Republic of India

Chennai Metropolitan Water
Supply and Sewerage Board

Republic of India
Preparatory Survey on
Chennai Seawater Desalination Plant
Project

Final Report
Appendices

February 2017

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd.
INGÉROSEC Corporation
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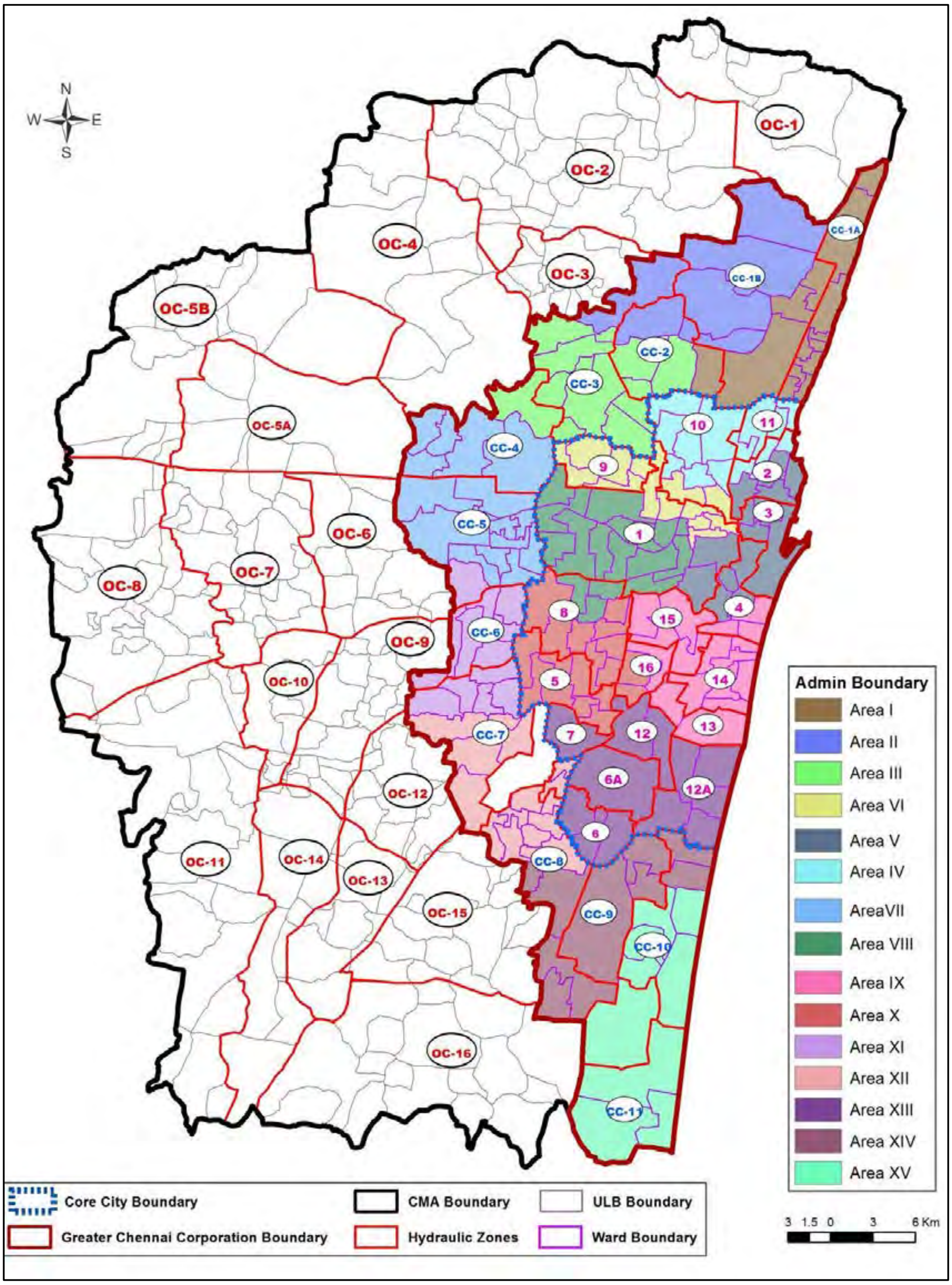
Appendix 2.1 Map of CMA with Administrative Boundaries and CMWSSB's Administration Area & Water Distribution Zone (WDZ) Boundaries

A2.1.1 Administrative Boundaries of Wards and ULBs, Administrative Boundaries and WDZs of CMWSSB

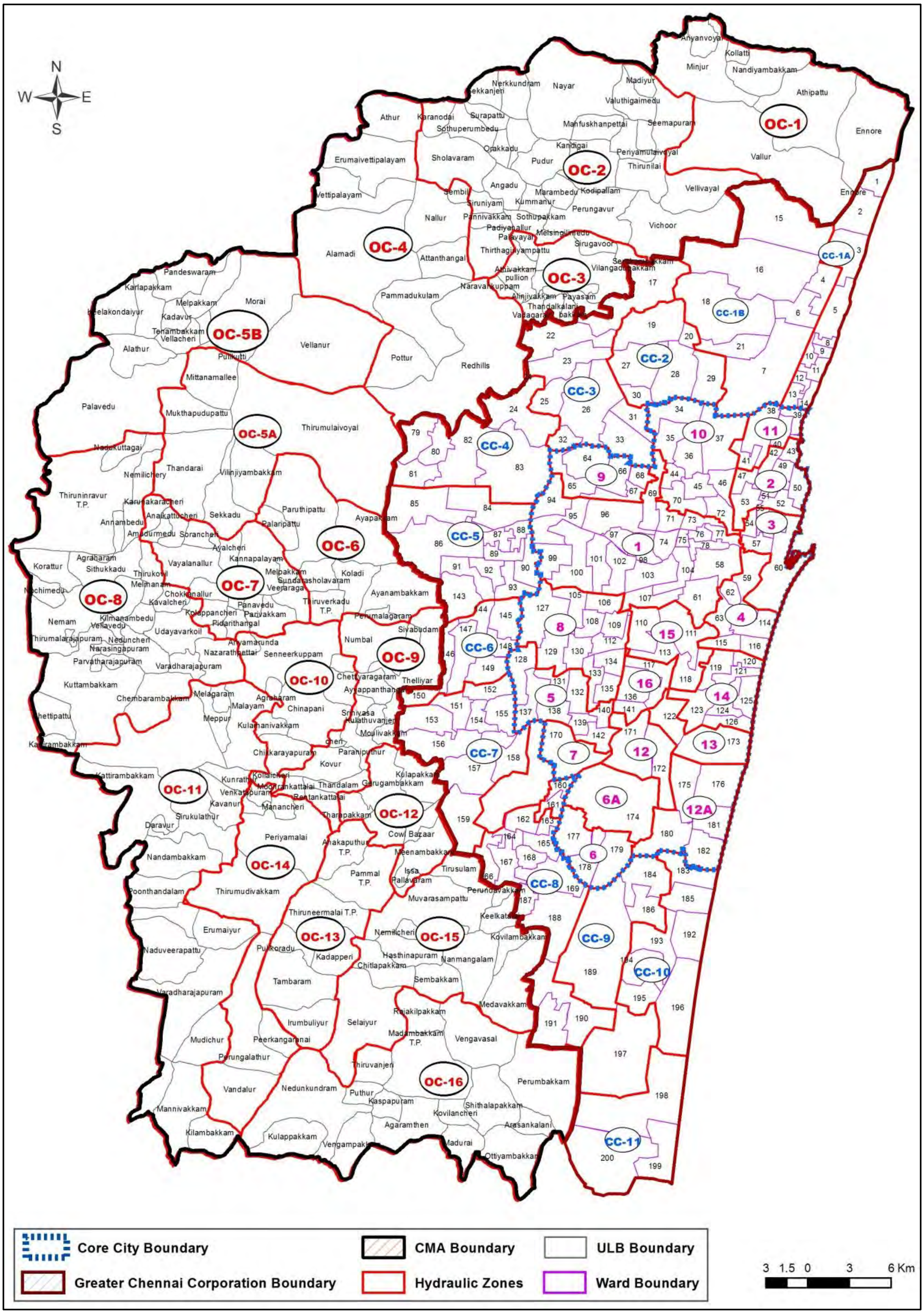


Note 1: Administration Area: Zoning by CMWSSB for administration purposes

Note 2: Water Distribution Zones: Zoning by CMWSSB, each of which has a water distribution centre

Source: JICA Study Team

A2.1.2 Administrative Boundaries with Ward Numbers and ULB Names with Boundaries of WDZs of CMWSSB



Note: See Appendix 2.2 for general information on the wards and ULBs
Source: JICA Study Team

Appendix 2.2 List of Wards, Depots, Urban Local Bodies (ULBs) in the Chennai Metropolitan Area (CMA)

CHENNAI CORE CITY

Ward/ Depot Number	Water Distribution Zone (Existing) /Hydraulic Zone	Adm in Area	Name of the Locality		Total Area (ha)	Population in Thousands as per 2001 Census	Population in Thousands as per 2011 Census	Annual population growth in 2001-2011 (%)	Population density by area (persons /ha)
61	1	5	Royapuram	-	17,617.7	4,344.000	4,647.000	0.68%	264
69	1	6	Thiruvi-Ka-Nagar	−					
71	1	6	Thiruvi-Ka-Nagar	−					
73	1	6	Thiruvi-Ka-Nagar	−					
76	1	6	Thiruvi-Ka-Nagar	−					
77	1	6	Thiruvi-Ka-Nagar	−					
78	1	6	Thiruvi-Ka-Nagar	−					
74	1	8	Thiruvi-Ka-Nagar	−					
75	1	8	Thiruvi-Ka-Nagar	−					
94	1	8	Anna Nagar	−					
95	1	8	Anna Nagar	−					
96	1	8	Anna Nagar	−					
97	1	8	Anna Nagar	−					
98	1	8	Anna Nagar	−					
99	1	8	Anna Nagar	−					
100	1	8	Anna Nagar	−					
101	1	8	Anna Nagar	−					
102	1	8	Anna Nagar	−					
103	1	8	Anna Nagar	−					
104	1	8	Anna Nagar	−					
42	2	4	Tondiarpet	−					
43	2	4	Tondiarpet	−					
47	2	4	Tondiarpet	−					
48	2	4	Tondiarpet	−					
49	2	5	Royapuram	−					
50	2	5	Royapuram	−					
51	2	5	Royapuram	−					
52	2	5	Royapuram	−					
53	2	5	Royapuram	−					
54	3	5	Royapuram	−					
55	3	5	Royapuram	−					
56	3	5	Royapuram	−					
57	3	5	Royapuram	−					
58	3	5	Royapuram	−					
60	3	5	Royapuram	−					
59	4	5	Royapuram	−					
62	4	5	Royapuram	−					
63	4	5	Royapuram	−					
114	4	9	Teynampet	−					
115	4	9	Teynampet	−					
116	4	9	Teynampet	−					
128	5	10	Kodambakkam	−					
131	5	10	Kodambakkam	−					
132	5	10	Kodambakkam	−					
137	5	10	Kodambakkam	−					
138	5	10	Kodambakkam	−					
139	5	10	Kodambakkam	−					
140	5	10	Kodambakkam	−					
142	5	10	Kodambakkam	−					

177	6	13	Adyar	–					
178	6	13	Adyar	–					
179	6	13	Adyar	–					
170	7	13	Adyar	–					
105	8	8	Anna Nagar	–					
106	8	8	Anna Nagar	–					
107	8	8	Anna Nagar	–					
108	8	8	Anna Nagar	–					
109	8	9	Teynampet	–					
112	8	9	Teynampet	–					
127	8	10	Kodambakkam	–					
129	8	10	Kodambakkam	–					
130	8	10	Kodambakkam	–					
133	8	10	Kodambakkam	–					
134	8	10	Kodambakkam	–					
135	8	10	Kodambakkam	–					
64	9	6	Thiruvi-Ka-Nagar	–					
66	9	6	Thiruvi-Ka-Nagar	–					
68	9	6	Thiruvi-Ka-Nagar	–					
65	9	8	Thiruvi-Ka-Nagar	–					
67	9	8	Thiruvi-Ka-Nagar	–					
34	10	4	Tondiarpet	–					
35	10	4	Tondiarpet	–					
36	10	4	Tondiarpet	–					
37	10	4	Tondiarpet	–					
44	10	4	Tondiarpet	–					
45	10	4	Tondiarpet	–					
46	10	4	Tondiarpet	–					
70	10	6	Thiruvi-Ka-Nagar	–					
72	10	6	Thiruvi-Ka-Nagar	–					
38	11	4	Tondiarpet	–					
39	11	4	Tondiarpet	–					
40	11	4	Tondiarpet	–					
41	11	4	Tondiarpet	–					
171	12	13	Adyar	–					
172	12	13	Adyar	–					
122	13	9	Teynampet	–					
173	13	9	Adyar	–					
119	14	9	Teynampet	–					
120	14	9	Teynampet	–					
121	14	9	Teynampet	–					
123	14	9	Teynampet	–					
124	14	9	Teynampet	–					
125	14	9	Teynampet	–					
126	14	9	Teynampet	–					
110	15	9	Teynampet	–					
111	15	9	Teynampet	–					
113	15	9	Teynampet	–					
118	15	9	Teynampet	–					
117	16	9	Teynampet	–					
136	16	10	Kodambakkam	–					
141	16	10	Kodambakkam	–					
175	12A	13	Adyar	–					
176	12A	13	Adyar	–					
180	12A	13	Adyar	–					
181	12A	13	Adyar	–					
182	12A	13	Adyar	–					
174	6A	13	Adyar	–					
SUB-TOTAL					**17617.7**	**4,344**	**4,647**	**0.68%**	**264**

CHENNAI CORPORATION (EXPANDED AREA)

Ward/ Depot Number	Water Distribution Zone (Planned)/Hydraulic Zone		Name of the Locality (Former name as ULB)	ULB Classification by 2011 (M: Municipality, T: Town Panchayat, V: Village Panchayat)	Total Area (ha)	Population in Thousands as per 2001 Census	Population in Thousands as per 2011 Census	Annual population growth in 2001-2011 (%)	Population density by area (persons/ha)
1 TO 14	CC1-A	-	Kathivakkam	M	475.1	32.590	36.620	1.17%	77
		-	Thiruvottiyur	M	2,135.5	212.280	249.450	1.63%	117
18-P	CC1-B	-	Manali	M	374.3	14.300	17.625	2.11%	47
15		-	Edayanchavadi	V	842.9	9.128	12.119	2.87%	14
16		-	Sadayankuppam	V	695.0	1.940	5.348	10.67%	8
16, 17		-	Kadapakkam	V	310.7	2.659	2.941	1.01%	9
21		-	Chinnasekkadu	T	83.3	4.870	6.200	2.44%	74
18-P	CC2	-	Manali	M	374.3	14.300	17.625	2.11%	47
17		-	Thiyambakkam	V	64.3	0.132	0.153	1.49%	2
19,20		-	Mathur	V	297.7	7.541	27.674	13.88%	93
17,26,27, 30,31,32, 33		-	Madhavaram	M	1,741.3	76.090	119.110	4.58%	68
28,29		-	Chinnasekkadu	T	83.3	4.870	6.200	2.44%	74
17	CC3	-	Vadaperumbakkam	V	173.9	1.213	1.682	3.32%	10
25		-	Kathirvedu	V	159.0	4.870	7.580	4.52%	48
22,23		-	Puzhal	T	673.7	20.640	31.670	4.37%	47
24	CC4	-	Soorapattu	V	278.5	5.557	10.444	6.51%	38
83		-	Puthagaram	V	192.8	6.451	10.263	4.75%	53
79,80,81, 82		-	Ambattur	M	1,888.5	155.485	233.100	4.13%	123
84,85,86, 87,88,89, 90,91,92, 93	CC5	-	Ambattur	M	1,888.5	155.485	233.100	4.13%	123
143		-	Nolambur	V	256.6	8.594	21.973	9.84%	86
148,149,152	CC6	-	Valasarawakkam	M	297.1	30.980	47.380	4.34%	159
144,146,147		-	Maduravoyal	M	478.0	43.610	86.200	7.05%	180
145		-	Nerkunram	V	265.0	39.826	59.790	4.15%	226
150		-	Karambakkam	T	106.7	14.950	21.376	3.64%	200
151,153	CC7	-	Porur	T	371.8	28.920	46.690	4.91%	126
154,155		-	Ramapuram	V	269.2	27.895	52.295	6.49%	194
157		-	Manapakkam	V	412.0	8.605	13.344	4.48%	32
158		-	Nandambakkam	T	261.0	9.340	11.240	1.87%	43
159		-	Meenambakkam	T	302.7	3.610	4.290	1.74%	14
156		-	Mugalivakkam	V	186.9	9.154	25.117	10.62%	134
160,161,162		-	Alandur	M	403.8	73.145	82.215	1.18%	204
163,164,165,166,167,168	CC8	-	Alandur	M	403.8	73.145	82.215	1.18%	204
169		-	Ullagaram-Puzhudhivakkam	M	364.4	30.420	53.320	5.77%	146
187,188		-	Madippakkam	V	340.1	15.548	35.752	8.68%	105
191	CC9	-	Jalladianpet	V	228.0	7.240	19.100	10.19%	84
184,186		-	Perungudi	T	464.3	23.580	43.110	6.22%	93
189,190		-	Pallikkaranai	T	1,742.7	22.070	43.490	7.02%	25
183	CC10	-	Kottivakkam	V	247.0	13.884	20.217	3.83%	82
185		-	Palavakkam	V	207.2	14.361	26.766	6.42%	129
192,193		-	Neelankarai	V	280.5	15.637	28.458	6.17%	101

196		-	Injambakkam	V	518.6	10.117	21.158	7.66%	41
197		-	Karapakkam	V	244.4	3.795	8.958	8.97%	37
194,195		-	Oggiam Thuraipakkam	V	603.1	25.952	76.600	11.43%	127
197,198		-	Sholinganallur	T	1,535.1	15.560	26.640	5.52%	17
200	CC11	-	Semmanjeri	V	701.4	3.744	29.751	23.03%	42
199		-	Uthandi	V	340.8	2.497	5.037	7.27%	15
SUB -TOTAL					**24,564.5**	**1,306.580**	**2,021.386**	4.46%	82

REST OF CMA

	Water Distribution Zone (Planned)/Hydraulic Zone		**ULB**	**ULB Classification (M: Municipality, T: Town Panchayat, Name: Village Panchayat (Union Name)**	**Total Area (ha)**	**Population in Thousands as per 2001 Census**	**Population in Thousands as per 2011 Census**	**Annual population growth in 2001-2011 (%)**	**Population density by area (persons/ha)**
-	OC1	-	Athipattu	Minjur	914.50	8.513	11.030	2.62%	12
-	OC1	-	Ennore	Minjur	677.20	0.660	0.930	3.49%	1
-	OC1	-	Nandiambakkam	Minjur	415.62	3.531	6.268	5.91%	15
-	OC1	-	Vallur	Minjur	997.41	5.662	5.965	0.52%	6
-	OC2	-	Vallur	Minjur	997.41	5.662	5.965	0.52%	6
-	OC2	-	Angadu	Sholavaram	232.39	0.839	0.703	-1.75%	3
-	OC2	-	Arumandai	Sholavaram	176.17	1.189	1.699	3.63%	10
-	OC2	-	Chinnamullaivoyal	Sholavaram	81.31	0.060	0.070	1.55%	1
-	OC2	-	Girudalapuram	Sholavaram	147.91	0.000	0.000	#DIV/0!	0
-	OC2	-	Kandigai	Sholavaram	32.37	0.240	1.146	16.92%	35
-	OC2	-	Karanodai	Sholavaram	136.43	2.991	3.779	2.37%	28
-	OC2	-	Kodipallam	Sholavaram	52.70	0.495	0.591	1.79%	11
-	OC2	-	Kummanur	Sholavaram	136.93	1.603	1.807	1.21%	13
-	OC2	-	Madiyur	Sholavaram	94.43	0.333	0.313	-0.62%	3
-	OC2	-	Mafuskhanpet	Sholavaram	168.44	0.967	1.018	0.52%	6
-	OC2	-	Marambedu	Sholavaram	152.26	0.626	0.668	0.65%	4
-	OC2	-	Melsingilimedu	Sholavaram	52.76	0.000	0.000	#DIV/0!	0
-	OC2	-	Nayur	Sholavaram	1,031.73	2.935	4.516	4.40%	4
-	OC2	-	Nerkundram	Sholavaram	211.10	0.474	0.714	4.18%	3
-	OC2	-	Orakkadu	Sholavaram	115.81	1.698	1.610	-0.53%	14
-	OC2	-	Padianallur	Sholavaram	358.66	20.938	23.819	1.30%	66
-	OC2	-	Pannivakkam	Sholavaram	93.94	0.000	0.000	#DIV/0!	0
-	OC2	-	Periyamullaivoyal	Sholavaram	185.26	0.953	0.977	0.25%	5
-	OC2	-	Perungavoor	Sholavaram	607.12	2.014	2.270	1.20%	4
-	OC2	-	Pudupakkam	Sholavaram	126.46	0.544	0.386	-3.37%	3
-	OC2	-	Budur	Sholavaram	332.44	0.000	0.000	#DIV/0!	0
-	OC2	-	Seemapuram	Sholavaram	365.66	1.604	1.870	1.55%	5
-	OC2	-	Sekkanjeri	Sholavaram	123.85	0.410	0.740	6.08%	6
-	OC2	-	Sembilivaram	Sholavaram	92.09	1.400	1.240	-1.21%	13
-	OC2	-	Sholavaram	Sholavaram	598.72	6.760	9.397	3.35%	16
-	OC2	-	Siruniam	Sholavaram	105.45	0.843	1.300	4.43%	12
-	OC2	-	Soorapattu	Sholavaram	117.04	5.550	10.440	6.52%	89
-	OC2	-	Sothupakkam	Sholavaram	125.02	0.000	0.000	#DIV/0!	0
-	OC2	-	Sothuperumbedu	Sholavaram	223.90	1.305	1.670	2.50%	7
-	OC2	-	Thirunilai	Sholavaram	315.17	1.225	0.957	-2.44%	3
-	OC2	-	Valuthigaimedu	Sholavaram	221.14	1.486	1.279	-1.49%	6
-	OC2	-	Vellivoyal	Sholavaram	539.49	3.230	3.511	0.84%	7
-	OC2	-	Vichoor	Sholavaram	895.32	4.399	5.765	2.74%	6
-	OC4	-	Alamathi	Sholavaram	1,747.86	5.812	7.420	2.47%	4
-	OC4	-	Athur	Sholavaram	378.08	2.917	3.866	2.86%	10
-	OC4	-	Attanthangal	Sholavaram	258.50	9.982	14.830	4.04%	57
-	OC4	-	Erumaivettipalaya	Sholavaram	662.09	1.790	1.654	-0.79%	2

			m						
-	OC4	-	Nallur	Sholavaram	486.32	2.299	19.595	23.90%	40
-	OC4	-	Old Erumaivettipalayam	Sholavaram	469.53	0.904	1.456	4.88%	3
-	OC4	-	Vijayanallur	Sholavaram	62.95	0.624	1.040	5.24%	17
-	OC3	-	Alinjivakkam	Puzhal	53.98	1.203	1.305	0.82%	24
-	OC3	-	Amulavoyal	Puzhal	126.58	0.000	0.000	#DIV/0!	0
-	OC3	-	Ariyalur	Puzhal	132.15	1.754	2.693	4.38%	20
-	OC3	-	Athivakkam	Puzhal	70.49	1.013	3.560	13.39%	51
-	OC3	-	Chettimedu	Puzhal	58.21	0.274	0.200	-3.10%	3
-	OC3	-	Elanthancheri	Puzhal	25.22	0.803	0.685	-1.58%	27
-	OC3	-	Grant Lyon	Puzhal	176.01	3.198	3.074	-0.39%	17
-	OC3	-	Kosappur	Puzhal	238.46	0.000	0.000	#DIV/0!	0
-	OC3	-	Lyon	Puzhal	204.08	0.546	0.390	-3.31%	2
-	OC3	-	Manjambakkam	Puzhal	89.40	1.526	1.840	1.89%	21
-	OC3	-	Palavoyal	Puzhal	86.82	0.526	0.430	-1.99%	5
-	OC3	-	Payasambakkam	Puzhal	66.56	0.137	1.097	23.13%	16
-	OC3	-	Sendrambakkam	Puzhal	110.98	3.649	6.150	5.36%	55
-	OC3	-	Sirugavur	Puzhal	128.46	0.045	0.099	8.20%	1
-	OC3	-	Thandalkalani	Puzhal	73.10	0.770	0.640	-1.83%	9
-	OC3	-	Theerthakiriyampattu	Puzhal	71.74	3.328	5.412	4.98%	75
-	OC3	-	Vadagarai	Puzhal	49.28	2.470	2.672	0.79%	54
-	OC3	-	Vaikkadu	Puzhal	179.91	0.000	0.000	#DIV/0!	0
-	OC3	-	Vilakkupattu	Puzhal	14.80	0.000	0.000	#DIV/0!	0
-	OC3	-	Vilangadupakkam	Puzhal	559.00	4.244	5.668	2.94%	10
-	OC6	-	Adayalampattu	Villivakkam	115.21	1.735	1.874	0.77%	16
-	OC6	-	Ayappakkam	Villivakkam	421.52	6.440	29.500	16.44%	70
-	OC9	-	Chettiyaragaram	Villivakkam	64.85	0.000	0.000	#DIV/0!	0
-	OC9	-	Sivabudham	Villivakkam	65.50	1.240	1.480	1.79%	23
-	OC9	-	Thandalam	Villivakkam	88.22	1.275	1.594	2.26%	18
-	OC9	-	Vanagaram	Villivakkam	280.94	8.526	19.208	8.46%	68
-	OC4	-	Pammadukulam	Villivakkam	792.09	6.594	9.271	3.47%	12
-	OC4	-	Pothur	Villivakkam	464.12	1.272	2.739	7.97%	6
-	OC5B	-	Alathur	Villivakkam	338.24	2.939	3.636	2.15%	11
-	OC5B	-	Arakkambakkam	Villivakkam	182.14	1.405	1.402	-0.02%	8
-	OC5B	-	Kadavur	Villivakkam	108.69	0.490	0.800	5.02%	7
-	OC5B	-	Karlapakkam	Villivakkam	265.84	3.464	4.110	1.72%	15
-	OC5B	-	Kilakondaiyur	Villivakkam	335.33	3.570	2.525	-3.40%	8
-	OC5B	-	Melpakkam	Villivakkam	94.30	0.455	0.518	1.31%	5
-	OC5B	-	Morai	Villivakkam	1,154.31	3.373	10.873	12.42%	9
-	OC5B	-	Palavedu	Villivakkam	565.82	5.657	7.944	3.45%	14
-	OC5B	-	Pandeswaram	Villivakkam	360.95	1.956	2.310	1.68%	6
-	OC5B	-	Pulikutti	Villivakkam	70.56	15.349	19.925	2.64%	282
-	OC5B	-	Tenambakkam	Villivakkam	54.30	6.600	8.950	3.09%	165
-	OC5B	-	Vellacheri	Villivakkam	127.08	0.501	0.399	-2.25%	3
-	OC5B	-	Vellanur	Villivakkam	1,605.22	6.889	11.668	5.41%	7
-	OC5B	-	Pakkam	Thiruvallur	1,138.51	8.719	17.342	7.12%	15
-	OC5B	-	Nadukkuthagai	Poonamallee	167.88	6.283	9.251	3.94%	55
-	OC6	-	Senneerkuppam	Poonamallee	87.36	2.234	5.412	9.25%	62
-	OC7	-	Amudurmedu	Poonamallee	74.99	0.741	1.041	3.46%	14
-	OC7	-	Anaikattucheri	Poonamallee	120.87	6.050	14.210	8.91%	118
-	OC7	-	Ayalcheri	Poonamallee	126.14	0.390	0.527	3.06%	4
-	OC7	-	Chokkanallur	Poonamallee	114.71	0.000	0.000	#DIV/0!	0
-	OC7	-	Kannapalaiyam	Poonamallee	556.94	2.776	3.950	3.59%	7
-	OC7	-	Karunakaracheri	Poonamallee	118.76	0.565	0.875	4.47%	7
-	OC7	-	Kolappancheri	Poonamallee	126.24	1.186	1.240	0.45%	10
-	OC7	-	Melpakkam	Poonamallee	78.17	0.455	0.518	1.31%	7
-	OC7	-	Panaveduthottam	Poonamallee	54.23	0.000	0.000	#DIV/0!	0

-	OC7	-	Parivakkam	Poonamallee	210.50	3.017	3.911	2.63%	19
-	OC7	-	Pidarithangal	Poonamallee	94.61	1.249	0.882	-3.42%	9
-	OC7	-	Soranjeri	Poonamallee	122.00	2.798	4.161	4.05%	34
-	OC7	-	Voyalanallur	Poonamallee	404.22	4.813	6.525	3.09%	16
-	OC7	-	Senneerkuppam	Poonamallee	87.36	2.234	5.412	9.25%	62
-	OC8	-	Agraharam	Poonamallee	66.97	0.668	3.056	16.42%	46
-	OC8	-	Annambedu	Poonamallee	156.55	0.000	0.000	#DIV/0!	0
-	OC8	-	Ariyapancheri	Poonamallee	34.37	0.000	0.000	#DIV/0!	0
-	OC8	-	Kavalacheri	Poonamallee	129.26	0.000	0.000	#DIV/0!	0
-	OC8	-	Kilmanambedu	Poonamallee	109.69	0.862	1.845	7.91%	17
-	OC8	-	Korattur	Poonamallee	228.60	2.754	6.528	9.01%	29
-	OC8	-	Kuthambakkam	Poonamallee	748.94	3.953	5.407	3.18%	7
-	OC8	-	Melmanambedu	Poonamallee	194.55	0.000	0.000	#DIV/0!	0
-	OC8	-	Mothirambedu	Poonamallee	44.59	0.000	0.000	#DIV/0!	0
-	OC8	-	Narasingapuram	Poonamallee	41.76	0.701	0.893	2.45%	21
-	OC8	-	Neman	Poonamallee	526.77	1.662	3.434	7.53%	7
-	OC8	-	Nemilicheri	Poonamallee	172.05	4.831	5.743	1.74%	33
-	OC8	-	Nochimedu	Poonamallee	104.40	0.884	0.398	-7.67%	4
-	OC8	-	Parvatharajapuram	Poonamallee	88.84	0.460	0.789	5.54%	9
-	OC8	-	Sithukadu	Poonamallee	367.17	0.000	0.000	#DIV/0!	0
-	OC8	-	Thirukovilpattu	Poonamallee	47.99	0.000	0.000	#DIV/0!	0
-	OC8	-	Thirumalarajapura m	Poonamallee	27.02	0.000	0.000	#DIV/0!	0
-	OC8	-	Thirumanam	Poonamallee	121.25	0.000	0.000	#DIV/0!	0
-	OC8	-	Varadharajapuram	Poonamallee	197.73	2.931	4.540	4.47%	23
-	OC8	-	Vellavedu	Poonamallee	50.23	1.298	1.868	3.71%	37
-	OC9	-	Goparasanallur	Poonamallee	73.05	0.000	0.000	#DIV/0!	0
-	OC9	-	Kattupakkam	Poonamallee	191.64	4.015	23.914	19.54%	125
-	OC10	-	Senneerkuppam	Poonamallee	87.36	2.234	5.412	9.25%	62
-	OC11	-	Agaramel	Poonamallee	80.23	2.992	4.609	4.42%	57
-	OC11	-	Chembarambakka m	Poonamallee	481.32	0.000	0.000	#DIV/0!	0
-	OC11	-	Meppur	Poonamallee	173.56	2.521	3.493	3.31%	20
-	OC11	-	Nazarethpettai	Poonamallee	121.58	5.157	8.660	5.32%	71
-	OC11	-	Palanjur	Poonamallee	331.17	0.000	0.000	#DIV/0!	0
-	OC11	-	Chembarambakka m (pt) Tank portion	Srierumpudur	997.98	0.000	0.000	#DIV/0!	0
-	OC11	-	Daravur	Srierumpudur	27.34	0.080	0.020	-12.94%	1
-	OC11	-	Kattirambakkam Tank portion	Srierumpudur	861.52	1.453	2.157	4.03%	3
-	OC8	-	Chettipattu	Srierumpudur	130.10	0.673	0.749	1.08%	6
-	OC9	-	Ayyappanthangal	Kundrathur	139.88	7.066	23.808	12.92%	170
-	OC9	-	Chinnapanicheri	Kundrathur	28.38	0.000	0.000	#DIV/0!	0
-	OC9	-	Kolathuvancheri	Kundrathur	100.08	0.000	0.000	#DIV/0!	0
-	OC9	-	Kovur	Kundrathur	290.92	5.948	10.961	6.30%	38
-	OC9	-	Paraniputhur	Kundrathur	72.04	3.009	15.225	17.60%	211
-	OC9	-	Rendamkattalai	Kundrathur	150.95	0.000	0.000	#DIV/0!	0
-	OC9	-	Srinivasapuram	Kundrathur	70.25	0.000	0.000	#DIV/0!	0
-	OC9	-	Thelliaragaram	Kundrathur	73.54	0.520	0.380	-3.09%	5
-	OC10	-	Chikkarayapuram	Kundrathur	123.66	0.000	0.000	#DIV/0!	0
-	OC14	-	Thirumudivakkam	Kundrathur	473.23	3.027	4.083	3.04%	9
-	OC12	-	Gerugambakkam	Kundrathur	393.93	5.478	11.551	7.75%	29
-	OC12	-	Kolapakkam	Kundrathur	315.36	2.594	7.970	11.88%	25
-	OC12	-	Madanandapuram	Kundrathur	129.68	1.564	5.340	13.07%	41
-	OC12	-	Periyapanicheri	Kundrathur	58.92	0.993	2.379	9.13%	40
-	OC12	-	Tharapakkam	Kundrathur	125.60	1.861	2.232	1.83%	18
-	OC12	-	Mowlivakkam	Kundrathur	46.87	1.080	4.647	15.71%	99
-	OC12	-	Thandalam	Kundrathur	53.57	1.824	2.680	3.92%	50
-	OC11	-	Erumaiyur	Kundrathur	317.71	2.047	2.379	1.51%	7

-	OC11	-	Kavanur	Kundrathur	223.06	2.104	1.586	-2.79%	7
-	OC11	-	Malayambakkam	Kundrathur	513.46	5.025	8.250	5.08%	16
-	OC11	-	Naduveerapattu	Kundrathur	573.59	4.517	6.291	3.37%	11
-	OC11	-	Nandambakkam	Kundrathur	458.57	5.454	12.560	8.70%	27
-	OC11	-	Palanthandalam	Kundrathur	529.73	0.000	0.000	#DIV/0!	0
-	OC11	-	Poonthandalam	Kundrathur	359.33	1.009	3.117	11.94%	9
-	OC11	-	Sirukalathur	Kundrathur	529.81	3.629	6.117	5.36%	12
-	OC11	-	Varadharajapuram	Kundrathur	911.03	1.973	5.846	11.47%	6
-	OC10	-	Kollaicheri	Kundrathur	60.05	2.089	3.793	6.15%	63
-	OC10	-	Kozhumanivakkam	Kundrathur	89.59	1.649	2.729	5.17%	30
-	OC9	-	Mowlivakkam	Kundrathur	46.87	1.080	4.647	15.71%	99
-	OC9	-	Thandalam	Kundrathur	53.57	1.824	2.680	3.92%	50
-	OC9	-	Chikkarayapuram	Kundrathur	123.66	0.000	0.000	#DIV/0!	0
-	OC11	-	Mudichur	St. Thomas Mount	172.50	1.837	7.719	15.44%	45
-	OC12	-	Cowl Bazaar	St. Thomas Mount	122.68	1.270	2.784	8.16%	23
-	OC12	-	Polichalur	St. Thomas Mount	247.70	14.760	21.906	4.03%	88
-	OC14	-	Mudichur	St. Thomas Mount	172.50	1.837	7.719	15.44%	45
-	**OC15**	-	Koilambakkam	St. Thomas Mount	147.53	9.277	27.374	11.43%	186
-	**OC15**	-	Kulathur	St. Thomas Mount	188.84	9.395	6.279	-3.95%	33
-	**OC15**	-	Medavakkam	St. Thomas Mount	509.05	8.444	29.710	13.41%	58
-	**OC15**	-	Moovarasampettai	St. Thomas Mount	61.69	6.162	9.672	4.61%	157
-	**OC15**	-	Nanmangalam	St. Thomas Mount	394.76	3.323	18.567	18.77%	47
-	**OC15**	-	Perundavakkam	St. Thomas Mount	19.92	0.000	0.000	#DIV/0!	0
-	**OC15**	-	Tirusulam	St. Thomas Mount	241.80	5.972	14.086	8.96%	58
-	**OC16**	-	Agaramthen	St. Thomas Mount	382.19	1.222	4.172	13.06%	11
-	**OC16**	-	Arasankalani	St. Thomas Mount	128.45	0.527	1.092	7.56%	9
-	**OC16**	-	Kasbapuram	St. Thomas Mount	121.28	0.603	2.606	15.76%	21
-	**OC16**	-	Kovilancheri	St. Thomas Mount	121.80	0.572	1.253	8.16%	10
-	**OC16**	-	Maduraipakkam	St. Thomas Mount	131.24	0.727	1.021	3.45%	8
-	**OC16**	-	Meppedu	St. Thomas Mount	191.69	0.000	0.000	#DIV/0!	0
-	**OC16**	-	Mulacheri	St. Thomas Mount	40.80	0.770	0.148	-15.20%	4
-	**OC16**	-	Ottiyambakkam	St. Thomas Mount	428.17	0.811	2.129	10.13%	5
-	**OC16**	-	Perumbakkam	St. Thomas Mount	831.86	2.630	24.625	25.07%	30
-	**OC16**	-	Sithalapakkam	St. Thomas Mount	459.91	3.298	13.542	15.17%	29
-	**OC16**	-	Thiruvancheri	St. Thomas Mount	216.33	0.638	3.379	18.14%	16
-	**OC16**	-	Vengaivasal	St. Thomas Mount	528.84	8.892	13.671	4.40%	26
-	**OC16**	-	Vengapakkam	St. Thomas Mount	266.60	1.142	2.758	9.22%	10
-	**OC16**	-	Kolapakkam	Kattankulathur	326.49	5.419	7.970	3.93%	24
-	**OC16**	-	Nedungundram	Kattankulathur	1,077.06	6.870	14.390	7.67%	13

-	**OC16**	-	Puthur	Kattankulathur	109.24	1.243	2.700	8.07%	25
-	**OC16**	-	Kilambakkam	Kattankulathur	243.54	2.765	5.189	6.50%	21
-	**OC16**	-	Vandalur	Kattankulathur	279.53	6.688	8.426	2.34%	30
-	OC14	-	Vandalur	Kattankulathur	279.53	6.688	8.426	2.34%	30
-	OC11	-	Mannivakkam	Kattankulathur	510.63	6.382	13.308	7.63%	26
-	OC9	-	Mangadu	T	281.52	9.710	19.090	6.99%	68
-	OC9	-	Kundrathur	T	304.09	6.268	10.533	5.33%	35
-	OC10	-	Mangadu	T	281.52	9.710	19.090	6.99%	68
-	OC10	-	Kundrathur	T	304.09	6.268	10.533	5.33%	35
-	OC11	-	Kundrathur	T	304.09	6.268	10.533	5.33%	35
-	OC13	-	Thiruneermalai	T	293.64	9.615	15.350	4.79%	52
-	OC14	-	Perungalathur.	T	703.54	19.590	37.340	6.66%	53
-	**OC15**	-	Chitlapakkam	T	290.30	25.310	37.960	4.14%	131
-	**OC15**	-	Sembakkam	T	635.13	21.500	45.360	7.75%	71
-	OC1	-	Minjur	T	862.71	23.740	28.340	1.79%	33
-	OC3	-	Naravarikuppam	T	2,075.64	18.330	20.950	1.34%	10
-	**OC16**	-	Peerkankaranai	T	88.03	8.755	12.935	3.98%	147
-	**OC16**	-	Madambakkam	T	791.82	17.000	31.680	6.42%	40
-	OC14	-	Kundrathur	T	304.09	6.268	10.533	5.33%	35
-	OC14	-	Thiruneermalai	T	293.64	9.615	15.350	4.79%	52
-	OC14	-	Peerkankaranai	T	88.03	8.755	12.935	3.98%	147
-	OC8	-	Thirumazhisai	T	725.23	16.290	19.730	1.93%	27
-	OC8	-	Thirunindravur	T	727.82	14.665	18.550	2.38%	25
-	OC5B	-	Thirunindravur	T	727.82	14.665	18.550	2.38%	25
-	OC9	-	Thiruverkadu	M	620.93	10.733	20.940	6.91%	34
-	OC10	-	Poonamallee	M	327.31	21.300	28.610	2.99%	87
-	OC12	-	Anakaputhur	M	149.23	15.960	24.025	4.17%	161
-	OC13	-	Pammal	M	520.05	50.000	75.870	4.26%	146
-	OC13	-	Anakaputhur	M	149.23	15.960	24.025	4.17%	161
-	OC13	-	Tambaram	M	518.00	34.483	43.698	2.40%	84
-	OC13	-	Pallavaram	M	804.55	72.310	107.710	4.07%	134
-	OC14	-	Tambaram	M	518.00	34.483	43.698	2.40%	84
-	**OC16**	-	Tambaram	M	518.00	34.483	43.698	2.40%	84
-	**OC15**	-	Pallavaram	M	804.55	72.310	107.710	4.07%	134
-	**OC15**	-	Tambaram	M	518.00	34.483	43.698	2.40%	84
-	OC7	-	Poonamallee	M	327.31	21.300	28.610	2.99%	87
-	OC7	-	Avadi	M	2,052.25	76.467	115.333	4.20%	56
-	OC7	-	Thiruverkadu	M	620.93	10.733	20.940	6.91%	34
-	OC6	-	Thiruverkadu	M	620.93	10.733	20.940	6.91%	34
-	OC6	-	Avadi	M	2,052.25	76.467	115.333	4.20%	56
-	OC5A	-	Avadi	M	2,052.25	76.467	115.333	4.20%	56
SUB-TOTAL					**76,733.94**	**1,412.837**	**2,303.069**	**5.01%**	**30**

CHENNAI CORE CITY	**176.18**	**43.44**	**46.47**	**0.68%**	**264**
CHENNAI CORPORATION	**245.64**	**13.07**	**20.21**	**4.46%**	**82**
REST OF CMA	**767.34**	**14.13**	**23.03**	**5.01%**	**30**
TOTAL OF CMA AREA	**1,189**	**70.63**	**89.71**	**2.42%**	**75**

LEGEND
- (blue) *Influence area of the Perur DSP* ***in 2025 but not in 2035***
- (pink) *Influence area of the Perur DSP* ***in 2025 and 2035 (Directly fed from the transmission main from Perur DSP)***
- (orange) *Influence area of the Perur DSP* ***in 2025 and 2035 (Fed through the Porur WDS)***

Source: JICA Study Team

Appendix 2.3 Social Conditions in the Study Area

A2.3.1 Politics

The Indian politics has evolved based on the framework of the Indian Constitution. The President of India is the Head of the State and Supreme Commander of the armed forces, who is elected for a five-year period by the elected members of both Houses of Parliament and the Legislative Assemblies of the State and Union Territories (New Delhi and Puducherry) of India. The President of India appoints the Prime Minister of India from a political party or coalition that secures the highest number of seats in the Lok Sabha (lower house of the Parliament, which represents the people of India).

There are two types of political parties, i.e., national parties and regional/state parties. It has been estimated that there are more than 200 political parties at both the national and state levels, in India post- independence. In general, the state and central governments of the country are formed through the general elections conducted by the Election Commission at every five-year period. The state governments are represented by the Chief Ministers from the parties having the majority of seats in the State Legislative Assembly whereas the Prime Minister serves as the senior member of cabinet in the executive branch of the government. Politics plays a major role in the economic growth of India. The introduction of certain infrastructure development-oriented policy decisions by the Indian government seek to attract investors in various sectors of the global market.

A2.3.2 Economy

(1) India

According to a recent report published by the World Bank, India is one of the world's fastest-growing major economies. The improvement in India's economic fundamentals has accelerated with the combined impact of the strong government reforms, the Reserve Bank of India (RBI's) inflation focus further supported by the benign global commodity prices.

The size of the Indian economy was at INR 129.57 trillion (USD 2.01 trillion) for the year 2014. The service sector has the major contribution to the Indian GDP, followed by the Industry sector and Agriculture sector that stands in the third position in terms of contribution to the GDP.

As shown in Table A2.3.1, the annual GDP growth in 2015 was estimated at 7.6% and the similar rates of growth are also expected in 2016 and 2017. According to the International Monetary Foundation (IMF) World Economic Outlook April 2015, India ranks seventh globally in terms of Gross Domestic Product (GDP) at current prices.

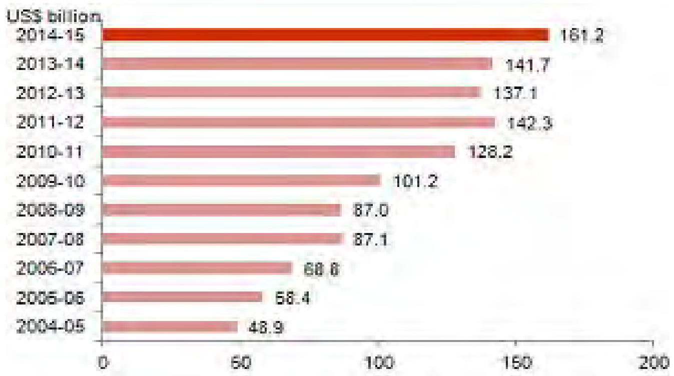
Table A2.3.1 Economic Growth of India

Selected Economic Indicators (%) - India		Performance			Estimation	Forecast	
		2012	2013	2014	2015	2016	2017
GDP Growth (%)		5.1	6.9	7.3	7.6	7.4	7.8
GDP share by sector (%)	Agriculture	18.7	18.6	17.8	-	-	-
	Industry	31.7	30.5	30.1	-	-	-
	Services	49.6	50.9	52.1	-	-	-

Source: World Bank

(2) Tamil Nadu

As per the document 'Vision Tamil Nadu 2023', it is estimated that the state will increase its per capita income (at current prices) by six times from INR 73,278 (USD 1,628) in 2010-11 to INR 450,000 (USD 10,000) in 2023, which is in line with the per capita income of Upper Middle Income (UMI) countries. The state targets that its factor endowments along with the combination of its strengths and opportunities will lead to increase its Gross State Domestic Production (GSDP) at 11% or more per annum. This estimated growth rate is about 20% more than the expected growth rate of India's GDP during 2012 to 2023. The GSDP of the Tamil Nadu State is USD 161.2 billion as shown in Figure A2.3.1.



Source: Directorate of Economics & Statistics of Tamil Nadu

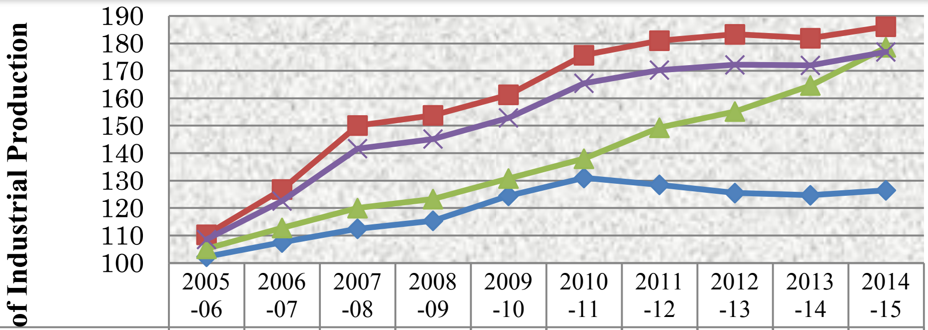
Figure A2.3.1 GSDP of the Tamil Nadu State from 2004-15

A2.3.3 Industry

(1) India

The contribution of the Industry sector to the total GDP in India in 2014 was 30.1% and this value is constant since 2012. This shows that the industry sector has been continuously contributing to the recent rapid growth of the Indian economy.

The Index of Industrial Production (IIP) of India for the past 10 years (2005 to 2014) based on the average annual values is presented in Figure A2.3.2. The IIP of manufacturing sector indicates a continuous growth from the year 2005 to 2014 and has achieved 68.7% increase over the year 2005 (186.1 / 110.3 = 1.687).



	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10	2010 -11	2011 -12	2012 -13	2013 -14	2014 -15
Mining	102.3	107.5	112.5	115.4	124.5	131	128.5	125.5	124.7	126.5
Manufacturing	110.3	126.8	150.1	153.8	161.3	175.7	181	183.3	181.9	186.1
Electricity	105.2	112.8	120	123.3	130.8	138	149.3	155.2	164.7	178.6
General	108.6	122.6	141.7	145.2	152.9	165.5	170.3	172.2	172	176.9

Source: Annual Report, Year (2015-16) Ministry of Statistics and Programme Implementation, GOI

Figure A2.3.2 Index of Industrial Production of India (2005-2014)

The "Make in India" initiative is based on four pillars, which have been identified to give a boost to entrepreneurship in India, not only in the manufacturing sector but also other sectors. An Investor Facilitation Cell (IFC) comprising of eight committee members was formed in September 2014for the promotion of Make in India program. The Make in India program supports and facilitates the fast track investments from Japan through the Japan Plus Team, which was set up by the Department of Industrial Policy & Promotion (DIPP) and was operationalized from October 8, 2014.

The Government of India is building a pentagon of corridors across the country to boost the manufacturing activities and to project India as a global manufacturing destination of the world. The following corridors have been proposed.

- Delhi Mumbai Industrial Corridor (DMIC)
- Chennai Bangalore Industrial Corridor (CBIC)
- Bengaluru Mumbai Economic Corridor (BMEC)
- Amritsar Kolkata Industrial Corridor (AMIC)
- Vizag Chennai Industrial Corridor (VCIC)

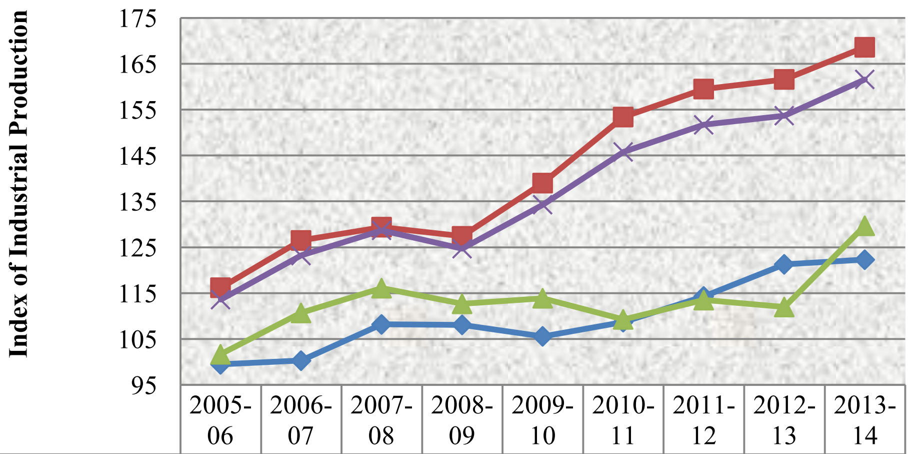
The target project of the Study, the construction of the Perur DSP, is one of the priority projects expected to support the development of CBIC by providing reliable domestic, commercial and industrial water to Chennai Metropolitan Area (CMA).

(2) Tamil Nadu

Tamil Nadu is the fourth largest state in India. The state contributed 7.9% to India's overall GDP in 2014-15. It ranks first among the states in terms of number of factories and industrial workers. The manufacturing sector in this state is diversified and the major leaders are automobiles and auto components, engineering, pharmaceuticals, garments, textile products, leather products, chemicals, plastics, etc.

The Tamil Nadu State has a well-developed infrastructure with an excellent road and rail network, three major ports, 23 minor ports, and seven airports across the state providing excellent connectivity. In line with Vision 2023, it aims to establish infrastructure investment from 4 to 5% of GSDP currently to 10% by 2015 and 11.5% by 2019.

Tamil Nadu is at the second place ahead of Uttar Pradesh with a GSDP at INR 976,703 as of 2014-15. The IIP for the period 2005 to 2013 is shown in Figure A2.3.3. The IIP of manufacturing sector indicates a continuous growth from the year 2005 to 2013 , which achieved 45.1% increase over the year 2005 (168.6 / 116.2 = 1.451).

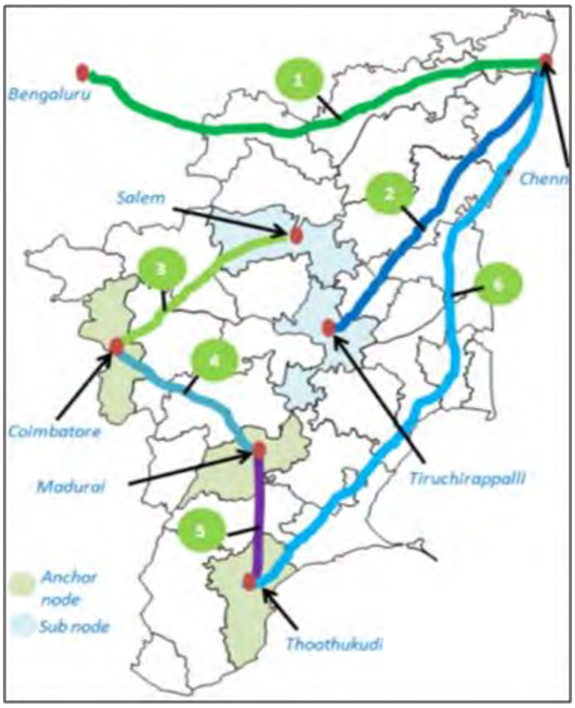


	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Mining	99.5	100.3	108.2	108.1	105.6	108.7	114.3	121.3	122.3
Manufacturing	116.2	126.5	129.4	127.4	139	153.4	159.5	161.6	168.6
Electricity	101.7	110.7	116.1	112.7	113.9	109.3	113.5	112	129.7
General	113.6	123.2	128.7	124.7	134.3	145.8	151.7	153.7	161.6

Source: State Industrial Profile of Tamil Nadu, Year (2014-15) Ministry of Micro, Small and Medium Enterprises, GoI

Figure A2.3.3 Index of Industrial Production of Tamil Nadu (2005-2013)

The Planned Industrial Corridors in Tamil Nadu State are (1) Chennai Bengaluru Industrial Corridor (CBIC), (2) Chennai Tiruchirappalli Industrial Corridor (CTIC), (3) Coimbatore Salem Industrial Corridor (CSIC), (4) Coimbatore Madurai Industrial Corridor (CMIC), (5) Madurai Thoothukudi Industrial Corridor (MTIC) and (6) Chennai Thoothukudi Industrial Corridor (CTIIC) as shown in Figure A2.3.4.



Source: Tamil Nadu Vision Document 2023

Figure A2.3.4 Planned Industrial Corridors in Tamil Nadu

A2.3.4 Public Health

The infant mortality rate (IMR) in 2013 was 21 per 1,000 live births, and the maternal mortality rate (MMR) in 2010-2012 was 90 in the Tamil Nadu State. Mortality rate, in the state all inclusive of the total mortality rate, which was 1.7 in 2012, is found to be much better than the overall India, excluding crude death rate, as shown in Table A2.3.2. Public health in the state is evaluated as much superior to the average level in the country.

The development status of the health infrastructures and the deficiencies are presented in Table A2.3.3. Although the public health conditions in the state are more advanced than the national average, there still exists the need for the development of health centers and human resources in the public health sector.

Table A2.3.2 Mortality Rates in India and the Tamil Nadu State

Indicator*	Tamil Nadu	India
Infant Mortality Rate (2013)	21	40
Maternal Mortality Rate (2010-12)	90	178
Total Fertility Rate (2012)	1.7	2.4
Crude Birth Rate (2013)	15.6	21.4
Crude Death Rate (2013)	7.3	7.0

* All rates are per 1,000 live births.
Source: National Health Mission, Ministry of Health & Family Welfare, GOI

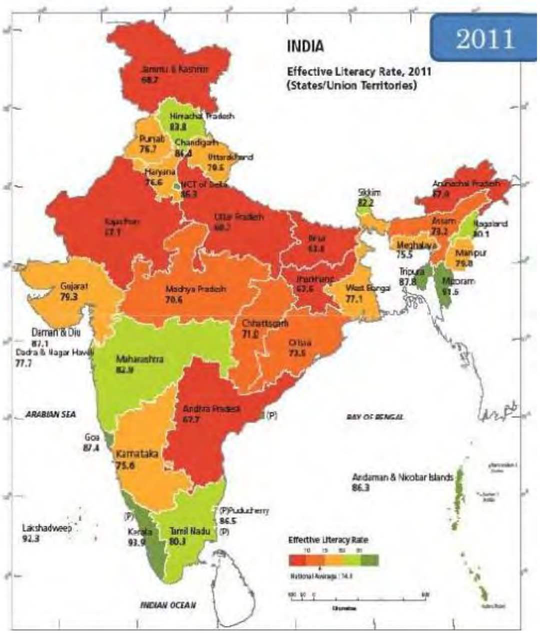
Table A2.3.3 Development Status of Health Infrastructures and Human Resources in the Tamil Nadu State

Particulars	Required	Existing	Shortfall
Sub-Center	7,555	8,706	-
Primary Health Center (PHC)	1,254	1,227	27
Community Health Center (CHC)	313	385	-
Health worker (Female)/Auxiliary Nurse Midwife (ANM) at Sub Centers & PHCs	9,933	9,253	680
Health Worker (Male) at Sub Centers	8,706	1,266	7,440
Health Assistant (Female)/Lady Health Worker (LHV) at PHCs	1,227	1,027	200
Health Assistant (Male) at PHCs	1,227	2,393	-
Doctor at PHCs	1,227	2,271	-
Obstetricians & Gynecologists at CHCs	385	0	385
Pediatricians at CHCs	385	0	385
Total specialists at CHCs	1,540	0	1,540
Radiographers at CHCs	385	151	234
Pharmacist at PHCs & CHCs	1,612	1,412	200
Laboratory Technicians at PHCs & CHCs	1,612	1,073	539
Nursing Staff at PHCs & CHCs	3,922	7,046	-

Source: National Health Mission, Ministry of Health & Family Welfare, GOI

A2.3.5 Education

Tamil Nadu is one of the most literate states in India. The overall literacy rate of the state was 80.33% in 2011 as shown in A2.3.5. The state had recorded 73.45% literacy in the year 2001. A survey conducted by the Industry Body, Associated Chambers of Commerce and Industry of India (ASSOCHAM) places the Tamil Nadu State at the top most rank among the other Indian states with about 100% Gross Enrollment Ratio (GER) in primary and upper primary education.



Source: Census of India, 2011

Figure A2.3.5 Literacy Rate in India for 2011

Appendix 2.4 Natural Conditions in the Study Area

A2.4.1 Weather, Climate and Climate Change

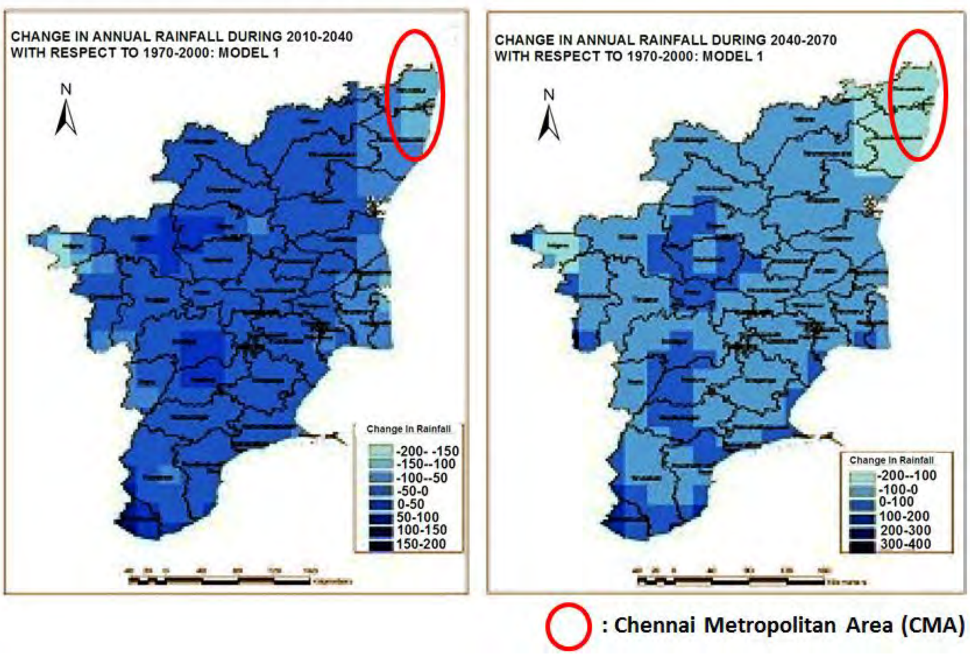
(1) Tamil Nadu

The climate of Tamil Nadu is tropical with fairly hot temperatures over the year except for the few months of monsoon. The summer season sets in from April in the state until the mid of June with May being the hottest month. The velocity of hot winds during April and May ranges from 8-16 km/hour.

In Tamil Nadu, winters arrive in the month of November and last till mid of March. The state receives rainfall in two distinct phases of monsoon. One is the southwest monsoon that starts from June till September with strong southwest winds, and the other is the northeast monsoon starting from October till December with dominant northeast winds.

The average annual rainfall of the state is 945 mm, out of which 48% is predominantly through the northeast monsoon and 32% through the southwest monsoon. Tamil Nadu majorly depends on rainfall for agriculture, drinking water, power, and other minor purposes, and failing monsoons result in moderate or severe drought effects and water scarcity.

As per the Tamil Nadu State Action Plan for Climate Change, the annual rainfall projection made for the period 2010-2040 with reference to 1970-2000 does not indicate any significant decrease in the overall rainfall rate in the state, but exceptionally CMA will face a decrease by 100 to 150 mm as shown in Figure A2.4.1. The same projection for 2040-2070 indicates that the rainfall in CMA will also be lower than that in 1970-2000 by 100 to 200 mm. Most of the other areas in the state will also face a decrease in rainfall by 0 to 100 mm.



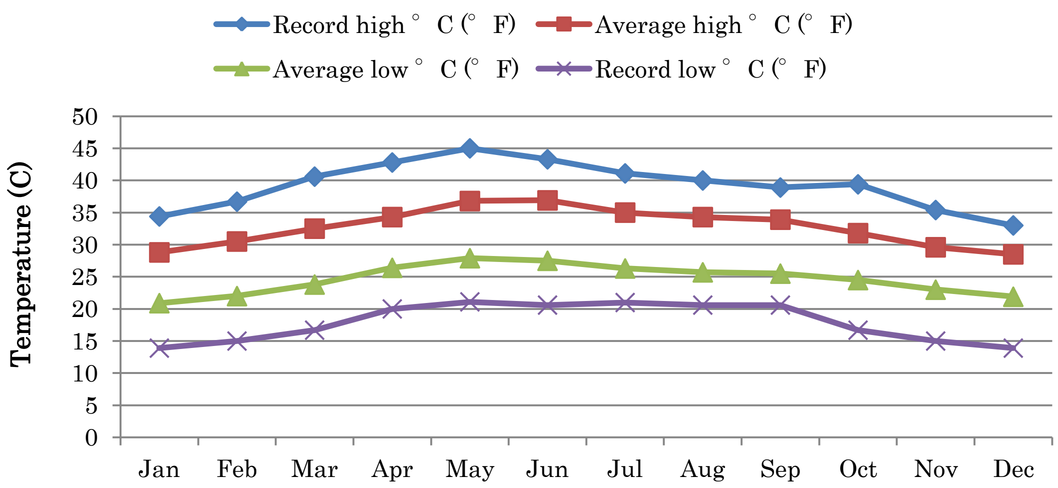
Source: Tamil Nadu State Climate Change Action Plan

Figure A2.4.1 Projection of Rainfall for Tamil Nadu

From the above climate change simulations, it is evident that CMA is likely to suffer from decrease in rainfall resulting in lower limit of water availability from the reservoirs whose catchment area includes the regions in and around Chennai. Water resources outside the CMA may maintain the current and future water availability until 2040, but the availability may deteriorate during 2040-2070.

(2) Chennai

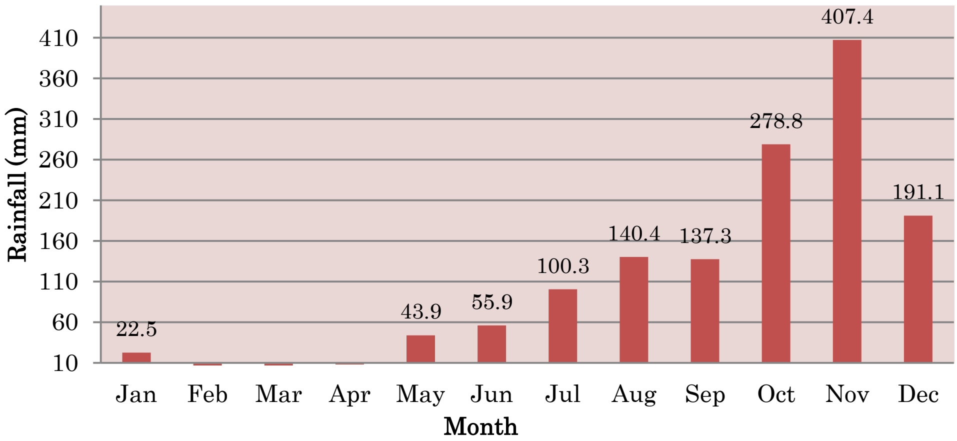
Chennai has a tropical wet and dry climate. The summers arrive in between late March and early June with maximum temperature reaching at 45°C in the month of May. The coolest part of the year is in the month of January, with average low temperature about 20 °C. Based on the data obtained from Indian Meteorological Department (IMD), the average and the recorded (maximum and minimum) temperature values are presented in Figure A2.4.2.



Source: Indian Meteorological Department (IMD), as observational data in 1971-2000

Figure A2.4.2 Variation of Temperature for Chennai

Chennai is highly dependent on the annual rainfall during the monsoons to replenish the water reservoirs, as there are no major water resources or perennial rivers to serve the city. The average annual rainfall of the city is 1,400 mm with around 60 rainy days in a year, most of which is the seasonal rainfall received from the north-east monsoon (from mid-October to mid-December). Cyclones often hit Chennai during the monsoons. The highest annual rainfall is 2,570 mm, which was recorded in 2005. During the recent floods in the city in the year 2015, highest rainfall of 539 mm in December was recorded against a monthly average of 191 mm, which is almost three times as the normal rainfall in December. The average monthly trend in rainfall for Chennai is shown in Figure A2.4.3.



Source: Indian Meteorological Department (IMD), as observational data in 1971-2000

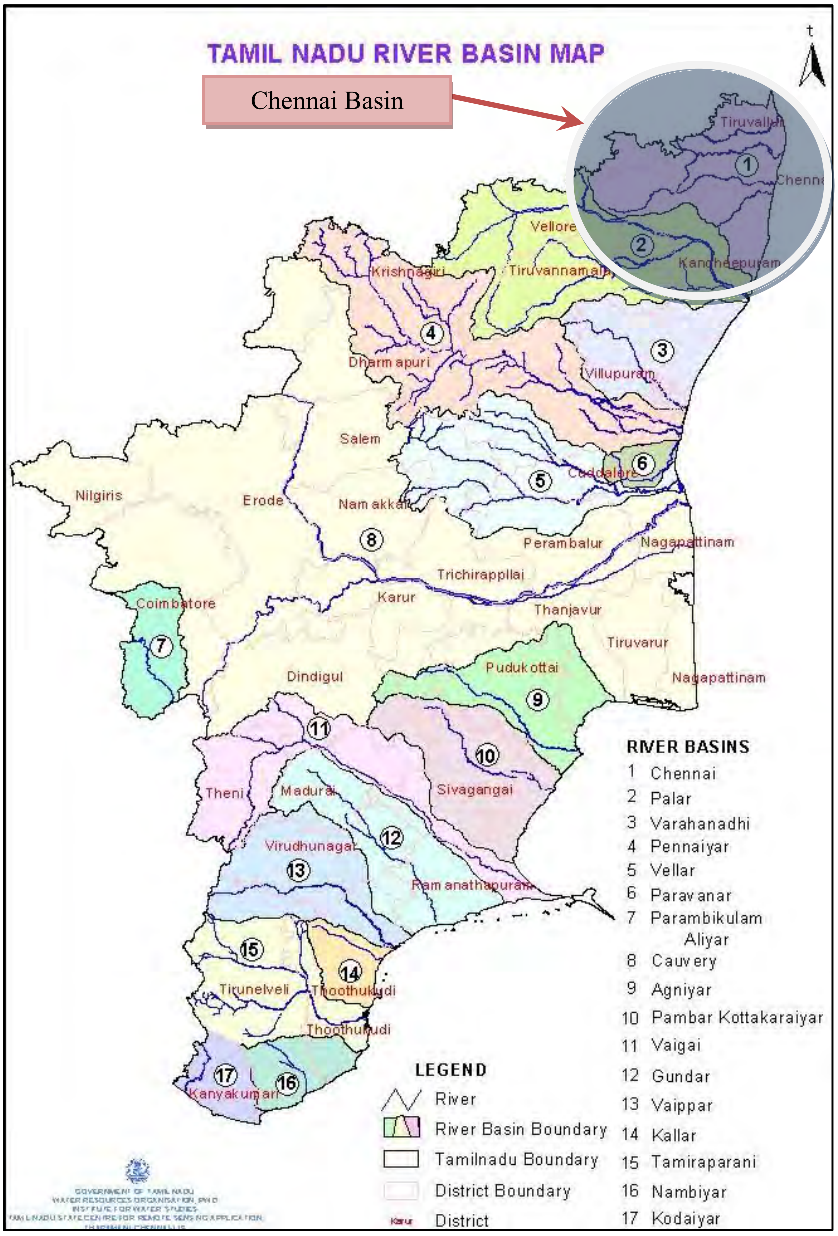
Figure A2.4.3 Average Monthly Rain fall for the Chennai Corporation

A2.4.2 Topography and Geology

(1) Topography and Geology of Tamil Nadu

The Tamil Nadu State lies between N 8 00' and N 13 30' latitudes, and E 76 16' and E 80 18' longitudes. The state is bounded by the Andhra Pradesh and Karnataka on the northern side and Kerala on the western side.

