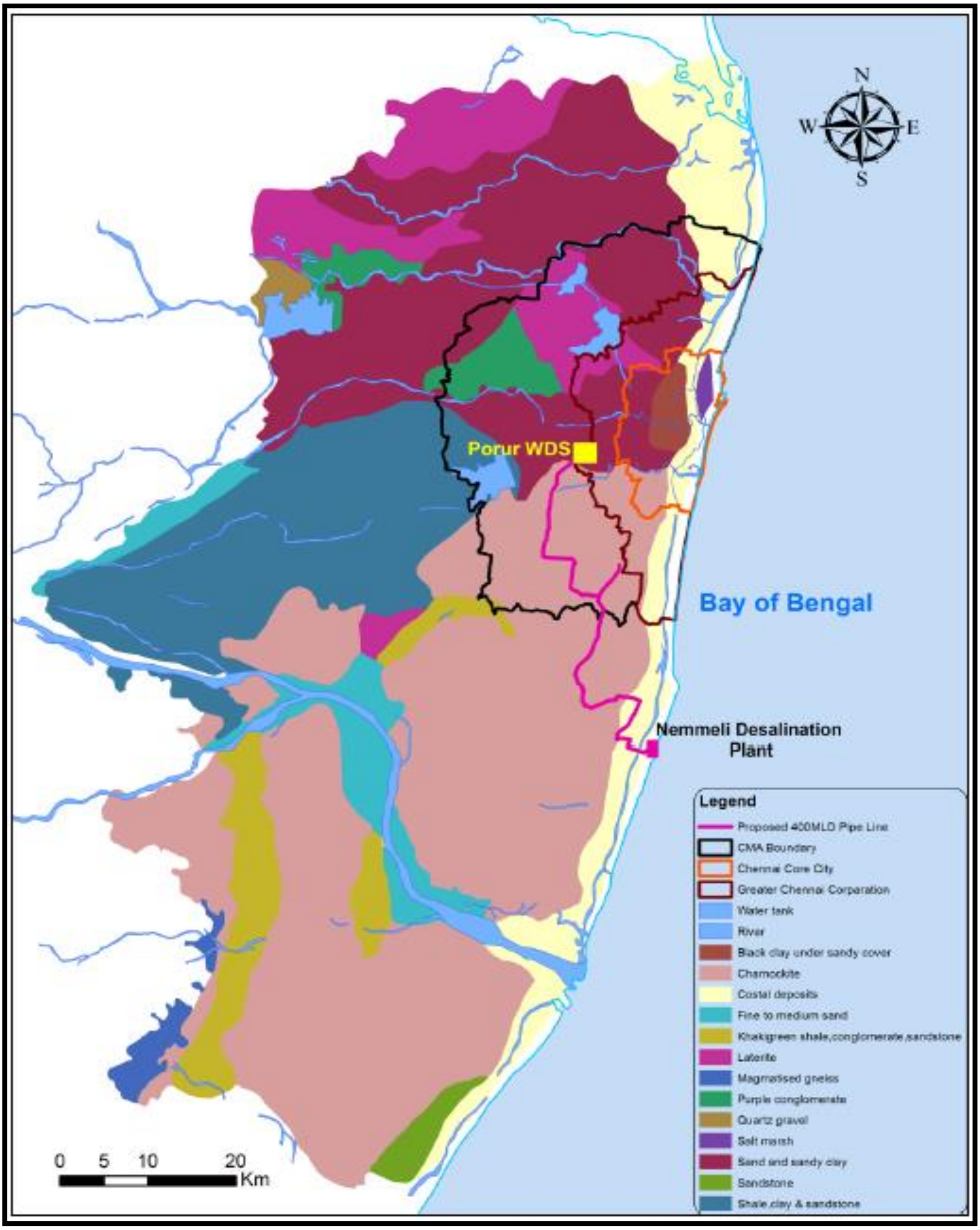
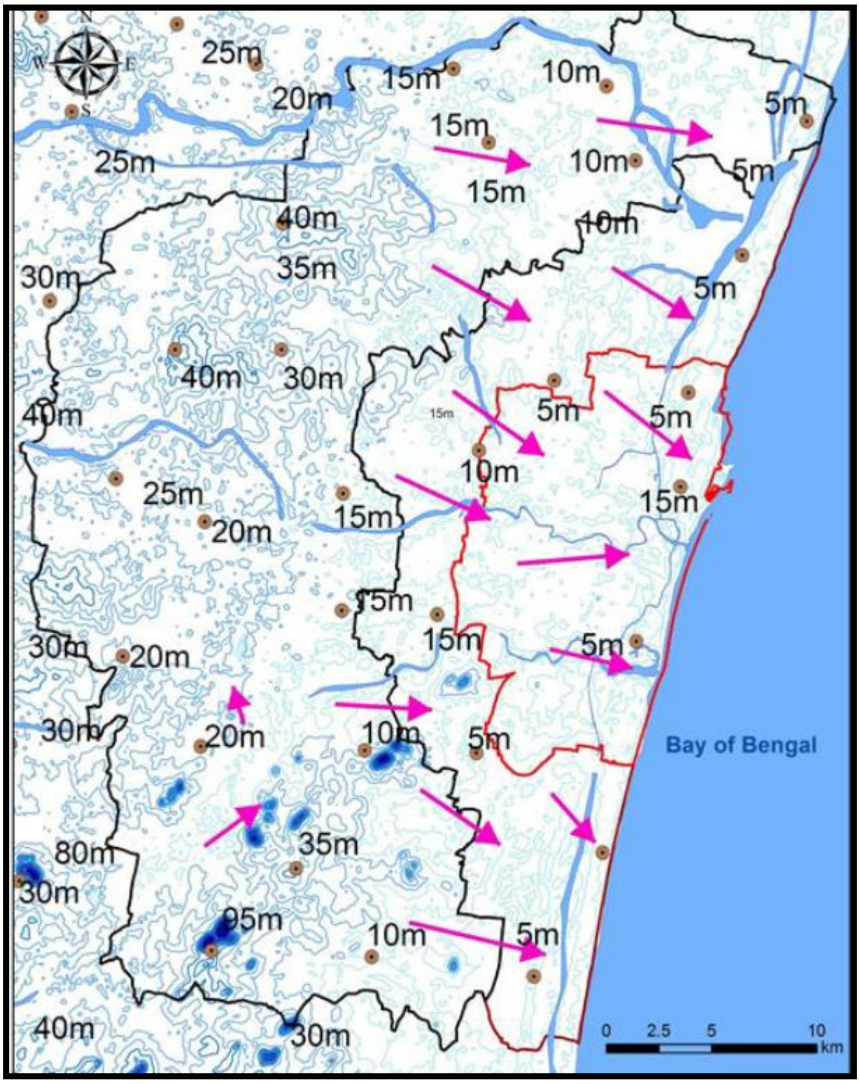


Figure 12.6 Geological Map of Greater Chennai Corporation and surrounding areas

7- Topography

The topography of Chennai is very gentle and varies from 1/5,000 to 1/10,000. It is a low laying area and resembles a pancake. The city's elevation away from the core area increases with the distance from the seashore up to 7 m above the mean sea level (MSL). Moreover, many localities at the MSL affect the drainage system that causes inundation within the city. The general topography of the city is shown in Figure *12.7*

Figure 12.7 Topography of Chennai Metropolitan Area



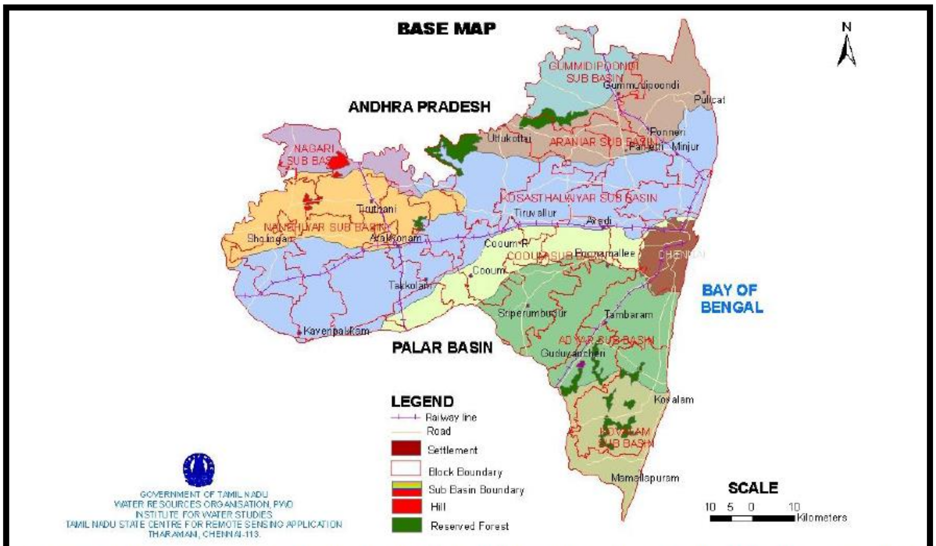
8- Seismology

Bureau of Indian Standards, based on the past seismic history, grouped the country into four seismic zones, viz. Zone-II, -III, -IV and –V. Zone V is the most seismically active region, while zone II is the least. As per the IS:1893 (Part-1) 2016 of Bureau of Indian Standards (BIS), the project location/study area falls in Zone III, categorised as a Moderate Risk Zone. The seismicity map of India is shown in Figure *12.8*.

