23.4.4 Water Quality

(1) General

The water quality survey including sea bottom material (sediment) was carried out for consecutive 7 days for both the wet and the dry seasons. The sampling was done for both the low tide and the high tide time.

(2) Selection of sampling points

The sampling points selected for carrying out the survey in and around the Mumnai Port are shown in Figure 23.4.2 and briefly described in the following paragraphs.

1) Pir Pau (At Trombay) (WQ - 1)

The location WQ-1 was selected to study the environmental condition on the upstream of the proposed development plan.

2) Butcher Island (WQ-2)

The sampling was carried out at the marine oil terminal (MOT). The location WQ-2 was selected to study the baseline conditions near the marine oil terminal (MOT).

3) Cross Island (WQ-3)

The location WQ-3 was selected to study the existing conditions of the water quality near the proposed development.

4) Indira Dock (WQ-4)

The location WQ-4 was selected to assess the existing conditions near the MBPT and near the proposed development plan.

5) Naval Dock (WQ-5)

The sampling point WQ-5 was selected to study the baseline conditions on the downstream side of the MBPT.

(3) Methodology

1) Water Quality

a) Sampling Method

The sampling points were confirmed using a compass and mapping the co-ordinates using stationary objects within the vicinity. Surface samples were drawn using normal sampling bottle. Actual water depth was measured at the sampling point and then sample was also drawn from mid depth. For mid depth sampling simple laboratory depth sampler was used. This consisted of a bottle with adequate counter weights. The mouth of the bottle is sealed with a rubber cork as the bottle is dipped into water. The cork can be removed or reaching the desired depth to facilitate entry of water into sampler at that depth. Data such as sampling location, tide condition, time/date, depth of sampling, etc. were recorded at the field. The samples drawn were checked for parameters like pH and temperature immediately and then distributed and preserved into smaller containers as per the parameters to be analyzed and transported to laboratory for testing.

b) Analytical Procedure

All standard methods as recommended by American Public Health Association (APHA) or relevant India Standard were used for analysis of various parameters. Each sample was analyzed in triplicate for verifying the result consistency.

The table below depicts the test procedures and principles used for analysis of water quality.

Parameters	**Method**	**Principle**
pH		pH is negative log of H^+ ion concentration in the solution measured with pH electrode.
Dissolved Oxygen	Azide Modification	Adition of divalant manganese solution followed by strong alkali to the sample in glass stoppered bottle divalant manganous hydroxides oxidised to higher valancy then in presence of Iodine & acidification it again convert to divalant state liberating Iodine equivalent to Dissolved Oxygen which is titrated with thiosulphate using starch.

Biological Oxygen Demand		The test measures oxygen required for biochemical degradation of organic (carbonaceous) matter & oxygen required to oxedise material such as sulfate & ferrous iron. Method includes placing a sample in tight bottle and incubation the bottle under specified conditions for specific time (27°c for 3 days) and then computing BOD by measuring difference between initial and final Dissolved Oxygen level.
Chemical Oxygen Demand	Dichromate reflux Method	Sample is refluxed with known excess of potassium dichromate and then unreduced dichromatic is titrated with ferrous ammonium sulfate and consumed potassium-dichromate amount is determined & amount of oxydizable organic matter is calculated in terms of oxygen.
Total Suspended Solids	Gravimetric Method	Sample is centrifuged. Sediment washed with D.W. and then in evaporate in weighted dish with inference in weight will give TSS.
Oil & Grease (Ether extractable)		Oil and grease present in the water can be extracted in petroleum ether, in acidic condition. The ether layer is washed with water, after evaporation of this petroleum ether oil & grease is calculated gravimetricaliy.
Phenolic	Chloroform	Extraction Steam distilled phenols at pH 7.9

Compound	Method	with 4 ammino antipyrine in presence of potassium ferricynide forms coloured antipyrine dye which is extracted with chloroform and phenol measured on spectrophotometer.
Total Ammonical Nitrogen	Distillation & Nesslerization	The sample buffered at pH 9.5 using carbonate buffer & distilled. Distillate collected in plain boric acide which is then nesslerized.
Total Nitrogen	K-Jelda Nitrogen	Organic & Inorganic Nitrogen is converted to diammonium sulfate at the time of digestion with sulfuric acid, potassium sulfate and mercuric sulfate. Then it is distilled and ammonia is find out by nesselrisation.
Phosphorous	Stannous chloride	Molybdophosporic acid is formed method and reduced by stannous chloride to formed intensely coloured molybdenum blue which is measured on spectrophotometer.
Cadmium	Dithizone Method	Cadmium ions react with dithizone to formed pink to red colour which can be extracted with chloroform and measured on spectrophotometer.
Chromium	Colorimetry Method	All chromium converted to hexavalant form are reacted with diphenyl carbazide dye in acidic media and measured

		spectrophotometrically.
Copper	Neocuproine Method	In slightly acidic condition cuperous ions react with necuproine to form complex which is extracted in chloroform - methanol mixture and measured on spectrophotometer.
Nickel	Dimethlylglyoxime	After digestion with nitric acid - sulfuric acid mixture, iron and copper are removed by extraction of the cupferrates with chloroform. Nickel is separated from other ions by extraction of Nickel - dimethylglyoxime complex with chloroform reextracted into the aqueous with HCl and determined colorimetrically in the acidic solution with dimethylglyoxime in presence of an oxidant.
Iron	Phenanthroline Method	Iron is reduced to ferrous state with acid and hydroxyl amine hydrochloride and then treated with 1,10 phonanthroline to form orange red complex which is measured on spectrophotometer.
Lead	Dithizone Method	Acidified sample mixed with ammoniac citrate cyanide reducing solution and extracted with chloroform to form cherry red lead dithiozonate colour and measured on pectrophotometer.

Zinc	Dithizone Method	Zinc react with dithizone to form dithizonate which is extracted with carbon tetrachloride and coloured complex measured using spectrophotometer.

Source : **Standard Methods** for the Examination of Water and wastewater by APHA , AWWA , WEF for all above analytical procedures

2) Sediment Quality

Grab sea bottom material samples were collected using the Eckman Dredge sampler. The samples were collected during the low tide time once in a wet season and dry season.

(4) Results and Discussion

The water quality tested are presented in Tables from 23.4.4 to 23.4.15 and results are briefly described in following sections.

1) Water Qulity

a) Wet season

The pH of water samples is ranging between 7.5 and 7.8. Water temperature at all sampling stations is reported between 29℃ and 31℃. The concentration of DO is varying from 5 mg/l to 6.4 mg/l. The concentration of BOD is found between 2mg/l and 22 mg/l. The maximum concentration of BOD (22 mg/l) is found at WQ-5 during the low tide time, while the minimum concentration (2mg/l) at WQ-5 during the high tide time. The concentration of COD is varying from 8 mg/l to 183 mg/l. The maximum concentration of COD (183 mg/l) is found at WQ-3, while the minimum concentration (8 mg/l) is reported at WQ-5. The concentration of oil and grease is varying from 0 to 92 mg/l. The maximum concentration (92mg/l) of Oil and Grease is found at the station at WQ-2 (Butcher Island).

Data pertaining to the water quality indicate that the concentration of pH, temperature, COD, phenolic compounds, ammonical nitrogen, Cd, Cu, Cr^{6+}, Zn, Ni, Pb, and Fe are found to be less than the tolerance limit for harbour waters.{Ref Appendix A- 8.1 (b)}

The concentration of BOD is exceeding the tolerance limit(4 mg/l). The concentration of Oil and Grease is found to be more than tolerance limit (1 mg/l). {Ref Appendix A-8.1 (b)}

b) Dry Season

pH of the water samples ranged between 8.0 and 8.5. Water temperature is varying from 30℃ to 31℃ at all locations. The concentration of DO is found between 6.2 mg/l and 6.8 mg/l. The BOD concentration is varying from 3mg/lto 8.0 mg/l. The maximum BOD concentration (8 mg/l) is found at WQ-5 during low tide time.

The concentration of COD, phenolic compounds, ammonical nitrogen, Cd, Cu, Cr^{6+}, Zn, Ni, Pb, and Fe are found to be less than tolerance limit for harbour waters. {Ref. Appendix

A-8.1(b)}

2) Sediment Quality

Data pertaining to the sediment analysis indicate that the clay and silt particles are reported to be more than the fine sand during wet season. At all locations, the density of the sediment samples is varying from 1.019gm/ml to 1.207gm/ml during the wet season, while it is found between 1.211gm/ml and 1.342 gm/ml in the dry season.

The concentration of COD is found between 0.40mg/g and 0.85mg/g during the wet season as well as the dry seasons.

The concentration of Cd and Hg is reported to be nil at all sampling stations. The concentration of Arsenic is not detected at all locations.

Detailed analytical report is presented in Tables 23.4.16 (a) and (b) for the wet and the dry seasons, respectively.

Table 23.4.1a Ambient Air Quality Results (Wet Season)

SR NO	LOCATION	DAY	DATE	SPM µg/m3	SO_2 µg/m3	NO_x µg/m3	CO ppm
1	AQ-1	Holiday	28/09/97 (24 hrs)	520.7	40.7	19.4	* ND
		Weekday	29/09/97 (24 hrs)	577	51.9	22.3	ND
2	AQ-2	Holiday	28/09/97 (24 hrs)	273.7	29.5	11	ND
		Weekday	29/09/97 (24 hrs)	337.2	36.1	13.1	ND
3	AQ-3	Holiday	28/09/97 (24 hrs)	846.2	39.4	20.1	ND
		Weekday	29/09/97 (24 hrs)	1112	46.6	22.4	ND
4	AQ - 4	Holiday	28/09/97 (24 hrs)	588.7	36.1	15.4	ND
		Weekday	29/09/97 (24 hrs)	739	49.2	23.7	ND
5	AQ - 5	Holiday	28/09/97 (24 hrs)	534	49.9	24.0	ND
		Weekday	29/09/97 (24 hrs)	637.5	51.2	25.5	ND

Note :

AQ : Air Quality Stations.

***N.D :** Not Detectable.

Carbon monoxide (CO) :- below 10 ppm, Not detectable by CO-detector tubes as well as Gas Chromatography Methods

Table 23.4.1b Ambient Air Quality Index (Dry Season)

SR NO	LOCATION	DAY	DATE	SPM µg/m3	SO_2 µg/m3	NO_x µg/m3	CO ppm
1	AQ-1	Holiday	12/10/97 (24 hrs)	510	42.5	27.1	* ND
		Weekday	13/10/97 (24 hrs)	528	53.0	32.5	ND
2	AQ-2	Holiday	12/10/97 (24 hrs)	313.5	30.0	16.4	ND
		Weekday	13/10/97 (24 hrs)	365.4	32.6	17.4	ND
3	AQ-3	Holiday	12/10/97 (24 hrs)	752	53.7	28.6	ND
		Weekday	13/10/97 (24 hrs)	863	64.2	31.7	ND
4	AQ - 4	Holiday	12/10/97 (24 hrs)	575	42.1	21.6	ND
		Weekday	13/10/97 (24 hrs)	713	49.3	30.9	ND
5	AQ - 5	Holiday	12/10/97 (24 hrs)	762	39	27.8	ND
		Weekday	13/10/97 (24 hrs)	842	45.6	32.5	ND

AQ : Air Quality Stations.

***N.D** : Not Detectable.

Note : Carbon monoxide (CO) :- below 10 ppm,

Not detectable by CO-detector tubes as well as Gas Chromatography Methods.

Table 23.4.2a Noise Level Data Wet Season

(All values are in dB(A))

Location Code		L_{10}	L_{50}	L_{90}	Leq.	Lmin.	Lmax.
NQ-1	Holiday	87	78	70	85	66	92
	Weekday	86	81	75	82	73	87
NQ-2	Holiday	83	73	64	81	60	87
	Weekday	84	76	69	80	64	87
NQ-3	Holiday	82	74	67	80	60	86
	Weekday	92	81	66	90	60	96
NQ-4	Holiday	86	73	66	86	55	95
	Weekday	88	73	66	87	60	100
NQ-5	Holiday	95	81	68	96	64	106
	Weekday	96	83	70	94	68	106

Table 23.4.2b Noise Level Data Dry Season
(All values are in dB(A))

Location Code		L_{10}	L_{50}	L_{90}	Leq.	Lmin.	Lmax.
NQ-1	Holiday	86	78	71	84	64	92
	Weekday	88	79	72	85	66	90
NQ-2	Holiday	84	76	65	82	59	90
	Weekday	96	83	70	81	68	106
NQ-3	Holiday	87	74	68	84	60	91
	Weekday	88	73	66	84	62	102
NQ-4	Holiday	84	74	65	83	56	92
	Weekday	90	79	67	88	54	96
NQ-5	Holiday	89	76	70	86	66	93
	Weekday	80	78	70	84	65	91

NQ : Noise Quality Stations.

Li : i % of the time noise level exceeds the given value.

Table 23.4.3a Vibration Index Wet Season

(All values in microns)

Location Code		L_{10}	L_{50}	L_{90}	Lmin.	Lmax.
VQ-1	Holiday	87.5	64.5	29	10	117
	Weekday	85.5	58	23	12	115
VQ-2	Holiday	75.5	40	17.5	10	97
	Weekday	67	42	22	12	95
VQ-3	Holiday	85	60	25	10	110
	Weekday	72	32.5	15	10	100
VQ-4	Holiday	80	44	12	4	117
	Weekday	84.5	38	15	8	118
VQ-5	Holiday	115	59	24.5	10	171
	Weekday	133	67.5	26	15	186

Table 23.4.3b Vibration Index Dry Season

(All values in microns)

Location Code		L_{10}	L_{50}	L_{90}	Lmin.	Lmax.
VQ-1	Holiday	107.5	70	30	12	138
	Weekday	75.5	40	20	10	110
VQ-2	Holiday	50	30	20	10	90
	Weekday	50	40	20	10	65
VQ-3	Holiday	94	31	15	8	124
	Weekday	63	25	14	8	106
VQ-4	Holiday	97.5	50	20	10	144
	Weekday	75	40	10	10	130
VQ-5	Holiday	140	42.5	24.5	10	169
	Weekday	81	35	17.5	15	138

VQ : **Vibration Monitoring Stations.**

Li : i % of the time vibration exceeds the given value.

Table 23.4.4 Water Quality Monitoring Results
(Wet Season)

Sampling Date :4/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time :	12.45 P.M.		2.10 P.M.		11.55 A.M.		2.40 P.M.		11.25 A.M.		3.05 P.M.		11.10 A.M.		3.15 P.M.		10.50 A.M.		3.30 P.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid De	Surface	Mid De	Surface	Mid De	Surface	id Dept	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep
pH	8.1	8.1	8	8	8.2	8.2	8.1	8.1	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.2	8.2	8.1	8.1
Water Temperature –C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.9	6.1	6.1	6.9	6.9	6.1	6.1	6.1	6.1	6.9	6.1	6.1
B.O.D., 27–C, 3 days	10	11.8	14	16	14	10	17.2	18	13	11	13	8	12	19	17	9.4	12	15	10	10.6
Chemical Oxygen Demand	61	52	56	44	50	63	110	68	65	49	57	41	88	100	77	69	116	59	80	89
Total Suspended Solids	84	394	48	94	54	126	27	114	116	428	38	58	40	158	60	136	52	106	62	74
Oil & Grease(Ether Extractable)	34	Nil	42	Nil	18	38	44	22	52	28	62	46	Nil	Nil	32	Nil	4	40	52	26
Phenolic Compound	0.003	0.006	0.003	0.005	0.004	0.014	0.004	0.002	0.014	0.015	0.003	0.005	0.006	0.006	0.0024	0.0089	0.008	0.008	0.01	0.002
Total Amonical Nitrogen	0.106	0.086	0.114	0.045	0.255	0.056	Nil	0.0179	0.051	0.035	0.032	0.024	0.173	0.143	0.095	0.084	0.161	0.114	0.173	0.143
Total Nitrogen	0.2	0.16	0.6	0.16	0.32	0.27	ND	0.09	0.4	0.74	0.26	0.4	0.8	0.22	0.2	0.74	0.2	0.42	0.6	0.22
Phosphate	0.01	0.0085	0.011	0.005	0.025	0.025	0.02	0.03	0.04	0.05	0.03	0.03	0.005	0.04	0.02	0.005	0.04	0.04	0.05	0.05
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	Nil	Nil	Nil	0.029	Nil	Nil	Nil	0.038	Nil	Nil	Nil	Nil	Nil	0.13	Nil	Nil	Nil	0.1	0.12	0.038
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.26	0.14	0.5	0.96	0.53	1.7	0.44	0.92	0.48	1.72	0.98	1.5	0.41	1.47	0.64	1.45	0.24	0.66	1.56	0.91
Lead	1.3	ND	ND	ND	ND	ND	0.42	ND	1.06	ND	ND	ND	ND	ND	ND	9.3	ND	8.03	1.05	1.37
Zinc	0.01	0.02	0.03	0.04	0.071	Nil	0.013	0.08	0.008	0.005	0.005	0.007	0.008	0.004	0.001	0.004	0.04	0.01	0.07	0.01

Note : 1) All Parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable.

