Republic of India

Preparatory Survey for Chennai Seawater Desalination Plant Project

Final Report

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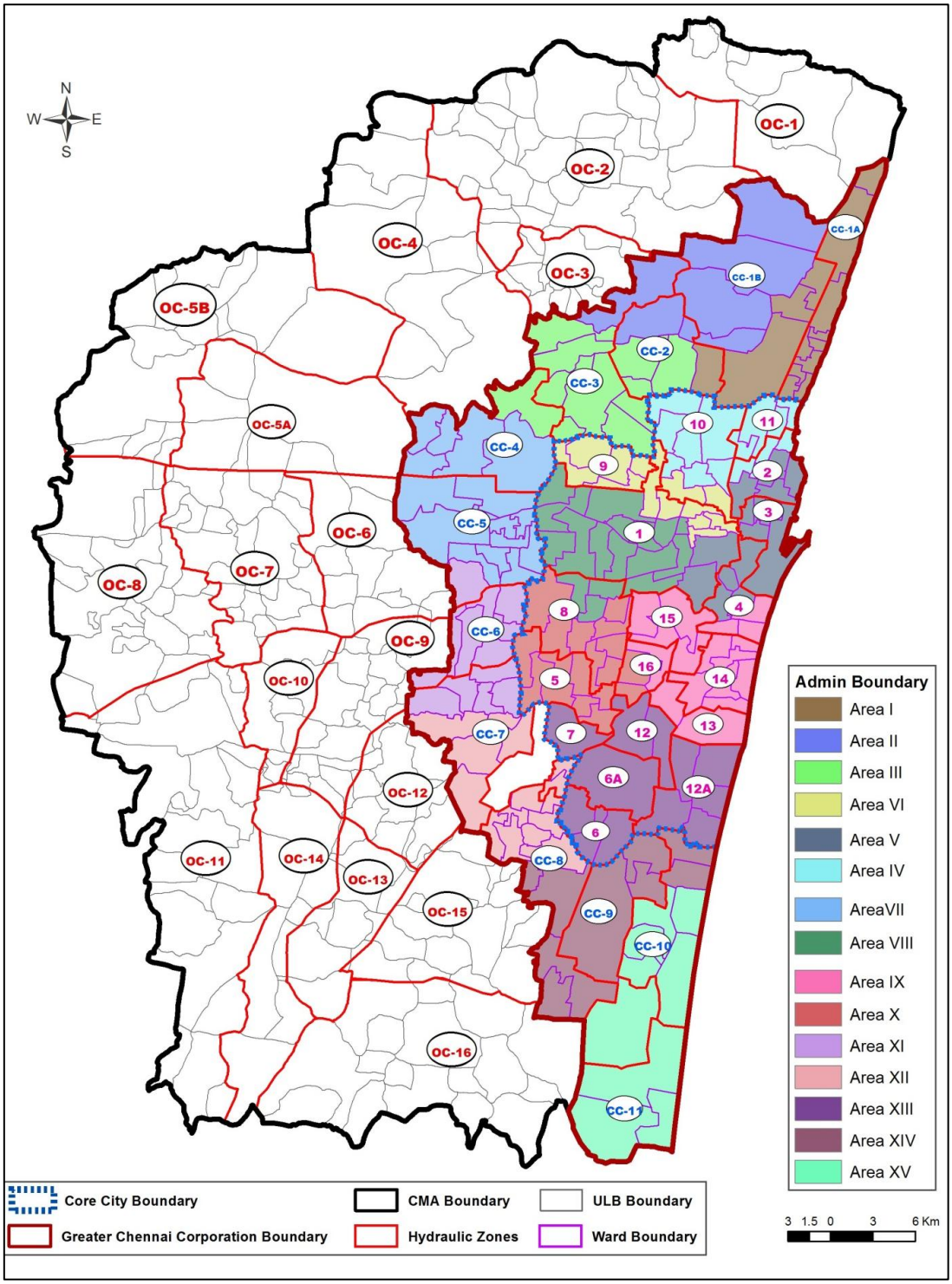
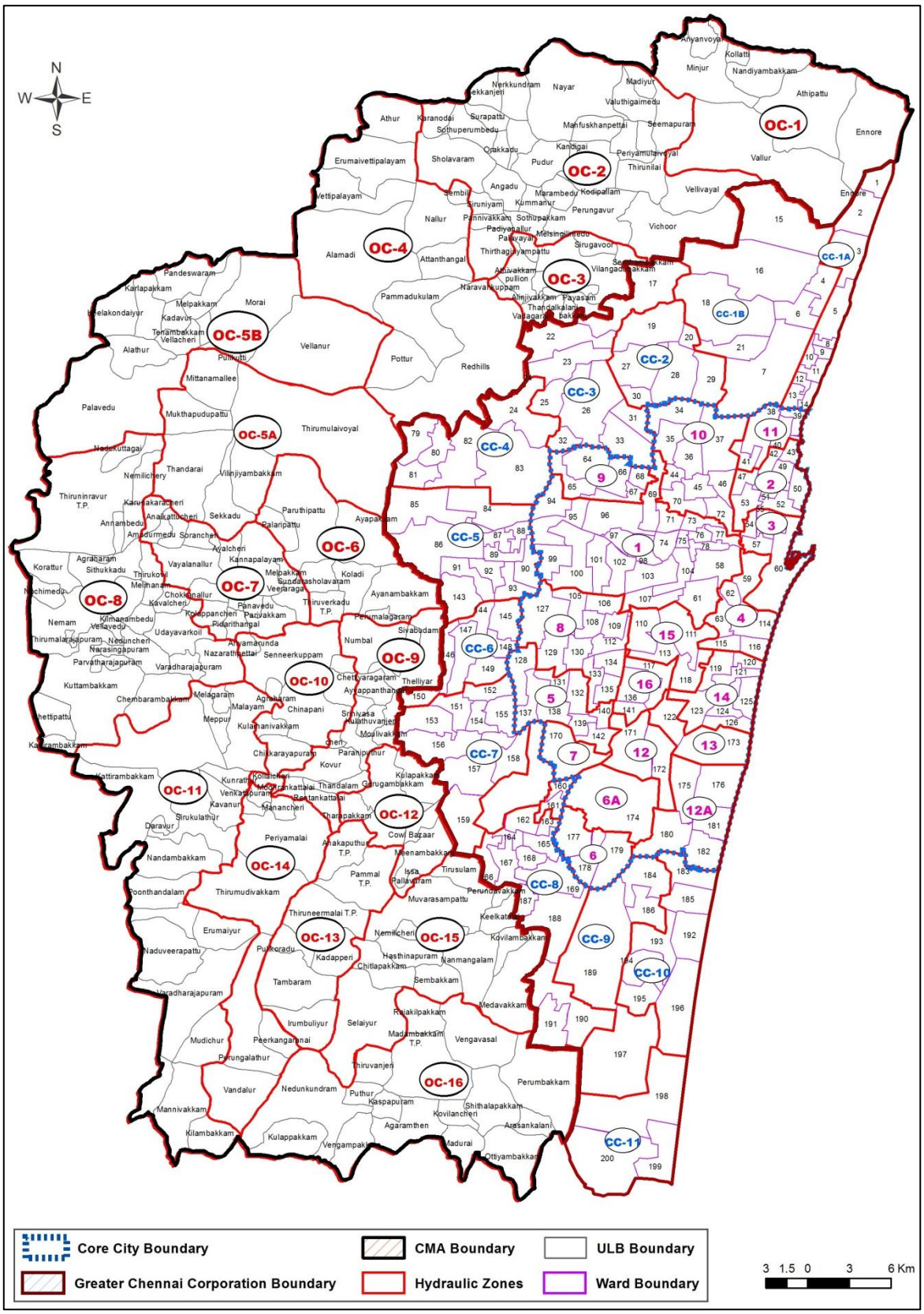


Note 1: Administration Area: Zoning by CMWSSB for administration purposes
Note 2: Water Distribution Zones: Zoning by CMWSSB, each of which has a water distribution centre
Source: JICA Study Team

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)	Populati on in Thousan ds 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	CC11	-	Sholinganallur	T	1,535.1	15.560	26.640	5.52%	17
200		-	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	-	Thirumalarajapuram	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	-	Chembarambakkam	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	-	Chembarambakkam (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	Kattankulathu r	109.24	1.243	2.700	8.07%	25
-	**OC16**	-	Kilambakkam	Kattankulathu r	243.54	2.765	5.189	6.50%	21
-	**OC16**	-	Vandalur	Kattankulathu r	279.53	6.688	8.426	2.34%	30
-	OC14	-	Vandalur	Kattankulathu r	279.53	6.688	8.426	2.34%	30
-	OC11	-	Mannivakkam	Kattankulathu r	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

Influence area of the Perur DSP ***in 2025 but not in 2035***

Influence area of the Perur DSP ***in 2025 and 2035 (Directly fed from the transmission main from Perur DSP)***

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.

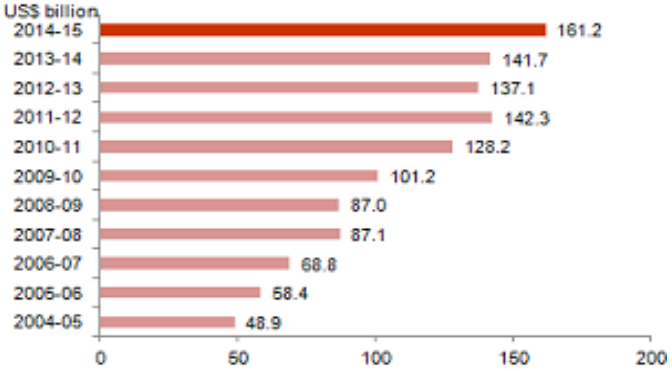
Table A2.3.1 Economic Growth of India

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

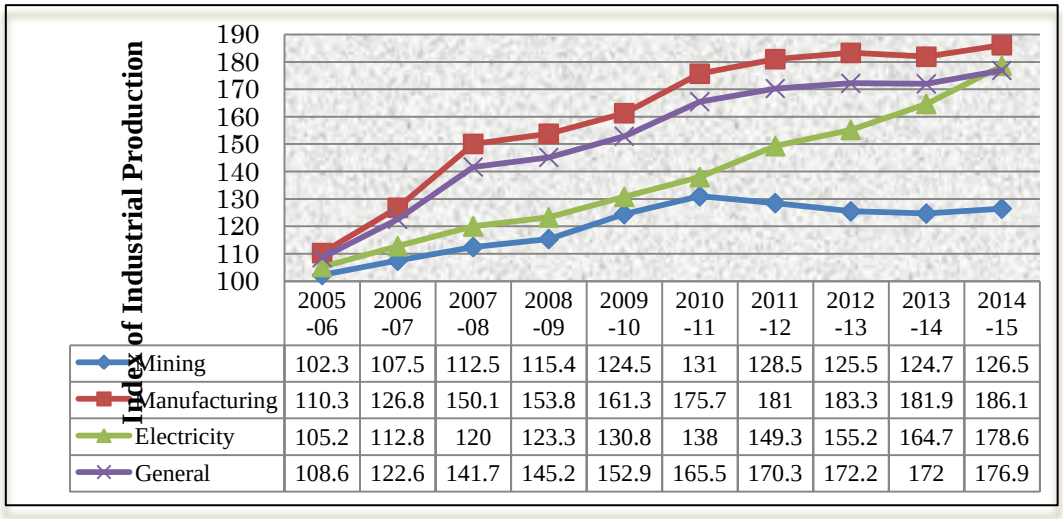
Figure A2.3.1 GSDP of the Tamil Nadu State from 2004-15

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)

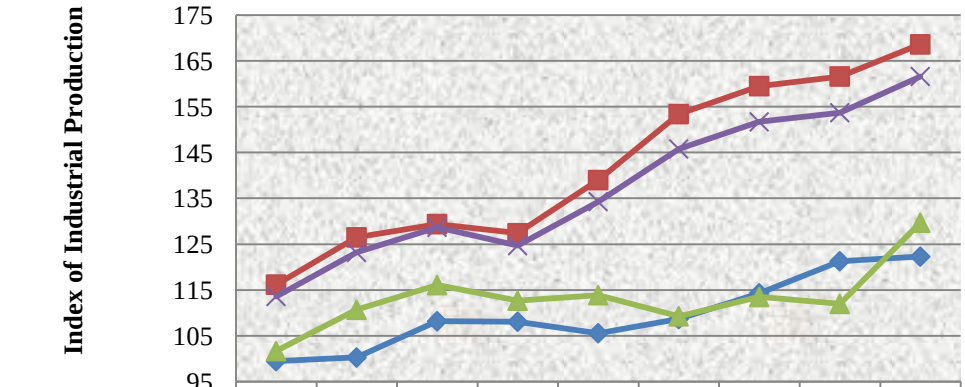
The target project of the Study, the construction of the Perur DSP, is one of the priority projects expected to support the development of CBIC by providing reliable domestic, commercial and industrial water to Chennai Metropolitan Area (CMA).

(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).

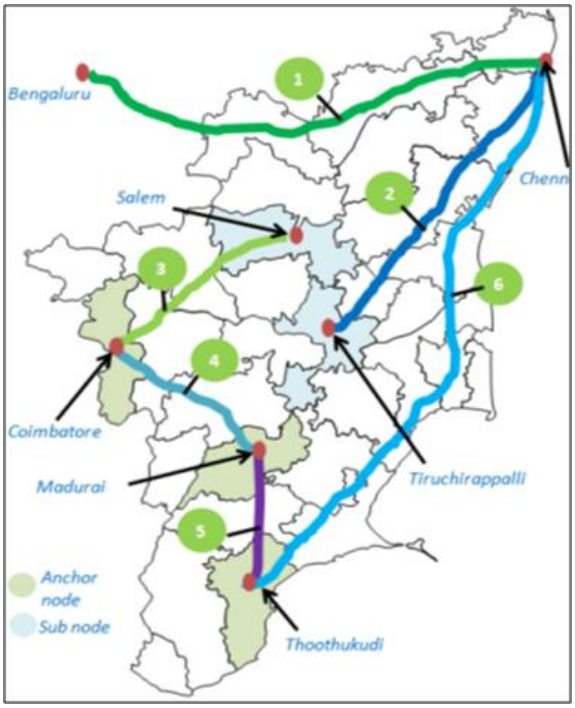


	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Mining	99.5	100.3	108.2	108.1	105.6	108.7	114.3	121.3	122.3
Manufacturing	116.2	126.5	129.4	127.4	139	153.4	159.5	161.6	168.6
Electricity	101.7	110.7	116.1	112.7	113.9	109.3	113.5	112	129.7
General	113.6	123.2	128.7	124.7	134.3	145.8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

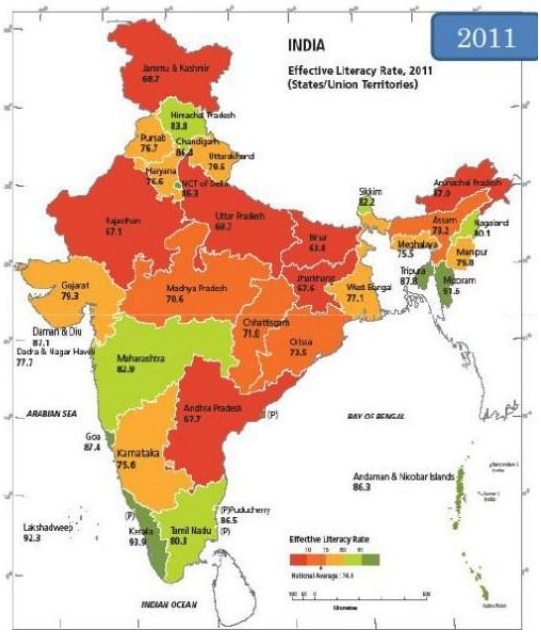
Table A2.3.3 Development Status of Health Infrastructures and Human Resources in the Tamil Nadu State

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

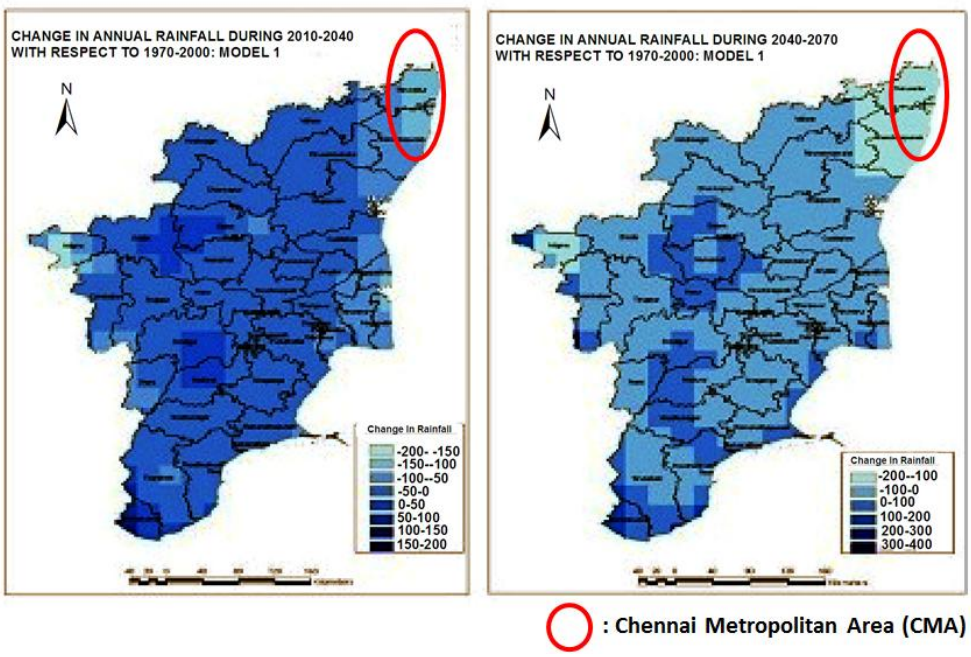
(1) Tamil Nadu

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.



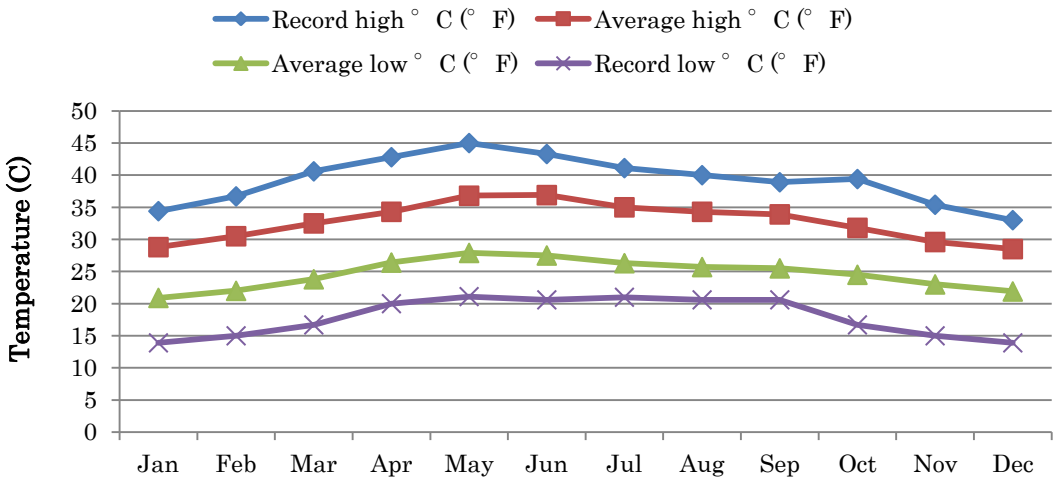
Source: Tamil Nadu State Climate Change Action Plan

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

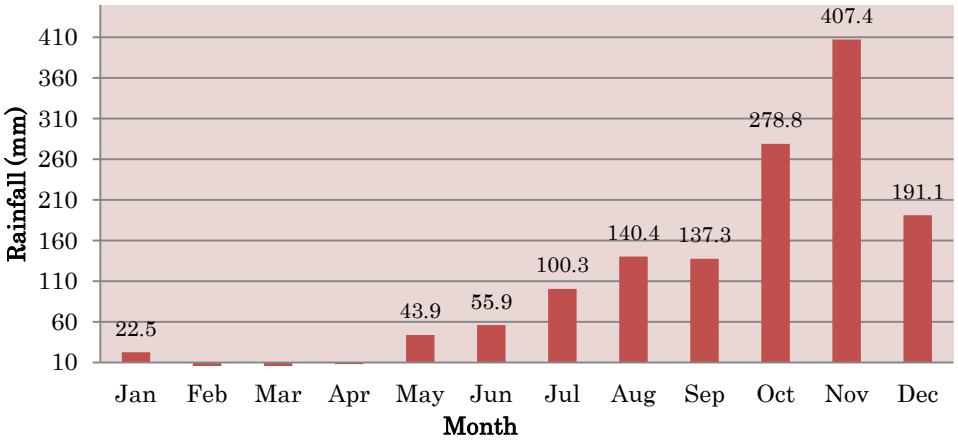
Chennai has a tropical wet and dry climate. The summers arrive in between late March and early June with maximum temperature reaching at 45°C in the month of May. The coolest part of the year is in the month of January, with average low temperature about 20 °C. Based on the data obtained from Indian 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

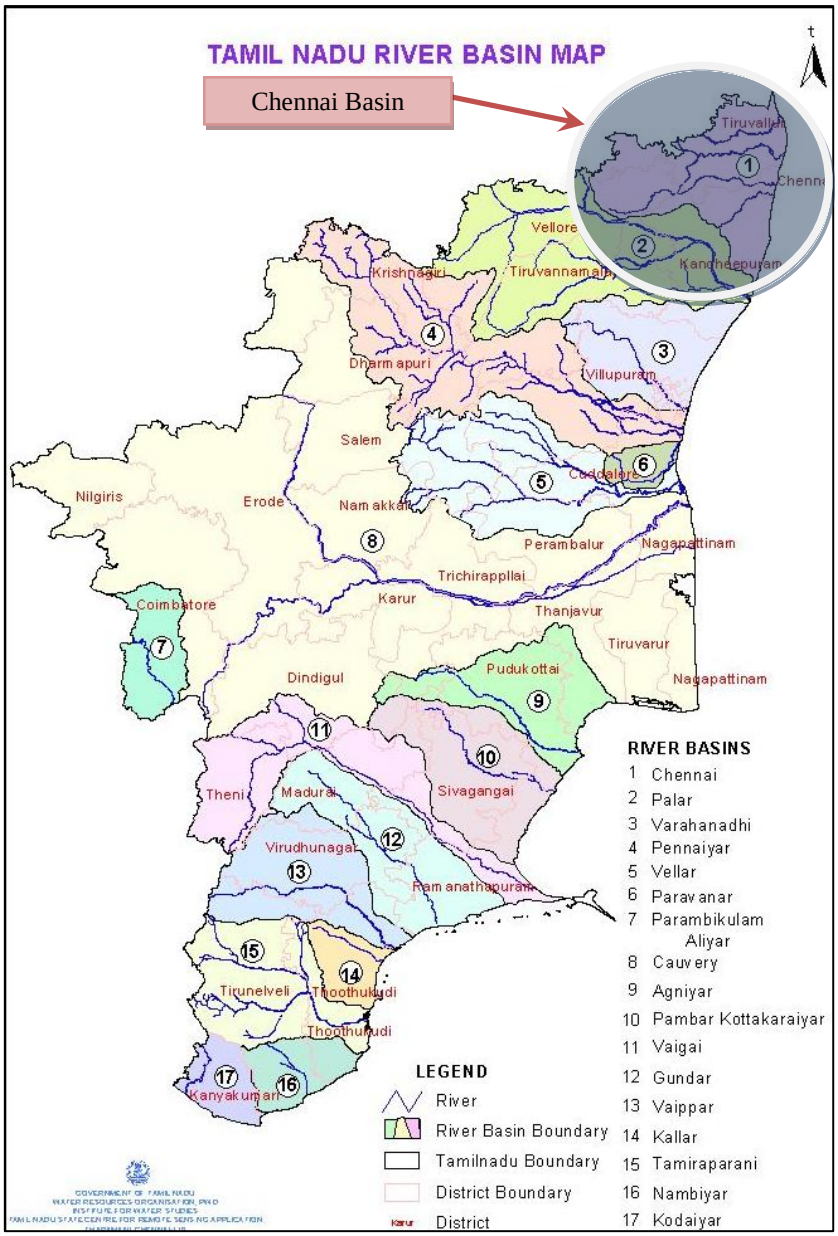
Figure A2.4.3 Average Monthly Rain fall for the Chennai Corporation

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

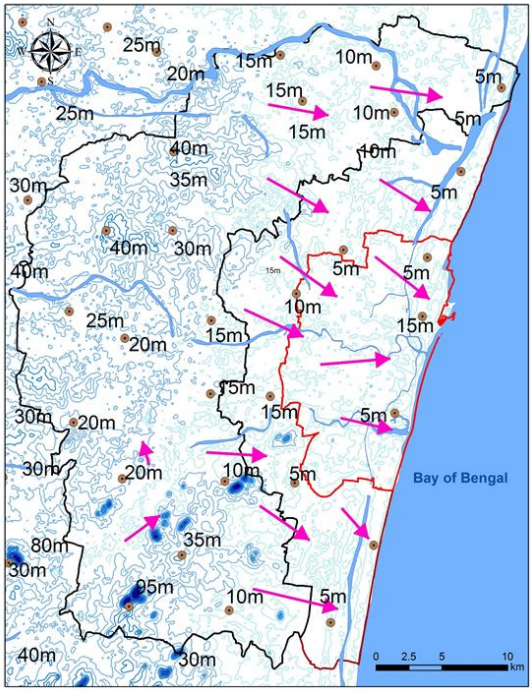
Figure A2.4.4 River Basins in Tamil Nadu

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.

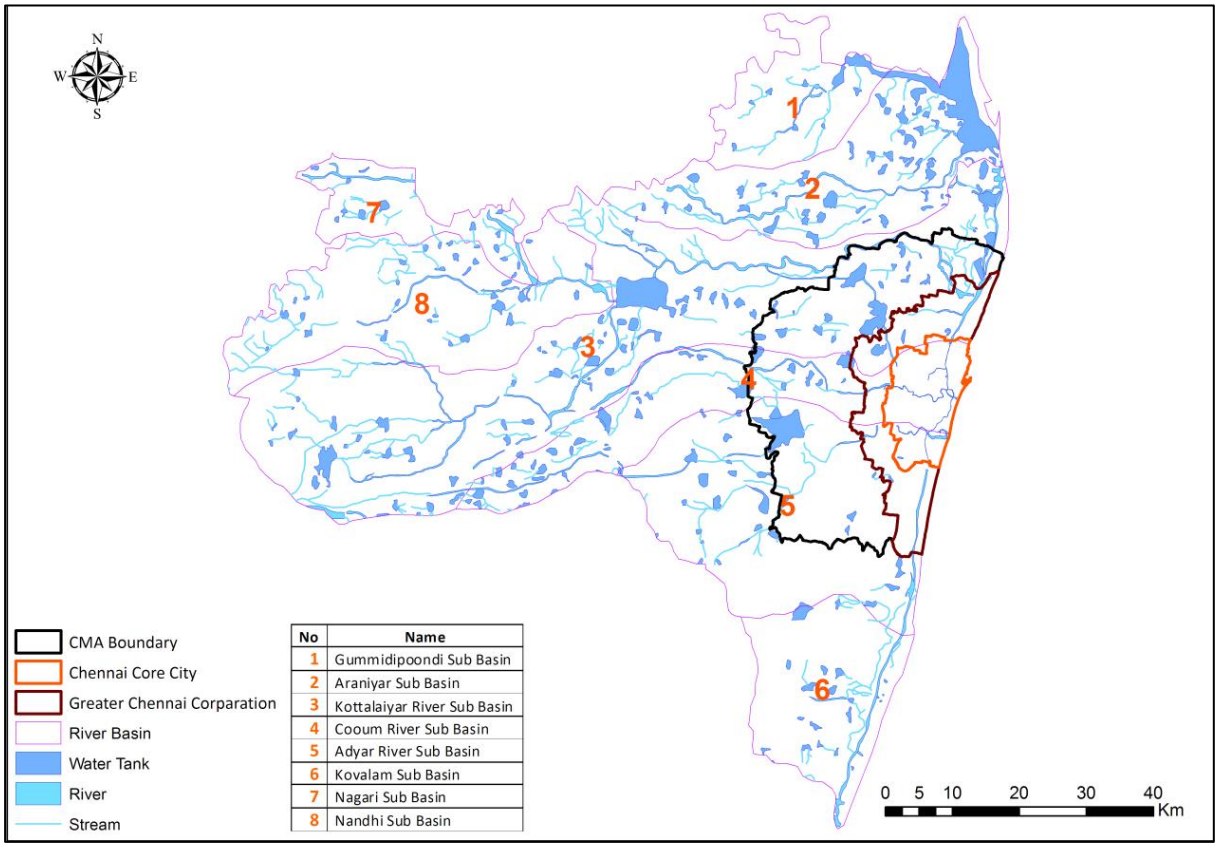
(2) Topography and Geology of Chennai

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

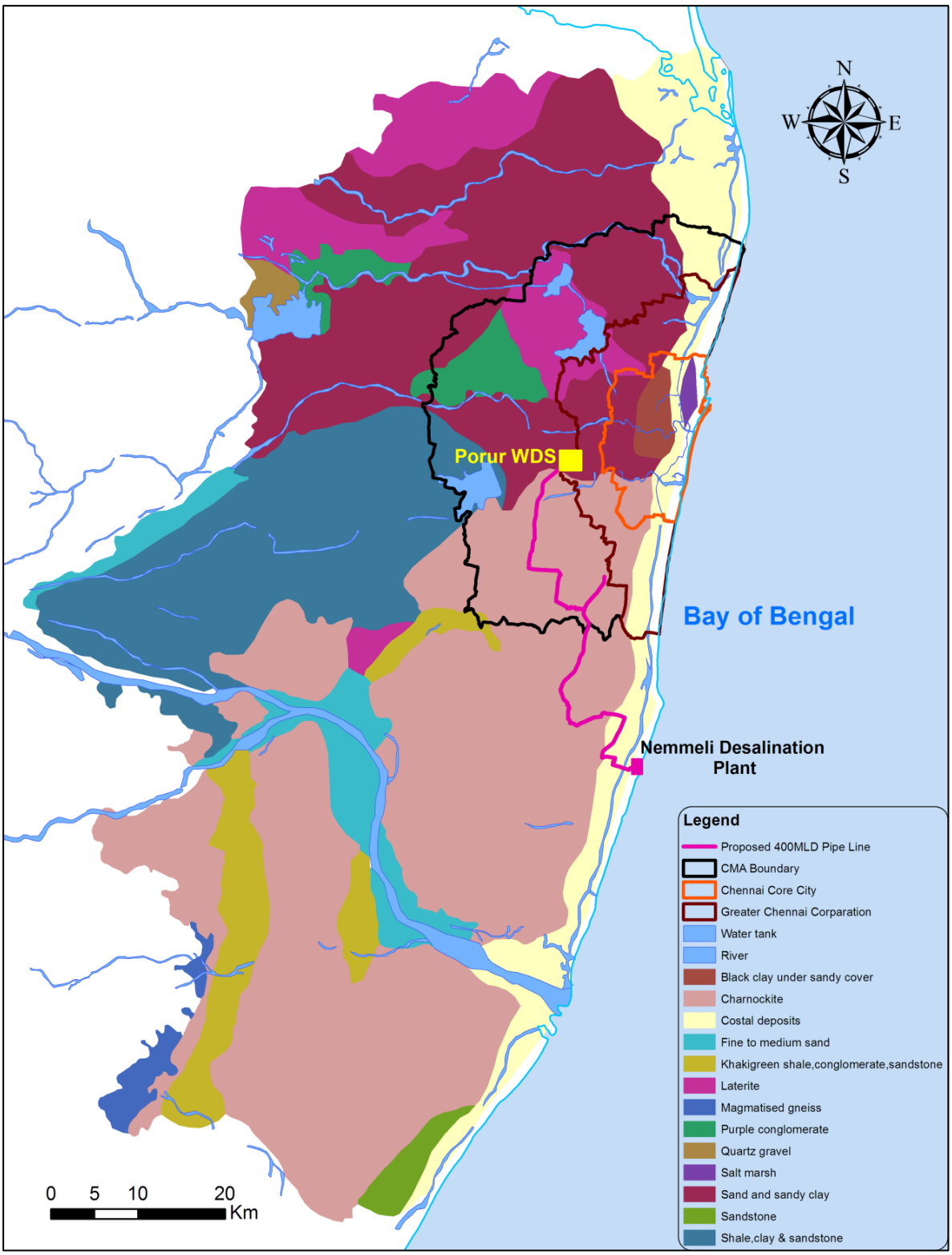
Figure A2.4.5 Topographical Map of CMA



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

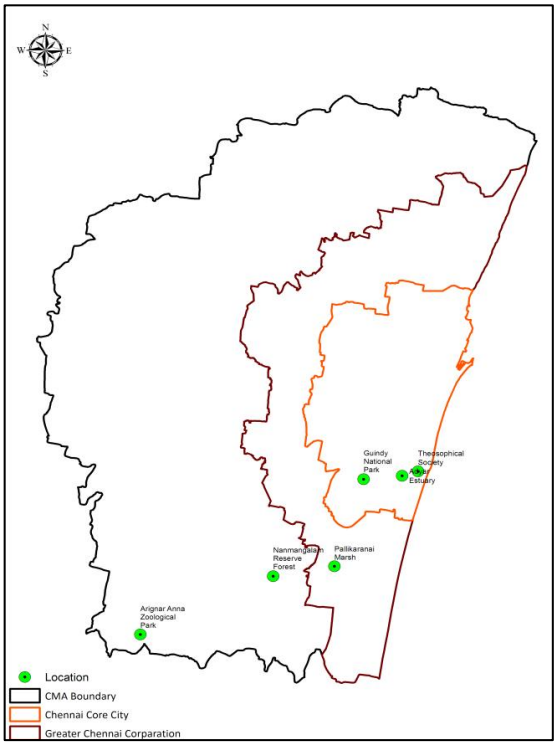
(1) Tamil Nadu

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.



Source: JICA Study Team

Figure A2.4.8 Locations of Fauna

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.

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.

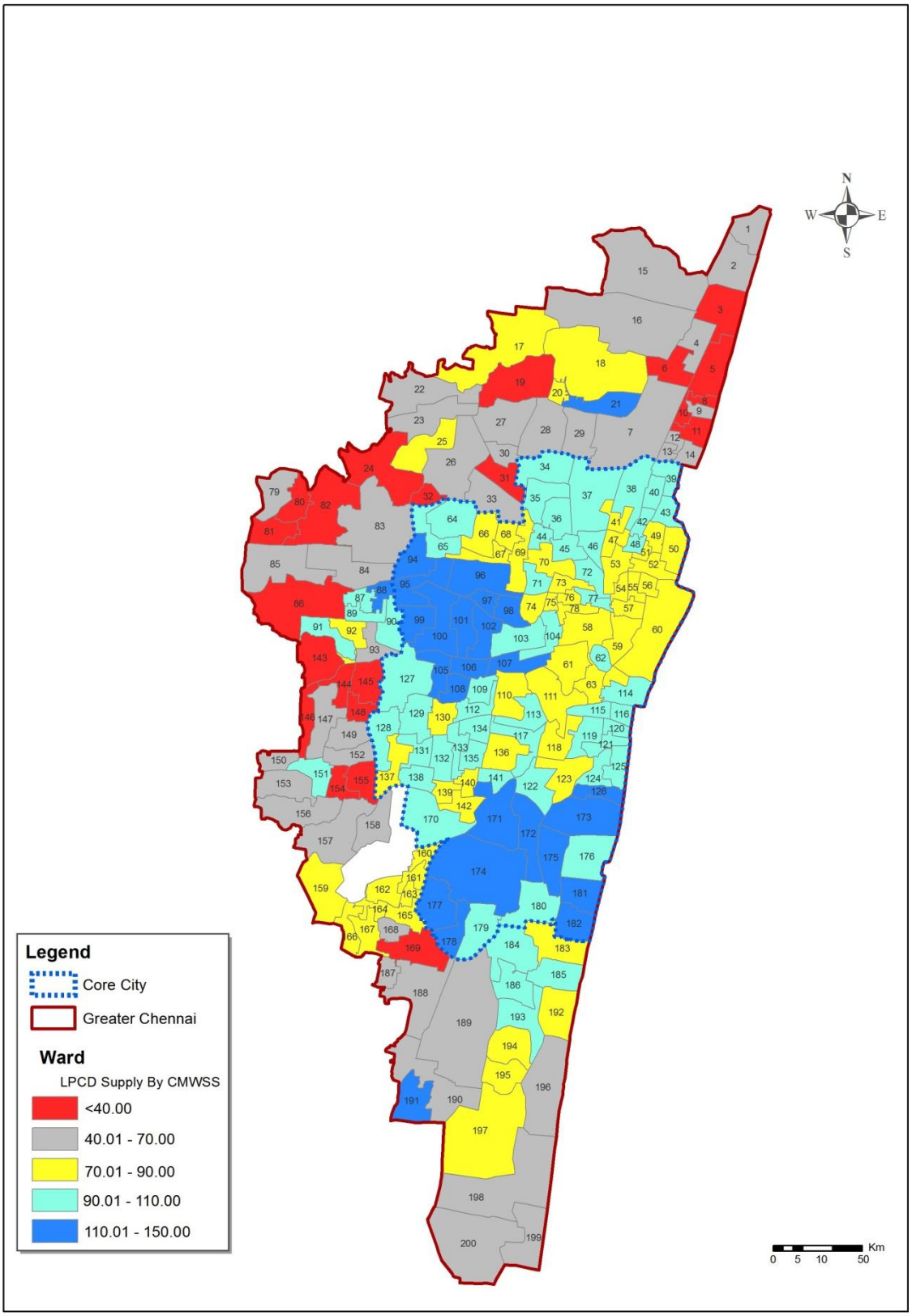
(2) Chennai Corporation

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

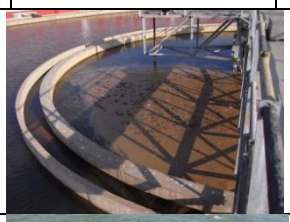
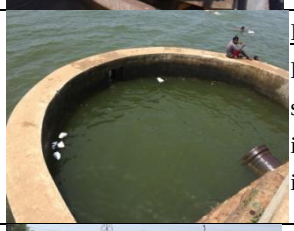
Vadakuthu WTP was commissioned in the year 2004. It adopts the conventional water treatment process with a capacity of 180 MLD and utilizes some civil structures of an old WTP constructed in 1974 at the same place, which was decommissioned prior to the construction of Vadakuthu WTP. The O&M of the facility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

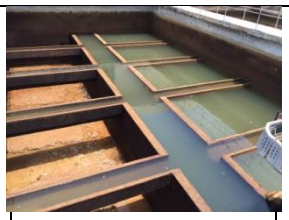
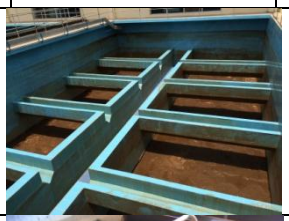
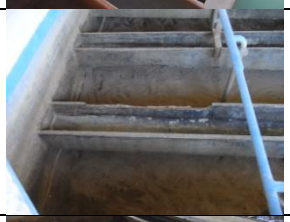
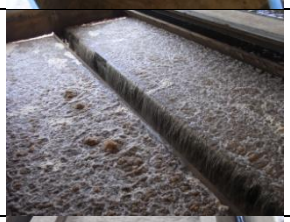
carried out by an O&M contracting company with 190 staff members (36 for RWPS, 79 for WTP and 75 for bore wells).

(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

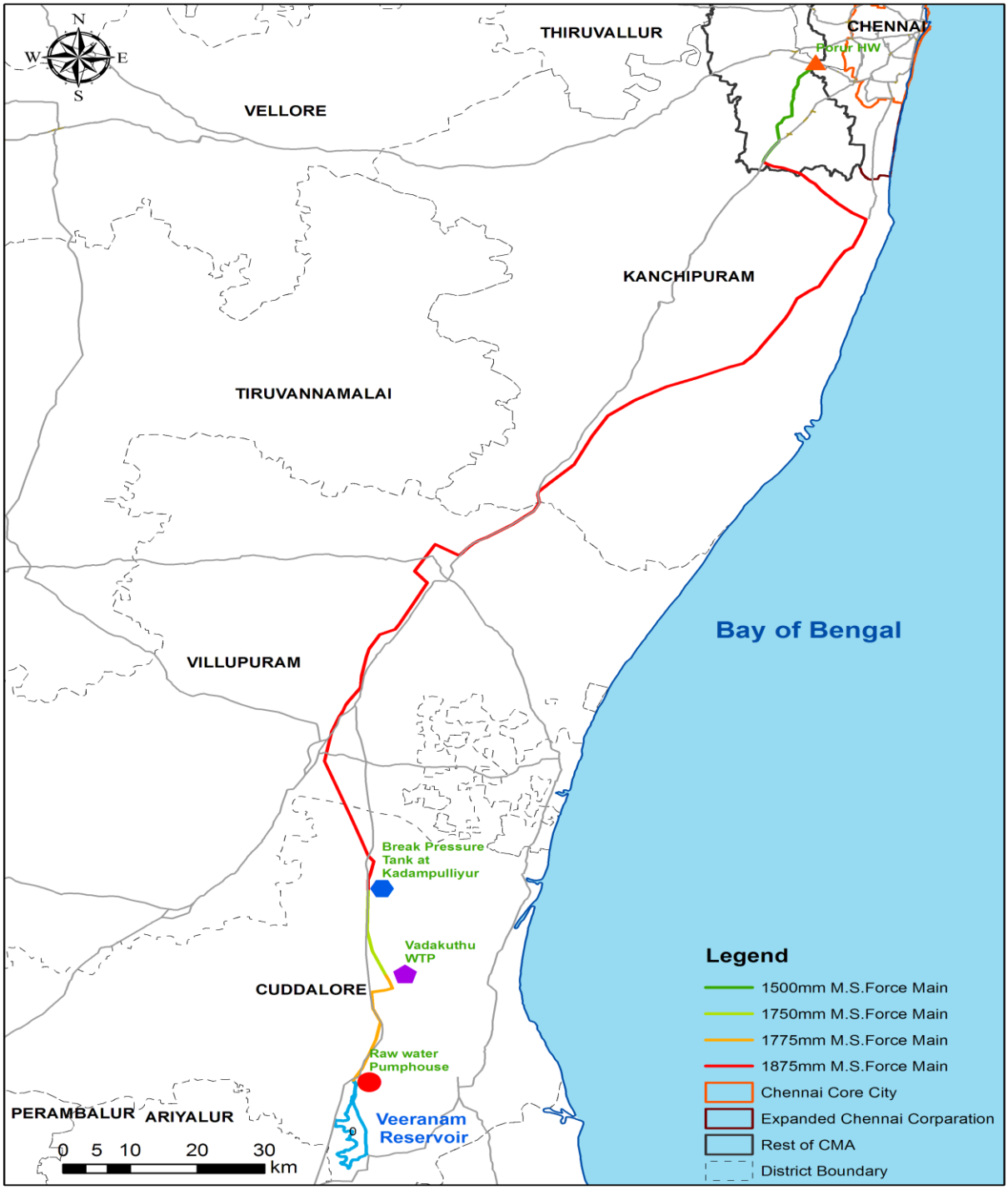
Appendix 3.5 Existing Water Transmission Mains of CMWSSB

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

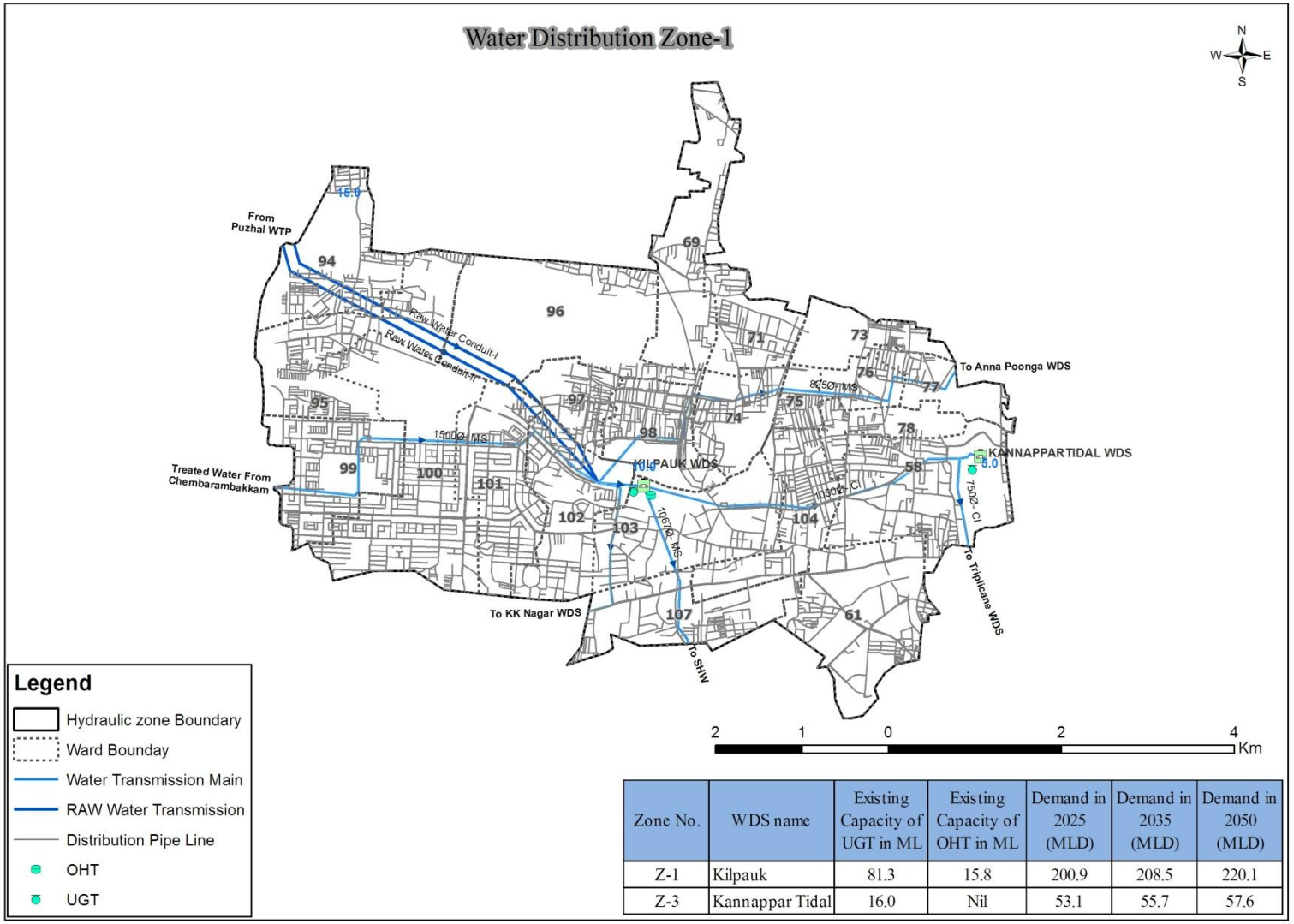
Sources: JICA Study Team based on Information from CMWSSB



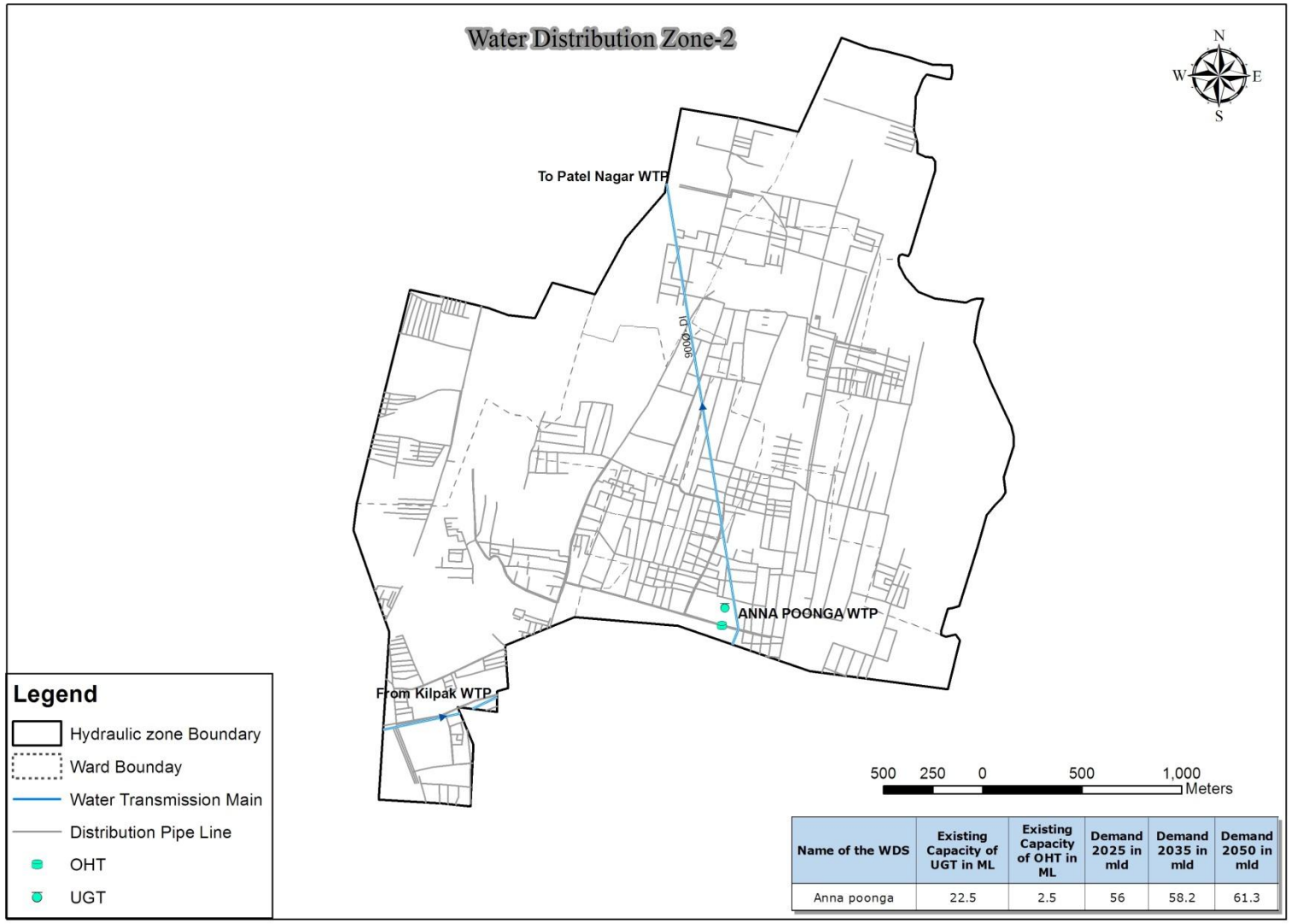
Source: JICA Study Team based on Information from CMWSSB

Figure A3.5.1 Layout of the Veeranam Transmission Main

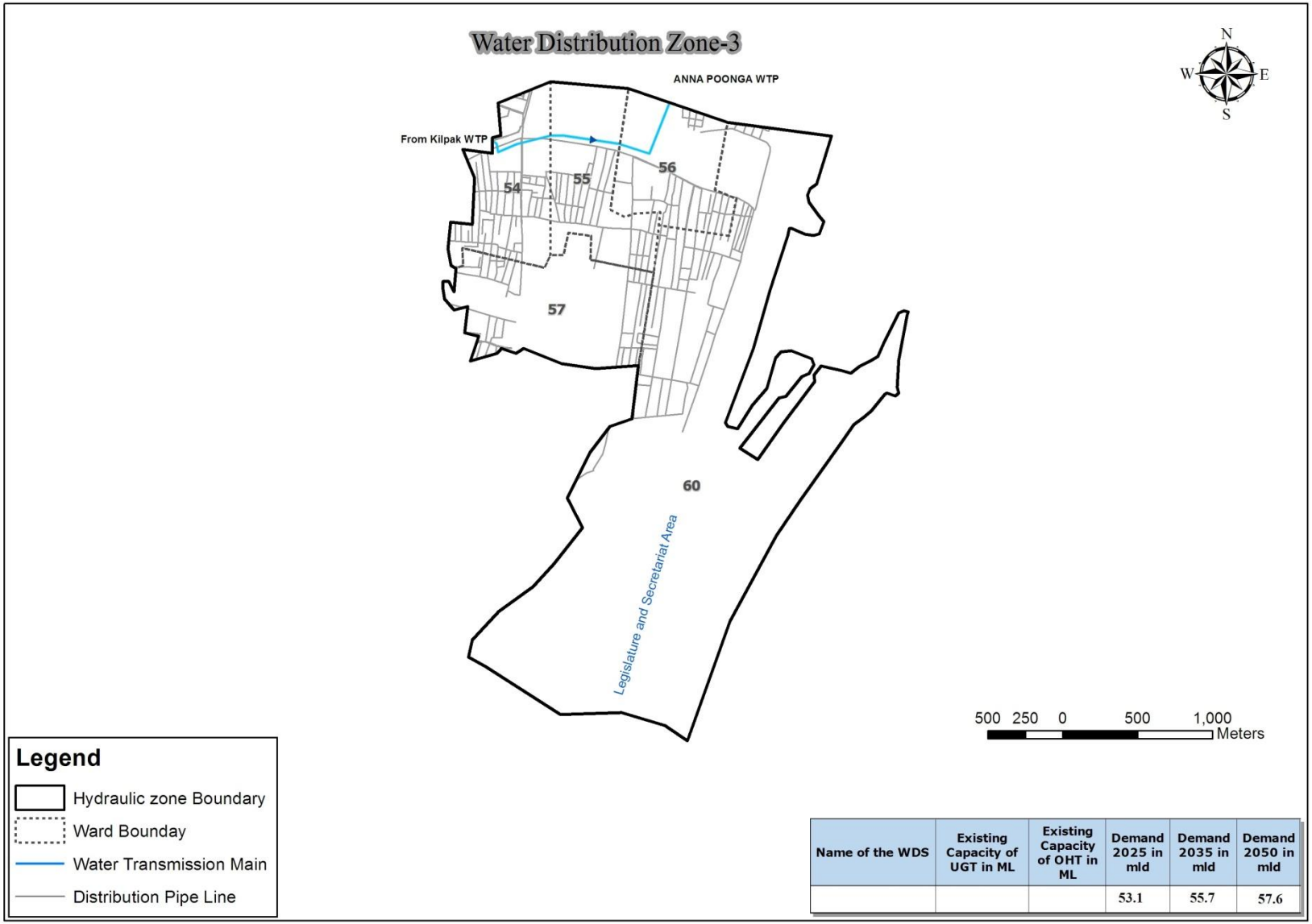
Appendix 3.6 Water Distribution Network Maps for the Water Distribution Zones (from Zone 1 to 16)



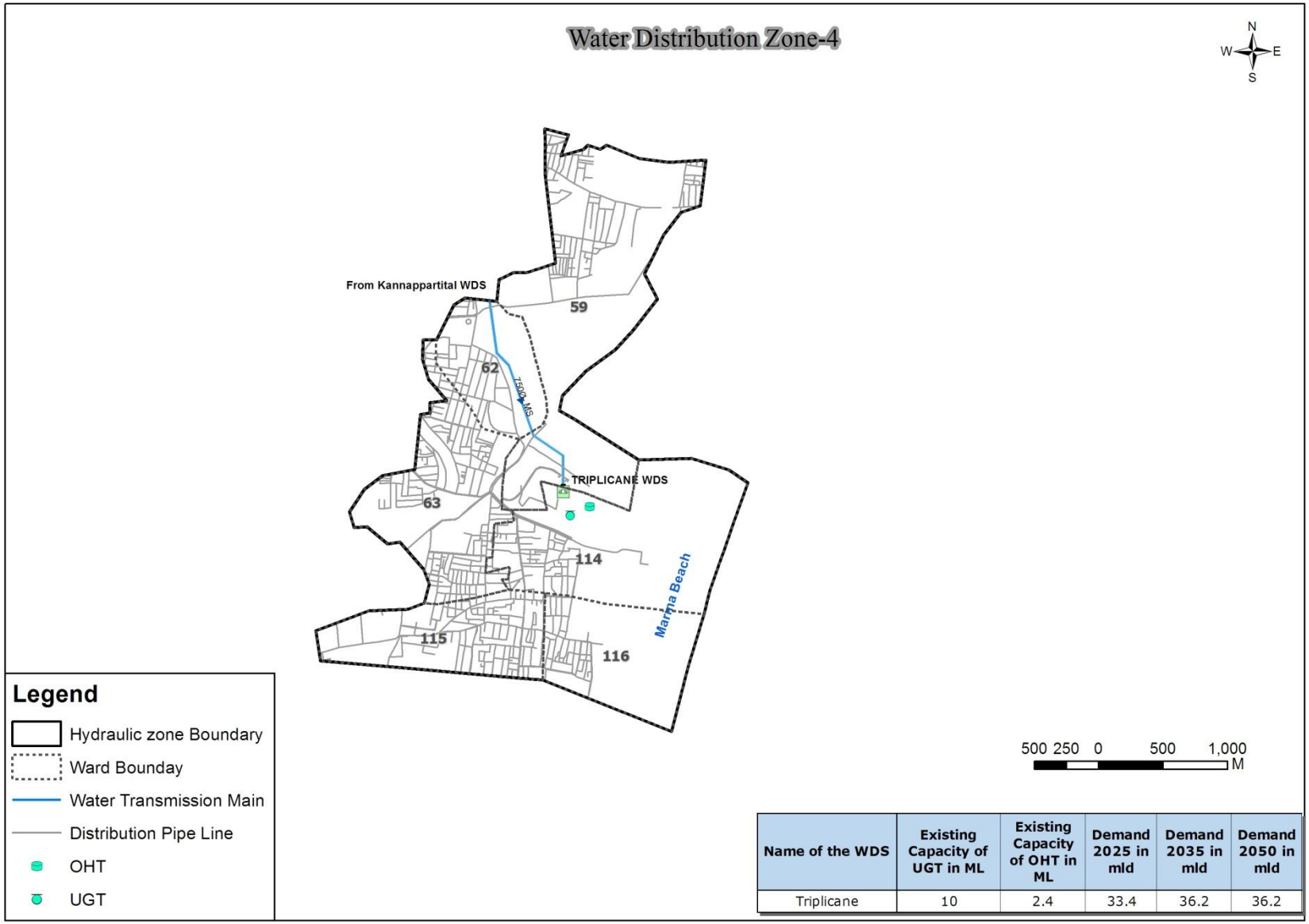
Zone No.	WDS name	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand in 2025 (MLD)	Demand in 2035 (MLD)	Demand in 2050 (MLD)
Z-1	Kilpauk	81.3	15.8	200.9	208.5	220.1
Z-3	Kannappar Tidal	16.0	Nil	53.1	55.7	57.6



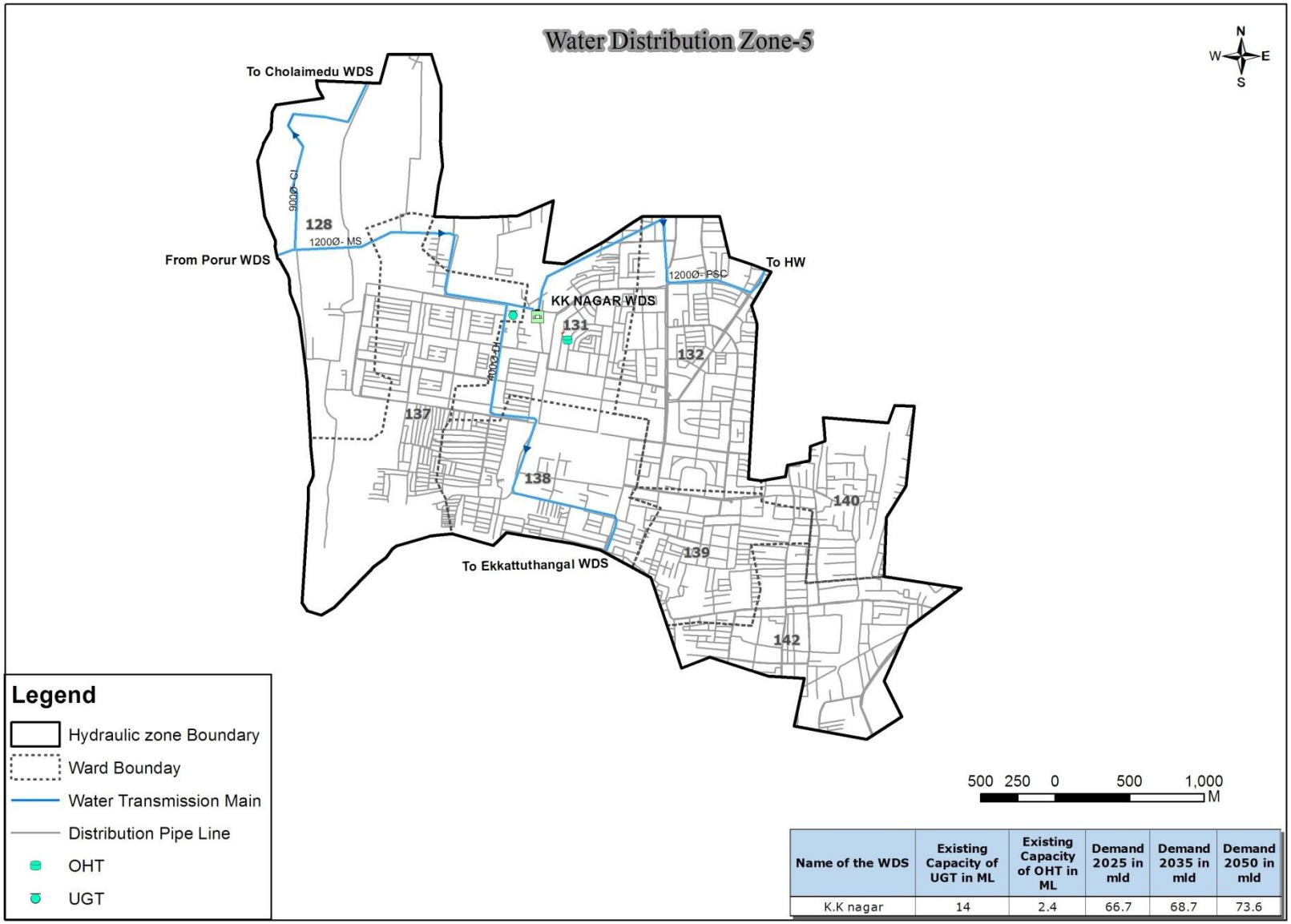
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Anna poonga	22.5	2.5	56	58.2	61.3



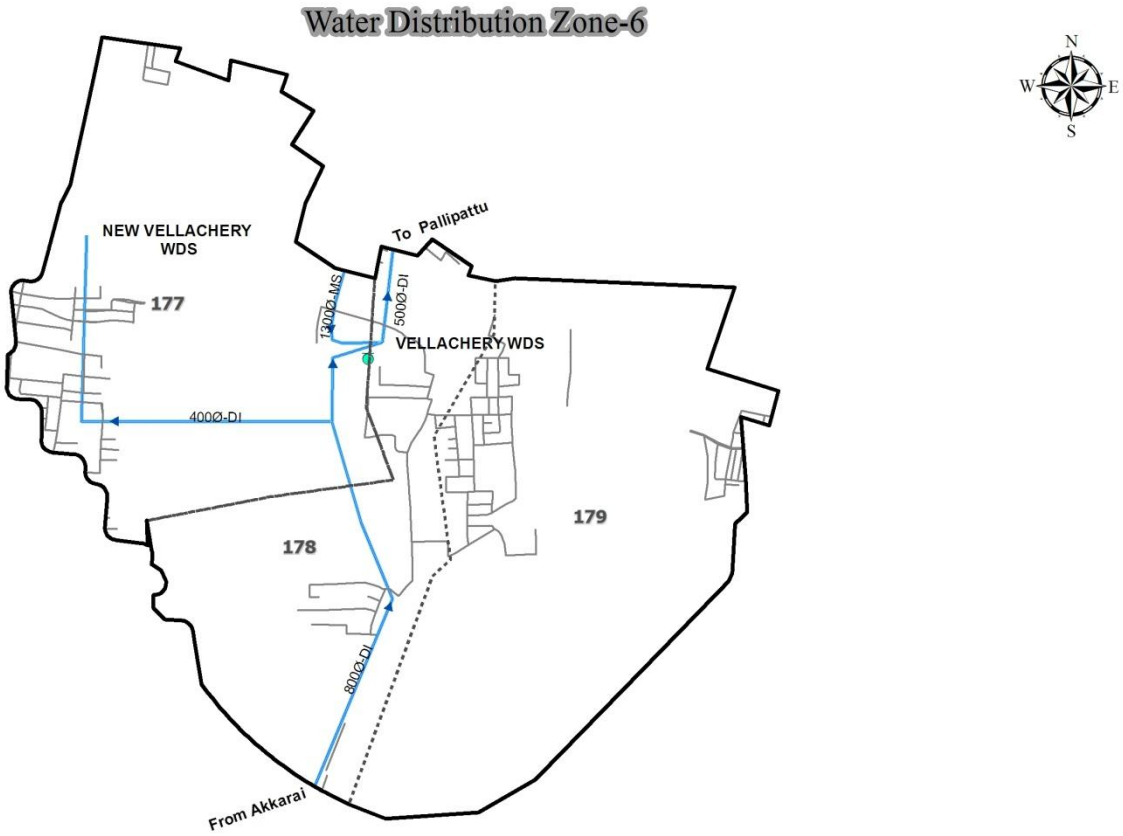
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
			53.1	55.7	57.6



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

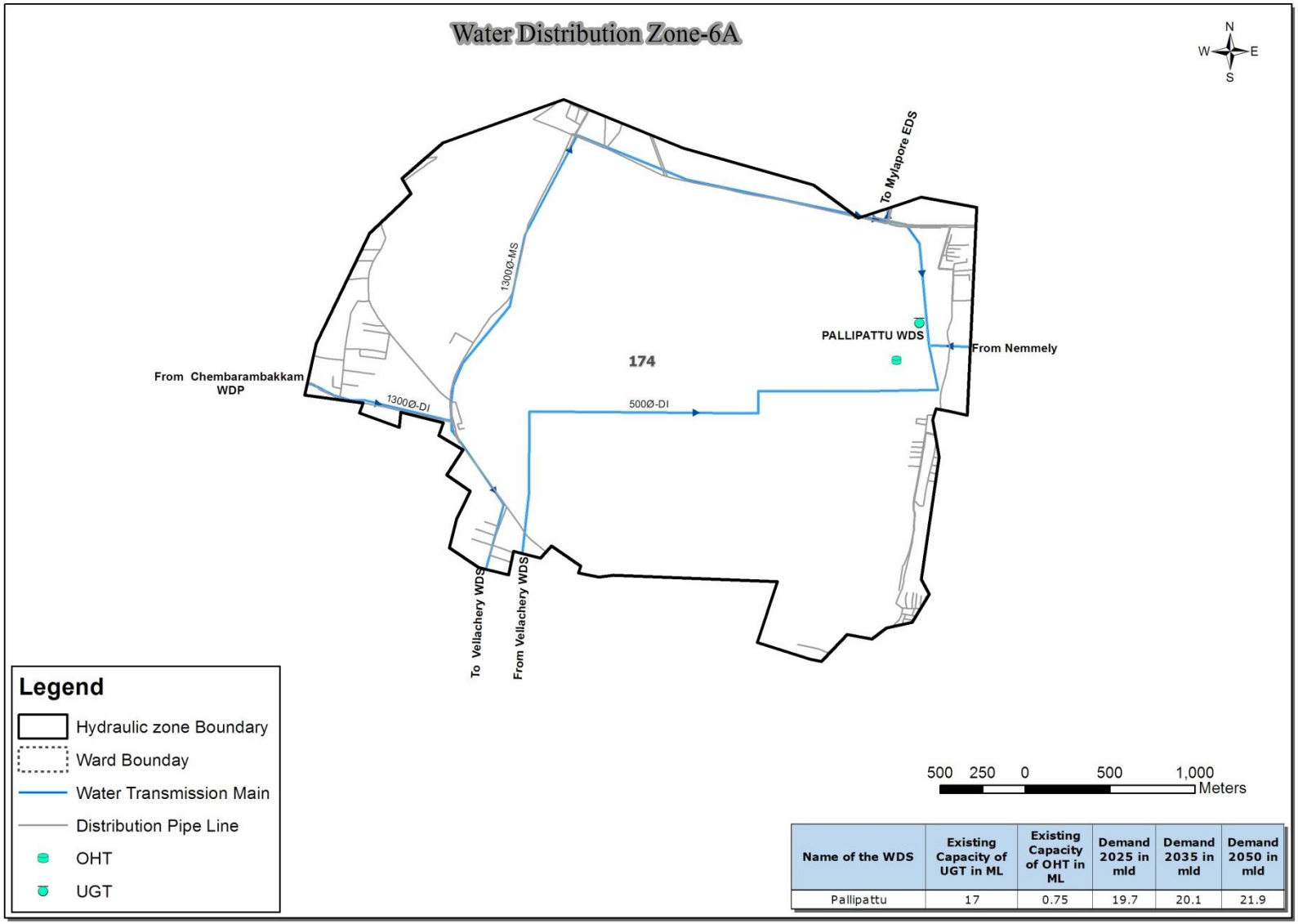


Legend

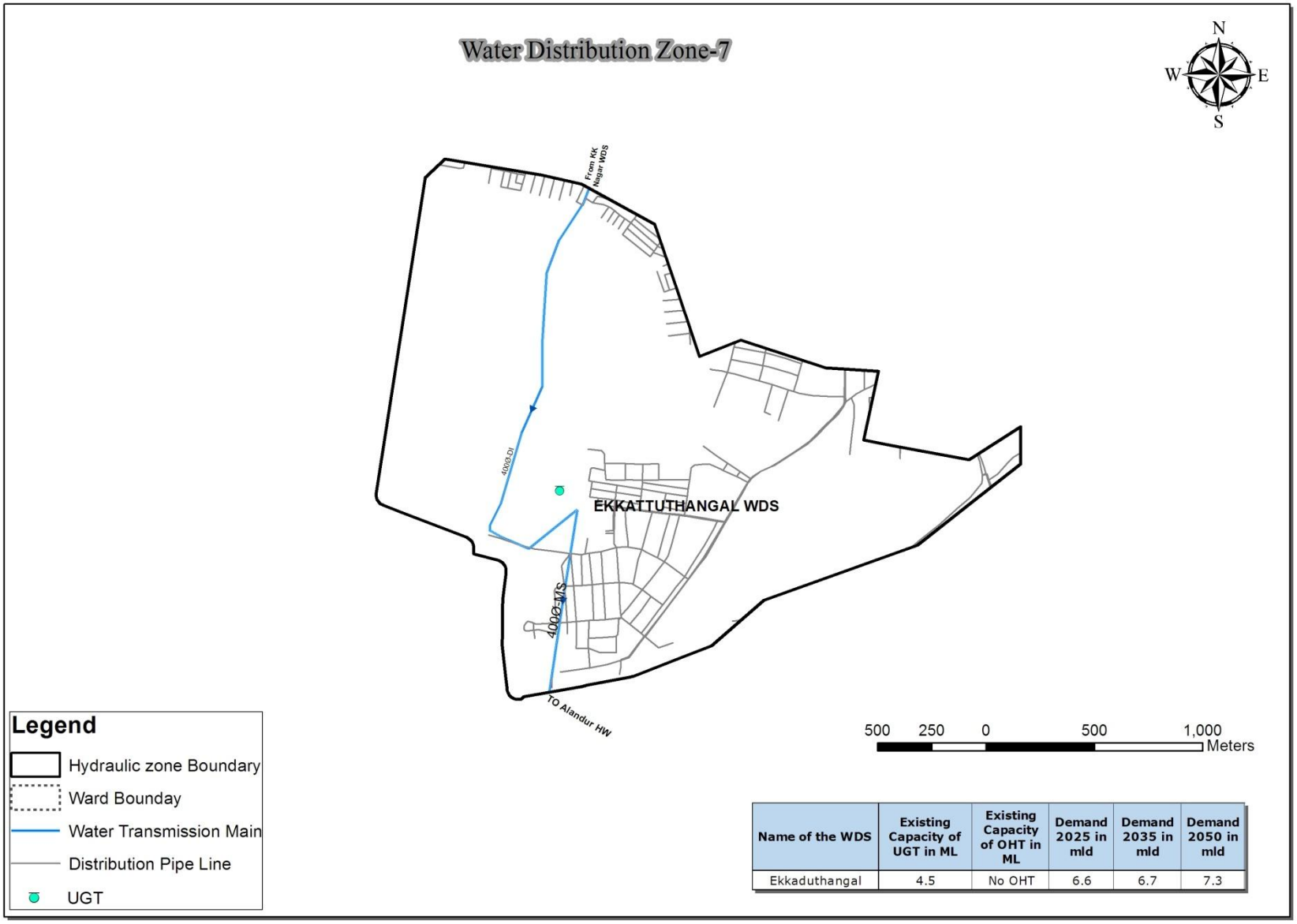
- Hydraulic zone Boundary
- Ward Bounday
- Water Transmission Main
- Distribution Pipe Line
- UGT

500 250 0 500 1,000 Meters

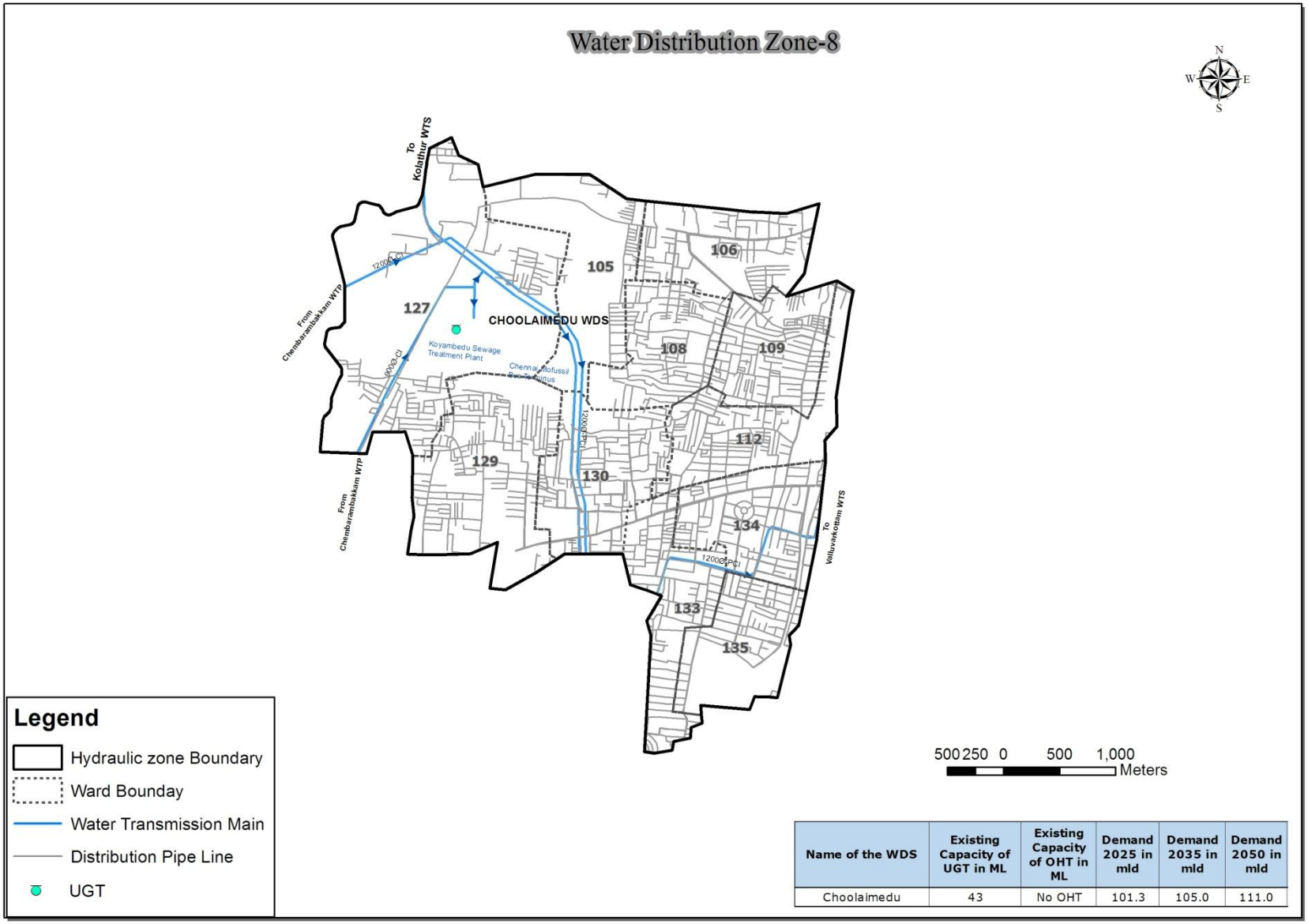
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Velachery	6	No OHT	34.5	35.2	38.4
Velachery (new)	2	No OHT	5.4	5.6	6.0



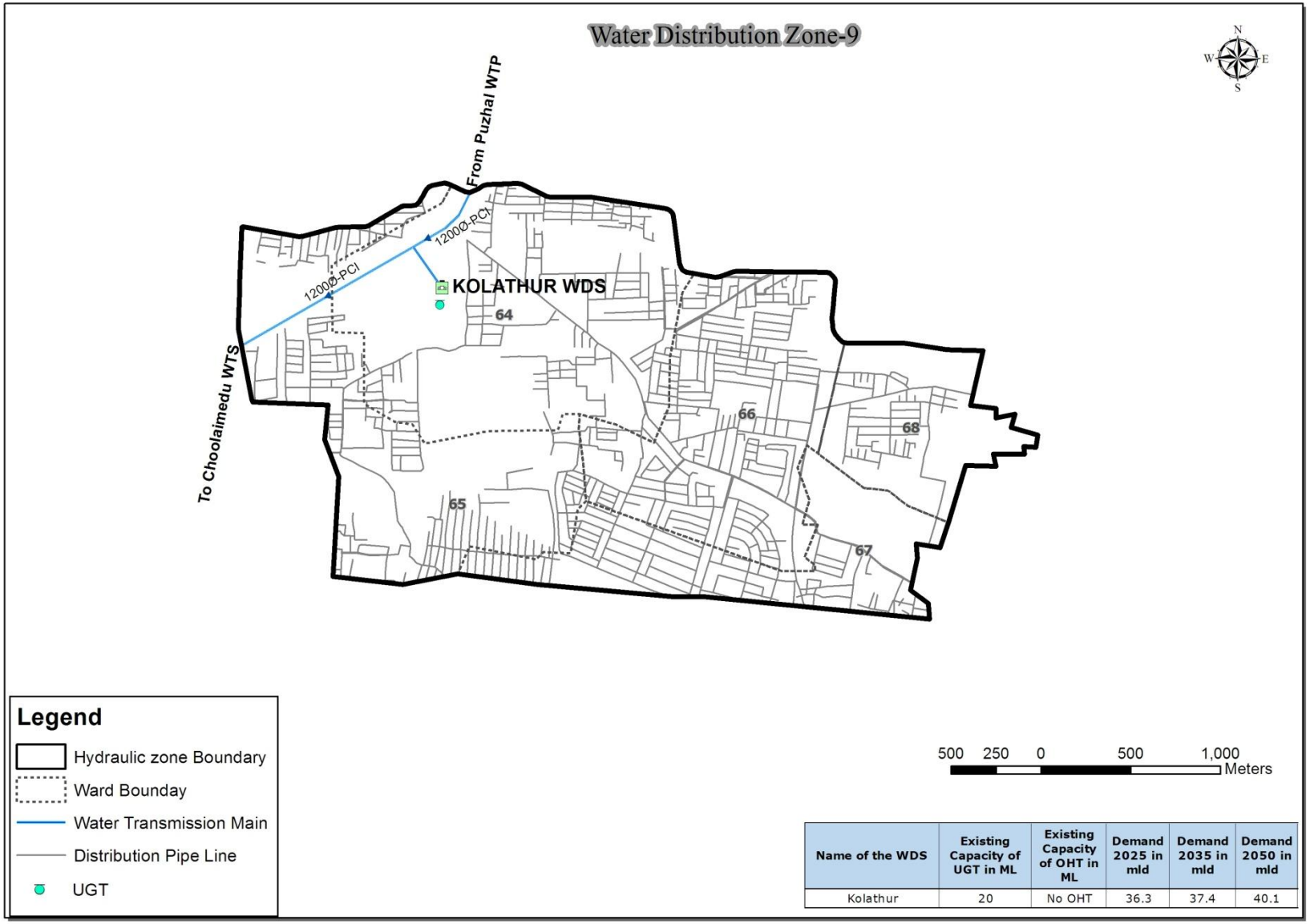
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Pallipattu	17	0.75	19.7	20.1	21.9



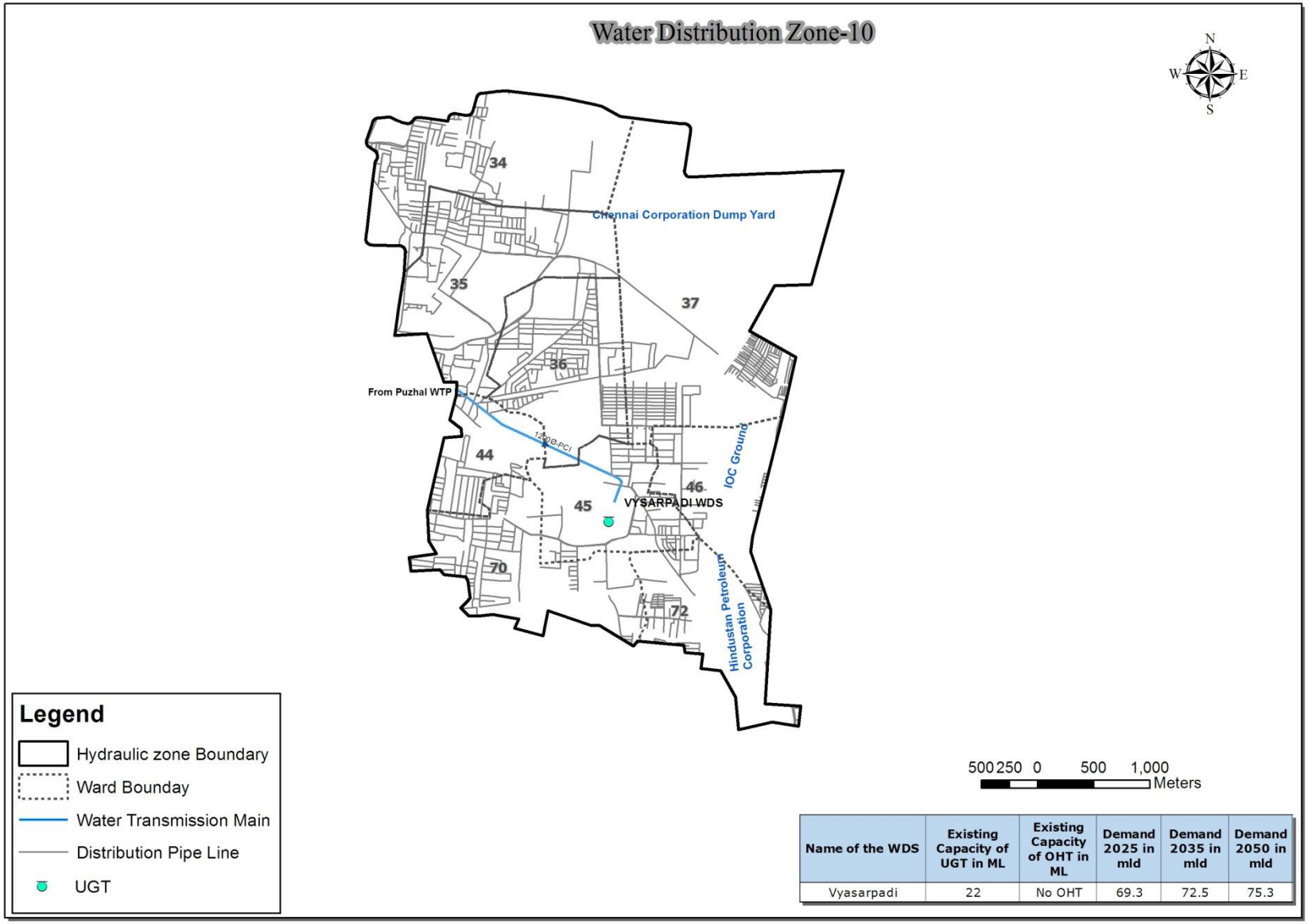
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Ekkaduthangal	4.5	No OHT	6.6	6.7	7.3



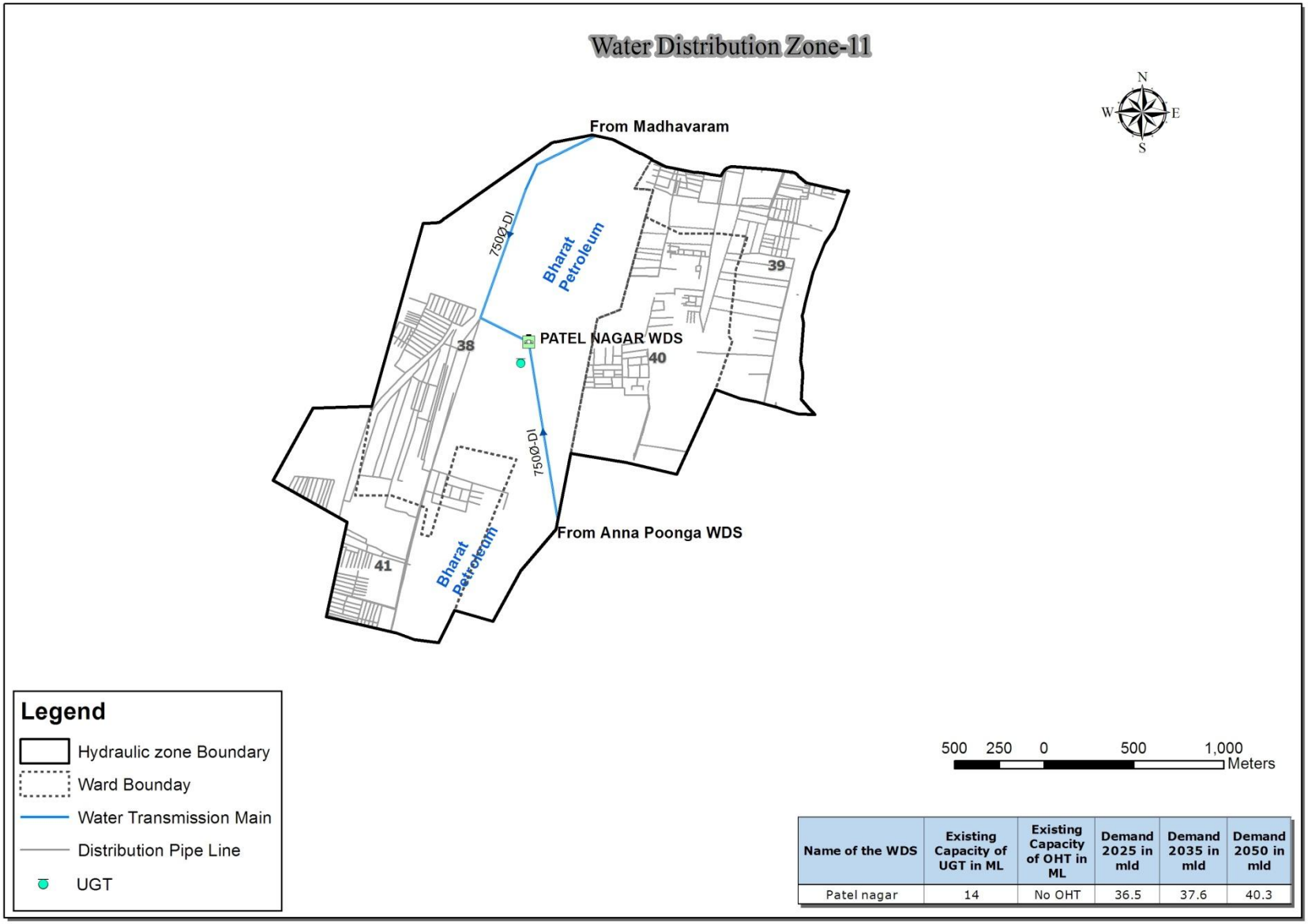
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Choolaimedu	43	No OHT	101.3	105.0	111.0



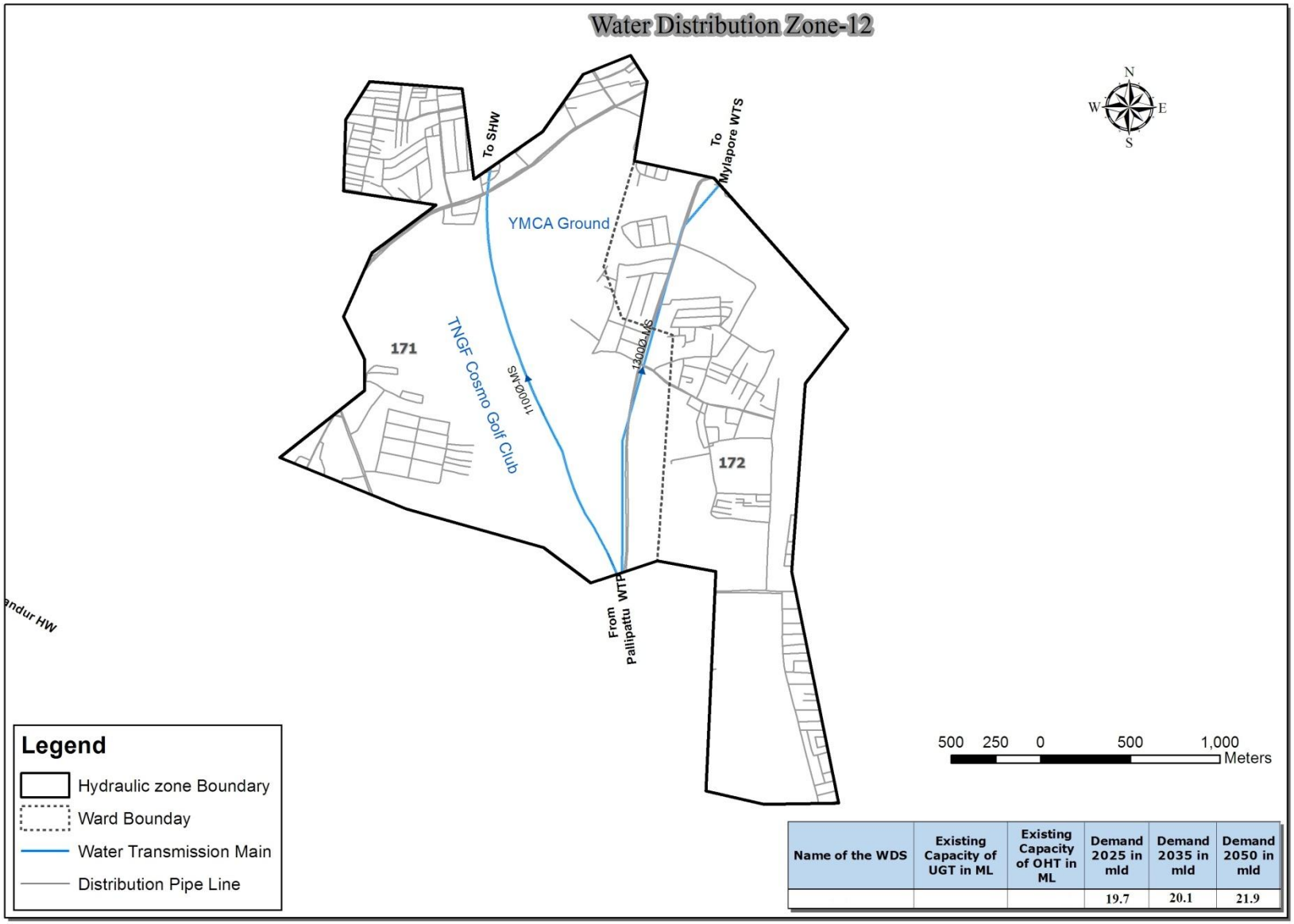
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Kolathur	20	No OHT	36.3	37.4	40.1



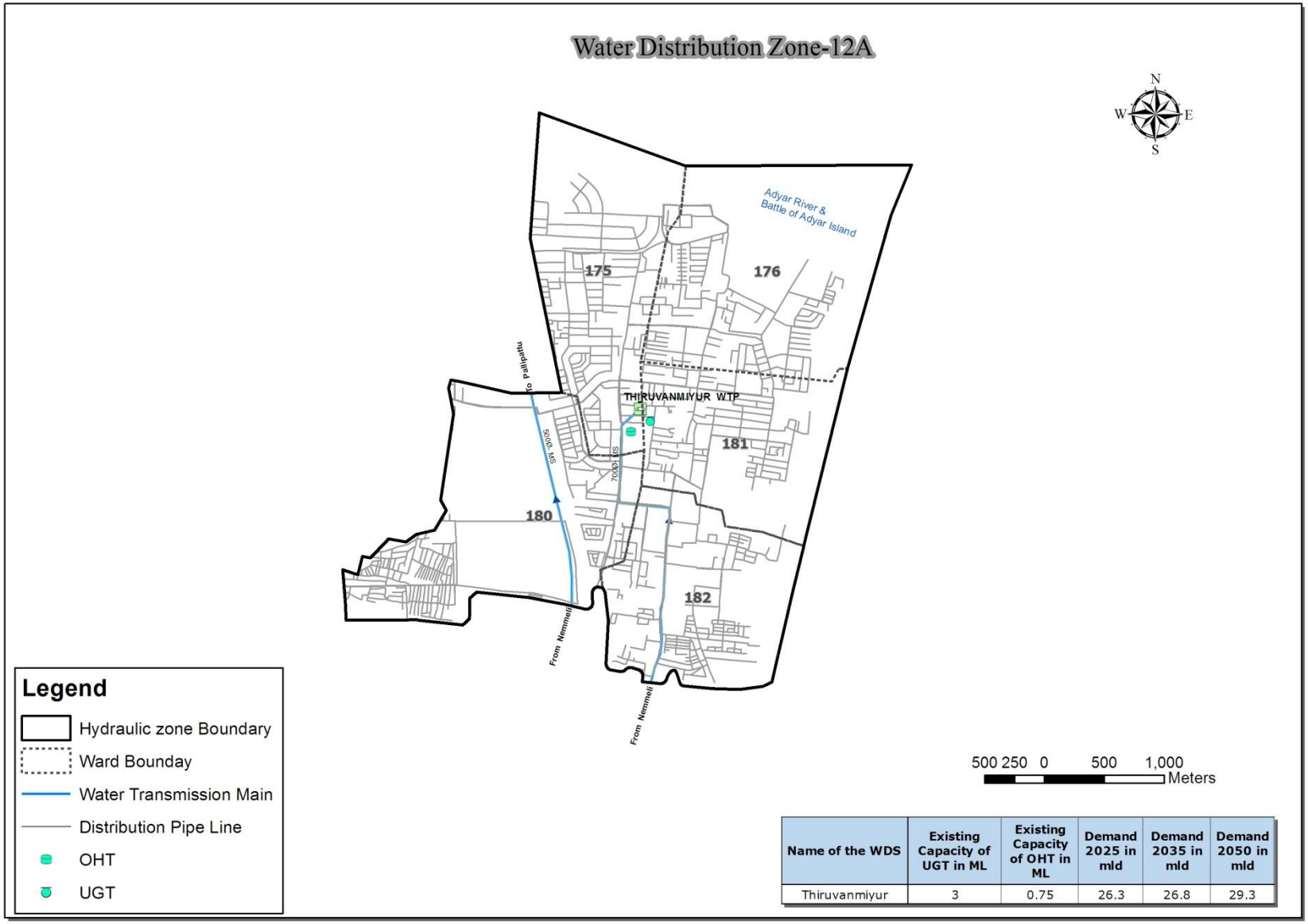
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Vyasarpadi	22	No OHT	69.3	72.5	75.3