Figure 12.8 Seismicity map of Chennai Metropolitan Area

9- Hydrology

Figure *12.9* shows eight sub-basins in the Chennai basin. Two major rivers meander through Chennai City - Adyar and Cooum. A third river, Kosasthalayar, flows through the northern fringes of Chennai City before draining into the Bay of Bengal at Ennore. The Buckingham canal flows parallel to the coast linking Coovam and Adyar rivers. The proposed subproject Area X is located between Coovam and Adyar rivers. The site is in the Chennai District, which is located in the Chennai River Basin.



Source: Tamil Nadu State Centre for Remote Sensing Application, Institute for Water Studies, Public Works Department, Government of Tamil Nadu

Figure 12.9 River Sub-Basins in Chennai Basin

12.3 Policy, Legal and Administrative Framework

1- JICA Environmental and Social Framework:

JICA requires the consideration of environmental and social matters in all aspects of JICA operations. The requirements for environmental and social considerations as described in JICA guidelines for environmental and social considerations (April 2010) are to be considered for any project to be financed by JICA loan. JICA guidelines endeavour to achieve transparency, predictability, and accountability in support of and examination of environmental and social considerations.

Screening and Categorisation

JICA Guidelines requirement depends on the "project categorisation" of the Project, which is stipulated in the JICA Guidelines, as shown in Table 12.2. Based on the Initial Environmental Examination, the subproject shall be categorised under "Category B. However, if the Project is likely to have any significant adverse impacts on the environment and society in the study, the Project may be recategorized as "Category A".

Table 12.2 **Project Category in the JICA Guidelines**

Category	Description
A	The projects are classified as "Category A" if they are likely to have significant adverse impacts on the environment and society. Projects with complicated or unprecedented impacts that are difficult to assess, or projects with a wide range of impacts or irreversible impacts, are also classified as "Category A". These impacts may affect an area broader than the sites or facilities subject to physical construction. "Category A", in principle, includes projects in sensitive sectors, projects that have characteristics that are liable to cause adverse environmental impacts, and projects located in or near sensitive areas.
B	The projects are classified as "Category B" if their potential adverse impacts on the environment and society are less adverse than those of "Category A" projects. Generally, they are site-specific; few are irreversible; in most cases, normal mitigation measures can be designed more readily.
C	The projects are classified as "Category C" if they are likely to have a minimal adverse impact on the environment and society.

2- Applicability of Various World bank Safeguard Policies:

Environmental requirements of the World Bank are specified in detail in its Operational Policy (OP) 4.01 and other related Operation Policies. In instances where the procedural and regulatory requirements differ, the more stringent applies. The World Bank environmental requirements are based on a three-part classification system.

- Category A- projects require a full Environmental Assessment (EA).
- Category B-projects require a lesser level of environmental investigation.
- Category C-projects require no environmental analysis.

Table 12.3 World Bank Safeguard Policies

S. No.	Safeguard Policy	Key features	Assessment of Project Area
1	OP/BP 4.01 Environmental Assessment	Potential environmental consequences of projects identified early in the project cycle. EA and mitigation plans are required for projects with significant environmental impacts or involuntary resettlement. EA should include analysis of alternative designs and sites, or consideration of "no option" Requires public participation and information disclosure before Board approval.	Applicable to this Project.

S. No.	Safeguard Policy	Key features	Assessment of Project Area
2	OP/BP 4.04 Natural Habitats	Prohibits financing of projects involving "significant conversion of natural habitats unless there are no feasible alternatives". Requires environmental cost-benefit analysis. Requires EA with mitigation measures.	Not applicable, Since schemes to be taken up under the project would not convert or degrade natural habitats.
3	OP/BP 4.36 Forestry	Prohibits financing for commercial logging operations or acquisition of equipment for use in primary moist tropical forests.	Not Applicable to the Project.
4	OP/BP 4.12 Involuntary Resettlement	Implemented in projects which displace people. Requires public participation in resettlement planning as part of EA for Project. It is intended to restore or improve the income earning capacity of displaced populations.	Not Applicable The Project will ensure that people are not displaced. Scheme components will be cited within Government lands.
5	OP/BP 4.20 Indigenous Peoples	The purpose is to ensure indigenous peoples benefit from bank-financed development and avoid or mitigate adverse effects on indigenous peoples. Applies to projects that might adversely affect indigenous peoples or targeted beneficiaries. Requires participation of indigenous peoples in the creation of "indigenous people development plans".	The Project will ensure that people are not displaced. Scheme components will be cited within Government lands.
6	OP/BP 4.11 Physical Cultural Resources	The purpose is to assist in preserving cultural property, such as sites with archaeological, paleontological, historical, religious and unique cultural values. Generally, it seeks to assist in their preservation and avoid their elimination.	Not Applicable to the Project. No existing cultural property will be damaged.

S. No.	Safeguard Policy	Key features	Assessment of Project Area
		Discourages financing of projects that will damage cultural property.	However, any cultural relics, if found during any excavation during the Project works, will be deposited with the relevant Government authority, whose recommendation regarding further excavation will also be taken

Based on data and information collected during the field survey and visualising potential associated impact, the Project has been categorised as Category B per World bank guidelines. Therefore, this Project requires environmental assessment with a lesser level of environmental investigation.

3- Project Categorisation based on TNUIFSL's Environmental Climate change and Social Management Framework (ECSMF, 2016)

The urban infrastructure projects are expected to improve general living standards within urban localities. However, depending on location and the nature of project activities, these projects will have varying impacts on the urban environment.

The rigour of environmental assessment required to identify and mitigate the impacts largely depends upon the complexities of project activities. TNUIFSL has categorised the projects into different categories – E1, E2 and E3 linked to the severity of impacts and regulatory requirements to facilitate effective screening and address the issues from infrastructure projects. The Environmental screening form filled for the proposed subproject is furnished under Annexure 12.1.

Table 12.4 TNUIFSL Categorization of Projects

Category	Description		Type of Project
	Level of issues	Management Measures	
E-1	Major Environmental issues expected	Project-specific EA by an independent agency	Projects impacting sensitive environmental components Projects triggering the World Bank Ops 4.01, 4.11, 4.04, 4.36 Projects requiring Environmental clearance as per EIA notification of MoEF& CC.
E-2	Moderate Environmental issues expected	Project-specific EA along with DPR	Projects with less adverse impacts than the E1 category are mostly generic. Projects triggering the World Bank OP 4.01
E-3	Minor Environmental issues, if any expected	Generic EMP	Projects with minor environmental impacts are expected.

E2 category as per ECSMF is similar to the Environmental Category B of the World Bank Safeguard Policy. These impacts are site-specific, and, in most cases, mitigation can be designed more readily than for E1 projects.

4- Project Categorisation based on ADB Safeguard Policy (SPS June 2009)

ADB requires the consideration of environmental issues in all aspects of the Bank's operations, and the requirements for environmental assessment are described in ADB's Safeguard Policy Statement (SPS), 2009. As per the Government of India Environmental Impact Assessment (EIA) Notification, 2006, this subproject do not require EIA study or environmental clearance.

As per ADB Safeguard Policy Statement (SPS), 2009, the subproject is classified as environmental **Category B**. The subproject's potential adverse environmental impacts are less adverse than category A and are site-specific. In most cases, mitigation measures can be designed more readily than category A projects. An initial environmental examination (IEE) is required to be in place for the Category B project.

12.4 Regulations, Laws and Permitting

Environmental Assessment: The Government of India Environmental Impact Assessment (EIA) Notification of 2006 (replacing the EIA Notification of 1994) sets out the requirement for Environmental Assessment in India. This states that Environmental Clearance is required for specified activities/projects, and this must be obtained before any construction work or land preparation (except land acquisition) may commence. Projects are categorised as A or B depending on the scale of the Project and the nature of its impacts.

Category A projects require Environmental Clearance from the central Ministry of Environment, Forests and Climate Change (MoEF &CC). The proponent is required to provide preliminary details of the Project in the prescribed manner with all requisite details, after which an Expert Appraisal Committee (EAC) of the MoEF&CC prepares comprehensive terms of reference (TOR) for the EIA study. On completion of the study and review of the report by the EAC, MoEF&CC considers the recommendation of the EAC and provides the Environmental Clearance if appropriate.

Category B projects require environmental clearance from the State Environment Impact Assessment Authority (SEIAA). The State level EAC categorises the Project as either B1 (requiring EIA study) or B2 (no EIA study) and prepares TOR for B1 projects within 60 days. On completion of the study and review of the report by the EAC, the SEIAA issues the Environmental Clearance based on the EAC recommendation. The Notification also provides that any project or activity classified as category B will be treated as category A if it is located in whole or in part within 10 km from the boundary of protected areas, notified areas or interstate or international boundaries.