Table 23.4.5 Water Quality Monitoring Results
(Wet Season)

Sampling Date :5/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time :	12.20 P.M.		9.15 A.M.		12.45 P.M.		8.50 A.M.		2.00 P.M.		7.30 A.M.		1.45 P.M.		7.45 A.M.		1.30 P.M.		8.10 A.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid De	Surface	Mid Dep
pH	8.2	8.2	8	8.1	8.3	8.3	8.2	8.2	8.3	8.2	8.1	8.1	8.3	8.2	8.2	8.2	8.3	8.2	8.2	8.2
Water Tempreture –C	30	30	30	30	31	31	31	31	30	30	30	30	29	29	29	29	31	31	31	31
Dissolved Oxygen	5.4	5.4	6.1	6.1	6.1	6.1	6.1	5.8	5.8	5.4	6.1	6.1	6.1	6.1	6.1	5.8	6.1	6.1	6.1	6.1
B.O.D., 27–C. 3 days	12	12	14.2	14	7	6	14	4	11	16	14	4	17	15	10	5	3	2	4	3
Chemical Oxygen Demand	175	114	179	114	69	89	65	61	77	134	163	130	138	130	118	102	81	61	89	41
Total Suspended Solids	140	258	60	302	122	136	40	112	120	442	118	286	116	418	196	318	126	266	160	406
Oil & Grease (Ether Extractable)	18	44	8	12	17	36	46	32	24	60	40	48	14	36	5	12	26	18	12	32
Phenolic Compoundl	0.0001	Nil	0.0001	Nil	0.0004	0.0003	0.0001	0.0002	0.0004	0.0002	0.0004	0.0004	Nil	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003
Total Amonical Nitrogen	0.108	0.071	0.115	0.047	0.255	0.279	0.196	0.275	0.058	0.243	0.04	0.139	0.169	0.125	0.144	0.127	0.146	0.126	0.105	0.113
Total Nitrogen	0.56	0.99	0.54	0.16	0.54	0.62	0.44	0.8	0.28	1.12	0.33	1.92	0.21	0.61	0.72	0.92	0.36	0.84	0.3	0.61
Phosphate	0.004	0.006	0.012	0.005	0.027	0.035	0.01	0.03	0.04	0.04	0.08	0.04	0.006	0.04	0.02	0.006	0.12	0.12	0.06	0.08
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	0.11	0.087	0.12	0.18	Nil	Nil	0.24	0.42	0.1	0.092	0.116	0.092	0.12	0.11	0.038	0.033	0.14	0.18	0.116	0.092
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.42	0.78	0.04	0.68	0.67	0.94	0.75	1.16	0.04	1.08	0.99	1.45	0.37	0.064	0.86	1.43	0.29	1.42	1.42	0.39
Lead	0.95	ND	ND	ND	ND	ND	0.76	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND	0.36
Zinc	0.01	0.02	0.03	0.04	0.01	0.02	0.02	0.02	0.01	0.007	0.004	0.011	0.008	0.01	0.08	0.01	0.02	0.01	0.01	0.02

Note : 1) All Parameters except pH are expressed as mg/L.
2) Mide Dep = Mid Depth.
3) ND = Not Detectable.

Table 23.4.6 Water Quality Monitoring Results

(Wet Season)

Sampling Date :6/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time :	10.15 A.M.		9.20 A.M.		10.45 A.M.		8.50 A.M.		11.55 A.M.		7.40 A.M.		11.45 A.M.		7.50 A.M.		11.30 A.M.		8.10 A.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid De	Surface	Mid Dep
pH	7.9	8	7.8	7.9	8.1	8.1	8.1	8.1	8.1	8.1	8	8	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Water Temprature –C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.1	5.7	6.1	6.9	6.9	6.1	6.9	6.5	6.1	5.3	6.1	6.1	6.1	6.1	6.1	6.1	6.4	5.7	6.1	6.1
B.O.D., 27–C. 3 days	3	8	8	8	11	9	12	11	6	14	15	14	7	9	8	7	12	11	6	13
Chemical Oxygen Demand	107	103	77	52	155	110	98	85	142	98	80	102	99	73	68	99	130	130	8	122
Total Suspended Solids	120	642	122	142	110	138	96	138	88	422	122	264	108	398	368	446	118	128	290	370
Oil & Grease (Ether Extractable)	56	56	24	22	42	40	32	86	32	26	26	18	26	24	16	26	52	42	38	74
Phenolic Compoundl	0.0002	0.0002	0.0001	0.0001	0.0005	0.0003	0.0001	0.0002	0.0003	0.0002	0.0004	0.0003	0.0003	0.0003	0.0006	0.0002	0.0002	0.0004	0.0004	0.0004
Total Amonical Nitrogen	0.102	0.151	0.113	0.271	0.212	0.201	0.132	0.261	0.019	0.031	0.029	0.027	0.186	0.153	0.205	0.192	0.03	0.161	0.03	0.026
Total Nitrogen	0.42	0.22	0.93	2.2	0.71	0.61	0.43	0.96	0.54	0.97	0.37	0.2	0.66	0.21	0.51	0.64	0.46	1.06	0.83	0.96
Phosphate	0.037	0.025	0.043	0.017	0.08	0.06	0.086	0.054	0.011	0.002	0.005	0.002	0.017	0.023	0.017	0.008	0.0028	0.002	0.025	0.002
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	0.014	0.004	Nil	0.004	Nil	Nil	Nil	0.005	0.004	Nil	0.004	0.004	Nil	0.009	Nil	0.004	0.004	Nil	Nil	0.009
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.37	0.77	0.314	0.76	0.82	1.36	1.43	1.46	0.03	1.49	1.08	1.35	0.61	1.46	0.75	0.82	1.45	0.51	0.84	0.68
Lead	ND	ND	1.24	ND	ND	ND	0.88	ND	ND	ND	ND	ND	1.6	ND	ND	ND	ND	ND	ND	ND
Zinc	0.01	0.02	0.03	0.04	0.02	0.02	0.02	0.02	0.008	0.01	0.002	0.01	0.007	0.008	0.01	0.01	0.021	0.014	0.01	0.01

Note : 1) All parameters except pH are expressed as mg/L.

2) Mid Dep = Mid Depth.

3) ND = Not Detectable.

Table 23.4.7 Water Quality Monitoring Results
(Wet Season)

Sampling Date :7/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	11.30 A.M.		10.00 A.M.		12.00 A.M.		9.30 A.M.		1.15 P.M.		8.15 A.M.		1.00 P.M.		8.30 A.M.		12.45 P.M.		8.45 A.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid De	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep
pH	8.1	8.1	8	8.1	8.2	8.2	8.1	8.1	8.2	8.2	8.1	8.1	8.2	8.2	8.1	8.1	8.2	8.2	8	8.1
Water Temperature −C	30	30	30	30	30	30	30	30	29	29	29	29	29	29	29	29	29	29	29	29
Dissolved Oxygen	5.8	5.7	5.8	5.9	5.7	5.6	5.8	5.8	5.8	5.8	5	5.8	5.6	5.5	5.4	5.7	5.6	5.6	5.6	4.8
B.O.D., 27−C. 3 days	7	16	5	5	16	15	18	10	5	5	5	12	6	5	8	5	5	4	9	9
Chemical Oxygen Demand	64	86	60	52	90	86	86	60	43	60	52	77	30	56	39	64	64	21	52	43
Total Suspended Solids	102	62	130	100	108	64	32	1184	86	398	116	246	118	130	318	408	116	98	280	298
Oil & Grease (Ether Extractable)	32	38	34	22	22	16	20	32	18	24	2	18	12	11	18	36	16	12	10	6
Phenolic Compoundl	0.0001	0.0001	0.0001	0.0001	0.0005	0.0004	0.0002	0.0002	0.0004	0.0002	0.0005	0.0004	0.0001	0.0002	0.0002	0.0001	0.0003	0.0003	0.0003	0.0005
Total Amonical Nitrogen	0.099	0.151	0.117	0.081	0.24	0.201	0.171	0.249	0.01	0.029	0.047	0.035	0.201	0.149	0.237	0.201	0.041	0.051	0.043	0.03
Total Nitrogen	0.2	0.2	0.34	1.61	0.12	0.3	0.36	1.21	0.19	0.08	0.58	0.72	0.36	1.22	0.85	1.04	0.23	0.1	0.43	0.72
Phosphate	0.145	0.142	0.071	0.066	0.1	0.05	0.071	0.037	0.037	0.04	0.025	0.005	0.017	0.008	0.122	0.18	0.077	0.08	0.017	0.008
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	0.033	Nil	0.043	Nil	0.634	Nil	0.348	0.196	0.43	0.087	0.072	Nil	Nil	0.0048	Nil	0.0048	0.058	0.033	0.087	0.043
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.41	0.35	0.31	0.52	1.07	0.55	0.607	0.357	0.35	0.98	0.88	1.27	1.11	0.85	0.76	1.45	1.45	0.51	0.84	0.68
Lead	ND	ND	ND	ND	ND	1.7	ND	ND	ND	ND	ND	1.68	ND	ND	ND	ND	ND	ND	ND	0.12
Zinc	0.012	0.022	0.038	0.042	0.026	0.022	0.024	0.024	0.014	0.008	0.013	0.03	0.082	0.074	0.014	0.03	0.012	0.018	0.016	0.024

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.8 Water Quality Monitoring Results
(Wet Season)

Sampling Date :8/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	12.45 P.M.		10.50 A.M.		1.00 P.M.		10.15 A.M.		2.30 P.M.		8.40 A.M.		2.15 P.M.		8.50 A.M.		2.00 P.M.		9.20 A.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid De	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid De	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep
pH	8	8.1	8.1	8.1	8.2	8.2	8.1	8.1	8.2	8.2	8.1	8.1	8.2	8.1	8.1	8.1	8.2	8.2	8.1	8.1
Water Temperature -C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.2	6	6	5.8	5.8	5.8	6	5.8	6.4	6.2	5.6	6.2	5	5.2	6.2	5.8	5.6	5.6	6	5.4
B.O.D., 27-C 3 days	5	4	14	8	4	14	8	8	4	5	16	6	13	10	12	6	16.2	14	12	22
Chemical Oxygen Demand	72	63	153	85	94	124	98	94	50	33	125	59	151	130	126	92	200	157	136	161
Total Suspended Solids	100	66	134	112	106	114	84	140	86	420	114	288	124	118	346	366	114	92	272	308
Oil & Grease (Ether Extractable)	30	20	36	42	20	24	42	60	16	14	14	4	56	30	48	40	64	14	54	30
Phenolic Compoundl	0.0001	0.0001	0.0001	0.0001	0.0005	0.0003	0.0001	0.0001	0.0004	0.0003	0.0005	0.0004	0.0001	0.0006	0.0002	0.0001	0.0004	0.0003	0.0003	0.0005
Total Amonical Nitrogen	0.111	0.045	0.153	0.169	0.291	0.119	0.54	0.24	0.015	0.025	0.028	0.031	0.171	0.17	0.271	0.191	0.133	0.049	0.035	0.028
Total Nitrogen	0.22	0.06	0.93	1.12	0.76	0.16	0.71	0.67	0.15	1.2	1.01	0.81	0.23	0.88	0.3	0.35	1.52	0.77	0.73	0.47
Phosphate	0.06	0.08	0.031	0.066	0.097	0.077	0.103	0.06	0.006	0.026	0.109	0.052	0.02	0.037	0.017	0.037	0.034	0.011	0.02	0.009
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	0.03	Nil	0.116	0.1	0.019	0.121	Nil	0.295	0.024	Nil	Nil	0.038	0.154	Nil	Nil	Nil	0.009	Nil	0.217	0.004
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.21	0.82	Nil	0.153	0.014	0.2	0.128	1.1	Nil	0.55	0.22	0.77	Nil	1.06	0.8	0.457	Nil	0.6	0.014	0.37
Lead	ND	0.99	ND	0.81	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	0.01	0.018	0.018	0.024	0.012	0.016	0.04	0.032	0.03	0.026	0.006	0.014	0.06	0.04	0.032	0.02	0.022	0.018	0.016	0.026

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.9 Water Quality Monitoring Results
(Dry Season)

Sampling Date :9/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	2.15 P.M.		11.00 A.M.		2.40 P.M.		10.20 A.M.		4.00 P.M.		9.00 A.M.		3.50 P.M.		9.20 A.M.		3.25 P.M.		9.40 A.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid De	Surface	Mid Dep
pH	8.2	8.2	8	8.1	8.2	8.2	8.1	8.1	8.2	8.2	8.1	8.1	8.2	8.2	8.1	8.1	8.2	8.2	8.2	8.2
Water Temperature -C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.8	6.4	6.4	6.2	6.6	6.4	6.5	6.4	6.8	6.4	6.7	6.4	6.8	6.4	6.4	6.2	6.6	6.4	6.6	6.4
B.O.D., 27-C. 3 days	3	4	4	4	4	4	3	5	4	3	4	4	4	3	3	4	3	4	4	4
Chemical Oxygen Demand	86	72	82	64	80	60	88	64	78	62	86	72	72	58	90	85	74	82	62	82
Total Suspended Solids	42	12.6	36	62	18	68	22	54	72	54	40	80	72	58	32	92	54	46	54	64
Oil & Grease (Ether Extractable)	24	22	26	22	18	40	16	28	20	34	28	26	22	38	30	32	24	22	30	32
Phenolic compound	0.0069	0.0005	0.0068	0.0027	0.005	0.0002	0.0006	0.0018	0.0165	0.0085	0.0088	0.001	0.0109	0.0059	0.0069	0.0066	0.002	0.0005	0.0172	0.01
Total Amonical Nitrogen	0.416	0.295	0.509	0.322	0.42	0.617	0.519	0.42	0.311	0.14	0.19	0.329	0.558	0.531	0.378	0.188	0.269	0.371	0.345	0.43
Total Nitrogen	0.64	0.37	0.68	0.84	0.67	1.12	0.88	1.66	0.55	0.32	0.22	0.61	0.73	0.69	0.75	0.21	0.32	0.39	0.43	0.43
Phosphate	0.026	0.023	0.003	0.011	0.02	0.034	0.028	0.026	0.017	0.014	0.023	0.017	0.023	0.031	0.017	0.028	0.011	0.017	0.031	Nil
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	Nil	0.106	0.019	0.004	0.033	0.034	0.077	0.077	0.038	0.03	0.053	0.058	0.048	0.029	0.174	0.125	0.2.3	0.024	0.203	0.13
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.98	1.135	0.48	0.78	0.1	1.07	0.396	0.378	0.257	0.84	0.435	1.121	0.086	0.902	0.264	0.871	0.435	0.8	0.514	0.957
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.68	0.59	ND	ND	0.77	ND	ND	ND
Zinc	Nil	0.0014	0.0014	Nil	Nil	0.0014	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.0014	0.0014	Nil	Nil	Nil	Nil	Nil

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.10 Water Quality Monitoring Results
(Dry Season)

Sampling Date :10/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	3.00 P.M.		2.0C P.M.		3.20 P.M.		1.20 P.M.		4.50 P.M.		12.00 Noon		4.40 P.M.		12.10 P.M.		4.25 P.M.		12.20 P.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	id De	Surface	id De	urfac	id De	Surfac	Mid Dep	Surface	Mid Dep	Surface	Mid Dep
pH	8.4	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.4	8.3	8.3	8.3	8.4	8.4	8.3	8.3	8.4	8.4	8.3	8.3
Water Temperature –C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.4	6.2	6.8	6.4	6.6	6.4	6.6	6.2	6.6	6.4	6.6	6.4	6.7	6.5	6.5	6.4	6.4	6.2	6.6	6.4
B.O.D., 27–C. 3 days	3	4	4	3	3	5	3	4	6	3	3	5	3	3	4	3	3	3	4	4
Chemical Oxygen Demand	80	58	75	100	86	72	86	82	78	86	68	74	80	66	92	88	71	60	58	60
Total Suspended Solids	56	106	42	68	22	66	24	64	68	54	66	92	84	64	40	108	66	44	60	72
Oil & Grease (Ether Extractable)	28	26	24	38	40	36	40	38	20	28	22	30	28	30	22	24	20	20	24	20
Phenolic compound	0.006	0.0042	0.0028	0.001	0.004	0.0002	0.0005	0.0003	0.0072	0.003	0.0044	0.003	0.012	0.006	0.007	0.0066	0.0042	0.0026	0.0044	0.0054
Total Amonical Nitrogen	0.12	0.345	0.295	0.188	0.277	0.219	0.2	0.293	0.357	0.3	0.338	0.435	0.253	0.332	0.289	0.153	0.3	0.361	0.1	0.144
Total Nitrogen	0.2	0.55	C.67	0.72	0.69	0.44	1.12	0.71	0.96	1.2	0.35	1.22	0.34	0.79	0.72	0.2	0.98	1.04	0.2	1.05
Phosphate	0.057	0.051	0.049	0.028	0.037	0.043	0.043	0.051	0.097	0.043	0.046	0.049	0.054	0.051	0.057	0.04	0.043	0.049	0.04	0.04
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	0.005	Nil	0.005	0.014	0.039	Nil	0.174	0.034	Nil	Nil	0.005	0.014	Nil	Nil	0.179	0.014	0.024	0.019	0.048	0.04
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.114	1.05	0.25	0.45	0.242	0.37	0.04	0.428	0.136	0.985	Nil	0.771	0.528	1.23	0.06	1.2	0.5	0.628	0.428	0.878
Lead	ND	0.82	ND	ND	ND	ND	ND	ND	ND	ND	0.89	ND	ND	0.68	ND	ND	0.84	ND	ND	ND
Zinc	0.0043	Nil	0.0024	0.0029	0.0019	0.0019	0.0034	0.0015	0.0014	0.003	0.0029	Nil	0.002	0.001	0.002	0.0014	0.0014	Nil	0.0014	0.0029