The topography of Tamil Nadu comprises coastal plains in the east and uplands, hills, and plains in the west. The latter covers more than 50% area of the state. The state encompasses 17 river basins as shown in Figure A2.4.4. CMA is located in the Chennai Basin, which is made by the rivers of Araniar, Kosathalaiyar, Cooum, and Adyar.



Source: Water Resources Department, TN State

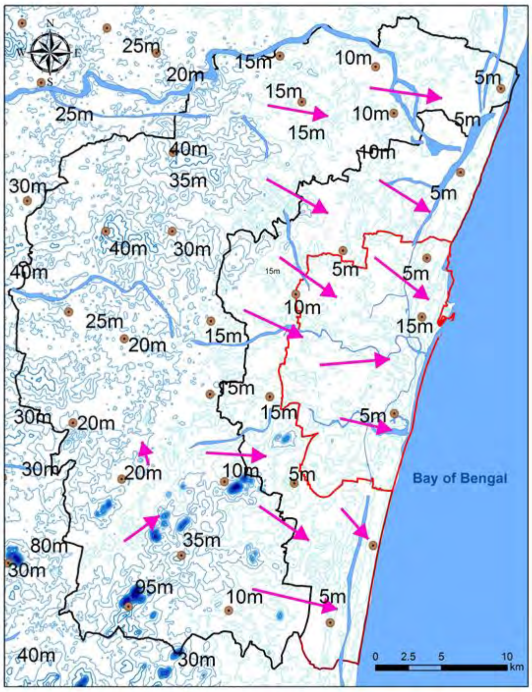
Figure A2.4.4 River Basins in Tamil Nadu

Tamil Nadu represents a high-grade metamorphic terrain of global importance, and geologically, the state has been divided into three zones, i.e., northern region, southern region, and central region. CMA falls on to the Northern Region. The state is rich in varied mineral sources like Quartz, Limestone, Lignite, Feldspar, Magnesite, Bauxite, Graphite, Garnet, Clay, and Granite. It is also occupied by the amphibolite facies terrain, which is the southern extension of Dharwar craton.

The notable geological formation found in Tamil Nadu is the Cuddalore formation belonging to the Tertiary age, which contains plant fossils. Besides this, Upper Gondwana rock formations have also been noticed near Sriperumbudur (close to Chennai) and Satyavedu (A.P state). These are composed mainly of white to pink clays, shale, and felspathic sandstone.

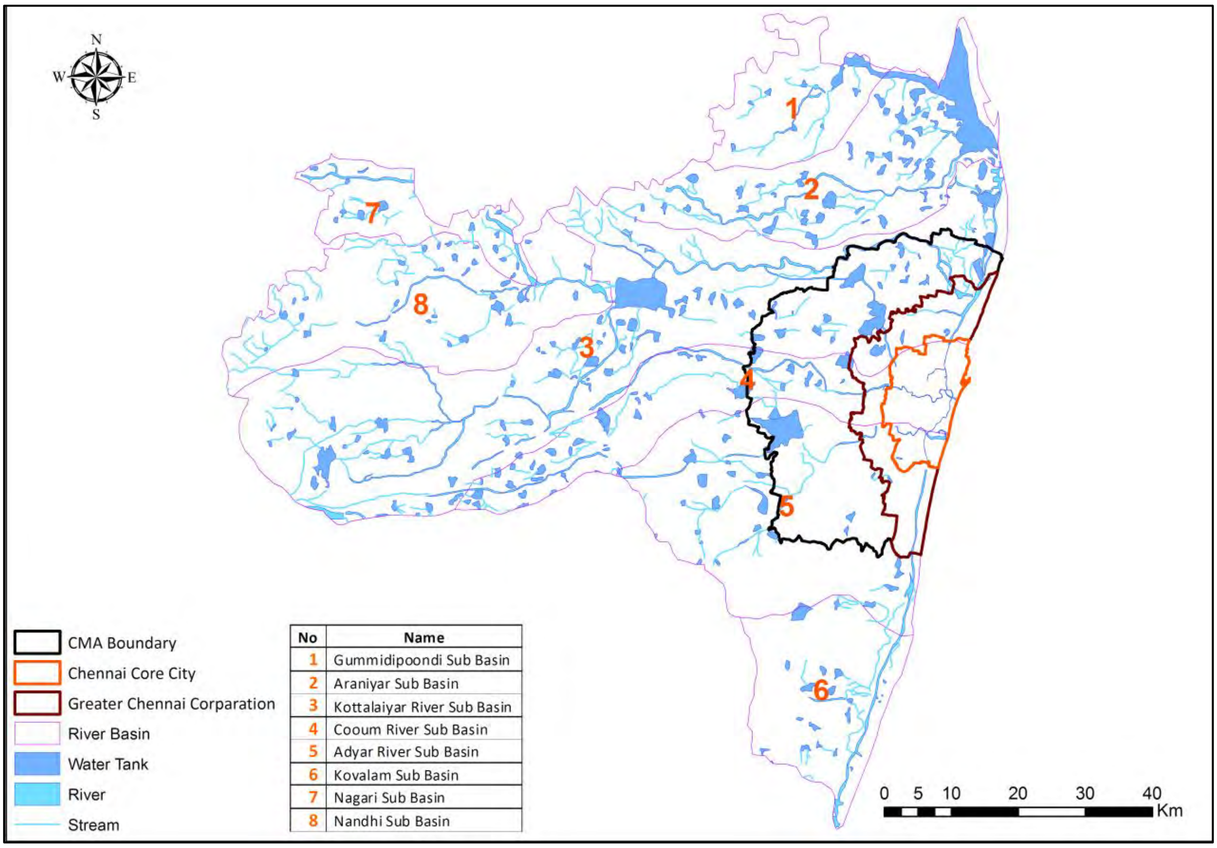
(2) Topography and Geology of Chennai

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 elevation of the city away from the core area increases with the increase in the distance from seashore up to 7 m above the mean sea level (MSL). Moreover, many localities situated at the MSL affect the drainage system that causes inundation within the city. The general topography of the city is shown in Figure A2.4.5, and Figure A2.4.6 shows the demarcation of the project area in Chennai River Basin.



Source: JICA Study Team

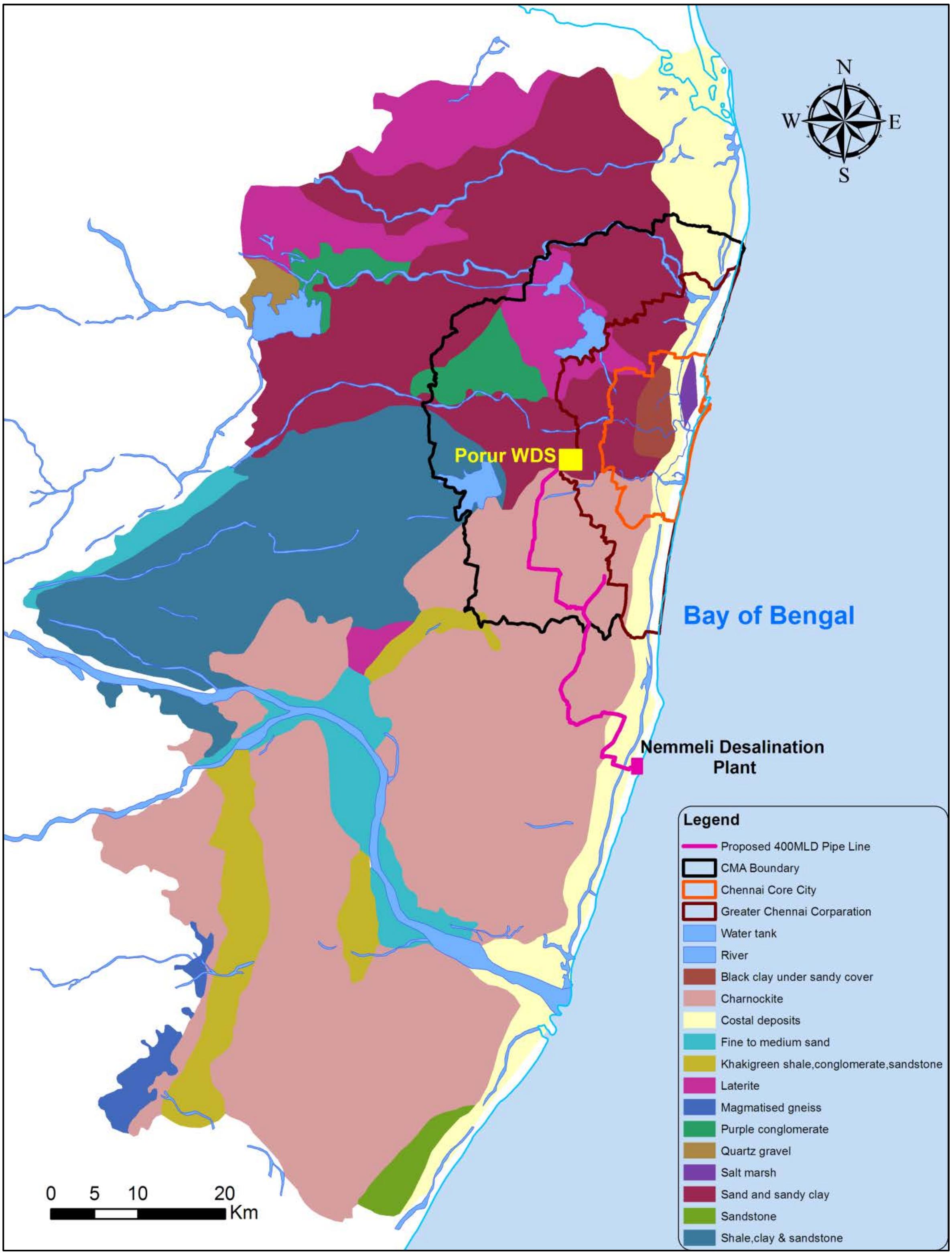
Figure A2.4.5 Topographical Map of CMA



Source: Water Resources Department, TN State

Figure A2.4.6 Demarcation of Project Area in Chennai River Basin

The geology of Chennai also comprises clay, shale, and sandstone. The Chennai Corporation is classified into three regions based on its geological features, i.e., sandy, clayey, and hard-rocks areas. Sandy areas are found along the river banks and coasts, whereas the clayey regions cover most of the city area. Hard rock areas are Guindy, Velachery, Adambakkam, and a part of Saidapet. Rainwater run-off percolates very quickly in sandy areas such as Tiruvanmayur, 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. T.Nagar, West Mambalam, Anna Nagar, Perambur and Virugambakkam are enlisted under the clayey areas. The geology of the planned 400 MLD DSP at Perur is located in the coastal deposits. As for the construction site of the transmission main in the Project, covering the coastal deposits of the state near the plant, the geology is Charnockite deposits towards its northern side where it meets with sand & sandy clay near Porur Head Works, as shown in Figure A2.4.7.



Source: JICA Study Team

Figure A2.4.7 Geological Map of the Project Area

A2.4.3 Flora and Fauna

(1) Tamil Nadu

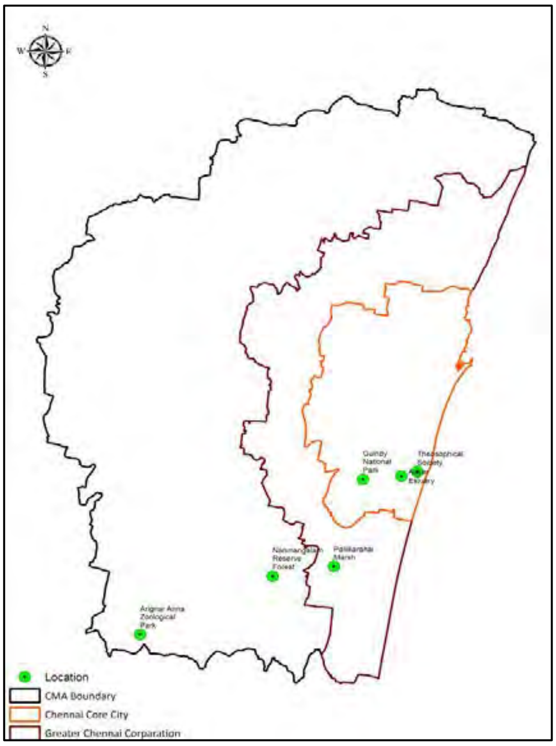
The wild plant diversity of Tamil Nadu includes a vast number of Bryophytes, Lichens, Fungi, Algae, and Bacteria. There are 1,559 medicinal species found in Tamil Nadu, of which about 533 are identified as endemic, 260 as wild relatives of cultivated plants, and 230 as red-listed species.

In Tamil Nadu, several species of mammals are found of which the endangered ones are the Slender Loris, Lion Tailed Macaque, Indian Pangolin, Jackal, Indian Fox, Indian Wild Dog, Sloth Bear Ratel, Striped Hyena, Jungle Cat, Leopard, Tiger, Mouse Deer, Gaur, Blackbuck, Nilgiri Tahr, Grizzled Grey Squirrel, Common Dolphin and Dugong. The tiger population in Tamil Nadu increased from 76 in 2006 to 163 in 2010. The estimated population of the wild elephants in Tamil Nadu escalated up to 3,867 in 2007-08, which were only 3,052 in 2002. The faunal diversity of Tamil Nadu includes 165 identified fresh water fishes, 76 amphibians, 127 reptiles, 545 birds, and 187 mammals[1].

(2) Chennai

The Flora and Fauna of Chennai are mainly found in the Guindy National Park, the Theosophical Society, Adyar Estuary, Pallikaranai Marsh, Nanmangalam Reserve Forest, Arignar Anna Zoological Park, and along the southern stretches of the beach in Chennai as shown in Figure A2.4.8. These national parks are not influenced by the construction works of the Project, including the DSP and the transmission lines.

In flora, more than 350 species of plants have been found in the national parks, including trees, shrubs, climbers, herbs, grasses, and exotic plant species.



Source: JICA Study Team

Figure A2.4.8 Locations of Fauna

The faunal diversity found in these places are endangered Eurasian Eagle Owl (Bubo bubo), Chital, Blackbuck, toddy cat, civets, jungle cat, pangolin, and hedgehog, snakes, certain species of tortoise and turtles, lizards, geckos, chameleons, the common Indian monitor lizard, and endangered Olive Ridley turtles. Madras Crocodile Bank Trust, situated towards the south of the city along the East Coast Road, hosts several fresh-water and salt-water crocodiles, alligators, gharials, turtles and snakes[2].

[1]Source: Centre of Excellence in Environmental Economics, January 2016
[2]Source: Madras Naturalists' Society, NGO

Appendix 2.5 Infrastructure Development in the Study Area

A2.5.1 Transportation

(1) Airports

There are eight airports in Tamil Nadu that include six operational airports (Chennai, Tiruchirapalli, Coimbatore, Salem, Madurai and Tuticorin) and two non-operational airports (Vellore and Thanjavur) that are currently not being used due to poor patronage.

Chennai has both international and domestic airports. In the year 2014-2015, it had 122,377 international and domestic aircraft movements and handled 14,299,200 international and domestic passengers and 303,904 t of international and domestic freight[1]. The Chennai airport is connected to other airports in South Asia, South East Asia, Middle East, Europe and North America through various international carriers.

(2) Seaports

There are two major seaports and 15 notified minor and intermediate seaports in Tamil Nadu. Chennai Corporation has two ports, namely Chennai and Ennore (Kamarajar Port Limited), and they have collectively handled 82.79 million tons of cargo during the year 2014-2015[2]. Besides, a seaport named "Kattupalli International Container Terminal (KICT)" has started its operation from the year 2014, north of Ennore Port near Kattupalli village in Thiruvallur district near Chennai. This port has been developed and maintained by L&T Shipbuilding Limited (LTSB), a joint venture of Larsen & Toubro (L&T) and Tamil Nadu Industrial Development Corporation Ltd (TIDCO), a state-owned company.

(3) Roads

Tamil Nadu has an extensive roadwork coverage of 153 km per 100 km^2 area with a road length of 199,040 km as of March 2010. As of March 2016, the total length of roads maintained by the Chennai Corporation in the Chennai city is 6,010 km, of which 387 km are bus route roads, and the remaining 5,623 km are interior roads[3].

(4) Railways

As of October 2015, the Southern Railways of Government of India in the state of Tamil Nadu had 3,846 km of route length (3,452 km of broad gauge (BG) and 394 km of meter gauge (MG)) and 4,943 km of running track length (4,548 km of BG and 395 km of MG)[4].

The rail infrastructure in CMA basically comprises of three sections of railway that are treated as suburban sections viz., (I) North line towards Gummidipoondi (Chennai Central – Gummidipoondi, BG line, 48 km, 16 stations); (II) West line towards Arakkonam (Chennai Central to Arakkonam, BG line, 69 km, 29 stations); and (III) Southern line towards Chengalpattu (Chennai Beach to Tambaram,

[1] Source: www.aai.aero
[2] Source: www.ipa.nic.in
[3] Source: www.chennaicorporation.gov.in
[4] Source: www.sr.indianrailways.gov.in

BG line, 30 km, 18 stations). Apart from the above, there is also a Rapid Transit System (RTS) on the north-south corridor along the Buckingham Canal alignment from Chennai Beach to Velachery (BG line) with a route length of 20 km. The extension from Velachery to St. Thomas mount is under execution.

The Chennai Metro Rail (CMRL) system at a total estimated cost of Rs 147,500 million (having JICA loan amount is Rs 85,900 million) is a rapid transit with Phase I of the project consisting of two corridors viz., Corridor - 1 from Thiruvottiyur to Chennai Airport, of length 23.085 km (14.300 km is underground, 8.785 km is elevated) with 18 stations and Corridor - 2 from Chennai Central to St Thomas Mount, of length 21.961 km (partly underground, partly elevated) with 15 stations of which 10 km stretch with 7 stations has been operating from June 2015 onwards[5].

(5) Bus Transportation

The State Transport Corporation of Tamil Nadu, a state-owned company, has a fleet strength of 22,474 buses and operates 9 million km per day with scheduled services of 20,684 in Tamil Nadu including 3,531 bus services in the Chennai Corporation, as of March 2015[6].

A2.5.2 Sewerage

(1) Responsible organization

By the Act 28 of 1978, CMWSSB is responsible for the provision of sewerage services in CMA. The CMWSSB conducts the development and operation and maintenance (O&M) of the sewerage system in the Chennai Corporation including the core city and the Expanded Area. However, the works in the Rest of CMA are carried out by urban local bodies (ULBs). Sometimes, CMWSSB carries out sewerage development projects, but it needs to be paid by the ULB. The O&M of such facilities are done by the ULB.

(2) Present situations and future plan

Table A2.5.1 is a list of Sewage Treatment Plants (STPs) of CMWSSB in the Chennai Corporation as of 2015. The STPs in the table covers the entire core city and a part of the Expanded Area. As not all the STPs have a flow meter, the operation rates of the STPs are unknown. In the core city, the sewerage network has covered 98% of the city area., while the coverage in the Expanded Area is unknown.

The total capacity of the STPs is sufficient against the estimated current water consumption (652 MLD) among the water supplied by CMWSSB, but the total consumption including groundwater extracted by private wells may be greater than the STP capacity.

[5] Source: http://chennaimetrorail.gov.in/pdf/project_brief_updated_aug08(1).pdf
[6] Source: cms.tn.gov.in

Table A2.5.1 List of Sewage Treatment Plants of CMWSSB

Location of Treatment Plant	Treatment Capacity (MLD)	Length of sewer network in km	Sewer connections in number	Sewage Pumping Stations in number
Nesapakkam	117			
Kodungaiyur	270			
Koyambedu	214			
Perungudi	151			
Villivakkam	5			
Alandur	12			
Total	769	3,994	778,488	228

Source: Policy Note 2015 – 2016 of Municipal Administration and Water Supply Department of Government of Tamil Nadu

In the Expanded Area, which consists of 42 ULBs[7], 16 ULBs are currently constructing new sewerage systems, and 22 ULBs have construction plans as shown in Table A2.5.2.

Table A2.5.2 Stages of Underground Sewerage Schemes in the Expanded Area

Total No. of added areas in the Expanded Area (municipalities, towns and villages)	Works Completed	Works In progress	Works to be taken up	
			DPRs Completed	DPRs under preparation
42	4	16	10	12

Source: Policy Note 2015 – 2016 of Municipal Administration and Water Supply Department of Government of Tamil Nadu.

The outlines of the existing STPs under the corporation are shown in Table A2.5.3 (Alandur and Villivakkam STPs are excluded from the descriptions below because of their tiny capacities):

- Kodungaiyur STP system

As per the Master Plan, the existing plant at Zone-I and II are currently operating at half the capacity. Thus, there is a requirement to replace the equipment and perform major repairs to STPs as the existing plants are approximately 25 years old. Another 110 MLD plant of about 10 years old may need minor repairs in the future.

- Koyambedu STP system

The Master Plan indicates that the commissioning of 120 MLD plant in this location will create a surplus capacity to the extent of 9.0 MLD. The existing 34 MLD STP is about 40 years old, and the plant is neither space efficient nor energy efficient. Subsequently, the Master Plan recommends replacing the existing plants with new ones. Additionally, a 25 MLD plant may be necessary to meet the 2020 requirement, and an 80 MLD capacity addition is proposed for meeting the 2035 requirement. An additional treatment capacity of 100 MLD is suggested for the target year of 2050. At present, the sewage generated is lower than the installed capacities due to the insufficient water supply status in the city.

- Nesapakkam STP system

[7] Although the ULBs in the Expanded Area were disestablished after the mergence in 2011, sewerage systems are developed by grouping the Expanded Area by the former administrative boundaries of the ULBs.

Due to the recent commissioning of 54 MLD STP, the existing 23 MLD plant can be de-commissioned in the near future. Additionally, a 15 MLD treatment capacity will be necessary to meet the requirement of 2035, and a 35 MLD capacity will be necessary to meet the requirement of 2050.

- Perungudi STP system

At present, 79 MLD and 72 MLD capacity STPs are operating at lower operating capacities at 45 and 48 MLD, respectively; the reason being a shortage of sewage due to constraints in the pumping system. Additionally, 70 MLD treatment capacity will be necessary for the immediate phase, 50 MLD treatment capacity will be required to meet the sewage generation in 2035, and 60 MLD treatment capacity will be required for 2050.

- Sholinganallur STP system

The Master Plan recommends the addition of a treatment capacity of 15 MLD for the immediate phase. Additionally, 60 MLD treatment capacity will be necessary to meet the requirement of 2035 and 100 MLD treatment capacity will be required to meet the treatment requirement of 2050.

- Thiruvottiyur STP system:

The existing STP of 31 MLD capacity (likely to be commissioned in 2016) will be suitable for the immediate requirement. Additionally, a treatment capacity of 25 MLD STP will be required for the year 2035, and 12.5 MLD will be required to be added in the year 2050.

Table A2.5.3 Details of Existing and Under-Construction STPs in Chennai Corporation

Locations	STP's Name	Capacity of Existing STP (MLD)	Capacity of planned STP (MLD)	Service Area
Core City	Kodungaiyur	270	-	Zone-I & II
Core City	Koyembedu	214	-	Zone-III
Core City	Nesapakkam	117	-	Zone-IV
Core City	Perungudi	151	-	Zone-V
Expanded Area	Alandur	12	12	
Expanded Area	Villivakkam	5	-	
Expanded Area	Thiruvottiyur	-	31*	
Expanded Area	Sholinganalur	-	18*	

* Under construction
Source: Master Plan for Water supply and Sewerage sections in Chennai Corporation and Rest of CMA

For the Rest of CMA, the Tamil Nadu State has a plan to expand the coverage of sewerage system to the entire CMA. The "Master Plan for Water supply and Sewerage sections in Chennai Corporation and Rest of CMA" has developed a development plan of sewerage systems to cover the CMA.

A2.5.3 Drainage

(1) Present situations

In Tamil Nadu, storm water drains are built and maintained by the respective corporations and local bodies. For the Chennai Corporation area, the storm water drains are not under the control of CMWSSB but are under the Greater Chennai Corporation authority. For the Rest of CMA, the respective local bodies like municipalities, town panchayats, and village panchayats construct maintain the storm water drains.

The Chennai Corporation maintains 7,351 numbers of storm water drains of a total length of 1,894.82 km and 30 numbers of canals for a total length of 48.803 km. Under the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) funding of Government of India, a 329.05 km network of storm water drains at a cost of INR 5,216.4 million has been constructed in the last four years. Subsequently, the number of flood prone areas in the Chennai Corporation has reduced to below 100 from about 300 earlier.

In order to improve drainage conditions, the Chennai Corporation has prepared a DPR for Kosasthalaiyaru, Cooum, Adayar, and Kovalam Basin of integrated storm water drain networks for a total length of 1,069.40 km at a project cost of INR 40,343 million. It is proposed to execute the first phase of the work under the Tamil Nadu Sustainable Urban Infrastructure Development Project (TNSUDP) in Zones-7 (Ambathur), 11 (Valasaravakkam) and 12 (Alandur), covering an area of 53.79 km^2 of the corporation in Cooum and Adayar basin for a length of 270 km. The project cost is estimated to be INR 11014.3 million and will be funded by the World Bank.

(2) Flood in and around the Chennai Corporation in October to December 2015

In 2015, the unprecedented northeast monsoon resulted in heavy rains in four phases between October and December, which caused large-scaled destruction including the killing of 470 people and about 100,000 livestock and damaging of crops in about 383,000 hectares of land in Chennai, Kancheepuram, Tiruvallore, Cuddalore, Tuticorin and Tirunelveli districts of Tamil Nadu. Reportedly, a total of about 3,042,000 families had suffered partial or complete damage to their dwelling units, including huts.

Heavy rains in the monsoon season are common in Chennai. However, the monthly rainfall in December 2015 was the record highest of 539 mm against a monthly average of 191 mm. The rainfall in December is more than one-third of the annual rainfall in Chennai (1,400 mm). Some areas of Chennai had more than 250 mm rainfall in just 24 hours. This extreme rainfall volume over a short duration caused floods over an area of 55,175 ha and disrupted critical infrastructures.

According to Sigma Swiss Re report, a global insurance research firm, the total losses due to Chennai floods between 28th November 2015 and 4th December 2015 were estimated to be at least INR 133 billion (USD 2 billion). Insured losses were INR 50 billion (USD 0.755 billion), making the floods the second costliest insurance event in India on sigma records with 289 people dead and 1000 people injured. A large part of the losses originated from commercial lines as Chennai is home to several manufacturing companies, particularly in the automobile and automotive parts industry.

The disastrous flood caused a serious loss to the Japanese firms, who operate in and around the corporation. According to a questionnaire survey conducted by the Japanese Chamber of Commerce and Industry, Chennai (JCCIC), the flood incurred various losses to 36 firms out of 84 responders, and their total loss amounted to INR 3.4 billion. JCCIC reported the Government of Tamil Nadu regarding the damages and losses suffered by the Japanese firms. In addition, the JCCIC proposed a technical action plan for flood control to the government.

For recovery from the serious disaster, the Government of Tamil Nadu demanded a central assistance of INR 259,124.5 million from the Government of India for the relief and restoration works.

A2.5.4 Solid Waste Management

(1) Tamil Nadu

In the Tamil Nadu State, about 7,597 t of municipal solid waste is generated daily in 11 Corporations (other than the Chennai Corporation) and 124 municipalities. Besides 1,967 t of municipal solid waste is generated daily in 528 town panchayats. At present, bio and vermi composting of solid waste are being done successfully at 461 and 132 town panchayats, respectively, in a month that has resulted in a production of 493.73 t of bio compost and 47.14 t of vermi compost, respectively. During the year 2013-14, comprehensive solid waste management projects at a total cost of INR 437.28 million under the Special Solid Waste Management fund have been taken up in 77 town panchayats.

To strengthen the primary collection and transportation of municipal solid waste, 56,065 vehicles and equipment of 12 different types at a total cost of INR 1,435.2 million have been procured under IUDM and Special Sold Waste Management fund. The Integrated Solid Waste Management (ISWM) projects have been taken up at a cost of INR 990 million for 6 ULBs, and the trial run of the Refuse Derived Fuel (RDF) Plant is in progress. DPRs have been prepared for 5 clusters covering 29 ULBs at an estimated cost of INR 6,310 million, and a financial tie-up is being arranged. Special Solid Waste Management (SWM) Fund has been constituted with a sum of INR 1,000 million per year for financing the projects to weaker ULBs for implementation of ISWM projects. Under this project, 263 works have been taken up at an estimated cost of INR 2,111.8 million.

Under the Urban Infrastructure and Governance (UIG) of Jawaharlal Nehru National Urban Renewal Mission (JnNURM) of Government of India, solid waste management works DPRs at a total cost of INR 2150.1 million have been prepared for 4 ULBs. The works taken up in 3 ULBs have been completed in 2 ULBs and are in progress in 1 ULB.

Under the Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) of Jawaharlal Nehru National Urban Renewal Mission (JnNURM) of Government of India, solid waste management work for 1 ULB at a total cost of INR 35.8 million has been taken up and completed (p 64 to 91 of Policy note 2015-2016 of MAWS department of Govt. of Tamil Nadu).

Under the Government of India - Urban Infrastructure Development Scheme for Satellite Town (UIDSST) Fund, solid waste management work for Sriperumbudur Town Panchayat at a total cost of INR 44.4 million has been taken up and completed.

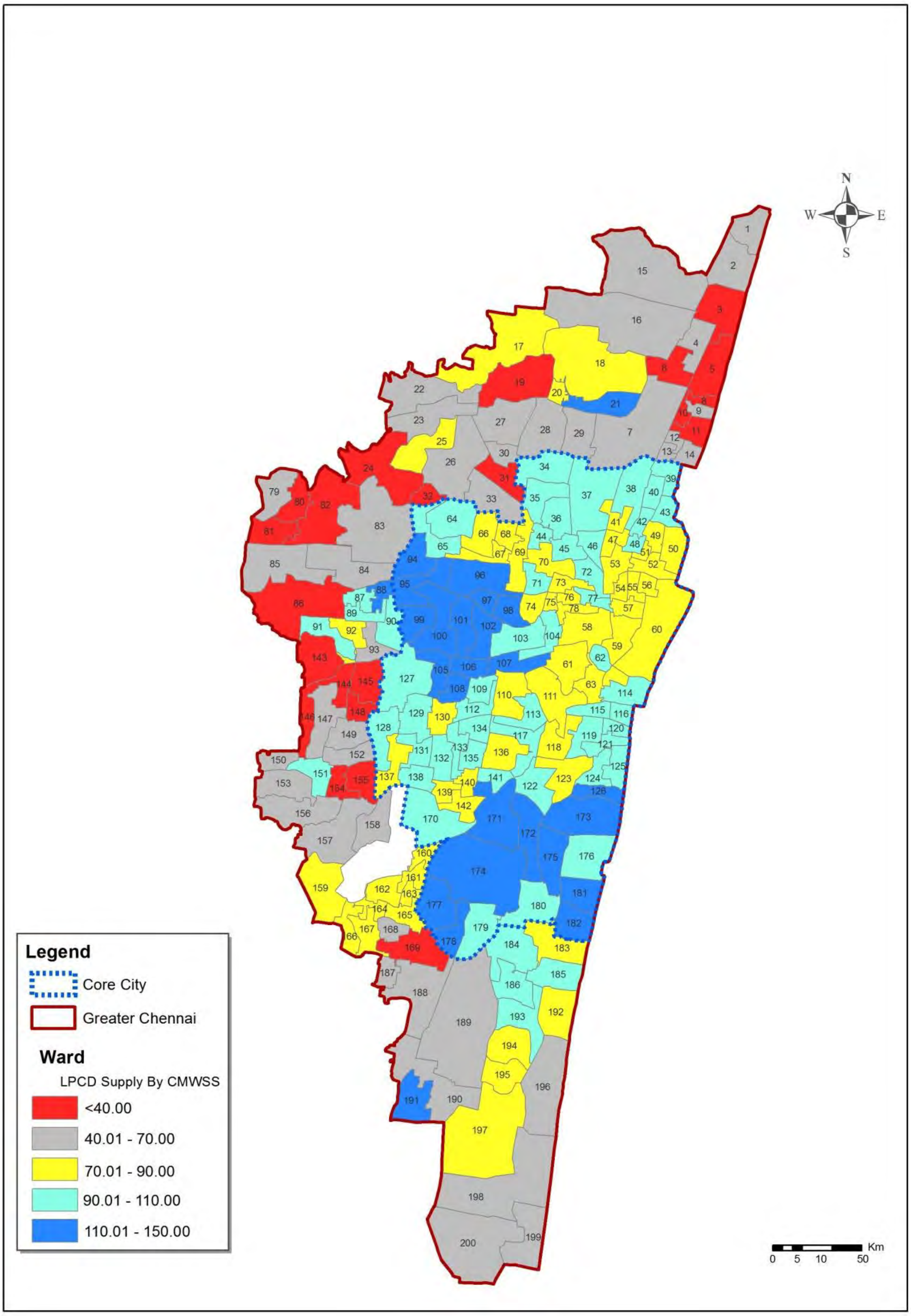
(2) Chennai Corporation

The generation of municipal solid waste in the Chennai Corporation area is 5,200 t per day (Garbage 4,500 t and building debris 700 t). At present, the primary and secondary collections of solid waste are managed using 17026 conservancy workers by deploying 7,632 vehicles of 7 different types. At present, for Greater Chennai Corporation, two dumping grounds, viz. 1) Kodungaiyur (area 0.8 km^2 and in existence for past 30 years) and 2) Perungudi (area 0.8 km^2 and in existence for past 25 years), are being used wherein open dumping and partly covering with debris are being carried out. For remediation of the existing landfill or scientific closure, the International Expression of Interest was called, and the developers were short-listed, and the Request for Proposal is under preparation. During the years 2011-14, under Chennai Mega City Development Fund, 250 numbers of vehicles at a cost of INR 442.6 million have been purchased.

Appendix 3.1 Summary of water supply services by administration area

S. No.	Administration Area	General Information				Domestic			Non-Domestic			Total Connections			Served population by connection	
		Number of Houses	Population	Area (km^2)	Total Assesses	Meter	Flat	Total Domestic	Meter	Flat	Total Non-Domestic	Meter	Flat	Total	Served population by connection	Connection rate
S. No.	I	59,830	317,463	26.09	44,472	97	6,812	6,909	15	2	17	112	6,814	6,926	58,727	18.5%
2	II	21,304	131,932	70.53	23,356	24	7,063	7,087	9	103	112	33	7,166	7,199	60,240	45.7%
3	III	59,426	286,449	40.55	52,361	264	6,288	6,552	19	25	44	283	6,313	6,596	55,692	19.4%
4	IV	99,368	662,669	21.03	75,284	560	50,519	51,079	1,148	6,638	7,786	1,708	57,157	58,865	434,172	65.5%
5	V	58,370	862,820	19.88	69,902	1,978	21,635	23,613	7,594	13,755	21,349	9,572	35,390	44,962	200,711	23.3%
6	VI	93,536	925,488	25.57	83,635	888	59,010	59,898	879	7,481	8,360	1,767	66,491	68,258	509,133	55.0%
7	VII	79,764	417,813	40.37	97,245	1,467	21,660	23,127	260	1,257	1,517	1,727	22,917	24,644	196,580	47.0%
8	VIII	116,022	1,002,139	35.03	108,800	832	72,084	72,916	1,320	9,519	10,839	2,152	81,603	83,755	619,786	61.8%
9	IX	88,289	809,427	42.54	114,435	1,507	75,090	76,597	2,652	14,713	17,365	4,159	89,803	93,962	651,075	80.4%
10	X	138,375	963,091	34.05	140,404	343	96,208	96,551	1,112	11,624	12,736	1,455	107,832	109,287	820,684	85.2%
11	XI	78,951	461,349	29.02	90,921	690	25,498	26,188	65	144	209	755	25,642	26,397	222,598	48.2%
12	XII	50,915	259,110	39.10	65,467	304	37,425	37,729	82	3	85	386	37,428	37,814	320,697	123.8%
13	XIII	128,233	810,049	54.25	119,844	875	77,262	78,137	930	6,708	7,638	1,805	83,970	85,775	664,165	82.0%
14	XIV	74,911	339,156	32.00	79,629	75	10,694	10,769	3	196	199	78	10,890	10,968	91,537	27.0%
15	XV	64,178	380,517	38.57	51,869	259	7,645	7,904	18	9	27	277	7,654	7,931	67,184	17.7%
Subtotal (Core City)		722,193	6,035,683	232	712,304	6,983	451,808	458,791	15,635	70,438	86,073	22,618	522,246	544,864	3,899,724	**64.6%**
Subtotal (Expanded Area)		489,279	2,593,789	316	505,320	3,180	123,085	126,265	471	1,739	2,210	3,651	124,824	128,475	1,073,253	**41.4%**
Total (Corporation)		1,211,472	8,629,472	549	1,217,624	10,163	574,893	585,056	16,106	72,177	88,283	26,269	647,070	673,339	4,972,976	**57.6%**
Core City Share		59.6%	69.9%	42.4%	58.5%	68.7%	78.6%	78.4%	97.1%	97.6%	97.5%	86.1%	80.7%	80.9%	78.4%	112.1%

Appendix 3.2 Estimated domestic LPCD map by CMWSSB



Non-domestic consumptions and water loss in the water distribution networks have not been counted.
Source: JICA Study Team based on estimated LPCD by CMWSSB

Appendix 3.3 Raw Water Transmission Mains of CMWSSB

Name of WTP	Kilpauk WTP	Surapet WTP	Redhills (Puzhal) WTP	Chembarambakkam WTP	Vadakuthu WTP
Intake Point	Redhills	Redhills	Redhills/Poondi	Chembarambakkam	Veeranam
Year of Construction	1959/1969/1983	1965	1996	2007	2004
Intake Type	Tower Intake	Intake Wall	Tower Intake	Tower Intake	Tower Intake
Type of Supply	Gravity	Gravity	Pump	Pump	Pump
Length	11km x 3nos.	Next to the Reservoir	2km x 45km	3 km x 2 nos.	20 km
Diameter Material	Masonry arch conduits	800 mm, CI	1,200 mm, PSC 1,000 mm, DI	1,500 mm, MS	1800 mm, MS
Condition	1 conduit damaged 2 conduits deteriorated	Fair	Fair	Fair	Fair
Quality of Raw Water	High turbidity	Meet with standard	Meet with standard	Meet with standard	Meet with standard
O/M by	CMWSSB	CMWSSB	VATECH WABAC	Degremont	IVRCL
O/M TOR	All O/M	All O/M	All O/M except major repairing of the facility and electricity cost	All O/M issues except electricity cost	All O/M except electricity cost

Sources: JICA Study Team

Appendix 3.4 O&M Conditions of the Existing Water Treatment Plants of CMWSSB

Descriptions of the O&M conditions of the existing water treatment plants (WTPs) of CMWSSB are given below and the notable issues are presented in Table A3.4.1.

(1) Kilpauk Water Treatment Plant

Kilpauk WTP is the first WTP of Chennai equipped with slow sand filters commissioned in the year 1914. Subsequently, the expansion of the WTP was done in three stages in the year 1959, 1969 and 1983 due to increase of the water demand. The usage of slow sand filter was abandoned in the year 2000. At present, three water treatment plants are working in Kilpauk WTP, which employ same water treatment methods.

According to the result of water quality analysis, the treated water meets with WHO water quality standard except for turbidity. Turbidity of the water sample at the test tap was often found to be above the permissible level of 5 NTU, this was due to the contamination of raw water caused by deterioration of the masonry conduits and WTP. This WTP especially for capacity of 45 MLD WTP is rapidly deteriorating and will need to be entirely replaced in the near future and other WTPs also need rehabilitations for efficient water supply.

(2) Surapet Water Treatment Plant

The Surapet WTP was taken over by CMWSSB from Tamilnadu Water Supply and Drainage Board (TWAD) Board in August, 2009 for operation and maintenance. The treatment method is conventional treatment process with the capacity of 14 MLD constructed in the year 1965. However, current water production capacity is about 5 MLD due to malfunctioned clarifloculators. Treated water is exclusively supplied to the heavy vehicle factory of Ministry of Defence. All of the facilities are deteriorating and need to be replaced by new facilities.

(3) Puzhal (Redhills) Water Treatment Plant

Puzhal WTP was commissioned in the year1996 based on conventional water treatment process with a capacity of 300 MLD. Operation and maintenance of the WTP is being done by an O&M contracting company. However major repairing works are out of their scope of contract as the facility is old and it is difficult to evaluate in advance the major repairing cost as the O&M cost. The rehabilitation of the facility is not properly scheduled and carried out by the CMWSSB, thereby causing rapid deterioration of the facility.

(4) Vadakuthu Water Treatment Plant

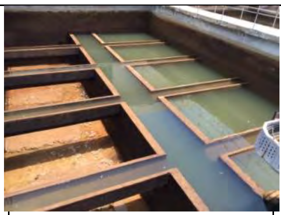
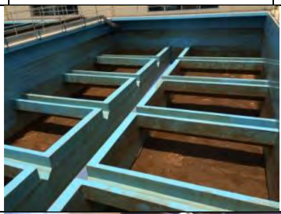
Vadakuthu WTP was commissioned in the year 2004. It adopts the conventional water treatment process with a capacity of 180 MLD and utilizes some civil structures of an old WTP constructed in 1974 at the same place, which was decommissioned prior to the construction of Vadakuthu WTP. The O&M of the facility including the WTP, raw water pumping station (RWPS) and bore wells are being carried out by an O&M contracting company with 190 staff members (36 for RWPS, 79 for WTP and 75 for bore wells).

(5) Chembarambakkam Water Treatment Plant

Chembarambakkam WTP is most advanced WTP of the CMWSSB with a capacity of 530 MLD commissioned in the year 2007. Due to present availability of single 2,000 mm diameter water transmission main instead of originally designed twin line and also non availability of sufficient raw water, current water treatment capacity does not exceed 260 MLD as on date. This WTP is only equipped with a filter backwash water recovery system which reduces the water loss in the WTP to less than 1%. O&M of Chembarambakkam WTP is fairly done except for back washing.

Table A3.4.1 Notable Issues in the Operation and Maintenance of the Existing WTPs of CMWSSB

Name of WTP	Pictures	Descriptions
Kilpauk WTP		Floating of the foreign materials in the clarifloculator This is due to the improper screening, thereby causing the inefficient operation and maintenance.
Surapet WTP		Improper management of the intake well During the time of site visiting, it was observed that people were swimming in the intake well as there is no protection fence for the intake well. This is a very dangerous situation and not recommendable in terms of water quality.
Surapet WTP		Deterioration of clarifloculators Two flocculaters are totally damaged due to old facility and inadequate operation and maintenance.
Redhills WTP		Direct use of chlorine gas cylinders along the road margin For additional chlorination before filtration, chlorine gas cylinders along the road margin are being used without any protection and measurement of dosing. This type of direct use should be avoided and must be used only after following all safety procedures in order to avoid any accident and proper dosing amount.
Redhills WTP		Non uniform air scouring during the back washing of filter Half of the left side of cell has no air scouring, while right side has. This is due to the clogging of air scouring holes or unbalanced air supply.

Redhills WTP		Unbalanced water level in the filter Right side compartment has full water depth whereas left side compartment is dry and has no retaining water. This may be either due to the seepage from the side wall of adjacent filter to the right side compartment or seepage through bottom slab of left side compartment due to poor construction.
Redhills WTP		Muddy filter It seems that flocculation is not properly functioning due to improper alum dosing.
Vadakuthu WTP		Muddy filter It seems that flocculation is not properly functioned due to improper alum dosing.
Vadakuthu WTP		Filter in extremely deteriorated condition Concrete trough is broken. This is due to the old facilities and poor construction quality. Deterioration of the facilities is accelerated by non lime dosing.
Chembarambakkam WTP		Unbalanced back washing Right side compartment of the cell is overflowing while left side is not. This is due to the unbalanced back wash water volume and rate, also air scouring of the left side compartment is not uniform because of blockage and/or broken of the nozzles.
Chembarambakkam WTP		Unbalanced surface media pattern observed in an empty filter This is the evidence of unbalanced air scouring during back washing of filters.

Source: JICA Study Team

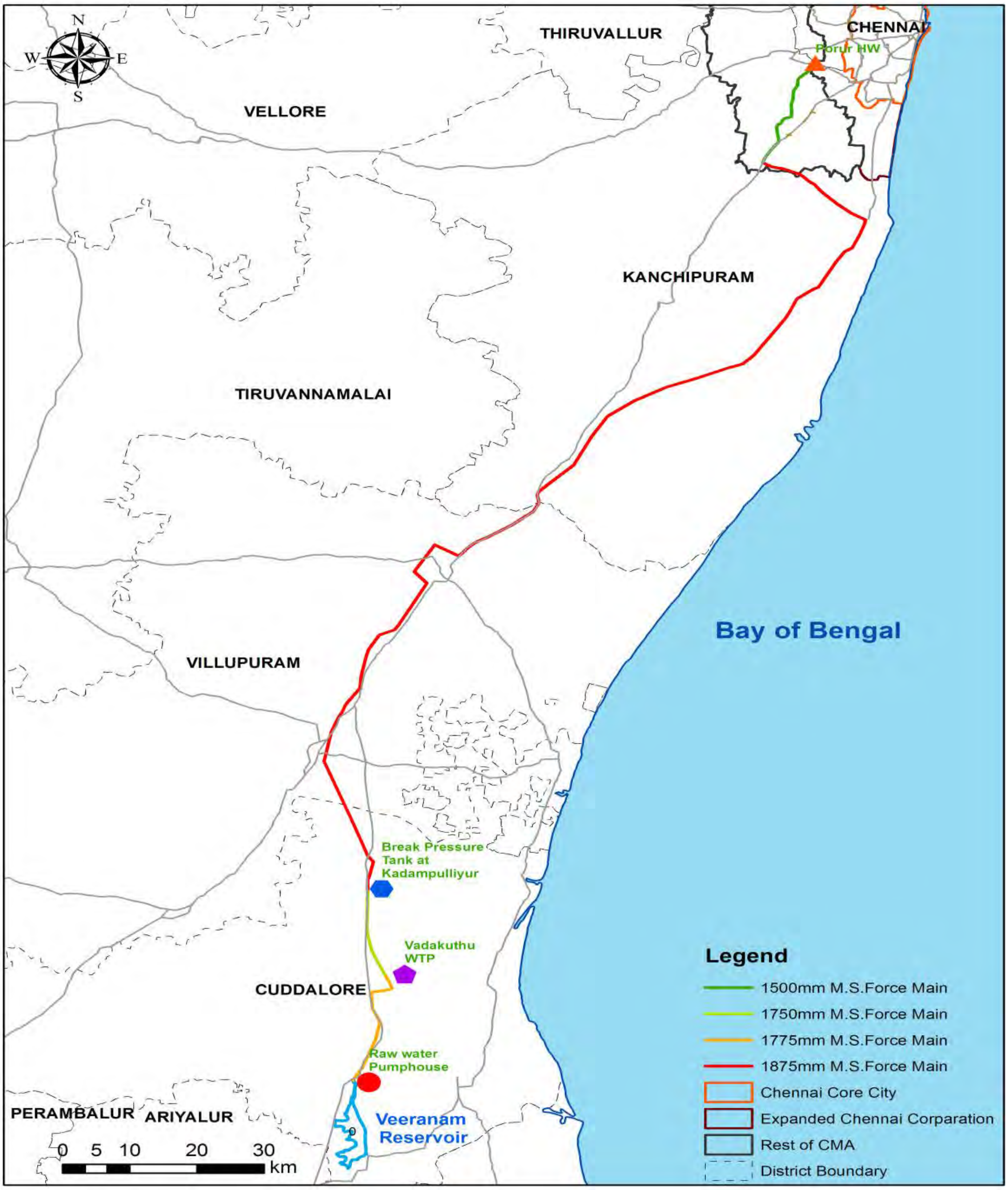
Appendix 3.5 Existing Water Transmission Mains of CMWSSB

Table A 3.5.1 Characteristics of the Existing Water Transmission Mains of CMWSSB

Name of Pipeline	From	To	Year	Diameter (mm)	Material
North Chennai Main	Puzhal WTP	Vysarpadi/Anna Poonga WDS	1996	1,200	MS/PSC
Central Chennai Main	Puzhal WTP	Kolathur/Choolaimedu/ Southern Headworks WDS	1996	1,200	MS/PSC
South Chennai Main	Puzhal WTP	KK Nagar/Ekkatuthangal WDS	1999	1,200/400	PSC/DI
K 1 Main	Kilpauk WTP/WDS	Southern Headworks WDS	1914	1,067 (42”)	MS
K 2 Main	Kilpauk WTP/WDS	Triplicane WDS	1948	1,067 (42”)	CI
K 2 Main Branch	K 2 Main	Kannaparthidal WDS	1948	762 (30”)	CI
K 3 Main	Kilpauk WTP/WDS	Anna Poonga WDS	1948	838 (33”)	CI
K 4 Main	Kilpauk WTP/WDS	KK Nagar WDS	1985	750	CI
K5 Main	Kilpauk WTP/WDS	Government Hospital/ Railways	1948	228 (9”)	CI
K6 Main	Kilpauk WTP/WDS	Port Trust	1948	355 (14”)	CI
Chembarampakkam WTP water used	Chembarampakkam WTP	Saveetha College Junction	2007	2,000	MS
Chembarampakkam WTP water used	Saveetha College Junction	Koyambedu Inner ring road junction	2007	1,900	MS
Chembarampakkam WTP water used	Saveetha College Junction	Porur junction/Kathipara junction	2007/2004	2,000/1,500	MS
Chembarampakkam WTP water used	Kathipara Junction	Pallipattu ToP after passing Vellacheri ToP	2004	1,300	MS
Chembarampakkam WTP water used	Kathipara Junction	Alandur WDS	2004	400	DI
Chembarampakkam WTP water used	Vellacheri TOP	Vellacheri WDS	2004	800	MS
Chembarampakkam WTP water used	Pallipattu TOP	Pallipattu WDS	2004	800	MS
Chembarampakkam WTP water used	Pallipattu TOP	Mylapore/ Nandanam WDS	2004	1,300/1,100	MS
Veeranam Pumping Main	Vadakuthu WTP	Kadampuliyur BPT	2004	1,750	MS
Convey Veeranam Water Main	Kadampuliyur BPT	Porur WDS with a tapping to Kelampakkam WDS	2004	1,875	MS
-	Minjur Desalination Plant	Madhavaram booster station and Puzhal WTP	2010	1,000/900	DI
-	Nemmeli Desalination Plant	Thiruvanmiyur, Kelampakkam Pallipattu WDS	2013	1,000/700	DI

Notes: MS: Mild Steel, PSC: Pre-Stressed Concrete, DI: Ductile Iron, CI: Cast Iron, TOP: Take off Point, BPT: Break Pressure Tank

Sources: JICA Study Team based on Information from CMWSSB

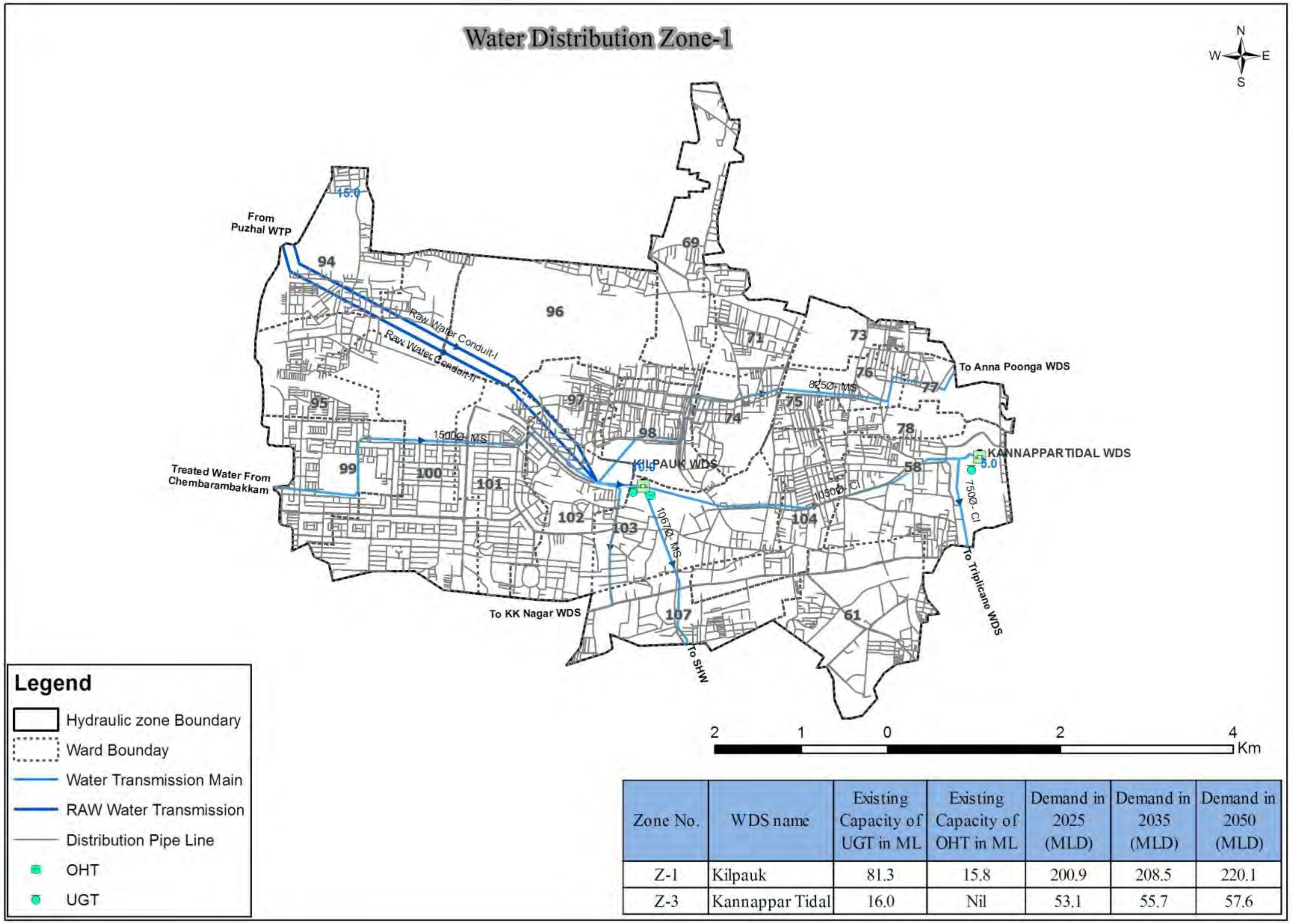


Source: JICA Study Team

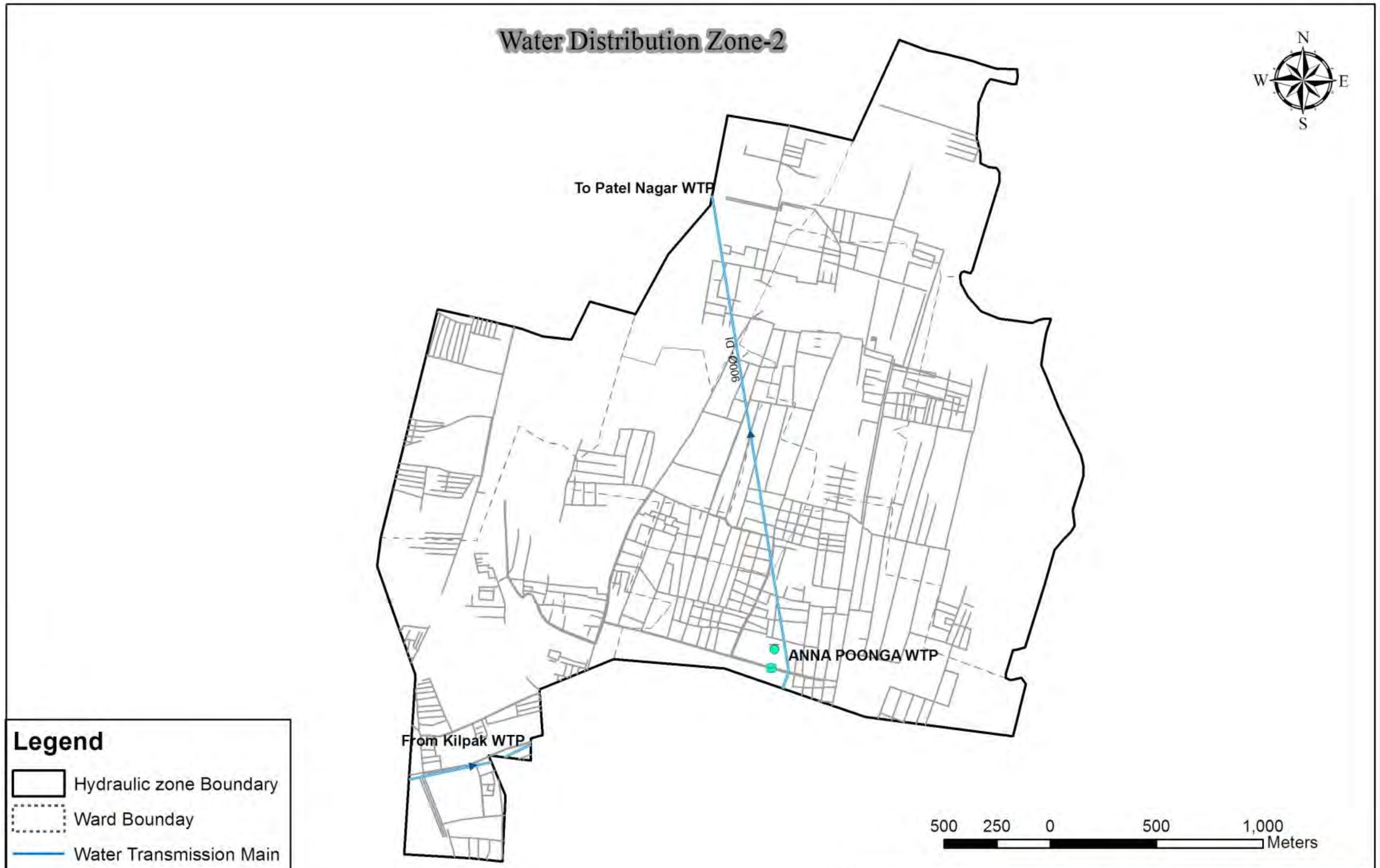
Source: JICA Study Team based on Information from CMWSSB

Figure A3.5.1 Layout of the Veeranam Transmission Main

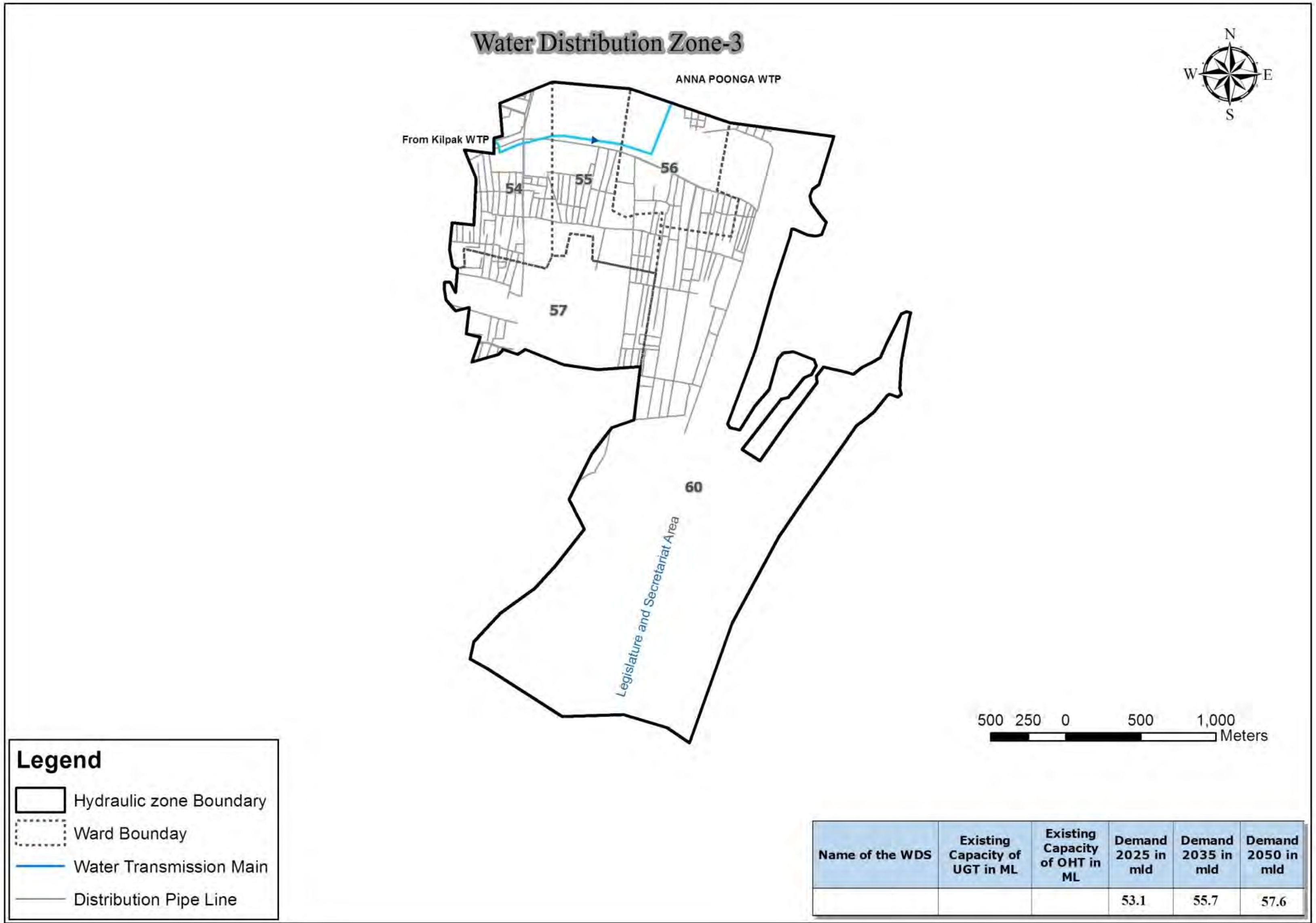
Appendix 3.6 Water Distribution Network Maps for the Water Distribution Zones (from Zone 1 to 16)



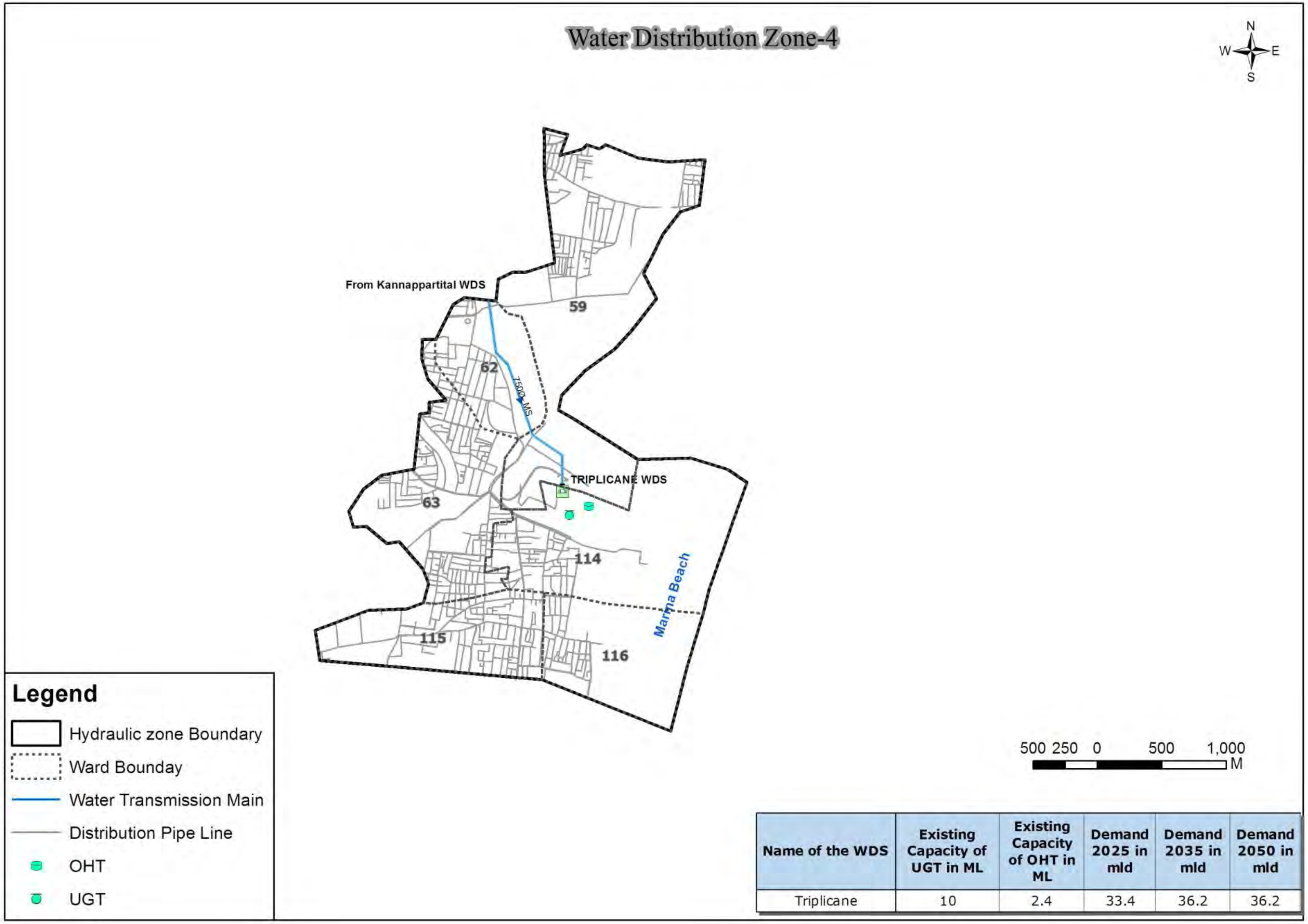
Zone No.	WDS name	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand in 2025 (MLD)	Demand in 2035 (MLD)	Demand in 2050 (MLD)
Z-1	Kilpauk	81.3	15.8	200.9	208.5	220.1
Z-3	Kannappar Tidal	16.0	Nil	53.1	55.7	57.6