None of the components of this Water supply subproject falls under the ambit of the EIA Notification 2006, and, therefore, EIA Study or Environmental Clearance is not required for the subproject.

Besides EIA Notification 2006, various other acts, rules, policies, and regulations in India deal with environmental issues that could apply to infrastructure development. The specific regulatory compliance requirements of the subproject are shown in Table 12.5

Table 12.5 Specific Regulatory Compliance Requirements for the Improvement of Existing Water Supply System and Allied works

Policy/ Law	Description	Requirement	Project Phase/ Applicability
National Environment Policy (NEP), 2006.	NEP is a comprehensive guiding document in India for all environmental conservation programs and legislation by central, state and local Governments. The dominant theme of this policy is to promote the betterment of livelihoods without compromising or degrading environmental resources. The policy	The projects should adhere to the NEP principle of "enhancing and conserving environmental resources and pollution abatement".	All phases of the Project

Policy/ Law	Description	Requirement	Project Phase/ Applicability
	also advocates collaboration methods of different stakeholders to harness potential resources and strengthen environmental management.		
EIA Notification,2006	The EIA Notification of 2006 and 2009 (replacing the EIA Notification of 1994) set out the requirement for environmental assessment in India. This states that Environmental Clearance is required for certain defined activities/projects, and this must be obtained before any construction work, or land preparation (except land acquisition) may commence. Projects are categorised as A or B, depending on the scale of the Project and the nature of its impacts. Category A projects require Environmental Clearance from the National Ministry of Environment, Forest and Climate Change (MoEF & CC). Category B projects require Environmental Clearance from the State Environmental Impact Assessment Authority (SEIAA).	Pipeline laying and Construction of OHTs not classified under EIA notification, 2006	Not Applicable
CRZ Notification, 2019	To impose restrictions on activities, operations and processes within the Coastal Regulation Zone (CRZ)	Kodambakkam (Area X) does not fall under the CRZ area.	Not applicable
Water (Prevention and Control of Pollution) Act of 1974, Rules of 1975, and amendments	Control of water pollution is achieved by administering conditions imposed in consent issued under the Water (Prevention and Control of Pollution) Act of 1974. These conditions regulate the quality and quantity of effluent, the location of discharge and the frequency of monitoring of effluents. Any component of the project that can generate sewage or trade effluent will come under the purview of this Act, its rules and amendments. Such projects must obtain Consent to Establish (CTE)	Pipeline laying and Construction of OHTs are proposed.	Applicable during the construction phase

Policy/ Law	Description	Requirement	Project Phase/ Applicability
	under Section 25 of the Act from Tamil Nadu State Pollution Control Board (TNPCB) before starting implementation and Consent to Operate (CTO) before commissioning. The Water Act also requires the occupier of such subprojects to take measures for abating the possible pollution of receiving water bodies.		
Air (Prevention and Control of Pollution) Act of 1981, Rules of 1982 and amendments.	The subprojects that can emit air pollutants into the atmosphere must obtain CTE under Section 21 of the Air (Prevention and Control of Pollution) Act of 1981 from TNPCB before starting implementation and CTO before commissioning the Project. The occupier of the project/facility is responsible for adopting necessary air pollution control measures for abating air pollution.	Pipeline laying and Construction of OHTs are proposed	Applicable during the Construction phase and operation phase
The Motor Vehicles Act, 1988 (59 of 1988) (14 Oct. 1988)	The subprojects have the potential to emit smoke and vapour carrying air pollutants, and enforcement of other applicable rules as per the motor vehicle act As per Rule no 115. Emission of smoke, vapour, etc., from motor vehicles and Rule no 116. Test for smoke emission level and carbon monoxide level for motor vehicles of the Central Motor Vehicles Rules, 1989	A pollution under control (PUC) certificate is required for all construction and vehicle used for the subproject.	Construction phase
Environment (Protection) Act, 1986 and CPCB Environmental Standards.	Emissions and discharges from the facilities to be created or refurbished, or augmented shall comply with the notified standards notified.	National ambient air quality standards for air and noise to be followed during the construction phase.	Construction phase
Noise Pollution (Regulation and	Rule 3 of the Act specifies ambient air quality standards regarding noise for different areas/zones.	Contractors are required to ensure all noise-	Construction phase

Policy/ Law	Description	Requirement	Project Phase/ Applicability
Control) Rules, 2002 amended up to 2010.		producing activities during civil works conform to applicable standards	
Municipal Solid Wastes Management Rules, 2016	Rules to manage municipal solid waste generated; provides rules for segregation, storage, collection, processing and disposal.	The solid waste generated at proposed facilities shall be managed and disposed of in accordance with the Rules.	Construction phase
Construction and Demolition (C&D) Waste Management Rules 2016	C&D waste generated during the construction phase needs to be managed as per this rule.	The C&D waste generated during the construction phase needs to be transported to a designated place for disposal in consultation with the Corporation and Tamil Nadu Pollution Control Board (TNPCB)	Construction phase
Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016	According to the Rules, hazardous wastes have constituents specified in Schedule II of the Rules if their concentration is equal to or more than the limit indicated in the said schedule.	Hazardous waste such as Paints, varnishes etc., the excavated material is are to be stored and disposed of only in such facilities as may be authorised by the TNPCB for the purpose.	Construction phase
Forest (Conservation) Act, 1980 and Forest Conservation Rules, 2003 as amended	As per Rule 6, every user agency, who wants to use any forest land for non-forest purposes, shall seek approval from the Central Government.	Tree cutting permission required to be obtained from the Chennai corporation	Not applicable
Manufacture, Storage, and Import of Hazardous Chemical Rules, 1989	Defines hazardous chemicals • Stipulates rules, procedures to manufacture, storage and import hazardous chemicals • Requires permission, authorisation from various agencies if the total storage exceeds specified quantity; requires an emergency management plan	Requires permission, authorisation from various agencies if the total storage exceeds specified quantity; for the hazardous material used for the Project like fuel oil for DG sets, Storage of Chlorine (threshold quantity greater than 10 tons, but less than 25 tons)	Chlorine tonners usage for disinfection. However, the quantities to be stored shall be less than 5 tons.

Policy/ Law	Description	Requirement	Project Phase/ Applicability
Indian Explosives Act, 1884, Explosive rules, 2008, Gas cylinder rules, 2004	Set of acts and rules to provide a grant of approval, licences for, storage of explosives, prescribing safe procedures and methods	Grant of licence for storing fuel oil, lubricants, diesel, Chlorine gas cylinders etc. at the project site - Chief Controller of Explosives/ as applicable	
The Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act 2010	The Rules designate areas within a radius of 100m and 200m from the "protected property/ monument/ area" as "prohibited area" and "regulated area", respectively. Henceforth, no permission for construction of any public projects or any other nature shall be granted in the prohibited areas of the protected monument and protected area. In respect of the regulated area, the Competent Authority may grant permission for construction, reconstruction, repair and renovation based on the recommendation of the National Monument Authority duly taking note of heritage bye-laws, which shall be prepared in respect of each protected monument and protected area.	There is no protected property/ monument/ area" as "prohibited area" and "regulated area" on the project corridor.	Construction phase
The National Green Tribunal (NGT) Act, 2010	Being a dedicated tribunal for environmental matters with the necessary expertise to handle environmental disputes. NGT provides effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources, including enforcement of any legal right relating to the environment and giving relief and compensation for damages to persons and property and matters connected in addition to that. NGT has jurisdiction over matters related to Water Act, 1974; Water Cess Act,	Stakeholders / affected persons may approach NGT to resolve Project induced environmental issues	Construction phase

Policy/ Law	Description	Requirement	Project Phase/ Applicability
	1977; Forest (Conservation) Act, 1980; Air Act, 1981; Environment (Protection) Act, 1986; Public Liability Insurance Act, 1991; and Biodiversity Act, 2002. Consequently, no other court will have jurisdiction over the matters related to the environment falling under the above-referred Acts.		

The proposed Project involves the Improvement of the existing Water Supply Distribution Network, including the construction of Overhead tanks (OHTs) in Area X of Chennai core city. The Project involves revamping the existing distribution network to provide equitable water (flow, pressure) supply with uniform frequency at all nodes of the zones, including improvements of the internal distribution system, including house service connection and metering.

In the case of this Project, (i) most of the individual elements involve simple construction and operation, so impacts will be mainly localised and not greatly significant; (ii) most of the predicted impacts are associated with the construction process and are produced because that process is invasive, involving excavation and earth movements; and (iii) being mostly located in an urban area, will not cause a direct impact on biodiversity values. The Project will be in properties held by the local government, and access to the project location is through public rights-of-way and existing roads; hence, land acquisition and encroachment on private property will not occur.

12.5 Clearances/ Permissions to be obtained by Contractor

The indicative list of Clearance and Permissions required for the proposed Project is furnished in Table *12.6.* The Principal Employer and Contractor should ascertain the requirements and obtain all necessary clearances/ permission before construction and during the operation phase.