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.11 Water Quality Monitoring Results

(Dry Season)

Sampling Date :11/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	9.15 A.M.		11.00 A.M.		8.35 A.M.		11.20 A.M.		7.20 A.M.		1.40 P.M.		7.35 A.M.		12.15 P.M.		7.45 A.M.		12.00 Noon	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	urfac	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	id De	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep
pH	8.2	8	8.4	8.3	8.3	8.3	8.4	8.3	8.2	8.1	8.3	8.1	8.3	8.3	8.4	8.2	8.3	8.2	8.4	8.2
Water Temperature -C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.6	6.4	6.8	6.4	6.4	6.2	6.6	6.4	6.6	6.4	6.8	6.4	6.6	6.2	6.6	6.4	6.8	6.4	6.4	6
B.O.D., 27-C, 3 days	6	4	4	5	3	3	6	5	4	4	5	4	4	6	3	3	8	6	4	5
Chemical Oxygen Demand	84	76	82	66	68	60	90	82	88	60	78	80	85	76	86	63	82	70	90	82
Total Suspended Solids	60	72	54	112	46	74	42	36	36	56	44	104	52	92	74	90	54	88	94	102
Oil & Grease (Ether Extractable)	38	24	38	22	22	40	32	18	28	20	38	30	34	16	32	14	52	24	40	22
Phenolic compounds	0.0058	0.0035	0.0063	0.0023	0.0043	0.0006	0.001	0.0006	0.0073	0.0054	0.0079	0.0059	0.0111	0.006	0.0062	0.0042	0.0027	0.0005	0.0068	0.0011
Total Amonical Nitrogen	0.76	0.81	0.72	0.48	0.82	0.44	0.32	0.8	0.44	0.91	0.11	0.76	0.32	0.44	0.42	0.66	0.51	0.43	0.33	0.63
Total Nitrogen	1	1.25	0.91	0.72	1.52	0.86	0.58	0.85	0.64	1	0.2	0.85	0.85	0.64	0.64	0.91	1.1	0.64	0.85	0.96
Phosphate	0.02	0.011	0.002	0.014	0.014	0.022	0.008	0.017	0.02	0.02	0.011	0.014	0.014	0.014	0.022	0.055	0.034	0.025	0.022	0.031
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	Nil	Nil	Nil	0.03	0.034	0.019	Nil	0.014	Nil	Nil	0.014	Nil	0.024	Nil	Nil	0.01	0.019	0.019	0.019	0.009
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.36	0.34	0.6	Nil	0.23	0.77	0.26	0.52	0.37	1.87	0.1	1.28	0.25	0.52	0.2	0.78	0.18	1.14	0.114	0.9
Lead	ND	ND	1.1	ND	0.2	ND	ND	ND	ND	ND	ND	1.44	0.76	ND	0.78	ND	ND	ND	ND	ND
Zinc	Nil	0.0014	0.0014	0.0029	0.0029	Nil	Nil	0.0014	0.0014	0.0029	0.0029	0.002	0.005	0.002	0.0014	0.0014	0.0087	Nil	0.0058	0.0029

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.12 Water Quality Monitoring Results
(Dry Season)

Sampling Date :12/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	9.50 A.M.		12.00 Noon		9.15 A.M.		12.20 P.M.		7.50 A.M.		1.30 P.M.		8.10 A.M.		1.15 P.M.		8.30 A.M.		1.00 P.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	id De	Surface	Mid Dep
pH	8.3	8.1	8.5	8.2	8.2	8.1	8.4	8.2	8.1	8.1	8.4	8.3	8.3	8.2	8.5	8.2	8.3	8	8.4	0.83
Water Temperature ~C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.6	6.4	6.6	6.4	6.6	6.4	6.6	6.4	6.8	6.4	6.6	6.4	6.4	6.2	6.7	6.2	6.7	6.2	6.4	6.2
B.O.D., 27~C, 3 days	4	4	3	3	4	4	4	4	5	5	4	4	4	4	4	3	5	4	4	3
Chemical Oxygen Demand	80	87	74	62	51	94	92	58	60	58	94	90	80	78	86	80	84	82	57	77
Total Suspended Solids	82	132	58	92	42	112	62	40	40	60	54	66	72	120	56	96	88	76	86	124
Oil & Grease (Ether Extractable)	32	16	38	22	22	54	36	34	38	32	32	46	24	28	36	28	22	36	38	24
Phenolic compound	0.0054	0.0039	0.006	0.0046	0.0046	0.0009	0.005	0.0017	0.007	0.0049	0.0069	0.0057	0.0064	0.0051	0.0066	0.0058	0.0029	6E-04	0.0063	0.0035
Total Amonical Nitrogen	0.52	0.11	0.42	0.64	0.1	0.41	0.23	0.6	0.078	0.33	0.36	0.82	0.83	0.35	0.62	0.33	0.41	0.32	0.23	0.32
Total Nitrogen	0.94	0.52	0.98	1.05	0.45	3.2	0.4	0.98	0.2	0.88	0.86	1.2	2.1	0.55	1.1	3.9	0.84	1.2	0.52	0.75
Phosphate	0.074	0.086	0.043	0.051	0.017	0.04	0.037	0.025	0.165	0.046	0.131	0.108	0.025	0.017	0.02	0.02	0.2	0.046	0.04	0.11
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	0.135	0.053	Nil	0.068	0.169	0.8	0.096	0.174	0.043	0.048	0.024	0.068	0.126	0.145	0.135	0.15	0.043	0.019	0.038	0.058
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	Nil	0.057	Nil	0.22	0.007	Nil	Nil	Nil	Nil	Nil	Nil	0.22	Nil	0.15	Nil	0.57	Nil	Nil	Nil	Nil
Lead	0.86	ND	ND	1.15	ND	ND	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND	1.05	ND	ND	ND
Zinc	0.0029	0.0014	0.0014	0.0058	0.0029	0.0014	0.0029	Nil	0.0014	0.004	Nil	Nil	Nil	0.0014	0.0058	0.0029	0.0058	0.007	0.0014	Nil

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.13 Water Quality Monitoring Results
(Dry Season)

Sampling Date :13/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	10.10 A.M.		1.30 P.M.		9.35 A.M.		1.55 P.M.		8.25 A.M.		2.50 P.M.		8.35 A.M.		2.40 P.M.		8.50 A.M.		2.30 P.M.	
Parameters	Surface	Mid De	Surface	Mid De	Surface	Mid De	Surface	Mid Dep	Surface	Mid De	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep
pH	8.2	8.1	8.4	8.3	8.2	8.1	8.3	8.3	8.1	8.1	8.4	8.1	8.2	8.2	8.3	8.2	8.2	8.2	8.2	8.2
Water Temperature -C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.6	6.4	6.6	6.4	6.4	6.2	6.6	6.4	6.4	6.2	6.4	6.2	6.6	6.4	6.8	6.4	6.4	6.2	6.6	6.4
B.O.D., 27-C, 3 days	3.5	3	3.5	3	4	6	3	4	3	3	5	3.5	6	4.5	7	3	7	3.5	3	4
Chemical Oxygen Demand	87	84	46	74	76	60	88	97	38	64	82	84	60	56	78	92	83	90	92	58
Total Suspended Solids	78	80	76	68	66	74	46	42	54	98	74	104	36	80	110	68	66	82	98	128
Oil & Grease (Ether Extractable)	22	32	24	34	20	24	22	32	16	34	20	28	16	18	26	32	32	26	20	24
Phenolic compound	0.0071	0.0035	0.0077	0.0042	0.0054	0.0011	0.0068	0.0017	0.007	0.0043	0.0075	0.0052	0.0069	0.0045	0.0068	0.0059	0.0034	0.0009	0.0049	0.0025
Total Amonical Nitrogen	0.58	0.6	0.8	0.3	0.6	0.3	0.3	0.1	0.2	0.8	0.3	0.4	0.5	0.2	0.1	0.3	0.3	0.4	0.3	0.4
Total Nitrogen	0.58	0.67	1.2	1.6	1	0.62	0.35	0.82	0.56	2	0.83	2.88	1	0.8	0.4	1.02	0.8	0.9	0.8	1
Phosphate	0.028	0.017	0.0085	0.017	0.014	0.028	0.02	0.022	0.02	0.022	0.02	0.017	0.02	0.02	0.02	0.017	0.025	0.02	0.017	0.022
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	0.073	0.15	0.034	0.106	0.14	0.804	0.111	0.135	0.034	0.073	0.029	0.092	0.068	0.039	0.01	0.135	0.043	0.073	0.039	0.097
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.4	0.436	0.136	0.64	0.22	0.61	0.257	0.5	0.22	0.628	0.4	0.85	0.293	0.486	0.271	0.84	0.35	1.128	0.271	0.878
Lead	ND	ND	0.56	ND	0.48	ND	ND	ND	ND	1.18	0.74	0.88	ND	0.36	ND	0.87	ND	ND	ND	ND
Zinc	0.0029	0.004	0.0014	0.0029	0.0029	0.0015	0.0014	Nil	0.007	0.004	0.0029	Nil	0.0029	0.0014	0.0058	Nil	0.0058	0.004	Nil	Nil

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.14 Water Quality Monitoring Results
(Dry Season)

Sampling Date :14/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	11.30 A.M.		1.10 P.M.		10.50 A.M.		1.40 P.M.		9.40 A.M.		3.10 P.M.		9.50 A.M.		2.50 P.M.		10.05 A.M.		2.35 P.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep
pH	8.2	8.2	8.2	8.2	8.2	8.1	8.3	8.3	8	8	8.2	8.2	8.1	8.1	8.2	8.2	8.2	8.1	8.2	8.2
Water Temperature -C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.6	6.4	6.7	6.5	6.6	6.4	6.8	6.4	6.6	6.4	6.6	6.4	6.8	6.6	6.6	6.4	6.6	6.4	6.7	6.2
B.O.D., 27-C, 3 days	5.5	5	6.2	6	6	6	6	5	6	6	5.5	6	6	6	5	5	5	5.5	5	4
Chemical Oxygen Demand	86	67	83	46	82	85	93	76	42	42	68	76	80	79	90	88	92	59	75	79
Total Suspended Solids	60	72	72	58	36	38	18	32	44	64	56	38	52	28	24	28	108	80	38	62
Oil & Grease (Ether Extractable)	30	22	26	22	28	34	24	26	32	28	22	26	20	28	26	36	24	16	28	26
Phenolic compound	0.077	0.065	0.082	0.062	0.1514	0.0457	0.0714	0.0114	0.08	0.085	0.085	0.88	0.04	0.042	0.105	0.0542	0.77	0.77	0.088	0.045
Total Amonical Nitrogen	0.25	0.16	0.6	0.62	0.35	0.14	0.1	0.48	0.7	0.64	0.45	0.85	0.22	0.66	0.68	0.17	0.67	0.13	0.21	0.19
Total Nitrogen	0.45	0.36	1	0.82	0.55	0.3	0.2	0.8	1	0.98	0.75	1.05	0.52	1.05	0.98	0.25	0.86	0.25	0.32	0.25
Phosphate	0.077	0.065	0.082	0.062	0.151	0.0457	0.071	0.0114	0.08	0.085	0.085	0.082	0.04	0.042	0.105	0.054	0.077	0.077	0.088	0.045
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	Nil	Nil	Nil	0.005	0.007	Nil	0.019	0.024	Nil	Nil	0.013	0.013	Nil	0.005	Nil	0.013	0.019	Nil	Nil	0.005
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	0.893	1.31	0.736	0.53	0.843	1.457	1.2	0.643	0.964	1.44	0.6	1.31	0.871	1.121	1.35	1.321	0.621	0.85	1.707	1.421
Lead	ND	0.71	ND	ND	ND	0.75	ND	ND	ND	0.73	1.04	ND	0.74	ND	ND	ND	ND	ND	ND	0.96
Zinc	0.0014	Nil	0.0029	0.0014	0.0014	Nil	0.0029	0.0014	0.0058	0.0029	0.0058	0.0044	0.0014	Nil	0.0044	0.0029	0.0029	0.0014	0.0044	0.0029

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.15 Water Quality Monitoring Results
(Dry Season)

Sampling Date :15/10/97

Location :	WQ - 1				WQ - 2				WQ - 3				WQ - 4				WQ - 5			
	High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide	
Time	11.20 A.M.		12.30 P.M.		10.45 A.M.		12.50 P.M.		9.35 A.M.		2.10 P.M.		9.50 A.M.		1.50 P.M.		10.05 A.M.		1.30 P.M.	
Parameters	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep	Surface	Mid Dep
pH	8.1	8	8.1	8.1	8.1	8.1	8.1	8.1	8	8	8.1	8.1	8.1	8.1	8.1	8.1	8.2	8.2	8.1	8.1
Water Temperature –C	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dissolved Oxygen	6.6	6.4	6.6	6.2	6.7	6.4	6.6	6.4	6.4	6.2	6.6	6.4	6.7	6.2	6.5	6.4	6.8	6.2	6.6	6.4
B.O.D., 27–C, 3 days	6.2	6.3	5.5	5.3	6.5	6.5	6.3	6	6.5	4.9	6	6	6	6	5.3	6	5.5	6	6	6
Chemical Oxygen Demand	82	90	86	72	70	49	78	68	80	76	91	86	66	49	41	49	63	75	58	91
Total Suspended Solids	52	62	18	16	52	70	28	34	72	46	42	90	38	22	48	36	88	36	33	26
Oil & Grease (Ether Extractable)	21	24	32	24	26	12	19	22	38	32	40	32	22	28	28	20	22	26	24	28
Phenolic Compoundl	0.0064	0.0082	0.0044	0.0053	0.007	0.008	0.0034	0.0064	0.0056	0.0018	0.0018	0.0063	0.0062	0.0046	0.014	0.004	0.0064	0.0046	0.0026	0.0032
Total Amonical Nitrogen	1.2	0.36	0.8	0.11	0.36	0.86	0.46	0.34	0.4	0.42	0.1	0.43	0.16	0.31	0.29	0.98	0.12	0.12	0.2	0.54
Total Nitrogen	1.8	0.78	1	0.31	0.74	1.24	0.6	0.58	0.6	0.86	0.2	0.8	0.25	0.62	0.6	1.12	0.2	0.32	0.4	0.8
Phosphate	0.08	0.08	0.045	0.0514	0.02	0.034	0.031	0.02	0.148	0.034	0.0114	0.102	0.028	0.02	0.02	0.022	0.028	0.022	0.017	0.02
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	0.116	0.077	0.067	0.087	0.145	0.116	0.174	0.072	Nil	0.116	Nil	Nil	0.48	0.135	0.116	0.13	Nil	0.22	Nil	0.23
Chromium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	2.08	1.87	2.1	2.07	2.02	2.09	2.08	2	2.02	2.2	1.51	1.87	2.27	2.21	1.88	1.58	1.36	1.97	1.51	1.87
Lead	1.12	ND	ND	ND	ND	ND	1	ND	0.97	ND	1	1.2	1.42	ND	ND	ND	0.81	1.26	ND	ND
Zinc	0.0014	0.0029	0.0014	0.0029	0.0014	0.0014	0.0044	0.0029	0.0029	0.0044	0.0044	0.0029	0.0014	Nil	0.0029	0.0014	Nil	0.0014	0.0029	0.0029

Note : 1) All parameters except pH are expressed as mg/L.
2) Mid Dep = Mid Depth.
3) ND = Not Detectable

Table 23.4.16a Result of Sediment Analysis
Wet Season

Sr. No	Parameter	SQ-1	SQ-2	SQ-3	SQ-4	SQ-5
1	Particle Size Distribution					
	1) Clay %	35	40	40	45	30
	2) Silt %	40-45	45	45	35	55
	3) Fine Sand %	25-20	15	15	20	15
2	Ignition Loss (%)	71.86	71.37	76.84	69.76	73.23
3	Density (gm/ml)	1.019	1.090	1.207	1.173	1.023
4	Loss on Drying (%)	55.89	56.24	67.95	55.45	60.21
5	Chemical Oxygen Demand. (mg/g)	0.46	0.42	0.80	0.84	0.42
6	Cadmium (mg/g)	ND	ND	ND	ND	0.0108
7	Total Chromium	Nil	Nil	Nil	Nil	Nil
8	Lead (mg/g)	0.0147	0.16	ND	0.0126	0.0178
9	Mercury (mg/g)	Nil	Nil	Nil	Nil	Nil
10	Arsenic (mg/g)	ND	ND	ND	ND	ND

NOTE : ND = Not Detectable.

SQ : Sediment Quality Stations.