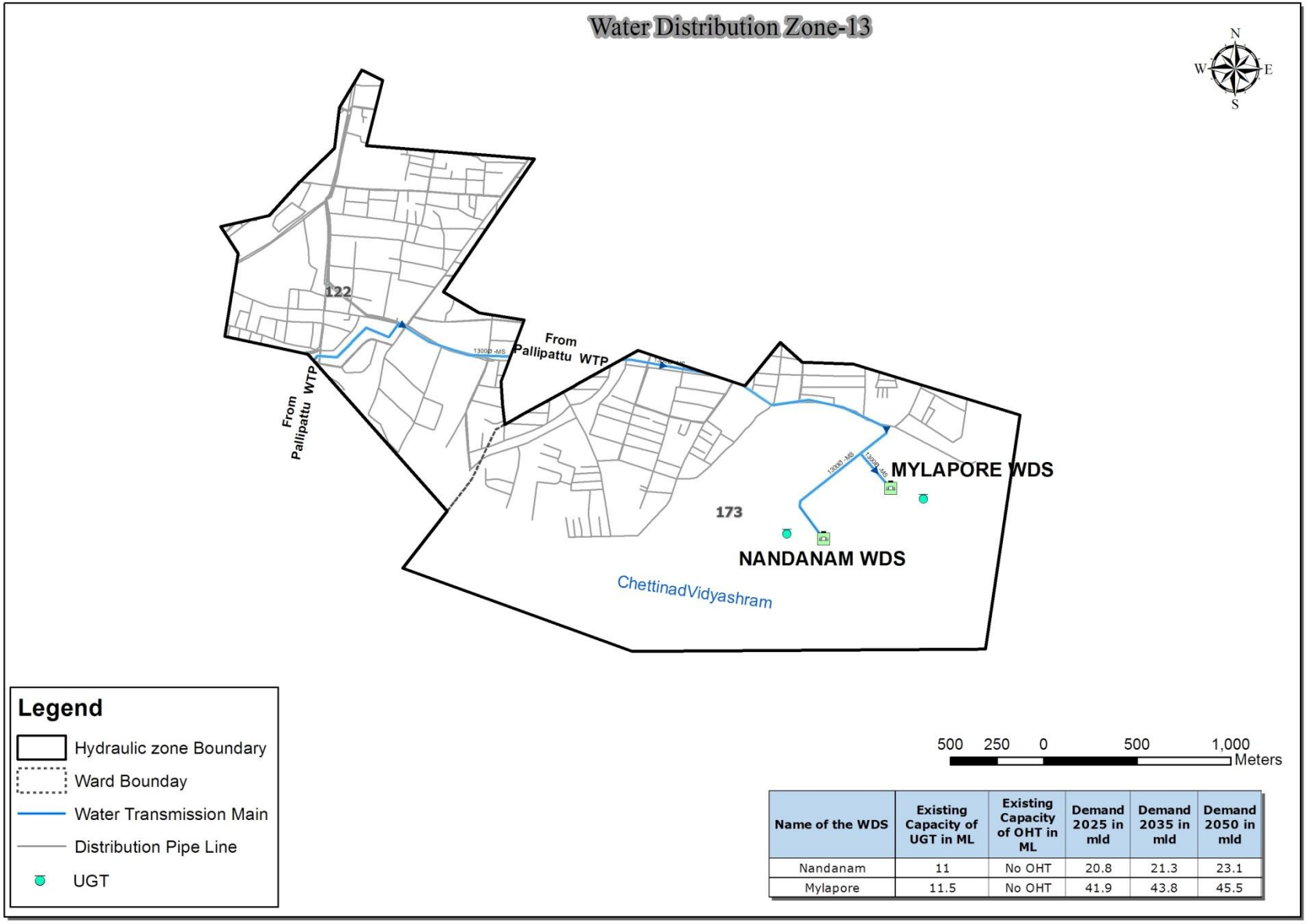
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Patel nagar	14	No OHT	36.5	37.6	40.3



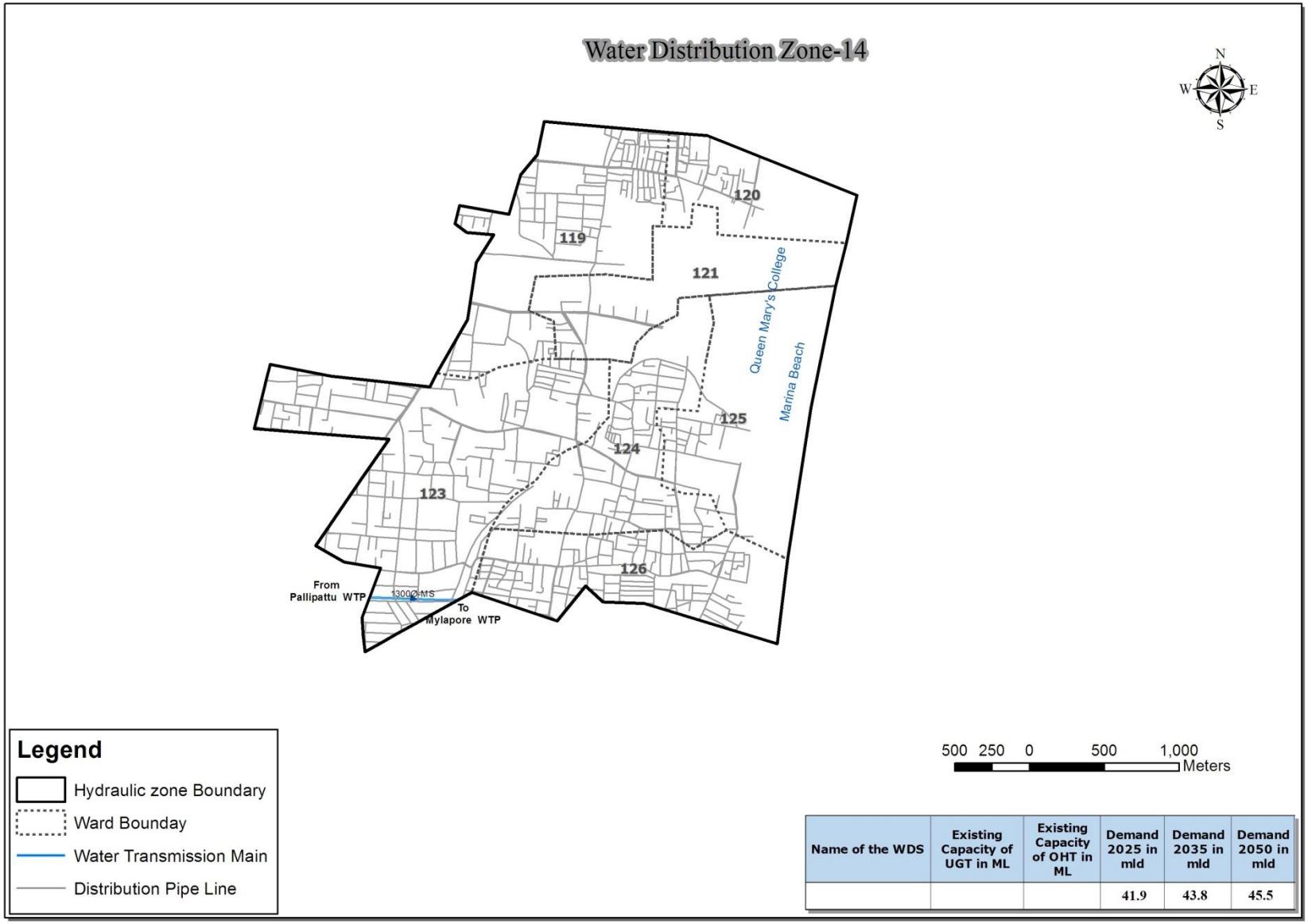
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
			19.7	20.1	21.9



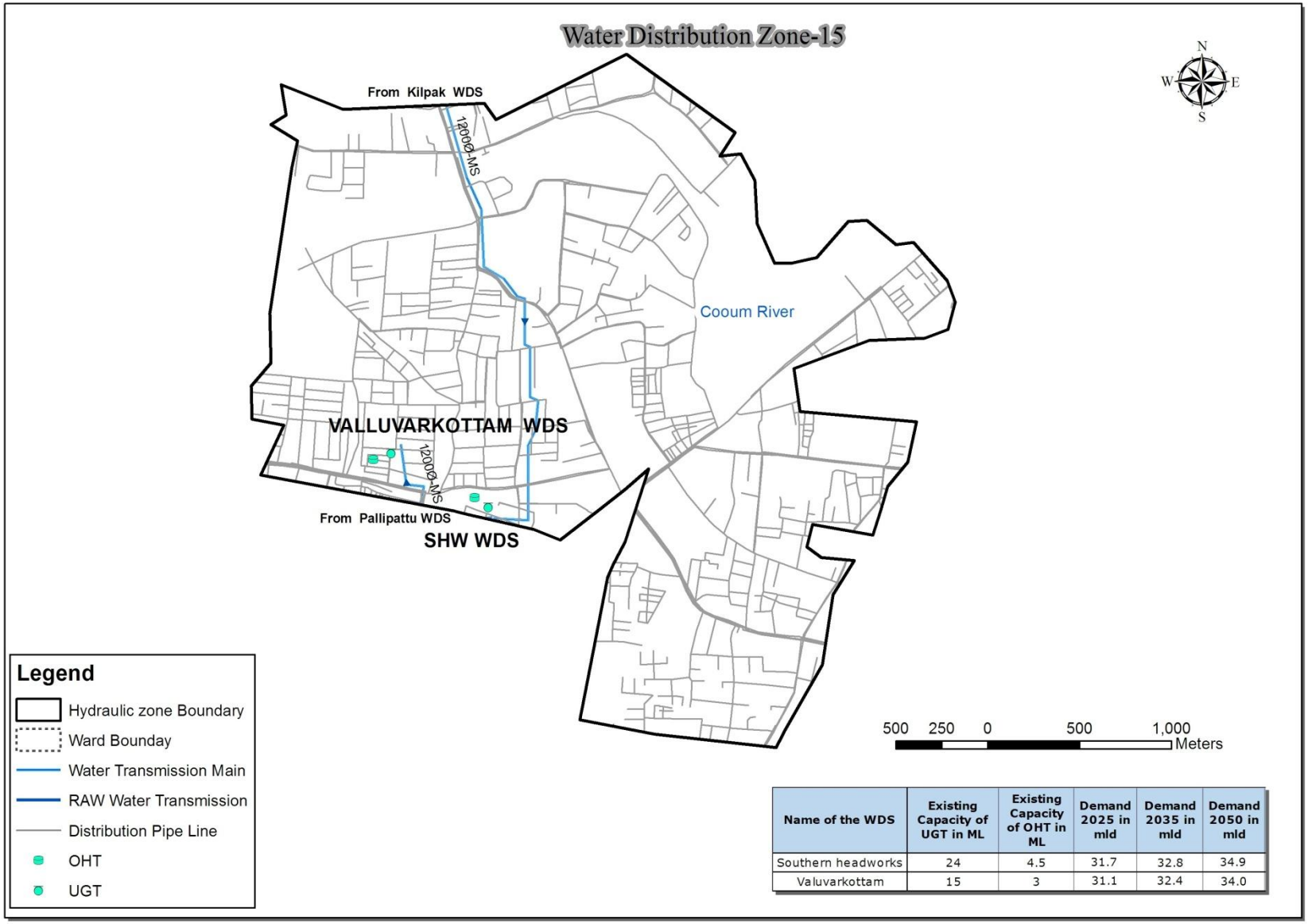
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Thiruvanmiyur	3	0.75	26.3	26.8	29.3



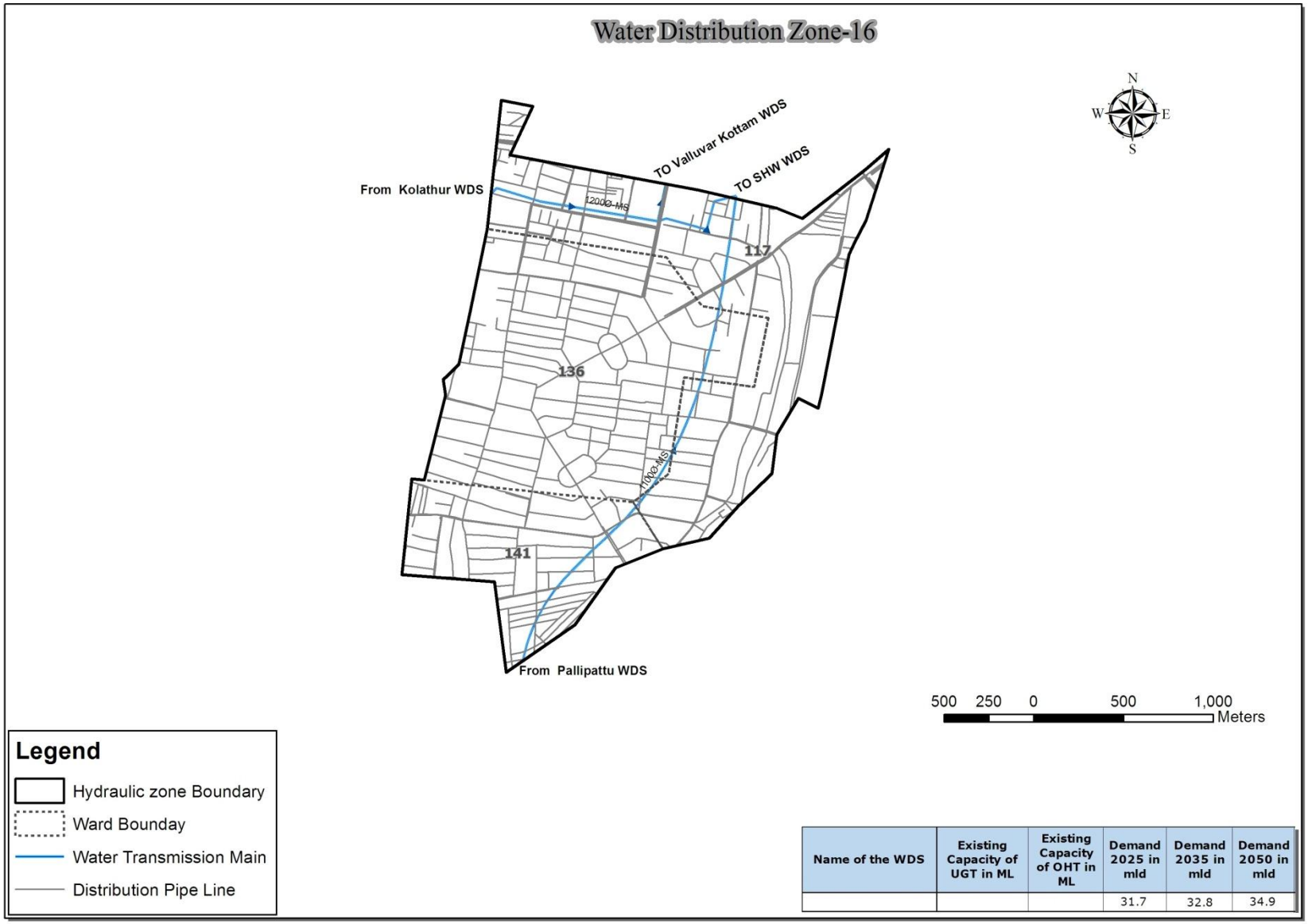
Name of the WDS	Existing Capacity of UGT in ML	Existing Capacity of OHT in ML	Demand 2025 in mld	Demand 2035 in mld	Demand 2050 in mld
Nandanam	11	No OHT	20.8	21.3	23.1
Mylapore	11.5	No OHT	41.9	43.8	45.5



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%

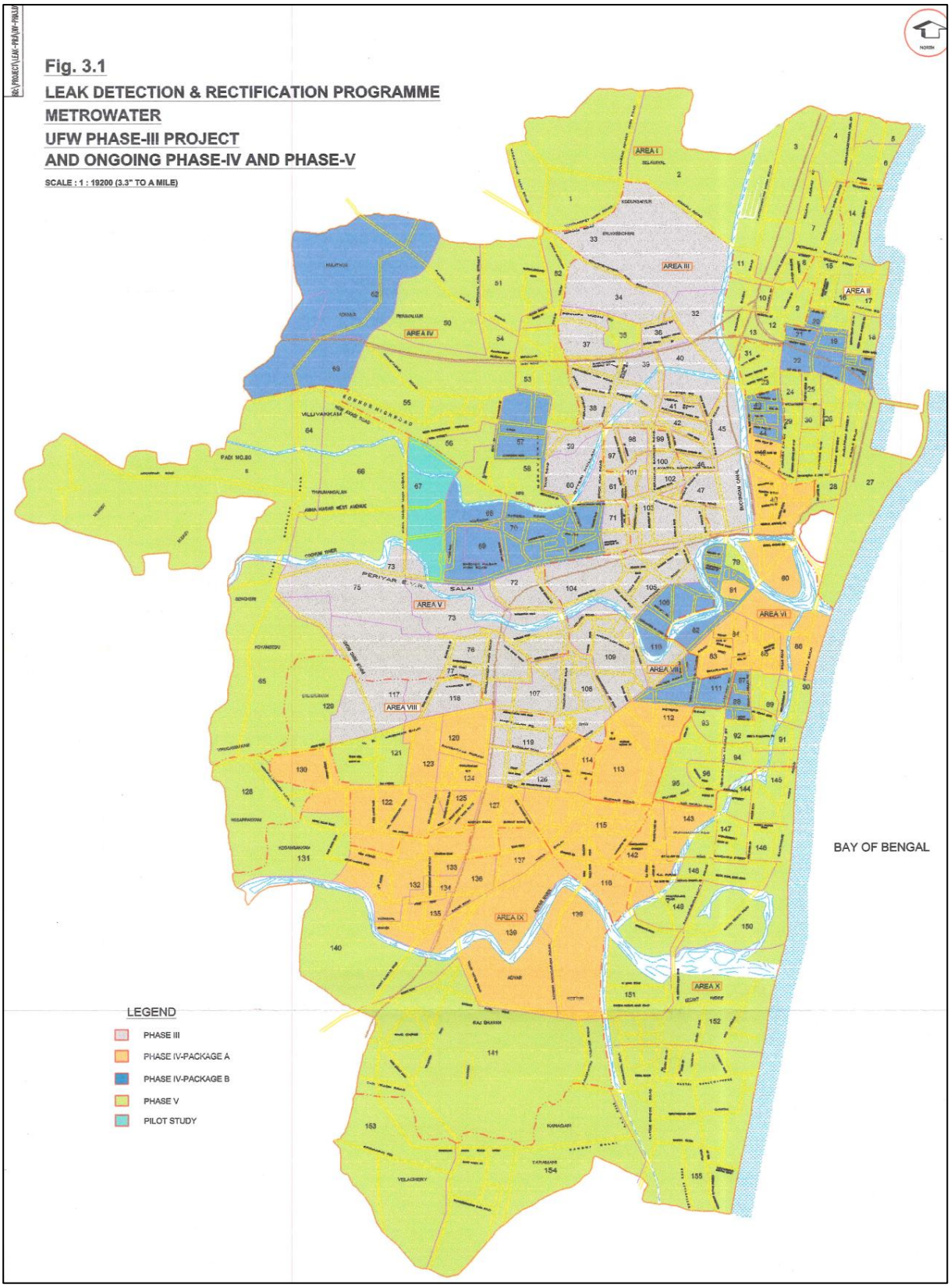
The contents of the program phase by phase are described below, and the program's coverage is shown in Figure A3.9.1.

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.



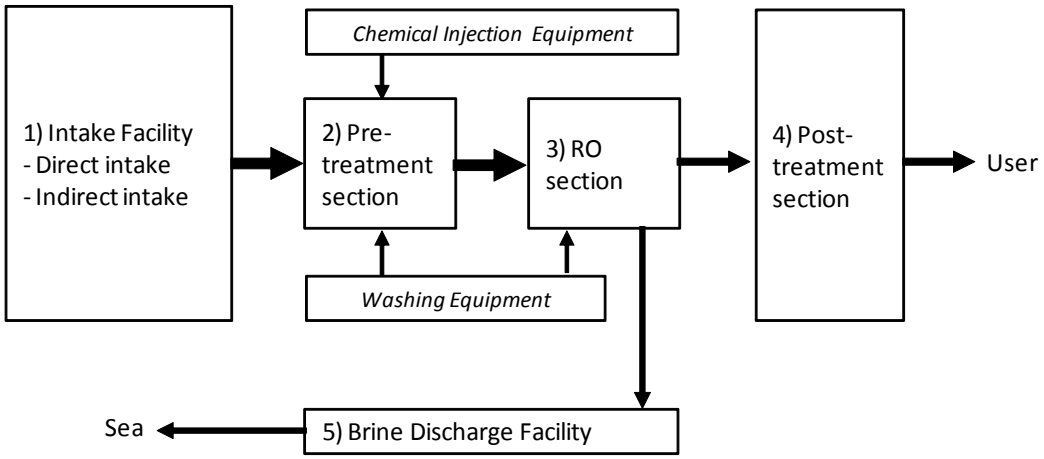
Source: Report on reduction in UFW in Chennai city (Phase-III)

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

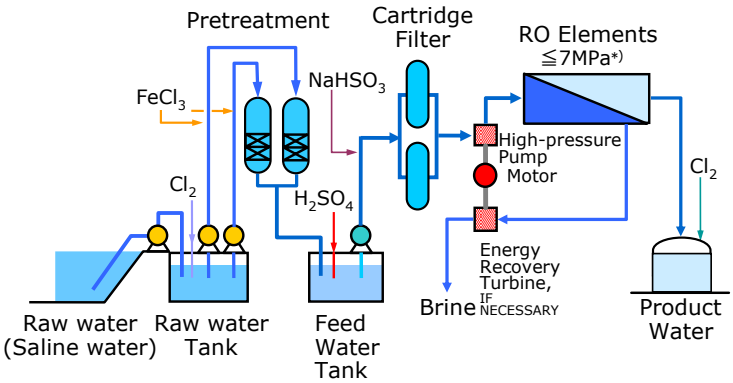
The function of intake facility is to take seawater and transport the seawater to the on-shore plant. There are two major methods in the intake type:

- 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.



Source: JICA Study Team

Figure A3.10.2 Typical Configuration of Pre-Treatment and RO 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.

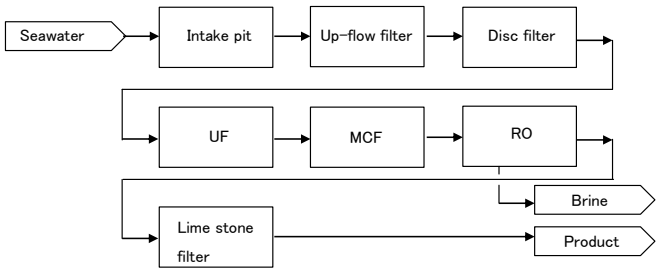
Appendix 3.11 Present Conditions of the Exiting DSPs

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

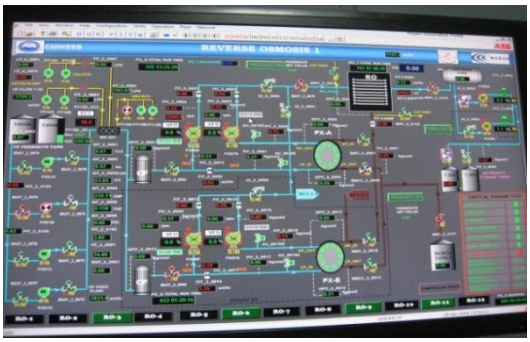
Picture A3.11.3 RO racks in the Nemmeli DSP

[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	Number Standby	Number 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	Eficiency: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	

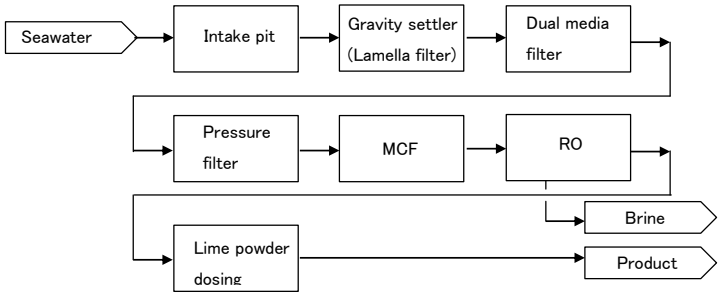
Source: CMWSSB compiled by JICA Study Team

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.

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.

Source: JICA Study Team

Picture A3.11.6 Gravity Settler in the Minjur DSP

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

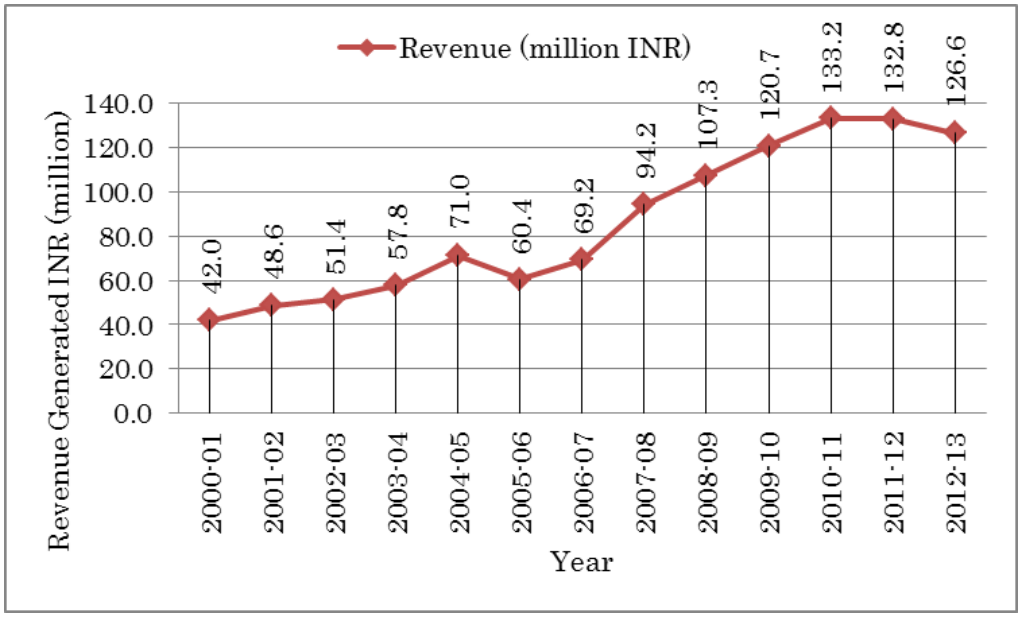
work. PX of the Pressure Exchanger was noisier than the Nemmeli DSP, as the PX in the Minjur DSP was not covered.

Table A3.11.2 Major Equipment in the Minjur DSP

No	Equipment	Capacity (m3/h)	Head (m)	Number Duty	Number Standby	Number Total	Input (kW)	Manufacture	Country	Other condition
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

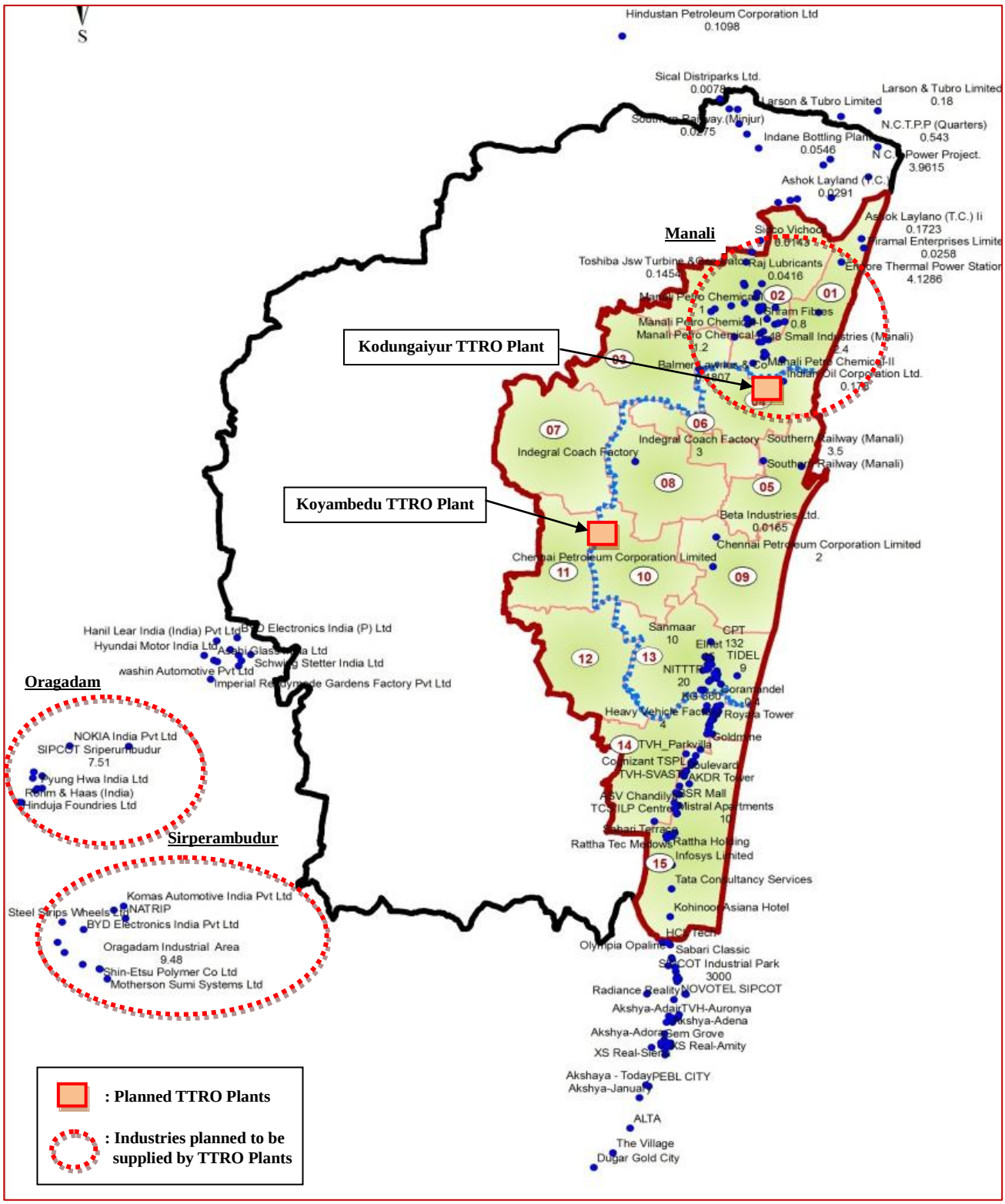
Source: JICA Study Team

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	

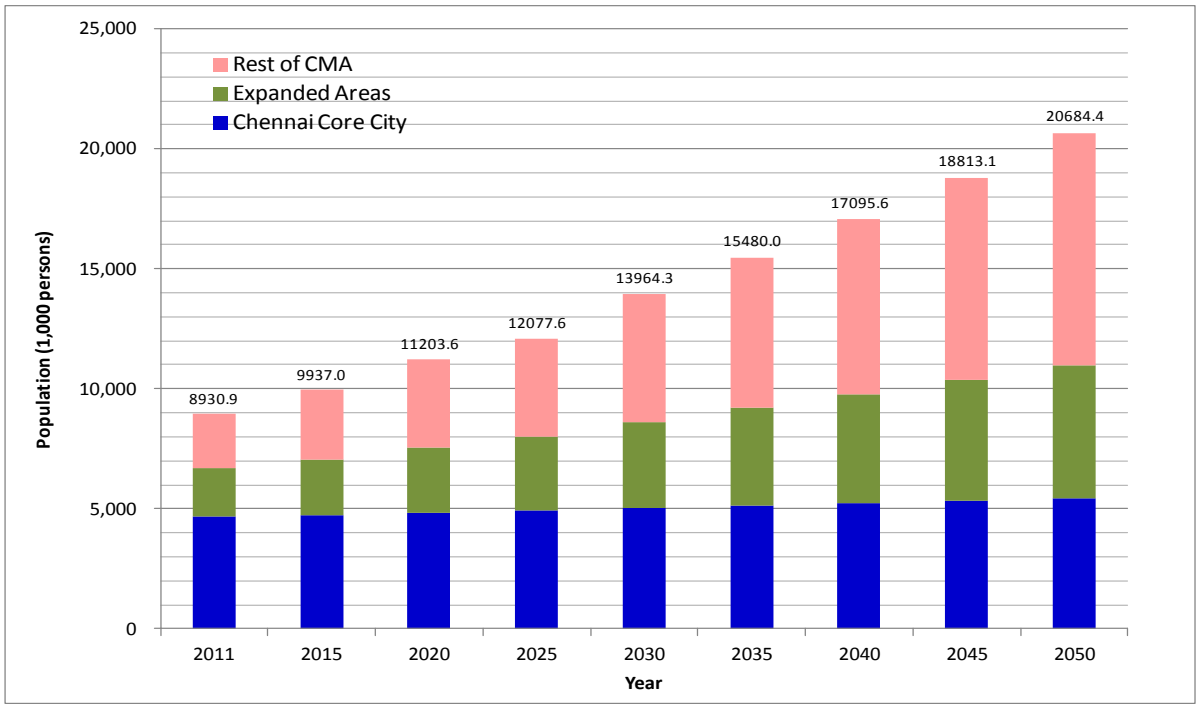
Source: Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

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.

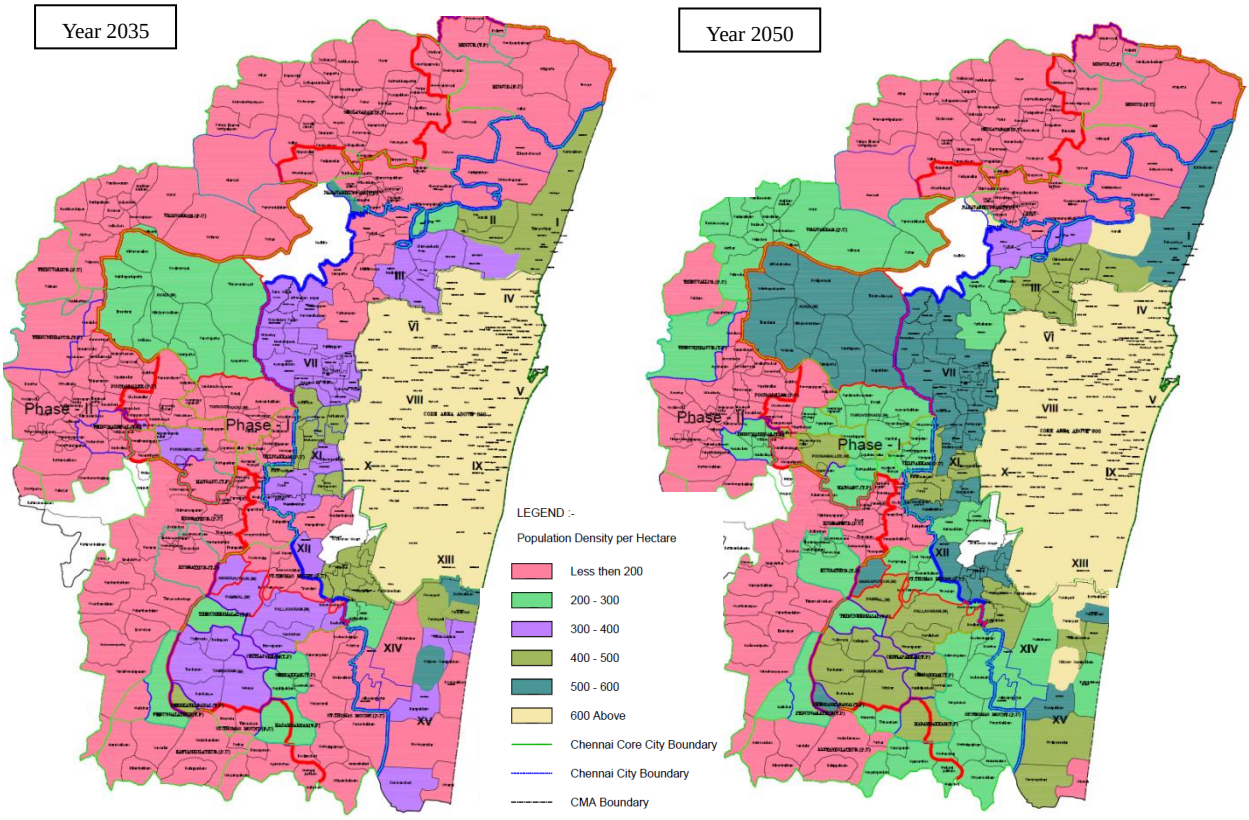


Area	Population								
	2011	2015	2020	2025	2030	2035	2040	2045	2050
Rest of CMA	2,264.3 (-)	2,883.2 (6.23%)	3,646.3 (4.81%)	4,104.2 (2.39%)	5,345.6 (5.43%)	6,299.9 (3.34%)	7,337.2 (3.10%)	8,468.8 (2.91%)	9,711.8 (2.78%)
Expanded Area	2,019.6 (-)	2,326.1 (3.60%)	2,727.0 (3.23%)	3,034.9 (2.16%)	3,585.2 (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

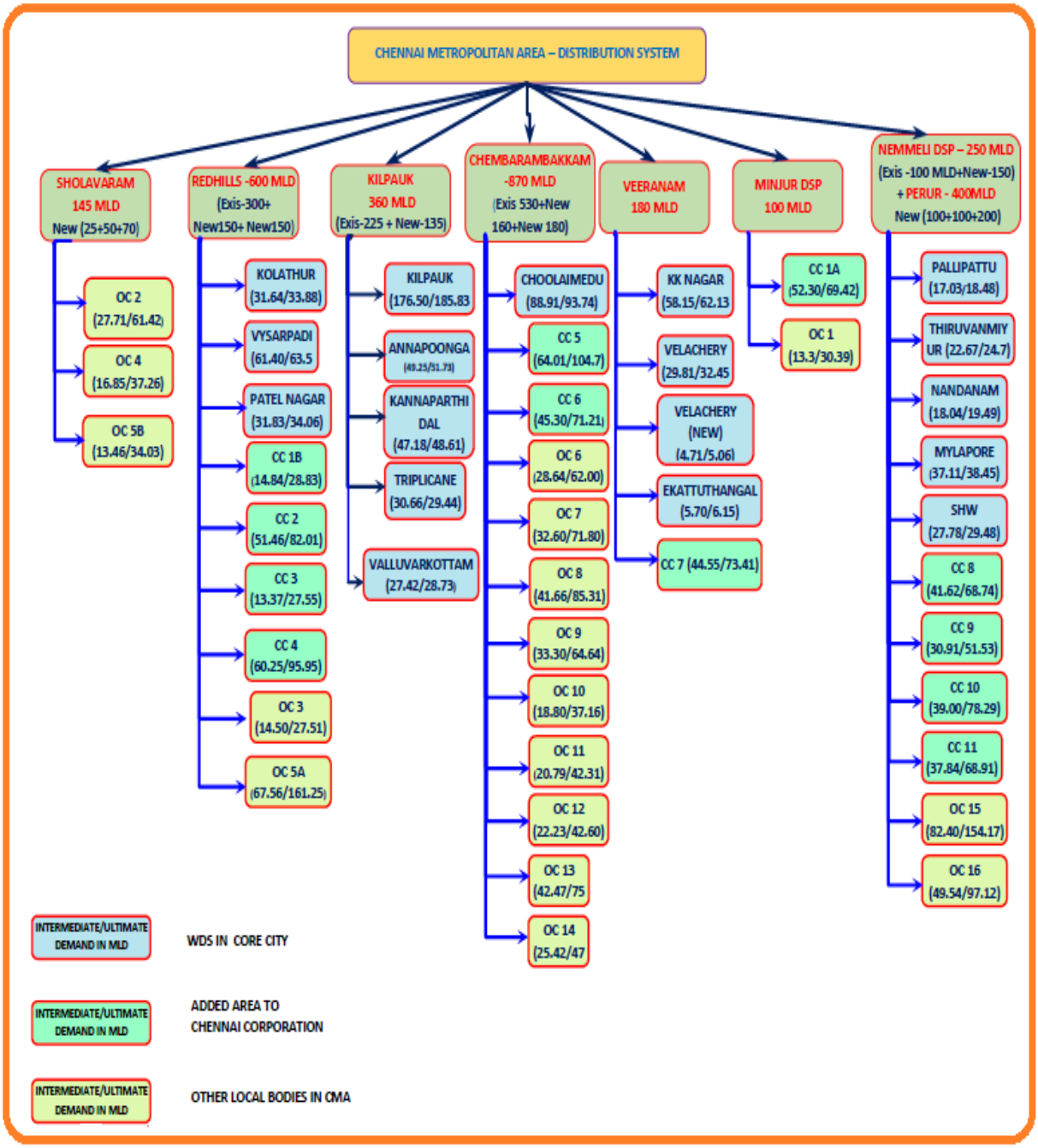
Source: JICA Study Team based on Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

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

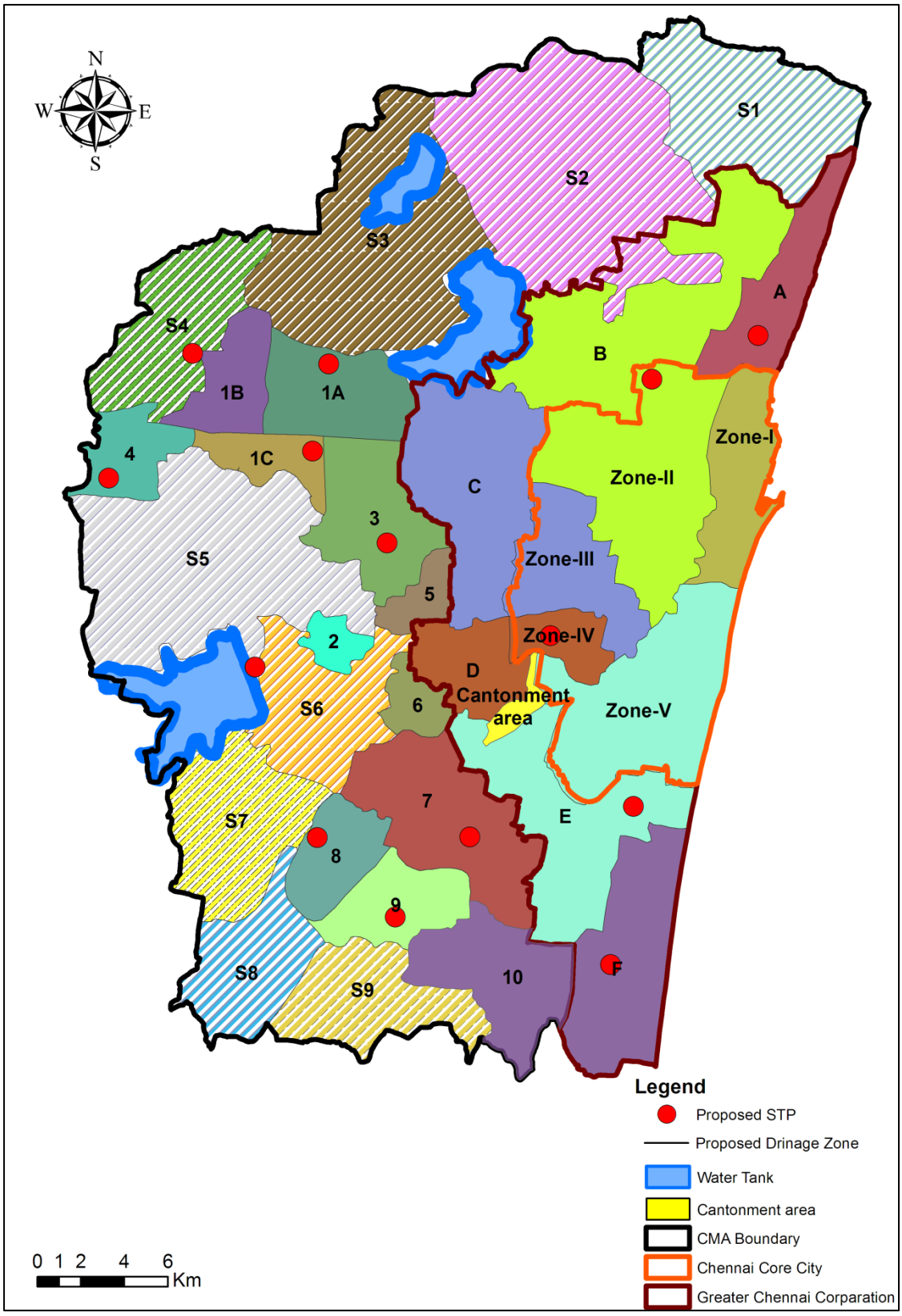
S.No	Area	Total planned capacity of STPs (MLD)			Total Capacity (MLD)
		2020	2035	2050	
1	Near Existing STP Locations	430.0	300.0	387.5	1,117.5
2	New Locations	161.5	170.5	266.0	598.0
	Total	591.5	470.5	653.5	1,715.5

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

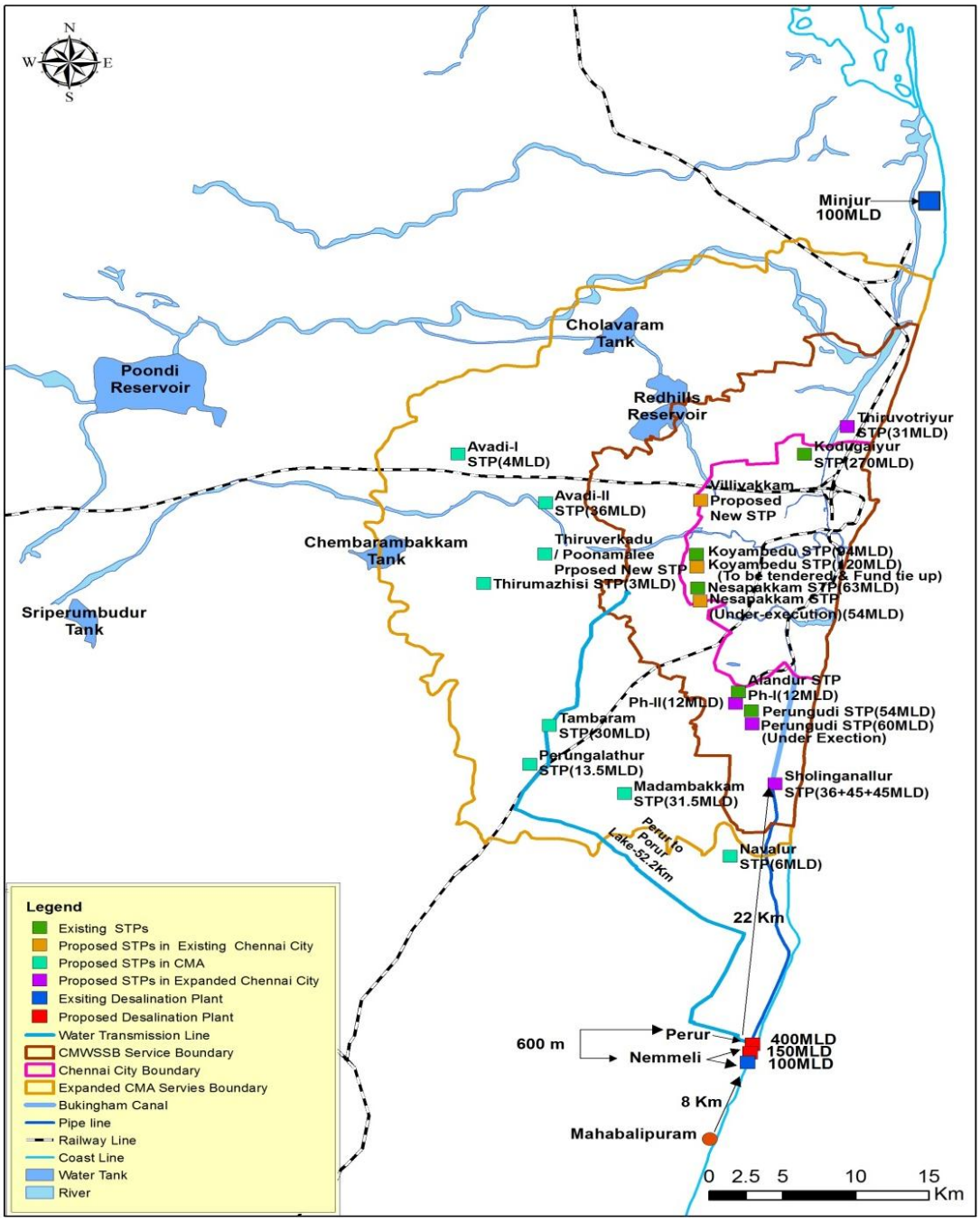
Sl.No	Area	Sewer Collection Network (Km)			Diameter Range (mm)
		Existing	Replacement	New	
1	Core city	1,765.10	529.53	1,023.43	200-1100
2	Expanded Area	-	-	1,460.99	200-1000
3	Rest of CMA	-	-	4,850.00	200-1000
		Total	529.53	7,334.42	

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)						

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)
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									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	
1.	CHENNAI CORPORATION - OLD	17618	4647.0	4727.7	4830.2	4938.6	5033.4	5137.7	5239.3	5327.6	5436.9	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	**17618**	**4647.0**	**4727.7**	**4830.2**	**4938.6**	**5033.4**	**5137.7**	**5239.3**	**5327.6**	**5436.9**		**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	**17618**	**4647.0**	**4727.7**	**4830.2**	**4938.6**	**5033.4**	**5137.7**	**5239.3**	**5327.6**	**5436.9**		**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		**IN PRESENT CORPORATION**																																							
2.	Kathivakkam	475	36.6	38.6	41.1	43.7	46.2	48.7	51.3	53.8	56.4	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	2135	249.5	266.1	286.9	307.8	328.6	349.4	370.2	391.1	411.9	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	749	35.3	38.3	42.5	47.2	52.4	58.2	64.6	71.7	79.6	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	1741	119.1	151.2	191.3	231.4	271.5	311.6	351.7	391.8	431.9	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	3777	466.2	516.0	584.6	660.2	742.8	832.4	929.0	1032.6	1143.2	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	478	86.2	99.1	115.2	131.3	147.5	163.6	179.7	195.8	212.0	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	297	47.4	52.9	60.7	69.5	79.3	90.1	101.9	114.7	128.5	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	808	164.4	177.1	192.9	208.7	224.5	240.3	256.1	271.9	287.7	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	364	53.3	60.2	70.2	81.6	94.6	109.0	125.0	142.4	161.4	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	**10824**	**1258.0**	**1399.5**	**1585.5**	**1781.4**	**1987.3**	**2203.3**	**2429.5**	**2665.9**	**2912.5**		**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		**IN PRESENT CORPORATION**																																							
18.	Chinnasekkadu	167	12.4	13.9	16.0	18.3	20.9	23.7	26.8	30.1	33.7	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	674	31.7	36.7	44.0	52.9	63.5	76.3	91.6	110.1	132.2	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	372	46.7	51.0	56.4	61.8	67.2	72.6	78.0	83.4	88.8	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	261	11.2	13.5	16.3	19.1	21.9	24.7	27.4	30.2	33.0	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	303	4.3	4.6	5.0	5.5	6.0	6.5	7.1	7.7	8.4	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	464	43.1	55.2	70.4	85.6	100.7	115.9	131.0	146.2	161.3	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	1743	43.5	49.5	58.5	69.3	81.8	96.1	112.1	129.9	149.4	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	1535	26.6	57.7	96.5	135.2	174.0	212.8	251.6	290.4	329.2	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	**5518**	**219.5**	**282.0**	**363.0**	**447.5**	**535.9**	**628.4**	**725.6**	**827.9**	**935.9**		**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 distrnbution 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									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	
	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	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	695	5.3	9.4	14.5	15.5	24.5	29.5	34.5	39.5	44.5	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	311	1.1	6.0	9.7	10.5	17.2	20.9	24.6	28.3	32.0	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	64	0.2	1.3	2.8	3.1	5.8	7.3	8.8	10.3	11.8	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	174	27.7	30.3	33.5	34.2	40.0	43.3	46.5	49.8	53.0	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	298	1.7	3.9	6.7	7.3	12.3	15.1	18.0	20.8	23.6	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	278	10.4	12.9	16.1	16.7	22.3	25.4	28.5	31.6	34.7	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	159	7.6	8.7	10.4	10.8	14.8	17.7	21.1	25.2	30.1	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	193	10.3	13.4	17.3	18.1	25.1	29.1	33.1	37.0	40.9	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	257	22.0	33.5	47.9	50.8	77.0	91.4	105.8	120.3	134.8	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	107	21.4	21.9	22.5	22.6	23.8	24.4	25.0	25.7	26.3	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	265	59.8	65.3	72.2	73.6	86.0	92.9	99.8	106.7	113.6	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	269	52.3	57.3	63.5	64.7	75.9	82.1	88.4	94.6	100.8	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	187	25.1	28.8	34.5	35.8	49.9	59.4	70.3	82.4	95.8	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	412	13.3	17.4	22.5	23.5	32.9	38.0	43.2	48.3	53.4	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	247	20.2	22.5	25.7	26.3	33.2	37.6	42.4	47.6	53.2	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	207	26.8	26.3	29.4	30.0	35.6	38.8	41.9	45.0	48.1	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	280	28.5	32.4	37.3	38.3	47.1	52.0	56.9	61.8	66.7	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	519	21.2	24.1	28.5	29.5	39.9	46.9	54.8	63.5	73.1	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	244	9.0	10.2	12.1	12.5	16.8	19.7	22.9	26.4	30.3	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	603	76.6	95.1	118.2	122.9	164.5	187.6	210.5	233.6	256.8	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	340	35.8	40.9	48.7	50.5	69.3	82.0	96.3	112.2	129.8	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	228	19.1	20.9	23.2	23.7	27.8	30.1	32.4	34.6	36.9	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	701	29.8	38.3	49.0	51.1	70.5	81.2	92.0	102.7	113.5	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	341	5.0	6.8	8.9	9.4	13.5	15.7	17.9	20.1	22.2	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
		8222	**542.1**	**644.6**	**778.6**	**806.0**	**1062.0**	**1210.6**	**1364.1**	**1523.0**	**1687.3**		**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		**24564**	**2019.6**	**2326.1**	**2727.0**	**3034.9**	**3585.2**	**4042.4**	**4519.2**	**5016.7**	**5535.7**		**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		**42182**	**6666.6**	**7053.8**	**7557.2**	**7973.5**	**8618.6**	**9180.1**	**9758.5**	**10344.3**	**10972.6**		**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.	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	
	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%	18.2	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%		10.2311829		20%		13.4739929		15%		16.16895		10%		14.6254179		10%		19.5962096		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 Villages)	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 | | | | | | | | |

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: Good 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			
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
					Seawater desalination									
			Surface water	Groundwater	Nemmeli (Existing)	Nemmeli (Expansion)	Minjur	**Perur**	**Operation rate of the Perur against 400MLD**	Others	Seawater Desalination Total	Recycled water	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**

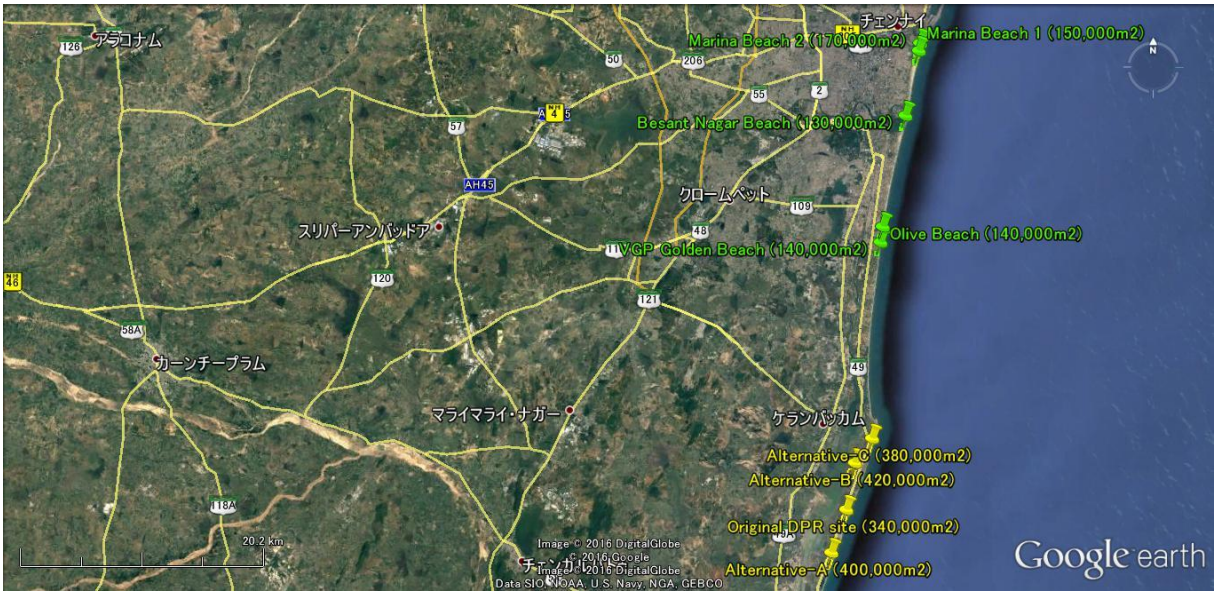
WATER ALLOCATION PLAN FOR CHENNAI METROPOLITAN AREA (2035)

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

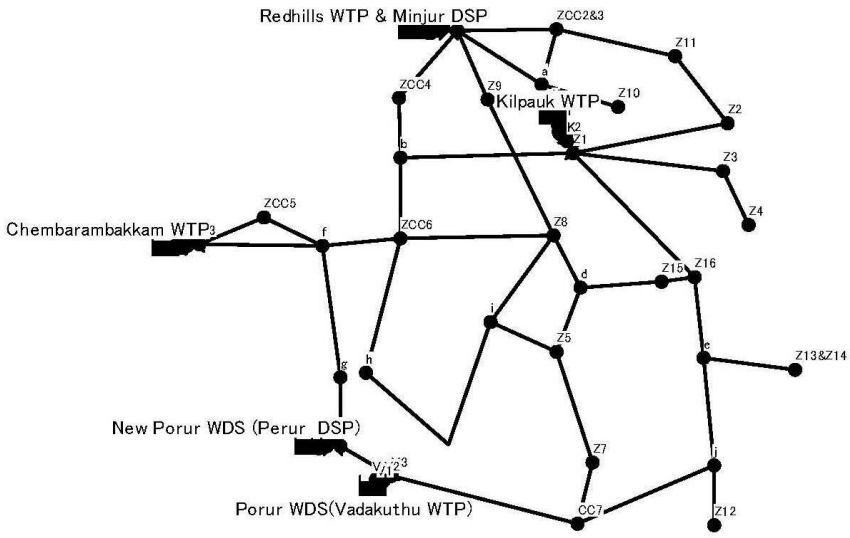


Source: JICA Study Team

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

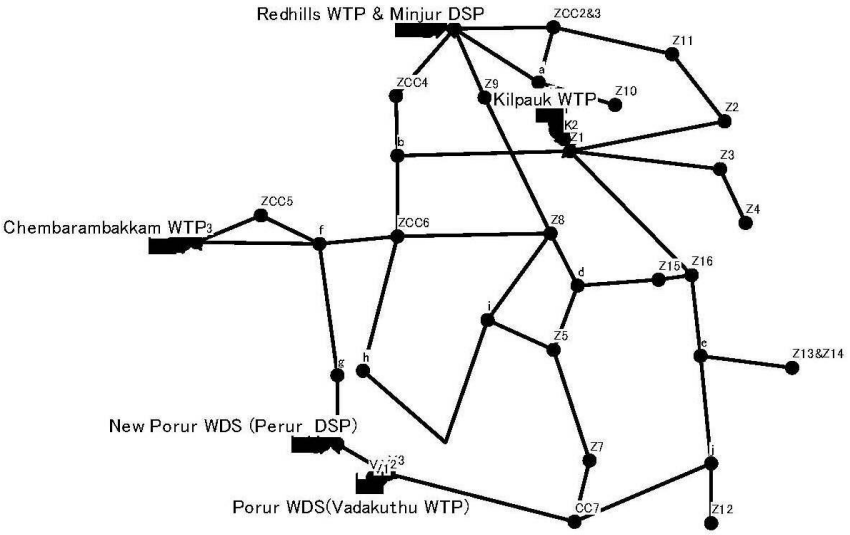
Network Table - Links at 0:00 Hrs

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

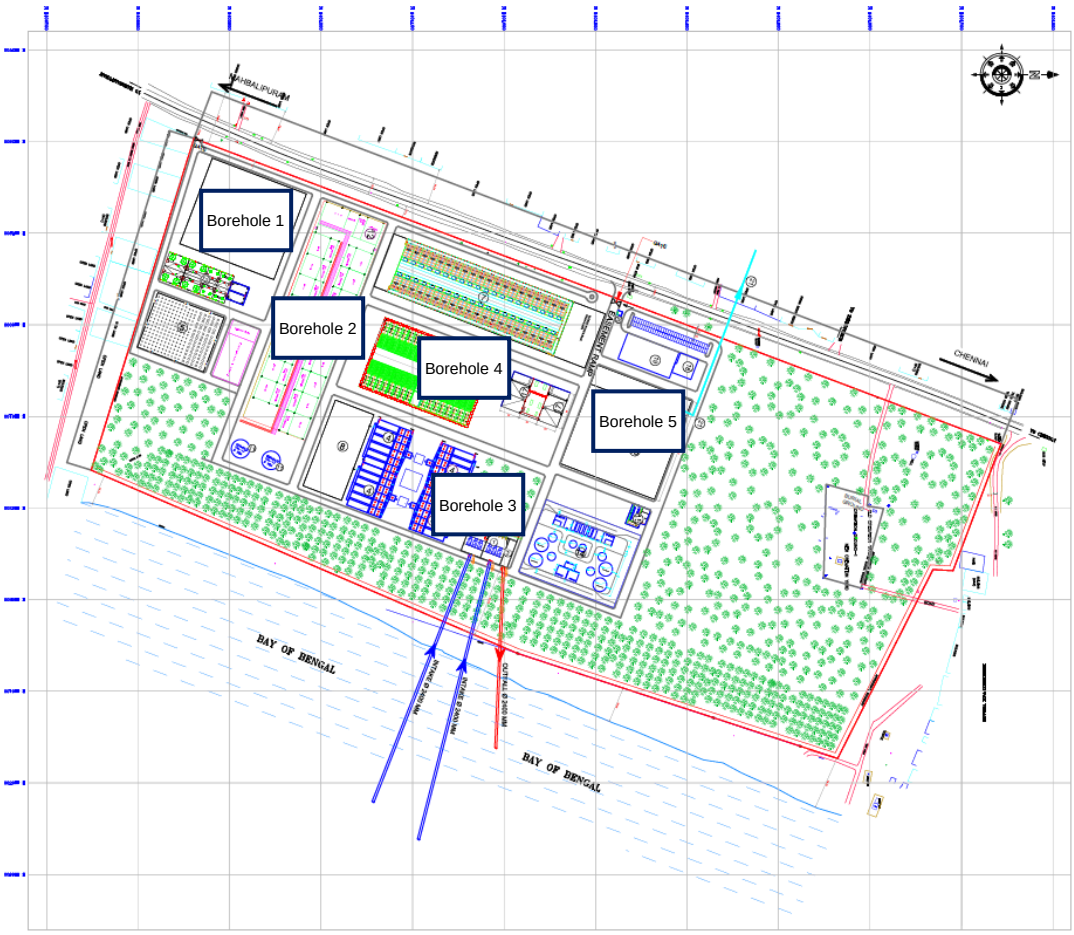
In order to identify the soil condition in the site of the New Perur DSP, a geotechnical survey was conducted in the DPR. Five borehole locations were selected according to the layout of the plant facilities (Figure A6.1.1).

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 15	30	45	N	Relative Density/ Consistency
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 15	30	45	N	Relative Density/ Consistency
1.00		Brown Sand	4	6	6	12	Medium Dense
2.00		Brown Sand	6	8	10	18	Medium Dense
3.00		Brown Sand	3	6	6	12	Medium Dense
4.00		Brown Sand	6	15	18	33	Dense
5.00		Brown Sand	15	18	18	36	Dense
6.00		Brown Sand	17	18	22	40	Dense
7.50		Brown Sand	13	15	18	33	Dense
9.00		Brown Sand	11	11	13	24	Medium Dense
10.5		Grayish Brown Clayey Sand	12	13	14	27	Medium Dense
12.0		Grayish Brown Clayey Sand	9	10	11	21	Medium Dense
13.5		Grayish Silty Clay	10	11	11	22	Very Stiff
15.0		Grayish Silty Clay	9	18	18	36	Very Stiff
16.5		Grayish Brown Clayey Sand	11	15	23	38	Dense
17.9		Grayish Brown Weathered Rock	54 (2 cm) Hammer Rebound			> 100	Hard

Borehole Termination Depth is 17.9 m from the Existing Ground Level

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 15	30	45	N	Relative Density/ Consistency
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 15	30	45	N	Relative Density/ Consistency
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

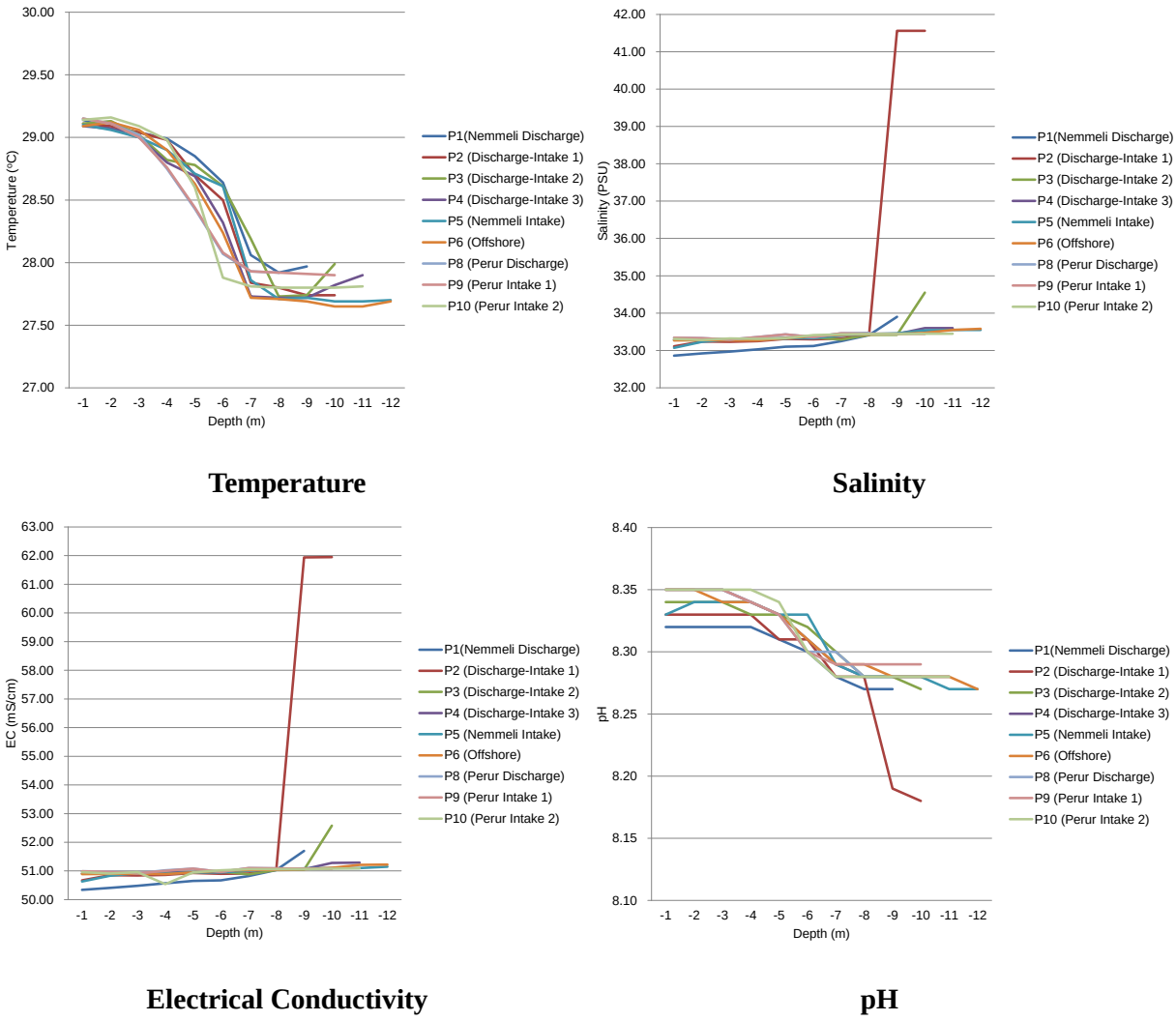
A6.2.2 Results of the In-Situ Test

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



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 6.20 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"

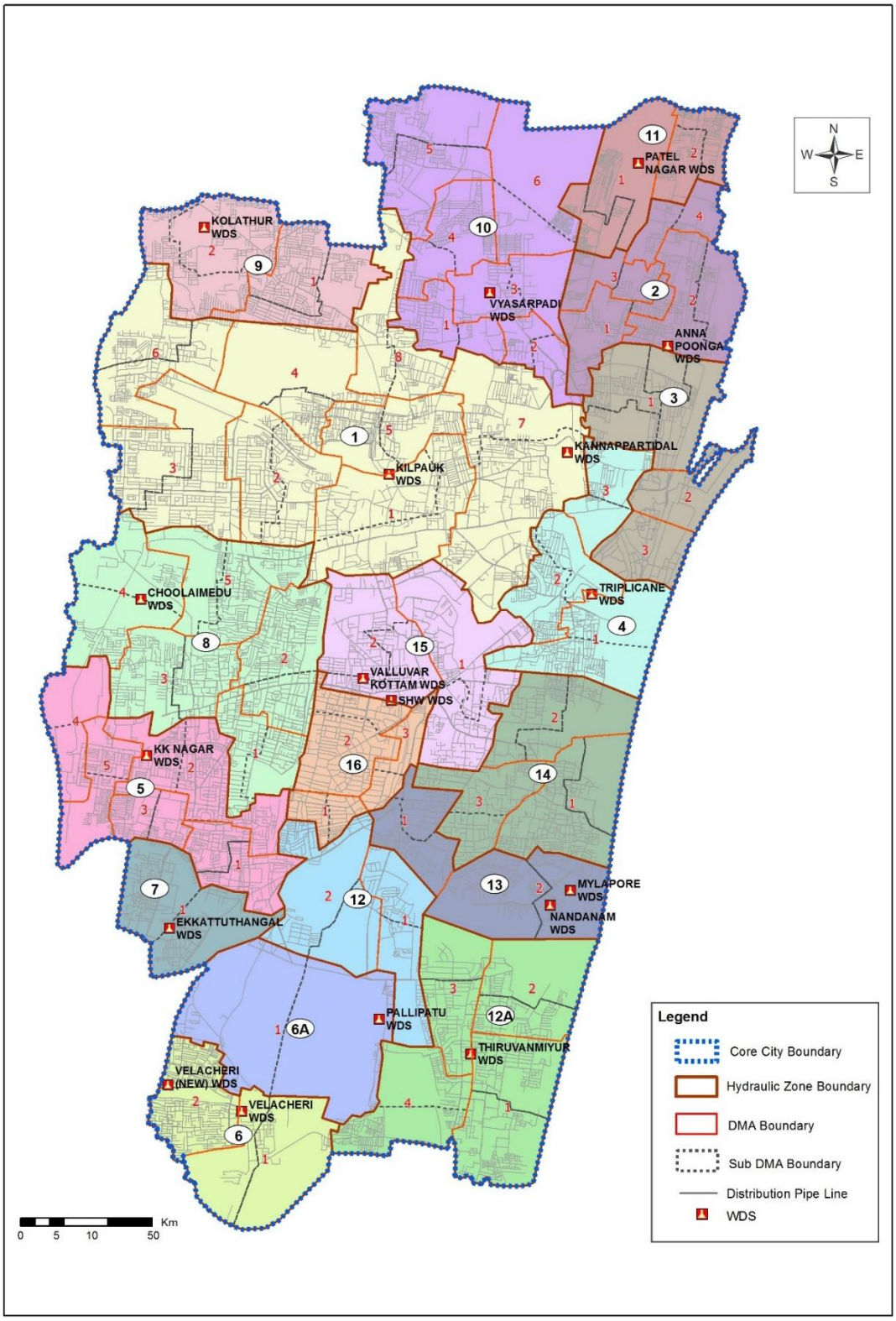
Source: JICA Study Team

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

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
		Weathered Rock				4.0	50/10cm	
						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	
						2.0	4	LOOSE	
		Silty sand with traces of clay				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	
						11.0	5	LOOSE	
		Silty sand				12.0	8	LOOSE	
		With clay				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	2	LOOSE	
4.0		----------	4.0			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	
		----------	15.0			19.0	34	MEDIUM	
19.0		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)

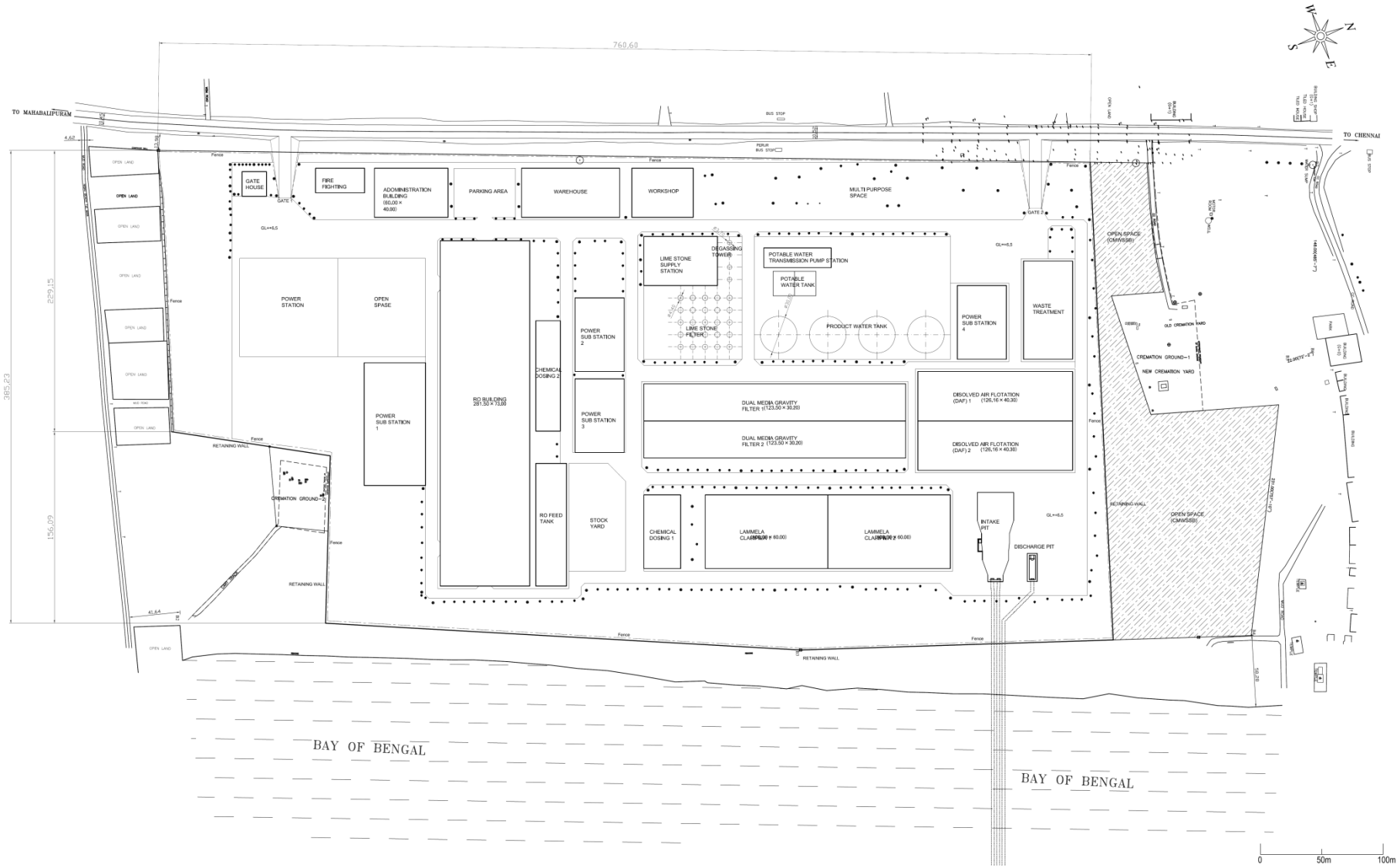
Depth in 'm'	Layer	Wn %	Grain Size Distribution					Density Test		Direct Shear Test	
			Clay %	Silt %	Sand %	Gravel %	Sp.Gravity	rb gm/cc	rd gm/cc	C g/cm^2	Degree
BOREHOLE – 1											
1.0-8.0	Silty sand with traces of clay	10.15	10	52	38	0	2.560	1.798	1.632	--	25°25'
8.0-18.0	Silty sand with clay	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/cm^2	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 Duty	Number Standby	Number Total	Model
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 Duty	Number Standby	Number Total	Model
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 Duty	Number Standby	Number Total	Model
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**

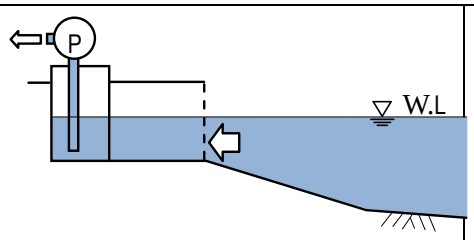
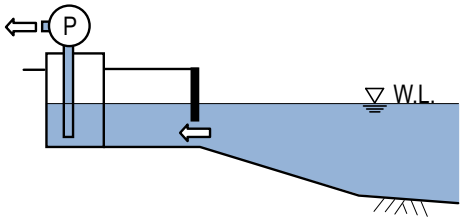
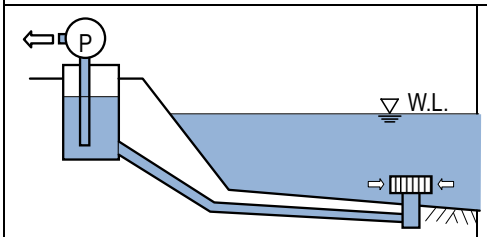
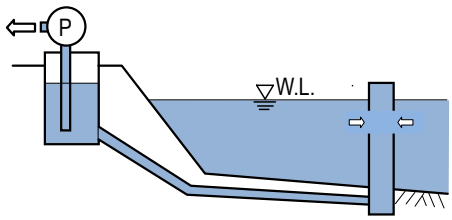
No.	Equipment name	Capacity(need)	Units	Capacity(select)	Units	Head(m)	Input(kW)	Number Duty	Number Standby	Number Total	Service Power kW	Travelling Time	Loading Factor	Availability Factor	Erectricity Consumed kW/d	Erectricity Usage kW	Model	Specification	Material/Other
1	Margin														46,537.17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

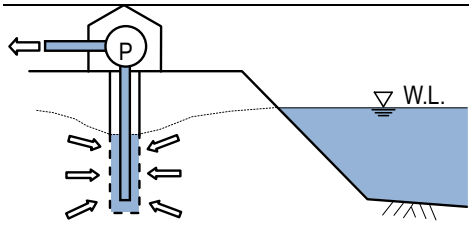
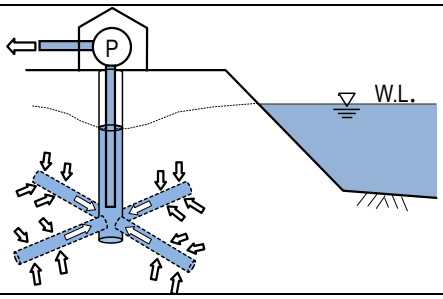
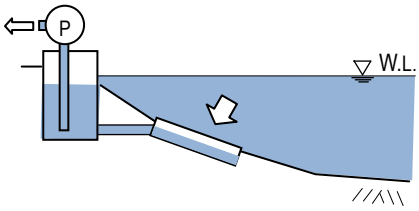
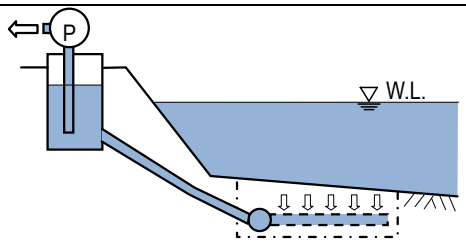
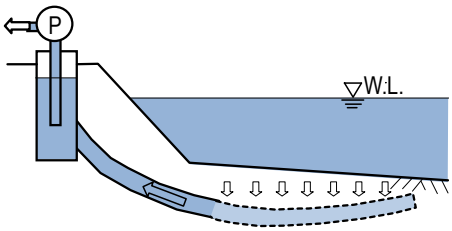
400.00 MLD
3,994.44 kW/MLD
3.99 kW/m3

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

Source; JICA Study Team

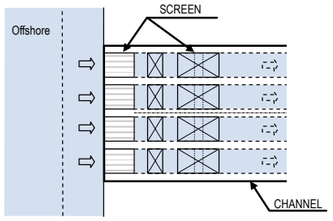
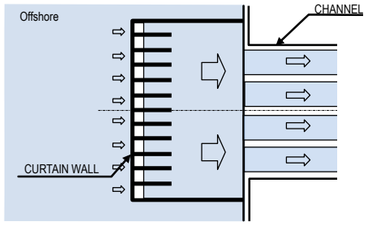
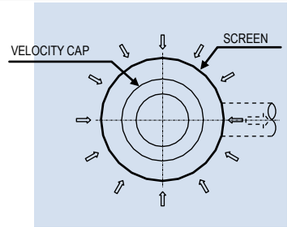
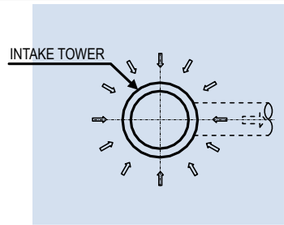
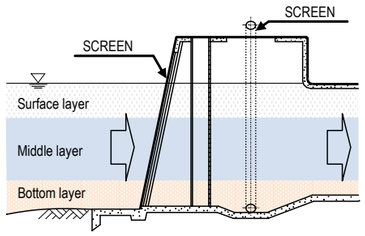
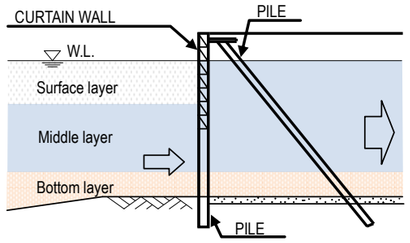
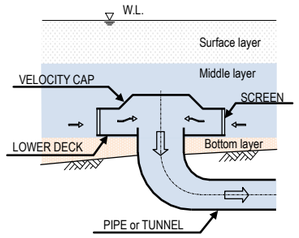
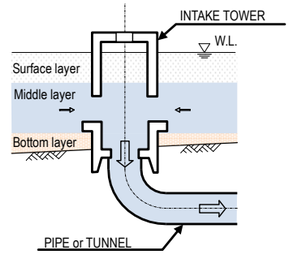
Appendix 6.7 Conceptual Diagrams of Direct and Indirect Seawater Intake Methods and Types

	Onshore intake	
A. Surface water intake system		
Intake type	A1. Onshore direct	A2. Onshore selective
B. Deep water intake system	Offshore intake	
		
Intake type	B1.Velocity cap	B2. Tower

	Onshore intake	
C. Beach well system		
Intake type	C1. Vertical beach well	C2. Horizontal collector well
C. Beach well system		
	C3. High-speed Seabed Infiltration (HiSIS)	
D. Seabed filtration system	Offshore intake	
		
Intake type	D1. Seabed filtration gallery	D2. Horizontal wells with directionally drilled (HDD) collectors

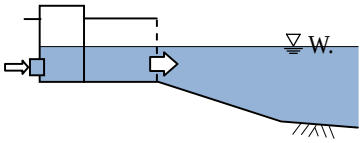
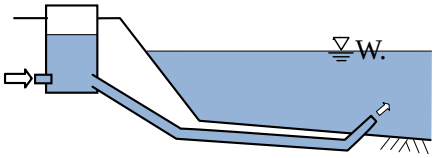
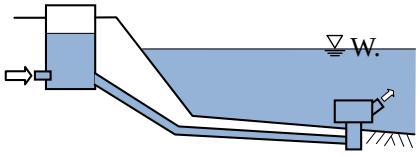
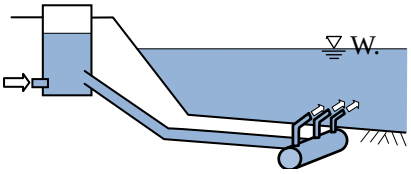
Source: JICA Study Team

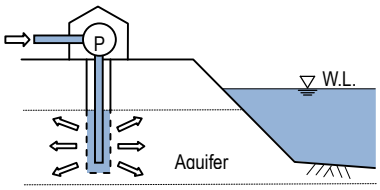
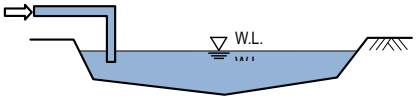
Appendix 6.8 Alternative Study on Direct intake type

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	
Discharge type	C1. Deep well ex-filtration	Discharge type	D1. Evaporation ponds

Source; JICA Study Team

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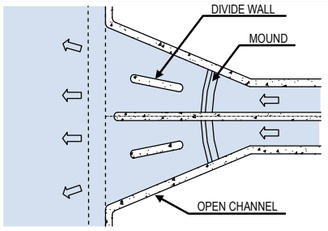
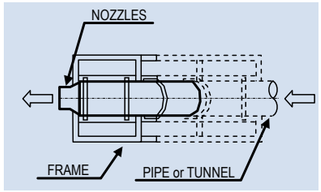
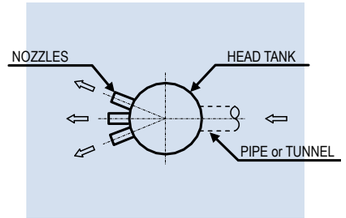
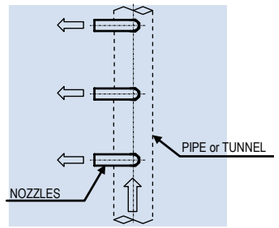
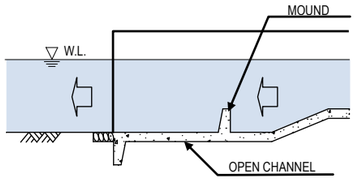
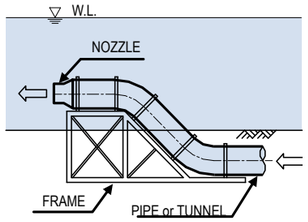
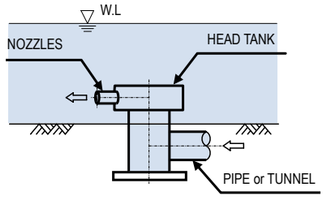
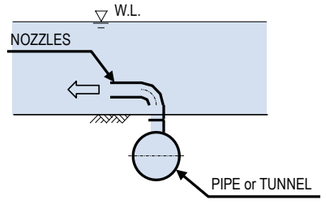
Appendix 6.10 Alternative study on direct discharge type

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.

Appendix 6.12 Methodology for the Brine Diffusion Simulation

In order to evaluate the impact of the discharged brine, the simulation phase is divided into Near-field and Far-field as shown in Figure A6.12.1 because these diffusion characteristics are different.

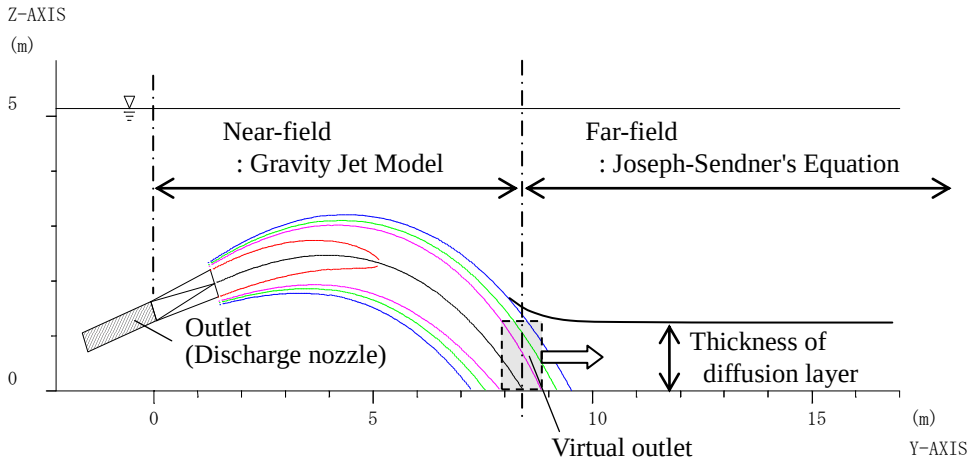


Figure A6.12.1 Cross-sectional view and distribution of discharged brine (Section distribution of brine discharge)

(1) Near-field

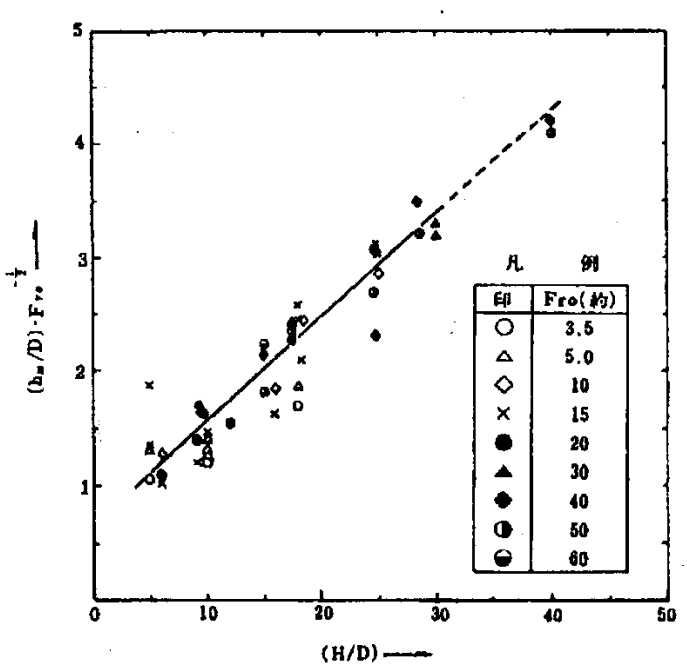
Near-field includes the area from the discharge outlet to the point where the discharged brine reaches the seabed.

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

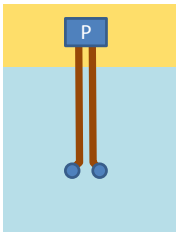
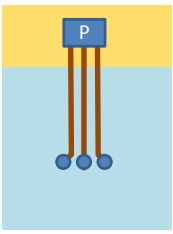
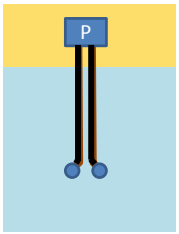
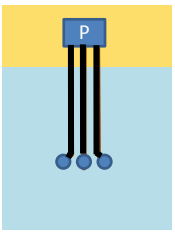
Figure A6.12.2 Thickness of diffusion layer

(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)	
	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.

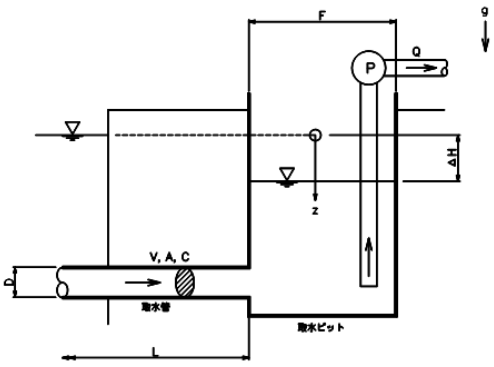
(3) Design Condition

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]

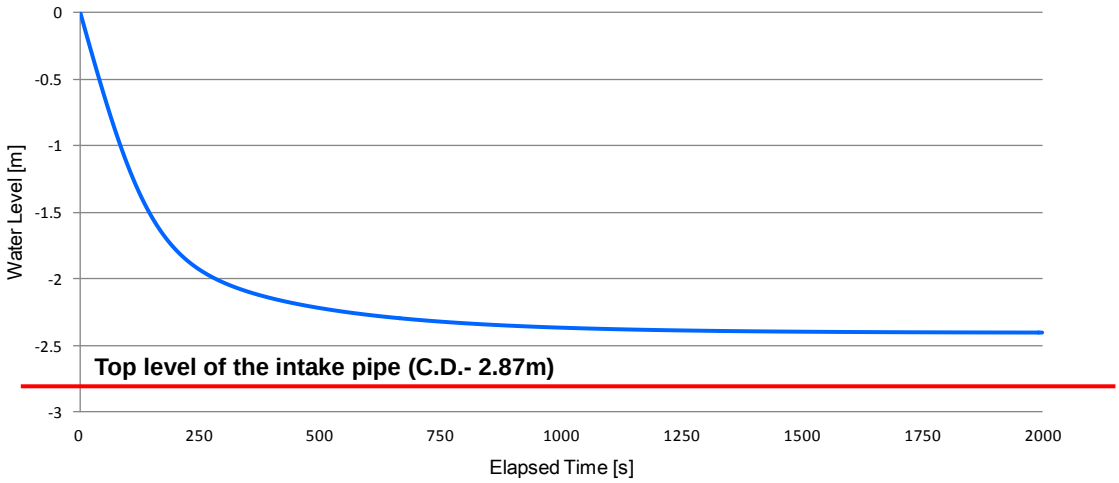
C: the loss coefficient

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

(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.

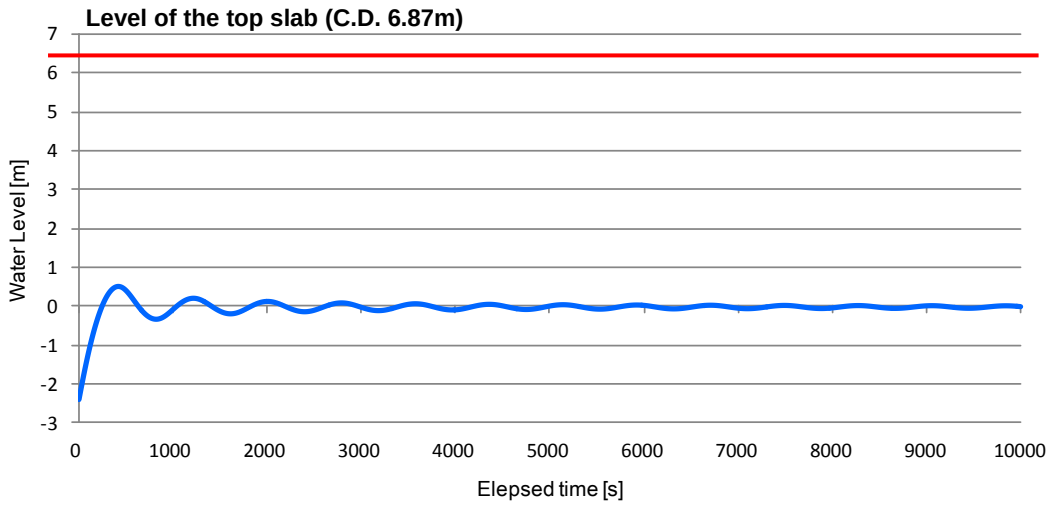


Source: JICA Study Team

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.