Table 12.6 **Clearances and Permissions Required for Improvement in Water supply System**

Sl. No.	Construction activity	Statutory authority	Regulatory requirement	Implementation responsibility	Supervision
1.	Laying of Water distribution Pipelines and OHTs	Ministry of Environment and Forests and Climate Change (MoEF & CC)	Coastal zone regulations, 2019	Contractor	PIU -CMWSSB

Sl. No.	Construction activity	Statutory authority	Regulatory requirement	Implementation responsibility	Supervision
2.	Generation potential to emit air pollution (including but not limited to diesel generators and vehicles)	Tamil Nadu Pollution Control Board (TNPCB)	Consent to Establish/ Operate from the State Pollution Control Board under the Air Act 1981	Contractor	PIU -CMWSSB
3.	Generation of Municipal solid waste	Tamil Nadu Pollution Control Board (TNPCB)	Authorization under MSW (M&H) Rules 2016	Contractor	PIU-CMWSSB
4.	Noise generation	Tamil Nadu Pollution Control Board (TNPCB)	Noise pollution (Regulation and Control) rules, 2000 and its amendments, 2010	Contractor	PIU-CMWSSB
5.	Tree cutting	Department of Forest and District Collector	Clearances from the authorities as per the Tamil Nadu Timber Transit Rules,1968 or latest/ Greater Chennai Corporation	Contractor	PIU-CMWSSB
6	Laying of Water distribution Pipelines along National Highways and State highways	National Highways and State highways authority	No objection certificate to be obtained	Contractor	PIU-CMWSSB

12.6 Summary of Clearances required during the Construction stage of Project

The following clearances are required before construction and during the construction stages of the Project:

- Chief Engineer, State Highways, Guindy, Chennai – for obtaining permission for the works to be carried out on State Highways.
- Superintending Engineer, Public Works Department (PWD), Chennai – for obtaining permission for the works to be carried out on Nallahs and rivers under PWD control
- Department of Forest and District Collector, Chennai District – for obtaining permission to cut the trees during execution.

- Superintendent of Police, Chennai District – for obtaining permission to divert the traffic / to declare one-way traffic during the construction stage.
- Respective Regional Head for shifting utilities like Electrical Post, Telephone Cables etc.
- Tamil Nadu Pollution Control Board – for installation of Batching Plant
- No objection certificate from Southern Railways for railway crossing.

Table 12.7 indicates the list of National and State Highways in Area X.

Table 12.7 National and State Highways in Area X

S.NO.	Type	Name	Estimated Length in m
1	National Highway	NH-4	1344
2	State Highway	Inner ring road (100 Feet Road) (SH-2)	5163
3	State Highway	Arcot Road (SH-113)	4850

Water bodies (Nallahs/ Ponds and rivers) within Area X - Coovam river

Feeder main (450 dia.) from Valuvarkottam WDS to United colony OHT crosses the railway track close to Kodambakkam railway station under Kodambakkam bridge in Arcot road as per the proposed design.

Maps indicating the road and rail networks and water bodies are presented in Figure *12.10*

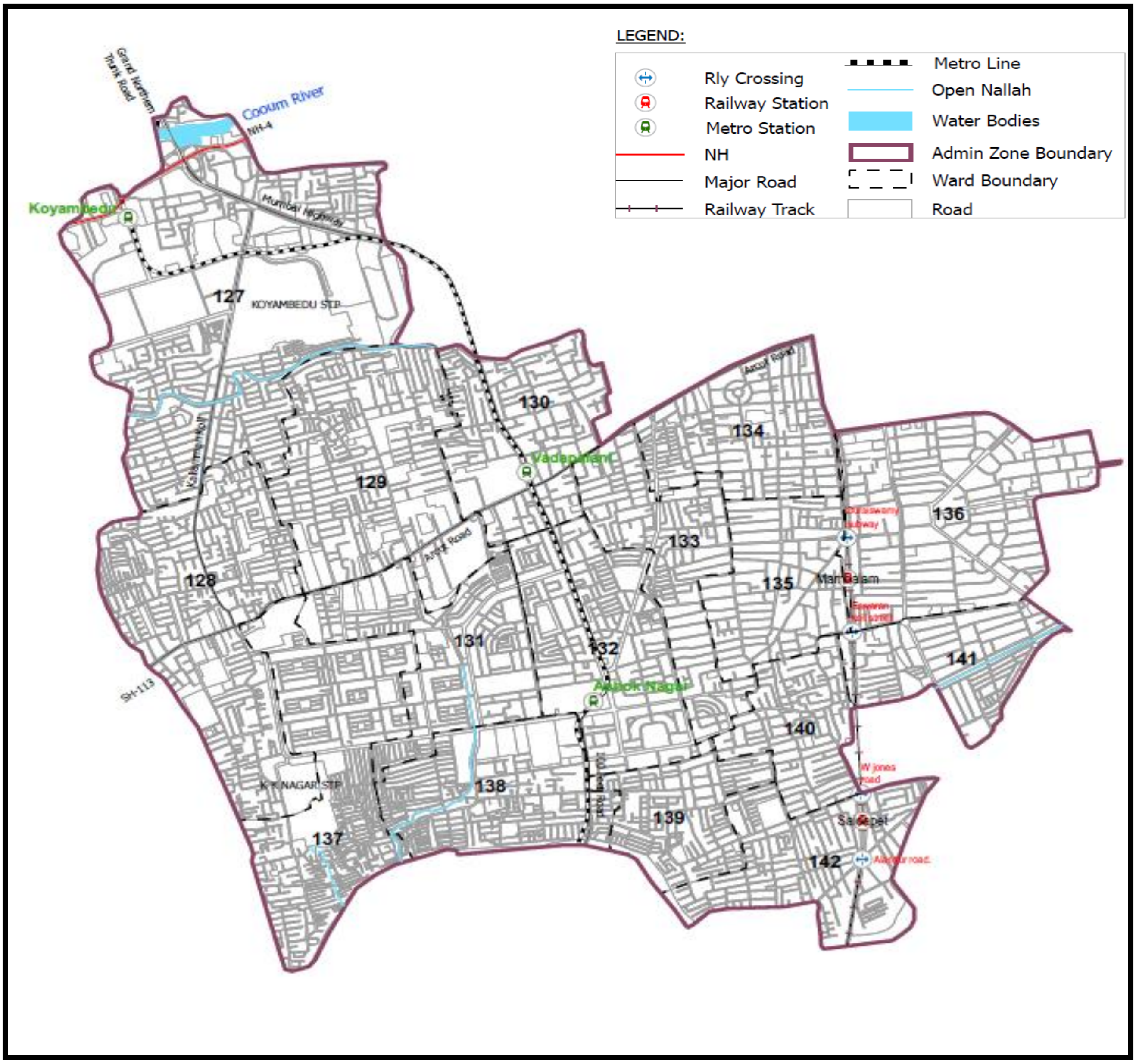


Figure 12.10 Area X map Indicating NH/ SHs and Rail network

12.7 Anticipated Environmental Impact Identification, Prediction and Assessment

Impact can be defined as "any alteration of environmental conditions or creation of a new set of environmental conditions, adverse or beneficial, caused or induced by the action or set of actions under consideration".

Potential environmental impacts of the proposed infrastructure components are presented in this section. Mitigation measures to minimise/mitigate negative impacts are recommended, along with the agency responsible for implementation. Monitoring actions during the implementation phase is also recommended to reduce the impact.

The proposed project is likely to create impacts on the environment in two distinct phases of the project, namely:

- During the construction phase, which may be regarded as temporary or short term; and
- During the operational phase, which will have long-term effects.

The construction and operational phases of the proposed Project comprise various activities, each of which will impact one or more environmental parameters. Various impacts during the project's operational phase have been studied to estimate the environmental impact and are discussed briefly in the subsequent sections. The existing environmental features of the proposed locations are furnished in Annexure 12.2

Impacts

1- Air Environment:

The potential ambient air quality impacts arising from the proposed water supply improvement project would occur mainly during the construction phase. The project would have two major impacts on ambient air quality during construction: increased gaseous emissions by heavy construction equipment's vehicles and increased dust by construction activities. The dust levels in the OHTs construction areas are expected to increase substantially during construction activity, a temporary impact. Similarly, the trenching work for pipelines will generate considerable dust pollution along the pipeline routes.

Earth excavation work, material storage, transportation and handling of construction materials, and wind erosion are the major factors that would produce a temporary, localised increase in PM 10 and PM 2.5 levels. The earthmoving operations and the emissions from equipment will be the largest contributors of emissions. The dust emissions will vary substantially daily based on activity level, specific operations, and prevalent meteorological conditions. The site grading operations will entail bringing material into the site or transporting excess cut material off-site, resulting in PM10 emissions.

Operation DG sets as a standby power backup system would generate gaseous emissions. However, as DG sets are standby, the impacts are insignificant. The degree of dust generated would depend on the soil compaction and moisture content of the ground surface during construction. Dust and exhaust particulate emissions from heavy equipment operations would temporarily degrade air quality in the immediate construction zone. The performance of the work would minimise the increase in air particulates. The construction contractor should visually monitor dust levels on the site during construction. Dust suppression will be instituted, using water tankers mounted on tractors, sprinklers, and other means as necessary if high dust levels are observed, strong winds and dry conditions make dust generation likely, and complaints about dust are received.