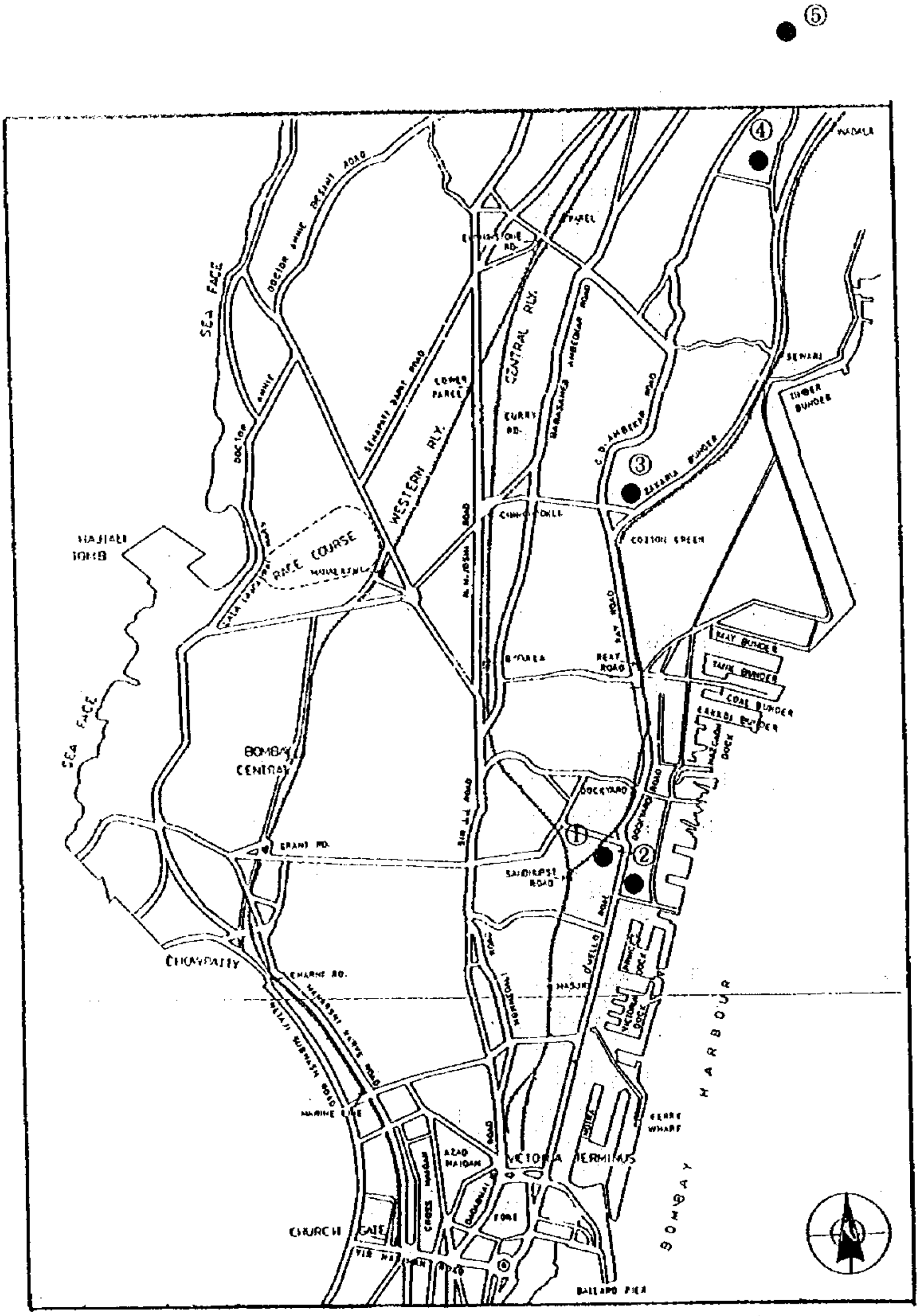
Table 23.4.16b Result of Sediment Analysis

Dry Season

Sr. No	Parameter	SQ-1	SQ-2	SQ-3	SQ-4	SQ-5
1	Particle Size Distribution 1) Clay % 2) Silt % 3) Fine Sand %	 25 35 40	 30 50 20	 35 35 30	 30 50 20	 55 25 20
2	Ignition Loss (%)	69.64	75.85	75.98	77.82	56.53
3	Density (gm/ml)	1.342	1.313	1.313	1.291	1.211
4	Loss on Drying (%)	50.27	54.33	58.17	60.75	30.29
5	Chemical Oxygen Demand. (mg/g)	0.47	0.44	0.82	0.85	0.43
6	Cadmium (mg/g)	ND	ND	0.0083	0.0076	ND
7	Total Chromium	Nil	Nil	Nil	Nil	Nil
8	Lead (mg/g)	0.0084	0.0094	0.0146	0.015	0.016
9	Mercury (mg/g)	Nil	Nil	Nil	Nil	Nil
10	Arsenic (mg/g)	ND	ND	ND	ND	ND

NOTE : ND = Not Detectable.

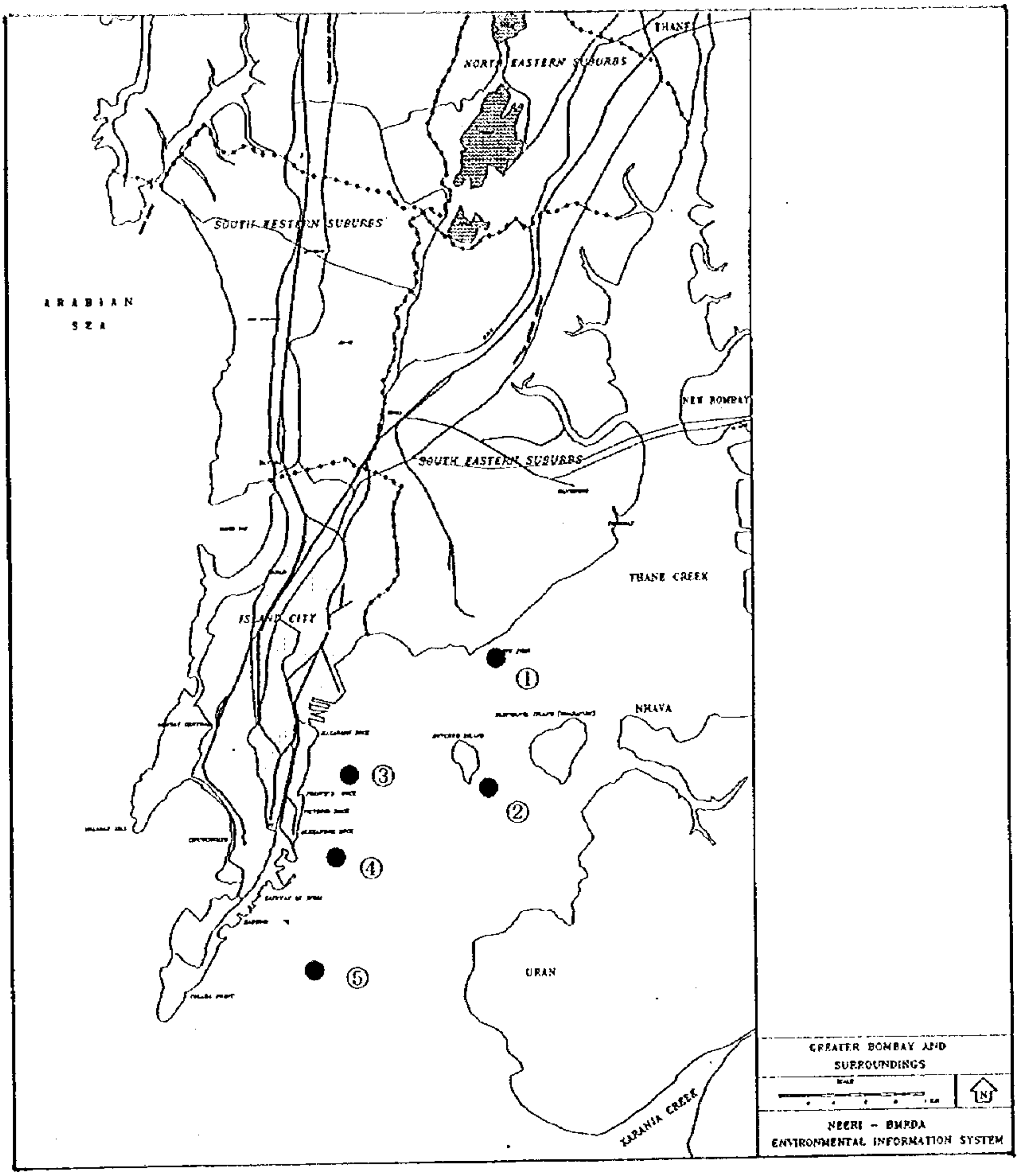
SQ : Sediment Quality Stations



● Air Quality Monitoring Stations (Tentative)

① D.Mello Road
② Link Road
③ Cotton Green Station
④ Wadala Fly Over
⑤ Eastern Express Way Chembur

Figure 23.4.1 Location Map of Environmental Monitoring Stations



① Trombay
② Butcher Island
③ Cross Island
④ Indira Dock
⑤ Naval Dock

Figure 23.4.2 Water and Sediment Quality Sampling Stations

23.5 Identification, Forecast and Assessment of Environmental Impacts

Major components of the Short-term Development Plan are 1) off-shore jetty-type container berths, 2) Victoria Dock Container Yard, 3) dedicate road for container traffic, and 4) Deepening both basin and approach channel.

Since off-shore jetty-type container berths and its access bridge are designed as water-through structure, no significant adverse effect is anticipated on tidal current. Victoria Dock Container Yard is planned to be built on reclaimed Victoria Dock. Since reclamation of the dock may not cause any significant adverse effect on open-sea. Dedicated road for container traffic will change traffic flow in and around MBP. All the port-related cargo traffic is assigned to container-dedicated road, Link Road and Anik-Everard Nagar Road up to Everard Nagar Junction without merging city traffic (see Figure 17.3.2). Reduction of the port-related cargo traffic is anticipated on P D'Mello Road, Cotton Green and Wadala Flyover, while an increase of the port-related traffic is anticipated on Link Road and Anik-Everard Nagar Road. Therefore, vehicle emission along those points will be further studied in the following Section. Since heavy metals of Cd and Hg, and Arsenic were not detected in the bottom sediments during the field survey, handling of dredged materials does not pose a potential impact from heavy metals.

23.5.1 Vehicle Emission

(1) General

Since the total volume of containers and conventional cargo to be handled at MBP for the year 2007 based on the Short-term Development Plan will generates additional port-related vehicle traffic, a certain degree of air quality, noise and vibration is to be anticipated especially along the roads adjacent to MBP. Port-related cargo traffic flow is forecast and presented in Section 17.3. All the port-related cargo traffic is forecast and assigned to container-dedicated road, Link Road and Anik-Everard Nagar Road up to Everard Nagar Junction without merging city traffic.

In and around Mumbai port, field survey was conducted to study the baseline vehicular traffic for forecasting the increase in air quality loads and estimated changes in the future traffic volume due to the implementation of the Short-term Development Plan for MBPT.

(2) Selection of Sampling Points

As discussed in section 23.4.1, following sampling points were selected for carrying out the traffic survey.

Location -1	:	P.D.' Mello Road
Location -2	:	Link Road
Location -3	:	Cotton Green
Location -4	:	Wadala Flyover
Location -5	:	Chembur (Everard Nagar Junction)

Above mentioned sampling locations have been depicted in Figure 23.4.1.

(3) Methodology

The traffic survey was done continuously for 24 hours on a holiday and a weekday during wet and dry season. The traffic volume count was conducted at the same locations where the air quality, noise level and vibration survey were carried out. At each location, enumerators were stationed for counting the city as well as port bound traffic. The vehicle count were undertaken on the both sides of road. For conducting the survey, the traffic was divided in 7 categories viz Trucks & tankers, containers, tempos, cars & taxies, 3 wheelers, 2 wheelers and buses.

(4) Results and Discussion

1) Traffic Survey

Vehiclewise total traffic flow for each location is presented in Table 23.5.1(a) and (b) for wet and dry season respectively. Average and forecasted vehicle wise traffic volume are presented in Table 23.5.2. Weekday traffic flow characteristics for wet and dry season are shown in Figure 23.5.1 and 23.5.2 respectively.

Data pertaining to the traffic volume survey indicate the following:

- Total traffic volume for working day is more than the traffic for holiday.
- Maximum traffic consists of trucks and tankers followed by car and taxis and then by container traffic.
- Three wheeler and bus traffic are not observed at location 2 (link road).

- Highest traffic count is found at location 5 (Chamber Pryadarshini) while the lowest is observed at location 2 (Link Road).
- Truck and tankers and container traffic is high and consistently heavy due to port oriented origin and destination

During the survey, it is observed that the traffic is heavy throughout the day except at mid night for 4 hours.

2) Air Quality Prediction

Existing ambient air quality in and around Mumbai port has been studied in Section 23.4.1 and the maximum concentration obtained during the field investigations is presented in Table 23.5.3. Increase in the air quality loads due to implementation of the Short-term Developmental Plan is briefly described in the following paragraphs:

The major source of emission of different air pollutants due to traffic are as follows:

- Types of vehicles i.e. heavy vehicles, commercial vehicles, 3 wheelers, 2 wheelers etc.
- Age and type of vehicles and maintenance of vehicle
- Type of fuel used and combustion efficiency
- Traffic speeds and flow characteristics (congestion factor)

The emission factor used for computing the concentration of air pollutants are given in Table 23.5.4. (Source : Prevention and Pollution Control, (Status of Auto Exhaust Pollution in Bombay and its Abatement Options, By NEERI))

The emission rate of various air pollutants due to the projected traffic are given in Table 23.5.5 for both year 2007. Increase in concentration of the air pollutants due to projected traffic has been computed using double Gaussion diffusion expression and are presented in Table 23.5.6 for the year 2007. Methodology adopted for predicting the concentration of various pollutants is given in Annexure A- 8.5.

The concentrations of air pollutants have been computed by adding the increase in concentrations to maximum baseline concentrations of the pollutants. The predicted concentrations of parameters such as SPM, SO_2 and NO_x is given Table 23.5.7. It is seen from the Table 23.5.7 that the concentrations of SO_2 and NO_x will remain far below the limit (80μg/m^3) stipulated by CPCB. Further it is also seen that that the emission of SPM due to the increase in port bound traffic will be insignificant. However, baseline SPM is found to be exceeding the limit (200 $\mu g/m^3$) prescribed by CPCB.

23.6 Environmental Protection Measures

23.6.1 Reclamation Work of Victoria Dock

Soil quantity required for reclamation of Victoria Dock is estimated as 1.3 million cu. meters. In case of reclamation with soft bottom materials dredged by pump, the reasonable spillage treatment method suitable for the effluent and environmental conditions must be adopted. It may be one of the effective ways to promote settling of suspended solids by providing baffle walls in the reclamation pond. Reclamation of Victoria Dock, however, such hydraulic transportation of the filling-in materials is not desirable and economical from a viewpoint of spillage treatment.

At the first stage of reclamation works, the filling-in solids will be carried in by hopper barges and dumped directly into the basin, as the barges can enter the basin through the existing dock gate. After construction of closing structure at the place of the existing dock gate, filling-in materials will be unloaded through Victoria Dock harbour walls and conversely by bulldozers. The following countermeasures shall be considered when designing the reclamation method.

1) During the period of dumping solids by hopper barges, a line of movable flexible curtain type turbidity diffusion protector shall be installed around the entrance of the dock gate.
2) At the final stage of dumping solids, hopper barges with shallow water depth shall be selected to promote reclamation works.
3) When the water depth becomes too shallow for dumping the solids directly, the existing dock gate shall be closed with a suitable structure. After construction of the walls there, one waste way shall be provided at a seaside corner of the dock.
4) Lower the water level in the dock as low as possible to reduce the volume of spillage to be treated.
5) To reclaim the basin from the seaside toward land side to secure enough distance to an outlet gate.
6) To provide a flexible curtain type turdibity diffusion protector around the outlet gate.

23.6.2 Dredging Work of both Basin and Approach Channel

Drag suction dredger generally performs overflow dredging, that is, muddy water overflow through the weir of her hopper during dredging in order to increase dredged soils in the hopper. This overflow of muddy water causes diffusion of turbidity over the dredged area widely. The most simple and reliable method to prevent such disadvantages is to stop loading mixture in the hopper at the overflow level of the hopper. The more active preventive method for this purpose is to improve the mechanism of overflow and separate air bubbles from the overflow mixture. This system is called anti-turbidity overflow system and employed in Japanese drag suction dredgers.

It is difficult to prevent turbidity during grab dredging. However, a flexible curtain type turbidity protector is provided in these days around the excavation area, particularly in front of the bow of the grab dredgers. Such kind of protector installed from the water surface level to near the seabed is effective for reduction of diffusion of turbidity.

At the time of designing the protector, tidal current at the site, maintenance of the protector and anchoring system, and additional time required for shifting the protector in accordance with movement of dredging area shall be considered.

23.7 Conclusions of Environmental Impact Assessment

Initial Environmental Examination (IEE) is carried out based on the checklist of adverse effects of the Master Plan and the following points are screened.