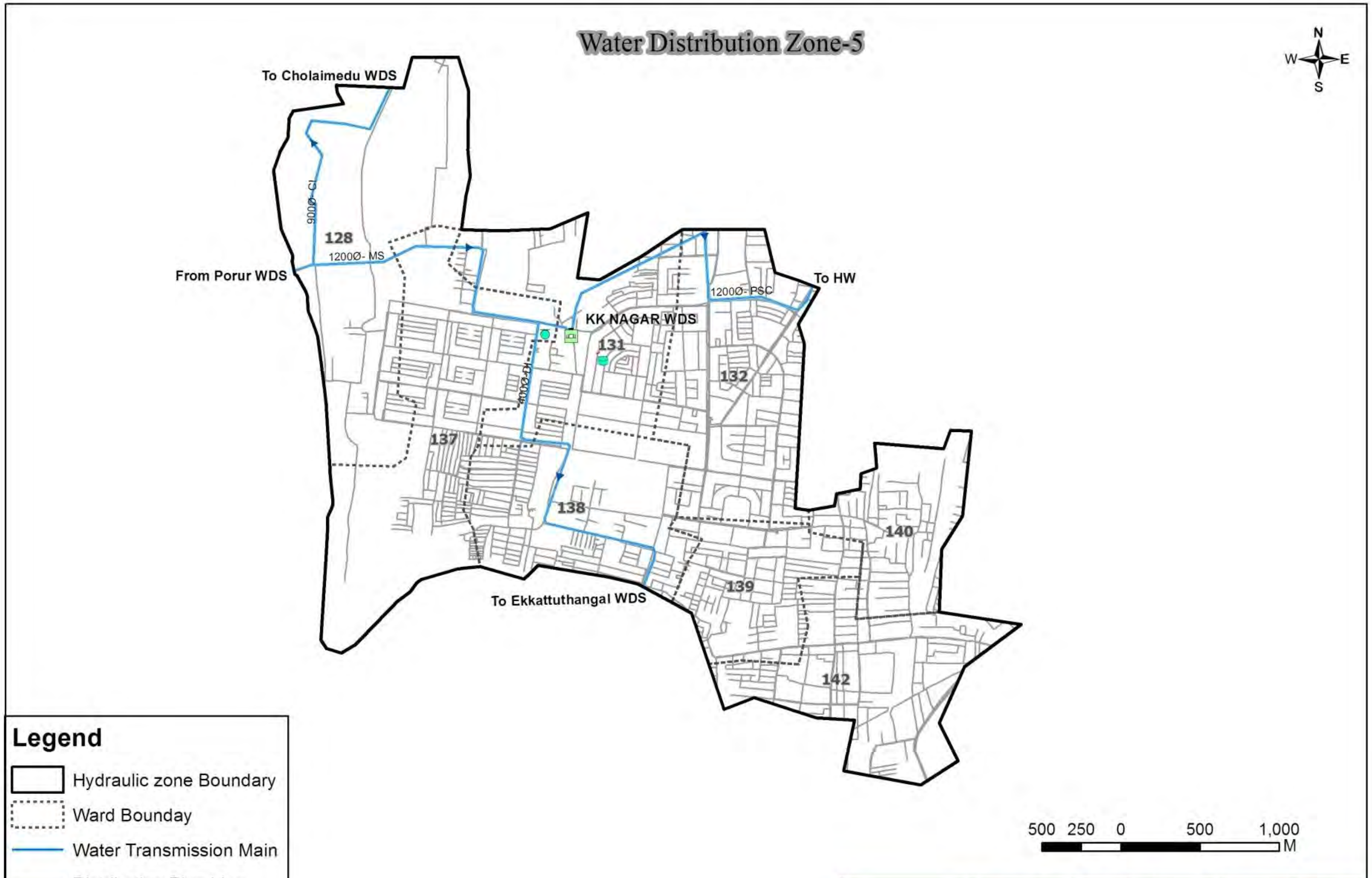
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Anna poonga	22.5	2.5	56	58.2	61.3



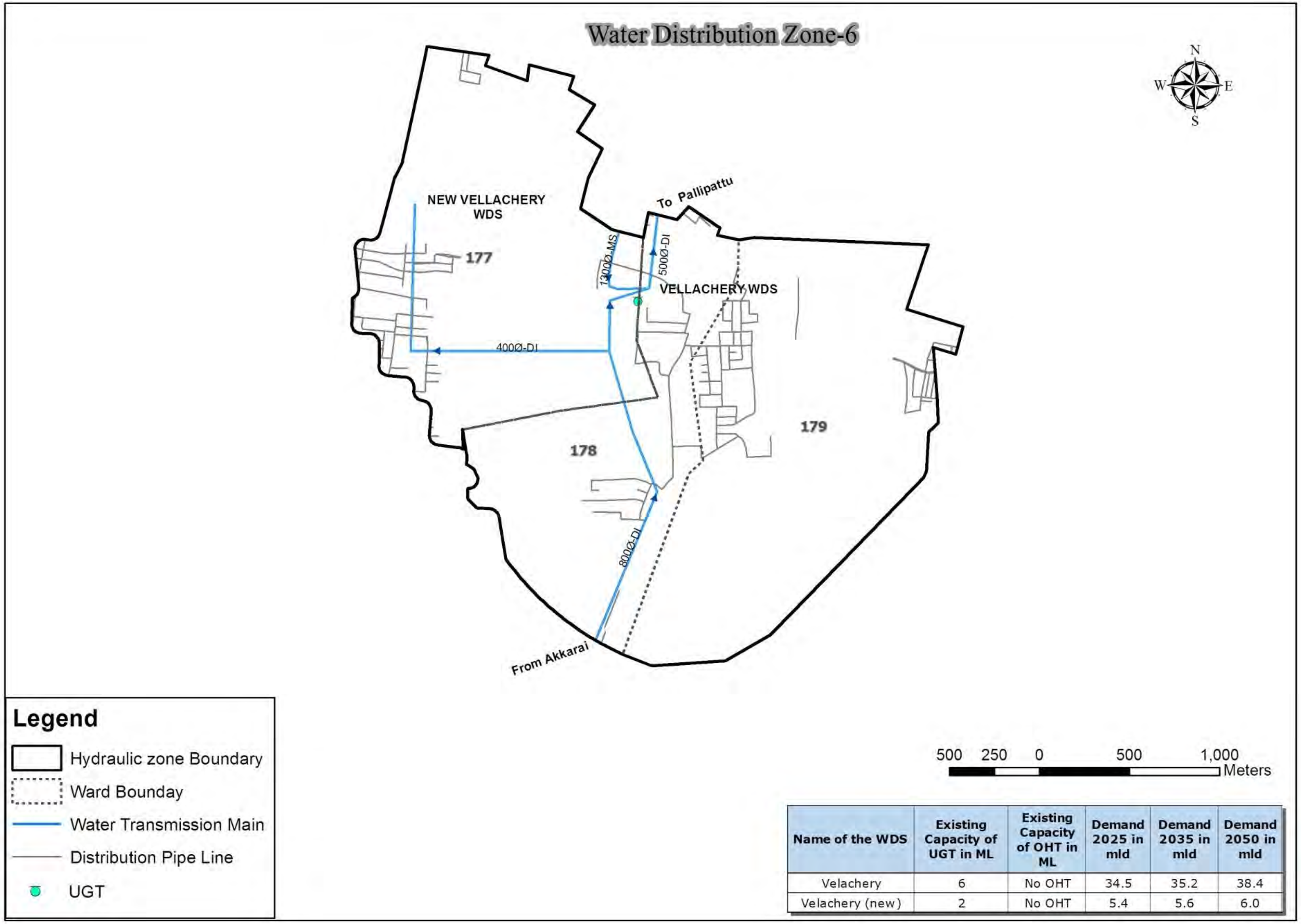
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
			53.1	55.7	57.6



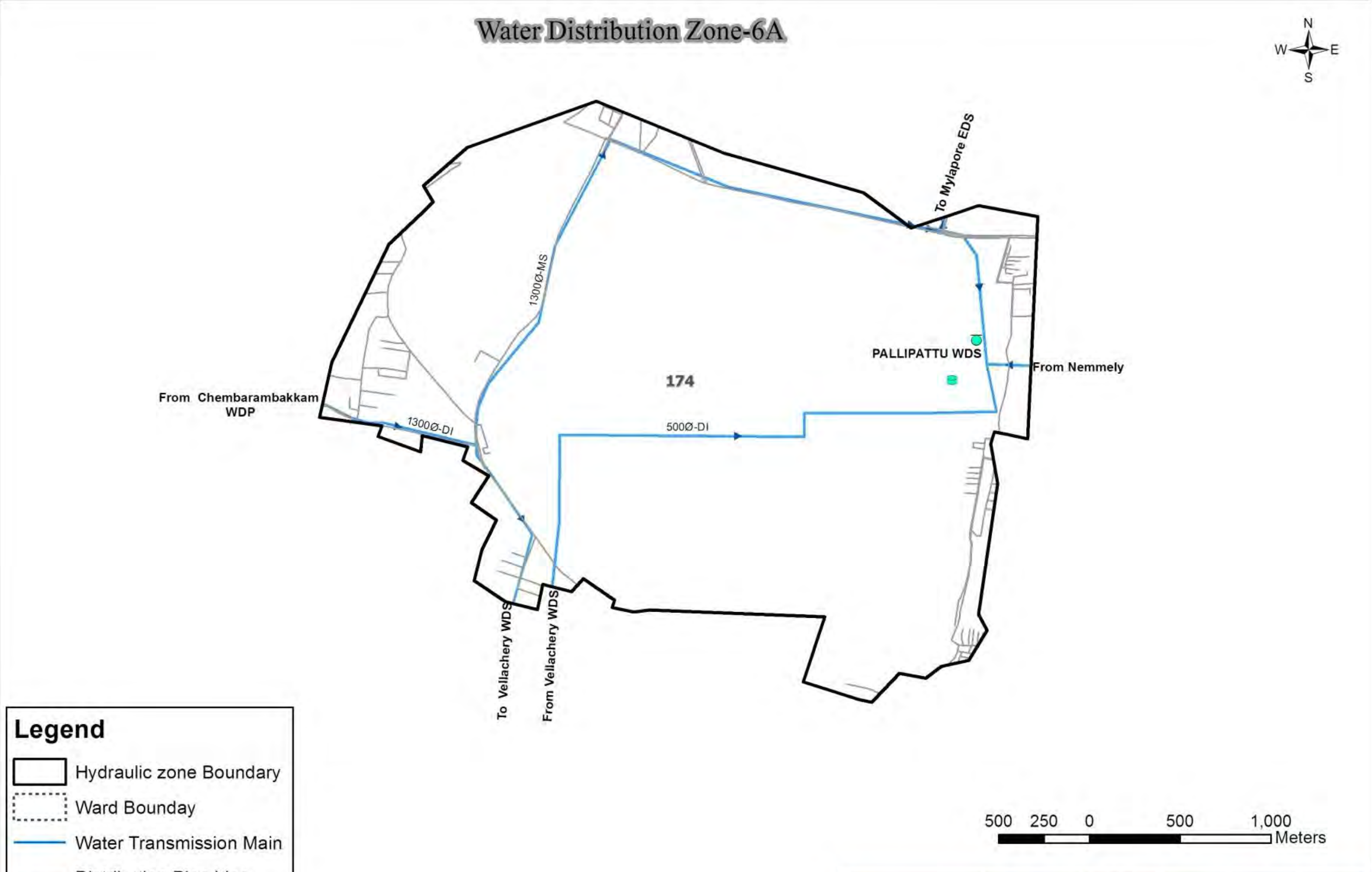
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Triplicane	10	2.4	33.4	36.2	36.2



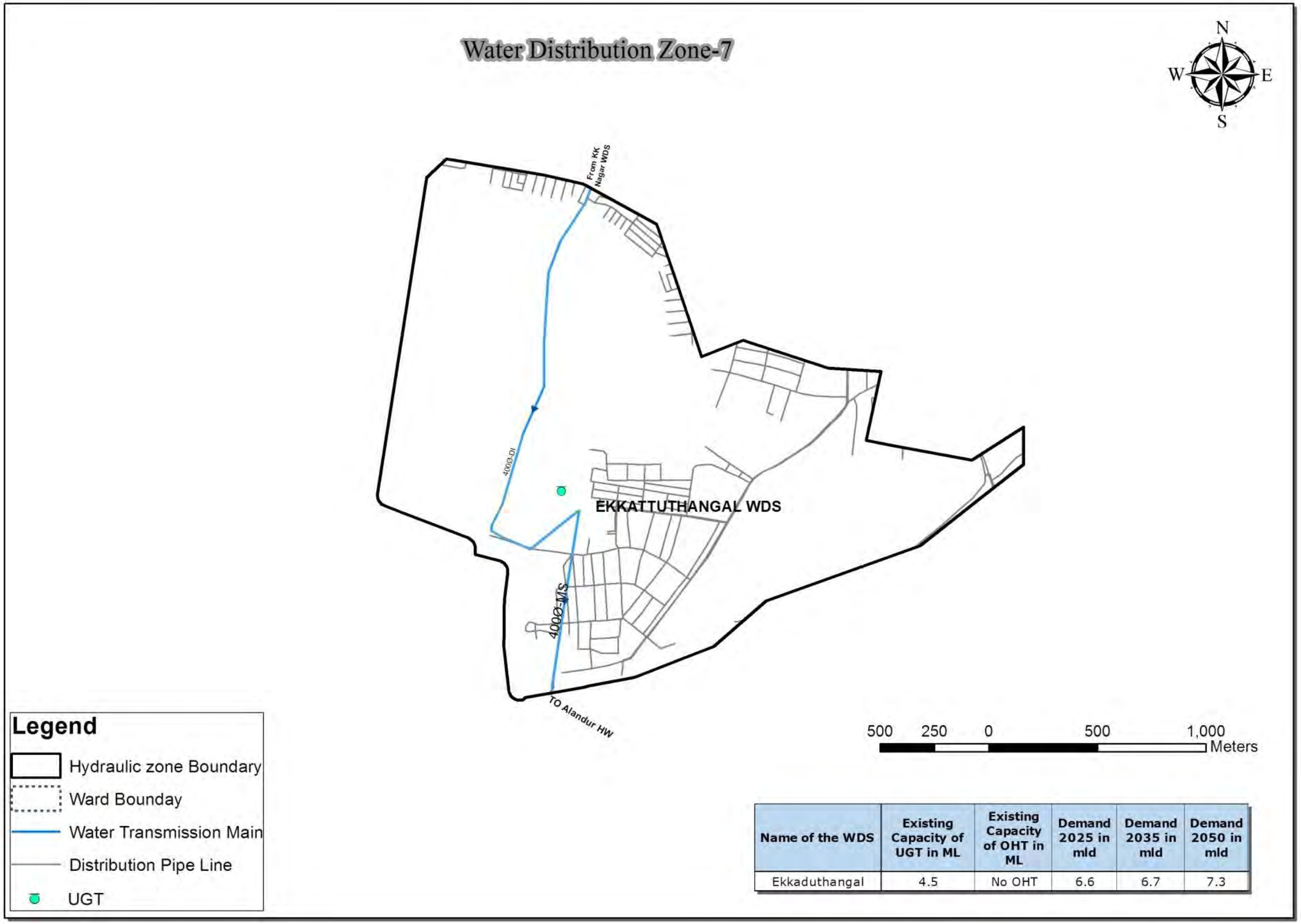
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
K.K nagar	14	2.4	66.7	68.7	73.6



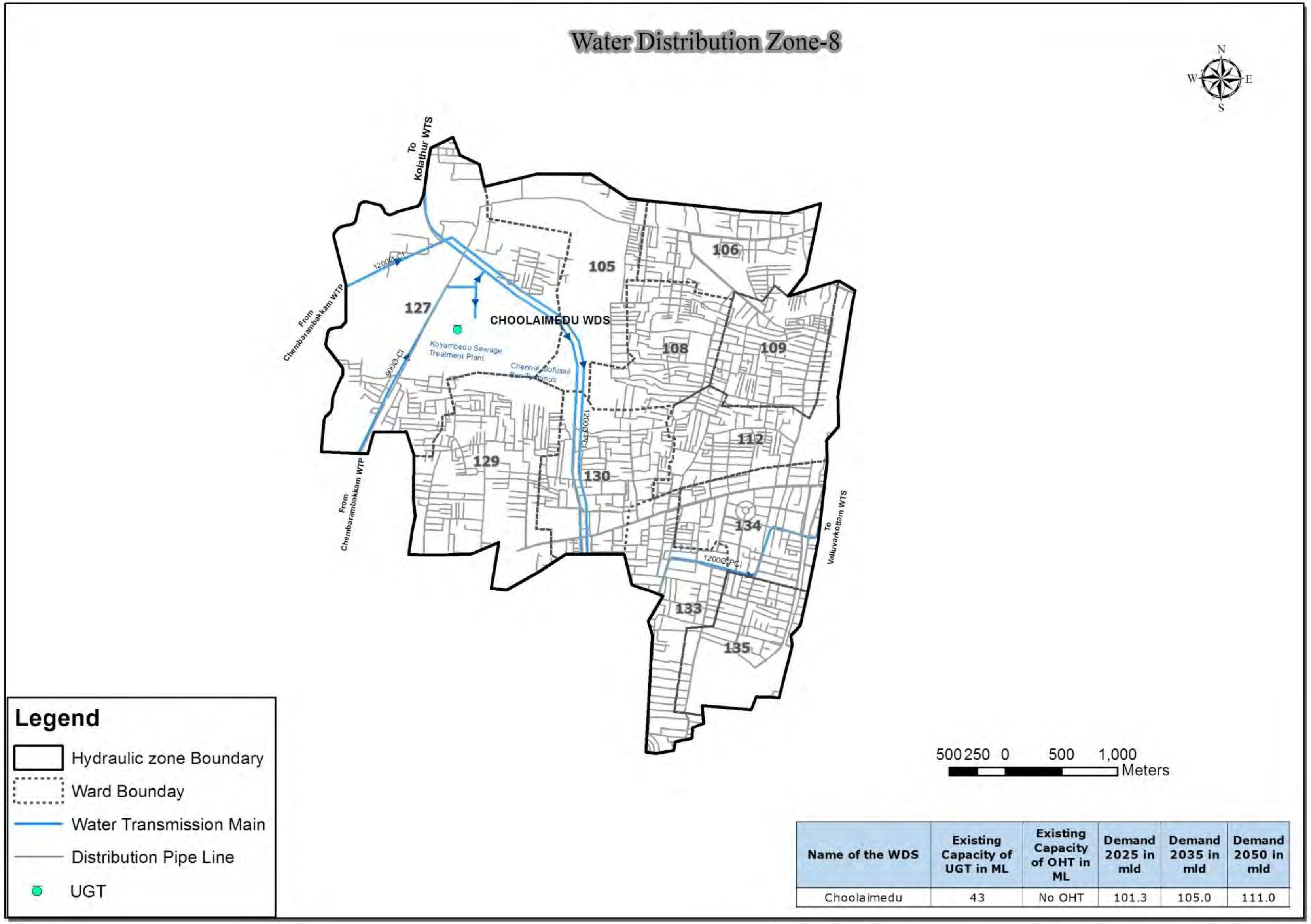
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Velachery	6	No OHT	34.5	35.2	38.4
Velachery (new)	2	No OHT	5.4	5.6	6.0



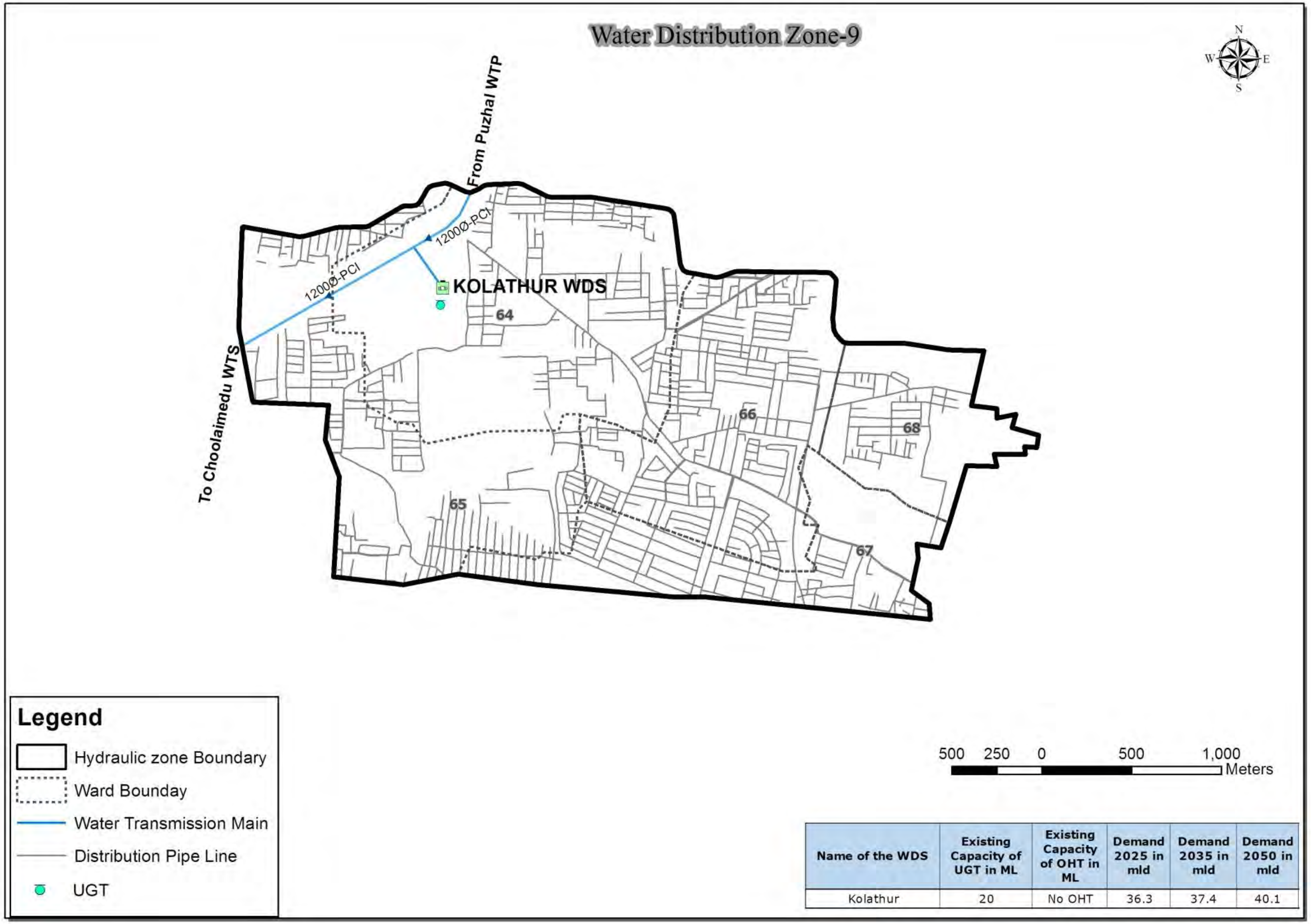
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Pallipattu	17	0.75	19.7	20.1	21.9



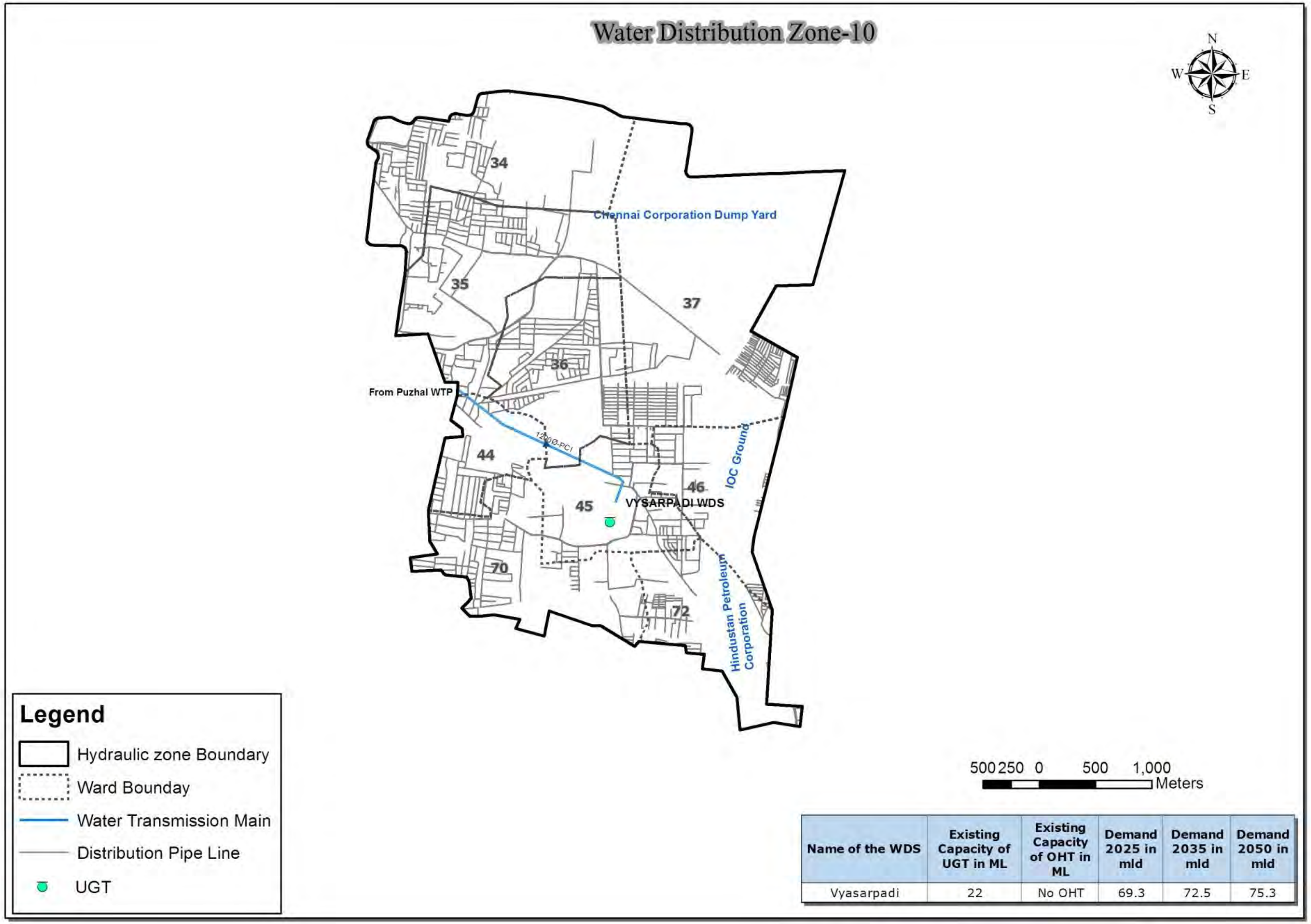
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Ekkaduthangal	4.5	No OHT	6.6	6.7	7.3



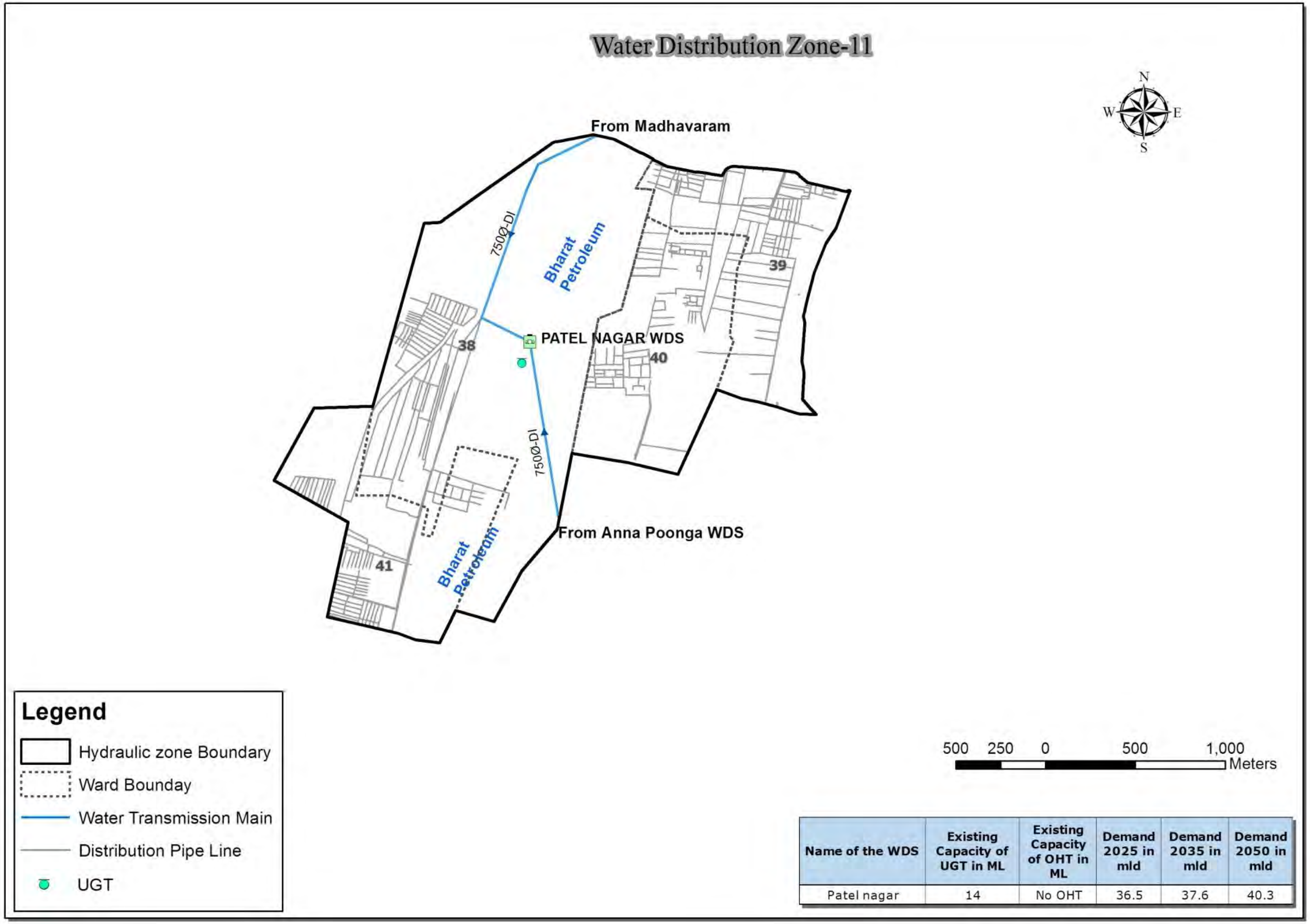
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Choolaimedu	43	No OHT	101.3	105.0	111.0



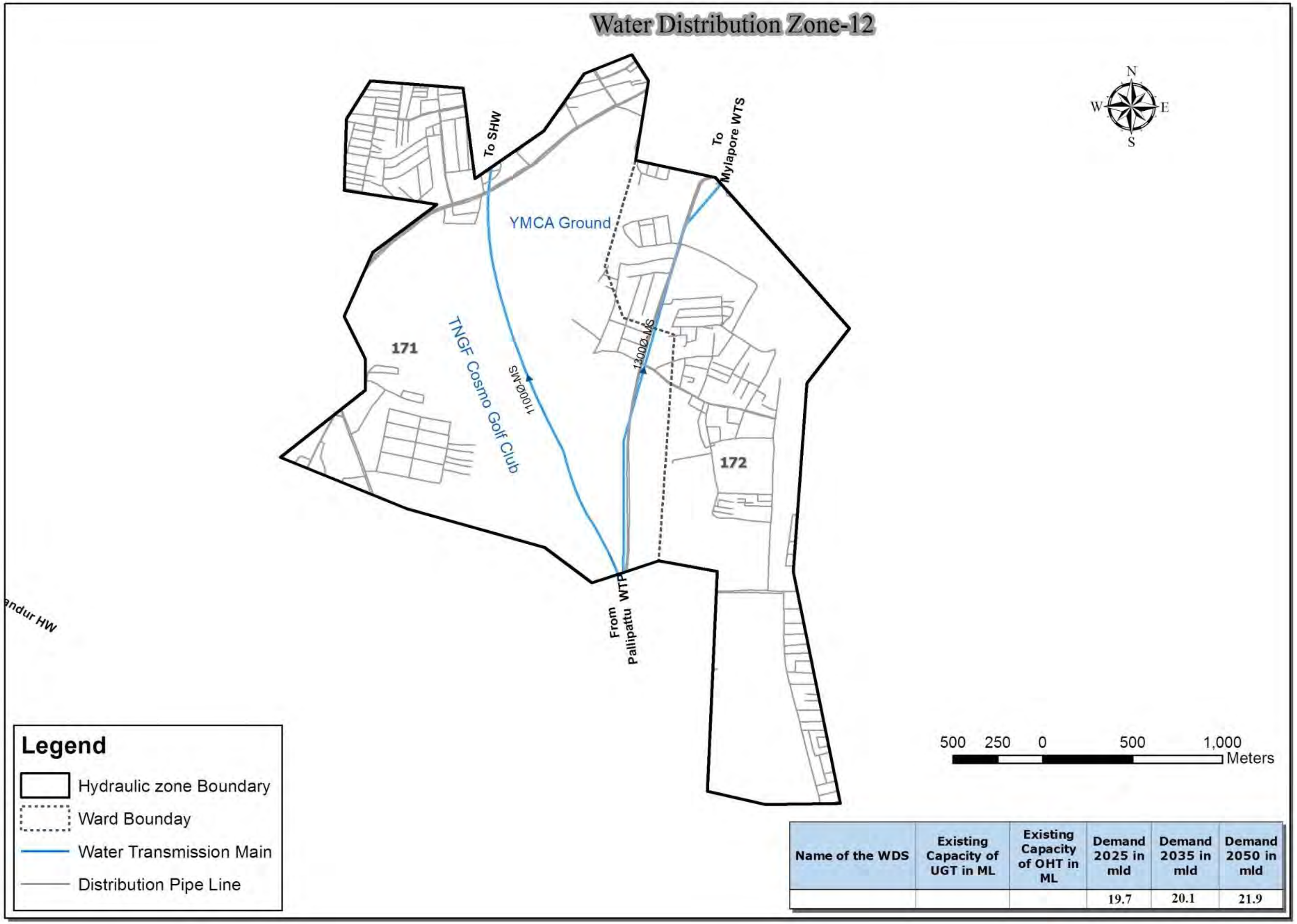
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Kolathur	20	No OHT	36.3	37.4	40.1



Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Vyasarpadi	22	No OHT	69.3	72.5	75.3

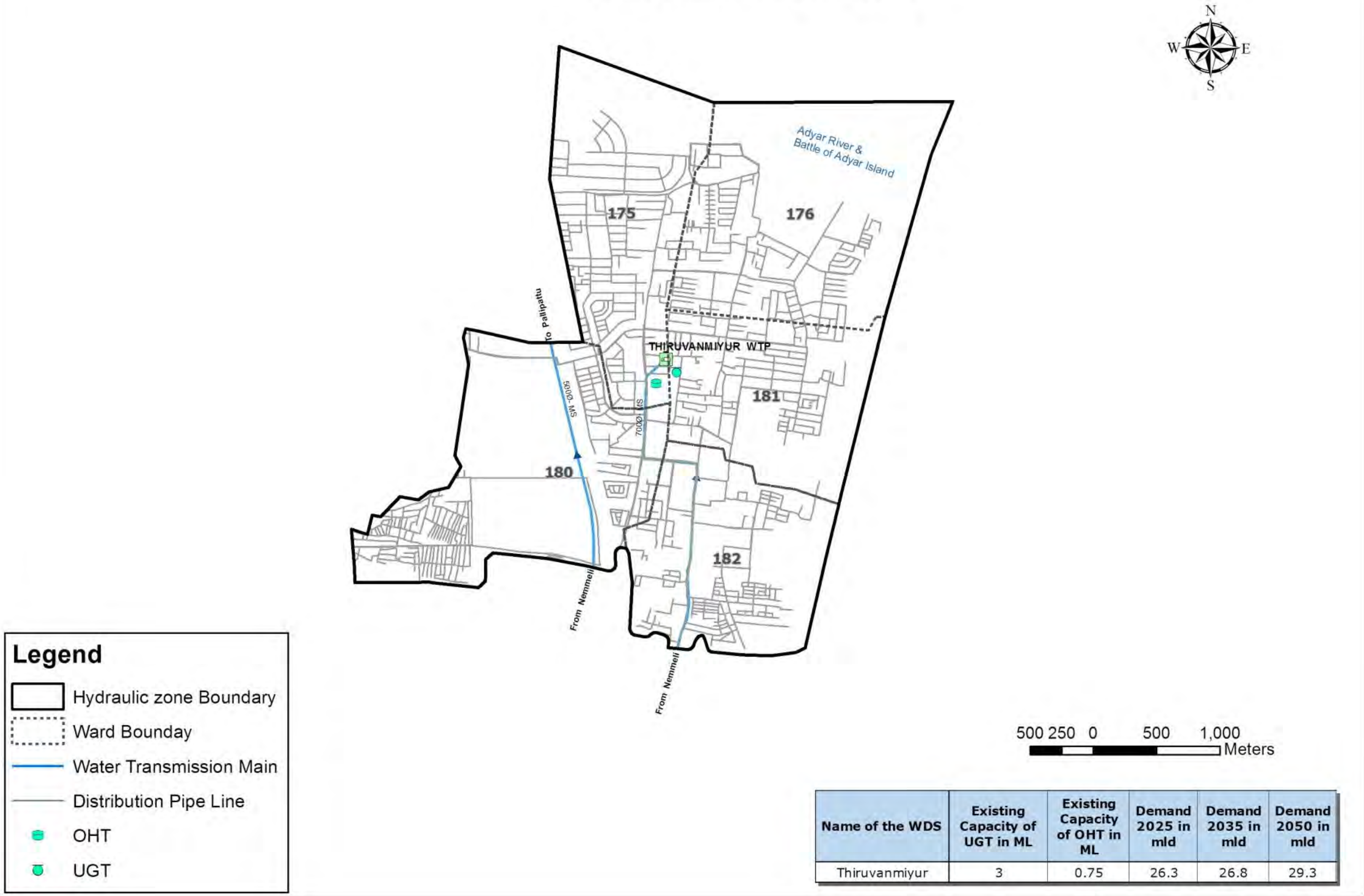


Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Patel nagar	14	No OHT	36.5	37.6	40.3

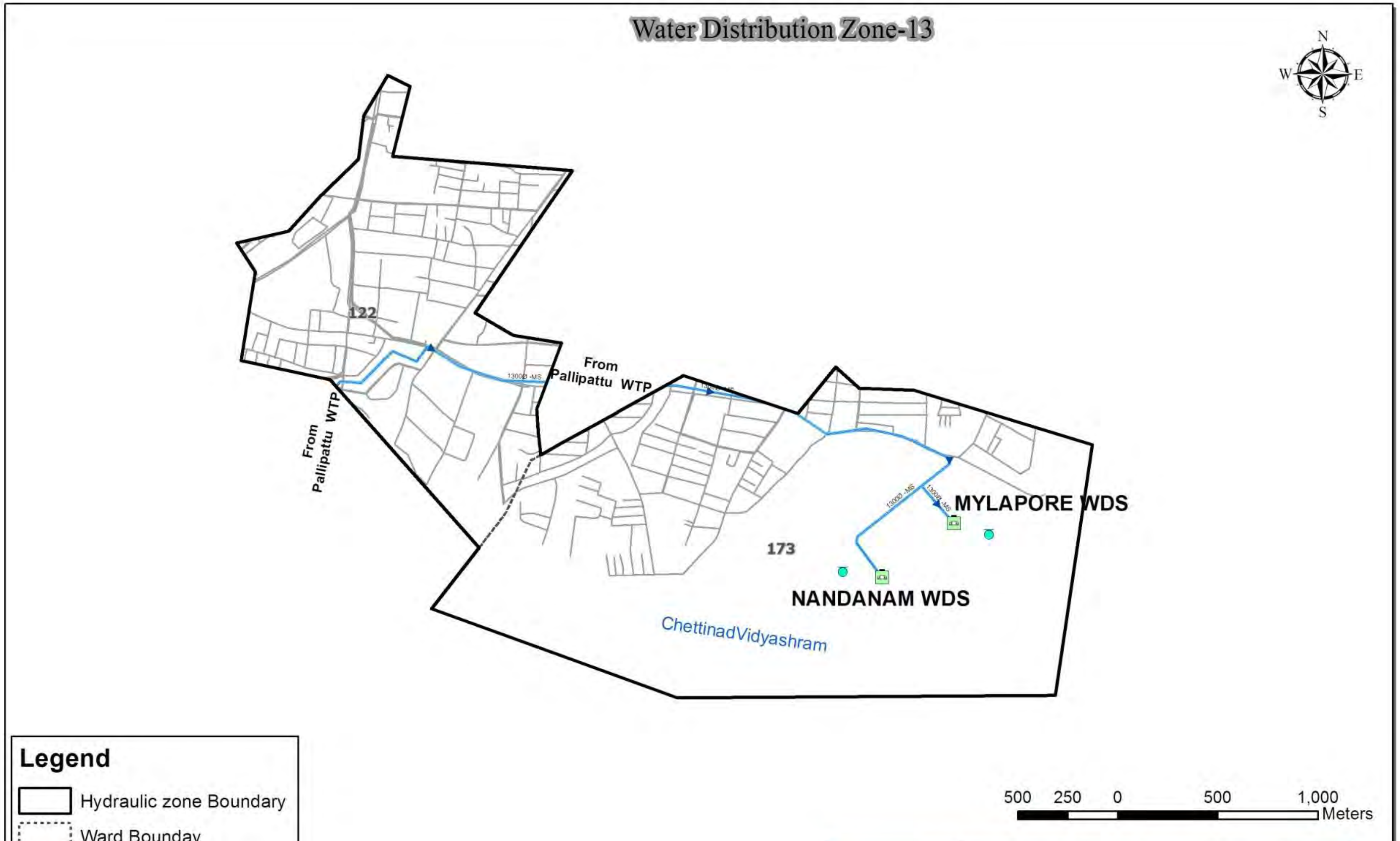


Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
			19.7	20.1	21.9

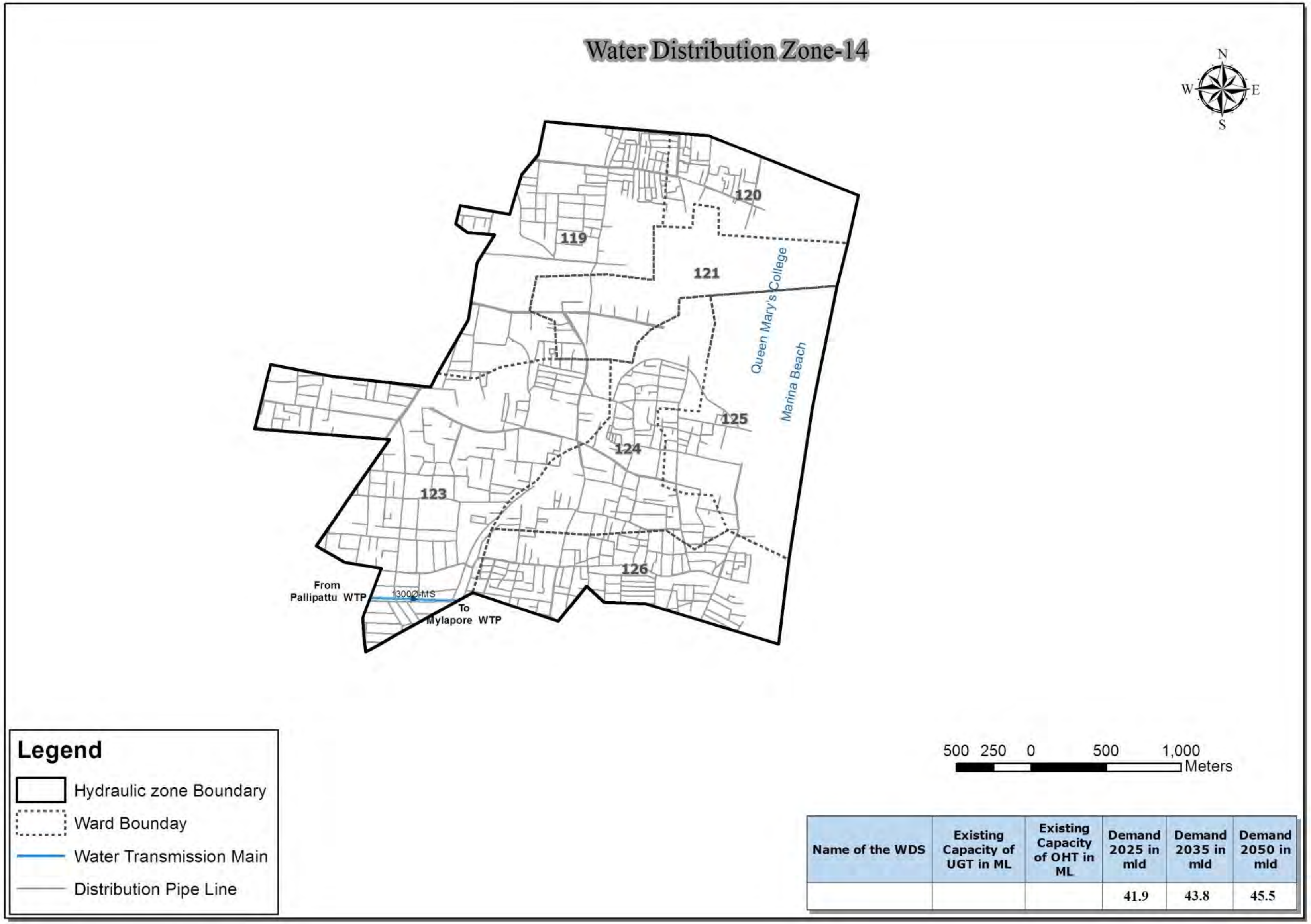
Water Distribution Zone-12A



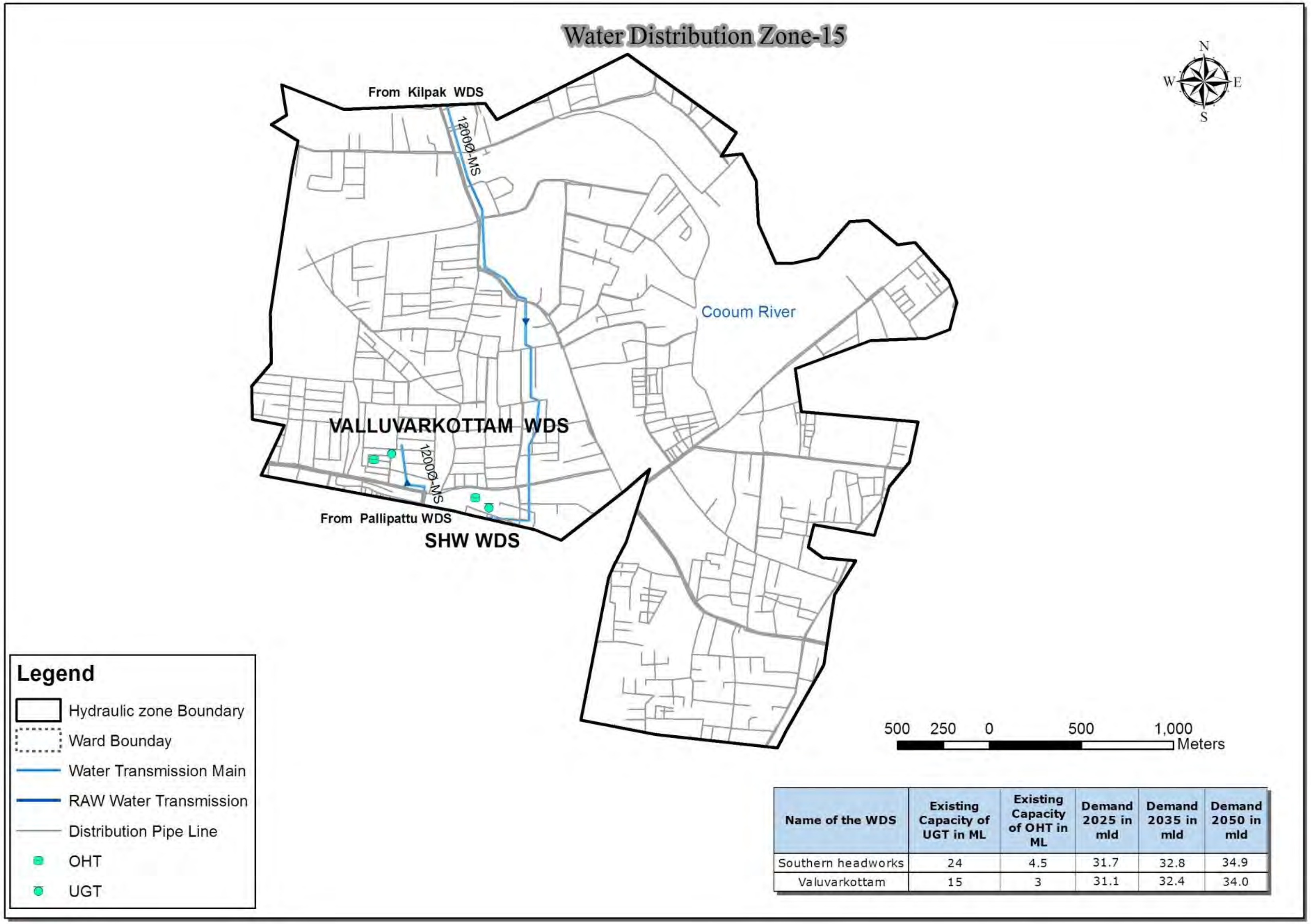
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Thiruvanmiyur	3	0.75	26.3	26.8	29.3



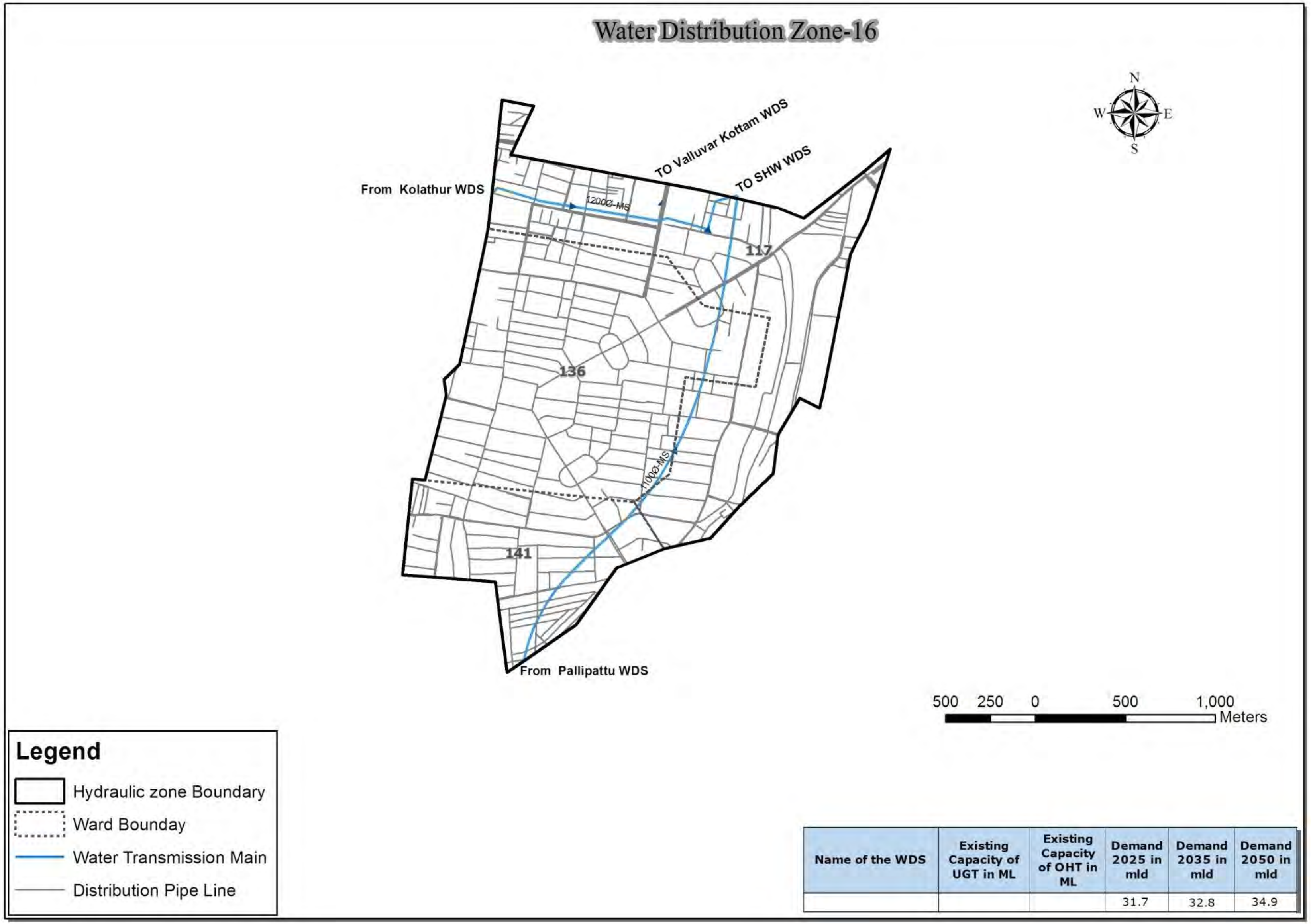
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Nandanam	11	No OHT	20.8	21.3	23.1
Mylapore	11.5	No OHT	41.9	43.8	45.5



Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
			41.9	43.8	45.5



Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Southern headworks	24	4.5	31.7	32.8	34.9
Valuvarkottam	15	3	31.1	32.4	34.0



Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
			31.7	32.8	34.9

Appendix 3.7 Technical and Management Problems in the Service Connections and Water Meters in the Service Area of CMWSSB

(1) Technical problems

- Due to the limited water supply hours, water pressure in the distribution pipes is often low or negative. It causes the contamination of the treated water.
- The intermittent water supply also allows entrance of air into the distribution pipes. In that situation, fluctuation of the water surface in the pipes pushes the entrapped air and causes movement in the water meter even without any water flow, which results in inaccurate metering.
- Due to low water pressure, water consumers have to operate hand held pumps in wide areas to lift water from their private water tanks.
- It is observed that service connections are installed poorly and such connections are leaking at their pipe joints.
- Service pipes in the service connection sometimes cross the storm water drains. It is often damaged and/or disconnected during the maintenance works carried out by the storm water drainage management agency. Also, the service connections are sometimes damaged by various construction works carried out by the various public and private bodies. A proper development method needs to be devised so that the house pipes are not affected.

(2) Management and O&M problems

- CMWSSB is responsible for installation of the service connection only up to the boundary of a private house, and it is the responsibility of the water consumers to install the pipes inside their premises and fittings and other necessary equipment such as check valves and stop valves to prevent any water contamination. However, the water consumers often fail to do it properly. This is one of the reasons for leakages and contamination of the treated water.
- Short availability of water supply has brought about doubts in people’s mind on the reliability of water supply, so during the supply hours most water consumers store water in all sorts of vessels to enable continuous water use. This is giving excessive load to the water distribution network.
- Due to the excessive load to the water distribution network, water does not reach the water consumers far from the WDSs.
- As water supply charges are not metered but only charged on a flat rate, the water consumers always keep taps of both public stand posts and service connections open leading to wastage of water whenever the supply is resumed.
- Inventory of the service connections are not available. It needs to be prepared and updated for handy reference and smooth operation and maintenance.

Appendix 3.8 Indian Drinking Water Standard

Bureauof Indian Standards Drinking Water

Specifications for the Key Parameters in IS 10500 – 2012 (Second Revision)

S. No.	Characteristic	Unit	Requirement (Acceptable Limit)	Permissible Limit in the absenceof alternate source
1	Total Dissolved Solids(TDS)	mg/l	500	2,000
2	Colour	Hazen unit	5	15
3	Turbidity	NTU	1	5
4	Total Hardness	mg/l	200	600
5	Ammonia	mg/l	0.5	0.5
6	Free ResidualChlorine	mg/l	0.2	1.0
7	pH	--	6.5-8.5	6.5-8.5
8	Chloride	mg/l	250	1,000
9	Fluoride	mg/l	1.0	1.5
10	Arsenic	mg/l	0.01	0.05
11	Iron	mg/l	0.3	0.3
12	Nitrate	mg/l	45	45
13	Sulphate	mg/l	200	400
14	Selenium	mg/l	0.01	0.01
15	Zinc	mg/l	5.0	15.0
16	Mercury	mg/l	0.001	0.001
17	Lead	mg/l	0.01	0.01
18	Cyanide	mg/l	0.05	0.05
19	Copper	mg/l	0.05	1.5
20	Chromium	mg/l	0.05	0.05
21	Nickel	mg/l	0.02	0.02
22	Cadmium	mg/l	0.003	0.003
23	E-ColiorThermotolerant coliforms	Number/ 100 ml	NIL	NIL

Appendix 3.9 Contents and Coverage of the UFW Program in the Chennai City Assisted by the World Bank

The Unaccounted for Water (UFW) reduction program in Chennai core city has been carried out and most of the distribution pipeline and 205,000 service connections have been replaced by the program to evaluate and reduce the water losses from the distribution pipeline and service connection in five phases from 1989 to 2001 under World Bank fund. The project's completion report evaluated that water leakage ratio in the target area of the project was reduced to 11%

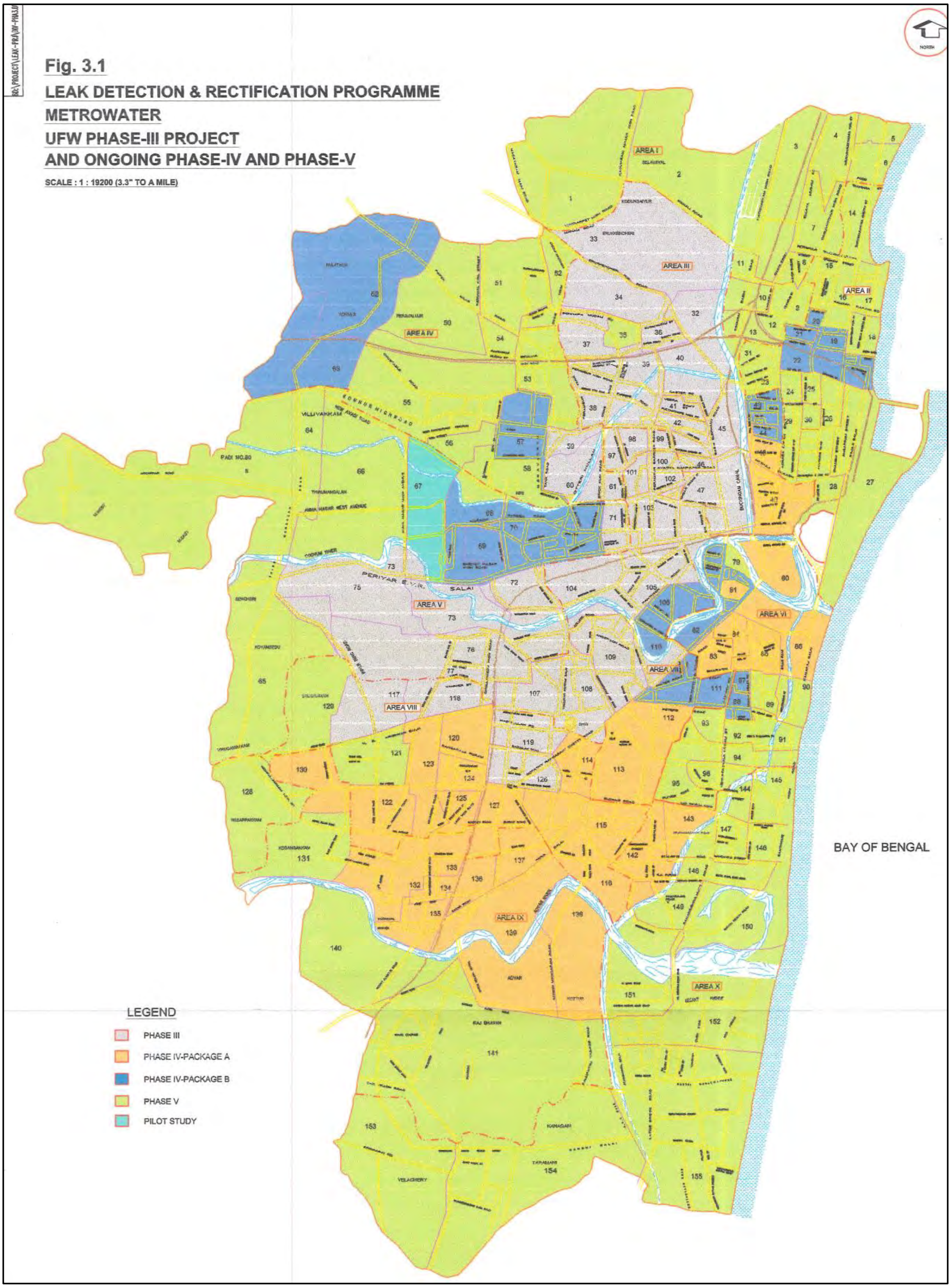
The contents of the program phase by phase are described below, and the program's coverage is shown in Figure A3.9.1.

Phase-I: The study has been carried out in the year 1989 to 1991 covering 14,600 service connections. Important conclusion from the study disclosed that 70% of the leaks occurred at ferrule points. Therefore, replacement of service connection point with proper materials is recommended.

Phase-II: The study has been carried out during 1994 to 1995 covering 14,600 service connections, which have been examined in Phase-I. The study in Phase-II has been carried out duly replacing all defective ferrules identified in Phase-I and repairing the leakage points in the distribution pipes. The leak levels have been identified in the range of 265 to 391 liter/service connection / hr at 10 m working head.

Phase-III: The study has been carried out during the 1996 to 1999 period, covering a total area of 36.65 km^2, for a pipe length of 258 km/ Material of pipes used are uPVC and DI. The 34,800 nos. of service connections have been replaced. The leakage levels achieved in this study is 4.73 liter/capita/hr.

Phase-IV, V: This phase includes the implementation of the replacement of the distribution pipe and service connection, and was completed in 2001.



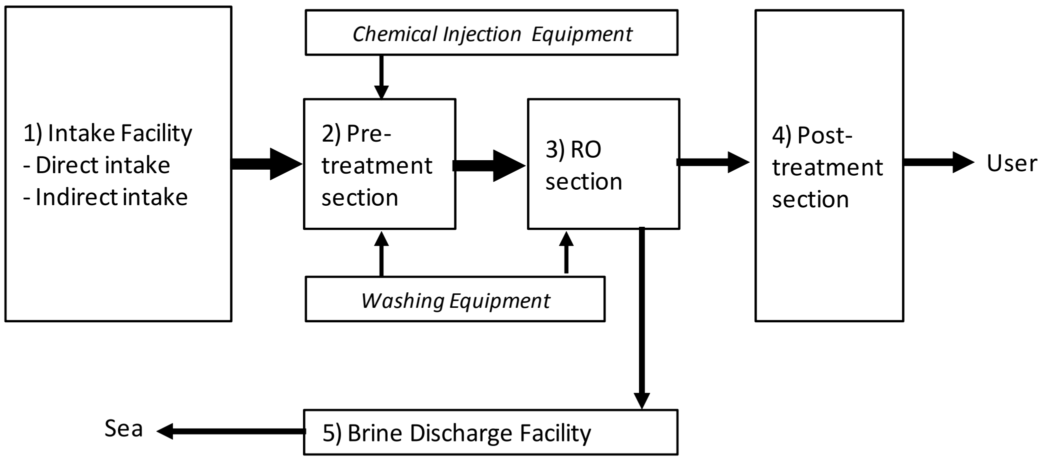
Source: Report on reduction in UFW in Chennai city (Phase-III)

Figure A3.9.1 Coverage of the Unaccounted for Water Program in Chennai Core City Assisted by the World Bank

Appendix 3.10 General Descriptions of Seawater Desalination Process by Reverse Osmosis Technology (SWRO)

(1) Components

SWRO mainly consists of five components and their accessories, excluding the power receiving facility, buildings, warehouses, and offices as shown in Figure A3.10.1.



Source: JICA Study Team

Figure A3.10.1 General Configuration of SWRO

(2) Outlines of each component

1) Intake facility

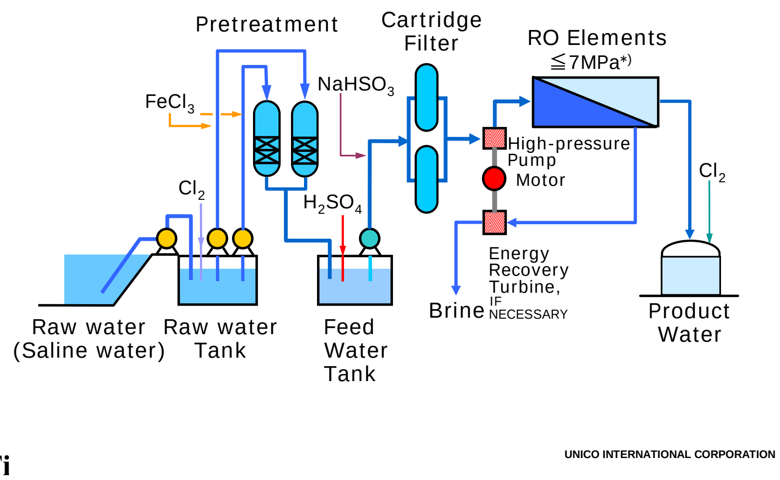
The function of intake facility is to take seawater and transport the seawater to the on-shore plant. There are two major methods in the intake type:

- Direct Intake: Direct intake is to take seawater by off-shore intake facility or construct an open channel on the shore. Usually, chlorine is used at the off-shore intake point to avoid clogging of the intake pipe by shellfish and seaweed inside the pipeline.
- Indirect Intake: The typical method for the indirect intake is a beach well, which intakes seawater by tube-wells to be installed along the shore. The other type in the indirect intake is seabed intake method, which intakes water from the seabed.

2) Pre-treatment section

Pre-treatment as well as RO sections are illustrated in Figure A3.10.2. Pre-treatment section functions with the accessory equipment of chemical injection facility and backwashing equipment.

The objective of the pre-treatment is to treat the raw seawater to avoid any damage on the succeeding RO membrane by unwanted particles or aggressive contents in the seawater. Typical pre-treatment is sand filtration process. In recent years, pre-treatment by membranes such as Microfiltration (MF) membrane or Ultrafiltration (UF) membrane is often employed.



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Sections in SWRO

Chemical injection facility is an equipment to give necessary dose of chemicals for pre-treatment. Chemicals which are commonly used for pre-treatment are as follows:

- Sodium hypochlorite (NaClO) for disinfection, to prevent bacteria growth
- Ferric chloride ($FeCl_3$) as flocculant before sand filtration
- Sulphuric acid (H_2SO_4) or hydrochloric acid (HCl) for pH adjustment, for protecting the membrane and preventing scale production that causes clogging on the membrane surface
- Sodium bisulfite ($NaHSO_3$ or Sodium Bisulfit (SBS)) as reductant for reneutralization of chloride, which is injected for disinfection, to protect RO membrane (Polyamide composite membrane is dominantly used but this RO type does not have high durability against chloride)

The particles of sand and plankton caught in the pre-treatment unit, especially the sand filter, are to be washed out. In order to do so, washing equipment is necessary. Membranes are also washed several times a year. Thus, the equipment for preparation of washing chemicals is to be installed.

3) RO section

RO section consists of RO membrane units, high pressure pumps and energy recovery equipment. High pressure pumps are the equipment to give sufficient pressure to the seawater for filtration by RO. Energy recovery equipment is used to utilize the high energy held by the rejected brine from the RO to save the energy consumption in SWRO.

4) Post-treatment Facility

For drinking water, the addition of hardness such as calcium or pH adjustment is required to meet the drinking water standard. A disinfectant (e.g. chlorine) is injected in order to prevent the generation of bacteria at reservoirs and pipes.

5) Brine Effluent Facility

Besides clean water a membrane process also produces concentrated seawater, or brine. This brine is returned to the sea at the off-shore point by brine discharge facility, which consists of brine discharge pipe and discharge head. Discharge point will be determined so that the brine will not have adverse impact on the marine ecosystem. The discharge facility is also designed so that the brine will not affect the raw seawater to be taken at the intake point.

6) Chemical Injection Equipment (ClA, $FeCl_3$, $NaHSO_3$, etc.)

Chemical injection equipment injects various chemicals to pre-treatment and RO sections and other points when the design needs it. Chemical storages, solution tanks and injection pumps are the major equipment.

7) Washing Equipment

8) The sand particles and planktons caught at the pre-treatment units, especially in the sand filters, is washed out, for which washing equipment is necessary. Membranes also need to be washed several times in a year. Thus, the equipment for preparation of washing chemicals is to be installed. Product Water Storage Facility

The product water storage facility is installed in order to store water for on-site use, and for emergency use during a power failure or malfunction of the plant. When the product water is distributed by pump, the product water storage will facilitate the pump operation.

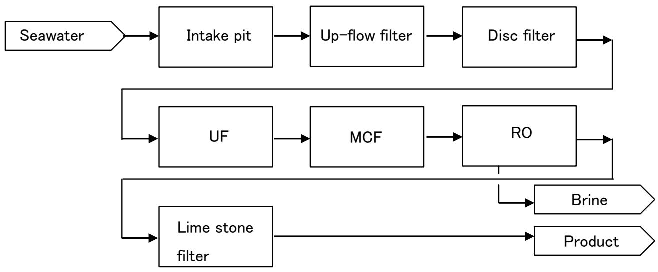
Appendix 3.11 Present Conditions of the Exiting DSPs

A3.11.1 Nemmeli DSP

(1) Treatment process

1) General

The treatment process of the Nemmeli DSP is illustrated in Figure A3.11.1. The plant takes seawater from the Bay of Bengal and treats the seawater by RO technology.



Source: JICA Study Team based on CMWSSB's information

Figure A3.11.1 Block flow sheet of Nemmeli DSP

2) Intake facility

The seawater inlet pipe is 1,600 mm in diameter and has a length of about 1,200 m. At the intake, Sodium hypochlorite is added to raw seawater to avoid clogging of the intake pipe by organisms such as clams and seaweeds. The raw seawater is filled into an on-shore intake pit by gravity. Here hypochlorite is added to the pumped seawater, and it is then pumped to the pre-treatment section.