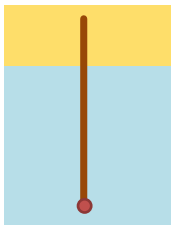
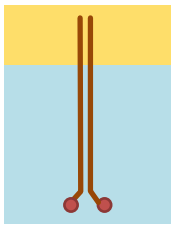
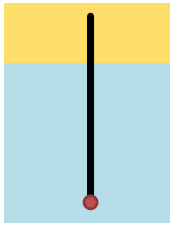
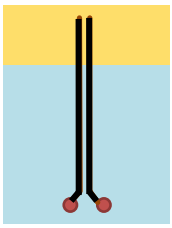


Source: JICA Study Team

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)	
	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**

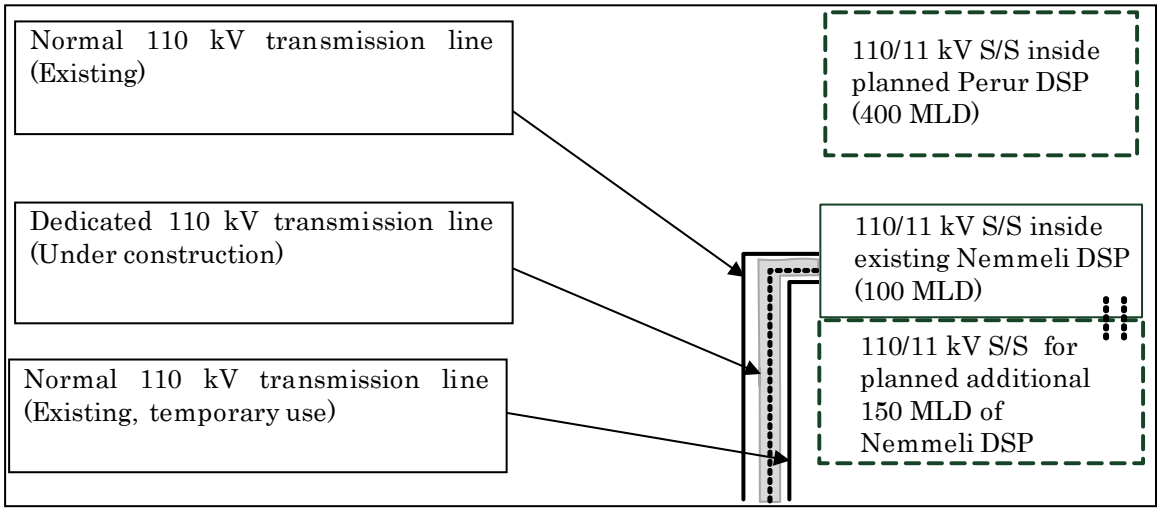
Source; JICA Study Team

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.



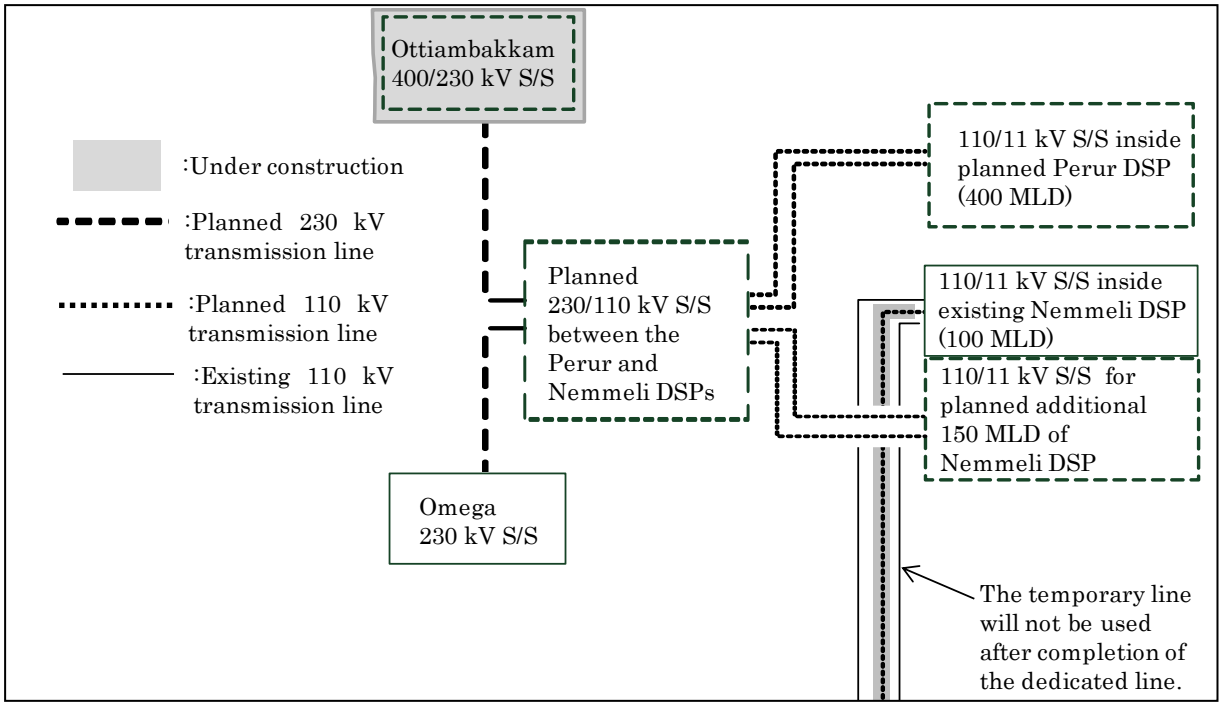
Source: JICA Study Team

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

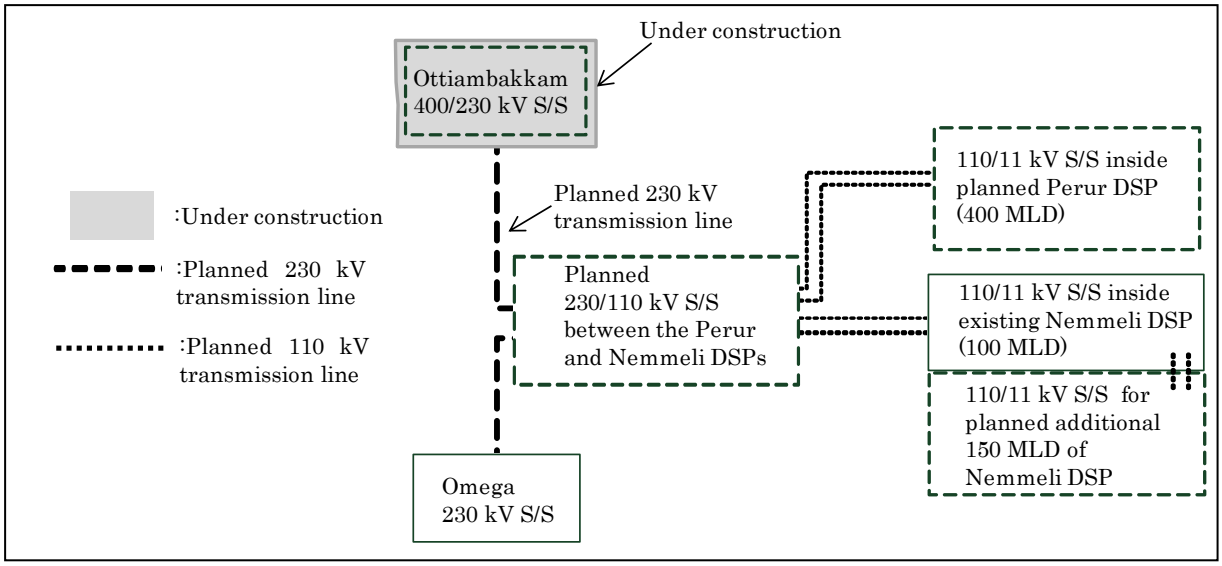
In the plan, the two DSPs, including the additional 150 MLD of the Nemmel DSP, are to receive power supply through a new 230/110 kV S/S, which would be located between the Nemmeli and Perur DSPs. The land for the substation was planned to be about 32,000 m^2. The Perur DSP was to be connected with the 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.



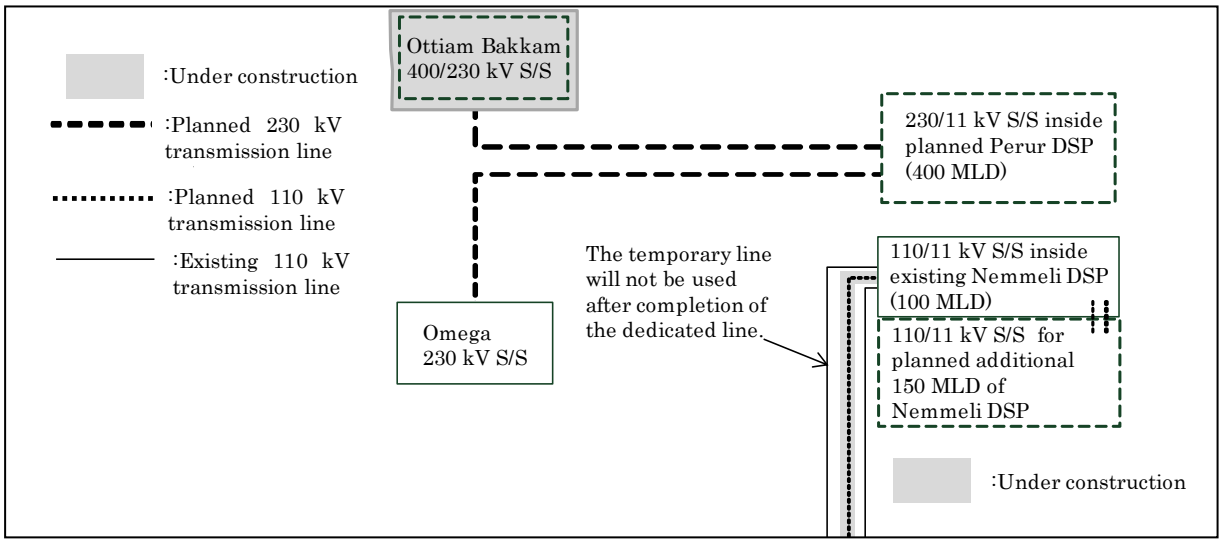
Source: JICA Study Team

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.

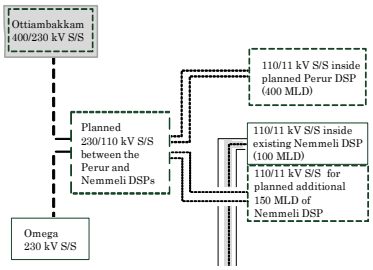
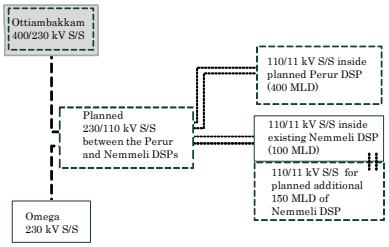
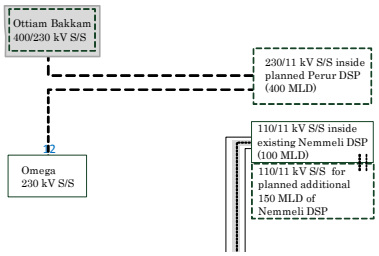
Table A6.17.1 shows the comparison of the three alternatives mentioned above. All alternatives have advantages and disadvantages, but the Study Team recommends Alternative A as the original one. The ideal plan for CMWSSB is to integrate the power receiving system for the three DSPs as planned in Alternative 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

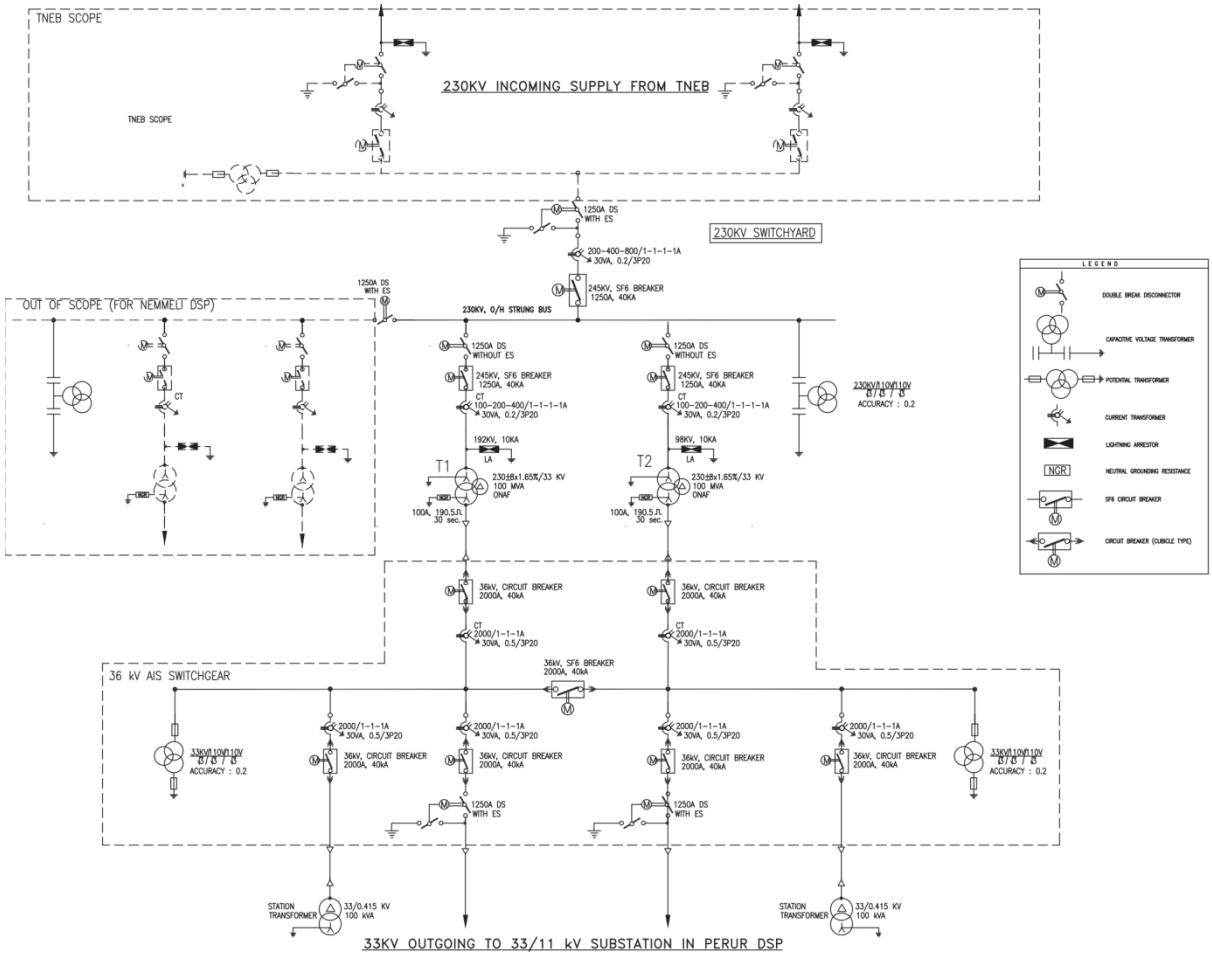
Figure A6.17.1 Proposed Power Receiving Plan by JICA Study Team

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 7.1 Environmental and Social Conditions Relevant to the Project

A7.1.1 Pollution

(1) Air Pollution

For the EIA study, ambient air quality monitoring surveys were carried out from March to May 2012 at eight locations set up in an area of 10 km radius around the proposed project site. The results of these surveys are summarized in Table A7.1.1.

Table A7.1.1 Ambient Air Quality around Proposed Project Site

Location	PM_{10} (μg/m^3)		$PM_{2.5}$ (μg/m^3)		SO_2 (μg/m^3)		NO_x (μg/m^3)		CO (μg/m3)	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Near Plant Site	49.9	40.9	18.5	12.8	10.7	8.6	14.2	10.7	514	383
Thiruporur	51.5	42.4	19.5	13.8	10.8	8.2	13.6	11.0	527	390
Alathur	47.3	41.4	17.3	13.9	9.8	8.3	13.3	10.4	481	373
Pudunemmenlkuppan	46.0	37.8	17.4	12.9	9.6	7.5	13.7	9.7	495	365
Thiruvidanthal	44.7	36.7	16.1	12.4	10.2	7.9	13.5	10.0	486	371
Kelambakkam	52.5	45.2	19.5	15.1	10.4	8.6	14.8	11.4	536	394
Nenneli	40.0	32.7	14.6	11.0	9.9	8.2	13.8	10.2	489	368
Tandalam	43.6	36.3	15.4	11.8	9.8	8.2	13.1	10.4	497	377
Range	32.7-52.5		11.0-19.5		7.5-10.8		9.7-14.8		365-536	
Standards	100		60		80		80		2,000	

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

Based on the table, the EIA report concluded that the concentrations of the ambient air pollutants of PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO were within the air quality standards for Industrial, Rural, Residential and Other areas of the Central Pollution Control Board (CPCB).

(2) Water Pollution

For the EIA study, ground and surface water quality monitoring surveys were carried out in 2012 at four and two locations, respectively, that were set up in an area of 10 km radius around the proposed project site, as shown in Table A7.1.2. The results of these surveys are summarized in Table A7.1.3.

Table A7.1.2 Water Quality Monitoring Location

		Location	Distance from Project Site (km)	Direction from Project Site
Groundwater	GW1	Alathur	5.0	SW
	GW2	Thiruporur	4.7	MW
	GW3	Pudunemmelikuppam	1.9	SSW
	GW4	Thiruvidanthai	6.9	NNE
Surface Water	SW1	Pattipulam	2.7	SSW
	SW2	Vada Nemmeli	4.6	NNE

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

Table A7.1.3 Ground and Surface Water Quality around Proposed Project Site

Parameters	Unit	IS:10500 Limits	GW1	GW2	GW3	GW4	SW1	SW2
pH	-	6.5-8.5 (NR)	7.4	7.5	7.3	7.6	7.9	7.9
Color	Hazen	5 (25)	2	3	2	2	2	2
Taste	-	Agreeable	Ag	Ag	Ag	Ag	51,600	51,800
Odor	-	U.O	U.O	U.O	U.O	U.O	-	-
Conductivity	µS/cm	$	1,601	1,676	104	1,568	-	-
Turbidity	NTU	5 (10)	1	2	1	1	-	-
TDS	mg/l	500 (2000)	1,040	1,080	65	1,015	33,540	33,670
Total Hardness	mg/l	300 (600)	473	497	39	640	7,013	7,059
Total Alkalinity	mg/l	200 (600)	485	350	22	510	145	150
Calcium as Ca	mg/l	75 (200)	160.5	165	10.2	85	690	700
Magnesium as Mg	mg/l	30 (100)	17.5	20.5	5.3	40	1,285	1,290
Residual Chlorine	mg/l	0.2 Min	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Boron	mg/l	1	0.01	0.02	<0.01	0.02	0.04	0.05
Chloride as Cl	mg/l	250 (1000)	140.2	235	10.2	85	17,359	17,458
Sulphate as SO_4	mg/l	200 (400)	86.5	112.2	6.1	120	0.1	650
Fluorides as F	mg/l	1.0 (1.5)	0.9	0.8	0.5	0.7	620	2
Nitrates as NO_3	mg/l	45 (NR)	30.2	35	11.2	36	2	3.5
Sodium as Na	mg/l	$	145	150	6.2	65	3	8524
Potassium as K	mg/l	$	15.6	16	0.6	14	8,500	350
Phenolic compounds	mg/l	0.001 (0.002)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cyanides	mg/l	0.05 (NR)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Anionic Detergents	mg/l	0.2 (1.0)	<0.1	<0.1	<0.1	<0.1	Absent	Absent
Mineral Oil	mg/l	0.01 (0.03)	<0.01	<0.01	<0.01	<0.01	-	-
Cadmium as Cd	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic as As	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper as Cu	mg/l	0.05 (1.5)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead as Pb	mg/l	0.05 (NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese as Mg	mg/l	0.1 (0.3)	0.01	0.04	<0.01	0.02	-	-
Iron as Fe	mg/l	0.3 (1.0)	0.06	0.04	0.02	0.05	0.03	0.03
Chromium as Cr^{+6}	mg/l	0.05 (NR)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium as Se	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc as Zn	mg/l	5 (15)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Aluminum as Al	mg/l	0.03 (0.2)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury as Hg	mg/l	0.001 (NR)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pesticides	mg/l	Absent	Absent	Absent	Absent	Absent	Absent	Absent
E. Coli	-	Absent	Absent	Absent	Absent	Absent	-	-
Total Coli forms	MPN/100	10	<2	<2	<2	<2	<2	<2
DO	mg/l	$	-	-	-	-	5.5	5.6
BOD	mg/l	$	-	-	-	-	<3	<3
COD	mg/l	$	-	-	-	-	<5	<5
Phosphates as PO_4	mg/l	$	-	-	-	-	0.1	0.1
Oil and Grease	mg/l	$	-	-	-	-	<1	<1
SAR	-	$	-	-	-	-	44.17	44.15

Note: Values in parenthesis are 'Permissible limit in the absence of Alternate source'. NR: No relaxation, $: Limits not specified, UO: Un-Objectionable, Ag-: Agreeable, SAR: Sodium Absorption Ratio

IS: 10500 (the standard prescribes the requirements for the essential and desirable characteristics required to be tested for ascertaining the suitability of water for drinking purpose)

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water

According to the table, the ground water and surface water surveyed are discussed as follows:

- TDS (Total Dissolved Solid), Hardness ($CaCO_3$), Total Alkalinity and Calcium (Ca) showed higher values than the Indian Standard for safe drinking water of IS 10500 in the wells other than the GW3.
- TDS (Total Dissolved Solid), Hardness (CaCO3), Calcium (Ca) and Magnesium (Mg) showed higher values than the Indian Standard for Safe Drinking Water of IS 10500 in both surface water and ground water.

(3) Waste

Specific information and data on waste management systems around the proposed project have not been identified by the relevant reviews.

(4) Soil Characteristics

For the EIA study, soil samples were collected for analysis from eight locations of 10 km radius around the proposed project site as shown in Table A7.1.4; the results have been summarized as follows.

Table A7.1.4 Soil Quality Monitoring Location

	Location	Distance from Project Site (km)	Direction from Project Site
S1	Near- Plant Site	0.0	-
S2	Thiruporur	4.7	NW
S3	Aalathur	5.0	SW
S4	Pudunellikuppam	1.9	SSW
S5	Thiruvidanthal	6.9	NNE
S6	Kelambakkam	9.2	NNW
S7	Nemmeli	1.2	NW
S8	Thandalam	3.2	W

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

- pH of soil samples ranged from 7.8 to 8.1
- Electrical Conductivity (EC) of the soil samples varied from 144 to 280 μmhos/cm
- Phosphorus (P) values ranged between 28.2 kg/ha and 78.0 kg/ha
- Nitrogen (N) values ranged between 38.0 kg/ha and 65.0 kg/ha
- Potassium (K) values ranged between 0.06 kg/ha and 0.20 kg/ha

(5) Noise

For the EIA study, noise levels were monitored at eight locations of 10 km radius around the proposed project site; the results have been summarized in Table A7.1.5.

Table A7.1.5 Noise Level around Proposed Project Site

	Location	Distance from Project Site (km)	Direction from Project Site	Zone	L_{10}	L_{50}	L_{90}	L_{eq}	L_{day}	L_{night}	L_{dn}
N1	Near- Plant Site	0.0	-	Residential	44.3	40.4	36.7	41.4	42.2	38.6	45.7
N2	Thiruporur	4.7	NW	Residential	47.7	43.8	40.1	44.8	45.6	42.0	49.1
N3	Aalathur	5.0	SW	Residential	45.8	41.9	38.2	42.9	43.7	40.1	47.2
N4	Pudunellikuppam	1.9	SSW	Residential	45.1	41.2	37.5	42.2	43.0	39.4	46.5
N5	Thiruvidanthal	6.9	NNE	Residential	46.2	42.3	38.6	43.3	44.1	40.5	47.6
N6	Kelambakkam	9.2	NNW	Residential	48.3	44.4	40.7	45.4	46.2	42.6	49.7
N7	Nemmeli	1.2	NW	Residential	45.5	41.6	37.9	42.6	43.4	39.8	46.9
N8	Thandalam	3.2	W	Residential	44.9	41.0	37.3	42.0	42.8	39.2	46.3

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

- The day-night noise level (L_{dn}) near the proposed project site was observed as 45.7 dB(A).
- The noise levels observed were within the acceptable levels as per the standards of Central Pollution Control Board (CPCB).

(6) Subsidence

Specific information and data on ground subsidence in and around the proposed project have not been identified by the relevant reviews. However, the proposed project site is a flat near the sea beach sandy areas.

(7) Offensive Odor

Specific information and data on offensive odor in and around the proposed project have not been identified by the relevant reviews. However, by considering the following circumstances, it is considered that there is no offensive odor in and around the project area as the proposed project site is a flat and open area adjusting sandy beach in the East (easy to disuse if there are some odor from ECR traffic exhaust gasses and crematory activities).

- The East Coast Road (ECR) is located on the west side of the proposed project site.
- Small crematory facilities are situated on the North West side in the proposed project land.
- Nemmeli Panchayat (Village) is located next to the proposed project site.

A7.1.2 Natural Conditions

(1) Climate

1) Temperature, Rainfall and Humidity

Table A7.1.6 and Table A7.1.7 show meteorological data in Chennai and the project site, respectively.

Table A7.1.6 Meteorological Data in Chennai (1971-2000)

Month	Mean Temperature (°C)		Mean Total Rainfall (mm)	Mean Number of Rainy Days	Mean Number of days with			
	Daily Minimum	Daily Maximum			Hail	Thunder	Fog	Squall
Jan	20.9	28.8	22.5	1.3	0	0	0.3	0
Feb	22	30.5	2.2	0.4	0	0.1	0.2	0
Mar	23.8	32.5	4	0.3	0	0.2	0.1	0
Apr	26.4	34.3	7.7	0.6	0	0.7	0	0
May	27.9	36.8	43.9	1.4	0	1.8	0	0.1
Jun	27.5	36.9	55.9	4	0	3.3	0	0.2
Jul	26.3	35	100.3	6.9	0	3.3	0	0.1
Aug	25.7	34.3	140.4	8.5	0	4.6	0	0.1
Sept	25.5	33.9	137.3	7.1	0	5.4	0	0
Oct	24.5	31.8	278.8	10.6	0	5.9	0	0
Nov	23	29.6	407.4	11.7	0	2.8	0	0
Dec	21.9	28.5	191.1	6.3	0	0.7	0	0
Annual	24.6	32.8	1,391.5	59.1	0	28.8	0.7	0

Source: Regional Metrological Centre in Chennai, India Metrological Department:
(http://www.imd.gov.in/section/climate/extreme/chennai2.htm)

Table A7.1.7 Meteorological Monitoring Data in the Proposed Project Site (2013)

Month (2013)	Temperature (°C)		Relative Humidity (%)		Total Rainfall (mm)
	Max	Min	Max	Min	
Aug.	37.5	23.7	100	28	73
Sept.	36.8	22.9	100	34	89
Oct.	36.3	22.6	100	21	121

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

2) Wind

Table A7.1.8 shows wind data in Chennai, and it can be evaluated that the prevailing wind direction in Chennai is from South to South-West.

Table A7.1.8 Wind Pattern (India Meteorological Department (IMD), Chennai)

Season	Month	First Predominant Wind		Second Predominant Wind		Calm Condition in %	
		0830	1730	0830	1730	0830	1730
Pre-monsoon	Mar.-Jun.	S	S	SSW	SSW	10.3	1.7
Monsoon	Jul.-Sept.	SSW	SSW	SW	S	10.5	8.2
Post-monsoon	Oct.-Dec.	NNE	E	N	NE	21.0	25.0
Winter	Jan.-Feb.	NE	S	NNE	E	31.0	16.7
Annual		SSW	S	SW	SSW	15.8	12.9

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

(8) Geology

The Detailed Project Report for the project (Feb. 2014) summarizes that subsoil of the proposed project site is made up of three distinct layers as shown in Table A7.1.9.

Table A7.1.9 Geology of the Proposed Project Site

Layer	Depth (m)	SPTs (standard penetration tests)- N Value
Grayish Silty Fine Sand	0.0 -10.0/13.0	10 - 64
Brownish Silty Sand	10.0-13.0	7 - 9
Soft Disintegrated Rock	13.0/15.0-19.0	>100
Hard Rock	17.0-23.0	-

Source: Detailed Project Report (DPR) for the Project, Feb. 2014, AECOM for Chennai Metro Water

(9) Earthquake and Tsunami Disaster

1) Earthquake

Table A7.1.10 shows a list of earthquakes/earth tremors of more than magnitude 5 in Tamil Nadu State since 1807.

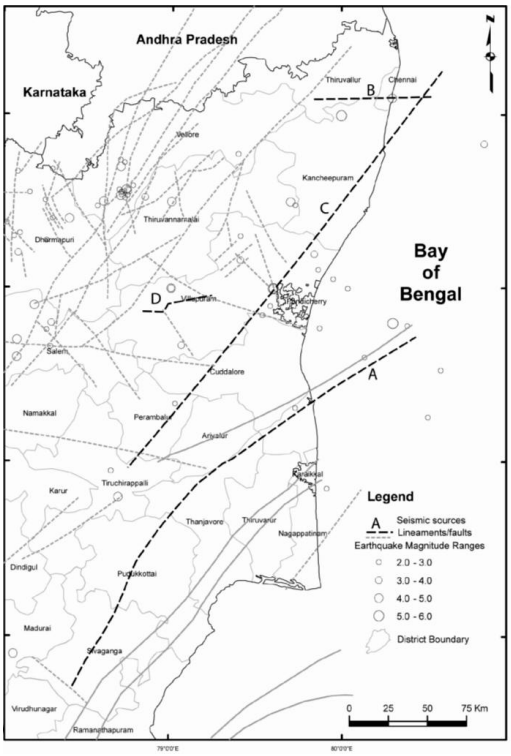
Table A7.1.10 Earthquakes/Earth Tremors of >5 Magnitude in Tamil Nadu State Since 1807

No.	Year/Month/Date	Latitude	Longitude	Magnitude	Location
1	1807/12/10	13.1000	80.3000	5.0	Chennai (Off the Coast)
2	1816/09/16	13.1000	80.3000	5.0	Chennai (Off the Coast)
3	1822/01/29	12.0000	79.0000	5.0	Thirukkovilur, Villupuram
4	1822/01/29	12.5000	79.7000	5.0	Vandavasi, Thiruvannamalai
5	1823/03/02	13.0000	80.0000	5.3	Sriperumpudur, Chennai
6	1859/01/03	12.5000	79.0000	5.0	Polur, Thiruvannamalai
7	1865/08/02	12.7000	78.7000	5.0	Vaniyambadi. Vellore
8	1867/07/03	12.0000	79.6000	5.7	Vikkiravandi, Villupuram
9	1882/02/28	11.4600	76.6000	5.7	Ooty, Nilgiris
10	1900/02/08	10.8000	76.8000	6.0	South West of Walayar, Coimbatore
11	1972/07/29	11.0000	77.0000	5.0	Northeast of Coimbatore
12	2001/09/25	11.8600	80.3000	5.6	40 km east of Pondicherry (Off the coast)

Source: Seismic Hazard Assessment Based on Attenuation Relationship for Tamil Nadu State, India, Dr. S. Rajarathnam, Dr. G.P. Ganapathy & Mr. R. Muthukumar, Centre for Disaster Mitigation and Management, Anna University, Chennai (http://nidm.gov.in/idmc/Proceedings/A1%20Earthquake/A1-35-RAJARATHNAM.pdf)

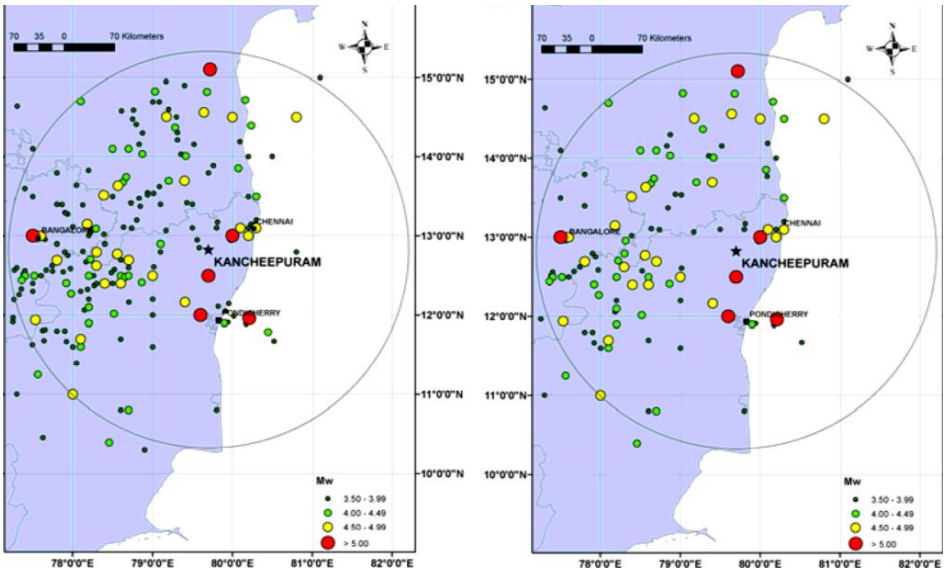
Chennai area including Kancheepuram District (where the proposed project site is located) is in Zone III (Moderate Seismic Hazard) classified by the Bureau of Indian Standard.

Figure A7.1.1 and Figure A7.1.1 show seismic sources and faults in Chennai area and seismicity around Kancheepuram, respectively.



Source: First level seismic microzonation map of Chennai city - a GIS approach G.P. Ganapathy Centre for Disaster Mitigation and Management, VIT University, Vellore, 21 Feb. 2011, Natural Hazards and Earth System Sciences

Figure A7.1.1 Seismic Sources and Faults in Chennai Area



(a) Before de-clustering (b) After de-clustering

Source: Seismic Hazard at the Historical Site of Kancheepuram in Southern India Ornthammarath, T., Lai, C.G., Menon, A., Corigliano, M., Dodagoudar, G.R. and Gonavaram, K. K. The 14th World Conference on Earthquake Engineering Oct. 12-17, 2008, Beijing, China

Figure エラー! 指定したスタイルは使われていません。**2 Seismicity around Kancheepuram**

2) Tsunami

Detailed Project Report (DPR) and the EIA report for the project summarized tsunami disaster in Chennai are as follows.

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

(10) Protected Areas

Table A7.1.11 shows a list of protected areas in Tamil Nadu State; among which, the nearest such areas from the proposed project site are Guindy National Park (more than 30 km north of the site) and Vedanthangal Bird Sanctuary (more than 50 km south-west of the site).

Table A7.1.11 Protected Areas in Tamil Nadu State

S. No.		Name of the National Park / Sanctuary/ Conservation Reserve	Year	Area (km^2)	District (s)
National Parks	1.	Mudumalai National Park	1990	103.23	Nilgiris
	2.	Indira Gandhi National Park	1989	117.10	Coimbatore
	3.	Mukurthi National Park	1990	78.46	Nilgiris
	4.	Guindy National Park	1976	2.82	Chennai
	5.	Gulf of Mannar Marine National Park	1986	526.02	Ramanathapuram & Thoothukudi
Wildlife Sanctuaries	1.	Mudumalai Wildlife Sanctuary	1940	217.76	Nilgiris
	2.	Indira Gandhi Wildlife Sanctuary	1976	841.49	Coimbatore
	3.	Mundanthurai Wildlife Sanctuary	1962	582.08	Tirunelveli
	4.	Kalakad Wildlife Sanctuary	1976	223.58	Tirunelveli
	5.	Grizzled Squirrel Wildlife Sanctuary	1988	485.20	Virudhunagar
	6.	Point Calimere Wildlife Sanctuary	1967	17.26	Nagapattinam
	7.	Vallanadu Blackbuck Sanctuary	1987	16.41	Thoothukudi
	8.	Kanyakumari Wildlife Sanctuary	2002	457.78	Kanyakumari
	9.	Vedanthangal Birds Sanctuary	1996	0.30	Kanchipuram
	10.	Karikili Birds Sanctuary	1989	0.61	Kanchipuram
	11.	Pulicat Lake Birds Sanctuary	1980	153.67	Tiruvallur
	12.	Vettangudi Birds Sanctuary	1977	0.38	Sivagangai
	13.	Kanjirankulam Birds Sanctuary	1989	1.04	Ramanathapuram
	14.	Chitrangudi Birds Sanctuary	1989	0.48	Ramanathapuram
	15.	Udayamarthandapuram Birds Sanctuary	1991	0.45	Tiruvarur
	16.	Vaduvoor Birds Sanctuary	1996	1.28	Tiruvarur
	17.	Koonthankulam - Kadankulam Birds Sanctuary	1994	1.29	Tirunelveli
	18.	Karaivetti Birds Sanctuary	1999	4.54	Perambalur
	19.	Vellode Birds Sanctuary	1997	0.77	Erode
	20.	Melaselvanoor -Kilaselvanoor Birds Sanctuary	1998	5.93	Ramanathapuram
Conservation Reserve	1.	Tirupudaimarudhur Birds Conservation Reserve	2005	0.03	Tirunelveli

Source: State of Environment Atlas of Tamil Nadu 2006, SoE Cell and ENVIS Centre Department of Environment, Government of Tamil Nadu

In addition, the following forest and biodiversity sites are located around Chennai metropolis.

- Palikaranai Marsh Land (235 km^2): This area falls under Perungudi and Pallikaranai in the Kanchipuram District villages and about 20 km south in the Chennai Metropolitan Area.
- Nanmangalam Reserve Forest (320 ha): A protected area located at Medavakkam on Velachery High Road between Velachery and Tambaram and about 24 km of the southern part of Chennai center

  (Source: State of Environment Report of Chennai Metropolitan Area 2013 ENVIS Centre Government of Tami Nadu)

The Marsh land and Forest exist more than 20 km from the proposed project site.

(11) Ecosystem

1) Mangrove

According to the "State of Environment Atlas of Tamil Nadu 2006, SoE Cell and ENVIS Centre Department of Environment, Government of Tamil Nadu", mangroves in Tamil Nadu State have been confirmed as follows.

- Spread over 35 km^2 in Chidambaram, Cuddalore, Nagapattinam, Ramanathapuram and Thanjavur (Muthupet).
- In Cuddalore, mangroves are found in Pitchavaram and located about 225 km south of Chennai. Pitchavaram mangroves are bathed in the Vellar-Coleroon estuarine complex and spread to an area of 1,100 ha.
- The Pitchavaram area consists of 51 islets (small and large), which are traversed by numerous creeks, gullies, channels and canals.

In addition, "the State of Environment Report of Chennai Metropolitan Area 2013 ENVIS Centre Government of Tami Nadu" notes that mangrove stands on the southern bank of the Adyar Estuary of Adyar River.

Those mangroves exist more than 30 km from the proposed project site.

2) Turtle Nesting Areas

In Tamil Nadu, five species of sea turtles (Olive Ridley, Loggerhead Turtle, Hawksbill Turtle, Green Turtle and Leatherback Turtle) have been reported as follows.

- Olive Ridley (arribada) nests sporadically along northern Tamil Nadu coast and high nesting was observed along Nagapattinam and Chennai coasts.
- Olive Ridley is classified under Schedule I of the Wildlife Act of India.
- One such location is the Chennai coast between the Neelankarai-Napier Bridge stretch.
- The other turtle nesting areas are the coasts between Tranquebar and Pazhayaru, Mamallapuram and Chennai and Point Calimere and Nagapattinam.
- Turtle nesting was reported during December to February and also during April to June.

- Olive Ridleys nest along the Chennai coast between January and March.

  (Source: "State of Environment Atlas of Tamil Nadu 2006, SoE Cell and ENVIS Centre Department of Environment, Government of Tamil Nadu", State of Environment Report of Chennai Metropolitan Area 2013 ENVIS Centre Government of Tami Nadu)

3) Coral Reef

In Tamil Nadu State, coral reefs are found in the Gulf of Mannar and the Palk Bay located in more than 200 km south of the proposed project site in Perur.

(Source: "State of Environment Atlas of Tamil Nadu 2006, SoE Cell and ENVIS Centre Department of Environment, Government of Tamil Nadu")

(12) Marine Environment

The marine (seashore and offshore) environment around the proposed project site and in Chennai coast have been summarized in the EIA report for the project as shown in Table A7.1.12.

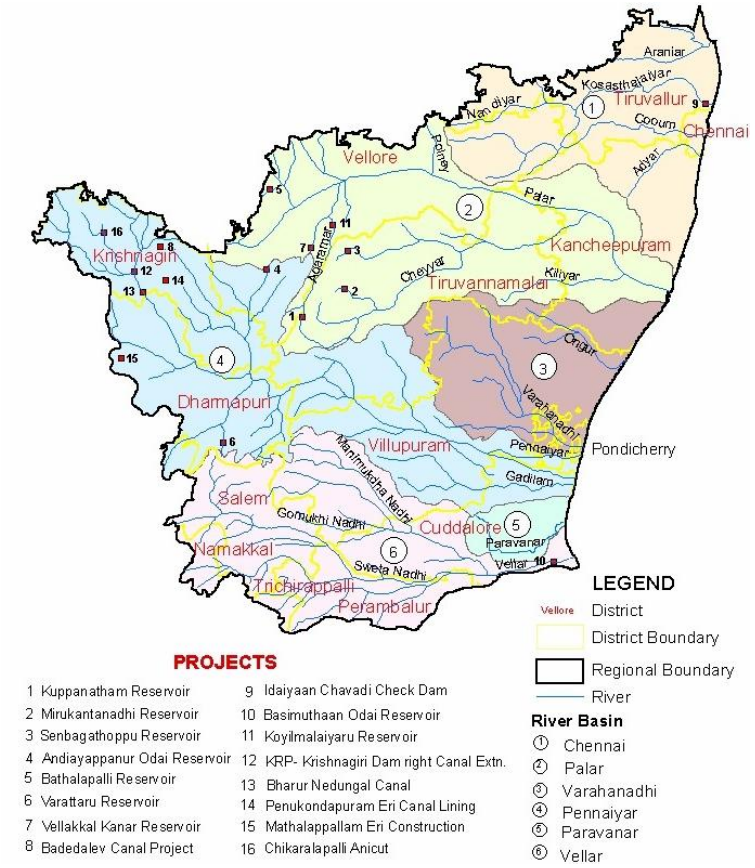
Table A7.1.12 Marine Environment around the Proposed Project Site

Item	Description
Wind	• Wind speed varies between 7 to 11 knots throughout the year • During Apr., May, Jun. and Dec. the wind speed varies around 10-11 knots • During the remaining months, wind speeds vary between 7 and 9 knots. • During Apr. to Sept., the morning wind mostly prevailed from SW and W, and during Nov. to Feb., it mostly prevailed from NW.
Storm	• In total, 58 storms had crossed within 300 km from the project region, and the occurrence of storms in this region are more frequent in Oct. and in Nov.
Tide	• MHWS (Mean High Water Spring): 1.15m • MHWN (Mean High Water Neap): 0.84 m • MSL (Mean Sea Level): 0.65 m • MLWN (Mean Low Water Neap): 0.43 m • MLWS (Mean Low Water Spring) : 0.14 m
Current	• During the measurement period, the maximum current speed recorded was 0.33 m/s. • The current direction was shifting with tides showing the variation within the sector of 330°-90°.
Waves	• The significant wave height varies between 0.5 m and 1.0 m during Feb. to Apr. • Between 1m and 3 m during May to Sept. • Between 1m and 2 m during rest of the year • The zero crossing period of the waves varied between 5 s. and 8 s.
Salinity	• Between 32.0 ppt. to 34.5 ppt. throughout the year.
Temperature	• Between 27°C and 30°C throughout the year.
Littoral drift	• The sediment transport rates were high in May and Dec. and low in Mar. • The littoral drift was towards north from Apr. to Oct. and towards south during the remaining months of the year.
Bathymetry	• At offshore, the seabed shows a steep gradient of 1:70 till 7 m depth. • And the water depth is 4 m at 225 m, 5 m at 340 m, 7 m at 520 m, 8 m at 66 m, 9 m at 83 m, 10 m at 1,040 m, 11 m at 1,360 m, 12 m at 1,890 m, 13 m at 2,160 m, 14 m at 2,460 m, 15 m at 2,720 m and 16 m at 2,950 m.
Seismic survey Result	• The shallow seismic study reveals that the sub-seabed consists of a sedimentary layer such as sand and clay up to few meters below the seabed. • The submerged and buried rocks are also noticed within the study region.
Side scan survey Result	• The analyzed records reveal that the seabed is generally covered by sandy clay, clayey sand, coarse sand with scattered rocky outcrops.

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

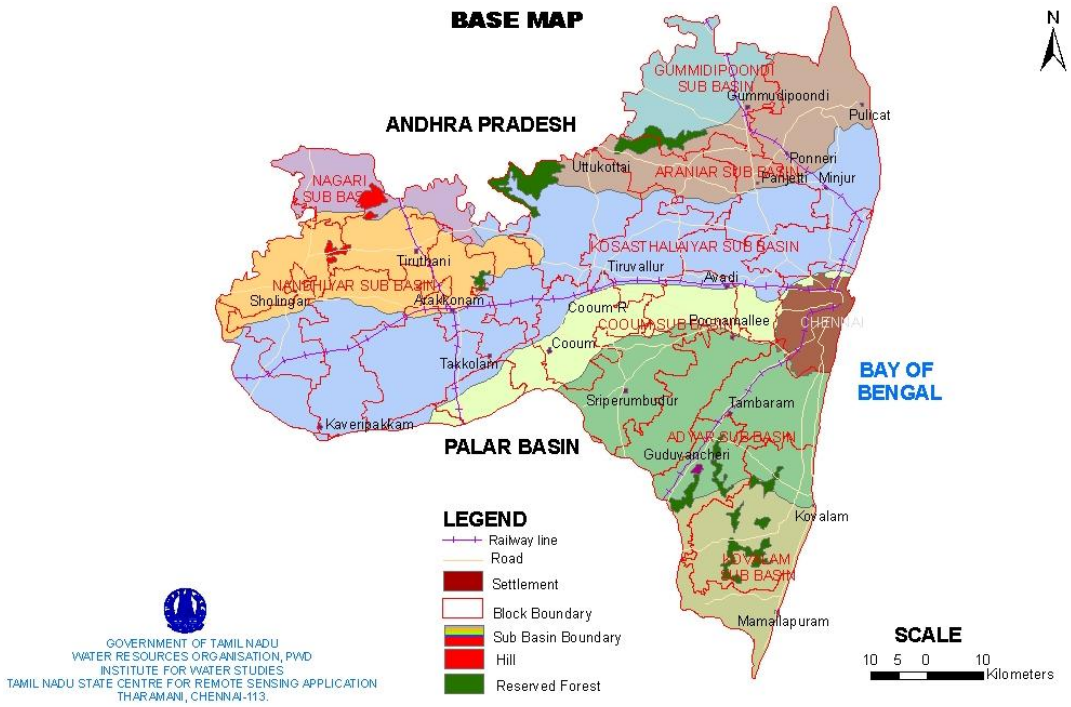
(13) Hydrology

Figure A7.1.3 shows six river basins of the Chennai Region of Water Resources Organization of Tamil Nadu. Among those, the Chennai basin is located in the North-East area of the region. In addition, Figure A7.1.4 shows eight sub-basins in the Chennai basin.



Source: Public Works Department, Government of Tamil Nadu (http://www.wrd.tn.gov.in/images/Region-CHN-E.jpg)

Figure A7.1.3 River Basins in Chennai Region



Source: Tamil Nadu State Centre for Remote Sensing Application, Institute for Water Studies, Public Works Department, Government of Tamil Nadu

Figure A7.1.4 Sub-Basins in Chennai Basin

The proposed project site is located in the Kovalam sub-basin in the Chennai Basin between Adyar River and Palar River in the Chennai region. Administratively, the site is in the Kancheepuram District, which is located in the Chennai River Basin.

(14) Flora and Fauna

1) Flora

Table A7.1.3 shows a list of critically endangered and endangered flora species found in Tamil Nadu State.

Table A7.1.13 Critically Endangered and Endangered Flora Species in Tamil Nadu State

Flora	Scientific Name	
Critically Endangered Species	*Actinodaphne lanata*	*Meteoromyrtus wynaadensis*
	Berberis nilghiriensis	*Nothopegia aureo-fulva*
	Cinnamomum walaiwarense	*Paphiopedilum druryi (Drury's Paphiopedilum)*
	Dipterocarpus bourdilloni	*Pittosporum viridulatum*
	Elaeocarpus gaussenii	*Poeciloneuron pauciflorum*
	Eugenia singampattiana	*Pseudoglochidion anamalayanum*
	Ficus angladei	*Syzygium courtallense*
	Hildegardia populifolia	*Utleria salicifolia*
	Hopea erosa	*Valeriana leschenaultii*
	Hygrophila madurensis	*Vateria indica*
	Memecylon sisparense	-
Endangered Species	*Actinodaphne bourneae*	*Hopea utilis*
	Actinodaphne salicina	*Humboldtia bourdillonii*
	Anacolosa densiflora	*Humboldtia vahliana*
	Ardisia blatteri	*Hydrocotyle conferta*
	Atuna indica	*Isonandra villosa*
	Atuna travancorica	*Ixora saulierei*
	Byrsophyllum tetrandrum	*Kingiodendron pinnatum*
	Chionanthus linocieroides	*Koilodepas calycinum*
	Cinnamomum chemungianum	*Kyllinga pluristaminea*
	Cinnamomum filipedicellatum	*Lindernia minima*
	Cinnamomum wightii	*Litsea beddomei*
	Cleistanthus travancorensis	*Litsea nigrescens*
	Cryptocarya anamallayana	*Melicope indica*
	Cyathea crinita	*Melicope lunu-ankenda*
	Cycas circinalis	*Memecylon flavescens*
	Cynometra travancorica	*Memecylon subramanii*
	Dalbergia congesta	*Microtropis densiflora*
	Decalepis hamiltonii	*Nostolachma crassifolia*
	Dimorphocalyx beddomei	*Orophea thomsoni*
	Dipterocarpus indicus	*Palaquium ravii*
	Drypetes porteri	*Polyalthia rufescens*
	Dysoxylum malabaricum (White Cedar)	*Popowia beddomeana*
	Elaeocarpus blascoi	*Psychotria globicephala*
	Eugenia discifera	*Psychotria macrocarpa*
	Eugenia floccosa	*Psydrax ficiformis*
	Eugenia indica	*Rotala ritchiei*
	Euonymus paniculatus	*Shorea roxburghii (White Meranti)*
	Euonymus serratifolius	*Shorea tumbuggaia*
	Euphorbia santapauii	*Sophora wightii*
	Farmeria indica	*Symplocos anamallayana*
	Fimbristylis crystallina	*Symplocos barberi*
	Glochidion pauciflorum	*Symplocos nairii*
	Glochidion sisparense	*Symplocos oligandra*
	Glochidion tomentosum	*Syzygium beddomei*
	Goniothalamus rhynchantherus	*Syzygium microphyllum*
	Homalium jainii	*Syzygium myhendrae*
	Hopea glabra	*Syzygium parameswaranii*
	Hopea parviflora	*Tarenna monosperma*
	Hopea ponga	-

Source: International Union for Conservation of Nature (IUCN)

In addition, the vegetation in the proposed project site identified by the EIA report is shown below.

- The project area is widely dominated by *Casuarina litorea* trees and sparsely populated with Veelikkaruvai (*Prospopis juliflora*), *Ipomea pes caprae*, *Pandanus odoratissimus*, *Catharanus rouseus*, *Thespesia populnea*, *Cocus nucifera*, *Borassus flabellifer*, *Azadirachta indica*, *Pedalium sp*., *Calotropis gigantean* and *Spinifex littoreus*.
- Especially, the front face of the site towards the sea face is fully planted with *Casuarina litorea* tree. Plantations were grown and maintained by the Department of Forest, Government of Tamil Nadu.

2) Fauna

Table A7.1.14 shows a list of critically endangered and endangered fauna species found in Tamil Nadu State.

Table A7.1.14 Critically Endangered and Endangered Fauna Species in Tamil Nadu State

Fauna		English Name	Scientific Name
Critically Endangered Species	Birds	Spoon Billed Sandpiper	*Eurynorhynchus pygmeus*
	Mammals	Large Rock Rat	*Cremnomys elvira*
	Reptiles	Hawksbill Turtle	*Eretmochelys imbricata*
	Amphibians	Anamalai Flying Frog	*Rhacophorus pseudomalabaricus*
		Kerala Indian Frog	*Indirana phrynoderma*
		Griet Bush Frog	*Raorchestes griet*
		Large Ponmudi Bush Frog	*Raorchestes ponmudi*
		Sushil's Bush Frog	*Raorchestes sushili*
	Fish	Pondicherry Shark	*Carcharhinus hemiodon*
Endangered Species	Mammals	Blackbuck	*Antilope cervicapra*
		Nilgiri langur	*Presbytis johni*
		Lion Tailed Macaque	*Macaca silenus*
		Nilgiri tahr	*Nilgiritragus hylocrius*
		Servant mouse	*Mus famulus*
		Salim Ali's Fruit Bat	*Latidens salimalii*
	Reptiles	Perrotet's Vine Snake	*Ahaetulla perroteti*
		Boulenger's Dasia	*Dasia subcaerulea*
		Indian Kangaroo Lizard	*Otocryptis beddomii*
		Travancore Hills Thorntail Snake	*Platyplectrurus madurensis*
		Tamil Nadu Earth Snake	*Rhinophis travancoricus*
	Fish	Aruli Barb	*Dawkinsia arulius*
		Tambraparini Barb	*Dawkinsia tambraparniei*
		Nilgiri Danio	*Devario neilgherriensis*
		Cardamon Garra	*Garra hughi*
		Kalakad Stone Carp	*Garra kalakadensis*
		Anamalai Sucker Catfish	*Glyptothorax anamalaiensis*
		ray-finned fish	*Glyptothorax housei*
		Zig Zag Sucker Fish	*Homaloptera montana*
		Lipped Algae Eater	*Horalabiosa joshuai*
		Curcuma barb	*Hypselobarbus curmuca*
		Nilgiri Barb	*Hypselobarbus dubius*
		Korhi barb	*Hypselobarbus micropogon*
		Hump Backed Mahseer	*Hypselobarbus mussullah*
		Broadfin Shark	*Lamiopsis temminckii*
		Chennai Sawfin Barb	*Pethia sharmai*
		Round Tailed Killer Catfish	*Pterocryptis wynaadensis*
		Nukta	*Schismatorhynchos nukta*
		Great Hammerhead	*Sphyrna mokarran*
		Black Mahseer	*Tor khudree*
		Malabar Mahseer	*Tor malabaricus*
	Spiders	Parambikulam Large Burrowing Spider	*Haploclastus kayi*
		Beautiful Parachute Spider	*Poecilotheria formosa*
		Reddish Parachute Spider	*Poecilotheria rufilata*

Source: Critically Endangered Animal Species of India, 2011 MoEF, International Union for Conservation of Nature (IUCN)

In addition, the small animals in the proposed project site identified by the EIA report are as follows.

- Dead shells of gastropod and bivalve mollusks are largely found washed on the shore line.

3) Marine Biodiversity

The marine (seashore and offshore) biodiversity around the proposed project site and in Chennai coast have been summarized in the EIA report for the project as shown in Table A7.1.15

Table A7.1.15 Marine Biodiversity around the Proposed Project Site

Item	Description
Floral Diversity	• Varies from 21 to 29 species. • Most dominant species are: Bacillariophyceae (Diatoms) formed the major group followed by Dinophyceae (Dinoflagellates) and Cyanophyceae (blue-green algae). • Phytoplankton population analyzed at various stations showed that their numerical abundance varied from 68 to 103 nos./ml. • As many as 55 species of phytoplankton (net and unit samples put together) represented by 3 diverse groups namely, diatoms (43 species consisting of 34 centrales and 9 pennales), dinophyceans (11) and chlorophyceae (1). • There were relatively fewer (46) species in the unit samples.
Zooplankton	• Fluctuates from 38 to 44 species. • Zooplankton mostly consists of *Coryceas danae* (13.5% to 8.7%), *Paracalanus parvus* (7.2% to 2.0%), *Oithona brevicornis* (6.8% to 0.6%), *Coryceas catus* (6.8% to 1.8%) and Copepod stages (5.6% to 1.9%).
Benthos	• Benthic faunal population in an environment depends on the nature of the substratum and the organic matter content of the substratum. • Sediment characteristics are of coarse to medium sand, the numerical abundance of benthic fauna varied between 80 and 170 nos/m^2 mainly consisting of amphipods, polychaetes, bivalves and mysids. • Intertidal benthos: Numerical abundance varied between 30 to 75 nos/m^2. • Generally, in a project area without pollution/stress/disturbance, the Shannon diversity values and Margalef's richness indices are higher in the range of 2.5 to 3.5, whereas it is low in the project area-which can be attributed to nature of sediment-which is sand in the area.
Microbiology	• The study indicated that there is no microbiological pollution. • Bacterial densities were higher in the sediment samples than those in the water samples, which can be attributed to rich organic content in sediment and lesser residence time of microorganisms in the water than the sediments.
Turtles	• Observed during February and March 2012, and devoid of nesting during the Survey period (July 2013).

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

A7.1.3 Social Conditions

(1) Demographic Situation and Community

1) Population and Household

The EIA report summarizes the population and household around the proposed project site by reviewing the District Census Hand Book 2011 as shown in Table A7.1.16. However, the site reconnaissance confirmed that there is no household in the proposed project site.

Table A7.1.16 Population and Household around the Proposed Project Site

Particulars		0-3 km	3-7 km	7-10km	0-10km (Total)
Population	Male (People)	1,974	18,994	16,031	36,999
	Female (People)	1,848	18,470	15,928	36,246
	Total (People)	3,822	37,464	31,959	73,245
	Density (People/km^2)	336	717	557	605
Household	Household (Number)	1,009	9,190	7,762	17,961
	Average /Household (People)	3.79	4.08	4.12	4.06

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

2) Social Structure

The EIA report summarizes the social structure around the proposed project site by reviewing the District Census Hand Book 2011 as shown in Table A7.1.17.

Table A7.1.17 Social Structure around the Proposed Project Site

Particulars		0-3 km	3-7 km	7-10 km	0-10 km (Total)
Scheduled Caste (SC)	Population (People)	203	14,864	9,973	25,040
	% to the Total Population	5.31	39.68	31.21	34.19
Scheduled Tribe (ST)	Population (People)	124	398	240	762
	% to the Total Population	3.24	1.06	0.75	1.04
SC and ST	Total Population (People)	327	15,262	10,213	25,802
	% to the Total Population	8.56	40.74	31.96	35.23
Total Population		3,822	37,464	31,959	73,245

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

3) Literate and Literacy Rate

The EIA report summarizes the literate and literacy rate around the proposed project site by reviewing the District Census Hand Book 2011 as shown in Table A7.1.18.

Table A7.1.18 Literate and Literacy Rate around the Proposed Project Site

Particulars		0-3 km	3-7 km	7-10 km	0-10 km (Total)
Population	Male (People)	1,974	18,994	16,031	36,999
	Female (People)	1,848	18,470	15,928	36,246
	Total (People)	3,822	37,464	31,959	73,245
Literate	Male (People)	1,546	15,125	12,489	29,160
	Female (People)	1,206	12,357	10,487	24,050
	Total (People)	2,752	27,482	22,976	53,210
Literacy Rate	Male (%)	56.18	55.04	54.36	54.80
	Female (%)	43.82	44.96	45.64	45.20
	Average Male Literacy to the total population (%)	40.45	40.37	39.08	39.81
	Average Female Literacy to the total population (%)	31.55	32.98	32.81	32.84
	Total Literacy Rate (%)	72.00	73.36	71.89	72.65

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

4) Occupational Structure

The EIA report summarizes the occupational structure around the proposed project site by reviewing the District Census Hand Book 2011 as shown in Table A7.1.19.

Table 7.1.19 Occupational Structure around the Proposed Project Site

Particulars		0-3 km	3-7 km	7-10 km	0-10 km (Total)
Total Population (People)		3,822	37,464	31,959	73,245
Total Workers		1,402	14,378	12,660	28,440
Work Participation Rate (%)		36.68	38.38	39.61	38.83
Main Workers	Number (People)	1,319	10,588	10,440	22,347
	% of Main Workers to Total Population	34.51	28.26	32.67	30.51
Marginal Workers	Number (People)	83	3,790	2,220	6,093
	% of Marginal Workers to Total Population	2.17	10.12	6.95	8.32
Non-Workers	Non-Workers	2,420	23,086	19,299	44,805
	% of Non-Workers to Total Population	63.32	61.62	60.39	61.17

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

(2) Land Use

The EIA report summarizes the land use around the proposed project site by reviewing the District Census Hand Book 2001 as shown in Table A7.1.20.

Table A7.1.20 Land Use around the Proposed Project Site

Particulars		0-3 km	3-7 km	7-10 km	0-10 km (Total)
Forest Land (Ha)		0	390	1,151	1,541
Land under Cultivation	Irrigation Land (ha)	238	1,188	1,611	3,037
	Un Irrigated Land (ha)	164	1,389	1,073	2,626
Cultivatable Waste Land (ha)		208	1,016	554	1,779
Are not Available for Cultivation (ha)		528	1,244	1,350	3,122
Total Area		1,138	5,228	5,740	12,105

Source: EIA Report for Proposed 400 MLD Sea Water Reverse Osmosis Desalination Plant at Perur Along ECR, Chennai, Tamil Nadu, India, AECOM for Chennai Metro Water (Simplified by JICA Survey Team)

(3) Archaeological Cultural site

Table A7.1.21 shows a list of protected monuments in Chennai Metro.

Table A7.1.21 Protected Monument in Chennai Metro

Category	Name of Monument / Site
Protected by Archaeological Survey of India (ASI)	Arsenal
	Big Ware house
	Chaplian's House
	Clive's House
	Garrison Engineer's Depot
	Guard Room
	King's Barrack
	Last House On The Left Of 'Snob' Alley'
	Nursing Sister's House
	Old British Infantry Officer's Mess
	Rampart, Gates, Bastion, Pavilions With Vaulted Chambers and Water Cisterns Underneath: Moat And Defense Walls All Round With Glacis To the Extent Of The Existing Barbed Wire Fence
	St. Mary's Church
	Wellesley's House
	David Yale and Joseph Hynmer's Tomb
	Old Town Wall
Protected by Tamil Nadu, the State Department of Archaeology (TNSDA)	Memorial Pillar

Source: State of Environment Report of Chennai Metropolitan Area, 2013, ENVIS Centre, Department of Environment, Government of Tamil Nadu

In addition, near the proposed project site there are two archaeological sites as follows

- Tiger Cave: 7 km south of the proposed project site.
- A group of Monuments at Mahabalipuram: (UNESCO World Heritage, Inscription in 1984) 11 km south of the proposed project site.

Appendix 7.2 International Treaty on Environment

International Conventions/Treaties/Protocols in the field of Environment to which India is a party are summarized in Table A7.2.1.

Table A7.2.1 International Convention/Treaty/Protocol on Environment

Field	International Convention/Treaty/Protocol	Year (ratified/signed)
Hazardous waste	Basel Convention on Trans-Boundary Movement of Hazardous Substances 1991-92.	1992
International resources	Antarctic Treaty (Washington, 1959)	1983
	United Nations Convention on the Law of the Sea (Montego Bay, 1982)	1994
	International Tropical Timber Agreement (Geneva, 1983)	1996
Global climate	Vienna Convention on Ozone Depleting Substances.	1991
	Montreal Protocol	1992
	Framework Convention on Climate Change	1992
	Kyoto Protocol 1992	2002
Marine pollution	International Convention for the Prevention of Pollution from Ships 1973	1986
	International Convention on Civil Liability for Oil Pollution Damage 1969 (effective from June 19, 1975).	1987
	Protocol to the International Convention on Civil Liability for Oil Pollution Damage, 1969.	1987
	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 1971 (effective from October 16, 1978).	1990
	Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 1971.	1994
Wildlife	Convention on Biologic Diversity	1992
	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Washington D.C.	1976
	Convention on Wetlands of International Importance, Especially as Waterfowl Habitat (The Ramsar Convention).	1982
	Convention relative to the Preservation of Fauna and Flora in their Natural State, London 1936	1939
	International Convention for the Regulations of Whaling (Washington, 1946)	1981
	International Plant Protection Convention (Rome, 1951)	1952
	Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979)	1982
	Convention on the Conservation of Antarctic Marine Living Resources (Canberra,1980) 1992	1985
Environmental Planning	Convention to Combat Desertification 1992, 1994	1996
Other environmental fields	Convention concerning the Protection of Workers Against Ionising Radiation (Geneva, 1960)	1975
	Protection (of Industrial Workers) Against Hazards of Poisoning Arising from Benzene	1991
	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (Brussels, 1975).	1963
	Convention on the Protection of World Cultural and Natural Heritage (Paris, 1972)	1977

Source: Handbook on National Environmental Legislation and Institutions in India (2002), Handbook on International Environmental Agreements: An Indian Perspective (2006)

Appendix 7.3 Environmental Impact Assessment (EIA) System in India

Under the Environmental (Protection) Act (1986), a revised Environmental Impact Assessment (EIA) notification (S.O. 1533 (E), 14th Sept. 2006) was brought out by MoEF, which stipulates prior Environmental Clearance (EC) systems, categorization of projects and activities subject to EIA, and EIA processes and so on, as summarized below.

A7.3.1 Prior Environmental Clearance (EC)

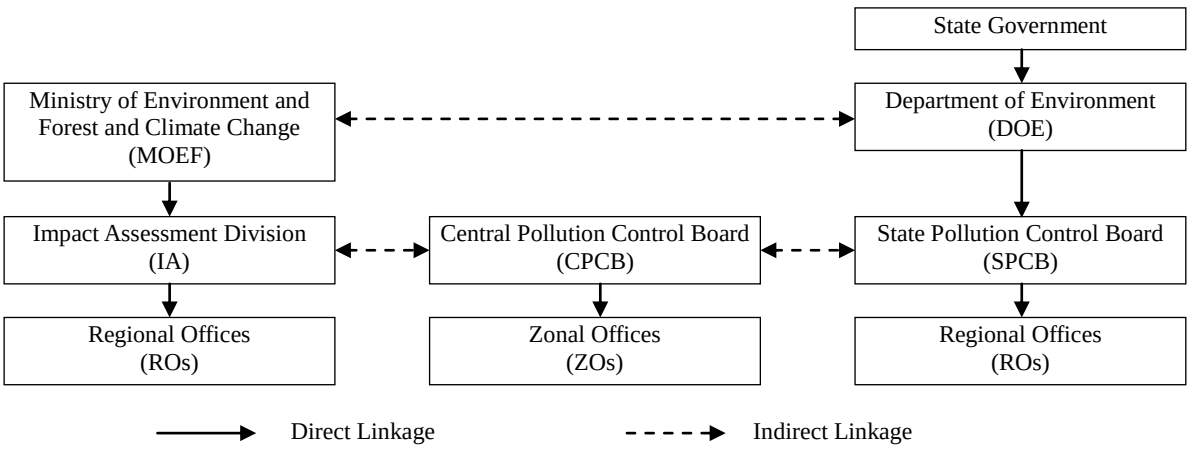
Before any construction work or preparation of land, except for securing the land, the following projects or activities shall require prior environmental clearance (EC) from the concerned regulatory authority.

- All new projects or activities listed in the Schedule to the notification.
- Expansion and modernization of existing projects or activities listed in the Schedule to this notification with the addition of capacity beyond the limits specified for the concerned sector, i.e., projects or activities that cross the threshold limits given in the Schedule after expansion or modernization.
- Any change in the product-mix in an existing manufacturing unit included in the Schedule beyond the specified range.

A.7.3.2 Administrative Framework

The EC process is a two-tier system involving both central and state authorities as shown in Figure A 7.3.1.

At the central level, the Impact Assessment Division (IA) of MOEF, Regional Offices of MoEF and Central Pollution Control Board (CPCB) are three important institutions, whereas SPCBs and State Departments of Environment (DOE) are working at the province level.



Source: Ministry of Environment, Forest and Climate Change

Figure A7.3.1 Relationship Diagram of Entities Involved in EIA Process

A7.3.3 State Level Environment Impact Assessment Authority (SEIAA)

A State Environment Impact Assessment Authority (SEIAA) is constituted by MoEF under the Environment (Protection) Act (1986) that acts as the Authority for issuance EC for category B projects and activities in the State. SEIAA is composed of three members including a Chairman and a Member Secretary nominated by the State Government.

In Tamil Nadu State, as of March 2016, Tamil Nadu Environmental Impact Assessment Authority has been constituted by MOEF with the Notification No. S.O. 2199 (E), New Delhi, dated 12th August 2015.

A7.3.4 Categorization of Projects and Activities

Projects and activities are categorized into Category A and Category B, which are specified in the SCHEDULE, "List of Project or Activities Requiring Prior Environmental Clearance", attached in the Notification (S.O. 1533 (E), 14th Sept. 2006).

Table A7.3.1 summarizes relevant authority for issuance of EC and relevant committee to recommend for the authority for the issuance by the project category.

Table A7.3.1 Environmental Clearance and Authority by Project Category

Project	Authority for Issuance of Environmental Clarence (EC)	Committee to Recommend
Category A	Ministry of Environment, Forest and Climate Change (MoEF)	Expert Appraisal Committee (EAC)
Category B	State Environment Impact Assessment Authority (SEIAA)	State Expert Appraisal Committee (SEAC)

Note : Category A and B are stipulated in the Schedule List, SEIAA is constituted by MOEF under the Environment (Protection) Act (1986), EAC and SEAC are constituted by MOEF
Source: EIA notification MOEF (tabulated by JICA Study Team)

With regard to Category 'B', at the screening stage of EIA process, such a project or activity is scrutinized by the concerned State level Expert Appraisal Committee (SEAC) for determining whether or not the project or activity requires further environmental studies for preparation of an EIA for its appraisal prior to the grant of EC depending up on the nature and location specificity of the project.

- Category B1: Projects requiring an EIA report
- Category B2: Remaining projects and not requires an EIA report.

For categorization of projects into B1 or B2 except item 8 (b) (Townships and Area Development Projects), MoEF issues appropriate guidelines from time to time.

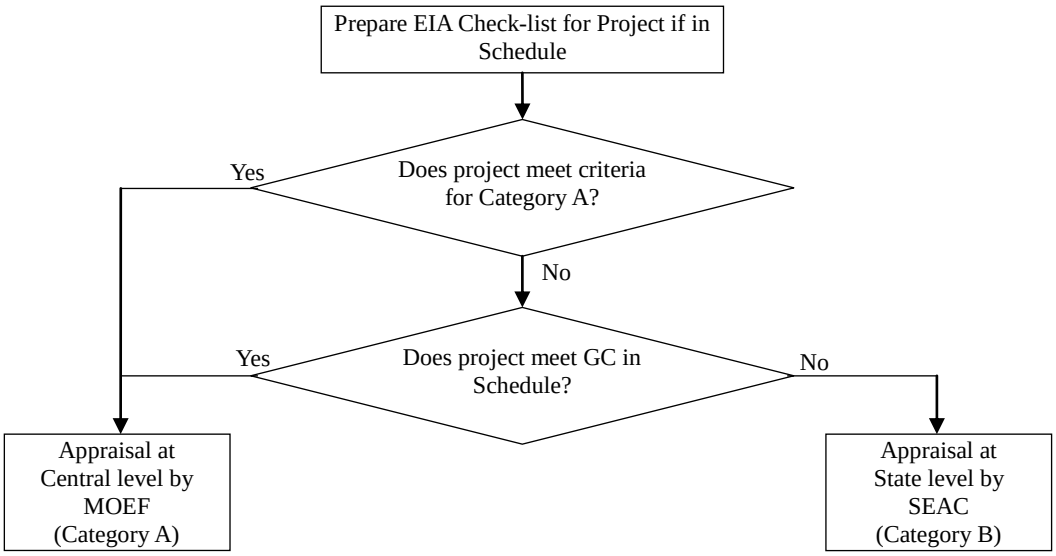
A7.3.5 General Condition (GC)

"General Condition (GC)" is stipulated in the EIA Notification that for any project or activity specified in "Category B" will be treated as "Category A" if located in whole or in part within 10 km from the boundary of the following.

- Protected areas notified under the Wild Life (Protection) Act, 1972

- Critically polluted areas as notified by the Central Pollution Control Board (CPCB) from time to time
- Notified Eco-sensitive areas
- Inter-State boundaries and international boundaries

Figure A7.3.2 shows the categorization flowchart at the screening of the EIA process.



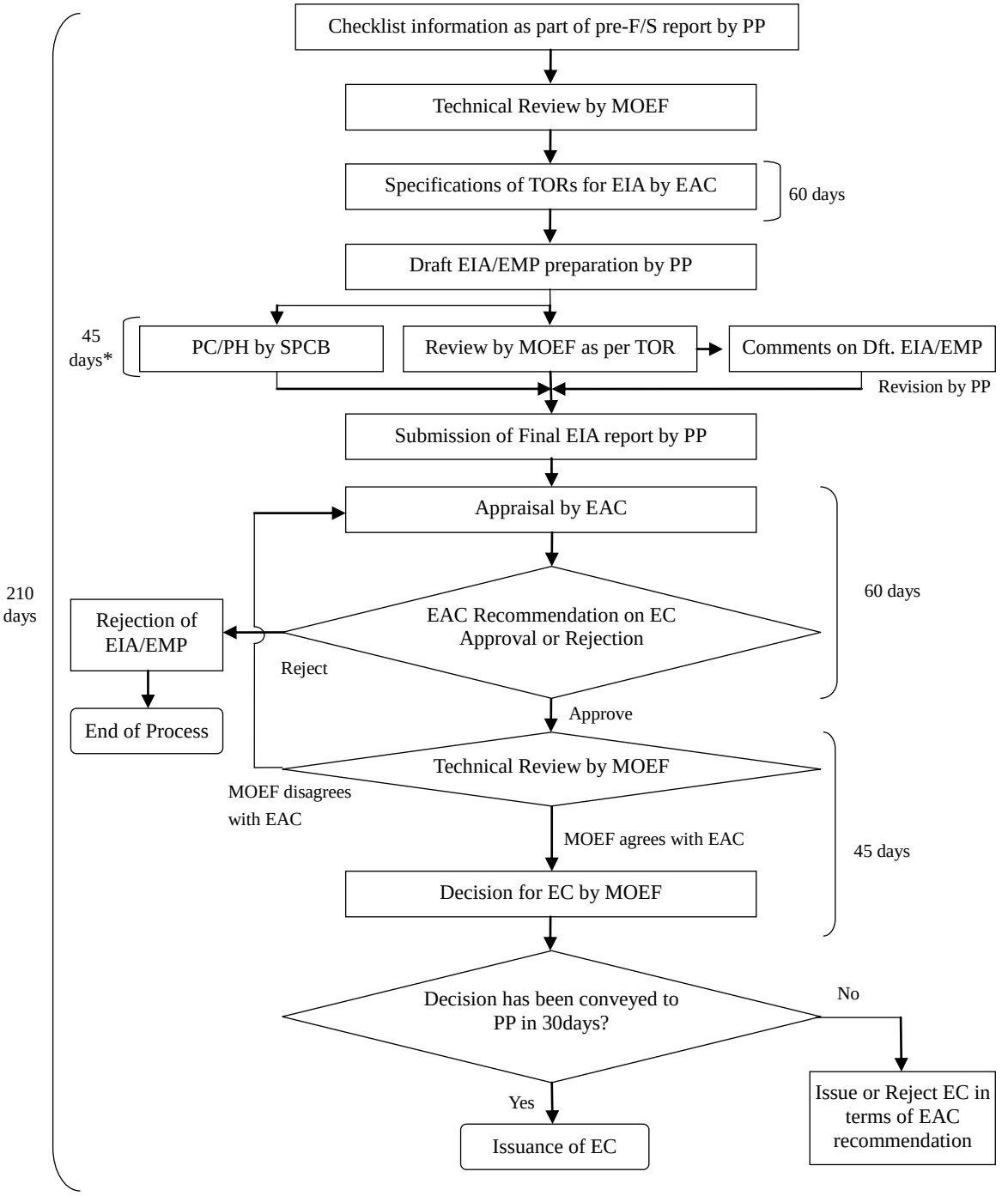
GC: General Condition, SEAC: Expert Appraisal Committee
Source: Notification No.S.O. 1533 (E), 14th Sept. 2006 MoEF, Environmental Impact Assessment (Revised Environmental Clearance Process), Dr. Subrahamanyam, Advisor, 16th May 2014 MOEF (modified by JICA Study Team)

Figure A7.3.2 Flowchart of Categorization at Screening of EIA Process

A7.3.6 EC Process in EIA System

In accordance with the EIA notification (2006) MOEF, three different EC processes are identified in the EIA system of India by projects and activities classified as “Category A” or “Category B” as follows, which are illustrated in Figure A 7.3.3, Figure A 7.3.4, and Figure A 7.3.5, respectively.

- EC Process for Category A Projects (Central Level)
- EC Process for Category B Projects excluding Buildings (State Level)
- EC Process for Category B Projects for Buildings (State Level)



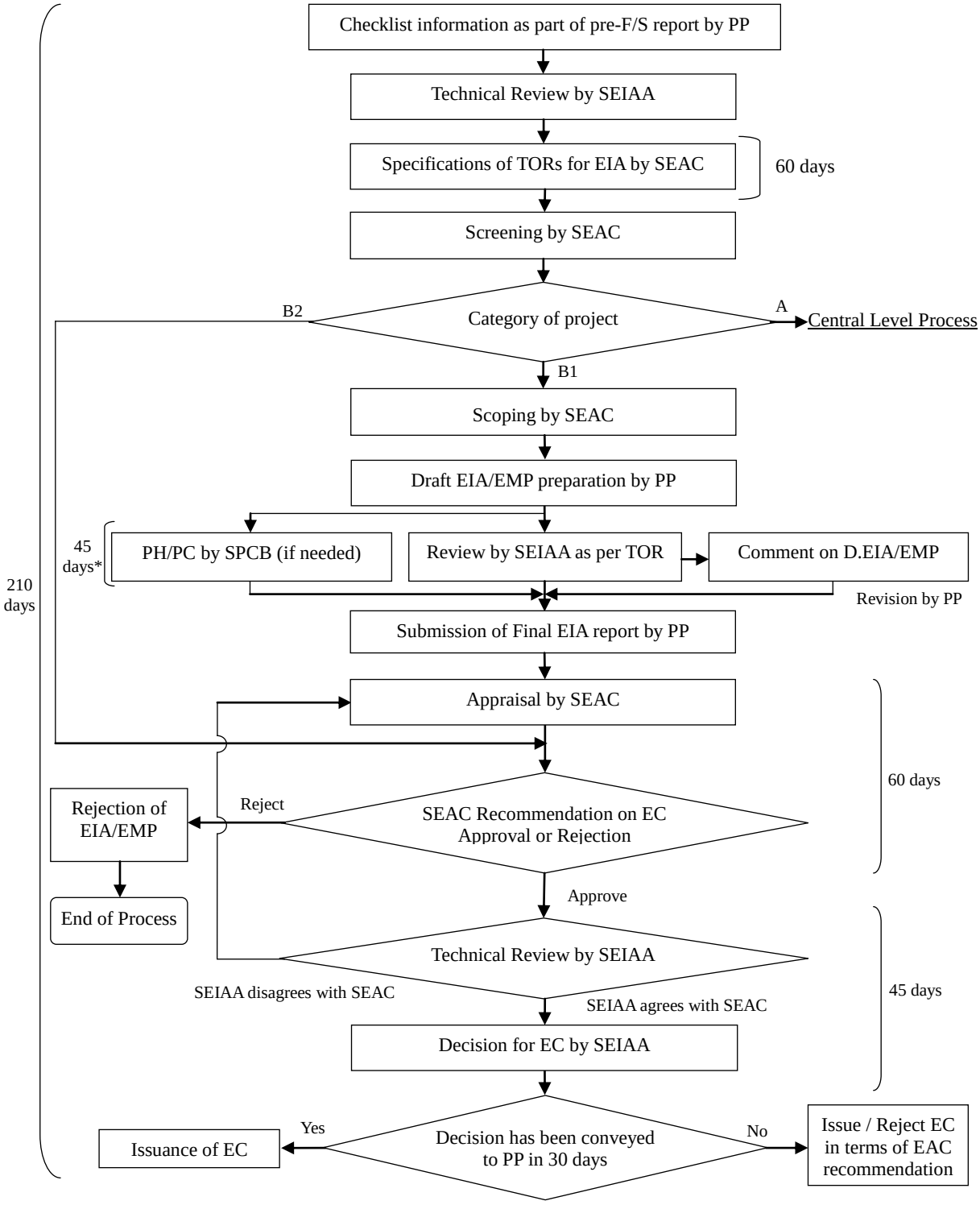
PC/PH; *7 days: To finalize date, venue, *30 days: Provided to public for response, *8 days: To send proceedings to MOEF

EAC: Expert Appraisal Committee
EC: Environmental Clearance
EMP: Environmental Management Plan

PC/PH: Public Consultation/Public Hearing
PP: Project Proponent
SPCB: State Pollution Control Board

Source: Notification No. S.O. 1533 (E), 14th Sept. 2006 MOEF, Environmental Impact Assessment (Revised Environmental Clearance Process), Dr. Subrahamanyam, Advisor, 16th May 2014 MOEF (modified by JICA Study Team)

Figure A7.3.3 EC Process for Category A Projects (Central Level)

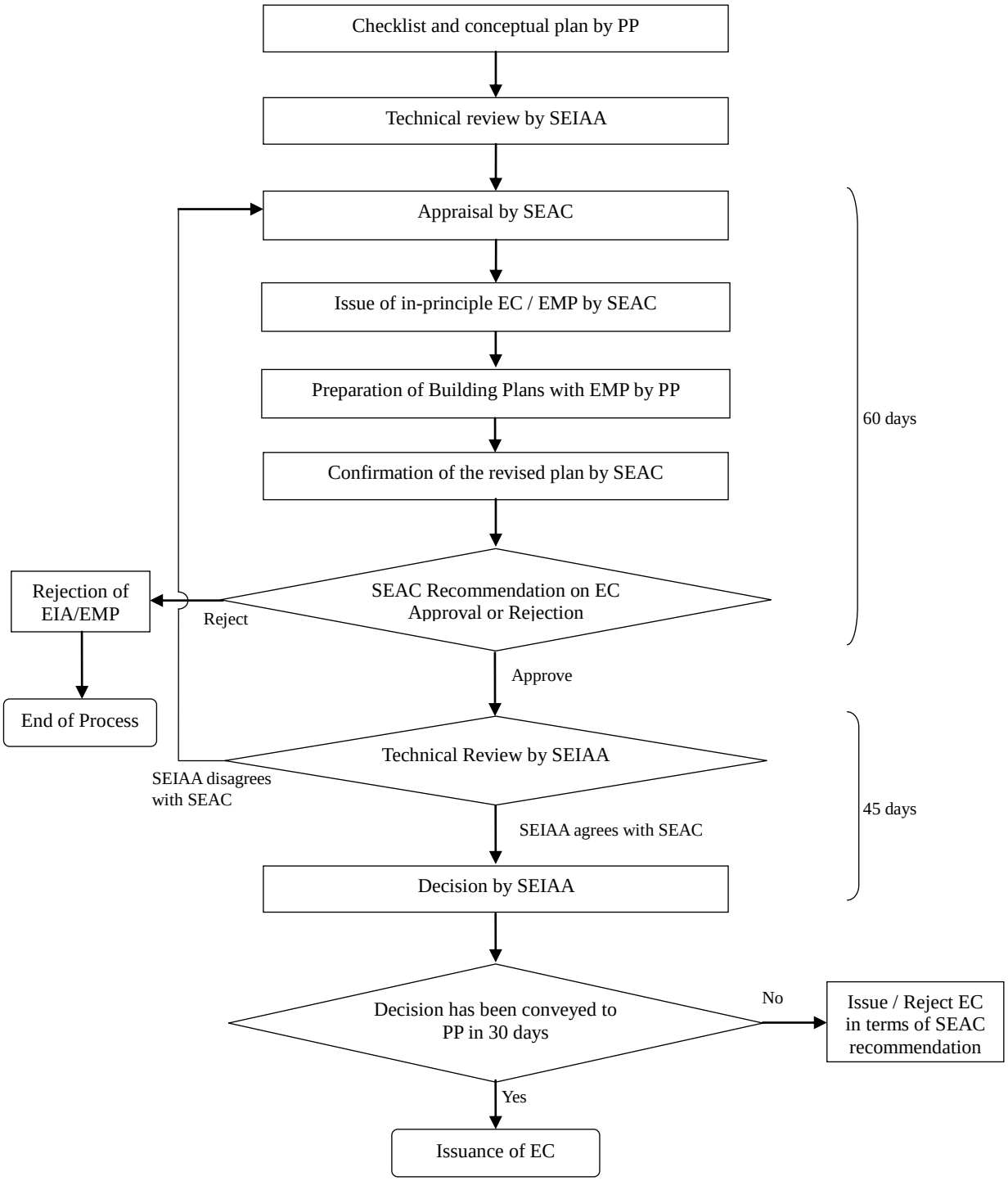


EC: Environmental Clearance
EMP: Environmental Management Plan
PC/PH: Public Consultation/Public Hearing
PP: Project Proponent

SEAC: State level Expert Appraisal Committee
SEIAA: State Level Environment Impact Assessment Authority
SPCB: State Pollution Control Board

Source: Notification No. S.O. 1533 (E), 14th Sept. 2006 MOEF, Environmental Impact Assessment (Revised Environmental Clearance Process), Dr. Subrahamanyam, Advisor, 16th May 2014 MOEF (modified by JICA Study Team)

Figure A7.3.4 EC Process for Category B Projects excluding Buildings (State Level)



EC: Environmental Clearance
EMP: Environmental Management Plan
PP: Project Proponent

SEAC: State level Expert Appraisal Committee
SEIAA: State Level Environment Impact Assessment Authority
SPCB: State Pollution Control Board

Source: Notification No. S.O. 1533 (E), 14th Sept. 2006 MOEF, Environmental Impact Assessment (Revised Environmental Clearance Process), Dr. Subrahamanyam, Advisor, 16th May 2014 MOEF (modified by JICA Study Team)

Figure A7.3.5 EC Process for Category B Projects for Buildings (State Level)

Appendix 7.4 Land Acquisition and Resettlement Systems in India

A7.4.1 Legal and Institutional Framework

(1) Policy, Act, Rules and Ordinance on land acquisition and Resettlement

Land acquisition and Resettlement in India is regulated by the following relevant laws and regulations.

- National Policy on Resettlement and Rehabilitation for Project Affected Families (2003 MORD 2004)
- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013
- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Social Impact Assessment and Consent) Rules, 2014
- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Social Impact Assessment and Consent) Rules, 2015
- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Amendment) Ordinance, 2014
- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Amendment) Second Ordinance, 2015

(2) Official Entities for Land Acquisition and Resettlement

At the central level, the nodal Ministry of India in charge of the land acquisition and resettlement is the Ministry of Rural Development (MORD).

In addition, appropriate governments which handle land acquisition and resettlement are specified in the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (Act 2013) as follows.

- Land situated within the State: State Government.
- Land situated within Union territory (except Puducherry): Central Government.
- Land situated within Union territory of Puducherry: Government of union territory of Puducherry
- Land for public purpose in more than one State-Central Government in consultation with State Government or Union territories.

At the State level, according to the Manual under Right to Information Act, 2005, Revenue Department, each state has a Revenue Department which is the custodian of all lands and is concerned with all land disposals. The Revenue Department administers all the Government lands including those vested with the various departments of the state government. The work relating to land assignment, land acquisition, alienation of land, updating and maintenance of Land Revenue Records, Grant of Pattas (Legal documents for land ownership), Land Reforms, Land Ceiling, Levy and collection of Urban Land Tax are looked after by the Revenue Department.

Under a Revenue Department, a Land Administration Department is organized which deals with various important Revenue subjects such as Assignment (cultivable land / house site), Lease, Transfer of land, Alienation, Acquisition, Estate/Inam Abolition Acts, Cinematograph Act, Eviction of encroachments in Government lands, Irrigation etc., Government lands are allotted to private Individuals, Government Departments and Quasi Government Organizations by way of Lease, Transfer, Alienation, Land Acquisition and Assignment.

(3) Compensation

Compensation for land owners are specified in the First Schedule of the Act (2013). Namely, component of compensation package in respect of land acquired under the Act (2013) shall constitute the minimum compensation package to be given to those to tenants in a proportion to be decided by the appropriate government.

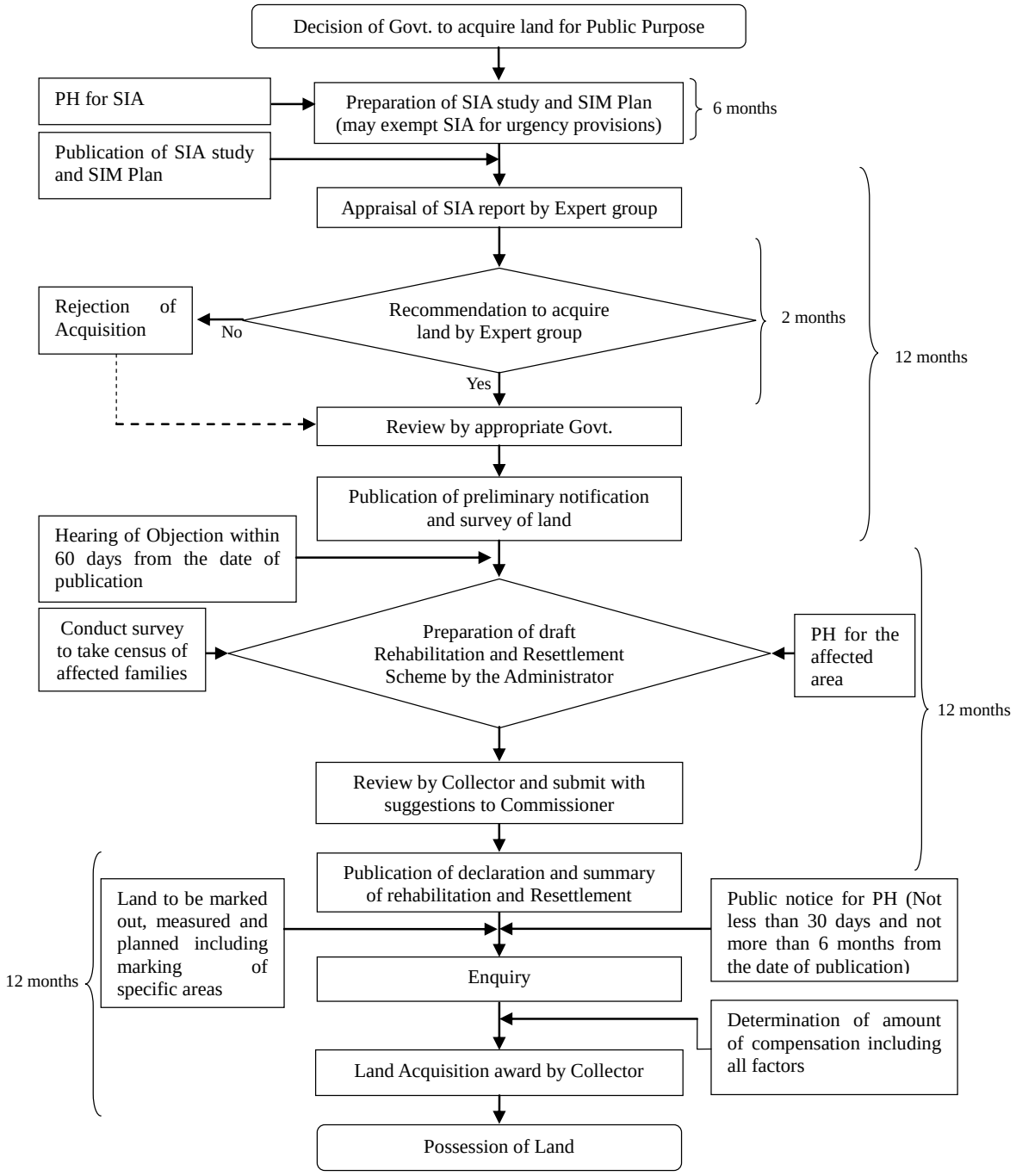
(4) Social Impact Assessment (SIA) and EIA

In accordance with the Act (2013), Social Impact Assessment (SIA) is required for land acquisition and resettlement. For SIA, the Act (2013) specifies that "whenever EIA is carried out, a copy of the SIA report shall be made available to the Impact Assessment Agency authorised by the Central Government to carry out EIA.

However, the Act (2013) notes that where land is proposed to be acquired invoking the urgency provisions, the appropriate government may exempt undertaking of the SIA study.

A7.4.2 Procedures for Land Acquisition and Resettlement

Based on the Act (2013), the procedures for land acquisition and resettlement can be depicted as shown in Figure A 7.4.1



SIA: Social Impact Assessment
SIM: Social Impact Management
PH: Public Hearing

Appropriate Govt.:
Land situated within the State: State Govt.
Land situated within Union territory (except Puducherry): Central Govt.
Land situated within Union territory of Puducherry: Govt. of union territory of Puducherry
Land for public purpose in more than one State-Central Govt. in consultation with State Govt. or Union territories.

