2.2 Construction Works

2.2.1 Construction Schedule

18. For the purpose of the feasibility study, it is planned that the construction works of the Project will be started in 1997 with the completion targeted for the year 2005. Part 4 Table 5.1.1 shows the overall construction schedule and TABLE 2.2.1 gives the major construction works with their respective quantities and construction periods.

TABLE 2.2.1 Major Construction Works of the Project

No.	Major Work	Quantity	Construction Period
1	QEQ No. 6 Quaywall	-14.0 m, L = 350 m	1997 to 1999
2	New West QEQ Quaywall	-16.0 m, L = 840 m	1998 to 2003
3	Seawall	Total length 2,950 m	1998 to 2005
4	Revetment and Inner Breakwater	Total length 690 m	2002 to 2005
5	Dredging of Turning Basin	3,800,00 m^3	1999, 2002 and 2003
6	Reclamation	8,900,000 m^3	1999 to 2004
7	Container Yard	713,000 m^2	2000, 2003 to 2005
8	Channel Dredging for West Entrance	1,460,000 m^3	2004 and 2005

2.2.2 Quaywall, Seawall and Breakwater

(1) Graded Rock

19. Construction of the quaywalls, seawall and breakwater under the Project requires graded rocks in an estimated total quantity of nearly 1,600,000 m^3 and, during the most active period of the construction operations, 27,000 m^3 are estimated to be needed each month. Quarries are located in the hills 15 to 20 km east of the Port of Colombo. Trucks will be used for rock transportation to the construction sites. During the busiest period of the construction activities, 250 to 300 trucks will be needed each day for rock transportation. FIGURE 2.2.2 shows the locations of the areas which around in quarries currently in operation.

20. Graded rocks hauled from quarries will be stored throughout the construction period in a storage yard which will be specially provided in the suburbs of Colombo; when called for, they will be transported to construction sites with shorelines where they will be transferred to barges for placement at offshore works under construction. Supposing the stock requirements at the jobsite cover nearly one month of consumption, the storage yard needs an area of 10,000 m^2.

21. TABLE 2.2.2 gives the graded rock requirements as broken down by type of work and by year as well as the monthly and daily stacking needs in each year of the construction period.

(2) Concrete Blocks

22. Three types of concrete block will be used for the construction of the Project. They are wave-breaking blocks, foot protection blocks and armouring blocks. These blocks will be produced near the job sites in three different unit weight categories, i.e. 22 tons, 6 tons and 2 tons. The total number of block units required for the quaywalls, seawall and revetment planned under the Project is estimated at 58,000. Quantities of annual and monthly production of concrete blocks are summarized in TABLE 2.2.3.

23. The concrete blocks will be produced in advance and kept in stock until they are called for to meet the needs of construction works. The required jobsite stock level is considered to be adequate to cover six months of block work. Thus, it is deemed necessary to provide near the job sites a 30,000 m² block production/storage yard with a contiguous shoreline available for block loading.

24. TABLE 2.2.3 gives the concrete block requirements as broken down by type of work and by month as well as estimated monthly and daily production in each year of the construction period.

(3) Fabrication, Launching and Installation of Concrete Caissons

25. A total of 136 concrete caissons will be required to form the main structure of the seawall planned under the Project. These caissons will be fabricated over a period of 8 years. It is planned to fabricate 5 caissons, each weighing nearly 1,700 tons, in a 10,000-ton capacity floating dock at a time. Each year 20 caissons will be produced in 4 cycles of fabrication for launching and installation. At 43 days per cycle a total of 172 days will be devoted per year to caisson fabrication for the seawall construction.

26. Construction of the quaywalls and revetment calls for the production of a total of 68 caissons, all of which will be nearly equal in size. Three caissons, each weighing nearly 2,900 tons, will be produced in the 10,000-ton capacity floating dock at a time. Four annual cycles of fabrication activities will turn out 12 caissons each year for launching and installation. At 51 days per cycle a total of 204 days will be devoted to caisson production for the quaywall and revetment construction.