3) Pre-treatment and RO sections

Pre-treatment section comprises of the up-flow filter, disc filter and UF membrane. The up-flow filter is 14 m deep and contains pebbles at a height of 1.7m. Seawater flows to the bottom of the filter, and then flows upward through the pebble layers. While flowing through the pebble layers the suspended solids in the raw seawater is reduced.

Effluent from the up-flow filter flows into the raw seawater tank. This seawater is then pumped to the disc filter which is followed by UF membrane filtration.

Disc filters are installed to protect UF membrane from unexpected particles that may come out from the up-flow filter. Four disc filters are grouped as one set, and one set of disc filters is installed in each UF unit. Therefore, a total of 120 disc filters is used in 30 UF units present in the plant. In the respective sets of four filters, one filter is in the backwashing stage in rotation, and the other three are in service. The designed suspended solids (SS) in the effluent from the disc filters is 50 mg/l. The designed coagulant, to be injected before UF, is $FeCl_3$. Usually, the chemical is not injected as the effluent from the disc filters is better than expected.

The unit of UF membranes is known as "skids" and each skid contains 4 rows x 30 modules (= 120 modules per skid). Therefore, a total of 3,600 modules is installed in the plant. Chemicals used for UF backwashing are NaOCl, NaOH, and H_2SO_4.

Effluent from UF is stored in the UF product water tank which is then pumped to the RO unit after passing it through the micron cartridge filters (MCF). Before the effluent is passed through MCF, chemicals such as NaOH for pH adjustment, SBS for reductant and anti-scalant are added to it.

A total of 12 units of RO are installed in a single stage in the plant[1]. The recovery ratio is 45%. In each RO unit, one high-pressure pump (HPP), one recycle booster pump (RBP), one permeate pump and a unit of energy recovery equipment of pressure exchangers (PX) are arranged. HPP and RBP motors are provided with variable frequency devices (VFD) to enable flexible adjustment of pressure.

After recovery of energy from brine by the energy recovery equipment, the brine is sent from RO unit to a brine tank with a capacity of 4,000 m^3.

4) Post-treatment section

RO permeate is sent to post-treatment section consisting of a CO_2 injection system, limestone filters, a degassing tower and the associated facilities such as blowers CO_2 storage, NaOH dosing system, and disinfection dosing system.

Treated water from the post-treatment section is delivered to the Chennai Corporation. In case of suspension of the plant operation, product water is sent to two tanks, each of which has a capacity of 14,000 m^3.

5) Brine discharge facility

Brine discharge pumps present in the plant, discharge the brine from RO unit into the sea. However the pumps are not used, because it has been found that the 1,200 mm discharge pipe can discharge the brine by gravity flow. Length of the discharge pipe is 500 m.

Source: JICA Study Team

Picture A3.11.1 Up-flow filter in the Nemmeli DSP

Source: JICA Study Team

Picture A3.11.2 UF racks in the Nemmeli DSP

Source: JICA Study Team

Picture A3.11.3 RO racks in the Nemmeli DSP

[1]Some SWRO plants have multiple stage RO. It is mostly aimed at removing boron to satisfy the old WHO guidelines, which were stricter than the present guidelines.

(2) SWRO Equipment

Equipments used in the Nemmeli DSP are listed in Table A3.11.1.

During site visit to the plant, it is evaluated that the equipments are functioning with no critical problems. Some leakages were observed around the pumps and the plumbing but they were of acceptable level. Paintings on equipment are generally well maintained. PX of the pressure exchanger was controlled; it was made silent by using soundproof cover.

Source: JICA Study Team

Picture A3.11.4 Monitoring Panel in the Nemmeli DSP

Table A3.11.1 Major Equipment in the Nemmeli DSP

No	Equipment	Capacity (m3/h)	Head (m)	Number Duty	Standby	Total	Input (kW)	Manufacture	Country	Other condition
Pump										
1	Seawater Pump	5,530	25	2	2	4	530	KIROSKAR	INDIA	
2	Raw Water Transfer Pump	5,475	60	2	2	4	950	KIROSKAR	INDIA	
3	Dirty Water Transfer Pump	300	50	1	1	2	55	FLOWSERVE	USA	
4	High Pressure Pump	360	700	12	3	15	900	FLOWSERVE	USA	
5	Cartridge Filter Feed Pump	4,628	25	2	2	4	400	FLOWSERVE	USA	
6	UF Back Wash Pump	600	20	2	2	4	45	FLOWSERVE	USA	
7	Disc Filter Back Wash Pump	240	40	1	1	2	30	FLOWSERVE	USA	
8	Reject Water Transfer Pump	3,430	50	2	2	4	650	FLOWSERVE	USA	
9	RO Membrain Cleaning Pump	300	50	1	1	2	55	FLOWSERVE	USA	
10	Permeate Transfer Pump	350	25	12	3	15	30	FLOWSERVE	USA	
11	Recorbonation Tower Feed Pump	2,100	20	2	2	4	160	FLOWSERVE	USA	
12	Absorber Feed Booster Pump	680	40	2	1	3	90	FLOWSERVE	USA	
13	Lime Stone Recharging Booster Pump	135	80	1	1	2	37	FLOWSERVE	USA	
14	Treated Water Transfar Pump	1,085	100	4	1	5	400	WPIL limited	INDIA	
Filtration										
1	Disk Filter			120	0	120			ISRAEL	
2	UF			30	0	30		Norit	Holland	Total modules: 30×4×30=3,600modules
3	Cartridge filter			2	0	2				15micron
4	Cartridge filter for chemical cleaning			1	0	1				15micron
5	Limestone Filter			4	1	5				Gravel+Limestone
Reverse osmosis										
1	RO train			12	0	12		NITTO DENKO	JAPAN	8,400m3/d/unit, Menbrane Model:SWC5Max
Energy recovery system										
1	Pressure Exchanger(PX)			110	5	115		Energy Recovery	USA	Efficiency:98.0%
Chemical dosing										
1	Sodium hypochlorite for intake	0.4	40	1	1	2		MILTON ROY	USA	
2	Sodium hypochlorite for UF back	2.6	40	1	1	2		MILTON ROY	USA	
3	Sulphuric acid	0.85	25	1	1	2		MILTON ROY	USA	
4	Ferric chloride for UF CEB	0.15	40	1	1	2		MILTON ROY	USA	
5	Sodium bisulfite	0.45	60	1	1	2		MILTON ROY	USA	
6	Antiscalant	0.45	60	1	1	2		MILTON ROY	USA	
7	Caustic soda for UF CEB	0.2	40	1	1	2		MILTON ROY	USA	
8	Caustic soda	0.02	27	2	1	3		MILTON ROY	USA	
9	Sodium hypochlorite for potable water	0.03	27	1	1	2		MILTON ROY	USA	

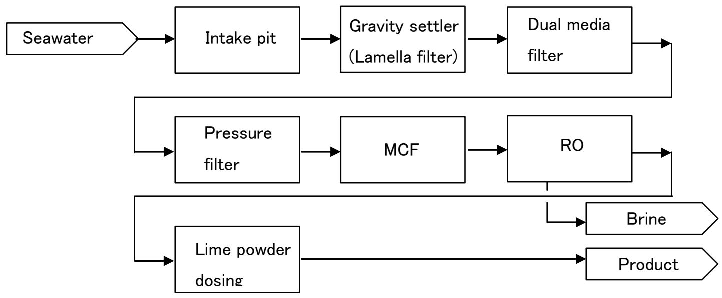
Source: CMWSSB compiled by JICA Study Team

A3.11.2 Minjur DSP

(1) Treatment process

1) General

The treatment process of the Minjur DSP is illustrated in Figure A3.11.2. Similar to the Nemmeli DSP, the Minjur DSP also takes seawater from the Bay of Bengal and treats the seawater by RO technology.



Source: JICA Study Team based on CMWSSB's information

Figure A3.11.2 Block flow sheet of Minjur DSP

2) Intake facility

The seawater inlet pipe is 1,600 mm in diameter and has a length of about 640 m. As the plant operator was not allowed by the Pollution Control Board (PCB) to inject the chemical at the intake point, so sodium hypochlorite was injected only at the on-shore intake pit. The plant operator informed the study team there was no reported case of clogging in the seawater intake pipe. The frequency of cleaning inside the pipe is about three times a year. The raw seawater, introduced into the on-shore intake pit by gravity, is pumped to the pre-treatment section.

3) Pre-treatment and RO sections

Pre-treatment section comprises of the gravity settler (or lamella filter), which is after the flocculation basin and dual media filter (DMF). Chemicals to be injected in the flocculation basin are H_2SO4 for pH adjustment, $FeCl_3$ and polyelectrolyte for coagulation.

The lamella filter, which has four rows, removes most of the suspended solids in the raw seawater. Designed removal ratio is from 92% to 98%. According to the plant operator, the gravity settler is generally cleaned twice a year, which are before and after the monsoon season.

Effluent from the lamella filter is sent to the gravity-type dual media filter (DMF). The DMF consists of four rows, each of which has 10 cells. Therefore, the total number of the filter cells is 40. The output of the DMF is collected in the filtered water storage tank and pumped to the RO section.

Once a week backwashing of the DMF is done using brine from the RO. According to the plant operator, backwashing procedure consists of air scouring for 10-15 minutes, backwashing for 40-45 minutes, and rinsing for 45-60 minutes. Duration of the main backwashing (40-45 minutes) is much longer than in general cases.

Source: JICA Study Team

Picture A3.11.5 RO Train in the Minjur DSP

The pumped filtered water is first sent to the pressure filters (PF) for further filtration, then to micron cartridge filters (MCF) which is safety filter and then to the RO membrane. It is noted by the operation representative of the Minjur DSP that PF may not be required as the effluent from the DMF is already in the acceptable range of RO membrane.

Source: JICA Study Team

Picture A3.11.6 Gravity Settler in the Minjur DSP

The RO unit consists of a high-pressure pump (HPP), an energy recovery equipment of pressure exchanges (PX), a recycle booster pump (RBP), and an RO membrane. Five RO units are installed. The recovery ratio is 45%.

Similar to Nemmeli DSP, HPP and RBP motors are provided with variable frequency devices (VFD) to enable flexible adjustment of pressure.

4) Post-treatment section

The permeate water from RO is treated with CO_2 and lime powder solution injection for drinking water application, and sodium hypochlorite injection for disinfection, and then sent to Chennai city.

5) Brine discharge facility

Brine from RO is discharged to the sea by gravity. No discharge pumps are engaged, as in the case of Nemmeli DSP. Brine discharge pipe is 1,600 mm in diameter and 840 m in length.

Source: JICA Study Team

Picture A3.11.7 Monitoring Panel in the Minjur DSP

(2) SWRO equipment

Equipments used in the Minjur DSP are listed in Table A3.11.2.

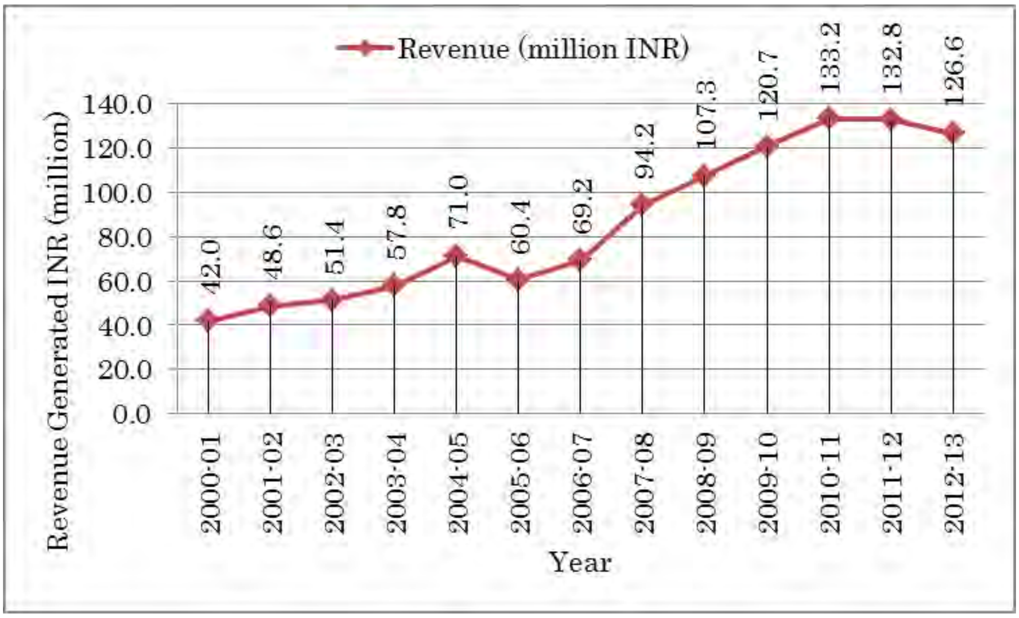
During the site visit to the plant, it is evaluated that the equipments are functioning with no critical problems. However, lack of standby RO unit sometimes causes less production during maintenance work. PX of the Pressure Exchanger was noisier than the Nemmeli DSP, as the PX in the Minjur DSP was not covered.

Table A3.11.2 Major Equipment in the Minjur DSP

No	Equipment	Capacity (m3/h)	Head (m)	Number			Input (kW)	Manufacture	Country	Other condition
				Duty	Standby	Total				
Pump										
1	Seawater Pump	4,960	14.7	2	1	3	360	SULZER	SPAIN	
2	Intermediate Pump	1,944	60	5	1	6	400	SULZER	SPAIN	
3	High Pressure Pump	896.5	671	5	0	5	2,200	FLOWSERVE	USA	
4	Booster Pump	1,048.9	50	5	0	5	200	SULZER	SPAIN	
5	Chemical cleaning and flushing pump	992	55	2	1	3	200	SULZER	SPAIN	
Filtration										
1	Pressure filter	608		16	0	16		HIDUSTAN DORR-OLIVER	INDIA	φ3.6m×11m(40m2),15.2m/h(0.253m/min) 16.2m/h(0.27m/min)
2	Cartridge filter			10	0	10				15micron,13.65m/h(0.23m/min)
3	Cartridge filter for chemical cleaning			1	0	1				13.6m/h(0.23m/min)
Reverse osmosis										
1	RO train			5		5		NITTO DENKO	JAPAN	20,000m3/d/unit, Menbrane Model:SWC4+
Energy recovery system										
1	Pressure Exchanger(PX)			110	5	115		Energy Recovery	USA	Eficiency:93.02%
Chemical dosing										
1	Sodium hypochlorite in seawater			2	1	3		GRUNDFOS	DENMARK	Storage tank:φ3.2m×2m(10m3)×2
2	Sodium hypochlorite in pretreatment			2	1	3		GRUNDFOS	DENMARK	Storage tank:φ3.2m×2m(10m3)×2
3	Sulphuric acid			5	1	6		GRUNDFOS	DENMARK	Storage tank:φ3.0m×9m(60m3)×2
4	Ferric chloride			2	1	3		GRUNDFOS	DENMARK	Storage tank:φ3.0m×4.5m(30m3)×2
5	Calcium hydroxide in pretreatment			2	1	3		GRUNDFOS	DENMARK	Silo:60m3×1
6	Polyelectrolyte			2	1	3		GRUNDFOS	DENMARK	
7	Sodium metabisulphite			5	1	6		GRUNDFOS	DENMARK	Storage tank:φ1.0m×2.0m(1.6m3)×2
8	Antiscalant			5	1	6		GRUNDFOS	DENMARK	Storage tank:φ1.4m×2.0m(3.0m3)×2
9	Carbon dioxide			2	1	3		GRUNDFOS	DENMARK	Storage tank:φ3.0m×10m(70m3)×2
10	Calcium hydroxide in post treatment			2	1	3		GRUNDFOS	DENMARK	Storage tank:φ3.0m×11.3m(80m3)×2 Dilution tank:φ2.0m×1.3m(4m3)×2
11	Sodium hypochlorite in post treatment			2	1	3		GRUNDFOS	DENMARK	Storage tank:φ3.0m×5m(35m3)×2

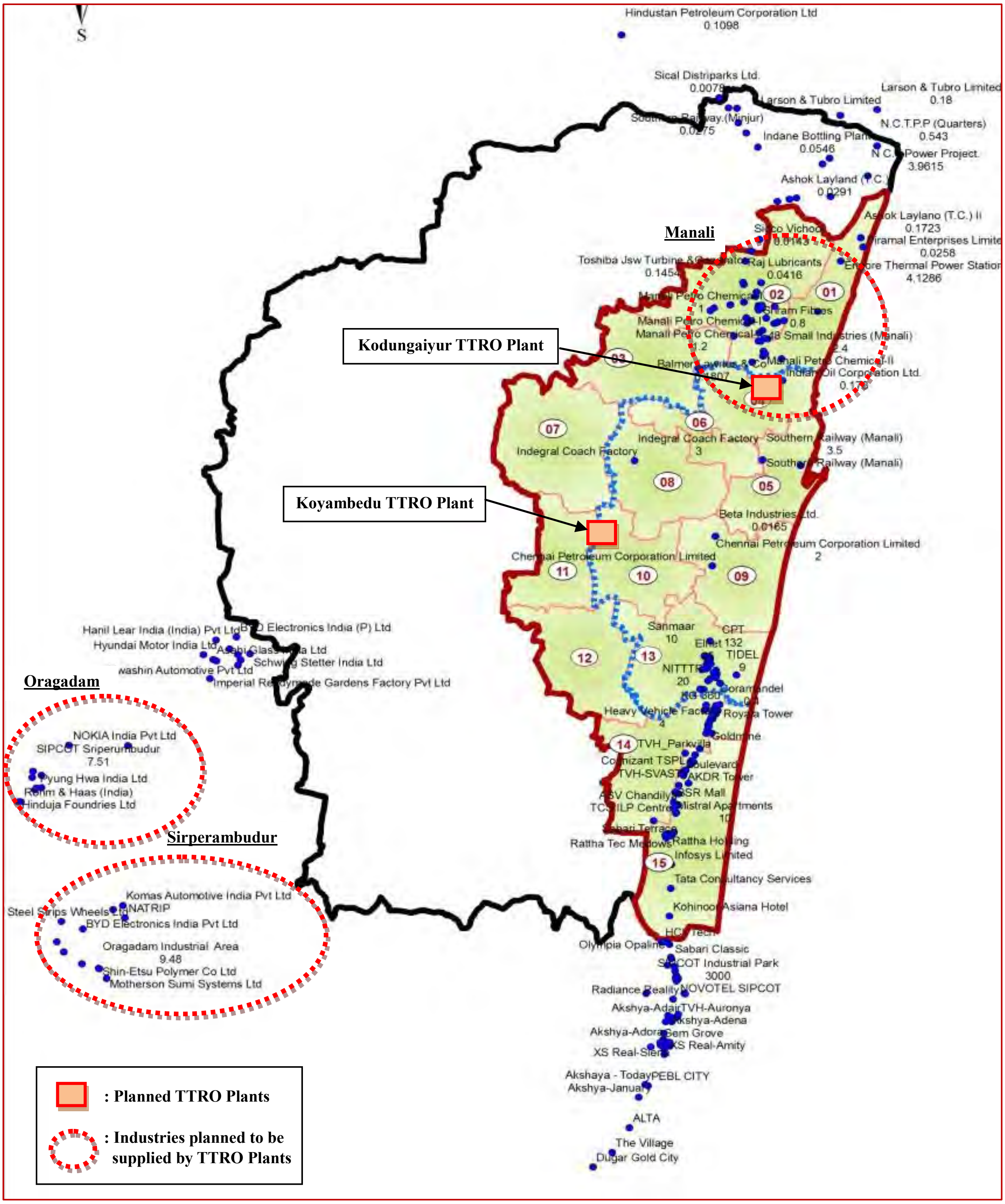
Source: JICA Study Team

Appendix 3.12 Present Conditions of Water Recycling by CMWSSB



Source: CMWSSB Annual Report (2012-13) compiled by JICA Study Team

Figure A.3.12.1 Revenue Generation from Sales of Secondary Treated Sewage by CMWSSB



Note: Values in the figure are projected water demand of the industries for 2025 in the study report below.

Source: JICA Study Team based on Demand Assessment Study Report on the supply of TTRO water to the industrial units located in North Chennai prepared by ITCOT Consultancy and Services

Figure A. 3.12.2 Locations of the Existing and Planned Industries Planned to be Catered by CMWSSB and the Coverage of the Planned TTRO Plants

Appendix 4.1 Population forecast in the Master Plan

A4.1.1 Methodologies of the Forecast

The previous population forecast for CMA was conducted in "Second Master Plan for Chennai Metropolitan Area, 2026" (hereinafter, "CMDA-MP"), which was prepared by the Chennai Metropolitan Development Authority in 2008. CMDA-MP is the latest city planning document for the entire CMA.

Population forecast in M/P began with its evaluation in CMDA-MP. By comparing the forecast population for 2011 in CMDA-MP with the result of a census in 2011, M/P pointed out that the forecast in CMDA-MP was an overestimation for the corporation. The average annual population growth between 2001 and 2011 in CMDA-MP forecast and that from census results were 1.31% and 0.68%, which generated a difference of 300 thousand in population. From this evaluation, the M/P declared that the population forecast needs to be updated to incorporate the latest trend found in the censuses 2011.

M/P carried out population projections by seven methods, which were suggested in the manual of the Central Public Health and Environmental Engineering Organization (CPHEEO). These methods were 1) Arithmetic Increase Method, 2) Incremental Increase Method, 3) Geometrical Progression Method, 4) Line of Best Fit Method, 5) Exponential Method, 6) Semilog Graphical Method, and 7) Density Method. The basic population in the projections was the result of the census 2011, and the past populations found by the census 1971, 1981, 1991 and 2001 were referred to forecast the future growth trend.

The projections were conducted for the respective wards (in the corporation), municipalities, towns, and villages. M/P compared the projections with those in CDMA-MP. If the census 2011 and the projected population for 2026 in a municipality/town/village by a method almost matched with the forecasts for the same years in CMDA-MP, the method was adopted. Otherwise M/P adopted density method, where the population densities for the target years were determined based on the trend in the population density and on the socio-economic factors. The socio-economic factors considered in the forecast were the current physical maturity of the residential areas, possible development or decline of the local industries, development level of public utilities, etc.

The M/P presented typical population densities in residential areas, instead of total area, by status and locations of the areas as shown in Table A4.1.1.

Table A4.1.1 Criteria of Population Density by Residential Area in the M/P

Target area		Population density	Remarks
Chennai Corporation	Core City	500 - 650 persons/hectare	Population density based on residential area for 2050
	Expanded area	500 - 800 persons/hectare	
Rest of CMA	Municipalities/Towns/Villages adjacent to the corporation	450 - 600 persons/hectare	
	Municipalities/Towns far from the corporation	200 - 350 persons/hectare	
	Villages far from the corporation	150 - 250 persons/hectare	

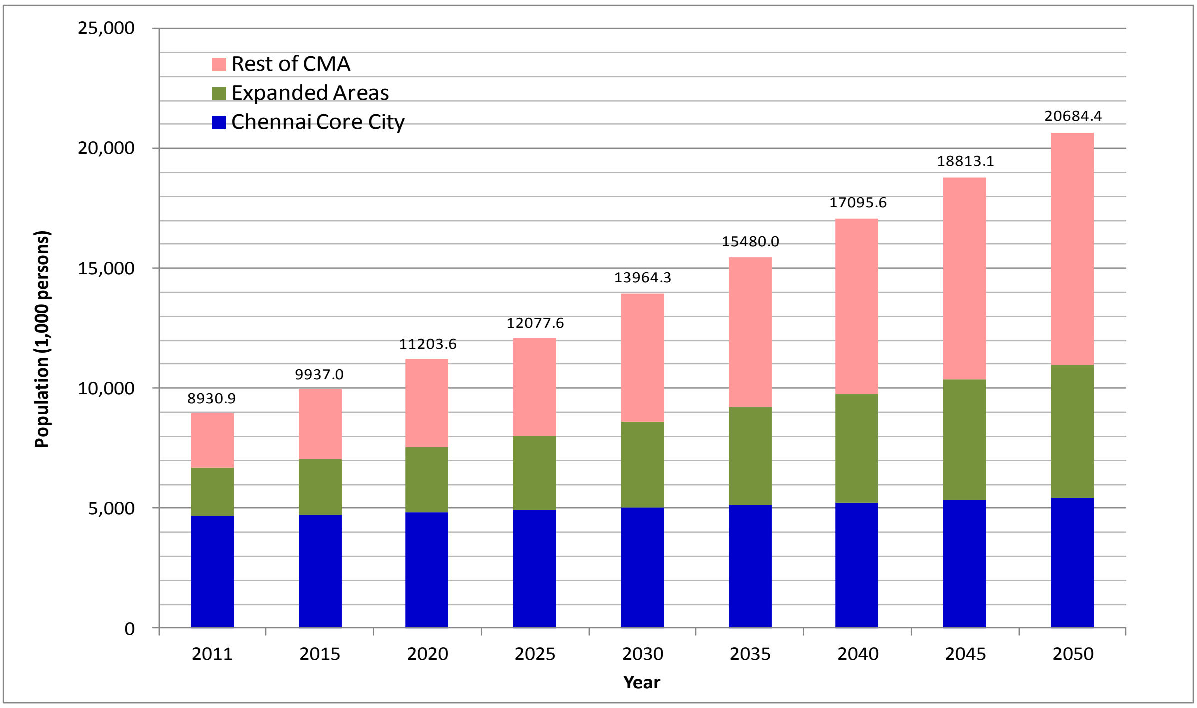
Source: Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

A4.1.2 Results of the Forecast

The results of the population in the M/P are shown in Figure A4.1.1. Figures 4.1.2 present the forecast population densities in 2035 and 2050.

The forecast population expresses that the general trends in the Chennai Core City will involve only little growth potential and that the population growth will happen in the outskirts of the Core City.

As for the population density in 2050, the population densities in wide areas are much lower than the typical density ranges presented in Table A4.1.1. For example, the population densities in the expanded area are in the range of 400 - 500 persons/hectare in the highest areas while the typical density presented in Table A4.1.1 is 500 - 800 persons/hectare.

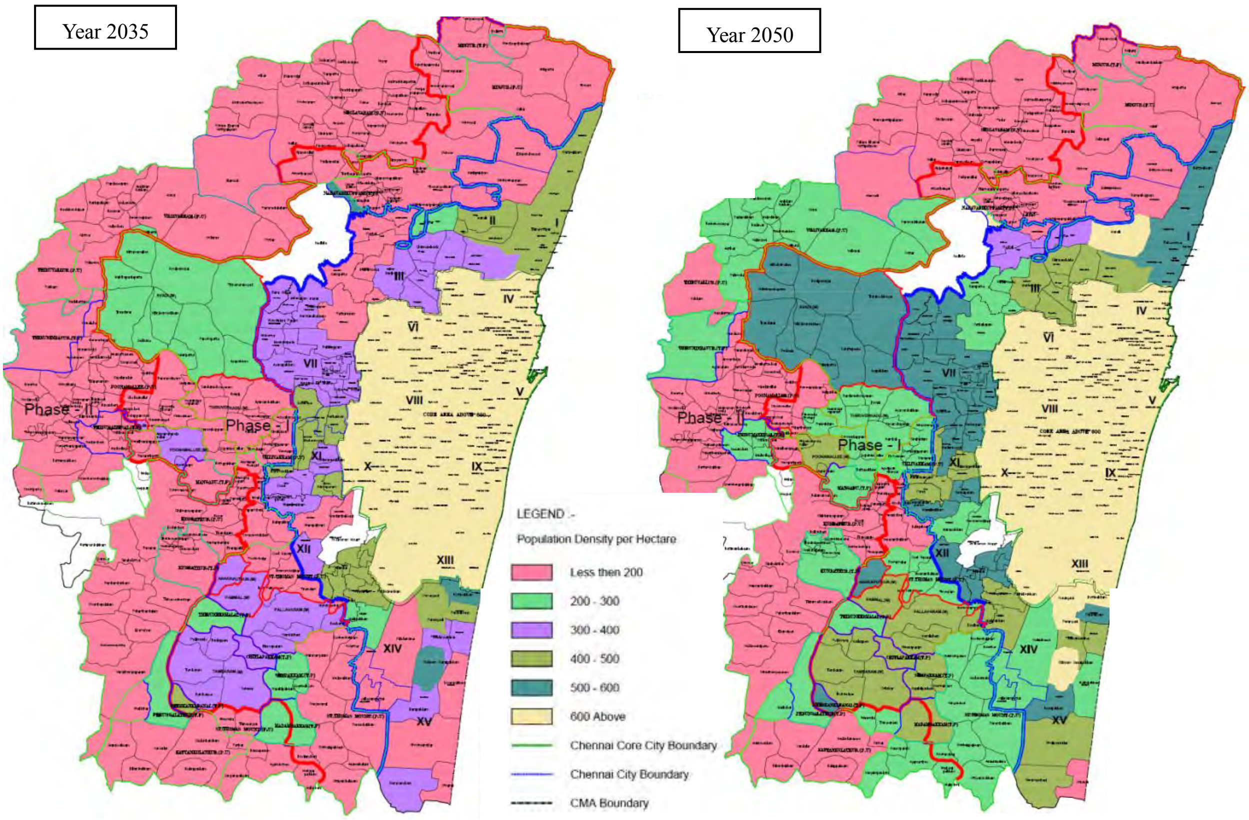


Area	Population								
	2011	2015	2020	2025	2030	2035	2040	2045	2050
Rest of CMA	2,264.3 (-)	2,883.2 (6.23%)	3,646.3 (4.81%)	4,104.2 (2.39%)	5,345.6 (5.43%)	6,299.9 (3.34%)	7,337.2 (3.10%)	8,468.8 (2.91%)	9,711.8 (2.78%)
Expanded Area	2,019.6 (-)	2,326.1 (3.60%)	2,727.0 (3.23%)	3,034.9 (2.16%)	3,585.2 (3.39%)	4,042.4 (2.43%)	4,519.2 (2.25%)	5,016.7 (2.11%)	5,535.7 (1.99%)
Chennai Core City	4,647.0 (-)	4,727.7 (0.43%)	4,830.2 (0.43%)	4,938.6 (0.44%)	5,033.4 (0.38%)	5,137.7 (0.41%)	5,239.3 (0.39%)	5,327.6 (0.33%)	5,436.9 (0.41%)
CMA Total	8,930.9 (-)	9,937.0 (2.70%)	11,203.6 (2.43%)	12,077.6 (1.51%)	13,964.3 (2.95%)	15,480.0 (2.08%)	17,095.6 (2.01%)	18,813.1 (1.93%)	20,684.4 (1.91%)

*: Values in the brackets are annual population growth in % from the previous population

Source: JICA Study Team based on Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

Figure A4.1.1 Population Forecast in the M/P



Source: Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

Figure A4.1.2 Forecast Population Density by Residential Area in the M/P

Appendix 4.2 Water transmission and Distribution Plans in the Master Plan

A4.2.1 Specifications of the Water Transmission Pipelines in the M/P

Table A4.2.1 Length and Diameters of the Planned Transmission Mains in the M/P

Water Supply System	Transmission Main	Pipe Line Length (km)					Pipe Diameter Range (mm)
		Total	Existing	Replacement	Strengthening	New	
Nemmeli DSP	TM-1	32.16	32.16	-	9.64	-	700-1000
Nemmeli DSP	TM-2	32.73	27.18	2.03	26.53	3.52	800-1600
Nemmeli DSP	TM-3	18.50	13.30	-	13.30	5.20	500-900
Nemmeli DSP	TM-4	32.70	0.00	-	-	32.70	900-1900
Veeranam WSS	TM-5A	9.33	4.98	4.35	-	-	400-1200
Veeranam WSS	TM-5B	16.21	8.95	5.38	-	1.88	300-2000
Chembarambakkam WSS	TM-6	18.58	11.28	7.30	-	-	1200-2000
Chembarambakkam WSS	TM-7	21.28	5.48	0.00	0.00	15.80	700-2000
Chembarambakkam WSS	TM-8	32.15	-	-	-	32.15	500-2000
Redhills WSS	TM-9	24.17	12.55	11.62	-	-	750-1500
Redhills WSS	TM-10	16.78	10.33	0.00	10.33	6.45	900-1500
Redhills WSS (Soorapattu lake)	TM-11	2.00	-	2.00	-	-	600-600
Cholavaram WSS	TM-12	19.51	19.51	-	9.80	-	900-1000
Cholavaram WSS	TM-13A	0.10	-	-	-	0.10	800-800
Cholavaram WSS	TM-13B	22.00	-	-	-	22.00	700-1300
Minjur DSP	TM-14	33.49	23.48	-	-	10.01	500-1100
Kilpauk WSS	TM-15	7.30	7.30	-	-	-	700-850
Redhills WSS	TM-16	5.71	5.71	-	-	-	700-1200
Cholavaram WSS	TM-17	9.86	8.05	1.81	-	-	800-1200
Redhills WSS	TM-18A	0.20	0.20	0.00	-	-	1200
Redhills WSS	TM-18B	0.10	0.10	-	-	-	1400
	Total	354.86	190.56	34.49	69.60	129.81	

WSS – Water Supply System

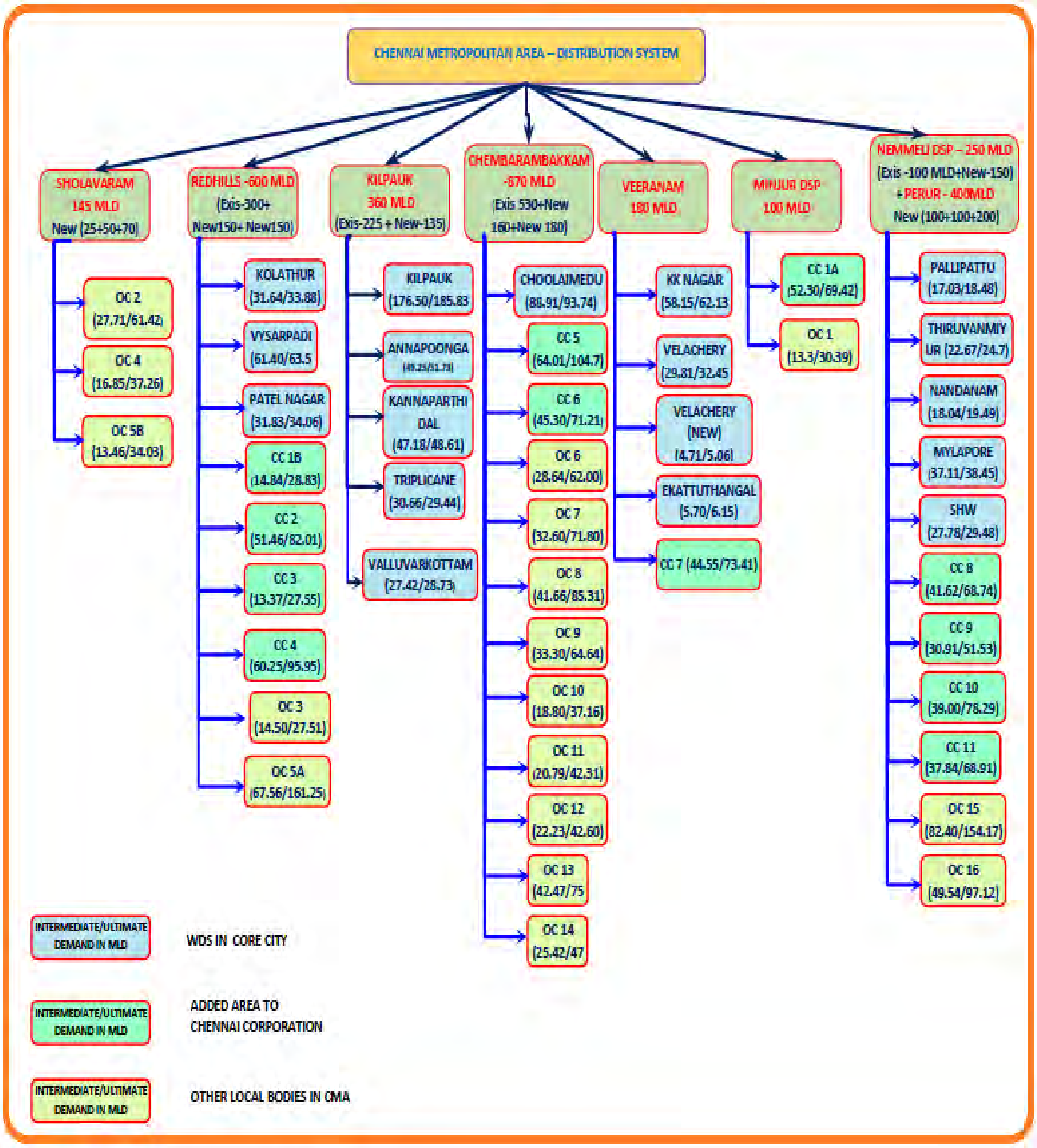
Source: JICA Study Team based on Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

Table A4.2.2 Pipe Materials for the Transmission Mains in the M/P

Pipe Material	Existing Pipe (Km)	Replacement Pipe (Km)	Strengthening (Km)	New Pipe (Km)
Mild Steel (MS)	43.06	-	69.60	129.81
Ductile Iron (DI)	123.04	-	-	-
Cast Iron (CI)	24.45	-	-	-
Pre-Stressed Concrete(PSC)	34.49	34.49	-	-
TOTAL	225.04	34.49	69.60	129.81

Source: JICA Study Team based on Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

A4.2.2 Configuration of the Water Distribution System for CMA Planned in the M/P



Source: JICA Study Team based on Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

Figure A4.2.1 Configuration of the Water Distribution System for CMA in the M/P

Appendix 4.3 Sewerage System Development Plan in the Master Plan

Sewerage segment of the M/P described that the current sewerage system for the Core City has five zones that are being served with four STPs. In addition, the M/P proposed that the Expanded Area would be covered by six sewerage zones. Additionally, the M/P proposed new ten sewerage zones for the Rest of CMA as shown in Figure A4.3.1. The locations of the existing and planned STPS are shown in Figure A4.3.2.

The M/P targeted to cover 100% of Chennai corporation area by 2035. It was considered that 85% of water supplied would be sewage generation, out of which 80% would be direct sewage contribution and 5% would be infiltration.

The M/P proposed to develop additional STPs near the existing STP locations for a total capacity of 1,117.5 MLD and 598 MLD at new locations. Overall, the M/P proposed a total STP capacity of 1,715.50 MLD based on the demand-supply gap as shown in Table A4.3.1. The M/P utilized the existing total STP capacity of 750 MLD in Chennai Corporation and 854 MLD in CMA.

According to the M/P, the existing sewer collection network is in a dilapidated condition, and thus, it proposes to replace the sewer network below 200 mm diameter with Cast Iron (CI) or High Density Poly Ethylene (HDPE) pipes. It was assessed that 30% of the existing sewer network of the Core City would need to be replaced; however, the exact volume to be replaced would be decided during Detailed Project Report (DPR) stage. The summary of planned sewer collection network in the Core City, Expanded Area, and Rest of CMA is shown in Table A4.3.2.

Table A4.3.1 Summary of Planned Capacities of STPs

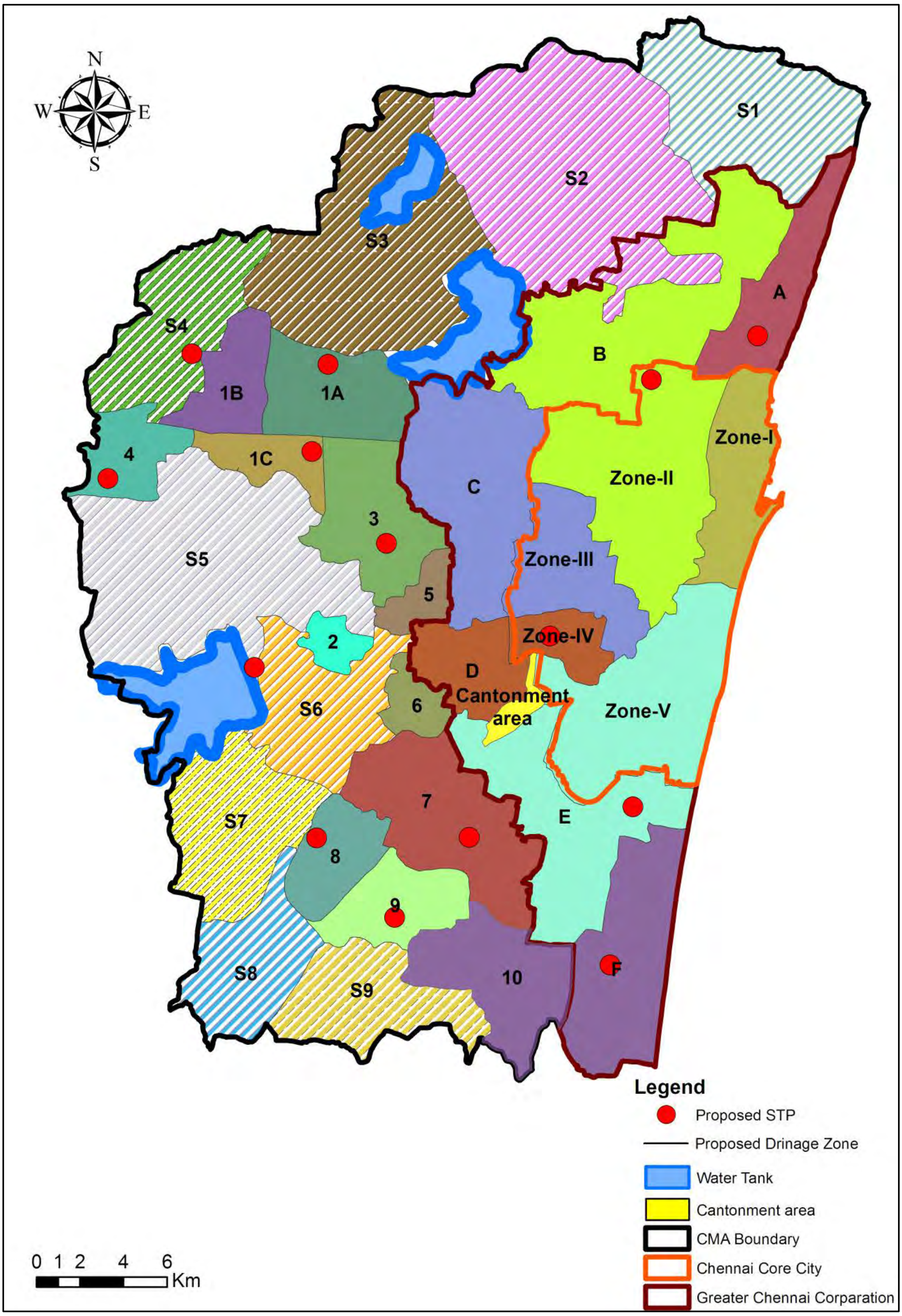
S.No	Area	Total planned capacity of STPs (MLD)			Total Capacity (MLD)
		2020	2035	2050	
1	Near Existing STP Locations	430.0	300.0	387.5	1,117.5
2	New Locations	161.5	170.5	266.0	598.0
	Total	591.5	470.5	653.5	1,715.5

Source: Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

Table A4.3.2 Summary of Sewer Collection Network

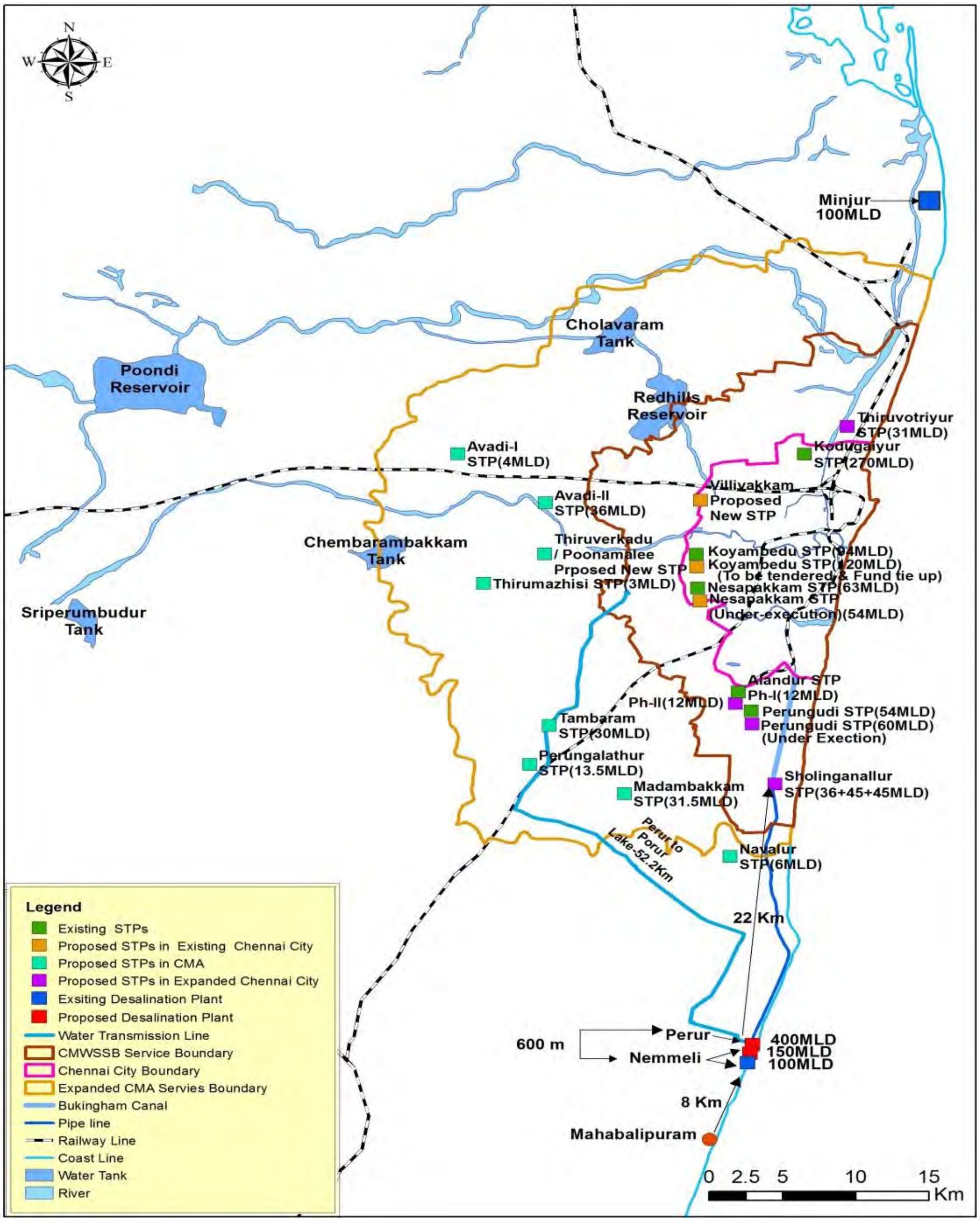
Sl.No	Area	Sewer Collection Network (Km)			Diameter Range (mm)
		Existing	Replacement	New	
1	Core city	1,765.10	529.53	1,023.43	200-1100
2	Expanded Area	-	-	1,460.99	200-1000
3	Rest of CMA	-	-	4,850.00	200-1000
	Total		529.53	7,334.42	

Source: Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015



Source: Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

Figure A4.3.1 Planned Sewerage Systems for CMA in the M/P



Source: JICA Study Team based on Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

Figure A4.3.2 Existing and Planned Sewerage Zones for CMA in the M/P

Appendix 4.4 Investment Plan for Water Supply and Sewerage Systems in the Master Plan

The below tables indicate investment plan for water supply and sewerage systems in CMA prepared by Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015.

(1) For water supply

S. No	Description	Qty	Amount in Millions	Phasing of Project in Millions			
				Immediate (Phase I)	Phase II (2020-30)	Phase III (2030- 40)	Phase IV (2040-50)
1	Source Augmentation						
1a)	Surface Water - To bring Mettur water to Chennai (As per separate estimate)	700 Mld	57580.00		30000.00	27580.00	
1c)	Construction of Additional Desalination Plants at Nemmeli	550 Mld	41250.00	11250.00	15000.00	15000.00	
1d)	Telugu Ganga conveyance of water through closed conduit (2 rows of pipeline) from kandelaru to poondi		46671.00		46671.00		
1e)	Provision for Rainwater Harvesting / Strom Water Harvesting	L.S	500.00	500.00			
1f)	Augmentation of Chennai City water supply-drawal of sub-surface water from Cauvery River and conveyed up to Vadakuthu during depletion of Veeranam Lake 2025-30		6810.00		6810.00		
1g)	Interconnection between exisitng mains to from Ring Main	L.S	100.00	100.00			
2)	WATER TREATMENT PLANT- Construction of proposed WTPs including all electro-mechanical components	920 Mld	3220.00	560.00	700.00	560.00	1400.00
3	Pumping Plants including cost of pumpsets, construction of pumphouse, electrical & mechanical works etc. for WTPs, Conveying Mains and Feeder Mains (Details as per Annexure 12.6)						
3a)	Replacement of exising Raw water Pumps in WTPs including electrical accessories complete		1180.80		1180.80		
3b)	Replacement of exising Treated water Pumps in WTPs including electrical accessories etc complete		476.19		476.19		
3c)	New Raw Water Pumps at Proposed WTPs including electrical accessories, pump room etc complete		489.99		183.06	306.93	
3d)	New Treated Water Pumps at Proposed WTPs including electrical accessories, pump room etc complete		506.09		177.53	328.57	
3e)	Replacement of exising pumps in WDSs including electrical accessories etc complete		832.33		832.33		
3f)	Replacement of existing pumps in Booster stations & sub-WDSs in core area including electrical accessories complete		40.00		40.00		
3g)	New pumps at Group sumps in CMA including electrical accessories, pump room etc complete		1242.93		1242.93		
3h)	Rehabilitation of pump rooms in the exisitng Redhills and Kilpuak WTPs		9.00	9.00			
3i)	Rehabilitation of pump rooms in the exisitng WDS's		27.00	27.00			
3j)	Water Audit for Chennai Core area including forming DMA, 100% metering etc complete		785.00		523.33	261.67	
3k)	Water Audit for 42 local bodies added to Chennai city including forming DMA, 100% metering etc complete		537.00		358.00	179.00	

S. No	Description	Qty		Amount in Millions	Phasing of Project in Millions			
					Immediate (Phase I)	Phase II (2020-30)	Phase III (2030- 40)	Phase IV (2040-50)
3l)	Instrumentation, SCADA			180.00		30.00	150.00	
4	Supplying, laying, jointing and testing of Conveying Mains, Feeder Mains & Branch Mains including the cost of Fittings, Fixtures, Appurtenances and other accessories							
4a)	Conveying Mains using MS Pipes (Qty as per Annexure 5.20)							
	Diameter of pipes ranging from 800mm to 2200mm	42500	m	1294.35		592.11	702.24	
4b)	Feeder Mains using MS pipes (Qty as per Annexure 5.23)							
	Diameter of pipes ranging from 300mm to 2000mm	233895	m	7426.57		4258.72	3167.84	
4c)	Branch Mains (Qty as per Annexure 5.24)							
	i) DI Pipes							
	Diameter of pipes ranging from 200mm to 400mm	62000	m	296.99	118.80	178.20		
	ii) MS Pipes							
	Diameter of pipes ranging from 500mm to 1300mm	89380	m	1201.20	480.48	720.72		
5	Construction of Sump using RCC M30 grade of Concrete including the cost of reinforcement, cantering, shuttering etc. (Details as per Annexure 5.10)	930	LL	464.75		464.75		
6	Construction of Service Reservoirs using RCC M30 grade of Concrete including the cost of reinforcement, cantering, shuttering etc.	537	LL	988.08		988.08		

S. No	Description	Qty		Amount in Millions	Phasing of Project in Millions			
					Immediate (Phase I)	Phase II (2020-30)	Phase III (2030- 40)	Phase IV (2040-50)
7	Supplying, laying, jointing and testing of Distribution Mains including the cost of Fittings, Fixtures, Appurtenances and other accessories (upto 200mm dia HDPE Pipe and above 200mm dia DI pipes)							
7a)	Core Area Existing Distribution Mains	1860883	m					
	Optimization of Distribution Mains including Replacement/Rehabilitation of Existing length of mains Diameter of pipes ranging from 150mm to 400mm	558266	m	1107.46	1107.46			
	Proposed Distribution Mains for the leftout length Diameter of pipes ranging from 150mm to 400mm	980994	m	1692.21		1692.21		
7b)	Added Area Existing Pipeline	2270358	m					
	Optimization of Distribution Mains including Replacement/Rehabilitation of Existing length of mains Diameter of pipes ranging from 150mm to 350mm	681107	m	1155.33	1155.33			
	Proposed Distribution Mains for the leftout length Diameter of pipes ranging from 150mm to 350mm	733632	m	1082.11		1082.11		
7c)	Rest of CMA Area	4850000	m					

S. No	Description	Qty		Amount in Millions	Phasing of Project in Millions			
					Immediate (Phase I)	Phase II (2020-30)	Phase III (2030- 40)	Phase IV (2040-50)
	Proposed Distribution Mains for rest of CMA area Diameter of pipes ranging from 150mm to 350mm	4850000	m	7153.75		7153.75		
8	Pilot Project for use of Recycle water for Non-Domestic purpose		L.S	1000.00		1000.00		
9	Improvements to the Catchment Areas of Existing reservoirs via removing the encroachments if any, strengthening the water ways			1000.00	1000.00			
10	Water Management Plan		L.S	500.00			500.00	
	Sub Total			188800.15	16308.07	122355.83	48736.25	1400.00
11	Price Contingencies @10%			18880.02	1630.81	12235.58	4873.63	140.00
12	Physical Contingencies @ 3%			5664.00	489.24	3670.68	1462.09	42.00
13	Supervision Charges @ 5%			9440.01	815.40	6117.79	2436.81	70.00
	Total Cost in Millions			222784.18	19243.52	144379.8	57508.78	1652.00
	Total Cost in Crores			22278.00	1924.00	14438.00	5751.00	165.00

Incremental Cost per year @ 16% of Base year cost

(2) For sewerage

Sl. No	Description	Qty		Amount in Millions	Phasing of Project in Millions			
					Immediate Phase I	Phase II	Phase III	Phase IV
1	Supplying, laying, jointing and testing of Sewer Mains includiing the cost of jointing materials and other accessories							
1a)	Core Area Existing Sewer Mains	1765100.00	m					
	Replacement/Rehabilitation Required @30% of Existing length of mains Diameter of pipes ranging from 200mm to 1100mm	529530	m	2866.35	2866.35			
	Proposed Sewer Mains for the leftout length Diameter of pipes ranging from 200mm to 1100mm	1023429	m	5539.82		5539.82		
1b)	Proposed Sewer Mains for the leftout length of Added Area Diameter of pipes ranging from 200mm to 1000mm	1460990	m	6533.55		6533.55		
1c)	Proposed Sewer Mains for the Rest of CMA area Diameter of pipes ranging from 200mm to 1000mm	4850000	m	16766.45			16766.45	
1d)	Add 30% cost for construction of Manholes			9511.85	859.90	3622.01	5029.94	
1e)	Add 25% cost for laying of mains in different depths			7926.54	716.59	3018.34	4191.61	
2	Supplying, laying, jointing and testing of Transmission Mains & Gravity Trunk Mains includiing the cost of jointing materials and other accessories	37800	m					
	Replacement/Rehabilitation Required @30% of Existing length of mains Diameter of pipes ranging from 200mm to 900mm	11340	m	140.92	140.92			
3	Rehabilitation of existing Sub Pumping Stations	226	Nos	678.00	678.00			

Sl. No	Description	Qty	Amount in Millions	Phasing of Project in Millions			
				Immediate Phase I	Phase II	Phase III	Phase IV
4	Construction of Proposed Sub Pumping Stations including the cost of pumping machinery, electrical and mechanical components etc.						
	For Added Area	150 Nos	825.00		825.00		
	For Rest of CMA Area	85 Nos	467.50			467.50	
5	Supplying, laying, jointing and testing of Pumping Mains using DI K9 pipes includiing the cost of Fittings, Fixtures, Appurtenances and other accessories Diameter of pipes ranging from 250mm to 900mm	750000 m	9635.25			9635.25	
6	Pumping Plants including cost of pumpsets, construction of pumphouse, electrical & mechanical works etc. for Sub Pumping Stations						
6a)	Replacing existing sewage pumps including electrical accessories under Category-I		4305.69	3.00	2870.46	1432.23	
6b)	Replacing existing sewage pumps including electrical accessories under Category-II		3286.21		1643.11	1643.11	
6c)	Replacing existing sewage pumps including electrical accessories under Category-III		2760.64		2760.64		
6d)	Providing grit pumps with accessories in all SPSs		147.50	147.50			
6e)	providing/replacing sluice gates & Screens at inlet in SPSs		86.60	86.60			
6f)	Refurbishing the civil structures in all SPSs		112.20	74.80	37.40		

Sl. No	Description	Qty		Amount in Millions	Phasing of Project in Millions			
					Immediate Phase I	Phase II	Phase III	Phase IV
7	Construction of proposed STPs including all electro-mechanical components. (Details vide separate sheet)							
	Expansion in exisitng STP	1118	mld	5981.78		2116.81	1623.65	2241.3248
	New STP	598	mld	3416.71		986.22	941.75	1488.7378
8	Construction of proposed Tertiary Treatment Plant including all electro-mechanical components	650	mld	1702.00		476.66	557.69	667.645
9	Miscellaneous items like Sewer Cleaning equipment, safety equipment, minor tool kits and other major equipment		L.S	500.00		250.00	500.00	
10	Construction of Tank within tank in selected Water Bodies		L.S	1000.00		1000.00		
11	Provision of Dual Water Supply System		L.S	1000.00		1000.00		
	Sub Total			85190.56	5573.66	32680.02	42789.18	4397.71
12	Price Contingencies @10%			8519.06	557.37	3268.00	4278.92	439.77
13	Physical Contingencies @ 3%			2555.72	167.21	980.40	1283.68	131.93
14	Supervision Charges @ 5%			4259.53	278.68	1634.00	2139.46	219.89
	Total Cost in Millions			100524.86	6576.92	38562.42	50491.23	5189.29
	Total Cost in Crores			10052.00	658.00	3856.00	5049.00	519.00

Incremental Cost per year @ 16% of Base year cost

Appendix 5.1 Water Demand Forecast in the Study

SUMMARY

Population (in M/P and the Study)

	2011 Census	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Core City	**4,647**	**4,728**	**4,748**	**4,769**	**4,789**	**4,810**	**4,830**	**4,852**	**4,874**	**4,895**	**4,917**	**4,939**	**4,958**	**4,977**	**4,995**	**5,014**	**5,033**	**5,054**	**5,075**	**5,096**	**5,117**	**5,138**	**5,158**	**5,178**	**5,199**	**5,219**	**5,239**	**5,257**	**5,275**	**5,292**	**5,310**	**5,328**	**5,349**	**5,371**	**5,393**	**5,415**	**5,437**
Expanded Area	2,020	2,326	2,406	2,486	2,567	2,647	2,727	2,789	2,850	2,912	2,973	3,035	3,145	3,255	3,365	3,475	3,585	3,677	3,768	3,860	3,951	4,042	4,138	4,233	4,328	4,424	4,519	4,619	4,718	4,818	4,917	5,017	5,121	5,224	5,328	5,432	5,536
Rest of CMA	2,264	2,883	3,036	3,188	3,341	3,494	3,646	3,738	3,829	3,921	4,013	4,104	4,352	4,601	4,849	5,097	5,346	5,536	5,727	5,918	6,109	6,300	6,507	6,715	6,922	7,130	7,337	7,563	7,790	8,016	8,242	8,469	8,717	8,966	9,215	9,463	9,712
Corporation	**6,667**	**7,054**	**7,154**	**7,255**	**7,356**	**7,457**	**7,557**	**7,640**	**7,724**	**7,807**	**7,890**	**7,973**	**8,102**	**8,232**	**8,361**	**8,490**	**8,619**	**8,731**	**8,843**	**8,955**	**9,068**	**9,180**	**9,296**	**9,411**	**9,527**	**9,643**	**9,758**	**9,876**	**9,993**	**10,110**	**10,227**	**10,344**	**10,470**	**10,596**	**10,721**	**10,847**	**10,973**
CMA Total	**8,931**	**9,937**	**10,190**	**10,444**	**10,697**	**10,950**	**11,204**	**11,378**	**11,553**	**11,728**	**11,903**	**12,078**	**12,455**	**12,832**	**13,210**	**13,587**	**13,964**	**14,267**	**14,571**	**14,874**	**15,177**	**15,480**	**15,803**	**16,126**	**16,449**	**16,773**	**17,096**	**17,439**	**17,783**	**18,126**	**18,470**	**18,813**	**19,187**	**19,562**	**19,936**	**20,310**	**20,684**

Served Population

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Core City	**4,728**	**4,748**	**4,769**	**4,789**	**4,810**	**4,830**	**4,852**	**4,874**	**4,895**	**4,917**	**4,939**	**4,958**	**4,977**	**4,995**	**5,014**	**5,033**	**5,054**	**5,075**	**5,096**	**5,117**	**5,138**	**5,158**	**5,178**	**5,199**	**5,219**	**5,239**	**5,257**	**5,275**	**5,292**	**5,310**	**5,328**	**5,349**	**5,371**	**5,393**	**5,415**	**5,437**
Expanded Area	2,326	2,406	2,486	2,567	2,647	2,727	2,789	2,850	2,912	2,973	3,035	3,145	3,255	3,365	3,475	3,585	3,677	3,768	3,860	3,951	4,042	4,138	4,233	4,328	4,424	4,519	4,619	4,718	4,818	4,917	5,017	5,121	5,224	5,328	5,432	5,536
Rest of CMA	666	741	815	890	965	1,039	1,675	2,311	2,946	3,582	4,218	4,476	4,734	4,993	5,251	5,509	5,714	5,918	6,123	6,327	6,532	6,749	6,967	7,184	7,402	7,619	7,860	8,102	8,343	8,584	8,826	9,097	9,368	9,640	9,911	10,182
Corporation	**7,054**	**7,154**	**7,255**	**7,356**	**7,457**	**7,557**	**7,640**	**7,724**	**7,807**	**7,890**	**7,973**	**8,102**	**8,232**	**8,361**	**8,490**	**8,619**	**8,731**	**8,843**	**8,955**	**9,068**	**9,180**	**9,296**	**9,411**	**9,527**	**9,643**	**9,758**	**9,876**	**9,993**	**10,110**	**10,227**	**10,344**	**10,470**	**10,596**	**10,721**	**10,847**	**10,973**
CMA Total	**7,720**	**7,895**	**8,070**	**8,246**	**8,421**	**8,596**	**9,315**	**10,034**	**10,753**	**11,472**	**12,191**	**12,579**	**12,966**	**13,353**	**13,740**	**14,128**	**14,444**	**14,761**	**15,078**	**15,395**	**15,712**	**16,045**	**16,378**	**16,711**	**17,044**	**17,378**	**17,736**	**18,095**	**18,453**	**18,812**	**19,170**	**19,567**	**19,964**	**20,361**	**20,758**	**21,155**

Served Population by service connection

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Core City	**3,073**	**3,231**	**3,389**	**3,548**	**3,706**	**3,864**	**4,030**	**4,195**	**4,361**	**4,526**	**4,692**	**4,710**	**4,728**	**4,746**	**4,764**	**4,782**	**4,802**	**4,821**	**4,841**	**4,861**	**4,881**	**4,900**	**4,919**	**4,939**	**4,958**	**4,977**	**4,994**	**5,011**	**5,028**	**5,044**	**5,061**	**5,082**	**5,103**	**5,124**	**5,144**	**5,165**
Expanded Area	1,047	1,165	1,283	1,400	1,518	1,636	1,764	1,892	2,020	2,148	2,276	2,395	2,513	2,631	2,750	2,868	3,022	3,176	3,330	3,484	3,638	3,724	3,810	3,896	3,981	4,067	4,157	4,246	4,336	4,426	4,515	4,608	4,702	4,795	4,889	4,982
Rest of CMA	278	339	400	462	523	585	779	973	1,168	1,362	1,556	1,869	2,181	2,494	2,807	3,119	3,461	3,803	4,145	4,487	4,829	5,086	5,344	5,601	5,859	6,116	6,417	6,718	7,020	7,321	7,622	7,846	8,069	8,293	8,517	8,741
Corporation	**4,120**	**4,396**	**4,672**	**4,948**	**5,224**	**5,500**	**5,794**	**6,087**	**6,381**	**6,674**	**6,968**	**7,104**	**7,241**	**7,377**	**7,513**	**7,650**	**7,824**	**7,998**	**8,171**	**8,345**	**8,519**	**8,624**	**8,729**	**8,834**	**8,939**	**9,045**	**9,151**	**9,257**	**9,364**	**9,470**	**9,576**	**9,690**	**9,805**	**9,919**	**10,033**	**10,147**
(Connection Rate)	**58%**	**61%**	**64%**	**67%**	**70%**	**73%**	**76%**	**79%**	**82%**	**85%**	**87%**	**88%**	**88%**	**88%**	**89%**	**89%**	**90%**	**90%**	**91%**	**92%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**93%**	**92%**	**92%**
CMA Total	**4,397**	**4,735**	**5,072**	**5,410**	**5,747**	**6,085**	**6,573**	**7,061**	**7,549**	**8,036**	**8,524**	**8,973**	**9,422**	**9,871**	**10,320**	**10,769**	**11,285**	**11,801**	**12,316**	**12,832**	**13,348**	**13,711**	**14,073**	**14,436**	**14,798**	**15,161**	**15,568**	**15,976**	**16,383**	**16,791**	**17,198**	**17,536**	**17,874**	**18,212**	**18,550**	**18,888**
(Connection Rate)	**44%**	**46%**	**49%**	**51%**	**52%**	**54%**	**58%**	**61%**	**64%**	**68%**	**71%**	**72%**	**73%**	**75%**	**76%**	**77%**	**79%**	**81%**	**83%**	**85%**	**86%**	**87%**	**87%**	**88%**	**88%**	**89%**	**89%**	**90%**	**90%**	**91%**	**91%**	**91%**	**91%**	**91%**	**91%**	**91%**

Domestic and Non-Domestic Water Demand

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Core City	**500**	**527**	**553**	**579**	**605**	**632**	**664**	**696**	**728**	**761**	**793**	**796**	**799**	**801**	**804**	**807**	**810**	**814**	**817**	**820**	**823**	**826**	**829**	**832**	**835**	**838**	**841**	**844**	**846**	**849**	**852**	**855**	**858**	**862**	**865**	**868**
Expanded Area	136	150	165	179	193	208	233	257	282	307	332	360	388	417	445	474	499	525	551	576	602	616	630	644	657	671	686	700	715	729	744	759	774	789	805	820
Rest of CMA	36	36	36	36	36	36	55	74	93	111	130	148	167	185	203	222	258	295	332	369	406	385	364	343	322	302	306	310	314	319	323	338	353	368	383	398
Corporation	**636**	**677**	**718**	**758**	**799**	**840**	**897**	**954**	**1,011**	**1,068**	**1,125**	**1,156**	**1,187**	**1,218**	**1,250**	**1,281**	**1,310**	**1,338**	**1,367**	**1,396**	**1,425**	**1,442**	**1,459**	**1,476**	**1,493**	**1,510**	**1,527**	**1,544**	**1,561**	**1,579**	**1,596**	**1,614**	**1,633**	**1,651**	**1,670**	**1,688**
CMA Total	**672**	**713**	**754**	**794**	**835**	**876**	**951**	**1,027**	**1,103**	**1,179**	**1,255**	**1,304**	**1,354**	**1,403**	**1,453**	**1,502**	**1,568**	**1,634**	**1,699**	**1,765**	**1,831**	**1,827**	**1,823**	**1,819**	**1,815**	**1,811**	**1,833**	**1,854**	**1,876**	**1,897**	**1,919**	**1,952**	**1,986**	**2,019**	**2,053**	**2,086**

Total Requirement

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Core City	**600**	**626**	**651**	**676**	**701**	**727**	**756**	**785**	**814**	**843**	**872**	**875**	**878**	**882**	**885**	**888**	**891**	**895**	**898**	**902**	**905**	**909**	**912**	**915**	**919**	**922**	**925**	**928**	**931**	**934**	**937**	**941**	**944**	**948**	**952**	**955**
Expanded Area	177	187	198	208	218	229	256	283	310	338	365	396	427	459	490	521	549	577	606	634	662	677	693	708	723	739	755	770	786	802	818	835	852	868	885	902
Rest of CMA	88	97	106	115	123	132	180	227	275	323	371	410	449	489	528	567	633	698	764	830	895	899	903	907	910	914	945	975	1,006	1,037	1,067	1,131	1,194	1,258	1,321	1,385
Corporation	**777**	**813**	**848**	**884**	**920**	**955**	**1,012**	**1,068**	**1,124**	**1,181**	**1,237**	**1,271**	**1,306**	**1,340**	**1,374**	**1,409**	**1,441**	**1,472**	**1,504**	**1,536**	**1,567**	**1,586**	**1,605**	**1,623**	**1,642**	**1,661**	**1,680**	**1,699**	**1,718**	**1,737**	**1,755**	**1,776**	**1,796**	**1,816**	**1,837**	**1,857**
CMA Total	**865**	**910**	**954**	**998**	**1,043**	**1,087**	**1,191**	**1,295**	**1,400**	**1,504**	**1,608**	**1,681**	**1,755**	**1,829**	**1,902**	**1,976**	**2,073**	**2,171**	**2,268**	**2,365**	**2,463**	**2,485**	**2,508**	**2,530**	**2,552**	**2,575**	**2,624**	**2,674**	**2,724**	**2,773**	**2,823**	**2,907**	**2,990**	**3,074**	**3,158**	**3,242**