Source: Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 27th Sep. 2013

Figure A 7.4.1 Land Acquisition, Rehabilitation and Resettlement Process

Appendix 7.5 Environmental and Social Conditions around the Transmission Pipeline Routes

Chain Name	Chain No.	Distance from Starting Point in Perur (km)	Construction Method	Location/Road Name	Land Use		Road Width (m)	River/Rail crossing points	Remarks
					Right side	Left side			
Chainage of Main Transmission Pipeline Route (Perur to Porur)									
CH	0	0	Open cut	Perur desalination plant	Perur desalination plant	Perur desalination plant		No	-
CH	50	0.05	Pipe Jacking (Chainage 20 - 80)	East Coast Road	East Coast Road	East Coast Road	12	No	-
CH	150	0.15	Open cut	Perur Road	Residential building	Commercial building	7	No	-
CH	250	0.25	Open cut	Perur Road	Garden	Residential building	7	No	-
CH	250-950	0.95	Open cut	Perur Road	Vacant land	Vacant land	7	No	-
CH	950-1450	1.45	Open cut	Gandhi Road	Vacant land	Vacant land	7	No	-
CH	1500	1.5	Open cut	Gandhi Road	Proposed Transmission main bridge	Proposed Transmission main bridge	7	Yes	Buckingham canal crosses
CH	1500-1900	1.9	Open cut	Gandhi Road	Vacant land	Vacant land	7	No	-
CH	1900-2050	2.05	Open cut	Gandhi Road	Salt Swamp	Salt swamp	7	No	-
CH	2050-2150	2.15	Open cut	Gandhi Road	Vacant land	Vacant land	7	No	-
CH	2250	2.25	Open cut	Rajiv gandhi Expressway	Salt Swamp	Salt swamp	7	No	-
CH	2250-2650	2.65	Open cut	Rajiv gandhi Expressway	Salt Swamp	Salt swamp	7	No	-
CH	2750	2.75	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	7	No	-
CH	2850	2.85	Open cut	Rajiv gandhi Expressway	Vacant land	Building	7	No	At approx. 0.28 km there is a culvert
CH	2950	2.95	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	7	No	-
CH	3050	3.05	Open cut	Rajiv gandhi Expressway	Temple	Building	7	No	-
CH	3050-4050	4.05	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	7	No	At approx. 3.88 km there is a culvert
CH	4150	4.15	Open cut	Rajiv gandhi Expressway	Residential building	Shed	7	No	At approx. 4.08 km and 4.12 km there is a culvert
CH	4250	4.25	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	7	No	-
CH	4300	4.35	Open cut	Rajiv gandhi Expressway	Commercial building	Vacant land	7	No	-
CH	4300-4650	4.7	Open cut	Rajiv gandhi Expressway	Agriculture land	Agriculture land	7	No	-
CH	4750	4.75	Open cut	Rajiv gandhi Expressway	Pond	Pond	7	No	At approx.4.72km there is a culvert
CH	4750-4900	4.9	Open cut	Rajiv gandhi Expressway	Agriculture land	Agriculture land	7	No	-
CH	4900-5500	5.5	Open cut	Rajiv gandhi Expressway	Agriculture land	Agriculture land	7	No	At approx. 4.91 km, 4.97km and 4.98 km, 5.28km and 5.39km there is a culvert
CH	5600	5.6	Open cut	Rajiv gandhi Expressway	Commercial building	Pond	7	No	-
CH	5700	5.7	Open cut	Rajiv gandhi Expressway	Industrial building	Vacant land	7	No	-
CH	5700-5900	5.9	Open cut	Rajiv gandhi Expressway	Residential building	Residential building	7	No	Congested area, construction should be done during night time
CH	6000	6	Open cut	Rajiv gandhi Expressway	Residential building/ School	Residential/Commercial building	7	No	
CH	6000-6300	6.3	Open cut	Rajiv gandhi Expressway	Residential/Commercial building	Residential/Commercial building	12	No	At approx. 6.28 km there is a culvert. Congested area, construction should be done during night time
CH	6300-6600	6.6	Open cut	Rajiv gandhi Expressway	Residential/Commercial building	Residential/Commercial building	12	No	Congested area, construction should take during night time
CH	6600-6900	6.9	Open cut	Rajiv gandhi Expressway	Residential/Commercial building	Residential/Commercial building	12	No	
CH	7000	7	Open cut	Rajiv gandhi Expressway	Commercial building	Commercial building	12	No	
CH	7100	7.1	Open cut	Rajiv gandhi Expressway	Commercial building	Residential/Commercial building	12	No	
CH	7200	7.2	Open cut	Rajiv gandhi Expressway	Residential buiding	Industrial building	12	No	
CH	7200-7700	7.7	Open cut	Rajiv gandhi Expressway	Vacant land	Residential and commercial building	12	No	
CH	(7-9)	7.9	Open cut	Rajiv gandhi Expressway	Vacant land	Commercial building	12	No	
CH	8000	8	Open cut	Rajiv gandhi Expressway	Vacant land	Commercial building	12	No	
CH	8150	8.15	Open cut	Rajiv gandhi Expressway	Residential building	Residential building	12	No	
CH	8450	8.45	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	12	No	

Chain	Chain No.	Distance from	Construction	Location/Road Name	Land Use		Road Width (m)	River/Rail	Remarks
CH	8600	8.6	Open cut	Rajiv gandhi Expressway	Residential buiding	Residential/Commercial building	12	No	
CH	8700	8.7	Open cut	Rajiv gandhi Expressway	Industrial building	Vacant land	12	No	-
CH	8800	8.8	Open cut	Rajiv gandhi Expressway	Building	Residential building	12	No	-
CH	9000	9	Open cut	Rajiv gandhi Expressway	Vacant land	Agriculture land	12	No	At approx. 8.87 km there is a well
CH	9000-9400	9.4	Open cut	Rajiv gandhi Expressway	Vacant land	Commercial building	12	No	At approx. 9.33 km there is a culvert
CH	9600	9.6	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	12	No	-
CH	9600-9800	9.8	Open cut	Rajiv gandhi Expressway	Building	Vacant land	12	No	-
CH	9900	9.9	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	12	No	-
CH	9900-10450	10.45	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	12	No	At approx. 10.29 km there is a culvert
CH	10450-10650	10.65	Open cut	Rajiv gandhi Expressway	Vacant land	Apartments	12	No	-
CH	10650-11000	11	Open cut	Rajiv gandhi Expressway	Vacant land	Vacant land	12	No	At approx. 10.72 km, 10.87 km and 10.95 km there is a culvert
CH	11300	11.3	Open cut	Rajiv gandhi Expressway	Vacant land	Industrial building	12	No	-
CH	11300-11700	11.7	Open cut	Rajiv gandhi Expressway	Vacant land along with few shops	Vacant land	12	No	At approx. 11.42km, 11.56 km and 11.63 km there is a culvert
CH	11700-11900	11.9	Deep Excavation for crossing Veeranam pipeline	Rajiv gandhi Expressway	Factory	Commercial building	5.5	No	At approx. 11.8 km there is a culvert
CH	11900-12100	12.1	Open cut	Rajiv gandhi Expressway	Industrial building	Vacant land	5.5	No	-
CH	12100-12300	12.3	Open cut	Senkanmal village	School	Vacant land	5.5	No	-
CH	12300-12500	12.5	Open cut	Senkanmal village	Vacant land	Industrial/Commercial buiding	5	No	-
CH	12600	12.6	Open cut	Senkanmal village	Vacant land with a shop	Commercial building	6	No	-
CH	12700	12.7	Open cut	Senkanmal village	Residential/Commercial building	Building	6.5	No	At approx. 12.63km there is a culvert
CH	12700-13000	13	Open cut	Senkanmal village	Vacant land	Vacant land with few huts	6	Yes	At approx. 12.75 km, 12.94 km there is a culvert. Canal passes
CH	13000-13200	13.2	Open cut	Senkanmal village	Vacant land	Vacant land	5.5	No	-
CH	13300	13.3	Open cut	Senkanmal village	Vacant land with a building	Vacant land	5.5	No	-
CH	13300-13500	13.5	Open cut	Senkanmal village	Kohinoor Garden	Vacant land	5.5	No	At approx. 13.47 km there is a culvert
CH	13500-13700	13.7	Open cut	Senkanmal village	Vacant land with a building	Vacant land	5.5	No	At approx. 13.6 km there is a culvert
CH	13700-13900	13.9	Open cut	Senkanmal village	Vacant land with a building	Coconut plantation	5.5		
CH	14000	14	Open cut	Velichi	Building	Vacant land	5.5	No	-
CH	14000-14200	14.2	Open cut	Velichi	Vacant land	Vacant land	5.5	No	-
CH	14200-14850	14.8	Open cut	Velichi	Vacant land	Vacant land	5.5		At approx. 14.26 km, 14.72 km and 14.84 km there is a culvert
CH	14850-15000	15	Open cut	Velichi	Vacant land	Building	5.5	No	-
CH	15000-15400	15.4	Open cut	Velichi	Vacant land	Vacant land	4	No	At approx. 15.03 km, 15.19 km there is a culvert
CH	15400-18300	18.3	Open cut	Velichi	Reserve forest	Reserve forest	4	No	At approx. 15.73 km, 15.94 km, 16.85 km and 18.29 km there is a culvert
CH	18300-18700	18.7	Open cut	Velichi	Reserve forest	Building	4	No	At approx. 18.37 km, 18.65 km there is a culvert
CH	18700-19350	19.35	Open cut	Velichi	Residential/Commercial building	Residential/Commercial building	4-upto 19.05 km 7-upto 19.35 km	No	At approx. 19.16 km there is a culvert
CH	19350-19700	19.7	Open cut	Major district Road-Mambakkam	Vacant land with well motor room	Vacant land with a shed and a motor room	7	No	-
CH	19700-20200	20.2	Open cut	Major district Road-Mambakkam	Vacant land	Vacant land	7	No	At approx. 19.76 km, 19.96 km there is a culvert
CH	20200-20500	20.5	Open cut	Major district Road-Mambakkam	Vacant land with a bulding	Vacant land with well and motor room	7	No	At approx. 20.25 km, 20.33 km and 20.39 km there is a culvert
CH	20500-20700	20.7	Open cut	Major district Road-Mambakkam	Rubi Engineerng College	Rubi Engineering College	7	No	-
CH	20800	20.8	Open cut	Major district Road-Mambakkam	Vacant land with coconut plantation	Vacant land	7		At approx. 20.8 km there is a culvert
CH	20800-21000	21	Open cut	Major district Road-Mambakkam	Vacant land	Vacant land	7	No	-
CH	21000-21400	21.4	Open cut	Major district Road-Mambakkam	Building	Residential/Commercial building	7	No	At approx. 21.05 km, 21.15 km, 21.19 km, 21.24 km, 21.28 km and 21.4 km there is a culvert

Chain	Chain No.	Distance from	Construction	Location/Road Name	Land Use		Road Width (m)	River/Rail	Remarks
CH	21400-23250	23.25	Open cut	Major district Road-Mambakkam	Forest land	Forest land	7	No	At approx. 21.9 km, 22.18 km, 22.26 km, 22.47 km, 22.53 km, 23.03 km, 23.2 km there is a culvert
CH	23350	23.35	Open cut	Major district Road-Mambakkam	Forest land	Institutional building	7	No	At approx. 21.68 km and 21.74 km there is a culvert
CH	23350-23650	23.65	Open cut	Major district Road-Mambakkam	Forest land	Vacant land	7	No	At approx. 23.58 km there is a culvert
CH	23750	23.75	Open cut	Major district Road-Mambakkam	Vacant land	Mango plantation	7	No	At approx. 23.67 km there is a culvert
CH	23750-24250	24.25	Open cut	Major district Road-Mambakkam	Vacant land with a building	NA	7	No	At approx. 24.23 km there is a culvert
CH	24250-24400	24.4	Open cut	Major district Road-Mambakkam	Vacant land with few buildings	Commercial building and a well	7	No	At approx. 24.34 km there is a culvert
CH	24400-25450	25.45	Open cut	Major district Road-Mambakkam	Vacant land	Vacant land	7	No	At approx. 24.58 km, 24.85 km, 25.13 km, 25.32 km and 25.44 km there is a culvert
CH	25450-25900	25.9	Open cut	Major district Road-Mambakkam	Residential/Commercial building	Vacant land	7	No	At approx. 25.86 km there is a culvert
CH	25900-26600	26.6	Open cut	Medavakkam-Mambakkam Road	Forest land	Forest land	6	No	At approx. 26.05 km there is a culvert
CH	26600-26750	26.75	Open cut	Medavakkam-Mambakkam Road	Coconut plantation	Residential/Commercial building	6	No	-
CH	26750-27100	27.1	Deep Excavation for crossing Veeranam pipeline	Medavakkam-Mambakkam Road	Residential/Commercial building	Residential/Commercial building	6	No	-
CH	27100-27350	27.35	Open cut	Medavakkam-Mambakkam Road	Mango Plantation	Industrial building	6	No	-
CH	27450	27.45	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Industrial building	6	No	-
CH	27550	27.55	Open cut	Medavakkam-Mambakkam Road	Vacant land	Residential/Commercial building	6	No	-
CH	27550-27750	27.75	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Residential/Commercial building	6	No	-
CH	27750-28000	28	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Pond	6	No	-
CH	28000-28150	28.15	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Residential/Commercial building	6	No	-
CH	28250	28.25	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Vacant land	6	No	-
CH	28350	28.35	Open cut	Medavakkam-Mambakkam Road	Pond and temples	Temples	7	No	-
CH	28450	28.45	Open cut	Medavakkam-Mambakkam Road	Vacant land	Pond	7	No	-
CH	28450-28600	28.6	Open cut	Medavakkam-Mambakkam Road	Vacant land with a building	Coconut plantation	7	No	At approx. 28.43 km and 28.6 km there is a culvert
CH	28700	28.7	Open cut	Medavakkam-Mambakkam Road	Vacant land	Vacant land	7	No	At approx. 28.7 km there is a culvert
CH	28700-28900	28.9	Open cut	Medavakkam-Mambakkam Road	Vacant land with dugwells	Industrial building	7	No	-
CH	28900-29250	29.25	Open cut	Medavakkam-Mambakkam Road	Vacant land	Vacant land	7	No	At approx. 29.08 km there is a culvert
CH	29250-29400	29.4	Open cut	Medavakkam-Mambakkam Road	Commercial building	Industrial building	7	No	-
CH	29400-29650	29.65	Open cut	Medavakkam-Mambakkam Road	Industrial building	Vacant land	7	No	At approx. 29.47 km, 29.54 km there is a culvert
CH	29750	29.75	Open cut	Medavakkam-Mambakkam Road	Tata consultancy Services	Vacant land	7	No	At approx. 29.67 km there is a culvert
CH	29850	29.85	Open cut	Medavakkam-Mambakkam Road	Coconut plantation	Residential building	7	No	-
CH	29850-30000	30	Open cut	Medavakkam-Mambakkam Road	Princess Dr. K Vasudevan College of Engineering	Residential/Commercial building	7	No	At approx. 29.97 km there is a culvert
CH	30100	30.1	Open cut	Medavakkam-Mambakkam Road	Agriculture land	Vacant land	7	No	-
CH	30100-30300	30.3	Open cut	Medavakkam-Mambakkam Road	Vacant land	Residential/Commercial building	7	No	At approx. 30.14 km and 30.21 km there is a culvert
CH	30300-30800	30.8	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Residential/Commercial building	7	No	-
CH	30900	30.9	Open cut	Medavakkam-Mambakkam Road	Vacant land	Vacant land and a well	7	No	-
CH	31000	31	Open cut	Medavakkam-Mambakkam Road	Industrial building	Residential/Commercial building	7	No	At approx. 30.94 km there is a culvert
CH	31000-31200	31.2	Open cut	Medavakkam-Mambakkam Road	Agriculture land	Residential building	7	No	-
CH	31200-31400	31.4	Open cut	Medavakkam-Mambakkam Road	Vacant land	Vacant land	7	No	At approx. 31.38 km there is a culvert
CH	31550	31.55	Open cut	Medavakkam-Mambakkam Road	Residential building	Residential/Commercial building	7	No	-

Chain	Chain No.	Distance from	Construction	Location/Road Name	Land Use		Road Width (m)	River/Rail	Remarks
CH	31650	31.65	Open cut	Medavakkam-Mambakkam Road	Building	Coconut plantation	7	No	-
CH	31650-33300	33.3	Open cut	Medavakkam-Mambakkam Road	Forest land	Forest land	7	No	At approx. 31.65 km, 31.98 km, 32.82 km there is a culvert
CH	33300-33450	33.45	Open cut	New Agaram Road	Residential/Commercial building	Kovilamcheri village	NA	No	-
CH	33450-33600	33.6	Open cut	New Agaram Road	Pond	Garden	7	No	At approx. 33.55 km there is a culvert
CH	33700	33.7	Open cut	New Agaram Road	Vacant land	Vacant land	7	No	-
CH	33700-34000	34	Open cut	New Agaram Road	Residential/Commercial building	Residential/Commercial building	7	No	At approx. 33.71 km there is a culvert
CH	34000-34250	34.25	Open cut	New Agaram Road	Vacant land	Industrial building	7	No	-
CH	34250-34450	34.45	Open cut	New Agaram Road	Pond	Commercial building and a garden	7	No	-
CH	34450-34600	34.6	Open cut	New Agaram Road	Well	NA	7	No	At approx. 32.96 km there is a culvert
CH	34600-35000	35	Open cut	New Agaram Road	Agriculture land	Agriculture land	7	No	At approx. 34.86 km there is a culvert
CH	35000-35200	35.2	Open cut	New Agaram Road	Residential/commercial building	Vacant land with few houses	7	No	At approx. 35.18 km there is a culvert
CH	35200-35350	35.35	Open cut	New Agaram Road	Vacant land	Eshwari temple and buildings	7	No	-
CH	35350-36000	36	Open cut	New Agaram Road	Residential/Commercial building	Residential/commercial building	7	No	-
CH	36000-36250	36.25	Open cut	New Agaram Road	Residential/commercial building	Residential/commercial building	7	No	-
CH	36350	36.35	Open cut	Agaram Road	Vacant land	Residential/Commercial building	7	No	-
CH	36350-37000	37	Open cut	Agaram Road	Residential/Commercial building	Residential/Commercial building	7	No	-
CH	37000-37950	37.95	Open cut	Agaram Road	Residential/Commercial building	Residential/Commercial building	7-upto 37.5 km 20- upto 37.95 km	No	-
CH	38050	38.05	Open cut	Camp Road	Vacant land	Commercial building	20	No	-
CH	38050-38300	38.3	Open cut	Camp Road	Residential/Commercial building	Industrial building	20	No	-
CH	38300-38650	38.5	Open cut	Camp Road	Vacant land	Vacant land with a shop	20	No	-
CH	38650-38850	38.85	Open cut	Camp Road	Commercial building	Industrial building	20	No	-
CH	38950	38.95	Open cut	Camp Road	Residential building	Vacant land	20	No	-
CH	39050	39.05	Open cut	Camp Road	Petrol bunk	Commercial building	20	No	-
CH	39150	39.15	Open cut	Camp Road	Vacant land with a house	Vacant land	20	No	-
CH	39150-39350	39.35	Open cut	Camp Road	Commercial/Industrial building	Commercial building	20	No	-
CH	39450	39.45	Open cut	Camp Road	Commercial building	Bharath University	20	No	-
CH	39450-41000	41	Open cut	Camp Road	Commercial building	Commercial building	20-upto 40.6 km 8-upto 41km	No	Congested area, construction should be done during night time
CH	41000-42050	42	Open cut	Kamaraj Garden Street	Commercial/Industrial building	Commercial/Industrial building	8-upto 41.15 km 20-upto 42.05 km	No	
CH	42050-42250	42.25	Open cut	Kamaraj Garden Street	Commercial building	Institutional building	20	No	
CH	42300	42.3	Open cut	Kamaraj Garden Street	Commercial building	Commercial building	20	No	
CH	42300-42600	42.6	Open cut	Kamaraj Garden Street	Commercial building	Institutional building	20-upto 42.5 km 10-upto 42.6 km	No	
CH	42600-43150	43.15	Open cut	Kamaraj Garden Street	Commercial building	Industrial building	10-upto 42.85 km 30-upto 43.15 km	No	
CH	43150-43700	43.7	Open cut	Kamaraj Garden Street	Tambaram Railway quarters area	Madras Christian College	30	No	
CH	43700-43900	43.9	Open cut	Kamaraj Garden Street	Tambaram Railway quarters area	Commercial building	30	No	

Chain	Chain No.	Distance from	Construction	Location/Road Name	Land Use		Road Width (m)	River/Rail	Remarks
CH	43900-44050	44.05	Open cut	Kamaraj Garden Street	NA	Commercial building	20	No	
CH	44050-44250	44.25	Pipe Jacking (Chainage 44110-44250)	Tambaram flyover	Tambaram flyover	Tambaram flyover	14	Yes-Tambaram Railway track	
CH	44250-44450	44.45	Open cut	Tambaram-Mudichur-Sriperumbudur Road	Commercial/Institutional building	NA	14	No	
CH	44450-44600	44.6	Open cut	Tambaram-Mudichur-Sriperumbudur Road	Residential/Commercial building	Residential Quarters	14	No	
CH	44600-44900	44.9	Open cut	Kakkan Street	Commercial building	Residential/Commercial building	10	No	
CH	45000	45	Open cut	Kakkan Street	Institutional building	Hospital	10	No	
CH	45100	45.1	Open cut	Gandhi Road	Commercial building	Commercial building	6	No	
CH	45200	45.2	Open cut	Kishkintha Road	Vacant land	Vacant land	6	No	
CH	45300	45.3	Open cut	Kishkintha Road	Vacant land with a house	Institutional building	6	No	-
CH	45300-45650	45.65	Open cut	Thiruneermalai road	Vacant land	Cementery	6	No	-
CH	45650-46600	46.6	Open cut	Thiruneermalai road	Residential/Commercial building	Residential/Commercial building	6	No	-
CH	46600-46850	46.85	Open cut	Thiruneermalai road	Residential/Commercial building	Vacant land and a temple	6	No	-
CH	46850-47300	47.3	Open cut	Thiruneermalai road	Vacant land	Vacant land	6	No	-
CH	47300-47550	47.55	Open cut	Thiruneermalai road	Vacant land	Vacant land	10	No	-
CH	475500-47800	47.8	Pipe Jacking approx. from 47.75 km	Thiruneermalai road	Industrial building	Vacant land	10	No	-
CH	47800-48100	48.1	Pipe Jacking approx. till 47.85 km	Thiruneermalai road	Chennai to bangalore service road	Vacant land	6	No	At approx. 48.04 km there is a culvert
CH	48200	48.2	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Building	6	No	-
CH	48550	48.55	Open cut	Service road of Chennai Bypass Road	Lake	Lake	6	No	At approx. 48.48 km there is a culvert
CH	49600	49.6	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Vacant land	6	No	At approx. 48.57 km, 48.84 km, 48.9 km, 49.37km, 49.52 km there is a culvert
CH	49700	49.7	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Residential/commercial building	6	No	-
CH	49700-50100	50.1	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Vacant land	6	No	-
CH	50900	50.9	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Vacant land with few buildings	6	No	At approx. 50.48 km, 50.59 km there is a culvert
CH	51000	51	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Residential/Commercial building	6	No	-
CH	51200	51.2	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Vacant land	6	No	At approx. 51.05 km there is a culvert
CH	51550	51.55	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Residential/commercial building	6	No	At approx. 51.37 km there is a culvert
CH	51550-51750	51.75	Open cut	Service road of Chennai Bypass Road	Adyar river	Adyar river	6	No	Bridge
CH	51850	51.85	Open cut	Service road of Chennai Bypass Road	Adyar river	Bushes with few huts	6	No	Bridge
CH	53050	53.05	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Vacant land	6	No	At approx. 52.01 km, 52.14 km, 52.28 km, 52.54 km, 52.74 km, 52.47 km and 52.94 km there is a culvert
CH	53150	53.15	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Commercial building	6	No	At approx. 53.06 km there is a culvert

Chain	Chain No.	Distance from	Construction	Location/Road Name	Land Use		Road Width (m)	River/Rail	Remarks
CH	53150-54000	54	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Vacant land with few buildings	6	No	At approx. 53.36 km, 53.62 km, 53.68 km, 53.77 km and 54 km there is a culvert
CH	54600	54.6	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Vacant land	6	No	At approx. 54.02 km, 54.25 km, 54.4 km there is a culvert
CH	54700	54.7	Pipe Jacking	Chennai Bypass Road	Veeranam water pipe culvert line	Veeranam water pipe culvert line	6	No	-
CH	55800	55.8	Open cut	Kundrathur main road	Residential/Commercial building	Residential/Commercial building	6	No	Congested area, construction should be done during night time
CH	55900	55.9	Open cut	Kundrathur main road	Vacant land	Residential/Commercial building	6	No	
CH	57000	57	Open cut	Kundrathur main road	Residential/Commercial building	Residential/Commercial building	6	No	
CH	57000-57500	57.5	Open cut	Kundrathur main road	Commercial/Industrial building	Commercial/Industrial building	6	No	
CH	57500-58200	52	Open cut	Kundrathur main road	Residential/Commercial building	Residential/commercial building	12	No	
CH	58400	58.4	Open cut	Kundrathur main road	Commercial/Industrial building	NA	12	No	
CH	58700	58.7	Open cut	Kundrathur main road	Commercial/Industrial building	Commercial/Industrial building	12	No	
CH	58800	58.5	Open cut	Mount Poonamall road	Residential/Commercial building	Residential/Commercial building	12	No	
CH	58950	58.9	Open cut	Mount Poonamall road	Commercial building	Commercial building	25	No	
CH	59150	59.15	Open cut	Mount Poonamalle road	Commercial building	Commercial building	25	No	
CH	59250	59.25	Open cut	Mount Poonamalle road	Vacant land	Porur lake area	25	No	
CH	59250-59600	59.6	Deep Excavation form approx. 59.55 km	Service road of Chennai Bypass Road	Residential/Commercial building	Porur lake area	25	No	
CH	59700	59.7	Deep Excavation approx. upto 59.65 km	Service road of Chennai Bypass Road	Veeranam water pipe culvert line	Burial ground	5	No	-
CH	59900	59.9	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Vacant land with few houses	5	No	-
CH	59900-60150	60.15	Open cut	Service road of Chennai Bypass Road	Chennai to bangalore service road	Porur head works	5	No	-
CH	60220	60.22	Open cut	Service road of Chennai Bypass Road	Porur head works	Porur head works	NA	No	-
Chainage of Transmission Pipeline Route (branch line)									
CH0	0	0	Open cut	Medavakkam-Mambakkam Road	Sithalapakkam lake	Residential building	14	No	-
	0-8	0.8	Open cut	Medavakkam-Mambakkam Road	Sithalapakkam lake	Vacant land	14	No	At approx. 0.1 km there is a culvert
	9	0.9	Open cut	Medavakkam-Mambakkam Road	Sithalapakkam lake	Residential building	14	No	-
CH1	0	1	Open cut	Medavakkam-Mambakkam Road	Vacant land	Residential/Commercial building	14	No	-
	2	1.2	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Residential/Commercial building	14	No	-
	2-5	1.5	Open cut	Medavakkam-Mambakkam Road	Commercial building	Commercial building	14	No	-
	5-9	1.9	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Residential/Commercial building	14	No	-
CH2	1	2.1	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Residential/Commercial building	14	No	-
	1-3.5	2.35	Open cut	Medavakkam-Mambakkam Road	Commercial/Industrial building	Vacant land with drainage	14	No	-
	3.5-6	2.6	Open cut	Medavakkam-Mambakkam Road	Vacant land	Industrial building	14	No	-
	6-9	2.9	Open cut	Medavakkam-Mambakkam Road	Vacant land	Residential building	14	No	-
CH3	0	3	Open cut	Medavakkam-Mambakkam Road	Vacant land	Residential building	14	No	-
	0-1.5	3.15	Open cut	Medavakkam-Mambakkam Road	Vacant land	Wastage area	14	No	-
	1.5-3	3.3	Open cut	Medavakkam-Mambakkam Road	Shops	Vacant land	14	No	-

Chain	Chain No.	Distance from	Construction	Location/Road Name	Land Use		Road Width (m)	River/Rail	Remarks
	3-9	3.9	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Industrial building	14	No	Congested area, construction should be done during night time
CH4	0	4	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Industrial building	14	No	
	0-5	4.5	Open cut	Medavakkam-Mambakkam Road	Residential/Commercial building	Commercial/Industrial building	14	No	
	5-9.5	4.95	Open cut	Medavakkam-Mambakkam Road	Shops	Commercial/Industrial building	14	No	
NA-Not Available, CH-Chainage									

Appendix 7.6 Response from CMWSSB to TNCZMA on Sea Turtles

CHENNAI METROPOLITAN WATER SUPPLY AND SEWERAGE BOARD
No. 1, Pumping Station Road, Chintadripet, Chennai-600 002.

MANAGING DIRECTOR

Lr.No.CMWSSB/SE(Desal)/400MLD Desal Plant/Spl/2015 Dated 26.10.2015

To

The Member Secretary,
Tamil Nadu State Level Coastal Zone
Management Authority & Director of
Environment,
No.1, Jennis Road, Panagal Building,
Ground Floor, Saidapet, Chennai 15.

Sir,

Sub: CMWSSB – Setting up of 400 MLD SWRO Desalination Plant at Perur – CRZ clearance requested from State Level Coastal Management Authority – Certain details called for – Reply furnished – Early clearance requested - Reg.

Ref: Lr.No.RC.No.P1/790/2015 dated 08.10.2015 from the Director, Department of Environment for 400 MLD Desalination Plant.

**

Further to the reference cited above, the required details / documents for the proposed 400mld Desalination Plant at Perur are detailed as follows along with necessary enclosures for taking further action by Tamil Nadu State Coastal Zone Management Authority (TNSCZMA).

Sl.No.	Details called by TNSCZMA	Reply of CMWSSB
1	A detailed turtle nesting conservation plan in and around the project area.	The Report is furnished in Annexure I
2	A report on the impact of eco system due to intake and outfall pipelines shall be furnished and the mitigation measures taken on the adverse impacts shall be furnished.	The Report is furnished in Annexure II
3	As CMWSSB has already constructed a desalination plant at Nemmeli, a report on the functioning of the said plant with reference to the conditions imposed in the Environmental Clearance should be furnished.	The existing 100MLD SWRO Desalination Plant at Nemmeli has been constructed and being under Operation & Maintenance as per the conditions imposed in the Environmental Clearance given by Ministry of Environment and Forest, GoI. The analysis report details of the dispersal of the reject disposed from this Plant are furnished in Annexure III.
4	Baseline data of the Nemmeli Plant, details of the 600MLD plant being constructed by Reliance on Rann of Kutch and other relevant baseline study reports shall be furnished to enable a comparison and obtain learning	The intake and outfall pipes of the existing 100 MLD Plant is 1040 m and 680 m away from the shore. As per the analysis report of the plant furnished in Annexure III, it is observed that the salinity of the reject reaches 2 ppt above ambient level within 50 m from the discharge point and also noticed that the ambient level of 38 ppt is reached within a radius of 100 m from the discharge point. As per the modeling report, submitted in the EIA Report already, on dispersion of reject from the existing 100 MLD Desal Plant as well as the proposed 150 MLD and 400 MLD plants, it is observed that there is no merging between the outfalls. Further, the study also shows that the brine reject discharged into the shoreline do not reach the shore and there will be no shoreline connection and no contaminations of the water near the coast. And also noticed that there is no recirculation of water discharged into the intake. As per the available data regarding the desalination plants at Reliance Industries in Rann of Kutch, Gujarat (of 600 MLD capacity) , the following are observed: The Total capacity of Desalination Plants at Reliance is 400 MLD only. 1. 160 MLD Plant is Thermal Desalination based on MED and is in operation for more than 5 years. 2. And balance 240 MLD is as below a) 168 MLD RO based Desalination plant – under construction b) 72 MLD Thermal Desalination plant on MED – under construction The said two plants as stated under poin

Sl.No.	Details called by TNSCZMA	Reply of CMWSSB
		The said two plants as stated under point no 2 are under the phase of Erection and Testing and shall most probably be put into commissioning by Nov 2015, with commercial operations in Feb-March 2016. However, a copy of the Environmental Clearance Notification given by the MoEF, GoI for the above proposal is enclosed as Annexure IV for kind perusal. Hence, no dispersion details of the rejects from the plants could be availed.

As such, it is requested that necessary arrangements may kindly be made to obtain the approval of the State Level Coastal Zone Management Authority and its recommendations to MoEF, GoI for CRZ clearance to set up 400mld Desalination Plant at Perur at the earliest.

26/10/201

MANAGING DIRECTOR

Encl: as above (49 Pages)

Received
16/x/15

ANNEXURE-I
Turtle nesting conservation plan around the Project area

Background

Tamil Nadu has a coastal length of 1076 km (13% of the country's coastline) and a continental shelf of approximately 41,412 sq.km, and is one of the leading states in marine fish production. The State has a fishermen population of 1.05 million of which 0.20 million fishermen are actively engaged in fishing from 591 marine fishing villages scattered along 13 coastal districts.

The Chennai Metropolitan Development Authority (CMDA) is the nodal agency responsible for planning and development of Chennai Metropolitan Area, which is spread over an area of 1,189 Sq. km, covering the Chennai district and parts of Tiruvallur and Kanchipuram districts. The CMDA has drafted a second Master Plan that aims to develop satellite townships around the city. The city's contiguous satellite towns include Mahabalipuram in the south, Chengalpattu and Maraimalai Nagar in the southwest, and Sriperumpudur, Arakkonam, Kanchipuram and Tiruvallur to the west.

Chennai has 25.6 km of sea coast which is flat and sandy for about a km. from the shore. The Coast in Kanchipuram district under which the present site comes, has 87 Km of sea coast wherein 44 fishing villages with 2 major and 37 minor fish landing centers exist. The proposed site is 43 KM away from Chennai city.

Chennai coast is characterized by fairly wide sandy beaches like the Marina, Elliot's, Neelangarai beach, Thiruvanmiyur and Valmiki Nagar beaches. The sand texture is soft and suitable for sea turtle nesting.

Turtles of Indian waters

Five of the seven known species of sea turtles: Leatherback turtle (*Dermochelys coriacea*), Hawksbill turtle (*Eretmochelys imbricate*), Loggerhead (*Caretta caretta*), Green turtle (*Chelonia mydas*) and Olive Ridley turtle (*Lepidochelys olivacea*) are reported from the Indian waters. Except for the Loggerhead turtle, all four other species are known to nest along the coast of mainland and the Bay Islands of India.

Sea turtle population

Four species of sea turtles; olive ridley, hawksbill (*Eretmochelys imbricate*), green turtle (*Chelonia mydas*), and leatherback turtle (*Dermochelys coriacea*) were recorded during the course of various studies conducted along the Indian coast. Olive Ridley turtles, the smallest and the most numerous of the seven species are famously known for their unique behavior of forming enormous nesting aggregations - a phenomenon known as "arribada" (Spanish for arrival).

Tamilnadu and Andhra Pradesh coasts are considered as the migratory pathways of Olive Ridleys for approaching mass nesting in Odisha.

The three main rookeries or turtle nesting beaches along the 480 km stretch of Odisha coast are the Gahirmatha rookery (Bustard, 1976), between the Brahmini and Baitarani, located north of Paradip; the rookery at the Devi river mouth, about 100 km south of Gahirmatha (Kar, 1982) and the rookery located 320 km south of Gahirmatha, near the mouth of Rushikulya river (Pandav et. al., 1994). The Olive Ridley population in Orissa is of global significance since it is one the major mass nesting rookeries in the world, along with Mexico, and Costa Rica .

Olive Ridley nets sporadically along northern Tamil Nadu Coast and high nesting was observed along Nagapattinam and Chennai Coasts. The Other turtle nesting areas are the coasts between Tranquebar and Pazhayaru, Mahabalipuram and Chennai and Point Calimere and Nagapattinum. Sea turtles congregate on the eastern coastal waters by November – December and nesting is usually between January and end March with peak nesting happening in February.

Sea Turtle Surveys and Monitoring by Research Organisations and NGO's

Surveys and documentation of sea turtles in India began at two sites, namely Gahirmatha in Orissa, and Chennai (Madras) in Tamil Nadu. In Chennai (Madras), monitoring of status and threats (and hatchery programs for conservation) was initiated by the Madras Snake Park Trust, surveyed much of the Indian coast over the next few years.

Sea turtle monitoring in Chennai has been nearly continuous over the last forty years thanks to the efforts of the Madras Snake Park Trust (1973 –1976), Central Marine Fisheries Research Institute (1977-1981), Tamil Nadu Forest Department (1982 – till now) and Students Sea Turtle Conservation Network (SSTCN) from 1988 till the present.

Protection and Intelligence Gathering -- Staff Strength and Distribution

Each year, during the turtle nesting season, a volunteer group establishes a hatchery at Neelangarai, and every night from end-December through end-March, the same 7 km stretch of beach is patrolled. Since 2009 the Marina stretch too is being monitored making the total length covered 14 km with an additional hatchery in Marina (This area is 42 KM from the Project site).

Every weekend during the season, members of the general public and school and college students from Chennai and other places accompany volunteers on 'turtle walks' where they learn about sea turtles and marine conservation.

Over the years more than 25,000 people have participated in the walks. Many student members have been motivated to pursue careers in ecology, ecotourism, wildlife management and conservation.

Fishermen Communities -- Participation in Protection of Species

Although the fishermen communities were initially suspicious and sometimes hostile towards the work of conservation volunteers every night, their shift in attitude to that of support has been quite dramatic especially in the Marina stretch. The people from the community who used to poach eggs have become protectors of nests. Some even call volunteers' mobile phones to inform them that there is a nest that they need to pick up. It is noteworthy that the fishermen expect nothing in return for their help. If wild nests hatch and hatchlings stray towards the bright lights on the beach, fishermen often call volunteers or our hatchery supervisor (a fisherman himself) for help to track down and release hatchlings before they are picked off by dogs and crows.

Street theatre programmes are organised for fishing communities to spread the message about the need to protect sea turtles and preserve the biodiversity in the ocean.

Threats to sea turtle

The major threats to the sea turtles are:

i. Fishing by trawlers and Gill netters in nearshore and offshore coastal waters is a vital obstacle for the sea turtles. They are hurt and killed by slashing of propellers of mechanical boats. Most of the turtles including mating pairs die due to suffocation when they are entangled in trawl nets and gill nets. (This is not applicable to this project)

ii. Artificial lighting from anchoring vessels, ports, harbours, fishing jetties and other coastal developmental activities are known to have impacts on breeding, nesting and hatching as light is known to greatly disorient them while moving. (The project has no plan to use lights in the beach)

iii. Introduction of improved beach landing crafts and settlement of migratory fishermen from neighboring states on important nesting beaches resulting in destruction of nesting habitats. (Not applicable to this project)

iv. Oil spills and marine pollution will inevitably occur in the event of large port being set up.

v. Changes in the land use pattern of coastal areas in the vicinity of important nesting as well as mass nesting beaches such as beach loss and beach modification, beach littering, casuarinas plantation neat the High Tide Line (HTL), increased lighting in the beaches have been reported have significant impacts. Similarly, changes in the sea use pattern such as increasing fishing activities, increasing ship/boat activities because of developmental activities around breeding grounds, feeding and developmental habitats as well as migratory paths etc. have their influence on sea turtles and their habitats.

vi. Human poaching of turtle eggs and predation of eggs by other animals are the most common activities that result in the loss of turtle population.

Identification of the exact non-breeding grounds of Olive Ridleys nesting

Though Olive Ridleys spend almost six months in a year in the coastal waters off Odisha, till recently nothing was known about the area where they spend the remaining six months. Recovery of 22 turtles tagged in Odisha from Sri Lanka and Gulf of Mannar during this study indicates that this could possibly be the non-breeding grounds for the ridleys migrating to the Odisha coast every winter. Although the tagged turtles have been recovered all around Sri Lanka, most of the recoveries are made from Gulf of Mannar and the west coast of Sri Lanka. Satellite telemetry studies can provide definite answers about olive ridleys non-breeding area. However, with the existing tag returns it is clear that olive ridleys are migrating from as far south as Sri Lanka to breed in Odisha.

Also it is understood that area near Nagapattinam is favored place for nesting and the same is approx. 200 km from the proposed site.

Nesting survey was carried out fortnightly in the stretch between Neelankarai and Uthandi by WWF-India personnel. The survey was conducted from January to March 2012. A total of 6 Olive Ridley nests were recorded during the survey. Uthandi is about 19.2 KM away from the proposed Project site. Hence, the stretch along the proposed site does not have any impact on turtle nesting .

Further, a beach stretch of 50 km from Mahabalipuram to Pondicherry was monitored by WWF-India personnel and a resource person. The nesting survey was carried out on a fortnightly basis and nesting information was recorded. Mahabalipuram is about 9.8 KM away from the proposed Project site and hence the proposed plant does not have any impact on turtle nesting.

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

Further , during the survey conducted by the Volunteers of Students Sea Turtle Conservation Network (SSTCN) from January to February 2014, in the stretch between Neelangarai in south and Napier Bridge in North (which is 21 KM away from the Project site) , 332 nests were observed which is comparatively higher than the observations made during the previous years.

Already one 100 MLD SWRO Desalination plant is operating at the same place for last three years and **so far no such turtle nesting has been reported so far**.

In spite of **no impact** observed on the nesting of Olive Ridley Turtle along the stretch of the proposed Project site, CMWSS Board will extend support to Forest Department/ Students Sea Turtle Conservation Network (SSTCN) for the conservation of Olive Ridley Turtles as required.

Impact of Proposed desalination plant on turtle population

The intake and outfall are proposed at 1000 m and 650 m from the shoreline which is beyond the "active zone" of the turtle population. While intake of seawater is expected not to cause any impact on the turtle population because of it's location offshore some 650 m away from the coast. Further the intake head is provided with the screens / trash bars to prevent its entry into the same.

Outfall is designed with a multiple port diffuser for faster mixing and dilution of the brine which is expected to have a salinity of 71ppt i.e. 33 ppt higher than the ambient seawater. This increase in salinity gets reduced to 1.0 ppt within 100 m distance from the outfall. The modeling study conducted also confirms that the rate of mixing of brine reject is very effective for outfall located at 650 m distance offshore.

The brine from the desalination plant will only have a higher quantity of salt and it may not bring any adverse effect on the breeding population.

Onshore impacts:

The turtles select sandy beaches for nesting and they normally lay their eggs beyond the HTL. The area where LFP is to be located is free from any nests possibly because of high sand dunes present near the HTL. The backshore region is having 8 to 10 m high sand dunes. The top of intake and outfall pipelines are to be buried almost 1.0 m from the sea bed surface and once they are laid they will not interfere with nesting as the turtles usually dig 30 to 50 cm deep to lay their eggs. So far no reports have been published on the mass nesting of Olive Ridley or other species in this area.

Mitigation

It is proposed to have the pipe laying activity in non-mating season and also the lighting towards the coast should be of low intensity. It is also advisable to avoid Casuarina plantation near the HTL as the sand dunes are very stable and sufficiently high to be a good barrier for natural disasters like tsunami and cyclones.

Appendix 7.7 Meeting Minutes for the 1st Stakeholders Meeting

MINUTES OF THE STAKEHOLDERS MEETING CONDUCTED BY CHIEF ENGINEER (O&M) II REGARDING THE PROPOSED 400 MLD DESAL PLANT AT PERUR ON 8.7.2016

PRESENT:

1. Chief Engineer III, CMWSSB.
2. Superintending Engineer (Desal)
3. Executive Engineer (Desal)
4. President, Nemmeli Village Panchayat
5. Block Development Officer, Thiruporur
6. Village Administrative Officer, Thiruporur
7. Representative from Arulmigu Alavandar Trust
8. Representative from Study Team of JICA
9. Local Public of Nemmelikuppam

**

At the outset, the Executive Engineer (Desal) welcomed the gathering and explained the purpose of the meeting and briefly enlightened the details of the project and requested the local public to offer their opinion and suggestions for the proposed 400 MLD Desal Plant at Perur. Subsequently, the Superintending Engineer (Desal) outlined the necessity of the proposed 400 MLD & 150 MLD Desalination Plants in addition to the existing 100 MLD Desalination Plant at Nemmeli with details of the units proposed to be set up under this project.

The following points were discussed in detail.

a) The local public welcomed the proposed project and in general, agreed to extend their cooperation for the successful completion of the project.

b) The local public informed that the protection given for the shore erosion which caused damage to their houses during execution of existing 100 MLD Desalination Plant was not of sufficient relief and requested to provide protection in the form of construction of dyke for a length of approximately 300 m before commencement of construction works for the new project. SE (Desal) accepted their demand of providing necessary protective system to the seashore of the village which will be consulted with implementation team of the project.

c) The local public further informed that the boats and fishing net arrangements are likely to be damaged during dredging for laying intake pipeline and requested to provide necessary compensation for attending the defects and to protect their livelihood. SE (Desal) assured them that these will be considered during the execution of the project.

d) The President, Nemmelikuppam Village has enquired about the process of laying the intake / outfall pipeline work whether it will be above the sea bed or below the sea bed. SE (Desal) informed that the intake / outfall pipeline will be laid below the sea bed by conventional dredging method during non season time which usually exists for a period of three to four months. The local public requested to consider providing necessary protection in the form of dyke during pipe laying work to avoid further soil erosion at shore near their village.

e) It was also informed that there are 4 burial grounds existing in this site for a total extent of 1.85 acres. Out of which 3 clustered burial grounds for an extent of 1.32 acres located on the north side are accessible from the east & west side and 1 burial ground for an extent of 0.53 acres located on the south side is accessible from south east side.

f) Based on the request of the locals, the officials inspected the eroded shore and the existing burial ground (3 clustered) located in the site earmarked for the proposed plant.

(i) The local public requested to restore the damaged concrete platform of the temple due to soil erosion by waves subsequent to the construction of 100 MLD Desalination Plant

(ii) With regard to 3 cluster burial ground, the local public represented that the path leading to this burial ground is presently from shore only. The locals requested CMWSSB that this path may be rested with them to perform funeral rites. EE (Desal) informed that

CMWSSB will construct a compound wall around the plant leaving the existing burial grounds. The public insisted to allocate full stretch of land along East / West encompassing the burial ground which would also allow other commuters to enter the burial ground from the western end. SE (Desal) informed that the land belongs to Alavandar Trust and has been allotted for this project on "long term lease basis" by the Government. Hence, this is to be decided in consultation with Alavandar Trust, GoTN and local Revenue Department officials.

The meeting ended with vote of thanks given by CE (O&M) II.

Sd/.....20.07.2016
CHIEF ENGINEER (O&M) II i/c

/.t.c.f.b.o./

S.E (Desal)
20/7/16

Appendix 7.8 Participant List for the 1st Stakeholders Meeting

METRO WATER

7

S.NO	Name / பெயர்	Village / கிராமம்	Signature / கையொப்பம்	Department
1.	V. Sivalingam Manager.		8/7/16	
2.	V.N. Parimala	BDO (VP) பெரும்பாக்கம்	8/7/16	R.D. Dept
3.	E. RAJENDRAN	V.A.O		

METRO WATER

8

S.NO	Name / பெயர்	Village / கிராமம்	Signature / கையொப்பம்
1.	Anbu	Nemmeli village	P.
2.	Rajaram		B.
3.	Bakiri	"	C.
4.	Arivazhagan	"	
5.	R. Dilly Babu	Nemmelikuppam	R. Dilly Babu
6.	P. Babu	Nemmelikuppam	P.
7.	B. BASKARAN	Nemmelikuppam	
8.	B. Alagban	"	
9.	A.	"	
10.		"	
11.		"	
12.	S. DESINGU	Nemmelikuppam	
13.	P. Raghu	"	
14.	D.	"	
15.	S.	"	
16.	G. Ruthrakotty	Nemmelikuppam	G. Ruthrakotty
17.	J. VIJAY	"	
18.	M. Kaviarasu	"	
19.	D. Raghuman	"	D.
20.	K.	"	K.
21.	A. Akash	"	
22.	E. Mohan	"	E.
23.	P. NATHANKUMAR	"	P.
24.		"	
25.			R.
26.			
27.			
28.			

METRO WATER

9

S.No	Name / பெயர்	Village / கிராமம்	Signature / கையெழுத்து
	F Govin	[illegible]	F. Govin

Appendix 7.9 Meeting Minutes for the 2nd Stakeholders Meeting

MINUTES OF THE STAKEHOLDERS MEETING CONDUCTED BY SUPERINTENDING ENGINEER (DESAL) REGARDING THE PROPOSED 400 MLD DESAL PLANT AT PERUR ON 18.8.2016.

PRESENT:

1. Superintending Engineer (Desal)
2. Executive Engineer (Desal)
3. President, Nemmeli Village Panchayat
4. Representative from Arulmigu Alavandar Trust
5. Representative from Study Team of JICA
6. Local Public of Soolerikattu Kuppam

**

At the outset, the Executive Engineer (Desal) welcomed the gathering and explained the purpose of the meeting and briefly enlightened the details of the project and requested the local public to offer their opinion and suggestions for the proposed 400 MLD Desal Plant at Perur. Subsequently, the Superintending Engineer (Desal) outlined the necessity of the proposed 400 MLD & 150 MLD Desalination Plants in addition to the existing 100 MLD Desalination Plant at Nemmeli with details of the units proposed to be set up under this project and requested the public to offer their views & issues.

The following points were discussed in detail:

a) The local public welcomed the proposed project and in general, agreed to extend their cooperation for the successful completion of the projects taken up by CMWSS Board.

b) The local public informed that due to the implementation of two new desalination plants, their livelihood may get affected and requested to provide permanent employment opportunities per person per family. SE (Desal) assured that suitable action will be taken to place this issue before the Government through CMWSS Board.

c) It was also requested that a relief amount of Rs.300 / day totaling to Rs.9000/ month has to be given to all the members of the Fisherman Cooperative Society of Soolerikattu Kuppam. Further, the villagers had also requested that the Education Fee (school as well as college levels) for the students belonging to their community has to be borne by the Govt. SE (Desal) assured that suitable action will be taken to place this issue before the Government through CMWSS Board.

d) It was further informed that the protection given for the shore erosion which caused damage to their houses during execution of existing 100 MLD Desalination Plant was not of sufficient relief and requested to provide sufficient protection before commencement of construction works for the new projects. SE (Desal) accepted their demand of providing necessary protective system to the seashore of the village which will be provided in consultation with implementation team of the project.

e) The local public further informed that there are chances of further shore erosion in their village due to the implementation of the new plants, which may result in vacating this area completely. Hence, they have requested to provide alternative arrangements for their settlement by Government at free of cost. SE (Desal) assured that suitable action will be taken to place this issue before the Government through CMWSS Board.

f) The President, Nemmeli Village has enquired about the process of laying the intake / outfall pipeline work whether it will be above the sea bed or below the sea bed. SE (Desal) informed that the intake / outfall pipeline will be laid below the sea bed by conventional dredging method during non season time which usually exists for a period of three to four months. The local public requested to consider providing necessary protection in the form of dyke during pipe laying work to avoid further soil erosion at shore near their village.

g) It was also informed by local that there are 4 burial grounds existing in this site for an extent of 1.85 acres. Out of which 3 clustered burial grounds located on the north side are accessible from the east & west side and 1 burial ground located on the south side is accessible from south east side. It was also confirmed that there are no other burial grounds than the existing four burial grounds. EE (Desal) informed that CMWSSB would construct a compound wall around the plant leaving the existing burial grounds with suitable pathway for the burial grounds.

h) The local public also requested on the following:

i) to provide proper storm water drain upto the sea to drain out the rain water during the monsoon period to protect their village from flooding / stagnation of water.

ii) allotment of land to an extent of 6 acres and 30 cents to the local public from the Alavandar Trust as already approved during 1983 and to issue patta for all the houses in the Soolerikattu Kuppam.

iii) To facilitate to complete the construction of Community Hall which was stopped by the Alavandar Trust at present.

In this regard, SE (Desal) informed that suitable action will be initiated to address the above issues with the concerned Departments.

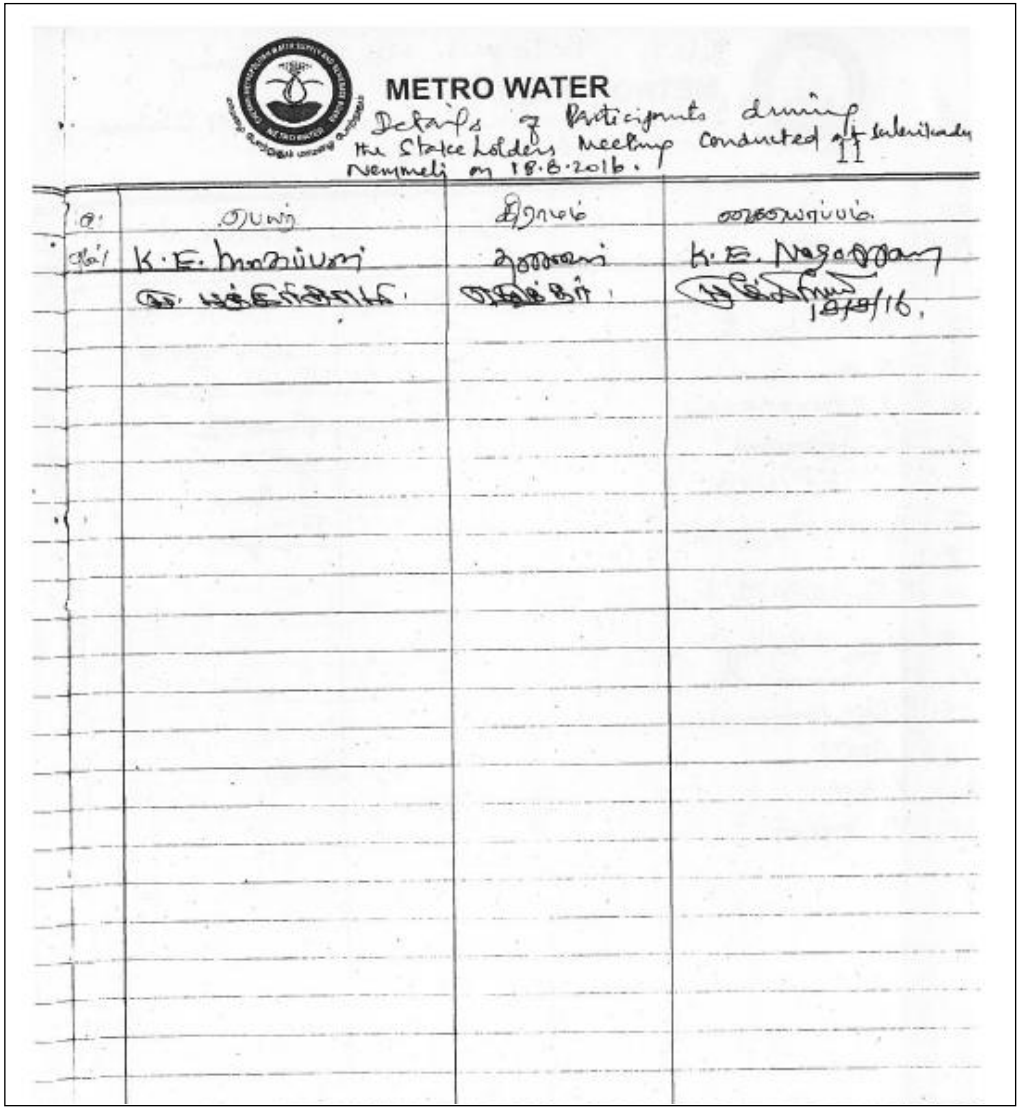
The meeting ended with vote of thanks given by SE (Desal)

Sd/.....18.08.2016
SUPERINTENDING ENGINEER (DESAL)

t.c.f.h.o.

17/8/16
EE/Desal.

Appendix 7.10 Participant List (2nd Stakeholders Meeting)

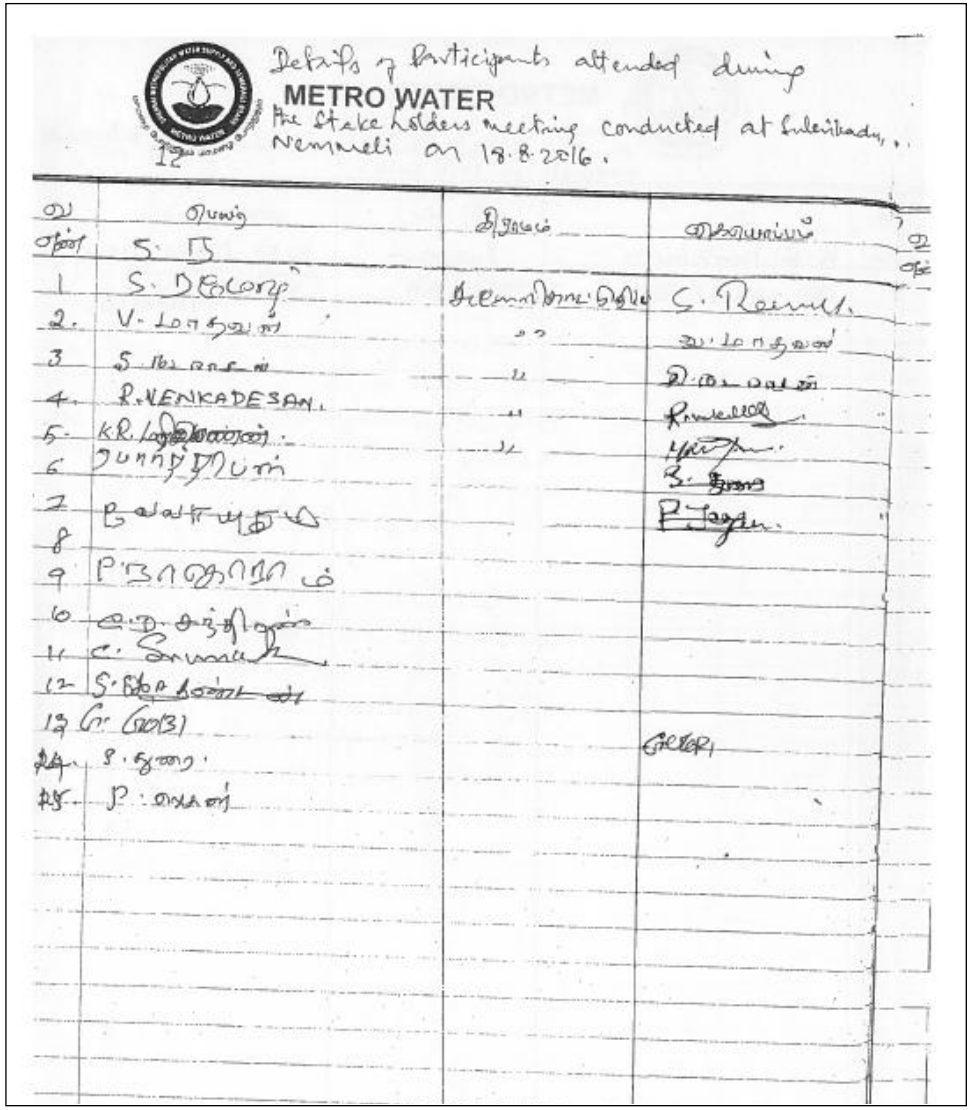


METRO WATER

Details of Participants during the Stake holders meeting conducted at Sulevikady Nemmeli on 18.8.2016.

11

	K.E.		K.E. Nagarajan



METRO WATER

Details of Participants attended during the Stake holders meeting conducted at Sulevikady, Nemmeli on 18.8.2016.

12

1	S.		S. Ramu
2.	V.		
3	S.		
4.	R. VENKADESAN.		
5.	K.R.		
6			
7			
8			
9			
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Appendix 7.11 Monitoring Form (Draft)

1. Pre-Construction Phase (Tree cutting)

The latest results of the below monitoring items shall be submitted to the lenders as part of Progress Report throughout the pre-construction phase.

1.1 Air Pollution

- Exhaust Gases

Date	Type of Construction Vehicles/Equipment	Fleet/Registration Number	Exhaust Gases Discharge Conditions				Frequency
(Day, Month, Year)			Items	Yes	No	If Yes, Measures Taken	Daily
			Black Smoke				
			White Smoke				
			Others (Specify)				

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.
If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

- Soil Dust (Dry Season only)

Date	Location	Dust and dried sandy soil stirred up by construction activities				Frequency
(Day, Month, Year)	Construction Site including access roads	Items	Yes	No	If Yes, Measures Taken (such as water supplying)	Daily
		Dusts				
		Dried Sandy Soil				
		Others (Specify)				

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.

1.2 Land Acquisition/Resettlement (Progress of the tree cutting)

Items	Implementation (as of :)			Frequency
Cutting Schedule	1. As scheduled ( )	2. Delayed (months)	3. Postponed ( )	Once/week
Total Value of Trees	1. Decided (Rs)	2. Under evaluation ( )	3. No action ( )	
Budget Allocation	1. Allocated by ( )	2. Under discussion ( )	3. No action ( )	
Compensation to Land owner	1. Compensated ( )	2. Under preparation ( )	3. No action ( )	
Auction for tree cutting	1. Conducted (when)	2. Under preparation ( )	3. No action ( )	
Waste Management	1. Properly Managed ( )	2. Under preparation ( )	3. No action ( )	

Progress of the preparation and implementation shall be submitted to CMWSSB monthly

2. Construction Phase Monitoring Form

The latest results of the below monitoring items shall be submitted to the lenders as part of the Quarterly Progress Report throughout the construction phase.

2.1 Air Pollution

- Exhaust Gases

Date	Type of Construction Vehicles/Equipment	Fleet/Registration Number	Exhaust Gases Discharge Conditions				Frequency
(Day, Month, Year)			Items	Yes	No	If Yes, Measures Taken	Daily
			Black Smoke				
			White Smoke				
			Others (Specify)				

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.
If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

- Soil Dust (Dry Season only)

Date	Location	Dust and dried sandy soil stirred up by construction activities				Frequency
(Day, Month, Year)	Construction Site including access roads	Items	Yes	No	If Yes, Measures Taken (such as water supplying)	Daily
		Dusts				
		Dried Sandy Soil				
		Others (Specify)				

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.

2.2 Water Quality

- On-site toilets

Date	On-site Toilet Number/location	Sewerage water Conditions				Frequency
(Day, Month, Year)		Items	Yes	No	If Yes, Measures Taken	Daily
		Black (sewage)water leakage				
		Bad odor				
		Emergency of Flies				
		Others (Specify)				

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.

- Turbidity (Seawater Turbidity during installation of intake/outfall pipelines)

Date	Location of installation of Intake/outfall (GPS position)	Turbid water Conditions				Frequency
(Day, Month, Year)	Intake ( ) Outfall ( ) GPS Position	Items	Yes	No	If Yes, Measures Taken	Daily
		Silts				
		Sea sands				
		Bottom sediments				
		Others (Specify)				

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.

2.3 Soil Contamination

- Oil and Fuel leakage (spill)

Date	Type of Construction Vehicles/Equipment	Fleet/Registration Number	Oil/Fuel Leakage Conditions				Frequency
(Day, Month, Year)			Items	Yes	No	If Yes, Measures Taken	Daily
			Engine oil				
			Hydric power unit oil				
			Fuel				
			Others (Specify)				

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.
If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

2.4 Wastes

- Construction wastes and debris

Waste Composition	Waste Quantity (ton/month)	Transportation, Disposal/Treatment Methods (Specify: ex. Registered Service Provider, Officially final disposal site, registered treatment facility (or company)	Frequency

		Transport	Disposal	Treatment	Remarks	
Construction Debris						Once/Month
Surplus Soil						
Toxic and chemical Waste						
Other (specify)						

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.

2.5 Noise and Vibration

- Noise from Construction Vehicles and Equipment

Visual Inspection Date	Type of Construction Vehicles/Equipment	Fleet/Registration Number	Condition of Silencer equipped with construction vehicles/Equipment				Frequency
(Day, Month, Year)			Items	Yes	No	If Yes, Measures Taken (such as water sprinkling)	Daily
			Properly Equipped				
			Damaged				
			Large noise discharge				
			Others (Specify)				

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.
If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

2.6 Ecosystem

- Turbidity

(same format specified in 1.2 Water Quality)

- Environmental Education on Marin ecosystems and Sea Turtles

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community ( )		Twice/year
				Worker/Labor ( )		
				Others (Specify)		
				Total ( )		

Participant list and educational materials shall be attached

- Sea Turtles Sightings

Item	Sighting Report					Frequency
Sea turtles	Time/Date	Place (In or around Perur DSP construction site)	Sighted by whom (ex, Villager, Worker/labor, rumor and others	Description of the Sighting	Actions taken to the sightings	In the event of Sighting*
					See the Actions on Sea Turtle Sightings (specified below)	

*During egg laying season of sea turtles, hearing survey on the sighting shall be done in the surrounding communities twice of the season

- Actions on Sea Turtle Sightings

Item	Sighting Report			Frequency
Actions on Sea turtle sighting	Construction Suspension Periods	Records of the announcements	relevant entities contacted)	In the event of Sighting

2.7 Living and Livelihood

- Seawater Turbidity during installation of intake/outfall pipelines

(same format specified in 1.2 Water Quality)

- Pipelines installation schedules and Installation (Construction) Management

Date	Location	Management				Compensation budget and status (Specify)	Frequency
		Type Space used (1. Paddy Field, 2. Farmland, 3. Others ( ))	Area (m^2)	Duration of use	Condition of the Space		Daily during the installation
(Day, Month, Year)							

2.8 Social Infrastructure and Services

- Road Traffic

Date	Location	Construction Vehicle Management				Frequency
		Traffic Control (Specify the details)				Daily
		Time Restriction	Avoidance of Rush	Avoidance of Rush	Others (Specify)	

			Hour	Hour		
(Day, Month, Year)						

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.

- Commercial Activities (for the transmission pipelines installations)

Date	Location	Management				Frequency
		Traffic Control (Specify the details)				Daily during the installation
		Diversion Route	Time Restriction	No Control	Others (Specify)	
(Day, Month, Year)						

- Meetings with surrounding Communities (for the transmission pipelines installations)

Date	Location /Community	Meeting Venue	Number of Participants	Agenda	Opinions Requests	Countermeasures	Frequency
(Day, Month, Year)			Community ( )				Where necessary
			Officals ( )				
			Others (Specify)				
			Total ( )				

Participant list and meeting minutes shall be attached

2.9 Risks of Infectious diseases such as HIV/AIDS

- Health and Sanitation Education

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community ( )		Once/year
				Worker/Labor ( )		
				Others (Specify)		
				Total ( )		

Participant list and educational materials shall be attached

2.10 Working Conditions/Work safety for the construction

- Personnel Protective Equipment (PPE)

Date	Monitoring Item	If any problems, measures taken	Frequency
(Day, Month, Year)	PPE: such as Helmet, Gloves, Masks, shoes) -		Daily

Log Book: to be prepared and recorded by contractor(s) which is submitted to CMWSSB monthly.

2.11 Accidents

- Meetings with surrounding Communities (for the transmission pipelines installations) for Traffic Safety
(same format specified in 2.9 Health and Sanitation Education)

3. Operation Phase Monitoring Form

The latest results of the below monitoring items shall be submitted to the lenders on biannual basis for the first two years of operation.

3.1 Water Quality

- Raw Seawater and Potable Water (as specified in Table 6.3.5 of the JICA study report)

No.	Seawater	Raw seawater	Potable water	Frequency
1	Silt Density Index	✓		Daily
2	pH	✓	✓	Daily
3	Total Dissolved Solids	✓	✓	Daily
4	Temperature	✓	✓	Daily
5	Electrical conductivity	✓	✓	Daily
6	Turbidity	✓	✓	Daily
7	Residual chlorine	✓	✓	Daily
8	Boron content	✓	✓	Daily
9	Langelier index	-	✓	Daily
10	Oxidation–reduction potential	-	-	Daily
11	Alkalinity	-	✓	Daily

Operational Monitoring Report on the Raw Seawater and Potable Water monitored at DSP can be attached

- Brain Concentration

Date	Sampling Location	Brain Concentration (ppt)	Remarks	Frequency
				Daily

- Domestic Water (Sewerage Treatment Plant in DSP)

Monitoring Item	Method	If any negative results, measures Taken (Ex: Stop STP operation, Stop DSP operation, respire work, pesticide inputs and others)	Frequency
Bad Odor	Visual Inspection (Common sensation)		Once/month
Water Leakage	Visual Inspection		
generation of flies	Visual Inspection		
Other necessary actions to be monitored as per the instruction and manuals on the operation and maintenance of aerated waste water treatment facilities (STP) is to be installed.			Once/month (or instructions of the contractor of STP)

3.2 Ecosystem

- Environmental Education on Marin ecosystems and Sea Turtles

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community ( )		Once/year
				Worker/Labor ( )		
				Others (Specify)		
				Total ( )		

Participant list and educational materials shall be attached

- Sea Turtle

	Sighting Report					Frequency
Sea turtle	Time/Date	Place (In or around Perur DSP)	Sighted by whom (ex, Villager, Worker/labor, rumor and others	Description of the Sighting	Actions taken to the sightings (Ex: report to relevant authorities or NGOs, warning to workers/labours, suspend of the construction and Others),	In the event of Sighting

- Sea Turtles Sightings

Item	Sighting Report					Frequency
Sea turtles	Time/Date	Place (In or around Perur DSP site)	Sighted by whom (ex, Villager, Worker/labor, rumor and others	Description of the Sighting	Actions taken to the sightings	In the event of Sighting*
					See the Actions on Sea Turtle Sightings (specified below)	

*During egg laying season of sea turtles, hearing survey on the sighting shall be done in the surrounding communities twice of the season

- Actions on Sea Turtle Sightings

Item	Sighting Report			Frequency
Actions on Sea turtle sighting	Construction Suspension Periods	Records of the announcements	relevant entities contacted)	In the event of Sighting

4. EIA Monitoring format for EIA and CZMAs Recommendations (Draft as reference)

4.1 Construction Phase

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
Water Quality	Changes in the selected physiochemical parameters	Salinity, temperature, DO, current etc.	Periodically	Kancheepuram District CZMA*	
General Environment	Site conditions	Any adverse impacts on the coast	Every Year	Tamil Nadu State CZMA*	

*: MOEF may request any environmental monitoring activities as supplementary conditions in the issuance of CZR clearance for the Perur DSP by referring the EIA report and those recommendations from the CZMAs.

4.2 Operation Phase

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
Water Quality	Seawater & Sediment Quality	Nutrients and heavy metals	Each season: April (Fair Weather), July (SW monsoon) and November (NE monsoon)	EIA Report	
Ecosystem	Marine Benthic Fauna	Benthic fauna composition	Each season as indicated above	EIA Report	
Ecosystem	Intake entrapment of marine fauna	Screens on pump stations and effectiveness of management measure	Each season as indicated above	EIA Report	
Ecosystem	Entrainment of marine fauna	Abundance of fauna within the pond/storage sump/well	Each season as indicated above	EIA Report	
Ecosystem	Seawater outfall	Abundance and distribution of both phytoplankton and zooplankton	Each season as indicated above	EIA Report	
Ecosystem		Abundance and distribution of benthic animal communities	Each season as indicated above	EIA Report	
Water Quality/ Ecosystem	Post-project marine quality	Marine quality including water quality and biological characteristics.	Continuous	Kancheepuram District CZMA*	
Ecosystem	Marine biodiversity	Not specified	Twice in a year	Kancheepuram District CZMA*	
Water Quality	Reject water	Concentration of toxic trace metals	Periodical	Kancheepuram District CZMA*	
Water Quality	Changes in the selected physiochemical parameters	Salinity, temperature, DO, current etc.	Periodical during the construction and operation phases	Kancheepuram District CZMA*	
Water Quality	The high salinity reject water (may be monitored through appropriate standard procedures)	Physiochemical and toxic trace metal contents	Periodical (May be)	Kancheepuram District CZMA*	
Water Quality	Marine water	Parameter is not specified/ to be monitored at the outfall area	Every Quarter	Tamil Nadu State CZMA*	
General Environment	Site conditions	Any adverse impacts on the coast	Every Year	Tamil Nadu State CZMA*	
Ecosystem	Impact on the corals*, marine organisms, Turtle nesting etc.	Corals**, marine organisms, Turtle nesting etc.	Not specified (to be monitored by experts)	Tamil Nadu State CZMA*	

*: MOEF may request any environmental monitoring activities as supplementary conditions in the issuance of CZR clearance for the Perur DSP by referring the EIA report and those recommendations from the CZMAs.
**: Corals have not been observed around Perur seashore and offshore (See Appendix 7.1 of JICA Report)

Appendix 7.12 Proposed and Recommended Environmental Monitoring Plans

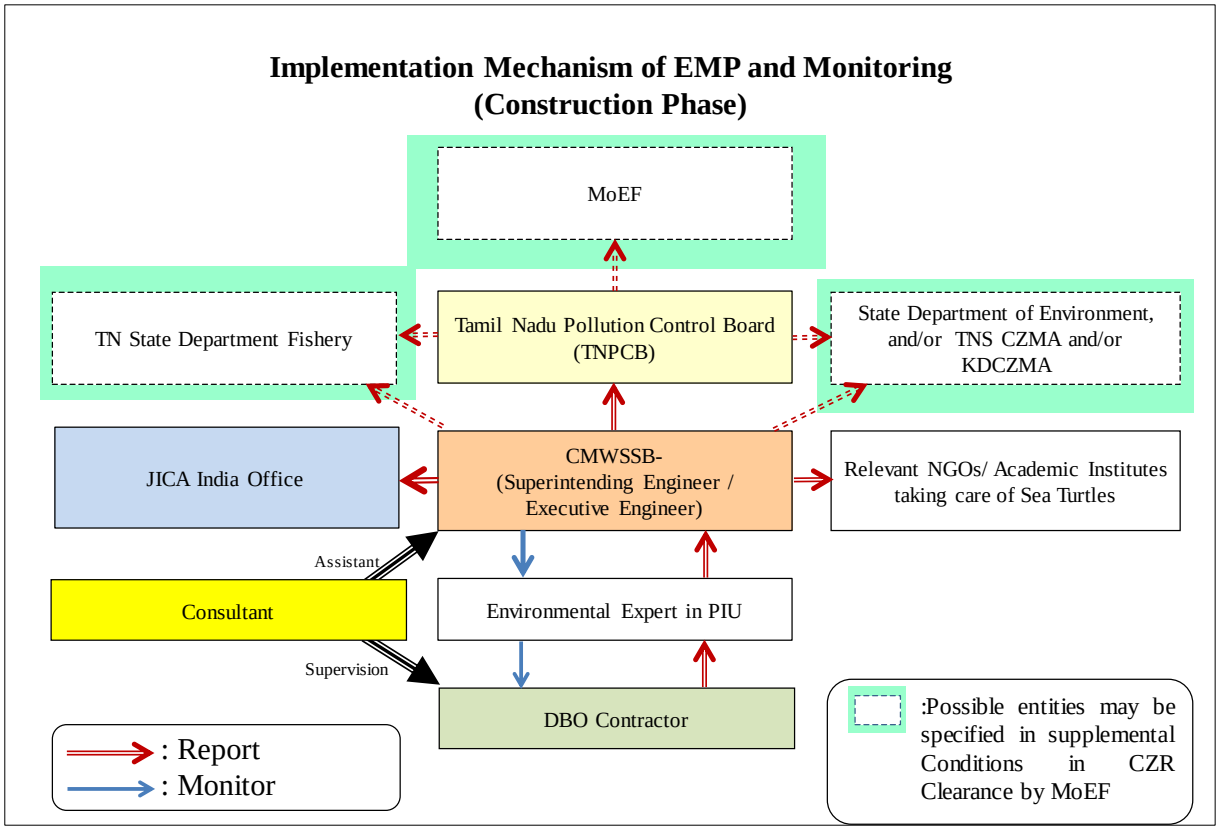
Items	Monitoring Items	Parameters	Locations	Period and Frequency	Responsible Organization	Cost	Remarks	Proposed or Recommended by
Pre- Construction Phase (For Tree Cutting in the Perur DSP project site)								
Air Pollution	Exhaust Gases	Discharge conditions of exhaust gases (Black/white gases) of dump trucks, other trucks and heavy equipment	Motor Pools of Construction Site	Daily	Contractors	Included in Tree Cutting Cost	Visual Inspection	JICA Study
Air Pollution	Soil Dusts	Soil dusts diffusions by construction works	Construction Site	Daily (Dry Season only)	Contractors	Included in Tree Cutting Cost	Visual Inspection	JICA Study
Land Acquisition/ Resettlement	Plan for the tree cutting in the site	Cutting Schedules, Total value of the trees, Budget allocations, compensation to the landowner, auction of tree cutting for pulps, waste management.	Construction site and others	Once/week	Contractors/ CMWSSB	Included in Tree Cutting Cost	Preparation of Tree Cutting Action Plan	JICA Study
Construction Phase								
Water Quality	Changes in the selected physiochemical parameters	Salinity, temperature, DO, current etc.	Vicinity of the effluent discharge	Periodically	(CMWSSB)*	(Prepared by CMWSSB) *	A moored data buoy shall be maintained	Kancheepuram District CZMA*
General Environment	Site conditions	Any adverse impacts on the coast	Construction Site and the Coast	Every Year	(CMWSSB)*	(Prepared by CMWSSB) *	A system shall be evolved for a close and continuous monitoring during the construction phase through reputed institutions such as NCSCM, Anna University, Chennai/NIOT, Chennai /IIT. To take mitigation measures on the event of any adverse impacts on the coast.	Tamil Nadu State CZMA*
Air Pollution	Exhaust Gases	Discharge conditions of exhaust gases (Black/white gases) of dump trucks, other trucks and heavy equipment	Construction Site	Daily	Contractors	Included in the project Coast	Visual Inspection	JICA Study
Air Pollution	Soil Dusts	Soil dusts diffusions by construction works	Construction Site	Daily (Dry Season only)	Contractors	Included in the project Coast	Visual Inspection	JICA Study
Water Quality	On-site toilets	Back (sewage) water leakage (overflow), bad odour, emergence of vector flies and de-sludge activities)	Construction Site	Once/month	Contractors	Included in the project Coast	Visual Inspection	JICA Study
Water Quality	Turbidity	Turbid seawater	Seawater around Intake/Outfall Pipelines installation	Daily	Contractors	Included in the project Coast	Visual Inspection	JICA Study
Soil Contamination	Oil and Fuel leakage	Oil and Fuel leakage conditions (from Engine, hydraulic power units and fuel tanks) of dump trucks, other trucks and heavy equipment	Construction Site	Daily	Contractors	Included in the project Coast	Visual Inspection	JICA Study
Wastes	Construction Wastes	Waste composition, quantity, transportation and treatment methods	Construction Site	Once/month	Contractors	Included in the project Coast	-	JICA Study
Noise and Vibration	Vehicle and Equipment Noise	Silencer conditions of dump trucks, other trucks and heavy equipment	Construction Site	Daily	Contractors	Included in the project Coast	Visual inspection (common sensation)	JICA Study
Ecosystem	Turbidity	Turbid seawater (during installation of intake/outfall pipelines)	Seawater around Intake/Outfall Pipelines installation	Daily	Contractors	Included in the project Coast	Visual Inspection	JICA Study
Ecosystem	Marine ecosystem and sea turtles.	Implementation environmental education on marine ecosystem and sea turtles.	Construction site and surrounding communities	Twice/ year	Contractors /CMWSSB	Included in the project Coast	-	JICA Study

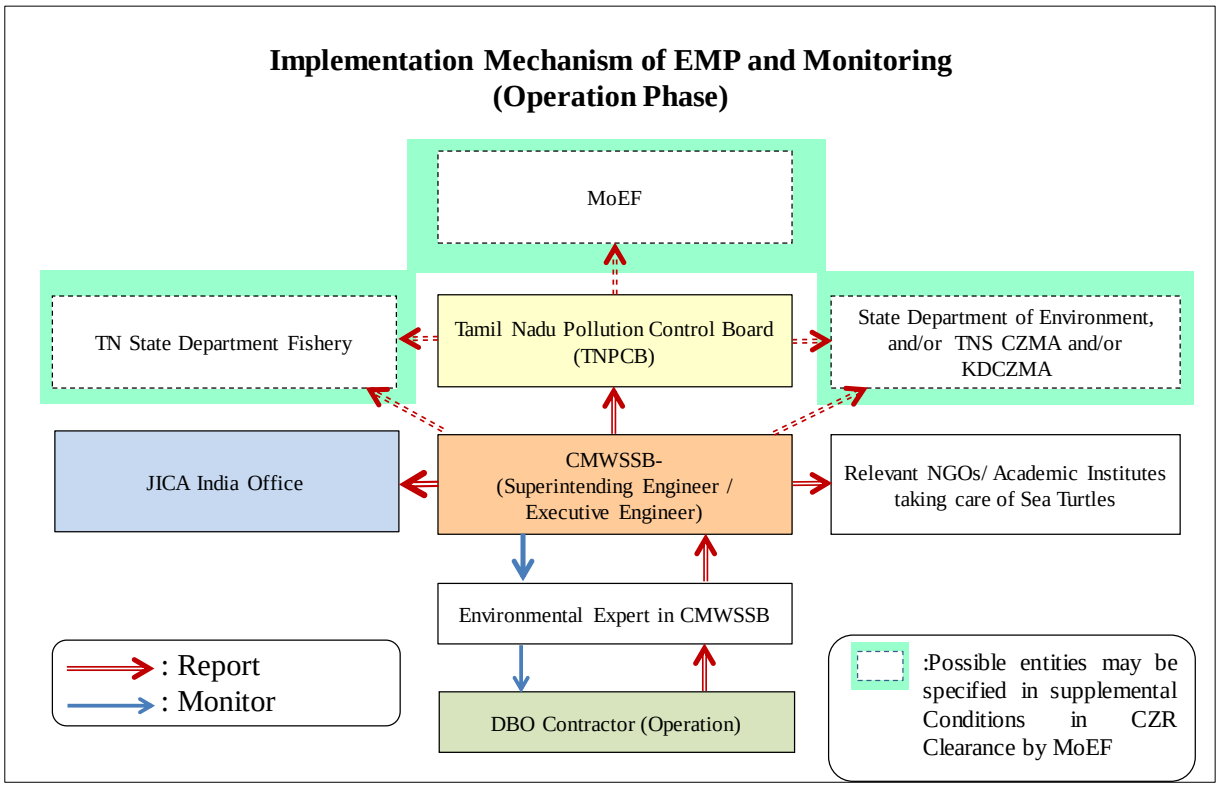
Items	Monitoring Items	Parameters	Locations	Period and Frequency	Responsible Organization	Cost	Remarks	Proposed or Recommended by
Ecosystem	Sea turtles	Information on Sea turtle sightings in and around the seashore in Perur	Construction site	In the event of Sightings	Contractors /CMWSSB	Included in the project Coast	-	JICA Study
Ecosystem	Actions on sea turtle sighting	Construction suspensions periods, records of the announcements and relevant entities contacted	Construction site and surrounding communities	In the event of Sightings	CMWSSB	Included in the project Coast	-	JICA Study
Living and Livelihood	Turbidity	Turbid seawater (during installation of intake/outfall pipelines)	Seawater around Intake/Outfall Pipelines installation	Daily for the installation period	Contractors	Included in the project Coast	Visual Inspection	JICA Study
Living and Livelihood	Construction Management	Pipelines installation schedules and Installation (Construction) Management	Seawater around Intake/Outfall Pipelines installation	Daily for the installation period	Contractors	Included in the project Coast	-	JICA Study
Social Infrastructure and Services	Road Traffic	Implementation of construction vehicle management plans (time restrictions to avoid rush hours and days of surrounding roads	Construction site	Daily	Contractors	Included in the project Coast	-	JICA Study
Social Infrastructure and Services	Commercial Activities	Implementation of commercial area road traffic controls (diversion routes, time restriction) for the instauration of transmission pipelines	Construction site	Daily	Contractors	Included in the project Coast	-	JICA Study
Social Infrastructure and Services	Meetings	Implementation of meetings with communities	Construction site and surrounding communities	Where necessary	CMWSSB/ Contractors	Included in the project Coast	-	JICA Study
Risk of infectious diseases such as HIV/AIDS	Health and Sanitation	Implementation of Health and Sanitation education on STD.	Construction site and surrounding communities	Once/ year	CMWSSB/ Contractors	Included in the project Coast	-	JICA Study
Working Conditions/ Work Safety	Personal Protective Equipment (PPE)	Utilization of PPE by workers/labors	Construction site	Daily	Contractors	Included in the project Coast	-	JICA Study
Accidents	Traffic Safety	Implementation of Traffic safety education	Construction site and surrounding communities	Once/ year	CMWSSB/ Contractors	Included in the project Coast	-	JICA Study
Operation Phase								
Water Quality	Seawater & Sediment Quality	Nutrients and heavy metals	Near Seawater	Each season: April (Fair Weather), July (SW monsoon) and November (NE monsoon)	(CMWSSB)*	(Prepared by CMWSSB) *	Sediment samples collected from sides at risk of pollution	EIA Report
Ecosystem	Marine Benthic Fauna	Benthic fauna composition	Water outfall region	Each season as indicated above	(CMWSSB)*	(Prepared by CMWSSB) *	-	EIA Report
Ecosystem	Intake entrapment of marine fauna	Screens on pump stations and effectiveness of management measure	DSP	Each season as indicated above	(CMWSSB)*	(Prepared by CMWSSB) *	-	EIA Report
Ecosystem	Entrainment of marine fauna	Abundance of fauna within the pond/storage sump/well	DSP	Each season as indicated above	(CMWSSB)*	(Prepared by CMWSSB) *	-	EIA Report
Ecosystem	Seawater outfall	Abundance and distribution of both phytoplankton and zooplankton	Near the outfall	Each season as indicated above	(CMWSSB)*	(Prepared by CMWSSB) *	-	EIA Report
Ecosystem		Abundance and distribution of benthic animal communities	near the outfall	Each season as indicated above	(CMWSSB)*	(Prepared by CMWSSB) *	-	EIA Report

Items	Monitoring Items	Parameters	Locations	Period and Frequency	Responsible Organization	Cost	Remarks	Proposed or Recommended by
Water Quality/ Ecosystem	Post-project marine quality	Marine quality including water quality and biological characteristics.	Not specified	Continuous	(CMWSSB)*	(Prepared by CMWSSB) *	-	Kancheepuram District CZMA*
Ecosystem	Marine biodiversity	Not specified	Not specified	Twice in a year	(CMWSSB)*	(Prepared by CMWSSB) *	-	Kancheepuram District CZMA*
Water Quality	Reject water	Concentration of toxic trace metals	Not specified	Periodical	(CMWSSB)*	(Prepared by CMWSSB) *	-	Kancheepuram District CZMA*
Water Quality	Changes in the selected physiochemical parameters	Salinity, temperature, DO, current etc.	Vicinity of the effluent discharge	Periodical during the construction and operation phases	(CMWSSB)*	(Prepared by CMWSSB) *	A moored data buoy shall be maintained	Kancheepuram District CZMA*
Water Quality	The high salinity reject water (may be monitored through appropriate standard procedures)	Physiochemical and toxic trace metal contents	Not specified	Periodical (May be)	(CMWSSB)*	(Prepared by CMWSSB) *	-	Kancheepuram District CZMA*
Water Quality	Marine water	Parameter is not specified/ to be monitored at the outfall area		Every Quarter	(CMWSSB)*	(Prepared by CMWSSB) *	-	Tamil Nadu State CZMA*
General Environment	Site conditions	Any adverse impacts on the coast	Construction Site and the Coast	Every Year	(CMWSSB)*	(Prepared by CMWSSB) *	A system shall be evolved for a close and continuous monitoring during the operation phase through reputed institutions such as NCSCM, Anna University, Chennai/NIOT, Chennai /IIT. To take mitigation measures on the event of any adverse impacts on the coast.	Tamil Nadu State CZMA*
Ecosystem	Impact on the corals*, marine organisms, Turtle nesting etc.	Corals**, marine organisms, Turtle nesting etc.		Not specified (to be monitored by experts)	(CMWSSB)*	(Prepared by CMWSSB) *	-	Tamil Nadu State CZMA*
Water Quality	Water Quality	Raw seawater and Potable water as specified in Table 6.3.5 of the JICA Study Report	DSP	Daily	DSP Operator	Included in Operation Cost	-	JICA Study
Water Quality	Water Quality	Brine Concentration	The nearest Beach	Daily	DSP Operator	Included in Operation Cost	-	JICA Study
Water Quality	Domestic water	Back (sewage) water leakage (overflow), bad odour, emergence of vector flies of Sewerage Treatment Plant (STP)	DSP	Once/month	DSP Operator	Included in Operation Cost	Visual inspection	JICA Study
		STP effluent water quality in accordance with instructions as suggested by the STP construction contractor.	DSP	Once/month	DSP Operator	Included in Operation Cost	Operational Inspection	JICA Study
Ecosystem	Marine ecosystem and sea turtles	Implementation environmental education on marine ecosystem and sea turtles.	DSP surrounding communities	Once/ year	DSP Operator /CMWSSB	Included in Operation Cost	-	JICA Study
Ecosystem	Sea turtles	Information on Sea turtle sightings in and around the seashore in Perur	DSP and surrounding communities	In the event of Sightings	DSP Operator /CMWSSB	Included in Operation Cost	-	JICA Study
Ecosystem	Sea turtles	Actions (Records of the announcements and relevant entities contacted) taken	DSP and surrounding communities	In the event of Sightings	CMWSSB	Included in Operation Cost	-	JICA Study

*: MOEF may request any environmental monitoring activities as supplementary conditions in the issuance of CZR clearance for the Perur DSP by referring the EIA report and those recommendations from the CZMAs.
**: Corals have not been observed around Perur seashore and offshore (See Appendix 7.1 of JICA Report)

Appendix 7.13 Implementation Mechanism of EMP and Monitoring (Draft)





Appendix 7.14 Environmental Checklist

<table>
<tr><th>Category</th><th>Environmental Item</th><th>Main Check Items</th><th>Yes: Y
No: N</th><th>Confirmation of Environmental Considerations
(Reasons, Mitigation Measures)</th></tr>
<tr><td rowspan="2">1 Permits and Explanation</td><td rowspan="2">(1) EIA and Environmental Permits</td><td rowspan="2">(a) Have EIA reports been already prepared in official process?

(b) Have EIA reports been approved by authorities of the host country's government?

(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?

(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?</td><td rowspan="2">(a) Y
(b) N
(c) N
(d) Y</td><td>(a) <u><Sea Water Desalination Plant (DSP)></u>
An EIA report for the Sea Water Desalination Plant (DSP) was prepared by CMWSSB on Jul. 2014 which was submitted to the Kancheepuram District Coastal Zone Management Authority (KDCZMA) (on Mar. 2015) and the Tamil Nadu State Coastal Zone Management Authority (TNSCZMA) (on Sept. 2015) because that the project is proposed to be constructed in the Coastal Regulation Zone (CRZ) of the Ministry of Environment, Forest and Climate Change (MoEF).

Namely the Project located in CRZ III is required to obtain a CRZ Clearance of CZM system from MoEF based on CRZ Notification 2011.

<u><Transmission Pipelines></u>
The transmission pipelines are included in the Check list of application for CRZ clearance prepared and submitted by CMWSSB.

Based on the provisions stipulated in the notifications, environmental clearances required for the Project composed of DSP and Transmission Pipelines (TPs) are summarized in the following table. Thus, only CRZ clearance is required for the Project.
<table>
<tr><th>Clearance</th><th>DSP located in CRZ</th><th>DSP located out of CRZ</th><th>TPs installed in CRZ</th><th>TPs installed out of CRZ</th></tr>
<tr><td>EC</td><td>Not Required*</td><td>Not Required*</td><td>Not Required*</td><td>Not Required*</td></tr>
<tr><td>CRZ</td><td>Required</td><td>Required**</td><td>Required</td><td>Not Required</td></tr>
</table>
*: Water supply projects are not listed in the Schedule (project list requiring prior EC) in the Revised EIA Notification
**: Intake/outfall pipelines are to be constructed in CRZ as necessary facilities of DSP
Note: As for the distribution pipelines, environmental and social considerations for distribution pipelines are to be the same as the transmission pipelines.</td></tr>
<tr><td>(b) <u><Sea Water Desalination Plant (DSP)></u>
Not yet. Both KDCZMA and TNSCZMA accepted the EIA report, but a CRZ Clearance from MoEF will be obtained by March, 2017. The following actions have been taken by CMWSSB as of Nov, 2016.

- CMWSSB applied to MoEF for the CRZ Clearance on 18th Oct. 2016 through the MoEF portal site with soft copies of necessary documents for the application including the EIA report (Proposal No. IA/TN/MIS/59770/2016).

- The application was accepted by MoEF on 7th Nov. 2016 (the Acceptance Letter of F. No. 11-37 2016).

- According to CMWSSB, the Superintending Engineer visited MoEF at Delhi on 11th Nov. 2016 to submit hardcopies of the EIA report and other necessary documents, as requested in the Acceptance Letter, for the CRZ clearance for the Project.

- After the submission, a presentation on the project at MoEF is required to be made by CMWSSB for the issuance. (As of Nov 2016, CMWSSB is waiting for an official communication on the presentation from MoEF.)

<u><Transmission Pipelines></u>
Not applicable</td></tr>
</table>

<table>
<tr><th>Category</th><th>Environmental Item</th><th>Main Check Items</th><th>Yes: Y
No: N</th><th>Confirmation of Environmental Considerations
(Reasons, Mitigation Measures)</th></tr>
<tr><td rowspan="3"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td>(c) <u><Sea Water Desalination Plant (DSP)></u>
KDCZMA made a total of 14 recommendations (supplemental conditions) to the TNSCZMA on Apr. 2015.
And then TNSCZMA made a total of 13 recommendations to MoEF on Jan. 2016 for the CRZ Clearance.
There is possibility that MoEF requests any supplementary conditions in the issuance of the CZR clearance for the Perur DSP by referring the EIA report and those recommendations from the CZMAs.
<u><Transmission Pipelines></u>
Not applicable</td></tr>
<tr><td>(d) <u><Sea Water Desalination Plant (DSP)></u>
After getting the CRZ Clearance from MoEF, a No Objection Certificate (NOC) is to be obtained from Tamil Nadu State Pollution Control Board (TNPCB).
<u><Transmission Pipelines></u>
Not applicable</td></tr>
<tr><td>(2) Explanation to the Local Stakeholders</td><td>(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders?
(b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?</td><td>(a) Y
(b)-Y</td><td>(a) <u><Sea Water Desalination Plant (DSP)></u>
According to CRZ notification (2011), public hearing/consultation is not required in the process.
However, the 1st Stakeholders Meeting was held on 8th July 2016by CMWSSB as follows.
<table>
<tr><td colspan="3">Date: 8th July, 2016</td><td colspan="2">Time: 11:45-12:30</td><td colspan="2">Venue: Community hall, Perur</td></tr>
<tr><td>Participants</td><td>CMWSSB</td><td>Land Owner</td><td>Local Official</td><td>JICA Study Team</td><td>Local People</td><td>Total</td></tr>
<tr><td>Number</td><td>4</td><td>1</td><td>3</td><td>1</td><td>29</td><td>38</td></tr>
</table>
<table>
<tr><th rowspan="4">Main Discussion Points</th><th>Opinions from the Village people</th><th>Countermeasures by CMWSSB</th></tr>
<tr><td>Shore erosion caused damage to their houses during execution of the 100 MLD desalination plant in Nemmeli. Hence they requested to provide dykes for a length of 300m approx. for protection before commencement of construction work for the new project.</td><td>Superintending Engineer (SE) accepted their demand and will be consulting with the implementation team of the project to provide necessary protection.</td></tr>
<tr><td>Boats and fishing nets are likely to get damaged during dredging for laying of intake pipeline.</td><td>It will be taken into consideration during execution of the project.</td></tr>
<tr><td>Public insisted to allocate full stretch of land along East/West encompassing the burial ground which would also allow other commuters to enter burial ground from western end.
And also requested to restore the damaged concrete platform of the temple due to soil erosion by waves during the construction of the 100MLD desalination plant in Nemmeli.</td><td>SE informed that land belongs to Alavandar Trust and has been allotted for this project on “Long term lease basis” by the Government.
Hence, this is to be decided in consultation with the Alavandar Trust, GoTN and local Revenue department officials.</td></tr>
</table></td></tr>
</table>

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				In addition, the 2nd Stakeholders Meeting was held on 18th August 2016 by CMWSSB as follows

Date: 18th August, 2016			Time: 11:00-12:00		Venue: Meeting Room of Nemmeli DSP	
Participants	CMWSSB	Land Owner	Local Official	JICA Study Team	Local People	Total
Number	2	1	1	1	15	20

Main Discussion Points	Opinions from the Village people	Countermeasures by CMWSSB
	Due to the implementation of two new desalination plants, their livelihood may get affected and requested to provide permanent employment opportunities per person per family.	SE (Desal) assured that suitable action will be taken to place this issue before the Government through CMWSSB.
	A relief amount of Rs.300 / day totaling to Rs.9000/ month has to be given to all the members of the Fisherman Cooperative Society of Soolerikattu Kuppam. Further, the villagers had also requested that the Education Fee (school as well as college levels) for the students belonging to their community has to be borne by the Govt.	SE (Desal) assured that suitable action will be taken to place this issue before the Government through CMWSS Board.
	Protection given for the shore erosion which caused damage to their houses during execution of existing 100 MLD DSP was not of sufficient relief and requested to provide sufficient protection before commencement of construction works for the new projects.	SE (Desal) accepted their demand of providing necessary protective system to the seashore of the village which will be provided in consultation with implementation team of the project.
	There are chances of further shore erosion in their village due to the implementation of the new plants, which may result in vacating this area completely. Hence, they have requested to provide alternative arrangements for their settlement by Government at free of cost.	SE (Desal) assured that suitable action will be taken to place this issue before the Government through CMWSS Board.
	The local public requested to consider providing necessary protection in the form of dyke during pipe laying work to avoid further soil erosion at shore near their village.	SE (Desal) informed that the intake / outfall pipeline will be laid below the sea bed by conventional dredging method during non-season time which usually exists for a period of three to four months.
	It was also informed by local that there are 4 burial grounds existing in this site for an extent of 1.85 acres. Out of which 3 clustered burial grounds located on the north side are accessible from the east & west side and 1 burial ground located on the south side is accessible from south east side. It was also confirmed that there are no other burial grounds than the existing four burial grounds	EE (Desal) informed that CMWSSB would construct a compound wall around the plant leaving the existing burial grounds with suitable pathway for the burial grounds.

<Transmission Pipelines>
According to CMWSSB, necessary explanations on the installations to the surrounding communities will be held before the installation works.

(b) <Sea Water Desalination Plant (DSP)>
At the 1st meeting, countermeasures against opinions and opinions from local people were expressed by CMWSSB as summarized above.

