APPENDIX C

WATER TRANSPORT

Table C-5.1.1 Main Commodity of Import and Export at Bangladesh Ports

Unit: thousand ton

Import	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
Foodgrain	2,390	1,575	1,805	1,696	1,300	982	2,398	2,120	1,039	1,164
Cement	1,432	1,439	1,389	1,450	1,838	1,594	2,044	2,484	2,026	2,001
Fertilizer	644	400	486	622	349	272	588	352	753	737
Coal	52	475	138	103	25	5	11	13	79	28
Clinker								182	312	604
Wood pulp		3	6	5	3	3	3	4	3	0
Machinery	2	5	2	1	3	2	12	11	2	0
Salt	339	113	311	368	44	325	60		51	
Cotton	2	0	0	0	0	0	0	0	0	
S. Pipe/CI sheet	3				3		2	0		
S/Oil		4	1	5	0		2			
Sugar	132	137	13	3	82	69	151	22	130	105
POL	1,922	1,878	1,904	1,818	1,993	2,178	2,446	2,384	2,759	2,794
Edible Oil			375	338	384	332	342	366	419	366
G. Cargo	2,085	2,659	1,754	1,914	2,229	2,429	2,986	3,355	3,712	4,099
Total	9,004	8,690	8,186	8,322	8,254	8,192	11,045	11,294	11,287	11,900
excl.POL	5,200	4,920	4,379	4,450	4,503	4,551	6,478	6,467	6,357	6,767

Export	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
Jute & Jute Products	719	762	665	754	758	651	756	621	743	763
Leather goods	4	13	13	7	11	11	21	21	23	49
Garments	11	44	74	110	164	194	249	265	339	343
Fertilizer	348	109	271	107	394	377	485	400	352	331
Tea	20	17	24	23	23	21	26	23	30	40
Shrimp	8	10	11	10	13	16	15	17	21	17
Fish & other	5	11	17	17	21	22	29	15	22	21
Crash bone	0	1	0	0	1	0	0	0	0	
Machinery						0	0	0	0	0
Tobacco	0	0	0	1	0	0	0	1	2	1
Naphtha	139	152	227	181	171	146	149	89	98	110
Ammonia							17	136	73	39
G. Cargo	218	271	172	156	185	198	312	256	253	339
Total	1,473	1,390	1,475	1,366	1,741	1,637	2,061	1,846	1,957	2,055

Total	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
Import	9,004	8,690	8,186	8,322	8,254	8,192	11,045	11,294	11,287	11,900
Import (excl.POL)	5,200	4,920	4,379	4,450	4,503	4,551	6,478	6,467	6,357	6,767
Export	1,473	1,390	1,475	1,366	1,741	1,637	2,061	1,846	1,957	2,055
Total	10,477	10,080	9,661	9,688	9,995	9,828	13,105	13,140	13,244	13,954
Total excl.POL	6,036	5,615	5,297	5,220	5,623	5,720	7,833	7,917	7,793	8,294

Source: Mongla Port Authority (MPA) and Chittagong Port Authority (CPA)

Table C-5.2.1 Main Commodity of Import and Export at Mongla Port

Unit: thousand ton

Import	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	97/98 Share (%)
Foodgrain	684	459	530	460	292	239	498	594	253	285	12.18
Cement	634	867	875	968	1,169	865	1,107	1,284	1,075	955	40.83
Fertilizer	413	258	304	391	168	91	349	173	376	412	17.61
Coal	30	196	93	72	17				19	17	0.73
Clinker								182	312	604	25.81
Wood pulp		3	6	5	3	3	3	4	3	0	0.04
Machinery	2	5	2	1	3	2	12	11	2	0	0.04
Salt	49	8	33	115	6	194	27		20		
Cotton	2	0	0	0	0	0	0	0	0		
S. Pipe/CI sheet	3				3		2	0			
S/Oil		4	1	5	0		2				
Sugar							6				
G. Cargo	66	92	59	38	95	69	113	194	109	65	2.76
Total	1,882	1,892	1,904	2,054	1,758	1,463	2,120	2,443	2,171	2,339	100.00
Nepalese Transit Cargo										41	

Export	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	97/98 Share (%)
Jute	271	319	244	255	264	183	247	168	305	355	67.32
Jute Goods	342	363	279	328	288	243	258	208	192	149	28.31
Fertilizer	13	0	18		50	22	184				
Shrimp	8	10	11	10	13	16	15	17	21	17	3.23
Fish & other	0	0	0	0	0	0	0	0	0	0	0.00
Crash bone	0	1	0	0	1	0	0	0	0		
Machinery						0	0	0	0	0	0.15
Tobacco	0	0	0	1	0	0	0	1	2	1	0.26
G. Cargo	1	0	3	1	5	3	0	0	0	4	0.73
Total	637	695	557	596	621	467	706	396	521	528	100.00

Total	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
Import	1,882	1,892	1,904	2,054	1,758	1,463	2,120	2,443	2,171	2,339
Export	637	695	557	596	621	467	706	396	521	528
Total	2,519	2,587	2,461	2,650	2,379	1,931	2,826	2,839	2,692	2,867
Import Share (%)	74.71	73.13	77.37	77.52	73.90	75.79	75.01	86.05	80.65	81.59
Export Share (%)	25.29	26.87	22.63	22.48	26.10	24.21	24.99	13.95	19.35	18.41

Source: Mongla Port Authority (MPA)

Table C-5.2.2 Container Cargo at Mongla Port

		88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
Import Stuffed	20' (TEU)	n.a.	n.a.	453	283	345	757	906	1,341	1,583	724
	40' (TEU)	n.a.	n.a.	574	192	494	818	948	2,998	3,478	1,304
	Total (TEU)	n.a.	n.a.	1,027	475	839	1,575	1,854	4,339	5,061	2,028
	Total (No)	n.a.	n.a.	740	379	592	1,166	1,380	2,840	3,322	1,376
	Ton	4,788	11,242	6,118	5,566	7,530	16,408	19,457	56,481	56,574	27,819
Empty	20' (TEU)	n.a.	n.a.	3,500	2,740	2,466	2,612	2,754	2,137	2,262	3,516
	40' (TEU)	n.a.	n.a.	2,992	3,606	3,066	3,456	3,500	3,170	3,066	4,010
	Total (TEU)	n.a.	n.a.	6,492	6,346	5,532	6,068	6,254	5,307	5,328	7,526
	Total (No)	n.a.	n.a.	4,996	4,543	3,999	4,340	4,504	3,722	3,795	5,521
Sub-Total	20' (TEU)	n.a.	n.a.	3,953	3,023	2,811	3,369	3,660	3,478	3,845	4,240
	40' (TEU)	n.a.	n.a.	3,566	3,798	3,560	4,274	4,448	6,168	6,544	5,314
	Total (TEU)	7,053	8,823	7,519	6,821	6,371	7,643	8,108	9,646	10,389	9,554
	Total (No)	n.a.	n.a.	5,736	4,922	4,591	5,506	5,884	6,562	7,117	6,897
	Ton	4,788	11,242	6,118	5,566	7,530	16,408	19,457	56,481	56,574	27,819
Export Stuffed	20' (TEU)	n.a.	n.a.	3,794	2,946	2,635	3,049	3,219	3,136	2,635	3,979
	40' (TEU)	n.a.	n.a.	3,176	3,576	3,358	3,930	5,278	4,856	3,358	4,968
	Total (TEU)	n.a.	n.a.	6,970	6,522	5,993	6,979	8,497	7,992	5,993	8,947
	Total (No)	n.a.	n.a.	5,382	4,734	4,314	5,014	5,858	5,564	4,314	6,463
	Ton	79,044	96,422	82,226	79,156	72,306	85,697	92,019	91,414	105,208	116,120
Empty	20' (TEU)	n.a.	n.a.	306	107	84	296	308	240	84	325
	40' (TEU)	n.a.	n.a.	408	188	218	330	286	942	218	634
	Total (TEU)	n.a.	n.a.	714	295	302	626	594	1,182	302	959
	Total (No)	n.a.	n.a.	510	201	193	461	451	711	193	642
Sub-Total	20' (TEU)	n.a.	n.a.	4,100	3,053	2,719	3,345	3,527	3,376	2,719	4,304
	40' (TEU)	n.a.	n.a.	3,584	3,764	3,576	4,260	5,564	5,798	3,576	5,602
	Total (TEU)	6,903	8,959	7,684	6,817	6,295	7,605	9,091	9,174	6,295	9,906
	Total (No)	n.a.	n.a.	5,892	4,935	4,507	5,475	6,309	6,275	4,507	7,105
	Ton	79,044	96,422	82,226	79,156	72,306	85,697	92,019	91,414	105,208	116,120
Total Stuffed	20' (TEU)	n.a.	n.a.	4,247	3,229	2,980	3,806	1,214	4,477	4,218	4,703
	40' (TEU)	n.a.	n.a.	3,750	3,768	3,852	4,748	1,234	7,854	6,836	6,272
	Total (TEU)	n.a.	n.a.	7,997	6,997	6,832	8,554	2,448	12,331	11,054	10,975
	Total (No)	n.a.	n.a.	6,122	5,113	4,906	6,180	1,831	8,404	7,636	7,839
	Ton	83,832	107,664	88,344	84,722	79,836	102,105	111,476	147,895	161,782	143,939
Empty	20' (TEU)	n.a.	n.a.	3,806	2,847	2,550	2,908	5,973	2,377	2,346	3,841
	40' (TEU)	n.a.	n.a.	3,400	3,794	3,284	3,786	8,778	4,112	3,284	4,644
	Total (TEU)	n.a.	n.a.	7,206	6,641	5,834	6,694	14,751	6,489	5,630	8,485
	Total (No)	n.a.	n.a.	5,506	4,744	4,192	4,801	10,362	4,433	3,988	6,163
Total	20' (TEU)	n.a.	n.a.	8,053	6,076	5,530	6,714	7,187	6,854	6,564	8,544
	40' (TEU)	n.a.	n.a.	7,150	7,562	7,136	8,534	10,012	11,966	10,120	10,916
	Total (TEU)	13,956	17,782	15,203	13,638	12,666	15,248	17,199	18,820	16,684	19,460
	Total (No)	n.a.	n.a.	11,628	9,857	9,098	10,981	12,193	12,837	11,624	14,002
	Ton	83,832	107,664	88,344	84,722	79,836	102,105	111,476	147,895	161,782	143,939

Source: MPA

Table C-5.2.3 Commodity-wise Imported Container Cargo in '97/'98

Commodity	Container Boxes (TEU)	Quantity (Tons)
General Cargo	1,877	25,952
Machinery	52	436
Cotton	97	1,407
Frozen Foods	2	24
Total	2,028	27,819

Notes: Empty container boxes are excluded
Source: Original Survey through Interviews