Water Supply per Capita (LPCD)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Core City	**127**	**132**	**136**	**141**	**146**	**150**	**156**	**161**	**166**	**171**	**177**	**177**	**177**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**	**176**
Expanded Area	76	78	79	81	82	84	92	99	107	114	120	126	131	136	141	145	149	153	157	160	164	164	164	164	163	163	163	163	163	163	163	163	163	163	163	163
Rest of CMA	31	32	33	34	35	36	48	59	70	80	90	94	98	101	104	106	114	122	129	136	142	138	134	131	128	125	125	125	125	126	126	130	133	137	140	143
Corporation	**110**	**114**	**117**	**120**	**123**	**126**	**132**	**138**	**144**	**150**	**155**	**157**	**159**	**160**	**162**	**163**	**165**	**166**	**168**	**169**	**171**	**171**	**171**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**169**	**169**	**169**
CMA Total	**87**	**89**	**91**	**93**	**95**	**97**	**105**	**112**	**119**	**126**	**133**	**135**	**137**	**138**	**140**	**141**	**145**	**149**	**152**	**156**	**159**	**157**	**155**	**154**	**152**	**151**	**150**	**150**	**150**	**150**	**150**	**151**	**153**	**154**	**155**	**157**

Sl. No.	Description	Area in Hect.	Population Projection in thousands								
			2011 census	2015	2020	2025	2030	2035	2040	2045	2050
1.	CHENNAI CORPORATION - OLD	17618	4647.0	4727.7	4830.2	4938.6	5033.4	5137.7	5239.3	5327.6	5436.9
	Total	**17618**	**4647.0**	**4727.7**	**4830.2**	**4938.6**	**5033.4**	**5137.7**	**5239.3**	**5327.6**	**5436.9**
	TOTAL	**17618**	**4647.0**	**4727.7**	**4830.2**	**4938.6**	**5033.4**	**5137.7**	**5239.3**	**5327.6**	**5436.9**
	MUNICIPALITIES		**IN PRESENT CORPORATION**								
2.	Kathivakkam	475	36.6	38.6	41.1	43.7	46.2	48.7	51.3	53.8	56.4
3.	Thiruvottiyur	2135	249.5	266.1	286.9	307.8	328.6	349.4	370.2	391.1	411.9
4.	Manali	749	35.3	38.3	42.5	47.2	52.4	58.2	64.6	71.7	79.6
5.	Madhavaram	1741	119.1	151.2	191.3	231.4	271.5	311.6	351.7	391.8	431.9
6.	Ambattur	3777	466.2	516.0	584.6	660.2	742.8	832.4	929.0	1032.6	1143.2
7.	Maduravoyal	478	86.2	99.1	115.2	131.3	147.5	163.6	179.7	195.8	212.0
8.	Valasarawakkam	297	47.4	52.9	60.7	69.5	79.3	90.1	101.9	114.7	128.5
9.	Alandur	808	164.4	177.1	192.9	208.7	224.5	240.3	256.1	271.9	287.7
10.	Ullagaram-Puzhudhivakkam	364	53.3	60.2	70.2	81.6	94.6	109.0	125.0	142.4	161.4
	Total	**10824**	**1258.0**	**1399.5**	**1585.5**	**1781.4**	**1987.3**	**2203.3**	**2429.5**	**2665.9**	**2912.5**
	TOWN PANCHAYATS		**IN PRESENT CORPORATION**								
18.	Chinnasekkadu	167	12.4	13.9	16.0	18.3	20.9	23.7	26.8	30.1	33.7
19.	Puzhal	674	31.7	36.7	44.0	52.9	63.5	76.3	91.6	110.1	132.2
20.	Porur	372	46.7	51.0	56.4	61.8	67.2	72.6	78.0	83.4	88.8
21.	Nandambakkam	261	11.2	13.5	16.3	19.1	21.9	24.7	27.4	30.2	33.0
22.	Meenambakkam	303	4.3	4.6	5.0	5.5	6.0	6.5	7.1	7.7	8.4
23.	Perungudi	464	43.1	55.2	70.4	85.6	100.7	115.9	131.0	146.2	161.3
24.	Pallikkaranai	1743	43.5	49.5	58.5	69.3	81.8	96.1	112.1	129.9	149.4
25.	Sholinganallur	1535	26.6	57.7	96.5	135.2	174.0	212.8	251.6	290.4	329.2
	Total	**5518**	**219.5**	**282.0**	**363.0**	**447.5**	**535.9**	**628.4**	**725.6**	**827.9**	**935.9**

Sl. No.	Description	Population by service level in thousands																															
		2015				2020				2025				2030				2035				2040				2045				2050			
		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others	
1.	CHENNAI CORPORATION - OLD	65%	3073.0	35%	1654.7	80%	3864.2	20%	966.0	95%	4691.7	5%	246.9	95%	4781.7	5%	251.7	95%	4880.8	5%	256.9	95%	4977.3	5%	262.0	95%	5061.2	5%	266.4	95%	5165.1	5%	271.8
	Total		**3073.0**		**1654.7**		**3864.2**		**966.0**		**4691.7**		**246.9**		**4781.7**		**251.7**		**4880.8**		**256.9**		**4977.3**		**262.0**		**5061.2**		**266.4**		**5165.1**		**271.8**
	TOTAL		**3073.0**		**1654.7**		**3864.2**		**966.0**		**4691.7**		**246.9**		**4781.7**		**251.7**		**4880.8**		**256.9**		**4977.3**		**262.0**		**5061.2**		**266.4**		**5165.1**		**271.8**
	Domestic Demand by service connections / Standposts and lorries	120	368.8	40	66.2	135	521.7	40	38.6	150	703.8	40	9.9	150	717.3	40	10.1	150	732.1	40	10.3	150	746.6	40	10.5	150	759.2	40	10.7	150	774.8	40	10.9
	Total Domestic Demand				**434.9**				**560.3**				**713.6**				**727.3**				**742.4**				**757.1**				**769.8**				**785.6**
	Industrial Demand @ 10% of Domestic Demand in 2015 and constant				43.5				43.5				43.5				43.5				43.5				43.5				43.5				43.5
	Commercial Demand @ 5% of Domestic Demand				21.7				28.0				35.7				36.4				37.1				37.9				38.5				39.3
	Total Demand				**500.2**				**631.8**				**792.8**				**807.2**				**823.0**				**838.4**				**851.8**				**868.4**
	(Served population)				4727.7				4830.2				4938.6				5033.4				5137.7				5239.3				5327.6				5436.9
	(Service connection rate)				65%				80%				95%				95%				95%				95%				95%				95%
	(Domestic LPC)				92				116				145				145				145				145				145				145
	(Combined LPC)				106				131				161				160				160				160				160				160
	Water loss in the transmission and distribution systems		20%		100.0		15%		94.8		10%		79.3		10%		80.7		10%		82.3		10%		83.8		10%		85.2		10%		86.8
	TOTAL REQUIREMENT (in the Core Chennai City)				**600.2**				**726.6**				**872.1**				**887.9**				**905.3**				**922.3**				**937.0**				**955.2**
	(Combined LPC including water loss by the total population)				127				150				177				176				176				176				176				176
	MUNICIPALITIES																																
2.	Kathivakkam	45%	17.4	55%	21.2	60%	24.7	40%	16.4	75%	32.7	25%	10.9	80%	37.0	20%	9.2	90%	43.9	10%	4.9	90%	46.2	10%	5.1	90%	48.5	10%	5.4	90%	50.8	10%	5.6
3.	Thiruvottiyur	45%	119.7	55%	146.4	60%	172.2	40%	114.8	75%	230.8	25%	76.9	80%	262.9	20%	65.7	90%	314.5	10%	34.9	90%	333.2	10%	37.0	90%	352.0	10%	39.1	90%	370.7	10%	41.2
4.	Manali	45%	17.2	55%	21.1	60%	25.5	40%	17.0	75%	35.4	25%	11.8	80%	41.9	20%	10.5	90%	52.4	10%	5.8	90%	58.2	10%	6.5	90%	64.6	10%	7.2	90%	71.7	10%	8.0
5.	Madhavaram	45%	68.0	55%	83.2	60%	114.8	40%	76.5	75%	173.5	25%	57.8	80%	217.2	20%	54.3	90%	280.4	10%	31.2	90%	316.5	10%	35.2	90%	352.6	10%	39.2	90%	388.7	10%	43.2
6.	Ambattur	45%	232.2	55%	283.8	60%	350.8	40%	233.9	75%	495.2	25%	165.1	80%	594.3	20%	148.6	90%	749.2	10%	83.2	90%	836.1	10%	92.9	90%	929.4	10%	103.3	90%	1028.9	10%	114.3
7.	Maduravoyal	45%	44.6	55%	54.5	60%	69.1	40%	46.1	75%	98.5	25%	32.8	80%	118.0	20%	29.5	90%	147.2	10%	16.4	90%	161.7	10%	18.0	90%	176.2	10%	19.6	90%	190.8	10%	21.2
8.	Valasarawakkam	45%	23.8	55%	29.1	60%	36.4	40%	24.3	75%	52.1	25%	17.4	80%	63.4	20%	15.9	90%	81.1	10%	9.0	90%	91.7	10%	10.2	90%	103.2	10%	11.5	90%	115.7	10%	12.9
9.	Alandur	45%	79.7	55%	97.4	60%	115.7	40%	77.2	75%	156.5	25%	52.2	80%	179.6	20%	44.9	90%	216.3	10%	24.0	90%	230.5	10%	25.6	90%	244.7	10%	27.2	90%	258.9	10%	28.8
10.	Ullagaram-Puzhudhivakkam	45%	27.1	55%	33.1	60%	42.1	40%	28.1	75%	61.2	25%	20.4	80%	75.6	20%	18.9	90%	98.1	10%	10.9	90%	112.5	10%	12.5	90%	128.2	10%	14.2	90%	145.2	10%	16.1
	Total		**629.8**		**769.7**		**951.3**		**634.2**		**1336.0**		**445.3**		**1589.9**		**397.5**		**1983.0**		**220.3**		**2186.5**		**242.9**		**2399.3**		**266.6**		**2621.3**		**291.3**
	Domestic Demand by service connections / Standposts and lorries	80	50.4	40	30.8	100	95.1	40	25.4	135	180.4	40	17.8	150	238.5	40	15.9	150	297.5	40	8.8	150	328.0	40	9.7	150	359.9	40	10.7	150	393.2	40	11.7
	Total Domestic Demand (In Municipalities in the Corporation)				**81.2**				**120.5**				**198.2**				**254.4**				**306.3**				**337.7**				**370.6**				**404.8**
	Industrial Demand @ 10% of Domestic Demand in 2015 and constant				8.1				8.1				8.1				8.1				8.1				8.1				8.1				8.1
	Commercial Demand @ 5% of Domestic Demand				4.1				6.0				9.9				12.7				15.3				16.9				18.5				20.2
	Total Demand				**93.3**				**134.6**				**216.2**				**275.2**				**329.7**				**362.7**				**397.2**				**433.2**
	(Served population)				1399.5				1585.5				1781.4				1987.3				2203.3				2429.5				2665.9				2912.5
	(Service connection rate)				45%				60%				75%				80%				90%				90%				90%				90%
	(Domestic LPC)				58				76				111				128				139				139				139				139
	(Combined LPC)				67				85				121				138				150				149				149				149
	Water loss in the transmission and distribution systems		0.3		28.0		0.1		13.5		0.1		21.6		0.1		27.5		0.1		33.0		0.1		36.3		0.1		39.7		0.1		43.3
	TOTAL REQUIREMENT (in Municipalities in the Corporation)				**121.3**				**148.1**				**237.8**				**302.7**				**362.7**				**399.0**				**436.9**				**476.5**
	(Combined LPC including water loss by the total population)				87				93				134				152				165				164				164				164
	TOWN PANCHAYATS																																
18.	Chinnasekkadu	45%	6.2	55%	7.6	60%	9.6	40%	6.4	75%	13.7	25%	4.6	80%	16.7	20%	4.2	90%	21.3	10%	2.4	90%	24.1	10%	2.7	90%	27.1	10%	3.0	90%	30.3	10%	3.4
19.	Puzhal	45%	16.5	55%	20.2	60%	26.4	40%	17.6	75%	39.7	25%	13.2	80%	50.8	20%	12.7	90%	68.7	10%	7.6	90%	82.5	10%	9.2	90%	99.1	10%	11.0	90%	119.0	10%	13.2
20.	Porur	45%	23.0	55%	28.1	60%	33.8	40%	22.6	75%	46.3	25%	15.4	80%	53.7	20%	13.4	90%	65.3	10%	7.3	90%	70.2	10%	7.8	90%	75.0	10%	8.3	90%	79.9	10%	8.9
21.	Nandambakkam	45%	6.1	55%	7.4	60%	9.8	40%	6.5	75%	14.3	25%	4.8	80%	17.5	20%	4.4	90%	22.2	10%	2.5	90%	24.7	10%	2.7	90%	27.2	10%	3.0	90%	29.7	10%	3.3
22.	Meenambakkam	45%	2.1	55%	2.5	60%	3.0	40%	2.0	75%	4.1	25%	1.4	80%	4.8	20%	1.2	90%	5.8	10%	0.6	90%	6.4	10%	0.7	90%	7.0	10%	0.8	90%	7.6	10%	0.8
23.	Perungudi	45%	24.9	55%	30.4	60%	42.2	40%	28.2	75%	64.2	25%	21.4	80%	80.6	20%	20.1	90%	104.3	10%	11.6	90%	117.9	10%	13.1	90%	131.6	10%	14.6	90%	145.2	10%	16.1
24.	Pallikkaranai	45%	22.3	55%	27.2	60%	35.1	40%	23.4	75%	51.9	25%	17.3	80%	65.4	20%	16.4	90%	86.4	10%	9.6	90%	100.9	10%	11.2	90%	116.9	10%	13.0	90%	134.4	10%	14.9
25.	Sholinganallur	45%	26.0	55%	31.7	60%	57.9	40%	38.6	75%	101.4	25%	33.8	80%	139.2	20%	34.8	90%	191.5	10%	21.3	90%	226.4	10%	25.2	90%	261.3	10%	29.0	90%	296.2	10%	32.9
	Total		**126.9**		**155.1**		**217.8**		**145.2**		**335.6**		**111.9**		**428.7**		**107.2**		**565.6**		**62.8**		**653.0**		**72.6**		**745.1**		**82.8**		**842.3**		**93.6**
	Domestic Demand by service connections / Standposts and lorries	40	5.075658	40	6.2	70	15.2	40	5.8	100	33.6	40	4.5	135	57.9	40	4.3	150	84.8	40	2.5	150	98.0	40	2.9	150	111.8	40	3.3	150	126.3	40	3.7
	Total Domestic Demand (In Municipalities in the Corporation)				**11.3**				**21.1**				**38.0**				**62.2**				**87.4**				**100.9**				**115.1**				**130.1**
	Industrial Demand @ 10% of Domestic Demand in 2015 and constant				1.1				1.1				1.1				1.1				1.1				1.1				1.1				1.1
	Commercial Demand @ 5% of Domestic Demand				0.6				1.1				1.9				3.1				4.4				5.0				5.8				6.5
	Total Demand				**13.0**				**23.2**				**41.1**				**66.4**				**92.8**				**107.0**				**122.0**				**137.7**
	(Served population)				282.0				363.0				447.5				535.9				628.4				725.6				827.9				935.9
	(Service connection rate)				45%				60%				75%				80%				90%				90%				90%				90%
	(Domestic LPC)				40				58				85				116				139				139				139				139
	(Combined LPC)				46				64				92				124				148				148				147				147
	Water loss in the transmission and distribution systems		30%		3.9		0.1		2.3		0.1		4.1		0.1		6.6		0.1		9.3		0.1		10.7		0.1		12.2		0.1		13.8
	TOTAL REQUIREMENT (in Towns in the Corporation)				**16.9**				**25.6**				**45.2**				**73.0**				**102.1**				**117.7**				**134.1**				**151.5**
	(Combined LPC including water loss by the total population)				60				70				101				136				163				162				162				162

Sl. No.	Description	Area in Hect.	Population Projection in thousands: 2011 census	2015	2020	2025	2030	2035	2040	2045	2050
	VILLAGE PANCHAYATS		IN PRESENT CORPORATION								
VP.1	Edayanchavadi	843	12.1	17.1	23.4	24.6	36.3	42.6	48.8	55.1	61.4
VP.2	Sadayankuppam	695	5.3	9.4	14.5	15.5	24.5	29.5	34.5	39.5	44.5
VP.3	Kadapakkam	311	1.1	6.0	9.7	10.5	17.2	20.9	24.6	28.3	32.0
VP.4	Thiyambakkam	64	0.2	1.3	2.8	3.1	5.8	7.3	8.8	10.3	11.8
VP.5	Mathur	174	27.7	30.3	33.5	34.2	40.0	43.3	46.5	49.8	53.0
VP.6	Vadaperumbakkam	298	1.7	3.9	6.7	7.3	12.3	15.1	18.0	20.8	23.6
VP.7	Soorapattu	278	10.4	12.9	16.1	16.7	22.3	25.4	28.5	31.6	34.7
VP.8	Kathirvedu	159	7.6	8.7	10.4	10.8	14.8	17.7	21.1	25.2	30.1
VP.9	Puthagaram	193	10.3	13.4	17.3	18.1	25.1	29.1	33.1	37.0	40.9
VP.10	Nolambur	257	22.0	33.5	47.9	50.8	77.0	91.4	105.8	120.3	134.8
VP.11	Karambakkam	107	21.4	21.9	22.5	22.6	23.8	24.4	25.0	25.7	26.3
VP.12	Nerkunram	265	59.8	65.3	72.2	73.6	86.0	92.9	99.8	106.7	113.6
VP.13	Ramapuram	269	52.3	57.3	63.5	64.7	75.9	82.1	88.4	94.6	100.8
VP.14	Mugalivakkam	187	25.1	28.8	34.5	35.8	49.9	59.4	70.3	82.4	95.8
VP.15	Manapakkam	412	13.3	17.4	22.5	23.5	32.9	38.0	43.2	48.3	53.4
VP.16	Kottivakkam	247	20.2	22.5	25.7	26.3	33.2	37.6	42.4	47.6	53.2
VP.17	Palavakkam	207	26.8	26.3	29.4	30.0	35.6	38.8	41.9	45.0	48.1
VP.18	Neelankarai	280	28.5	32.4	37.3	38.3	47.1	52.0	56.9	61.8	66.7
VP.19	Injambakkam	519	21.2	24.1	28.5	29.5	39.9	46.9	54.8	63.5	73.1
VP.20	Karapakkam	244	9.0	10.2	12.1	12.5	16.8	19.7	22.9	26.4	30.3
VP.21	Oggiam Thuraipakkam	603	76.6	95.1	118.2	122.9	164.5	187.6	210.5	233.6	256.8
VP.22	Madippakkam	340	35.8	40.9	48.7	50.5	69.3	82.0	96.3	112.2	129.8
VP.23	Jalladianpet	228	19.1	20.9	23.2	23.7	27.8	30.1	32.4	34.6	36.9
VP.24	Semmanjeri	701	29.8	38.3	49.0	51.1	70.5	81.2	92.0	102.7	113.5
VP.25	Uthandi	341	5.0	6.8	8.9	9.4	13.5	15.7	17.9	20.1	22.2
		8222	**542.1**	**644.6**	**778.6**	**806.0**	**1062.0**	**1210.6**	**1364.1**	**1523.0**	**1687.3**
	Expanded Area Total	**24564**	**2019.6**	**2326.1**	**2727.0**	**3034.9**	**3585.2**	**4042.4**	**4519.2**	**5016.7**	**5535.7**
	Corporation Total	**42182**	**6666.6**	**7053.8**	**7557.2**	**7973.5**	**8618.6**	**9180.1**	**9758.5**	**10344.3**	**10972.6**

Sl. No.	Description	Population by service level in thousands: 2015 Service connection		2015 Others		2020 Service connection		2020 Others		2025 Service connection		2025 Others		2030 Service connection		2030 Others		2035 Service connection		2035 Others		2040 Service connection		2040 Others		2045 Service connection		2045 Others		2050 Service connection		2050 Others	
	VILLAGE PANCHAYATS IN PRESENT CORPORATION																																
VP.1	Edayanchavadi	45%	7.7	55%	9.4	60%	14.0	40%	9.3	75%	18.5	25%	6.2	80%	29.0	20%	7.3	90%	38.3	10%	4.3	90%	43.9	10%	4.9	90%	49.6	10%	5.5	90%	55.2	10%	6.1
VP.2	Sadayankuppam	45%	4.2	55%	5.2	60%	8.7	40%	5.8	75%	11.6	25%	3.9	80%	19.6	20%	4.9	90%	26.5	10%	2.9	90%	31.0	10%	3.4	90%	35.5	10%	3.9	90%	40.0	10%	4.4
VP.3	Kadapakkam	45%	2.7	55%	3.3	60%	5.8	40%	3.9	75%	7.9	25%	2.6	80%	13.7	20%	3.4	90%	18.8	10%	2.1	90%	22.1	10%	2.5	90%	25.5	10%	2.8	90%	28.8	10%	3.2
VP.4	Thiyambakkam	45%	0.6	55%	0.7	60%	1.7	40%	1.1	75%	2.4	25%	0.8	80%	4.6	20%	1.2	90%	6.6	10%	0.7	90%	7.9	10%	0.9	90%	9.3	10%	1.0	90%	10.6	10%	1.2
VP.5	Mathur	45%	13.6	55%	16.7	60%	20.1	40%	13.4	75%	25.6	25%	8.5	80%	32.0	20%	8.0	90%	38.9	10%	4.3	90%	41.9	10%	4.7	90%	44.8	10%	5.0	90%	47.7	10%	5.3
VP.6	Vadaperumbakkam	45%	1.8	55%	2.2	60%	4.0	40%	2.7	75%	5.4	25%	1.8	80%	9.9	20%	2.5	90%	13.6	10%	1.5	90%	16.2	10%	1.8	90%	18.7	10%	2.1	90%	21.2	10%	2.4
VP.7	Soorapattu	45%	5.8	55%	7.1	60%	9.6	40%	6.4	75%	12.5	25%	4.2	80%	17.9	20%	4.5	90%	22.9	10%	2.5	90%	25.6	10%	2.8	90%	28.4	10%	3.2	90%	31.2	10%	3.5
VP.8	Kathirvedu	45%	3.9	55%	4.8	60%	6.2	40%	4.2	75%	8.1	25%	2.7	80%	11.9	20%	3.0	90%	15.9	10%	1.8	90%	19.0	10%	2.1	90%	22.7	10%	2.5	90%	27.0	10%	3.0
VP.9	Puthagaram	45%	6.0	55%	7.4	60%	10.4	40%	6.9	75%	13.6	25%	4.5	80%	20.1	20%	5.0	90%	26.2	10%	2.9	90%	29.8	10%	3.3	90%	33.3	10%	3.7	90%	36.8	10%	4.1
VP.10	Nolambur	45%	15.1	55%	18.4	60%	28.8	40%	19.2	75%	38.1	25%	12.7	80%	61.6	20%	15.4	90%	82.3	10%	9.1	90%	95.2	10%	10.6	90%	108.3	10%	12.0	90%	121.3	10%	13.5
VP.11	Karambakkam	45%	9.8	55%	12.0	60%	13.5	40%	9.0	75%	17.0	25%	5.7	80%	19.0	20%	4.8	90%	22.0	10%	2.4	90%	22.5	10%	2.5	90%	23.1	10%	2.6	90%	23.7	10%	2.6
VP.12	Nerkunram	45%	29.4	55%	35.9	60%	43.3	40%	28.9	75%	55.2	25%	18.4	80%	68.8	20%	17.2	90%	83.6	10%	9.3	90%	89.9	10%	10.0	90%	96.1	10%	10.7	90%	102.3	10%	11.4
VP.13	Ramapuram	45%	25.8	55%	31.5	60%	38.1	40%	25.4	75%	48.6	25%	16.2	80%	60.7	20%	15.2	90%	73.9	10%	8.2	90%	79.5	10%	8.8	90%	85.1	10%	9.5	90%	90.7	10%	10.1
VP.14	Mugalivakkam	45%	13.0	55%	15.8	60%	20.7	40%	13.8	75%	26.9	25%	9.0	80%	39.9	20%	10.0	90%	53.5	10%	5.9	90%	63.2	10%	7.0	90%	74.2	10%	8.2	90%	86.2	10%	9.6
VP.15	Manapakkam	45%	7.8	55%	9.6	60%	13.5	40%	9.0	75%	17.6	25%	5.9	80%	26.3	20%	6.6	90%	34.2	10%	3.8	90%	38.8	10%	4.3	90%	43.5	10%	4.8	90%	48.1	10%	5.3
VP.16	Kottivakkam	45%	10.1	55%	12.4	60%	15.4	40%	10.3	75%	19.8	25%	6.6	80%	26.6	20%	6.6	90%	33.9	10%	3.8	90%	38.2	10%	4.2	90%	42.8	10%	4.8	90%	47.9	10%	5.3
VP.17	Palavakkam	45%	11.8	55%	14.5	60%	17.6	40%	11.8	75%	22.5	25%	7.5	80%	28.5	20%	7.1	90%	34.9	10%	3.9	90%	37.7	10%	4.2	90%	40.5	10%	4.5	90%	43.3	10%	4.8
VP.18	Neelankarai	45%	14.6	55%	17.8	60%	22.4	40%	14.9	75%	28.7	25%	9.6	80%	37.7	20%	9.4	90%	46.8	10%	5.2	90%	51.2	10%	5.7	90%	55.6	10%	6.2	90%	60.0	10%	6.7
VP.19	Injambakkam	45%	10.8	55%	13.2	60%	17.1	40%	11.4	75%	22.1	25%	7.4	80%	31.9	20%	8.0	90%	42.2	10%	4.7	90%	49.3	10%	5.5	90%	57.1	10%	6.3	90%	65.8	10%	7.3
VP.20	Karapakkam	45%	4.6	55%	5.6	60%	7.2	40%	4.8	75%	9.4	25%	3.1	80%	13.4	20%	3.4	90%	17.7	10%	2.0	90%	20.6	10%	2.3	90%	23.8	10%	2.6	90%	27.3	10%	3.0
VP.21	Oggiam Thuraipakkam	45%	42.8	55%	52.3	60%	70.9	40%	47.3	75%	92.2	25%	30.7	80%	131.6	20%	32.9	90%	168.8	10%	18.8	90%	189.5	10%	21.1	90%	210.3	10%	23.4	90%	231.1	10%	25.7
VP.22	Madippakkam	45%	18.4	55%	22.5	60%	29.2	40%	19.5	75%	37.9	25%	12.6	80%	55.4	20%	13.9	90%	73.8	10%	8.2	90%	86.7	10%	9.6	90%	101.0	10%	11.2	90%	116.8	10%	13.0
VP.23	Jalladianpet	45%	9.4	55%	11.5	60%	13.9	40%	9.3	75%	17.8	25%	5.9	80%	22.2	20%	5.6	90%	27.1	10%	3.0	90%	29.1	10%	3.2	90%	31.2	10%	3.5	90%	33.2	10%	3.7
VP.24	Semmanjeri	45%	17.2	55%	21.1	60%	29.4	40%	19.6	75%	38.3	25%	12.8	80%	56.4	20%	14.1	90%	73.1	10%	8.1	90%	82.8	10%	9.2	90%	92.5	10%	10.3	90%	102.1	10%	11.3
VP.25	Uthandi	45%	3.0	55%	3.7	60%	5.4	40%	3.6	75%	7.0	25%	2.3	80%	10.8	20%	2.7	90%	14.1	10%	1.6	90%	16.1	10%	1.8	90%	18.0	10%	2.0	90%	20.0	10%	2.2
			290.1		**354.6**		**467.2**		**311.4**		**604.5**		**201.5**		**849.6**		**212.4**		**1089.6**		**121.1**		**1227.7**		**136.4**		**1370.7**		**152.3**		**1518.6**		**168.7**
	Expanded Area Total		**1046.8**		**1279.4**		**1636.2**		**1090.8**		**2276.1**		**758.7**		**2868.2**		**717.0**		**3638.1**		**404.2**		**4067.3**		**451.9**		**4515.1**		**501.7**		**4982.2**		**553.6**
	Corporation Total		**4119.8**		**2934.1**		**5500.4**		**2056.9**		**6967.8**		**1005.6**		**7649.9**		**968.7**		**8519.0**		**661.1**		**9044.6**		**713.9**		**9576.3**		**768.1**		**10147.2**		**825.4**
	Domestic Demand by service connections / Standposts and lorries	40	11.60352	40	14.2	70	32.7	40	12.5	100	60.4	40	8.1	135	114.7	40	8.5	150	163.4	40	4.8	150	184.2	40	5.5	150	205.6	40	6.1	150	227.8	40	6.7
	Total Domestic Demand (In Villages in the Corporation)				**25.8**				**45.2**				**68.5**				**123.2**				**168.3**				**189.6**				**211.7**				**234.5**
	Industrial Demand @ 10% of Domestic Demand in 2015 and constant				2.6				2.6				2.6				2.6				2.6				2.6				2.6				2.6
	Commercial Demand @ 5% of Domestic Demand				1.3				2.3				3.4				6.2				8.4				9.5				10.6				11.7
	Total Demand				**29.7**				**50.0**				**74.5**				**131.9**				**179.3**				**201.7**				**224.9**				**248.8**
	(Served population)				644.6				778.6				806.0				1062.0				1210.6				1364.1				1523.0				1687.3
	(Service connection rate)				45%				60%				75%				80%				90%				90%				90%				90%
	(Domestic LPC)				40				58				85				116				139				139				139				139
	(Combined LPC)				46				64				92				124				148				148				148				147
	Water loss in the transmission and distribution systems		30%		8.9		10%		5.0		10%		7.5		10%		13.2		10%		17.9		10%		20.2		10%		22.5		10%		24.9
	TOTAL REQUIREMENT (in Villages in the Corporation)				**38.5**				**55.0**				**82.0**				**145.1**				**197.2**				**221.8**				**247.4**				**273.7**
	(Combined LPC including water loss by the total population)				60				71				102				137				163				163				162				162
	Total Domestic Demand (In New corporation Area Excluding Erstwhile Corporation)				**118.2**				**186.7**				**304.7**				**439.7**				**561.9**				**628.2**				**697.3**				**769.5**
	Industrial Demand				11.8				11.8				11.8				11.8				11.8				11.8				11.8				11.8
	Commercial Demand				5.9				9.3				15.2				22.0				28.1				31.4				34.9				38.5
	Total Demand				**136.0**				**207.9**				**331.8**				**473.5**				**601.8**				**671.4**				**744.0**				**819.8**
	(Served population)				2326.1				2727.0				3034.9				3585.2				4042.4				4519.2				5016.7				5535.7
	(Service connection rate)				45%				60%				75%				80%				90%				90%				90%				90%
	(Domestic LPC)				51				68				100				123				139				139				139				139
	(Combined LPC)				58				76				109				132				149				149				148				148
	Water loss in the transmission and distribution systems				40.8				20.8				33.2				47.4				60.2				67.1				74.4				82.0
	TOTAL REQUIREMENT(in the Expanded Area of the Corporation)				**176.8**				**228.7**				**365.0**				**520.9**				**662.0**				**738.5**				**818.4**				**901.7**
	(Combined LPC including water loss by the total population)				76				84				120				145				164				163				163				163
	Total Domestic Demand In the Corporation				**553.2**				**747.0**				**1018.4**				**1167.1**				**1304.3**				**1385.2**				**1467.2**				**1555.1**
	Industrial Demand @ 10% of Domestic Demand				55.3				55.3				55.3				55.3				55.3				55.3				55.3				55.3
	Commercial Demand @ 5% of Domestic Demand				27.7				37.4				50.9				58.4				65.2				69.3				73.4				77.8
	Total Demand				**636.2**				**839.7**				**1124.6**				**1280.7**				**1424.8**				**1509.8**				**1595.8**				**1688.2**
	(Served population)				7053.8				7557.2				7973.5				8618.6				9180.1				9758.5				10344.3				10972.6
	(Service connection rate)				58%				73%				87%				89%				93%				93%				93%				92%
	(Domestic LPC)				78				99				128				135				142				142				142				142
	(Combined LPC)				90				111				141				149				155				155				154				154
	Water loss in the transmission and distribution systems				140.8				115.6				112.5				128.1				142.5				151.0				159.6				168.8
	TOTAL REQUIREMENT (In the Corporation)				**777.0**				**955.2**				**1237.0**				**1408.8**				**1567.3**				**1660.8**				**1755.4**				**1857.0**
	(Combined LPC including water loss by the total population)				110				126				155				163				171				170				170				169

Sl. No.	Description	Area in Hect.	2011 census	Population Projection in thousands								Population by service level in thousands																															
				2015	2020	2025	2030	2035	2040	2045	2050	2015				2020				2025				2030				2035				2040				2045				2050			
												Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others		Service connection		Others	
	REST OF CMA	OUT SIDE CORPORATION AREA AND WITHIN CMA																																									
	MUNICIPALITIES	OUT SIDE CORPORATION AREA AND WITHIN CMA																																									
11.	Avadi	6157	346.0	407.8	500.9	615.1	755.5	927.8	1139.5	1399.5	1718.7	25%	102.0	35%	142.7	45%	225.4	35%	175.3	60%	369.1	40%	246.1	75%	566.6	25%	188.9	90%	835.0	10%	92.8	90%	1025.5	10%	113.9	90%	1259.5	10%	139.9	90%	1546.9	10%	171.9
12.	Poonamallee	655	57.2	64.4	74.6	86.5	100.2	116.2	134.6	156.0	180.8	25%	16.1	35%	22.5	45%	33.6	35%	26.1	60%	51.9	40%	34.6	75%	75.2	25%	25.1	90%	104.5	10%	11.6	90%	121.2	10%	13.5	90%	140.4	10%	15.6	90%	162.7	10%	18.1
13.	Thiruverkadu	1863	62.8	72.1	85.8	101.9	121.2	144.0	171.2	203.5	241.9	25%	18.0	35%	25.2	45%	38.6	35%	30.0	60%	61.2	40%	40.8	75%	90.9	25%	30.3	90%	129.6	10%	14.4	90%	154.1	10%	17.1	90%	183.2	10%	20.4	90%	217.7	10%	24.2
14.	Pallavaram	1609	215.4	235.5	263.4	294.7	329.1	366.9	407.8	452.1	499.5	25%	58.9	35%	82.4	45%	118.5	35%	92.2	60%	176.8	40%	117.9	75%	246.9	25%	82.3	90%	330.2	10%	36.7	90%	367.1	10%	40.8	90%	406.9	10%	45.2	90%	449.6	10%	50.0
15.	Pammal	520	75.9	83.2	92.9	103.0	113.7	124.8	136.5	148.6	161.3	25%	20.8	35%	29.1	45%	41.8	35%	32.5	60%	61.8	40%	41.2	75%	85.3	25%	28.4	90%	112.3	10%	12.5	90%	122.8	10%	13.6	90%	133.8	10%	14.9	90%	145.2	10%	16.1
16.	Anakaputhur	298	48.1	52.8	59.6	61.1	76.2	86.0	96.8	108.6	121.4	25%	13.2	35%	18.5	45%	26.8	35%	20.8	60%	36.6	40%	24.4	75%	57.1	25%	19.0	90%	77.4	10%	8.6	90%	87.1	10%	9.7	90%	97.7	10%	10.9	90%	109.2	10%	12.1
17.	Tambaram	2072	174.8	194.3	221.8	253.2	289.0	329.9	376.6	429.9	490.7	25%	48.6	35%	68.0	45%	99.8	35%	77.6	60%	151.9	40%	101.3	75%	216.8	25%	72.3	90%	296.9	10%	33.0	90%	338.9	10%	37.7	90%	386.9	10%	43.0	90%	441.6	10%	49.1
		13174	**980.2**	**1110.1**	**1298.9**	**1515.5**	**1784.9**	**2095.6**	**2463.0**	**2898.1**	**3414.3**		**277.5**		**388.5**		**584.5**		**454.6**		**909.3**		**606.2**		**1338.6**		**446.2**		**1886.0**		**209.6**		**2216.7**		**246.3**		**2608.3**		**289.8**		**3072.9**		**341.4**
	Domestic Demand by service connections / Standposts and lorries											60	**16.7**	40	**15.5**	70	**40.9**	40	**18.2**	90	**81.8**	40	**24.2**	100	**133.9**	40	**17.8**	110	**207.5**	40	**8.4**	135	**299.3**	40	**9.9**	135	**352.1**	40	**11.6**	150	**460.9**	40	**13.7**
	Total Domestic Demand (In Municipaities in the Rest of CMA)														**32.2**				**59.1**				**106.1**				**151.7**				**215.8**				**309.1**				**363.7**				**474.6**
	Industrial Demand @ 20% of Domestic Demand														6.4				11.8				21.2				30.3				43.2				61.8				72.7				94.9
	Commercial Demand @ 5% of Domestic Demand														1.6				3.0				5.3				7.6				10.8				15.5				18.2				23.7
	Total Demand														**40.2**				**73.9**				**132.6**				**189.6**				**269.8**				**386.4**				**454.6**				**593.2**
	(Served population)														666.1				1039.1				1515.5				1784.9				2095.6				2463.0				2898.1				3414.3
	(Service connection rate)														25%				45%				60%				75%				90%				90%				90%				90%
	(Domestic LPC)														48				57				70				85				103				126				126				139
	(Combined LPC)														60				71				88				106				129				157				157				174
	Water loss in the transmission and distribution systems												30%		12.1		30%		22.2		25%		33.2		20%		37.9		15%		40.5		10%		38.6		10%		45.5		10%		59.3
	TOTAL REQUIREMENT (in Municipalities in the Rest of CMA)														**52.3**				**96.0**				**165.8**				**227.6**				**310.3**				**425.0**				**500.1**				**652.6**
	(Combined LPC including water loss by the total population)														47				74				109				128				148				173				173				191
	TOWN PANCHAYATS	OUT SIDE CORPORATION AREA AND WITHIN CMA																																									
26.	Chitlapakkam	290	38.0	41.7	46.9	52.5	58.7	65.3	72.5	80.1	88.3	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	13.1	75%	39.4	50%	29.3	50%	29.3	70%	45.7	30%	19.6	80%	58.0	20%	14.5	90%	72.1	10%	8.0	90%	79.4	10%	8.8
27.	Kundrathur	1216	42.1	64.0	91.3	118.6	145.9	173.3	200.6	227.9	255.2	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	29.7	75%	89.0	50%	73.0	50%	73.0	70%	121.3	30%	52.0	80%	160.4	20%	40.1	90%	205.1	10%	22.8	90%	229.7	10%	25.5
28.	Madambakkam	792	31.7	59.5	94.2	129.0	163.7	198.5	233.2	268.0	302.7	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	32.2	75%	96.7	50%	81.9	50%	81.9	70%	138.9	30%	59.5	80%	186.6	20%	46.6	90%	241.2	10%	26.8	90%	272.4	10%	30.3
29.	Mangadu	563	38.2	42.7	49.6	58.1	68.0	79.5	92.4	106.9	122.8	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	14.5	75%	43.5	50%	34.0	50%	34.0	70%	55.6	30%	23.8	80%	73.9	20%	18.5	90%	96.2	10%	10.7	90%	110.5	10%	12.3
30.	Peerkankaranai	176	25.9	28.1	30.9	33.7	36.5	39.2	42.0	44.8	47.6	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	8.4	75%	25.3	50%	18.2	50%	18.2	70%	27.5	30%	11.8	80%	33.6	20%	8.4	90%	40.3	10%	4.5	90%	42.8	10%	4.8
31.	Perungalathur.	704	37.3	48.7	62.8	77.0	91.1	105.3	119.4	133.5	147.7	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	19.2	75%	57.7	50%	45.6	50%	45.6	70%	73.7	30%	31.6	80%	95.5	20%	23.9	90%	120.2	10%	13.4	90%	132.9	10%	14.8
32.	Sembakkam	635	45.4	60.7	79.9	99.1	118.3	137.5	156.7	175.9	195.1	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	24.8	75%	74.3	50%	59.1	50%	59.1	70%	96.2	30%	41.2	80%	125.3	20%	31.3	90%	158.3	10%	17.6	90%	175.6	10%	19.5
33.	Thiruneermalai	587	30.7	33.1	36.2	39.2	42.3	45.3	48.4	51.4	54.5	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	9.8	75%	29.4	50%	21.1	50%	21.1	70%	31.7	30%	13.6	80%	38.7	20%	9.7	90%	46.3	10%	5.1	90%	49.0	10%	5.4
34.	Minjur	863	28.3	36.7	43.3	51.1	60.2	71.0	83.7	98.7	116.3	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	12.8	75%	38.3	50%	30.1	50%	30.1	70%	49.7	30%	21.3	80%	67.0	20%	16.7	90%	88.8	10%	9.9	90%	104.7	10%	11.6
35.	Naravarikuppam	2076	20.9	21.2	21.4	21.7	22.0	22.3	22.5	22.8	23.1	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	5.4	75%	16.3	50%	11.0	50%	11.0	70%	15.6	30%	6.7	80%	18.0	20%	4.5	90%	20.5	10%	2.3	90%	20.8	10%	2.3
36.	Thirumazhisai	725	19.7	32.2	47.8	63.4	79.0	94.6	110.2	125.8	141.4	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	15.9	75%	47.6	50%	39.5	50%	39.5	70%	66.2	30%	28.4	80%	88.1	20%	22.0	90%	113.2	10%	12.6	90%	127.2	10%	14.1
37.	Thirunindravur	1456	37.1	47.9	60.0	75.2	94.3	118.1	148.0	185.5	232.5	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	18.8	75%	56.4	50%	47.1	50%	47.1	70%	82.7	30%	35.4	80%	118.4	20%	29.6	90%	167.0	10%	18.6	90%	209.2	10%	23.2
		10083	**395.3**	**516.5**	**664.4**	**818.5**	**979.9**	**1149.8**	**1329.6**	**1521.3**	**1727.1**		**0.0**		**0.0**		**0.0**		**0.0**		**204.6**		**613.9**		**490.0**		**490.0**		**804.9**		**344.9**		**1063.7**		**265.9**		**1369.1**		**152.1**		**1554.4**		**172.7**
	Domestic Demand by service connections / Standposts and lorries											40	**0.0**	40	**0.0**	40	**0**	40	**0.0**	40	**8.2**	40	**24.6**	70	**34.29741**	40	**19.6**	90	**72.436896**	40	**13.8**	100	**106.4**	40	**10.6**	110	**150.604641**	40	**6.1**	135	**209.841192**	40	**6.9**
	Total Domestic Demand (In Towns in the Rest of CMA)														**0.0**				**0.0**				**32.7**				**53.9**				**86.2**				**117.0**				**156.7**				**216.7**
	Industrial Demand @ 20% of Domestic Demand														0.0				0.0				6.5				10.8				17.2				23.4				31.3				43.3
	Commercial Demand @ 5% of Domestic Demand														0.0				0.0				1.6				2.7				4.3				5.9				7.8				10.8
	Total Demand														**0.0**				**0.0**				**40.9**				**67.4**				**107.8**				**146.3**				**195.9**				**270.9**
	(Served population)														0.0				0.0				818.5				979.9				1149.8				1329.6				1521.3				1727.1
	(Service connection rate)														0%				0%				25%				50%				70%				80%				90%				90%
	(Domestic LPC)														#DIV/0!				#DIV/0!				40				55				75				88				103				126
	(Combined LPC)														#DIV/0!				#DIV/0!				50				69				94				110				129				157
	Water loss in the transmission and distribution systems												30%		0		30%		0		25%		10.231825		20%		13.4739825		15%		16.16895		10%		14.625479		10%		19.58620963		10%		27.1
	TOTAL REQUIREMENT (in Towns in the Rest o CMA)														**0.0**				**0.0**				**51.2**				**80.8**				**124.0**				**160.9**				**215.4**				**298.0**
	(Combined LPC including water loss by the total population)														0				0				63				83				108				121				142				173
	PANCHAYAT UNIONS	OUT SIDE CORPORATION AREA AND WITHIN CMA																																									
38.	Minjur (4 villages)	4002	30.2	56.3	89.0	95.5	155.1	187.5	219.6	252.6	285.7	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	23.9	75%	71.6	50%	77.6	50%	77.6	70%	131.2	30%	56.2	80%	175.7	20%	43.9	90%	227.3	10%	25.3	90%	257.1	10%	28.6
39.	Sholavaram (40 Villages)	12315	131.8	233.1	356.9	381.7	603.9	727.4	850.9	974.3	1097.8	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	95.4	75%	286.2	50%	302.0	50%	302.0	70%	509.2	30%	218.2	80%	680.7	20%	170.2	90%	876.9	10%	97.4	90%	988.0	10%	109.8
40.	Puzhal (20 villages)	2515	32.4	57.4	84.3	89.7	137.6	164.1	190.7	217.3	243.9	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	22.4	75%	67.3	50%	68.8	50%	68.8	70%	114.9	30%	49.2	80%	152.6	20%	38.1	90%	195.6	10%	21.7	90%	219.5	10%	24.4
41.	Villivakkam (21 Villages)	7555	129.8	157.4	182.5	188.1	246.8	285.9	329.8	378.4	431.7	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	47.0	75%	141.1	50%	123.4	50%	123.4	70%	200.2	30%	85.8	80%	263.9	20%	66.0	90%	340.6	10%	37.8	90%	388.5	10%	43.2
42.	Thiruvallur (1	1139	17.3	18.8	22.5	23.3	32.2	38.5	46.0	55.0	65.7	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	5.8	75%	17.5	50%	16.1	50%	16.1	70%	26.9	30%	11.5	80%	36.8	20%	9.2	90%	49.5	10%	5.5	90%	59.1	10%	6.6
43.	Poonamallee (42 villages)	7544	123.9	193.6	262.5	276.3	400.6	469.7	538.8	607.9	676.9	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	69.1	75%	207.2	50%	200.3	50%	200.3	70%	328.8	30%	140.9	80%	431.0	20%	107.8	90%	547.1	10%	60.8	90%	609.2	10%	67.7
44.	Kundrathur (28villages)	7437	147.8	215.6	296.0	312.1	455.0	536.4	618.4	698.3	777.7	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	78.0	75%	234.1	50%	227.5	50%	227.5	70%	375.5	30%	160.9	80%	494.8	20%	123.7	90%	628.5	10%	69.8	90%	699.9	10%	77.8
45.	Sriperumbudur (4 villages)	2017	2.2	3.6	4.5	4.6	6.1	7.0	7.9	8.8	9.6	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	1.2	75%	3.5	50%	3.1	50%	3.1	70%	4.9	30%	2.1	80%	6.3	20%	1.6	90%	7.9	10%	0.9	90%	8.6	10%	1.0
46.	St.Thomas Mount (23 Viilages)	6128	213.0	247.0	294.4	305.1	419.4	496.9	584.4	682.0	789.6	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	76.3	75%	228.8	50%	209.7	50%	209.7	70%	347.8	30%	149.1	80%	467.6	20%	116.9	90%	613.8	10%	68.2	90%	710.6	10%	79.0
47.	Kattankulathur (6 villages)	2826	60.4	73.7	90.4	93.7	124.2	141.1	158.0	174.9	191.9	0%	0.0	0%	0.0	0%	0.0	0%	0.0	25%	23.4	75%	70.3	50%	62.1	50%	62.1	70%	98.8	30%	42.3	80%	126.4	20%	31.6	90%	157.5	10%	17.5	90%	172.7	10%	19.2
		53477	**888.8**	**1256.6**	**1683.0**	**1770.2**	**2580.8**	**3054.6**	**3544.6**	**4049.4**	**4570.4**		**0.0**		**0.0**		**0.0**		**0.0**		**442.5**		**1441.3**		**1290.4**		**1453.8**		**2138.2**		**1148.1**		**2835.7**		**990.8**		**3644.5**		**762.0**		**4113.3**		**927.6**
	Rest of CMA Total	**76734**	**2264.3**	**2883.2**	**3646.3**	**4104.2**	**5345.6**	**6299.9**	**7337.2**	**8468.8**	**9711.8**		**277.5**		**388.5**		**584.5**		**454.6**		**1556.5**		**2661.4**		**3119.0**		**2389.9**		**4829.1**		**1702.6**		**6116.0**		**1503.0**		**7621.9**		**1204.0**		**8740.6**		**1441.8**
	Domestic Demand by service connections / Standposts and lorries											40	**0.0**	40	**0.0**	40	**0.0**	40	**0.0**	40	**17.7**	40	**57.7**	70	**90.3**	40	**58.2**	90	**192.4**	90	**103.3**	40	**113.4**	100	**99.1**	40	**145.8**	110	**83.8**	40	**164.5**	135	**125.2**
	Total Domestic Demand (In Vilages in the Rest of CMA)														**0.0**				**0.0**				**75.4**				**148.5**				**295.8**				**212.5**				**229.6**				**289.8**
	Industrial Demand @ 20% of Domestic Demand														0.0				0.0				15.1				29.7				59.2				42.5				45.9				58.0
	Commercial Demand @ 5% of Domestic Demand														0.0				0.0				3.8				7.4				14.8				10.6				11.5				14.5
	Specific water demand in contracted user (Onehub Chennai)														36.0				36.0				36.0				36.0				36.0				36.0				36.0				36.0
	Total Demand														**36.0**				**36.0**				**130.2**				**221.6**				**405.7**				**301.6**				**323.0**				**398.2**
	(Served population)														0.0				0.0				1883.8				2744.2				3286.3				3826.5				4406.5				5041.0
	(Service connection rate)														0%				0%				25%				50%				70%				80%				90%				90%
	(Domestic LPC)														#DIV/0!				#DIV/0!				40				54				90				56				52				57
	(Combined LPC)														#DIV/0!				#DIV/0!				69				81				123				79				73				79
	Water loss in the transmission and distribution systems												30%		0		30%		0		25%		23.5		20%		37.1		15%		55.5		10%		26.6		10%		28.7		10%		36.2
	TOTAL REQUIREMENT (in Vilages in the Rest o CMA)														**36.0**				**36.0**				**153.7**				**258.7**				**461.2**				**328.2**				**351.7**				**434.4**
	(Combined LPC including water loss by the total population)														12				6				37				48				73				45				42				45

Sl. No.	Description	Area in Hect.	Population Projection in thousands									Population by service level in thousands															
			2011 census	2015	2020	2025	2030	2035	2040	2045	2050	2015		2020		2025		2030		2035		2040		2045		2050	
												Service connection	Others	Service connection	Others	Service connection	Others	Service connection	Others	Service connection	Others	Service connection	Others	Service connection	Others	Service connection	Others
	Total Domestic Demand (Rest of CMA)												**32.2**		**59.1**		**214.2**		**354.1**		**597.8**		**638.6**		**750.0**		**981.1**
	Industrial Demand @ 20% of Domestic Demand												6.4		11.8		42.8		70.8		119.6		127.7		150.0		196.2
	Commercial Demand @ 5% of Domestic Demand												1.6		3.0		10.7		17.7		29.9		31.9		37.5		49.1
	Total Demand												**76.2**		**109.9**		**303.7**		**478.6**		**783.3**		**834.3**		**973.5**		**1262.4**
	(Served population)												666.1		1039.1		4217.8		5509.0		6531.7		7619.0		8825.9		10182.4
	(Service connection rate)												10%		16%		38%		58%		77%		83%		90%		90%
	(Domestic LPC)												48		57		51		64		92		84		85		96
	(Combined LPC)												114		106		72		87		120		109		110		124
	Water loss in the transmission and distribution systems												**12.1**		**22.2**		**66.9**		**88.5**		**112.1**		**79.8**		**93.8**		**122.6**
	TOTAL REQUIREMENT												**88.3**		**132.0**		**370.7**		**567.1**		**895.4**		**914.1**		**1067.3**		**1385.0**
	(Combined LPC including water loss by the total population)												31		36		90		106		142		125		126		143
	ALL CMA	**118916**	**8930.9**	**9937.0**	**######**	**######**	**######**	**######**	**######**	**######**	**######**	**4397.3**	**3322.6**	**6084.9**	**2511.5**	**8524.3**	**3667.0**	**10768.9**	**3358.7**	**13348.0**	**2363.8**	**15160.6**	**2216.9**	**17198.2**	**1972.0**	**18887.8**	**2267.2**
	Total Domestic Demand (ENITIRE CMA)												**585.4**		**806.1**		**1232.5**		**1521.1**		**1902.1**		**2023.9**		**2217.2**		**2536.2**
	Industrial Demand												61.8		67.1		98.2		126.1		174.9		183.0		205.3		251.5
	Commercial Demand												29.3		40.3		61.6		76.1		95.1		101.2		110.9		126.8
	Specific water demand in contracted user (Onehub Chennai)												36.0		36.0		36.0		36.0		36.0		36.0		36.0		36.0
	Total Demand												**712.4**		**949.6**		**1428.3**		**1759.3**		**2208.1**		**2344.1**		**2569.3**		**2950.6**
	(Served population)												**7719.9**		**8596.4**		**12191.3**		**14127.6**		**15711.8**		**17377.5**		**19170.2**		**21155.0**
	(Service connection rate)												44%		54%		71%		77%		86%		89%		91%		91%
	(Domestic LPC)												76		94		101		108		121		116		116		120
	(Combined LPC)												92		110		117		125		141		135		134		139
	Water loss in the transmission and distribution systems												152.9		137.7		179.4		216.6		254.6		230.8		253.3		291.5
	TOTAL REQUIREMENT												**865.3**		**1087.3**		**1607.7**		**1975.9**		**2462.7**		**2574.9**		**2822.7**		**3242.0**
	(Combined LPC including water loss by the total population)												87		97		133		141		159		151		150		157

Appendix 5.2 Water production projection for the Perur DSP

(1) Case 1 (Surface water availability: Average availability)

Year	Daily peak factor	Peak Water Demand (MLD)	Water production in average water demand case											Balance
			Surface water	Groundwater	Seawater desalination							Recycled water	Total	
					Nemmeli (Existing)	Nemmeli (Expansion)	Minjur	**Perur**	**Operation rate against 400MLD**	Others	Seawater Desalination Total	TTRO		
2015	1.00	865	535	150	80	0	90	-	-	0	170	0	855	-11
2016	1.00	910	535	150	80	0	90	-	-	0	170	0	855	-55
2017	1.00	954	604	150	80	0	90	-	-	0	170	0	924	-30
2018	1.00	999	604	150	80	0	90	-	-	0	170	65	989	-10
2019	1.00	1,043	604	150	80	0	90	-	-	0	170	66	990	-53
2020	1.00	1,087	636	150	52	92	90	-	-	0	234	67	1,087	0
2021	1.00	1,191	722	150	56	100	90	-	-	0	246	73	1,191	0
2022	1.00	1,295	722	150	80	143	90	-	-	0	313	80	1,265	-31
2023	1.00	1,400	722	150	47	83	90	222	55%	0	442	86	1,400	0
2024	1.00	1,504	722	150	60	107	90	284	71%	0	541	90	1,504	0
2025	1.00	1,608	754	150	68	122	90	325	81%	0	605	98	1,608	0
2026	1.00	1,681	823	150	71	120	95	318	80%	0	604	104	1,681	0
2027	1.00	1,755	823	150	61	102	95	271	68%	143	672	109	1,755	0
2028	1.00	1,829	823	150	68	114	95	303	76%	160	740	115	1,829	0
2029	1.00	1,902	1,025	150	54	91	95	241	60%	127	607	121	1,902	0
2030	1.00	1,976	1,025	150	61	103	95	273	68%	144	675	126	1,976	0
2031	1.00	2,073	1,101	150	62	105	95	279	70%	147	688	135	2,073	0
2032	1.00	2,171	1,101	150	71	120	95	320	80%	168	774	146	2,171	0
2033	1.00	2,268	1,302	150	60	100	95	266	67%	140	661	155	2,268	0
2034	1.00	2,365	1,302	150	69	116	95	307	77%	162	748	165	2,365	0
2035	1.00	2,463	1,302	150	59	100	95	265	66%	316	836	175	2,463	0
2036	1.00	2,485	1,323	150	59	100	95	266	66%	316	836	177	2,485	0
2037	1.00	2,508	1,323	150	61	103	95	273	68%	325	857	178	2,508	0
2038	1.00	2,530	1,323	150	63	106	95	281	70%	335	879	179	2,530	0
2039	1.00	2,552	1,323	150	65	109	95	288	72%	344	900	180	2,552	0
2040	1.00	2,575	1,340	150	65	109	95	290	73%	346	905	180	2,575	0
2041	1.00	2,624	1,340	150	68	115	95	305	76%	364	947	187	2,624	0
2042	1.00	2,674	1,340	150	72	121	95	321	80%	383	992	192	2,674	0
2043	1.00	2,724	1,340	150	57	96	95	254	64%	535	1,037	196	2,724	0
2044	1.00	2,773	1,340	150	60	100	95	267	67%	561	1,083	201	2,773	0
2045	1.00	2,823	1,357	150	61	103	95	274	69%	577	1,110	205	2,823	0
2046	1.00	2,907	1,357	150	66	111	95	294	74%	619	1,185	215	2,907	0
2047	1.00	2,990	1,357	150	70	118	95	314	79%	662	1,260	224	2,990	0
2048	1.00	3,074	1,357	150	66	110	95	293	73%	771	1,334	233	3,074	0
2049	1.00	3,158	1,357	150	69	117	95	310	78%	817	1,409	242	3,158	0
2050	1.00	3,242	1,357	150	73	123	95	328	82%	863	1,483	252	3,242	0

Source: JICA Study Team

(2) Case 2 (Surface water availability: <u>Good availability</u>)

Year	Daily peak factor	Peak Water Demand (MLD)	Water production in average water demand case											Balance
			Surface water	Groundwater	Seawater desalination							Recycled water	Total	
					Nemmeli (Existing)	Nemmeli (Expansion)	Minjur	**Perur**	**Operation rate against 400MLD**	Others	Seawater Desalination Total			
2015	1.00	865	651	150	-26	0	90	-	-	0	64	0	865	0
2016	1.00	910	651	150	19	0	90	-	-	0	109	0	910	0
2017	1.00	954	735	150	-21	0	90	-	-	0	69	0	954	0
2018	1.00	999	735	150	-41	0	90	-	-	0	49	65	999	0
2019	1.00	1,043	735	150	2	0	90	-	-	0	92	66	1,043	0
2020	1.00	1,087	774	150	2	4	90	-	-	0	96	67	1,087	0
2021	1.00	1,191	879	150	0	-1	90	-	-	0	89	73	1,191	0
2022	1.00	1,295	879	150	35	62	90	-	-	0	187	80	1,295	0
2023	1.00	1,400	879	150	26	46	90	123	31%	0	285	86	1,400	0
2024	1.00	1,504	879	150	39	70	90	186	46%	0	384	90	1,504	0
2025	1.00	1,608	918	150	47	83	90	221	55%	0	441	98	1,608	0
2026	1.00	1,681	1,002	150	46	78	95	206	52%	0	425	104	1,681	0
2027	1.00	1,755	1,002	150	42	70	95	187	47%	99	493	109	1,755	0
2028	1.00	1,829	1,002	150	49	83	95	219	55%	115	561	115	1,829	0
2029	1.00	1,902	1,247	150	30	51	95	136	34%	72	384	121	1,902	0
2030	1.00	1,976	1,247	150	38	63	95	168	42%	88	452	126	1,976	0
2031	1.00	2,073	1,340	150	37	63	95	166	42%	87	448	135	2,073	0
2032	1.00	2,171	1,340	150	46	78	95	207	52%	109	535	146	2,171	0
2033	1.00	2,268	1,585	150	30	50	95	133	33%	70	378	155	2,268	0
2034	1.00	2,365	1,585	150	39	66	95	174	44%	92	465	165	2,365	0
2035	1.00	2,463	1,585	150	37	62	95	164	41%	195	553	175	2,463	0
2036	1.00	2,485	1,610	150	36	61	95	163	41%	194	549	177	2,485	0
2037	1.00	2,508	1,610	150	38	64	95	170	43%	203	570	178	2,508	0
2038	1.00	2,530	1,610	150	40	67	95	178	44%	212	591	179	2,530	0
2039	1.00	2,552	1,610	150	41	70	95	185	46%	221	613	180	2,552	0
2040	1.00	2,575	1,631	150	42	70	95	186	46%	221	614	180	2,575	0
2041	1.00	2,624	1,631	150	45	76	95	201	50%	239	656	187	2,624	0
2042	1.00	2,674	1,631	150	49	82	95	217	54%	259	701	192	2,674	0
2043	1.00	2,724	1,631	150	39	66	95	176	44%	370	746	196	2,724	0
2044	1.00	2,773	1,631	150	42	71	95	188	47%	396	791	201	2,773	0
2045	1.00	2,823	1,652	150	43	73	95	194	49%	409	815	205	2,823	0
2046	1.00	2,907	1,652	150	48	81	95	215	54%	452	890	215	2,907	0
2047	1.00	2,990	1,652	150	52	88	95	235	59%	494	965	224	2,990	0
2048	1.00	3,074	1,652	150	50	84	95	223	56%	587	1,039	233	3,074	0
2049	1.00	3,158	1,652	150	54	91	95	241	60%	634	1,114	242	3,158	0
2050	1.00	3,242	1,652	150	58	97	95	258	65%	680	1,188	252	3,242	0

Source: JICA Study Team

(3) Case 3 (Surface water availability: Moderate drought)

Year	Daily peak factor	Peak Water Demand (MLD)	Water production in average water demand case											Balance
			Surface water	Groundwater	Seawater desalination							Recycled water	Total	
					Nemmeli (Existing)	Nemmeli (Expansion)	Minjur	**Perur**	**Operation rate of the Perur against 400MLD**	Others	Seawater Desalination Total			
2015	1.00	865	465	150	80	0	90	-	-	0	170	0	785	-80
2016	1.00	910	465	150	80	0	90	-	-	0	170	0	785	-125
2017	1.00	954	525	150	80	0	90	-	-	0	170	0	845	-109
2018	1.00	999	525	190	80	0	90	-	-	0	170	65	950	-49
2019	1.00	1,043	525	190	80	0	90	-	-	0	170	66	951	-92
2020	1.00	1,087	553	190	67	120	90	-	-	0	277	67	1,087	0
2021	1.00	1,191	628	190	75	135	90	-	-	0	300	73	1,191	0
2022	1.00	1,295	628	190	80	143	90	-	-	0	313	80	1,211	-85
2023	1.00	1,400	628	190	54	96	90	**256**	**64%**	0	496	86	1,400	0
2024	1.00	1,504	628	190	67	120	90	**319**	**80%**	0	596	90	1,504	0
2025	1.00	1,608	656	190	76	136	90	**361**	**90%**	0	664	98	1,608	0
2026	1.00	1,681	716	190	81	136	95	**360**	**90%**	0	672	104	1,681	0
2027	1.00	1,755	716	190	68	114	95	**303**	**76%**	160	740	109	1,755	0
2028	1.00	1,829	716	190	75	126	95	**335**	**84%**	176	808	115	1,829	0
2029	1.00	1,902	891	190	64	107	95	**285**	**71%**	150	701	121	1,902	0
2030	1.00	1,976	891	190	71	119	95	**317**	**79%**	167	769	126	1,976	0
2031	1.00	2,073	957	190	73	123	95	**327**	**82%**	172	791	135	2,073	0
2032	1.00	2,171	957	190	82	139	95	**368**	**92%**	194	878	146	2,171	0
2033	1.00	2,268	1,132	190	73	123	95	**327**	**82%**	172	791	155	2,268	0
2034	1.00	2,365	1,132	190	82	139	95	**368**	**92%**	194	878	165	2,365	0
2035	1.00	2,463	1,132	190	70	117	95	**312**	**78%**	372	966	175	2,463	0
2036	1.00	2,485	1,150	190	70	118	95	**313**	**78%**	373	969	177	2,485	0
2037	1.00	2,508	1,150	190	72	121	95	**321**	**80%**	382	990	178	2,508	0
2038	1.00	2,530	1,150	190	73	124	95	**328**	**82%**	391	1,011	179	2,530	0
2039	1.00	2,552	1,150	190	75	126	95	**336**	**84%**	400	1,033	180	2,552	0
2040	1.00	2,575	1,165	190	76	127	95	**339**	**85%**	403	1,040	180	2,575	0
2041	1.00	2,624	1,165	190	79	133	95	**354**	**88%**	421	1,082	187	2,624	0
2042	1.00	2,674	1,165	190	83	139	95	**370**	**92%**	440	1,127	192	2,674	0
2043	1.00	2,724	1,165	190	65	109	95	**291**	**73%**	612	1,172	196	2,724	0
2044	1.00	2,773	1,165	190	68	114	95	**303**	**76%**	638	1,217	201	2,773	0
2045	1.00	2,823	1,180	190	70	117	95	**311**	**78%**	655	1,247	205	2,823	0
2046	1.00	2,907	1,180	190	74	125	95	**331**	**83%**	697	1,322	215	2,907	0
2047	1.00	2,990	1,180	190	79	132	95	**351**	**88%**	740	1,397	224	2,990	0
2048	1.00	3,074	1,180	190	73	122	95	**325**	**81%**	856	1,471	233	3,074	0
2049	1.00	3,158	1,180	190	77	129	95	**343**	**86%**	902	1,546	242	3,158	0
2050	1.00	3,242	1,180	190	81	136	95	**360**	**90%**	949	1,620	252	3,242	0

Source: JICA Study Team

(4) Case 4 (Surface water availability: Severe drought)

Year	Daily peak factor	Peak Water Demand (MLD)	Water production in average water demand case											Balance
			Surface water	Groundwater	Seawater desalination							Recycled water	Total	
					Nemmeli (Existing)	Nemmeli (Expansion)	Minjur	**Perur**	**Operation rate of the Perur against 400MLD**	Others	Seawater Desalination Total			
2015	1.00	865	326	150	80	0	90	-	-	0	170	0	646	-220
2016	1.00	910	326	150	80	0	90	-	-	0	170	0	646	-264
2017	1.00	954	368	150	80	0	90	-	-	0	170	0	688	-267
2018	1.00	999	368	190	80	0	90	-	-	0	170	65	792	-206
2019	1.00	1,043	368	190	80	0	90	-	-	0	170	66	794	-249
2020	1.00	1,087	387	190	80	150	90	-	-	0	313	67	957	-130
2021	1.00	1,191	440	190	80	150	90	-	-	0	313	73	1,016	-175
2022	1.00	1,295	440	190	80	150	90	-	-	0	313	80	1,022	-273
2023	1.00	1,400	440	190	79	150	90	**374**	**94%**	0	684	86	1,400	0
2024	1.00	1,504	440	190	80	150	90	**380**	**95%**	0	693	90	1,413	-91
2025	1.00	1,608	459	190	80	150	90	**380**	**95%**	0	693	98	1,440	-167
2026	1.00	1,681	501	190	85	150	95	**380**	**95%**	0	703	104	1,498	-183
2027	1.00	1,755	501	190	85	143	95	**380**	**95%**	200	903	109	1,704	-51
2028	1.00	1,829	501	190	85	143	95	**380**	**95%**	200	903	115	1,709	-119
2029	1.00	1,902	624	190	85	143	95	**380**	**95%**	200	903	121	1,837	-65
2030	1.00	1,976	624	190	85	143	95	**380**	**95%**	200	903	126	1,843	-133
2031	1.00	2,073	670	190	85	143	95	**380**	**95%**	200	903	135	1,898	-175
2032	1.00	2,171	670	190	85	143	95	**380**	**95%**	200	903	146	1,909	-262
2033	1.00	2,268	792	190	85	143	95	**380**	**95%**	200	903	155	2,041	-227
2034	1.00	2,365	792	190	85	143	95	**380**	**95%**	200	903	165	2,051	-315
2035	1.00	2,463	792	190	85	143	95	**380**	**95%**	453	1,156	175	2,313	-150
2036	1.00	2,485	805	190	85	143	95	**380**	**95%**	453	1,156	177	2,327	-158
2037	1.00	2,508	805	190	85	143	95	**380**	**95%**	453	1,156	178	2,328	-179
2038	1.00	2,530	805	190	85	143	95	**380**	**95%**	453	1,156	179	2,329	-201
2039	1.00	2,552	805	190	85	143	95	**380**	**95%**	453	1,156	180	2,330	-222
2040	1.00	2,575	816	190	85	143	95	**380**	**95%**	453	1,156	180	2,341	-234
2041	1.00	2,624	816	190	85	143	95	**380**	**95%**	453	1,156	187	2,349	-276
2042	1.00	2,674	816	190	85	143	95	**380**	**95%**	453	1,156	192	2,353	-321
2043	1.00	2,724	816	190	85	143	95	**380**	**95%**	800	1,503	196	2,705	-19
2044	1.00	2,773	816	190	85	143	95	**380**	**95%**	800	1,503	201	2,709	-64
2045	1.00	2,823	826	190	85	143	95	**380**	**95%**	800	1,503	205	2,724	-98
2046	1.00	2,907	826	190	85	143	95	**380**	**95%**	800	1,503	215	2,734	-173
2047	1.00	2,990	826	190	85	143	95	**380**	**95%**	800	1,503	224	2,743	-248
2048	1.00	3,074	826	190	85	143	95	**380**	**95%**	1,000	1,703	233	2,952	-122
2049	1.00	3,158	826	190	85	143	95	**380**	**95%**	1,000	1,703	242	2,961	-197
2050	1.00	3,242	826	190	85	143	95	**380**	**95%**	1,000	1,703	252	2,971	-271