<Transmission Pipelines>
Not applicable (According to CMWSSB, necessary explanations on the installations to the surrounding communities will be held before the installation works.)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) <u><Sea Water Desalination Plant (DSP)></u> Initially, another site in Pattipulam Village (several km South from Perur site) was selected for the DSP project. However, due to encroachment in the site insisted the ownerships of such areas, there is an appeal pending in the High Court Madras regarding the ownership of the identified land and hence the land will be spared to CMWSSB "as is here is" condition. Including this site in Pattipulam, total 4 sites were selected as alternative site. However, by evaluations of social considerations of each site, the site at Perur village has been selected. <u><Transmission Pipelines></u> The pipelines are planned to be constructed under the existing roads.
2 Pollution Control	(1) Air Quality	(a) Is there a possibility that chlorine from chlorine storage facilities and chlorine injection facilities will cause air pollution? Are any mitigating measures taken? (b) Do chlorine concentrations within the working environments comply with the country's occupational health and safety standards?	(a) N (b) Y	(a) <u><Sea Water Desalination Plant (DSP)></u> Chlorine is planned to be used as required for disinfection of the product water and for shock chlorination as follows. - Chlorine will be supplied as liquefied gas in 900 kg drums. - The unloading of chlorine drums from transport trucks will occur within the chlorine building, thereby reducing the risk of a chlorine leak occurring outside the building. - The system will be configured as a vacuum gas draw system with vacuum valves connected directly to the chlorine drums. - Those operation and maintenance on the Chlorine and Chlorination is subject to IS 4263 (Code of Safety for Choline) and IS 10553 (Chlorination equipment requirements) as safety measures. With above mentioned steps, there will be no possibility of air pollution caused by usage of chlorine. <u><Transmission Pipelines></u> Booster pump stations are not planned to be constructed, chlorine is not utilized. (b) <u><Sea Water Desalination Plant (DSP)></u> The chlorine utilize plan and the facilities have been designed in accordance with relevant regulations and standards in India as follows. - IS 4263 (the latest edition Code of Safety for Chlorine) - IS 10553 (Part 1) 1983 (Requirements of Chlorination equipment for its safe operations). <u><Transmission Pipelines></u> Not applicable

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Water Quality	(a) Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	(a) Y	(a) <u><Sea Water Desalination Plant (DSP)></u> Waste water management in operation phase is proposed in DPR as follows - Pre-Treatment Waste Water: Waste Water will be generated in the pre-treatment system (Lamella settlers – settled sludge, DAF float, Filter backwash from gravity dual media filters) all the discharges will be directed to the ocean via the outfall. - Membrane CIP Wastewater: After neutralisation, wastewater will be directed to the ocean via the outfall, for the same a neutralization tank has been provided in the design. - Domestic Sewage: Domestic sewage waste will be treated independently from all other liquid wastes. A dedicated sewage treatment package plant will be used to treat this waste to a standard suitable for re-use for irrigation or similar. For the same an STP (Stabilization Pond) is proposed within the plant premises. <u><Transmission Pipelines></u> Not applicable
	(3) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed in accordance with the country's regulations?	(a) Y	(a) <u><Sea Water Desalination Plant (DSP)></u> The following waste management has been proposed in DPR - Screenings: Screenings will be flushed from the screens into wire baskets and the wash water from the screens will be returned upstream of the screens, and the screenings will be disposed of to a municipal landfill. - Limewater Clarifier Waste: The waste from the limewater clarifier will be dewatered and trucked from the site as a solid. - Spent Membranes: Spent membranes will be disposed of to a credited inert landfill which will need to be rinsed with fresh water (or permeate) prior to disposal. In addition, as for sludge, approximately 60-70 ton/day depend on suspended solid concentration in sea water inlet during the operation is predicted in the check list for CRZ clearance application. As well, with regard to domestic waste, the following are explained in the check list for CRZ clearance application, - During operation/ construction phases, domestic waste of about 0.3 ton per month is envisaged to be generated from about 150 temporary sheds. - According to Nemmeli DSP, solid waste is suitably disposed by local solid waste service providers hired by DSP operator. In addition, according to CMWSSB, trees planted in the Perur site will be cut before starting the construction of DSP and may be utilized as pulp trees. <u><Transmission Pipelines></u> Not applicable

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as pumping stations comply with the country's standards?	(a) Y	(a) <u><Sea Water Desalination Plant (DSP)></u> Noise levels of 85 -110 dB (A) are generated from pumping station, power generation and RO pumping facilities. However, those facilities are planned to be covered and installed in specific buildings of the plant. In addition, the DSP is planned to be constructed in a broad vacant land of about 87 acres. Therefore, it is predicted that the Noise levels in outside of the buildings can be reduced to the national noise standard of 75 dB (day)/ 70 dB (night) in Industrial area (Noise Pollution (Regulation and Control) Rules 2000) in the surrounding environment. <u><Transmission Pipelines></u> Not applicable
	(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	(a) N	(a) <u><Sea Water Desalination Plant (DSP)></u> Due to Sea water desalination plant (DSP), extraction of groundwater is not planned. <u><Transmission Pipelines></u> Not Applicable
3 Natural Environment	(1) Protected Areas	(a) Is the project site or discharge area located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) <u><Sea Water Desalination Plant (DSP)></u> Such protected areas have not been identified in the surrounding area of the project site in Perur. <u><Transmission Pipelines></u> The pipelines are planned to be constructed under the existing roads.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site or discharge area encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic	(a) N (b) N (c) N (d) N	(a)(b)(c)(d) <u><Sea Water Desalination Plant (DSP)></u> In the proposed project site, such ecosystems are not identified. Intake and outfall pipelines are proposed to be designed to protect marine environment (flora and fauna) as follows - Deep Water Intake having velocity cap and screen is proposed (The intake velocity is limited to 0.15 m/s and the bar screen of 0.3 m width is installed) - Port riser type is proposed because its brine diffusion efficiency is the best among all types of Outfall Diffuser - Chlorine can be maintained less than 0.02 ppm as recommended in the EIA report (2014) as follows ・ Chlorine (Cl_2) dosing rate to intake sea water is designed to be 1 ppm maximum. ・ Residual Cl_2 concentration will be approximately 0.5ppm at the outlet of pretreatment system by consuming Cl2 in the intake and pretreatment processes. ・ Discharge Cl_2 concentration will be 0.15 ppm = (210*0.5+470*0)/680. (Pretreatment discharge water = 210 MLD, RO Brine = 470MLD, Total = 680MLD) ・ To protect the RO membrane from chlorine attack, Sodium Bisulfite (SBS) is injected for removing Cl_2 at the inlet of the RO membrane. Accordingly the brine has no chlorine as calculated in above equation. ・ Usually injected amount of SBS in the RO feed water shall be sufficient enough for safety reason. ・ So, the brine contains an excess SBS which can reduce the Cl_2 concentration in the discharge. During normal operation, he Cl_2 concentration of the discharge from DSP can be maintained less than 0.2 ppm. Sea turtles' nesting activities around Perur can be summarized as follow.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		environments, such as aquatic organisms?		- Sea Turtles of Olive Ridley have been observed around seawater body in the Tamil Nadu State. - It can be considered that offshore sea around Perur is a migratory route of the Olive Ridley. - Most observations are typically within 15 km of mainland shores in protected, relatively shallow marine waters (22 - 55 m deep) and Olive Ridleys are occasionally found in open waters. (Source: Olive ridley sea turtle, Wikipedia)[1] - In the Perur DSP project, however, the intake pipe is planned to be installed in a distance of 1,140m at the sea depth of 10m and the outfall pipe is planned to be installed in a distance of 1,760m at the sea depth of 12m. - Based on above recognitions, therefore, the surrounding area of intake and outfall pipes are considered out of the sea turtle migratory route. - Nesting and egg laying activities of Olive Ridley have mostly been observed in northern part from the Madras Crocodile Bank Trust located at approximately 3km north of the Perur DSP site, and southern part from Mahabalipuram located at approximately 10km south of the Perur DSP site. - It can be considered that such nesting and egg-laying activities on seashore around Perur have been discouraged due to impacts caused by developments and human activities (habitats, Fishery, especially lighting in the night) in the area (Source: Head Curator of Madras Crocodile Bank Trust) <Transmission Pipelines> The pipelines are basically planned to be constructed under the existing roads including the following river and lake crossings. - Buckingham Canal (not protected area: used for a Salt Lake for producing salts): the pipeline is planned to be installed along a bridge road over the canal. - Porur lake and other ponds (not protected area): the pipelines are planned to be installed under existing roads along the lake and ponds.
	(3) Hydrology	(a) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect surface water and groundwater flows?	(a) N	(a) <Sea Water Desalination Plant (DSP)> Due to Sea water desalination plant (DSP), extraction of groundwater and surface water are not planned. <Transmission Pipelines> The pipelines are planned to be constructed under the existing roads by open cut method and jacking method, which include 159 Culverts, 2 river crossing points (See above column), lake/pond (Either side of the transmission pipeline route). However, no impact at all is predicted for the operation. Impacts during installation phase are limited with short periods.
4 Social Environment 4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance	(a) N (b) N/A (c) N/A (d) N/A (e) N/A (f) N/A (g) N/A (h) N/A	(a) <Sea Water Desalination Plant (DSP)> The proposed project site for DSP including the land for substation is a basically vacant land of a religious and charitable Trust ownership which is planned to be leased for 30 years to CMWSSB. Therefore, no land acquisitions and involuntary resettlements are predicted by the DSP construction. <Transmission Pipelines> Transmission pipelines are planned to be constructed under the existing roads by open cut method and jacking method. Therefore, no land acquisitions and involuntary resettlements are predicted by the pipeline installations

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(i) N/A (j) N/A	(b) (c)(d)(e)(f)(g)(h)(i)(j) <u><Sea Water Desalination Plant (DSP)></u> Not applicable <u><Transmission Pipelines></u> Not applicable
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	(a) N (b) N	(a)<u><Sea Water Desalination Plant (DSP)></u> Due to the fact that fishery is active in the surrounding village of Nemmeli, therefore designs of sea water intake facilities and outfall facilities including brine outfall quality are considered not to provide negative impacts on the marine ecosystem and fishery activities during operation phase as follows. - Laying of submarine pipelines - Deep Water Intake having velocity cap and screen is proposed (The intake velocity is limited to 0.15 m/s and the bar screen of 0.3 m width is installed) - Port riser type is proposed because its brine diffusion efficiency is the best among all types of Outfall Diffuser Possible recruitments of surrounding people are predicted during construction and operation phases as labours and

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				workers. <Transmission Pipelines> The pipelines are basically planned to be constructed under the existing roads
				(b) <Sea Water Desalination Plant (DSP)> Due to DSP, extraction of groundwater and surface water is not planned. <Transmission Pipelines> Extraction of groundwater and surface water is not planned for the pipelines under the existing roads.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) <Sea Water Desalination Plant (DSP)> Around the proposed project site there are two archaeological sites as follows - Tiger Cave: 7km south. - Group of Monuments at Mahabalipuram (UNESCO World Heritage, Inscription in 1984): Located in about 10km south from Perur. No impact is predicted to those sites by the proposed project. On the other hand, there are two burial grounds including individual grave stones, the paths (access roads), crematories and tube wells of which total areas are 1.85 acres. Those areas of burial grounds are planned to be excluded from the proposed project. Those burial grounds including other relevant facilities are occupied in the project land which belongs to the Religious and charitable Trust (the land owner) maintained by Hind Religion & Charitable Endowment (HR&CE) department of Tamil Nadu Government. <Transmission Pipelines> The pipelines are basically planned to be constructed under the existing roads
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a)N	(a) <Sea Water Desalination Plant (DSP)> The proposed site in Perur is a vacant and flat land of about 87 acres where facing a sandy sea coast on East side in which four (4) water reservoir tanks (each 9,000m^3 capacity with about 15m height) are planned to be constructed in the project site. Intake and outfall pipelines are planned to be buried by trench method. According to CRZ Clearance application by CMWSSB, the plant has been proposed 90 m into onshore and well grown Casuarina Trees along the shore have been retained as they will act as barrier for the plant. In addition, Tamil Nadu Coastal Zone Management Authority has recommended that "the proponent shall implement the Green Belt as envisaged in EIA report". Therefore, no negative impact on the landscape is predicted in the site. <Transmission Pipelines> The pipelines are basically planned to be constructed under the existing roads. Therefore, no negative impact on the landscape is predicted by the pipelines.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a)N/A (b)N/A	(a) <Sea Water Desalination Plant (DSP)> Specific ethnic minorities and indigenous peoples to be protected have not been existed around the proposed project site. <Transmission Pipelines> The pipelines are basically planned to be constructed under the existing roads. (b) <Sea Water Desalination Plant (DSP)> Not applicable <Transmission Pipelines> Not applicable
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) (b) (c) (d) <Sea Water Desalination Plant (DSP)> and <Transmission Pipelines> Work conditions and safety can be managed in compliance with the following act and rule of the Government of India. - The Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Act, 1996 - The Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Central Rules, 1998 In addition, the Bureau of Indian Standards published "Safety colours and safety signs - Code of Practice (First Revisions) on December 2005 In DPR, occupational health and safety, as well, Safety, Health Working conditions and Environmental are proposed to be implemented.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce	(a) Y (b) Y (c) Y (d) Y	In general, the construction of the proposed DSP and the installation of the pipelines will be carried out by the relevant laws, regulations and norms in India (a) <Sea Water Desalination Plant (DSP)> and <Transmission Pipelines> **(a)-1 Air Quality** - **Exhaust Gas**: Countermeasure 【Utilization of well-maintained construction vehicles and equipment, daily visual inspection of exhaust gases of those vehicles and equipment】 - **Dust**: Countermeasure【Daily visual inspection of dust diffusions on-site and necessary water spraying (during dry season only)】 **(a)-2 Water Quality** - **Human Waste**: Countermeasure【Sanitation facilities are subject to "Act and Rule on Working Condition and Work

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?		Safety in India". Leaching pit and/or septic tank methods as temporary sanitation facilities shall be established a minimum safe distance recommended by WHO (at least 30 m from the nearest water source and 2 m from the groundwater table). Septic tank septage disposed to sewage systems is subject to the Standards for Discharge of Sewages of the Water (Prevention and control of pollution) act, 1974 India】 - **Turbid seawater** (caused by installation of Intake/outfall Pipelines): Countermeasures【Utilization of Silt screens/fences and short period construction management】 **(a)-3 Wastes** - **Surplus soil** : Countermeasure【Management by back-filling】 - **Construction waste, debris and Industrial waste** :Countermeasure【waste management by the use of relevant industrial waste collection and treatment companies】 - **Toilet sludge** : Countermeasure【Periodical de-sludge by the use of public services or service providers】 - **Waste oil** (from hydraulic systems and etc.): Countermeasure【Collection and treatment by such wastes collection companies】 **(a)-4 Soil Contamination** - **Spilled Oil and Fuel** (from Construction vehicles and Equipment): Countermeasure【Periodical inspection of such trucks and equipment. Stopping lane and load and unload position management. Spilled oil and fuel management as waste. Oil spills are subject to the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules 2008】 **(a)-5 Noise and Vibration** - **Noise**: Countermeasure【Utilization of well-maintained construction vehicles and equipment. Daily visual inspection of silencers of those vehicles and equipment】 - **Vibration**: Countermeasure【An "Earth Auger" is planned to be utilized for DSP piling of which vibration level is relatively small (50 dB* to 62 dB* at the positon of 7 m). (*Ministry of the Environment of Japan】 (b) <Sea Water Desalination Plant (DSP)> - **Marin Ecosystem (**Turbid seawater caused by installation of Intake/outfall Pipelines): Countermeasures【Utilization of Silt screens/fences, short period construction management, visual inspection during the installation, environmental education to labors/workers and communities】 - **Sea turtles:** Countermeasures【suspension of installation works during egg laying seasons of sea turtles, sighting reports, environmental education to labors/workers and communities】 <Transmission Pipelines> - No adverse impact on natural environment is expected since the pipelines are basically planned to be constructed under the existing roads. (c) <Sea Water Desalination Plant (DSP)> - **Living and Livelihood** (Fishery activity impacts caused by installation of Intake/outfall Pipelines): Countermeasure【Turbid seawater management (utilization of silt screens/fences) and visual inspection, monetary compensations for fisheries if there is any negative impacts during the installations, shorter installation schedule

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No: N</th><th>Confirmation of Environmental Considerations
(Reasons, Mitigation Measures)</th></tr>
<tr><td></td><td></td><td></td><td></td><td>management, meetings with surrounding communities】

<u><Transmission Pipelines></u>
- <u>Living and Livelihood</u> <u>(Temporary use of paddy fields and farm lands during the installations)</u>: Countermeasures【Road traffic management including diversion routes and time restrictions, compensations for the utilization to landowners even though short utilization period】

CHAPTER 7 (d) <u><Sea Water Desalination Plant (DSP)></u>

- <u>Road traffic congestions</u>: Traffic congestion of ECR by increase in the numbers of the dump trucks and other trucks (24 - 33 dump trucks/day in gross and 6 - 8 other trucks/day in gross for the 42-month construction period) is predicted for the 42-month construction phase (minor impacts): Countermeasures【Road traffic management including time restrictions to avoid rush hours and days】

<u><Transmission Pipelines></u>
- Transmission pipelines are basically planned to be installed under the existing roads by the open-cut construction methods.
- 0.4 - 0.6 dump truck/day/km and 0.2 - 0.3 heavy equipment/day/km in gross are operated for the 48-month installation work</td></tr>
<tr><td>5 Others</td><td>(2) Monitoring</td><td>(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?

(b) What are the items, methods and frequencies of the monitoring program?

(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?

(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?</td><td>(a) Y
(b) Y
(c) Y
(d) Y</td><td>(a) (b) <u><Sea Water Desalination Plant (DSP)></u>

- As per the recommendations from CZMAs, the following monitoring are to be done by CMWSSB.
<table>
<tr><th>CZMA</th><th>Monitoring Activity</th><th>Frequency</th><th>Submitted to</th></tr>
<tr><td rowspan="5">Kancheepuram District (KDCZMA)</td><td>Post-project marine quality including water quality and biological characteristics.</td><td>Continuous</td><td>Not specified</td></tr>
<tr><td>Marine biodiversity</td><td>Twice in a year</td><td>MoEF/TNPCB</td></tr>
<tr><td>Concentration of toxic trace metals in the reject water</td><td>Periodical</td><td>Not specified</td></tr>
<tr><td>A moored data buoy shall be maintained in the vicinity of the effluent discharge to continuously monitor the changes in the selected physiochemical parameters (salinity, temperature, DO, current etc.).</td><td>Periodical during the construction and operation phases</td><td>Not specified</td></tr>
<tr><td>The high salinity reject water may be periodically monitored for the physiochemical and toxic trace metal contents through appropriate standard procedures.</td><td>Periodical</td><td>Not specified</td></tr>
<tr><td rowspan="3">Tamil Nadu State (TNSCZMA)</td><td>Marine water at the outfall area</td><td>Every Quarter</td><td>TNSCZMA</td></tr>
<tr><td>Periodical report on the site conditions so as to take mitigation measures on the event of any adverse impacts on the coast</td><td>Every Year</td><td>TNSCZMA</td></tr>
<tr><td>Impact on the corals*, marine organisms, Turtle nesting etc. should be evaluated and monitored through experts (ecologists).</td><td>Not specified</td><td>Not specified</td></tr>
</table>
*: Corals have not been observed around Perur seashore and offshore
Source: JICA Study Team based on recommendations from KDCZMA and TNSCZMA

- In EIA report, post project monitoring activities are proposed as follows
<table>
<tr><th>Monitoring</th><th>Purpose</th><th>Parameter</th><th>Frequency</th></tr>
<tr><td>Seawater & Sediment Quality</td><td>To monitor impacts on</td><td>Measurements of levels of</td><td>Each season</td></tr>
</table></td></tr>
</table>

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				seawater and sediment quality / nutrients and heavy metals in water and sediment samples collected from sides at risk of pollution / April (Fair Weather), July (SW monsoon) and November (NE monsoon) Marine Benthic Fauna / To determine the composition and distribution of major groups of fauna / Benthic fauna composition in the water outfall region / Each season as indicated above Intake / To determine the incidence of entrapment and mortality of marine fauna / Screens on pump stations and effectiveness of management measure / Each season as indicated above To determine the impact of entrainment within and external ponds/storage sump/well to assess the loss of fishery / Record abundance of fauna within the pond/storage sump/well / Each season as indicated above Seawater outfall / To determine the effect of increased temp/salinity on the plankton / Monitor abundance and distribution of both phytoplankton and zooplankton near the outfall / Each season as indicated above Monitor abundance and distribution of benthic animal communities near the outfall / Each season as indicated above - MoEF may request any environmental monitoring activities as supplementary conditions in the issuance of CZR clearance for the Perur DSP. If to do so, CMWSSB shall conduct such monitoring activities requested by MoEF. <Transmission Pipelines> Not applicable
				(c) <Sea Water Desalination Plant (DSP)> and <Transmission Pipelines> - CMWSSB has the grievance redressal mechanisms and E-governance - Deployment of an environmental expert in PIU is proposed by JICA Study - An analytical laboratory is planned to be set up in the Perur DSP. Those functions above can be utilized for organizing the monitoring system in CMWSSB.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				(d) <Sea Water Desalination Plant (DSP)> - CRZ Notification stipulates the post clearance monitoring which is required to be submitted half yearly compliance reports in respect of the stipulated terms and conditions of the clearance to regulatory authorities. - In the official CRZ clearance process for the DSP in Perur, KDCZMA and TNSCZMA have made recommendations in which several monitoring activities have been included as shown above. - The EIA report has proposed that the results of monitoring shown above can be reported to the relevant authority annually or as required which could include MoEF, State Department of Environment, State Department of Fishery, and State Pollution Control Board. <Transmission Pipelines> Not applicable
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Dam and River Projects checklist should also be checked.	(a)N/A	(a) Not applicable
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) Project is planned to be constructed in Tamil Nadu State of the Indian territory. RO systems are planned to be used for the DSP which will not discharge high concentration of CO_2 and other greenhouse gases as well as ozone-depleting compounds.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which the project is located.

Appendix 9.1 Organizational Structure of CMWSSB

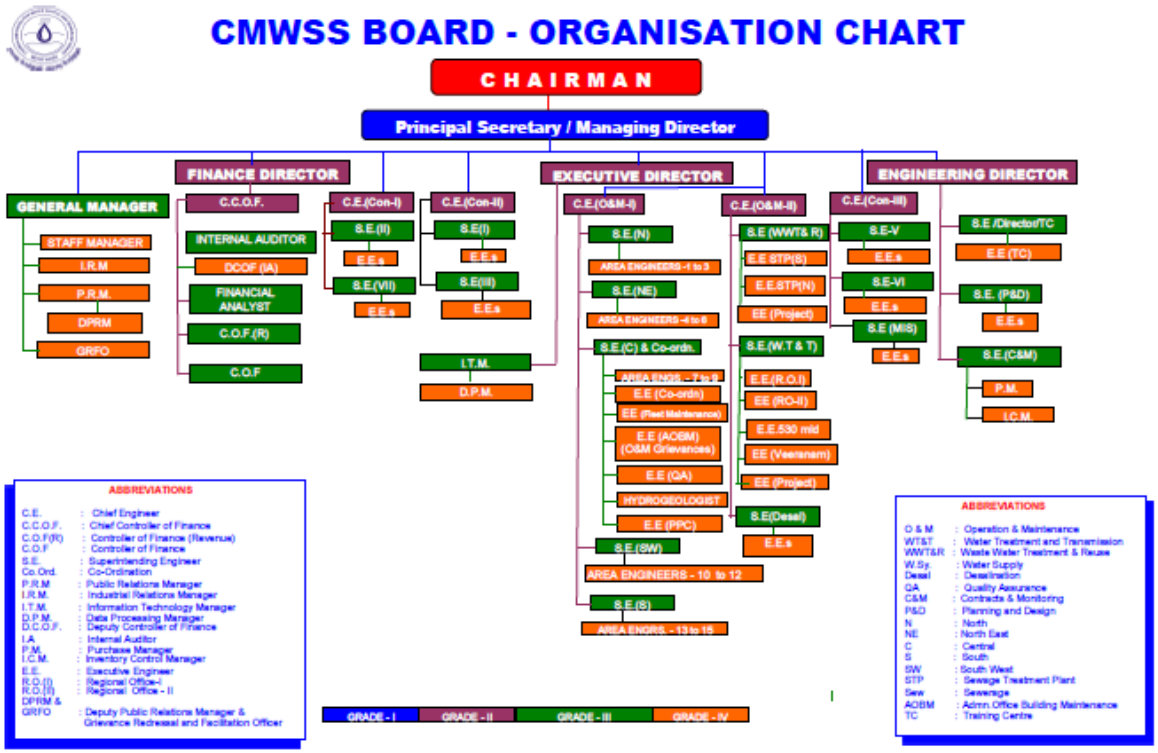


Figure A9.1.1 CMWSSB Organization Chart 2016

Organizational Structure

CMWSSB STAFF STRENGTH

CHENNAI METROPOLITAN WATER SUPPLY AND SEWERAGE BOARD STAFF STRENGTH PARTICULARS AS ON 01.02.2016

Sl. No.	Designation	Method of appointment	GROUP	Sanctioned Strength	Operating Strength	No. of Vacant Post
1	Managing Director	I.A.S.	A	1	1	0
2	Executive Director	I.A.S.	A	1	1	0
3	Finance Director	IA & AS	A	1	0	1
4	Engineering Director	Promotion	A	1	0	1
5	Chief Engineer	Promotion	A	5	2	3
6	Chief Controller of Finance	Promotion	A	1	0	1
7	General Manager	Deputation	A	1	1	0
8	Internal Auditor	Deputation	A	1	0	1
9	Superintending Engineer (1 S.E. Deputed to CMRL)	Promotion	A	17	16	1
10	Controller of Finance	Promotion	A	2	2	0
11	Financial Analyst	Direct	A	1	1	0
12	Industrial Relations Manager	Direct/ Promotion	A	1	0	1
13	Staff Manager	Deputation / Promotion	A	1	0	1
14	Public Relations Manager	Deputation	A	1	1	0
15	Deputy Controller of Finance	Deputation / Direct	A	7	2	5
16	Information Technology Manager	Promotion	A	1	1	0
17	Data Processing Manager	Direct/ Promotion	A	1	1	0
18	Executive Engineer	Promotion	A	57	48	9
19	Hydrogeologist	Promotion	A	1	0	1
20	Grievance Redressal & Facilitation Officer	Direct/ Promotion	B	1	1	0
21	Senior System Analyst	Direct/ Promotion	B	1	0	1
22	Chief Analyst	Promotion / Direct	B	1	0	1
23	Medical Officer	Deputation	B	1	1	0
24	Assistant Executive Engineer (Civil & Mech)	Promotion	B	132	77	55
	Assistant Executive Engineer (Electrical)	Promotion	B	29	27	2
25	Chief Chemist / Water Analyst	Promotion	B	7	4	3
26	Deputy Hydrogeologist	Promotion	B	2	0	2
27	Senior Accounts Officer / Senior Admv.Officer	Promotion	B	25	10	15
	Senior Accounts Officer	Direct	B	12	9	3
28	Deputy Public Relations Manager	Transfer /Promotion/ Deputation	B	1	0	1
29	System Analyst (2 Post kept in abeyance)	Direct/ Promotion/ transfer	B	3	1	2

Source: CMWSSB

Sl. No.	Designation	Method of appointment	GROUP	Sanctioned Strength	Operating Strength	No. of Vacant Post
30	Assistant Engineer (Civil/Mech)	Direct & transfer	B	262	187	75
31	Assistant Engineer (Electrical)	Direct & transfer	B	118	58	60
32	Junior Engineer (Civil/Mech)	Promotion	B	88	47	41
33	Junior Engineer (Electrical)	Promotion	B	40	53	-13
34	Assistant Hydrogeologist	Direct / transfer	B	6	2	4
35	Technical Officer	Direct & Promotion	B	1	1	0
36	Accounts / Admv.Officer	Promotion	B	37	36	1
37	Programmer	Direct/Promotion/ transfer	B	10	6	4
38	Junior Accounts / Junior Admv. Officer	Promotion	B	130	7	123
39	Assistant Water Analyst / Chemist	Direct / transfer	B	20	0	20
40	Depot Manager Grade-I	Promotion	B	22	16	6
41	Steno Typist Grade-I	Promotion	C	7	6	1
42	System Operator	Direct/ Promotion/ transfer	C	18	13	5
43	Photographer	Direct	C	1	0	1
44	Technical Assistant/ Technician	Direct	C	3	1	2
45	Steno Typist Grade-II	Promotion	C	20	20	0
46	Overseer	(Absorbed from T.Panchayat)	C	1	1	0
47	Draughtsman-cum-Surveyor	Direct / transfer	C	65	9	56
48	Electrical Operator (HT)	Direct / transfer	C	171	16	155
49	Electrical Operator (LT)	Promotion	C	46	43	3
50	Lab Technician Grade-I	Promotion	C	11	6	5
51	Lab Technician Grade-II	Direct / transfer	C	15	0	15
52	Pharmacist	Other Method	C	1	1	0
53	Assistant	Promotion	C	100	42	58
54	Librarian	Direct	C	1	0	1
55	Depot Manager Grade-II	Promotion	C	88	38	50
56	Electrician	Promotion	C	128	92	36
57	Junior Assistant (Newly Merged post) (242 + 35)	Promotion/ Direct/transfer	C	277	89	188
58	Junior Assistant *	Promotion/ Direct/transfer	C	27	27	0
59	Steno Typist Grade-III *	Direct	C	13	13	0
60	Data Entry Operator*	Direct/transfer	C	6	6	0
61	Typist & Typist Grade-I *	Direct/transfer	C	11	11	0
62	Depot Manager * NON TECH	Direct/transfer	C	35	35	0
63	Driver	Direct/transfer	C	67	19	48

Source: CMWSSB

Sl. No.	Designation	Method of appointment	GROUP	Sanctioned Strength	Operating Strength	No. of Vacant Post
64	Telephone Operator	Direct/transfer	C	4	2	2
65	Motor Cycle Messenger (manned by LMV Driver)	Direct/transfer	C	1	0	1
66	Sewer Superintendent	Promotion	C	100	0	100
67	Fitter Grade-II ^	Direct and promotion	C	2	2	0
68	Fitter	(Absorbed from T.Panchayat)	C	1	1	0
69	Mechanic Gr.II ^		C	1	1	0
70	Pump Operator I & II		C	10	2	8
71	Electrical Pumpsman		C	154	2	152
72	Chloronome Operator	tranfer	C	8	3	5
73	Filter Operator	tranfer	C	17	3	14
74	Pipeline Fitter (Gr.I &II) ^	(Absorbed from T.Panchayat)	C	3	3	0
75	Lift Operator	Direct / transfer	D	1	1	0
76	Record Assistant	Direct / Promotion	D	45	11	34
77	Office Assistant	Direct	D	102	24	78
78	Switch Board Operator	(Absorbed from T.Panchayat)	D	2	2	0
79	Wireman	(Absorbed from T.Panchayat)	D	1	1	0
80	Electrical Helper	(Absorbed from T.Panchayat)	D	2	2	0
81	Sweeper / Scavenger / Sanitary Worker	Direct	D	15	9	6
82	Watchman / Gurkha Watchman	Direct	D	50	29	21
83	Tahsildar (Regular -2 + Retired - 9)	Deputation		11	9	2
84	Field Assistant/Sub Ins. Survey	Deputation		2	0	2
	Total Staff Strength			2695	1215	1480
85	Labour Establishment (Field Worker/Sewer Worker / Maistry / Cleaner)	Direct	D	4552	1847	2705
86	Driver (HMV)		C	101	46	55
	Grand Total			**7348**	**3108**	**4240**

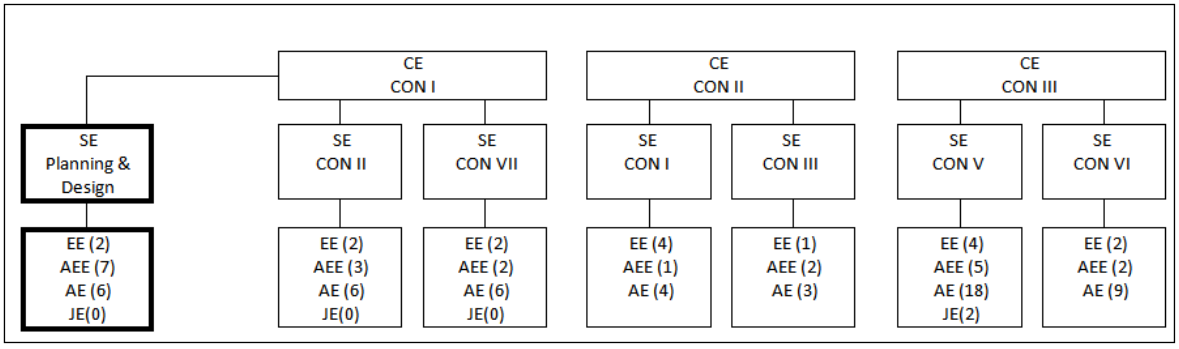
* Resultant vacancies will be merged with Newly Created Junior Assistant Post

^ Post will be abolished when the incumbent retires accordingly vide B.P.No.15/2007, Dated 26.07.2007

Temporary Appointment

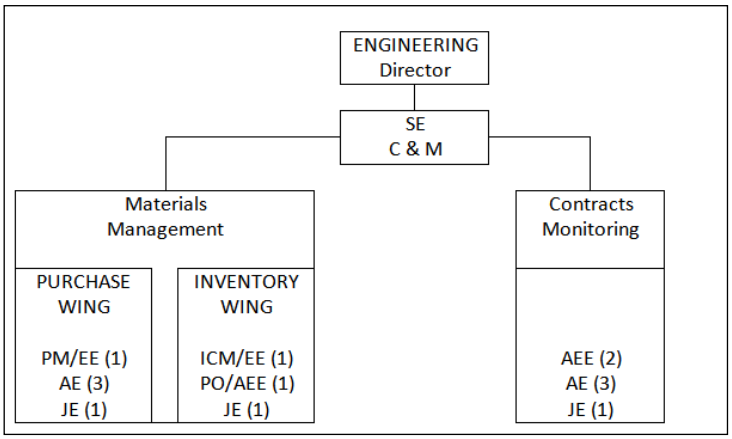
Nodal Officer	1
Law Officer	1
Assessors (Retd. COC)	10

Source: CMWSSB



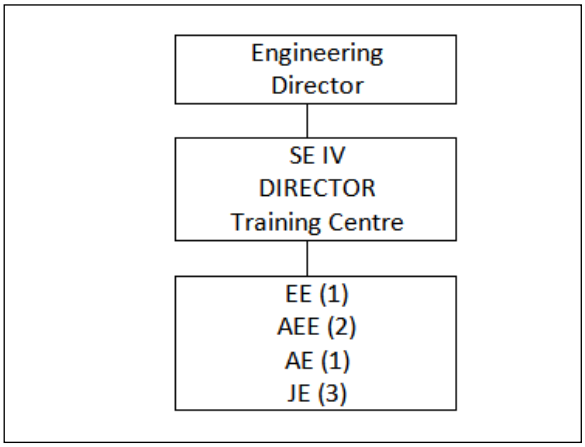
Source: JICA Study Team

Figure A9.1.2 Project Construction/Works Function



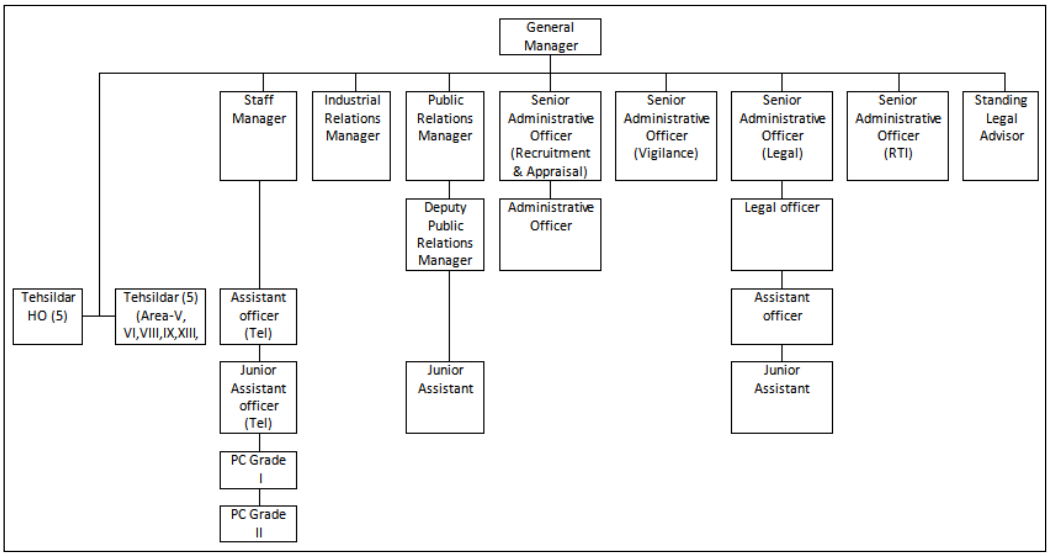
Source: JICA Study Team

Figure A9.1.3 Contracts and Project Monitoring Function



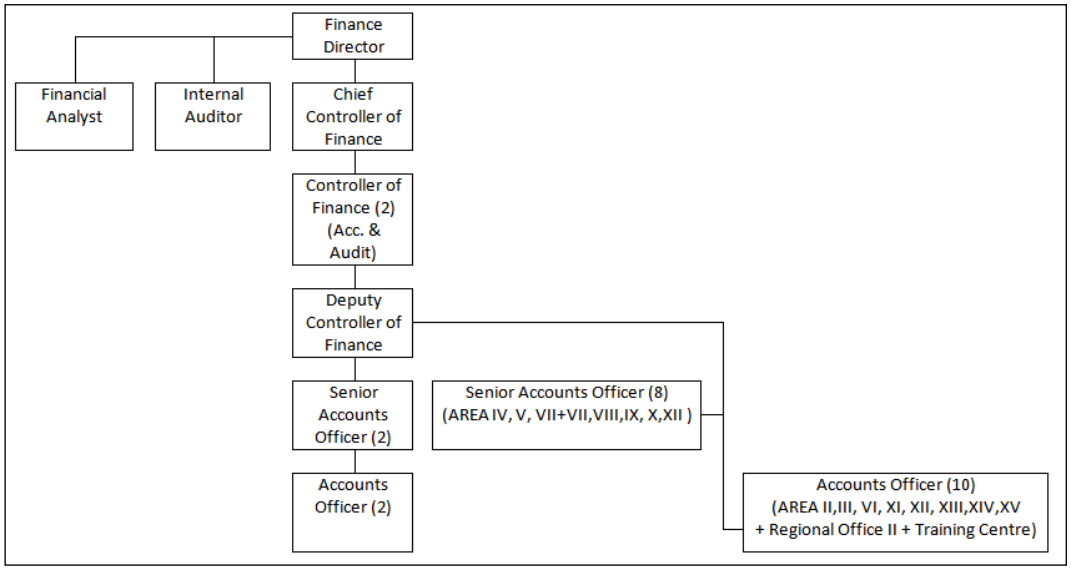
Source: JICA Study Team

Figure A9.1.4 Training Function



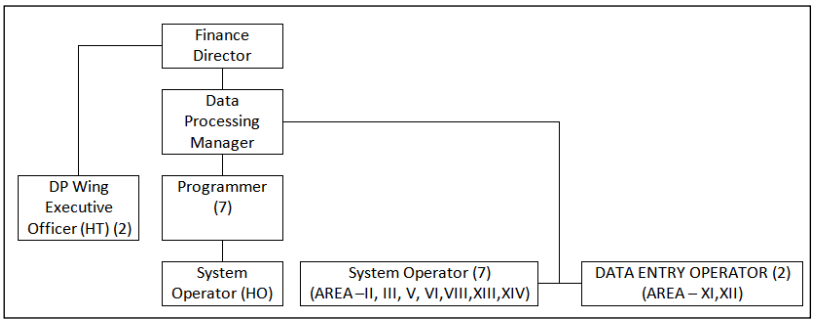
Source: JICA Study Team

Figure A9.1.5 Personal, Administration and Vigilance Function



Source: JICA Study Team

Figure A9.1.6 Finance and Accounts Function



Source: JICA Study Team

Figure A9.1.7 Information Technology Function

Appendix 9.2 Decision Making

Table A9.2.1 Review Meetings in CMWSSB

Chaired By	Participants	Periodicity	Agenda
PRINCIPAL SECRETARY Dept. of MAWS	Managing Director Engg. Director All CE's All SE's	Quarterly	Financial & Physical progress review of all Projects Funding for new projects
MINISTER Dept. of MAWS CHAIRMAN, Board of Directors	Principal Secretary to Government, Dept. of MAWS Principal Secretary to Government, Finance Department Managing Director, CMWSSB Commissioner, Corporation of Chennai Executive Director, CMWSSB Finance Director, CMWSSB Engineering Director, CMWSSB Member Secretary, CMDA Managing Director, TWAD Board General Manager CMWSSB	Bi-Monthly	Various – CMWSSB matters
MAYOR Corporation of Chennai	Managing Director CE (O & M – I) CE (O & M – II) All SE's All EE's	Pre- Monsoon	Flood preparedness Drought preparedness Social disease outbreak preparedness
MANAGING DIRECTOR	CE (O & M – I) All SE's All EE's	Twice per month Daily Alternate day	O & M issues Customer complaint monitoring Poor monsoon -water crisis Adequate monsoon -sewerage
	CE (O & M – II) All SE's All EE's	Once per month	O & M - T & T issues
	CE (O & M – II) Concerned SE & EE	Once per month	Visit to review work at problematic site
MANAGING DIRECTOR	CE (Cons – I, II, III) All SE's All EE's All Project Contractors	Once per month	Financial & Physical progress review of each Project – external issues
	Engg. Director Finance Director CE (Cons – I, II, III) All SE's All EE's	Once per month	Financial & Physical progress review of each Project – internal issues Special review of slow moving projects Special review of projects nearing completion

Chaired By	**Participants**	**Periodicity**	**Agenda**
	Engg. Director Contracts & Monitoring Team Concerned CE, SE, EE	Twice per month	Contract issues – new and old projects
	Engg. Director Planning and Design Team Concerned CE, SE, EE	Once per month	Planning and Design issues
	Engg. Director Director Training EE	Once per month	Past performance Future Plans Issues
	Engg. Director All CE's All SE's	Once per month	Special initiative meeting
	Finance Director General Manager	Once per month	Financial health review of CMWSSB
	General Manager P & A Team	Once per month	Land acquisition by CMWSSB Legal issues HR issues- pay/promotions/ recruitment/retirements etc.
CE (O&M – I)	All SE's All EE's	Trice per month	O & M issues Customer complaint monitoring Poor monsoon -water crisis Adequate monsoon -sewerage
SE's (O&M) (N, S, C, NE, SW)	Respective Area EE's	Weekly	O & M issues Customer complaint monitoring Flood preparedness Drought preparedness Social disease outbreak preparedness Poor monsoon -water crisis Adequate monsoon -sewerage
EE's (O&M)	Respective Depot Engineers Customers	Twice per month	Customer complaints
CE (O&M – II)	Concerned SE & EE	Two days per month Twice /Trice per month	O & M - T & T issues of all WTP's/STP's Visit to review work at problematic site
SE (O&M – T&T)	Concerned EE's	Twice per month	O & M - T & T issues
SE (Desalination)	Concerned EE's DBOOT Contractor	Once per month	Production issues
EE	Concerned WTP/STP Team	Weekly	O & M - T & T production preventive maintenance review
CE (Con –I, II, III)	Concerned SE's & EE's	Every 3 days	Site inspection
SE (Con – I,II,III,V,VI,VII)	Concerned EE's	Daily Alternate day	Progress review Site inspection
EE (Con)		Daily	Site inspection Report progress / issues to SE every evening

Source: JICA Study Team

Appendix 9.3 CMWSSB Procurement Process

Table A9.3.1 Procurement Procedure Sequence

S.No	Activity	Time-line (Average)
1.	Normally, bid documents are prepared by Consultant using government approved CMWSSB 'Standard Bidding Document'; alternatively, funding agency's prescribed documents are used.	15-20 days
2.	Documents are checked by Superintending Engineer –DESALINATION (SE-Desal), verified by Superintending Engineer – Contracts and Monitoring (SE-C&M) plus Chief Engineer (O&M-II) and approved by Engineering Director(ED)	10 days
3.	Bid Documents are uploaded by SE-C&M and his team on GoTN web site; anyone from the public is allowed to download; there is no password, no restriction is imposed to raising Pre-Bid queries. Note: For the DSP 150 MLD Project, a recent change to the existing process is the introduction of Rupee One Hundred Thousand (INR 100,000.00) fee, to be paid by bidders in order to participate in pre bid meeting and submission of tenders. The amount is in admission to the bid security amount. Anyone can raise queries and all are answered and uploaded on the web site for general viewing and free download.	Prebid meeting 10 days of announcement
4.	All answers, along with addendum (if any), are uploaded by SE-C&M and his team on GoTN web site	20-30days
5.	In case of any 'submission date extension', SE-C&M and his team announce the change through print, and electronic media	Bids opening 90 days of bid announcement
6.	An independent three member 'Tender Scrutiny Committee' (TSC) is constituted (1 SE + 1 EE + 1 Dy. Controller of Finance). They witness the complete bidding process, prior to the award of contract, and are required to make observations on the process and to sign each document.	
7.	Bids received are opened on the specified date and time by SE-C&M and his team, in the presence of bidders, TSC and Consultant; the bid opening process is videographed.	0.5 day
8.	'Pre-Qualification' process is not carried out separately. Technical bid evaluation includes 'Pre-Qualification'	
9.	Technical evaluation is carried out by SE-C&M and his team assisted by Consultant.	60-90 days
10.	SE-C&M prepares the agenda for the 'Tender Committee' (TC); General Manager presents the findings of the technical evaluation to the TC. [Tender Committee comprises Principal Secretary Finance (GoTN), MD-CMWSSB, Executive Director-CMWSSB, Finance Director-CMWSSB, Engineering Director-CMWSSB and General Manager is the Convener].	TC meeting called within 05-07 days
11.	After deliberations, TC presents the findings to the Board of Directors, recommending the list of bidders whose financial bids can be opened for their decision to approve/reject.	1-2 days after TC meeting
12.	Only Technically responsive bidders are informed about the financial bid opening date and time.	3-5 days after Board meeting
13.	Financial bids are opened by SE-C&M and his team, supported by Consultant, in the presence of TSC and invited bidders; the financial bid opening process is videographed.	0.5 day
14.	All monetary values are openly declared.	
15.	After financial evaluation exercise is completed, including the negotiation process, SE-C&M, through GM presents the findings to the TC. TC recommends the successful bidder for the decision to the CMWSS Board of Directors for their approval.	Financial evaluation, 45-60 days
16.	SE-C&M issues the award of contract to the successful bidder.	1-2 days

S.No	Activity	Time-line (Average)
17.	Complete details of the bid results are consolidated per month and declared for mass consumption in 'GoTN Tender Bulletin', which is a weekly publication.	
18.	After the successful bidder has furnished the performance guarantee and signed the contract, security deposits are refunded to the unsuccessful bidders along with unopened financial bids (if any).	15-20 days
19.	In case of rejection at any stage, retendering is ordered and all bidders are informed, without specifying any reason.	

Notes:

For externally funded projects, the procedure and documents prescribed by the funding agency are utilised; JICA's Standard Bidding Documents and procedure will be followed for JICA funded project.

At CMWSSB, presently, time-range for any procurement process to be completed is 290-320 days; since JICA's concurrence will be needed after 'Activity S. Nos.' 2, 11 and 15, an additional time of 75 days can be added to this time-range.

Appendix 9.4 Project Implementation - Procedures and Decision Making Process

Table A9.4.1 Project Approval Process

STEP	Activity	Action Time	Remarks
1	Preparation of Scheme/ DPR by Desalination Wing CMWSSB, using services of AECOM Consultants	5 months	Process completed
2	Engineering Director gives TECHNICAL approval; documents presented to Board of Directors, CMWSSB submits to GoTN for ADMINISTRATIVE approval.	3 months	
3	Scheme/ DPR documents submitted to Principal Secretary, Municipal Administration & Water Supply Department (MA&WSD) for Government of Tamil Nadu's (GoTN) ADMINISTRATIVE Approval.	3 months	GOVERNMENT ORDER (GO) yet to be issued granting ADMINISTRATIVE & FINANCIAL approval for the Scheme/DPR. Awaiting Y/L agreement signing, GO will be issued as a parallel process.
a.	Scheme/ DPR documents submitted by Principal Secretary, (MA&WSD) to Principal Secretary, Department of Finance (GoTN) for FINANCIAL concurrence.		
b.	Scheme/ DPR documents submitted by Principal Secretary, (MA&WSD) to MINISTER (MA&WSD) for overall concurrence. REWORD as		
c.	MINISTER (MA&WSD obtains ADMINISTRATIVE & FINANCIAL concurrence of the Scheme from the CHIEF MINISTER (GoTN)		
4	Scheme/DPR documents submitted to Tamil Nadu Urban Infrastructure Financial Services Limited (TNUIFSL)for 3rd party Technical Review	6 months	3rd party Technical Review/ proof checking of DPR documents is carried out by Tata Consulting Engineers (TCE) *(Completed)* MA&WSD, GoTN will decide any future involvement of TNUIFSL on the project.
5	CMWSSB submits DPR documents to Ministry of Urban Development (MoUD) of Government of India (GoI) for i) Obtaining Government of India (GoI) consent ii) Processing Loan Agreements with JICA	6months	Process coincides with Step 3 above CMWSSB Officials accompanied by AECOM Consultant, present the DPR to CPHEEO for review
a.	MoUD forwards DPR to CPHEEO for review and appraisal		CPHEEO – Central Public Health and Environmental Engineering Organization is the technical wing of MoUD
b.	Appraised DPR forwarded to Department of Economic Affairs, Ministry of Finance, GoI to award sanction as a guarantor.	3 months	Followed up by team of CMWSSB staff
6	JICA Preparatory Study	11 months	
7	Signing of Tripartite agreement between GoTN-GoI-JICA		Targeted for December 2016
8	Project Implementation	42 months	CMWSSB – Executing Agency TNUIFSL – Nodal Agency for routing project finances and carries out physical and financial progress review (only if GoTN decides to use their services).

Source: JICA Study Team

Table A9.4.2 Project stage-wise decision making

Planning Phase

S. No.	Activities	Types of Decision/s required to be taken (Decision/s with respect to)	Decision by
1	Project conceptualization	○ Can the project be done? ○ Should the project be done 'In-house (by SE-P&D)' or to be outsourced?	CMWSS Board
2	Pre & feasibility study of the project	○ What are the major deliverables? ○ Approve funds for pre/feasibility study ○ Concept and basic economics ○ Possible sources of raw water resource	CMWSS Board
3	Administrative approval of the project	○ Type of technology- options ○ Decision to continue ○ 'In-house (SE-P&D)' or to be outsourced DPR work ○ Approve funds for DPR	CMWSS Board + GoTN
4	Preparation/updation of the Detailed Project Report(DPR)	○ Functional design ○ Life cycle financial analysis ○ Risk analysis of the project ○ Identified works, prepared schedule, and estimated costs (DPR) ○ Phasing of works, cost and its timing	CMWSS Board + GoTN + GoI-CPHEEO

Pre-Implementation Phase

5	Updation of the Detailed Project Report(DPR)	○ Correction of Master Plan with respect to water allocation ○ Revised length of transmission, its alignment; added distribution network ○ Enhanced costs thereof ○ Mitigation measures – EMP and its costing	CMWSS Board + GoTN + GoI CPHEEO
6	Technical and Financial Sanctioning of the DPR	○ Approval sought for revised detailed project report ○ Approval of a communication plan and delivery method describing the information needed by stakeholders ○ Whether or not to continue with existing Consultant ○ LOAN AGREEMENT (L/A) - Economic considerations/repayment options	CMWSS Board + GoTN + GoI CPHEEO + Funding Agency
7	Project Initiation	○ Formation of Steering Committee and operations ○ Formation of PIU work group and its operations ○ Type of training –new skills, knowledge for Staff ○ Developing procedures for getting work done	CMWSS Board + GoTN

Procurement Phase

S. No.	Activities	Types of Decision/s required to be taken (Decision/s with respect to)	Decision by	
			Current	Proposed
8	Procurement of the Consultant	○ Approval sought for engaging 'Project Management(PM) / Design Supervision(DS)' Consultant ○ Quality control by third party arranged by PM/DS Consultant ○ Approval of PQ criteria, Bid document ○ Approval of Award of contract	CMWSS Board of Directors	P.D.-P.I.U. (Decision maker) + CMWSS Board of Directors (Approvers)
9a	Project-Procurement CP-1	○ Procurement method- EPC, DBOT, etc. ○ Approval of PQ criteria, Bid document ○ Approval of evaluation results ○ Finalization of the negotiated contract	CMWSS Board of Directors	P.D.-P.I.U. (Decision maker) + CMWSS Board of Directors (Approvers)
9b	Project-Procurement CP-2, & 3	○ Procurement method –BT, etc. ○ Approval of PQ criteria, Bid document ○ Approval of evaluation results ○ Finalization of the negotiated contract	CMWSS Board of Directors	P.D. –P.I.U. (Decision maker) + CMWSS Board of Directors (Approvers)

Implementation Phase

10	Execution and Controlling/ Overview of project progress	○ Approval for 'Go ahead' ○ Finalised working drawing ○ Approval of quality management plan ○ Approval of construction schedule; ○ Issues identified - physical and financial monitoring; corrective action as needed ○ Approval of contract variations- change in cost due to change in design ○ Termination /blacklisting of defaulters (if any) ○ Settlement of arbitrations (if any)	CE (Const)	P.D. - P.I.U + Steering Committee
11	Closure	○ Releasing final deliverables, approval of final bill ○ Approval of 'Completion Report' including lessons-learned studies ○ Releasing project resources-staff/equipment demobilisation	CE (Const)	P.D. - P.I.U + Steering Committee

Source: JICA Study Team

Steering Committee facilitates as and where needed

Appendix 9.5 Organizational Strengthening Plan

A9.5.1 CMWSSB Business Plan

The business plan integrates plans for addressing the technical challenges, customer satisfaction, financial sustainability and organizational improvements for effective water supply and sewerage management and its monitoring.

The plan also sets out baseline for the performance of CMWSSB, its priorities and aims for the future. The business plan will be a guide to implementation of projects and reforms to be undertaken by CMWSSB. In addition, the Business Plan would provide a basis for additional resource mobilization to enhance the credit worthiness of CMWSSB.

Background

CMWSSB serves the fifth largest metropolis in India serving a population of 6.727 million. To cope with the rapid growth and urbanization, more so since the last six years, CMWSSB aims to develop comprehensive infrastructure to not only cater to existing demands of water supply and sewerage management etc. but also to meet future demands.

To address these challenges on a sustained basis, CMWSSB need to develop a long term (20 years) and a five year business plan to not only manage the treatment, transmission, distribution of water along with a collection, treatment, plus disposal facilities, but also to establish a sustainable and sound management system for the water supply and sewerage sector.

Objectives of Business Plan

Business objectives are the ends that CMWSSB has set out to achieve. These objectives and plans, are determined by balancing the requirements of the various stakeholders (Government, elected representatives, public/customers, employees etc.). The objectives of CMWSSB are thus a blend of various interests of these stakeholder groups. These set objectives are:

- To improve customer satisfaction on quality of services as well as value for money
- Full realization/recovery of water and sewerage bills
- Establish a mechanism to ensure full recovery of O&M cost of water supply and sewerage management in next 5 years;
- Generate revenue to adequately meet the cost of O&M costs (manpower, electricity, chemicals, etc.). in next 10 years
- Full recovery of cost of water supply and sewerage management (O&M, Depreciation, Interest, other charges) by CMWSSB in 20 years (by 2035)

Vision, Mission and Goals

VISION STATEMENT (EXAMPLE): Produce ample superior quality water, vigilantly maintaining water and wastewater infrastructure, and providing responsive and efficient customer-oriented service

in a cost-effective and innovative manner emphasizing responsible environmental stewardship and compliance with all regulatory requirements.

MISSION STATEMENT (as in Citizen's Charter): Our Mission is to enhance the health and quality of life for citizens in Chennai City by providing them adequate supply of clean and good quality of water and safe disposal of sewage/waste water at reasonable price.

In its endeavours to achieve the objectives indicated in the Mission Statement, Metrowater being customer driven will be guided by the following:

** Feedback from consumers*

** Delivering excellence in products and services*

** Doing business with ethics and integrity*

** Continuous endeavour to improve quality of service.*

Goal - CMWSSB has set itself the goal of providing 24x7 self-sustainable, safe drinking water supply, sewerage collection, treatment, enhanced reuse of treated waste water for pollution free rivers and sea by the year 2035.

Based on internal discussions, technical, financial and institutional goals have been established. These include the following:

Short term goals: Short term goals address immediate operational parameters such as procurement, coverage etc. over the next three-five years (by 2020). This mainly includes:

- Expansion of water supply network for an improved coverage raising it from the current 65 % to 95%.
- Expansion of sewerage network for improved coverage raising it from the current 65 % to 85%.
- Increased capacity of WTPs with the addition of 3067 MLD and STPs with the addition of 591MLD by 2020.
- Recovery of O&M costs (staff salaries, electricity, chemicals, normal repair and maintenance) to be increased to 100%.
- Asset management system will be in place and operational
- Automated Customer grievance management system linked to MIS will be in place.

Medium term goals: These are goals, which are targeted during next seven-eight years, especially for coverage, infrastructure development, potential PPP/outsourcing arrangements, O&M sustainability etc. To include:

- Expansion of water supply network for improved coverage to rise from 95 % to 100%.
- Expansion of sewerage network for improved coverage of 100% of design population.
- Increased capacity of WTPs and STPs (adequate for the design population of 2023)
- Recovery of O&M costs (staff salaries, electricity, chemicals, normal repair and maintenance) to be sustained at 100%.

- Fully operational asset management system will support the decision making.
- Improved reuse of treated water, will be enhanced from the existing 5% to 20%

Long- term goals: The long-term goals have been set for a period of about 20 years (say by 2035). This includes

- Increased capacity of STPs with the addition of 470 MLD by 2035
- 100 % sustained realization/recovery of water bills and sewerage bills
- Increased Customer satisfaction to grading level of 'Very Good'.
- Recovery of total cost of O&M (operational as well as capital component)
- Improved reuse of treated water to 40%

The business plan is developed to address expansion/improvement of CMWSSB to meet shortcomings in the institutional, operational and financial aspects. Thus, the assessment focuses on institutional/governance, financial capabilities and human resources.

1) *The institutional component* focuses on mapping of the existing division of responsibilities between various entities for the provision of water supply and sewerage management services, decision making process, transparency, accountability at various levels, public participation and infrastructure elements covered in the operational assessment.

   Current level of achievement of service outcome and targets for key performance indicators have been indicated in Table below.

Table A9.5.1 Goals and Service Outcomes

S. No.	Indicators	GoI* Standard	Current ** 2015-16	Target *** 2020	2035
Water Supply					
1.	Network cover for general households - %	100	60	95	100
2.	Per capita supply - lpcd	135	110	135	135
3.	Extent of metered water connections - %	100	10	50	100
4.	Supply duration - hours	24	6	24	24
5.	Quality of water supplied - %	100	100	100	100
6.	Un-accounted water - %	20	30	20	10
7.	O & M cost recovery - %	100	85	100	100
8.	Collection efficiency - %	90	80	90	90
9.	Customer complaint redressal efficiency	80	80	80	80
10.	Customer satisfaction – Fair/ Good / Very Good	-			V Good
11.	Rain water harvesting - %	80	80	100	100
Sewerage					
12.	Coverage of toilets - %	100	100	100	100
13.	Coverage of sewerage network - %	100	50	85	100
14.	Collection efficiency of sewerage network - %	100	90	100	100
15.	Treatment and disposal adequacy - %	100	100	100	100
16.	Quality of treated sewerage - %	100	100	100	100
17.	Recycling and reuse - %	20	5	20	20
18.	Customer complaint redressal efficiency	80	80	80	80
19.	Collection efficiency - %	90	75	100	100
20.	Cost recovery of O&M - %	100	75	100	100
21.	Customer satisfaction – Fair/ Good / Very Good	-			V Good

*Source: *Handbook of Service Level Benchmarking (MoUD, GoI)*

*Source: ** &***CHENNAI DISTRICT GAZETTE (L&G-2/2124/2015, Dated 10.03.2016)*

Source: CMWSSB

2) *The Financial Assessment* focuses on a set of key financial indicators which have been derived using the financial data, based on the audited account. Table below presents these indicators. The indicators are utilized to assess the performance with regards to resource mobilization, fund utilization, financial performance and collection efficiencies.

Table A9.5.2 Key Financial Indicators

			2011-12	2012-13	2013-14	
	KEY FINANCIAL INDICATORS		Value	Value	Value	UNIT
A	**Resource Mobilization**					
1	Sources of Funds					
	a	Share of Own Sources (Sale of Water) in Total Revenue Income (RI)	45%	43%	37%	%
	b	Share of Revenue Grants & Subsidies in Total RI	22%	29%	36%	%
	c	Share of Water and Sewerage Tax in Total Revenue Income	20%	18%	16%	%
2	Growth in Total Revenue Income (over previous year)			15%	18%	% p.a.
	a	Growth in Revenue from Sale of Water		9%	1%	%
	b	Growth in Revenue from Grants & Subsidies		50%	46%	%
	c	Growth in Revenue from Water and Sewerage Tax		4%	4%	%
3	Per Capita Total Revenue Income (per person)		785.9	903.2	1,011.4	Rs p.a./ per person
4	Per Capita Revenue from Sale of Water (per connection)		4,583.9	4,168.9	4,178.3	Rs p.a./ connection
5	Per Capita Revenue from Sale of Water (per person)		353.3	386	369.3	Rs p.a./ per person
B	**Fund Application (Expenditure)**					
1	Uses of Funds					
	a	Share of Establishment Expenditure in Total Revenue Expenditure (RE)	61%	56%	49%	%
	b	Share of O & M Expenditure in Total Revenue Expenditure	39%	44%	51%	%
2	Growth in Total Revenue Expenditure (over previous year)			11%	15%	%
	a	Growth in Establishment Expenditure (over previous year)		3%	-0.1%	%
	b	Growth in O&M Expenditure (over previous year)		24%	34%	%
C	**Ratio Analysis (Expenditure vs Revenue)**					
	a	Revenue Expenditure to Revenue Income	1.27	1.23	1.20	
	b	Establishment Expenditure to Revenue Income	0.77	0.69	0.59	
	c	O&M Expenditure to Revenue Income	0.50	0.54	0.61	
	d	O&M Expenditure to Income from Sale of Water	1.11	1.26	1.68	
	e	O&M Expenditure to Revenue Income less Grants & Subsidies	0.64	0.76	0.96	
D	**Liability Management**					
1	Per Capita Liability					
	a	Outstanding Debt (Long Term Borrowings) per Capita population served	2,037	1,947.8	1,793.6	Rs
	b	Outstanding Non-Debt Liability per Capita	6,568.5	7,545.2	8,222.8	Rs
	c	Total Outstanding Liability per Capita	8,605.5	9,493.0	10,016.3	Rs
2	As a Proportion of Revenue Income					
	a	Outstanding Debt to Revenue Income	2.59	2.16	1.77	
	b	Outstanding Non-Debt Liability to Revenue Income	8.36	8.35	8.13	
	c	Total Outstanding Liability to of Revenue Income	10.95	10.51	9.90	
3	As a Proportion of Own Revenue Income (Sale of Water)					
	a	Outstanding Debts to Own Revenue Sources	5.77	5.05	4.86	
	b	O/S Non- Debt Liability to Own Revenue Sources	18.59	19.55	22.27	
	c	Total O/S Liability to Own Revenue Sources	24.36	24.59	27.13	
4	Non-Debt Liability as % of Total Liability		76%	79%	82%	%
5	Debt Servicing Ratio (Debt Service Charges/Revenue Income)		18%	16%	13%	%

E	**Performance Indicators**				
1	Operating Ratio (Revenue Expenditure to Revenue Income)	1.27	1.23	1.20	Ratio
2	Per Capita Own Income	353.33	386.04	369.25	Rs
	Growth in per Capita Own Income (per person)		9.3%	-4.3%	%
3	Per Capita Grant	174.65	261.86	364.02	Rs
	Growth in Per Capita Grant		49.9%	39.0%	%
4	Per Capita Total Revenue Income	785.95	903.19	1,011.4	Rs
	Growth in Per Capita Total Revenue Income		14.9%	12.0%	%
5	Per Capita Establishment Expenditure	607.45	624.54	594.01	Rs
	Growth in Per Capita Establishment Expenditure		2.8%	-4.9%	%
6	Per Capita O & M Expenditure	391.36	486.54	621.77	Rs
	Growth in Per Capita O & M Expenditure		24.3%	27.8%	%
7	Per Capita Revenue Expenditure	998.81	1,111.1	1,215.8	Rs
	Growth in Per Capita Revenue Expenditure		11.2%	9.4%	%
F	**Efficiency Indicators**				
1	Revenue Collection Performance				
a	Growth in Revenue from Sale of Water (over previous year)		9%	1%	%
b	Growth in Revenue from Water and Sewerage Tax (over previous year)		4%	4%	%
2	Revenue from Sale of Water per Connection	4,583.9	4,168.9	4,178.3	Rs
3	No. of CMWSSB Staff per 1000 persons (Population served)	0.46	0.46	0.44	Nos.
4	Total Revenue Income per CMWSSB staff	17,01,119	19,54,888	23,00,023	Rs
5	Revenue from Sale of Water per CMWSSB staff	7,64,748	8,35,542	8,39,728	Rs

Source: JICA Study Team

The above have been derived from the audited accounts for 2011-12, 2012-13 and 2013-14 as below:

Table A9.5.3 Audited Accounts

BALANCE SHEET

Description	**2011-12**	**2012-13**	**2013-14**
	Rs. Crores	**Rs. Crores**	**Rs. Crores**
Liabilities			
Contributions	12,31,77,46,006.59	14,23,71,92,420.59	14,83,67,67,957.74
Grants From Government	14,85,62,26,487.53	19,39,42,18,304.53	25,07,97,07,963.53
Long Term Borrowings	13,70,31,54,271.00	13,10,29,67,530.00	12,67,68,55,900.00
Deferred Credits & Deposits	8,61,16,93,016.41	8,12,07,56,329.36	8,85,18,71,344.21
Current Liabilities	8,40,04,00,691.80	9,00,42,63,346.87	9,35,01,00,184.77
Total	57,88,92,20,473.33	63,85,93,97,931.35	70,79,53,03,350.25
Non-Debt Liabilities	44,18,60,66,202.33	50,75,64,30,401.35	58,11,84,47,450.25
Assets			
Fixed Assets	44,80,87,37,708.60	48,57,09,20,341.47	54,52,42,07,185.24
Current Assets, Loans, Advances & Deposits	9,16,25,98,524.72	9,69,97,69,907.31	8,85,50,68,031.58
Accumulated Deficit	3,91,78,84,340.01	5,58,87,07,682.57	7,41,60,00,000.00
Total	57,88,92,20,473.33	63,85,93,97,931.35	70,79,52,75,216.82

Profit & Loss Statement

Particulars			
Income			
Sale Of Water	2,37,68,35,424.21	2,59,68,63,064.30	2,60,98,74,945.9
Grants And Subsidies	1,17,48,37,500.00	1,76,15,43,079.24	2,57,28,73,582.0
Water And Sewerage Tax	1,03,69,22,939.27	1,07,41,00,144.95	1,11,41,64,866.3
Other Income	69,84,82,849.07	64,32,86,347.28	85,15,58,624.3
Provisions Written Back			
- Water Charges Unmetered	26,54,209.00	-	
- Taxes	1,17,89,284.00	-	
Revenue Income	5,28,70,78,712.55	6,07,57,92,635.77	7,14,84,72,018.49

Particulars	2011-12 Rs. Crores	2012-13 Rs. Crores	2013-14 Rs. Crores
Excess Of Expenditure Over Income	1,81,72,02,619.51	1,67,08,23,442.56	1,83,68,50,009.90
Total	7,11,87,24,825.06	7,74,66,16,078.33	8,98,53,22,028.39
Expenditure			
Operating & Maintenance Expenditure	2,63,26,64,783.57	3,27,29,76,874.34	4,39,47,02,929.6
Payments & Provision To Employees	1,58,66,19,840.67	1,53,71,34,601.60	1,57,26,93,648.3
Office Administrative Expenses	6,35,13,502.11	6,72,85,013.42	6,56,54,215.5
Prior Period Adjustment	32,64,58,390.18	24,16,57,034.69	39,21,29,922.6
Water Lorry Hire Charges	19,47,95,912.00	25,20,34,355.00	18,59,17,825.0
Depreciation	1,30,14,94,303.31	1,38,43,37,397.28	1,46,37,66,926.5
Debt Service Charges	93,98,78,132.00	96,04,56,094.00	90,57,28,149.0
Provision For Doubtful Debts			47,28,412.0
- Water Charges Metered	7,32,99,961.22	1,76,79,585.00	
- Water Charges Unmetered	0	21,26,277.00	
- Taxes	0	1,09,28,846.00	
Total	7,11,87,24,825.06	7,74,66,16,078.33	8,98,53,22,028.39
Revenue Expenditure	6,71,89,66,473.66	7,47,42,24,335.64	8,59,31,92,105.80
Establishment Expenditure	4,08,63,01,690.09	4,20,12,47,461.30	4,19,84,89,176.24
CMWSSB Staff strength	3,108	3,108	3,108
Population served	67,27,000	67,27,000	70,68,000
No. of connections (Water Supply)	5,18,514	6,22,906	6,24,631
No. of connections (Sewerage)	6,11,275	7,35,608	7,71,168

Source: JICA Study Team

Above presented KEY FINANCIAL INDICATORS are clear indications that there exists a decline in growth in total revenue from sale of water and tax collection and increase in dependence on grants and subsidies. Indicators on Per capita Total Revenue Income, Per capita revenue from sale of water per connection and Per capita revenue from sale of water per person have to be used for benchmarking after a comparative study with other progressive cities, e.g. Surat.

Increase in Share of O & M Expenditure in Total Revenue Expenditure is an indicator of aging plant and equipment. Currently sale of water is not even covering the O&M expenditure. In-spite of grants being 46% of revenue income, there is a shortfall of 20%, indicating that a major effort is needed to increase Revenue income by way of a revised strategy of revised tariff, more connections, more meters, more collection and reduced NRW. 15 % growth per annum in the share of Own Sources of Funds (Sale of Water) in Total Revenue Income (RI) has to be benchmarked.

Another benchmark has to be set to bring the Debt Servicing Ratio (Debt Service Charges/Revenue Income) to 6% (as is the Engineering Industry norm) by increase revenue to cover for revenue expenditure, reduce debt, increase grants and by using grants for capital investment only. The indicator is to be used for benchmarking after comparison with other progressive cities, e.g. Pune.

3) *The human resource component* focuses on preliminary assessment of staff capabilities (including qualifications) to determine whether present staffing meets the emerging (time based) needs of water supply and sewerage management operations including the requirements arising from diversification of technologies. As per plans the assessment focuses and preliminarily identify

redundancies, work load patterns in the staffing structure and assess overall changes needed in management structure and internal communications procedures. The identified staffing needs for management of expanded infrastructure have been developed. For existing staff, the training and capacity building requirements have been identified and presented in Section 9.4.7 of the main report.

Desired Scenario (Future) of Water Supply and Sewerage Management by CMWSSB

Sections 9.4.3 to 9.4.8 outline the required expansion and improvement in asset management, supporting operational and monitoring systems (i.e. SCADA, Centralized Control Unit), information technology systems, customer redressal system etc. to facilitate improved management. The "Master Plan for Water Supply and Wastewater Management for Chennai Metropolitan Area" outlines the required annual capacity increments including rehabilitation of existing infrastructure as well as expansion to meet the service requirements.

The financial strategy estimates the cost of capital investments required to expand as per goals as well as create the supporting infrastructure required. The investment plans in CMA for Water Supply, Sanitation and Sewerage are detailed out in appendix **4-1 (number may change)** and **4-2 (number may change)** respectively. The related capital expenditure is summarised below

Table A9.5.4 Capital Expenditure

Sector	Capital Expenditure (in million Rs. except "Total in million USD")				
	Total amount	Phase I	Phase II	Phase III	Phase IV
	(By 2050)	(By 2020)	(2020-2030)	(2030-2040)	(2040-2050)
Water Supply	222,784.18	19,243.52	144,379.80	57,508.78	1,652.00
Sanitation and Sewerage	100,524.86	6,576.92	38,562.42	50,491.23	5,189.29
Total	323,309.04	25,820.44	182,942.22	108,000.01	6,841.29
Total in million USD	4,854.49	387.69	2,746.88	1,621.62	102.72

* UDS1 = Rs 66.6
Source: Master Plan for Water Supply and Sewerage Sectors in Chennai Corporation and Rest of CMA, 2015

Steps for improved financial management will be taken for achieving the target of revenue income becoming higher than revenue expenditure. From a long term planning perspective, the tariff and tax rates will also include partial recovery of cost from customers. The Organizational Strengthening Action plan is being adopted by CMWSSB to achieve the desired goals.

A9.5.2 Proposal for Water and Sewerage tariff revision and collection system

(1) Water and Sewerage tariff revision

The general consensus in India is that tariff setting must focus on economic and financial viability, without losing sight of social affordability. The approach paper to the Ninth Five-Year Plan states that "Efforts will be made to enhance the financial viability of the water supply and sanitation sector through policies based on full cost recovery to permit resource mobilization… Subsidies, if required for the poorer sections of the urban society, should be selectively well targeted and transparent…"

Tariff setting by CMWSSB has to be based on the principle of 'use more pay more' to disincentivize excessive use or wastage of water. In cases where bulk connection is provided to a group housing society serving a number of residential premises, water charges have to be worked out as per residential unit-wise domestic rates.

Introducing calendarized payment timelines, metering of Bulk, Industrial and Special Domestic Customers, Spot Billing for Metered Customers are all measures that will go a long way to improve the revenue of CMWSSB. Further, as per the norm in other progressive cities, the sewerage charges should be levied at 60% of the water consumption charges. Special subsidies can be allowed to weaker sections of the society where water charges can be recovered on a standard consumption of 10 KL. per connection per day.

Therefore to enhance revenues it is proposed to create District Metering Areas (DMA), meter bulk, industrial consumers and special domestic consumers in multi-storeyed buildings with more than 3 floors (G+2). In the case of industrial / commercial customers, efficiencies of scale can be derived if there is spot billing (for metered consumers) and printing done centrally and through an outsourced agency (for unmetered consumers). Incentives for online payments / payments through mobile phones etc. have to be introduced to encourage collection levels.

(2) Water and Sewerage tariff collection system

Billing and collection are commercial functions which need to be separated out from Finance and Accounts, as a first action. CMWSSB has to outsource the collection work to a private agency to increase the collection rate and enhance efficiency. The outsourced works will included i) Renewal of household collection database, ii) (re)-design and update the software system, iii) carry out meter reading iv) collect charges and taxes, v) setup on-line help desk, vi) arrange SMS system for payment activities. Payment to the contracted agency would be made based on the revenue amount collected, and hence, a significant improvement in collection rate and amount can be expected. This will also pave the way for systematized billing and collection when the program of full metering is achieved. The outsourcing can be for an initial period of three-year.

A9.5.3 Proposal for CMWSSB's Asset Management System

The first stage of implementation of the asset management system for infrastructure would involve mapping the inventory of all available assets including location, age, quantity/value, and physical characteristics.

CMWSSB's water supply assets basically comprise of all the assets from the headwork's, treatment plant, sump, transmission mains, pumping mains, feeder mains, distribution mains and sub mains, including all valves, connections, meters and all related facilities for the efficient delivery service of water. There are also different types of fixtures related to the intake from groundwater, viz. bore wells, public taps open wells hand pumps, OH tanks. Sewerage system would have a similar list. More examples of assets include land and buildings which are of both types - remunerative assets and non-remunerative assets.

Operation and maintenance of such a vast water supply and sewerage system is as it is a big problem and adding to this is the admission by CMWSSB that it has limited documented information about the sizes, types, material and year of installation. As-built drawings are also scarce, as many of the lines are old, or have been laid out at different periods of time, under different projects and schemes. Considering that assets lose value over time as the system ages and deteriorates, O&M costs increase affecting customer service quality and without asset management, CMWSSB may be faced with excessive costs that it can no longer afford.

Development of the water supply and sewerage asset Geo-database, Consumer Mapping for Chennai Metropolitan Area, including Web/GIS based water supply and sewerage utilities will require a series of specialised activities. These have been tabulated below

Table A9.5.5 Asset Management System Activities

S.No.	Activity Description	Unit/Qty
	Development of Water utility Assets Database	
1	Procurement of High Resolution Satellite Image(WV-II 0.5mtr)	426 sq km
2	Processing & Geo-referencing of HRSI through GCP survey	426 sq km
3	Composition of Base Map (A3 size equivalent)	500 nos. (approx)
4	Mapping of supply water (6520 km)/ sewerage (3,994 km) utility assets covering the following	10514 km
	a. Collection/ collation & Compilation of records/ maps of existing water/ sewerage utility assets	
	b. Digitisation & Mapping of existing water/ sewerage utility assets	
	c. Field survey & ground truthing for verification of the maps/ data	
	d. Field Survey & collection of attribute data of the utility assets	
	e. Generation of Assets Database (tabulation)	
5	Valuation of assets (in consultation with the CMWSSB)	
6	Preparation of city wide water and sewerage utilities Web-enabled Geo-database in GIS environment including thematic mapping, shape/ style/ colour/ symbol, feature-attribute data linking	
7	Development of water and sewerage utility asset inventory maps & reports	
	Preparation of Consumer Database	
8	Door to door Household Survey for Data Collection in survey format & collection of GPS coordinates & Mapping for each legal/ illegal connections	Per Household (750000 nos. approx)

9	Preparation of Consumer Geo-database and integration with the water and sewerage utility Geo-database	

After the development and piloting the above system, the above will require a further on-site support and facility management for an estimated time frame of three years (including Application/ Geo-database maintenance); a team of (two each) GIS professionals and Database Assistants will be needed to carry out this on-site support and facility management to cater to service contingencies.

A9.5.4 Proposal for Web based Management Information System (MIS)

CMWSSB has to develop a GIS-based Management Information System (MIS) for its water and sewerage utilities, fully computerizing as much of data as possible – physical, financial, human resources, operation and maintenance, customer connections, customer relations and customer care, complaints and redressal.

The overall scope will include the provision of Geographic Information Systems (GIS) support services to create detailed database for CMWSSB using high resolution (0.50 Meters or better resolution) satellite imagery, and overlay all infrastructure data like road, drain, water supply lines, sewer supply lines, over the base maps, in various layers. These databases are to be created using door-to-door household surveys and onsite physical surveying of assets. The master database thus created will be linked to GIS Compatible Web based Management Information System (MIS) to facilitate the process of revenue generation and proper management of assets. This would entail the following actions:

- Develop performance indicator for management of core services provided by CMWSSB.
- Preparation of up-to-date large-scale base map of CMA using high-resolution satellite imagery and ground based engineering survey techniques.
- Interpretation of high-resolution satellite imagery for capturing of building footprints, plot boundary, roads, major landmarks and other visible features.
- Incorporate information of utilities like water supply network and sewerage network (household level), as provided by CMWSSB.
- Detailed surveys for Water, Drainage pipelines (and sewerage, where it exists) through the conduct of on-site physical surveys as per format to be approved by CMWSSB officials to create the updated database of all assets that includes connection to each household.
- Study, design, develop, configure and implementation of web-GIS based MIS with various modules accessible by CMWSSB staff.
- Maintain data and system up to the completion of the project period and handholding period of six months after completion of the project.
- User training for both technical and end-user training.
- Preparation of Technical/ User Manual documentation.

The above development steps of GIS based MIS have been summarized below

1. Development of detailed SRS for CMA level Web GIS on water and sewerage utilities Management Information System
2. Development of Web GIS based Decision Support System covering the following
   a) *Web GIS Application Modules*
   b) *Mobile GIS Application Modules*
   c) *Modification/ development & Integration of existing grievance redressal management application to facilitate Web/ Mobile GIS enabled grievance redressal mechanism*
   d) *Development of application -Web GIS application Modules for billing/ collection reconciliation process management and integration with the existing Financial Management Information System (FMIS)*
3. Staff Training & Technology Transfer

It is proposed that the agency entrusted with developing the Asses management system should be asked to carry out the development and implementation of this GIS based MIS

A9.5.5 Proposed Non-Revenue Water (NRW) management plan

Due to the low metered rate and the flat rate charge to the unmetered customers, concept of NRW management has never been adopted by CMWSSB in recent times. The need to minimise NRW losses has become increasingly important therefore NRW Management plan for CMWSSB would include

1. Establish series of District Metering Area (DMA) all across CMA

The water service connections of commercial establishments, industrial & institutions and Domestic service connections through House Service Connection (HSC) to be considered.

2. Detect Leaks Acoustically

Acoustic leak detection is an important way that can identify and account for non-revenue water. A dynamic combination of acoustic leak sensors and innovative data analysis software enables proactive leak mitigation. Using a communication module with an integrated acoustic leak sensor, water providers can collect and analyze vibration patterns from anywhere in the distribution system. The acoustic leak detection system will allow optimizing the system performance with automatic daily surveying for distribution leaks. This will result in lower pipeline repair costs by finding and repairing leaks before they become costly main breaks. This also reduces the risk of bacteria and viruses entering the water supply through burst pipe. Pumping and treating less water, will in-turn prolong the life of the treatment and pumping facilities.

3. Perform District Metering Analysis

By grouping and aggregating data stored in an simple analytic software application, district metering can be performed via the following steps:

- Install the meter or meters that feed water into the district (i.e., the “master meter”).

- Identify the group of meters in the district and aggregate the total consumption of these meters on an interval-by-interval basis. Accrue the aggregated consumption of the district into a virtual meter.
- Compare the net consumption of the master meter (the measured input to the district) with the metered consumption of the aggregated district (the measured consumption within the district) on a time-synchronized interval-by-interval basis. Any difference between the net consumption of the master meter and the aggregated consumption of the virtual meter is considered NRW, which can include leaks.

Once the district metering analysis has been conducted and the analytics application has ranked the various districts according to severity, CMWSSB can prioritize where to look for leaks.

4. Manage Distribution System Pressure

To effectively manage pressure, it is important to comprehensively evaluate a service area and gain an understanding of its background losses before introducing pressure control. With a pressure management program, the distribution system can be broken down into pressure zones. Pressure is monitored at the inlet, average zone point and the critical zone point. The average zone point is a location that exhibits the average pressure rate for the zone. The critical zone point is a location where pressure is the lowest, usually the highest elevation in the zone.

5. Analyze Meter Tampers

Persistent monitoring will say when the potential leak or tamper began, whether it is improving or getting worse. When reported over time, cases with higher incidents of theft and related NRW may be spotted for further investigation.

By taking the preceding five steps, CMWSSB can reduce NRW and thereby reduce the amount of water they have to pump and treat to meet current and future demand. This reduces the amount of energy required to pump the water, the amount of water lost and the amount of CO^2 produced.

A9.4.6 Proposal for Improved customer services system

The foremost task is to have a commercial orientation and outlook to the business of water supply and sewerage. A dedicated section for undertaking the "Commercial" function has to be established at CMWSSB. The 'Citizens' charter' needs to be relooked and should represent CMWSSB commitment of towards standard, quality and time frame of service delivery, grievance redress mechanism, transparency and accountability.

Customer Service System:

The Customer Service System would provide relevant information to customers, process applications from customers, generate bills, distribute bills to customers, collect payments, and facilitate the grievance redressal. It would give the 'customer and payment' details, status, existing customer records, procedures related to applications for new connections, disconnection, and reconnections.

Simultaneous action is needed in devising a system to resolve customer complaints at the CMWSSB Depot office level itself. This will require a thorough study and evaluation of the existing public relations and complaint handling system including understanding the variety of complaints and the flow to resolve them. Accordingly, the need is to devise a simple software, operable from each of the 200 Depot Offices, for logging complaints which become visible to each concerned department for needful action and for recording progress at each stage.

For collections, CMWSSB has to outsource the collection work to a private agency to increase the collection rate and enhance efficiency. Further, handling customer queries through the use of this system should result in assimilation of, a) frequently asked questions, b) log of customer concerns, c) manner of handling irate customers and d) details of fire-fighting situations.

Customer Care Services: For the system to work and deliver the desired results, the staff had to be provided the requisite skills to be able to have customer orientation with desired spirit and enthusiasm and additionally have the skills to operate the system. The staff-customer interface will comprise a) understanding customer expectations, b) One-on-one customer interaction, c) communicating effectively, and d) telephone etiquettes.

There the 'Improved customer care system' will require the following actions:

1. Establishing a dedicated section for undertaking the "Commercial" function – Commercial Unit
2. A relook and probably redrafting the 'Citizens' Charter' for water supply, sewerage, water conservation and reuse
3. Thorough study and evaluation of the existing public relations and complaint handling system
4. Redefining roles, providing adequate and appropriate staff to resolve customer complaints at the Depot office level itself.
5. Customised 'Customer Service System' software and hardware put in place for use by staff of Commercial Unit
6. Outsourcing the collection work
7. Training of staff for them to provide the level of service needed

A9.4.7 Improved HR management and HR development Plan

(1) HR management

The key HRM management initiatives, towards organizational strengthening of CMWSSB are listed below.

- CMWSSB has to develop a business linked, objective 'Performance Management System' for the employees - driving accountability through a revised review mechanism. This should include organization level Key Result Areas and Key Performance Indicators, which have then to cascade down to the individual level.

- The currently prevalent O&M monitoring of a contractor-managed desalination unit requires techno-commercial & legal capabilities as against a pure technical monitoring; the need, however, is for developing internal capabilities of the O&M team by introducing appropriate manpower for monitoring the present and future desalination infrastructure.
- The existing quality assurance team and the hydro-geologist team require to be restructured and strengthened to ensure a revised focus on the aspect of quality assurance and water conservation
- The present C & M Cell has to be revamped to have a fresh outlook towards contracts and risk management for legal assessment of the tender / contract document.
- Strengthening of the Commercial team by i) demarcating the Revenue/ Commercial function from the F&A departments, and ii) improving focus on Billing & Collection by creating roles with dedicated responsibilities
- There is a need to creation a Stakeholder Engagement Cell for engaging in Customer Engagement Surveys before construction of a new project; this team will service the need for a dedicated PR, Branding and Marketing, for developing ads and outreach programmes for CMWSSB; thus modified roles & responsibilities and manpower have to be put in place to facilitate this transition.
- To keep pace with the present times it is essential to IT enable all F&A and HRM processes to reduce administrative hassles (Online Service Book, Leave Management System, Etc.) Strengthening of in-house IT Function by making the presence of IT Staff in all departments for resolution of User issues;

(2) HR Development

The following sets of actions are essential towards HR Development and capacity building of CMWSSB

- CMWSSB has to draft and introduce a new Human Resource Development Policy document for providing an impetus to the declining focus on capacity building. The CMWSSB HRD Policy, based on a strategic approach, would cover the policy framework, policy statement and objectives, HRD and Training strategy, and Implementation related aspects etc. to achieve a target of minimum 15 days 'need based' training to at least 50% of staff in a training year.
- The initiative taken in 1982 has once again got to be revived by developing the Training Centre into becoming a self sustaining "Centre of Excellence". As a possible first action, a retired Head of one the Business Schools should be contracted by CMWSSB to head the Centre.
- Formulation and operation of human resources development plan: The list of training topics identified in the Table below forms the basis of the human resources development plan.

Table: A9.5.6 Training Titles and Estimated number of participants

1. Management Training

S.No	Course Title	Estimated number of participants		
		PIU	CMWSSB	Total
1.	Understanding leadership and management	6	20	26

S.No	Course Title	Estimated number of participants		
		PIU	CMWSSB	Total
1.	Understanding leadership and management	6	20	26
2.	Understanding project management concepts	8	50	58
3.	How to use MS Project / Primavera software for project management	8	50	58
4.	Understanding requirements of construction supervision (Project implementation)	17	50	67
5.	Understanding contract management process and risk management principles	10	30	40
6.	Contract administration and procurement procedures – FIDIC conditions	6	30	36
7.	Understanding JICA procurement procedures	7	8	15
8.	How to monitor and report physical & financial progress of work	18	35	53
9.	Land acquisition, resettlement and rehabilitation policies	10	40	51
10.	How to prepare a traffic management plan	9	30	39
11.	Financial accounting and management in Projects	6	23	29
12.	Understanding commercial banking operations and statutory requirements under IT Act (TDS) and Service Tax for contract management	6	50	56

2. Technical Training

1.	Urban water and sewerage management	Course part of CMWSSB Annual Training calendar		
2.	Construction of water supply and sewerage system - planning, norms, and institutional issues	Course part of CMWSSB Annual Training calendar		
3.	Operation and maintenance of water supply network	Course part of CMWSSB Annual Training calendar		
4.	Preventive maintenance of water and sewerage network	Course part of CMWSSB Annual Training calendar		
5.	Leak detection and loss management in the water supply network	Course part of CMWSSB Annual Training calendar		
6.	How to carry out topographical surveys, using total station equipment	Course part of CMWSSB Annual Training calendar		
7.	Quality Assurance Systems and TQM for Water Supply projects	Course part of CMWSSB Annual Training calendar		
8.	Quality control tests in field and laboratories	Course part of CMWSSB Annual Training calendar		
9.	Reorientation of computer skills with respect to updated versions of MS Office - MS Word and MS Excel, internet explorer, send e-mails and carry out electronic data transfer	Course part of CMWSSB Annual Training calendar		
10.	Performance and operating conditions of RO and nano-filtration technology for seawater desalination using Membrane Processes	11	50	61
11.	Reverse Osmosis Operation and Maintenance fundamental concepts about RO systems	11	50	61
12.	Reverse Osmosis Monitoring, Interpreting Water Analysis, Bio-fouling Control Recordkeeping, data interpretation and Reporting	11	50	61
13.	Operations Overview and Environmental Compliance Requirements	11	50	61
14.	How to use GIS and GPS	17	50	67
15.	Basic concept on how to use SCADA	5	15	20
16.	Concepts/ principles of 'Energy management audit'	5	50	55

3. Customized workshops

1.	Understanding elements and developing CMWSSB Quality Policy	3	16	19
2.	Tariff setting and revenue collection practices for	-	100	100

	CMWSSB			
3.	Concepts of asset management	-	18	18
4.	How to enter asset data, generate reports and manage asset e-register	-	120	120
5.	How to prepare an asset maintenance plan for CMWSSB	-	18	18
6.	Customized MIS operations for CMWSSB	15	50	65
7.	Complaint handling system and public relations for CMWSSB	-	100	100

4. Study Tours –

i. In-Country exposure visits for 6 days (10 participants) @ 2 visits per year for 3 years; total participation 60 Nos.

ii. Overseas exposure visits for 5 days (10 participants) @ 1 visit per alternate year over 5 years; total participation 30 Nos.