No component of the proposed improvement in the water supply system is a source of air pollution during operation except DG sets which would be operated only during power failures.

Material Handling, Transportation and Storage

- To minimise the dust from open area sources, including storage piles, control measures such as installing enclosures and covers and increasing the moisture content will be used.
- Suitable cover material such as tarpaulin sheets shall be used for haul trucks to prevent fugitive emissions during transportation of construction materials.
- For minimising dust from material handling sources, water suppression will be employed.
- The excess fill material shall be transported and stockpiled prior to loading into the truck.
- Limited vehicular movement shall be permitted on disturbed soils;
- All unpaved roads used for vehicular movement shall be watered daily, and the vehicle speeds will be restricted to 25 mph;
- During backfilling, the material will be emptied slowly to prevent the generation of dust plumes;
- The drop height shall be kept to a minimum while unloading/screening of material;
- The haul trucks shall be loaded in such a way that the freeboard is not less than six inches when the material is transported on any paved road;
- Contractors shall be required to maintain valid PUC – Pollution under Control certificates and maintain proper maintenance records for their fleet as part of the contract bid and at regular intervals throughout the contract's life. A monetary incentive/disincentive provision shall be established to encourage contractors to comply with regular maintenance requirements
- Downwash of trucks (especially tyres) shall be done before departure from site to reduce the mud and dirt carryout.

The overall impact on the air quality is assessed to be moderate; however, with mitigation measures, the impact can be contained with minor residual impacts.

2- Noise Environment

The major sources of noise pollution from the proposed Project are the construction activities, movement of vehicles and operation of construction equipment and DG sets etc. The noise likely to be generated during excavation, loading and transportation of material will be in the range of 90 to 105 dB (A), and this will occur only when all the equipment operates together and simultaneously. This is, however, is a remote possibility.

The workers in general are likely to be exposed to an equivalent noise level of 80 to 90 dB (A) in an 8-hours shift, for which all statutory precautions are taken into consideration. However, careful planning of machinery selection, operations, and operations scheduling can reduce these levels. There will be an increase in the ambient noise level during the pipe laying period. Staggering construction equipment operations could mitigate the impact on sensitive areas. Considering the onsite noise levels, Personal Protective Equipment (PPE) such as earmuffs, etc., to the construction workers are to be provided.

The noise generation during construction activities would be considerable and may potentially impact the health of construction workers. The impacts during the construction phase shall be temporary and marginal on the surrounding communities.

No component of the proposed water supply system is a source of noise pollution during operation except DG sets which would be operated only during power failures.

3- Land Environment

Soil erosion may be caused by exposure of soil surfaces to rain and wind during site clearing, earthmoving, and excavation activities. The mobilisation and transport of soil particles may, in turn, result in sedimentation of surface drainage networks, which may result in impacts on the quality of natural water bodies and, ultimately, the biological systems that use these waters.

The construction and decommissioning activities will also include storage, handling and disposal of petroleum-based products such as lubricants, hydraulic fluids, or fuels during their storage, transfer, or use in equipment. The improper storage, handling and disposal of these products may pose a risk of potential leakage and contamination of the land. The disposal of sewage/sludge on land can also lead to soil contamination.

The construction activities will also generate waste such as construction debris, site clearance, excavated materials, and municipal solid waste from labour colonies. The dumping of municipal waste can lead to soil contamination, and the leaching of the waste material can cause contamination of the surface and groundwater resources in and around the dumping site.

Excavation of soil is required for the structures of OHTs construction. The excavated soil will be utilised in the OHT site to fill the foundations and site grading. Since the quantity of earthwork involved in the Project is not significant, no significant changes in the topography of the project area are anticipated due to the Project.

Mitigation

Each Project shall implement the mitigation measures listed below based on the applicability to the individual Project's activities and processes.

Soil Erosion Control Measures

- Major activities about site grading and excavation for foundation and backfilling will be avoided during monsoons and shall be planned for dry season;
- Surface run-off from the construction site and exposed areas will be diverted using dykes, drainage swales or ditches. The method of choice will depend on the size of the drainage area and the steepness of the slope;
- Retention wall or bund shall be provided around the storage areas for excavated soil and other construction material to check the flow of sediments with stormwater in case of rain;

- Excavated soil shall be used/ transported at the earliest for filling low lying areas at the site for raising of level as planned;
- Proper routing and adequate capacity of the stormwater run-offs drains with catch pits shall be provided at all construction sites;
- Completed earthworks will be sealed and re-vegetated as soon as reasonably practicable with the help of a landscape expert;
- The excavated soil material shall be stacked in earmarked areas. It is advised to be dumped properly and stabilised with grass and trees or utilised for greenbelt development to avoid its washing due to rains;
- Moreover, the washed soil will also be arrested by creating garland drains, leading to settling pond/s to allow its settling and avoid mixing with surface water and result in their silting.

Prevention of Contamination

- Storage facilities will be designed within the paved surface, provided with a covered shed and adequate containment facility at the construction site to prevent contamination of soil due to accidental spills of lubricating oil, fuel oil, paints, thinners, varnishes, chemicals etc.;
- Storage of machine oil used oil and grease will be provided with adequate secondary containment to avoid any soil contamination;
- Adequate hazardous waste collection and storage facilities shall be provided in a designated place away from stormwater drains or watercourses with proper access control and proper labelling;
- All the hazardous waste containers will be properly labelled with the waste being stored and the date of generation;
- The hazardous waste shall not be stored for more than 90 days at the site and will be sold to authorised recyclers;
- The contractors shall maintain an inventory of the hazardous waste generated and sold to recyclers;
- Portable spill containment and clean up equipment will be available at the site, and training in the equipment deployment will be imparted to the contractors;
- Covered garbage bins shall be provided for the construction camps and will be collected and transferred to the existing/proposed waste management facilities;
- The construction waste shall be used as a fill material for the low-lying areas and construction of roads;
- Empty containers, which may contain some toxic substances such as paints, solvents, adhesives and sealants shall be returned to the manufacturers or disposed of appropriately as the case may be;
- Waste generated will be segregated into biodegradable and non-biodegradable contents. All biodegradable waste from the kitchen will be collected for secondary use, such as animal feed or vermicompost. Other biodegradable wastes to be collected and disposed of in humus pits generated onsite for subsequent use as manure;

- Construction wastes from the site, such as metal cuttings debris, plastic packing material, wooden logs etc., will be segregated and kept in specially identified waste bins. All metal scrap will be sold while concrete waste/debris and other inert materials that cannot be recycled to be crushed and reused for level raising onsite or in road/pavement development within site;
- Hazardous wastes including used oil, waste oil and residue containing oil or other hazardous substances will be stored at a designated place at all construction sites for disposal through authorised vendors approved by the State Pollution Control Board;
- Paintbrushes and equipment for water and oil-based paints shall be cleaned within a contained area and shall not be allowed to contaminate site soils, watercourses, or drainage systems;
- Segregation of potentially hazardous waste from non-hazardous construction site debris;
- The contractor shall educate the workers and subcontractors about hazardous waste storage and disposal procedures;
- After the labour camps are evacuated to complete work, the septic tanks shall be abandoned and filled with earth.

The overall impact on the soil resources is assessed to be moderate to high. It is assessed that the overall impact can be maintained as minor with implementing suggested mitigation measures.

Table 12.8 Possible Impacts on Environment

Project Activities	Components of Environment						
		Air		Water		Biodiversity	
	Land	Air Quality	Noise	Surface Water	Ground Water	Flora	Fauna
Clearing & Cutting	Yes	Yes	Yes	No	No	Yes	No
Excavation & Filling Operations	Yes	Yes	Yes	No	No	No	No
Disposal of excavated Soil	Yes	Yes	No	No	No	No	No
Construction Camps	Yes	No	No	Yes	No	No	No

4- Water Environment

The impact on water resources and quality from the construction phase of the project arises from the following:

- Requirement of water for construction and labour camps
- Sediment runoff from the construction area
- Disposal of sewage from construction camps

The construction activities will require the setting up of construction camps. The labour camps will require water for the domestic consumption of workers and housekeeping. It is expected that during the construction phase, there will be the generation of sewage from construction camps and rejected water from testing of overhead tanks and pipelines during the commissioning of the Project. There is a potential for contamination of surface and groundwater resources resulting from improper sewage management. Besides, the water requirement for construction will put additional pressure on the local water resources.

The construction activities will disturb topsoil, rendering it vulnerable to erosion and run-off. The potential impact on water quality can be due to the escape of excavated soil along the existing channels where the loose silt and sand could be washed along the surface drainage. Improper storage of excavated soil, raw material for construction and debris can lead to contamination/siltation of adjoining water bodies. There is potential for soil and groundwater contamination due to spillage and migration of fuel, lubricants, etc., being used for heavy machinery and generators.