Source: JICA Study Team

Appendix 5.3 Water Allocation Plan for the Years 2025, 2035 and 2050

WATER ALLOCATION PLAN FOR CHENNAI METROPOLITAN AREA (2025)

Name of the Zone	Demand 2025	Red Hills (314E)	Chembarambakkam (530E)	Kilpauk (270E)	Veeranam (180E)	Minjur (100 E)	Nemmeli (100E)	Nemmeli (150 P))	Perur (400 P)	Ground Water (North& South and Rest of CMA)	TTRO (135P)	Total Water Supply
Installed Capacity		**314 MLD**	**530 MLD**	**270 MLD**	**180 MLD**	**100 MLD**	**100 MLD**	**150 MLD**	**400 MLD**		**135 MLD**	
Available Water in MLD 1647		**150**	**150**	**176**	**180**	**90**	**80**	**153**	**380**	**190**	**98**	
1	200.9	35.80		95.10	28.80				19.50	1.00	20.70	200.9
2	56.0	4.90		51.10								56.0
3	53.1			21.10	32.00							53.1
4	33.4			8.40	10.00						15.00	33.4
5	66.7								66.70			66.7
6	34.5							10.00	24.50			34.5
6 A	5.4							5.40				5.4
7	6.6								6.60			6.6
8	101.3				88.00				13.30			101.3
9	36.3	30.80								5.17		36.0
10	69.3	11.40								21.80	30.00	63.2
11	36.5	36.50										36.5
12	19.7							19.70				19.7
12 A	26.3						26.30			1.00		27.3
13	20.8								20.80			20.8
14	41.9								41.90			41.9
15	31.1		4.60						16.10	10.20		30.9
16	31.7		15.10						15.60	1.00		31.7
Sub Total of Core Area	**871.6**	119.4	19.7	175.7	158.8	0.0	26.3	35.1	225.0	40.2	65.7	**865.9**
CC1-A	46.5					46.50						46.5
CC1-B	13.3					13.30						13.3
CC2	34.4	21.40				5.90				4.11		31.4
CC3	7.2	3.20								3.46		6.7
CC4	3.5	3.00								0.50		3.5
CC5	92.5		55.00							29.70		84.7
CC6	36.4		5.40		18.70					12.30		36.4
CC7	49.0				2.50				42.00	4.23		48.7
CC8	15.9							15.90				15.9
CC9	20.2						15.30	4.90				20.2
CC10	28.4						16.10			11.56		27.7
CC11	22.3						22.25					22.3
Sub Total of Expanded Area	**369.7**	27.6	60.4	0.0	21.2	65.7	53.7	20.8	42.0	65.9	0.0	**357.2**
OC1	6.9					5.90				0.90		6.8
OC2	12.9					11.90				0.90		12.8
OC3	7.5					6.50				1.00		7.5
OC4	8.0									7.52		7.5
OC5A	41.5	3.00								5.11	30.00	38.1
OC5B	8.0									7.52		7.5
OC6	17.8		16.80							1.00		17.8
OC7	19.4		17.50							1.79		19.3
OC8	23.1		7.10							6.98		14.1
OC9	18.5		17.50							1.00		18.5
OC10	11.8		11.00							1.00		12.0
OC11	11.0									10.34		10.3
OC12	12.4							10.40		6.00		16.4
OC13	31.2							29.20		7.00		36.2
OC14	16.0									15.09		15.1
OC15	55.5							37.50	10.00	8.00		55.5
OC16	29.3								26.30	2.82		29.1
Sub Total of Rest of CMA	**330.7**	3.0	69.9	0.0	0.0	24.3	0.0	77.1	36.3	84.0	30.0	**324.6**
Peripheral of CMA	36.0								36.0			36.0
Grnad Total	**1,608.0**	**150.0**	**150.0**	**175.7**	**180.0**	**90.0**	**80.0**	**133.0**	**339.3**	**190.0**	**95.7**	**1583.7**

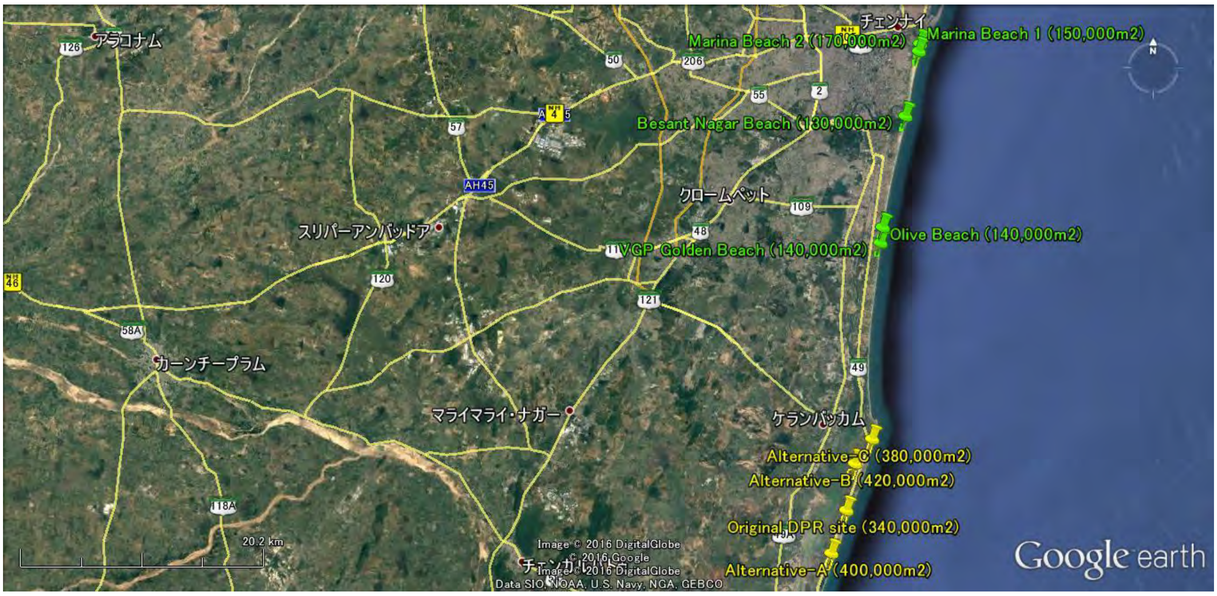
WATER ALLOCATION PLAN FOR CHENNAI METROPOLITAN AREA (2035)

Name of the Zone	Demand 2035	Red Hills (314E)	Chembarambakkam (530E + 70P)	Kilpauk (270E)	Sholavaram (50 P)	Veeranam (180E)	Minjur (100 E)	Nemmeli (100E)	Nemmeli (150 P))	Perur (400 P)	Ground Water (North& South and Rest of CMA)	TTRO (180P)	Additional SWRO (370P)	Total Water Supply
Installed Capacity		314 MLD	600 MLD	270 MLD	50 MLD	180 MLD	100 MLD	100 MLD	150 MLD	400 MLD		180 MLD	430 MLD	
Available Water in MLD 2630		150	506	266	30	180	90	80	153	380	190	175	430	
1	208.5	18.70	36.00	130.90							1.00	21.90		208.50
2	58.2			58.20										58.20
3	55.7			55.70										55.70
4	36.2			21.20								15.00		36.20
5	68.7					50.00				18.70				68.70
6	35.2									35.20				35.20
6 A	5.6									5.60				5.60
7	6.7					5.70				1.00				6.70
8	105.0		60.00			20.00				25.00				105.00
9	37.4	2.00	30.00								5.38			37.38
10	72.5	14.00	25.00								3.50	30.00		72.50
11	37.6	37.60												37.60
12	20.1									20.10				20.10
12 A	26.8							26.80			1.00			27.80
13	21.3					6.30				15.00				21.30
14	43.8					18.85				25.00				43.85
15	32.4		13.50								10.20			23.70
16	32.8					6.80				25.00	1.00			32.80
Sub Total of Core Area	**904.8**	72.3	164.5	266.0	0.0	107.7	0.0	26.8	0.0	170.6	22.1	66.9	0.0	**896.8**
CC1-A	65.0						65.00							65.00
CC1-B	30.6						4.60						26.00	30.60
CC2	61.2	46.00									4.00		11.16	61.16
CC3	17.8	14.00									3.83			17.83
CC4	8.9	8.20									0.70			8.90
CC5	150.9		123.00								27.61			150.61
CC6	60.6		30.00			12.80					17.80			60.60
CC7	85.5					59.54				9.60	16.40			85.54
CC8	31.2									31.20				31.20
CC9	39.5								39.50					39.50
CC10	62.5							31.20	19.00		12.30			62.50
CC11	50.6							22.00	28.60					50.60
Sub Total of Expanded Area	**664.4**	68.2	153.0	0.0	0.0	72.3	69.6	53.2	87.1	40.8	82.6	0.0	37.2	**664.0**
OC1	22.4						5.00				0.90		17.40	23.30
OC2	44.5						10.40				0.90		34.10	45.40
OC3	24.2						5.00				1.00		19.24	25.24
OC4	27.8				7.80						4.00		16.05	27.85
OC5A	105.6	9.50			14.20						4.50	30.00	47.43	105.63
OC5B	22.6				8.00						5.00		9.65	22.65
OC6	43.9		9.94								1.00		33.00	43.94
OC7	50.0		15.00								1.79		33.21	50.00
OC8	63.9		16.03								11.00		36.87	63.90
OC9	51.1		51.06								1.00			52.06
OC10	28.8		19.00								9.80			28.80
OC11	31.9		6.88								11.00	14.00		31.88
OC12	34.1		7.56						19.10		6.00			32.66
OC13	65.1		24.04						24.40		15.00			63.44
OC14	39.0		38.99								1.00			39.99
OC15	126.4								22.40	95.60	8.39			126.39
OC16	76.0									73.00	3.00			76.00
Sub Total of Rest of CMA	**857.5**	9.5	188.5	0.0	30.0	0.0	20.4	0.0	65.9	168.6	85.3	44.0	247.0	**859.1**
Peripheral of CMA	36.0												36.0	36.00
Grnad Total	**2,462.7**	**150.0**	**506.0**	**266.0**	**30.0**	**180.0**	**90.0**	**80.0**	**153.0**	**380.0**	**190.0**	**110.9**	**320.1**	**2456.0**

WATER ALLOCATION PLAN FOR CHENNAI METROPOLITAN AREA (2050)

Name of the Zone	Demand 2050	Red Hills (314E)	Chembarambakkam (530E + 70P)	Kilpauk (270E)	Sholavaram (50 P)	Veeranam (180E)	Minjur (100 E)	Nemmeli (100E)	Nemmeli (150 P)	Perur (400 P)	Ground Water (North& South and Rest of CMA)	Harvesting Rain Water	TTRO (180P+90P)	Additional SWRO (370P+470P)	Total Water Supply
Installed Capacity		580 MLD	600 MLD	270 MLD	50 MLD	180 MLD	100 MLD	100 MLD	150 MLD	400 MLD			270 MLD	950 MLD	
Available Water in MLD 3275		150	515	266	39	180	90	80	153	380	190	30	252	950	
1	220.1	55.70		130.90							13.50		20.00		220.10
2	61.3			58.20								3.08			61.28
3	57.6			55.70								1.88			57.58
4	36.2			21.20									15.00		36.20
5	73.6					55.00				13.70		4.90			73.60
6	38.4									35.20		3.24			38.44
6 A	6.0									5.60		0.39			5.99
7	7.3									6.70		0.58			7.28
8	111.0		24.90			55.10				25.00		6.04			111.04
9	40.1	8.00	24.00								8.13				40.13
10	75.3	16.00	6.00								23.25		30.00		75.25
11	40.3	37.60										2.75			40.35
12	21.9									20.10		1.79			21.89
12 A	29.3							26.80			2.48				29.28
13	23.1					6.30				15.00		1.79			23.09
14	45.5					18.85				25.00		1.70			45.55
15	34.0		32.50								1.53				34.03
16	34.9					7.80				25.00	2.12				34.92
Sub Total of Core Area	956.1	117.3	87.4	266.0	0.0	143.1	0.0	26.8	0.0	171.3	51.0	28.1	65.0	0.0	956.0
CC1-A	77.1						30.00							47.14	77.14
CC1-B	42.8						4.60							38.24	42.84
CC2	82.8	5.00					25.00				5.00			47.75	82.75
CC3	30.2	18.00					10.00				2.22				30.22
CC4	12.3	8.20									4.09				12.29
CC5	207.8		159.10								16.90		31.81		207.81
CC6	78.1		35.00			20.60					5.00		17.50		78.10
CC7	110.6					16.35				9.60	4.60		23.05	57.00	110.60
CC8	49.3									31.20				18.14	49.34
CC9	58.5								39.50					19.03	58.53
CC10	87.9							31.20	19.00		12.30			25.39	87.89
CC11	77.6							22.00	28.60			1.86		25.13	77.59
Sub Total of Expanded Area	915.1	31.2	194.1	0.0	0.0	37.0	69.6	53.2	87.1	40.8	50.1	1.9	72.4	277.8	915.1
OC1	37.4						10.00				0.90			27.37	38.27
OC2	73.5						10.40				0.90			63.08	74.38
OC3	34.0				9.00						1.00			24.02	34.02
OC4	45.4				7.80						4.00			33.56	45.36
OC5A	189.7	1.50			14.20						4.00		30.00	139.96	189.66
OC5B	41.6				8.00						4.00			29.61	41.61
OC6	74.2		21.90								1.00			51.26	74.16
OC7	85.6		21.00								4.00		32.91	27.64	85.55
OC8	101.3		24.67								7.44		10.51	58.66	101.28
OC9	75.2		51.00								4.00		20.22		75.22
OC10	43.2		19.00								24.24				43.24
OC11	49.2		22.23								13.20		14.00		49.43
OC12	49.6		15.00						12.00		2.00			20.58	49.58
OC13	87.7		12.60						12.00		2.00			61.10	87.70
OC14	55.1		46.10								9.00				55.10
OC15	179.4								41.90	94.90	4.20			38.42	179.42
OC16	113.0									73.00	3.00			37.03	113.03
Sub Total of Rest of CMA	1335.0	1.5	233.5	0.0	39.0	0.0	20.4	0.0	65.9	167.9	88.9	0.0	107.6	612.3	1337.0
Peripheral of CMA	36.0													36.0	36.00
Grnad Total	3242.2	150.0	515.0	266.0	39.0	180.0	90.0	80.0	153.0	380.0	190.0	30.0	245.0	926.1	3244.1

Appendix 5.4 Vacant Lands Along the Coast Line between the Nemmeli DSP and the City Centre of Chennai

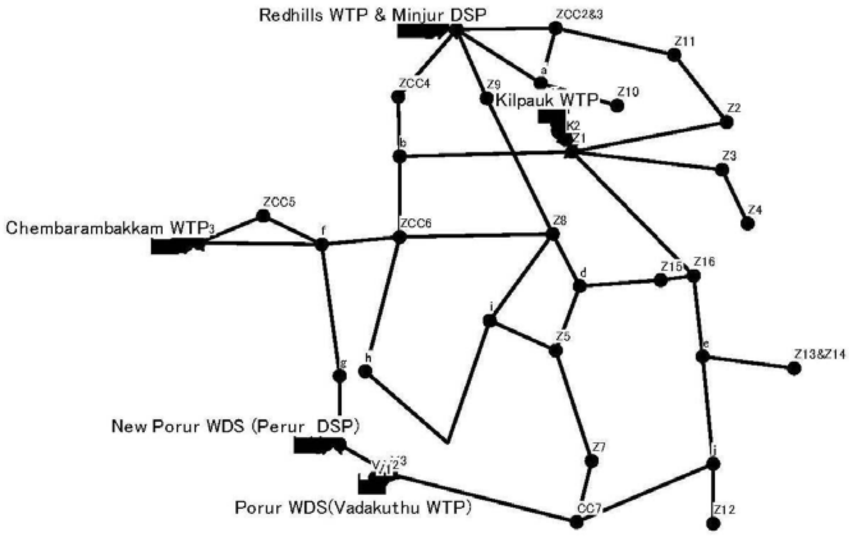


Source: JICA Study Team

Appendix 5.5 EPANET Data for Examination of the Exiting Water Transmission Network

EPANET DATA (2025)

Network Model



Water Demand and Supply (2025)

Zone	Redhills & Minjur DSP	Chembarambakkam	Kilpauk	Vadakuthur	Perur DSP	Total Demand (MLD)	Total Demand (LPS)
1	36.80		95.10	28.80	19.50	180.20	2,086
2	4.90		51.10			56.00	648
3			21.10	32.00		53.10	615
4			8.40	10.00		18.40	213
5					66.70	66.70	772
7					6.60	6.60	76
8				88.00	13.30	101.30	1,172
9	35.97					35.97	416
10	33.20					33.20	384
11	36.50					36.50	422
13					20.80	20.80	241
14					41.90	41.90	485
15	10.20	4.60			16.10	30.90	358
16	1.00	15.10			15.60	31.70	367
CC2	31.41					31.41	364
CC3	6.66					6.66	77
CC4	3.50					3.50	41
CC5	29.70	55.00				84.70	980
CC6	12.30	5.40		18.70		36.40	421
CC7	4.23			2.50	42.00	48.73	565
Total Supply (MLD)	246.37	80.10	175.70	180.00	242.50	924.67	
Total Supply (LPS)	2,852	927	2,034	2,083	2,807		10,703

Input / Output Data (2025)

Network Table – Nodes at 0:00 Hrs

Node ID	Elevation m	Demand LPS	Head m	Pressure m
Junc R1	20	0.00	20.00	0.00
Junc R2	20	0.00	48.00	28.00
Junc R3	20	0.00	38.91	18.91
Junc ZCC2&3	7	441.00	33.69	26.69
Junc Z11	4	422.00	13.21	9.21
Junc Z2	7	648.00	12.13	5.13
Junc a	8	0.00	35.51	27.51
Junc Z10	6	384.00	35.13	29.13
Junc ZCC4	30	41.00	36.52	6.52
Junc b	17	0.00	35.43	18.43
Junc Z1	9	2086.00	23.51	14.51
Junc K1	9	0.00	9.00	0.00
Junc K2	9	0.00	32.00	23.00
Junc ZCC6	16	421.00	35.61	19.61
Junc Z8	13	1172.00	33.54	20.54
Junc Z9	9	416.00	35.22	26.22
Junc Z3	6	615.00	18.02	12.02
Junc Z4	8	213.00	15.79	7.79
Junc d	14	0.00	30.31	16.31
Junc Z15	11	358.00	27.64	16.64
Junc Z16	12	367.00	27.47	15.47
Junc e	10	0.00	28.18	18.18
Junc Z13&Z14	6	726.00	25.62	19.62
Junc i	14	0.00	33.38	19.38
Junc Z5	12	772.00	30.04	18.04
Junc h	17	0.00	35.02	18.02
Junc g	17	0.00	39.67	22.67
Junc P3	17	0.00	39.99	22.99
Junc V3	15	0.00	40.00	25.00
Junc CC7	13	565.00	34.26	21.26
Junc Z7	11	76.00	31.17	20.17
Junc j	12	0.00	30.05	18.05
Junc Z12	11	0.00	30.05	19.05
Junc f	19	0.00	37.58	18.58
Junc ZCC5	21	980.00	37.57	16.57
Junc C3	25	0.00	37.68	12.68
Junc C1	25	0.00	25.00	0.00
Junc C2	25	0.00	51.00	26.00

Node ID	Elevation m	Demand LPS	Head m	Pressure m
Junc P2	17	0.00	42.00	25.00
Junc P1	17	0.00	17.00	0.00
Junc V2	15	0.00	40.00	25.00
Junc V1	15	0.00	15.00	0.00
Resvr R	20	-2852.00	20.00	0.00
Resvr K	9	-2034.00	9.00	0.00
Resvr C	25	-927.00	25.00	0.00
Resvr P	17	-2807.00	17.00	0.00
Resvr V	15	-2083.00	15.00	0.00

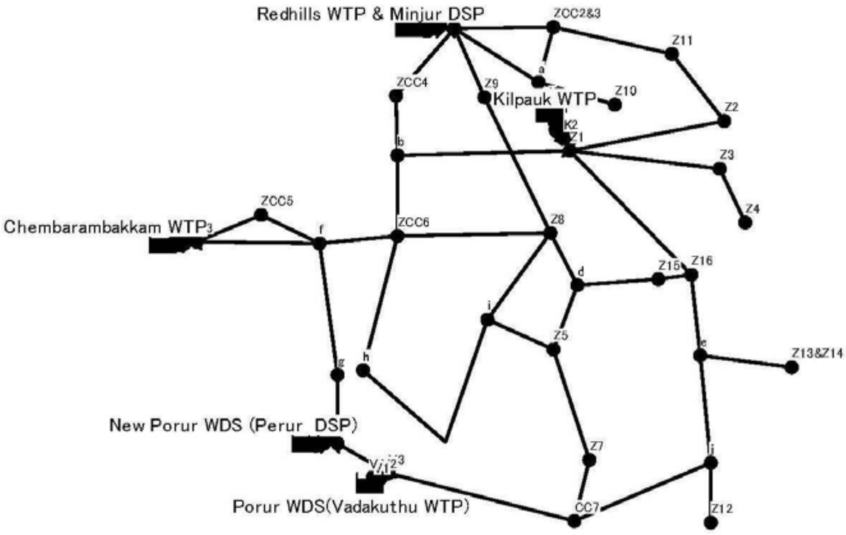
Network Table - Links at 0:00 Hrs

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s
Pipe R	0.1	2000	100	2852.00	0.91
Pipe 1	7740	1050	100	614.63	0.71
Pipe 2	6880	750	100	565.19	1.28
Pipe 3	4640	750	100	143.19	0.32
Pipe 4	6290	1200	100	775.56	0.69
Pipe 5	4890	1000	100	391.56	0.50
Pipe 6	2570	1200	100	384.00	0.34
Pipe 7	7900	1200	100	567.11	0.50
Pipe 8	4100	1200	100	526.11	0.47
Pipe K	0.1	2000	100	2034.00	0.65
Pipe 9	9690	1000	100	747.65	0.95
Pipe 10	7500	825	100	504.81	0.94
Pipe 11	5230	1200	100	894.70	0.79
Pipe 12	7600	1200	100	478.70	0.42
Pipe 13	3410	1200	100	-221.54	0.20
Pipe 14	6650	1900	100	1929.89	0.68
Pipe 15	4680	1050	100	828.00	0.96
Pipe 16	3260	700	100	213.00	0.55
Pipe 17	2920	1200	100	1139.18	1.01
Pipe 18	3100	1200	100	996.89	0.88
Pipe 19	440	1200	100	638.89	0.56
Pipe 20	5490	1050	100	-637.16	0.74
Pipe 21	3460	1100	100	-365.27	0.38
Pipe 22	3500	1100	100	726.00	0.76
Pipe C	0.1	2000	100	927.00	0.30
Pipe 24	5700	2000	100	499.38	0.16
Pipe 25	940	2000	100	-480.62	0.15
Pipe 26	3410	2000	100	3075.95	0.98
Pipe 27	6430	2000	100	427.62	0.14
Pipe 28	3500	2000	100	-3128.95	1.00
Pipe 29	2430	1200	100	503.52	0.45
Pipe 30	6750	1200	100	503.52	0.45
Pipe 31	540	2000	100	-3128.95	1.00
Pipe 33	3310	900	100	-97.42	0.15
Pipe 34	1370	800	100	600.94	1.20
Pipe 35	1580	800	100	-142.29	0.28
Pipe 36	4420	400	100	-28.78	0.23
Pipe 37	1100	400	100	-104.78	0.83

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s
Pipe 38	1000	2000	100	-321.95	0.10
Pipe 39	6880	1500	100	1761.05	1.00
Pipe 40	6100	1300	100	1091.27	0.82
Pipe 41	680	700	100	0.00	0.00
Pipe 42	2700	1300	100	1091.27	0.82
Pipe P	0.1	2000	100	2807.00	0.89
Pipe V	0.1	2000	100	2083.00	0.66
Pump RP	#N/A	#N/A	#N/A	2852.00	0.00
Pump KP	#N/A	#N/A	#N/A	2034.00	0.00
Pump CP	#N/A	#N/A	#N/A	927.00	0.00
Pump PP	#N/A	#N/A	#N/A	2807.00	0.00
Pump VP	#N/A	#N/A	#N/A	2083.00	0.00
Valve RV	#N/A	2000	#N/A	2852.00	0.91
Valve KV	#N/A	2000	#N/A	2034.00	0.65
Valve CV	#N/A	2000	#N/A	927.00	0.30
Valve PV	#N/A	2000	#N/A	2807.00	0.89
Valve VV	#N/A	2000	#N/A	2083.00	0.66

EPANET DATA (2035)

Network Model



Water Demand and Supply (2035)

Zone	Redhills & Minjur DSP	Chembarambakkam	Kilpauk	Vadakuthur	Perur DSP	Total Demand (MLD)	Total Demand (LPS)
1	19.70	36.00	130.90			186.60	2,160
2			58.20			58.20	674
3			55.70			55.70	645
4			21.20			21.20	245
5				50.00	18.70	68.70	795
7				5.70	1.00	6.70	78
8		60.00		20.00	25.00	105.00	1,215
9	7.38	30.00				37.38	433
10	17.50	25.00				42.50	492
11	37.60					37.60	435
12					20.10	20.10	233
13				6.30	15.00	21.30	247
14				18.85	25.00	43.85	508
15	10.20	13.50				23.70	274
16	1.00			6.80	25.00	32.80	380
CC2	50.00					50.00	579
CC3	17.83					17.83	206
CC4	8.90					8.90	103
CC5	27.61	123.00				150.61	1,741
CC6	17.80	30.00		12.80		60.60	701
CC7	16.40			59.54	9.60	85.54	990
Total Supply (MLD)	231.92	317.50	266.00	179.99	139.40	1134.81	
Total Supply (LPS)	2,684	3,675	3,079	2,083	1,613		13,134

Input / Output Data (2035)

Network Table – Nodes at 0:00 Hrs

Node ID	Elevation m	Demand LPS	Head m	Pressure m
Junc R1	20	0.00	20.00	0.00
Junc R2	20	0.00	48.00	28.00
Junc R3	20	0.00	37.94	17.94
Junc ZCC2&3	7	785.00	29.88	22.88
Junc Z11	4	435.00	14.54	10.54
Junc Z2	7	674.00	14.40	7.40
Junc a	8	0.00	32.65	24.65
Junc Z10	6	492.00	32.05	26.05
Junc ZCC4	30	103.00	37.37	7.37
Junc b	17	0.00	37.25	20.25
Junc Z1	9	2160.00	31.32	22.32
Junc K1	9	0.00	9.00	0.00
Junc K2	9	0.00	31.32	22.32
Junc ZCC6	16	701.00	37.68	21.68
Junc Z8	13	1215.00	35.42	22.42
Junc Z9	9	433.00	35.84	26.84
Junc Z3	6	645.00	25.05	19.05
Junc Z4	8	245.00	22.16	14.16
Junc d	14	0.00	32.98	18.98
Junc Z15	11	274.00	31.39	20.39
Junc Z16	12	380.00	31.29	19.29
Junc e	10	0.00	31.15	21.15
Junc Z13&Z14	6	755.00	28.39	22.39
Junc i	14	0.00	35.36	21.36
Junc Z5	12	795.00	32.37	20.37
Junc h	17	0.00	37.06	20.06
Junc g	17	0.00	40.93	23.93
Junc P3	17	0.00	41.03	24.03
Junc V3	15	0.00	41.03	26.03
Junc CC7	13	990.00	34.36	21.36
Junc Z7	11	78.00	32.40	21.40
Junc j	12	0.00	31.78	19.78
Junc Z12	11	233.00	31.23	20.23
Junc f	19	0.00	40.29	21.29
Junc ZCC5	21	1741.00	40.30	19.30
Junc C3	25	0.00	41.64	16.64
Junc C1	25	0.00	25.00	0.00
Junc C2	25	0.00	51.00	26.00

Node ID	Elevation m	Demand LPS	Head m	Pressure m
Junc P2	17	0.00	42.00	25.00
Junc P1	17	0.00	17.00	0.00
Junc V2	15	0.00	41.03	26.03
Junc V1	15	0.00	15.00	0.00
Resvr R	20	-2684.00	20.00	0.00
Resvr K	9	-3212.29	9.00	0.00
Resvr C	25	-3675.00	25.00	0.00
Resvr P	17	-1613.00	17.00	0.00
Resvr V	15	-1949.71	15.00	0.00

Network Table - Links at 0:00 Hrs

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s
Pipe R	0.1	2000	100	2684.00	0.85
Pipe 1	7740	1050	100	776.88	0.90
Pipe 2	6880	750	100	483.57	1.09
Pipe 3	4640	750	100	48.57	0.11
Pipe 4	6290	1200	100	983.69	0.87
Pipe 5	4890	1000	100	491.69	0.63
Pipe 6	2570	1200	100	492.00	0.44
Pipe 7	7900	1200	100	262.93	0.23
Pipe 8	4100	1200	100	159.93	0.14
Pipe K	0.1	2000	100	3212.29	1.02
Pipe 9	9690	1000	100	512.55	0.65
Pipe 10	7500	825	100	625.43	1.17
Pipe 11	5230	1200	100	660.49	0.58
Pipe 12	7600	1200	100	227.49	0.20
Pipe 13	3410	1200	100	-352.61	0.31
Pipe 14	6650	1900	100	2019.95	0.71
Pipe 15	4680	1050	100	890.00	1.03
Pipe 16	3260	700	100	245.00	0.64
Pipe 17	2920	1200	100	978.35	0.87
Pipe 18	3100	1200	100	754.64	0.67
Pipe 19	440	1200	100	480.64	0.42
Pipe 20	5490	1050	100	49.41	0.06
Pipe 21	3460	1100	100	150.05	0.16
Pipe 22	3500	1100	100	755.00	0.79
Pipe C	0.1	2000	100	3675.00	1.17
Pipe 24	5700	2000	100	1896.47	0.60
Pipe 25	940	2000	100	155.47	0.05
Pipe 26	3410	2000	100	3586.68	1.14
Pipe 27	6430	2000	100	1778.53	0.57
Pipe 28	3500	2000	100	-1652.68	0.53
Pipe 29	2430	1200	100	513.12	0.45
Pipe 30	6750	1200	100	513.12	0.45
Pipe 31	540	2000	100	-1652.68	0.53
Pipe 33	3310	900	100	-54.09	0.09
Pipe 34	1370	800	100	567.21	1.13
Pipe 35	1580	800	100	-223.70	0.45
Pipe 36	4420	400	100	-4.08	0.03
Pipe 37	1100	400	100	-82.08	0.65

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s
Pipe 38	1000	2000	100	−39.68	0.01
Pipe 39	6880	1500	100	1910.03	1.08
Pipe 40	6100	1300	100	837.95	0.63
Pipe 41	680	700	100	233.00	0.61
Pipe 42	2700	1300	100	604.95	0.46
Pipe P	0.1	2000	100	1613.00	0.51
Pipe V	0.1	2000	100	1949.71	0.62
Pump RP	#N/A	#N/A	#N/A	2684.00	0.00
Pump KP	#N/A	#N/A	#N/A	3212.29	0.00
Pump CP	#N/A	#N/A	#N/A	3675.00	0.00
Pump PP	#N/A	#N/A	#N/A	1613.00	0.00
Pump VP	#N/A	#N/A	#N/A	1949.71	0.00
Valve RV	#N/A	2000	#N/A	2684.00	0.85
Valve KV	#N/A	2000	#N/A	3212.29	1.02
Valve CV	#N/A	2000	#N/A	3675.00	1.17
Valve PV	#N/A	2000	#N/A	1613.00	0.51
Valve VV	#N/A	2000	#N/A	1949.71	0.62

Appendix 5.6 Preliminary hydraulic analysis on the existing water distribution networks in the Chennai core city

Preliminary Hydraulic Assessment (2035)																	
Zone	Water Distribution Station	Demand 2035 (MLD)	HGL (m)	Avg.GL @ WDS (m)	Residual Head (designed)	Residual Head (Ferrule)	Population in 2035	Population/ unit length	Popualtion in Pipe	Discharge in pipe (m3/hr)	Critical point in distribution Network: Distance from WDS (m)	Critical point in distribution Network: Elevation (m)	Equivalent Diameter of Pipe (mm)	Hazen-Williams "C" value	Head Loss (m)	Residual Pressure @ Critical point (m)	Check
1	Kilpauk	208.5	27.00	7.00	10.00	7.00	1176633	1.78	13148.18	82.18	7402	10.00	350	100	2.37	14.6	OK
2	Anna Poonga	58.2	23.58	3.58	10.00	7.00	328313	2.79	4857.03	30.36	1740	5.00	275	100	0.28	18.3	OK
3	Kannapathidal	55.7	25.26	5.60	10.00	7.00	314527	4.69	10585.64	66.16	2257	5.00	200	100	7.37	12.9	OK
4	Triplicane	36.2	23.00	3.00	10.00	7.00	204380	1.52	2914.82	18.22	1917	10.00	200	100	0.57	12.4	OK
5	K.K.Nagar	68.7	29.00	9.00	10.00	7.00	387640	1.46	10407.54	65.05	7112	9.00	225	100	12.69	7.3	Expected Low Pressure
6	Velachery	40.8	26.80	6.00	10.00	7.00	230120	6.02	12008.96	75.06	1996	5.00	200	100	8.24	13.6	OK
7	Ekkatuthangal	6.7	30.05	7.00	10.00	7.00	37987	1.04	2194.37	13.71	2113	7.00	150	100	1.52	21.5	OK
8	Choolaimedu	105.0	29.00	9.00	10.00	7.00	592753	4.80	28325.24	177.03	5901	9.00	325	100	11.21	8.8	Expected Low Pressure
9	Kulathur	37.4	27.00	10.50	10.00	7.00	210907	1.45	4165.68	26.04	2866	7.00	243	100	0.64	19.4	OK
10	Vysarpadi	72.5	25.00	4.00	10.00	7.00	409347	1.86	5307.43	33.17	2855	5.00	150	100	10.54	9.5	Expected Low Pressure
11	Patel Nagar	37.6	24.00	3.00	10.00	7.00	212227	0.89	2704.79	16.90	3054	5.00	228	100	0.42	18.6	OK
12	Pallipattu	46.9	27.50	5.00	10.00	7.00	264660	3.14	7200.59	45.00	2291	6.00	150	100	14.88	6.6	Expected Low Pressure
13	Mylapore	21.3	22.50	2.50	10.00	7.00	120267	1.38	5585.04	34.91	4047	3.00	165	100	10.33	9.2	Low Pressure
14	Nandanam	43.8	22.50	2.50	10.00	7.00	247427	1.47	1912.01	11.95	1303	3.00	223	100	0.10	19.4	OK
15	Valluvarkottam	32.4	26.50	4.00	10.00	7.00	182820	1.02	6637.82	41.49	6513	6.00	253	100	2.87	17.6	OK
16	Southern Head works	32.8	25.50	7.00	10.00	7.00	185167	1.46	13908.61	86.93	9548	9.00	300	100	7.18	9.3	Expected Low Pressure

Assumptions:
1.Hydraulic Design details by Kirloskar Consultants HGL at WDS, Residual Presssure etc are considered
2. Discharge in each pipe is a Population / Unit Length in distribution zone x Target Pipe Length under consideration
3. Equivalen pipe diameter has been considered for computing friction losses by weighted average
4. Critical Point is considered to be farthest point from WDS within zone
5. Haze-Williams "C" Value for existing pipe considered as "100"

Table A5.6.1 Preliminary Hydraulic Assessment Residual Pressures in Core City (2035)

Source: JICA Study Team

Table A5.6.2 Preliminary Hydraulic Assessment Residual Pressures in Core City (2050)

Preliminary Hydraulic Assessment (2050)																	
Zone	Water Distribution Station	Demand 2050 (MLD)	HGL (m)	Avg.GL @ WDS (m)	Residual Head (designed)	Residual Head (Ferrule)	Population in 2050	Population/ unit length	Popualtion in Pipe	Discharge (m3/hr)	Critical point in distribution Network: Distance from WDS (m)	Critical point in distribution Network: Elevation (m)	Equivalent Diameter of Pipe (mm)	Hazen-Williams "C" value	Head Loss (m)	Residual Pressure @ Critical point (m)	Check
1	Kilpauk	220.1	27.00	7.00	10.00	7.00	1238893	1.87	13843.90	86.52	7402	10.00	350	100	2.60	14.4	OK
2	Anna Poonga	61.3	23.58	3.58	10.00	7.00	344887	2.93	5102.21	31.89	1740	5.00	275	100	0.31	18.3	OK
3	Kannapathidal	57.6	25.26	5.60	10.00	7.00	324060	4.83	10906.49	68.17	2257	5.00	200	100	7.79	12.5	OK
4	Triplicane	36.2	23.00	3.00	10.00	7.00	196240	1.46	2798.73	17.49	1917	10.00	200	100	0.53	12.5	OK
5	K.K.Nagar	73.6	29.00	9.00	10.00	7.00	414187	1.56	11120.28	69.50	7112	9.00	225	100	14.34	5.7	Expected Low Pressure
6	Velachery	44.4	25.80	6.00	10.00	7.00	250067	6.54	13049.88	81.56	1996	5.00	200	100	9.61	11.2	OK
7	Ekkatuthangal	7.3	30.05	7.00	10.00	7.00	40993	1.12	2368.06	14.80	2113	7.00	150	100	1.75	21.3	OK
8	Choolaimedu	111.0	29.00	9.00	10.00	7.00	624947	5.06	29863.62	186.65	5901	9.00	325	100	12.37	7.6	Expected Low Pressure
9	Kulathur	40.1	27.00	10.50	10.00	7.00	225867	1.56	4461.16	27.88	2866	7.00	243	100	0.73	19.3	OK
10	Vysarpadi	75.3	25.00	4.00	10.00	7.00	423500	1.92	5490.94	34.32	2855	5.00	150	100	11.23	8.8	Expected Low Pressure
11	Patel Nagar	40.3	24.00	3.00	10.00	7.00	227040	0.95	2893.58	18.08	3054	5.00	228	100	0.48	18.5	OK
12	Pallipattu	51.2	27.50	5.00	10.00	7.00	287980	3.42	7835.06	48.97	2291	6.00	150	100	17.40	4.1	Expected Low Pressure
13	Mylapore	23.1	22.50	2.50	10.00	7.00	129947	1.49	6034.57	37.72	4047	3.00	165	100	11.92	7.6	Expected Low Pressure
14	Nandanam	45.5	22.50	2.50	10.00	7.00	256300	1.52	1980.58	12.38	1303	3.00	223	100	0.11	19.4	OK
15	Valluvarkottam	34.0	26.50	4.00	10.00	7.00	191547	1.07	6954.67	43.47	6513	6.00	253	100	3.13	17.4	OK
16	Southern Head works	34.9	25.50	7.00	10.00	7.00	196533	1.55	14762.40	92.27	9548	9.00	300	100	8.01	8.5	Expected Low Pressure

Assumptions:
1.Hydraulic Design details by Kirloskar Consultants HGL at WDS, Residual Presssure etc are considered
2. Discharge in each pipe is a Population / Unit Length in distribution zone x Target Pipe Length under consideration
3. Equivalen pipe diameter has been considered for computing friction losses by weighted average
4. Critical Point is considered to be farthest point from WDS within zone
5. Haze-Williams "C" Value for existing pipe considered as "100"

Source: JICA Study Team

Appendix 6.1 Geotechnical Survey Results in the DPR

A6.1.1 Scope of the Survey

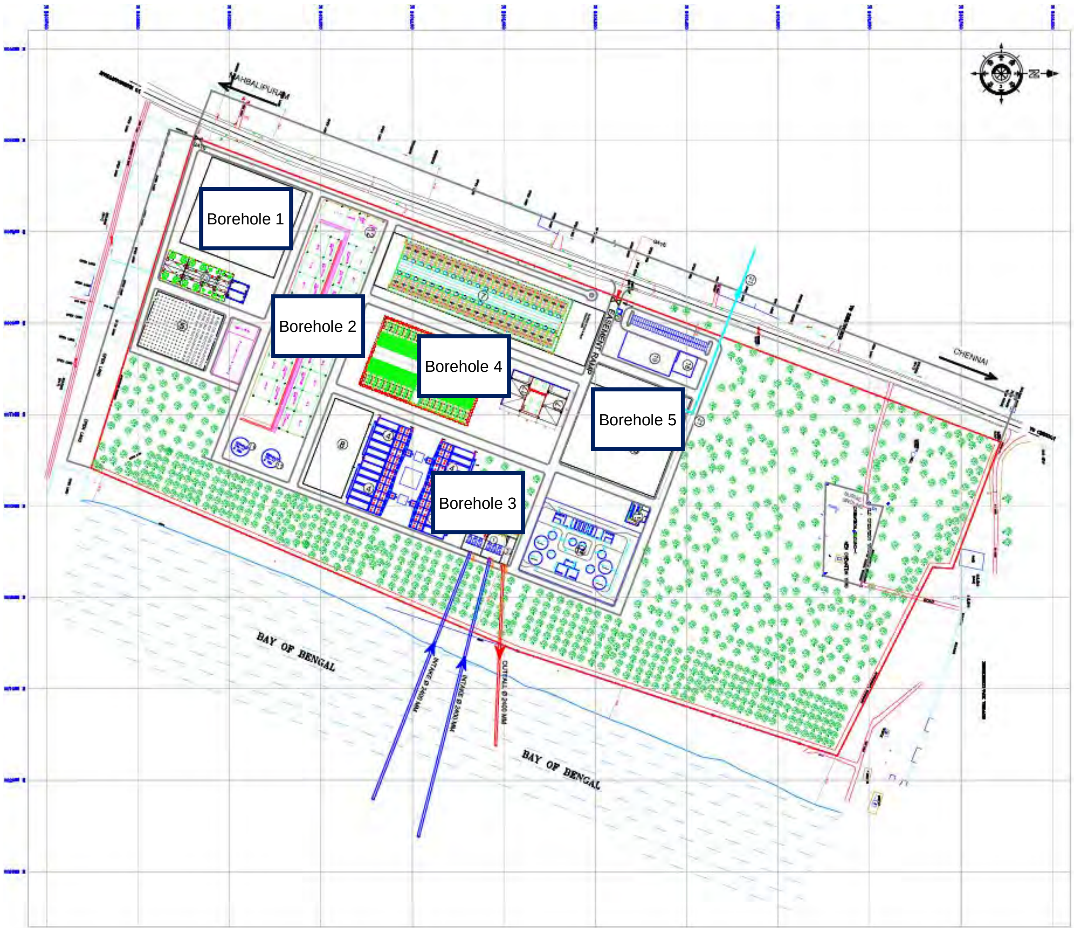
In order to identify the soil condition in the site of the New Perur DSP, a geotechnical survey was conducted in the DPR. Five borehole locations were selected according to the layout of the plant facilities (Figure A6.1.1).

A6.1.2 Results of the Survey

According to the columnar sections attached to the DPR (Figure A6.1.2), the major soil layers at the new Perur DSP site and their approximate depths are as follows:

- Grayish silty fine sand: from −0.0 m to −10.0 m (SPT N value = 10 to 64)
- Brownish silty stiff clay: from −10.0 m to −13.0 m /−15.0 m (SPT N value = 7 to 9)
- Soft disintegrated rock: from −13.0/−15.0 m to −19.0 m (SPT N value ≧100)
- Hard granite rock: from −17.0 m to −23.0 m

(STP: Standard Penetration Test)



Source: DPR for the Perur DSP Project

Figure A6.1.1 Location of Borehole at the New Perur DSP conducted by the DPR

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR			
BH NO	1	DATE OF START	03.11.2014
SITE	Perur	DATE OF COMPLETION	04.11.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.60 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	3	5	6	11	Medium Dense
2.00		Brown Sand	6	7	11	18	Medium Dense
3.00		Brown Sand	10	10	18	28	Medium Dense
4.00		Brown Sand	9	10	14	24	Medium Dense
5.00		Brown Sand	10	12	15	27	Medium Dense
6.00		Brown Sand	12	18	18	36	Medium Dense
7.50		Brown Sand	9	7	7	14	Medium Dense
9.00		Brown Sand	11	13	15	28	Medium Dense
10.5		Brown Sand	8	10	11	21	Medium Dense
12.0		Grayish Silty Sand	9	11	12	23	Medium Dense
13.5		Grayish Clayey Sand	8	12	12	24	Medium Dense
15.0		Brown Silty Clay	11	18	20	38	Hard
16.5		Grayish Brown Clayey Sand	21	55 (13 cm) Rebound		> 100	Hard
18.0		Grayish Brown Weathered Rock	54 (2 cm) Hammer Rebound			> 100	Hard
19.5		Grayish Brown Weathered Rock	54 (1 cm) Hammer Rebound			> 100	Hard
20 - 21.5		Pinkish Gray Granite Rock	CR = 60%, RQD = 20%			> 100	Hard
Borehole Termination Depth is 21.5 m from the Existing Ground Level							

Borehole 1

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR			
BH NO	2	DATE OF START	01.11.2014
SITE	Perur	DATE OF COMPLETION	02.11.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.70 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	4	6	6	12	Medium Dense
2.00		Brown Sand	6	8	10	18	Medium Dense
3.00		Brown Sand	3	6	6	12	Medium Dense
4.00		Brown Sand	6	15	18	33	Dense
5.00		Brown Sand	15	18	18	36	Dense
6.00		Brown Sand	17	18	22	40	Dense
7.50		Brown Sand	13	15	18	33	Dense
9.00		Brown Sand	11	11	13	24	Medium Dense
10.5		Grayish Brown Clayey Sand	12	13	14	27	Medium Dense
12.0		Grayish Brown Clayey Sand	9	10	11	21	Medium Dense
13.5		Grayish Silty Clay	10	11	11	22	Very Stiff
15.0		Grayish Silty Clay	9	18	18	36	Very Stiff
16.5		Grayish Brown Clayey Sand	11	15	23	38	Dense
17.9		Grayish Brown Weathered Rock	54 (2 cm) Hammer Rebound			> 100	Hard
Borehole Termination Depth is 17.9 m from the Existing Ground Level							

Borehole 2

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR			
BH NO	3	DATE OF START	05.11.2014
SITE	Perur	DATE OF COMPLETION	05.11.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.54 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	2	5	6	11	Medium Dense
2.00		Brown Sand	3	6	6	12	Medium Dense
3.00		Brown Sand	4	7	8	15	Medium Dense
4.00		Brown Sand	5	8	10	18	Medium Dense
5.00		Brown Sand	6	8	10	18	Medium Dense
6.00		Brown Sand	11	15	19	34	Dense
7.50		Grayish Brown Sand	7	7	8	15	Medium Dense
9.00		Grayish Brown Clayey Sand	7	11	11	22	Medium Dense
10.5		Grayish Silty Clay	7	11	12	23	Very Stiff
12.0		Grayish Silty Clay	8	10	12	22	Very Stiff
13.5		Grayish Brown Clayey Sand	9	10	17	27	Medium Dense
15.0		Grayish Brown Clayey Sand	11	18	24	42	Dense
16.5		Grayish Brown Weathered Rock	57 (8 cm) Hammer Rebound			> 100	Hard
17.0		Grayish Brown Weathered Rock	55 (3 cm) Hammer Rebound			> 100	Hard
18.5		Grayish Granite Rock	CR = 25%, RQD = 7%			> 100	Hard
Borehole Termination Depth is 18.5 m from the Existing Ground Level							

Borehole 3

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR			
BH NO	4	DATE OF START	30.10.2014
SITE	Perur	DATE OF COMPLETION	31.10.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.65 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	5	5	7	12	Medium Dense
2.00		Brown Sand	6	9	9	18	Medium Dense
3.00		Brown Sand	4	6	6	12	Medium Dense
4.00		Brown Sand	6	7	8	15	Medium Dense
5.00		Grayish Brown Sand	8	12	21	33	Medium Dense
6.00		Grayish Brown Sand	9	16	20	36	Dense
7.50		Grayish Brown Sand	6	8	10	18	Medium Dense
9.00		Grayish Brown Clayey Sand	8	11	13	24	Medium Dense
10.5		Grayish Brown Clayey Sand	9	12	12	24	Very Stiff
12.0		Grayish Brown Clayey Sand	10	12	16	28	Very Stiff
13.5		Grayish Brown Clayey Sand	16	25	33	58	Very Dense
15.0		Grayish Brown Clayey Sand	17	33	34	67	Very Dense
16.5		Grayish Brown Weathered Rock	55 (5 cm) Hammer Rebound			> 100	Hard
17.0		Grayish Brown Weathered Rock	53 (2 cm) Hammer Rebound			> 100	Hard
18.5		Grayish Granite Rock	CR = 20%, RQD = 7%			> 100	Hard
Borehole Termination Depth is 18.5 m from the Existing Ground Level							

Borehole 4

PROJECT : Proposed Construction of Desalination Plant at Perur, ECR

BH NO	5	DATE OF START	28.10.2014
SITE	Perur	DATE OF COMPLETION	30.10.2014
DIA OF BORING	150 mm	GROUND WATER LEVEL	1.72 m
TYPE OF BORING	Rotary (Calyx)	RL	-

Depth below EGL (m)	Soil / Rock Profile	Description / Classification of Soil / Rock	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density/ Consistency
			15	30	45	N	
1.00		Brown Sand	4	7	7	14	Medium Dense
2.00		Brown Sand	5	8	10	18	Medium Dense
3.00		Brown Sand	10	14	21	35	Dense
4.00		Brown Sand	11	15	18	33	Dense
5.00		Brown Sand	12	18	18	36	Dense
6.00		Brown Sand	12	15	20	35	Dense
7.50		Brown Sand	6	10	10	20	Medium Dense
9.00		Brown Clayey Sand	9	12	15	27	Medium Dense
10.5		Brown Clayey Sand	8	10	12	22	Medium Dense
12.0		Grayish Brown Silty Sand	18	23	31	54	Very Dense
13.5		Grayish Brown Silty Sand	20	30	42	72	Very Dense
15.0		Grayish Brown Clayey Sand	21	30	33	63	Very Dense
16.5		Grayish Brown Weathered Rock	54 (1 cm) Hammer Rebound			> 100	Hard
18.0		Grayish Brown Weathered Rock	58 (1 cm) Hammer Rebound			> 100	Hard
19.6		Grayish Brown Weathered Rock	54 (0 cm) Hammer Rebound			> 100	Hard
19.6 - 21.1		Grayish Granite Rock	CR = 20%, RQD = 0%			> 100	Hard

Borehole Termination Depth is 21.1 m from the Existing Ground Level

Borehole 5

Source: DPR for the Perur DSP Project

Figure A6.1.2 Columnar Section

A6.1.3 Foundation System

One of the important criteria to determine any foundation is a settlement of the soil layer. If the foundation is laid on a clay layer, the state of clay, such as moisture content and consolidation, should be carefully examined because the clay layer is expected to undergo consolidation over a period due to sustained loading.

As per the geotechnical report mentioned above, the width of the shallow foundation is assumed as 2.5 m × 2.5 m to determine the safe bearing capacity for varying depths of foundation shown in following Table A6.1.1.

Table A6.1.1 Settlement Values with the Safe Bearing Capacity

Size of Foundation	Depth of Foundation (m)	Safe Bearing Capacity (kN/m^{2})	Settlement (mm)
2.5 m × 2.5 m	2.0	158	17.99
	2.5	209	20.99
	3.0	274	26.62

Source: DPR

As an alternative to the shallow foundation, bored cast in-situ pile with the diameters of the pile as 400 mm, 500 mm, 600 mm and 750 mm, and the length of the pile as 17 m to 20 m on the hard granite rock layer are also recommended in the DPR apart from the shallow foundation.

Appendix 6.2 Seawater Quality Survey in the Study

A6.2.1 Scope and Objectives of the Survey

The JICA Study Team conducted a seawater quality survey at the end of February 2016. During the survey, an in-situ test was conducted at each point (every 1 m from the surface to the bottom of the sea) to confirm the influences from brine of the Nemmeli DSP to the sea. The sampling points are shown in Table A6.2.1 and Figure A6.2.1.

Table A6.2.1 Coordinates of the Sampling Points for the Seawater Quality Survey in the Study

Sampling point	Location	Coordinate (UTM)	
		X	Y
Nemmeli DSP			
P1	Discharge	416699	1404348
P2	Discharge -Intake 1	416767	1404285
P3	Discharge -Intake 2	416849	1404214
P4	Discharge -Intake 3	416933	1404141
P5	Intake	417010	1404077
P6	Offshore	417085	1404008
P7	Intake chamber	—	—
Proposed Perur DSP			
P8	Discharge	417066	1405582
P9	Intake 1	417447	1405280
P10	Intake 2	417339	1405010

Source: JICA Study Team

Source: JICA Study Team

Figure A6.2.1 Location of the Sampling Points for the Seawater Quality Survey in the Study

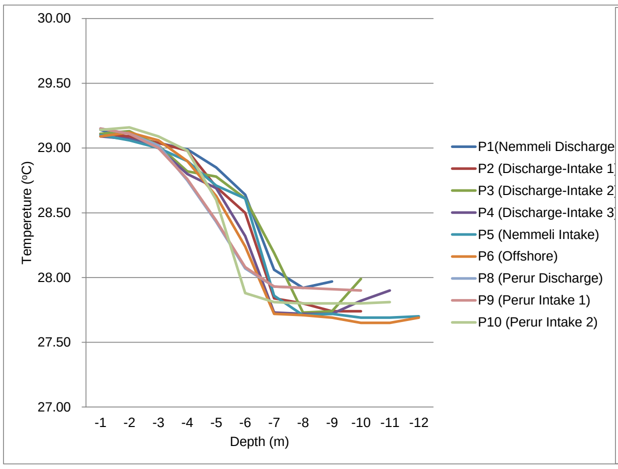
A6.2.2 Results of the In-Situ Test

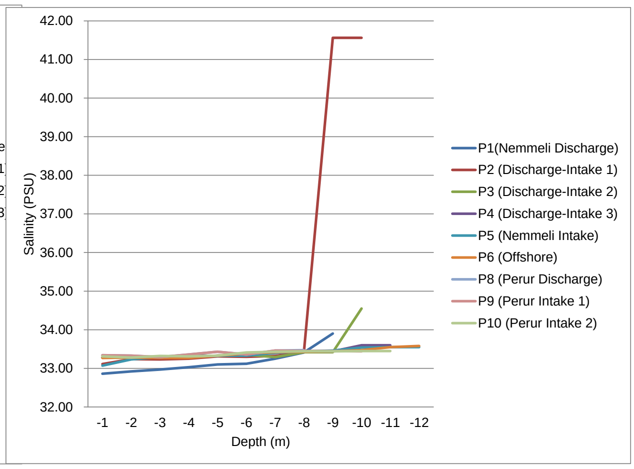
The results of the in-situ test are shown in Table A6.2.2 and Figure A6.2.2.

Table A6.2.2 Results of the In-situ Test

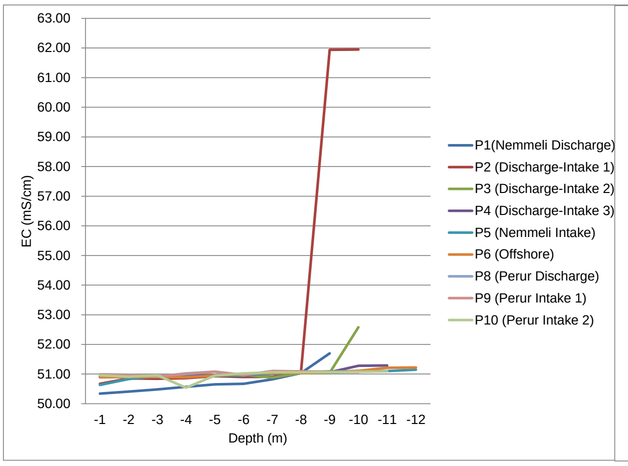
	pH	EC (mS/cm)	TDS	Salinity (PSU)	Temperature (°C)
P1					
Average	8.3	50.84	25.42	33.25	28.58
Minimum	8.32	51.70	25.87	33.95	29.14
Maximum	8.26	50.34	25.17	32.86	27.92
P2					
Average	8.28	53.89	26.95	35.63	28.48
Minimum	8.18	50.67	25.34	33.11	27.74
Maximum	8.33	61.95	30.99	41.57	29.11
P3					
Average	8.31	51.25	25.63	33.55	28.47
Minimum	8.27	50.88	25.44	33.27	27.73
Maximum	8.34	52.59	26.31	34.55	29.13
P4					
Average	8.31	51.05	25.53	33.41	28.32
Minimum	8.23	50.90	25.45	33.28	27.72
Maximum	8.35	51.29	25.65	33.61	29.09
P5					
Average	8.3	50.99	25.51	33.39	28.27
Minimum	8.26	50.63	25.32	.33.07	27.69
Maximum	8.34	51.19	25.63	33.59	29.10
P6					
Average	8.31	51.03	25.52	33.41	28.23
Minimum	8.27	50.81	25.45	33.27	27.65
Maximum	8.35	51.25	25.63	33.67	29.12
P7					
Average	8.22	50.57	25.29	33.07	28.04
Minimum	8.21	50.54	25.27	33.05	28.04
Maximum	8.22	50.60	25.31	33.09	28.04
P8					
Average	8.31	51.03	25.46	33.39	28.49
Minimum	8.20	50.92	25.00	33.29	27.92
Maximum	8.35	51.10	25.55	33.48	29.15
P9					
Average	8.31	51.03	23.43	33.40	28.39
Minimum	8.28	50.92	25.54	33.29	27.90
Maximum	8.35	51.10	25.56	33.46	29.15
P10					
Average	8.31	50.98	25.51	33.39	28.31
Minimum	8.27	50.54	25.46	33.28	27.80
Maximum	8.35	51.10	25.55	33.46	29.16

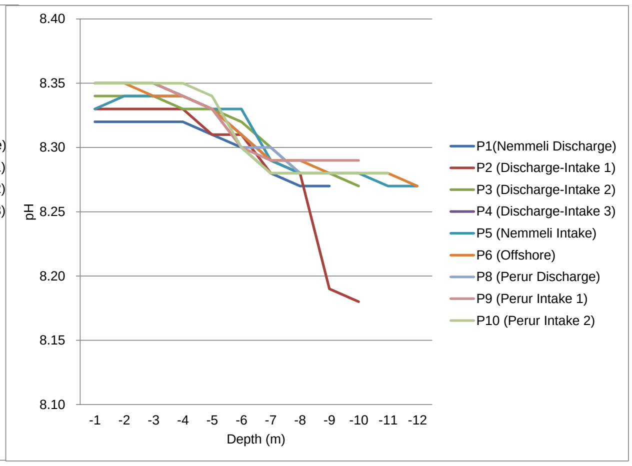
Source: JICA Study Team





Temperature **Salinity**





Electrical Conductivity **pH**

Source: JICA Study Team

Figure6.2.2 Seawater Quality Survey Results in the Study

The distance between the sampling points P1 to P6 related to the existing Nemmeli DSP is 100 m. The brine coming from the existing Nemmeli DSP is discharged at P1, approximately −5.0 m from the surface of the sea.

The above figures clearly show that the brine influences the seawater quality around the area within 200 m from P1, especially on the seawater quality at the bottom layer (−8.0 m ~ −10.0 m) of the points P2 and P3. It shows that the high-concentration salt water has accumulated at the bottom of the sea in the vicinity of the drain outlet.

On the other hand, when the points move away approximately 300 m from the drain outlet (P4 ~ P6), including the intake point of the Nemmeli DSP (P5), the influences of the brine are almost invisible. These results show that the layout of the intake point and discharge point of the existing Nemmeli DSP is generally reasonable, and the proposed new Perur DSP shall also be planned according to this layout.

A6.2.3 Result of the Laboratory Test

In addition to the in-situ test mentioned above, the laboratory test was conducted at the proposed intake points (P9 and P10), particularly, in order to identify the intake facilities and configuration for the new DSP.

The results of the seawater quality test at a laboratory in India with samples collected at the proposed intake points of the new Perur DSP (P9 and P10) are shown in Table A6.2.3.

Table A6.2..3 Result of the Laboratory Test

Sampling Point	Layer	Turbidity	DO	TSS	E. Conductivity	TDS	Ca^{2+}	Mg^{2+}	Na^{+}	SO_4^{2-}	Cl^{-}	Mn	Cu	Fe	HCO_3^{-}	B	Si	SiO_2	SiO_3
		NTU	mg/l	mg/l	mS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
P9 Intake Point (1)	Surface Layer (-1.0 m)	0.10	5.00	143	50,290	40,309	1,178	4,052	12,603	536.0	21,440	0.006	0.06	0.120	6,124.4	3.10	0.09	0.20	0.54
	Intake Level (-5.0 m)	0.10	4.70	123	50,830	40,856	786	2,622	14,533	475.0	21,440	0.006	0.06	0.130	4,593.0	2.80	0.09	0.21	0.56
P10 Intake Point (2)	Surface Layer (-1.0 m)	0.10	4.50	189	51,400	41,489	393	2,622	13,503	478.0	23,993	0.005	0.07	0.059	4,593.0	2.90	0.11	0.24	0.65
	Intake Level (-5.0 m)	0.10	4.80	116	50,400	40,048	393	3,098	12,603	472.5	23,482	0.001	0.02	0.090	4,593.0	3.20	0.25	0.11	0.67

Source: JICA Study Team

A6.2.4 Result of the Seawater Quality Test by Japanese Laboratory

TDS and Boron (B) are the most important parameters for designing of the RO plant; therefore, the same samples were also tested in a Japanese laboratory. The results are shown in Table A6.2.4.

Every value is lower than the value provided from the laboratory in India. The reason is supposed that the results from the Indian laboratory may contain some suspended solids even after the filtration process of the test.

Table A6.2.4 Result of the Seawater Quality Test by Japanese Laboratory

Sampling point	TDS	B
	mg/l	mg/l
P9: Intake Point (1) Intake Level (−5 m)	37,300	4.1
P10: Intake Point (2) Intake Level (−5 m)	38,100	4.3

Source: JICA Study Team

Appendix 6.3 Geotechnical Survey in the Study

A6.3.1 Construction Site for the Pipeline by Trenchless Method

(1) Scope of the survey

The JICA Study Team conducted a geotechnical survey during May 2016. The objectives of the survey are to examine the geotechnical characteristic of the soil at the proposed Trenchless pipe working site.

The survey consists of 1) Boring test, 2) Standard Penetration Test (SPT), 3) Core sampling, 4) Laboratory test, and 5) Collection of Geological map including site area.

The laboratory test was conducted at the laboratory accredited to the Notional Accreditation Board for Laboratories (NABL) in India.

The items of the laboratory test includes a) Grain Size Distribution (sieve analysis), b) Moisture Content, c) Density, d) Specific gravity, e) Atterberg limits (Liquid Limit and Plastic Limit), f) Internal friction angle, g) Consolidation test, and h) Uniaxial compression test.

Figure A6.3.1 shows proposed pipeline route and boring locations at the proposed Trenchless pipe construction site (P-A1: 404,153.00 m E, 1,428,837.00 m N, 34.327 m AMSL) near the Tambaram railway station.

Source: JICA Study Team

Figure A6.3.1 Site Location of the Trenchless Pipe construction at Tambaram

(2) Results of the survey

The formation consisted of filling soil until -1 m, followed by traces of clay up to -3 m from the ground level. Below -3 m, the soil consists of weathered igneous rock up to -8 m and hard massive rock laid after -8 m. The SPT N value varied from 33 to 105 at -2 m to -3 m in dense soil. After -3 m, the SPT N value in weathered rock exceeded 50 blows with rebound indicating dense rock. The safe bearing capacity varied from 11.43 tons/square meter at -2 m to 104.33 tons/square meter at -8 m. The water table was not encountered.

Project : Construction of Trenchless Pipeline 2m dia
Borehole No: 1
Type of Boring: Calyx
Work Order No: 1320

Date of commencement:29.05.2016.
Date of Completion : 29.05.2016
G.W.L. :NIL

Depth below G.L. M	Soil Profile	Description of Soil	Thickness of layer M	Depth of which samples are collected		Standard Penetration Test		
				D.S. M	U.D.S. M	Depth at which test is conducted	N- Value	Relative density consistency
		Filling Soil						
1.0	---------	-----------------	1.0					
		Silty sand With traces of Clay				2.0	81	DENSE
3.0		----------------	2.0			3.0	29	MEDIUM
						4.0	50/10cm	
		Weathered Rock						
						5.0	50/0 Penetration	
						6.0	50/0 Penetration	
						7.0	-	
8.0	-----------	----------------	5.0			8.0	-	
		Hard Rock						

Remarks: Soil classification is subject to confirmation by laboratory tests.

Source: JICA Study Team

Figure A6.3.2 Columnar Section (P-A1)

Table A6.3.1 Result of the Laboratory Test

Depth in 'm'	Layer	Wn %	Grain Size Distribution					Density Test		Direct Shear Test	
			Clay %	Silt %	Sand %	Gravel %	Sp.Gravity	rb gm/cc	rd gm/cc	C g/cm^2	Degree
BOREHOLE – 1											
1.0-3.0	Silty sand with traces of clay	15.52	10	30	60	0	2.526	1.824	1.579	--	26°00'
3.0-8.0	Weathered Rock	1.82	0	20	55	25	2.535	1.840	1.807	--	29°30'

Depth in 'm'	ATTERBERG LIMITS			FREE SWELL%
	LL%	PL%	PI%	
BOREHOLE NO:1				
1.0-3.0	20.11	11.58	8.53	10.00
3.0-8.0	NIL	NIL	NIL	NIL

Source: JICA Study Team

A6.3.2 Construction Site for the New Reservoir and Pumping Station

(1) Scope of the survey

The objectives of the survey are to examine the geotechnical characteristic of the soil and the bearing capacity at the proposed new reservoir and pumping station site. The survey locations (P-B1: 407,631.00 m E, 1,441,786.00 m N, 16.559 m AMSL and P-B2: 407,705.00 m E, 1,441,786.00 m N, 16.829 m AMSL) are detailed in Figure A6.3.3.

Source: JICA Study Team

Figure A6.3.3 Site Location of the New Reservoir and Pumping Station at Porur

(2) Results of the survey

As per the geological map, the Porur area falls under sedimentary terrain and is made of Flood Plain Deposits belonging to Quaternary formations. The soil mainly consists of sands, clays, and gravels.

- Borehole: PB-1

The formation was silty sand up to -8 m from the ground level with silt comprising of 49%, sand 38% ,and clay 10%. The liquid limit of silty sand is 15%, plastic limit 5%, plasticity index is 10%, and the free swell index is 8%. The SPT N value varied from 2 to 11, indicating mainly loose quality soil.

The above layer is followed by silty sand with clay up to -18 m and comprises of silt 45%, sand 40% and clay 15% with liquid limit 20%, plastic limit 10%, plasticity index 10%, and free swell index 10%. The SPT N value varied from 6 to 28, indicating loose to medium quality soil.

Below -18 m up to -20 m, the formation is silty sand with 49% silt, 40% sand, clay 11%, liquid limit 15%, plastic limit 6%, plasticity index 9% and free swell index 7%, and the SPT N value varied from 40 to 46, indicating medium quality soil.

The safe bearing capacity at shallow depths from 0 m to -5 m is within the range from 6 to 20 tons/square meter. The water table was encountered at -3 m from the ground level.

- Borehole: PB-2

The formation was silty sand up to -4 m from the ground level with silt comprising of 49%, sand 42%, and clay 9%. The liquid limit of silty sand is 15%, plastic limit 7%, plasticity index is 8%, and free swell index is 8%. The SPT N value varied from 2 to 14, indicating mainly loose quality soil.

The above layer is followed by silty sand with clay up to -19 m and comprises of silt 46%, sand 40% and clay 14% with liquid limit 25%, plastic limit 13%, plasticity index 12% and free swell index 11%. The SPT N value varied from 5 to 24, indicating loose to medium quality soil.

Below -19 m to -20 m, the formation is silty sand having 48% silt, 41% sand, clay 11%, liquid limit 12%, plastic limit 8%, plasticity index 5%, and free swell index 7%. The SPT N value varied from 34 to 38 indicating medium quality soil.