Each of these training topics have been translated into 'Training profile sheets' which serve as 'Terms of Reference' for those who are to deliver the training. At this early training planning stage, one needs to be open minded and flexible on aspects like duration, training methods etc. However, clear titles, precise training objectives and a short description of the key concept in key words, or indicative course contents, has been provided to avoid confusion when the modules are to be produced by training providers. Wherever '***Case Studies***' have been suggested, it is expected that the training providers will assimilate '***best practices***' globally and use them as a method of demonstration to the participants. The next section includes these Training profile sheets

Training profile sheets

TITLE	**Understanding Leadership and Management**
TARGET GROUP	PIU: PD, PM, FM, select Dy PM - CMWSSB: select CE, SE and EE; ED, GM
OBJECTIVE / S	After the training the participants will be able to 1. develop a change management plan 2. find solutions to leadership issues at the work place
KEY CONCEPTS-	• What is leadership? The difference between leadership and management; Assessing leadership competencies and developmental needs; Articulate leadership vision, in light of the assessment, and consider the best way(s) to realize it • Processes for establishing direction, aligning people, and motivating people to follow the vision • Identifying different leadership style: Tasking, Encouraging, Steering, Entrusting • Leading Effective Teams • What is a team? The stages of team development: Forming, Storming, Norming, Performing, Adjourning • Leading and maintaining effective, productive teams • Evaluating team progress and coaching team members as necessary • Building Relationships: How individual differences affect your ability to lead • Identifying motivational patterns: How to be more influential by understanding motivational patterns; Using an understanding of individual differences to help manage conflict more effectively • Ethics and Leadership: The definition of ethics and the link between ethics and trust; The role of ethical 16erkeley16 and leadership; The difference between personal and organizational ethics; Discuss the effect of the triple constraint on ethics • Negotiating Conflict; Major sources of conflict on project teams • The five modes of handling conflict – Forcing, Smoothing,

	Withdrawing, Compromising, Problem Solving • The difference between competitive negotiation and collaborative negotiation • Conflict scenarios and strategies for initiating conflict resolution • Power bases used in typical organizations • How to plan and conduct collaborative negotiation • Leading Change – Self's Role in a changing organization; Predictable stages of adjusting to change; Appropriate leadership strategies for each stage • Developing a change management plan
	Mock exercises and Role Plays
DURATION	Three (3) Days
VENUE – Institute, Location	Indian Institute of Management, Bangalore
METHOD/S	Interactive group discussions, Group Discussions, Working exercises
COST (Indicative approximation)	INR 19500 per head per day

Source: JICA Study Team

TITLE	**Understanding Project Management concepts**
TARGET GROUP	PIU: PD, PM, FM, Dy PM - CMWSSB: CE, SE, select EE & AEE
OBJECTIVE / S	After the training the participants will be able to
	1. Understand the concepts
	2. Apply project management principles
	3. Use Project Management Planning Software
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Introduction to Project Management; What are "projects"?;Why project management?
	• The project life cycle; Influences on a project; Key stakeholders
	• Project management process groups; Project manager responsibilities
	• Project Initiation
	• Understanding the role of senior management
	• Needs Assessment; Project selection; Benefit/cost ratio; Present value and net present value
	• Building SMART objectives – Specific, Measurable, Agreed to, Realistic, Time-constrained
	• Developing Requirements; Project charters; Project Requirements Document
	• Project Planning; Scope planning; The work breakdown structure
	• Estimating; Schedule Planning
	• Network Diagrams – CPM; Speeding up the Schedule
	• Project Management Planning Software – PRIMAVERA / MS PROJECT (OVERVIEW ONLY – Software training covered separately)
	• Cost Planning
	• Responsibility Matrix; Resource Loading and Levelling; Risk Planning; Procurement
	• Planning; Communication and quality planning
	• Project Implementation; Baselines; Developing the project team; Organizations and team structures; Managing change; Managing Risk
	• Performance reporting; Assessing and monitoring project performance
	• Reserves; Earned value; Sunk costs
	• Project Closeout – Scope verification and acceptance; Administrative and contractual closure
	• Transferring lessons learned to current/future project
	• Case study
DURATION	Two (2) Days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from Project Management Institute, NOIDA
METHOD/S	Interactive group discussions, Group Discussions, Working exercises
COST (Indicative approximation)	INR 3500 per head per day

Source: JICA Study Team

TITLE	**How to use Primavera / MS Project software for project management**
TARGET GROUP	PIU: All Dy PM, all FE CMWSSB: select EE & AEE
OBJECTIVE / S	After the training the participants will be able to
	1. Understand the concepts
	2. Confidently apply Primavera / MS Project software for project management in current works
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	Overview • Building a Project plan. • Networking techniques for Time, Resource and Cost Scheduling – Tracking and Monitoring of projects • Multiple Project Management, Data interface with Excel • Project coordination and integration management • Tracking Progress • Assessing the quality of the project. • Communication
	Software demonstration and application • Activities, Calendars- Definition, Sequencing & Estimate Duration • How to Develop a Schedule Plan and Control • Network Analysis-CPM, PERT,PDM • How to Prepare Work Breakdown Structure (WBS) • How to update WBS • Constraints • How to Manage Cost in a Project • How to do Resource Planning and Cost Estimation • How to Prepare Resource Sheet • How to Apply Resource to each Activity • How to Define Resource Pool and to Allocate Resources • Filters and Grouping • How Material Resources are being allocated • Analyzing resources using Crashing, Stretching & Splitting • Earned Value Analysis • Method of Developing Different types of reports according to Industrial needs • Schedule in multiple Projects • Customization • Exercise Project
	Practical exercises to reinforce topics covered
DURATION	Four (4) Days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from Project Management Institute, NOIDA
METHOD/S	Interactive group discussions, Group Discussions, Working exercises
COST (Indicative approximation)	INR 3500 per head per day
Special requirements	One computer should be available per participant with Primavera / MS Project software

Source: JICA Study Team

TITLE	**Understanding requirements of Construction Supervision (Project Implementation)**
TARGET GROUP	PIU: PM, All Dy PM, all FE, CMWSSB: select SE's, select EE & AEE
OBJECTIVE / S	After the training the participants will be able to
	1. Prepare a checklist / Do-list to follow when supervising projects
	2. Implement best practices of construction supervision
	3. Execute timely closure to the projects supervised
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Overview of contract documents
	• Roles of Employer, Engineer and Contractor, Contract Administration
	• Encumbrances at site, social and environment concerns
	• Specifications and standards
	• Quality control, testing procedures, recording of results

	• Quantity measurements and checks, recording of measurement
	• Variation Orders, fixing of rates
	• Liquidated Damages, Updating of Program, Extension of time
	• Determination of Contract
	• Dispute Resolution Mechanisms
	• Processing of IPCs and Final Payments
	• Supervision during Defect Liability Period
	• Case Study
DURATION	Two (2) days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from Engineering Staff College of India, Hyderabad
METHOD/S	Interactive presentations
COST (Indicative approximation)	INR 3000 per head per day

Source: JICA Study Team

TITLE	**Understanding Contract Management process**
TARGET GROUP	PIU: PM, FM, All Dy PM, all FE, CMWSSB: select SE's, select EE & AEE, CoF, Dy. CoF
OBJECTIVE / S	After the training the participants will be able to
	1. Understand the concepts
	2. Apply contract management principles to current / future projects
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Contract management definition; Description and uses of contracts; Client and Contractor perspectives
	• Teamwork—Roles and Responsibilities; Concept of agency; Types of authority; Privacy of contract; Contractor personnel
	• Concepts and Principles of Contract Law; Mandatory elements of a legally enforceable contract; Terms and conditions; Remedies; Interpreting contract provisions
	• Contracting Methods; Contracting methods—competitive and noncompetitive; Purchase cards, imprest funds or petty cash; Sealed bidding, two-step sealed bidding, competitive negotiation and competitive proposals;
	• Purchase agreements vs. contracts; Single-source negotiation vs. sole-source negotiation
	• Developing Contract Pricing Agreements; Uncertainty and risk in contract pricing
	• Categories and types of contracts; Incentive; Fixed-price; Time and materials; Cost-reimbursement ; Selecting contract types
	• Pre-award Phase: Buyer activities –Plan purchases and acquisitions; Plan contracting; Request response; Bid/no-bid decision; Bid or proposal preparation
	• Award Phase: Source selection process; Selection criteria: management, technical and price criteria; Evaluation standards, Evaluation procedures
	• Negotiation objectives; Negotiating a contract; Tactics and counter-tactics; Document agreement or walk away
	• Contract Administration: Key contract administration policies, Continued communication, Tasks for Client and Contractor
	• Contract analysis: Performance and progress; Records, files and documentation
	• Resolving claims and disputes
	• Termination
	• Case studies
DURATION	Three (3) days
VENUE – Institute, Location	National Institute of Management Studies, (NIMS) Chennai
METHOD/S	Interactive presentations, Practical working exercises
COST (Indicative approximation)	INR 1800 per head per day

Source: JICA Study Team

TITLE	**Contract administration and procurement procedures – FIDIC**

	conditions
TARGET GROUP	PIU: PM, FM, select Dy PM, select FE, CMWSSB: select SE's, select EE & AEE, CoF, Dy. CoF
OBJECTIVE / S	After the training the participants will be able to
	1. Comprehend the various FIDIC conditions of contract
	2. Carry out procurement using FIDIC conditions of contract
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Introduction o Principles o Background to FIDIC Contracts o Harmonisation based on the type of project o FIDIC Family of Conditions of Contract o Principles and general review of the FIDIC Contracts
	• Features o Structure of the FIDIC contracts o Clauses and other documents in the Contracts for Construction and for Plant & Design-Build o Forms o Terms and definitions
	• User Friendliness o Design Responsibilities and Workmanship o Obligations and quality procedures for design and construction
	• Contract Preparation o Procedures during Construction o Project management procedures during construction o Financial Procedures o Procedures for variations and payment
	• Risk allocation o Works contract and service agreement discrepancies o Claims Procedures o Procedures for submitting and dealing with claims by the Employer and the Contractor o Dispute Resolution o The Dispute Adjudication Board and other dispute resolution procedures
	• Case Study
DURATION	Three (3) Days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from NICMAR (PUNE)
METHOD/S	Interactive presentations
COST (Indicative approximation)	INR 3500 per head per day

Source: JICA Study Team

TITLE	**Understanding JICA procurement procedures**
TARGET GROUP	PIU: PD, PM, FM, All Dy PM, all FE, CMWSSB: select SE's, select EE & AEE, CoF, Dy. CoF
OBJECTIVE / S	After the training the participants will be able to
	1. Understand the concepts
	2. Apply JICA procurement principles to current / future projects
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Definition; Description and uses;
	• Concepts and Principles of Contract Law with respect to JICA; Terms and conditions; Interpreting contract provisions
	• Contracting methods—competitive and non-competitive; Sealed bidding, two-step sealed bidding, competitive negotiation and competitive proposals;
	• JICA prescribed agreements vs. contracts; Single-source negotiation vs. sole-source negotiation
	• Categories and types of contracts; Incentive; Fixed-price; Time and materials; Cost-reimbursement ; Selecting contract types

	• Contract Administration: Key contract administration policies, Continued communication, Tasks for Client and Contractor
	• Contract analysis: Performance and progress; Records, files and documentation
	• Termination
	• Case studies
DURATION	One (1) day workshop
FACULTY	By invitation from JICA, New delhi
VENUE – Institute, Location	In- house, CMWSSB Training Centre
METHOD/S	Interactive presentations, Practical working exercises
COST (Indicative approximation)	INR 500 per head per day

Source: JICA Study Team

TITLE	**How to monitor and report physical & financial progress of work**
TARGET GROUP	PIU: PM, FM, select Dy PM, select FE, CMWSSB: select SE's, select EE & AEE, CoF, Dy. CoF
OBJECTIVE / S	After the training the participants will be able to
	1. Understand the need for progress monitoring and reporting
	2. Monitor and report physical & financial progress of work in the prescribed form
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Overview – principles
	• Choice of Key Performance Indicators ○ Traditional Physical Progress Measurement Limits ○ Effort-Based KPIs ○ Comparison
	• Overall Physical Progress Index ○ Weight Matrix ○ Overall Physical Progress Equation ○ 'S Curve' of the Overall Physical Progress
	• Baseline to Measure Against ○ Planned Baseline ○ Ideal Baseline ○ Comparison
	• Visual Management
	• Document Management System to view ○ Construction equipment details, Meeting/Site visit reports ○ Contract & Correspondence documents, Quality Reports, etc.
	• Executive summary of progress details (including latest, location map, Linear & Numerical progress details)
	• Following type of information from site office ○ Contractor Schedule ○ Work Progress ○ Financial Progress ○ Bill information ○ Quality Maintenance details
	• Customised reports ○ Physical Progress Report – Quantity wise ○ Physical Progress Bar Chart ○ Financial Progress Report ○ Bill payment status report ○ 'S-curve report'
	• Case Study
	• Practical working exercises
DURATION	Three (3) Days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from Engineering Staff College of India, Hyderabad
METHOD/S	Interactive group discussions, Group Discussions, Working exercises
COST (Indicative approximation)	INR 3200 per head

Source: JICA Study Team

TITLE	**Land acquisition, resettlement and rehabilitation policies**
TARGET GROUP	PIU: PM, FM, select Dy PM, select FE, CMWSSB: select SE's, select EE & AEE, CoF, Dy. CoF, select SAO
OBJECTIVE / S	After the Seminar the participants will be able to
	1. Understand the statutes and clauses of LA act
	2. Apply the guidelines in infrastructure projects
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• GoI & GoTN Land acquisition, resettlement and rehabilitation policies
	• Land Acquisition Act
	• Ownerships of land
	• Action necessary for acquisition depending on ownership of land o Private land o Government land o Defence land
	• Importance of accurate valuation
	• Role of CMWSSB officers in land Acquisition
	• Procedure and documentation
	• How to expedite the procedure
DURATION	One (1) day
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from Administrative Staff College of India, Hyderabad
TRAINING METHODS	Interactive presentations, group discussions
COST (Indicative approximation)	INR 3000 per head per day

Source: JICA Study Team

TITLE	**How to prepare a Traffic Management Plan**
TARGET GROUP	PIU: PM, select Dy PM, select FE, CMWSSB: select SE's, select EE & AEE
OBJECTIVE / S	After the training the participants will be able to
	1. Comprehend the national (IRC & UTIPEC) and international guidelines
	2. Understand the use and principles of traffic signs and design the same using IRC 67: 2012
	3. Understand the use and principles of road markings and design the same using IRC 37
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Traffic management at construction zones
	• Safety at constriction zones
	• Traffic management measures at accident sites
	• Traffic management planning in urban areas, rural areas and intercity sections
	• Select and design urban street furniture such as bollards, guard rails and crash barriers
	• Design the bus stops and bus bays for urban conditions
DURATION	Two (2) Days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from Central Road Research Institute, New Delhi
TRAINING METHODS	Interactive presentations and practice sessions
COST (Indicative approximation)	INR 3000 per head per day

Source: JICA Study Team

TITLE	**Financial Accounting and Management in Projects**
TARGET GROUP	PIU: PM, FM, select Dy PM, select FE, CMWSSB: select EE & AEE, CoF, select SAO
OBJECTIVE / S	After the training the participants will be able to
	1. understand succinctly financial accounting concepts
	2. comprehend different principles of financial accounting
	3. Understand Generally Accepted Accounting Principles (GAAP)
	4. Develop skills in analysing and interpreting financial and accounting information
	5. Identify limitations of Financial Accounting
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Introduction o Role of Financial Accounting

	○ Principles of Financial Accounting ○ Importance of Financial Accounting ○ Benefits of Financial Accounting ○ Limitations of Financial Accounting
	• Accounting Principles ○ Accounting Concepts and Conventions ○ Accounting Standards in India and International Accounting Standards
	• Information for decision making both financial and non-financial
	• Understanding and analysing the balance sheet, income statement and cash flow statement
	• Planning, budgeting and cash flow forecasting
	• Cash flow and working capital management
	• Understanding and managing costs
	• Break-even and contribution analysis
	• Driving and monitoring divisional performance
	• Preparing and evaluating capital project appraisals
	• How to drive and monitor performance and create value
	• Case studies
	• Practice exercise
DURATION	Two (2) Days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from ASCI
TRAINING METHODS	Interactive presentations, Case studies, Example exercise
COST (Indicative approximation)	INR 3000 per head per day

Source: JICA Study Team

TITLE	**Understanding commercial banking operations and statutory requirements under IT Act (TDS) and Service Tax for contract management**
TARGET GROUP	PIU: PM, FM, select Dy PM, select FE, CMWSSB: select EE & AEE, CoF, select SAO, AO, JAO
OBJECTIVE / S	After the training the participants will be able to
	1. Conversant with different commercial practices and options
	2. Efficiently use banking facilities
	3. Facilitate compliance with tax rules
KEY CONCEPTS-	• Commercial banking practices and procedures
	• How to open an LC
	• How to prepare BG's
	• Procedure for encashing a BG
	• Provisions relating to TDS under IT ACT and provisions of Service tax law
DURATION	Two (2) Days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from ASCI
TRAINING METHODS	Interactive presentations, Case studies, Example exercise
COST (Indicative approximation)	INR 3000 per head per day

Source: JICA Study Team

TITLE	**How to operate MS Office including MS Word and MS Excel, internet explorer, send e-mails and carry out electronic data transfer**
TARGET GROUP	PIU: select staff who are not conversant with computers CMWSSB: select staff who are not conversant with computers
OBJECTIVE / S	After the training the participants will be able to
	1. Connect computer hardware
	2. Prepare letters and simple reports in MS Word
	3. Tabulate information in MS Excel
	4. Carry out web search and send emails/ transfer data
	5. Use maintenance software
KEY CONCEPTS- INDICATIVE	• Using Windows XP

PROGRAMME OUTLINE	• Working in MS Word
	• Working in MS Excel
	• Zipping / Unzipping files & folders
	• Internet Technologies
	• anti virus software usage
	• Back up procedures
	• Exercises
DURATION	Five (5) Days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	National Informatic Centre (NIC), Chennai
TRAINING METHODS	Interactive presentations, Demonstrations, Example exercise
COST (Indicative approximation)	INR 1800 per head per day
Special requirements	One computer should be available per participant

Source: JICA Study Team

TITLE	**Construction of sewerage system - planning, norms, and institutional issues**
TARGET GROUP	As per CMWSSB Annual training calendar
COST (Indicative approximation)	**CPHEEO Sponsored**

OPTIONAL

OBJECTIVE / S	After the training the participants will be able to:
	1. Understand concepts of Technical Planning, Management and Organization
	2. Carry out selection of a management system
	3. Practice the correct construction procedure
KEY CONCEPTS - INDICATIVE PROGRAMME OUTLINE	• Technical Planning o Route Selection o Sewer Design o Sewer Alignment o Estimating Works
	• Management and Organization o Project Cycle o Levels of Management o Administration and Logistics o Site Management
	• Appropriate Setting Out Methods o General Observations o The Centre Line o Ditching and Sloping
	• Construction Procedures o Site overview o Clearing o Earthworks o Embankments o Drainage o Culverts o Compaction o Erosion Protection
DURATION	Three (3) days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from ESCI, Hyderabad
TRAINING METHODS	Presentations, Group discussions, Case studies
COST (Indicative approximation)	INR 3200 per head per day

Source: JICA Study Team

TITLE	**How to carry out topographical surveys, using total station equipment**
TARGET GROUP	As per CMWSSB Annual training calendar
COST (Indicative approximation)	**CPHEEO Sponsored**

OPTIONAL

OBJECTIVE / S	After the training the participants will be able to

	1. Familiar with every component of the Total Station equipment
	2. Take measurement with the equipment
	3. Collect and present survey data
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Total Station o Technology o Advantages of Total Station Surveying o Limitations
	• Equipment handling procedure o Components Used in Total Station Surveying o RTK Positioning
	• Measurements o Coordinate measurement o Angle measurement o Distance measurement
	• Data processing, recording and data presentation
	• Exercise - Practice session (each participant to practice)
DURATION	Two (2) days
VENUE – Institute, Location	IIT, Madras
TRAINING METHODS	Interactive presentations, Field Demonstration and practice sessions
COST (Indicative approximation)	INR 1300 per head per day

Source: JICA Study Team

TITLE	**Quality Assurance Systems and TQM for Water supply and Sewerage projects**
TARGET GROUP	As per CMWSSB Annual training calendar
COST (Indicative approximation)	**CPHEEO Sponsored**

OPTIONAL

OBJECTIVE / S	After the training the participants will be able to
	1. Explain the meaning of total quality management (TQM)
	2. Identify costs of quality
	3. Apply tools for identifying and solving quality problems
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Overview
	• Elements of total quality management (TQM) • Customer-focused • Total employee involvement • Process-centered • Integrated system • Continual improvement • Fact-based decision making • Communications
	• TQM practices • cross-functional outcome • process management • supplier quality management • customer involvement • information and feedback • committed leadership • strategic planning • cross-functional training • employee involvement
	• How to implement Quality Assurance • Quality management plan • Quality metrics • Process improvement plan • Work performance information • Approved change requests • Quality control measurements • Quality Assurance Outputs • Requested changes • Recommended corrective actions • Project management plan updates

	• Quality Control Methods • Statistical Quality Control with sampling by attributes • Statistical Quality Control with sampling by variables • The seven tools: • Cause-and-effect diagram (also known as the "fishbone" or Ishikawa diagram) • Check sheet • Control chart • Histogram • Pareto chart • Scatter diagram • Stratification (alternately, flow chart or run chart) • Exercise to apply each of the above
	• Quality Audit • Why Audit? • What is an Audit? • Types of Audit • Internal and External Audits • The purpose of an Internal Audit System • The structure of an Internal Audit System • The basic approaches to Auditing • Organizing Audits: Management • Auditors • Exercise in Auditing
DURATION	Five (5) days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from NICMAR (PUNE)
METHOD/S	Interactive presentations, Practical working exercises
COST (Indicative approximation)	INR 3300 per head per day

Source: JICA Study Team

TITLE	**Performance and operating conditions of RO and nano-filtration technology for seawater desalination using Membrane Processes**
TARGET GROUP	PIU: PD, PM, Dy PM, and select FE, CMWSSB: select CE, SE's, EE & AEE
OBJECTIVE / S	After the training the participants will be able to
	Understand practical concepts of products, design process, operation conditions of membrane systems and economics of the membrane desalting and water treatment applications
KEY CONCEPTS - INDICATIVE PROGRAMME OUTLINE	• an introduction to membrane technology, • description of commercial membrane elements, • illustration of the membrane system design process • overview of systems operation.
DURATION	One (1) day
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from IIT, Madras and Perur Plant vendor
TRAINING METHODS	Presentations, Group discussions, Case studies
COST (Indicative approximation)	INR 1300 per head per day

Source: JICA Study Team

TITLE	**Reverse Osmosis Operation and Maintenance fundamental concepts about RO systems**
TARGET GROUP	PIU: PM, Dy PM, and select FE, CMWSSB: select CE, SE's, EE & AEE
OBJECTIVE / S	After the training the participants will be able to
	Understand practical aspects of Operation and Maintenance of RO systems
KEY CONCEPTS - INDICATIVE PROGRAMME OUTLINE	• water contamination, • membranes, • pressure vessels, • operation, • potential problems, • pre-treatment and

	• chemical cleaning.
DURATION	One (1) day
VENUE – Institute, Location	In- house, CMWSSB Desalination Plant Nemmeli/Minjur
FACULTY	By invitation from RO Nemmeli/Minjur DSP Operator, IITM and Perur Plant vendor
TRAINING METHODS	Presentations, Group discussions, Case studies
COST (Indicative approximation)	INR 500 per head per day

Source: JICA Study Team

TITLE	**Reverse Osmosis Monitoring, Interpreting Water Analysis, Bio-fouling Control Recordkeeping, data interpretation and Reporting**
TARGET GROUP	PIU: PM, Dy PM, and select FE, CMWSSB: select CE, SE's, EE & AEE
OBJECTIVE / S	After the training the participants will be able to
	apply basic and advanced understanding of operations to the new plant at Perur

KEY CONCEPTS - INDICATIVE PROGRAMME OUTLINE	Reverse Osmosis Monitoring
	• interpretation of data,
	  ○ permeate conductivity,
	  ○ feed pressures,
	  ○ cleaning and element replacement rates
	• understanding of RO technology,
	• monitoring and troubleshooting skills,
	• understanding of performance trends
	trend interpretation and actions required to correct problems

	Interpreting Water Analysis • source waters, • contaminants, • reading water analysis reports, • evaluating scaling and fouling potentials
	Bio-fouling Control • overview of bacteria, • water characteristics, • design and operational schemes that promote biofouling • case studies
DURATION	One (1) day
VENUE – Institute, Location	In- house, CMWSSB Desalination Plant Nemmeli/Minjur
FACULTY	By invitation from RO Nemmeli/Minjur DSP Operator, IITM and Perur Plant vendor
TRAINING METHODS	Presentations, Group discussions, Case studies
COST (Indicative approximation)	INR 500 per head per day

Source: JICA Study Team

TITLE	**Operations Overview and Environmental Compliance Requirements**
TARGET GROUP	PIU: PM, Dy PM, and select FE, CMWSSB: select CE, SE's, EE & AEE
OBJECTIVE / S	After the training the participants will be able to
	apply basic and advanced understanding of operations to the new plant at Perur
KEY CONCEPTS - INDICATIVE PROGRAMME OUTLINE	• Plant Description • Influent Water Quality • Product Water Quality • Waste Stream Management • Treatment Process Overview • Operational Parameters
	Environmental Compliance • Environmental Compliance Overview • Parameters monitored - Temperature; pH; SDI; Conductivity; Turbidity; TOC; Barium; Boron; Bromide; Chloride; Alkalinity; Hydrogen; Carbonates; Strontium; Sulphates; Calcium; Magnesium; Sodium; Potassium; Total Bacteria; TDS; Colour; Iron; Metals; Total

	Coliform • Reporting Requirements • Facilities
DURATION	One (1) day
VENUE – Institute, Location	In- house, CMWSSB Desalination Plant Nemmeli/Minjur
FACULTY	By invitation from RO Nemmeli/Minjur DSP Operator, IITM and Perur Plant vendor
TRAINING METHODS	Presentations, Group discussions, Case studies
COST (Indicative approximation)	INR 1300 per head per day

Source: JICA Study Team

TITLE	**How to use GIS and GPS**
TARGET GROUP	PIU: All FE, CMWSSB: select AEE, AE / JE
OBJECTIVE / S	After the training the participants will be able to
	1. Comprehend the concept of GPS
	2. Use GIS techniques
	3. Confidently use the GIS and GIS equipment to record data
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• GPS o Basic concept of GPS o Structure ▪ Space segment ▪ Control segment ▪ User segment o Applications o Message format o Satellite frequencies o Demodulation and decoding o Navigation equations o Bancroft's method o Multidimensional Newton-Raphson calculations o Error sources and analysis o Accuracy enhancement and surveying o Augmentation o Precise monitoring o Equipment handling procedure
	• GIS o Applications o GIS techniques and technology o Relating information from different sources o GIS uncertainties o Data representation o Data capture o Raster-to-vector translation o Projections, coordinate systems, and registration o Spatial analysis with GIS o Slope and aspect o Data analysis o Topological o Geometric Networks o Hydrological o Cartographic o Map overlay o Geo-statistics o Address geo-coding o Reverse geo-coding o Multiple Criteria Decision Analysis o Data output and cartography o Graphic display techniques o Spatial Extract, Transform, Load (ETL) software o GIS data mining

	○ OGC standards ○ Equipment handling procedure
	• 'MAP INFO' TRAINING (OPTIONAL) ○ File operations (open & close MapInfo; transfer files between directories; add & delete files & workspaces) ○ Move around an open Mapper (pan, zoom, change scale, grabber etc.) ○ Examine & interpret data in a Mapper or browser view ○ Change the appearance of a map ○ Use of labelling & the I Tool; use of layer control ○ Carrying out simple queries (by attribute & by location) ○ Simple thematic mapping & graphing ○ Map layout; making & printing a map ○ Adding a field to a browser table; attribute data entry; computing the contents of a field ○ Importing data from a spreadsheet ○ Simple SQL queries ○ An integrating exercise ○ The underpinning principles of a GIS ○ Directories & folder structures ○ Difference between vector & raster data ○ The importance of coordinate & IDs ○ The difference between graphic features & their attributes ○ What is thematic mapping; main types; where & how to use ○ What are the main GIS functions
	• Practical exercises to reinforce topics covered
DURATION	Three (3) Days
VENUE – Institute, Location	By invitation from Anna University, Chennai
TRAINING METHODS	Interactive presentations, Demonstrations, Example exercise
COST (Indicative approximation)	INR 1800 per head per day

Source: JICA Study Team

TITLE	**Concepts of Asset management**
TARGET GROUP	CMWSSB: ED, GM, FD, select SE, EE, AEE, AE / JE
OBJECTIVE / S	After the Workshop the participants will be able to:
	1. Understand the role asset management plays in supporting organizational strategy and objectives
	2. Comprehend the principles of asset whole life costing
	3. Describe the role of Risk Management in effective Asset Management
	4. Measure the Asset Management performance
KEY CONCEPTS - INDICATIVE PROGRAMME OUTLINE	• Introduction to Asset Management
	• What is Asset Management? ○ The benefits of AM over traditional approaches ○ Asset Management Roles & Responsibilities
	• Asset Management Policy ○ Outline an Asset Management Policy. ○ Relevance of Policies and Strategies ○ Overview of developing a policy
	• Asset Management Strategy ○ What is an Asset Management Strategy? ○ Outline an Asset Management Strategy ○ Overview of Developing a Strategy
	• Asset Management Planning ○ What is an Asset Management Plan? ○ Outline of an Asset Management Plan ○ Overview of developing a Plan
	• Whole of Life Costing ○ Outline Whole of Life Costing principles ○ Total Cost of Ownership

	○ Case Study – Replace v Repair
	• Importance of Risk Management in Asset Management
	• Importance of measuring Asset Management performance
	• Benefits of a Structured Approach to Asset Management
	• Case Study – Outline the benefits of AM
DURATION	One (1) day
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from ESCI and Customised Asset Management Software vendor
METHOD/S	Interactive presentations, Group discussions, Case studies
COST (Indicative approximation)	INR 3000 per head per day

Source: JICA Study Team

TITLE	**How to enter asset data, generate reports and manage asset e-register**
TARGET GROUP	CMWSSB: select SE, EE, AEE, AE / JE
OBJECTIVE / S	After the training the participants will be able to
	1. Understand the need for maintaining an asset register
	2. Authenticate and enter correct data in the asset e-register
	3. Generate customised and annual reports for management review
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Overview of asset management software
	• Basic data requirements
	• Data fields and data entry requirements
	• How to prepare and present customized /general reports
	• Example exercises
DURATION	Two (2) days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from vendor of Customised Asset Management Software
METHOD/S	Interactive presentations, Group discussions, Case studies
COST (Indicative approximation)	INR 500 per head per day
Special requirements	One computer should be available per participant

Source: JICA Study Team

TITLE	**How to enter data, and generate MIS reports**
TARGET GROUP	CMWSSB: select SE, EE, AEE, AE / JE
OBJECTIVE / S	After the training the participants will be able to
	1. Enter data
	2. Generate reports
	3. Analyze results
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Overview of MIS fields
	• Basic data collection protocol
	• Basic data entry requirements
	• Data fields and data entry requirements
	• How to prepare and present customized /general reports
	• Example exercises
DURATION	Two (2) days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from vendor of Customised MIS Software
METHOD/S	Interactive presentations, Group discussions, Case studies
COST (Indicative approximation)	INR 500 per head per day
Special requirements	One computer should be available per participant

Source: JICA Study Team

TITLE	**Understanding public relations and operate complaint handling system for CMWSSB**
TARGET GROUP	CMWSSB: select SE, EE, AEE, AE / JE (DM), JAO

OBJECTIVE / S	After the training the participants will be able to
	1. listen & log complaints; track the records during future references
	2. coordinate with the unit responsible for action
	3. access data
	4. communicate effectively so at to satisfy the customer
	5. understand the technicalities involved
	6. know about tariffs, billing and collection rules
	7. handle emergency situations
KEY CONCEPTS- INDICATIVE PROGRAMME OUTLINE	• Customer oriented communication skills
	• Basic computer data accessing skills
	• How to handle pressure situations
	• Telephonic conversations
	• Customer oriented communication skills
	• Basic computer data accessing skills
DURATION	Two (2) days
VENUE – Institute, Location	In- house, CMWSSB Training Centre
FACULTY	By invitation from ASCI, Hyderabad and vendor of Customised complaint handling system software
METHOD/S	Presentations, demonstrations and role plays
COST (Indicative approximation)	INR 3000 per head per day
Special requirements	Projection system, phone lines, one computer should be available per participant

Source: JICA Study Team

Table: A9.5.7 Per participant Per Day Cost when visiting the institute

All Figures in INR.

	Per participant per day cost				
Institute	**Institute Fee + Lodge + Board**	**D A***	**Travel cost***	**Total**	**Rounded off**
IIM (Bangalore)	17000	500	2000	19500	19500
PMI (NOIDA)	14000	500	5000	19500	19500
ESCI (HYD)	11000	500	2000	13500	13500
ASCI (HYD)	11000	500	2000	13500	13500
NICMAR (PUNE)	8000	500	2500	11000	11000
CRRI (DEL)	5000	500	5000	10500	10500
IIT Madras (CHENNAI)	3000	0	0	3000	3000
ANNA University (CHENNAI)	2000	0	0	2000	2000
NIMS (CHENNAI)	3000	0	0	3000	3000
NIC (Chennai)	2000	0	0	2000	2000

*Although, TA, DA is slightly varying for the different levels, for budgeting purpose the highest figures have been considered

Source: JICA Study Team

Table: A9.5.8 Per participant Per Day Cost when faculty is invited (group of 2 faculty) for 3-5 day programmes

All Figures in INR

Institute	**Visiting Faculty Fee Per day**	**Visiting Faculty TA + DA**	**Venue cost**	**Total**	**Per participant per day cost (20 participants)**	**Misc. cost, Tea, snacks, stationery per day**	**Participant TA + DA**	**Total**	**Rounded Total**
PMI (NOIDA)	60000	0	0	60000	3000	500	0	3500	3500
ESCI (HYD)	45000	9000	0	54000	2700	500	0	3200	3200
ASCI (HYD)	45000	9000	0	54000	2700	500	0	3200	3200
NICMAR (PUNE)	60000	0	0	60000	3000	500	0	3500	3500
CRRI (DEL)	40000	9000	0	49000	2450	500	0	2950	3000
IIT Madras (CHENNAI)	25000	0	0	25000	1250	500	0	1750	1800
ANNA University (CHENNAI)	25000	0	0	25000	1250	500	0	1750	1800
NIMS (CHENNAI)	25000	0	0	25000	1250	500	0	1750	1800
NIC (Chennai)	25000	0	0	25000	1250	500	0	1750	1800

Source: JICA Study Team

Table: A9.5.9 Per participants Per Day Cost when faculty (group of 2 faculty) is invited for 1-2 day workshops

All Figures in INR

Institute	Visiting Faculty Fee Per day	Visiting Faculty TA + DA	Venue cost	Total		Per participant per day cost (25 participants)	Misc. cost Tea, snacks stationary	Participant TA + DA	Total	Rounded off
PMI (NOIDA)	75000	0	0	75000		3000	500	0	3500	3500
ESCI (HYD)	50000	6000	0	56000		2240	500	0	2740	3000
ASCI (HYD)	50000	6000	0	56000		2240	500	0	2740	3000
NICMAR (PUNE)	70000	0	0	70000		2800	500	0	3300	3300
CRRI (DEL)	50000	6000	0	56000		2240	500	0	2740	3000
IIT Madras (CHENNAI)	18000	0	0	18000		720	500	0	1220	1300
ANNA University (CHENNAI)	18000	0	0	18000		720	500	0	1220	1300
NIMS (CHENNAI)	18000	0	0	18000		720	500	0	1220	1300
NIC (Chennai)	18000	0	0	18000		720	500	0	1220	1300
IN-House (CMWSSB Training Centre)	0	0	0	0		0	500	0	500	500

Source: JICA Study Team

Study Tours –

Table: A9.5.10 In-Country exposure visits for 6 days (10 participants)

Cost head	Per participant cost	Amount
Travel	20000	200000
Lodge & Board	24000	240000
Visit management charges	5000	50000
Total	49000	490000

Source: JICA Study Team

- Say INR 5,00,000/- per visit

Table: A9.5.11 Overseas exposure visits for 5 days (10 participants)

Cost head	Per participant cost	Amount
Travel (incl. local travel plus visa cost)	70000	700000
Lodge & Board (@ US$ 120)	39000	390000
Visit management fee/charges	85000	850000
Total	194000	1940000

Source: JICA Study Team

- Say INR 20,00,000/- per visit

Table: A9.5.12 Summary of Training Cost

S. No.	Course Title	Training Provider	Estimated number of participants	Course duration (Days)	Per head Per day cost (INR)	Total INR
Management Training						
1.	Understanding leadership and management	IIM-Blr	26	3	19500	1521000
2.	Understanding project management concepts	PMI-Noida	58	2	3500	406000
3.	How to use MS Project / Primavera software for project management	PMI-Noida	58	4	3500	812000
4.	Understanding requirements of construction supervision (Project implementation)	ESCI-HYD	67	2	3000	402000
5.	Understanding contract management process and risk management principles	NIMS-Chennai	40	3	1800	216000
6.	Contract administration and procurement procedures – FIDIC conditions	NICMAR-Pune	36	3	3500	378000
7.	Understanding JICA procurement procedures	JICA	15	1	500	7500
8.	How to monitor and report physical & financial progress of work	ESCI-HYD	53	3	3000	477000
9.	Land acquisition, resettlement and rehabilitation policies	ASCI-HYD	51	1	3000	153000
10.	How to prepare a traffic management plan	CRRI-DEL	39	2	3000	234000
11.	Financial accounting and management in Projects	ASCI-HYD	29	2	3000	174000
12.	Understanding commercial banking operations and statutory requirements under IT Act (TDS) and Service Tax for contract management	ASCI-HYD	56	2	3000	336000
					Sub Total A	**5116500**
Technical Training						
1.	Urban water and sewerage management	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
2.	Construction of water supply and sewerage system - planning, norms, and institutional issues	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
3.	Operation and maintenance of water supply network	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
4.	Preventive maintenance of water and sewerage network	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
5.	Leak detection and loss management in the water supply network	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
6.	How to carry out topographical surveys, using total station equipment	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
7.	Quality Assurance Systems and TQM for Water Supply projects	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
8.	Quality control tests in field and laboratories	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
9.	Reorientation of computer skills updated versions of MS Office	Course part of CMWSSB Annual Training calendar				CPHEEO sponsored
10.	Performance and operating conditions of RO and nano-filtration technology for seawater desalination using Membrane Processes	IITM-Chennai	61	1	1300	79300
11.	Reverse Osmosis Operation and Maintenance fundamental concepts about RO systems	DSP Operator	61	1	500	30500
12.	Reverse Osmosis Monitoring, Interpreting Water Analysis, Bio-fouling Control Recordkeeping, data interpretation and Reporting	DSP Operator	61	1	500	30500
13.	Operations Overview and Environmental Compliance Requirements	IITM-Chennai	61	1	1300	79300

14.	How to use GIS and GPS	ANNA University	67	3	1800	361800
15.	Basic concept on how to use SCADA	DSP Operator	20	1	500	10000
16.	Concepts/ principles of 'Energy management audit'	DSP Operator	55	1	500	27500
					Sub Total B	**618900**
Customized workshops						
1.	Understanding elements and developing CMWSSB Quality Policy	ASCI-HYD	19	1	3000	57000
2.	Tariff setting and revenue collection practices for CMWSSB	ASCI-HYD	100	1	3000	300000
3.	Concepts of asset management	ESCI-HYD	18	1	3000	54000
4.	How to enter asset data, generate reports and manage asset e-register	Software Vendor	120	2	500	120000
5.	How to prepare an asset maintenance plan for CMWSSB	ESCI-HYD	18	1	3000	54000
6.	Customized MIS operations for CMWSSB	Software Vendor	65	2	500	65000
7.	Complaint handling system and public relations for CMWSSB	Software Vendor	100	2	500	100000
					Sub Total C	**750000**

Source: JICA Study Team

Study Tours –

i. In-Country exposure visits for 6 days (10 participants) @ 2 visits per year for 3 years; total participation 60 Nos. i.e. 6 batches @ INR 5,00,000/- per batch = INR 30,00,000/-

ii. Overseas exposure visits for 5 days (10 participants) @ 1 visit per alternate year over 5 years; total participation 30 Nos. i.e. 3 batches @ INR 20,00,000/- per batch = INR 60,00,000/-

Sub Total D = 90,00,000/-

Total Cost = Sub Totals A + B + C + D = 1,54,85,400/-

Table A.9.5.13A Organizational Strengthening Action Plan - Schedule

.	Activity Group	Actions	2016		2017				2018				2019				2020				2021				2022			
			Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Autonomous business operations	Develop, Draft, get Board approval and implement cost-recovery policies - Tariff revision, 100% metering, incentive for metering, outsourcing billing and collection			■	■	■																					
		Frame policy to redefine mandate of existing departments and evolve new units to undertake new responsibilities				■	■	■	■	■	■	■	■															
		Redefine policy with revised administrative and financial powers at CE, SE & EE levels			■	■	■																					
		Develop and introduce human resource development policy			■																							
2	Business Planning	Define long term goals and targets (20 Years) of 'Service Level Indicators', assign responsibilities and communicate to those concerned			■	■				■				■				■				■			■			
		Define benchmaks, agree on annual, midium term and long term targets with respect to Key Financial Indicators, i.e. Revenue Income, Revenue Expenditure			■	■				■				■				■				■			■			
		Monitor progress on the basis of predefined periodicty, evaluate targets and carry out course correction					■				■				■				■				■				■	
3	Water and Sewerage tariff revision and collection system	Prepare and implement promotional campaign for individual house connection						■			■			■			■			■			■			■		
		Notify Consumers and campaign for mandatory water supply and sewerage connection, announcing incentives							■			■			■			■			■			■			■	
		Carry out door-to-door survey to collect data and prepare report on -							■	■	■	■	■	■														
		i) Status of installed water meters							■	■	■	■	■	■														
		ii) Illegal and unauthorized connections							■	■	■	■	■	■														
		iii) Other water connections (non-revenue generating)							■	■	■	■	■	■														
		iv) Present revenue system (meter reading, billing, revenue collection…etc.)							■	■	■	■	■	■														
		Study survey data report and develop metering implimentation plan											■	■														
		Implement improved service delivery plan based on survey results												■	■	■	■	■										
		Design an improved revenue collection system and carry out pilot of the revamped payment system (to include outsourcing of part /all activities of revenue collection)											■	■														
		Carry out campaign against defaulters and illegal connections													■	■			■	■			■	■			■	■
		Carry out enforcement of tariff collection 'Rules and Regulations'															■	■	■	■	■	■	■	■	■	■	■	■
4	Developing a reliable asset management system	Prepare list of assets of the existing water supply and sewerage facilities and operation offices, clarification of ownership, and asset evaluation							■	■	■	■	■	■	■	■	■	■	■	■	■	■						
		Prepare asset inventory, integrated operation with information management system							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
		Run pilot to debug the system											■	■														
		Establish asset management and operation within CMWSSB: linking financial management and O& M application (well programmed maintenance, proper timing of replacement of equipment)													■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Build in-house capacity through handholding and helpdesk													■	■	■	■	■	■	■	■	■	■	■	■	■	■
5	Management information system (MIS)	Study the current management/monitoring practices (situational analysis and needs analysis)													■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Prepare basic details of inventory of fields required for MIS - organization, operations, personnel, finance, assets, etc.													■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Design MIS for water supply and sewerage works													■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Develop, install and pilot test the MIS operations																	■	■								
		Prepare manual for MIS operations																	■									
		Establish and operationalize GIS database of water supply and sewerage facilities																	■	■	■	■	■	■	■	■	■	■
		Establish periodicity of data collection / monitoring system																	■									
		Implement data collection / monitoring system of water supply and sewerage network and at WTP/STP facilities																	■	■	■	■	■	■	■	■	■	■

.	Activity Group	Actions	2016		2017				2018				2019				2020				2021				2022			
			Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
6	Improved non-revenue water (NRW) management	Establish series of District Metering Areas (DMA)																										
		Perform acoustic leak detection per DMA																										
		Identify NRW through district metering analysis																										
		Analyze Meter Tampers																										
		Manage Distribution System Pressure																										
		Take corrective actions																										
7	Improved customer services	Study and evaluate the existing public relations and complaint handling system to decentralize																										
		Prepare water supply and sewerage specific REVISED 'Citizens' charter'																										
		Design a complaint handling system using the MIS based on Citizens' charter'																										
		Prepare complaint handling system manual																										
		Implement the improved public relations strategy and 'complaint handling system'																										
8	Improved HR management and TNA based HR development	Establish Project Implementation Unit (PIU) {Board Resolution}																										
		Establish Desalination unit																										
		Strengthen quality assurance and water conservation function																										
		Establish Commercial /Stakeholder Engagement Cell																										
		Introduce IT enabled HRM processes																										
		Define KRAs & KPI's, introduce 'Performance Management System'; Carry out annual review																										
		Develop Training Centre into self sustaining "Centre of Excellence"																										
		Conduct trainings for PIU & CMWSSB staff																										

Mobilization of PMC Services

JICA Study Team

Table A.9.5.13 B Organizational Strengthening Action Plan

S.No	Activity Group	Key Actions	Current status	Responsible department/section in CMWSSB	Timeline	Performance Indicator	Lead Implementing Agency
1	Autonomous business operations	Develop, Draft, get Board approval and implement cost-recovery policies - Tariff revision, 100% metering, incentive for metering, outsourcing billing and collection	(a) A draft on Tariff revision has been prepared sought for GoTN approval. (b) Guezzette on Service level bench mark hass been published vide L&G-2/2124/2015 dated 10.03.16	Finance Departement [FD]	Jan-17 to Sep-17	100% Metering.	CMWSSB
		Frame policy to redefine mandate of existing departments and evolve new units to undertake new responsibilities	-	Personnel & Administration Department [P&A]	Apr-17 to Mar-19	Approved policy	CMWSSB
		Redefine policy with revised administrative and financial powers at CE, SE & EE levels	Deligation of power with effect from 2010 and need updation on the same	P&A	Jan-17 to Sep-17	Policy on redefined delegation of powers	CMWSSB
		Develop and introduce human resource development policy	M/s Deliote has prepared the human resource development policy, sought approval from Board.	P&A	Jan-17 to Mar-17	Approved policy	CMWSSB

2	Business Planning	Define long term goals and targets (20 Years) of 'Service Level Indicators', assign responsibilities and communicate to those concerned	To prepare the 20 years service level Indiactors	Operations & Maintenance [O&M]	Jan-17 to Mar-22	Approved policy on Service Level indicators for 2035	CMWSSB
		Define benchmarks, agree on annual, medium term and long term targets with respect to Key Financial Indicators, i.e. Revenue Income, Revenue Expenditure	-	FD	Jan-17 to Mar-22	Medium / Long term objectives defined. Implementation of long term objectives already initiated and continues	CMWSSB
		Monitor progress on the basis of predefined periodicity, evaluate targets and carry out course correction	-	FD and O&M	Jul-17 to Sep-22	Updattion of Medium and Long Term Business plan achieved based on targets set	CMWSSB
3	Water and Sewerage tariff revision and collection system	Prepare and implement promotional campaign for individual house connection	Promotion campaign is being carriedout for expanded area in new water distribution network	O&M	Oct-17 to Jun-22	Short / Medium / Long term plans to be defined and targets to be achieved.	CMWSSB
		Notify Consumers and campaign for mandatory water supply and sewerage connection, announcing incentives	Not available	O&M	Jan-18 to Sep-22	Short / Medium / Long term plans to be defined and targets to be achieved.	CMWSSB
		Carry out door-to-door survey to collect data and prepare report on -	Survey to be conducted	FD and O&M			PMC
		i) Status of installed water meters	Existing details are available and needs updation	O&M	Jan-18 to Jun-19	Achivement of 100% metering, set annual targets to achieve the same	PMC

		ii) Illegal and unauthorized connections				Achiving 0% un-authorization connections	PMC
		iii) Other water connections (non-revenue generating)				Minimization of non-revenue generating connections	PMC
		iv) Present revenue system (meter reading, billing, revenue collection…etc.)		FD		Short / Medium / Long term objectives & targets to be set for achiving 100% efficieny	PMC
		Study survey data report and develop metering implementation plan		O&M	Jan-19 to Jun-19	Phased development plan for Implementation to achieve 100% metering	PMC
		Implement improved service delivery plan based on survey results		O&M	Apr-19 to June-20	Phased development plan for Implementation to achieve 100% coverage	PMC
		Design an improved revenue collection system and carry out pilot of the revamped payment system (to include outsourcing of part /all activities of revenue collection)	At present, CMWSSB is carrying out revenue collection through Depo office, Area office, Head office. No outsourcing is practiced.	FD	Jan-19 to Jun-19	Implementation of Pilot and phase wise implementation for target area	PMC and CMWSSB
		Carry out campaign against defaulters and illegal connections	Being carried out by CMWSSB	O&M	Jul-19 to Dec-22	Achiving 0% un-authorization connections	CMWSSB

		Carry out enforcement of tariff collection 'Rules and Regulations'	Being carried out by CMWSSB for Corporation area	O&M	Jan-20 to Dec-22	Regular Monitoring and 100% Consumer awareness	CMWSSB
4	Developing a reliable asset management system	Prepare list of assets of the existing water supply and sewerage facilities and operation offices, clarification of ownership, and asset evaluation	CMWSSB has assets information and needs updation	O&M	Jan-18 to Jun-21	Creation of Asset Map and functions to customize	PMC
		Prepare asset inventory, integrated operation with information management system	Not available	O&M	Jan-18 to Mar-22		PMC
		Run pilot to debug the system	-	O&M	Jan-19 to Jun-19	Implementation of Pilot and phase wise implementation for target area	PMC
		Establish asset management and operation within CMWSSB: linking financial management and O&M application (well programmed maintenance, proper timing of replacement of equipment)	-	FD and O&M	Jul-19 to Dec-22	Updation of Asset Managemnt System linking to O&M activities	PMC
		Build in-house capacity through handholding and helpdesk	-	O&M	Jul-19 to Dec-22	Establishment of Helpdesk	PMC
5	Management information system (MIS)	Study the current management/monitoring practices (situational analysis and needs analysis)	Existing information available and need updation	P&A	Jul-19 to Dec-22	Establishment of data management & analysis centre [MIS cell]	PMC & CMWSSB
		Prepare basic details of inventory of fields required for MIS - organization, operations, personnel, finance, assets, etc.	-	P&A	Jul-19 to Dec-22	Functional MIS database with customization tools	PMC

		Design MIS for water supply and sewerage works	-	P&A	Jul-19 to Dec-22		PMC
		Develop, install and pilot test the MIS operations	-	O&M and P&A	Jul-20 to Dec-20	Implementation of Pilot and phase wise implementation for target area	PMC
		Prepare manual for MIS operations	-	O&M and P&A	Jul-20 to Sep-20	Manual for MIS operations, customization & updation	PMC
		Establish and operationalize GIS database of water supply and sewerage facilities	-	O&M and P&A	Jul-20 to Dec-22	Functional GIS database to integrate with MIS	CMWSSB
		Establish periodicity of data collection / monitoring system	-	O&M	Jul-20 to Sep-20	GIS / MIS database updation, analysis & reporting	CMWSSB
		Implement data collection / monitoring system of water supply and sewerage network and at WTP/STP facilities	-	O&M	Jul-20 to Dec-22	Monitoring & Updation on regular basis	CMWSSB
6	Improved non-revenue water (NRW) management	Establish series of District Metering Areas (DMA)	-	O&M	Jan-18 to Jun-18	Comprehensive plan for District Metering Area (DMAs)	PMC
		Perform acoustic leak detection per DMA	-	O&M	Jul-18 to Dec-22	Leak Detection Activties to mitigate water loss due to leaks	PMC
		Identify NRW through district metering analysis	-	O&M	Oct-18 to Mar-22	NRW to be limited to set target to comply Plan for Service Level Indicators	PMC

		Analyze Meter Tampers	-	O&M	Oct-18 to Mar-22	Achiving 100% tampering of meters through enforcement & consumer awareness	PMC & CMWSSB
		Manage Distribution System Pressure	-	O&M	Oct-18 to Mar-22	Minimum Residual Pressure of 7m to be achived [CPHEEO]	PMC & CMWSSB
		Take corrective actions	-		Jul-19 to Sep-22	Monitor, Record, Analyze & Achieve	PMC
7	Improved customer services	Study and evaluate the existing public relations and complaint handling system	Complaint handling system is available	O&M	Jan-18 to Sep-18	Quality of services to be analyzed and benchmarks to be set	PMC
		Prepare water supply and sewerage specific REVISED 'Citizens' charter'	-	O&M	Oct-18 to Dec-18	Assessment of Value for Money in delivery of services	PMC
		Design a complaint handling system using the MIS based on Citizens' charter'	-	O&M	Jan-19 to Sep-19	Functional MIS linked complaint redressal system	PMC
		Prepare complaint handling system manual	-	O&M	Oct-19 to Dec-19	User friendly complaint handling system	PMC
		Implement the improved public relations strategy and 'complaint handling system'	-	O&M	Jul-19 to Dec-22	Average time taken to handle customer complaints / greivances	PMC
8	Improved HR	Establish Project Implementation Unit (PIU) {Board Resolution}	Yet to receive approval from Board	O&M	Oct-16 to Dec-16	Establishment of PIU	CMWSSB

	management and Trainig Need Analysis (TNA) based HR development	Establish Desalination unit	Desalination Unit under O&M is functional and need capacity building	O&M	Apr-17 to Sep-17	Capacity building to handle Desalination Infrastructure	CMWSSB
		Strengthen quality assurance and water conservation function	-	O&M	Jul-17 to Dec-17	Quality Assurance & Feedback	CMWSSB
		Establish Commercial /Consumer Engagement Cell	-	O&M	Oct-17 to Mar-18	Establishment of Cell	CMWSSB
		Introduce IT enabled HRM processes	-	P&A	Jan-18 to Dec-18	Information Strategy and Plan prepared for IT enabled HRM process	PMC & CMWSSB
		Define Key Result Areas (KRA) & Key Performance Indicator's (KPI), introduce ‘Performance Management System’; Carry out annual review	-	P&A	Jan-17 to Mar-22	IT based strategy and plan prepared for Performance Management System	PMC & CMWSSB
		Develop Training Centre into self-sustaining “Centre of Excellence”	Training Cell is functional and need capacity building	Training Centre [TC]	Jan-17 to Mar-18	Establishment of Centre of Excellence	CMWSSB
		Conduct trainings for PIU & CMWSSB staff		TC	Jan-17 to Dec-22	Training needs identified department wise and imparted training (in country & abroad). Training reports prepared & disseminated	PMC & CMWSSB

Appendix 10.1 Project Cost Estimated in the DPR

Item	Amount (million INR)
1. Construction of the seawater desalination plant	
1a. Seawater intake and brine discharge facilities	**2,694**
1b. Seawater intake pumping station	
1c. Seawater desalination facility	**14,179**
(1) Pre-treatment process	(5,883)
(2) RO process	(7,592)
(3) Post-treatment process	(704)
1d. Product water tank and transmission pumping station	**463**
1e. Buildings (Administrative etc.)	**3,854**
1f. Roads, drains, landscaping and compound wall with fencing	**95**
1g. Land development for the plant sites	**248**
1h. Power receiving 110/11 KV substation	**259**
1i. TNEB Sub substation	**310**
1j. Product water transmission mains and water reservoir	**748**
Sub-total 1	**22,849**
2. Others	
2a. Erection @ 5% of E&M cost	**621**
2b. Testing and Commissioning @5% E&M cost	**621**
2c. Contractors overhead and profit @15%	**2,699**
2d. Provision for shifting of underground utilities for Product main @0.5% of 1d	**19**
2e. Provision for physical contingencies @3%	**663**
2f. Project management consultancy @3%	**442**
2g. WCT/Tax @5.5%	**1,004**
Sub-total 2	**6,068**
Grand total	**28,917**

Source: JICA Study Team

Appendix 10.2 Comparison of the Construction Costs in the DPR and the Study

		DPR (Million INR)				JST (Million INR)					
	Item	Civil	E&M	Amount (INR)	Remark	Civil	E&M	Amount (INR)	Remark	JST/DPR	Difference between DPR and JST
1.	CP 1 Construction of the Perur DSP										
1a.	Seawater intake and brine discharge facilities including intake pumping station	586	1,879	2,465		1,557	2,211	3,768		53%	Civil 1) Total pipe installation length has been increase by 47% to based on revised brine discharge simulation. 2) Cost of backfilling has been newly counted. 3) Unit price of dredging work has been updated based on quotation from marine civil contractor. E&M 1) Total pipe length has been increased. 2) Unit price of pipe has been updated based on quotation from Indian plant supplier. 3) Intake pump cost has been increased due to increase intake volume by 7% to ensure sufficient backwash of the pre-treatment system.
1b.	Seawater desalination facility	4,419	8,677	13,096		3,918	13,418	17,336		32%	
(1)	Pre-treatment process	2,392	3,111	5,503		1,775	4,495	6,270		14%	
(1)-1	Lamella	786	754	1,540		677	1,492	2,168		41%	E&M 1) Main equipment costs have been updated based on quotation from Indian plant supplier. 2) Equipment capacity has been increased slightly due to the increased water flow. (After the previous estimation, the price of sludge mixer has been revised based on the comment from the DPR consultant. The cost for valves and pipes have been supplemented.)
(1)-2	DAF	852	1,266	2,118		380	2,102	2,482		17%	Civil The material quantities have been revised based on the design results and the unit costs have been replaced to the latest SoR. Subsequently the civil cost has been reduced. E&M 1) Main equipment costs have been updated based on quotation from Indian plant supplier. 2) Equipment capacity has been increased slightly due to the increased water flow. (After the previous estimation, the price of DAF module has been revised based on comments from the DPR consultant. The cost for valves and pipes have been supplemented.)
(1)-3	DMF	754	1,091	1,845		718	902	1,620		-12%	E&M 1) Main equipment cost has been updated based on quotation from Indian plant supplier but it is not higher than the DPR cost (After the previous estimation, the price of DAF module has been revised based on comments from the DPR consultant. The cost for valves and pipes have been supplemented.)
(2)	RO process	1,171	5,116	6,287		1,099	5,264	6,363		1%	
(2)-1	RO feed tank	122	0	122		90	0	90		-27%	Civic 1) Material quantities have been reviewed based on the design results and the unit prices have been replaced to the latest SoR. Subsequently the cost has been reduced.
(2)-2	RO building and equipment	1,049	5,116	6,165		1,009	5,264	6,273		2%	E&M 1) Main equipment cost has been updated by Indian plant supplier. Prices of RO membrane, HPP. other pumps and ERD have been checked by comparing with the manufactures or plant supplier (Toray, Torishima, Dengyosya, Mitsubishi Heavy Industries). (After the previous estimation, costs for brine tank and brine pump have been deleted based on the comment from AECOM. The cost for valves and pipes have been supplemented.)
(3)	Post treatment	195	296	491		240	1,103	1,343		174%	
(3)-1	Mineralization	195	249	443		240	978	1,218		175%	Civil Building cost has been increased due to the change in the treatment type (from power to filter, for better working environment and treatment efficiency) E&M 1) The treatment type change has been reflected. The cost was based on quotation from Indian plant supplier but has been adjusted by the Study Team based on the cost estimation in the DPR of the existing Nemmeli DSP. (After the previous estimation, the said adjustment has been carried out.)
(3)-2	CO2	0	47	47		0	125	125		162%	
(4)	Dosing system	140	153	293		189	237	426		45%	Civil The material quantities have been revised based on the design results and the unit costs have been replaced to the latest SoR. E&M 1) Main equipment costs have been updated based on quotation from Indian plant supplier but partly the prices of have been reduced based on the DPR's information. (After the previous estimation, the cost for valves and pipes have been supplemented. Also, the said reduction has been done.)
(5)	Tank	381	0	381		496	156	652		71%	
(5)-1	Product Water Tank	255	0	255	Cost in the DPR after reducing the pump area	396	156	552		116%	Civil The material quantities have been revised based on the design results and the unit costs have been replaced to the latest SoR. E&M 1) The cost of pipes, valves, cranes, and accessories have been added. (After the previous estimation, the cost for valves and pipes have been supplemented. Also, the said reduction has been done.)
(5)-2	Dirty Water Tank	126	0	126		100	0	100		-21%	Civil The material quantities have been revised based on the design results and the unit costs have been replaced to the latest SoR.
(6)	Building	141	0	141		116	0	116		-18%	
(6)-1	Administration building	31	0	31		36	0	36		15%	Civil The material quantities have been revised based on the design results and the unit costs have been replaced to the latest SoR.
(6)-2	Other buildings	110	0	110		80	0	80		-27%	Civil The material quantities have been revised based on the design results and the unit costs have been replaced to the latest SoR.
(7)	Control system	0	1,729	1,729		0	1,824	1,824		5%	
(7)-1	Power distribution	0	1,351	1,351	Cost in the DPR after reducing the cost for product water pump	0	1,443	1,443		7%	E&M Main equipment cost has been updated by Indian plant supplier.
(7)-2	DCS	0	378	378		0	381	381		1%	
(8)	Electrical Sub-Station	0	257	257	110kV/11kV Substation in the plant	4	339	342	33kV/11kV Substation in the plant	33%	Civil, E&M The costs have been updated based on the quotation from India manufacturer.
1c.	Site development	507		507		344	0	344		-32%	Civil 1) The soil volume and work quantities have been reviewed based on the design results. 2) Soil price has been updated.
A	Total-1: Cost of Civil and E&M Works of CP 1	5,512	12,542	18,055		5,819	15,629	21,448		19%	
2.	Erection and Testing			1,241	5% for erection and 5% for testing			1,280	10% of E&M cost for erection and testing	3%	
3.	Shipping and transportation			0	included in E&M cost			256	2% of E&M cost	-	This cost is not included in the prices quoted from Indian plant supplier. After the previous estimation, the percentage has been reduced from 3% to 2%.
4.	Overhead, Profit			2,699	15% of construction cost including engineering			3,522	15% of construction cost including engineering	30%	(In the previous estimation, this item was not counted. We newly added this as 15% of the plant cost)
B	Total-2: Cost of CP 1 excluding 9.			21,995	811 USD/m^3/day			26,505	977 USD/m^3/day	21%	
5.	Part of CP 1 Construction of Substation (step-down from 230 KV)			0	Missing cost in the DPR	19	216	236			
E.	Total-3: CP 1			21,995				26,741		22%	
6.	CP 2 Pumping stations in Perur DSP and Porur										
6a.	Perur Pumping Station	61	132	193		52	271	323		67%	E&M 1) Increased pump head by 30% after revision of water transmission plan 2) Updated cost from international pump supplier
6b.	Porur Pumping Station	0	0	0	Not planned in the DPR	38	140	179		-	Civil, E&M Newly designed by the Study Team.
6c.	Porur Reservoir	114	0	114		56	6	63	Reservoirs in Porur	-45%	Civil Cost estimation has been done based on the design results and the latest SoR.
C	Total -4: CP 2	174	132	307		146	417	564		84%	
7	CP 3 Installation of Product water transmission mains										
7a.	Conveyance of product water main			3,391				4,339		28%	Extended length of the main from 60 to 65 km (10%). Unit prices have been updated.
7b.	Road restoration charge			349				626		79%	Revision of the quantities and separate quantification for bus route. Unit price has been updated.
7c.	Provision for shifting of underground utilities			19				0	included in the above	-100%	
D	Total -5: CP 3			3,760				4,966		32%	
8.	CP 5 Installation of external transmission lines										
F.	Total-6 CP 5			748				960	Quotation from TNEB	28%	
G.	Total-7 (Total Base Cost for Construction)			26,809	Total cost of DSP			33,231		24%	
9.	WCT			1,004	5.5% of items 1 and 6			1,828	5.5% of Total-7	82%	Advice from CMWSSB on the appropriate percentage would be appreciated.
10.	Physical contingency			663	3% of total construction cost above costs excluding VAT and WCT			1,662	5% of total Total-7	151%	Please note that the standard physical contingency in JICA is 5%.
H.	Total-6 (Overall construction cost)			28,475				36,720		29%	
11	Consulting Services			442	PMC for CP 1, 2, 3			1,762	Design, TA, and CS for CP 1, 2 and 3 excluding design & TA for CP 3.	299%	In yesterday's sheet, "500" was here but this price has been replaced by the estimated cost by the Study Team. (We have breakup for the personnel cost and other direct costs)
I.	Total Project Cost			28,917	Approved cost			38,482		33%	

Source: JICA Study Team

Appendix 10.3 Details of the Project Cost

Table A10.3.1 Annual Fund Requirement

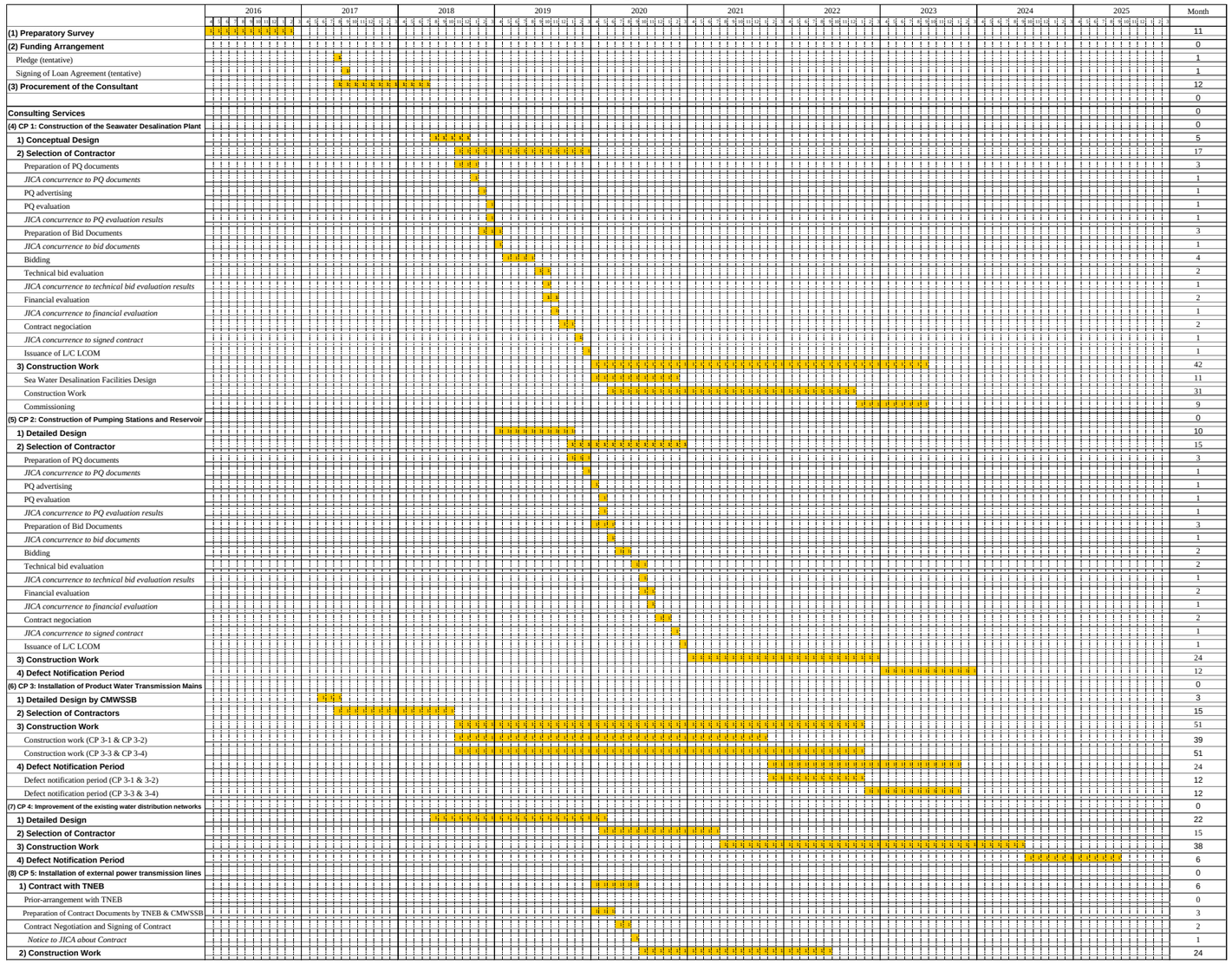
Annual Fund Requirement

Base Year for Cost Estimation:	Jan, 2017		FC & Total:	million JPY
Exchange Rates	INR = JPY	1.71	LC :	million INR
Price Escalation:	FC: 1.6%	LC: 3.7%		
Physical Contingency	5%			
Physical Contingency for Consultant	5%			

Item	Total			2016			2017			2018			2019			2020			2021			2022			2023			2024			2025		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION																																	
Ⅰ) Procurement / Construction	10,942	33,498	68,224	0	0	0	0	0	0	0	636	1,087	0	1,583	2,706	3,063	8,964	18,391	3,112	9,729	19,748	3,162	8,661	17,971	1,606	3,926	8,320	0	0	0	0	0	0
CP1 Construction of the seawater desalination plant	9,735	21,049	45,728	0	0	0	0	0	0	0	0	0	0	0	0	2,781	6,014	13,065	2,781	6,014	13,065	2,781	6,014	13,065	1,391	3,007	6,533	0	0	0	0	0	0
CP2 Construction of pumping stations and reservoirs	0	564	964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	282	482	0	282	482	0	0	0	0	0	0	0	0	0
CP3-1 Installation of product water transmission mains	0	1,606	2,747	0	0	0	0	0	0	0	206	352	0	494	845	0	494	845	0	412	704	0	0	0	0	0	0	0	0	0	0	0	0
CP3-2 Installation of product water transmission mains	0	1,614	2,760	0	0	0	0	0	0	0	207	354	0	497	849	0	497	849	0	414	708	0	0	0	0	0	0	0	0	0	0	0	0
CP3-3 Installation of product water transmission mains	0	995	1,701	0	0	0	0	0	0	0	98	167	0	234	400	0	234	400	0	234	400	0	195	334	0	0	0	0	0	0	0	0	0
CP3-4 Installation of product water transmission mains	0	751	1,284	0	0	0	0	0	0	0	74	126	0	177	302	0	177	302	0	177	302	0	147	252	0	0	0	0	0	0	0	0	0
CP5 Installation of external power transmission line	0	960	1,642	0	0	0	0	0	0	0	0	0	0	0	0	0	240	410	0	480	821	0	240	410	0	0	0	0	0	0	0	0	0
Base cost for JICA financing	9,735	27,538	56,825	0	0	0	0	0	0	0	584	999	0	1,402	2,397	2,781	7,655	15,872	2,781	8,012	16,482	2,781	6,878	14,543	1,391	3,007	6,533	0	0	0	0	0	0
Price escalation	687	4,365	8,150	0	0	0	0	0	0	0	22	37	0	106	181	136	882	1,643	182	1,253	2,325	230	1,370	2,573	139	732	1,391	0	0	0	0	0	0
Physical contingency	521	1,595	3,249	0	0	0	0	0	0	0	30	52	0	75	129	146	427	876	148	463	940	151	412	856	76	187	396	0	0	0	0	0	0
Ⅱ) Consulting services	1,886	747	3,164	0	0	0	0	0	0	252	60	355	318	114	512	373	124	584	296	129	516	319	144	566	226	114	421	86	55	180	16	8	29
Base cost	1,696	616	2,748	0	0	0	0	0	0	237	55	331	293	101	465	338	106	519	264	106	446	281	114	476	196	87	345	73	41	143	13	6	23
Price escalation	100	96	265	0	0	0	0	0	0	4	2	7	9	8	22	17	12	37	17	17	46	23	23	62	20	21	56	9	12	29	2	2	5
Physical contingency	90	36	151	0	0	0	0	0	0	12	3	17	15	5	24	18	6	28	14	6	25	15	7	27	11	5	20	4	3	9	1	0	1
Total (Ⅰ + Ⅱ + Ⅲ)	12,828	34,245	71,387	0	0	0	0	0	0	252	696	1,442	318	1,696	3,218	3,435	9,088	18,975	3,408	9,857	20,264	3,481	8,805	18,537	1,832	4,040	8,741	86	55	180	16	8	29
B. NON ELIGIBLE PORTION																																	
a Procurement / Construction	0	9,590	16,399	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,916	3,277	0	2,981	5,097	0	3,091	5,285	0	1,603	2,740	0	0	0
CP4 Improvement of the existing water distribution networks	0	7,496	12,818	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,578	2,699	0	2,367	4,048	0	2,367	4,048	0	1,184	2,024	0	0	0
Base cost for JICA financing	0	7,496	12,818	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,578	2,699	0	2,367	4,048	0	2,367	4,048	0	1,184	2,024	0	0	0
Price escalation	0	1,638	2,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	247	422	0	472	806	0	577	986	0	343	586	0	0	0
Physical contingency	0	457	781	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	156	0	142	243	0	147	252	0	76	130	0	0	0
b Land Acquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Price escalation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c Administration cost	0	513	878	0	0	0	0	0	0	0	8	14	0	19	32	0	111	190	0	138	235	0	138	236	0	82	140	0	17	29	0	0	0
d WCT and VAT	0	2,472	4,227	0	0	0	0	0	0	0	66	113	0	132	226	0	643	1,099	0	680	1,164	0	628	1,073	0	305	521	0	16	27	0	3	4
e Import Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (a+b+c+d+e)	0	12,575	21,504	0	0	0	0	0	0	0	75	128	0	151	258	0	754	1,289	0	2,734	4,676	0	3,746	6,406	0	3,477	5,946	0	1,636	2,797	0	3	5
TOTAL (A+B)	12,828	46,821	92,891	0	0	0	0	0	0	252	771	1,570	318	1,847	3,476	3,435	9,841	20,264	3,408	12,592	24,939	3,481	12,551	24,943	1,832	7,518	14,688	86	1,691	2,977	16	11	34
C. Interest during Construction	4,672	0	4,672	0	0	0	0	0	0	15	0	15	53	0	53	311	0	311	587	0	587	839	0	839	955	0	955	955	0	955	955	0	955
Interest during Construction(Const.)	4,670	0	4,670	0	0	0	0	0	0	15	0	15	53	0	53	311	0	311	587	0	587	839	0	839	955	0	955	955	0	955	955	0	955
Interest during Construction (Consul.)	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Front End Fee	143	0	143	0	0	0	0	0	0	143	0	143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAND TOTAL (A+B+C+D)	17,642	46,821	97,706	0	0	0	0	0	0	410	771	1,728	371	1,847	3,529	3,746	9,841	20,575	3,995	12,592	25,527	4,320	12,551	25,782	2,788	7,518	15,643	1,042	1,691	3,933	971	11	989
E. JICA finance portion (A)	12,828	34,245	71,387	0	0	0	0	0	0	252	696	1,442	318	1,696	3,218	3,435	9,088	18,975	3,408	9,857	20,264	3,481	8,805	18,537	1,832	4,040	8,741	86	55	180	16	8	29

Source: JICA Study Team

Table A10.3.2 Project Implementation Schedule



	Month
(1) Preparatory Survey	11
(2) Funding Arrangement	0
Pledge (tentative)	1
Signing of Loan Agreement (tentative)	1
(3) Procurement of the Consultant	12
	0
Consulting Services	0
(4) CP 1: Construction of the Seawater Desalination Plant	0
1) Conceptual Design	5
2) Selection of Contractor	17
Preparation of PQ documents	3
JICA concurrence to PQ documents	1
PQ advertising	1
PQ evaluation	1
JICA concurrence to PQ evaluation results	1
Preparation of Bid Documents	3
JICA concurrence to bid documents	1
Bidding	4
Technical bid evaluation	2
JICA concurrence to technical bid evaluation results	1
Financial evaluation	2
JICA concurrence to financial evaluation	1
Contract negociation	2
JICA concurrence to signed contract	1
Issuance of L/C LCOM	1
3) Construction Work	42
Sea Water Desalination Facilities Design	11
Construction Work	31
Commissioning	9
(5) CP 2: Construction of Pumping Stations and Reservoir	0
1) Detailed Design	10
2) Selection of Contractor	15
Preparation of PQ documents	3
JICA concurrence to PQ documents	1
PQ advertising	1
PQ evaluation	1
JICA concurrence to PQ evaluation results	1
Preparation of Bid Documents	3
JICA concurrence to bid documents	1
Bidding	2
Technical bid evaluation	2
JICA concurrence to technical bid evaluation results	1
Financial evaluation	2
JICA concurrence to financial evaluation	1
Contract negociation	2
JICA concurrence to signed contract	1
Issuance of L/C LCOM	1
3) Construction Work	24
4) Defect Notification Period	12
(6) CP 3: Installation of Product Water Transmission Mains	0
1) Detailed Design by CMWSSB	3
2) Selection of Contractors	15
3) Construction Work	51
Construction work (CP 3-1 & CP 3-2)	39
Construction work (CP 3-3 & CP 3-4)	51
4) Defect Notification Period	24
Defect notification period (CP 3-1 & 3-2)	12
Defect notification period (CP 3-3 & 3-4)	12
(7) CP 4: Improvement of the existing water distribution networks	0
1) Detailed Design	22
2) Selection of Contractor	15
3) Construction Work	38
4) Defect Notification Period	6
(8) CP 5: Installation of external power transmission lines	0
1) Contract with TNEB	6
Prior-arrangement with TNEB	0
Preparation of Contract Documents by TNEB & CMWSSB	3
Contract Negotiation and Signing of Contract	2
Notice to JICA about Contract	1
2) Construction Work	24

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Month
Land Acquisition	0	0	0	0	0	0	0	0	0	0	0
CP1 Construction of the seawater desalination plant	0	0	0	0	12	12	12	6	0	0	42
CP2 Construction of pumping stations and reservoirs	0	0	0	0	0	12	12	0	0	0	24
CP3-1 Installation of product water transmission mains	0	0	5	12	12	10	0	0	0	0	39
CP3-2 Installation of product water transmission mains	0	0	5	12	12	10	0	0	0	0	39
CP3-3 Installation of product water transmission mains	0	0	5	12	12	12	10	0	0	0	51
CP3-4 Installation of product water transmission mains	0	0	5	12	12	12	10	0	0	0	51
CP4 Improvement of the existing water distribution networks	0	0	0	0	0	8	12	12	6	0	38
CP5 Installation of external power transmission lines	0	0	0	0	6	12	6	0	0	0	24

Source: JICA Study Team

Table A10.3.3 Cost Breakdown for the Construction Packages

USD	=JPY	116
INR	=JPY	1.71

CP1 Construction of the seawater desalination plant Loan Coverage Ratio 100

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
1a. Seawater intake and brine discharge facilities	Ls	1			1,183,850,000	3,220,729,381	6,691,297,242
1b. Seawater desalination facility	Ls	1			6,623,467,013	12,646,418,010	28,248,841,810
1c. Power receiving substation	Ls	1			0	618,659,122	1,057,907,099
1d. SCADA system	Ls	1			600,000,000	30,000,000	651,300,000
1e. Power distribution	Ls	1			0	1,443,218,025	2,467,902,823
1g. Land development	Ls	1			0	344,079,000	588,375,090
1d. Others	Ls	1			1,261,097,552	2,745,466,000	5,955,844,412
1.h Dispute Board Cost	Ls	1			66,129,434	0	66,129,434
Total					9,734,543,999	21,048,569,538	45,727,597,910

CP2 Construction of pumping stations and reservoirs Loan Coverage Ratio 100

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
2a. Perur Pumping station	Ls	1			0	322,532,956	551,531,354
2b. Porur pumping station	Ls	1			0	178,670,990	305,527,394
2c. Porur Reservoir	Ls	1			0	62,546,106	106,953,842
					0	0	0
Total					0	563,750,052	964,012,589

CP3-1 Installation of product water transmission mains Loan Coverage Ratio 100

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
CP 3-1 (L=17,000 m)	Ls	1			0	1,606,313,120	2,746,795,435
					0	0	0
Total					0	1,606,313,120	2,746,795,435

CP3-2 Installation of product water transmission mains Loan Coverage Ratio 100

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
CP 3-2 (L=21,550 m)	Ls	1			0	1,613,814,209	2,759,622,298
					0	0	0
Total					0	1,613,814,209	2,759,622,298

CP3-3 Installation of product water transmission mains Loan Coverage Ratio 100

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
CP 3-3 (L=14,450 m)	Ls	1			0	994,849,204	1,701,192,140
					0	0	0
Total					0	994,849,204	1,701,192,140

CP3-4 Installation of product water transmission mains Loan Coverage Ratio 100

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
CP 3-4 (L: 12,220 m)	Ls	1			0	750,787,129	1,283,845,991
					0	0	0
Total					0	750,787,129	1,283,845,991

CP4 Improvement of the existing water distribution networks Loan Coverage Ratio

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
4a. Reinforcement of the existing water distribution networks (101km, D150-700)	Ls	1			0	554,400,000	948,024,000
4b. Reinforcement of storage capacity by UGT (1 location, 4.33 ML)	Ls	1			0	28,720,000	49,111,200
4c. Reinforcement of storage capacity by ESRs (16 locations, 49.32 ML)	Ls	1			0	2,131,600,000	3,645,036,000
4d. Replacement of existing pipes (375 km, D100-450)	Ls	1			0	1,635,710,000	2,797,064,100
4e. Installation of supplementary pipes (258 km, D100-150)	Ls	1			0	958,800,000	1,639,548,000
4f. Setup of DMAs	Ls	1			0	75,590,000	129,258,900
4g. Replacement and new installation of service connections including water meters	nos	185,496			0	1,104,387,535	1,888,502,685
4h. Installation of water meters	nos	614,029			0	1,006,640,782	1,721,355,737
					0	0	0
Total					0	7,495,848,317	12,817,900,622

CP5 Installation of external power transmission line Loan Coverage Ratio 100

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
Installation of exteral power transmission lines					0	960,000,000	1,641,600,000
					0	0	0
Total					0	960,000,000	1,641,600,000

Source: JICA Study Team

Table A10.3.4 Cost Breakdown for the Consulting Services

USD = JPY 116
INR = JPY 1.71

	Unit	Qty.	Foreign Portion (JPY) Rate	Foreign Portion (JPY) Amount ('000)	Local Portion INR Rate	Local Portion INR Amount ('000)	Combined Total ('000) JPY
A Remuneration							
1 Professional (A)	M/M	385	3,073,000	1,183,105	0	0	1,183,105
2 Professional (B)	M/M	883	0	0	391,000	345,253	590,383
3 Supporting Staffs	M/M	654	0	0	100,000	65,400	111,834
Subtotal of A				1,183,105		410,653	1,885,322
Direct Cost							
1 International Airfare (from Abroad)	Nos	142	440,899	62,608		0	62,608
Domestic Travel	Nos	40		0	10,000	400	684
Accommodation and Allowance	Month	385		0	220,000	84,700	144,837
Vehicle Rental	Month	258		0	200,000	51,600	88,236
Office Rental	Month	86		0	590,000	50,740	86,765
Communications	Month	385		0	2,000	770	1,317
Office Supply	Month	86		0	60,000	5,160	8,824
Office Furniture and Equipment	Ls	1		0	300,000	300	513
Report Preparation	Month	86		0	50,000	4,300	7,353
Topo&Geotech survey (sub-let)	Ls	1		0	7,000,000	7,000	11,970
Asset Information and Hydraulic Mod	Ls	1	450,000,000	450,000	0	0	450,000
Subtotal of B				512,608		204,970	863,106
Total				1,695,713		615,623	2,748,428

Source: JICA Study Team

Table A10.3.5 Consultant MM Schedule

		Position	Billing Rate FC/ JPY	Billing Rate LC/ INR	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
			0	0											0
A	1	Project Manager	3,073,000	0											76
A	2	Desalination Expert	3,073,000	0											51
A	3	Water Supply Engineer	3,073,000	0											22
A	4	Civil and Structure Engineer (Desal)	3,073,000	0											42
A	5	Mechanical Engineer (Desal)	3,073,000	0											16
A	6	Mechanical Engineer (Distribution)	3,073,000	0											3
A	7	Electric Engineer (Desal)	3,073,000	0											14
A	8	Electric Engineer (Distribution)	3,073,000	0											3
A	9	Monitoring and control expert (Desal)	3,073,000	0											12
A	10	Monitoring and control expert (Distribution)	3,073,000	0											12
A	11	Pipeline Engineer	3,073,000	0											75
A	12	Specification Specialist (Desal)	3,073,000	0											3
A	13	Specification Specialist (Distribution)	3,073,000	0											2
A	14	Financial Expert	3,073,000	0											6
A	15	Contract Specialist (Desal)	3,073,000	0											7
A	16	Contract Specialist (Distribution)	3,073,000	0											7
A	17	Environmental Specialist	3,073,000	0											9
A	18	Commissioning Engineer	3,073,000	0											7
A	19	Social Communication Specialist	3,073,000	0											9
A	20	Organizational Expert	3,073,000	0											9
															0
		0	0	0											0
b	1	Senior Civil Engineer	0	391,000											76
b	2	Civil Engineer	0	391,000											74
b	3	Mechanical Engineer	0	391,000											52
b	4	Electrical Engineer	0	391,000											52
b	5	Structural Engineer	0	391,000											14
b	6	Architect	0	391,000											14
b	7	Building Mechanical and Electrical Engineer	0	391,000											8
b	8	Senior Pipeline Engineer	0	391,000											75
b	9	Pipeline Engineer 1	0	391,000											61
b	10	Pipeline Engineer 2	0	391,000											61
b	11	Pipeline Engineer 3	0	391,000											57
b	12	Hydraulic Modeler 1	0	391,000											3
b	13	Hydraulic Modeler 2	0	391,000											3
b	14	Construction Planner/Cost Estimator	0	391,000											5
b	15	Specification Specialist	0	391,000											4
b	16	Environmental Specialist	0	391,000											24
b	17	Social Communication Specialist	0	391,000											74
b	18	Safety and Health Expert 1	0	391,000											42
b	19	Safety and Health Expert 2	0	391,000											71
b	20	Quantity Surveyor 1	0	391,000											42
b	21	Quantity Surveyor 2	0	391,000											71
															0
			0	0											0
			0	0											0
		[Total of Pro-A]			**0**	**0**	**60**	**68**	**80**	**58**	**61**	**41**	**14**	**3**	**385**
		[Total of Pro-B]			**0**	**0**	**69**	**140**	**149**	**155**	**170**	**132**	**61**	**7**	**883**
		[Total of Pro-A+Pro-B]			0	0	129	208	229	213	231	173	75	10	1,268
		Total Cost of FC for Each Month(Pro-A)			0	0	184,380,000	208,964,000	245,840,000	178,234,000	187,453,000	125,993,000	43,022,000	9,219,000	1,183,105,000
		Total Cost of FC for Each Month(Pro-B)			0	0	0	0	0	0	0	0	0	0	0
		Total Cost of LC for Each Month(Pro-A)			0	0	0	0	0	0	0	0	0	0	0
		Total Cost of LC for Each Month(Pro-B)			0	0	26,979,000	54,740,000	58,259,000	60,605,000	66,470,000	51,612,000	23,851,000	2,737,000	345,253,000
			0	0											0
C	1	Secretary	0	100,000											160
C	2	CAD Operator	0	100,000											66
C	3	GIS Operator	0	100,000											22
C	4	Office Keeper	0	100,000											160
C	5	Inspector	0	100,000											246
															0
			0	0											0
			0	0											0
			0	0											0
			0	0											0
		[Total of Supporting Staff]			**0**	**0**	**74**	**122**	**104**	**110**	**106**	**78**	**48**	**12**	**654**
		Total Cost of LC for Each Month(SS)			0	0	7,400,000	12,200,000	10,400,000	11,000,000	10,600,000	7,800,000	4,800,000	1,200,000	65,400,000
		Grand Total			**0**	**0**	**203**	**330**	**333**	**323**	**337**	**251**	**123**	**22**	**1,922**

Source: JICA Study Team

Table A10.3.6 Cost by Item

Breakdown of Cost	Foreign Currency Portion (million JPY)			Local Currency Portion (millon INR)			Total (million JPY)		
	Total Cost	JICA Portion	Others	Total Cost	JICA Portion	Others	Total Cost	JICA Portion	Others
CP1 Construction of the seawater desalination plant	9,735	9,735	0	21,049	21,049	0	45,728	45,728	0
CP2 Construction of pumping stations and reservoirs	0	0	0	564	564	0	964	964	0
CP3-1 Installation of product water transmission mains	0	0	0	1,606	1,606	0	2,747	2,747	0
CP3-2 Installation of product water transmission mains	0	0	0	1,614	1,614	0	2,760	2,760	0
CP3-3 Installation of product water transmission mains	0	0	0	995	995	0	1,701	1,701	0
CP3-4 Installation of product water transmission mains	0	0	0	751	751	0	1,284	1,284	0
CP4 Improvement of the existing water distribution networks	0	0	0	0	0	0	0	0	0
CP5 Installation of external power transmission lines	0	0	0	960	960	0	1,642	1,642	0
CP4 Improvement of the existing water distribution networks	0	0	0	7,496	0	7,496	12,818	0	12,818
Civil Works Sub Total	**9,735**	**9,735**	**0**	**35,034**	**27,538**	**7,496**	**69,643**	**56,825**	**12,818**
Price Escalation	687	687	0	6,002	4,365	1,638	10,951	8,150	2,800
Physical Contingency	521	521	0	2,052	1,595	457	4,030	3,249	781
Consulting Services	1,886	1,886	0	747	747	0	3,164	3,164	0
Land Acquisition	0	0	0	0	0	0	0	0	0
Administration Cost	0	0	0	513	0	513	878	0	878
VAT	0	0	0	2,472	0	2,472	4,227	0	4,227
Import Tax	0	0	0	0	0	0	0	0	0
Interest during construction	4,672	0	4,672	0	0	0	4,672	0	4,672
Front End Fee	143	0	143	0	0	0	143	0	143
Total	**17,642**	**12,828**	**4,814**	**46,821**	**34,245**	**12,575**	**97,706**	**71,387**	**26,318**

Source: JICA Study Team

Table A10.3.7 Cost by Year

Breakdown of Cost	Total	JICA Portion	Others
2017	0	0	0
2018	1,728	1,442	286
2019	3,529	3,218	311
2020	20,575	18,975	1,600
2021	25,527	20,264	5,263
2022	25,782	18,537	7,245
2023	15,643	8,741	6,902
2024	3,933	180	3,752
2025	989	29	960
Total	97,706	71,387	26,318

Source: JICA Study Team

Appendix 10.4 Operation and Maintenance Cost in Case of Operation Rate of 75% (Production: 300 MLD)

1. Electric cost (basic charge)								
Contract Capacity							85,000	kW
Basic monthly rate							350	INR/kW
Basic monthly charge	85,000	kW	x	350	INR/kW	=	29,750,000	INR/month
Monthly production of water	300,000	m^3/day	x	30	days	=	9,000,000	m^3/month
Thus,	29,750,000	INR/year	/	9,000,000	m^3/year	=	3.3	INR/m^3
2. Electric cost (meter rate charge)								
Unit electric consumption								
Average Electricity load							45,325	kW
Daily Electricity consumption	45,325	kW	x	24	h	=	1,087,800	kWh
Daily production of water							300,000	m^3
Thus,	1,087,800	kWh	/	300,000	m^3	=	3.6	kWh/m^3
Off-peak time rate							6.35	INR/kWh
Peak time rate							6.35	INR/kWh
Average rate (Off peak: 20 hr, Peak time: 4 hr)							6.4	INR/kWh
Thus,	3.6	kWh/m^3	x	6	INR/kWh	=	23.0	INR/m^3
3. Personnel cost								
Manager (Foreign)	1,000,000	INR/month	x	1	person	=	1,000,000.0	INR/month
Assistant manager (Foreign)	500,000	INR/month	x	2	person	=	1,000,000.0	INR/month
Local Manager	350,000	INR/month	x	2	person	=	700,000.0	INR/month
Local chief operator/engineer	200,000	INR/month	x	3	person	=	600,000.0	INR/month
Local operator	75,000	INR/month	x	18	person	=	1,350,000.0	INR/month
Local technician	50,000	INR/month		5	person	=	250,000.0	INR/month
Local Labor	20,000	INR/month		14	person	=	280,000.0	INR/month
						Total	5,180,000.0	INR/month
Monthly production of water	300,000	m^3/day	x	30	days	=	9,000,000	m^3/month
Thus,	5,180,000	INR	/	9,000,000	m^3	=	0.6	INR/m^3
4. Repair and Maintenance cost								
Annual maintenance cost	33,028,000,000	INR	x	1.65	%	=	544,962,000	INR / year
Yearly production of water	300,000	m3/day	x	365	days	=	109,500,000	m^3/year
Thus,	544,962,000	INR	/	109,500,000	m^3	=	5.0	INR/m^3
5. Replacement cost								
1) RO membrane								
Annual replacement cost	1,420,000,000	INR		14	%	=	198,800,000	INR / year
2) Cartridge filter								
Annual replacement cost	10,200,000	INR		4	times		40,800,000	INR / year
Yearly production of water	300,000	m3/day	x	365	days	=	109,500,000	m^3/year
Thus,	239,600,000	INR	/	109,500,000	m^3	=	2.2	INR/m^3
6. Chemical cost								
Sodium hypochlorite solution	4,530	INR/t	x	12,727	t/year	=	57,654,545	INR/year
Sulphuric acid	18,000	INR/t	x	16,000	t/year	=	288,000,000	INR/year
Ferric chloride	40,000	INR/t	x	10,800	t/year	=	432,000,000	INR/year
Polyelectrolyte	350,000	INR/t	x	42	t/year	=	14,700,000	INR/year
Sodium bisulphite Soda	35,000	INR/t	x	1,000	t/year	=	35,000,000	INR/year
Carbon Dioxide	15,000	INR/t		7,000	t/year	=	105,000,000	INR/year
Lime stone	35	INR/t	x	20,000	t/year	=	700,000	INR/year
Sodium Hydroxide	50,000	INR/t	x	2,000	t/year	=	100,000,000	INR/year
Citric Acid	57,000	INR/t	x	150	t/year	=	8,550,000	INR/year
Ammnonia	161,000	INR/t	x	300	t/year	=	48,300,000	INR/year
					Total		1,089,904,545	INR/year
Yearly production of water	300,000	m3/day	x	365	days	=	109,500,000	m^3/year
Thus,	1,089,904,545	INR	/	109,500,000	m^3	=	**10.0**	INR/m^3
						Fixed cost	8.9	INR/m^3
						Variable cost	35.2	INR/m^3
						Total O&M cost	**44.0**	**INR/m^3**

Appendix 10.5 Production Cost including Depreciation Cost in Case of Operation Rate of 75% (Production: 300 MLD)

Item			Description
Operation and maintenance cost	44.0	INR	
Depreciation cost	9.8	INR / m3	= Annual depreciation cost / Annual water production amount
Construction cost	26,741	million INR	
Service life	25	year	Civil facilities (40% of the construction cost): 40 years Mechanical and electrical equipment (60% of the construction cost): 15
Annual depreciation cost	1,070	million INR	= Construction cost / Service life
Annual water production amoun	109.5	million m^3	
Water production cost	**53.8**	**INR/m^3**	

Appendix 11.1 Terms of reference (TOR) of the consultancy services

1 Background and Objectives of the Project

(1) Background

The Chennai metropolitan area (CMA) is facing chronic water shortage due to the short rainfall and increasing water demand resulting out of increasing population and economic growth. The surface water from the rivers and reservoirs, as well as the groundwater, has been the major water resources for the CMA. However, the yields from such conventional water resources are not stable because of frequent droughts.

To secure sufficient water supply for the people and businesses, as a countermeasure against the said issue, the State Government of Tamil Nadu (GOTN) decided to construct seawater desalination plants (DSPs) as one of the reliable water resources, which is not subject to drought.

At present, two DSPs are operational in the CMA, but the water demand is not yet satisfied. In order to further mitigate the water shortage, GOTN prepared an expansion plan of the existing Nemmeli DSP by 150 million litter per day (MLD) and a construction plan of a DSP with a capacity of 400 MLD at Perur (Perur DSP).

Between the two DSP projects above, the project for the additional Nemmeli DSP is being implemented with financial assistance from KfW. For the Perur DSP, the Government of India (GOI) proposed the Government of Japan (GOJ) to extend Japanese Official Development Assistance (ODA) loan. On receiving the proposal from GOI, the Japan International Cooperation Agency (JICA) conducted the Preparatory Survey for Seawater Desalination Plant Project in Chennai in 2016.

Through the appraisal and negotiation processes, based on the study results, GOJ and GOI finally agreed to utilize Japanese ODA Loan for eligible payments for the Project. This terms of reference (TOR) is issued for Consulting Services for the Project (hereinafter refer to “the Services”).

(2) Objectives of the Project

The Project aims to deliver an additional water production of 400 MLD by seawater desalination for the CMA and improve the efficiency of the existing water distribution network in the Chennai Core City, the central area of the CMA.

2 Outlines of the Project

(1) Construction items

The Project consists of the following components:

a) Construction of a seawater desalination plant, which is named as the “Perur Seawater Desalination Plant” (hereinafter refer to “Perur DSP”), having a production capacity of 400 MLD in Perur Commune, Tamil Nadu State

b) Construction of a product water transmission system to connect the Perur DSP and existing or planned transmission system

c) Improvement of the existing water distribution system in the Chennai Core City.

Construction items in the Project are listed in Table 1.

Table 1 Construction Items in the Project

Component	Construction items
a) Construction of the Perur DSP (400 MLD)	- Seawater intake facilities - Pre-treatment facility - Seawater desalination facilities by reverse osmosis (RO) technology - Post-treatment facility for remineralization and disinfection - Potable water storage - Effluent discharge pipelines - Substation for power receiving - All other buildings and structures necessary for the seawater desalination plant such as administration building, storage, guard house, etc.
b) Construction of product water transmission system	- Product water transmission pumping station on the premises of the Perur DSP - Product water transmission main (D1,000, 1,600, 1800 and 2,000mm, 65 km, MS or DCIP) - Water transmission pumping station and reservoir in the Porur Water Distribution Station (WDS)
c) Improvement of the existing distribution system in Chennai Core City	- Replacement of the existing distribution pipes (D100-450 mm, 375 km, DCIP) - Installation of supplementary distribution pipes to strengthen the capacity of the existing distribution networks (D150-700 mm, 101km, DCIP) - Installation of new water distribution pipes in un-covered streets in Core city.(D100-150 mm, 258km, DCIP) - Reinforcement of the storage capacity of Under Ground Tank (UGT) and Elevated Storage Tanks (ESRs) - Installation of service connections and water meters - Setup of district metered areas (DMA)

(2) Procurement packages and procedure

All contract packages from CP 1 to CP 3 will be procured through International Competitive Bidding (ICB) based on Single-Stage Two-Envelope Bidding Procedure with Pre-qualification (P/Q) in compliance with the JICA's Procurement Guideline (Section 2.03, Part II) .

All contract packages of CP 4 and CP 5 will be procured through Local Competitive Bidding (LCB), as shown in Table 2.

Table 2 Procurement Package and Procedure of the Project

	Package	Procurement procedure
CP 1	Construction of the Perur DSP (400MLD)	- International Competitive Bid (ICB) with P/Q - Single-Stage Two-Envelope - Design-Build-Operation (DBO) contract - 20 years of O&M of the DSP after the commissioning - JICA's Standard Bidding Document "Design-Build" *
CP 2	Construction of pumping stations and reservoir	- International Competitive Bid (ICB) with P/Q - Single-Stage Two-Envelope - Design-Bid-Build contract - JICA's Standard Bidding Document "Works"
CP 3	Installation of product water transmission mains CP 3-1: L=12.2 km CP 3-2: L=14.5 km CP 3-3: L=21.6 km CP 3-4: L=17.0 km	- International Competitive Bid (ICB) with P/Q - Single-Stage Two-Envelope - Design-Bid-Build contract - JICA's Standard Bidding Document "Works"
CP 4	Improvement of the existing water distribution system	- Local Competitive Bid (LCB)
CP 5	Installation of external power transmission line	- Local Competitive Bid (LCB)

* The general conditions of the contract shall be prepared using the FIDIC Gold book (Edition 2008).

(3) Funding Source

The funding source of the Project, including that for the Services, is Japanese ODA Loan.

(4) Executing Agency

The Executing Agency of the Project is Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB). Project Implementation Unit (PIU) in CMWSSB is the direct counterpart to the Consultant.