Table C-5.2.4 Commodity-wise Exported Container Cargo in '97/'98

Commodity	Container Boxes (TEU)	Quantity (Tons)
Raw Jute	1,329	22,582
Jute Caddis	232	3,490
Gunny	1,814	22,309
Jute Yarn	1,191	14,944
Jute Truss	2,298	29,885
Cloth	272	4,355
Shrimp	1,700	17,038
White Fish	4	43
Tobacco	133	1,357
Handicraft	4	8
Garments	9	37
Machinery	8	57
Vegetable	1	5
Dry Shrimp	2	10
Total	8,997	116,120

Notes: Empty container boxes are excluded
Source: Original Survey through Interviews

Table C-5.2.5 Ship Call at Mongla Port

Year	No. of Ships Arrived	No. of Ships Sailed	No. of Containers
1988/89	484	472	148
1989/90	479	472	133
1990/91	423	429	103
1991/92	436	436	80
1992/93	378	379	72
1993/94	312	306	79
1994/95	376	381	68
1995/96	371	366	54
1996/97	368	368	73
1997/98	355	342	50

Source: MPA

Table C-5.3.1 The Dimensions of Berths and the Actual Water Depths

Berths	Berth Length	Permissible	Permissible	Actual water
Jetty-5	183m	Up to 180m	7.0m	6.8m
Jetty-6	183m	Up to 180m	7.0m	5.7m
Jetty-7	183m	Up to 180m	7.0m	4.7m
Jetty-8	183m	Up to 180m	6.5m	5.8m
Jetty-9	183m	Up to 180m	6.5m	5.0m
Mooring-1		Up to 145m	4.1m	3.5m
Mooring-2		Up to 185m	8.0m	6.7m
Mooring –3		Up to 160m	8.0m	6.8m
Mooring-4		Up to 160m	7.5m	6.1m
Mooring-5		Up to 185m	6.6m	5.6m
Mooring-6		Up to 185m	6.7m	6.6m
Mooring-7		Up to 160m	7.9m	7.6m
Mooring-8		Up to 185m	8.0m	7.0m
Anchorage-2		Up to 130m	5.5m	5.1m
Anchorage-3		Up to 140m	5.2m	5.4m
Anchorage-5		Up to 145m	4.3m	4.5m
Anchorage-6		Up to 145m	5.0m	4.5m
Anchorage-7		Up to 160m	7.2m	5.8m
Anchorage-8		Up to 160m	6.3m	6.4m
Anchorage-9		Up to 185m	5.6m	6.5m
Anchorage-10		Up to 185m	5.5m	6.4m
Anchorage-11		Up to 185m	5.3m	5.3m
Anchorage-12		Up to 185m	5.5m	5.2m
Anchorage-13		Up to 160m	5.8m	5.6m
Anchorage-14		Up to 160m	7.0m	7.1m
Anchorage-15		Up to 200m	7.3m	6.4m
Anchorage-16		Up to 160m	7.8m	7.6m
Anchorage-17		Up to 160m	6.0m	7.6m
Anchorage-18		Up to160m	7.2m	6.9m
Anchorage-19		Up to 200m	7.6m	7.5m
Anchorage-20		Up to 200m	8.0m	7.7m
Anchorage-21		Up to 200m	8.0m	5.3m

Source: the MPA

Table C- 5.3.2 Handling Equipment of Mongla Port

Types of Equipment	Capacity	Numbers
Mobile crane	30 ton	1
Mobile crane	25 ton	1
Mobile crane	20 ton	1
Mobile crane	19 ton	3
Mobile crane	10 ton	1
Dockside crane	8 ton	1
Dockside crane	3 ton	3
Dockside crane	5 ton	7
Heavy fork lift	30 ton	1
Heavy fork lift	25 ton	1
Heavy folk lift	16 ton	1
Fork lift	5 ton	3
Fork lift	3.5 ton	4
Fork lift	3 ton	4
Fork lift	2.5 ton	3
Fork lift	2 ton	5
Straddle carrier (1 sent to Chittagong Port)	35 ton	3
Prime mover		3
Trailer	40 foot container	2
Trailer	20 foot container	10

Source: the MPA

Table C-5.6.1 Financial Status at Mongla Port

Unit: thousand Taka

Year	Income	Expenditure	Net Profit
1990/91	464,678	292,199	172,479
1991/92	524,233	304,456	219,777
1992/93	511,294	316,083	195,211
1993/94	454,458	328,028	126,430
1994/95	561,180	383,288	177,892
1995/96	573,943	407,874	166,069
1996/97	627,930	462,495	165,430
1997/98	651,808	479,260	172,548

Note: Data of 1997/98 is provisional.
Source: Mongla Port Authority

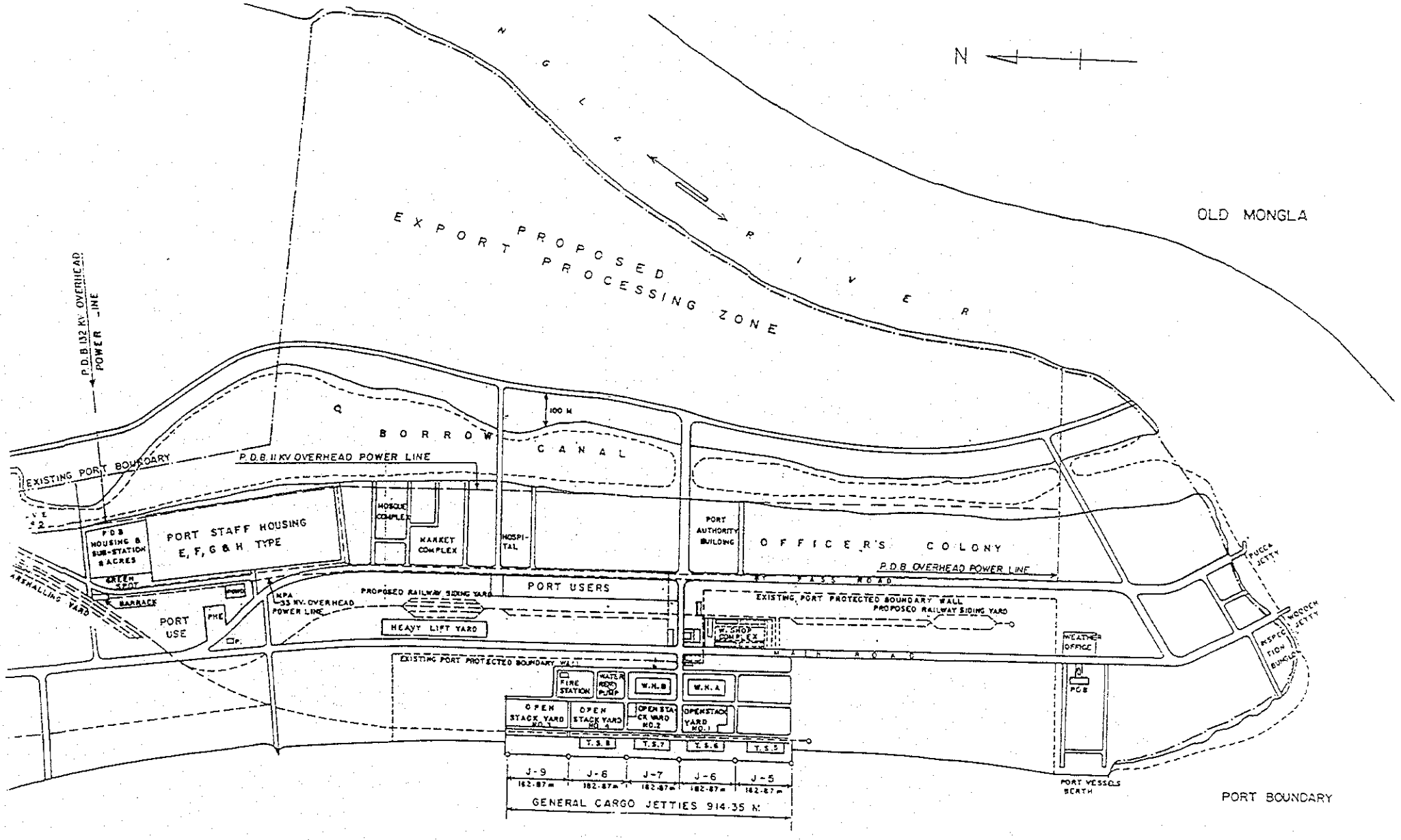

Fig. C-5.3.1 Layout of Mongla Port Jetty Area

Appendix C-5.4.2 List of Interviewees for the Survey on Siltation in Mongla Port

1. Khulna Traders Ltd.
2. Morrelganj Traders
3. Linkers International Ltd.
4. Bangladesh Shipping Lines
5. United Sea Transport
6. Bangladesh Steamer Agents' Association
7. Everett Bangladesh Ltd.
8. Makh Shipping
9. Inland Water Transport Owners' Association
10. Gafur Brothers Co.
11. Starpath Seatrade Ltd.
12. Bionic Sea Foods Ltd.
13. Jahanabad Sea Foods Ltd.
14. Ocean Wave Shipping Ltd.
15. Aqua Marine Ltd.
16. Ocean Trade Ltd.
17. Mehedi Shipping
18. Faruk Enterprise
19. Wahab and Sons
20. Regional Controller of Food

Appendix C-5.5.2 Brief Summary Industrial Development in the Adjacent Area of the Mongla Port

1) A Cement Factory in Mongla

--- Capacity of cement production	150,000 tons/year
--- Future production target	400,000 tons /year
--- Import transportation	importing clinker of about the same volume of production by using its own berth 2 vessel calls / month
--- Inland transportation mode	50% of cement by trucks and another 50% by inland water
--- Inland distribution	50% to Dhaka (of which 75% by inland water and 25% by trucks), 25% to Khulna (all by trucks), and 25% to Northwestern Region (all by trucks)
--- Berth development	extension of the berth to 200m from 150m deepening of the berth up to 8m from 6.5m

2) The Other Cement Factory in Mongla

--- Capacity of cement production	240,000 tons/year
--- Future production target	2.5 times or 600,000 tons/year
--- Import transportation	same as the other one, 26 vessel calls / year
--- Inland transportation mode	50% by trucks and 50% by inland water
--- Inland distribution	50% to Dhaka (all by inland water), 15% to Khulna (all by trucks), and 35% to Northwestern Region (all by trucks)
--- Berth development	no concrete plans (the existing one is 160m long and 7 m deep)

3) A New LPG Distribution Base in Mongla (next to a cement factory)

--- Capacity of distribution	8,000 LPG bottles/day, to be increased to 24,000 LPG bottles /day
--- Transportation	transport from Chittagong by vessels distributes to the whole western region by trucks
--- Road transportation	A truck carries 50 LPG bottles one time

4) A Jute Mill in Khulna

--- Produced goods	jute bags and jute cloth
--- Production scale	18,000 to 20.000 tons / year, 98% is exported
--- Inland transportation	using all modes (trucks, inland water, and railway)
--- Export transportation	75-80 % to Mongla Port by inland water 20-25 % to Mongla Port by trucks
--- Future perspective	increase of production more trucks are to be used if the Rupsa Bridge is opened

5) A Food Processing Plant in Khulna

--- Producing goods	frozen shrimp and fish
--- Production scale	350 tons / year, 100% is exported, 35 plants are in Khulna area
--- Inland transportation	collecting shrimp by trucks from hatchery fields
--- Export transportation	100 % transported by refrigerator trucks to Mongla Port
--- Future perspective	increase of production use of refrigerator container in the future

6) Three Oil Companies in Khulna

--- Roles of companies	domestic distribution of oil
--- Scales of distribution	255,000, 300,000, 300,000 kl/year
--- Origin of oil	all is transported from Chittagong by tankers up to 1.500-1,700 DWT with 13 foot draft
--- Distribution area	mainly to Khulna Division
--- Distribution mode	all is distributed by trucks
--- Future perspective	distribution volume will increase corresponding to regional development. relocation to downstream is difficult due to cost and safety problem of pipeline.