Mitigation

Each sub-project's mitigation measures shall be implemented in different WDZs based on their applicability to the activities and processes. Construction activities close to water channels shall ensure a greater degree of precautions and effectiveness of implementation.

Water Consumption

- Water for the construction phase will be source authorised by the proponent.
- The construction campsites will put in place optimal water conservation measures along with adequate awareness measures for the workforces.
- Temporary toilet facilities shall be made available in Construction camps.

Run-off Management

- All the debris resulting from construction activities shall be removed from the site regularly to prevent their run-off. Secondary containment and bund shall be provided around excavated soil or loose construction material to prevent run-off to nearby water bodies;

- Construction operations shall be scheduled and performed so that preventative soil erosion control measures are in place before excavation in critical areas and temporary stabilisation measures immediately following backfilling operations. This would ensure the minimal area for cut and fill, thereby maintaining the slopes;
- The storage area shall be kept away from the stormwater drain to prevent any wash away into water bodies outside the facility;
- Construction activities shall ensure silt traps and bunds around the construction area before commencement of any other activity to avoid any run-off to adjoining natural water bodies.
- Implement a rainwater harvesting system for all the project sites for effective recharge of groundwater during the rainy season

The overall impact on the water resources is assessed to be moderate; however, with mitigation measures, the impact can be contained with minor residual impacts.

<u>5- Impact on Traffic and Transport</u>

The construction phase will entail transportation of construction materials, cut and fill material to and from site and transportation of labour. National Highway - 45, Anna Salai, falls within Area X. The internal road connectivity within the site is reasonably good.

It is assumed that the construction phase will involve many additional trucks per day to transport materials. The additional traffic during the construction phase will add to the traffic along existing roads and may lead to traffic congestions, and may cause a reduction in speeds. Also, the turning movement of vehicles to construction camps may lead to further travel time.

The construction activities will not be limited to areas around the major roads and will be accessed through internal roads.

Mitigation

The following mitigation measures are suggested for minimising the impacts on traffic and transportation. The proponent will implement these measures:

- The construction site will be provided with an exclusive entry and exit point of the construction vehicle.
- The proponent shall ensure that the access roads to the construction sites are developed well in advance to facilitate smooth movement of traffic;
- The vehicles to be employed during the construction phase will be checked for fitness. The contractor shall be responsible for maintaining the maintenance records and 'Pollution Under Control' certificates;
- The contractor shall train the drivers regarding the traffic rules and management provisions. The contractor shall maintain training records;

The overall impact on the traffic and transportation is assessed to be moderate to high. It is assessed that the overall impact can be maintained as minor with implementing suggested mitigation measures.

12.8 Environmental Management Plan

An Environmental Management Plan (EMP) can be defined as "an environmental management tool used to ensure that undue or reasonably avoidable adverse impacts of the construction, operation of a project are prevented; and that the positive benefits of the projects are enhanced". EMPs are important tools for ensuring that the management actions arising from Initial Environmental Examination (IEE) processes are clearly defined and implemented through all phases of the project life cycle. This plan also helps an organisation map its progress toward achieving continual improvements. The EMP typically consists of the following:

- Identify a range of mitigation measures that could reduce and mitigate the potential environmental impacts to minimal or insignificant levels.
- To identify measures that could optimise beneficial impacts.
- To create management structures that address all the stakeholders' concerns and complaints regarding the development.
- To establish a method of monitoring and auditing environmental management practices during construction and operation phases.
- Describe the practical mitigation measures implemented in pipeline works to prevent or mitigate any negative environmental impacts and enhance positive issues.
- Detail specific actions deemed necessary to mitigate the environmental impact of the Project.
- Ensure that the environment and safety measures are complied with.
- Propose mechanisms for monitoring compliance with the EMP and reporting thereon.
- Establish the roles and responsibilities of Contractor and PIU in the implementation of environmental controls;

The EMP for the proposed water supply improvement project has been prepared in tabular format for the pre-construction, construction and operation phase. The EMP ensures that the resources are utilised to the maximum extent, waste generation is minimised, residuals treated adequately, and by-products are recycled to the extent possible. The details of various environmental issues, environmental mitigation measures, and responsibility for implementation, supervision and monitoring are presented in **Error! Reference source not found.**.

Table 12.9 Environmental Management Plan for the proposed Water Supply Improvement Works

S. No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
I.	**Pre-Construction Stage**			
i	Assure compliance with relevant construction field legislation	All clearances required from other departments for Environmental aspects shall be ensured and made available before the start of work. Acquire construction permits and Provide Water management guidelines. Ensure community consensus and minimum impact to community utilities like a telephone cable, electric cables and electric poles, water taps. Proper clearance must be obtained from the concerned authorities and sent to the PIA before the commencement of works.	Prospective Contractor	CMWSSB
ii	Utility Relocation	• Identify the common utilities that would be affected, such as telephone cables, electric cables, electric poles, water pipelines etc., • Affected utilities shall be relocated with prior approval of the concerned agencies before construction starts. • Alternate temporary arrangements for crossing over shall be provided.	Co-ordination - CMWSSB Execution - Contractor	CMWSSB
iii.	Supply of Material and resources	Procurement of construction material only from permitted sites and licensed/authorised quarries. Identify locally available resources/ materials and eco-friendly materials.	Prospective Contractor	CMWSSB

S. No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
iv.	Water	The Contractor will be responsible for arranging an adequate water supply of the required quantity for the entire construction period. The contractor will minimise the wastage of water during construction.	Prospective Contractor	CMWSSB
v.	Appointment of Environment Health & Safety Officer	The contractor will appoint a qualified and experienced Environmental Engineer /Accident Prevention officer who will work and ensure EMP implementation, including Occupational health and safety issues at the camp and construction work sites.	Prospective Contractor	CMWSSB
vi.	Other Construction Vehicles, Equipment and Machinery	All vehicles, equipment and machinery to be procured for construction/ protection work will conform to the relevant Bureau of Indian Standard (BIS) norms/ CPCB standards. The discharge standards promulgated under the Environment Protection Act, 1986 and Motor Vehicles Act, 1988 will be strictly adhered to. Soundproof DG set as per Environment Protection rules,1986 will be used at the project site. The contractor will maintain Pollution Under Control (PUC) certificates for all vehicles used during the contract period. The contractor will be produced to the Project Implementation Unit for verification whenever required.	Prospective Contractor	CMWSSB
vii	Land selection	Site selection is to be based on proper design considerations and study of the area's geology, hydrology, and topography to minimise the impacts.	Design Consultant	CMWSSB
viii.	Project development and design – Structural damages in OHT's &	Proper structural design should be considered concerning terrain and soil characteristics, hydrology, and geology.	Design Consultant	CMWSSB

S. No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
	Pumping stations and flooding of nearby areas			
ix.	Baseline Parameters (Environmental Monitoring)	(i) Baseline parameters shall be recorded and ensure conformance until the project's completion. (ii) The contractor shall undertake periodical air, water, noise and soil quality through a NABL approved monitoring agency. The monitoring parameter, frequency and duration of the monitoring plan shall be prepared. Adequate measures shall be taken and checked to control any pollution, and a report is sent to the Engineer.	Prospective Contractor	CMWSSB
x.	Planning of temporary Traffic arrangements	The activities are limited to the project sites and right of way. During the execution of works, as per the need in the site, necessary permissions for temporary diversion will be obtained. Signages and safety measures, including flagmen, are provided at the site.	Prospective Contractor/ CMWSSB	CMWSSB
xi	Storage of materials	The contractor shall identify the site for temporary use of land for construction sites /storage of construction materials, etc.,	Prospective Contractor	CMWSSB
xii.	Tree Cutting	i)Try to save the trees by changing the alignment ii) Provide adequate protection to the trees to be retained with three guards (e.g. Masonry tree guards, Low-level RCC tree guards, Circular Iron Tree Guard with Bars) as required. ii) Identify the number of trees affected by girth size & species type along with the sewer mains, pumping/lifting station sites, and sewerage treatment plant sites. The details are to be indicated in a strip map plan.	Prospective Contractor	CMWSSB

S. No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
		iii) Trees shall be removed from the construction sites before the commencement of construction with prior permission from the Forest department. iv) Undertake afforestation in nearby areas. v) Compensatory plantation by way of Re-plantation of at least twice the number of trees cut should be carried out in the project area.		