1) Dredging sediments
2) Disturbance due to dredging
3) Air quality due to the future traffic in and around MBP

Those matters are further studied.

Concerning dredging, since heavy metals of Cd and Hg, and Arsenic were not detected in the bottom sediments during the field survey, handling of dredged materials does not pose a potential impact from heavy metals. A flexible curtain type turbidity protector is recommended to be provided around the excavation area for grab dredging so as to minimize the impact on the ambient marine environment.

Concerning ambient air quality, no significant increase of SO_2 and NO_X are found and SO_2 and NO_X remains far below the tolerance limit (80 μ g/m^3) at selected five points along the roads in and around MBP for the year 2007. No significant increases of SPM are also found at those points for the year 2007, while the baseline concentration of SPM is exceeding the tolerance limit (200 μ g/m^3).

These impacts which can be controlled within acceptable levels, consequently there are no environmental reasons against the project proceeding of the Short-term Development Plan.

Table 23.5.1a Total Traffic Flows (Wet Season)

Type of Vehicle	LOCATION - 1 P D'Mello Road		LOCATION - 2 Link Road		LOCATION - 3 Cotton green		LOCATION - 4 Wadala		LOCATION - 5 Priyadarshani - Chembur	
	Working Day	Holiday	Working Day	Holiday	Working Day	Holiday	Working Day	Holiday	Working Day	Holiday
Trucks & Tankers	11895	9405	3101	1187	8605	6157	5901	2928	24742	13331
Containers	2673	1062	6062	4137	839	622	2131	1337	3280	2252
Tempos	6419	2955	34	9	2427	1718	1143	462	9892	7037
Cars + Taxis	12286	7333	5850	4161	6429	5870	10123	7479	25365	15139
3 wheelers	738	345	-	-	17	53	235	220	11174	9128
2 wheelers	6362	3361	5166	2975	4038	2971	4241	3458	10980	9632
Buses	1128	989	-	1	10	30	1344	1182	12842	10364
Total	41501	25450	20213	12470	22365	17421	25118	17066	98275	66883

Table 23.5.1b Total Traffic Flows (Dry Season)

Type of Vehicle	LOCATION - 1 P D'Mello Road		LOCATION - 2 Link Road		LOCATION - 3 Cotton green		LOCATION - 4 Wadala		LOCATION - 5 Priyadarshani - Chembur	
	Working Day	Holiday	Working Day	Holiday	Working Day	Holiday	Working Day	Holiday	Working Day	Holiday
Trucks & Tankers	11337	5899	1026	527	14317	8757	14855	4789	20651	12086
Containers	1640	1292	3733	2751	1093	1198	7824	2795	3336	1997
Tempos	2986	2161	64	7	4127	3059	2637	802	7247	5092
Cars + Taxis	7754	4488	4694	1021	14818	9342	17757	11422	27483	25757
3 Wheelers	449	169	-	-	292	97	563	401	10492	11972
2 Wheelers	4593	3052	2563	870	4742	3729	9357	4739	8545	10180
Buses	685	760	7	3	94	69	2213	1549	11698	9813
Total	29444	17821	12087	5179	39483	26251	55206	26497	89452	76897

Table 23.5.2 Projected Traffic Volume in 2007

Location	Types of Vehicles	Wet Season 29/9/97	Dry Season 15/10/97	Average	Forecasted Traffic Year 2007 Peak	Total Traffic in 2007
		Two-Directional One day Traffic (vehicles / d)				
1	Trucks & Tankers	11,895	11,337	11,616	0	0
	Containers	2,673	1,640	2,157	0	0
	Tempos	6,419	2,986	4,703	-	4,703
	Cars & Taxis	12,286	7,754	10,020	-	10,020
	3 wheelers	738	449	594	-	594
	2 wheelers	6,362	4,593	5,478	-	5,478
	Buses	1,128	685	907	-	907
	Total	41,501	29,444	35,473	-	21,700
2	Trucks & Tankers	3,101	1,026	2,064	8,056	8,056
	Containers	6,062	3,733	4,898	7,950	7,950
	Tempos	34	64	49	-	49
	Cars & Taxis	5,850	4,694	5,272	-	5,272
	3 wheelers	-	-	-	-	-
	2 wheelers	5,166	2.563	3,865	-	3,865
	Buses	-	7	4	-	4
	Total	20,213	12,087	16,150	-	25,195
3	Trucks & Tankers	8,605	14,317	11,461	0	0
	Containers	839	1,093	966	0	0
	Tempos	2,427	4,127	3,277	-	3,277
	Cars & Taxi	6,429	14,818	10,624	-	10,624
	3 wheelers	17	292	155	-	155
	2 wheelers	4,038	4,742	4,390	-	4,390
	Buses	10	94	52	-	52
	Total	22,365	39,483	30,924	-	18,497
4	Trucks & Tankers	5,901	14,855	10,378	0	0
	Containers	2,131	7,824	4,978	0	0
	Tempos	1,143	2,637	1,890	-	1,890
	Cars & Taxis	10,123	17,757	13,940	-	13,940
	3 wheelers	-	563	282	-	282
	2 wheelers	4,241	9,357	6,799	-	6,799
	Buses	1,344	2,213	1,779	-	1,779
	Total	24,883	55,206	40,045	-	24,689
5	Trucks & Tankers	24,742	20,651	22,697	15,598	15,598
	Containers	3,280	3,386	3,333	3,774	3,774
	Tempos	9,892	7,247	8,570	-	8,570
	Cars & Taxis	25,365	27,483	26,424	-	26,424
	3 wheelers	11,174	10,492	10,833	-	10,833
	2 wheelers	10,980	8,545	9,763	-	9,763
	Buses	12,842	11,698	12,270	-	12,270
	Total	98,275	89,502	93,889	-	87,231

Table 23.5.3 Maximum Baseline Concentration of Air Pollutants

Location	SPM	SO2	NOx	CO
AQ-1	577	53	32.5	ND
AQ-2	365.4	36.1	17.4	ND
AQ-3	1112	64.2	31.7	ND
AQ-4	739	49.3	30.9	ND
AQ-5	842	51.2	32.5	ND

Note: Units are expressed in $\mu g/m^3$

Table 23.5.4 Emission Factors for Different Vehicles (g/km)

Vehicle Type	CO	HC	NOx	SO2	TSP
Two vehicles	8.3	5.18	-	0.013	-
Car	24.03	3.57	1.57	0.053	-
Three wheelers	12.25	7.65		0.029	-
Buses	4.51	1.75	8.52	1.48	0.28
Trucks	3.52	1.36	6.66	1.16	0.22

Table 23.5.5 Emission Rates of Pollutants due to Projected Traffic

Location	Types of Vehicles	Year 2007 Emission Rate Kg/d per Km			
		SPM	SO_2	NO_x	CO
1	Trucks&Tankers	3.21	16.92	97.17	51.36
	Containers	0.48	2.5	14.37	7.6
	Tempos	1.03	5.5	31.32	16.55
	Cars & Taxis	0	0.53	15.73	35.27
	3 wheelers	0	0.02	0	14.27
	2 wheelers	0	0.07	0	45.46
	Buses	0.26	1.34	7.73	4.1
	Total	3.95	26.88	166.32	174.61
2	Trucks & Tankers	1.74	9.81	52.73	27.87
	Containers	3.06	16.14	92.69	48.99
	Tempos	0.01	0.06	0.33	0.17
	Cars & Taxis	0	0.28	8.28	126.69
	3 wheelers	0	0	0	0
	2 wheelers	0	0.05	0	32.08
	Buses	0	0	0.03	0.02
	Total	4.81	26.34	154.06	235.82
3	Trucks & Tankers	2.52	13.29	76.33	40.34
	Containers	0.21	1.12	6.43	3.4
	Tempos	0.72	3.8	21.82	11.54
	Cars & Taxi	0	0.56	16.68	255.29
	3 wheelers	0	0	0	1.89
	2 wheelers	0	0.06	0	1.29
	Buses	0.02	0.08	0.44	0.23
	Total	3.47	18.91	121.7	313.98
4	Trucks & Tankers	3.64	19.17	110.04	58.16
	Containers	1.82	7.55	43.36	22.92
	Tempos	0.42	2.19	12.59	6.65
	Cars & Taxis	0	0.74	21.89	334.98
	3 wheelers	0	0.01	0	4.89
	2 wheelers	0	0.09	0	56.43
	Buses	0.5	2.63	15.16	8.02
	Total	6.38	32.38	203.04	492.05
5	Trucks & Tankers	4.99	26.32	151.16	79.89
	Containers	1.97	10.4	56.69	31.55
	Tempos	1.88	9.94	57.08	30.16
	Cars & Taxis	0	1.4	41.49	634.97
	3 wheelers	0	0	0.31	132.7
	2 wheelers	0	0.01	0	81.03
	Buses	3.44	18.16	104.54	55.34
	Total	12.88	66.23	411.27	1045.64

Table 23.5.6 Increment in Concentration of Pollutants at 500 m Distance

(Year 2007)

Location	Stability Condition A				Stability Condition E			
	SPM	SO2	NOX	CO	SPM	SO2	NOX	CO
1	0.01	0.09	0.53	0.55	0.40	2.88	17.00	17.83
2	0.02	0.08	0.49	0.75	0.49	2.63	15.74	24.09
3	0.01	0.06	0.39	1.00	0.35	1.93	12.43	32.08
4	0.02	0.10	0.64	1.57	0.65	3.31	20.74	50.27
5	0.04	0.21	1.32	3.33	1.25	6.77	42.32	106.82

Units : All values are expressed in ƒÊg/m'

Table 23.5.7 Projected Concentration of Air Pollutants

(Year 2007)

Location	Stability Condition A				Stability Condition B			
	SPM	SO2	NOX	CO	SPM	SO2	NOX	CO
1	577.012	53.09	33.03	0.55	577.4	55.88	49.5	17.83
2	365.415	36.18	17.89	0.75	365.89	38.73	33.14	24.09
3	1112.01	64.26	32.09	1	1112.35	66.13	44.13	32.08
4	739.02	49.4	31.54	1.57	739.65	52.61	51.64	50.27
5	842.039	51.41	33.82	3.33	843.25	57.97	74.82	106.82

Units : All values are expressed in ƒÊg/m'

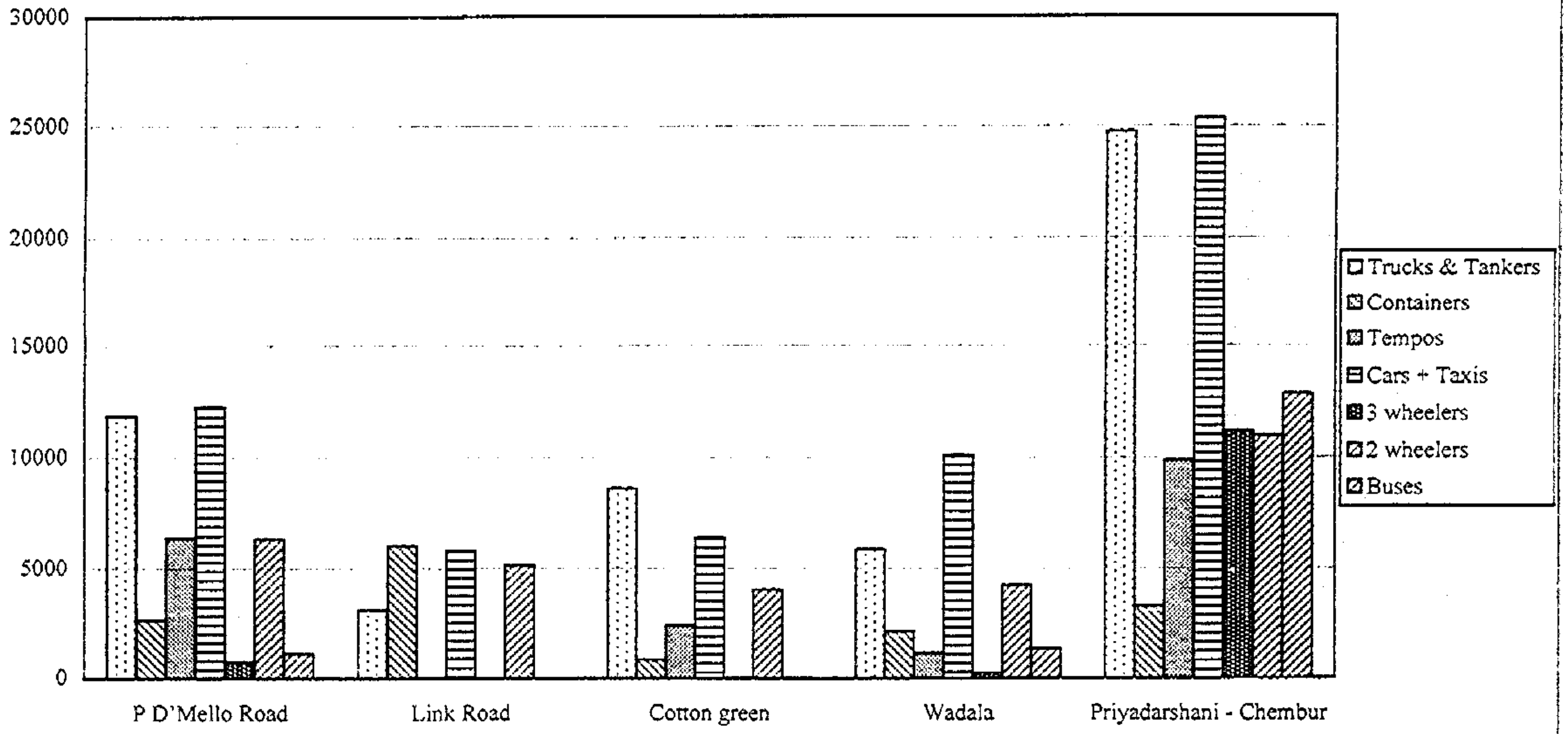


Figure 23.5.1
Traffic Flow Characteristics Week Day (Wet Season)

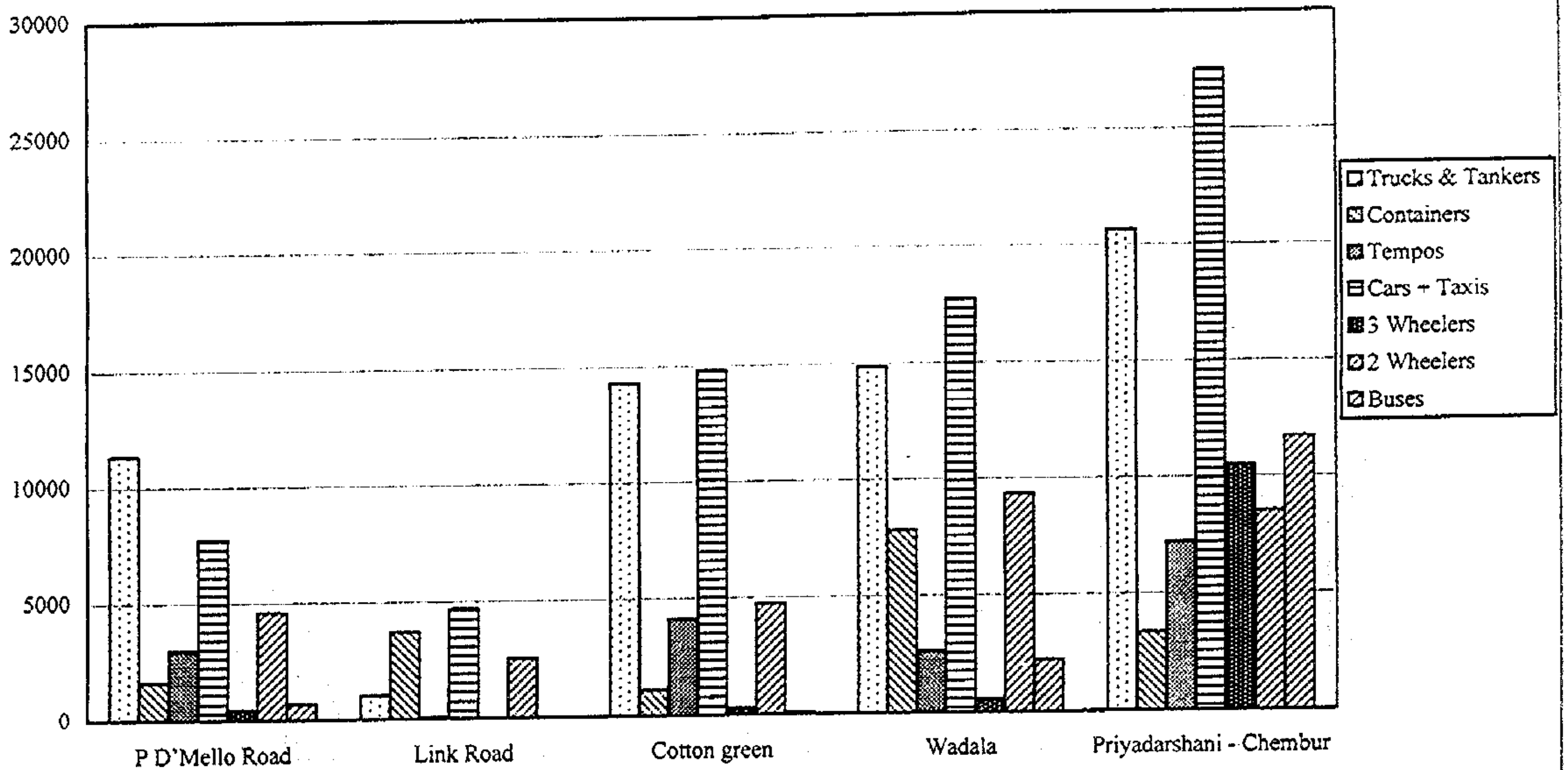


Figure 23.5.2
Traffic Flow Characteristics Week Day (Dry Season)

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Necessity of Development of the Port of Mumbai

The Port of Mumbai (MBP) is the largest port in India in traffic volume and serve a wide hinterland, conspicuous in handling containers and petroleum.