7) Export Processing Zone (EPZ) in Mongla

Mongla EPZ has already been approved by the Bangladesh Government, and the first development will be initiated this year (1998). This is the third EPZ in Bangladesh, following the successful predecessors, Chittagong EPZ (453 acres) and Dhaka EPZ (145 acres).

Some 113 factories presently are operating in the two EPZs, and 70,000 workers are employed there. Industries are export-oriented comprising such ones as garments, textile, artificial flowers, and electronics. A lot of favorable treatment is given to industries in terms of taxes, customs, and labor conditions.

The major features of Chittagong EPZ are as follows;

--- History	started in 1983
--- Land area	453 acres (several km from the Chittagong Port)
--- Industries	83 industries, garments, metal product, electronics, textile, plastic, shoes, fishing and golf equipment, and etc.
--- Type of industry	53 of type A (100% foreign investment), 15 of type B (joint investment), and 15 type C (100% local investment)

--- Transportation matters	200 trucks and trailers to/from the Port 800 buses for workers, 500 cars for investors, and other 1,000 cars coming and going to/from the EPZ
--- Future perspective	the existing facilities are almost fully utilized. private EPZ plan using Korean funds at the opposite side of the River has already been approved by the Government.

The Mongla EPZ is planned to cover 480 acres in total, but as the initial phase, development of 139 acres will be initiated by the Bangladesh Export Processing Zones Authority (BEPZA) in 1998. The first phase plan aims at employing 22,000 people and exporting TK 3 billion with 40 industries. It is stated that BEPZA would invest TK 580 million for the first stage development and it would be completed in 3 years.

Appendix 5.8.1 Salient Features of Chittagong Port

1) Port Facilities

Chittagong Port has 15 public berths among which 2 berths are dedicated to container handling, while the maximum permissible draft of vessels ranges from 8.5m to 9.14m. Other than these public berths, the Port has 7 major private berths to handle POL, cement, and fertilizer. Furthermore, many inland coasters and vessels use a lot of small jetties and pontoons. While all the major public berthing facilities are located on the right bank of the river, two major private berths of fertilizer plants are on the left bank, connected by two bridges over the river. The layout map is shown in Fig. C-5.8.3.

The container terminal has 2 berths, a length of 450m, which is sometimes used by 3 smaller vessels simultaneously, with CFS and other necessary container facilities but no gantry cranes. Alternatively, container handling is carried out by ship gears. While its handling capacity is estimated to be 190 thousand TEUs per annum, this congested port handled 329 thousand TEUs in '97/'98. Since storage space in the container terminal is not sufficient for this volume, a lot of small spaces behind the other public berths are used for container storage. Every possible effort to increase the capacity has been made by the CPA.

As mentioned earlier the CPA also develops and maintains its navigational channel from the river estuary. The annual volume of maintenance dredging is approximately 1 million cubic meters, which is carried out by its own dredger, M.D.Khanak, with the hopper capacity of 2,500 cubic meters.

2) Port Administration

The port is administered by CPA, an autonomous quasi-governmental organization under the Ministry of Shipping, in the same manner as Mongla Port.

Port charges are different from those of Bangladesh port, which are shown in the Table 5.6.1 in the Main Report

3) Development of the Surrounding Area

Chittagong area is the most industrialized area in Bangladesh, which boasts the highest per capita income in the nation. Complying with the development of Bangladesh, lots of industrial activities will be seen in this area in the future, among which Chittagong EPZ has achieved remarkable success so far and will continue to do so in the future. Being one of the two existing EPZs in Bangladesh which now produces more than 10% of the total industrial output of the nation, Chittagong EPZ is much larger than its counterpart, Dhaka EPZ, in terms of size and activities. Chittagong EPZ was initiated in 1983 with the planned area of 453 acres, at present 428 acres has already been developed and fully utilized. In the near future an EPZ financed by Korean capital might be developed on the left side bank of the river over an area of 2,500 acres, whose establishment has already been approved by the Bangladesh Government. Other than the EPZ, gas related industry is the most likely new industry to be introduced at Chittagong area together with expansion of the existing oil refinery industry.

As mentioned, industry around Chittagong Port is very thriving, and will continue to do so.

4) Future Development of the Port

CPA has a master plan for port development with the target year of 2010. Though the detailed contents of the master plan were not made open to the public, the interviews with the CPA personnel reveal the following outline of the plans;

Targeted container volume	---	509 thousand TEUs up to 2005 723 thousand TEUs up to 2010
Major development works	---	Acquisition of various cargo handling equipment including 4 gantry cranes for the existing container terminal using ADB funds and removal of some railway tracks and knocking down a few warehouses / transit sheds
	---	Development of a new container terminal next to the existing one, with berth length of 600m and 22ha storage area using its own funds (US$ 150

million). The capacity of the new terminal is to be 300 thousand TEUs. The consultant is now being chosen, and construction work will be initiated in1999.

--- BOO (Build, Operate, Own) of container terminal will be introduced near the river estuary on the right hand side river bank. The Stevedoring Service of America (S.S.A.) was approved to construct and manage the new container terminal with the length of 1,000m, vessels' draft of 10.5m, land of 105 acres, and the handling capacity of 400 thousand TEUs. The project cost is estimated to be more than US$ 400 million. The project will be combined with the inland water container terminal at Dhaka Port with eight 90m inland water container berths so as to transport some containers by inland water vessels.

The CPA has clear target and salient plans for the future, though, of course, some problems may be involved, e.g., gantry cranes cannot be acquired using ADB funds without the introduction of privatization for some of port handling activities, and lots of opposition can be found; for example, strikes have taken place against introduction of the privatization scheme. However, the CPA has an aggressive attitude for the future, stating that even the left side bank of the river might be developed for the public port facilities with several bridge connections in the future, if necessary.

Table C-5.8.1 Main Commodity of Import and Export at Chittagong Port

Unit: thousand ton

Import	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	97/98 Share (%)
Foodgrain	1,706	1,117	1,275	1,236	1,008	743	1,899	1,526	786	880	9.20
Cement	799	572	514	482	669	729	936	1,200	951	1,046	10.94
Fertilizer	232	142	182	231	181	181	240	179	377	325	3.40
Coal	22	279	45	31	7	5	11	13	60	10	0.11
Salt	291	106	278	253	38	131	33		31		
Sugar	132	137	13	3	82	69	145	22	130	105	1.10
POL	1,922	1,878	1,904	1,818	1,993	2,178	2,446	2,384	2,759	2,794	29.22
Edible Oil			375	338	384	332	342	366	419	366	3.82
General Cargo	2,019	2,568	1,696	1,876	2,133	2,360	2,872	3,161	3,603	4,035	42.20
Total	7,122	6,798	6,282	6,267	6,496	6,728	8,925	8,851	9,116	9,561	100.00
excl.POL	5,200	4,920	4,379	4,450	4,503	4,551	6,478	6,467	6,357	6,767	70.78

Export	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	97/98 Share (%)
Jute & Jute Products	106	80	141	171	206	225	251	245	246	258	16.90
Leather goods	4	13	13	7	11	11	21	21	23	49	3.24
Tea	20	17	24	23	23	21	26	23	30	40	2.61
Garments	11	44	74	110	164	194	249	265	339	343	22.48
Fertilizer	336	109	253	107	345	355	301	400	352	331	21.68
Frozen goods	5	11	17	17	21	21	28	15	22	20	1.34
Naphtha	139	152	227	181	171	146	149	89	98	110	7.20
Ammonia							17	136	73	39	2.57
General cargo	216	270	169	155	180	196	311	256	253	336	21.98
Total	836	695	919	770	1,120	1,169	1,354	1,450	1,436	1,527	100.00

Total	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
Import	7,122	6,798	6,282	6,267	6,496	6,728	8,925	8,851	9,116	9,561
Import (excl.POL)	5,200	4,920	4,379	4,450	4,503	4,551	6,478	6,467	6,357	6,767
Export	836	695	919	770	1,120	1,169	1,354	1,450	1,436	1,527
Total	7,958	7,493	7,201	7,038	7,616	7,897	10,279	10,301	10,552	11,087
Total excl.POL	6,036	5,615	5,297	5,220	5,623	5,720	7,833	7,917	7,793	8,294
Import Share (%)	89.49	90.72	87.24	89.05	85.29	85.20	86.82	85.92	86.39	86.23
Export Share (%)	10.51	9.28	12.76	10.95	14.71	14.80	13.18	14.08	13.61	13.77

Source: Chittagong Port Authority (CPA)