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
II	**Construction Phase**							
i.	Laying of distribution pipelines	Water quality	Short Term Reversible	Water contamination Traffic disruption	Traffic regulation: Adequate actions to direct and regulate traffic shall be taken with PIU, Dept. of Police to prevent jamming of roads during construction. While planning alternative routes, care to be taken to minimise congestion and negative impacts at sensitive receptors such as Schools & hospitals.	Design consultant	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Adequate precautions should be taken while laying the water distribution lines to avoid the possibility of cross-connection with the sewer lines.			
ii.	Shifting of community utilities	___	Short Term Localised Reversible	Delay in execution	Ensure community consensus and minimum impact to community utilities like a telephone cable, electric cables and electric poles, water taps. Proper clearance must be obtained from the concerned authorities and sent to the PIU before the commencement of works. Using modern machinery such as JCBs, backhoes etc., shall be used to minimise the construction period.	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
iii.	Disposal of construction debris and excavated materials.	Water Quality Air Quality	Short Term Reversible	Negative Impact of water quality The negative impact of Air quality	A suitable site should be identified for safe disposal, in relatively low-lying areas, away from the water bodies, residential and agricultural fields etc., and approved by the Engineer. Care should be taken that dumped material does not affect the natural drainage system. Minimise the construction debris by balancing the cut and fill requirements. All vehicles delivering material to the site shall be covered to avoid material spillage.	Prospective Contractor	Prospective Contractor	CMWSSB
iv.	Dust Pollution near settlements	Air Quality	Short Term Localised Reversible	Negative Impact of air quality	Unpaved haul roads near / passing through residential and commercial areas to be watered a day thrice. Trucks carrying construction material to be adequately covered to avoid dust pollution and material spillage.	Prospective Contractor	Prospective Contractor	CMWSSB
v.	Vehicular noise pollution at residential /	Noise Quality	Short Term Localised	Impacts due to Noise generation	Idling of temporary trucks or other equipment should not be permitted during periods of loading/unloading or when they	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
	sensitive receptors		Reversible		are not in active use. The practice must be ensured, especially near residential/commercial/sensitive areas. Construction activity-induced noise levels shall be mitigated at the residential and sensitive receptors. The Contractor shall employ mitigation measures as directed by the PIU. Stationary construction equipment will be kept at least 500m away from sensitive receptors. All possible and practical measures to control noise emissions during drilling shall be employed. The PIU may direct to take adequate controls measures depending on site conditions.			
vi.	Protection of residential / sensitive receptors.	Noise quality	Short Term Localised	Noise quality in residential and sensitive receptor	Noisy construction operations in residential and sensitive areas shall be within the norms stipulated by TNPCB. Preventive maintenance of construction equipment and vehicles to meet emission standards and keep low noise.	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Provision of enclosing generators and concrete mixers at the site. Sound barriers in inhabited areas shall be installed during the construction phase. Adequate barricading/other measures to protect dust pollution near sensitive receptors like schools and hospitals etc. to be ensured.			
vii.	Barricading site	Human safety and property loss	Short Term Localised	Accidents	The construction site should be barricaded at all times in a day with adequate marking, flags, reflectors etc. for the safety of general traffic movement and pedestrians	Prospective Contractor	Prospective Contractor	CMWSSB
viii.	Safety Aspects	Human safety and property loss	Short Term Localised	Accidents	Adequate precautions shall be taken to prevent accidents and from the machinery. All machines used shall confirm the relevant Indian standards Code and be regularly inspected by the PIU. Provide temporary crossing/bridges wherever necessary to facilitate normal life and business	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Shoring and strutting shall be provided to avoid soil collapse where loose soil is met. The contractor shall supply all necessary safety appliances such as safety goggles, helmets, belts, earplugs, masks, etc., to workers and staff. A readily available first aid unit includes an adequate supply of sterilised dressing materials and appliances per the Factories Rules in every work zone. Availability of suitable transport at all times to take an injured or sick person(s) to the nearest hospital			
ix.	Chance Found Archaeological Property	___	Short Term Localised	Loss of Archaeological Property	All fossils, coins, articles of the value of antiquity, structures and other remains or things of geological or archaeological interest discovered on the site shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation. The contractor will take reasonable precautions to prevent his workmen or any	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					other persons from removing and damaging any such article or thing. He will, immediately upon discovery and before removal, acquaint the Engineer of such discovery and carry out the SC's instructions for dealing with the same, waiting which all work shall be stopped. The Engineer will seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work on the site.			
x.	Monitoring of Environment parameters				The contractor shall undertake seasonal monitoring of air, water, noise and soil quality through an approved monitoring agency. The parameter to be monitored, frequency and duration of the monitoring plan shall be prepared	Prospective Contractor	Prospective Contractor	CMWSSB
xi.	Clearing of construction of camps and restoration	Water Quality	Short Term Localised	Negative Impact of water quality	Contractor to prepare site restoration plans for approval by the Engineer. The plan is to be implemented by the contractor before demobilisation.	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					On completion of the works, all temporary structures will be cleared away, all rubbish cleared, excreta or other disposal pits or trenches filled in and effectively sealed off and the site left clean and tidy, at the contractor's expenses, to the entire satisfaction of the Engineer			
xii.	Tree protection, Tree Planting	Air and Noise quality	Long Term Localised	Loss of Trees	Giving due protection to the trees that fall in the shoulders /corridor of impact shall be the prime focus during Construction/ post-construction Masonry tree guards, Low-level RCC tree guards, Circular Iron Tree Guard with Bars, use of plate compactors near trees may also be considered where necessary Re-plantation of at least twice the number of trees cut should be carried out along the project road. Since the major portion of the project road may pass through open lands, planting trees along the entire stretch of the road is recommended as an enhancement measure.	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Growth and survival of trees planted shall be ensured, and monitoring is done at least 3 years. Survival status shall be reported every month to the Engineer in charge.			
xiii.	Protection of topsoil & Environmental enhancing	Soil quality	Long Term Localised	Loss of topsoil	The topsoil is to be protected and compacted after completion of work. Topsoil from the Reservoirs/ OHTs area should be stored in stockpiles, and that can be used for gardening purposes at Reservoirs/ OHTs site, which will be an environmental enhancing measure. The topsoil is to be protected and compacted after completion of work, where the pipelines run.	Prospective Contractor	Prospective Contractor	CMWSSB
xiv.	Pollution from Fuel and Lubricants	Soil quality Water quality	Short term Localised	Negative Impact of Soil quality Negative impact of Water quality	The contractor will ensure that all construction vehicle parking locations, fuel/lubricants storage sites, vehicle, machinery and equipment maintenance and refuelling sites will be located at least 500m from rivers and irrigation canal/ponds. All location and layout plans of such sites will be submitted by the Contractor before	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					their establishment and approved by the Engineer. The contractor will arrange for collection, storing and disposal of oily wastes to the pre-identified disposal sites (list to be submitted to Engineer) and approved by the Engineer. The contractor will ensure that all vehicle/machinery and equipment operation, maintenance and refuelling will be carried out so that spillage of fuels and lubricants does not contaminate the ground. All spills and collected petroleum products will be disposed of following MoEF&CC and TNPCB guidelines.			
xv.	Storage of chemicals and other hazardous materials	Soil quality	Short term Localised	Negative Impact of Soil quality	The site was identified for safe storage and handling of chemicals and other hazardous materials provided with proper display of requirements and marking as a protected area.	Prospective Contractor	Prospective Contractor	CMWSSB
xvi.	First Aid	Human safety and property loss	Short term Localised	Loss of Human life	The contractor will arrange for: A readily available first aid unit includes an adequate supply of sterilised dressing	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					materials and appliances per the Factories Rules in every work zone. Availability of suitable transport at all times to take an injured or sick person(s) to the nearest hospital.			
xvii.	Risk from Electrical Equipments	Human safety and property loss	Short term Localised	Electrical related Accidents	The contractor will take all required precautions to prevent danger from electrical equipment and ensure that, No material will be stacked or placed to cause danger or inconvenience to any person or the public. All necessary fencing and lights will be provided to protect the public in construction zones. All machines to be used in the construction will conform to the relevant Indian Standard (IS) codes, be free from patent defect, be kept in good working order, be regularly inspected and properly maintained as per IS provision, and to the satisfaction of the Engineer.	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
xviii.	Informatory signs and Hoardings	Human safety and property loss	Short term Localised	Accidents	The contractor will provide, erect and maintain informatory/ safety signs hoardings written in English and local language, wherever required or as suggested by the Engineer	Prospective Contractor	Prospective Contractor	CMWSSB
III	**Operation Phase**							
i.	Storage of water	Structural failure	Short term Localised	Flooding of the downstream areas; soil erosion; water logging of low-lying areas etc.,	Ensure proper technical design of the storage reservoir/ OHTs to minimise seepage and chances of possible failure of the structure	Prospective Contractor	Prospective Contractor	CMWSSB
ii.				Increased moisture content in the soil, which affects the structures/foundation of buildings in nearby areas	Ensure proper site selection. Ensure proper design, construction and operation of the structure and system to minimise seepage and appropriate implementation techniques.	Prospective Contractor	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
iii.	Collection and Pumping operation	Natural resources	Long term Localised	High energy demand for pumping operation.	Use of energy-efficient pumps Periodical maintenance	Design Consultant	Prospective Contractor	CMWSSB
iv.	Water Management	--	Long term Localised	Water and energy	Control valves would be provided in the inlet of the sump and service reservoirs to control the flow. It can be used to stop the flow until the leakage is rectified. Water meters at pumping stations are used to measure and monitor the flow. In this project, monitoring and controlling the flow in the system will be done with a flow control valve with the help of the SCADA system.	Design Consultant	Prospective Contractor	CMWSSB
v.	Plantation	--	Long term Localised	Environment enhancement	Plantation of Saplings shall be carried out inside the OHTs premises. Growth and survival of trees planted shall be ensured, and monitoring is done at least 3 years. Survival status shall be monitored every month by the Engineer in charge. Turfing shall be made on the margin of land kept for plantation to avoid soil erosion.	Design Consultant	Prospective Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Fencing should be provided around the tree for protection			
vi.	Environmental Monitoring	--			The water, air, soil and noise quality will be monitored during the operation phase as detailed in the report.	Prospective Contractor	Prospective Contractor	CMWSSB
vii.	Online Monitoring System through SCADA	Water quality		Negative Impact of water quality and quantity	Install SCADA System for online monitoring at the Over Head Tank (OHTs)/ Underground reservoirs (UGTs), gathering real-time data from remote locations.	Prospective Contractor	Prospective Contractor	CMWSSB