(5) Technical Information

The final report on the "Preparatory Survey for Chennai Seawater Desalination Plant Project" is available at CMWSSB. Also, the natural condition survey results implemented by CMWSSB are available as below:

- Bathymetric survey of the seabed
- Geotechnical survey in the DSP site
- Topographical survey in the DSP site
- Raw seawater quality of the existing Nemmeli DSP
- EIA Report including assessment of the environmental conditions of the Project
- Ocean current survey conducted at in front of the DSP site

3 Objectives of the Consulting Services

The consulting services shall be provided by a single or a J/V of international consulting firm(s) in compliance with Guidelines for the Employment of Consultants under Japanese ODA Loans, April 2012. The objectives of the Consulting Services are to achieve efficient and proper preparation and implementation of the Project through the following works:

- Design works (CP1, CP2 and CP4)
- Bid document preparation and Tender assistance (CP1, CP2 and CP4)
- Construction supervision including defect notification period (CP1, CP2, CP3 and CP4)
- Facilitation of implementation of Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP) (CP1, CP2, CP3,CP4 and CP5)
- Capacity development and Institutional improvement

4 Scope of the Consulting Services

The Consultant shall carry out the Consulting Services through the following work items:

(1) Design works (CP1, CP2 and CP4)

The conceptual design for CP 1 will include the following works:

a) Review of the technical information on the Project

b) Implementation of the supplementary natural condition surveys, which will be provided as a part of the tender document

c) Conceptual design of the Perur DSP, which includes brine diffusion analysis using the ocean current survey data

d) Preparation of conceptual design report, which includes a description of all the processes, general layout plan, water and material balance sheet, overall process flow diagram, and instrumentation plan.

e) Preparation of technical specifications to be included in the bid documents.

f) Preparation of "Operation and Maintenance Requirement (including risk allocation, payment method, monitoring and evaluation method etc.) " to be included in the bid documents

The detailed design for CP 2 will include the following works:

a) Review of the technical information on the Project;

b) Implementation of the topographic and geotechnical surveys for the construction area of the pumping stations in the premises of the Perur DSP and the pumping station and reservoir in the Porur WDS;

c) Review of the preliminary design in the DPR;

d) Hydraulic analyses of the product water transmission main for final determination of the pump head and countermeasure for water hammer;

e) Detailed design of the pumping stations and reservoir including architectural, structural, civil, mechanical and electrical works;

f) Preparation of the construction plan including design of the temporary works;

g) Preparation of detailed design drawings; and

h) Preparation of technical specifications and bill of quantities to be included in the bid documents

The detailed design for CP 4 will include the following works:

a) Review of the technical information on the Project

b) Collect and review topographic data for the Chennai Core City

c) Review of the inventory data of the distribution network map to be provided by CMWSSBS

d) Study on specifications of software for water distribution network management in CMWSSB and determination of the software through discussion with CMWSSB

e) Procurement of the desktop personal computers and software

f) Preparation of the database by the software procured for the Chennai Core City

g) Provision of training to CMWSSB staff on the database preparation and maintenance through on-the-job training (OJT)

h) Preparation of the hydraulic modeling for the existing water distribution networks in the core city and calibration

i) Plan of the improvement of the existing network taking into account the establishment of district metered areas (DMAs)

j) Hydraulic analyses of the water distribution network to determine the scope of the improvement of the existing water distribution network

k) Preparation of detailed design drawings for the improvement of the existing distribution networks

l) Preparation of technical specifications and bill of quantities to be included in the bid documents

(2) Bid document preparation (CP1, CP2 and CP4)

The bid document preparation will include the following works:

a) Preparation of the pre-qualification (PQ) document, complying with the following instructions:

- ✓ The technical and financial requirements for PQ shall take into account the technical feature and the magnitude of the Project;
- ✓ The PQ part shall be in accordance with the latest version of Standard Prequalification Documents under Japanese ODA Loans;
- ✓ Assistance to CMWSSB in PQ announcement, addendum/corrigendum, and clarifications to the applicants' queries;
- ✓ PQ evaluation of the applicants in accordance with the criteria set forth; and
- ✓ Preparation of PQ evaluation report to be submitted to CMWSSB.

b) Preparation of the Bid document, complying with the following instructions:

- ✓ For procurement of goods and services under CP 1, the latest version of "Standard Bidding Documents under Japanese ODA Loans, Procurement of Electrical and Mechanical Plant, and for Building and Engineering Works, Designed by the Contractor" will be applied, together with all relevant specifications, drawings and other documents. The general conditions of the contract shall be prepared using the FIDIC Gold book (Edition 2008), since the operation work of the DSP will be included in CP 1 under DBO scheme.
- ✓ For procurement of goods and services under CP 2, the latest version of "Standard Bidding Documents under Japanese ODA Loans, Procurement of Works" will be applied, along with all relevant specifications, drawings, and other documents; and
- ✓ Prepare bidding documents which includes i) clauses stating that the Contractor is to comply with the requirement of the Environmental Management Plan (EMP) and JICA Guidelines for environmental and social considerations (April 2010) (JICA Environmental Guidelines) and to conduct environmental monitoring following the Environmental Monitoring Plan (EMoP), ii) the specification clearly stipulating the safety requirements in accordance with the laws and regulations in the country of the Borrower, relevant international standards (including guidelines of international organization), if any, and also in consideration of "the Guidance for the Management of Safety for Construction Works in Japanese ODA Projects of JICA," iii) the requirement to furnish a safety plan to meet the safety requirements, iv) the requirement for the personnel for key positions to include an accident prevention officer, and v) the requirement to submit method statements of safety to CMWSSB and the consultant at the construction stage.

(3) Tender assistance (CP1, CP2 and CP 4)

The Consultant shall assist CMWSSB in the bid by the following works:

a) Assistance to CMWSSB in tender call, addendum/corrigendum, clarifications to the bidders and conducting pre-bid conferences;

b) Evaluations of the bids in accordance with the criteria set forth in the bidding documents, laws, regulations;

c) Preparation of bid evaluation reports for approval to be submitted to CMWSSB;

d) Assistance to CMWSSB in contract negotiations by preparing agenda and facilitating negotiations including preparation of minutes of negotiation meetings; and

e) Preparation of draft and final contract agreements.

(4) Construction supervision (CP1, CP2, CP3 and CP4)

The Consultant shall perform his duties during the construction period in accordance with the contracts to be executed between CMWSSB and the contractors. In this context, the Consultant shall act as the Engineer for CP 1 to execute construction supervision and contract administration services in accordance with the power and authority delegated by CMWSSB. Construction supervision by the Consultant will include the following works:

a) Act as the Engineer to execute construction supervision and contract administration services in accordance with the power and authority to be delegated by the Employer;

b) Provide assistance to the Employer concerning variations and claims that are to be ordered/issued at the initiative of the Employer. Advise the Employer on resolution of any dispute with the Contractor;

c) Issue instructions, approvals, and notices as appropriate;

d) Provide recommendation to the Employer for acceptance of the Contractor's performance security, advance payment security and required insurances;

e) Provide commencement order to the Contractor;

f) Assess adequacy of all inputs such as materials, labor, and equipment provided by the Contractor;

g) Check and approve the Contractor's method of work, including site organization, program of performance, quality assurance system, safety plan, method statements of safety, and environmental monitoring plan so that the requirements set forth in the applicable laws and regulations, the specifications or other parts of the contract are to be duly respected;

h) Regularly monitor physical and financial progress and take appropriate action to expedite progress, if necessary, so that the time for completion set forth in the contract will be duly respected by the Contractor;

i) Explain and/or adjust ambiguities and/or discrepancies in the Contract Documents and issue any necessary clarifications or instructions;

j) Review and approve the Contractor's design for the works to be constructed, working drawings, shop drawings and drawings for temporary works;

k) Liaise with the appropriate authorities to ensure that all the affected utility services are promptly relocated;

l) Carry out field inspections on the Contractor's setting out of the works in relation to original points, lines and levels of reference specified in the contract;

m) Organize, as necessary, management meetings with the Contractor to review the arrangements for future work. Prepare and deliver minutes of such meetings to the Employer and the Contractor;

n) Supervise the works so that all the contractual requirements are met by the Contractor, including those in relation to i) quality of the works, ii) safety, and iii) protection of the environment. Confirm that an accident prevention officer proposed by the Contractor is duly assigned at the project site. Require the contractors to take appropriate remedies if any questions are recognized regarding the safety measures;

o) Supervise field tests, sampling, and laboratory test to be carried out by the Contractor;

p) Inspect the construction method, equipment to be used, and workmanship at the site, and attend shop inspection and manufacturing tests in accordance with the Employer's Requirements;

q) Verify statements submitted by the Contractor and issue payment certificates such as interim payment certificates and final payment certificate as specified in the contract;

r) Coordinate the works among different contractors employed for the Project;

s) Modify the Employer's Requirements as may be necessary in accordance with the actual site conditions and issue variation orders (including necessary actions in relation to the works performed by other contractors working on other projects, if any);

t) Carry out timely reporting to the Employer for any inconsistency / causes of delay in executing the works and suggesting appropriate corrective measures to be applied;

u) Inspect, verify and fairly determine claims issued by the parties to the contract (i.e. the Employer and Contractor) in accordance with the contract;

v) Supervise the Test on Completion carried out by the Contractor and assist the Employer in carrying out the Test after Completion, if applicable;

w) Perform the inspection of the works and issue certificates such as the Taking-Over Certificate, Performance Certificate as specified in the contract,

x) Check and certify as-built drawings prepared by the Contractor; and

y) Check and certify the operation and maintenance manual prepared by the Contractor.

The Consultant shall perform his duties during the construction period in accordance with the contracts to be executed between CMWSSB and the contractors. In this context, the Consultant shall act as the Engineer for CP 2, CP 3 and CP 4 to execute construction supervision and contract administration services in accordance with the power and authority delegated by CMWSSB. Construction supervision by the Consultant will include the following works:

a) Act as the Engineer to execute construction supervision and contract administration services in accordance with the power and authority to be delegated by the Employer;

b) Provide assistance to the Employer concerning variations and claims that are to be ordered/issued at the initiative of the Employer. Advise the Employer on resolution of any dispute with the Contractor;

c) Issue instructions, approvals, and notices as appropriate;

d) Provide recommendation to the Employer for acceptance of the Contractor's performance security, advance payment security and required insurances;

e) Provide commencement order to the Contractor;

f) Assess adequacy of all inputs such as materials, labor, and equipment provided by the Contractor;

g) Check and approve the Contractor's method of work, including site organization, program of performance, quality assurance system, safety plan, method statements of safety, and environmental monitoring plan so that the requirements set forth in the applicable laws and regulations, the specifications or other parts of the contract are to be duly respected;

h) Regularly monitor physical and financial progress and take appropriate action to expedite progress if necessary, so that the time for completion set forth in the contract will be duly respected by the Contractor;

i) Explain and/or adjust ambiguities and/or discrepancies in the Contract Documents and issue any necessary clarifications or instructions. Issue further drawings and give instructions to the Contractor for any works that may not be sufficiently detailed in the contract documents, if any;

j) Review and approve the Contractor's working drawings, shop drawings, and drawings for temporary works. Also review and approve, if any, designs prepared by the Contractor for any part of the permanent works;

k) Liaise with the appropriate authorities to ensure that all the affected utility services are promptly relocated;

l) Carry out field inspections on the Contractor's setting out of the works in relation to original points, lines, and levels of reference specified in the contract;

m) Organize, as necessary, management meetings with the Contractor to review the arrangements for future work. Prepare and deliver minutes of such meetings to the Employer and the Contractor;

n) Supervise the works so that all the contractual requirements are met by the Contractor, including those in relation to i) quality of the works, ii) safety and iii) protection of the environment. Confirm that an accident prevention officer proposed by the Contractor is duly assigned at the project site. Require the contractors to take appropriate remedies if any questions are recognized regarding the safety measures;

o) Supervise field tests, sampling, and laboratory test to be carried out by the Contractor;

p) Inspect the construction method, equipment to be used, and workmanship at the site, and attend shop inspection and manufacturing tests in accordance with the specifications;

q) Survey and measure the work output performed by the Contractor. Assist the Employer to verify statements submitted by the Contractor and issue payment certificates such as interim payment certificates and final payment certificate as specified in the contract;

r) Coordinate the works among different contractors employed for the Project;

s) Modify the designs, technical specifications and drawings, relevant calculations and cost estimates as may be necessary in accordance with the actual site conditions, and issue variation orders (including necessary actions in relation to the works performed by other contractors working on other projects, if any);

t) Carry out timely reporting to the Employer for any inconsistency in executing the works and suggesting appropriate corrective measures to be applied;

u) Inspect, verify, and provide recommendation to the Employer concerning claims issued by the parties to the contract (i.e. the Employer and Contractor) in accordance with the civil works contract;

v) Perform the inspection of the works and issue certificates such as the Taking-Over Certificate, Performance Certificate as specified in the contract;

w) Supervise commissioning and carry out tests during the commissioning, if applicable;

x) Provide periodic and/or continuous inspection services during defects notification period, and if any defects are noted, instruct the Contractor to rectify;

y) Check and certify as-built drawings; and

z) Check and certify an operation and maintenance manual for the works constructed in the Project.

aa) Review of entire alignment of transmission main in terms of hydraulic, geo-technical aspects and flag any potential delays in terms of delay in obtaining permissions particularly on stretches pertaining to NHAI and Railways

(5) Facilitation of Implementation of Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP) (CP1, CP2, CP3, CP4 and CP5)

The Consultant shall assist CMWSSB in the environmental management and monitoring through the following works:

a) Review and update EMP according to the actual site conditions, designs, technical specifications and contract documents;

b) Review and update EMoP according to the updated EMP;

c) During the preparation of bidding documents, clearly identify environmental responsibilities as explained in the EIA, Final Report of Preparatory Survey and EMP;

d) Assist CMWSSB to review the Construction Contractor's Environmental Program to be prepared by the contractor in accordance with EMP, relevant plans and JICA Environmental Guidelines and to make recommendations to CMWSSB regarding any necessary amendments for its approval

e) Supervision of EMP implementation and implementation of regular compliance monitoring according to EMoP to ensure that the construction works are implemented in accordance with the EMP;

f) Assist CMWSSB to implement the measures identified in the EMP

g) Monitor the effectiveness of EMP and negative impacts on environment caused by the construction works and provide technical advice, including a feasible solution, so that CMWSSB can improve situation when necessary;

h) Assist CMWSSB in monitoring the compliance with conditions stated in the environmental permit certifications and the requirements under EMP and JICA Environmental Guidelines;

i) Assist CMWSSB in preparation of the answer to the request from JICA's advisory committee for environmental and social considerations if necessary; and

j) Assistance to CMWSSB in the capacity building of CMWSSB staff on environmental management through on-the-job training so that the EMoP would be carried out appropriately in the O&M of the seawater desalination plant.

5 Scope of the Consulting Services for CP 5

The Consultant shall perform the following tasks throughout the execution of CP5;

a) Prepare the technical requirement to CP 5

b) Monitor the progress of construction of CP5

c) Interface coordination between CP 1 and CP 5

6 Capacity Development and Organizational Improvement

The Consultant shall assist CMWSSB in capacity development and organizational improvement by the following services:

(1) Asset management

a) Assistance in development of digital pipe inventory data base using geotechnical information system (GIS) through OJT to CMWSSB staff during detailed design of CP 4

b) Assistance in development of capability of maintenance of the data base through OJT to CMWSSB staff during detailed design of CP 4

c) Assistance in preparation of water loss reduction plan within 12 months after commencement of the consulting services

(2) Acceleration of installation of service connections and water meters

a) Analysis on obstacles preventing in expansion of installation of service connections and water meters

b) Assistance in preparation of proposal of CMWSSB to GOTN on institutional improvement based on the analysis above for acceleration of service connection and water meter installation and the appropriate maintenance within 12 months after commencement of the consulting services

(3) Improvement of customer services and publication

a) Assistance in improvement of customer information data base within 12 months after commencement of the consulting services

b) Assistance in planning and implementation of customer satisfaction survey within 12 months after commencement of the consulting services and at the end of the project period

c) Assistance in publication for appreciation of and cooperation to activities of CMWSSB within 18 months after commencement of the consulting services based on customer satisfaction survey results

d) Assistance in preparation of improvement plan of procedure of water tariff payment to enhance tariff collection rate within 18 months after commencement of the consulting services based on customer satisfaction survey results

(4) Improvement of business operation

a) Assistance in preparation of financial plan to simulate appropriate future water rate within 12 months after commencement of the consulting services

b) Assistance in preparation of organizational restructuring plan for efficient business operation within 12 months after commencement of the consulting services

c) Assistance in introduction of information technology (IT) within 12 months after commencement of the consulting services

d) Assistance in preparation of training program of technical and administrative staff within 12 months after commencement of the consulting services

e) Assistance in preparation of business plan within 24 months after commencement of the consulting services based on the results of accomplishment of the all activities from (1) a) to (4) d) above

7 Expected Time Schedule

The total duration of consulting services will be 86 months including defects notification period. The implementation schedule expected is as shown in Figure 1.

8 Staffing

(1) Staffing and Consulting Input for the Respective Phase

It is proposed that 20 of Professional (A) consultants (Foreign Persons) and 21 of Professional (B) consultants (Local Persons) will be engaged for a total of 385 man-months (MM) for Professional (A) consultants and 883 MM for Professional (B) consultants. Total consulting input is 1,268 MM. In addition to the consultants, supporting staff such as secretaries, CAD operators, GIS operators, office keepers, and inspectors will be necessary, and the total input is estimated to 654 MM.

The Consultant Team for the design works, tender assistances, construction supervisions, and capacity development consists of the members listed in Table 3.

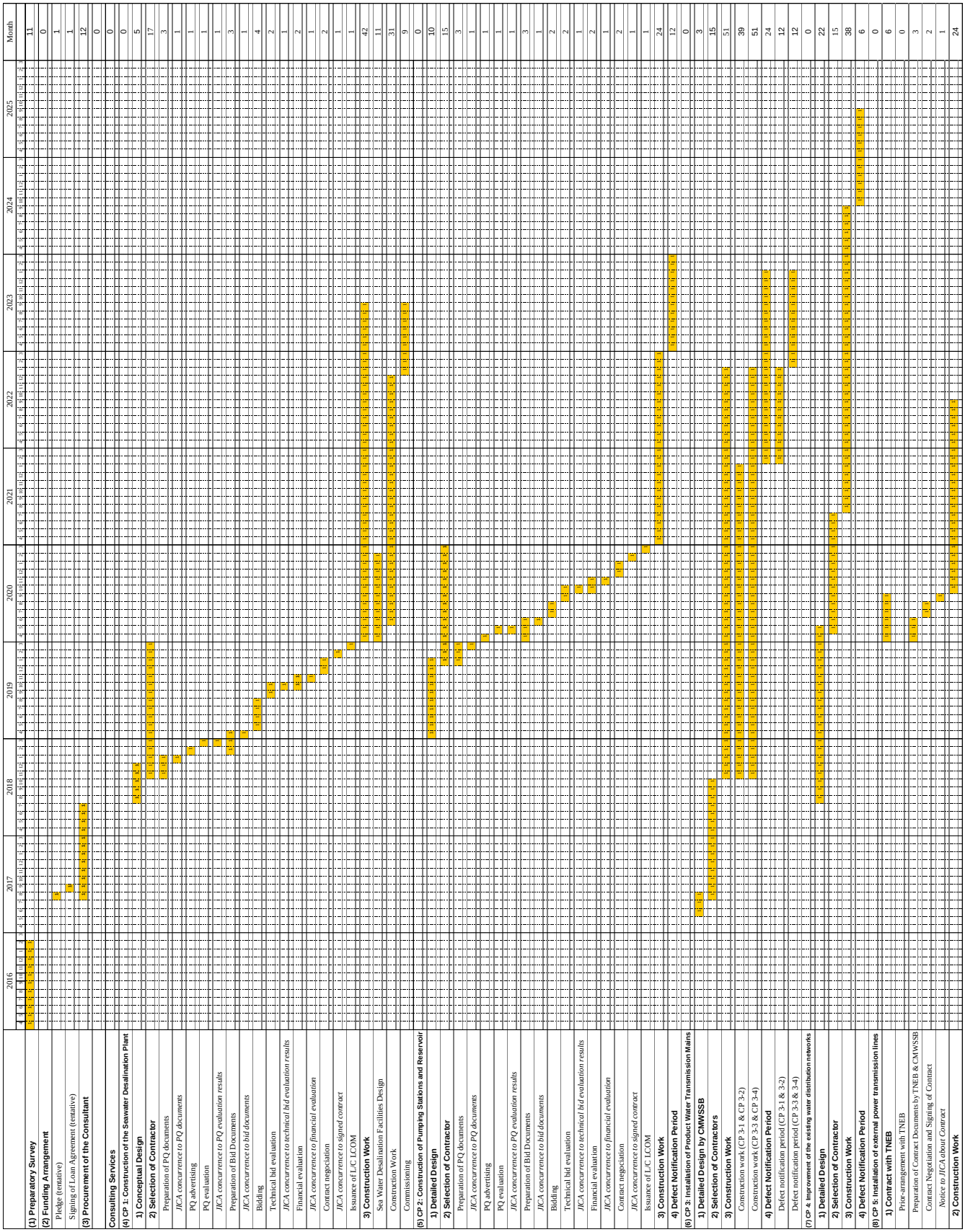


Figure 1 Schedule of the Consulting Services

Table 3 List of Consulting Experts

Pro. Type	No.	Position	Contract Package (CP)												CD
			1			2			3	4			5		
			D	TA	SV	D	TA	SV	SV	D	TA	SV	TA	SV	
A	1	Project Manager	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
A	2	Desalination Expert	✓	✓	✓										
A	3	Water Supply Engineer	✓	✓		✓	✓			✓	✓				✓
A	4	Civil and Structure Engineer (Desal)	✓	✓	✓										
A	5	Mechanical Engineer (Desal)	✓	✓	✓										
A	6	Mechanical Engineer (Distribution)				✓	✓								
A	7	Electric Engineer (Desal)	✓	✓	✓								✓		
A	8	Electric Engineer (Distribution)				✓	✓								
A	9	Monitoring and control expert (Desal)	✓	✓	✓										
A	10	Monitoring and control expert (Distribution)				✓	✓	✓		✓	✓	✓			
A	11	Pipeline Engineer							✓	✓	✓	✓			
A	12	Specification Specialist (Desal)	✓												
A	13	Specification Specialist (Distribution)				✓				✓					
A	14	Financial Expert	✓	✓											✓
A	15	Contract Specialist (Desal)	✓	✓											
A	16	Contract Specialist (Distribution)				✓	✓			✓	✓				
A	17	Environmental Specialist	✓		✓	✓		✓	✓	✓		✓	✓	✓	
A	18	Commissioning Engineer			✓										
A	19	Social Communication Specialist	✓		✓	✓		✓	✓	✓		✓	✓	✓	✓
A	20	Organizational Expert													✓
B	1	Senior Civil Engineer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B	2	Civil Engineer							✓	✓		✓			
B	3	Mechanical Engineer			✓	✓	✓	✓		✓	✓	✓			
B	4	Electrical Engineer			✓	✓	✓	✓		✓	✓	✓	✓	✓	
B	5	Structural Engineer			✓	✓		✓		✓		✓			
B	6	Architect	✓		✓	✓		✓							
B	7	Building Mechanical and Electrical Engineer	✓		✓	✓		✓							
B	8	Senior Pipeline Engineer							✓	✓		✓			
B	9	Pipeline Engineer 1								✓		✓			
B	10	Pipeline Engineer 2								✓		✓			
B	11	Pipeline Engineer 3							✓						
B	12	Hydraulic Modeler 1								✓					
B	13	Hydraulic Modeler 2								✓					
B	14	Construction Planner/Cost Estimator				✓				✓					
B	15	Specification Specialist				✓				✓					
B	16	Environmental Specialist	✓		✓	✓		✓	✓	✓		✓	✓	✓	
B	17	Social Communication Specialist	✓		✓	✓		✓	✓	✓		✓	✓	✓	✓
B	18	Safety and Health Expert 1			✓			✓				✓			
B	19	Safety and Health Expert 2							✓			✓			
B	20	Quantity Surveyor 1			✓			✓						✓	
B	21	Quantity Surveyor 2							✓			✓			

D: Design, TA: Tender Assistance, SV: Construction Supervision, CD: Capacity Development and Organizational Improvement

(2) Basic professional requirements of key expert

The key expert requirements with qualification and experience for each position are given in the table below.

Table 4 Qualification of Key Experts

Designation		Qualification
A1	Project Manager	• Post Graduate in Civil Engineering • At least 20 years' experience in water supply projects • At least two experiences of water supply projects of ICB contract financed by bilateral or international donor, of which each contract amount is more than USD 50 million • Have experience of working in developed as well as developing countries on projects assisted by bilateral and multilateral agencies
A2	Desalination Expert	• Graduate in Civil, Mechanical or Electrical Engineering • At least 15 years' experience in seawater desalination projects • Experience of at least three projects of seawater desalination plant construction projects by RO involving design and tender assistance, of which each plant capacity is 50 MLD or more, as desalination process expert
A3	Water Supply Engineer	• Graduate in Civil Engineering • At least 10 years' experience in water supply projects • At least three experiences of water supply projects involving planning or design of water distribution network • At least two water supply projects involving planning or design of water loss reduction program
A5	Mechanical Engineer (Desal)	• Graduate in Mechanical Engineering • At least 10 years' experience in seawater desalination projects • At least two experiences of seawater desalination plant construction projects by RO involving design and tender assistance, of which each plant capacity is 20 MLD or more, as mechanical engineer
A7	Electrical Engineer (Desal)	• Graduate in Electrical Engineering • At least 10 years' experience in seawater desalination projects • At least two experiences of seawater desalination plant construction projects by RO involving design and tender assistance, of which each plant capacity is 20 MLD or more, as electrical engineer
A11	Pipeline Engineer	• Graduate in Civil Engineering • At least 10 years' experience in water supply projects • At least three experiences of water supply projects involving detailed design and construction supervision of water transmission or distribution pipes, of which total pipe length is 30 km or more
A15	Contract Specialist (Desal)	• At least 10 years' experience as contract specialist • At least two experiences of international projects financed by bilateral or international donor • At least two experiences of water supply projects under public-private partnership (PPP) scheme involving O&M by private sector • At least one experience of seawater desalination project
A16	Contract Specialist (Distribution)	• At least 10 years' experience as contract specialist • At least two experiences of international water supply projects of ICB financed by bilateral or international donor
B1	Senior Civil Engineer	• Graduate in Civil Engineering • At least 15 years' experience in water supply projects • At least three experiences of water supply projects involving detailed design or construction supervision of water treatment plants • At least two international water supply projects financed by bilateral or international donor involving detailed design or construction supervision
B9	Senior Pipeline Engineer	• Graduate in Civil Engineering • At least 10 years' experience in water supply projects • At least two experiences of water supply projects involving detailed design or construction supervision of water transmission or distribution pipes, of which total pipe length is 20 km or more

(3) Task of Professional Staff

A1: Project Manager

a) Shall take the overall responsibility, and shall represent the project Consultant's Team in all matters relating to the performance of services, communication between the Client and Consultant's Team, coordinating with all other consultant's staff to deliver excellent product during the stipulated time schedule

b) Shall oversee and supervise the Consultant's services in design, tender assistance and construction phases

A2: Desalination Expert

a) Shall function as technical supervisor in design, tender assistance and construction supervision in CP 1

b) Shall conduct process design of the plant and coordinate with other engineers and specialists for design and bid documents for CP 1

c) Shall assist the Client in correspondence to clarifications from the bidders in technical aspects in CP 1 and evaluate the bids regarding process aspect

d) Shall assist the Client in contract negotiation with the successful bidder in CP 1

e) Shall review detailed design by the contractor and supervise the construction on site in process aspect as well as coordination with other supervision engineers for CP 1

A3: Water Supply Engineer

a) Shall function as technical supervisor in design and tender assistance for CP 2 and CP 4

b) Shall study the improvement of the water distribution network and plan the scope of CP 4

c) Shall evaluate the bids for CP 2 and CP 4 in technical aspects

d) Shall assist the Organizational Expert in capacity development and organizational improvement in technical aspects

e) Shall be responsible for skill transfer to CMWSSB for establishment and maintenance of GIS database and hydraulic model

A4: Civil and Structure Engineer (Desal)

a) Shall conduct civil, structural and building designs in CP 1 including preparation of technical specifications with Professionals B6 and B7

b) Shall evaluate the bids for CP 1 in civil, structural and building aspects

c) Shall supervise the civil, structural and building works in CP 1 with Professionals B5 to B7

A5: Mechanical Engineer (Desal)

a) Shall conduct mechanical design in CP 1 including preparation of technical specifications

b) Shall evaluate the bids for CP 1 in mechanical aspect

c) Shall review detailed design by the contractor and supervise the construction in mechanical aspect with Professional B3

A6: Mechanical Engineer (Distribution)

a) Shall conduct mechanical design in CP 2, for the reservoir and pumping stations, including preparation of technical specifications

b) Shall evaluate the bids for CP 2 in mechanical aspect

A7: Electrical Engineer (Desal)

a) Shall conduct electrical design in CP 1 including preparation of technical specifications

b) Shall prepare technical requirement to CP 5 and assist the Client in discussion and negotiation with CP 5 contractor.

c) Shall evaluate the bids for CP 1 in electrical aspect

d) Shall review detailed design by the contractor and supervise the construction in electrical aspect with Professional B4

A8: Electrical Engineer (Distribution)

a) Shall conduct electrical design in CP 2, for the reservoir and pumping stations, including preparation of technical specifications

b) Shall evaluate the bids for CP 2 in electrical aspect

A9: Monitoring and Control Expert (Desal)

a) Shall conduct design of monitoring and control system in CP 1 using distributed control system (DCS), including preparation of technical specifications

b) Shall evaluate the bids for CP 2 in monitoring and control aspect

c) Shall review detailed design by the contractor and supervise the construction in monitoring and control aspect

A10: Monitoring and Control Expert (Distribution)

a) Shall conduct design of monitoring and control system of the product water transmission system for CP 2 using supervisory control and data acquisition (SCADA), including preparation of technical specifications

b) Shall conduct planning of monitoring and control system for improvement of the water distribution network in the Chennai Core City

c) Shall conduct design of monitoring and control system in CP 4 including preparation of technical specifications

d) Shall evaluate the bids for CP 2 and 4 in monitoring and control aspect

e) Shall supervise the monitoring and control work during the constructions in CP 2 and 4

A11: Pipeline Engineer

a) Shall conduct hydraulic calculation for CP 4 with Professionals B8, B12 and B13

b) Shall conduct detailed design of pipelines for CP 4 including preparation of technical specifications, with Professional B15

c) Shall evaluate the bids for CP 4 in pipe installation work

d) Shall supervise pipe installation work in CP 3 and 4

A12: Specification Specialist (Desal)

a) Shall prepare technical specifications for CP 1 by compiling draft specifications to be provided by the design engineers

A13: Specification Specialist (Distribution)

a) Shall prepare technical specifications for 2 and 4 by compiling draft specifications to be provided by the design engineers

A14: Financial Expert

a) Shall prepare financial model for the bid documents and financial evaluation for CP 1 suitable to the DBO scheme

b) Shall evaluate the financial bid for CP 1

A15: Contract Specialist (Desal)

a) Shall prepare PQ documents and bid documents for CP 1

b) Shall assist the Client in PQ evaluation in CP 1

c) Shall assist the Client in correspondence to clarifications from the bidders and evaluate the bids in contractual aspects in CP 1

d) Shall assist the Client in contract negotiation with the successful bidder in CP 1

A16: Contract Specialist (Distribution)

a) Shall prepare PQ documents and bid documents for CP 2 and CP 4

b) Shall assist the Client in PQ evaluation in CP 2 and CP 4

c) Shall assist the Client in correspondence to clarifications from the bidders and evaluate the bids in contractual aspects in CP 2 and CP 4

d) Shall assist the Client in contract negotiations with the successful bidders in CP 2 and CP 4

A17: Environmental Specialist

a) Shall prepare requirement to the contractors from the viewpoint of environmental and social considerations in preparation of the bid documents for CP 1, 2, 4 and 5

b) Shall conduct facilitation of implementation of EMP and EMoP for CP1, CP2, CP3, CP4 and CP5

A18: Commissioning Engineer

a) Shall review commissioning plan from the contractor for CP 1

b) Supervise the commissioning of CP 1 on site with other desalination experts

A19: Social Communication Specialist

a) Shall provide assistance to CMWSSB for the capacity development in acceleration of installation of service connections and water meters and improvement of customer care and publication with Professional A20

b) Shall prepare requirement to the contractors from the viewpoint of social communication in preparation of bid documents for CP 1, 2, 4 and 5

c) Supervise the contractors for CP 1, 2, 3, 4 and 5 from the viewpoint of social communication for smooth implementation of the construction works

A20: Organizational Expert

a) Shall provide assistance to CMWSSB for all the scope in the capacity development and organizational strengthening

B1: Senior Civil Engineer

a) Shall function as leader of the Professional B consultants

b) Shall assist Project Manager in communication with the Client and all other relevant local authorities

c) Shall assist Professional A consultants in design of CP 1 and conduct civil design in CP 2

d) Shall supervise civil construction works in CP 1 and CP 2

e) Shall monitor the supervision works in CP 3 and 4

B2: Civil Engineer

a) Shall assist Professional A consultants in overall planning and design works in CP 4

b) Shall supervise civil works in CP 3 and CP 4

B3: Mechanical Engineer

a) Shall assist Professional A6 in mechanical design in CP 2 and 4

b) Shall assist Professional A6 in bid evaluation in CP 2 and CP 4 in mechanical aspect

c) Shall assist Professional A5 in supervision of mechanical work in CP 1

d) Shall supervise mechanical works in CP 2 and 4

B4: Electrical Engineer

a) Shall assist Professional A8 in electrical design in CP 2 and 4

b) Shall assist Professional A7 in preparation of technical requirement to CP 5

c) Shall assist Professional A8 in bid evaluation in CP 2 and CP 4 in electrical aspect

d) Shall assist Professional A7 in supervision of electrical work in CP 1

e) Shall supervise electrical works in CP 2, 4 and 5

B5: Structural Engineer

a) Shall conduct structural design in CP 2 and 4 including preparation of technical specifications

b) Shall assist Professional A4 in supervision of structural work in CP 1

c) Shall supervise structural works in CP 2 and 4

B6: Architect

a) Shall conduct building designs in CP 1 with Professional A4 including preparation of technical specifications

b) Shall conduct building designs in CP 2 including preparation of technical specifications

c) Shall supervise building works in CP 1 and 2

B7: Building Mechanical and Electrical Engineer

a) Shall conduct building mechanical and electrical designs in CP 1 and 2 with Professionals A4 and B6 including preparation of technical specifications

b) Shall supervise building mechanical and electrical works in CP 1 and 2

B8: Senior Pipeline Engineer

a) Shall conduct detailed design in CP 4 with Professional A11

b) Shall assist Project Manager in communication with the Client and all other relevant local authorities

c) Shall supervise pipe installation works in CP 3 and 4 with Professional A11

B9, B10: Pipeline Engineers 1 and 2

a) Shall assist Professionals A11 and B8 in detailed design in CP 4

b) Shall assist Professionals A11 and B8 in supervision of pipe installation works in CP 4

B11: Pipeline Engineer 3

a) Shall assist Professional A11 and B8 in supervision of pipe installation work in CP 3

B12, B13: Hydraulic Modelers 1 and 2

a) Shall operate the hydraulic model and simulation in the detailed design in CP 4

b) Shall assist Professional A3 in skill transfer to CMWSSB for establishment and maintenance of asset information management system and hydraulic model

B14: Construction Planner/Cost Estimator

a) Shall prepare construction plan in CP 2 and 4

b) Shall conduct cost estimate of the construction works in CP 2 and 4

B15: Specification Specialist

a) Shall assist Professional A16 in preparation of technical specifications in CP 2 and 4

B16: Environmental Specialist

a) Shall assist Professional A17 in preparation of requirement to the contractors from the viewpoint of environmental and social considerations in preparation of bid documents for CP 1, 2, 4 and 5

b) Shall assist Professional A17 in facilitation of implementation of EMP and EMoP for CP1, CP2, CP3, CP4 and CP5

B17: Social Communication Specialist

a) Shall assist Professional A19 in assistance to CMWSSB for the capacity development

b) Shall assist Professional A19 in preparation of requirement to the contractors for CP 1, 2, 4 and 5

c) Shall supervise the contractors for CP 1, 2, 3, 4 and 5 from the viewpoint of social communication for smooth implementation of the construction works with Professional A19

B18: Safety and Health Expert 1

a) Shall supervise the contractors in safety and health management aspect in CP 1 and 2 based on the Guidance for the Management of Safety for Construction Works in Japanese ODA Projects (September 2014, JICA)

B19: Safety and Health Expert s

a) Shall supervise the contractors in safety and health management aspect in CP 3 and 4 based on the Guidance for the Management of Safety for Construction Works in Japanese ODA Projects (September 2014, JICA)

B20: Quantity Surveyor 1

a) Shall analyze completed work for arrangement of payment to the contractors in CP 1, 2 and 5

b) Shall monitor the overall construction schedule including progress monitoring, future work projection and instruction to the contractors with other engineers in charge of construction supervision in CP 1, 2 and 5

B21: Quantity Surveyor 2

a) Shall analyze completed work for arrangement of payment to the contractors in CP 3 and 4

b) Shall monitor the overall construction schedule including progress monitoring, future work projection and instruction to the contractors with other engineers in charge of construction supervision in CP 3 and 4

9 Reporting

Within the scope of consulting services, the Consultant shall prepare and submit reports and documents to CMWSSB as shown in Table 5. The Consultant shall provide an electronic copy of each of these reports.

For the design reports and PQ and bid documents, draft reports or the documents shall be submitted before the final submission. As for the design reports, the draft reports of the conceptual design (for CP 1) and the detailed design reports (for CP 2 and 4) shall be submitted with 5 copies, respectively, 1 month before the due date in Table 5. The final design reports shall be submitted taking into account the review comments from CMWSSB.

Regarding the PQ documents and bid documents, the Consultant shall submit the draft documents 1 month before the due date. The final documents will be issued after the concurrences of JICA to the respective PQ and bid documents.

Table 5 Reports and Documents to be Submitted by the Consultant

	Report/Document	No of Copies	Due Date/ Frequency
1	**Inception Report**[*1]	10	End of Aug. 2018
2	**Monthly Progress Report**	10	Every Month
3	**Completion Report**[*2]	5	End of Sep. 2025
4	**For Design and Tender Assistance for CP 1**		
	4.1 Conceptual Design Report and Drawings	10	End of Dec. 2018
	4.2 PQ Document	10	Middle of Jan. 2019
	4.3 Bid Document	10	Middle of Apr. 2019
	4.4 PQ Evaluation Report	10	Middle of Mar. 2019
	4.5 Bid Evaluation Report (Technical)	10	Middle of Oct. 2019
	4.6 Bid Evaluation Report (Financial)	10	Middle of Nov. 2019
5	**For Design and Tender Assistance for CP 2 and CP 4**		
	5.1 Detailed Design Report and Drawings[*3]	10	End of Jan. 2020
	5.2 PQ Document[*3]	10	Middle of Mar. 2020
	5.3 Bid Document[*3]	10	Middle of Jun. 2020
	5.4 PQ Evaluation Report[*3]	10	Middle of May 2020
	5.5 Bid Evaluation Report (Technical)[*3]	10	Middle of Oct. 2020
	5.6 Bid Evaluation Report (Financial)[*3]	10	Middle of Nov 2020
6	**For Construction Supervision of CP 1**		
	6.1 Contractor's Design Review Report[*4]	10	End of Apr. 2021
	6.2 Quality and Quantity Control Report[*5]	10	Every Month
	6.3 Final Inspection Report[*5]	10	End of Sep. 2023
7	**For Construction Supervision of CP 2**		
	7.1 Quality and Quantity Control Report[*5]	10	Every Month
	7.2 Final Inspection Report	10	End of Mar. 2024
8	**For Construction Supervision of CP 3-1 to CP 3-4**		
	8.1 Quality and Quantity Control Report[*5]	10	Every Month
	8.2 Final Inspection Report (CP 3-1, CP 3-2)	10	End of Jan. 2023
	8.3 Final Inspection Report (CP 3-3, CP 3-4)	10	End of Jan. 2024
9	**For Construction Supervision of CP 4**		
	9.1 Quality and Quantity Control Report[*5]	10	Every Month
	9.2 Final Inspection Report	10	End of Sep. 2025
10	**Environmental and Social Safeguard**		
	10.1 EIA Review Report for CP 1	10	End of Oct. 2018
	10.2 Environmental Monitoring Report[*3]	10	Every Month
	10.3 Environmental and Social Safeguard Evaluation Report (CP 1)[*3]	20	End of Sep. 2022
	10.4 Environmental and Social Safeguard Evaluation Report (CP 2)[*3]	20	End of Mar. 2023
	10.5 Environmental and Social Safeguard Evaluation Report (CP 3-1 and CP 3-2)[*3]	20	End of Jan. 2022
	10.6 Environmental and Social Safeguard Evaluation Report (CP 3-3 and CP 3-4)[*3]	20	End of Jan. 2023
	10.7 Environmental and Social Safeguard Evaluation Report (CP 4)[*3]	20	End of Sep. 2024
11	**Progress Report and Project Completion Report**		
	11.1 Progress Report (P/R)	1	Every Month
	11.2 Project Completion Report (PCR)	1	End of Sep. 2025

*1: Inception Report shall be submitted within 1 month after commencement of the Consulting Services. It should present the methodologies, schedule, organization, etc.

*2: Completion Report of the consulting services shall be submitted before completion of the services. It should compile all activities done by the Consultant.

*3: Reports and documents shall be compiled for the respective contract packages separately.

*4: Contractor's Design Review Report shall be submitted within 1 month after submission of the contractor's design report.

*5: Quality and Quantity Control Report can be compiled as a part of the Monthly Progress Report.

10 Obligations of the Executing Agency, CMWSSB

A certain range of arrangements and services will be provided by CMWSSB to the Consultant for smooth implementation of the Consulting Services, which will include the followings:

(1) Report and data

CMWSSB will make the existing reports and data related to the Project available to the Consultant. Such data will include the EIA and any natural condition survey report available, ocean current survey report, operation data of the existing DSPs, pipe inventory data, the existing hydraulic model of the distribution networks if any, and all available data requested by the Consultant for hydraulic modeling.

(2) Cooperation and counterpart staff

CMWSSB will appoint counterpart officials in PIU as may be necessary for effective implementation of the Consulting Services;

(3) Assistance and exemption

CMWSSB will use its best efforts to ensure that the assistance and exemption, as described in the Standard Request for Proposal issued by JICA, will be provided to the Consultant, in relation to:

- work permit and such other documents,
- entry and exit visas, residence permits, exchange permits and such other documents,
- clearance through customs,
- instructions and information to officials, agent and representatives of the Borrower's Government,
- exemption from any requirement for registration to practice their profession, and
- privilege pursuant to the applicable law in India.

(4) Appointment of trainees for CP 4

CMWSSB will appoint trainees who will receive OJT on the preparation and maintenance of the database for the water distribution network for CP 4.

Appendix 12.1 Conditions and Methodologies for Financial and Economic Analyses

Table A12.1.1 Population Projection

('000)

Year	Population Chennai Core	Population Expanded Area	Population Rest of CMA	Population Total
2015	4,728	2,326	2,883	9,937
	4,748	2,401	3,021	10,170
	4,768	2,478	3,166	10,412
	4,789	2,558	3,318	10,665
	4,810	2,641	3,478	10,929
2020	4,830	2,727	3,646	11,204
	4,852	2,785	3,732	11,369
	4,873	2,845	3,821	11,540
	4,895	2,907	3,913	11,714
	4,917	2,970	4,007	11,894
2025	4,939	3,035	4,104	12,078
	4,957	3,136	4,323	12,417
	4,976	3,242	4,556	12,774
	4,995	3,352	4,803	13,150
	5,014	3,466	5,066	13,547
2030	5,033	3,585	5,346	13,964
	5,054	3,672	5,524	14,250
	5,075	3,761	5,709	14,545
	5,096	3,853	5,899	14,848
	5,117	3,946	6,096	15,159
2035	5,138	4,042	6,300	15,480
	5,158	4,133	6,495	15,786
	5,178	4,227	6,696	16,101
	5,198	4,322	6,903	16,423
	5,219	4,419	7,117	16,755
2040	5,239	4,519	7,337	17,096
	5,257	4,614	7,551	17,422
	5,274	4,712	7,770	17,757
	5,292	4,811	7,996	18,100
	5,310	4,913	8,229	18,452
2045	5,328	5,017	8,469	18,813
	5,349	5,116	8,704	19,169
	5,371	5,218	8,945	19,534
	5,393	5,322	9,194	19,908
	5,415	5,428	9,449	20,292
2050	5,437	5,536	9,712	20,684

Source: JICA Study Team

Table A12.1.2 Service Population Projection

('000)

Year	Serviced Population Chennai Core	Serviced Population Expanded Area	Serviced Population Rest of CMA	Serviced Population Total
2015	4,728	2,326		7,054
	4,748	2,401		7,149
	4,768	2,478		7,247
	4,789	2,558		7,347
	4,810	2,641		7,451
2020	4,830	2,727		7,557
	4,852	2,785		7,637
	4,873	2,845		7,718
	4,895	2,907		7,802
	4,917	2,970		7,887
2025	4,939	3,035		7,973
	4,957	3,136		8,094
	4,976	3,242		8,218
	4,995	3,352		8,347
	5,014	3,466		8,481
2030	5,033	3,585		8,619
	5,054	3,672		8,726
	5,075	3,761		8,836
	5,096	3,853		8,948
	5,117	3,946		9,063
2035	5,138	4,042		9,180
	5,158	4,133		9,291
	5,178	4,227		9,405
	5,198	4,322		9,520
	5,219	4,419		9,638
2040	5,239	4,519		9,758
	5,257	4,614		9,871
	5,274	4,712		9,986
	5,292	4,811		10,103
	5,310	4,913		10,223
2045	5,328	5,017		10,344
	5,349	5,116		10,466
	5,371	5,218		10,589
	5,393	5,322		10,715
	5,415	5,428		10,843
2050	5,437	5,536		10,973

*Ignored in the Calculations

Source: JICA Study Team

Table A12.1.3 With- and Without- Perur- Project Water Production Volume

	Total	With-Perur-Project Case	Without-Perur-Project Case	Perur
Year	Water Demand (MLD)	Water Production (MLD)	Water Production (MLD)	Water Production (MLD)
2015	865	855	855	0
	910	855	855	0
	954	924	924	0
	999	989	989	0
	1,043	990	990	0
2020	1,087	1,087	1,087	0
	1,191	1,191	1,191	0
	1,295	1,295	1,295	0
	1,400	1,400	1,134	266
	1,504	1,504	1,162	341
2025	1,608	1,608	1,224	383
	1,632	1,632	1,286	346
	1,704	1,704	1,402	302
	1,775	1,775	1,436	339
	1,847	1,847	1,585	262
2030	1,918	1,918	1,619	300
	2,013	2,013	1,708	305
	2,107	2,107	1,755	353
	2,202	2,202	1,915	287
	2,296	2,296	1,962	335
2035	2,391	2,391	2,096	295
	2,367	2,367	2,078	289
	2,388	2,388	2,091	297
	2,410	2,410	2,104	305
	2,431	2,431	2,118	313
2040	2,452	2,452	2,137	315
	2,499	2,499	2,169	331
	2,547	2,547	2,199	348
	2,594	2,594	2,311	283
	2,641	2,641	2,345	296
2045	2,688	2,688	2,384	304
	2,768	2,768	2,442	326
	2,848	2,848	2,500	348
	2,928	2,928	2,600	328
	3,008	3,008	2,661	347
2050	3,088	3,088	2,721	367

Source: JICA Study Team

Table A12.1.4 With- and Without- Pipeline Project Water Loss Ratio

	With-Pipeline-Project Case	Without-Pipeline-Project Case	Project Unaffected Area
Year	Water Loss Ratio (Chennai Core)	Water Loss Ratio (Chennai Core)	Water Loss Ratio (Average)
2015	20.0%	20.0%	30.0%
	20.0%	20.0%	30.0%
	19.0%	19.0%	30.0%
	18.0%	18.0%	30.0%
	17.0%	17.0%	30.0%
2020	16.0%	17.5%	30.0%
	14.5%	18.0%	30.0%
	13.0%	18.5%	30.0%
	11.5%	19.0%	30.0%
	10.0%	19.5%	30.0%
2025	10.0%	20.0%	25.0%
	10.0%	20.5%	25.0%
	10.0%	21.0%	25.0%
	10.0%	21.5%	25.0%
	10.0%	22.0%	25.0%
2030	10.0%	22.5%	20.0%
	10.0%	23.0%	20.0%
	10.0%	23.5%	20.0%
	10.0%	24.0%	20.0%
	10.0%	24.5%	20.0%
2035	10.0%	25.0%	15.0%
	10.0%	25.5%	15.0%
	10.0%	26.0%	15.0%
	10.0%	26.5%	15.0%
	10.0%	27.0%	15.0%
2040	10.0%	27.5%	10.0%
	10.5%	28.0%	10.0%
	11.0%	28.5%	10.0%
	11.5%	29.0%	10.0%
	12.0%	29.5%	10.0%
2045	12.5%	30.0%	10.0%
	13.0%	30.5%	10.0%
	13.5%	31.0%	10.0%
	14.0%	31.5%	10.0%
	14.5%	32.0%	10.0%
2050	15.0%	32.5%	10.0%

Source: JICA Study Team

Table A12.1.5 With- and Without- Pipeline Project Total Sold Water

	With-Pipeline-Project Case	Without-Pipeline-Project Case	#NAME?
Year	Total Sold Water (MLD)	Total Sold Water (MLD)	Difference in Total Sold Water (MLD)
2015	648	648	0
	651	651	0
	707	707	0
	762	762	0
	772	772	0
2020	850	840	9
	937	914	23
	1,025	987	38
	1,114	1,060	55
	1,205	1,132	72
2025	1,325	1,245	79
	1,340	1,259	81
	1,394	1,309	85
	1,448	1,359	89
	1,502	1,409	94
2030	1,613	1,515	98
	1,689	1,587	102
	1,765	1,658	107
	1,841	1,730	111
	1,917	1,801	115
2035	2,072	1,952	120
	2,051	1,929	122
	2,069	1,943	126
	2,088	1,957	131
	2,106	1,971	135
2040	2,207	2,067	140
	2,246	2,105	140
	2,284	2,143	141
	2,322	2,181	141
	2,361	2,219	142
2045	2,399	2,257	142
	2,467	2,324	143
	2,535	2,392	143
	2,602	2,459	144
	2,670	2,526	144
2050	2,738	2,593	145

Source: JICA Study Team

Table A12.1.6 With-and Without- Project Total Sold Water (Both Perur and Pipeline Projects)

	With-Perur-Project Case	Without-Perur-Project Case	
	With-Pipeline-Project Case	With-Pipeline-Project Case	
Year	Total Sold Water (MLD)	Total Sold Water (MLD)	Difference in Total Sold Water (MLD)
2015	648	648	0
	651	651	0
	707	707	0
	762	762	0
	772	772	0
2020	850	840	9
	937	914	23
	1,025	987	38
	1,114	844	270
	1,205	858	347
2025	1,325	939	386
	1,340	984	356
	1,394	1,071	324
	1,448	1,093	356
	1,502	1,204	298
2030	1,613	1,283	330
	1,689	1,352	337
	1,765	1,388	376
	1,841	1,512	329
	1,917	1,549	368
2035	2,072	1,731	341
	2,051	1,714	337
	2,069	1,723	346
	2,088	1,733	355
	2,106	1,742	364
2040	2,207	1,839	368
	2,246	1,867	378
	2,284	1,894	390
	2,322	1,980	342
	2,361	2,010	350
2045	2,399	2,044	355
	2,467	2,098	369
	2,535	2,151	383
	2,602	2,234	368
	2,670	2,290	380
2050	2,738	2,345	392

Source: JICA Study Team

Table A12.1.7 Incremental Sold Water by Category

Year	Incremental Sold Water Domestic (MLD)	Incremental Sold Water Commercial (MLD)	Incremental Sold Water Industrial (MLD)	Incremental Sold Water Total (MLD)
2015	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
2020	11	0	0	11
	24	0	0	24
	36	0	0	36
	234	12	24	270
	281	15	51	347
2025	314	17	55	386
	291	15	50	356
	257	14	52	324
	276	15	64	356
	226	13	59	298
2030	257	14	59	330
	254	15	69	337
	275	16	86	376
	233	14	82	329
	254	16	99	368
2035	227	15	100	341
	229	15	94	337
	236	15	95	346
	243	15	97	355
	250	16	98	364
2040	244	16	108	368
	250	16	113	378
	255	17	117	390
	223	15	104	342
	228	15	108	350
2045	230	15	110	355
	235	16	118	369
	240	17	127	383
	227	16	125	368
	232	16	132	380
2050	236	17	140	392

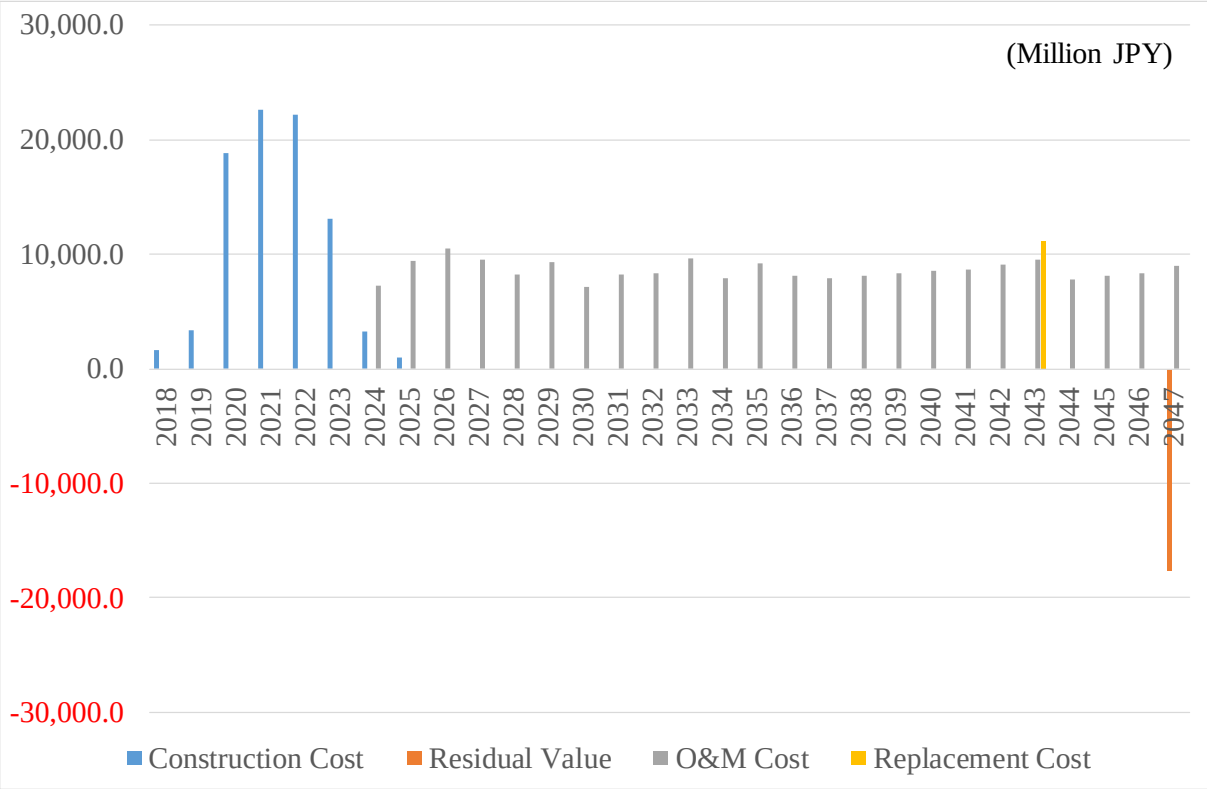
Source: JICA Study Team

Table A12.1.8 GRDP per Capita and EVT per Capita Projection

	GRDP per Capita	EVT per Capita	EVT per Capita
Year	Chennai (INR)	Chennai (INR)	Chennai (JPY)
2015	128,366	25,673	43,901
	135,554	27,111	46,360
	143,146	28,629	48,956
	151,162	30,232	51,697
	159,627	31,925	54,592
2020	168,566	33,713	57,650
	175,646	35,129	60,071
	183,023	36,605	62,594
	190,710	38,142	65,223
	198,719	39,744	67,962
2025	207,066	41,413	70,816
	215,762	43,152	73,791
	224,824	44,965	76,890
	234,267	46,853	80,119
	244,106	48,821	83,484
2030	254,359	50,872	86,991
	264,533	52,907	90,470
	275,114	55,023	94,089
	286,119	57,224	97,853
	297,564	59,513	101,767
2035	309,466	61,893	105,838
	321,845	64,369	110,071
	334,719	66,944	114,474
	348,108	69,622	119,053
	362,032	72,406	123,815
2040	376,513	75,303	128,768
	390,444	78,089	133,532
	404,891	80,978	138,473
	419,872	83,974	143,596
	435,407	87,081	148,909
2045	451,517	90,303	154,419
	468,223	93,645	160,132
	485,547	97,109	166,057
	503,512	100,702	172,201
	522,142	104,428	178,573
2050	541,462	108,292	185,180

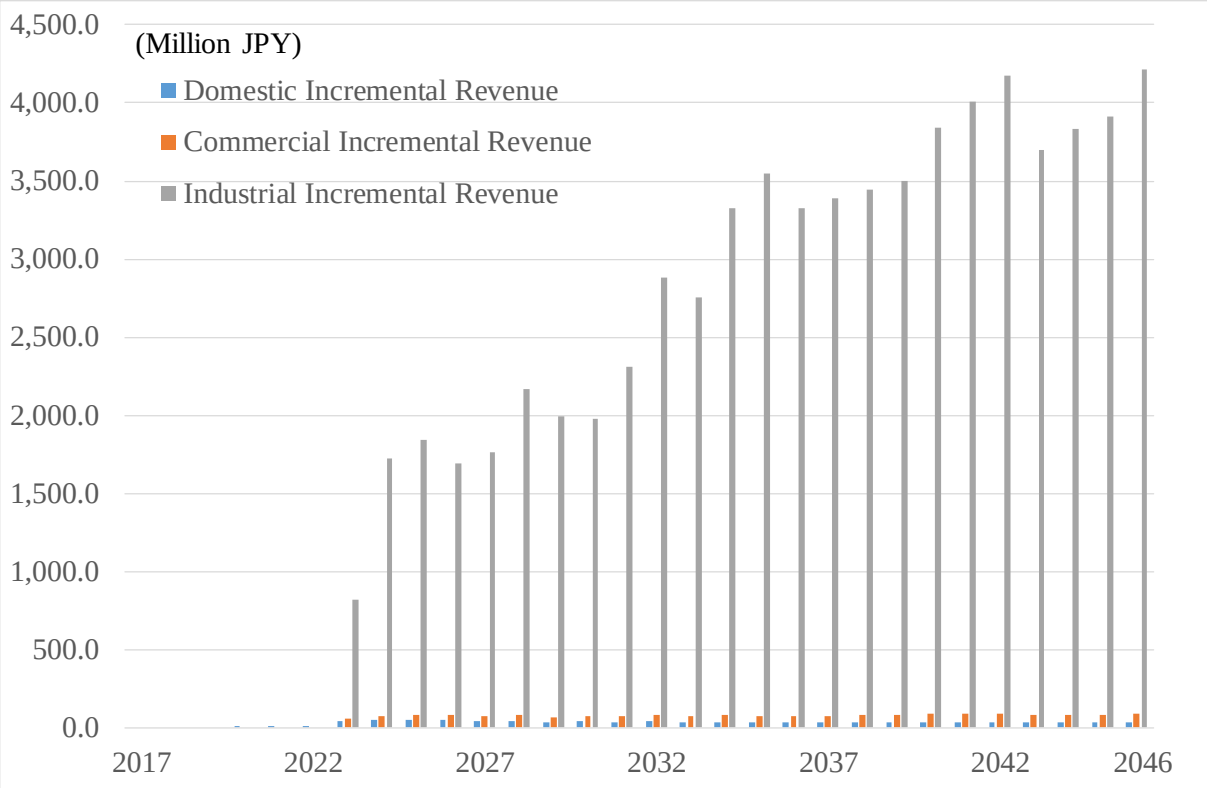
Source: JICA Study Team

Appendix 12.2 Financial Cost and Benefit



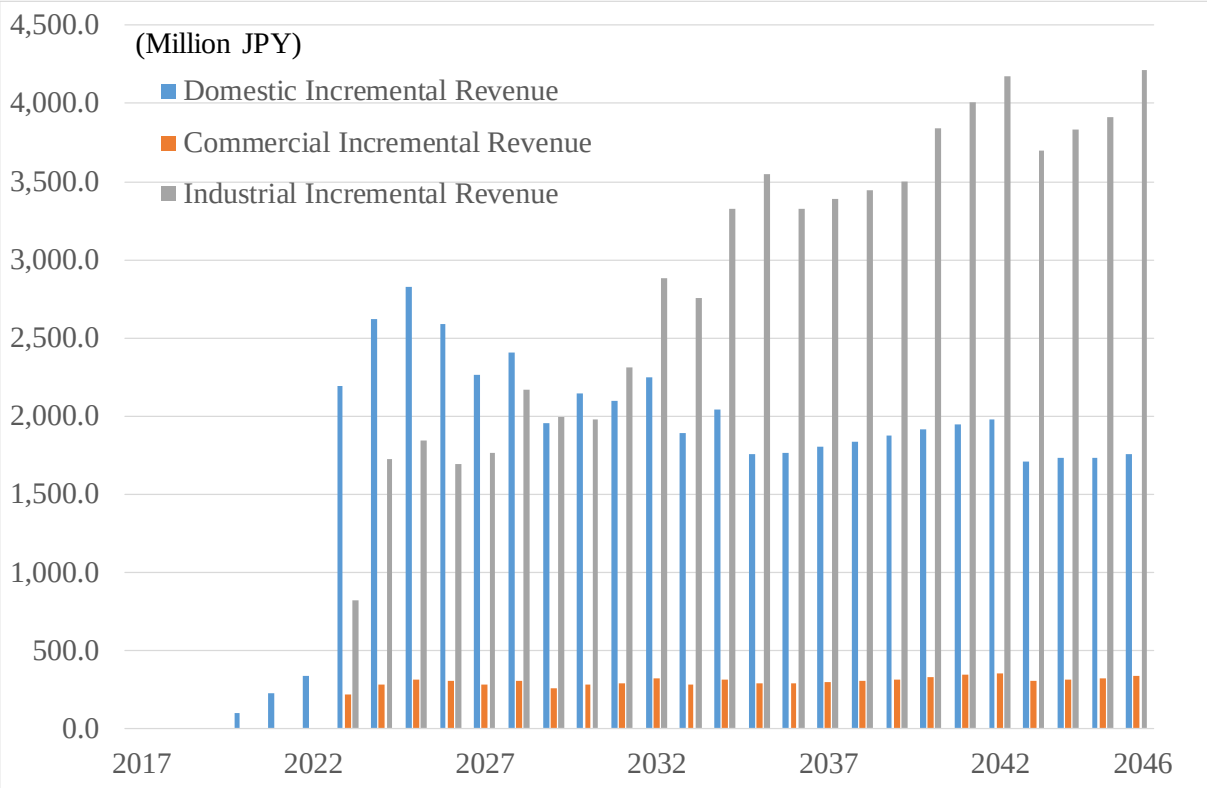
Source: JICA Study Team

Figure A12.2.1 Financial Cost Schedule



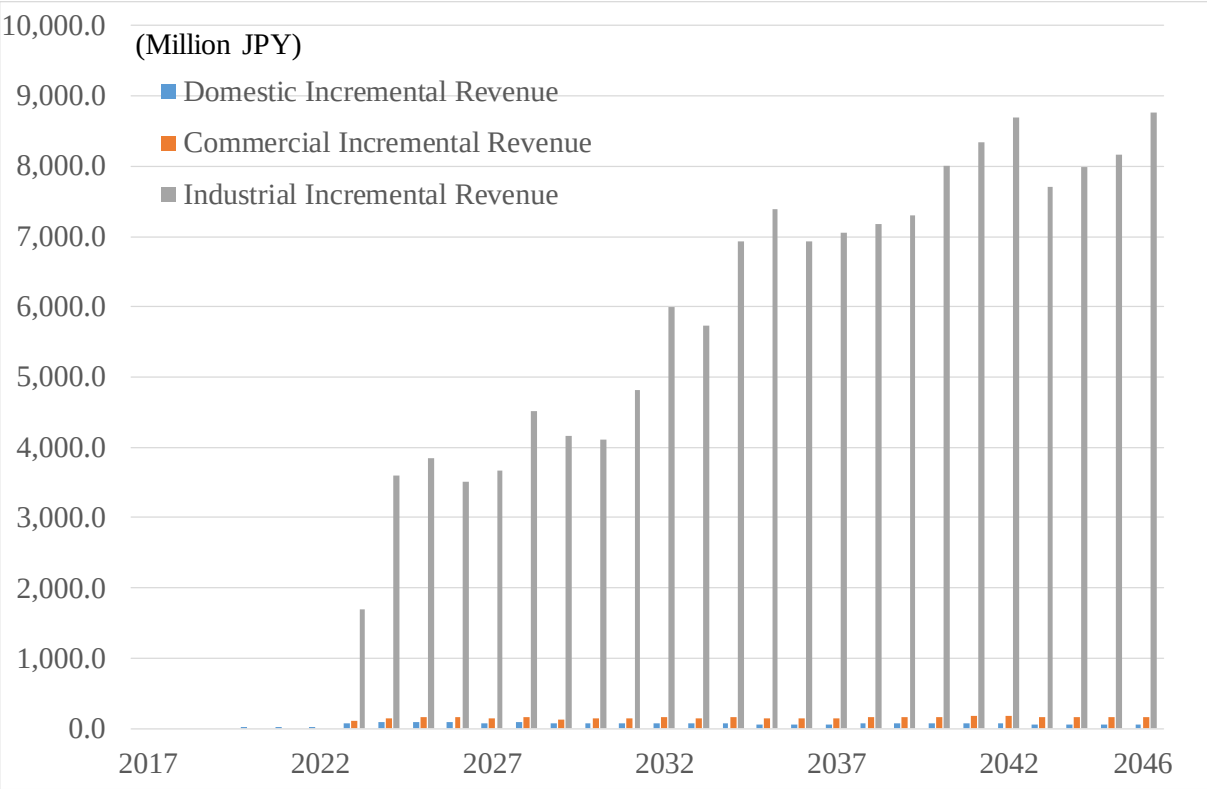
Source: JICA Study Team

Figure A12.2.2 Financial Benefit Schedule (Alternative 1)



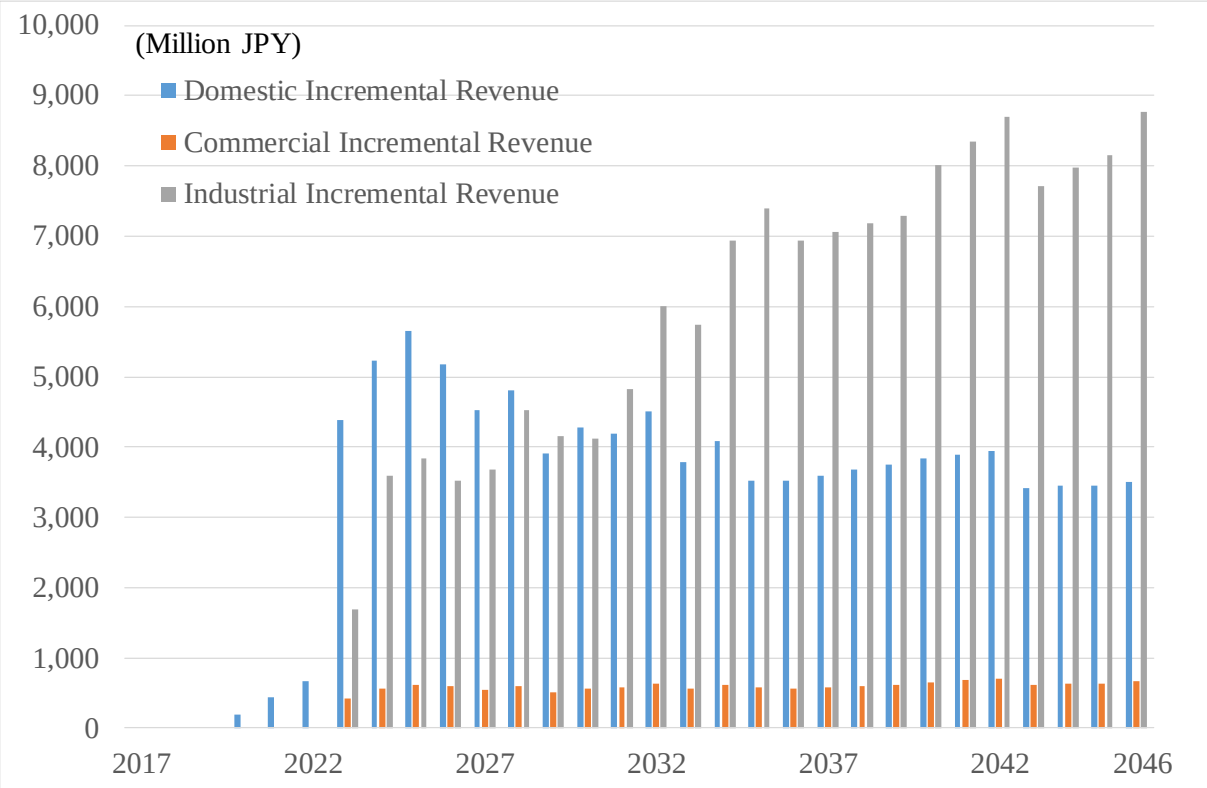
Source: JICA Study Team

Figure A12.2.3 Financial Benefit Schedule (Alternative 2)



Source: JICA Study Team

Figure A12.2.4 Financial Benefit Schedule (Alternative 1 – New Tariff)



Source: JICA Study Team

Figure A12.2.5 Financial Benefit Schedule (Alternative 2 – New Tariff)

Appendix 12.3 Financial Analysis Results

Table A12.3.1 Financial Analysis Results (Alternative 1 – Total Cost)

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	1,688.0	0.0	0.0	0.0	1,688.0	0.0	0.0	0.0	0.0	-1,688.0
2	2019	3,328.6	0.0	0.0	0.0	3,328.6	0.0	0.0	0.0	0.0	-3,328.6
3	2020	18,874.8	0.0	0.0	0.0	18,874.8	0.0	0.0	0.0	0.0	-18,874.8
4	2021	22,663.7	0.0	0.0	0.0	22,663.7	1.7	0.0	0.0	1.7	-22,662.0
5	2022	22,234.3	0.0	0.0	0.0	22,234.3	3.9	0.0	0.0	3.9	-22,230.4
6	2023	13,121.5	0.0	0.0	0.0	13,121.5	5.8	0.0	0.0	5.8	-13,115.6
7	2024	3,289.8	0.0	6,088.2	0.0	9,378.0	33.0	47.8	706.0	786.9	-8,591.1
8	2025	984.2	0.0	7,816.8	0.0	8,801.1	39.5	61.7	1,497.4	1,598.6	-7,202.5
9	2026	0.0	0.0	8,774.8	0.0	8,774.8	42.6	68.6	1,600.0	1,711.2	-7,063.6
10	2027	0.0	0.0	7,924.4	0.0	7,924.4	39.2	67.4	1,471.1	1,577.7	-6,346.7
11	2028	0.0	0.0	6,906.3	0.0	6,906.3	34.6	61.7	1,547.4	1,643.7	-5,262.6
12	2029	0.0	0.0	7,763.2	0.0	7,763.2	36.7	67.7	1,898.5	2,002.8	-5,760.4
13	2030	0.0	0.0	6,003.2	0.0	6,003.2	30.1	57.4	1,766.6	1,854.2	-4,149.0
14	2031	0.0	0.0	6,860.1	0.0	6,860.1	32.9	63.4	1,743.9	1,840.2	-5,019.9
15	2032	0.0	0.0	6,987.0	0.0	6,987.0	32.2	64.8	2,044.8	2,141.9	-4,845.1
16	2033	0.0	0.0	8,077.8	0.0	8,077.8	34.5	72.0	2,538.0	2,644.4	-5,433.3
17	2034	0.0	0.0	6,563.2	0.0	6,563.2	29.3	63.5	2,451.3	2,544.1	-4,019.1
18	2035	0.0	0.0	7,665.5	0.0	7,665.5	31.5	70.7	2,947.5	3,049.7	-4,615.8
19	2036	0.0	0.0	6,750.3	0.0	6,750.3	27.3	65.9	3,163.9	3,257.0	-3,493.3
20	2037	0.0	0.0	6,615.0	0.0	6,615.0	27.4	65.3	2,973.8	3,066.5	-3,548.5
21	2038	0.0	0.0	6,802.0	0.0	6,802.0	28.0	67.1	3,030.6	3,125.7	-3,676.3
22	2039	0.0	0.0	6,989.1	0.0	6,989.1	28.6	68.9	3,084.3	3,181.8	-3,807.2
23	2040	0.0	0.0	7,176.1	0.0	7,176.1	29.2	70.7	3,134.9	3,234.8	-3,941.3
24	2041	0.0	0.0	7,211.8	0.0	7,211.8	29.9	75.7	3,447.2	3,552.8	-3,659.0
25	2042	0.0	0.0	7,577.7	0.0	7,577.7	30.3	77.7	3,584.5	3,692.4	-3,885.3
26	2043	0.0	0.0	7,971.6	8,597.8	16,569.4	30.7	79.8	3,727.1	3,837.5	-12,731.9
27	2044	0.0	0.0	6,478.6	0.0	6,478.6	26.8	70.7	3,339.3	3,436.9	-3,041.7
28	2045	0.0	0.0	6,783.6	0.0	6,783.6	27.1	72.3	3,450.2	3,549.6	-3,234.0
29	2046	0.0	0.0	6,965.6	0.0	6,965.6	27.1	73.2	3,524.0	3,624.3	-3,341.3
30	2047	0.0	-17,635.9	7,469.7	0.0	-10,166.2	27.4	75.9	3,779.5	3,882.9	14,049.1
	Total	86,184.9	-17,635.9	172,221.6	8,597.8	249,368.4	767.1	1,630.0	62,451.9	64,849.0	-184,519.4
										IRR	**#NUM!**
								WACC	1.74%	**NPV COST**	**245,104**
									1.74%	**NPV BENEFIT**	**63,740**
									1.74%	**NPV BALANCE**	**-181,364**
										B/C	**0.26**

Source: JICA Study Team

Table A12.3.2 Financial Analysis Results (Alternative 1 – O&M Cost Only)

(Million JPY)

Evaluation Period	Year	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2021	0.0	0.0	0.0	1.7	0.0	0.0	1.7	1.7
5	2022	0.0	0.0	0.0	3.9	0.0	0.0	3.9	3.9
6	2023	0.0	0.0	0.0	5.8	0.0	0.0	5.8	5.8
7	2024	6,088.2	0.0	6,088.2	33.0	47.8	706.0	786.9	-5,301.3
8	2025	7,816.8	0.0	7,816.8	39.5	61.7	1,497.4	1,598.6	-6,218.3
9	2026	8,774.8	0.0	8,774.8	42.6	68.6	1,600.0	1,711.2	-7,063.6
10	2027	7,924.4	0.0	7,924.4	39.2	67.4	1,471.1	1,577.7	-6,346.7
11	2028	6,906.3	0.0	6,906.3	34.6	61.7	1,547.4	1,643.7	-5,262.6
12	2029	7,763.2	0.0	7,763.2	36.7	67.7	1,898.5	2,002.8	-5,760.4
13	2030	6,003.2	0.0	6,003.2	30.1	57.4	1,766.6	1,854.2	-4,149.0
14	2031	6,860.1	0.0	6,860.1	32.9	63.4	1,743.9	1,840.2	-5,019.9
15	2032	6,987.0	0.0	6,987.0	32.2	64.8	2,044.8	2,141.9	-4,845.1
16	2033	8,077.8	0.0	8,077.8	34.5	72.0	2,538.0	2,644.4	-5,433.3
17	2034	6,563.2	0.0	6,563.2	29.3	63.5	2,451.3	2,544.1	-4,019.1
18	2035	7,665.5	0.0	7,665.5	31.5	70.7	2,947.5	3,049.7	-4,615.8
19	2036	6,750.3	0.0	6,750.3	27.3	65.9	3,163.9	3,257.0	-3,493.3
20	2037	6,615.0	0.0	6,615.0	27.4	65.3	2,973.8	3,066.5	-3,548.5
21	2038	6,802.0	0.0	6,802.0	28.0	67.1	3,030.6	3,125.7	-3,676.3
22	2039	6,989.1	0.0	6,989.1	28.6	68.9	3,084.3	3,181.8	-3,807.2
23	2040	7,176.1	0.0	7,176.1	29.2	70.7	3,134.9	3,234.8	-3,941.3
24	2041	7,211.8	0.0	7,211.8	29.9	75.7	3,447.2	3,552.8	-3,659.0
25	2042	7,577.7	0.0	7,577.7	30.3	77.7	3,584.5	3,692.4	-3,885.3
26	2043	7,971.6	11,152.8	19,124.5	30.7	79.8	3,727.1	3,837.5	-15,286.9
27	2044	6,478.6	0.0	6,478.6	26.8	70.7	3,339.3	3,436.9	-3,041.7
28	2045	6,783.6	0.0	6,783.6	27.1	72.3	3,450.2	3,549.6	-3,234.0
29	2046	6,965.6	0.0	6,965.6	27.1	73.2	3,524.0	3,624.3	-3,341.3
30	2047	7,469.7	0.0	7,469.7	27.4	75.9	3,779.5	3,882.9	-3,586.8
	Total	172,221.6	11,152.8	183,374.4	767.1	1,630.0	62,451.9	64,849.0	-118,525.4
								IRR	**1316.3%**
						WACC	1.74%	**NPV COST**	**180,238**
							1.74%	**NPV BENEFIT**	**63,740**
							1.74%	**NPV BALANCE**	**-116,498**
								B/C	**0.35**

Source: JICA Study Team

Table A12.3.3 Financial Analysis Results (Alternative 2 – Total Cost)

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	1,688.0	0.0	0.0	0.0	1,688.0	0.0	0.0	0.0	0.0	-1,688.0
2	2019	3,328.6	0.0	0.0	0.0	3,328.6	0.0	0.0	0.0	0.0	-3,328.6
3	2020	18,874.8	0.0	0.0	0.0	18,874.8	99.5	0.0	0.0	99.5	-18,775.3
4	2021	22,663.7	0.0	0.0	0.0	22,663.7	222.3	0.0	0.0	222.3	-22,441.4
5	2022	22,234.3	0.0	0.0	0.0	22,234.3	336.2	0.0	0.0	336.2	-21,898.1
6	2023	13,121.5	0.0	0.0	0.0	13,121.5	1,899.0	187.0	706.0	2,791.9	-10,329.5
7	2024	3,289.8	0.0	6,088.2	0.0	9,378.0	2,270.8	241.0	1,497.4	4,009.2	-5,368.9
8	2025	984.2	0.0	7,816.8	0.0	8,801.1	2,448.8	268.2	1,600.0	4,317.0	-4,484.1
9	2026	0.0	0.0	8,774.8	0.0	8,774.8	2,252.9	263.4	1,471.1	3,987.4	-4,787.4
10	2027	0.0	0.0	7,924.4	0.0	7,924.4	1,988.0	241.0	1,547.4	3,776.4	-4,148.0
11	2028	0.0	0.0	6,906.3	0.0	6,906.3	2,106.7	264.4	1,898.5	4,269.5	-2,636.8
12	2029	0.0	0.0	7,763.2	0.0	7,763.2	1,729.8	224.4	1,766.6	3,720.9	-4,042.3
13	2030	0.0	0.0	6,003.2	0.0	6,003.2	1,889.5	247.7	1,743.9	3,881.1	-2,122.1
14	2031	0.0	0.0	6,860.1	0.0	6,860.1	1,853.1	253.2	2,044.8	4,151.2	-2,708.9
15	2032	0.0	0.0	6,987.0	0.0	6,987.0	1,980.5	281.4	2,538.0	4,799.9	-2,187.1
16	2033	0.0	0.0	8,077.8	0.0	8,077.8	1,682.4	248.1	2,451.3	4,381.9	-3,695.9
17	2034	0.0	0.0	6,563.2	0.0	6,563.2	1,808.3	276.3	2,947.5	5,032.1	-1,531.1
18	2035	0.0	0.0	7,665.5	0.0	7,665.5	1,566.4	257.5	3,163.9	4,987.8	-2,677.7
19	2036	0.0	0.0	6,750.3	0.0	6,750.3	1,574.2	255.3	2,973.8	4,803.2	-1,947.1
20	2037	0.0	0.0	6,615.0	0.0	6,615.0	1,609.2	262.4	3,030.6	4,902.1	-1,712.9
21	2038	0.0	0.0	6,802.0	0.0	6,802.0	1,643.7	269.4	3,084.3	4,997.5	-1,804.6
22	2039	0.0	0.0	6,989.1	0.0	6,989.1	1,677.8	276.5	3,134.9	5,089.2	-1,899.9
23	2040	0.0	0.0	7,176.1	0.0	7,176.1	1,718.1	295.7	3,447.2	5,461.0	-1,715.1
24	2041	0.0	0.0	7,211.8	0.0	7,211.8	1,739.1	303.4	3,584.5	5,627.0	-1,584.8
25	2042	0.0	0.0	7,577.7	0.0	7,577.7	1,762.7	311.8	3,727.1	5,801.6	-1,776.1
26	2043	0.0	0.0	7,971.6	11,152.8	19,124.5	1,541.6	276.3	3,339.3	5,157.2	-13,967.3
27	2044	0.0	0.0	6,478.6	0.0	6,478.6	1,556.6	282.6	3,450.2	5,289.4	-1,189.2
28	2045	0.0	0.0	6,783.6	0.0	6,783.6	1,555.6	286.0	3,524.0	5,365.6	-1,418.1
29	2046	0.0	0.0	6,965.6	0.0	6,965.6	1,576.2	296.6	3,779.5	5,652.3	-1,313.3
30	2047	0.0	-17,635.9	7,469.7	0.0	-10,166.2	1,595.4	306.9	4,033.4	5,935.8	16,102.0
	Total	86,184.9	-17,635.9	172,221.6	11,152.8	251,923.5	45,684.4	6,676.5	66,485.3	118,846.2	-133,077.3
										IRR	**#NUM!**
								WACC	1.74%	**NPV COST**	**247,615**
									1.74%	**NPV BENEFIT**	**116,814**
									1.74%	**NPV BALANCE**	**-130,801**
										B/C	**0.47**

Source: JICA Study Team

Table A12.3.4 Financial Analysis Results (Alternative 2 – O&M Cost Only)

(Million JPY)

Evaluation Period	Year	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2020	0.0	0.0	0.0	99.5	0.0	0.0	99.5	99.5
4	2021	0.0	0.0	0.0	222.3	0.0	0.0	222.3	222.3
5	2022	0.0	0.0	0.0	336.2	0.0	0.0	336.2	336.2
6	2023	0.0	0.0	0.0	1,899.0	187.0	706.0	2,791.9	2,791.9
7	2024	6,088.2	0.0	6,088.2	2,270.8	241.0	1,497.4	4,009.2	-2,079.0
8	2025	7,816.8	0.0	7,816.8	2,448.8	268.2	1,600.0	4,317.0	-3,499.8
9	2026	8,774.8	0.0	8,774.8	2,252.9	263.4	1,471.1	3,987.4	-4,787.4
10	2027	7,924.4	0.0	7,924.4	1,988.0	241.0	1,547.4	3,776.4	-4,148.0
11	2028	6,906.3	0.0	6,906.3	2,106.7	264.4	1,898.5	4,269.5	-2,636.8
12	2029	7,763.2	0.0	7,763.2	1,729.8	224.4	1,766.6	3,720.9	-4,042.3
13	2030	6,003.2	0.0	6,003.2	1,889.5	247.7	1,743.9	3,881.1	-2,122.1
14	2031	6,860.1	0.0	6,860.1	1,853.1	253.2	2,044.8	4,151.2	-2,708.9
15	2032	6,987.0	0.0	6,987.0	1,980.5	281.4	2,538.0	4,799.9	-2,187.1
16	2033	8,077.8	0.0	8,077.8	1,682.4	248.1	2,451.3	4,381.9	-3,695.9
17	2034	6,563.2	0.0	6,563.2	1,808.3	276.3	2,947.5	5,032.1	-1,531.1
18	2035	7,665.5	0.0	7,665.5	1,566.4	257.5	3,163.9	4,987.8	-2,677.7
19	2036	6,750.3	0.0	6,750.3	1,574.2	255.3	2,973.8	4,803.2	-1,947.1
20	2037	6,615.0	0.0	6,615.0	1,609.2	262.4	3,030.6	4,902.1	-1,712.9
21	2038	6,802.0	0.0	6,802.0	1,643.7	269.4	3,084.3	4,997.5	-1,804.6
22	2039	6,989.1	0.0	6,989.1	1,677.8	276.5	3,134.9	5,089.2	-1,899.9
23	2040	7,176.1	0.0	7,176.1	1,718.1	295.7	3,447.2	5,461.0	-1,715.1
24	2041	7,211.8	0.0	7,211.8	1,739.1	303.4	3,584.5	5,627.0	-1,584.8
25	2042	7,577.7	0.0	7,577.7	1,762.7	311.8	3,727.1	5,801.6	-1,776.1
26	2043	7,971.6	11,152.8	19,124.5	1,541.6	276.3	3,339.3	5,157.2	-13,967.3
27	2044	6,478.6	0.0	6,478.6	1,556.6	282.6	3,450.2	5,289.4	-1,189.2
28	2045	6,783.6	0.0	6,783.6	1,555.6	286.0	3,524.0	5,365.6	-1,418.1
29	2046	6,965.6	0.0	6,965.6	1,576.2	296.6	3,779.5	5,652.3	-1,313.3
30	2047	7,469.7	0.0	7,469.7	1,595.4	306.9	4,033.4	5,935.8	-1,533.9
	Total	172,221.6	11,152.8	183,374.4	45,684.4	6,676.5	66,485.3	118,846.2	-64,528.2
								IRR	**68.9%**
						WACC	1.74%	**NPV COST**	**180,238**
							1.74%	**NPV BENEFIT**	**116,814**
							1.74%	**NPV BALANCE**	**-63,425**
								B/C	**0.65**

Source: JICA Study Team

Appendix 12.4 Financial Sensitivity Analysis

Table A12.4.1 Sensitivity Analysis (Fluctuations in Cost and Benefit)

(Alternative 1 – Total Cost)

A-2											Benefit										
#NUM!	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	105%	110%	115%	120%	125%	130%	135%	140%	145%	150%
150%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
145%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
140%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
135%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
130%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-22.1%	#NUM!
125%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
120%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
115%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
110%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
105%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
100%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
95%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
90%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
85%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-13.2%	-12.5%
80%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-12.7%	-12.0%	-11.3%
75%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-16.4%	#NUM!	#NUM!	-13.7%	-12.9%	-12.1%	-11.4%	-10.7%	-10.1%
70%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-13.1%	-12.3%	-11.5%	-10.8%	-10.1%	-9.4%	-8.8%
65%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-15.4%	#NUM!	#NUM!	-12.5%	-11.6%	-10.8%	-10.1%	-9.4%	-8.7%	-8.1%	-7.5%
60%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-12.7%	-11.8%	-10.9%	-10.1%	-9.3%	-8.6%	-7.9%	-7.3%	-6.7%	-6.2%
55%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-13.0%	-11.9%	-11.0%	-10.1%	-9.3%	-8.5%	-7.8%	-7.1%	-6.5%	-5.9%	-5.3%	-4.8%
50%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	-13.3%	-12.1%	-11.1%	-10.1%	-9.2%	-8.3%	-7.6%	-6.8%	-6.2%	-5.6%	-5.0%	-4.4%	-3.9%	-3.4%

Source: JICA Study Team

Table A12.4.2 Sensitivity Analysis (Fluctuations in Cost and Benefit)

(Alternative 1 – O&M Cost Only)

	B-2											Benefit										
	1316.32%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	105%	110%	115%	120%	125%	130%	135%	140%	145%	150%
	150%	2028.0%	1957.2%	1894.2%	1837.7%	1786.6%	1739.9%	1697.1%	1657.6%	1620.9%	1586.7%	1554.8%	1524.8%	1496.5%	1469.9%	1444.6%	1420.6%	1397.8%	1376.0%	1355.3%	1335.4%	1316.3%
	145%	2002.6%	1932.4%	1870.1%	1814.2%	1763.5%	1717.3%	1674.9%	1635.7%	1599.4%	1565.6%	1533.9%	1504.2%	1476.2%	1449.7%	1424.7%	1400.9%	1378.3%	1356.7%	1336.1%	1316.3%	1297.4%
	140%	1976.5%	1907.1%	1845.4%	1790.1%	1739.9%	1694.2%	1652.2%	1613.4%	1577.4%	1543.9%	1512.5%	1483.0%	1455.3%	1429.0%	1404.2%	1380.6%	1358.2%	1336.8%	1316.3%	1296.7%	1278.0%
	135%	1949.8%	1881.1%	1820.1%	1765.3%	1715.7%	1670.4%	1628.8%	1590.4%	1554.8%	1521.6%	1490.5%	1461.3%	1433.8%	1407.8%	1383.2%	1359.8%	1337.6%	1316.3%	1296.0%	1276.6%	1258.0%
	130%	1922.4%	1854.5%	1794.1%	1739.9%	1690.8%	1646.0%	1604.8%	1566.8%	1531.5%	1498.7%	1467.9%	1439.0%	1411.7%	1386.0%	1361.6%	1338.4%	1316.3%	1295.3%	1275.2%	1255.9%	1237.4%
	125%	1894.2%	1827.1%	1767.4%	1713.8%	1665.2%	1620.9%	1580.2%	1542.6%	1507.6%	1475.1%	1444.6%	1416.0%	1389.0%	1363.5%	1339.3%	1316.3%	1294.5%	1273.6%	1253.6%	1234.5%	1216.2%
	120%	1865.2%	1798.9%	1739.9%	1686.9%	1638.9%	1595.1%	1554.8%	1517.6%	1483.0%	1450.8%	1420.6%	1392.3%	1365.5%	1340.3%	1316.3%	1293.6%	1271.9%	1251.2%	1231.4%	1212.4%	1194.3%
	115%	1835.4%	1769.9%	1711.6%	1659.2%	1611.8%	1568.4%	1528.6%	1491.8%	1457.6%	1425.7%	1395.9%	1367.8%	1341.3%	1316.3%	1292.6%	1270.0%	1248.6%	1228.0%	1208.4%	1189.6%	1171.6%
	110%	1804.6%	1739.9%	1682.4%	1630.6%	1583.7%	1540.9%	1501.6%	1465.2%	1431.4%	1399.8%	1370.3%	1342.5%	1316.3%	1291.5%	1268.0%	1245.7%	1224.4%	1204.1%	1184.6%	1166.0%	1148.1%
	105%	1772.8%	1709.0%	1652.2%	1601.1%	1554.8%	1512.5%	1473.6%	1437.6%	1404.2%	1373.0%	1343.8%	1316.3%	1290.4%	1265.9%	1242.6%	1220.5%	1199.4%	1179.2%	1159.9%	1141.4%	1123.7%
Cost	100%	1739.9%	1676.9%	1620.9%	1570.5%	1524.8%	1483.0%	1444.6%	1409.1%	1376.0%	1345.2%	1316.3%	1289.1%	1263.5%	1239.2%	1216.2%	1194.3%	1173.4%	1153.4%	1134.3%	1115.9%	1098.3%
	95%	1705.8%	1643.7%	1588.5%	1538.8%	1493.7%	1452.4%	1414.5%	1379.4%	1346.8%	1316.3%	1287.8%	1260.9%	1235.5%	1211.5%	1188.7%	1166.9%	1146.2%	1126.4%	1107.5%	1089.3%	1071.8%
	90%	1670.4%	1609.2%	1554.8%	1505.8%	1461.3%	1420.6%	1383.2%	1348.5%	1316.3%	1286.2%	1258.0%	1231.4%	1206.3%	1182.5%	1159.9%	1138.4%	1117.9%	1098.3%	1079.5%	1061.4%	1044.0%
	85%	1633.5%	1573.3%	1519.7%	1471.4%	1427.5%	1387.4%	1350.5%	1316.3%	1284.5%	1254.8%	1226.9%	1200.6%	1175.8%	1152.2%	1129.9%	1108.6%	1088.2%	1068.8%	1050.1%	1032.2%	1014.9%
	80%	1595.1%	1535.8%	1483.0%	1435.5%	1392.3%	1352.7%	1316.3%	1282.6%	1251.2%	1221.8%	1194.3%	1168.3%	1143.7%	1120.4%	1098.3%	1077.2%	1057.0%	1037.7%	1019.2%	1001.3%	984.2%
	75%	1554.8%	1496.5%	1444.6%	1397.8%	1355.3%	1316.3%	1280.4%	1247.2%	1216.2%	1187.2%	1159.9%	1134.3%	1110.0%	1086.9%	1065.0%	1044.0%	1024.0%	1004.9%	986.4%	968.7%	951.7%
	70%	1512.5%	1455.3%	1404.2%	1358.2%	1316.3%	1278.0%	1242.6%	1209.8%	1179.2%	1150.6%	1123.7%	1098.3%	1074.2%	1051.4%	1029.7%	1008.9%	989.0%	970.0%	951.7%	934.0%	917.0%
	65%	1467.9%	1411.7%	1361.6%	1316.3%	1275.2%	1237.4%	1202.6%	1170.2%	1140.0%	1111.8%	1085.2%	1060.0%	1036.2%	1013.6%	992.0%	971.4%	951.7%	932.7%	914.5%	896.9%	879.9%
	60%	1420.6%	1365.5%	1316.3%	1271.9%	1231.4%	1194.3%	1159.9%	1128.1%	1098.3%	1070.3%	1044.0%	1019.2%	995.6%	973.1%	951.7%	931.2%	911.5%	892.6%	874.4%	856.8%	839.7%
	55%	1370.3%	1316.3%	1268.0%	1224.4%	1184.6%	1148.1%	1114.3%	1082.8%	1053.4%	1025.8%	999.8%	975.1%	951.7%	929.3%	908.0%	887.5%	867.9%	849.0%	830.7%	813.0%	795.9%
	50%	1316.3%	1263.5%	1216.2%	1173.4%	1134.3%	1098.3%	1065.0%	1033.9%	1004.9%	977.5%	951.7%	927.2%	903.8%	881.6%	860.2%	839.7%	820.0%	800.9%	782.5%	1.4%	3.2%

Source: JICA Study Team

Table A12.4.3 Sensitivity Analysis (Fluctuations in Cost and Benefit)
(Alternative 2 – Total Cost)