The safe bearing capacity at shallow depths from 0 m to -5 m is within the range from 6 to 20 tons /square meter, as same as the borehole PB-1.

Project : Water Storage Tank
Borehole No: 1
Type of Boring: Calyx
Work Order No: 1312

Date of commencement:06.05.2016.
Date of Completion : 07.05.2016
G.W.L. :3.0m

Depth below G.L. M	Soil Profile	Description of Soil	Thickness of layer M	Depth of which samples are collected		Standard Penetration Test			Ground Water level
				D.S. M	U.D.S. M	Depth at which test is conducted	N-Value	Relative density consistency	
						1.0	6	LOOSE	
		Silty sand with traces of clay				2.0	4	LOOSE	
						3.0	3	LOOSE	
						4.0	2	LOOSE	
						5.0	7	LOOSE	
						6.0	8	LOOSE	
						7.0	11	LOOSE	
8.0		----------------	8.0			8.0	5	LOOSE	
						9.0	6	LOOSE	
						10.0	7	LOOSE	
		Silty sand				11.0	5	LOOSE	
		With clay				12.0	8	LOOSE	
						13.0	10	LOOSE	
						14.0	12	LOOSE	
						15.0	15	LOOSE	
						16.0	10	LOOSE	
						17.0	12	LOOSE	
		----------------	10.0			18.0	28	MEDIUM	
18.0		Silty sand with traces of clay				19.0	40	MEDIUM	
		----------------	2.0			20.0	46	MEDIUM	
20.0									

Remarks: Soil classification is subject to confirmation by laboratory tests.

Source: JICA Study Team

Figure A6.3.4 Columnar Section (P-B1)

Project : Water Storage Tank
Borehole No: 2
Type of Boring: Calyx
Work Order No: 1312

Date of commencement:07.05.2016.
Date of Completion : 08.05.2016
G.W.L. :3.0m

Depth below G.L. M	Soil Profile	Description of Soil	Thickness of layer M	Depth of which samples are collected		Standard Penetration Test			Ground Water Level
				D.S. M	U.D.S. M	Depth at which test is conducted	N-Value	Relative density consistency	
		Silty sand With traces of clay				1.0	4	LOOSE	
						2.0	4	LOOSE	
						3.0	2	LOOSE	
4.0		---------------	4.0			4.0	2	LOOSE	
						5.0	5	LOOSE	
						6.0	6	LOOSE	
		Silty sand				7.0	7	LOOSE	
		With clay				8.0	5	LOOSE	
						9.0	6	LOOSE	
						10.0	6	LOOSE	
						11.0	6	LOOSE	
						12.0	8	LOOSE	
						13.0	7	LOOSE	
						14.0	10	LOOSE	
						15.0	11	LOOSE	
						16.0	14	LOOSE	
						17.0	17	LOOSE	
						18.0	24	MEDIUM	
19.0		---------------	15.0			19.0	34	MEDIUM	
		Silty sand with traces of clay	1.0			20.0	38	MEDIUM	
20.0	----------	---------------							

Remarks: Soil classification is subject to confirmation by laboratory tests.

Source: JICA Study Team

Figure A6.3.5 Columnar Section (P-B2)

Table A6.3.2 Results of the Laboratory Test (P-B1 and P-B2)

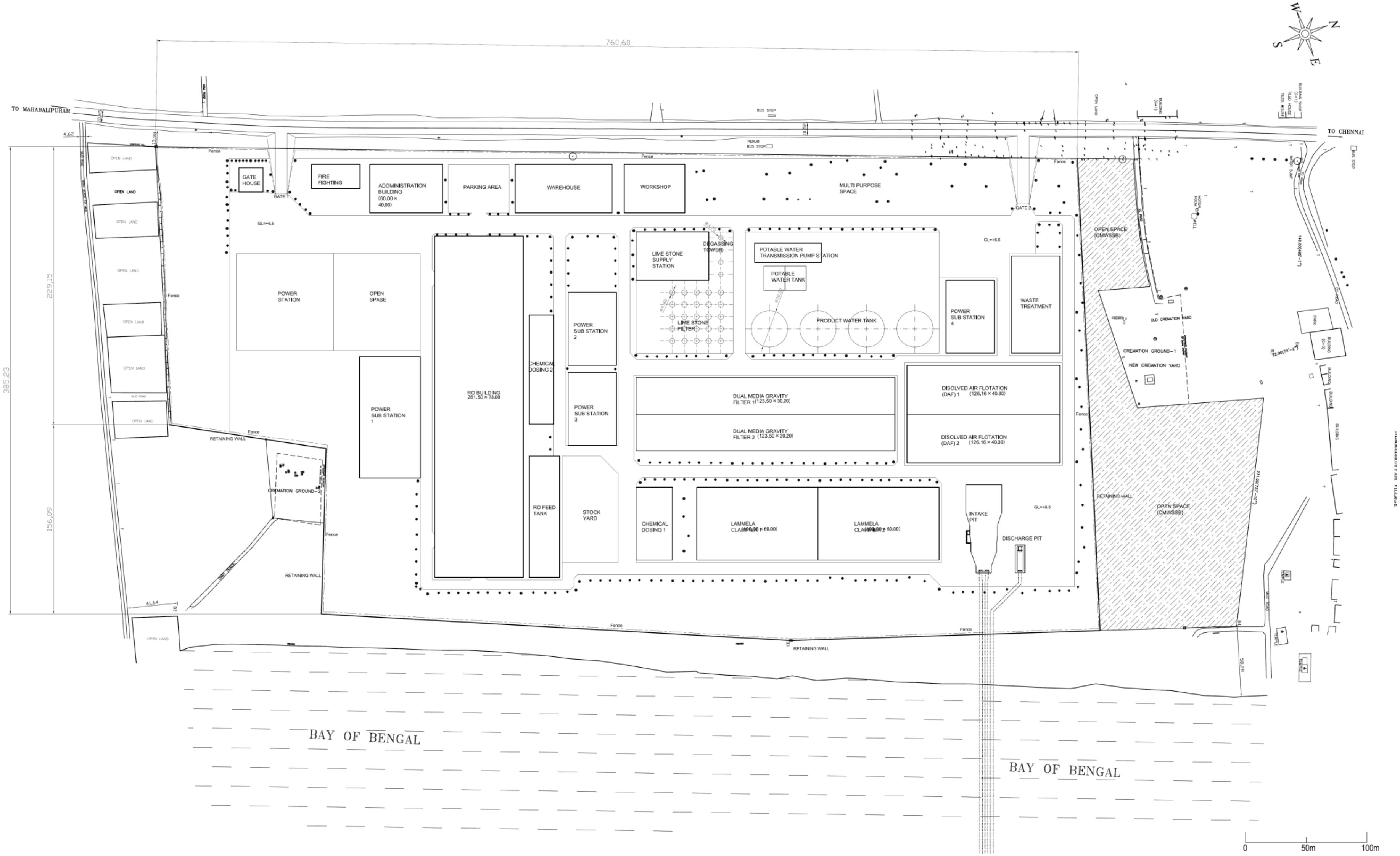
Depth in 'm'	Layer	Wn %	Grain Size Distribution					Density Test		Direct Shear Test	
			Clay %	Silt %	Sand %	Gravel %	Sp.Gravity	rb gm/cc	rd gm/cc	C g/cm²	Degree
BOREHOLE – 1											
1.0-8.0	Silty sand with traces of clay	10.15	10	52	38	0	2.560	1.798	1.632	--	25°25'
8.0-18.0	Silty sand with clay	12.25	15	45	40	0	2.565	1.799	1.603	--	25°48'
18.0-20.0	Silty sand with traces of clay	11.08	11	49	40	0	2.550	1.800	1.618	--	25°55'

Depth in 'm'	Layer	Wn %	Grain Size Distribution					Density Test		Direct Shear Test	
			Clay %	Silt %	Sand %	Gravel %	Sp.Gravity	rb gm/cc	rd gm/cc	C g/cm²	Degree
BOREHOLE – 2											
1.0-4.0	Silty sand with traces of clay	11.15	9	49	42	0	2.580	1.799	1.619	--	25°22'
4.0-19.0	Silty sand with clay	12.58	14	46	40	0	2.575	1.800	1.599	--	25°48'
19.0-20.0	Silty sand with traces of clay	9.06	11	48	41	0	2.560	1.801	1.651	--	25°53'

Depth in 'm'	**ATTERBERG LIMITS**			**FREE SWELL%**
	LL%	PL%	PI%	
BOREHOLE NO:1				
1.0-8.0	15.26	5.03	10.23	8.00
8.0-18.0	20.22	10.07	10.15	10.00
18.0-20.0	14.83	5.57	9.26	7.00
BOREHOLE NO:2				
1.0-4.0	15.22	6.96	8.26	8.00
4.0-19.0	25.22	12.79	12.43	11.00
19.0-20.0	12.43	7.84	4.59	7.00

Source: JICA Study Team

Appendix 6.4 Layout Plan of the Perur DSP



Appendix 6.5 Instrumentation List for the Perur DSP

Ⅰ Chemical Dosing

No.	Equipment name	Range	Units	Range(select)	Units	Alarm	Control	Number			Model
								Duty	Standby	Total	
1	Dosing Tank (NaClO) Level (Ultrasonic)	0 - 8,950	mm	0 - 8,950	mm	H,L	H,M,L	8	-	8	Level sensor
2	Dosing Tank (NaClO) Level (Gauge)	0 - 7,200	mm	0 - 7,200	mm	H,L	H,M,L	8	-	8	Level Gauge (Diaphragm)
3	Dosing Tank (H_2SO_4) Level (Ultrasonic)	0 - 11,000	mm	0 - 11,000	mm	H,L	H,M,L	3	-	3	Level sensor
4	Dosing Tank (H_2SO_4) Level (Gauge)	0 - 9,000	mm	0 - 9,000	mm	H,L	H,M,L	3	-	3	Level Gauge (Diaphragm)
5	Dosing Tank (FeCl3) Level (Ultrasonic)	0 - 11,000	mm	0 - 11,000	mm	H,L	H,M,L	10	-	10	Level sensor
6	Dosing Tank (FeCl3) Level (Gauge)	0 - 9,000	mm	0 - 9,000	mm	H,L	H,M,L	10	-	10	Level Gauge (Diaphragm)
7	Dosing Tank (NaOH) Level (Ultrasonic)	0 - 6,700	mm	0 - 6,700	mm	H,L	H,M,L	2	-	2	Level sensor
8	Dosing Tank (NaOH) Level (Gauge)	0 - 5,300	mm	0 - 5,300	mm	H,L	H,M,L	2	-	2	Level Gauge (Diaphragm)
9	(NaClO)Shock Dosing Pump discharge (Flow)	100 - 5,000	L/h	100 - 5,000	L/h			2	2	4	Rotameter
10	(NaClO)Shock Dosing Pump (Pressure)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			1	1	2	Diaphragm
11	(NaClO)Dosing Pump discharge (Flow)	100 - 800	L/h	100 - 800	L/h			4	2	6	Rotameter
12	(NaClO)Dosing Pump (Pressure)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			2	1	3	Diaphragm
13	(H_2SO_4)Dosing Pump discharge (Flow)	100 - 400	L/h	100 - 400	L/h			4	4	8	Rotameter
14	(H_2SO_4)Dosing Pump (Pressure)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			2	2	4	Diaphragm
15	($FeCl_3$)Dosing Pump discharge (Flow)(For Lamella)	50 - 200	L/h	50 - 200	L/h			24	12	36	Rotameter
16	($FeCl_3$)Dosing Pump (Pressure)(For Lamella)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			12	6	18	Diaphragm
17	($FeCl_3$)Dosing Pump discharge (Flow)(For DAF)	0 - 100	L/h	0 - 100	L/h			32	16	48	Rotameter
18	($FeCl_3$)Dosing Pump (Pressure)(For DAF)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			16	8	24	Diaphragm
19	(NaOH)Dosing Pump discharge (Flow)	50 - 200	L/h	50 - 200	L/h			4	4	8	Rotameter
20	(NaOH)Dosing Pump (Pressure)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			2	2	4	Diaphragm
21	Dosing Tank (Anti Scalant) Level (Ultrasonic)	0 - 3,870	mm	0 - 3,870	mm	H,L	H,M1,M2,M3,L	16	9	25	Level sensor
22	Dosing Tank (Anti Scalant) Level (Gauge)	0 - 3,770	mm	0 - 3,770	mm	H,L	H,M1,M2,M3,L	8	5	13	Level Gauge (Diaphragm)
23	(Anti Scalant)Dosing Pump discharge (Flow)	0 - 5	L/h	0 - 5	L/h			16	9	25	Rotameter
24	(Anti Scalant)Dosing Pump (Pressure)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			8	5	13	Diaphragm
25	Dosing Tank (SBS) Level (Ultrasonic)	0 - 11,000	mm	0 - 11,000	mm	H,L	H,M1,M2,M3,L	8	-	8	Level sensor
26	Dosing Tank (SBS) Level (Gauge)	0 - 9,000	mm	0 - 9,000	mm	H,L	H,M1,M2,M3,L	8	-	8	Level Gauge (Diaphragm)
27	(SBS)Dosing Pump discharge (Flow)	0 - 5	L/h	0 - 5	L/h			16	9	25	Rotameter
28	(SBS)Dosing Pump (Pressure)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			8	5	13	Diaphragm
29	Dosing Tank (POLY) Level (Ultrasonic)	0 - 11,000	mm	0 - 11,000	mm	H,L	H,M1,M2,M3,L	5	-	5	Level sensor
30	Dosing Tank (POLY) Level (Gauge)	0 - 9,000	mm	0 - 9,000	mm	H,L	H,M1,M2,M3,L	5	-	5	Level Gauge (Diaphragm)
31	(Poly)Dosing Pump discharge (Flow)(For Lamella)	150 - 900	L/h	150 - 900	L/h			24	12	36	Rotameter
32	(Poly)Dosing Pump (Pressure)(For Lamella)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			32	16	48	Diaphragm
33	(Poly)Dosing Pump discharge (Flow)(For DAF)	150 - 900	L/h	150 - 900	L/h			24	12	36	Rotameter
34	(Poly)Dosing Pump (Pressure)(For DAF)	0 - 10	kg/cm^2	0 - 10	kg/cm^2			32	16	48	Diaphragm
35	Carbon dioxide Storage Tank Level (Ultrasonic)	0 - 6,000	mm	0 - 6,000	mm	-	-	2	-	2	Level sensor

Ⅱ PRETREATMENT SYSTEM

No.	Equipment name	Range	Units	Range(select)	Units	Alarm	Control	Number			Model
								Duty	Standby	Total	
1	Intake pump discharge header(TOC)	0 - 100	ppm	0 - 100	ppm	H		1	-	1	TOC measurement
2	Intake pump discharge header(DOC)	0 - 100	ppm	0 - 100	ppm	H		1	-	1	DOC measurement
3	Intake pump discharge header (Turbidity)	0 - 200	NTU	0 - 200	NTU	H		1	-	1	Turbidity measurement
4	Intake pump discharge header (Ultrasonic)	0 - 1,200	mm	0 - 1,200	mm	H		1	-	1	Level sensor
5	Intake pump discharge header (Oil Analyzer)	0 - 50	ppm	0 - 50	ppm	H		1	-	1	Oil Analyzer
6	Lamella Clarifier Outlet header	0 - 100	NTU	0 - 100	NTU	H		2	-	2	Turbidity measurement
7	DAF Outlet (Turbidity)	0 - 100	NTU	0 - 100	NTU	H		2	-	2	Turbidity measurement
8	DAF header (oil analyzer)	0 - 10	ppm	0 - 10	ppm	H		2	-	2	Oil Analyzer
9	Dual Media Gravity Filter Level(Ultrasonic)	0 - 930	mm	0 - 930	mm	H		40	-	40	Level sensor
10	Dual Media Gravity Filter Level(Ultrasonic)	0 - 3,100	mm	0 - 3,100	mm	H		40	-	40	Level sensor
11	Dual Media Gravity Filter Outlet(Chlorine)	0 - 5	ppm	0 - 5	ppm	H		2	-	2	Chlorine measurement
12	Dual Media Gravity Filter (TOC)	0 - 100	ppm	0 - 100	ppm	H		2	-	2	TOC measurement
13	Dual Media Gravity Filter (DOC)	0 - 100	ppm	0 - 100	ppm	H		2	-	2	DOC measurement
14	Dual Media Gravity Filter (Turbidity)	0 - 5	NTU	0 - 5	NTU	H		2	-	2	Turbidity measurement
15	Dual Media Gravity Filter (Silt Density)	0 - 20	SDI	0 - 20	SDI	H		2	-	2	Silt Density Monitoring
16	Backwash Pump (Flow)	0 - 10,000	m^3/hr	0 - 10,000	m^3/hr			1	-	1	Electromagnetic Flow meter
17	Backwash Pump (Pressure)	0 - 6	kg/cm^2	0 - 6	kg/cm^2	H		2	-	2	Diaphragm
18	Backwash holding tank (Ultrasonic)	0 - 6,000	mm	0 - 6,000	mm	H,L	H,M,L	1	-	1	Level sensor
19	Backwash Blower (Pressure)	0 - 6	kg/cm^2	0 - 6	kg/cm^2	H		2	-	2	Bourdon

Ⅲ REVERSE OSMOSIS PLANT

No.	Equipment name	Range	Units	Range(select)	Units	Alarm	Control	Number			Model
								Duty	Standby	Total	
1	Cartridge Filter Outlet (Conductivity)	0-10,000	mS/cm	0-10,000	mS/cm	H		16	1	17	Conductivity measurement
2	Cartridge Filter Outlet (ORP)	-1,500 - 1,500	mV	-1,500 - 1,500	mV	H		16	1	17	ORP measurement
3	Cartridge Filter Outlet (pH)	0 - 14		0 - 14		H,L		16	1	17	pH measurement
4	Cartridge Filter Outlet (Pressure)	0 - 6	kg/cm^2	0 - 6	kg/cm^2	H		16	1	17	Diaphragm
5	Cartridge Filter Outlet (Pressure)	0 - 18	kg/cm^2	0 - 18	kg/cm^2	H		16	1	17	Diaphragm
6	Cartridge Filter Outlet (Temperature)	0 - 40	deg C	0 - 40	deg C	H		16	1	17	Temperature sensor
7	Cartridge Filter Outlet (Temperature)	0 - 60	deg C	0 - 60	deg C	H		16	1	17	Temperature transmitter
8	Cartridge Filter Inlet (Pressure)	0 - 6	kg/cm^2	0 - 6	kg/cm^2	H		16	1	17	Diaphragm
9	Cartridge Filter Inlet (Pressure)	0 - 18	kg/cm^2	0 - 18	kg/cm^2	H		16	1	17	Diaphragm
10	Across(Sea Water) Cartridge Filter (Pressure)	0 - 1	kg/cm^2	0 - 1	kg/cm^2	H		16	1	17	Transmitter(Diaphragm)
11	Across(acid/caustic) Cartridge Filter (Pressure)	0 - 1	kg/cm^2	0 - 1	kg/cm^2	H		16	1	17	Transmitter(Diaphragm)
12	High Pressure Pump Suction (Flow)	0 - 21,500	m^3/h	0 - 21,500	m^3/h			16	1	17	Electromagnetic Flow meter
13	High Pressure Pump Suction (Pressure)	0 - 18	kg/cm^2	0 - 18	kg/cm^2	H		16	1	17	Diaphragm
14	High Pressure Pump Suction (Pressure)	0 - 55	kg/cm^2	0 - 55	kg/cm^2	H		16	1	17	Transmitter(Diaphragm)
15	High Pressure Pump discharge (Pressure)	0 - 18	kg/cm^2	0 - 18	kg/cm^2	H		16	1	17	Diaphragm
16	High Pressure Pump discharge (Pressure)	0 - 55	kg/cm^2	0 - 55	kg/cm^2	H		16	1	17	Transmitter(Diaphragm)
17	ERD Booster Pump (Pressure)	0 - 15	kg/cm^2	0 - 15	kg/cm^2	H		16	1	17	Diaphragm
18	Wast disposal pump discharge (Pressure)	0 - 18	kg/cm^2	0 - 18	kg/cm^2	H		16	1	17	Diaphragm
19	CIP Tank Level (Ultrasonic)	0 - 6,000	mm	0 - 6,000	mm	H,L	H,M1,M2,L	1	-	1	Level sensor
20	CIP Tank Level (Gauge)	0 - 100	%	0 - 6(0 - 100%)	m	H,L	H,M1,M2,L	1	-	1	Level Gauge (Diaphragm)
21	CIP Pump discharge(pH)	0 - 14		0 - 14		H,L		1	-	1	pH measurement
22	CIP Pump discharge (Pressure)	0 - 2.5	kg/cm^2	0 - 2.5	kg/cm^2	H		2	-	2	Diaphragm
23	CIP Pump discharge header(Pressure)	0 - 4	kg/cm^2	0 - 4	kg/cm^2	H		1	-	1	Transmitter(Diaphragm)
24	RO Booster Pump (Pressure)	0 - 50	kg/cm^2	0 - 50	kg/cm^2	H		16	1	17	Diaphragm
25	RO Flushing Pump discharge header (Flow)	0 - 21,500	m^3/h	0 - 21,500	m^3/h	H		1	-	1	Electromagnetic Flow meter
26	RO Flushing Pump discharge (Pressure)	0 - 2.5	kg/cm^2	0 - 2.5	kg/cm^2	H		1	-	1	Diaphragm
27	RO Flushing Pump discharge (Pressure)	0 - 4	kg/cm^2	0 - 4	kg/cm^2	H		1	-	1	Transmitter(Diaphragm)
28	RO Permeate Water Pump (Pressure)	0 - 5	kg/cm^2	0 - 5	kg/cm^2	H		16	1	17	Diaphragm
29	RO Permeate Outlet (Conductivity)	0 - 10,000	mS/cm	0 - 10,000	mS/cm	H		16	1	17	Conductivity measurement
30	RO Permeate Outlet (pH)	0 - 14		0 - 14		H		16	1	17	pH measurement
31	RO Permeate Outlet (Flow)	0 - 21,500	m^3/h	0 - 21,500	m^3/h			16	1	17	Electromagnetic Flow meter
32	RO Brine reject	0 - 55	kg/cm^2	0 - 55	kg/cm^2			16	1	17	Transmitter(Diaphragm)
33	RO Brine reject	-1 - +1	kg/cm^2	-1 - +1	kg/cm^2			16	1	17	Pressure switch
34	RO feed	0 - 75	kg/cm^2	0 - 75	kg/cm^2			16	1	17	Transmitter(Diaphragm)
35	RO feed	-1 - +1	kg/cm^2	-1 - +1	kg/cm^2			16	1	17	Pressure switch

Ⅳ POST TREATNENT

No.	Equipment name	Range	Units	Range(select)	Units	Alarm	Control	Number			Model
								Duty	Standby	Total	
1	Lime Filter Outlet (pH)	0 - 14		0 - 14		H,L		2	-	2	pH measurement
2	Lime Filter Inlet (Flow)	0 - 500	m^3/h	0 - 500	m^3/h			2	-	2	Electromagnetic Flow meter
3	Lime Filter Backwash Water (Flow)	0 - 10	m^3/min	0 - 10	m^3/min	H		2	-	2	Electromagnetic Flow meter
4	Lime Filter Backwash Blower (Pressure)	0 - 6	kg/cm^2	0 - 6	kg/cm^2	H		4	-	4	Bourdon
5	Backwash (Pressure)	0 - 6	kg/cm^2	0 - 6	kg/cm^2	H		4	-	4	Diaphragm
6	Instrument Air System (Temperature)	0 - 60	deg C	0 - 60	deg C	H		2	-	2	Temperature Gauge
7	Instrument Air System (Pressure)	0 - 10	kg/cm^2	0 - 10	kg/cm^2	H		2	-	2	Bourdon
8	Instrument Air System (Pressure)	0 - 7.5	kg/cm^2	0 - 7.5	kg/cm^2	H		2	-	2	Pressure switch

Ⅴ WATER STRAGE AND TRANSFER

No.	Equipment name	Range	Units	Range(select)	Units	Alarm	Control	Number			Model
								Duty	Standby	Total	
1	Portable Water Tank (Ultrasonic)	0 - 5,000	mm	0 - 5,000	mm	H,L	H,M,L	2	-	2	Level sensor
2	Portable Water Tank (Float)	0 - 5,000	mm	0 - 5,000	mm	H,L	H,M,L	2	-	2	Level sensor
3	Product Water Tank (Ultrasonic)	0 - 20,000	mm	0 - 20,000	mm	H	H,M,L	2	-	2	Level sensor
4	Product Water Tank (Float)	0 - 20,000	mm	0 - 20,000	mm	H	H,M,L	2	-	2	Level sensor
5	Portable Water Tank (PH)	0 - 14		0 - 14		H,L		2	-	2	pH measurement

Source: JICA Study Team

Appendix 6.6 Equipment List for the Perur DSP

Ⅰ SEA WATER INTAKE 1,080 MLD

No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number Duty	Number Standby	Number Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
1	Intake terminal	1,080	MLD	22,500	m^3/hr	-	-	2		2									
2	Intake Pipe	1,080	MLD	1.38	m/s			2		2							HDPE Pipe,6.4bar	φ 2,400(I.D), φ 2,500(O.D)×2lines	HDPE PE-100 6.4bar
3	Stop log for intake pipe inlet	1,080	MLD	2,500	m^3/hr			18		18							Split type	Split type	CS+TarEpoxy
4	Trash rack	1,080	MLD	11,250	m^3/hr		1.5	4		4	6	24	85%	100%	122.40	5.10	Bar Screen	Bar Screen+rake	SUS316L Ti
5	Trash rack garbage machine						1.5	4		4	6	12	85%	100%	61.20	5.10			SUS316L Ti
6	Travelling Band Screen	1,080	MLD	11,250	m^3/hr	-	5.5	4		4	22	24	85%	100%	448.80	18.70	Band Screen	Mesh : 3mm,Wash Water : 15-20L/s each, 2in-1out	SUS316L Ti + Nylon
7	Screen Back Wash Pump			0.45	m^3/min	10	15	1	1	2	15	12	85%	100%	153.00	12.75	Centrifuge Pump		Super Duplex
8	Intake Pump	1,080	MLD	11,250	m^3/hr	25	1000	4	2	6	4,000	24	92%	100%	88,275.86	3,678.16	Virtical Turbin Pump		GFRPP
9	Shock Dosing Pump (NaClO)	3.8	m3/d	1,900.0	L/hr	30	3.7	2	1	3	7	1	85%	100%	6.29	6.29	Chemical Pump	Dose rate:10mg/l	Ti
															89,067.55	3,726.10			

Ⅱ CHEMICAL DOSING SYSTEM 1,077 MLD

No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number Duty	Number Standby	Number Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
1	Dosing Tank (H_2SO_4)	292.7	m^3	100	m^3	-	-	3		3								14days each,Concentration:98%	FRP
2	Dosing Pump (H_2SO_4)	20,905	L/d	217.8	L/hr	30	0.4	4	4	8	2	24	85%	100%	32.64	1.36	Chemical Pump	Dose rate:35mg/l	SUS316
3	Dosing Tank (NaOH)	106	m^3	60	m^3	-	-	2		2								14days,Concentration:50%	SUS316
4	Dosing Pump (NaOH)	7,582	L/d	79.0	L/hr	30	0.4	4	4	8	2	20	85%	100%	27.20	1.36	Chemical Pump	Coagulation/Flocculation pH:6.8,Concentration:50%	SUS316
5	Dosing Tank ($FeCl_3$)	922.70	m^3	100	m^3	-	-	10		10								14days,Concentration:40%	FRP
6	Dosing Pump ($FeCl_3$)(For Lamella)	47,072	L/d	82.0	L/hr	30	0.4	24	12	36	10	24	85%	100%	195.84	8.16	Chemical Pump	Dose rate:Max25mg/l,Concentration:40%	SUS316
7	Dosing Pump ($FeCl_3$)(For DAF)	18,829	L/d	25.0	L/hr	30	0.4	32	16	48	13	24	85%	100%	261.12	10.88	Chemical Pump	Dose rate:Max10mg/l,Concentration:40%	SUS316
8	Dosing System (Polymer)(For Lamella)	269,250	L/d	468	L/hr	30	11	24	12	36	264	24	85%	100%	5,385.60	224.40		Dose rate:0.1-0.5mg/l,Concentration:0.2%	SUS316
9	Dosing System (Polymer)(For DAF)	161,550	L/d	210	L/hr	30	7.5	32	16	48	240	24	85%	100%	4,896.00	204.00		Dose rate:0.1-0.3mg/l,Concentration:0.2%	SUS316
10	Dosing Tank (SBS)	787.7	m^3	100	m^3	-	-	8		8								14Days,,Concentration:40%	FRP
11	Dosing Tank Mixer (SBS)	150	s^{-1}	100-150	s^{-1}	-	15	8		8	120	12	85%	100%	1,224.00	102.00	Agitator	50Hz	SUS316
12	Dosing Pump (SBS)	60.3	L/d	0.2	L/hr	30	0.4	16	9	25	6	24	85%	100%	130.56	5.44	Chemical Pump	50Hz	SUS316
13	Dosing Tank (Anti Scalant)	36.6	m^3	20	m^3	-	-	2		2								14days,Dose rate:1.0mg/l,Concentration:35%	FRP
14	Dosing Tank Mixer (Anti Scalant)	150	s^{-1}	100-150	s^{-1}	-	5.5	2		2	11	12	85%	100%	112.20	9.35	Agitator	50Hz	SUS316
15	Dosing Pump (Anti Scalant)	2.6	L/d	0.1	L/hr	30	0.4	16	9	25	6	24	85%	100%	130.56	5.44	Chemical Pump	Dose rate:0.7mg/l	SUS316
16	Dosing Tank (NaClO)	616	m^3	80	m^3	-		8		8								14days,Sodium hypochlorite,Concentration:10%	FRP+PVC
17	Dosing Pump (NaClO)	44.6	m3/d	464.6	L/hr	10	0.4	4	2	6	2	24	85%	100%	32.64	1.36	Chemical Pump	Dose rateMax4.:5mg/l	Ti
															12,395.72	572.39			

Ⅲ PRETREATMENT SYSTEM 1,077 MLD

No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number Duty	Number Standby	Number Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
1	Coagulation Tank	12.00	m^2	12.25	m^2			4		4								3.5m×3.5m×7.0m	Concreat+epoxy coating
2	Flash Mixer(Coagulation)/Rapid Mixer	1,500	s^{-1}	Minimum 700	s^{-1}	-	37	4		4	148	24	90%	100%	3,196.80	133.20		25sec,Velocity Gradient:600,0.00103N.s/m2	SUS316L+HRL
3	Flocculator	12.00	m^2	12.78	m^2	-	-	96		96								Detention time:10minuts(minimum),3.5m×3.65m×7.0m	Concreat+epoxy coating
4	Stage-1 Mixer	100	s^{-1}	70-100	s^{-1}	-	2.2	48		48	106	24	90%	100%	2,280.96	95.04	Agitator:88.7m3	Velocity Gradient:70,0.00103N.s/m2	SUS316L+HRL
5	Stage-2 Mixer	50	s^{-1}	30-50	s^{-1}	-	3.7	48		48	178	24	90%	100%	3,836.16	159.84	Agitator:88.7m3	Velocity Gradient:30,0.00103N.s/m2	SUS316L+HRL
6	Lamella Clarifier(Gravity settler)	1,077	MLD	1,870	m^3/hr			24		24								Area required/unit:1,514.17m2,18m×7.8m×24	Concreat+epoxy coating
7	Sludge Scraper(for Lamella filter)					-	3.7	24		24	89	24	90%	100%	1,918.08	79.92		Circumferetial verocity 3m/min(Max)	SUS316
8	Sludge Mixer						5.5	4		4	22	24	90%	100%	475.20	19.80			SUS316L+HRL
9	Dissolved Air Flotation(DAF) System																	15m×6.7m×6.5m	Concreat+epoxy coating
10	Flash Mixer for DAF	36.74	m^2	38.44	m^2		37	8		8	296	24	90%	100%	6,393.60	266.40		30sec,6.2m×6.2m×5.0m	Concreat+epoxy coating
11	Flocculatar for DAF	45.92	m^2	48.24	m^2			128		128								10min,7.2m×6.7m×5.0m	Concreat+epoxy coating
12	Stage-1 Mixer	70	s^{-1}	70-100	s^{-1}		11	64		64	704	24	90%	100%	15,206.40	633.60	Agitator:153.6m3	Velocity Gradient:70,0.00103N.s/m2	SUS316L+HRL
13	Stage-2 Mixer	50	s^{-1}	30-50	s^{-1}		15	64		64	960	24	90%	100%	20,736.00	864.00	Agitator:153.6m3	Velocity Gradient:30,0.00103N.s/m2	SUS316L+HRL
14	DAF	1,058	MLD	502.5	m^3	-	-	32		32								Area:100.5m^2,Loading:15.0m/hr	Concreat+epoxy coating
15	DAF Recirculation Pump	126.96	MLD	165.4	m^3/hr	30	22	32	32	64	704	24	93%	100%	15,769.60	657.07		12%Recycle	Super Duplex
16	Air Compressor			6.96	l/min		22	4	2	6	88	24	85%	100%	1,795.20	74.80			
17	Sludge Scraper(for DAF)					-	11	32		32	352	24	85%	100%	7,180.80	299.20		Circumferetial verocity 3m/min(Max)	SUS316
18	Dual Media Gravity Filters	37	MLD	132.6	m^2	-	-	40		40								Verocity:8m/hr, Filler:Sand-Anthracite,16.2m×8.5m×	Concreat+epoxy coating
19	Backwash tank			1,300	m^3			2		2								13min	Concreat+epoxy coating
20	Backwash Pump	6,000	m^3/hr	100.0	m^3/min	8	190	1	1	2	220	4.5	95%	100%	942.86	209.52	Centrifuge Pump	40m/h,10min	Super Duplex
21	Air scouring Blower	9,280	Nm^3/hr	154.7	Nm^3/min	6	280	2	2	4	560	4.5	85%	100%	2,142.00	476.00	Rotary twin	70m/h,10min	FC250
22	Waste water tank	4,550	m^3	4,550	m^3			1	1	2									Concreat+epoxy coating
23	Waste Disposal Pump	5,600	m^3/hr	2,800	m^3/hr	20	200	2	2	4	400	24	93%	100%	8,930.23	372.09	Centrifuge Pump		SUS316
															90,803.89	4,340.48			

Ⅳ REVERSE OSMOSIS PLANT 869.6 MLD

No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number: Duty	Number: Standby	Number: Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
1	Filtered seawater Storage Tank	6,039	m^3	3,000	m^3	-	-	2		2								10min	
2	RO Filtered Water Pump	400	MLD	1,042	m^3/hr	150	620	16	1	17	9,920	24	88%	100%	208,320.00	8,680.00	Centrifuge Pump	Inverter Motor	Super Duplex
3	ERD Filtered Water Pump	470	MLD	1,223	m^3/hr	50	230	16	1	17	3,680	24	92%	100%	81,213.79	3,383.91	Centrifuge Pump	Inverter Motor	Super Duplex
4	ERD Recycle Booster Pump	470	MLD	1,223	m^3/hr	50	230	16	1	17	3,680	24	92%	100%	81,213.79	3,383.91	Centrifuge Pump	Inverter Motor	Super Duplex
5	Cartridge Filter(For HPP)	400	MLD	277	m^3/min	-	-	32	2	34									ERP,PP
6	Cartridge Filter(for ERD)	470	MLD	326	m^3/min	-	-	32	2	34									ERP,PP
7	RO High Pressure Pump	400	MLD	1,042	m^3/hr	560	2,150	16	1	17	34,400	24	93%	100%	768,000.00	32,000.00	HPP	Fixed Motor	
8	Seawater Reverse Osmosis(SWRO)	25	MLD/train	13.5	l/m2/h	-	-	16	1	17							8 inch spiral	Flax:13.5l/m2/h,2,128membranes(133membranes/train)	
9	Energy Recovery System(ERD) In case of DeROs	474	MLD	29.625	MLD	-	-	16	1	17								1uits/system	Piston type
10	Crane	15	ton	15	ton		7.5	2		2	15	1	85%	100%	12.75	12.75			
11	RO CIP Pump	1,250	m^3/hr	1,250	m^3/hr	60	260	5	1	6	1,300	12	91%	100%	14,181.82	1,181.82	Centrifuge Pump		SUS316
12	CIP Cartridge Filter	900	m^3/hr			-	-	2		2									ERP,PP
13	Flushing tank	800	m^3	800	m^3			1		1									Concreat+epoxy coating
14	Flushing Pump	1,063	m^3/hr	17.7	m^3/min	30	120	2	2	4	240	2	94%	100%	451.76	225.88	Centrifuge Pump		SUS316
15	Chemical Cleaning Tank	60	m^3	60	m^3	-	-	2		2									FRP
16	Chemical Cleaning Tank Mixer	60	m^3	60	m^3	-	15	2		2	30	1	80%	100%	24.00	24.00			SUS316
17	Chemical Cleaning Pump	1,800	m^3/hr	1,800	m^3/hr	45	290	1	1	2	290	2	93%	100%	539.53	269.77	Chemical Pump		
18	Plant Air Compressor	330	Nm3/hr	330	Nm3/hr	70	180	3	1	4	540	8	90%	100%	3,888.00	486.00			
19	Air Tank	11	m^3	11	m^3	-	-	3		3									
20	Air prefilter,dryer,filter	330	Nm3/hr	330	Nm3/hr		3.7	3	1	4	11	8	85%	100%	75.48	9.44			
21	Cooling water tank	34	m^3	34	m^3			2		2									
22	Cooling water pump	200	m3/hr	200	m3/hr	40	37	2	1	3	74	1	85%	100%	62.90	62.90			
23	Cooling tower	1	MMcl/h	1	MMcl/h		5.5	2	1	3									FRP
24	Pressurized Service Water System					-	30	12	6	18	360	12	85%	100%	3,672.00	306.00			
25	Permeat Water Pump	25,008	m^3/d	1,042	m^3/hr	25	100	16	1	17	1,600	24	86%	100%	33,185.19	1,382.72	Centrifuge Pump		SUS316
															1,194,841.01	51,409.10			

Ⅴ POST TREATMENT 400 MLD

No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number: Duty	Number: Standby	Number: Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
1	Lime Stone Filter Feed Pump	120,000	m^3/d	625	m^3/hr	25	60	8	2	10	480	24	98%	100%	11,239.02	468.29	Centrifuge Pump		SUS316
2	Lime Stone Filter	120,000	m^3/day	5,000	m^3/hr	-		16	4	20								LV=25m/hr, φ 4.4m(15.2m2)×4.9mH (4.3m)	SUS316
3	Degassing Air Blower	4,188	m^3/hr	69.8	m^3/min	228mmAq	5.5	2	2	4	11	0.2	85%	100%	1.87	9.35	Rotary twin		FC250
4	Degassing Tower	1,360	m^3/hr	80	m^3			4		4								φ 3.7m(10.7m2)×7.5mH,Air:1,094m3/hr,Water:2,094m3/hr	SUS316
5	Air scouring Blower	911	m^3/hr	15.2	m^3/min	5500mmAq	22	4	2	6	88	24	85%	100%	1,795.20	74.80	Rotary twin		FC250
6	Lime Stone unloading system	150	m^3/hr	150	m^3/hr	-	15	1		1	15	24	85%	100%	306.00	12.75	Screw Pump		SUS316
7	Lime Stone Recharging system	135	m^3/hr	135	m^3/hr	80	45	2		2	90	24	85%	100%	1,836.00	76.50	Screw Conveyor		SUS316
8	Backwash Waste tunk	190	m^3	190	m^3			1		1									CS+epoxy coating
9	Waste Disposal Pump	190	m^3/hr	190	m^3/hr	15	15	1	1	2	15	24	85%	100%	306.00	12.75	Screw Pump		SUS316
10	Process Water Pump	50	m^3/hr	50	m^3/hr	40	11	1	1	2	11	24	91%	100%	240.00	10.00	Centrifuge Pump		SUS316
11	Carbon Dioxide Plant	18,000	kg/day	750	kg/hr	-	30	2		2	60	24	85%	100%	1,224.00	51.00		Dose rate:Max:90mg/L,Ave:60mg/L	
12	Carbon Dioxide Storage	300	kg	11	ton	-	-	2		2								Number of Vessels:10	
13	Chlorine Gas flow	255	kg/day	11	kg/hr	-	-											Dose rate:Maximam:5mg/L,Average:2mg/L	
14	Chlorine Container			900	kg	-	-	1		1									
15	Chlorine Gus Drum	900	kg	300	kg	-	-	4		4								Strage Period:20days	
16	Chlorine Crane						75	4		4	300	1	90%	100%	270.00	270.00			
17	Chlorine Evaporator						22	7		7	154	24	90%	100%	3,326.40	138.60			
18	Carbon Dioxide absorber	750	m^3/hr	750	m^3/hr	-	-	2		2								Number of Vessels:10	
19	Recorbonation Tower Feed Pump	2,100	m^3/hr	2,100	m^3/hr	20	160	6	2	8	960	24	88%	100%	20,160.00	840.00	Centrifuge Pump		SUS316
															40,704.49	1,964.04			

Ⅵ Water Storage and Transfer 400 MLD

No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number: Duty	Number: Standby	Number: Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
1	Potable Water Tank	3,000	m^3	1,500		-	-	2		2								10min	Concreat+epoxy coating
2	Product Water Tank	36,000	m^3	9,000	m^3			4		4								2hr	CS+epoxy coating
3	Potable Water Delivery Pump	400	MLD	4,167	m^3/hr	77.8	1200	4	2	6	4,800	24	88%	100%	100,800.00	4,200.00	Centrifuge Pump		SUS316
4	Crane	10	ton	10	ton		5.5	2		2	11	1	80%	100%	8.80	8.80			
5	Dosing Tank (NaClO)	69.5	m^3	40.0	m^3	-		2		2								14days,Sodium hypochlorite,Concentration:10%	FRP+PVC
6	Dosing Pump (NaClO)	5.0	m3/d	25.9	L/hr	20	0.4	8	2	10	3	24	85%	100%	65.28	2.72	Chemical Pump	Dose rate:Max1.5mg/l	Ti
															100,874.08	4,211.52			

Ⅶ SeaWater Outfall 680.0 MLD

	No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number: Duty	Number: Standby	Number: Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
	1	Discharge Pipe	680	MLD	1.74	m/s	-	-	1		1							HDPE Pipe,6.4bar	φ 2,400(I.D), φ 2,500(O.D)×1lines	HDPE PE-100 6.4bar
	2	Discharge Tower	680	MLD					1		1									
	3	Cartodic protection							1		1	5.5	24	85%	100%	112.20	4.68			
																112.20	4.68			

Ⅷ Facility Power 400.0 MLD

	No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number: Duty	Number: Standby	Number: Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
	1	Facility							1		1	700	24	80%	100%	13,440.00	560.00			
	2	Lighting, Other Item							1		1	500	24	75%	100%	9,000.00	375.00			
																22,440.00	935.00			

Ⅸ Margin 400.0 MLD

	No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number: Duty	Number: Standby	Number: Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
	1	Margin														46,537.17	6,716.33			
																46,537.17	6,716.33			
Total																1,597,776.11	73,879.64			

400.00 MLD	
3,994.44 kW/MLD	
3.99 kW/m3	

400.00 MLD	
3,742.26 kW/MLD	Out of Transfer facility
3.74 kW/m3	

Source; JICA Study Team

Appendix 6.7 Conceptual Diagrams of Direct and Indirect Seawater Intake Methods and Types

<table>
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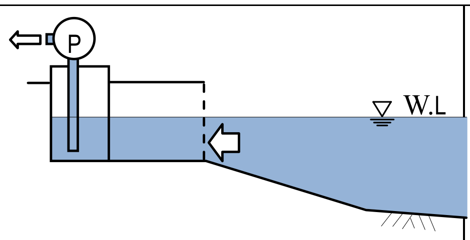
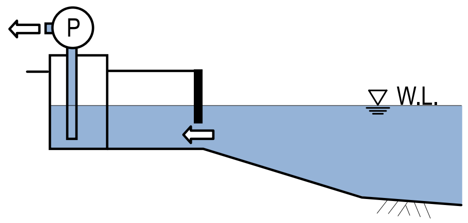
<tr><td>A. Surface water intake system</td><td>
</td><td>
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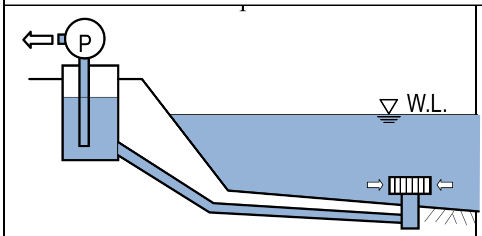
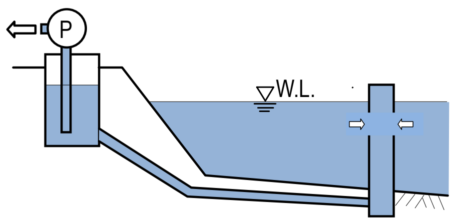
<tr><td>Intake type</td><td>A1. Onshore direct</td><td>A2. Onshore selective</td></tr>
<tr><td></td><td colspan="2">Offshore intake</td></tr>
<tr><td>B. Deep water intake system</td><td>
</td><td>
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<tr><td>Intake type</td><td>B1.Velocity cap</td><td>B2. Tower</td></tr>
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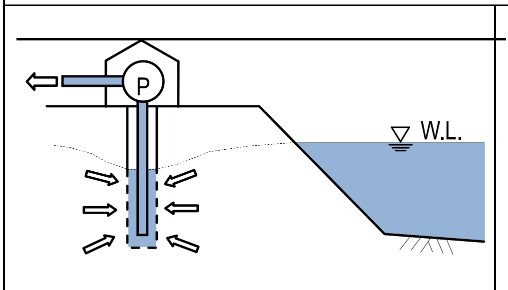
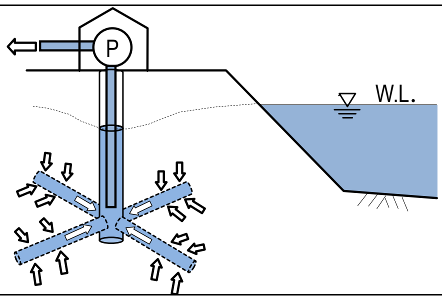
<tr><td>C. Beach well system</td><td>
</td><td>
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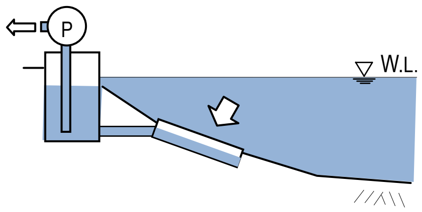
<tr><td>Intake type</td><td>C1. Vertical beach well</td><td>C2. Horizontal collector well</td></tr>
<tr><td>C. Beach well system</td><td>
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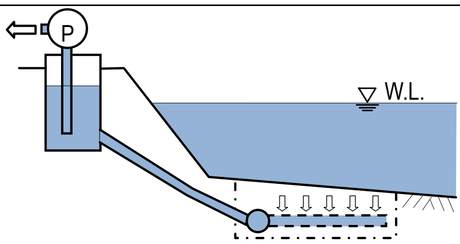
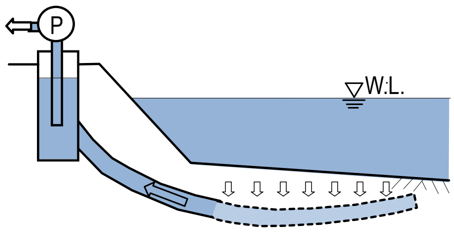
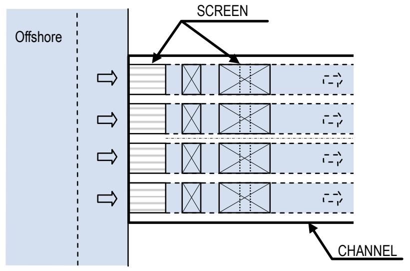
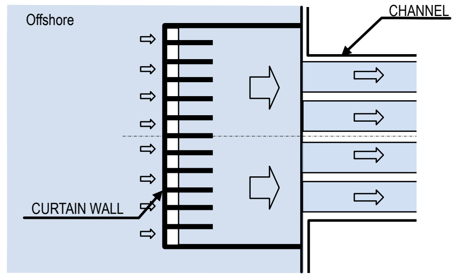
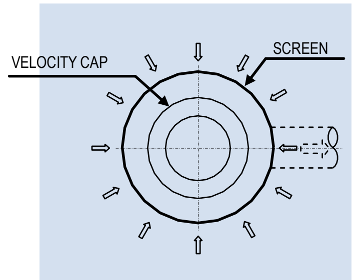
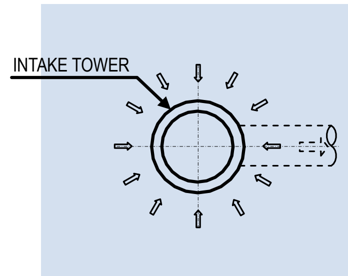
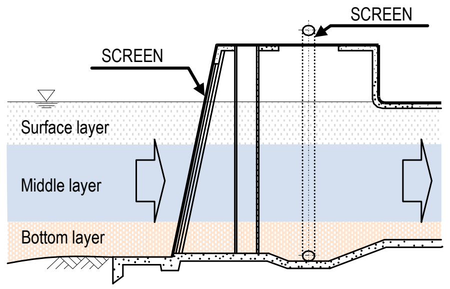
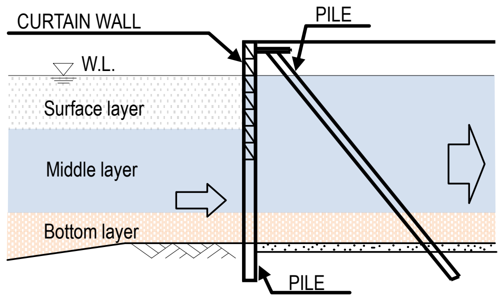
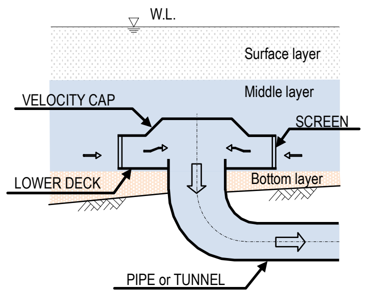
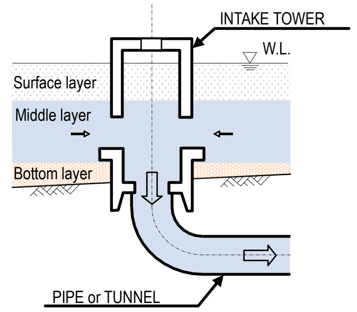
<tr><td></td><td>C3. High-speed Seabed Infiltration (HiSIS)</td><td></td></tr>
<tr><td rowspan="2">D. Seabed filtration system</td><td colspan="2">Offshore intake</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Intake type</td><td>D1. Seabed filtration gallery</td><td>D2. Horizontal wells with directionally drilled (HDD) collectors</td></tr>
</table>

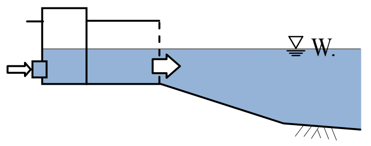
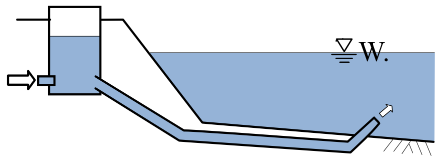
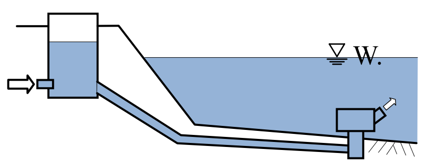
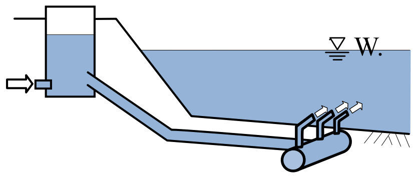
Source: JICA Study Team

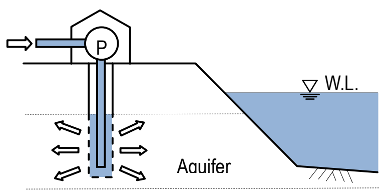
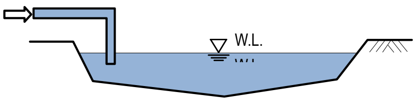
Appendix 6.8 Alternative Study on Direct intake type

Systems		A. Surface water intake				B. Deep water intake			
Types		A1. Onshore direct		A2. Onshore selective		B1. Velocity cap		B2. Tower	
Schematic illustration	Plan								
	Profile								
Description		It is the simplest type in the direct intake system. It is suitable to be built at the shore where the water depth is comparatively deeper in front of the shore. Its structure is made of marine concrete.		It is a selective intake type, which is the onshore direct type with the curtain wall. It is suitable to be built at the shore where the water depth is comparatively deeper in front of the shore line. Its structure is made of piles such as H-shaped steels and/or steel pipes are driven on the seabed in front of shore line, and the panels are set up like a curtain.		It is a selective intake type at offshore. It is suitable to be built at the offshore (deeper than -5.0m) The seawater is withdrawn horizontally through the screen between the velocity cap and lower deck. Withdrawn seawater is conveyed from the velocity cap to the intake pit via the pipeline/tunnel. The structure is made of steel, concrete or hybrid of steel and concrete.		It is a selective intake type at offshore. It is suitable to be built at offshore (deeper than -5.0m)The seawater is withdrawn horizontally from the inlet opening. Withdrawn seawater is conveyed from the intake tower to the Intake pit via the pipeline/tunnel. Its structure is made of concrete typically. The structure is made of concrete.	
Characteristics	Applicable flow rate	Regardless of the flow rate.	a	Regardless of the flow rate.	a	Regardless of the flow rate	a	It is effective in relatively larger flow rate.	a
	Footprint of the construction area	Larger in proportion to the flow rate.	b	Larger in proportion to the flow rate.	b	No significant change regardless of flow rate	a	No significant change regardless of flow rate.	a
	Selective intake	No selectable: The inflow of the surface and bottom water cannot be avoided.	c	The inflow of the bottom water cannot be avoided.	b	Selectable	a	Selectable.	a
	Wave protection	Necessary because of high wave height in Indian ocean which makes impact on the structure.	c	Unnecessary Unless the curtain wall has adequate strength by wave.	b	It is unnecessary.	a	It is largely affected by waves.	c
	Floating matter	The floating matter stagnate around and frontage of the screen. Most floating matter will be removed by screen.	b	The floating matter stagnate around and frontage of the curtain wall. Floating matter through the curtain wall will be removed by screen in the intake pit.	b	The floating matters do not stagnate and are not suctioned because of opening the sea area on the intake head.	a	The floating matter do not stagnate and are not suctioned because of opening the sea area on the intake tower.	a
	Spilled oil	If oil is spilled around the intake area, this intake type cannot avoid the inlet of spilled oil. It is necessary to set the oil fence in front of the screen quickly.	c	If oil is spilled around the intake area, this intake type can avoid the inlet of spilled oil for a certain time. It is necessary to set the oil fence in front of the curtain wall.	b	If oil is spilled around the intake area, this intake type can avoid the inlet of spilled oil for a certain time.	b	If oil is spilled around the intake area, this intake type can avoid the inlet of spilled oil for a certain time.	b
	Environmental impact	Major impact on natural coastline.	c	Major impact on natural coastline.	c	Minor impact on the coastline during construction and none after construction.	a	Minor impact on the coastline during construction and none after construction.	b
	Maintainability	Almost maintenance can be worked on land.	a	Almost maintenance can be worked on land. The curtain wall in water will be maintained by divers.	b	Almost maintenances are worked by divers.	c	Almost maintenances are worked by divers.	c
	Construction cost	The cost will become expensive due to dredging work because the depth in front of this project site is shallow. The cost will become expensive because intake requires protection against waves and turbidity.	c	Almost same as "A1. Onshore direct" type. The construction cost of curtain wall will become expensive.	c	Almost work are worked at offshore (Crane on barge, barges, divers, etc.). In case of buried pipeline, temporary cofferdam will be built at around shoreline for connection between on land and offshore pipeline.	c	Expensive: Same as the velocity cap type. In case of tunnel, start and arrival shaft for drilling machine will be built at on land and offshore.	c
Selection		a x 2, b x 2, c x 5		a x 1, b x 6, c x 2		a x 6, b x 1, c x 2		a x 4, b x 2, c x 3	
						Recommended			

Source; JICA Study Team a="Excellent," b="Good", c="Fair"

Appendix 6.9 Conceptual Diagrams of Direct and Indirect Discharge Systems and Types

A. Surface water discharge system	Onshore discharge	Offshore discharge
		
Discharge type	A1. Onshore direct	B1. Single-nozzle
B. Deep water discharge system	Offshore discharge	
		
Discharge type	B2. Multi-nozzle	B3. Port raiser

Type	Onshore discharge		
C. Deep well		D. Pond	 Evaporation ponds
Discharge type	C1. Deep well ex-filtration	Discharge type	D1. Evaporation ponds

Source; JICA Study Team

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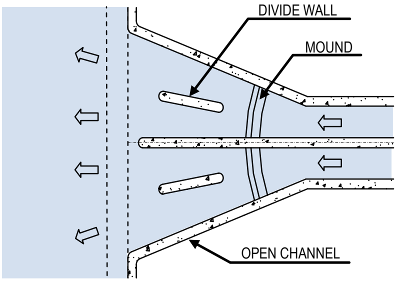
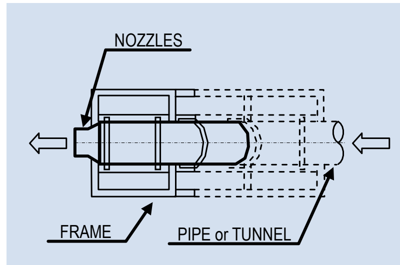
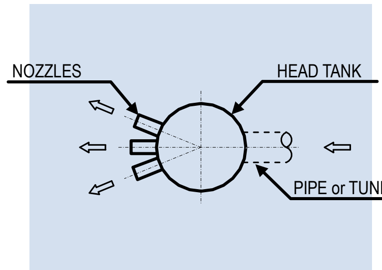
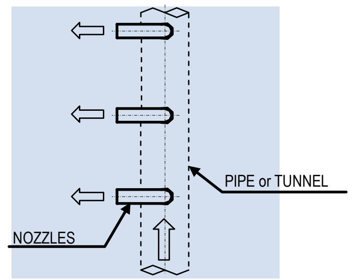
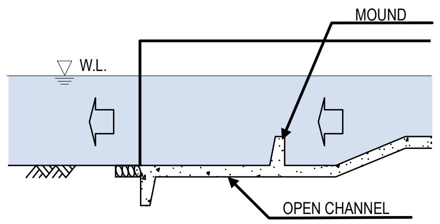
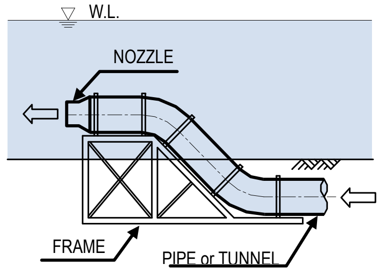
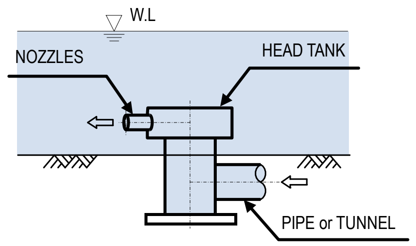
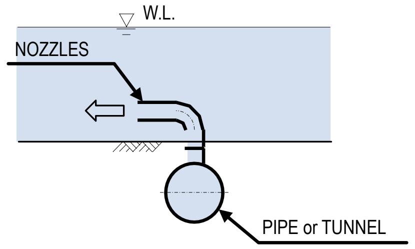
Appendix 6.10 Alternative study on direct discharge type

Systems		A. Surface water discharge		B. Deep water discharge					
Types		A1. Onshore direct (Open channel)		B1. Single-nozzle		B2. Multi-nozzles		B3. Port risers	
Schematic illustration	Plan								
	Profile								
Description		It is the simplest type in the direct discharge systems. It is suitable to be built at the shore where the water depth is comparatively deeper in front of the shore. Its structure is made of concrete which uses shore.		It is the simplest type in the offshore discharge systems. Its structure is made of steel, concrete, HDPE or GRP.		It is the most compact type in the offshore discharge systems. The diffusion efficiency is better than the single nozzle type in case enough water depth is secured.		It is simpler type than the multi nozzle type in the offshore discharge systems. It is designed for installation at shallow sea area. It secures the ability equivalent to the single nozzle type by adjusting of diameter and nozzle numbers and diameter at shallow sea area.	
Characteristics	Applicable flow rate	Regardless of the flow rate.	a	Regardless of the flow rate.	a	Regardless of the flow rate.	a	Regardless of the flow rate.	a
	Footprint of the construction area	Larger in proportion to flow rate.	b	Regardless of the flow rate and almost settled. (A nozzle diameter can change by the flow rate).	a	Regardless of the flow rate and almost settled. (It is an almost fixed size and the smallest)	a	The necessary footprint is increased depending on nozzle numbers.	b
	Control of surface velocity	Uncontrollable. Surface velocity is same as outlet velocity.	c	It can be controlled by adjusting of outlet velocity and vertical angle within the limit of flow rate.	b	It can be controlled by adjusting of outlet velocity, nozzle number and vertical angle.	a	It can be controlled by adjusting of outlet velocity, nozzle number, and vertical angle within the limit of flow rate.	a
	Diffusion area	The diffusion range is the largest in discharge systems due to the lowest capacity of initial mixing.	c	A larger area than other deep water discharge types.	b	The diffusion area is the narrowest by increase of number of nozzle.	a	The diffusion area is the narrowest by increase of the number of nozzles.	a
	Wave protection	Necessary because of high wave height in Indian ocean which makes impact on the structure.	b	Unnecessary.	a	Unnecessary	a	Unnecessary	a
	Environmental impact	Major impact on natural coastline.	b	Minor impact on the coastline during construction and none after construction.	a	Minor impact on the coastline during construction and none after construction.	a	Minor impact on the coastline during construction and none after construction.	a
	Impact on marine organisms	The largest impact due to the largest diffusion range.	c	Larger impact than other deep water discharge system.	b	The smallest impact because of smallest diffusion area	a	The smallest impact because of smallest diffusion area.	a
	Maintainability	Almost maintenance can be worked on land.	a	Almost maintenances are worked by divers.	c	Almost maintenances are worked by divers.	c	Almost maintenances are worked by divers.	c
	Construction cost	The cost will become expensive due to dredging work because the depth in front of this project site is shallow. The cost will become expensive because intake requires protection against waves and turbidity.	c	Almost work are worked at offshore. In case of buried pipeline, temporary cofferdam will be built at around shoreline for connection between on land and offshore pipeline	c	Almost work are worked at offshore. In case of buried pipeline, temporary cofferdam will be built at and around shoreline for connection between on land and offshore pipeline.	c	Almost all work is worked at offshore. In case of buried pipeline, temporary cofferdam will be built at and around shoreline for connection between on land and offshore pipeline.	c
Selection		a x 2, b x 3, c x 4		a x 4, b x 3, c x 2		a x 7, b x 0, c x 2		a x 6, b x 1, c x 2	
						Recommended			

Source; JICA Study Team a=”Excellent,” b=”Good”, c=”Fair”

Appendix 6.11 Study on current situation of Nemmeli DSP by water analysis

The current situation of the brine at the Nemmeli DSP is evaluated in accordance with the results of the seawater water quality survey mentioned in Chapter 6.2.1. The sampling points are shown below:

Table A6.11.1 Sampling Points

Sampling point	Location	Coordinate (UTM)	
		X	Y
Nemmeli DSP			
P1	Discharge	416699	1404348
P2	Discharge -Intake 1	416767	1404285
P3	Discharge -Intake 2	416849	1404214
P4	Discharge -Intake 3	416933	1404141
P5	Intake	417010	1404077
P6	Offshore	417085	1404008
P7	Intake chamber	—	—
Proposed Perur DSP			
P8	Discharge	417066	1405582
P9	Intake 1	417447	1405280
P10	Intake 2	417339	1405010

Source: JICA Study Team

Source: JICA Study Team using Google Earth Pro

Figure A6.11.1 Sampling points

The salinity values from P1 to P6, which are measurement points for the existing Nemmeli DSP and from P8 to P10 for the Perur DSP are shown in Table A6.11.2. As for P1 to P6, the distance between each point is approximately 100 m.

Table A6.11.2 Salinity Values at Each Measurement Point

Depth (m)	P1	P2	P3	P4	P5	P6	P8	P9	P10
1	32.86	33.11	33.28	33.28	33.07	33.27	33.34	33.34	33.31
2	32.92	33.24	33.27	33.28	33.23	33.28	33.33	33.33	33.28
3	32.97	33.23	33.29	33.28	33.29	33.27	33.29	33.29	33.32
4	33.03	33.25	33.32	33.33	33.29	33.27	33.36	33.36	33.31
5	33.10	33.31	33.32	33.32	33.33	33.33	33.43	33.43	33.33
6	33.12	33.30	33.35	33.37	33.33	33.38	33.36	33.36	33.41
7	33.25	33.32	33.29	33.40	33.40	33.42	33.46	33.46	33.43
8	33.41	33.42	33.42	33.44	33.44	33.43	33.47	33.45	33.44
9	33.95	41.56	33.42	33.44	33.46	33.44	33.48	33.45	33.44
10		41.57	34.55	33.60	33.54	33.47		33.46	33.45
11				33.61	33.55	33.55			33.46
					33.59	33.61			

Source: JICA Study Team

Pure Seawater Seawater with brine

According to the values of P8 to P10 where the impact on the brine from the Nemmeli DPS is not affected, the salinity values in this area are less than 33.5 g/L, but the values at bottom layer of P1 to P6 shows higher than others. Therefore, above table clearly indicates that the brine discharged at P1 at about 5.0 m depth flows to offing side along the sea bottom.

Regarding brine recirculation, comparing P5 where the seawater is drawn with P8 to P10 which have no impact by the brine from the Nemmeli DPS, the table shows same salinity values per depth except the values at bottom. The intake head of the Nemmeli DSP is withdrawing seawater at 7 m depth of P5 where the pure seawater is not mixed with the brine. Therefore, the recirculation of the brine has not happened at the Nemmeli DSP.

into Near-field

erent.

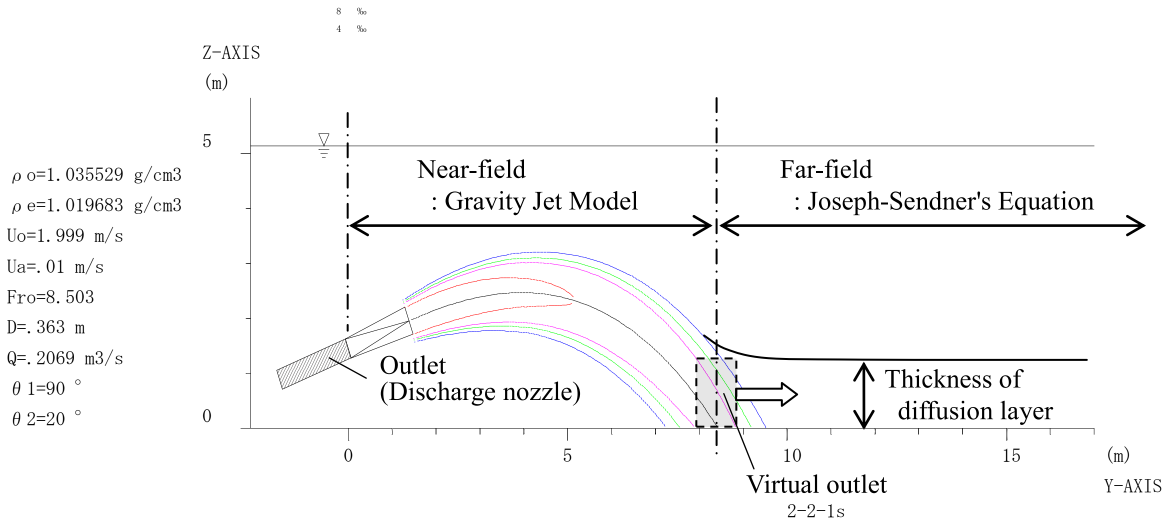


Figure A6.12.1 Cross-sectional view and distribution of discharged brine (Section distribution of brine discharge)

(1) Near-field

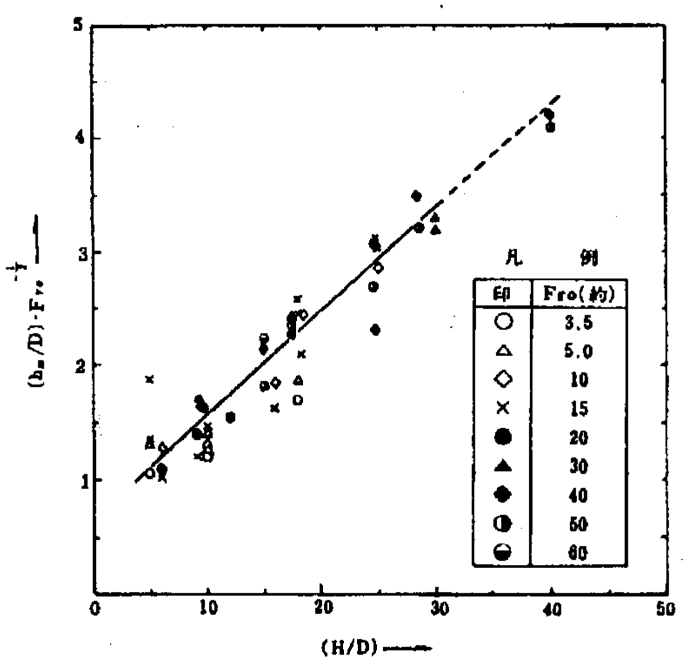
Near-field includes the area from the discharge outlet to the point where the discharged brine reaches the seabed.