27. Thus, a total of 376 days will be needed annually for the construction of the quaywalls, seawall and revetment. This is considered as one-year cycle of caisson fabrication. The excess days required per year for caisson fabrication activities will be absorbed by the fabrication period in the year 2004 or 2005, whichever will have time available for the purposes.

28. An onshore space of approximately 5,000 m² with a contiguous shoreline about 100 m long will be needed to serve as a caisson fabrication facility. In addition, a calm water surface will be required for temporary storage of about 20 caissons which will be produced during 6 to 7 southwest monsoon months.

29. TABLE 2.2.4 shows the annual caisson fabrication and launching schedules.

2.2.3 Dredging and Reclamation

30. The Project calls for dredging and reclamation by filling in total volumes of nearly 6,000,000 m^3 and 9,000,000 m^3, respectively. For the purpose of the feasibility study, it is planned that dredge spoils consisting of quality materials will be used to the maximum extent possible to fill up the reclamation area.

31. TABLE 2.2.5 gives the dredging and filling requirements as broken down by year. As can be seen from the table, the required volume of filling material will exceed that of dredge spoils in 1999, thus making it necessary to obtain filling material from offshore sources. During the 2001 - 2004 period, on the contrary, the dredged material will become surplus, necessitating offshore dumping of 100,000 m^3 to 300,000 m^3 annually.

32. FIGURE 2.2.3 shows the offshore dumping area designated by the Sri Lanka Ports Authority.

2.2.4 Construction Yard

33. Construction activities of the Project would be carried out in the outer harbour area of Colombo Port. In consequence, offshore construction operations during the unfavourable southwest monsoon season, in particular, are expected to encounter greater inconvenience. For this reason, it would be indispensable for efficient execution of the construction works to provide a construction yard which can be used throughout the construction period for fabrication and temporary storage of larger caissons during the southwest monsoon period, fabrication and storage of concrete blocks, and storage of graded rocks. Such a yard should be contiguous to a calm water surface.

34. In the inner harbour area of the port, however, it is practically difficult due to its limited spaces to secure a construction yard of adequate dimensions to serve the purposes mentioned above.

35. Therefore, the Study Team proposes reclaiming a part of the northern outer harbour area to build a construction yard for the exclusive use of the contractor. Part 4 FIGURE 5.2.2 illustrates the proposed construction yard for production and storage of construction materials explained in the former section. According to the SLPA, Prima Grain Elevator plans to reclaim a sea area of 5,000 m^2 with authorization from the SLPA and the Coast Conservation Department. The Study Team suggests that the SLPA undertakes the reclamation of the land area for the proposed construction yard through close coordination with Prima Grain Elevator.

36. Once the Project is completed, the construction yard can be expected to be reused as an important land area for redevelopment of the northern part of Colombo Port, e.g. sites for cement and grain silos or other port-related industrial facilities.

TABLE 2.2.2 Quantity Control of Graded Rock Work

No.	Description	Length	Q'ty per Meter	Total Quantity	1997	1998	1999	2000	2001	2002	2003	2004	2005
					1	2	3	4	5	6	7	8	9
I	Quantity of Graded Rock												
	Seawall	2,950 m	360 m3/m	1,062,000 m3		180,540	180,540	180,540	180,540	180,540	159,300		
	Quaywall (380m + 460m)	840 m	400 m3/m	336,000 m3			84,000	84,000	84,000	84,000			
	Revetment (250m + 260m)	510 m	400 m3/m	204,000 m3						67,320	67,320	69,360	
	Breakwater	180 m	200 m3/m	36,000 m3								36,000	
II	Total	4,480 m		1,638,000 m3		180,540	264,540	264,540	264,540	331,860	226,620	105,360	
III	Requirement for Yard												
	Monthly stacking quantity			m3		15,045	22,045	22,045	22,045	27,655	18,885	8,780	
	Daily stacking quantity			m3		684	1,002	1,002	1,002	1,257	858	399	
	Number of trucks(5m3)			No.		137	200	200	200	251	172	80	
	Stacking area for one month		Stacking height = 3.0 m	m²		5,015	7,348	7,348	7,348	9,218	6,295	2,927	
	Required area is calculated to be about 10,000 m².												