Table C-5.8.2 Container Cargo at Chittagong Port

		88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
Import Stuffed	20' (TEU)	n.a.	n.a.	n.a.	30,200	34,000	40,000	50,800	54,500	64,900	n.a.
	40' (TEU)	n.a.	n.a.	n.a.	11,400	15,000	18,700	25,600	30,000	35,000	n.a.
	Total (TEU)	n.a.	n.a.	n.a.	53,000	64,000	77,400	102,000	114,500	134,900	n.a.
	Total (No)	n.a.	n.a.	n.a.	41,600	49,000	58,700	76,400	84,500	99,900	n.a.
	Ton	472,554	667,777	546,323	679,815	844,854	1,005,073	1,341,498	1,534,370	1,771,880	n.a.
Empty	20' (TEU)	n.a.	n.a.	n.a.	2,500	3,200	2,300	1,900	1,500	1,100	n.a.
	40' (TEU)	n.a.	n.a.	n.a.	2,900	4,600	4,900	5,300	5,600	5,200	n.a.
	Total (TEU)	n.a.	n.a.	n.a.	8,300	12,400	12,100	12,500	12,700	11,500	n.a.
	Total (No)	n.a.	n.a.	n.a.	5,400	7,800	7,200	7,200	7,100	6,300	n.a.
Sub-Total	20' (TEU)	31,077	44,212	38,705	32,700	37,200	42,300	52,700	56,000	66,000	72,428
	40' (TEU)	8,486	12,303	12,047	14,300	19,600	23,600	30,900	35,600	40,200	45,526
	Total (TEU)	39,563	56,515	50,752	61,300	76,400	89,500	114,500	127,200	146,400	163,480
	Total (No)	31,077	44,212	38,705	47,000	56,800	65,900	83,600	91,600	106,200	117,954
Export	20' (TEU)	n.a.	n.a.	n.a.	20,500	24,800	28,700	32,800	32,300	34,200	n.a.
	40' (TEU)	n.a.	n.a.	n.a.	10,400	15,100	18,500	25,600	27,300	31,200	n.a.
	Total (TEU)	n.a.	n.a.	n.a.	41,300	55,000	65,700	84,000	86,900	96,600	n.a.
	Total (No)	n.a.	n.a.	n.a.	30,900	39,900	47,200	58,400	59,600	65,400	n.a.
	Ton	240,292	306,424	342,750	402,610	533,852	621,461	772,517	801,145	898,085	n.a.
Empty Stuffed	20' (TEU)	n.a.	n.a.	n.a.	11,100	12,000	11,700	18,700	22,500	30,300	n.a.
	40' (TEU)	n.a.	n.a.	n.a.	3,800	3,700	4,100	5,000	7,200	8,500	n.a.
	Total (TEU)	n.a.	n.a.	n.a.	18,700	19,400	19,900	28,700	36,900	47,300	n.a.
	Total (No)	n.a.	n.a.	n.a.	14,900	15,700	15,800	23,700	29,700	38,800	n.a.
Sub-Total	20' (TEU)	29,429	42,204	38,548	31,600	36,800	40,400	51,500	54,800	64,500	73,637
	40' (TEU)	8,530	11,925.	11,981	14,200	18,800	22,600	30,600	34,500	39,700	46,023
	Total (TEU)	37,959	54,129	50,529	60,000	74,400	85,600	112,700	123,800	143,900	165,683
	Total (No)	29,429	42,204	38,548	45,800	55,600	63,000	82,100	89,300	104,200	119,660
Total Stuffed	20' (TEU)	n.a.	n.a.	n.a.	50,700	58,800	68,700	83,600	86,800	99,100	n.a.
	40' (TEU)	n.a.	n.a.	n.a.	21,800	30,100	37,200	51,200	57,300	66,200	n.a.
	Total (TEU)	n.a.	n.a.	n.a.	94,300	119,000	143,100	186,000	201,400	231,500	n.a.
	Total (No)	n.a.	n.a.	n.a.	72,500	88,900	105,900	134,800	144,100	165,300	n.a.
	Ton	712,846	974,201	889,073	1,082,425	1,378,706	1,626,534	2,114,015	2,335,515	2,669,965	3,017,798
Empty	20' (TEU)	n.a.	n.a.	n.a.	13,600	15,200	14,000	20,600	24,000	31,400	n.a.
	40' (TEU)	n.a.	n.a.	n.a.	6,700	8,300	9,000	10,300	12,800	13,700	n.a.
	Total (TEU)	n.a.	n.a.	n.a.	27,000	31,800	32,000	41,200	49,600	58,800	n.a.
	Total (No)	n.a.	n.a.	n.a.	20,300	23,500	23,000	30,900	36,800	45,100	n.a.
Total	20' (TEU)	60,506	86,416	77,253	64,300	74,000	82,700	104,200	110,800	130,500	146,065
	40' (TEU)	17,026	24,228	24,028	28,500	38,400	46,200	61,500	70,100	79,900	91,549
	Total (TEU)	77,522	110,644	101,281	121,300	150,800	175,100	227,200	251,000	290,300	329,163
	Total (No)	60,506	86,416	77,253	92,800	112,400	128,900	165,700	180,900	210,400	237,614
	Ton	712,846	974,201	889,073	1,082,425	1,378,706	1,626,534	2,114,015	2,335,515	2,669,965	3,017,798

Source: CPA

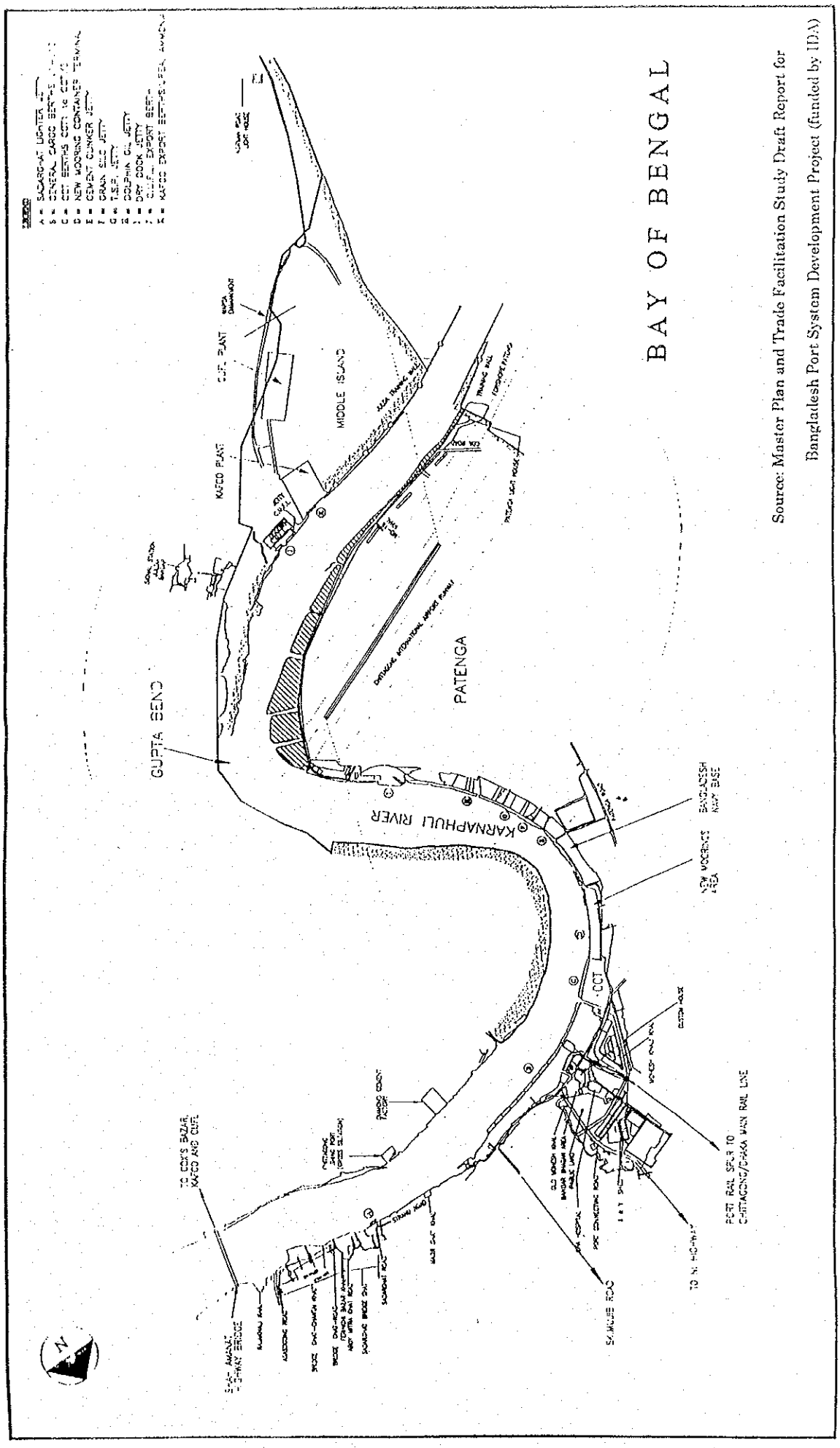

Fig. C-5.8.3 Layout of Chittagong Port

Appendix C-5.8.2 Salient Features of Calcutta and Haldia Port

1) Port Facilities

Calcutta Port has two dock systems, K.P. Docks (Kidderpore Docks) and N.S. Docks (Netaji Subhas Docks), which were constructed in the 1890s and 1920s respectively. K.P. Docks has 18 berths, 6 mooring buoys, and 3 dry docks, and N.S. Docks has 14 berths, 2 mooring buoys, and 2 dry docks. These docks can accommodate vessels with the draft of 7 to 9 m and maintenance works in the docks are easy to carry out, since locks at the entrances of the docks prevent intrusion of silt from the River. Outside of the docks 6 wharves handle petroleum. Container cargo is handled at the newly constructed No.8 berth as well as the No.7 berth of N.S. Docks. They have a relatively wide container yard and are equipped with sufficient handling facilities but no gantry cranes. Containers are stacked in four tiers.

Haldia Port, which has been newly developed as an outer port of Calcutta Port since the early 1970s, now has a single dock system comprising 8 berths and another 1 berth now under construction. The Docks has some advantage to Calcutta Port, since it is nearer to the river estuary and thus vessels with larger drafts can use the Docks. Taking this advantage, the Docks was planned and actually constructed to have deeper water depth, which can accommodate vessels with draft of from 10.5m to 11.0m inside the Docks (but in fact such large vessels cannot use Haldia Port due to lack of channel depth in the river.) Two large oil jetties handle POL outside of the Docks and another oil jetty is now under construction. Small oil jetties and anchorage area outside the Docks are also used. A small volume of container, 30 thousand TEUs in '97/'98, is handled at No.8 and No.9 berths in the Docks using ships' gear and other facilities.

The layout maps of Calcutta Port and Haldia Port are shown in Figs. C-5.8.4, C-5.8.5, C-5.8.6, and C-5.8.7.

A great effort has been made to properly maintain the depths of navigation channels in the River. The volume of solids lifted by dredgers varies year to year, ranging from 10 to 18 million cubic meters per annum. While CPT implements dredging works in and around the Docks by deploying its six dregders, Dredging Corporation of India is responsible for main dredging works in the River.

2) Port Administration

The ports are administered by Calcutta port Trust, an autonomous quasi governmental organization under the Ministry of Surface Transport. The administration structure is found to be almost the same as the one in Bangladesh.

The port charges of the Port are different from those of Bangladesh ports, which are shown in the Table 5.6.1 in the Main Report.

3) Development of the Surrounding Area

Calcutta area is one of the most populous areas in India, but is not very advanced in terms of economic and industrial development. In order to cope with the situation huge scale industrial development has been planned or is ongoing at the Haldia area and some other areas between Calcutta and Haldia, adding a new aspect to the existing industrial capabilities. Industries on the agenda are mostly heavy industries such as oil refinery, petrochemical and steel mill.

Haldia Port shall play a significant role in promoting this development, since, in general, port development should be synchronized with heavy industrial development in order to handle their import/export activities.

4) Future Development of the Port

The CPT has various aggressive development plans for the future. Assuming lots of measures can be put into effect, the cargo volume of CPT, the combination of Calcutta and Haldia, is estimated to be 40 million tons in one or two years, and 45 or 50 million tons in several years.

A lot of equipment, including 2 gantry cranes for container handling, will be provided to Calcutta Port so as to increase its efficiency and thus capability, since Calcutta Port has little room for expansion for new berths, being surrounded by urban land use. Container handling shall also be concentrated at Calcutta Port in the future; volume is estimated to reach 250 thousand TEUs or more in 2005.