1. The Port of Mumbai(MBP), administrated and managed by MBPT has been the largest port in India in terms of cargo volume handled. In 1995/96, MBP handled cargo of 34.0 million tons (16% of the total volume through the major ports in India) including container cargo of 6.7 million tons (518,000 TEUs, 40% of the total containers through the major ports), break-bulk/dry bulk cargoes of 5.7 million tons and 21.0 million tons of petroleum (22% of the total petroleum through the major ports) contributing to the economic activities in its hinterland, covering not only the Mumbai Metropolis composed of Greater Mumbai and New Mumbai and the remaining areas of Maharashtra State but also the west India including Gujarat State and the north India including the states of Delhi, Haryana and Punjab.

Since the last major development which dates back to the early 1970s except for the construction of marine oil jetties, the volume of cargo passing through MBP has increased continuously along with the economic growth of India, and that has resulted in serious port congestion.

2. The major berths which accommodate sea-going vessels at present are placed inside the docks of Indira, Victoria and Prince's connected with the open sea through lock gates or pairs of miter gates and at Ballard Pier facing the open sea. The construction of these facilities dates back to the 1870s - 1910s. Indira Dock and Ballarad Pier were extended in the 1970s, which represented the last major development of the port apart from the installation of the marine oil terminals at Butcher Island and Pir Pau. Since the last major development in the 1970s, the volume of cargo passing through the port has increased continuously along with the economic growth of India, and that resulted in serious port congestion.

The Port of Jawaharlal Nehru (JNP) was constructed at Sheva Island in the Mumbai harbour and opened in 1989 as a deep-sea port specialized for handling containers and dry bulk cargo so as to receive overflowed cargo from the congested MBP.

3. To meet both the ever-increasing port demand and the requirement of deep sea berths to accommodate large-sized container vessels for direct shipping services or dry bulk carriers, the construction of new port facilities was proposed, and eventually, the construction of a new port at Sheva Island was decided upon (extension plan of MBP was another option). MBP is situated close to the densely-populated urban areas of Mumbai City (Greater Mumbai) and has a constraint of space limitation for extension on land, and it was considered that the depth of the surface of hard materials under the sea bed in front of the docks was insufficient in elevation for economical deepening by dredging in the light of the technical level at that time. The new port was named as Jawaharlal Nehru (JNP) and was opened in 1989. JNP has been developed as a port specialized for handling containers and dry bulk cargo which has berths of 13.5m deep, spacious yards and equipment designed for above-mentioned specific cargoes.

Even after the opening of JNP to where a considerable volume of dry cargo shifted from congested MBP, the volume of cargo handled at MBP showed a continuous and steady increase in dry cargo containing containers, break-bulk and bulk cargoes ,resulting in port congestion getting more serious year by year.

4. Even after the opening of JNP to which a considerable volume of dry cargo shifted from congested MBP as mentioned above, the volume of cargo handled at MBP located in Mumbai City with a population of around 12 million as a commercial and industrial center in India, however, showed a continuous and steady increase from 8.9 to 11.5 million tons in dry cargo containing containers, break-bulk and bulk cargoes from 1989/90 to1995/96. This represent an average growth rate of 4.3% per annum. The number of containers passing through MBP in the same period increased from 309,000 to 518,000 TEUs showing a high average growth rate of. 9.0% per annuin. Thus, port congestion has been getting more serious year by year in MBP as evidenced by an excessively-long berth waiting time of 4.5 days per calling vessel on average in 1995/96. Even container vessels, which are generally operated to provide regular

services, are often forced to wait for berthing off-shore; average berth waiting time of 2.5 days per vessel was recorded in the same year.

It is necessary to develop MBP to resolve the present problems and to meet increasing demand for the port.

5. Thus, to resolve the present problems and meet increasing demand for the port in the foreseeable future, development of MBP is necessary. To survive in the competitive atmosphere of today's international shipping and port business, major investment and improved business practices on the part of private sectors are required.

(1) Handling of Container

Water depths along the existing container berths are insufficient at MBP.

6. Since the major container berths at MBP are located inside the docks of Indira, Victoria and prince's connected with the open sea through the lock gates, maximum water depth of those berths is only 9.8m, which can accommodate relatively small container vessels in the recent growing trend of container vessel size. Large container vessels provide a relatively low transportation cost especially on long distance routes such as India-Europe, India-East Asia and India-East Coast of America compared with medium-sized or small-sized container vessels. On the other hand, even on short distance routes such as India-the Middle East, India-Southeast Asia, India-East Coast of Africa and India-South Asia where containers are transported mainly by feeder services, feeder vessel size has shown an increasing trend. Thus, deeper container berths are required so as to reduce transportation costs to/from the trade partners of India without distinction of route distances.

There is a shortage of container-handling equipment, especially in quay-side container gantry cranes, contributing to low-container-handling productivity alongside.

7. As to container-handling machines, two quay-side container gantry cranes are installed only at

Balllard Pier and at the remaining container berths, Indira Nos.1-5, ship's gears are used to lift containers alongside. The shortage of quay-side container gantry cranes is a reason of low-container-handling productivity alongside. The average productivity at Indira Nos.1-5 is only 3.2 boxes per hour per gang in 1995/96, whereas 11.6 boxes per hour per gang was achieved at the container berth of Ballard Pier in the same year. On the container marshaling yard allocated behind the Bllarad Pier berth, three RTGs (Rubber-Tired Gantry) are installed, and on the remaining container yards inside the docks, reach-stackers are mainly used. Although reach-stackers are conveniently used in narrow space, they need more maneuvering space compared with other yard machines such as RTGs and straddle cranes, and therefore container stacking capacity is less.

<u>The modern container terminal operation system is not yet introduced into MBP, resulting in excessively-low container-handling productivity and consequent long berthing times</u>

8. At present, nobody controls the whole container-handling operations comprising stevedoring, hauling and stacking of containers without adopting the modern container operation system wholly controlled by a terminal operator that takes full responsibility for handling and storing containers after receipt or before delivery at the gate (referred to as "the closed terminal operation system"). Thus, container-handling operations alongside are done in chaotic conditions, resulting in excessively-low container-handling productivity and consequent long berthing times and long berth-waiting times.

<u>Intricate on-chassis container traffic is found within the dock area due to scattered container stacking yards designated transporter-wise.</u>

9. Within the dock area, the use of container stacking yards are permitted to shipping agents/lines by each operation, but actually designated and fixed in transporter-wise. Currently, over ten transporters are in operations and hence not so spacious "container parks" inside the docks are further divided into small yards and scattered inside the docks. In some container-handling operations alongside, transporter-wise designated container yards are not necessarily allocated adjacent to the operation site alongside, and hence on-chassis containers are hauled intricately

to the respective container yards by individual transporters within the narrow dock area.

It is necessary to allocate one million TEU containers per annum to MBP from the stage of the Short-Term Plan taking account of adequate functional allotment between MBP and JNP determined from various factors including potential capacity of container-handling, hinterlands and transport costs from the standpoint of the national economy.

10. To handle a large amount of containers through the two ports, MBP and JNP in the future, the amount needs to be allocated to MBP and JNP adequately considering various factors including potential capacity of container-handling, hinterlands and transport costs from the standpoint of the national economy. As to potential capacity in container-handling, the capacity of MBP is estimated to be approximately one million TEUs in the condition of preparing a new container terminal with a container marshaling yard prepared by converting the existing dock facilities without creating additional land off the docks and with jetty-typed off-shore berths connected to the marshaling yard by a bridge.

11. Currently, approximately one third of the total container cargoes through MBP and JNP originates from or is destined to Mumbai City. In case of short shipping distance routes as defined above where the container traffic volume accounts for approximately 50% of the total container traffic through the two ports at present, economical feeder vessel size is estimated to be in the range of 1,500 - 2,000 TEUs in lading capacity which could be received by MBP given the implementation of the proposed development. Hence, there is no difference in sea transport cost for containers on the short distance routes between MBP and JNP, and the total transport cost through JNP is higher than through MBP by land transport cost between JNP and Mumbai City. On the other hand, if water depths of JNP's container berths are kept intact, the maximum permissible limit to vessel drafts at MBP is the same as at JNP and the total transport cost through JNP is higher than through MBP by land transport cost between JNP and Mumbai City. In case when deeper berths are constructed at JNP and post-panamax typed vessels of 4,500 TEUs in loading capacity call at JNP, sea transport cost reduction exceeds the land transport cost between JNP and Mumbai City. In this case, however, costs for deepening the main channel from the present level and subsequent maintenance dredging must

be burdened to deploy post-panamax typed vessels, resulting no decisive difference between the total container transport costs through MBP and through JNP.

12. To reduce the detour transport of containers originating from or destined to Mumbai City through JNP by land, it is necessary to receive such containers at MBP as much as possible for the purpose of avoiding excessive road traffic congestion and consequent air and noise pollution caused by intricate hauling of container cargoes. In addition, not only in environmental but also in economical point of view as mentioned above, it is justified to make the most of MBP in container-handling. Currently, the hinterland of MBP in container transport widely covers not only Mumbai City but the areas of remaining Maharashtra State and the other states in the west and the north India, and in the future, the demand for container-handling at MBP is expected to be continuously generated from the latter areas, especially on the short distance routes showing no decisive difference between the sea transport costs through MBP and through JNP.

13. Although potential needs for handling container at MBP in the future is very large, one million TEU containers out of the total demand of 2.6 million TEUs in 2007 and 5.9 million TEUs in 2017 at MBP and JNP, are allocated to MBP due to its capacity limitation.

It is necessary to establish a full-scale new container terminal with deep berths and container-handling capacity of one million TEUs per annum at MBP by 2007.

14. Thus, to resolve the present problems mentioned above, meet a continuously increasing demand in container-handling and achieve economical container transport from the standpoint of the national economy, it is necessary to establish a full-scale new container terminal with deep berths and container-handling capacity of one million TEUs per annum at MBP by 2007.

(2) Handling of Conventional Cargo

In conventional cargo handling, adequate berth allocation appropriate to individual cargo package types is not done.

15. In conventional cargo handling in Indira, Victoria and Prince's Docks,, adequate berth allocation appropriate to individual cargo package types is not done, resulting in chaotic cargo-handling.

Conventional cargo is handled inefficiently and at the risk of cargo damage due to shortage of equipment, machines and slings appropriate to individual operations.

16. In loading/discharging bagged cargo such as rice and oil cakes onto/from vessels by ship gears, net slings are used at the risk of bag damage and subsequent cargo spill. In handling break-bulk cargo of other package types, net slings are also used at the same risk mentioned above. In handling long or/and heavy cargo such as coils, pipes and plates of steel products on dock-side, the shortage of forklift trucks is found in number and lifting capacity. In addition, attachments of forklift trucks designed to lift specified cargo efficiently and safely are not sufficiently prepared. In discharging dry bulk cargo such as phosphate rocks, sulfur and food-grains from vessels using ship cranes with grabs, hoppers placed alongside are used and their valves are not well maintained, resulting in cargo spill after trucks leave from hoppers.

It is necessary to improve conventional cargo handling operations by allocating specific berths by cargo type, viz. bag, dry bulk and long/heavy material, and preparing cargo-handling equipment, machines and slings appropriate to individual operations.

17. Thus, to resolve the present problems mentioned above, it is necessary to improve conventional cargo handling operations by allocating specific berths by cargo type, viz. bag, dry bulk and long/heavy material, and preparing cargo-handling equipment, machines and slings appropriate to individual operations.

18. The volume of conventional cargo is not expected to increase vigorously in the future, due to the anticipated shift of conventional cargo to container cargo through the progress of containerization. Given the construction of off-shore container berths, the existing berths inside the docks will be utilized exclusively for conventional cargoes.

(3) Handling of Petroleum

The shortage of the discharging capacity of the existing pipelines connected to the JD Nos.1-3 oil jetties is a bottleneck in handling petroleum, resulting in excessively long berth waiting times of tankers. The high increase in the volume of refined petroleum handled at MBP aggravates the congestion.

19. The shortage of the discharge capacity of pipelines connecting the Jawaharlal Dweep (JD) oil jetties Nos.1-3 at Butcher Island and the refineries at Trombay is a present bottleneck in discharging and loading petroleum through the jetties, resulting in excessively long berth waiting times of petroleum tankers, 5.2 days per vessel on average in 1995/96. These pipelines were designed to meet the original refinement capacity of 3.5 million tons per annum and have been left without replacement even after the expansion of refinement capacity up to 12 million tons per annum. The high increase in the volume of refined petroleum whose handling needs much longer berthing times than that of crude petroleum aggravates the congestion.

20. MBPT is proceeding with a project to replace the existing pipelines of 12 - 24 inches in diameter by larger-sized pipelines of 30-42 inches along with the renovation of discharging/loading facilities at the JD Nos.1-3 jetties (referred to as "the pipeline replacement project"). The project will be completed by the year 2003. It is said that additional storage tanks for petroleum could be installed on reserved land within the compound of the above refineries if required.

(4) Landed Estate of MBPT

Despite the effort of eviction of land which fell out of use or was no longer used for port-related activities for the recovery of port-related use and growing needs for more land for off-dock container depots, considerable portion of land is still left in non-port-related use.

21. The total area of landed estate under MBPT's control is about 753 ha most of which was created by reclamation from 1873 to 1907 and the part of land outside the docks was leased to private sectors on a long-term basis and was used for depots of port cargo such as raw cotton, grains, coal, timbers in log and manganese ore or sites for port-related manufacturers which imported raw materials or exported finished goods through MBP. Since then, the composition of port cargo commodity and package styles has changed drastically reflecting the progress of industrialization in India and the subsequent increase in containerized cargo. The dramatic progress of containerization in international shipping has accelerated the containerization at MBP.

22. To cope with the dramatic progress of containerization, MBPT has converted some areas under its control outside the docks which fell out of use or were no longer used for port-related activities into off-dock container depots after evicting the land from the former lessees. Despite such efforts and growing needs for more land for off-dock container depots, considerable portion of the landed estate of MBPT is still left in non-port-related use.

It is necessary to continue the effort of eviction of the leased land within the landed estate of MBPT so as to meet growing needs for more land for off-dock container depots to backup dockside operations done within limited space.

23. Thus, it is necessary to continue the effort of eviction of the leases land within the landed estate of MBPT so as to meet growing needs for more land for off-dock container depots, viz. container storage yards and CFS sites, to backup dockside operations done within limited space.

(5) Traffic within Landed Estate of MBPT

Presently, there is serious congestion in road traffic within the landed estate of MBPT and merging points with city roads due to insufficient port roads.

24. Presently, there is serious congestion in road traffic within the landed estate of MBPT and

merging points with city roads due to insufficient port roads. Though the traffic of tractor-trailer units for containers is partly separated from that of ordinary trucks by dedicated container roads, there is no fly-over and no elevated road, inducing congestion at plain cross sections. Within the landed estate of MBPT, city common roads run along the dock fences, and ordinary trucks are forced to use these roads together with city traffic in chaotic conditions to access dock areas. In addition, port roads merge with city roads at urban areas, causing congestion there. Presently, a new road with eight lanes which starts at the north end of the landed estate of MBPT and merges with the city road at Everard Nagar at the north outskirts of Mumbai City is being developed. From the merging point, the road is near the Eastern and Western Express Highways in the direction of the northern and eastern states and will be usable for port traffic.

It is necessary to improve the existing port roads so as to haul port cargoes smoothly within the port..

25. It is necessary to improve the existing port roads so as to haul port cargoes smoothly within the port.

(6) Main Channel

A project to deepen the main channel ("the main channel deepening project") is envisaged so as to save ship costs for waiting for high tide or reduce sea transport costs by deploying larger vessels such as post-panamax typed container vessels and crude petroleum tankers with deep draft.

26. The controlled water depths of Main Channel including Jawaharlal Nehru Channel extending from the entrance to JNP are in the range of 10.8 - 11m below CD. The deep-water berths, viz. JD No.4 oil jetty (14.3m) and JNP berths (13.5m) are located along and the end of the channel,, respectively. Within the channel, sedimentation occurs and therefore these water depths are maintained by maintenance dredging implemented from time to time. When a vessel with a deep draft approaches to or departs from these deep-water berths, she uses high

such situation, a project to deepen the main channel is envisaged so as to save ship costs for waiting for high tide or reduce sea transport costs by deploying larger vessels such as post-panamax typed container vessels and crude petroleum tankers with deep draft.