A-1												Benefit										
	#NUM!	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	105%	110%	115%	120%	125%	130%	135%	140%	145%	150%
Cost	150%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	145%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	140%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	135%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−13.2%
	130%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−13.1%	−12.3%
	125%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−13.0%	−12.2%	−11.4%
	120%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.9%	−12.0%	−11.2%	−10.4%
	115%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.8%	−11.9%	−11.0%	−10.2%	−9.4%
	110%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.7%	−11.7%	−10.8%	−10.0%	−9.2%	−8.4%
	105%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.5%	−11.6%	−10.6%	−9.8%	−8.9%	−8.2%	−7.4%
	100%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.4%	−11.4%	−10.4%	−9.5%	−8.7%	−7.9%	−7.1%	−6.4%
	95%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.2%	−11.2%	−10.2%	−9.2%	−8.4%	−7.5%	−6.8%	−6.1%	−5.4%
	90%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−13.2%	−12.0%	−10.9%	−9.9%	−8.9%	−8.0%	−7.2%	−6.4%	−5.7%	−5.0%	−4.3%
	85%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−13.1%	−11.8%	−10.7%	−9.6%	−8.6%	−7.7%	−6.8%	−6.0%	−5.3%	−4.6%	−3.9%	−3.3%
	80%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.9%	−11.6%	−10.4%	−9.3%	−8.3%	−7.3%	−6.4%	−5.6%	−4.8%	−4.1%	−3.4%	−2.8%	−2.1%
	75%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.7%	−11.4%	−10.1%	−8.9%	−7.9%	−6.9%	−6.0%	−5.1%	−4.3%	−3.6%	−2.9%	−2.2%	−1.6%	−1.0%
	70%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.5%	−11.1%	−9.8%	−8.5%	−7.4%	−6.4%	−5.5%	−4.6%	−3.8%	−3.0%	−2.3%	−1.6%	−1.0%	−0.4%	0.2%
	65%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	−12.3%	−10.8%	−9.4%	−8.1%	−6.9%	−5.9%	−4.9%	−4.0%	−3.2%	−2.4%	−1.7%	−1.0%	−0.4%	0.3%	0.9%	1.4%
	60%	#NUM!	#NUM!	#NUM!	#NUM!	−12.0%	−10.4%	−8.9%	−7.6%	−6.4%	−5.3%	−4.3%	−3.4%	−2.6%	−1.8%	−1.0%	−0.3%	0.4%	1.0%	1.6%	2.2%	2.8%
	55%	#NUM!	#NUM!	#NUM!	−11.7%	−10.0%	−8.4%	−7.1%	−5.8%	−4.7%	−3.7%	−2.7%	−1.8%	−1.0%	−0.2%	0.5%	1.2%	1.8%	2.5%	3.1%	3.7%	4.2%
	50%	#NUM!	#NUM!	−11.4%	−9.5%	−7.9%	−6.4%	−5.1%	−4.0%	−2.9%	−1.9%	−1.0%	−0.2%	0.6%	1.4%	2.1%	2.8%	3.4%	4.1%	4.7%	5.3%	5.8%

Source: JICA Study Team

Table A12.4.4 Sensitivity Analysis (Fluctuations in Cost and Benefit)
(Alternative 2 – O&M Cost Only)

B-1											Benefit										
	68.93%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	105%	110%	115%	120%	125%	130%	135%	140%	145%	150%
	150%	195.1%	183.9%	173.8%	164.6%	156.0%	148.1%	140.7%	133.8%	127.3%	121.1%	115.2%	109.7%	104.4%	99.3%	94.5%	89.8%	85.3%	81.0%	76.9%	72.8%	68.9%
	145%	191.1%	180.0%	169.9%	160.7%	152.1%	144.2%	136.8%	129.9%	123.4%	117.2%	111.4%	105.8%	100.5%	95.4%	90.6%	85.9%	81.5%	77.1%	73.0%	68.9%	65.0%
	140%	187.0%	175.9%	165.8%	156.6%	148.1%	140.2%	132.8%	125.9%	119.4%	113.2%	107.4%	101.8%	96.5%	91.4%	86.6%	81.9%	77.4%	73.1%	68.9%	64.9%	61.0%
	135%	182.8%	171.7%	161.7%	152.4%	143.9%	136.0%	128.7%	121.8%	115.2%	109.1%	103.2%	97.7%	92.4%	87.3%	82.4%	77.8%	73.3%	68.9%	64.7%	60.7%	56.7%
	130%	178.4%	167.3%	157.3%	148.1%	139.6%	131.7%	124.4%	117.5%	110.9%	104.8%	98.9%	93.4%	88.1%	83.0%	78.1%	73.4%	68.9%	64.6%	60.4%	56.3%	52.3%
	125%	173.8%	162.8%	152.8%	143.6%	135.1%	127.3%	119.9%	113.0%	106.5%	100.3%	94.5%	88.9%	83.6%	78.5%	73.6%	68.9%	64.4%	60.0%	55.8%	51.7%	47.6%
	120%	169.1%	158.1%	148.1%	138.9%	130.5%	122.6%	115.2%	108.3%	101.8%	95.7%	89.8%	84.2%	78.9%	73.8%	68.9%	64.2%	59.7%	55.3%	51.0%	46.8%	42.7%
	115%	164.2%	153.2%	143.2%	134.1%	125.6%	117.7%	110.4%	103.5%	97.0%	90.8%	84.9%	79.4%	74.0%	68.9%	64.0%	59.3%	54.7%	50.2%	45.9%	41.6%	37.4%
	110%	159.1%	148.1%	138.1%	129.0%	120.5%	112.7%	105.3%	98.4%	91.9%	85.7%	79.9%	74.3%	68.9%	63.8%	58.9%	54.1%	49.4%	44.9%	40.5%	36.0%	31.6%
	105%	153.7%	142.8%	132.8%	123.7%	115.2%	107.4%	100.0%	93.1%	86.6%	80.4%	74.5%	68.9%	63.6%	58.4%	53.4%	48.6%	43.9%	39.2%	34.5%	29.8%	24.9%
Cos	100%	148.1%	137.2%	127.3%	118.1%	109.7%	101.8%	94.5%	87.5%	81.0%	74.8%	68.9%	63.3%	57.9%	52.7%	47.6%	42.7%	37.8%	32.9%	27.9%	22.5%	16.1%
	95%	142.2%	131.3%	121.4%	112.3%	103.8%	96.0%	88.6%	81.7%	75.1%	68.9%	63.0%	57.3%	51.9%	46.6%	41.4%	36.3%	31.1%	25.7%	19.7%	11.4%	#NUM!
	90%	136.0%	125.2%	115.2%	106.1%	97.7%	89.8%	82.4%	75.5%	68.9%	62.7%	56.7%	51.0%	45.4%	40.0%	34.5%	29.0%	23.1%	16.1%	#NUM!	#NUM!	#NUM!
	85%	129.5%	118.6%	108.7%	99.6%	91.2%	83.3%	75.9%	68.9%	62.3%	56.0%	50.0%	44.1%	38.4%	32.6%	26.7%	20.0%	10.7%	#NUM!	#NUM!	#NUM!	#NUM!
	80%	122.6%	111.7%	101.8%	92.7%	84.2%	76.3%	68.9%	61.9%	55.3%	48.9%	42.7%	36.6%	30.4%	23.9%	16.1%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	75%	115.2%	104.4%	94.5%	85.3%	76.9%	68.9%	61.5%	54.4%	47.6%	41.1%	34.5%	27.9%	20.5%	9.7%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	70%	107.4%	96.5%	86.6%	77.4%	68.9%	61.0%	53.4%	46.2%	39.2%	32.2%	24.9%	16.1%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	65%	98.9%	88.1%	78.1%	68.9%	60.4%	52.3%	44.6%	37.0%	29.4%	21.1%	8.0%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	60%	89.8%	78.9%	68.9%	59.7%	51.0%	42.7%	34.5%	26.1%	16.1%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	55%	79.9%	68.9%	58.9%	49.4%	40.5%	31.6%	22.0%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	50%	68.9%	57.9%	47.6%	37.8%	27.9%	16.1%	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Source: JICA Study Team

Table A12.4.5 Sensitivity Analysis (New Tariff – Alternative 1 - Total Cost)

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	1,688.0	0.0	0.0	0.0	1,688.0	0.0	0.0	0.0	0.0	-1,688.0
2	2019	3,328.6	0.0	0.0	0.0	3,328.6	0.0	0.0	0.0	0.0	-3,328.6
3	2020	18,874.8	0.0	0.0	0.0	18,874.8	0.0	0.0	0.0	0.0	-18,874.8
4	2021	22,663.7	0.0	0.0	0.0	22,663.7	3.5	0.0	0.0	3.5	-22,660.2
5	2022	22,234.3	0.0	0.0	0.0	22,234.3	7.7	0.0	0.0	7.7	-22,226.6
6	2023	13,121.5	0.0	0.0	0.0	13,121.5	11.7	0.0	0.0	11.7	-13,109.8
7	2024	3,289.8	0.0	6,088.2	0.0	9,378.0	66.1	95.7	1,470.9	1,632.6	-7,745.4
8	2025	984.2	0.0	7,816.8	0.0	8,801.1	79.0	123.3	3,119.6	3,322.0	-5,479.1
9	2026	0.0	0.0	8,774.8	0.0	8,774.8	85.2	137.3	3,333.3	3,555.8	-5,219.0
10	2027	0.0	0.0	7,924.4	0.0	7,924.4	78.4	134.8	3,064.8	3,278.0	-4,646.4
11	2028	0.0	0.0	6,906.3	0.0	6,906.3	69.2	123.3	3,223.7	3,416.3	-3,490.0
12	2029	0.0	0.0	7,763.2	0.0	7,763.2	73.3	135.3	3,955.1	4,163.8	-3,599.4
13	2030	0.0	0.0	6,003.2	0.0	6,003.2	60.2	114.9	3,680.5	3,855.6	-2,147.6
14	2031	0.0	0.0	6,860.1	0.0	6,860.1	65.8	126.8	3,633.1	3,825.7	-3,034.4
15	2032	0.0	0.0	6,987.0	0.0	6,987.0	64.5	129.6	4,260.1	4,454.2	-2,532.8
16	2033	0.0	0.0	8,077.8	0.0	8,077.8	68.9	144.0	5,287.4	5,500.4	-2,577.4
17	2034	0.0	0.0	6,563.2	0.0	6,563.2	58.5	127.0	5,106.9	5,292.4	-1,270.8
18	2035	0.0	0.0	7,665.5	0.0	7,665.5	62.9	141.4	6,140.7	6,345.1	-1,320.5
19	2036	0.0	0.0	6,750.3	0.0	6,750.3	54.5	131.8	6,591.4	6,777.7	27.4
20	2037	0.0	0.0	6,615.0	0.0	6,615.0	54.8	130.6	6,195.4	6,380.8	-234.2
21	2038	0.0	0.0	6,802.0	0.0	6,802.0	56.0	134.3	6,313.7	6,504.0	-298.1
22	2039	0.0	0.0	6,989.1	0.0	6,989.1	57.2	137.9	6,425.6	6,620.7	-368.4
23	2040	0.0	0.0	7,176.1	0.0	7,176.1	58.4	141.5	6,531.0	6,730.9	-445.3
24	2041	0.0	0.0	7,211.8	0.0	7,211.8	59.8	151.3	7,181.7	7,392.8	181.1
25	2042	0.0	0.0	7,577.7	0.0	7,577.7	60.5	155.3	7,467.6	7,683.5	105.8
26	2043	0.0	0.0	7,971.6	8,597.8	16,569.4	61.3	159.6	7,764.7	7,985.7	-8,583.8
27	2044	0.0	0.0	6,478.6	0.0	6,478.6	53.6	141.4	6,956.9	7,152.0	673.4
28	2045	0.0	0.0	6,783.6	0.0	6,783.6	54.2	144.6	7,188.0	7,386.8	603.1
29	2046	0.0	0.0	6,965.6	0.0	6,965.6	54.1	146.4	7,341.7	7,542.3	576.6
30	2047	0.0	-17,635.9	7,469.7	0.0	-10,166.2	54.9	151.8	7,874.0	8,080.7	18,246.9
	Total	86,184.9	-17,635.9	172,221.6	8,597.8	249,368.4	1,534.3	3,259.9	130,108.0	134,902.3	-114,466.2
										IRR	**-9.3%**
								WACC	1.74%	**NPV COST**	**245,104**
									1.74%	**NPV BENEFIT**	**132,595**
									1.74%	**NPV BALANCE**	**-112,509**
										B/C	**0.54**

Source: JICA Study Team

Table A12.4.6 Sensitivity Analysis (New Tariff – Alternative 1 - O&M Cost)

(Million JPY)

Evaluation Period	Year	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2021	0.0	0.0	0.0	3.5	0.0	0.0	3.5	3.5
5	2022	0.0	0.0	0.0	7.7	0.0	0.0	7.7	7.7
6	2023	0.0	0.0	0.0	11.7	0.0	0.0	11.7	11.7
7	2024	6,088.2	0.0	6,088.2	66.1	95.7	1,470.9	1,632.6	-4,455.6
8	2025	7,816.8	0.0	7,816.8	79.0	123.3	3,119.6	3,322.0	-4,494.9
9	2026	8,774.8	0.0	8,774.8	85.2	137.3	3,333.3	3,555.8	-5,219.0
10	2027	7,924.4	0.0	7,924.4	78.4	134.8	3,064.8	3,278.0	-4,646.4
11	2028	6,906.3	0.0	6,906.3	69.2	123.3	3,223.7	3,416.3	-3,490.0
12	2029	7,763.2	0.0	7,763.2	73.3	135.3	3,955.1	4,163.8	-3,599.4
13	2030	6,003.2	0.0	6,003.2	60.2	114.9	3,680.5	3,855.6	-2,147.6
14	2031	6,860.1	0.0	6,860.1	65.8	126.8	3,633.1	3,825.7	-3,034.4
15	2032	6,987.0	0.0	6,987.0	64.5	129.6	4,260.1	4,454.2	-2,532.8
16	2033	8,077.8	0.0	8,077.8	68.9	144.0	5,287.4	5,500.4	-2,577.4
17	2034	6,563.2	0.0	6,563.2	58.5	127.0	5,106.9	5,292.4	-1,270.8
18	2035	7,665.5	0.0	7,665.5	62.9	141.4	6,140.7	6,345.1	-1,320.5
19	2036	6,750.3	0.0	6,750.3	54.5	131.8	6,591.4	6,777.7	27.4
20	2037	6,615.0	0.0	6,615.0	54.8	130.6	6,195.4	6,380.8	-234.2
21	2038	6,802.0	0.0	6,802.0	56.0	134.3	6,313.7	6,504.0	-298.1
22	2039	6,989.1	0.0	6,989.1	57.2	137.9	6,425.6	6,620.7	-368.4
23	2040	7,176.1	0.0	7,176.1	58.4	141.5	6,531.0	6,730.9	-445.3
24	2041	7,211.8	0.0	7,211.8	59.8	151.3	7,181.7	7,392.8	181.1
25	2042	7,577.7	0.0	7,577.7	60.5	155.3	7,467.6	7,683.5	105.8
26	2043	7,971.6	11,152.8	19,124.5	61.3	159.6	7,764.7	7,985.7	-11,138.8
27	2044	6,478.6	0.0	6,478.6	53.6	141.4	6,956.9	7,152.0	673.4
28	2045	6,783.6	0.0	6,783.6	54.2	144.6	7,188.0	7,386.8	603.1
29	2046	6,965.6	0.0	6,965.6	54.1	146.4	7,341.7	7,542.3	576.6
30	2047	7,469.7	0.0	7,469.7	54.9	151.8	7,874.0	8,080.7	611.0
	Total	172,221.6	11,152.8	183,374.4	1,534.3	3,259.9	130,108.0	134,902.3	-48,472.1
								IRR	**946.4%**
						WACC	1.74%	**NPV COST**	**180,238**
							1.74%	**NPV BENEFIT**	**132,595**
							1.74%	**NPV BALANCE**	**-47,643**
								B/C	**0.74**

Source: JICA Study Team

Table A12.4.7 Sensitivity Analysis (New Tariff – Alternative 2 – Total Cost)

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	1,688.0	0.0	0.0	0.0	1,688.0	0.0	0.0	0.0	0.0	-1,688.0
2	2019	3,328.6	0.0	0.0	0.0	3,328.6	0.0	0.0	0.0	0.0	-3,328.6
3	2020	18,874.8	0.0	0.0	0.0	18,874.8	199.0	0.0	0.0	199.0	-18,675.8
4	2021	22,663.7	0.0	0.0	0.0	22,663.7	444.5	0.0	0.0	444.5	-22,219.2
5	2022	22,234.3	0.0	0.0	0.0	22,234.3	672.3	0.0	0.0	672.3	-21,562.0
6	2023	13,121.5	0.0	0.0	0.0	13,121.5	3,797.9	373.9	1,470.9	5,642.7	-7,478.8
7	2024	3,289.8	0.0	6,088.2	0.0	9,378.0	4,541.6	482.0	3,119.6	8,143.2	-1,234.9
8	2025	984.2	0.0	7,816.8	0.0	8,801.1	4,897.7	536.4	3,333.3	8,767.4	-33.7
9	2026	0.0	0.0	8,774.8	0.0	8,774.8	4,505.9	526.8	3,064.8	8,097.5	-677.3
10	2027	0.0	0.0	7,924.4	0.0	7,924.4	3,975.9	482.0	3,223.7	7,681.7	-242.7
11	2028	0.0	0.0	6,906.3	0.0	6,906.3	4,213.3	528.8	3,955.1	8,697.2	1,791.0
12	2029	0.0	0.0	7,763.2	0.0	7,763.2	3,459.6	448.8	3,680.5	7,589.0	-174.2
13	2030	0.0	0.0	6,003.2	0.0	6,003.2	3,778.9	495.4	3,633.1	7,907.5	1,904.3
14	2031	0.0	0.0	6,860.1	0.0	6,860.1	3,706.3	506.4	4,260.1	8,472.8	1,612.7
15	2032	0.0	0.0	6,987.0	0.0	6,987.0	3,961.0	562.8	5,287.4	9,811.3	2,824.3
16	2033	0.0	0.0	8,077.8	0.0	8,077.8	3,364.9	496.3	5,106.9	8,968.1	890.3
17	2034	0.0	0.0	6,563.2	0.0	6,563.2	3,616.5	552.7	6,140.7	10,309.9	3,746.7
18	2035	0.0	0.0	7,665.5	0.0	7,665.5	3,132.9	515.0	6,591.4	10,239.3	2,573.8
19	2036	0.0	0.0	6,750.3	0.0	6,750.3	3,148.3	510.5	6,195.4	9,854.2	3,103.9
20	2037	0.0	0.0	6,615.0	0.0	6,615.0	3,218.3	524.7	6,313.7	10,056.7	3,441.7
21	2038	0.0	0.0	6,802.0	0.0	6,802.0	3,287.4	538.9	6,425.6	10,251.9	3,449.9
22	2039	0.0	0.0	6,989.1	0.0	6,989.1	3,355.7	552.9	6,531.0	10,439.6	3,450.5
23	2040	0.0	0.0	7,176.1	0.0	7,176.1	3,436.2	591.3	7,181.7	11,209.3	4,033.2
24	2041	0.0	0.0	7,211.8	0.0	7,211.8	3,478.2	606.9	7,467.6	11,552.8	4,341.0
25	2042	0.0	0.0	7,577.7	0.0	7,577.7	3,525.5	623.5	7,764.7	11,913.8	4,336.1
26	2043	0.0	0.0	7,971.6	11,152.8	19,124.5	3,083.2	552.6	6,956.9	10,592.7	-8,531.8
27	2044	0.0	0.0	6,478.6	0.0	6,478.6	3,113.2	565.2	7,188.0	10,866.4	4,387.8
28	2045	0.0	0.0	6,783.6	0.0	6,783.6	3,111.1	572.0	7,341.7	11,024.9	4,241.2
29	2046	0.0	0.0	6,965.6	0.0	6,965.6	3,152.5	593.1	7,874.0	11,619.6	4,654.0
30	2047	0.0	-17,635.9	7,469.7	0.0	-10,166.2	3,190.9	613.9	8,402.9	12,207.7	22,373.9
	Total	86,184.9	-17,635.9	172,221.6	11,152.8	251,923.5	91,368.9	13,353.0	138,511.0	243,232.8	-8,690.7
										IRR	**-0.6%**
								WACC	1.74%	**NPV COST**	**247,615**
									1.74%	**NPV BENEFIT**	**239,073**
									1.74%	**NPV BALANCE**	**-8,542**
										B/C	**0.97**

Source: JICA Study Team

Table A12.4.8 Sensitivity Analysis (New Tariff – Alternative 2 - O&M Cost)

(Million JPY)

Evaluation Period	Year	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2020	0.0	0.0	0.0	199.0	0.0	0.0	199.0	199.0
4	2021	0.0	0.0	0.0	444.5	0.0	0.0	444.5	444.5
5	2022	0.0	0.0	0.0	672.3	0.0	0.0	672.3	672.3
6	2023	0.0	0.0	0.0	3,797.9	373.9	1,470.9	5,642.7	5,642.7
7	2024	6,088.2	0.0	6,088.2	4,541.6	482.0	3,119.6	8,143.2	2,054.9
8	2025	7,816.8	0.0	7,816.8	4,897.7	536.4	3,333.3	8,767.4	950.5
9	2026	8,774.8	0.0	8,774.8	4,505.9	526.8	3,064.8	8,097.5	-677.3
10	2027	7,924.4	0.0	7,924.4	3,975.9	482.0	3,223.7	7,681.7	-242.7
11	2028	6,906.3	0.0	6,906.3	4,213.3	528.8	3,955.1	8,697.2	1,791.0
12	2029	7,763.2	0.0	7,763.2	3,459.6	448.8	3,680.5	7,589.0	-174.2
13	2030	6,003.2	0.0	6,003.2	3,778.9	495.4	3,633.1	7,907.5	1,904.3
14	2031	6,860.1	0.0	6,860.1	3,706.3	506.4	4,260.1	8,472.8	1,612.7
15	2032	6,987.0	0.0	6,987.0	3,961.0	562.8	5,287.4	9,811.3	2,824.3
16	2033	8,077.8	0.0	8,077.8	3,364.9	496.3	5,106.9	8,968.1	890.3
17	2034	6,563.2	0.0	6,563.2	3,616.5	552.7	6,140.7	10,309.9	3,746.7
18	2035	7,665.5	0.0	7,665.5	3,132.9	515.0	6,591.4	10,239.3	2,573.8
19	2036	6,750.3	0.0	6,750.3	3,148.3	510.5	6,195.4	9,854.2	3,103.9
20	2037	6,615.0	0.0	6,615.0	3,218.3	524.7	6,313.7	10,056.7	3,441.7
21	2038	6,802.0	0.0	6,802.0	3,287.4	538.9	6,425.6	10,251.9	3,449.9
22	2039	6,989.1	0.0	6,989.1	3,355.7	552.9	6,531.0	10,439.6	3,450.5
23	2040	7,176.1	0.0	7,176.1	3,436.2	591.3	7,181.7	11,209.3	4,033.2
24	2041	7,211.8	0.0	7,211.8	3,478.2	606.9	7,467.6	11,552.8	4,341.0
25	2042	7,577.7	0.0	7,577.7	3,525.5	623.5	7,764.7	11,913.8	4,336.1
26	2043	7,971.6	11,152.8	19,124.5	3,083.2	552.6	6,956.9	10,592.7	-8,531.8
27	2044	6,478.6	0.0	6,478.6	3,113.2	565.2	7,188.0	10,866.4	4,387.8
28	2045	6,783.6	0.0	6,783.6	3,111.1	572.0	7,341.7	11,024.9	4,241.2
29	2046	6,965.6	0.0	6,965.6	3,152.5	593.1	7,874.0	11,619.6	4,654.0
30	2047	7,469.7	0.0	7,469.7	3,190.9	613.9	8,402.9	12,207.7	4,738.1
	Total	172,221.6	11,152.8	183,374.4	91,368.9	13,353.0	138,511.0	243,232.8	59,858.4
								IRR	**#NUM!**
						WACC	1.74%	**NPV COST**	**180,238**
							1.74%	**NPV BENEFIT**	**239,073**
							1.74%	**NPV BALANCE**	**58,835**
								B/C	**1.33**

Source: JICA Study Team

Table A12.4.9 Sensitivity Analysis (Fluctuations in Water Supply Volume -20%)
(Current Tariff – Alternative 2 – Total Cost)

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	1,688.0	0.0	0.0	0.0	844.0	0.0	0.0	0.0	0.0	-844.0
2	2019	3,328.6	0.0	0.0	0.0	1,664.3	0.0	0.0	0.0	0.0	-1,664.3
3	2020	18,874.8	0.0	0.0	0.0	9,437.4	99.5	0.0	0.0	84.6	-9,352.8
4	2021	22,663.7	0.0	0.0	0.0	11,331.9	222.3	0.0	0.0	188.9	-11,142.9
5	2022	22,234.3	0.0	0.0	0.0	11,117.1	336.2	0.0	0.0	285.7	-10,831.4
6	2023	13,121.5	0.0	0.0	0.0	6,560.7	1,607.8	158.3	597.8	2,009.3	-4,551.5
7	2024	3,289.8	0.0	4,870.6	0.0	4,080.2	1,925.6	204.4	1,269.8	2,889.7	-1,190.5
8	2025	984.2	0.0	6,253.5	0.0	3,618.9	2,075.1	227.3	1,355.8	3,109.4	-509.5
9	2026	0.0	0.0	7,019.9	0.0	3,509.9	1,920.1	224.5	1,253.8	2,888.6	-621.3
10	2027	0.0	0.0	6,339.5	0.0	3,169.7	1,709.8	207.3	1,330.9	2,760.8	-408.9
11	2028	0.0	0.0	5,525.0	0.0	2,762.5	1,806.4	226.7	1,627.9	3,111.9	349.4
12	2029	0.0	0.0	6,210.5	0.0	3,105.3	1,506.6	195.5	1,538.7	2,754.6	-350.6
13	2030	0.0	0.0	4,802.5	0.0	2,401.3	1,638.6	214.8	1,512.4	2,860.9	459.6
14	2031	0.0	0.0	5,488.0	0.0	2,744.0	1,609.7	219.9	1,776.2	3,065.0	320.9
15	2032	0.0	0.0	5,589.6	0.0	2,794.8	1,711.8	243.2	2,193.6	3,526.4	731.6
16	2033	0.0	0.0	6,462.2	0.0	3,231.1	1,473.6	217.3	2,147.1	3,262.4	31.2
17	2034	0.0	0.0	5,250.6	0.0	2,625.3	1,574.6	240.6	2,566.7	3,724.7	1,099.4
18	2035	0.0	0.0	6,132.4	0.0	3,066.2	1,376.6	226.3	2,780.5	3,725.9	659.7
19	2036	0.0	0.0	5,400.3	0.0	2,700.1	1,386.7	224.9	2,619.8	3,596.7	896.5
20	2037	0.0	0.0	5,292.0	0.0	2,646.0	1,418.7	231.3	2,671.9	3,673.6	1,027.6
21	2038	0.0	0.0	5,441.6	0.0	2,720.8	1,450.3	237.7	2,721.3	3,748.0	1,027.1
22	2039	0.0	0.0	5,591.3	0.0	2,795.6	1,481.5	244.1	2,768.1	3,819.7	1,024.1
23	2040	0.0	0.0	5,740.9	0.0	2,870.4	1,520.0	261.6	3,049.7	4,106.6	1,236.1
24	2041	0.0	0.0	5,769.4	0.0	2,884.7	1,535.2	267.9	3,164.3	4,222.3	1,337.5
25	2042	0.0	0.0	6,062.1	0.0	3,031.1	1,552.6	274.6	3,282.8	4,343.6	1,312.5
26	2043	0.0	0.0	6,377.3	11,152.8	8,765.1	1,374.3	246.3	2,976.9	3,907.8	-4,857.2
27	2044	0.0	0.0	5,182.9	0.0	2,591.4	1,384.9	251.4	3,069.6	4,000.1	1,408.6
28	2045	0.0	0.0	5,426.9	0.0	2,713.5	1,382.7	254.2	3,132.5	4,054.0	1,340.6
29	2046	0.0	0.0	5,572.5	0.0	2,786.2	1,396.5	262.8	3,348.7	4,256.8	1,470.5
30	2047	0.0	-17,635.9	5,975.7	0.0	-5,830.1	1,409.3	271.1	3,562.9	4,456.9	10,287.0
	Total	86,184.9	-17,635.9	137,777.2	11,152.8	108,739.6	39,887.2	5,834.1	58,319.5	88,434.7	-20,304.9
										IRR	**-3.1%**
								WACC	1.74%	**NPV COST**	**106,880**
									1.74%	**NPV BENEFIT**	**86,922**
									1.74%	**NPV BALANCE**	**-19,958**
										B/C	**0.81**

Source: JICA Study Team

Table A12.4.10 Sensitivity Analysis (Fluctuations in Water Supply Volume -20%)
(Current Tariff – Alternative 2 - O&M Cost Only)

(Million JPY)

Evaluation Period	Year	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2020	0.0	0.0	0.0	99.5	0.0	0.0	99.5	99.5
4	2021	0.0	0.0	0.0	222.3	0.0	0.0	222.3	222.3
5	2022	0.0	0.0	0.0	336.2	0.0	0.0	336.2	336.2
6	2023	0.0	0.0	0.0	1,607.8	158.3	597.8	2,363.9	2,363.9
7	2024	4,870.6	0.0	4,870.6	1,925.6	204.4	1,269.8	3,399.7	-1,470.9
8	2025	6,253.5	0.0	6,253.5	2,075.1	227.3	1,355.8	3,658.1	-2,595.4
9	2026	7,019.9	0.0	7,019.9	1,920.1	224.5	1,253.8	3,398.4	-3,621.5
10	2027	6,339.5	0.0	6,339.5	1,709.8	207.3	1,330.9	3,248.0	-3,091.5
11	2028	5,525.0	0.0	5,525.0	1,806.4	226.7	1,627.9	3,661.1	-1,863.9
12	2029	6,210.5	0.0	6,210.5	1,506.6	195.5	1,538.7	3,240.7	-2,969.8
13	2030	4,802.5	0.0	4,802.5	1,638.6	214.8	1,512.4	3,365.8	-1,436.8
14	2031	5,488.0	0.0	5,488.0	1,609.7	219.9	1,776.2	3,605.8	-1,882.2
15	2032	5,589.6	0.0	5,589.6	1,711.8	243.2	2,193.6	4,148.7	-1,440.9
16	2033	6,462.2	0.0	6,462.2	1,473.6	217.3	2,147.1	3,838.1	-2,624.2
17	2034	5,250.6	0.0	5,250.6	1,574.6	240.6	2,566.7	4,382.0	-868.6
18	2035	6,132.4	0.0	6,132.4	1,376.6	226.3	2,780.5	4,383.4	-1,749.0
19	2036	5,400.3	0.0	5,400.3	1,386.7	224.9	2,619.8	4,231.4	-1,168.9
20	2037	5,292.0	0.0	5,292.0	1,418.7	231.3	2,671.9	4,321.9	-970.1
21	2038	5,441.6	0.0	5,441.6	1,450.3	237.7	2,721.3	4,409.4	-1,032.3
22	2039	5,591.3	0.0	5,591.3	1,481.5	244.1	2,768.1	4,493.7	-1,097.5
23	2040	5,740.9	0.0	5,740.9	1,520.0	261.6	3,049.7	4,831.3	-909.6
24	2041	5,769.4	0.0	5,769.4	1,535.2	267.9	3,164.3	4,967.4	-802.1
25	2042	6,062.1	0.0	6,062.1	1,552.6	274.6	3,282.8	5,110.1	-952.1
26	2043	6,377.3	11,152.8	17,530.1	1,374.3	246.3	2,976.9	4,597.5	-12,932.7
27	2044	5,182.9	0.0	5,182.9	1,384.9	251.4	3,069.6	4,706.0	-476.9
28	2045	5,426.9	0.0	5,426.9	1,382.7	254.2	3,132.5	4,769.4	-657.5
29	2046	5,572.5	0.0	5,572.5	1,396.5	262.8	3,348.7	5,008.0	-564.5
30	2047	5,975.7	0.0	5,975.7	1,409.3	271.1	3,562.9	5,243.4	-732.3
	Total	137,777.2	11,152.8	148,930.1	39,887.2	5,834.1	58,319.5	104,040.8	-44,889.3
								IRR	**59.1%**
						WACC	1.74%	**NPV COST**	**146,383**
							1.74%	**NPV BENEFIT**	**102,261**
							1.74%	**NPV BALANCE**	**-44,122**
								B/C	**0.70**

Source: JICA Study Team

Table A12.4.11 Sensitivity Analysis (Fluctuations in Water Supply Volume +20%)

(Current Tariff – Alternative 2 - Total Cost)

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	1,688.0	0.0	0.0	0.0	1,688.0	0.0	0.0	0.0	0.0	-1,688.0
2	2019	3,328.6	0.0	0.0	0.0	3,328.6	0.0	0.0	0.0	0.0	-3,328.6
3	2020	18,874.8	0.0	0.0	0.0	18,874.8	99.5	0.0	0.0	99.5	-18,775.3
4	2021	22,663.7	0.0	0.0	0.0	22,663.7	222.3	0.0	0.0	222.3	-22,441.4
5	2022	22,234.3	0.0	0.0	0.0	22,234.3	336.2	0.0	0.0	336.2	-21,898.1
6	2023	13,121.5	0.0	0.0	0.0	13,121.5	2,190.1	215.6	814.3	3,220.0	-9,901.4
7	2024	3,289.8	0.0	7,305.9	0.0	10,595.7	2,616.0	277.6	1,725.1	4,618.7	-5,977.0
8	2025	984.2	0.0	9,380.2	0.0	10,364.5	2,822.6	309.1	1,844.2	4,975.9	-5,388.5
9	2026	0.0	0.0	10,529.8	0.0	10,529.8	2,585.8	302.3	1,688.4	4,576.5	-5,953.3
10	2027	0.0	0.0	9,509.2	0.0	9,509.2	2,266.1	274.7	1,763.9	4,304.7	-5,204.6
11	2028	0.0	0.0	8,287.5	0.0	8,287.5	2,406.9	302.1	2,169.0	4,877.9	-3,409.6
12	2029	0.0	0.0	9,315.8	0.0	9,315.8	1,953.0	253.4	1,994.6	4,201.0	-5,114.8
13	2030	0.0	0.0	7,203.8	0.0	7,203.8	2,140.4	280.6	1,975.5	4,396.4	-2,807.4
14	2031	0.0	0.0	8,232.1	0.0	8,232.1	2,096.6	286.5	2,313.5	4,696.5	-3,535.5
15	2032	0.0	0.0	8,384.4	0.0	8,384.4	2,249.2	319.6	2,882.3	5,451.1	-2,933.3
16	2033	0.0	0.0	9,693.3	0.0	9,693.3	1,891.3	278.9	2,755.5	4,925.7	-4,767.6
17	2034	0.0	0.0	7,875.8	0.0	7,875.8	2,041.9	312.0	3,328.4	5,682.3	-2,193.6
18	2035	0.0	0.0	9,198.7	0.0	9,198.7	1,756.3	288.7	3,547.2	5,592.2	-3,606.4
19	2036	0.0	0.0	8,100.4	0.0	8,100.4	1,761.6	285.6	3,327.8	5,375.0	-2,725.4
20	2037	0.0	0.0	7,938.0	0.0	7,938.0	1,799.6	293.4	3,389.3	5,482.3	-2,455.7
21	2038	0.0	0.0	8,162.5	0.0	8,162.5	1,837.2	301.1	3,447.2	5,585.5	-2,576.9
22	2039	0.0	0.0	8,386.9	0.0	8,386.9	1,874.1	308.8	3,501.6	5,684.6	-2,702.3
23	2040	0.0	0.0	8,611.3	0.0	8,611.3	1,916.2	329.8	3,844.8	6,090.7	-2,520.6
24	2041	0.0	0.0	8,654.1	0.0	8,654.1	1,943.0	339.0	4,004.7	6,286.7	-2,367.4
25	2042	0.0	0.0	9,093.2	0.0	9,093.2	1,972.9	348.9	4,171.3	6,493.1	-2,600.1
26	2043	0.0	0.0	9,565.9	11,152.8	20,718.8	1,708.9	306.3	3,701.8	5,716.9	-15,001.9
27	2044	0.0	0.0	7,774.3	0.0	7,774.3	1,728.3	313.8	3,830.8	5,872.9	-1,901.4
28	2045	0.0	0.0	8,140.4	0.0	8,140.4	1,728.4	317.8	3,915.6	5,961.8	-2,178.6
29	2046	0.0	0.0	8,358.7	0.0	8,358.7	1,755.9	330.4	4,210.4	6,296.7	-2,062.0
30	2047	0.0	-17,635.9	8,963.6	0.0	-8,672.3	1,781.6	342.7	4,503.9	6,628.2	15,300.5
	Total	86,184.9	-17,635.9	206,665.9	11,152.8	286,367.8	51,481.6	7,518.9	74,651.0	133,651.5	-152,716.3
										IRR	**#NUM!**
								WACC	1.74%	**NPV COST**	**281,470**
									1.74%	**NPV BENEFIT**	**131,366**
									1.74%	**NPV BALANCE**	**-150,104**
										B/C	**0.47**

Source: JICA Study Team

Table A12.4.12 Sensitivity Analysis (Fluctuations in Water Supply Volume +20%)

(Current Tariff – Alternative 2 – O&M Cost Only)

(Million JPY)

Evaluation Period	Year	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2020	0.0	0.0	0.0	99.5	0.0	0.0	99.5	99.5
4	2021	0.0	0.0	0.0	222.3	0.0	0.0	222.3	222.3
5	2022	0.0	0.0	0.0	336.2	0.0	0.0	336.2	336.2
6	2023	0.0	0.0	0.0	2,190.1	215.6	814.3	3,220.0	3,220.0
7	2024	7,305.9	0.0	7,305.9	2,616.0	277.6	1,725.1	4,618.7	-2,687.2
8	2025	9,380.2	0.0	9,380.2	2,822.6	309.1	1,844.2	4,975.9	-4,404.3
9	2026	10,529.8	0.0	10,529.8	2,585.8	302.3	1,688.4	4,576.5	-5,953.3
10	2027	9,509.2	0.0	9,509.2	2,266.1	274.7	1,763.9	4,304.7	-5,204.6
11	2028	8,287.5	0.0	8,287.5	2,406.9	302.1	2,169.0	4,877.9	-3,409.6
12	2029	9,315.8	0.0	9,315.8	1,953.0	253.4	1,994.6	4,201.0	-5,114.8
13	2030	7,203.8	0.0	7,203.8	2,140.4	280.6	1,975.5	4,396.4	-2,807.4
14	2031	8,232.1	0.0	8,232.1	2,096.6	286.5	2,313.5	4,696.5	-3,535.5
15	2032	8,384.4	0.0	8,384.4	2,249.2	319.6	2,882.3	5,451.1	-2,933.3
16	2033	9,693.3	0.0	9,693.3	1,891.3	278.9	2,755.5	4,925.7	-4,767.6
17	2034	7,875.8	0.0	7,875.8	2,041.9	312.0	3,328.4	5,682.3	-2,193.6
18	2035	9,198.7	0.0	9,198.7	1,756.3	288.7	3,547.2	5,592.2	-3,606.4
19	2036	8,100.4	0.0	8,100.4	1,761.6	285.6	3,327.8	5,375.0	-2,725.4
20	2037	7,938.0	0.0	7,938.0	1,799.6	293.4	3,389.3	5,482.3	-2,455.7
21	2038	8,162.5	0.0	8,162.5	1,837.2	301.1	3,447.2	5,585.5	-2,576.9
22	2039	8,386.9	0.0	8,386.9	1,874.1	308.8	3,501.6	5,684.6	-2,702.3
23	2040	8,611.3	0.0	8,611.3	1,916.2	329.8	3,844.8	6,090.7	-2,520.6
24	2041	8,654.1	0.0	8,654.1	1,943.0	339.0	4,004.7	6,286.7	-2,367.4
25	2042	9,093.2	0.0	9,093.2	1,972.9	348.9	4,171.3	6,493.1	-2,600.1
26	2043	9,565.9	11,152.8	20,718.8	1,708.9	306.3	3,701.8	5,716.9	-15,001.9
27	2044	7,774.3	0.0	7,774.3	1,728.3	313.8	3,830.8	5,872.9	-1,901.4
28	2045	8,140.4	0.0	8,140.4	1,728.4	317.8	3,915.6	5,961.8	-2,178.6
29	2046	8,358.7	0.0	8,358.7	1,755.9	330.4	4,210.4	6,296.7	-2,062.0
30	2047	8,963.6	0.0	8,963.6	1,781.6	342.7	4,503.9	6,628.2	-2,335.4
	Total	206,665.9	11,152.8	217,818.7	51,481.6	7,518.9	74,651.0	133,651.5	-84,167.2
								IRR	**76.6%**
						WACC	1.74%	**NPV COST**	**214,093**
							1.74%	**NPV BENEFIT**	**131,366**
							1.74%	**NPV BALANCE**	**-82,728**
								B/C	**0.61**

Source: JICA Study Team

Table A12.4.13 Sensitivity Analysis (Fluctuations in Water Supply Volume -20%)

(New Tariff – Alternative 2 – O&M Cost Only)

(Million JPY)

Evaluation Period	Year	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2020	0.0	0.0	0.0	199.0	0.0	0.0	199.0	199.0
4	2021	0.0	0.0	0.0	444.5	0.0	0.0	444.5	444.5
5	2022	0.0	0.0	0.0	672.3	0.0	0.0	672.3	672.3
6	2023	0.0	0.0	0.0	3,215.6	316.6	1,245.3	4,777.5	4,777.5
7	2024	4,870.6	0.0	4,870.6	3,851.1	408.7	2,645.3	6,905.2	2,034.6
8	2025	6,253.5	0.0	6,253.5	4,150.1	454.5	2,824.5	7,429.2	1,175.7
9	2026	7,019.9	0.0	7,019.9	3,840.2	449.0	2,612.0	6,901.2	-118.7
10	2027	6,339.5	0.0	6,339.5	3,419.6	414.6	2,772.7	6,606.9	267.4
11	2028	5,525.0	0.0	5,525.0	3,612.9	453.4	3,391.5	7,457.8	1,932.8
12	2029	6,210.5	0.0	6,210.5	3,013.2	390.9	3,205.6	6,609.7	399.2
13	2030	4,802.5	0.0	4,802.5	3,277.2	429.6	3,150.7	6,857.6	2,055.0
14	2031	5,488.0	0.0	5,488.0	3,219.4	439.9	3,700.4	7,359.7	1,871.6
15	2032	5,589.6	0.0	5,589.6	3,423.6	486.5	4,570.0	8,480.1	2,890.6
16	2033	6,462.2	0.0	6,462.2	2,947.3	434.7	4,473.1	7,855.1	1,392.8
17	2034	5,250.6	0.0	5,250.6	3,149.3	481.3	5,347.3	8,977.9	3,727.3
18	2035	6,132.4	0.0	6,132.4	2,753.3	452.6	5,792.7	8,998.6	2,866.1
19	2036	5,400.3	0.0	5,400.3	2,773.5	449.7	5,457.8	8,681.1	3,280.8
20	2037	5,292.0	0.0	5,292.0	2,837.4	462.6	5,566.4	8,866.4	3,574.4
21	2038	5,441.6	0.0	5,441.6	2,900.6	475.4	5,669.5	9,045.5	3,603.9
22	2039	5,591.3	0.0	5,591.3	2,963.1	488.3	5,766.9	9,218.2	3,626.9
23	2040	5,740.9	0.0	5,740.9	3,040.0	523.1	6,353.6	9,916.7	4,175.8
24	2041	5,769.4	0.0	5,769.4	3,070.5	535.7	6,592.2	10,198.4	4,429.0
25	2042	6,062.1	0.0	6,062.1	3,105.3	549.2	6,839.3	10,493.8	4,431.6
26	2043	6,377.3	11,152.8	17,530.1	2,748.5	492.6	6,201.9	9,443.0	-8,087.1
27	2044	5,182.9	0.0	5,182.9	2,769.8	502.9	6,395.1	9,667.7	4,484.9
28	2045	5,426.9	0.0	5,426.9	2,765.4	508.5	6,526.0	9,799.9	4,373.0
29	2046	5,572.5	0.0	5,572.5	2,793.1	525.5	6,976.4	10,295.0	4,722.5
30	2047	5,975.7	0.0	5,975.7	2,818.7	542.3	7,422.8	10,783.7	4,808.0
	Total	137,777.2	11,152.8	148,930.1	79,774.5	11,668.1	121,499.0	212,941.6	64,011.5
								IRR	**#NUM!**
						WACC	1.74%	**NPV COST**	**146,383**
							1.74%	**NPV BENEFIT**	**209,300**
							1.74%	**NPV BALANCE**	**62,917**
								B/C	**1.43**

Source: JICA Study Team

Table A12.4.14 Sensitivity Analysis (Fluctuations in Water Supply Volume +20%)

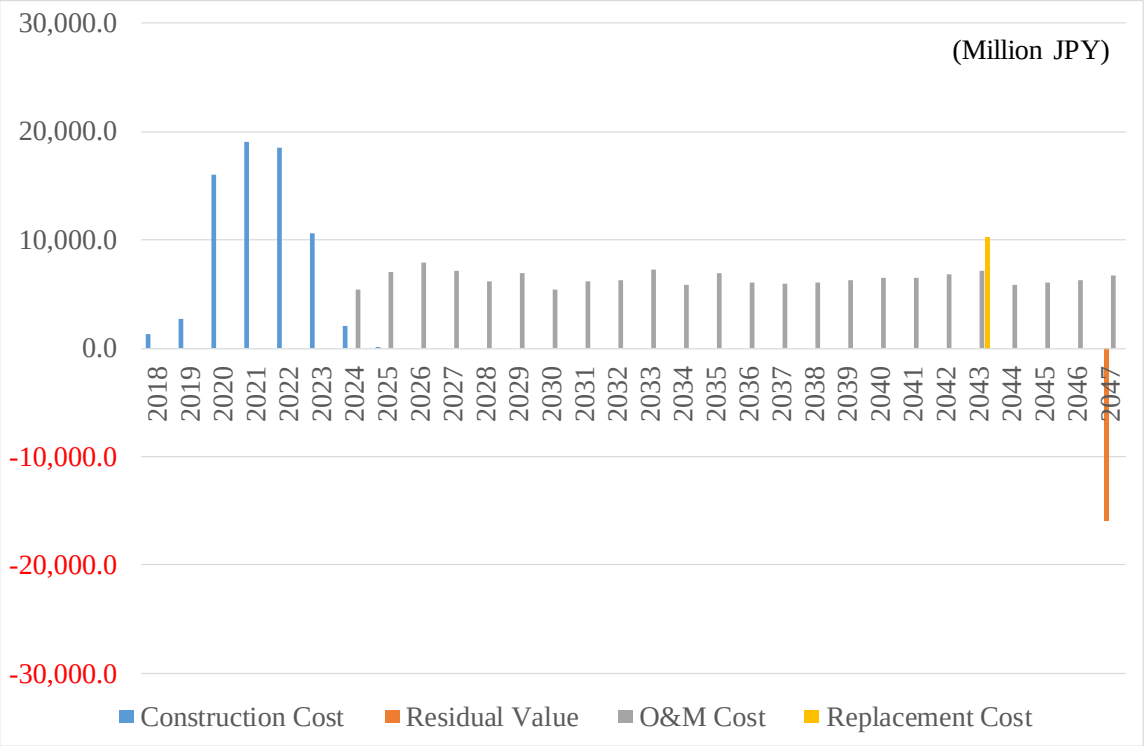
(New Tariff – Alternative 2 - O&M Cost Only)

(Million JPY)

Evaluation Period	Year	O&M Cost	Replacement Cost	**Total Cost**	Domestic	Commercial	Industrial	**Total Revenue**	**Balance**
1	2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2020	0.0	0.0	0.0	199.0	0.0	0.0	199.0	199.0
4	2021	0.0	0.0	0.0	444.5	0.0	0.0	444.5	444.5
5	2022	0.0	0.0	0.0	672.3	0.0	0.0	672.3	672.3
6	2023	0.0	0.0	0.0	4,380.2	431.2	1,696.4	6,507.9	6,507.9
7	2024	7,305.9	0.0	7,305.9	5,232.0	555.3	3,593.9	9,381.2	2,075.3
8	2025	9,380.2	0.0	9,380.2	5,645.2	618.3	3,842.1	10,105.6	725.4
9	2026	10,529.8	0.0	10,529.8	5,171.5	604.7	3,517.5	9,293.7	-1,236.0
10	2027	9,509.2	0.0	9,509.2	4,532.2	549.4	3,674.8	8,756.4	-752.9
11	2028	8,287.5	0.0	8,287.5	4,813.7	604.1	4,518.8	9,936.6	1,649.1
12	2029	9,315.8	0.0	9,315.8	3,906.1	506.7	4,155.4	8,568.3	-747.5
13	2030	7,203.8	0.0	7,203.8	4,280.7	561.2	4,115.5	8,957.4	1,753.6
14	2031	8,232.1	0.0	8,232.1	4,193.2	572.9	4,819.8	9,585.9	1,353.8
15	2032	8,384.4	0.0	8,384.4	4,498.5	639.2	6,004.8	11,142.4	2,758.0
16	2033	9,693.3	0.0	9,693.3	3,782.5	557.9	5,740.7	10,081.1	387.7
17	2034	7,875.8	0.0	7,875.8	4,083.8	624.1	6,934.1	11,642.0	3,766.1
18	2035	9,198.7	0.0	9,198.7	3,512.5	577.4	7,390.1	11,480.1	2,281.4
19	2036	8,100.4	0.0	8,100.4	3,523.1	571.3	6,933.0	11,027.4	2,927.0
20	2037	7,938.0	0.0	7,938.0	3,599.3	586.8	7,061.0	11,247.1	3,309.1
21	2038	8,162.5	0.0	8,162.5	3,674.3	602.3	7,181.8	11,458.3	3,295.9
22	2039	8,386.9	0.0	8,386.9	3,748.3	617.6	7,295.1	11,661.0	3,274.1
23	2040	8,611.3	0.0	8,611.3	3,832.5	659.5	8,009.9	12,501.9	3,890.5
24	2041	8,654.1	0.0	8,654.1	3,886.0	678.0	8,343.1	12,907.1	4,253.0
25	2042	9,093.2	0.0	9,093.2	3,945.7	697.8	8,690.2	13,333.8	4,240.6
26	2043	9,565.9	11,152.8	20,718.8	3,417.8	612.5	7,712.0	11,742.3	-8,976.5
27	2044	7,774.3	0.0	7,774.3	3,456.6	627.6	7,980.9	12,065.0	4,290.7
28	2045	8,140.4	0.0	8,140.4	3,456.8	635.6	8,157.5	12,249.8	4,109.4
29	2046	8,358.7	0.0	8,358.7	3,511.8	660.8	8,771.7	12,944.3	4,585.5
30	2047	8,963.6	0.0	8,963.6	3,563.1	685.5	9,383.1	13,631.7	4,668.1
	Total	206,665.9	11,152.8	217,818.7	102,963.2	15,037.8	155,522.9	273,523.9	55,705.2
								IRR	**#NUM!**
						WACC	1.74%	**NPV COST**	**214,093**
							1.74%	**NPV BENEFIT**	**268,846**
							1.74%	**NPV BALANCE**	**54,753**
								B/C	**1.26**

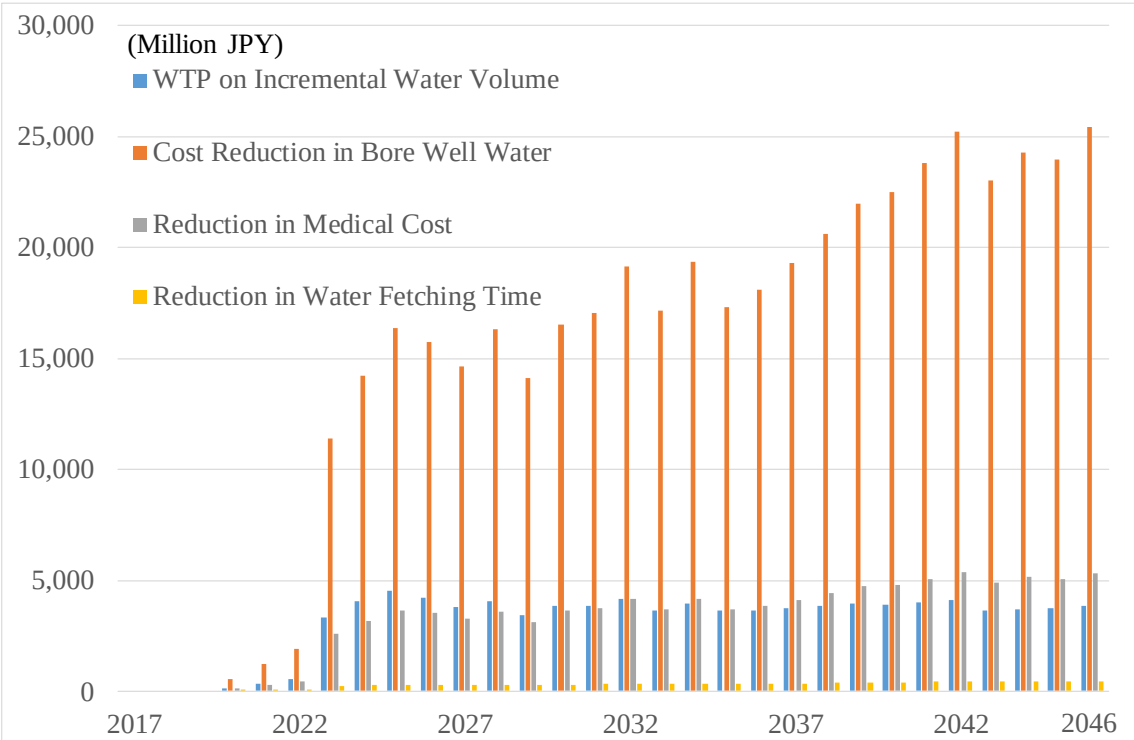
Source: JICA Study Team

Appendix 12.5 Economic Cost and Benefit



Source: JICA Study Team

Figure A12.5.1 Economic Cost Schedule



Source: JICA Study Team

Figure A12.5.2 Economic Benefit Schedule

Appendix 12.6 Economic Analysis Results

Table A12.6.1 Economic Analysis Result

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	EB1	EB2	EB3	EB4	**Total Revenue**	**Balance**
1	2018	1,294.9	0.0	0.0	0.0	1,294.9	0.0	0.0	0.0	0.0	0.0	-1,294.9
2	2019	2,765.4	0.0	0.0	0.0	2,765.4	0.0	0.0	0.0	0.0	0.0	-2,765.4
3	2020	15,996.6	0.0	0.0	0.0	15,996.6	153.8	533.6	123.2	10.0	820.5	-15,176.0
4	2021	19,089.1	0.0	0.0	0.0	19,089.1	344.8	1,228.1	283.6	23.1	1,879.6	-17,209.5
5	2022	18,563.2	0.0	0.0	0.0	18,563.2	523.6	1,914.4	442.0	36.2	2,916.2	-15,646.9
6	2023	10,623.9	0.0	0.0	0.0	10,623.9	3,300.9	11,402.3	2,574.1	211.4	17,488.7	6,864.9
7	2024	2,083.1	0.0	5,479.4	0.0	7,562.5	4,058.4	14,243.4	3,173.8	261.5	21,737.1	14,174.7
8	2025	23.2	0.0	7,035.2	0.0	7,058.3	4,530.4	16,348.1	3,646.6	301.4	24,826.4	17,768.1
9	2026	0.0	0.0	7,897.3	0.0	7,897.3	4,204.7	15,745.0	3,513.2	291.6	23,754.5	15,857.2
10	2027	0.0	0.0	7,131.9	0.0	7,131.9	3,780.1	14,628.8	3,247.7	270.7	21,927.3	14,795.3
11	2028	0.0	0.0	6,215.6	0.0	6,215.6	4,080.4	16,326.1	3,607.0	301.8	24,315.3	18,099.7
12	2029	0.0	0.0	6,986.8	0.0	6,986.8	3,412.2	14,120.6	3,105.4	260.8	20,899.1	13,912.3
13	2030	0.0	0.0	5,402.8	0.0	5,402.8	3,831.5	16,530.6	3,655.8	308.2	24,326.1	18,923.3
14	2031	0.0	0.0	6,174.0	0.0	6,174.0	3,834.4	17,056.6	3,746.2	316.9	24,954.1	18,780.1
15	2032	0.0	0.0	6,288.3	0.0	6,288.3	4,179.7	19,177.4	4,184.0	355.0	27,896.1	21,607.9
16	2033	0.0	0.0	7,270.0	0.0	7,270.0	3,619.9	17,138.2	3,715.2	316.3	24,789.7	17,519.7
17	2034	0.0	0.0	5,906.9	0.0	5,906.9	3,965.0	19,377.3	4,174.8	356.4	27,873.5	21,966.6
18	2035	0.0	0.0	6,899.0	0.0	6,899.0	3,618.2	17,312.0	3,683.7	314.0	24,927.9	18,028.9
19	2036	0.0	0.0	6,075.3	0.0	6,075.3	3,634.0	18,089.7	3,869.8	330.8	25,924.4	19,849.1
20	2037	0.0	0.0	5,953.5	0.0	5,953.5	3,740.9	19,320.3	4,136.2	354.6	27,552.0	21,598.5
21	2038	0.0	0.0	6,121.8	0.0	6,121.8	3,848.1	20,622.1	4,418.5	379.9	29,268.6	23,146.7
22	2039	0.0	0.0	6,290.2	0.0	6,290.2	3,955.7	21,999.4	4,717.5	406.7	31,079.3	24,789.1
23	2040	0.0	0.0	6,458.5	0.0	6,458.5	3,922.7	22,513.1	4,787.8	413.8	31,637.5	25,179.0
24	2041	0.0	0.0	6,490.6	0.0	6,490.6	4,012.3	23,804.4	5,055.2	437.9	33,309.8	26,819.2
25	2042	0.0	0.0	6,819.9	0.0	6,819.9	4,109.2	25,205.6	5,345.6	464.1	35,124.6	28,304.6
26	2043	0.0	0.0	7,174.5	10,347.6	17,522.0	3,630.9	23,029.2	4,877.9	424.4	31,962.5	14,440.4
27	2044	0.0	0.0	5,830.7	0.0	5,830.7	3,704.0	24,295.3	5,140.1	448.1	33,587.5	27,756.7
28	2045	0.0	0.0	6,105.3	0.0	6,105.3	3,739.4	23,997.6	5,044.4	439.1	33,220.5	27,115.2
29	2046	0.0	0.0	6,269.0	0.0	6,269.0	3,842.8	25,466.6	5,330.1	464.9	35,104.3	28,835.3
30	2047	0.0	-15,872.3	6,722.7	0.0	-9,149.6	3,943.8	26,995.3	5,626.6	491.7	37,057.4	46,207.0
	Total	70,439.3	-15,872.3	154,999.4	10,347.6	219,913.9	97,521.9	488,421.0	105,226.2	8,991.5	700,160.6	480,246.6
											IRR	**22.5%**
								WACC		10.00%	**NPV COST**	**199,922**
										10.00%	**NPV BENEFIT**	**636,510**
										10.00%	**NPV BALANCE**	**436,588**
											B/C	**3.18**

Source: JICA Study Team

Appendix 12.7 Economic Sensitivity Analysis Results

Table A12.7.1 EIRR Sensitivity Analysis (Fluctuations in Cost and Benefit)

												Benefit										
	22.48%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	105%	110%	115%	120%	125%	130%	135%	140%	145%	150%
Cost	150%	1.0%	2.7%	4.2%	5.5%	6.8%	8.1%	9.2%	10.3%	11.4%	12.4%	13.4%	14.4%	15.4%	16.3%	17.2%	18.2%	19.0%	19.9%	20.8%	21.6%	22.5%
	145%	1.6%	3.3%	4.8%	6.1%	7.4%	8.7%	9.8%	11.0%	12.0%	13.1%	14.1%	15.1%	16.1%	17.1%	18.0%	18.9%	19.8%	20.7%	21.6%	22.5%	23.3%
	140%	2.2%	3.9%	5.4%	6.7%	8.1%	9.3%	10.5%	11.6%	12.7%	13.8%	14.8%	15.9%	16.9%	17.8%	18.8%	19.7%	20.7%	21.6%	22.5%	23.4%	24.2%
	135%	2.9%	4.5%	6.0%	7.4%	8.7%	10.0%	11.2%	12.3%	13.4%	14.5%	15.6%	16.6%	17.6%	18.6%	19.6%	20.6%	21.5%	22.5%	23.4%	24.3%	25.2%
	130%	3.5%	5.1%	6.6%	8.1%	9.4%	10.7%	11.9%	13.1%	14.2%	15.3%	16.4%	17.5%	18.5%	19.5%	20.5%	21.5%	22.5%	23.4%	24.4%	25.3%	26.2%
	125%	4.2%	5.8%	7.3%	8.8%	10.1%	11.4%	12.6%	13.8%	15.0%	16.1%	17.2%	18.3%	19.4%	20.4%	21.5%	22.5%	23.5%	24.5%	25.4%	26.4%	27.3%
	120%	4.9%	6.5%	8.1%	9.5%	10.9%	12.2%	13.4%	14.7%	15.9%	17.0%	18.2%	19.3%	20.4%	21.4%	22.5%	23.5%	24.5%	25.5%	26.5%	27.5%	28.5%
	115%	5.6%	7.3%	8.8%	10.3%	11.7%	13.0%	14.3%	15.5%	16.8%	18.0%	19.1%	20.3%	21.4%	22.5%	23.6%	24.6%	25.7%	26.7%	27.7%	28.7%	29.7%
	110%	6.4%	8.1%	9.6%	11.1%	12.5%	13.9%	15.2%	16.5%	17.7%	19.0%	20.2%	21.3%	22.5%	23.6%	24.7%	25.8%	26.9%	28.0%	29.0%	30.0%	31.1%
	105%	7.2%	8.9%	10.5%	12.0%	13.4%	14.8%	16.2%	17.5%	18.8%	20.0%	21.3%	22.5%	23.7%	24.8%	26.0%	27.1%	28.2%	29.3%	30.4%	31.5%	32.5%
	100%	8.1%	9.8%	11.4%	12.9%	14.4%	15.9%	17.2%	18.6%	19.9%	21.2%	22.5%	23.7%	24.9%	26.1%	27.3%	28.5%	29.6%	30.8%	31.9%	33.0%	34.1%
	95%	9.0%	10.7%	12.4%	14.0%	15.5%	17.0%	18.4%	19.8%	21.1%	22.5%	23.8%	25.1%	26.3%	27.6%	28.8%	30.0%	31.2%	32.3%	33.5%	34.6%	35.8%
	90%	10.0%	11.7%	13.4%	15.1%	16.6%	18.2%	19.6%	21.1%	22.5%	23.9%	25.2%	26.5%	27.8%	29.1%	30.4%	31.6%	32.9%	34.1%	35.3%	36.4%	37.6%
	85%	11.0%	12.9%	14.6%	16.3%	17.9%	19.5%	21.0%	22.5%	23.9%	25.4%	26.8%	28.1%	29.5%	30.8%	32.1%	33.4%	34.7%	36.0%	37.2%	38.4%	39.6%
	80%	12.2%	14.1%	15.9%	17.6%	19.3%	20.9%	22.5%	24.0%	25.5%	27.0%	28.5%	29.9%	31.3%	32.7%	34.1%	35.4%	36.7%	38.0%	39.3%	40.6%	41.8%
	75%	13.4%	15.4%	17.2%	19.0%	20.8%	22.5%	24.1%	25.7%	27.3%	28.9%	30.4%	31.9%	33.3%	34.8%	36.2%	37.6%	39.0%	40.3%	41.7%	43.0%	44.3%
	70%	14.8%	16.9%	18.8%	20.7%	22.5%	24.2%	26.0%	27.7%	29.3%	30.9%	32.5%	34.1%	35.6%	37.1%	38.6%	40.0%	41.5%	42.9%	44.3%	45.6%	47.0%
	65%	16.4%	18.5%	20.5%	22.5%	24.4%	26.2%	28.0%	29.8%	31.5%	33.2%	34.9%	36.5%	38.1%	39.7%	41.2%	42.8%	44.3%	45.7%	47.2%	48.6%	50.0%
	60%	18.2%	20.4%	22.5%	24.5%	26.5%	28.5%	30.4%	32.2%	34.1%	35.8%	37.6%	39.3%	41.0%	42.6%	44.3%	45.9%	47.4%	49.0%	50.5%	52.0%	53.5%
	55%	20.2%	22.5%	24.7%	26.9%	29.0%	31.1%	33.1%	35.0%	37.0%	38.8%	40.7%	42.5%	44.3%	46.0%	47.7%	49.4%	51.0%	52.7%	54.3%	55.8%	57.4%
	50%	22.5%	24.9%	27.3%	29.6%	31.9%	34.1%	36.2%	38.3%	40.3%	42.3%	44.3%	46.2%	48.0%	49.9%	51.7%	53.5%	55.2%	56.9%	58.6%	60.3%	61.9%

Source: JICA Study Team

Table A12.7.2 NPV Sensitivity Analysis (Fluctuations in Cost and Benefit)

												Benefit										
	436,588	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	105%	110%	115%	120%	125%	130%	135%	140%	145%	150%
Cost	150%	18,372	50,198	82,023	113,849	145,674	177,500	209,325	241,151	272,976	304,801	336,627	368,452	400,278	432,103	463,929	495,754	527,580	559,405	591,231	623,056	654,882
	145%	28,368	60,194	92,019	123,845	155,670	187,496	219,321	251,147	282,972	314,798	346,623	378,449	410,274	442,100	473,925	505,750	537,576	569,401	601,227	633,052	664,878
	140%	38,364	70,190	102,015	133,841	165,666	197,492	229,317	261,143	292,968	324,794	356,619	388,445	420,270	452,096	483,921	515,747	547,572	579,398	611,223	643,048	674,874
	135%	48,360	80,186	112,011	143,837	175,662	207,488	239,313	271,139	302,964	334,790	366,615	398,441	430,266	462,092	493,917	525,743	557,568	589,394	621,219	653,045	684,870
	130%	58,357	90,182	122,007	153,833	185,658	217,484	249,309	281,135	312,960	344,786	376,611	408,437	440,262	472,088	503,913	535,739	567,564	599,390	631,215	663,041	694,866
	125%	68,353	100,178	132,004	163,829	195,655	227,480	259,305	291,131	322,956	354,782	386,607	418,433	450,258	482,084	513,909	545,735	577,560	609,386	641,211	673,037	704,862
	120%	78,349	110,174	142,000	173,825	205,651	237,476	269,302	301,127	332,953	364,778	396,604	428,429	460,254	492,080	523,905	555,731	587,556	619,382	651,207	683,033	714,858
	115%	88,345	120,170	151,996	183,821	215,647	247,472	279,298	311,123	342,949	374,774	406,600	438,425	470,251	502,076	533,902	565,727	597,552	629,378	661,203	693,029	724,854
	110%	98,341	130,166	161,992	193,817	225,643	257,468	289,294	321,119	352,945	384,770	416,596	448,421	480,247	512,072	543,898	575,723	607,549	639,374	671,200	703,025	734,850
	105%	108,337	140,162	171,988	203,813	235,639	267,464	299,290	331,115	362,941	394,766	426,592	458,417	490,243	522,068	553,894	585,719	617,545	649,370	681,196	713,021	744,847
	100%	118,333	150,159	181,984	213,809	245,635	277,460	309,286	341,111	372,937	404,762	436,588	468,413	500,239	532,064	563,890	595,715	627,541	659,366	691,192	723,017	754,843
	95%	128,329	160,155	191,980	223,806	255,631	287,457	319,282	351,108	382,933	414,758	446,584	478,409	510,235	542,060	573,886	605,711	637,537	669,362	701,188	733,013	764,839
	90%	138,325	170,151	201,976	233,802	265,627	297,453	329,278	361,104	392,929	424,755	456,580	488,406	520,231	552,056	583,882	615,707	647,533	679,358	711,184	743,009	774,835
	85%	148,321	180,147	211,972	243,798	275,623	307,449	339,274	371,100	402,925	434,751	466,576	498,402	530,227	562,053	593,878	625,704	657,529	689,354	721,180	753,005	784,831
	80%	158,317	190,143	221,968	253,794	285,619	317,445	349,270	381,096	412,921	444,747	476,572	508,398	540,223	572,049	603,874	635,700	667,525	699,351	731,176	763,002	794,827
	75%	168,313	200,139	231,964	263,790	295,615	327,441	359,266	391,092	422,917	454,743	486,568	518,394	550,219	582,045	613,870	645,696	677,521	709,347	741,172	772,998	804,823
	70%	178,310	210,135	241,961	273,786	305,612	337,437	369,262	401,088	432,913	464,739	496,564	528,390	560,215	592,041	623,866	655,692	687,517	719,343	751,168	782,994	814,819
	65%	188,306	220,131	251,957	283,782	315,608	347,433	379,259	411,084	442,910	474,735	506,560	538,386	570,211	602,037	633,862	665,688	697,513	729,339	761,164	792,990	824,815
	60%	198,302	230,127	261,953	293,778	325,604	357,429	389,255	421,080	452,906	484,731	516,557	548,382	580,208	612,033	643,858	675,684	707,509	739,335	771,160	802,986	834,811
	55%	208,298	240,123	271,949	303,774	335,600	367,425	399,251	431,076	462,902	494,727	526,553	558,378	590,204	622,029	653,855	685,680	717,506	749,331	781,157	812,982	844,807
	50%	218,294	250,119	281,945	313,770	345,596	377,421	409,247	441,072	472,898	504,723	536,549	568,374	600,200	632,025	663,851	695,676	727,502	759,327	791,153	822,978	854,804

Source: JICA Study Team

Table A12.7.3 B/C Sensitivity Analysis (Fluctuations in Cost and Benefit)

												Benefit										
	3.18	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	105%	110%	115%	120%	125%	130%	135%	140%	145%	150%
Cost	150%	1.06	1.17	1.27	1.38	1.49	1.59	1.70	1.80	1.91	2.02	2.12	2.23	2.33	2.44	2.55	2.65	2.76	2.87	2.97	3.08	3.18
	145%	1.10	1.21	1.32	1.43	1.54	1.65	1.76	1.87	1.98	2.09	2.20	2.31	2.42	2.53	2.63	2.74	2.85	2.96	3.07	3.18	3.29
	140%	1.14	1.25	1.36	1.48	1.59	1.71	1.82	1.93	2.05	2.16	2.27	2.39	2.50	2.62	2.73	2.84	2.96	3.07	3.18	3.30	3.41
	135%	1.18	1.30	1.42	1.53	1.65	1.77	1.89	2.00	2.12	2.24	2.36	2.48	2.59	2.71	2.83	2.95	3.07	3.18	3.30	3.42	3.54
	130%	1.22	1.35	1.47	1.59	1.71	1.84	1.96	2.08	2.20	2.33	2.45	2.57	2.69	2.82	2.94	3.06	3.18	3.31	3.43	3.55	3.67
	125%	1.27	1.40	1.53	1.66	1.78	1.91	2.04	2.16	2.29	2.42	2.55	2.67	2.80	2.93	3.06	3.18	3.31	3.44	3.57	3.69	3.82
	120%	1.33	1.46	1.59	1.72	1.86	1.99	2.12	2.26	2.39	2.52	2.65	2.79	2.92	3.05	3.18	3.32	3.45	3.58	3.71	3.85	3.98
	115%	1.38	1.52	1.66	1.80	1.94	2.08	2.21	2.35	2.49	2.63	2.77	2.91	3.05	3.18	3.32	3.46	3.60	3.74	3.88	4.01	4.15
	110%	1.45	1.59	1.74	1.88	2.03	2.17	2.32	2.46	2.60	2.75	2.89	3.04	3.18	3.33	3.47	3.62	3.76	3.91	4.05	4.20	4.34
	105%	1.52	1.67	1.82	1.97	2.12	2.27	2.43	2.58	2.73	2.88	3.03	3.18	3.34	3.49	3.64	3.79	3.94	4.09	4.25	4.40	4.55
	100%	1.59	1.75	1.91	2.07	2.23	2.39	2.55	2.71	2.87	3.02	3.18	3.34	3.50	3.66	3.82	3.98	4.14	4.30	4.46	4.62	4.78
	95%	1.68	1.84	2.01	2.18	2.35	2.51	2.68	2.85	3.02	3.18	3.35	3.52	3.69	3.85	4.02	4.19	4.36	4.52	4.69	4.86	5.03
	90%	1.77	1.95	2.12	2.30	2.48	2.65	2.83	3.01	3.18	3.36	3.54	3.71	3.89	4.07	4.25	4.42	4.60	4.78	4.95	5.13	5.31
	85%	1.87	2.06	2.25	2.43	2.62	2.81	3.00	3.18	3.37	3.56	3.75	3.93	4.12	4.31	4.49	4.68	4.87	5.06	5.24	5.43	5.62
	80%	1.99	2.19	2.39	2.59	2.79	2.98	3.18	3.38	3.58	3.78	3.98	4.18	4.38	4.58	4.78	4.97	5.17	5.37	5.57	5.77	5.97
	75%	2.12	2.33	2.55	2.76	2.97	3.18	3.40	3.61	3.82	4.03	4.25	4.46	4.67	4.88	5.09	5.31	5.52	5.73	5.94	6.16	6.37
	70%	2.27	2.50	2.73	2.96	3.18	3.41	3.64	3.87	4.09	4.32	4.55	4.78	5.00	5.23	5.46	5.69	5.91	6.14	6.37	6.60	6.82
	65%	2.45	2.69	2.94	3.18	3.43	3.67	3.92	4.16	4.41	4.65	4.90	5.14	5.39	5.63	5.88	6.12	6.37	6.61	6.86	7.10	7.35
	60%	2.65	2.92	3.18	3.45	3.71	3.98	4.25	4.51	4.78	5.04	5.31	5.57	5.84	6.10	6.37	6.63	6.90	7.16	7.43	7.69	7.96
	55%	2.89	3.18	3.47	3.76	4.05	4.34	4.63	4.92	5.21	5.50	5.79	6.08	6.37	6.66	6.95	7.24	7.53	7.81	8.10	8.39	8.68
	50%	3.18	3.50	3.82	4.14	4.46	4.78	5.09	5.41	5.73	6.05	6.37	6.69	7.00	7.32	7.64	7.96	8.28	8.60	8.91	9.23	9.55

Source: JICA Study Team

Table A12.7.4 Sensitivity Analysis (Fluctuations in Water Production Volume -20%)

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	EB1	EB2	EB3	EB4	**Total Revenue**	**Balance**
1	2018	1,294.9	0.0	0.0	0.0	1,294.9	0.0	0.0	0.0	0.0	0.0	-1,294.9
2	2019	2,765.4	0.0	0.0	0.0	2,765.4	0.0	0.0	0.0	0.0	0.0	-2,765.4
3	2020	15,996.6	0.0	0.0	0.0	15,996.6	153.8	533.6	123.2	10.0	820.5	-15,176.0
4	2021	19,089.1	0.0	0.0	0.0	19,089.1	344.8	1,228.1	283.6	23.1	1,879.6	-17,209.5
5	2022	18,563.2	0.0	0.0	0.0	18,563.2	523.6	1,914.4	442.0	36.2	2,916.2	-15,646.9
6	2023	10,623.9	0.0	0.0	0.0	10,623.9	2,794.7	9,654.0	2,179.5	179.0	14,807.2	4,183.4
7	2024	2,083.1	0.0	4,383.5	0.0	6,466.6	3,441.4	12,077.9	2,691.3	221.7	18,432.4	11,965.8
8	2025	23.2	0.0	5,628.1	0.0	5,651.3	3,838.9	13,852.8	3,090.0	255.4	21,037.1	15,385.8
9	2026	0.0	0.0	6,317.9	0.0	6,317.9	3,583.5	13,418.9	2,994.2	248.5	20,245.2	13,927.3
10	2027	0.0	0.0	5,705.5	0.0	5,705.5	3,251.2	12,582.1	2,793.3	232.8	18,859.5	13,153.9
11	2028	0.0	0.0	4,972.5	0.0	4,972.5	3,498.9	13,999.5	3,093.0	258.8	20,850.3	15,877.8
12	2029	0.0	0.0	5,589.5	0.0	5,589.5	2,971.9	12,298.5	2,704.7	227.2	18,202.3	12,612.8
13	2030	0.0	0.0	4,322.3	0.0	4,322.3	3,322.8	14,335.7	3,170.4	267.3	21,096.2	16,773.9
14	2031	0.0	0.0	4,939.2	0.0	4,939.2	3,330.7	14,815.8	3,254.0	275.2	21,675.8	16,736.6
15	2032	0.0	0.0	5,030.6	0.0	5,030.6	3,612.6	16,575.5	3,616.4	306.9	24,111.4	19,080.7
16	2033	0.0	0.0	5,816.0	0.0	5,816.0	3,170.7	15,011.3	3,254.2	277.0	21,713.1	15,897.1
17	2034	0.0	0.0	4,725.5	0.0	4,725.5	3,452.7	16,873.7	3,635.4	310.4	24,272.2	19,546.7
18	2035	0.0	0.0	5,519.2	0.0	5,519.2	3,179.8	15,214.2	3,237.3	276.0	21,907.3	16,388.1
19	2036	0.0	0.0	4,860.2	0.0	4,860.2	3,201.4	15,936.1	3,409.1	291.5	22,838.0	17,977.8
20	2037	0.0	0.0	4,762.8	0.0	4,762.8	3,298.1	17,033.5	3,646.6	312.7	24,290.9	19,528.1
21	2038	0.0	0.0	4,897.5	0.0	4,897.5	3,395.3	18,195.4	3,898.5	335.2	25,824.3	20,926.9
22	2039	0.0	0.0	5,032.1	0.0	5,032.1	3,492.9	19,425.5	4,165.6	359.1	27,443.1	22,410.9
23	2040	0.0	0.0	5,166.8	0.0	5,166.8	3,470.4	19,917.0	4,235.7	366.1	27,989.2	22,822.4
24	2041	0.0	0.0	5,192.5	0.0	5,192.5	3,541.9	21,013.7	4,462.6	386.6	29,404.8	24,212.4
25	2042	0.0	0.0	5,455.9	0.0	5,455.9	3,619.4	22,201.3	4,708.5	408.8	30,938.0	25,482.1
26	2043	0.0	0.0	5,739.6	10,347.6	16,087.1	3,236.8	20,529.8	4,348.5	378.3	28,493.5	12,406.4
27	2044	0.0	0.0	4,664.6	0.0	4,664.6	3,295.4	21,615.4	4,573.1	398.7	29,882.6	25,218.0
28	2045	0.0	0.0	4,884.2	0.0	4,884.2	3,324.0	21,331.3	4,483.9	390.3	29,529.5	24,645.2
29	2046	0.0	0.0	5,015.2	0.0	5,015.2	3,404.7	22,563.4	4,722.4	411.9	31,102.4	26,087.2
30	2047	0.0	-15,872.3	5,378.1	0.0	-10,494.1	3,483.8	23,846.3	4,970.2	434.4	32,734.8	43,228.9
	Total	70,439.3	-15,872.3	123,999.5	10,347.6	188,914.1	85,236.2	427,994.9	92,187.3	7,878.9	613,297.3	424,383.3
											IRR	**20.2%**
								WACC		10.00%	**NPV COST**	**171,740**
										10.00%	**NPV BENEFIT**	**557,543**
										10.00%	**NPV BALANCE**	**385,803**
											B/C	**3.25**

Source: JICA Study Team

Table A12.7.5 Sensitivity Analysis (Fluctuations in Water Production Volume +20%)

(Million JPY)

Evaluation Period	Year	Construction Cost	Residual Value	O&M Cost	Replacement Cost	**Total Cost**	EB1	EB2	EB3	EB4	**Total Revenue**	**Balance**
1	2018	1,294.9	0.0	0.0	0.0	1,294.9	0.0	0.0	0.0	0.0	0.0	-1,294.9
2	2019	2,765.4	0.0	0.0	0.0	2,765.4	0.0	0.0	0.0	0.0	0.0	-2,765.4
3	2020	15,996.6	0.0	0.0	0.0	15,996.6	153.8	533.6	123.2	10.0	820.5	-15,176.0
4	2021	19,089.1	0.0	0.0	0.0	19,089.1	344.8	1,228.1	283.6	23.1	1,879.6	-17,209.5
5	2022	18,563.2	0.0	0.0	0.0	18,563.2	523.6	1,914.4	442.0	36.2	2,916.2	-15,646.9
6	2023	10,623.9	0.0	0.0	0.0	10,623.9	3,807.0	13,150.6	2,968.8	243.8	20,170.2	9,546.4
7	2024	2,083.1	0.0	6,575.3	0.0	8,658.3	4,675.5	16,408.8	3,656.3	301.3	25,041.8	16,383.5
8	2025	23.2	0.0	8,442.2	0.0	8,465.4	5,221.9	18,843.3	4,203.1	347.4	28,615.8	20,150.4
9	2026	0.0	0.0	9,476.8	0.0	9,476.8	4,825.9	18,071.0	4,032.3	334.7	27,263.9	17,787.1
10	2027	0.0	0.0	8,558.3	0.0	8,558.3	4,308.9	16,675.5	3,702.1	308.6	24,995.1	16,436.7
11	2028	0.0	0.0	7,458.8	0.0	7,458.8	4,661.9	18,652.6	4,121.1	344.8	27,780.4	20,321.6
12	2029	0.0	0.0	8,384.2	0.0	8,384.2	3,852.5	15,942.8	3,506.2	294.5	23,596.0	15,211.8
13	2030	0.0	0.0	6,483.4	0.0	6,483.4	4,340.3	18,725.5	4,141.2	349.1	27,556.0	21,072.6
14	2031	0.0	0.0	7,408.9	0.0	7,408.9	4,338.2	19,297.4	4,238.3	358.5	28,232.4	20,823.6
15	2032	0.0	0.0	7,545.9	0.0	7,545.9	4,746.7	21,779.2	4,751.7	403.2	31,680.9	24,135.0
16	2033	0.0	0.0	8,724.0	0.0	8,724.0	4,069.2	19,265.2	4,176.3	355.5	27,866.2	19,142.2
17	2034	0.0	0.0	7,088.3	0.0	7,088.3	4,477.3	21,880.9	4,714.1	402.5	31,474.8	24,386.5
18	2035	0.0	0.0	8,278.8	0.0	8,278.8	4,056.7	19,409.7	4,130.1	352.1	27,948.5	19,669.7
19	2036	0.0	0.0	7,290.4	0.0	7,290.4	4,066.6	20,243.3	4,330.5	370.2	29,010.7	21,720.3
20	2037	0.0	0.0	7,144.2	0.0	7,144.2	4,183.6	21,607.0	4,625.8	396.6	30,813.0	23,668.8
21	2038	0.0	0.0	7,346.2	0.0	7,346.2	4,301.0	23,048.8	4,938.4	424.6	32,712.8	25,366.6
22	2039	0.0	0.0	7,548.2	0.0	7,548.2	4,418.6	24,573.3	5,269.5	454.3	34,715.6	27,167.4
23	2040	0.0	0.0	7,750.2	0.0	7,750.2	4,375.1	25,109.2	5,340.0	461.5	35,285.8	27,535.6
24	2041	0.0	0.0	7,788.7	0.0	7,788.7	4,482.7	26,595.0	5,647.9	489.2	37,214.8	29,426.1
25	2042	0.0	0.0	8,183.9	0.0	8,183.9	4,599.0	28,209.9	5,982.8	519.4	39,311.1	31,127.2
26	2043	0.0	0.0	8,609.3	10,347.6	18,956.9	4,025.0	25,528.7	5,407.4	470.5	35,431.4	16,474.5
27	2044	0.0	0.0	6,996.9	0.0	6,996.9	4,112.5	26,975.2	5,707.1	497.6	37,292.4	30,295.5
28	2045	0.0	0.0	7,326.3	0.0	7,326.3	4,154.9	26,663.9	5,604.9	487.9	36,911.5	29,585.2
29	2046	0.0	0.0	7,522.9	0.0	7,522.9	4,280.8	28,369.8	5,937.7	517.9	39,106.3	31,583.4
30	2047	0.0	-15,872.3	8,067.2	0.0	-7,805.1	4,403.9	30,144.2	6,282.9	549.1	41,380.1	49,185.1
	Total	70,439.3	-15,872.3	185,999.3	10,347.6	250,913.8	109,807.7	548,847.1	118,265.1	10,104.0	787,023.8	536,110.0
											IRR	**24.7%**
								WACC		10.00%	**NPV COST**	**228,103**
										10.00%	**NPV BENEFIT**	**715,476**
										10.00%	**NPV BALANCE**	**487,373**
											B/C	**3.14**

Source: JICA Study Team

Appendix 12.1 Conditions and Methodologies for Financial and Economic Analyses

Nondisclosure

Table A12.1.2 Service Population Projection

Nondisclosure

Table A12.1.3 With- and Without- Perur- Project Water Production Volume

Nondisclosure

Table A12.1.4 With- and Without- Pipeline Project Water Loss Ratio

Nondisclosure

Table A12.1.5 With- a

Nondisclosure

Table A12.1.6 With-and Without- Project Total Sold Water (Both Perur and Pipeline Projects)

Nondisclosure

Table A12.1.7 Incremental Sold Water by Category

Nondisclosure

Table A12.1.8 GRDP per Capita and EVT per Capita Projection

Nondisclosure

Appendix 12.2 Financial Cost and Benefit

Nondisclosure

Nondisclosure

Nondisclosure

Appendix 12.3 Financial Analysis Results

Nondisclosure

Table A12.3.3 Financial Analysis Results (Alternative 2 – Total Cost)

Nondisclosure

Appendix 12.4 Financial Sensitivity Analysis

Nondisclosure

Table A12.4.3 Sensitivity Analysis (Fluctuations in Cost and Benefit)

(Alternative 2 – Total Cost)

Nondisclosure

Table A12.4.5 Sensitivity Analysis (New Tariff – Alternative 1 - Total Cost)

Nondisclosure

Table A12.4.7 Sensitivity Analysis (New Tariff – Alternative 2 – Total Cost)

Nondisclosure

Table A12.4.9 Sensitivity Analysis (Fluctuations in Water Supply Volume -20%)
(Current Tariff – Alternative 2 – Total Cost)

Nondisclosure

Table A12.4.11 Sensitivity Analysis (Fluctuations in Water Supply Volume +20%)

(Current Tariff – Alternative 2 - Total Cost)

Nondisclosure

Table A12.4.13 Sensitivity Analysis (Fluctuations in Water Supply Volume -20%)
(New Tariff – Alternative 2 – O&M Cost Only)

Nondisclosure

Appendix 12.5 Economic Cost and Benefit

Nondisclosure

Appendix 12.6 Economic Analysis Results

Nondisclosure

Appendix 12.7 Economic Sensitivity Analysis Results

Nondisclosure

Table A12.7.4 Sensitivity Analysis (Fluctuations in Water Production Volume -20%)

Nondisclosure

Appendix 13.1 Risk management framework for the project

Risk Management Framework

Project Name: Chennai Seawater Desalination Plant Project (Perur Seawater Desalination Plant)
Country: Republic of India
Sector: Urban Water Supply

Officers in charge:
- Operational staff
- Engineering staff:
- Country office staff:

Potential project risks	Assessment
1. Stakeholder Risk	Probability: Low
(Description of risk) Delay in the Project implementation due to **conflicts with the land users of the project site** DSP site: There are burial grounds on the DSP site. Users of the burial grounds may raise opposition to the Project. (There is no risk in land acquisition. CMWSSB and the land owner, who is a trust maintained by HR&CE Department, have already agreed to the lease of the land itself.) Transmission line: Residents or businesses along the roads where the transmission lines will be installed may raise opposition to the Project.	Impact: High
	Analysis of probability and impact:
	If a conflict arises with the stakeholders, it may lead to the project being stopped, but its probability is low. CMWSSB has already secured the land and is in talks with the land users. Transmission line will be installed in public roads in principle. Permissions for construction will be necessary but they will not generate any conflict.
	Mitigation measures:
	The layout of the DSP has been planned in such a way so as to avoid any impact on the burial grounds. Stakeholder meeting by CMWSS was already held at Perur. Monitoring plan and grievance redressal mechanism have been proposed in the Study.
	Action during the implementation:
	CMWSSB will continue to communicate with the stakeholders. CMWSSB will follow the monitoring plan and establish and maintain the grievance redressal mechanism with the assistance of project management consultant (PMC). When necessary, CMWSSB will consider giving compensation to the people affected due to the construction of the plant and transmission line.
	Contingency plan (if applicable):
	-
2. Executing Agency Risk	
2.1. Capacity Risk	Probability: Low (Middle, if the proposed mitigation measure is not taken)
(Description of risk) Delay in the Project implementation due to **incapability of the Project Executing Agency** If the executing agency is not capable enough to handle daily works, timely decision makings, or coordination with relevant authorities, the project implementation may be seriously delayed. Such incapability may also lead to a dispute with the	Impact: Middle
	Analysis of probability and impact:
	CMWSSB has experience of handling DSP projects but no experience in handling JICA loan project. Current decision making procedure and frequent personnel changes in important positions will probably affect the implementation efficiency.
	Mitigation measures:
	A dedicated unit for the Project, project implementation unit (PIU), has been proposed in the Study and CMWSSB has committed to its establishment. A decision-making plan has also been proposed. JICA will provide key PIU members with seminars on implementation procedures and rules in JICA loan projects prior to the Project.
	Action during the implementation:

project management consultant (PMC) or the contractor on contractual or payment issues.	PMC will assist CMWSSB and PIU for timely and appropriate processes and decision makings. The Steering Committee will monitor the Project's progress and give instructions to CMWSSB for improvement when necessary. JICA will also monitor the progress.
	Contingency plan (if applicable):
	-
2.2. (1) Governance Risk-1	Probability: Low (Middle, if the proposed mitigation measure is not taken)
(Description of risk) Delay in the Project implementation due to **complicated procedures required to conduct the project or unsuccessful coordination with other authorities/utilities** The slow progress of any necessary external procedures or acquisition of approvals or permissions may delay the project. Permission for construction of roads and coordination with other utilities such as power supply, telecommunication, drainage, etc. are possible events that may cause such difficulties.	Impact: Middle
	Analysis of probability and impact:
	The Project will need various external procedures and coordination with other authorities/utilities. CMWSSB is not powerful enough to handle some of the procedures and coordination work smoothly and timely.
	Mitigation measures:
	Steering Committee (SC) for the Project has been proposed in the Study, and CMWSSB is committed to requesting the state government to formulate the committee. The committee will assist CMWSSB in any procedures or coordination work with the external authorities/utilities.
	Action during the implementation:
	CMWSSB will take a lead in the procedures or coordination without leaving them to the contractors. When they face difficulties, CMWSSB will immediately consult with key member(s) of the SC.
	Contingency plan (if applicable):
	-
2.2. (2) Governance Risk-2	Probability: Low
(Description of risk) Delay in the Project implementation due to **incompletion of the environmental procedure for the project** Incompletion or slow progress of environmental procedure may delay the Project's implementation. For the Project, Coastal Regulation Zone (CRZ) clearance is necessary. Certificate on EIA is not needed.	Impact: Middle
	Analysis of probability and impact:
	Documents for CRZ clearance on the Project has already been transferred from CZMA to MoEF in May 2016. Probably, the clearance notification will be given before the commencement of the construction, but there is no evidence that MoEF has started the evaluation
	Mitigation measures:
	At present CMWSSB is waiting for communication from MoEF. CMWSSB will need to ask MoEF the current status of the evaluation to detect any problem or error if any.
	Action during the implementation:
	- (The notification must be obtained before the completion)
	Contingency plan (if applicable):
	-
2.3. Fraud & Corruption Risk	Probability: Low
(Description of risk) **Corruption in the procurement procedure of PMC or the contractor** If corruption happens at any process of the project, such as procurement procedures of the	Impact: High
	Analysis of probability and impact:
	CMWSSB is not deemed to be corrupted. If corruption happens and it is exposed, the Project may be stopped.
	Mitigation measures:
	All procurement processes will be conducted strictly complying with JICA's guidelines.
	Action during the implementation:

PMC or the contractor, would prevent implementation of the project.	JICA will monitor the procurement procedures of the PMC and the contractor through the concurrence processes. In the procurement of the contractors, PMC will assist and monitor the bidding procedures in compliance with JICA's guidelines.
	Contingency plan (if applicable):
	-
3. Project Risk	
3.1. (1) Design Risk-1	Probability: Middle
(Description of risk) Delay in the Project due to **technical or financial capability of the contractors** Construction work may not be completed within the scheduled period if the contractor is not capable enough or the work volume of the contract package is too huge.	Impact: Middle
	Analysis of probability and impact:
	A good number of water supply projects in India are facing similar problems due to local contractors' incapability. In the Project, contract packages for the transmission lines have such possibilities.
	Mitigation measures:
	Construction of the transmission lines has been divided into four (4) contract packages so that the size of the contract will be within local contractors' capabilities.
	Action during the implementation:
	In the PQ processes, financial and technical qualifications will be appropriately examined. The bid evaluation will take into account the technical proposals and examine feasibilities of the financial proposals carefully by the bidders.
	Contingency plan (if applicable):
	-
3.1. (2) Design Risk-2	Probability: Middle
(Description of risk) Lower project's beneficial effects than expected due to **lower water demand derived from external causes** If the water demand is lower than projected, the operation rate of the Perur DSP will be lower than projected in the Study. It may lead to an evaluation that the Project is not generating beneficial effects as expected. Slow development of water distribution network in the CMA is another possible cause of such low production.	Impact: Low
	Analysis of probability and impact:
	As production requirement to DSPs depends on climate conditions, the production of the Perur DSP will possibly be lower than expected. However, it is definite that the Project will contribute to satisfying people's water demand even if the production is lower. Water distribution networks in the corporation will be completed soon by CMWSSB, but those in the Rest of CMA will take time.
	Mitigation measures:
	The Project's benefit in lower production case has been examined and validated in the financial and economic analysis in the Study. Water demand projection took into account gradual expansion of the water distribution network in Rest of CMA.
	Action during the implementation:
	- (Accept the risk)
	Contingency plan (if applicable):
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3.2. Program & Donor Risk	Probability: Middle (High, if the mitigation measure is not successful)
(Description of risk) Lower projects beneficial effects than expected due to **low operation rate for CMWSSB's financial reasons** DSPs are more costly to operate that other conventional WTPs. If the water tariff is not raised to the level of secure operational cost recovery of DSPs, CMWSSB	Impact: High
	Analysis of probability and impact:
	A similar situation exists in the existing Nemmeli DSP. Improvement in the metering rate and introduction of the volumetric tariff at a financially viable level are urgent issues.
	Mitigation measures:
	CMWSSB has already carried out a financial simulation to know the viable tariff level and prepared meter installation and tariff improvement plans. CMWSSB should achieve internal and external consensus on these plans.
	Action during the implementation:

may keep the operation rate of the Perur DSP low regardless of unsatisfactory LPCD.	CMWSSB must insist on implementation of the metering and tariff improvement plans.
	Contingency plan (if applicable):
	The state government will need to provide CMWSSB with sufficient amount of subsidy to satisfy the water demand.
3.3.(1) Delivery Quality Risk-1	Probability: Low
(Description of risk)	Impact: Middle
Lower project's beneficial effects due to **frequent failure in quantity or quality of the DSP or the transmission line derived from insufficient O&M skill or management** Incapability of O&M works may prevent the Project from generating the expected beneficial effects.	Analysis of probability and impact:
	The possibility of O&M failure is not high because it owns an existing DSP under the similar contract to the Project and another similar project will be commenced soon.
	Mitigation measures:
	The Project will adopt DBO contract, where the O&M works will be conducted by the plant supplier. The contract will require the contractor to train CMWSSB staff to obtain general knowledge of the plant to enable O&M supervision.
	Action during the implementation:
	CMWSSB will recruit and assign their staff as trainees to learn necessary knowledge for the DSP's supervision.
	Contingency plan (if applicable):
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3.3. (2) Delivery Quality Risk-2	Probability: Low
(Description of risk)	Impact: High
Lower project's beneficial effects due to **serious damage to the facilities by natural disaster** The Project site was affected by Tsunami in 2004 Indian Ocean earthquake. If the DSP is damaged by a similar natural disaster and loses its functional capability or takes a long time to recover, the Project's beneficial effect will be lowered.	Analysis of probability and impact:
	If the plant is seriously damaged, people may face water shortage for a long time. Recovery or reconstruction of the plant will need huge investment.
	Mitigation measures:
	The ground level of the site has been determined at a higher level than the water level after the 2004 Tsunami.
	Action during the implementation:
	CMWSSB and PMC will supervise the contractor to satisfy the required ground elevation.
	Contingency plan (if applicable):
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4. Overall Risk Rating	Probability: Middle
(Overall comments)	Impact: Middle
If the countermeasures are implemented successfully, there will be no critical risk of high probability that may prevent serious delay of the Project or deteriorate the Project's beneficial effects. The key mitigation measures for the Project's implementation are the **establishment of PIU with sufficient power in decision-making and SC to assist PIU**. For the Project's beneficial impacts, **improvement in metering ratio and introduction of volumetric tariff to recover the operation cost** will be the key.	