Besides No. 11 berth at Haldia Port now under construction, with a length of 190m, two berths, 4A and 4B, with a total length of 426m, are planned to be constructed in the following stage. One of these two berths is to be constructed under the BOT scheme, which will be followed by another project to construct No. 12 berth, multi-purpose terminal, also under the same scheme. Outside of the docks the fourth oil jetty will follow the third one now under construction. Though all of these works are to be seen in and around the existing arm, the CPT is now offering a tender to consultants to carry out a feasibility study on the second arm which can comprise 15 berths and the new lock, in order to meet the future demand originated from the industries to be newly located in nearby areas as mentioned earlier.

Large investment shall be made to deepen the channels in the River. The ultimate target is to accommodate vessels with drafts of 12m at Haldia and that of 10m at Calcutta. Though it might be a very challenging job to achieve the ultimate goal, various activities such as research works, capital dredging, and river training works are to be mobilized shortly.

Table C-5.8.3 Cargo Volume at Calcutta Port Trust

Unit: Million ton

Year	CDS			HDS			Total		
	Import	Export	Total	Import	Export	Total	Import	Export	Total
1988/89	3.40	0.94	4.34	6.29	3.59	9.88	9.69	4.53	14.22
1989/90	3.39	0.95	4.34	6.37	3.98	10.35	9.76	4.93	14.69
1990/91	3.16	0.97	4.13	7.44	3.67	11.11	10.60	4.64	15.24
1991/92	2.93	1.23	4.16	8.32	3.52	11.84	11.25	4.75	16.00
1992/93	3.68	1.48	5.16	9.24	3.94	13.18	12.92	5.42	18.34
1993/94	3.37	1.80	5.17	8.84	4.45	13.29	12.21	6.25	18.46
1994/95	4.10	1.70	5.80	9.98	4.75	14.73	14.08	6.45	20.53
1995/96	4.25	1.87	6.12	10.87	4.52	15.39	15.12	6.39	21.51
1996/97	4.24	1.78	6.02	11.99	5.11	17.10	16.23	6.89	23.12
1997/98	6.28	1.67	7.95	13.36	6.82	20.19	19.65	8.49	28.14

Source: CPT

Table C-5.8.4 Main Commodity of Import and Export at Calcutta Port Trust

Commodity-wise Traffic Handled at Calcutta Dock System (CDS)

Unit: thousand ton

	Commodity	1996/97			1997/98		
		Import	Export	Total	Import	Export	Total
1	POL (Crude)			0			0
2	POL (Product)	2,458	30	2,488	2,058	57	2,115
3	Fertilizer	42		42	30		30
4	Rock Phosphate	27		27	27		27
5	Sulphur	23		23	38		38
6	Foodgrain		8	8	8	25	33
7	Coal (Thermal)			0			0
8	Coal (Coaking)			0			0
9	Coal (Other)	12		12	8		8
10	Salt			0			0
11	Petroleum Coke	2		2			0
12	Sugar			0	44		44
13	Cement			0			0
14	Iron & Steel	112	193	305	86	125	211
15	Veg. Oil-LB	171		171	241	5	246
16	Other Liq. Cargo	34	14	48	49	4	53
17	Timber	47		47	208		208
18	Other Dry Cargo	1,079	1,223	2,302	1,277	1,251	2,528
	Total	4,007	1,468	5,475	4,074	1,467	5,541
	IVW Traffic	47	194	241	146	106	252
	Transshipment	181	126	307	2,064	95	2,159
77	Ground Total	4,235	1,788	6,023	6,284	1,668	7,952
Container Traffic							
1	Quayface TEUs	70,289	62,406	132,695	77,312	63,568	140,880
	Ton	878,977	1,072,016	1,950,993	1,005,554	1,116,076	2,121,630
2	Intermodal TEUs	43,325	47,438	90,763	54,950	55,101	110,051

Source: CPT

Commodity-wise Traffic Handled at Haldia Dock Complex (HDC)

Unit: thousand ton

	Commodity	1996/97			1997/98		
		Import	Export	Total	Import	Export	Total
1	POL (Crude)	3,713		3,713	5,202		5,202
2	POL (Product)	3,676	1,104	4,780	3,388	1,976	5,364
3	Fertilizer	31		31	21		21
4	Rock Phosphate	170		170	196		196
5	Sulphur	70		70	85		85
6	Foodgrain	2	2	4		4	4
7	Coal (Thermal)		3,628	3,628		4,136	4,136
8	Coal (Coaking)	3,188		3,188	2,980		2,980
9	Coal (Other)	232		232	459		459
10	Salt			0			0
11	Petroleum Coke	78	22	100	111	15	126
12	Sugar		60	60			0
13	Cement			0			0
14	Iron & Steel	3	184	187	10	303	313
15	Veg. Oil-LB	4		4			0
16	Other Liq. Cargo	531		531	481		481
17	Timber			0			0
18	Other Dry Cargo	293	108	401	431	390	821
	Total	11,991	5,108	17,099	13,364	6,824	20,188
	IVW Traffic	2		2			0
	Transshipment			0			0
	Ground Total	11,993	5,108	17,101	13,364	6,824	20,188
Container Traffic							
1	Quayface TEUs	1,930	6,869	8,799	9,138	19,074	28,212
	Ton	18,547	98,900	117,447	83,747	293,558	377,305
2	Intermodal TEUs	1,826	7,062	8,888	8,342	18,694	27,036

Source: CPT

Commodity-wise Traffic Handled at Calcutta Port (CDS & HDC)

Unit: thousand ton

	Commodity	1996/97			1997/98		
		Import	Export	Total	Import	Export	Total
1	POL (Crude)	3,713	0	3,713	5,202	0	5,202
2	POL (Product)	6,134	1,134	7,268	5,446	2,033	7,479
3	Fertilizer	73	0	73	51	0	51
4	Rock Phosphate	197	0	197	223	0	223
5	Sulphur	93	0	93	123	0	123
6	Foodgrain	2	10	12	8	29	37
7	Coal (Thermal)	0	3,628	3,628	0	4,136	4,136
8	Coal (Coaking)	3,188	0	3,188	2,980	0	2,980
9	Coal (Other)	244	0	244	467	0	467
10	Salt	0	0	0	0	0	0
11	Petroleum Coke	80	22	102	111	15	126
12	Sugar	0	60	60	44	0	44
13	Cement	0	0	0	0	0	0
14	Iron & Steel	115	377	492	96	428	524
15	Veg. Oil-LB	175	0	175	241	5	246
16	Other Liq. Cargo	565	14	579	530	4	534
17	Timber	47	0	47	208	0	208
18	Other Dry Cargo	1,372	1,331	2,703	1,708	1,641	3,349
	Total	15,998	6,576	22,574	17,438	8,291	25,729
	IVW Traffic	49	194	243	146	106	252
	Transshipment	181	126	307	2,064	95	2,159
	Ground Total	16,228	6,896	23,124	19,648	8,492	28,140
Container Traffic							
1	Quayface TEUs	72,219	69,275	141,494	86,450	82,642	169,092
	Ton	897,524	1,170,916	2,068,440	1,089,301	1,409,634	2,498,935
2	Intermodal TEUs	45,151	54,500	99,651	63,292	73,795	137,087

Source: CPT

Table C-5.8.5 Container Traffic Handled at Calcutta Port

Unit: TEUs

Year	CDS	HDS	Total
1988/89	50,815	15,901	66,716
1989/90	57,316	23,136	80,452
1990/91	48,985	23,396	72,381
1991/92	57,813	8,999	66,812
1992/93	73,601	7,324	80,925
1993/94	96,000	6,011	102,011
1994/95	112,032	5,745	117,777
1995/96	121,312	3,843	125,155
1996/97	132,695	8,799	141,494
1997/98	140,880	28,212	169,092