2. Master Plan (Target Year: 2017)

(1) Handling of Container

It is proposed to establish a full-scale new container terminal with off-shore jetties with a water depth of 13.5m at MBP, which can accommodate container vessels of the third generation in the range of 2,500 – 3,000 TEU lading capacity.

27. In the target year of the Master Plan, 2017, one million TEU of containers is planned to be allocated to MBP. To handle the allocated containers, it is proposed to establish a full-scale new container terminal with off-shore jetties with a deep water depth of 13.5m, which can accommodate container vessels of the third generation in the range of 2,500 – 3,000 TEU capacity.

It is proposed to introduce a closed terminal operation system in the planned container terminal.

28. It is proposed to introduce a closed terminal operation system in which a container terminal is wholly controlled by a terminal operator who takes the full responsibility of receipt, storage and delivery of containers at the terminal by conducting yard planning for container stacking and inventory control of containers within the terminal. This type of system is indispensable for a modernized container terminal.

It is proposed to deepen the existing access channel to Indira Dock to 11.0m to receive larger container vessels to approach the off-shore jetties of the proposed new container terminal.

29. It is proposed to deepen the existing access channel to Indira Dock from the present level to

receive larger container vessels to approach the off-shore jetties of the proposed new container terminal. The water depth of the deepened channel is proposed as 11.0m below CD based on dredging costs and benefits generated from reduction of ship waiting for high tide.

It is proposed to prepare additional off-dock container depots to be placed within the landed estate of MBPT by evicting the leased lands which are no longer used for port-related activities within its estate.

30. It is proposed to prepare additional off-dock container depots to be placed within the landed estate of MBPT to back up the container-handling operations at the proposed new container terminal to be operated within a limited space. For this purpose, it is necessary to evict the leased lands which are no longer used for port-related activities within its estate.

(2) Handling of Conventional Cargo

It is considered that the forecast volume of conventional cargo excluding petroleum to be handled at MBP will be able to be handled by using the existing dock berths even in the stage of the Master Plan

31. In the year 2017, the volume of conventional cargo excluding petroleum to be handled at MBP is estimated as 7.92 million tons (6.08 million in import and 1.84 million tons in export). It is considered that the forecast volume of conventional cargo will be able to be handled by using the existing dock berths even in the stage of the Master Plan.

(3) Handling of Petroleum

It is considered that the forecast volume of petroleum and liquid chemical products will be able to be handled at the existing marine oil jetties even in the stage of the Master Plan by the completion of the pipeline replacement project under progress.

32. In the year 2017, the volume of petroleum comprising crude oil and refined oil to be handled

at marine oil terminals at MBP is estimated as 36.50 million tons with 18.89 million of crude oil and 17.61 million tons of refined oil. In addition to these petroleum oils, liquid chemical products of 386,000 tons will be handled at the New Pir Pau Jetty together with refined oil in the same year. It is considered that the forecast volume of petroleum and liquid chemical products will be able to be handled at the existing marine oil jetties even in the stage of the Master Plan by the completion of the pipeline replacement project under progress by MBPT.

(4) Traffic within Landed Estate of MBPT

It is proposed to prepare a new dedicated container road with a fly-over bridge connecting the proposed new container terminal and off-dock container depots. It is also proposed to prepare a dedicated ordinary truck road along the existing dock fences by converting the existing dedicated container road so as to enable ordinary trucks to have an access to the dock gates without using the congested common roads.

33. It is proposed to prepare a new dedicated container road with a fly-over bridge connecting the proposed new container terminal to be placed within the existing dock area and off-dock container depots within the landed estate of MBPT. It is also proposed to prepare a dedicated ordinary truck road along the existing dock fences by converting the existing dedicated container road so as to enable ordinary trucks to have an access to the dock gates without using the congested common roads.

(5) Main Channel

It is proposed to deepen the existing main channel to 12m below CD to attract post-panamax typed container vessels to JNP.

34. Main channel deepening project is essential to attract post-panamax-typed mainline container vessels to JNP. The economic viability of the project and the optimum water depth were accessed from the comparison of costs comprising capital and maintenance dredging and benefits estimated by taking account of various factors including forecast cargo volume and

predicted tidal fluctuation. According to the assessment, it is considered that the main beneficiary is container transport through JNP by using post-panamax typed container vessels rather than crude petroleum transport through JD No.4 jetty. It must be noted that the viability of the project depends on whether a large amount of containers will be handled at JNP, and therefore the project seems to become viable from the stage of the Master Plan. The water depth of the channel is proposed to be deepened to 12m below CD which is considered to be an economical water depth based on dredging costs and benefits generated from reduction of sea transport costs by using larger vessels.

(6) Project Cost

35. The total project cost of the Master Plan is roughly estimated as 23.9 billion Rs.

(7) Initial Environmental Examination

As Initial Environmental Examination (IEE) is carried out, dredging sediments within planned area, disturbance due to dredging and air pollution due to the future port-related traffic are selected and should be included in the Environmental Impact Assessment (EIA) for the Short-term Plan.

36. As Initial Environmental Examination (IEE) is carried out, three points of 1) dredging sediments within planned area, 2) disturbance due to dredging, and 3) air pollution due to the future port-related traffic in and around MBP are selected and should be included in the Environmental Impact Assessment (EIA) for the Short-term Plan.

(8) Management, Operations and Institutional Matters

It is proposed that the new container terminal should be wholly controlled by a terminal operator to achieve efficient operation.

37. It is proposed that the new container terminal should be wholly controlled by a terminal

operator. The terminal operator should take the full responsibility of receipt, storage and delivery of the containers at the terminal. The terminal operator should supervise the overall container handling operation at the terminal by conducting yard planning and inventory control of containers. As for the organization of the terminal operator, the followings are considered:

- one department of MBPT
- establishing a new organization that is financially independent of MBPT
- private sector as a lessee of the terminal facility and cargo handling equipment

The terminal operator needs to have the necessary number of personnel to handle containers efficiently and to manage the organization efficiently. It is necessary to select and transfer highly motivated workers or staff of MBPT on condition that trade unions of MBP agree. The terminal operator needs to invite foreign experts to assist in on-the-job training for terminal employees. It is necessary to raise the wage rate or allowance as incentives if workers gain skill and expertise through the training and consequently improve the efficiency of container handling. In the long run, it is necessary to consider the establishment of joint ventures with foreign companies for further improvement of the operation and management if private sector involvement develops in the port.

(9) Potential Capacity for Container Handling Capacity at MBP

MBP could have the total container handling capacity of 2 million TEUs and more per annum.

38. In the Master Plan proposed in this study, the capacity of the proposed container terminal is estimated as one million TEUs per annum on the assumption that the existing facilities at the Indira Dock will be converted into a new container marshaling yard by filling the dock waters. However, the potential demand for handling containers at MBP would become much higher than that in the future. Hence, due to the space constraint, there would still be a large gap between the demand and the capacity for container handling at MBP, even after the creation of

the proposed new container terminal

39. However, the total container handling capacity of MBP could be increased to 2 million TEUs and more in the condition of constructing additional off-shore berths next to the berths proposed in the Master Plan., converting the existing facilities at Prince's Dock into another container marshaling yard. The second phase container terminal project at the Prince's Dock, so to speak, has a great advantage because the access channel, the connection bridge and the dedicated container road to be prepared in the first phase project would be usable as common infra-structures. The timing of the start of the second phase container terminal project needs be carefully determined after confirming satisfactory progress of the first phase project. In this meaning, the second phase container terminal project would be started beyond the target year of the Master Plan, 2017, and excluded in the Master Plan.

40. In this study, containers of one million TEUs are allocated to MBP, and the remaining volume is allocated to JNP out of the total demand for container handling on the assumption that JNPT has a sufficient potential container handling capacity to compensate for the conservative allocation to MBP. However, it must be noted that JNP's container handling capacity is not limitless. According to the conceptual plan made by JNPT, the total container handling capacity per annum does not seem to exceed 4 million TEUs. In this view, the possibility of starting the second phase project at MBP before 2017 should not be completely ruled out.

Ficilities	Unit	Alternative-6
1.Existing Container Berth		
1.Number of Berths		1
2.Berth Depth	(m)	-9.8
3.Berth Length	(m)	244
4.Berth Location		BPS
2.Proposed Container Berth		
1.Number of Berths		3
2.Berth Depth	(m)	-11 to -13.5
3.Berth Length	(m)	250 to 300
4.Berth Location		800 m off HW
3.Container Marshaling Yard	(G.slots)	3,446
1.Existing Yard	(G.slots)	516
2.Proposed Yard	(G.slots)	2,930
1.ID-1	(G.slots)	0
2.ID-2 to 5	(G.slots)	0
3.ID-HW	(G.slots)	0
4.Victoria Dock	(G.slots)	2,930
5.CDW	(G.slots)	0
6.TPS	(G.slots)	0
7.CRS	(G.slots)	0
4.Empty Container Yard	(G.slots)	3,341
1.Existing Yard	(G.slots)	0
2.Proposed Yard	(G.slots)	3,154
1.ID-1	(G.slots)	240
2.Victoria Dock	(G.slots)	802
3.CDW	(G.slots)	972
4.TPS	(G.slots)	1,140
5.CRS	(G.slots)	0
3.Shortage of Yard	(G.slots)	187
5.Container Freight Station	(sq.m)	67,687
1.Existing CFS	(sq.m)	48,487
2.Proposed CFS	(sq.m)	19,200
CDW	(sq.m)	19,200
6. Dedicated Road for Containers		
1. No. of Lanes	(lanes)	4
2. Ground Length	(m)	1,000
3. Elevated Length	(m)	700

Figure 1 Master Plan for Development of the Port of Mumbai

Container Berth		
800 m off ID-HW		
No.	Length	Depth
3 Berths	250 m to 300 m	-11.0m to -13.5m

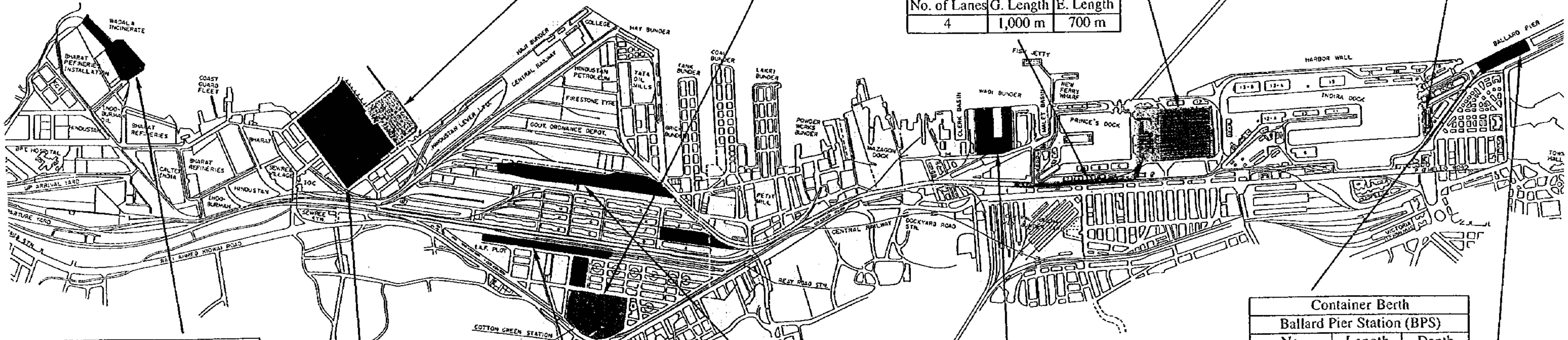
Cotton Depot West (CDW)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
0	972	19,200

Victoria Dock Container Yard		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
2,930	802	-

Indira Dock No.1 (ID-1)	
Empty Container Yard	
240	(G.Slots)

Timber Pond South (TPS)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
0	1,140	-

Dedicated Road for Containers		
No. of Lanes	G. Length	E. Length
4	1,000 m	700 m



Wadala Area (WA)	
Container Freight Station(CFS)	
2,890	(sq.m)

Frere Basin (FB)	
Container Freight Station(CFS)	
10,336	(sq.m)

Container Berth		
Ballard Pier Station (BPS)		
No.	Length	Depth
1 Berth	244 m	-9.8 m

Timber Pond (TP)	
Container Freight Station(CFS)	
14,020	(sq.m)

Cotton Depot (COD)	
Container Freight Station(CFS)	
11,003	(sq.m)

Manganese Ore Depot(MOD)	
Container Freight Station(CFS)	
10,238	(sq.m)

Ballard Pier Station (BPS)	
Marshaling Yard	
516	(G.Slots)

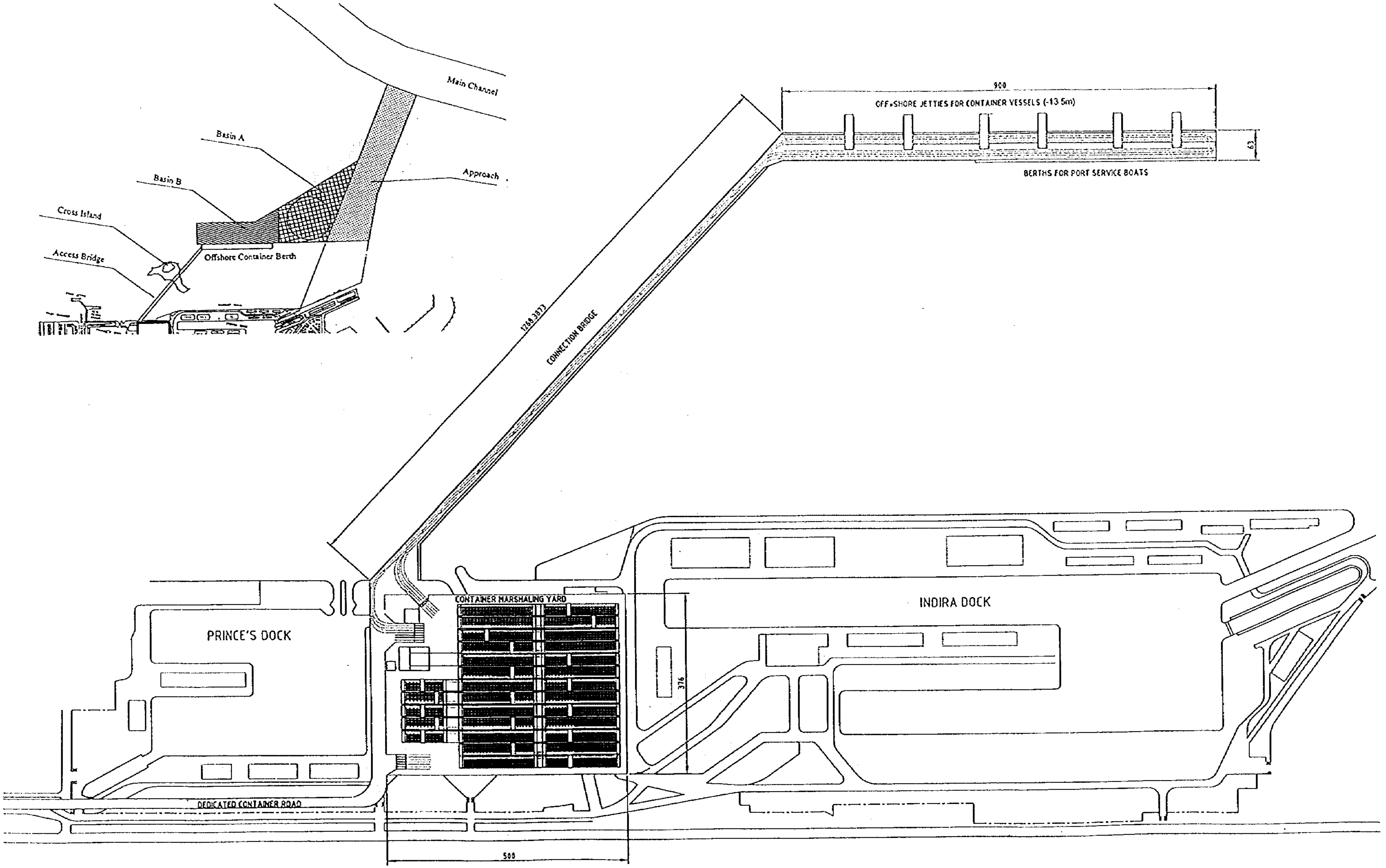


Figure 2 Layout of Master Plan for Container Handling

3. Short-Term Plan (Target Year: 2007)

(1) Handling of Container

It is proposed to establish a full-scale new container terminal with off-shore jetties with a deep water depth of 13.5m at MBP.

41. In the target year of the Short-Term Plan, 2007, one million TEUs of containers are allocated to MBP. To handle the allocated containers, it is proposed to establish a full-scale new container terminal with off-shore jetties with a deep water depth of 13.5m at MBP.

It is proposed to introduce a closed terminal operation system in the planned container terminal.

42. It is proposed to introduce a closed terminal operation system in which a container terminal is wholly controlled by a terminal operator that who the full responsibility of receipt, storage and delivery of containers at the terminal.