12.9 Environmental Monitoring Plan (EMoP)

The environmental monitoring programme helps signal the potential problems resulting from the proposed project activities and prompt corrective measures. Environmental monitoring will be required during both construction and operational phases. The following parameters (**Error! Reference source not found.**) are proposed to be monitored:

- Water Quality (Groundwater and Surface water)
- Air Quality
- Noise Intensity
- Soil Quality

Table 12.10 Environmental Monitoring Plan

Air Quality Monitoring	
Project stage	**Construction**
Parameter	PM10, PM 2.5, SOX and NOX
Sampling Method	Use method specified by CPCB for analysis
Standards	Ambient Air Quality Standards, CPCB, 1994, Air (Prevention and Control of Pollution) Act,1981
Frequency	Once every season except monsoon during the construction period
Duration	As per CPCB guidelines for monitoring
Location	Sensitive locations along with the alignment pipeline routing and in OHT sites.
Measures	Wherever air pollution parameters increase above specified standards, additional measures decided by the Engineer shall be adopted.
Implementation	Contractor through approved monitoring agencies
Supervision	Chennai Metropolitan Water Supply and Sewerage Board (CWMWSB)
Water Quality Monitoring	
Project stage	**Construction & Operation period**

Parameter	As per Drinking Water Standards as per IS 10500:2012
Sampling Method	Grab sample to be collected and analysed as per Standard Methods for Examination of Water and Wastewater
Standards	Indian standards for Inland Surface Water (IS: 2296, 1982) and Drinking water (IS:10500,2012)
Frequency	Once every season during the construction and operation period
Duration	Seasonal (4 times a year)
Location	Locations representing water quality from the distribution system.
Measures	At locations of variation in water quality/ increased pollution, remedial measures are to be adopted at the distribution system.
Implementation	Contractor through approved monitoring agencies during construction. CMWSSB during the Operation phase.
Supervision	Chennai Metropolitan Water Supply and Sewerage Board (CWMWSB)
Noise Level Monitoring	
Project stage	**Construction**
Parameter	Noise levels on dB (A) scale
Special guidance	• The free field at 1 m from the Equipment's whose noise level is being determined. • Equivalent noise levels using an integrated noise level meter kept at a distance of 15m from the edge of the pavement.
Standards	National Ambient Air Quality Standards in respect of Noise, Noise Pollution (Regulation and Control) Rules, 2000
Frequency	Seasonal during the construction period
Duration	Reading to be taken at 15 seconds intervals for 15 minutes every hour and then averaged
Location	• Wherever the contractor decides to locate the equipment yard • At sensitive locations such as schools, hospitals etc., along the alignment.

Measures	In case of noise levels causing disturbance to the sensitive receptors, management measures as suggested in the EMP shall be carried out.
Implementation	Contractor through approved monitoring agencies
Supervision	Chennai Metropolitan Water Supply and Sewerage Board (CWMWSB)

12.10 Environmental Compliance Report

The contractor shall submit a monthly progress report as per the reporting format approved by the Engineer on the status of the implementation of the EMP and get it duly approved by the Engineer for its compliance and for proceeding with the work. The Engineer, Environmental / Accident prevention Officer, will have access and authority to monitor the status based on the same and for which the Contractor shall make necessary facilities.

12.11 Risk Assessment

As part of post-project monitoring to manage and control the risk and to mitigate the impacts of the proposed activities and effective functioning of the water supply facilities, it is suggested that an Operation and Maintenance manual shall be prepared and strictly followed. It should include Comprehensive Maintenance Management System (CMMS) Guidelines, Emergency Procedures, Safe handling of Chlorine, Incident Management Plan and Environmental Response Plan. In case of any emergency incident management plan shall be followed to reduce impact due to risk.

12.12 Environmental Management Plan Cost Estimation

The environmental budget for the various environmental management measures proposed for the design, pre-construction, construction, and operation of the water supply improvement project is detailed in the table below.

An environmental management cost provision of about **INR. 45.06 Lakhs** has been kept in the project cost towards the environmental protection, control & mitigation measures. The operation cost of implementing EMP is estimated to be about **INR.12.68 Lakhs** per year. The budgetary cost estimate for the EMP is given in **Error! Reference source not found.**.

Table 12.11 Budget for Implementation of EMP for Proposed Water Supply Improvement Project in Area X

Sl. No.	Management Activities	Unit	Rate	Amount in (INR)
A.	**During Construction Phase**			
1	Sprinkling of water on the exposed site and dust suppression barriers to minimise the generation of dust and respirable suspended particulate matter.	LS		Included in Civil BoQ
2	Providing and Installing 2.5m long permanent type-IV barricade with 2.15m high from road level conforming to IRC-SP 55-2014 including Provision of LED Strip lighting to MS barricades as a safety measure during night hours.			Included in Civil BoQ
3	Costing for Signboards as per IRC specifications			Included in Civil BoQ
4	Costing for Rainwater harvesting system			Included in Civil BoQ
	Environmental Monitoring			
1	Environmental Monitoring during Construction Phase (3 Years)			45,06,000
	Environmental Monitoring cost during the construction phase			**45,06,000**

Sl. No.	Management Activities	Unit	Rate	Amount in (INR)
B.	**During Operational Phase**			
	Environmental Monitoring			
1	Compliance monitoring for Environmental protection (Quarterly Environmental monitoring report submission) for Area X per year - Environmental Monitoring of Air, Noise and Water quality			12,68,000
	Environmental Monitoring cost during Operation phase (per year)			**12,68,000**

12.13 Conclusion and Recommendation

1. The process described in this Chapter has assessed the environmental impacts of all elements of the proposed water supply subproject covering Zone X in Chennai Core City. All potential impacts were identified in relation to pre-construction, construction, and operation phases. Planning principles and design considerations have been reviewed and incorporated into the site planning and design process wherever possible; thus, environmental impacts due to the project design or location were not significant. Mitigation measures have been developed to reduce all negative impacts to acceptable levels. These were discussed with specialists responsible for the engineering aspects, and as a result, significant measures have been included in the designs for the infrastructure.
2. All statutory clearances/ Permission required from other departments for Environmental aspects shall be ensured and made available before the start of construction work.
3. The water body Coovam river is under Zone X. Tender document to be drafted with the requirement that no excavated material during the construction shall be dumped in water bodies or adjacent areas. The site shall be restored to its near original condition after completion of work.
4. Except for pipe laying works, all other construction activities will be confined to the selected sites and minimal interference with the general public and community. There will be temporary negative impacts, arising mainly from construction dust and noise, hauling of construction material, waste and equipment on local roads (traffic, dust, safety etc.,) mining of construction material, occupation health and safety aspects. Pipeline works will be conducted along the edge of public roads in an urban area congested with people, activities and traffic, subproject is likely to have significant impacts during construction. Impacts mainly arise from the construction dust and noise; from the disturbance of residents, businesses, traffic by the construction work, safety risk to workers, public and nearby buildings due to deep trench excavations, especially in narrow roads, dust, access impediment to houses and business, disposal of large quantities of construction waste, etc., These are all general impacts of construction in urban areas, and there are well-developed mitigation methods that are suggested in the EMP.
5. A program will ensure mitigation of environmental monitoring conducted during construction and operation to ensure that all measures are implemented and determine whether the environment is protected as intended. This will include observations on- and off-site, document checks, and interviews with workers and beneficiaries, and any requirements for remedial action will be reported to the PMU. Mitigation and

monitoring measures and the project agency responsible for such actions form part of the Environmental Management Plan.

6. Once the new system is in place, the facilities will operate with routine maintenance, not affecting the environment. Improved system operation will comply with the O&M manual and standard operating procedures for all the activities.
7. The EMP will assist the project agencies and contractors in mitigating the environmental impacts and guide them in the environmentally sound execution of the proposed Project. A copy of the updated EMP shall be kept on-site during the construction period at all times. The EMP shall be made binding on all contractors operating on the site to ensure compliance to the conditions set out in EMP and EMoP.
8. The new water supply system will provide safe drinking water of acceptable standard for the public, improving the overall public health in the project area. Diseases due to poor water quality, such as Cholera, diarrhoea and dysentery, will be reduced, so people should spend less on healthcare and lose fewer working days due to illness, so their economic status should also improve as their overall health.
9. The prospective contractor shall update this IEE during the beginning of the implementation phase to reflect any design changes.

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

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