Source: CPT

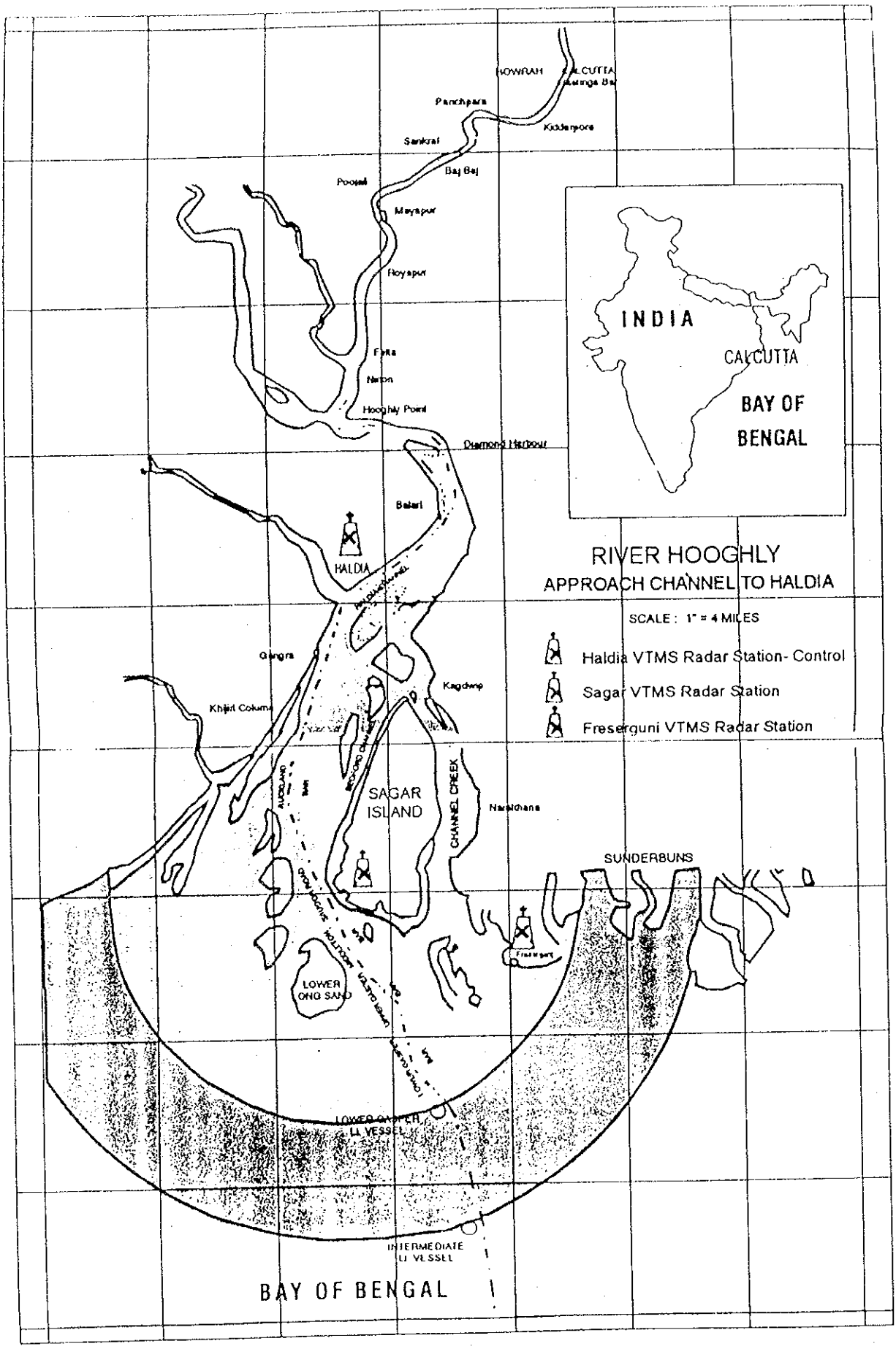

Fig. C-5.8.4 Approach Channel to Haldia and Calcutta Port

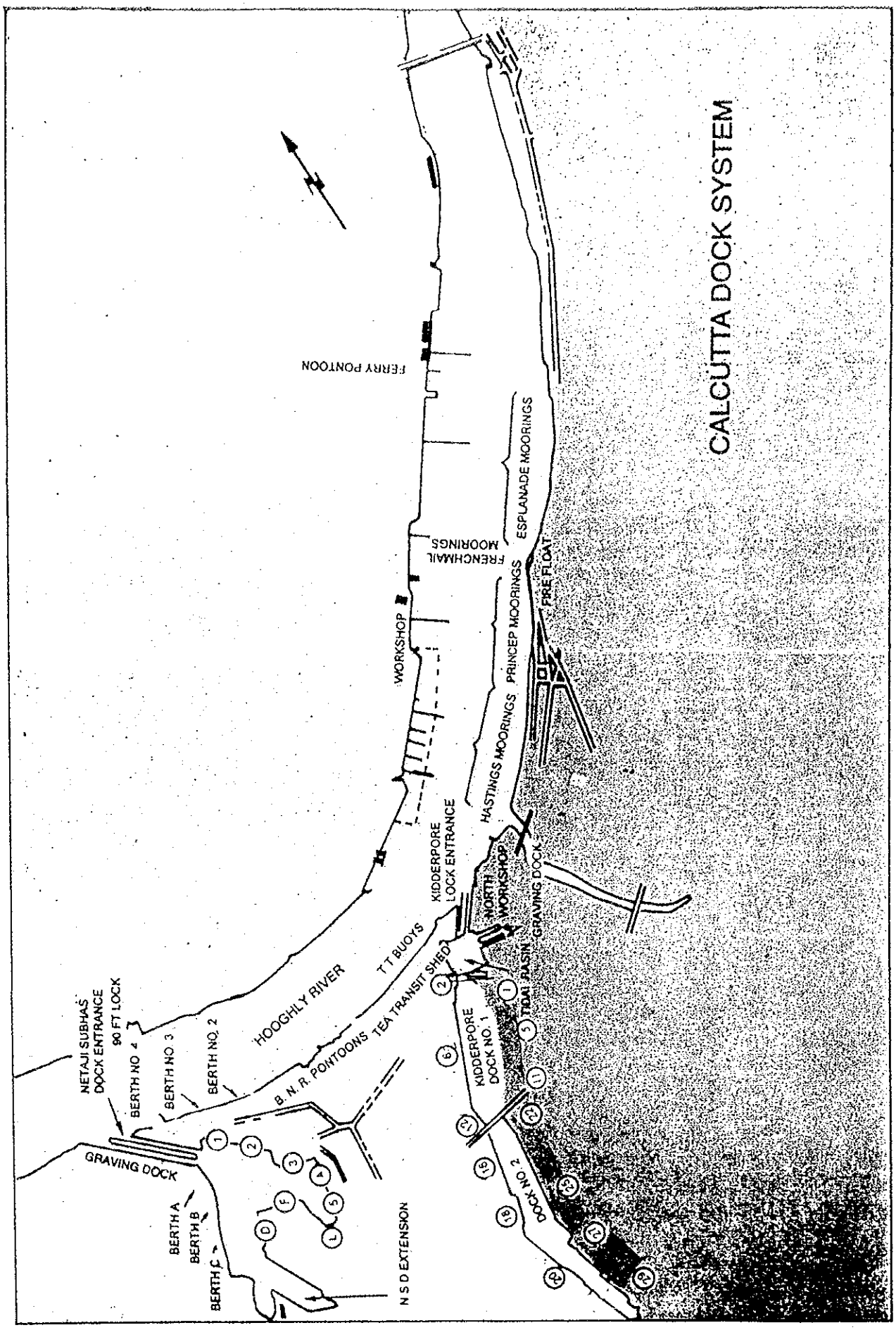

Fig. C-5.8.5 Layout of Calcutta Dock System (CDS)

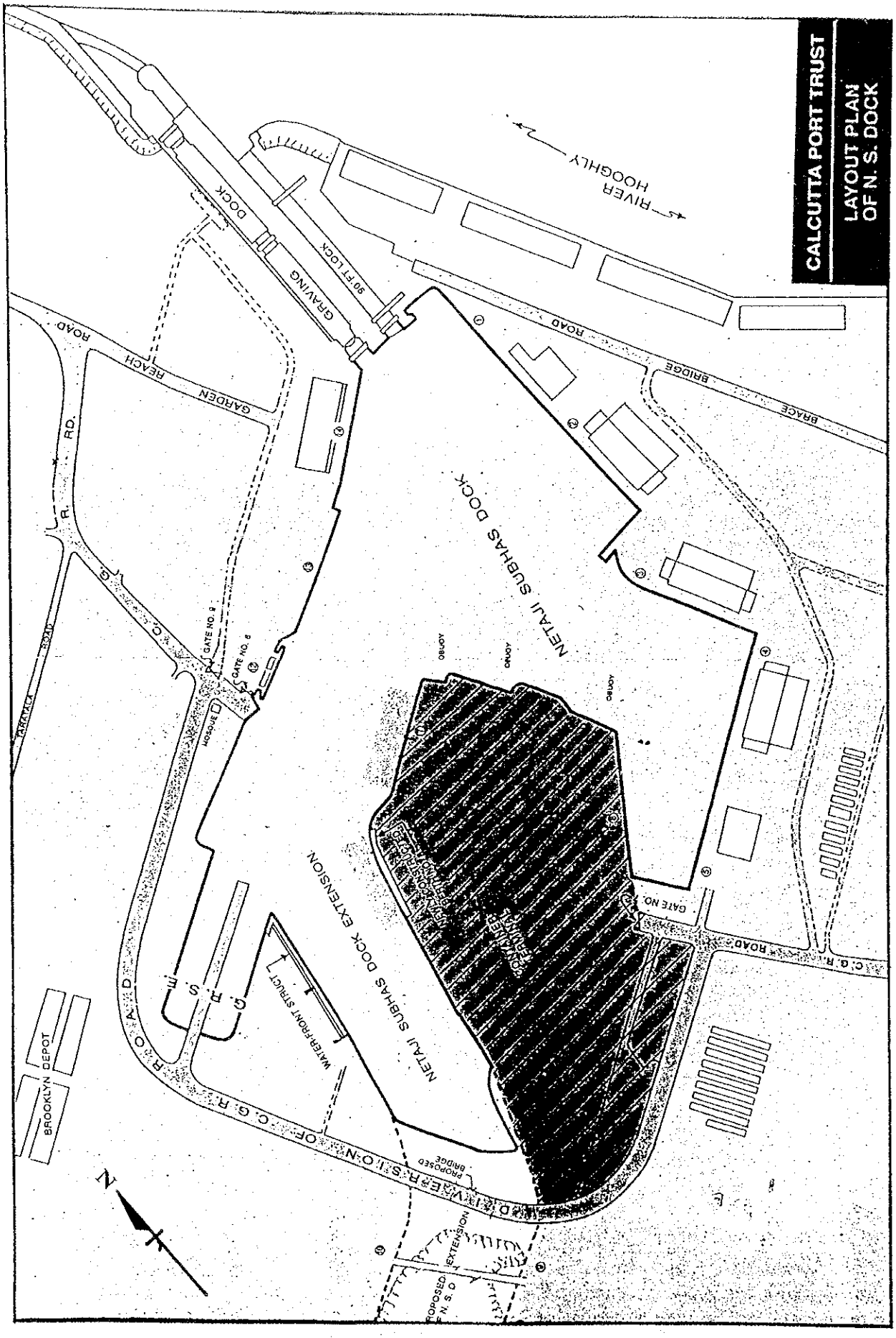

Fig. C-5.8.6 Layout Plan of Netaji Subash Dock at Calcutta Port

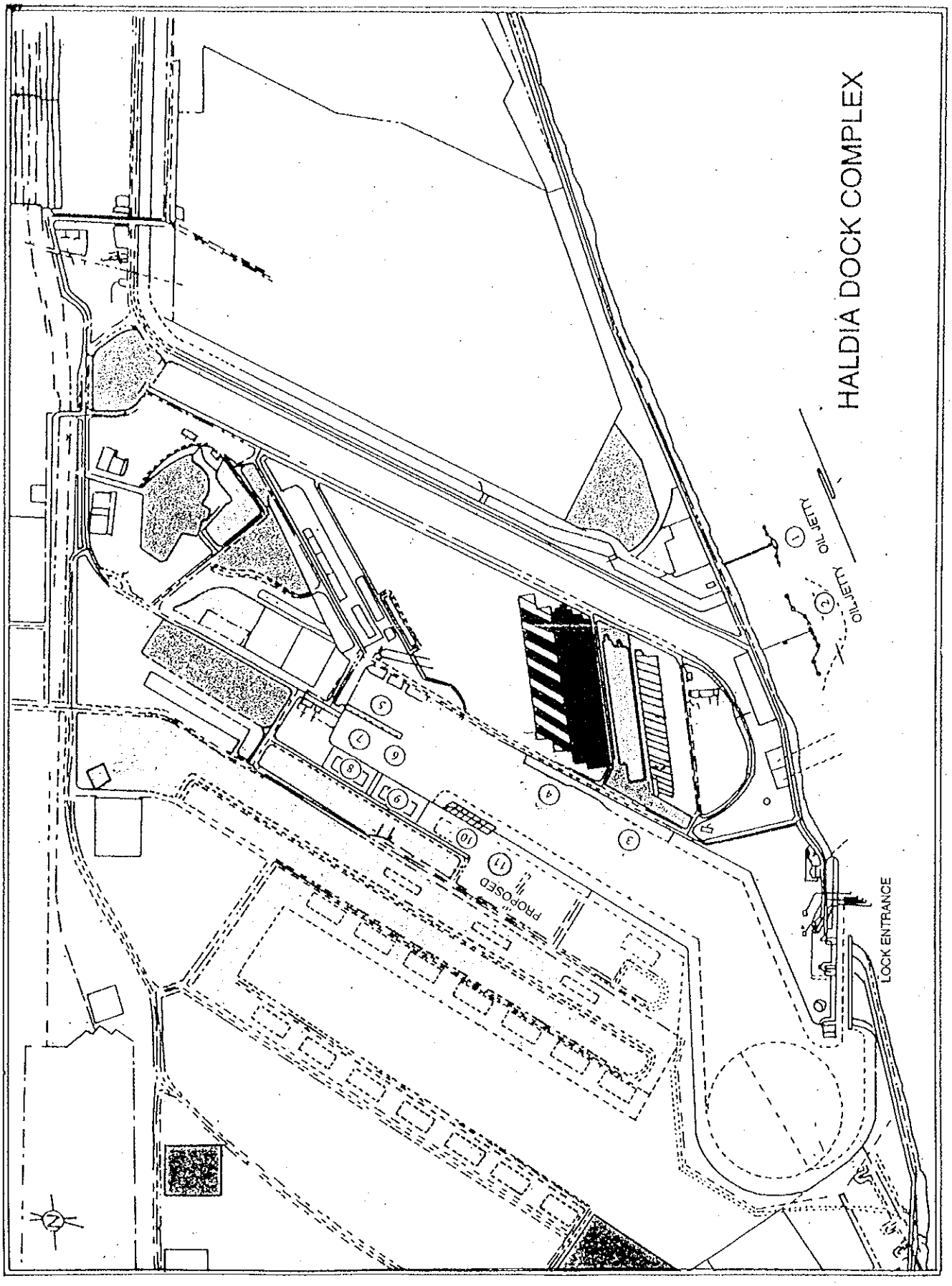

Fig. C-5.8.7 Layout Plan of Haldia Dock Complex (HDC) at Haldia Port

APPENDIX D

BRIDGE ENGINEERING

Engineering Site Survey for Bridge

All the bridges in this sub-section are referred to the bridges proposed by Mongla Port Area Development Project (MPADP) for the purpose of envisaging not particular engineering aspects but general features to make bridge planning.