The diffusion phenomenon in this area is dominant to entrainment and mixing of the brine due to the momentum.

The diffusion prediction in Near-field is implemented by Gravity Jet Model. This model can obtain the distribution data of salinity and velocity based on the conditions of the brine discharge and density.

It is prepared based on the results of hydraulic model test which cannot take into account the effects of boundaries of the surface or bottom. Therefore this model is applicable for the area, where approximately 3 times of the discharge nozzle diameter is far from the seabed. In addition, the Gravity Jet Model cannot consider interference of the brine from each nozzle. Hence, the prediction is performed for the brine from one nozzle without considering interference of the brine.

In order to decide the thickness of diffusion layer, the research results of the reference study shown in Figure A6.12.2 are referred.



h_w: Thickness of diffusion layer

D: discharge nozzle diameter

F_{ro}: Densimetric Froude number

H: discharge depth

Source: Naoaki Katano and Hiromi Kawamura, "Study on effect of reduction of water temperature in the sea by a single submerged jet for warmed cooling water", Research Report 376012(1977), Central Research Institute of Electric Power Industry in JAPAN

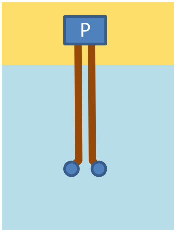
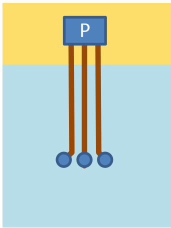
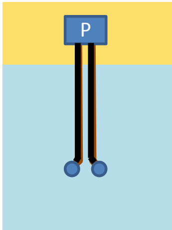
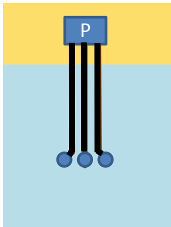
Figure A6.12.2 Thickness of diffusion layer

(2) Far-field

Far-field is defined as the outside area of Near-field. The diffusion in this area is dominant to the horizontal diffusion by current or turbulence (Note: tidal current is not taken into account for this simulation).

The Joseph-Sendner's equation is applied for this area to analyze the horizontal brine diffusion. The results of the forecast in Near-field (flow rate, salinity, thickness of the diffusion layer, etc.) are used as the input data at virtual outlet for the analysis on the horizontal brine diffusion in Far-field.

Appendix 6.13 Alternative Study on Number of Lines and Material of the Intake Pipe

Intake Pipe	No.1	No.2	No.3	No.4
Diagrams Steel pipe HDPE pipe Intake head				
Line	2 lines	3 lines	2 lines	3 lines
Material	Steel	Steel	HDPE	HDPE
Diameter (ID)	2300 mm (2100mm)	1600 mm	2300 mm (2100mm)	1600 mm
Length (tentative)	1,140 m	1,140 m	1,140 m	1,140 m
Acceptable Head Loss	3 m	3 m	3 m	3 m
Head Loss (aging) (m)	Less than 3 m	**More than 6 m**	Less than 3 m	**More than 6 m**
Water Production in operational difficulty of one intake facility	More than 200 MLD		More than 200 MLD	
Cost				
Installation and material of pipe including civil work for installation of discharge pipe — 1 m	16,480 (USD/m) (for 2 pipes)		15,980 (USD/m) (for 2 pipes)	
Installation and material of pipe including civil work for installation of discharge pipe — 1,140 m	18,780,000 (USD)		18,220,000 (USD)	
Installation and material of intake head	2,050,000 (USD) (for 2 intake heads)		2,050,000 (USD) (for 2 intake heads)	
Total	20,830,000 (USD)		20,270,000 (USD)	
Evaluation		**NG**	Recommended	**NG**

Source; JICA Study Team

Appendix 6.14 Study on surging in the intake pit

When the operation of pump is started or urgently stopped, the water level in the intake pit will be drastically decreased (called as "down-surge") or increased (called as "up-surge"). In these cases, the water level should not be reduced to the top level of intake pipe or should not exceed the level of top slab. Based on the parameters shown in Table A6.14.1, the study on the up-surge and down-surge is carried out.

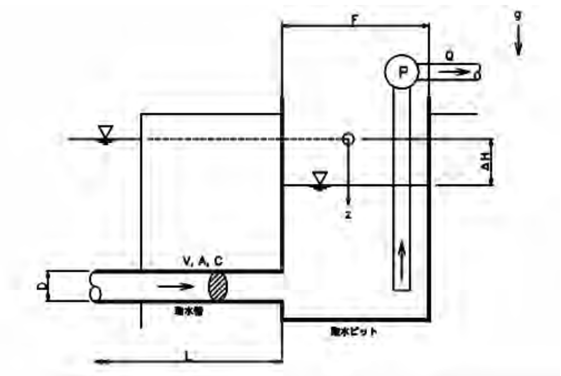
(3) Design Condition

Table A6.14.1 Design Condition for the Study on Surging

Category	Parameter	
Water volume	Volume for operation	$12.50m^3/sec$
	Volume after emergency stop	$0\ m^3/sec$
	Volume after start of operation	$12.50m^3/sec$
Water levels	LWL (for down-surge)	CD+0.04m
	HWL (for up-surge)	CD+1.57m
Intake facility	Inner diameter of intake pipe	2.83m($=2.0^2 \times \pi/4 \times 2$)
	Length of intake pipe	1110m
	Head loss of intake pipeline	3.3m
	Open area in intake pit	$800m^2$

(4) Calculation methodology

The following formula is applied to the surging analysis. Calculation is made by inputting initial value to the above mentioned basic equation (the simultaneous differentiation equation) and performing a numerical integration by the Runge-Kutta-Gill Method.



1) Equation of continuity:

$$\frac{dV}{dt} = \frac{Z - C|V||V|}{L/g}$$

2) Equation of motion:

$$\frac{dZ}{dt} = \frac{Q - A \cdot V}{F}$$

where,

V : the velocity in Intake pipeline [m/sec]

⊿H: the head loss at Intake pipeline [m]

z : the water level [m]

g: the acceleration due to gravity [m/sec2]

L: the length of Intake pipeline [m]

A: the sectional area of Intake pipe [m^2]

F: the water surface area of Intake basin [m^2]

Q: the flow rate [m^3/sec]

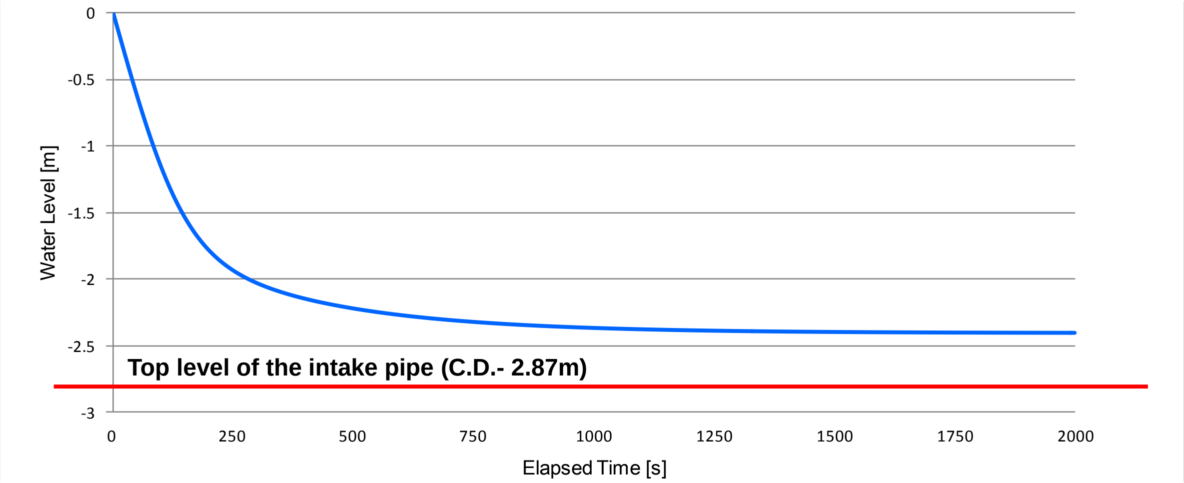
C: the loss coefficient

$$C = \Delta H / V^2$$

(5) Results of the Calculation

1) Down-surge (after the start of the pump operation)

The water level in the intake pit should be kept beyond the top level of the intake pipe in order to prevent the exposure of the intake pipe from seawater. According to Figure A6.14.1, the water level in the intake pit gradually decreases and reaches C.D. -2.365 m, and the level is higher than the top level of the intake pipe. Therefore, the result shows that the problem, resulting from the lowering of the water level, does not occur.

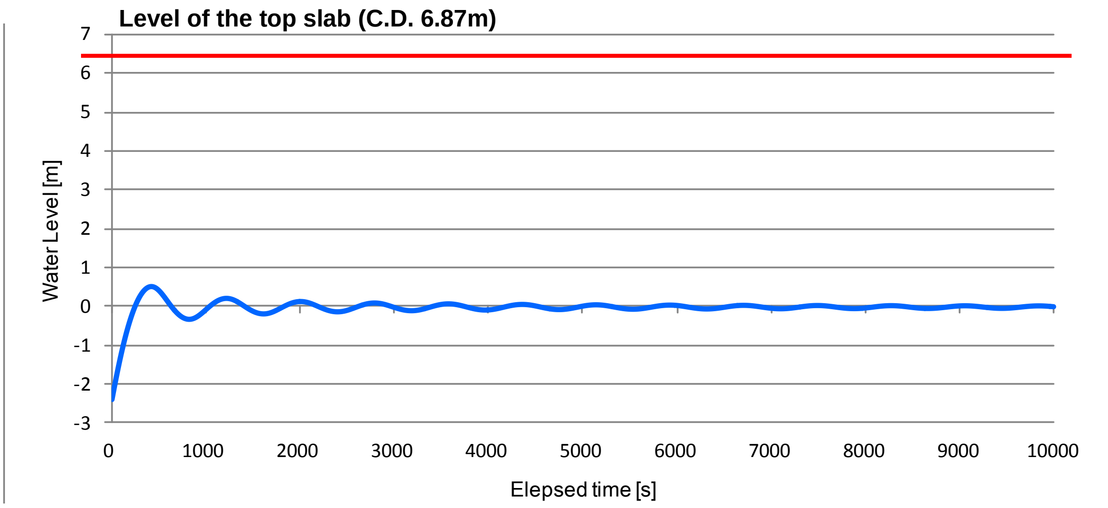


Source: JICA Study Team

Figure A6.14.1 Water Level in the Intake Pit after Start of the Operation

2) Up-surge (After the stop of pump operation)

The water level in the intake pit should be kept below the level of top slab in order to prevent the overflow of the seawater from the intake pit. Figure A6.13.2 shows that the water level quickly increases and fluctuates after the stop of the pump operation. However, the water level does not exceed C.D. 6.87 m, which is the level of the top slab. Therefore, the stop of the pump operation does not result in the overflow of the seawater from the intake pit.

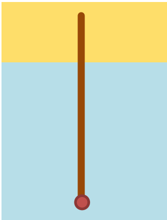
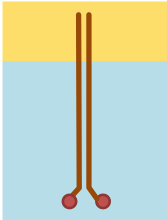
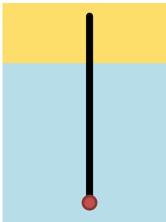
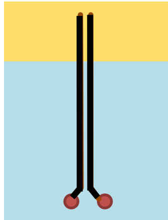


Source: JICA Study Team

Figure A6.14.2 Water Level in the Intake Pit after Start of the Operation

Therefore, as shown in the above results, the hydraulic validity of the design of the intake pit was verified.

Appendix 6.15 Alternative Study on Number of Lines and Materials of the Discharge pipe

Discharge Pipe	No.1	No.2	No.3	No.4
Diagrams Steel pipe HDPE pipe Discharge head				
Line	1 line	2 line	1 line	2 lines
Material	Steel	Steel	HDPE	HDPE
Diameter	2500 mm	1600 mm	2500 mm	1600 mm
Length (from intake head)	550 m	550 m	550 m	550 m
Acceptable Head Loss(m)	3 m	3 m	3 m	3 m
Head Loss (aging) (m)	Less than 3 m	**More than 3 m**	Less than 3 m	**More than 3 m**
Cost				
Installation and material of pipe — 1 m	9,770 (USD/m) (for 1 pipe)		9,600 (USD/m) (for 1 pipe)	
Installation and material of pipe — 550 m	5,370,000		5,270,000	
Installation and material of intake head	940,000 (USD) (for 1 intake head)		940,000 (USD) (for 1 intake head)	
Total	6,310,000		6,220,000	
		NG	Recommended	**NG**

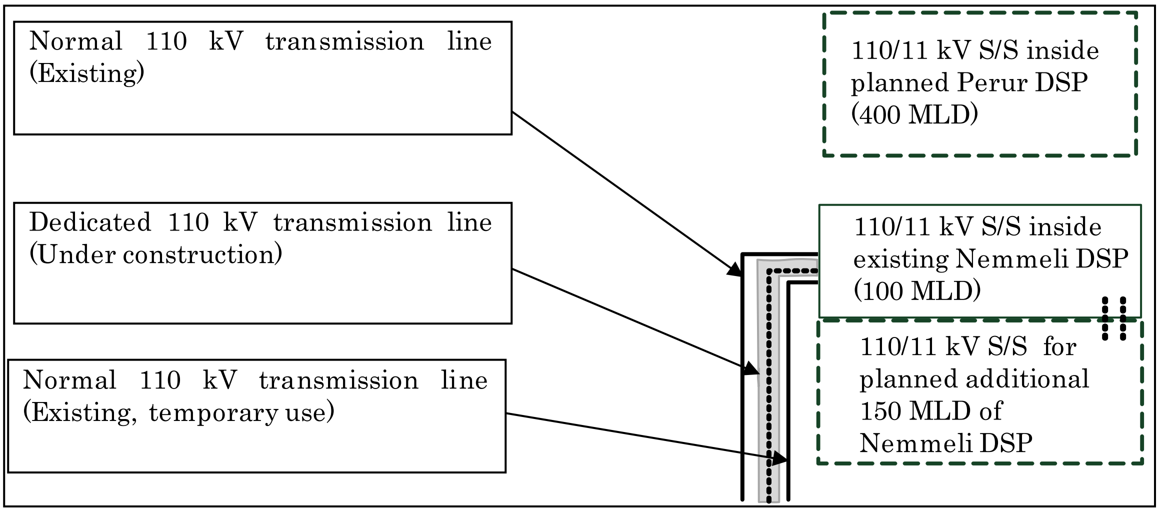
Source; JICA Study Team

Appendix 6.16 Present Situation and the Existing Plan of Power Receiving System

A6.16.1 Current Situation of the Existing Power Receiving system

The planned Perur DSP will be located 600 m north from the existing Nemmeli DSP with a capacity of 100 MLD. The existing plant has a 150 MLD expansion plan.

Figure A6.16.1 shows the existing and planned transmission lines for the Nemmeli DSP. At present, two lines of 110 kV are connected to the Nemmeli DSP. These power lines are shared with other consumers, viz. they are not dedicated lines. Currently, a dedicated power line for the DSP is under construction. One of the two existing power lines is a temporary line, which will not be used by the DSP after completion of the ongoing construction project on a dedicated line.



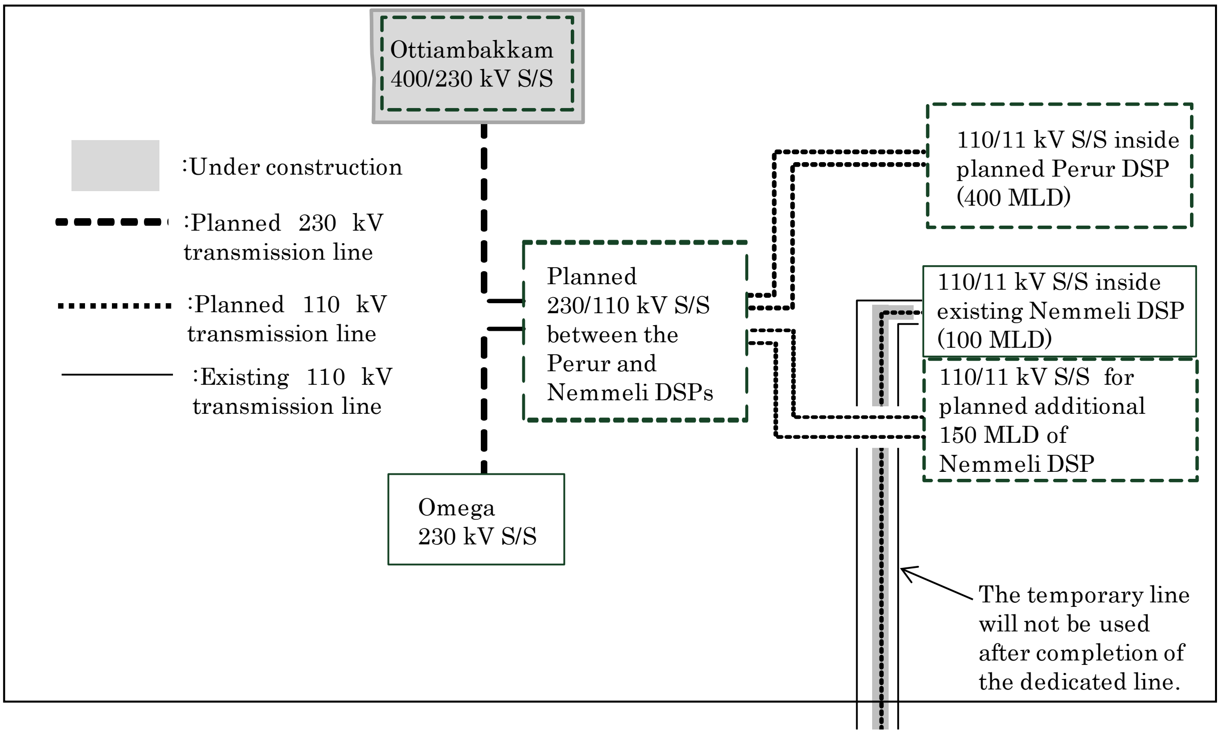
Source: JICA Study Team

Figure A6.16.1 Existing and Planned Transmission Lines for the Nemmeli DSP

A6.16.2 Original and Revised Power Receiving Plans of the DSPs including the Perur DSP

(1) Original power receiving plan:

In 2013, CMWSSB requested TNEB to provide an uninterrupted power supply of 110 MVA to the Perur DSP and the additional 150 MLD of the Nemmeli DSP. Corresponding to the request from CMWSSB, TNEB proposed a power transmission plan, where it aimed at supplying power to the two plants through two transmission lines of 230 kV including a dedicated line as shown in Figure A6.16.2.



Source: JICA Study Team

Figure A6.16.2 Original Power Receiving Plan of the Perur and Nemmeli DSPs

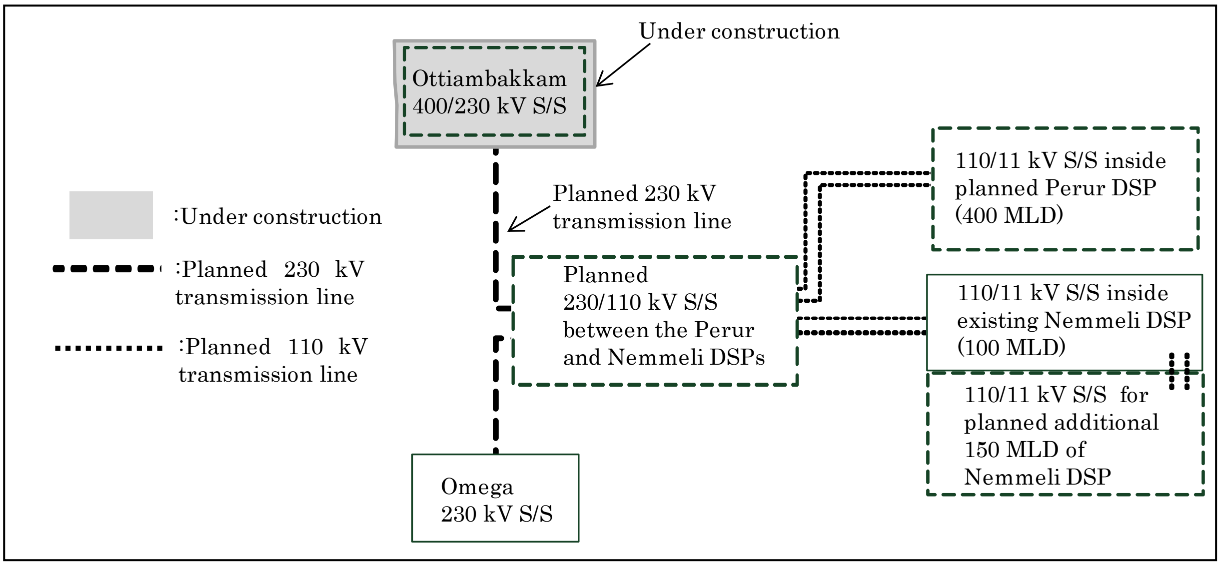
In the plan, the two DSPs, including the additional 150 MLD of the Nemmel DSP, are to receive power supply through a new 230/110 kV S/S, which would be located between the Nemmeli and Perur DSPs. The land for the substation was planned to be about 32,000 m^2. The Perur DSP was to be connected with the new substation with two lines of 110 kV. The 230/110 kV substation was planned to have two receiving lines of 230 kV. One line would come from Omega substation, but it would not be a dedicated line. The other line would be a dedicated line, which would come from Ottiambakkam substation.

(2) Revised power receiving plan:

In 2015, CMWSSB revised the power receiving plan to integrate the power transmission system of the existing Nemmeli DSP with that of the other two plants as shown in Figure A6.16.3. The revised points are as follows:

- Increased capacity of 230/110 kV S/S to supply power to the existing 100 MLD of Nemmeli DSP.
- Utilization of the 110 kV transmission line under construction as a 230 kV transmission line.

Regarding the second point mentioned above, although the dedicated 110 kV transmission line has been under construction, CMWSSB intended to utilize the transmission line as the 230 kV to reduce the construction cost of the 230 kV transmission line as much as possible. CMWSSB requested TNEB to change two points of the construction plan as described above but has not yet received any reply.



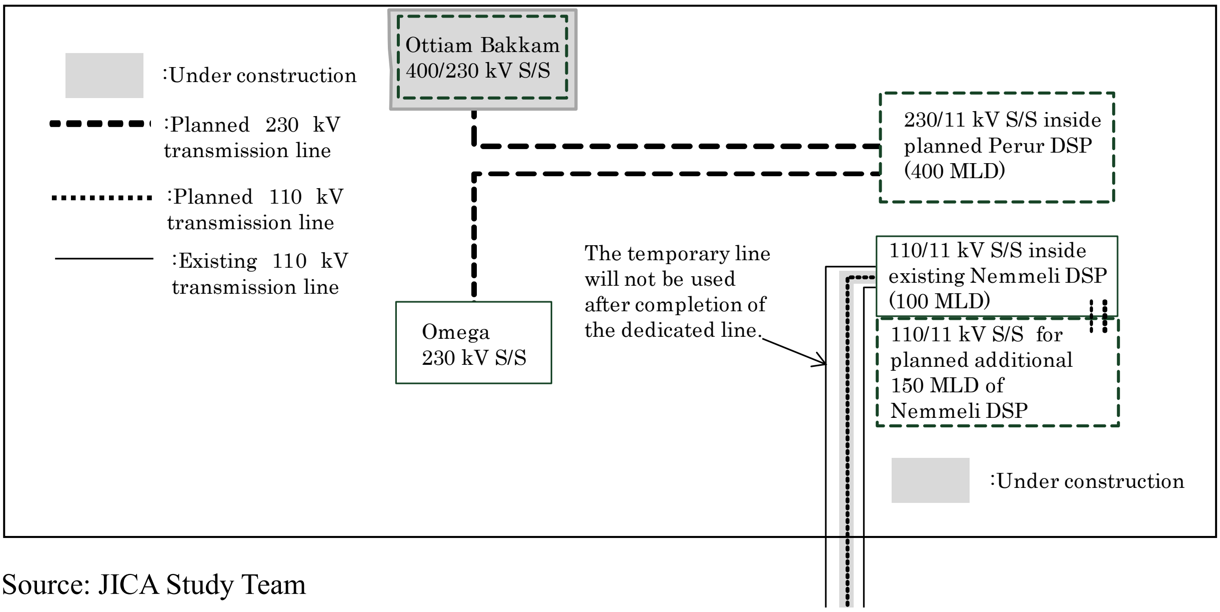
Source: JICA Study Team

Figure A6.16.3 Revised Power Receiving Plan for the Perur and Nemmeli DSPs

Appendix 6.17 Determination of the Power Receiving Plan of the Perur DSP

In the power receiving plan, the JICA Study Team proposes another alternative (Alternative C) to the original and revised plans (Alternatives A and B) as shown in Figure A6.17.1. The Alternative C does not require the 230/110 kV substation proposed by the Alternatives A and B and assumes that the two 230 kV transmission lines will be directly connected to 230/11 kV S/S in the Perur DSP.

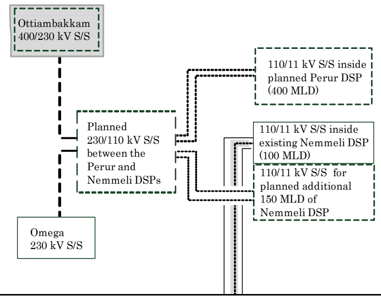
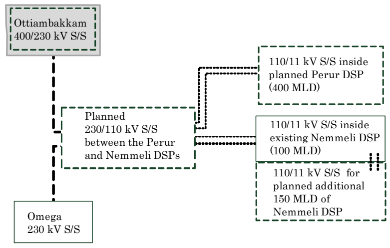
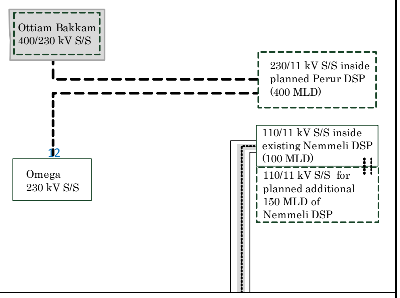
Table A6.17.1 shows the comparison of the three alternatives mentioned above. All alternatives have advantages and disadvantages, but the Study Team recommends Alternative A as the original one. The ideal plan for CMWSSB is to integrate the power receiving system for the three DSPs as planned in Alternative B. However, as a result of the interview with TNEB by the JICA Study Team, the transmission line under construction is available only for 110 kV line because the tower for 110 kV transmission line is not available for 230 kV transmission line. Thus, it is better for CMWSSB to maintain the original plan, where the 110 kV transmission line under construction will be utilized to avoid wasting of the investment that has been done so far. Besides, as TNEB has already accepted the Alternative A, the project will be implemented more smoothly by maintaining the original plan than changing the plan to the Alternative B or C.



Source: JICA Study Team

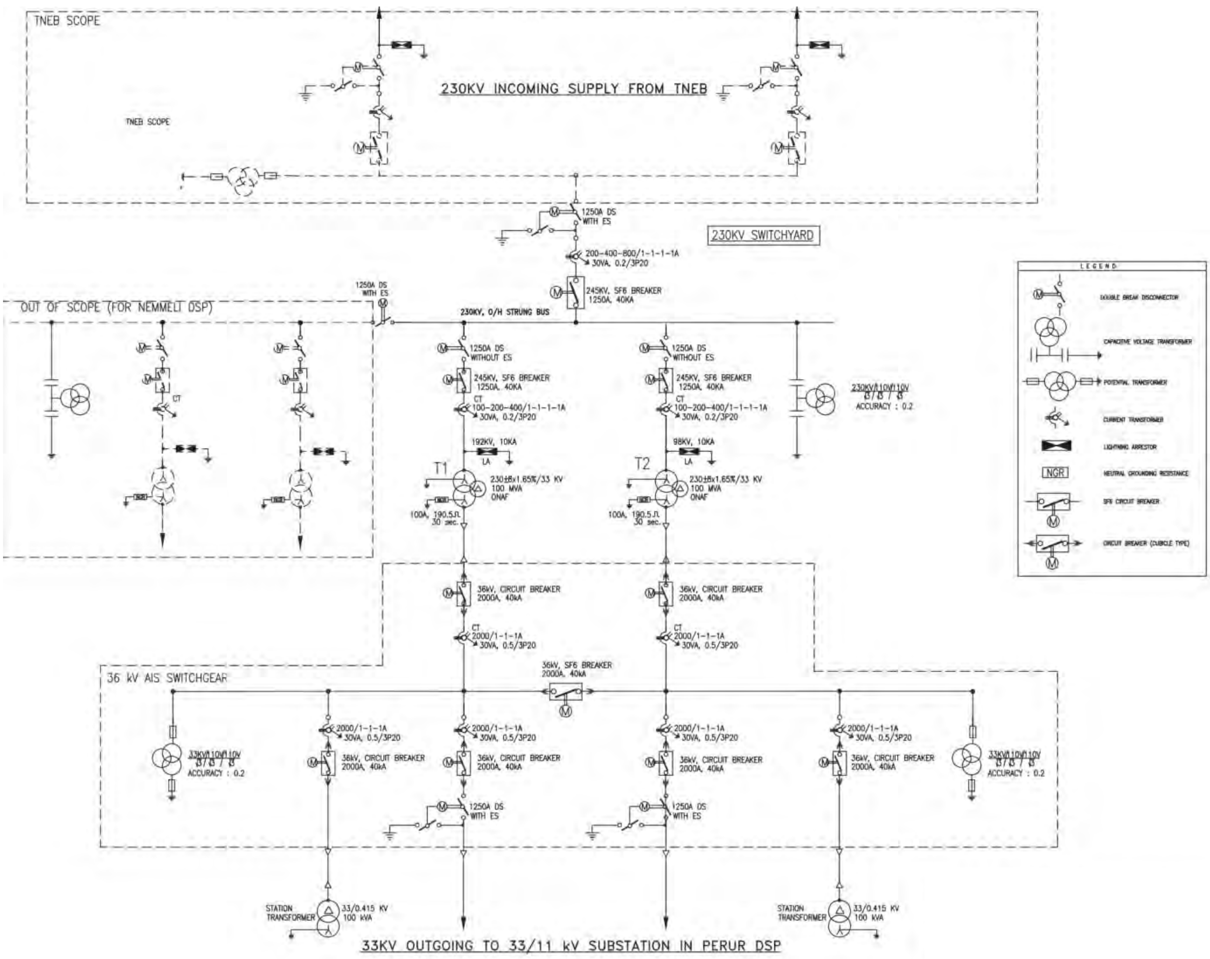
Figure A6.17.1 Proposed Power Receiving Plan by JICA Study Team

Table A6.17.1 Alternative Study on the Power Receiving Plan for the Perur DSP

Plan	Alternative A (Original plan)	Alternative B (Revised plan)	Alternative C (Additional plan suggestion by the JICA study team)
System			
Features	• The 230/110 kV S/S will be built. • The Perur DSP and the additional 150 MLD of Nemmeli DSP will be connected to the 230/110 kV S/S. • The Perur DSP will have 110/11 kV S/S.	• The 230/110 kV S/S will be built. • Both the Perur and the Nemmeli DSPs will be connected to the 230/110 kV S/S. • The Perur DSP will have 110/11 kV S/S. • **Power receiving point of the DSPs will be integrated to one S/S.**	• The 230/110 kV S/S will NOT be built. • The Perur DSP will be connected to the new 230 kV transmission lines. • The Perur DSP will have 230/11 kV S/S. • The Nemmeli DSP will utilize the existing and under-construction 110 kV transmission lines.
Project Implementation	• **TNEB has accepted this plan.** Thus, the project will be implemented more smoothly by proceeding with this plan without any further changes.	• CMWSSB requested to utilize some towers of 110 kV line as towers of 230 kV line, but they cannot be utilized. • **TNEB has not yet accepted** this power receiving system.	• The receiving point will be changed. Thus, **CMWSSB needs to inform TNEB of the change in the plan and request TNEB to change the transmission line plan accordingly**. • The additional 150 MLD of Nemmeli DSP needs to receive power through the existing transmission lines. However, it is unclear whether the transmission lines or the connected TNEB's substation can bear the load or not.
Economic Performance	• The construction cost and the maintenance cost for the 230/110 kV S/S is required. • The additional 150 MLD of Nemmeli DSP may be built earlier than the 230/110 kV S/S. Thus, the shift of the power source of the DSP requires more capital cost. • The existing 110 kV transmission lines to the Nemmeli DSP will be available.	• The construction cost and the maintenance cost for the 230/110 kV S/S are required. • The shift of the power source of the existing and the additional DSPs **require more capital cost**. • The **existing 110 kV transmission lines to the Nemmeli DSP should be demolished.** It is wastage of the investment made so far.	• It will be the **most cost effective** plan if the cost and the land for the 230/110 kV S/S are reduced. • The existing 110 kV transmission lines to the Nemmeli DSP will be available.
Others	• The existing 110 kV transmission lines to the Nemmeli DSP will be continuously available.	• Only two transmission lines of 230 kV will be connected to TNEB's substations. Thus, the towers and conductors for the transmission lines will be fewer than that of the Alternative A and C plans.	• The cost and the land for the 230/110 kV S/S are reduced. • The existing 110 kV transmission lines to the Nemmeli DSP will be continuously available.
Evaluation	**Recommended** (Already an agreed plan by TNEB and cost effective than Alternative B)	-	-

Source: JICA Study Team

Appendix 6.18 Single Line Diagram of 230/33 kV and 33/11 kV Substations



Source: JICA Study Team

Appendix 6.19 Cost Breakdown for Alternative Study on Product Water Transmission System

1. Required Pump Head and Pipeline Cost

Case-1-1: Direct Pumping (D1900)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	380	1900	1.55	30.28		
34						
	308	1600	1.77	6.97		
39						
	235	1500	1.54	3.47		
42					2.04	5% of Friction loss
				40.73	4.54	
				Total loss	45.27	
				Gross head	44.00	=47-3.0
				Total head	89.27	
				Design Pump head	90	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Pipe Grade
1900	34,000	70,000	2,380,000,000	Class A
1600	5,000	50,000	250,000,000	Class A
1500	3,000	44,000	132,000,000	Class A
		Total	2,762,000,000	

Case-1-2: Direct Pumping (D2000)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	380	2000	1.40	23.59		
34						
	308	1800	1.40	3.93		
39						
	235	1600	1.35	2.54		
42					1.50	5% of Friction loss
				30.05	4.00	
				Total loss	34.06	
				Gross head	44.00	=47-3.0
				Total head	78.06	
				Design Pump head	78	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Pipe Grade
2000	34,000	77,000	2,618,000,000	Class A
1800	5,000	64,000	320,000,000	Class A
1600	3,000	50,000	150,000,000	Class A
		Total	3,088,000,000	

Case-1-3: Direct Pumping (D2200)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	380	2200	1.16	14.83		
34						
	308	1900	1.26	3.02		
39						
	235	1800	1.07	1.43		
42					0.96	5% of Friction loss
				19.28	3.46	
				Total loss	22.74	
				Gross head	44.00	=47-3.0
				Total head	66.74	
				Design Pump head	67	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Pipe Grade
2200	34,000	98,000	3,332,000,000	Class A
1900	5,000	70,000	350,000,000	Class A
1800	3,000	57,000	171,000,000	Class B
		Total	3,853,000,000	

Case-2-1: Two Step Pumping (D1900)

DSP Pump Station

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	380	1900	1.55	30.28		
34					1.51	5% of Friction loss
				30.28	4.01	
				Total loss	34.30	
				Gross head	17.00	=20-3.0
				Total head	51.30	
				Design Pump head	52.00	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Remarks
1900	34000	70,000	2,380,000,000	Class A
		Total	2,380,000,000	

Booster Pump Station (For Porur WDS)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
34					2.50	at PS (assumed)
	308	1600	1.77	6.97		
39						
	235	1500	1.54	3.47		
42					0.52	5% of Friction loss
				10.45	3.02	
				Total loss	13.47	
				Gross head	37.00	=47-10
				Total head	50.47	
				Design Pump head	51.00	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Remarks
1600	5000	50,000	250,000,000	Class A
1500	3000	44,000	132,000,000	Class A
		Total	382,000,000	

Booster Pump Station (For No.6, No.6A&CC-8)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	72	1000	1.06	4.67		
5						
	31.2	800	0.72	6.49		
16					0.56	5% of Friction loss
Sub-total				11.16	3.06	
				Total loss	14.22	
				Terminal head	5.00	
				Total head	19.22	
				Design Pump head	20.00	

Case-2-2: Two Step Pumping (D2000)

DSP Pump Station

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	380	2000	1.40	23.59		
34					1.18	5% of Friction loss
				23.59	3.68	
				Total loss	27.27	
				Gross head	17.00	=20-3.0
				Total head	44.27	
				Design Pump head	45.00	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Remarks
2000	34000	70,000	2,380,000,000	Class B
		Total	2,380,000,000	

Booster Pump Station (For Porur WDS)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
34					2.50	at PS (assumed)
	308	1800	1.40	3.93		
39						
	235	1600	1.35	2.54		
42					0.32	5% of Friction loss
				6.47	2.82	
				Total loss	9.29	
				Gross head	37.00	=47-10
				Total head	46.29	
				Design Pump head	47.00	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Remarks
1800	5000	64,000	320,000,000	Class A
1600	3000	50,000	150,000,000	Class A
		Total	470,000,000	

Booster Pump Station (For No.6, No.6A&CC-8)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	72	1000	1.06	4.67		
5						
	31.2	800	0.72	6.49		
16					0.56	5% of Friction loss
Sub-total				11.16	3.06	
				Total loss	14.22	
				Terminal head	5.00	
				Total head	19.22	
				Design Pump head	20.00	

Case-2-3: Two Step Pumping (D2200)

DSP Pump Station

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	380	2200	1.16	14.83		
34					0.74	5% of Friction loss
				14.83	3.24	
				Total loss	18.07	
				Gross head	17.00	=20-3.0
				Total head	35.07	
				Design Pump head	35.00	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Remarks
2200	34000	85,000	2,890,000,000	Class B
		Total	2,890,000,000	

Booster Pump Station (For Porur WDS)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
34					2.50	at PS (assumed)
	308	1900	1.26	3.02		
39						
	235	1800	1.07	1.43		
42					0.22	5% of Friction loss
				4.45	2.72	
				Total loss	7.17	
				Gross head	37.00	=47-10
				Total head	44.17	
				Design Pump head	44.00	

Pipeline Cost (INR)

Dia (mm)	Length (m)	Unit Cost (INR/m)	Pipeline Cost (INR)	Remarks
1900	5000	70,000	350,000,000	Class A
1800	3000	57,000	171,000,000	Class B
		Total	521,000,000	

Booster Pump Station (For No.6, No.6A&CC-8)

Required Pump Head (m)

Chainage (km)	Flow (MLD)	Pipe Dia (mm)	Velocity (m/s)	Friction Loss (m)	Other loss (m)	Remarks
0					2.50	at PS (assumed)
	72	1000	1.06	4.67		
5						
	31.2	800	0.72	6.49		
16					0.56	5% of Friction loss
Sub-total				11.16	3.06	
				Total loss	14.22	
				Terminal head	5.00	
				Total head	19.22	
				Design Pump head	20.00	

2. Cost Comparison

Case 1-1 : Direct Pumping (D1900)

Feature of Pump Station at DSP

Design Flow (Q)	380	MLD
	4.40	m3/s
Design Head (H)	90	m

Life Cycle Cost

Item	Capacity/Size	Unit	Unit Cost (INR)	Cost (INR)	Remarks
Construction Cost					
Pump Station at DSP					
Civil cost (Pump house)	395.8	QxH (m3/s x m)	321,000	127,062,500	Derived from cost estimate in DPR
Civi cost (Resrvior)	2,800	m3	11,000	30,800,000	Derived from cost estimate in DPR
E&M cost	395.8	QxH (m3/s x m)	332,000	131,416,667	Derived from cost estimate in DPR
Pipeline cost (up to 42km)				2,762,000,000	Refer to 1.
Total of Construction Cost				**3,051,279,167**	
OM Cost					
Annual OM Cost (Electricity)	395.8	QxH (m3/s x m)	651,000	257,687,500	
Annual Maintenance (M&E)				2,628,333	
Annual Maintenance (Pipeline)				27,620,000	
OM cost for 30years (NPV)				**3,501,299,733**	Discount rate: 8%/year
Life Cycle Cost for 30years (NPV)				**6,552,578,900**	

Case 1-2 : Direct Pumping (D2000)

Feature of Pump Station at DSP

Design Flow (Q)	380	MLD
	4.40	m3/s
Design Head (H)	78	m

Life Cycle Cost

Item	Capacity/Size	Unit	Unit Cost (INR)	Cost (INR)	Remarks
Construction Cost					
Pump Station at DSP					
Civil cost (Pump house)	343.1	QxH (m3/s x m)	321,000	110,120,833	Derived from cost estimate in DPR
Civi cost (Resrvior)	2,800	m3	11,000	30,800,000	Derived from cost estimate in DPR
E&M cost	343.1	QxH (m3/s x m)	332,000	113,894,444	Derived from cost estimate in DPR
Pipeline cost (DSP to Porur WDS)				3,088,000,000	Refer to 1.
Total of Construction Cost				**3,342,815,278**	
OM Cost					
Annual OM Cost (Electricity)	343.1	QxH (m3/s x m)	651,000	223,329,167	
Annual Maintenance (M&E)				2,277,889	
Annual Maintenance (Pipeline)				30,880,000	
OM cost for 30years (NPV)				**3,118,882,596**	Discount rate: 8%/year
Life Cycle Cost for 30years (NPV)				**6,461,697,873**	

Case 1-3 : Direct Pumping (D2200)

Feature of Pump Station at DSP

Design Flow (Q)	380	MLD
	4.40	m3/s
Design Head (H)	67	m

Life Cycle Cost

Item	Capacity/Size	Unit	Unit Cost (INR)	Cost (INR)	Remarks
Construction Cost					
Pump Station at DSP					
Civil cost (Pump house)	294.7	QxH (m3/s x m)	321,000	94,590,972	Derived from cost estimate in DPR
Civi cost (Resrvior)	2,800	m3	11,000	30,800,000	Derived from cost estimate in DPR
E&M cost	294.7	QxH (m3/s x m)	332,000	97,832,407	Derived from cost estimate in DPR
Pipeline cost (DSP to Porur WDS)				3,853,000,000	Refer to 1.
Total of Construction Cost				**4,076,223,380**	
OM Cost					
Annual OM Cost (Electricity)	294.7	QxH (m3/s x m)	651,000	191,834,028	
Annual Maintenance (M&E)				1,956,648	
Annual Maintenance (Pipeline)				38,530,000	
OM cost for 30years (NPV)				**2,825,019,419**	Discount rate: 8%/year
Life Cycle Cost for 30years (NPV)				**6,901,242,799**	

Case 2-1 : Two Step Pumping (D1900)

Feature of Pump Station at DSP

Design Flow (Q)	380	MLD
	4.40	m3/s
Design Head (H)	52	m

Feature of Booster Pump Station

	to Porur		to CC-8, No.6&6A	
Design Flow (Q)	287.9	MLD	72	MLD
	3.33	m3/s	0.83	m3/s
Design Head (H)	51	m	20	m

Life Cycle Cost

Item	Capacity/Size	Unit	Unit Cost (INR)	Cost (INR)	Remarks
Construction Cost					
Pump Station at DSP					
Civi cost (Resrvior)	2,800	m3	11,000	30,800,000	Derived from cost estimate in DPR
Civil cost (Pump house)	228.7	QxH (m3/s x m)	401,250	91,767,361	Derived from cost estimate in DPR
E&M cost	228.7	QxH (m3/s x m)	415,000	94,912,037	Derived from cost estimate in DPR
Pipeline cost (DSP to Booster PS)				2,380,000,000	Refer to 1.
Booster Pump Station (for Porur WDS)					
Civi cost (Receiving tank)	2,700	m3	11,000	29,700,000	Derived from cost estimate in DPR
Civil cost (Pump house)	186.6	QxH (m3/s x m)	521,625	97,339,210	Derived from cost estimate in DPR
E&M cost	186.6	QxH (m3/s x m)	539,500	100,674,821	Derived from cost estimate in DPR
Pipeline cost (Booster PS to Porur)				382,000,000	Refer to 1.
Total of Construction Cost				**3,207,193,429**	
OM Cost					
Annual OM Cost (Electricity)	415.3	QxH (m3/s x m)	651,000	270,367,684	
Annual Maintenance (M&E)				3,911,737	
Annual Maintenance (Pipeline)				27,620,000	
OM cost for 30years (NPV)				**3,671,096,962**	Discount rate: 8%/year
Life Cycle Cost for 30years (NPV)				**6,878,290,391**	

Case 2-2 : Two Step Pumping (D2000)

Feature of Pump Station at DSP

Design Flow (Q)	380	MLD
	4.40	m3/s
Design Head (H)	45	m

Feature of Booster Pump Station

	to Porur		to CC-8, No.6&6A	
Design Flow (Q)	287.9	MLD	72	MLD
	3.33	m3/s	0.83	m3/s
Design Head (H)	47	m	20	m

Life Cycle Cost

Item	Capacity/Size	Unit	Unit Cost (INR)	Cost (INR)	Remarks
Construction Cost					
Pump Station at DSP					
Civi cost (Resrvior)	2,800	m3	11,000	30,800,000	Derived from cost estimate in DPR
Civil cost (Pump house)	197.9	QxH (m3/s x m)	401,250	79,414,063	Derived from cost estimate in DPR
E&M cost	197.9	QxH (m3/s x m)	415,000	82,135,417	Derived from cost estimate in DPR
Pipeline cost (DSP to Booster PS)				2,380,000,000	Refer to 1.
Booster Pump Station (for Porur WDS)					
Civi cost (Receiving tank)	2,700	m3	11,000	29,700,000	Derived from cost estimate in DPR
Civil cost (Pump house)	173.3	QxH (m3/s x m)	521,625	90,386,625	Derived from cost estimate in DPR
E&M cost	173.3	QxH (m3/s x m)	539,500	93,483,986	Derived from cost estimate in DPR
Pipeline cost (Booster PS to Porur)				470,000,000	Refer to 1.
Total of Construction Cost				**3,255,920,089**	
OM Cost					
Annual OM Cost (Electricity)	371.2	QxH (m3/s x m)	651,000	241,648,337	
Annual Maintenance (M&E)				3,512,388	
Annual Maintenance (Pipeline)				28,500,000	
OM cost for 30years (NPV)				**3,327,714,414**	Discount rate: 8%/year
Life Cycle Cost for 30years (NPV)				**6,583,634,503**	

Case 2-3 : Two Step Pumping (D2200)

Feature of Pump Station at DSP

Design Flow (Q)	380	MLD
	4.40	m3/s
Design Head (H)	35	m

Feature of Booster Pump Station

	to Porur		to CC-8, No.6&6A	
Design Flow (Q)	287.9	MLD	72	MLD
	3.33	m3/s	0.83	m3/s
Design Head (H)	44	m	20	m

Life Cycle Cost

Item	Capacity/Size	Unit	Unit Cost (INR)	Cost (INR)	Remarks
Construction Cost					
Pump Station at DSP					
Civi cost (Resrvior)	2,800	m3	11,000	30,800,000	Derived from cost estimate in DPR
Civil cost (Pump house)	153.9	QxH (m3/s x m)	401,250	61,766,493	Derived from cost estimate in DPR
E&M cost	153.9	QxH (m3/s x m)	415,000	63,883,102	Derived from cost estimate in DPR
Pipeline cost (DSP to Booster PS)				2,890,000,000	Refer to 1.
Booster Pump Station (for Porur WDS)					
Civi cost (Receiving tank)	2,700	m3	11,000	29,700,000	Derived from cost estimate in DPR
Civil cost (Pump house)	163.3	QxH (m3/s x m)	521,625	85,172,186	Derived from cost estimate in DPR
E&M cost	163.3	QxH (m3/s x m)	539,500	88,090,859	Derived from cost estimate in DPR
Pipeline cost (Booster PS to Porur)				521,000,000	Refer to 1.
Total of Construction Cost				**3,770,412,639**	
OM Cost					
Annual OM Cost (Electricity)	317.2	QxH (m3/s x m)	651,000	206,508,653	
Annual Maintenance (M&E)				3,039,479	
Annual Maintenance (Pipeline)				34,110,000	
OM cost for 30years (NPV)				**2,962,882,885**	Discount rate: 8%/year
Life Cycle Cost for 30years (NPV)				**6,733,295,524**	

Appendix 6.20 Preliminary Hydraulic Assessment Residual Pressures in Core City (2035 and 2050)

Preliminary Hydraulic Assessment (2035)

Zone	Water Distribution Station	Demand 2035 (MLD)	HGL (m)	Avg.GL @ WDS (m)	Residual Head (designed)	Residual Head (Ferrule)	Population in 2035	Population/ unit length	Discharge in pipe (m3/hr)	Critical point in distribution Network: Distance from WDS (m)	Critical point in distribution Network: Elevation (m)	Equivalent Diameter of Pipe (mm)	Hazen-Williams "C" value	Head Loss (m)	Residual Pressure @ Critical point (m)	Check
1	Kilpauk	208.5	27.00	7.00	10.00	7.00	1176633	1.78	82.18	7402	10.00	350	100	2.37	14.6	OK
2	Anna Poonga	58.2	23.58	3.58	10.00	7.00	328313	2.79	30.36	1740	5.00	275	100	0.28	18.3	OK
3	Kannapathidal	55.7	25.26	5.60	10.00	7.00	314527	4.69	66.16	2257	5.00	200	100	7.37	12.9	OK
4	Triplicane	36.2	23.00	3.00	10.00	7.00	204380	1.52	18.22	1917	10.00	200	100	0.57	12.4	OK
5	K.K.Nagar	68.7	29.00	9.00	10.00	7.00	387640	1.46	65.05	7112	9.00	225	100	12.69	7.3	Expected Low Pressure
6	Velachery	40.8	26.80	6.00	10.00	7.00	230120	6.02	75.06	1996	5.00	200	100	8.24	13.6	OK
7	Ekkatuthangal	6.7	30.05	7.00	10.00	7.00	37987	1.04	13.71	2113	7.00	150	100	1.52	21.5	OK
8	Choolaimedu	105.0	29.00	9.00	10.00	7.00	592753	4.80	177.03	5901	9.00	325	100	11.21	8.8	Expected Low Pressure
9	Kulathur	37.4	27.00	10.50	10.00	7.00	210907	1.45	26.04	2866	7.00	243	100	0.64	19.4	OK
10	Vysarpadi	72.5	25.00	4.00	10.00	7.00	409347	1.86	33.17	2855	5.00	150	100	10.54	9.5	Expected Low Pressure
11	Patel Nagar	37.6	24.00	3.00	10.00	7.00	212227	0.89	16.90	3054	5.00	228	100	0.42	18.6	OK
12	Pallipattu	46.9	27.50	5.00	10.00	7.00	264660	3.14	45.00	2291	6.00	150	100	14.88	6.6	Expected Low Pressure
13	Mylapore	21.3	22.50	2.50	10.00	7.00	120267	1.38	34.91	4047	3.00	165	100	10.33	9.2	Expected Low Pressure
14	Nandanam	43.8	22.50	2.50	10.00	7.00	247427	1.47	11.95	1303	3.00	223	100	0.10	19.4	OK
15	Valluvarkottam	32.4	26.50	4.00	10.00	7.00	182820	1.02	41.49	6513	6.00	253	100	2.87	17.6	OK
16	Southern Head works	32.8	25.50	7.00	10.00	7.00	185167	1.46	86.93	9548	9.00	300	100	7.18	9.3	Expected Low Pressure

Preliminary Hydraulic Assessment (2050)

Zone	Water Distribution Station	Demand 2050 (MLD)	HGL (m)	Avg.GL @ WDS (m)	Residual Head (designed)	Residual Head (Ferrule)	Population in 2050	Population/ unit length	Discharge (m3/hr)	Critical point in distribution Network: Distance from WDS (m)	Critical point in distribution Network: Elevation (m)	Equivalent Diameter of Pipe (mm)	Hazen-Williams "C" value	Head Loss (m)	Residual Pressure @ Critical point (m)	Check
1	Kilpauk	220.1	27.00	7.00	10.00	7.00	1238893	1.87	86.52	7402	10.00	350	100	2.60	14.4	OK
2	Anna Poonga	61.3	23.58	3.58	10.00	7.00	344887	2.93	31.89	1740	5.00	275	100	0.31	18.3	OK
3	Kannapathidal	57.6	25.26	5.60	10.00	7.00	324060	4.83	68.17	2257	5.00	200	100	7.79	12.5	OK
4	Triplicane	36.2	23.00	3.00	10.00	7.00	196240	1.46	17.49	1917	10.00	200	100	0.53	12.5	OK
5	K.K.Nagar	73.6	29.00	9.00	10.00	7.00	414187	1.56	69.50	7112	9.00	225	100	14.34	5.7	Expected Low Pressure
6	Velachery	44.4	25.80	6.00	10.00	7.00	250067	6.54	81.56	1996	5.00	200	100	9.61	11.2	OK
7	Ekkatuthangal	7.3	30.05	7.00	10.00	7.00	40993	1.12	14.80	2113	7.00	150	100	1.75	21.3	OK
8	Choolaimedu	111.0	29.00	9.00	10.00	7.00	624947	5.06	186.65	5901	9.00	325	100	12.37	7.6	Expected Low Pressure
9	Kulathur	40.1	27.00	10.50	10.00	7.00	225867	1.56	27.88	2866	7.00	243	100	0.73	19.3	OK
10	Vysarpadi	75.3	25.00	4.00	10.00	7.00	423500	1.92	34.32	2855	5.00	150	100	11.23	8.8	Expected Low Pressure
11	Patel Nagar	40.3	24.00	3.00	10.00	7.00	227040	0.95	18.08	3054	5.00	228	100	0.48	18.5	OK
12	Pallipattu	51.2	27.50	5.00	10.00	7.00	287980	3.42	48.97	2291	6.00	150	100	17.40	4.1	Expected Low Pressure
13	Mylapore	23.1	22.50	2.50	10.00	7.00	129947	1.49	37.72	4047	3.00	165	100	11.92	7.6	Expected Low Pressure
14	Nandanam	45.5	22.50	2.50	10.00	7.00	256300	1.52	12.38	1303	3.00	223	100	0.11	19.4	OK
15	Valluvarkottam	34.0	26.50	4.00	10.00	7.00	191547	1.07	43.47	6513	6.00	253	100	3.13	17.4	OK
16	Southern Head works	34.9	25.50	7.00	10.00	7.00	196533	1.55	92.27	9548	9.00	300	100	8.01	8.5	Expected Low Pressure

Assumptions:

1.Hydraulic Design details by Kirloskar Consultants HGL at WDS, Residual Presssure etc are considered
2. Discharge in each pipe is arrived Qp = Population / Unit Length in distribution zone x Target Pipe Length under consideration
3. Equivalen pipe diameter has been considered for computing friction losses by weighted average
4. Critical Point is considered to be farthest point from WDS within zone
5. Haze-Williams "C" Value for existing pipe considered as "100"

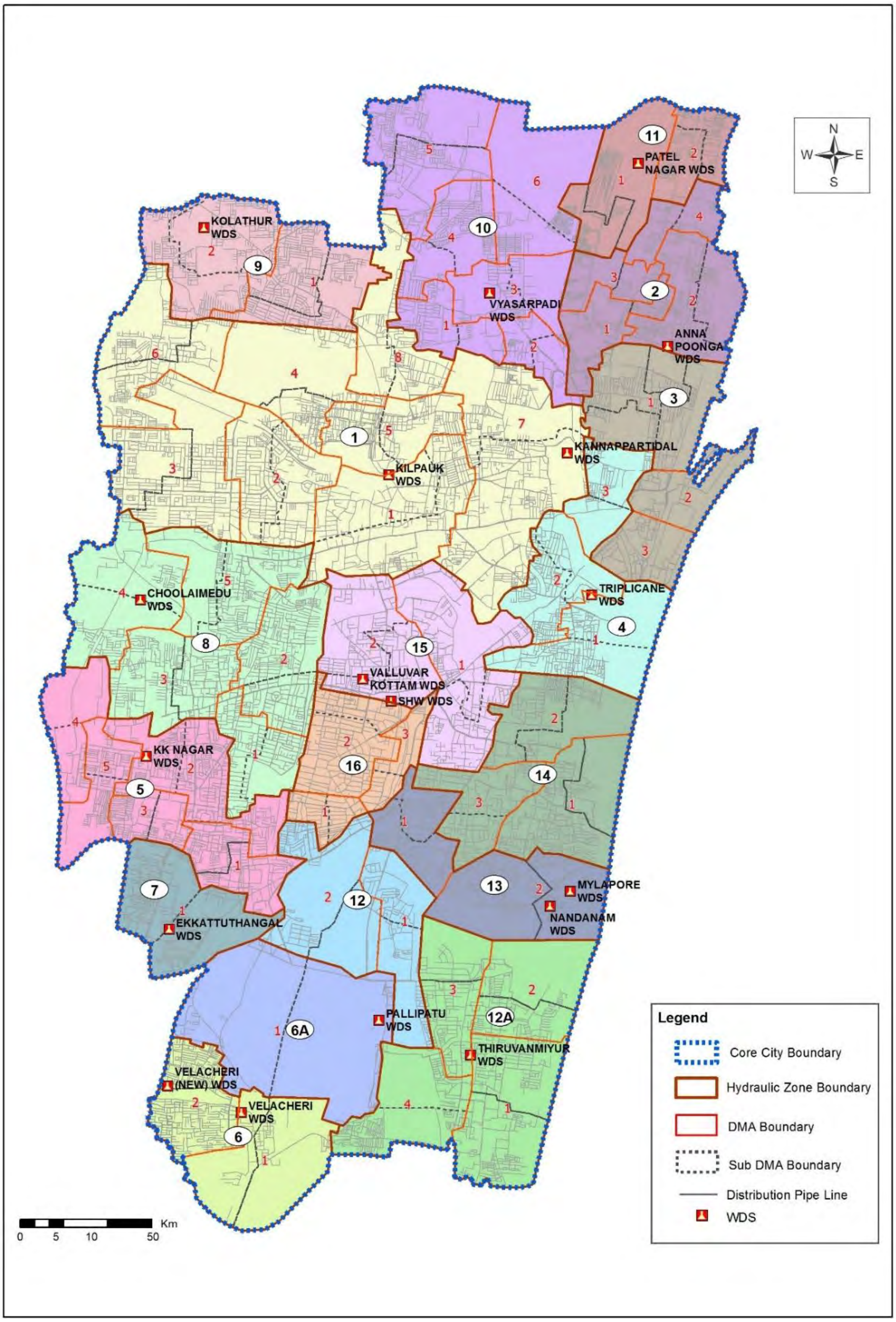
Source: JICA Study Team

Appendix 6.21 Quantification of the Required Water Storage Volume in the Project

WDZ		Existing Storage				Storage rate against the water demand		Storage Requirement in 2035				Storage Requirement in 2050				Deficiency in 2035			Deficiency in 2050			Proposed Scope in the Project*4		
								Water demand	Storage Requirement			Water demand	Storage Requirement											
		Total	UGT	ESR	ESR/Total	2035	2050		Total*1	UGT	ESR*2		Total*3	UGT	ESR*2	Total	UGT	ESR	Total	UGT	ESR	Total	UGT	ESR
		ML	ML	ML	%	Hours	Hours	MLD	ML	ML	ML	MLD	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML	ML
1	Kilpauk	97.12	81.32	15.80	16.3%	11.2	10.6	208.50	52.13	34.75	17.38	220.10	73.37	55.03	18.34	1.58	0.00	1.58	2.54	0.00	2.54	2.54	0.00	2.54
2	Annapoonga	25.00	22.50	2.50	10.0%	10.3	9.8	58.20	14.55	9.70	4.85	61.30	20.43	15.33	5.11	2.35	0.00	2.35	2.61	0.00	2.61	2.61	0.00	2.61
3	Kannappar Tidal	16.00	16.00		0.0%	6.9	6.7	55.70	13.93	9.28	4.64	57.60	19.20	14.40	4.80	4.64	0.00	4.64	4.80	0.00	4.80	4.80	0.00	4.80
4	Triplicane	12.40	10.00	2.40	19.4%	8.2	8.2	36.20	9.05	6.03	3.02	36.20	12.07	9.05	3.02	0.62	0.00	0.62	0.62	0.00	0.62	0.62	0.00	0.62
5	K.K.Nagar	16.40	14.00	2.40	14.6%	5.7	5.3	68.70	17.18	11.45	5.73	73.60	24.53	18.40	6.13	3.33	0.00	3.33	8.13	4.40	3.73	3.73	0.00	3.73
6	Velachery	6.00	6.00		0.0%	4.1	3.8	35.20	8.80	5.87	2.93	38.40	12.80	9.60	3.20	2.93	0.00	2.93	6.80	3.60	3.20	3.20	0.00	3.20
6A	Velachery New	2.00	2.00		0.0%	8.6	8.0	5.60	1.40	0.93	0.47	6.00	2.00	1.50	0.50	0.47	0.00	0.47	0.50	0.00	0.50	0.50	0.00	0.50
7	Ekkadu Thangal	4.50	4.50		0.0%	16.1	14.8	6.70	1.68	1.12	0.56	7.30	2.43	1.83	0.61	0.56	0.00	0.56	0.61	0.00	0.61	0.61	0.00	0.61
8	Choolai Medu	43.00	43.00		0.0%	9.8	9.3	105.00	26.25	17.50	8.75	111.00	37.00	27.75	9.25	8.75	0.00	8.75	9.25	0.00	9.25	9.25	0.00	9.25
9	Kolathur	20.00	20.00		0.0%	12.8	12.0	37.40	9.35	6.23	3.12	40.10	13.37	10.03	3.34	3.12	0.00	3.12	3.34	0.00	3.34	3.34	0.00	3.34
10	Vyasarpadi	22.00	22.00		0.0%	7.3	7.0	72.50	18.13	12.08	6.04	75.30	25.10	18.83	6.28	6.04	0.00	6.04	6.28	0.00	6.28	6.28	0.00	6.28
11	Patel Nagar	14.00	14.00		0.0%	8.9	8.3	37.60	9.40	6.27	3.13	40.30	13.43	10.08	3.36	3.13	0.00	3.13	3.36	0.00	3.36	3.36	0.00	3.36
12	Pallipattu	17.75	17.00	0.75	4.2%	21.2	19.5	20.10	5.03	3.35	1.68	21.90	7.30	5.48	1.83	0.93	0.00	0.93	1.08	0.00	1.08	1.08	0.00	1.08
12A	Thiruvanmiyur	3.75	3.00	0.75	20.0%	3.4	3.1	26.80	6.70	4.47	2.23	29.30	9.77	7.33	2.44	2.95	1.47	1.48	6.02	4.33	1.69	6.02	4.33	1.69
13	Nandanam	11.00	11.00		0.0%	12.4	11.4	21.30	5.33	3.55	1.78	23.10	7.70	5.78	1.93	1.78	0.00	1.78	1.93	0.00	1.93	1.93	0.00	1.93
14	Mylapur	11.50	11.50		0.0%	6.3	6.1	43.80	10.95	7.30	3.65	45.50	15.17	11.38	3.79	3.65	0.00	3.65	3.79	0.00	3.79	3.79	0.00	3.79
15	Valluvar Kottam	28.50	24.00	4.50	15.8%	20.9	19.8	32.80	8.20	5.47	2.73	34.50	11.50	8.63	2.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Southern Head Works	18.00	15.00	3.00	16.7%	13.0	12.8	33.20	8.30	5.53	2.77	33.70	11.23	8.43	2.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		368.92	336.82	32.10	8.7%	9.8	9.3	905.30	226.33	150.88	75.44	955.20	318.40	238.80	79.60	46.81	1.47	45.34	61.64	12.33	49.32	53.64	4.33	49.32

*1: Six hours volume of the water demand
*2: Two hours volume of the water demand
*3: Eight hours volume of the water demand
*4: Target WDZs are those whose storage volume are not sufficient for 2035. Additional storage by the Project is determined by the requirement for 2050
Source: JICA Study Team

Appendix 6.22 Layout plan of the DMAs in Chennai Core City



Appendix 6.23 Preliminary Assessment of distribution and storage requirement for OC-15 & OC-16

Summary of Water Distribution, Storage and Metering Requirement (OC-15)

Sl.No	Zone	Name of ULB	Length of Pipeline (km)			Total Storage Capacity Required (ML)			Meter Requirement (2025)
			Distribution	Transmission	Total	UGT	OHT	Total	
1	OC15	Koilambakkam	21.94	4.39	26.33	2.8	1.4	4.2	7720
2		Kulathur	46.16	9.23	55.4	0.64	0.32	0.96	1780
3		Medavakkam	32.47	6.49	38.96	3.04	1.52	4.56	8380
4		Moovarasampettai	28.14	5.63	33.77	0.99	0.49	1.48	2740
5		Nanmangalam	42.44	8.49	50.93	1.9	0.95	2.85	5240
6		Tirusulam	16.67	3.33	20	1.44	0.72	2.16	3980
7		Chitlapakkam	38.19	7.64	45.83	3.88	1.94	5.82	10500
8		Sembakkam	71.5	14.3	85.8	4.64	2.32	6.96	19820
9		Pallavaram-Part	45.46	9.09	54.55	22.02	11.01	33.03	29470
10		Tambaram-Part	25.68	5.14	30.82	17.87	8.93	26.8	12660
11		Nemmelicheri	69.49	13.9	83.39	0.59	0.29	0.88	2300
		Sub-Total	**438.14**	**87.63**	**525.77**	**59.80**	**29.90**	**89.70**	**104590**

Summary of Water Distribution, Storage and Metering Requirement (OC-16)

Sl.No	Zone	Name of ULB	Length of Pipeline (km)			Total Storage Capacity Required (ML)			Meter Requirement (2025)
			Distribution	Transmission	Total	UGT	OHT	Total	
1	OC16	Agaramthen	16.39	3.28	19.67	0.67	0.33	1	1180
2		Arasankalani	10.83	2.17	13	0.18	0.09	0.26	300
3		Kasbapuram	22.33	4.47	26.8	0.42	0.21	0.63	740
4		Kovilancheri	10.06	2.01	12.08	0.2	0.1	0.3	360
5		Maduraipakkam	7.85	1.57	9.42	0.16	0.08	0.25	280
6		Mulacheri	1.5	0.3	1.8	0.02	0.01	0.04	40
7		Ottiyambakkam	24.19	4.84	29.03	0.34	0.17	0.51	600
8		Perumbakkam	66.08	13.22	79.3	3.95	1.98	5.93	6960
9		Sithalapakkam	48.04	9.61	57.65	2.17	1.09	3.26	3820
10		Thiruvancheri	23.06	4.61	27.68	0.54	0.27	0.81	960
11		Vengaivasal	46.66	9.33	55.99	2.19	1.1	3.29	3860
12		Vengapakkam	18.94	3.79	22.73	0.44	0.22	0.66	780
13		Kolapakkam	26.89	5.38	32.26	1.28	0.64	1.92	2480

Summary of Water Distribution, Storage and Metering Requirement (OC-16)									
Sl.No	Zone	Name of ULB	Length of Pipeline (km)			Total Storage Capacity Required (ML)			Meter Requirement (2025)
			Distribution	Transmission	Total	UGT	OHT	Total	
14		Nedungundram	28.53	5.71	34.23	2.31	1.15	3.46	4460
15		Puthur	15.12	3.02	18.15	0.43	0.22	0.65	840
16		Kilambakkam	12.14	2.43	14.57	0.83	0.42	1.25	1620
17		Vandalur-Part	9.9	1.98	11.88	1.35	0.68	2.03	2610
18		Peerkankaranai-Part	18.11	3.62	21.74	2.08	1.04	3.11	3370
19		Madambakkam	80.71	16.14	96.85	5.08	2.54	7.63	25800
20		Tambaram-Part	70.31	14.06	84.37	7.01	3.51	10.52	12660
21		Perugulathur	14.28	2.86	17.14	5.99	3	8.99	15400
		Sub-Total	**571.94**	**114.39**	**686.33**	**37.67**	**18.83**	**56.50**	**89120**

Source: JICA Study Team