It is proposed to deepen the existing access channel to Indira Dock to 11.0m to receive larger container vessels approaching the proposed off-shore jetties.

43. It is proposed to deepen the existing access channel to Indira Dock to 11.0m to receive larger container vessels approaching the proposed off-shore jetties.

It is proposed to prepare additional off-dock container depots as back-up facilities to be placed within the landed estate of MBPT by evicting the leased lands which are no longer used for port-related activities within its estate.

44. It is proposed to prepare additional off-dock container depots as back-up facilities to be placed within the landed estate of MBPT to back up the container-handling operations at the proposed new container terminal to be operated within a limited space. For this purpose, it is

necessary to evict the leased lands which are no longer used for port-related activities within its estate.

(2) Handling of Conventional Cargo

It is considered that the forecast volume of conventional cargo excluding petroleum to be handled at MBP will be able to be handled by using the existing dock berths in the stage of the Short-Term Plan

45. In the year 2007, the volume of conventional cargo excluding petroleum to be handled at MBP is estimated as 6.25 million tons with 4.65 million in import and 1.60 million tons in export. It is considered that the forecast volume of conventional cargo will be able to be handled by using the existing dock berths

(3) Handling of Petroleum

It is considered that the forecast volume of petroleum and liquid chemical products will be able to be handled at the existing marine oil jetties in the stage of the Short-Term Plan by the completion of the pipeline replacement project under progress.

46. In the year 2007, the volume of petroleum comprising crude oil and refined oil to be handled at marine oil terminals at MBP is estimated as 28.68 million tons with 18.89 million of crude oil and 9.79 million tons of refined oil. In addition to these petroleum oils, liquid chemical products of 200,000 tons will be handled at the New Pir Pau Jetty together with refined oil at the same year. It is considered that the forecast volume of petroleum and liquid chemical products will be able to be handled at the existing marine oil jetties in the stage of the Short-Term Plan by the completion of the pipeline replacement project under progress by MBPT.

(4) Traffic within Landed Estate of MBPT

It is proposed to prepare a new dedicated container road with a fly-over bridge connecting the proposed new container terminal and off-dock container depots It is also proposed to prepare a dedicated ordinary truck road along the existing dock fences by converting the existing dedicated container road.

47. It is proposed to prepare a new dedicated container road with a fly-over bridge connecting the proposed new container terminal and off-dock container depots as back-up facilities. It is also proposed to prepare a dedicated ordinary truck road along the existing dock fences by converting the existing dedicated container road.

(5) Construction Cost

48. The total construction cost of the Short-Term Plan is estimated as20.0 billion Rs.

(6) Economic Analysis

The proposed project with the EIRR of 16.9% is considered to be economically justifiable.

49. A comparison between the "Without-Project" case and the "With-Project" case was carried out to evaluate the feasibility of the project for construction of a new container terminal including deepening of the access channel, preparation of off-dock container depots and construction of a new dedicated container road with a fly-over bridge at MBP proposed in the Short-Term Plan from the viewpoint of the national economy of India. The main economic benefits of the project are savings on sea transport costs for containers through MBP, port staying and off-shore waiting costs of container vessels calling at the port generated from the project. The resulting economic rate of return (EIRR) of the project is estimated as 16.9%, exceeding the general criterion to assess the economic justifiability.

(7) Financial Analysis

The proposed project with the FIRR of 10.2% is considered to be financially feasible.

50. The financial revenues are generated from port charges based on the tariff proposed to cover capital investment and operational costs by referring to the current tariff level and that of the neighboring port. The resulting financial rate of return (FIRR) of the project is estimated as 10.2 % which exceeds the weighted average interest rates of assumed fund raising plans and hence the project is considered to be financially feasible.

(8) Environmental Consideration

As Environmental Impact Assessment (EIA) was conducted concerning items selected through Initial Environmental Examination (IEE), there are no environmental reasons against the project proceeding of the Short-term Development Project.

51. Environmental Impact Assessment (EIA) was conducted. Since heavy metals of Cd and Hg, and Arsenic were not detected in the bottom sediments within the planned area during the field survey. It is possible to control environmental impact of dredging on ambient marine environment within an insignificant range by using a flexible curtain type turbidity protector around the excavation area for grab dredging. Concerning ambient air quality, no significant increase of SO_2 and NO_X are forecast, while SO_2 and NO_X currently remain far below the tolerance limit (80 $\mu g/m^3$) in and around MBP for the year 2007. No significant increase of SPM are also forecast for the year 2007, while the baseline concentration of SPM is exceeding the tolerance limit (200 $\mu g/m^3$). Consequently, there are no environmental reasons against the project proceeding of the Short-term Development Project.

(9) Management, Operations and Institutional Matters

It is proposed that the new container terminal should be wholly controlled by a terminal operator to achieve efficient operation.

52. It is proposed that the new container terminal should be wholly controlled by a full-fledged terminal operator. The terminal operator should take the full responsibility of receipt, storage and delivery of the containers at the terminal. The terminal operator should supervise the

overall container handling operation at the terminal by conducting yard planning and inventory control of containers. As for the organization of the terminal operator, the followings are considered.

- one department of MBPT
- establishing a new organization that is financially independent of MBPT
- private sector as a lessee of the terminal facility and cargo handling equipment

The terminal operator needs to have the necessary number of personnel to handle containers efficiently and to manage the organization efficiently.

It is proposed to transfer some part of workers or staff to the new organization from MBPT.

53. As for the recruitment of the new organization, it is necessary to select and transfer highly motivated workers or staff to the new organization from MBPT on condition that the trade unions of MBP agree. The new organization needs to invite foreign experts to assist in on-the-job training for terminal employees.

Ficilities	Unit	Alternative-6
1.Existing Container Berth		
1.Number of Berths		1
2.Berth Depth	(m)	-9.8
3.Berth Length	(m)	244
4.Berth Location		BPS
2.Proposed Container Berth		
1.Number of Berths		3
2.Berth Depth	(m)	-11 to -13.5
3.Berth Length	(m)	250 to 300
4.Berth Location		800 m off HW
3.Container Marshaling Yard	(G.slots)	3,446
1.Existing Yard	(G.slots)	516
2.Proposed Yard	(G.slots)	2,930
1.ID-1	(G.slots)	0
2.ID-2 to 5	(G.slots)	0
3.ID-HW	(G.slots)	0
4.Victoria Dock	(G.slots)	2,930
5.CDW	(G.slots)	0
6.TPS	(G.slots)	0
7.CRS	(G.slots)	0
4.Empty Container Yard	(G.slots)	3,341
1.Existing Yard	(G.slots)	0
2.Proposed Yard	(G.slots)	3,154
1.ID-1	(G.slots)	240
2.Victoria Dock	(G.slots)	802
3.CDW	(G.slots)	972
4.TPS	(G.slots)	1,140
5.CRS	(G.slots)	0
3.Shortage of Yard	(G.slots)	187
5.Container Freight Station	(sq.m)	67,687
1.Existing CFS	(sq.m)	48,487
2.Proposed CFS	(sq.m)	19,200
CDW	(sq.m)	19,200
6. Dedicated Road for Containers		
1. No. of Lanes	(lanes)	4
2. Ground Length	(m)	1,000
3. Elevated Length	(m)	700

Figure 3 Short-Term Plan for Development of the Port of Mumbai

Container Berth		
800 m off ID-HW		
No.	Length	Depth
3 Berths	250 m to 300 m	-11.0m to -13.5m

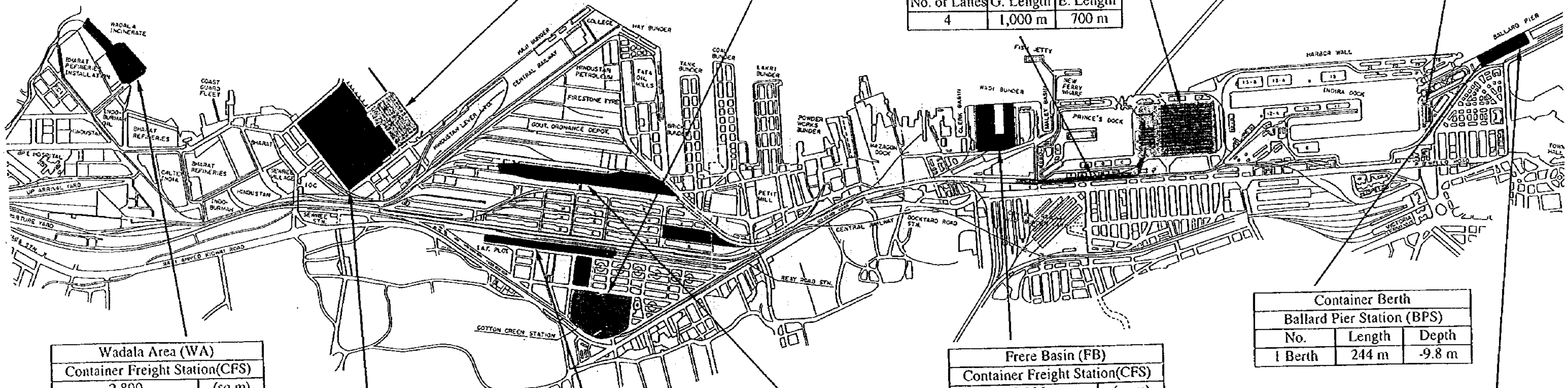
Cotton Depot West (CDW)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
0	972	19,200

Victoria Dock Container Yard		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
2,930	802	-

Indira Dock No.1 (ID-1)	
Empty Container Yard	
240	(G.Slots)

Timber Pond South (TPS)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
0	1,140	-

Dedicated Road for Containers		
No. of Lanes	G. Length	E. Length
4	1,000 m	700 m



Wadala Area (WA)	
Container Freight Station(CFS)	
2,890	(sq.m)

Timber Pond (TP)	
Container Freight Station(CFS)	
14,020	(sq.m)

Cotton Depot (COD)	
Container Freight Station(CFS)	
11,003	(sq.m)

Manganese Ore Depot(MOD)	
Container Freight Station(CFS)	
10,238	(sq.m)

Frere Basin (FB)	
Container Freight Station(CFS)	
10,336	(sq.m)

Container Berth		
Ballard Pier Station (BPS)		
No.	Length	Depth
1 Berth	244 m	-9.8 m

Ballard Pier Station (BPS)	
Marshaling Yard	
516	(G.Slots)

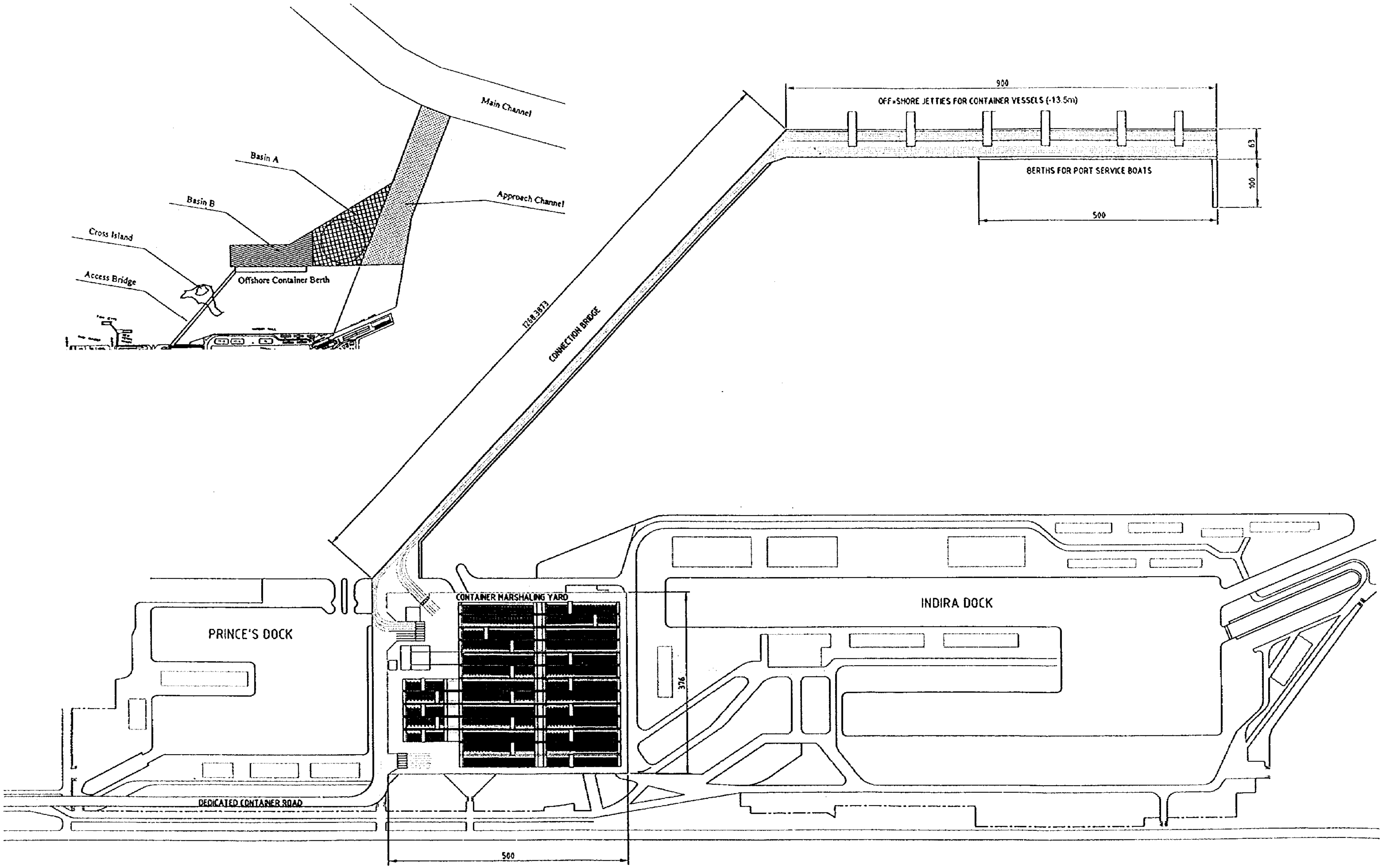


Figure 4 Layout of Short-term Plan for Container Handling

SCALE1:7,000

RECOMMENDATIONS

In accordance with the results of the study, it is recommended that the Government of India implement the development project of the Port of Mumbai and the improvement project of the Main Channel to contribute to the Indian economy. The former project is the first phase project to be completed by 2007, the target year of Short-Term Plan, and the latter project is the second phase project to be completed from 2007 to 2017, the target year of the Master Plan.

1. The First Phase Project

The main components of the development project of the Port of Mumbai as the first phase project are summarized as follows:

1.1 Establishment of a New Full-scale Container Terminal

(1) Construction of infra-structures

1) Off-shore berths with a total length of 900 m and water depth of 13.5m below CD
2) Connection bridge with 4 lanes and length of 1,180m
3) Marshaling yard with area of 19.0 ha and total storage capacity of 11,196 TEUs(3,732 ground slots)
4) Dedicated container road with a fly-over bridge: length of 700m
5) Off-dock container depots with area of 15.5 ha and total storage capacity of 6,336 TEUs(2,112 ground slots)
6) Supplementary jetty to prevent waves for port service crafts: length of 100m

(2) Construction of super-structures

1) 2 CFSs (Container Freight Station) with a total floor space of 19,200sq. m
2) Terminal control office
3) Gate house
4) Repair shop

(3) Preparation of water facilities

1) Deepening the existing approach channel with water depth of 11.0m below CD

2) Creation of turning basin with diameter of 520m and water depth of 11.0m below CD

3) Navigational aids

(4) Procurement of container-handling equipment

1) 6 quay-side container gantry cranes

2) 18 RTGs (Rubber Tyred Gantry Crane)(6 rows + 1 lane)

3) 4 Reach stackers

4) 97 Yard tractor-trailer units

5) 55 Road tractor-trailer units

(5) Introduction of a closed terminal operation system

(6) Engineering matters at the implementation stage

1) In conducting detail design of ancillary equipment of quay-side cranes such as cable guides on off-shore berth structures, it is necessary to take account of the possible installation of additional cranes after the opening of the terminal.

2) It is recommended that an experimental test be conducted at the implementation stage to confirm tranquillity of the proposed off-shore berthss for mooring vessels and container-handling operations.

1.2 Improvement of Conventional Cargo Handling Operations

(1) Allocation of specific berths by cargo type

(2) Preparation of necessary cargo-handling equipment

(3) Preparation of a dedicated ordinary truck road outside the dock areas

1.3 Management, Operations and Institutional Matters

(1) Comprehensive management by a terminal operator at the new container terminal

(2) Transfer of some personnel from MBPT

(3) Development of human resources through on-the-job training by foreign experts

2. The Second Phase Project

The main components of the improvement project of the Main Channel as the second phase project are summarized as follows.

2.1 Improvement of the Main Channel

(1) Deepening the present water depth to 12 m deep below CD in terms of the controlled depth

(2) Widening of channel at the narrow places to 500 m wide

(3) Others

1) It should be noted that the main beneficiary of the project is JNP.

2) It is recommended that the commencement timing of the project be periodically reviewed in the future due to the actual increasing trend of future container traffic.