For the sake of averting confusion regarding position of riverside, the left bank is referred to being located in the left side of river, along the flow direction towards the sea.

1. Rupsa Bridge

(1) Observation on Natural Conditions

1) Location

Located approximately 2.5 km downstream from the Rupsa Ferry Ghat and also 1 km downstream from the Khulna Shipyard. The proposed bridge in the right bank site is accessible by car, but the left the bank is so poorly eroded in a range of 500 m upstream of the proposed bridge site, that it is accessible only on foot.

2) Geography

There are embankments on both sides about 3 m high with a brick-paved, 3 to 5 m wide path on the top.

In the left bank side of the embankment, erosion induced collapses are observed at several locations.

On the right bank, houses are scattered along the embankment, and on the left some factories are situated but only very few number of houses are in the swamps in the hinterland at lower elevations. During rainy seasons it is inundated to 30-50 cm deep.

3) Width, Depth, Current Velocity and Discharge of the River

The results of the topographic, hydrological and bathymetric study are;

- River Width; 586 m (shoulder to shoulder)
- Maximum River Depth; 13.2 m (Water level = +3.615 m PWD)
- Current Velocity; Although during dry seasons a reverse flow (i.e. flow to the upstream) might be observed, the maximum velocity was 2.38 m/sec and no reverse flow was observed at the time of the measurement in the

monsoon season.

- Cross-sectional Area of the River; width at the top = 580 m, width at the bottom = 430 m, average depth = 12.0 m, and thus the cross sectional area is approximately calculated as 6,060 square meters.
- River Discharge; Discharge at high water level is calculated as 6,060 sqm x 2.38 m/sec = 14,400 cum/sec.

4) Shift of Riverbed

- From the hearing survey with selected residents of both sides of the river; one just in front of the shipyard, and the other near the Rupsa East Station, the following facts turned out.
- Around 1970's the river shifted eastward by 60 meters. As the result the land was reclaimed by the accumulated soil on the right bank where some houses and timber factories stand at present. The bank is now used as a road for the local community.
- The left bank has been eroded seriously in the range from the junction of Atherobaki and Rupsa Rivers to the Shipyard, and thus abandoned Rupsa East railway station had to move backward twice, and a mosque, several houses and some factories have drawn into the river bottom.
- According to the Fig.10.2.1 indicating the river shift in Khulna Area between 1973 and 1990, the river has become wider by 100 meters at most.

5) Soil Investigation

- Three soil investigations were conducted at the site by ADB, and the following observations were made.;
  - BH-1 (Right Bank) ; N-value is over 40 between GL-28 and GL-33.
  - BH-2 (Center); N-value is over 50 at GL-24 and deeper.
  - BH-3 (Left Bank); N-value is over 40 at GL-40 and deeper.

6) Inland Water Traffic

- The average of daily inland water traffic counted by type at the site in September, 1998 is as follows ;

Tanker	Passenger Ship	Cargo	Fishing & Others	Total
2	22	144	127	295

(2) Engineering Considerations

1) Bridge Planning

The river current is rapid and, what is worse, the river is also deep at this site.

As to this kind of site, selection of structural type and span length is an essential matter in terms of not only construction planning but also total economy of the project.

Where a river is deep and flows rapidly, less number of piers means less time and cost for constructing the foundations and substructures, and generally at the same time more cost for the superstructure. Selection of an appropriate number of piers, or in other words, span length may largely govern the economy of the project.

In addition to the natural conditions of the river, the navigational traffic must be taken into account in selecting the span length of the bridge during the construction period and after the completion.

Head loss of river section is defined as the ratio of total area of piers in the water against the whole cross-sectional area subject to discharge. Usually head loss is desirable to be lower than 5% in order to mitigate backwater stemmed from river flow. When the span length of the main bridge is over 100 meters and the pier is 4 meters wide, then the ratio is about 3.4 % which is enough below 5 %.

2) Erosion and Scouring

In order to keep the river alignment as it is, and also to protect the land and road/ bridge structures against the river flow, some countermeasures of river training may be required along the both banks.

Such structural calculation will be made on the strength of the foundation that it is safe enough even after the piles or caisson are exposed to the water as the result of scouring. Some other protections such as rip-rap work are required.

3) Transportation of Materials and Machinery to the Site

As mentioned above, the left bank is hardly accessible from existing road at present. Superstructure of bridge will be able to fabricate off-site, but the viaduct and approach road must be constructed on-site, and temporary roads will be required to mobilize materials and construction equipment to the site.

The right bank has an access road to the site but it is not wide enough for the construction purpose of the bridge.

Consequently, a comprehensive construction plan needs to be established, which includes a plan of constructing the access road, timing and order of constructing other relevant facilities like stock yard, approach road and viaduct structures, and may enable smooth land transportation of construction goods to keep the construction schedule.

2. Atherobaki Bridge

(1) Observation on Natural Conditions

1) Location

The proposed site is located at about 3.5 km along the Atherobaki River upstream from the junction with the Rupsa River.

There is a brick field in the vicinity of the site on the right bank.

The left bank of the proposed site is approximately 700 meters away in the north-east direction from abandoned Rupsa East railway station, and there are agricultural lands with few meters deep flood water and a cluster of housings.

The approach road of the Atherobaki Bridge will cross over the abandoned railway but the viaduct will not be affected because it ends before the crossing.

2) Geography

The proposed site is located at the bottom of U-shaped meandering of the Atherobaki River.

As regard the trace of collapse due to erosion on the banks, it was observed slightly more on the right bank side rather than on the left.

3) Width, Depth, Current Velocity and Discharge of the River

The results of the topographic, hydrological and bathymetric study are;

- River Width; 312 m (shoulder to shoulder)
- Maximum River Depth; 9.3 m (Water level = +3.050 PWD)
- Current Velocity; 0.88 m/sec
- Cross-sectional Area of the River; width at the top = 305 m, width at the bottom = 190 m, average depth = 7.0 m, and thus the cross sectional area is approximately calculated as 1,730 square meters.
- River Discharge; Discharge is calculated as
  1,730 sqm x 0.88 m/sec = 1,560 cum.

4) Shift of Riverbed

The bottom of the U-shaped meandering of the river has shifted southward by around 100 meters during the period between 1973 and1990.

5) Soil Investigation

From the vicinity of 32 meters from the ground level, there is a continuity of layers with the SPT values of more or less 40. From the features of these soil layers, they are presumed to be of having similar characteristics of ompacted sandy layers, distributed at Bhairab Bridge site.

6) Inland Water Traffic

- The average of daily inland water traffic counted by type at the site in September, 1998 is as follows ;

Tanker	Passenger Ship	Cargo	Fishing & Others	Total
0	0	146	179	325

(2) Engineering Considerations

1) Bridge Planning

The river current is not so rapid, and also the river is not so deep at this site. Furthermore the river belongs to Class III in terms of the navigational clearance. Thus there's no need to span a wide clearance.

There are pylons for electric power and the cables cross the river parallel to the proposed bridge. This must be born in mind when a construction plan is made.

The head loss of the river section is about 4.0 % when the span of 50 meters long and the pier of 3.0 meters wide are assumed.

2) Erosion and Scouring

As explained before, the river has shifted and this implies the possibility of continuing the same. Therefore the method and extent of the river training must be checked based on the more detailed observation.

3) Transportation of materials and machinery to the site

The similar consideration to that of the Rupsa Bridge must be taken into.

3. Atai Bridge

(1) Observation on Natural Conditions

1) Location

The site is located at about 800 meters upstream along the Atai River from the junction with the Bhairab River.

The right bank side is an island isolated by the Bhairab, Atai and Majudkhali Rivers, where there are agricultural lands without mobilized vehicle traffic except autorickshaw, and no ferry carrying cars to the island is operated.

The left bank is accessible only on foot, though ferry service is operated from the Jail-kana Ghat at the Khulna side.

2) Geography

The right bank shows many collapsed topography due to erosion, while slightly smoother topography appears on the left with an exception of the area in the vicinity of the junction point.

There is a canal on the left bank. The sorrounding area is inundated by the raised river water level to such an extent that the shape of the river alignment cannot be confirmed, and thus changed entirely to be a retarding basin.

3) Width, Depth, Current Velocity and Discharge of the River

The results of the topographic, hydrological and bathymetric study are;

- River Width; 281 m (shoulder to shoulder)
- Maximum River Depth; 12.8 m (Water level = +1.309 PWD)
- Current Velocity; 2.25 m/sec
- Cross-sectional Area of the River; width at the top = 280 m, width at the bottom = 180 m, average depth = 12.0 m, and thus the cross sectional area is approximately calculated as 2,760 square meters.
- River Discharge; Discharge is calculated as
- 2,760 sqm x 2.25 m/sec = 6,200 cum/sec.

4) Shift of Riverbed

According to the map of riverbed shift made by the Surface Water Modelling Centre, the junction point of the Bhairab and Atai River has shifted by about 500 meters. Consequently the portion of the Atai River at the proposed site also has moved by approximately 400 meters during the period between 1973 and 1990.

5) Soil Investigation

Soil from the surface of the right bank side was observed as silt with comparatively less stickiness.

Other soil characteristics are similar to that of the Atherobaki Bridge site.

6) Inland Water Traffic

- The average of daily inland water traffic counted by type at the site in September, 1998 is as follows ;

Tanker	Passenger Ship	Cargo	Fishing & Others	Total
0	1	44	884	929

(2) Engineering Considerations

1) Bridge Planning

Conditions of the river flow, depth and navigation limits are almost same as those of the Rupsa Bridge, but only the difference is the river width, namely the Atai River is approximately half as wide as the Rupsa.

The same idea of selecting the span length and the bridge type may be applied for the main bridge.

As the wide area surrounding the proposed bridge site is frequently inundated in rainy season, pier basis of the viaduct and wet zone of the embankment have to be protected against the water flow.

Of course the river training has to be so designed as to be longer enough than the other bridge sites.

The head loss of the river section is 3.6 % under similar assumption to the Rupsa.

2) Erosion and Scouring

A river training plan, which covers not only the bridge site but also the very wide

low land area, must be established.

Check for the scouring must be made for both the piers of the main bridge and those of the viaduct.

3) Transportation of Materials and Machinery to the Site

Generally it may be most convenient and time saving of the whole construction period to construct the foundations and the substructures during dry seasons when the river water is shallow and slow, and then the superstructures during rainy seasons.

While in the case of the Atai Bridge, construction of the superstructures of the viaduct is not easy during rainy seasons when the area is entirely inundated. In order to approach and construct them, most of the area must be elevated above high water level for construction yards, stockyards and access roads.

4. Bhairab Bridge

(1) Observation on Natural Conditions

1) Location

It is located at a point of 10.5 km upstream from the junction of the Atai and Bhairab Rivers, and also 400 meters downstream from the junction of the Bhairab and Majudkhali River.

The right bank side of the site is about 1.5 km eastward away from the National Road Route 7; between the road and the river a military cantonment and residential land developed by KDA are located.

The left bank side is in the same island as the right bank of Atai Bridge site, and a mosque and a cluster of houses are scattered there.

2) Geography

The right bank is almost flat, and on the left water covers the ground floor of the houses, when the water level of the river rises.

3) Width, Depth, Current Velocity and Discharge of the River

The results of the topographic, hydrological and bathymetric study are;

- River Width; 283 m (shoulder to shoulder)
- Maximum River Depth; 6.7 m (Water level = +3.323 PWD)

- Current Velocity; 1.45 m/sec
- Cross-sectional Area of the River; width at the top = 285 m, width at the bottom = 205 m, average depth = 6.5 m, and thus the cross sectional area is approximately calculated as 1,590 square meters.
- River Discharge; Discharge is calculated as
  1,590 sqm x 1.45 m/sec = 2,300 cum/sec.

4) Shift of Riverbed

Although unfortunately the site of the Bhairab Bridge is out of the study area of the riverbed shift map made by Surface Water Modelling Centre, the following may be easily guessed. The river has not shifted significantly and will not move so much, judging from the fact that the alignment of the river is almost straight in the vicinity of the bridge site, and also there remains a bench mark, established in 1967, near the site without any damage.

5) Soil Investigation

There is a distribution of sandy layer of comparatively well compacted below the surface, and at about the depth of 18 meters there are sandy layers of very high density with the SPT value of 45 to 50.

6) Inland Water Traffic

- The average of daily inland water traffic counted by type at the site in September, 1998 is as follows ;

Tanker	Passenger Ship	Cargo	Fishing & Others	Total
0	8	107	43	158

(2) Engineering Considerations

1) Bridge Planning

The river is not so deep and rapid, but the navigation clearance required is as wide as the Rupsa.

The head loss of the river section is 3.0 % under similar assumption to the Rupsa.

2) Erosion and Scouring

In order to keep the river alignment as it is, and also to protect the land and road/ bridge structures against the river flow, some countermeasures of river training may be required along the both banks.

Such structural calculation will be made on the strength of the foundation that it is safe enough even after the piles or caisson are exposed to the water as the result of scouring. Some other protections such as rip-rap work are required.

3) Transportation of Materials and Machinery to the Site

As mentioned above, the left bank is not accessible by land. The bridge over the river will be constructed offshore, but the viaduct and approach road must be constructed onshore and the materials and construction machinery have to be brought into the site by land.

The right bank has an access road to the site but it is not wide enough for the construction purpose of the bridge.

Consequently, a comprehensive construction plan needs to be established, which includes a plan of constructing the access road, timing and order of constructing other relevant facilities like stock yard, approach road and viaduct structures, and may enable smooth land transportation of construction goods to keep the construction schedule.

5. Common Conditions in the Study Area

Natural conditions that would affect the bridge planning were individually described above.

Mentioned here are the natural conditions such as salinity, earthquake and meteorological conditions that are rather common to all the bridges in the Study.

(1) Salinity

As shown in the Fig. 9.2.3, salinity of the river water in Khulna has an increasing trend between 1984 and 1996.

Salinity of the river water is much affected mainly by rainfall and discharge from upstream, and thus it is not constant in terms of time and place.

The record obtained from the above mentioned data shows the salinity of exceeding 20,000 micro-mhos for the year 1996. As far as the value is concerned, this is similar to

that of seawater.

It is not recommended to utilize steel materials in or near the water with salinity of as high as seawater, in other words to use it for superstructures or piles, considering vulnerable nature to corrosion of the materials.

(2) Meteorological Conditions

Some factors of meteorological conditions affect design of bridges, but others affect construction planning in such aspects as schedule and method.

1) Temperature

Bridges are thermally affected, and then expand and shrink, therefore they must be so designed as to endure the temperature changes.

The maximum and minimum temperature recorded at Khulna Observatory of the Bangladesh Meteorological Department between 1986 and 1995 are 39.4℃ and 7.0℃ respectively.

2) Wind

A superstructure will have wind force usually acting horizontally and thus bridge structure has to be so designed as to be safe against the static force. In case of a very long span and flexible structure, aerodynamic action must be taken into consideration.

According to the wind data recorded at the Khulna Observatory between 1986 and 1995, the maximum wind velocity is 40 knots or 20.6 m/sec. But on the other hand the Statistical Year Book of Bangladesh in 1996 describes that the cyclone which attacked Khulna recorded maximum wind velocity of 150 km/h or 44 m/sec.

3) Rainfall

Generally rainfall will not give any adverse effect except design of the drainage system of the bridge, in terms of design of structure.

On the hand, when construction is planned in detail, volume of rainfall and duration of rain have to be taken into account, as they will govern the construction period.

(3) Earthquake

Two kinds of data on seismic condition are available in Bangladesh as below;

- 「Geological Survey of Bangladesh」
  "Seismic Zoning Map of Bangladesh and Outline of Code for Earthquake Resistant Design of Structure"
- 「Meteorological Department of Bangladesh」
  "Seismic Zones of Bangladesh"

The former divide Bangladesh into three seismic zones, while the latter into four. In either data, Khulna is classified to the lowest zone. The former shows the seismic factor at Khulna to be 0.04, and the latter 0.05.

6. Study on the Existing Bridge Projects in Bangladesh

Design criteria of major bridges in Bangladesh are compared in Table. D-2.1, and present situation of other bridge projects are listed in the Table D-2.2.

Table D-2.1 Comparison of Design Criteria for Major Bridges

Bridge Name	Paksey	Jamuna	5-Bridge	Meghna Gumuti	Meghna
Road Class	National Highway	National Highway	National Road	National Highway Category A	National Highway Category A
Bridge Type	Road Bridge	Road cum Rail Bridge	Road Bridge	Road Bridge	Road Bridge
Bridge Length	1786 m	4800 m	60m thru 215 m	1410 m	930 m
Design speed (Road)	100 km/h				
Cross-section	1.0+7.5+0.67+7.5+1.0	Rail; 3.5, Road;1.0+13.2+0.8=15.0 Total=8.5 m	0.45+7.5+1.25=9.2 m	2@1.0+2@3.6=9.2 m	2@1.0+2@3.6=9.2 m
Number of lanes	4	4	2	2	2
Number of sidewalks	2	2	1	2	2
Longitudinal Gradient	2.40%	0.50%	Level	3.00%	3.00%
Navigation Clearance	V=12.2m (40 ft), H=76.3 m(250 ft)	V=14.65m (40ft) H=76.2m (250ft)	-	V=7.5 m, H=75.0 m	V=18.0 m, H=75.0 m
Design Standards	AASHTO	BS5400 (Code of Practice 3,4,5)	AASHTO, Japanese Standards	AASHTO	AASHTO
Live Load	HS20-44, checked for Alternate Military Loading and 25% overload of HS20-44	HA-Loading	HS	HS 20-44(MS 18)	HS 20-44(MS 18)
Wind	(ASSHTO) multiplied by 1.87	50 m/sec		150 mile/h (66.7m/sec)	140 mile/h (62.2m/sec)
Earthquake	Bangladesh National Design Code (BNDC) ZI=0.125	0.25g (Equivalent to a magnitude 7.0 at 25-50km distance	0.06	0.05	0.05
Temperature Effects		Range from 0 to 48 degrees centigrades			
Boat Collision	5000 kN	5000kN			
Facilities to be carried	High pressure natural gas pipeline,LPG pipeline, electrical interconnector, communication cables				

Table D-2.2 Bridge Project in Bangladesh (As of Sep., 1998)

No.	Bridge Name	Road Name	Remarks
1	5 Medium to short Bridges	Dhaka - Chittagong	Under construction
2	Paksey	Kushita - Ishardi	Tender document prepared
3	Bahirab	Dhaka - Sylhet	Consultant appointed
4	Dhaleswari-I	Dhaka - Khulna	Completed
5	Dhaleswari-II	Dhaka - Khulna	Nearly completed
6	2nd Buriganga	Dhaka - Khulna	Under construction
7	Shanghu	Patia - Anwara - Bashkhali	
8	2nd Karnafuli	Chittagong	
9	Old Brahmaputra	Tangail - Sherpyr	Under construction
10	Arialkha	Dhaka - Mawa - Bhanga	No progress
11	Kushiara	Dhaka - Fenchugonj - Sylhet	
12	Sheola	Sylhet - Bareigram - Kulaura	
13	Doratona	Bagerhat - Pirojpur	Under construction
14	Dharala	Kurigram - Bhurungamar	Feasibikity study
15	3rd Buriganga	Lalbag	Consultants offer received
16	Munshigan	Fatulla - Munsigan	Consultant appointed
17	Chitra	Narali - Lohagora	Under construction
18	Sadipur	Dhaka - Sylhet	Under construction
19	Kaksiali	Satkhira - Bhetkhali	Opened to traffic
20	Thakrakona	Netrokona - Mehendigonj	
21	Ashanmara	Sylhet - Sunamgonj	
22	Karatoyo	Boda - Gebigonj	Completed
23	Dakatia	Chandpur - Raipur	Under construction
24	Baleshrar	Bagerhat - Ourihoyr	Under construction
25	Nabagonga	Narail - Kalna - Batiapara	Under construction
26	Daudkandi	Dhaka - Chittagong	Completed
27	Doarkika	Patuakhali - Faridpur	Consultant appointed
28	Sikerpur	Patuakhali - Faridpur	Consultant appointed
29	Kaligonj(2nd Shitalakhaya	Tongi - Narshingdi	Consultant appointed