TABLE 2.2.3 Quantity Control of Concrete Block Work

No.	Description	Length	Q'ty per Meter	Total Quantity	1997	1998	1999	2000	2001	2002	2003	2004	2005
					1	2	3	4	5	6	7	8	9
I	Quantity of Graded Rock												
	Seawall type-A	240 m	23 No/m	5,520 No		5,520							
	Seawall type-B	300 m	15.7 No/m	4,710 No			4,710						
	Seawall type-C	2,020 m	18.7 No/m	37,774 No				9,444	9,444	9,444	9,444		
	Seawall type-D	390 m	18.7 No/m	7,293 No								3,647	3,647
	Breakwater	180 m	16.4 No/m	2,952 No									2,952
II	Total	3,130 m		58,249 No		5,520	4,710	9,444	9,444	9,444	9,444	3,647	6,599
III	Requirement for Yard												
	Monthly production			No.		460	393	787	787	787	787	304	550
	Daily production			No.		23	20	39	39	39	39	15	27
	Concrete per day	V=(22t*1.2no+6t*5.5no+2t*12no)/2.3=37m3/m V'=37m3/(1.2+5.5+12.0)no=2.0m3/no		m3		46	39	79	79	79	79	30	55
	Stacking area for one month	S=6.0m2*No.of month		m²		2,760	2,355	4,722	4,722	4,722	4,722	1,823	3,299
	Area of block yard shall be enough for the storage of 6 months products.			m²		16,560	14,130	28,331	28,331	28,331	28,331	10,940	19,796
	Required area is calculated to be about 30,000m².												

TABLE 2.2.4 Launching Schedule of Caissons

No.	Description	Q'ty	Unit	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
				1	2	3	4	5	6	7	8	9	Length
													(m)
1	Seawall Caisson	136	No.		15	20	20	20	20	20	15	6	2,720
2	Quaywall Caisson	42	No.			6	12	12	12				840
3	Revetment Caisson	26	No.							12	12	2	520
4	Breakwater Caisson	9	No.									9	180
5	Total Days for Fab.												
	Fabrication		Day		129	270	372	372	372	372	330	177	2,394
	Cycle		Cycle		3	4+2	4+4	4+4	4+4	4+4	3+4	4	300day/y (average)

Caisson Fabrication Schedule

1	Seawall Caisson	Total = 2,710 m	136	Nos	20 No.*6year+16 Nos
1-1	Volume of Caisson	12m*13m*20m	3,120	m3	20 Nos of annual fab.
1-2	Vilume of Concrete		686	m3	
1-3	Weight of Caisson		1,716	ton	r = 2.5
1-4	5 Caissons Fab.per Lot	Total Weight	8,580	ton	
1-5	5 Steps concreting	Days per Lot	43	days	5 step * 8 days+3days
1-6	Annual Required days	43days*4cycle	172	days	4cycle*5No.=20Nos
2	Quaywall Caisson	Total = 1,350m	68	Nos	12 No.*5 year+8 Nos
2-1	Volume of Caisson	18.5m*15m*20m	5,550	m3	(12 Nos of annual fab.)
2-2	Volume of Concrete		1,166	m3	
2-3	Weight of Caisson		2,914	ton	r = 2.5
2-4	3 Caissons Fab.per Lot	Total Weight	8,741	ton	
2-5	6 Steps concreting	Days per Lot	51	days	6 step * 8 days+3days
2-6	Annual Required days	51days*4cycle	204	days	4cycle*3No.=12Nos
3	Summary of Caisson Fabrication work				
3-1	Required Floating Dock		10,000	ton	one floating dock
3-2	Annual Required Days for Fabrication		376	days	(1-6)+(2-6)

FIGURE 2.2.2 Location Map of Quarry

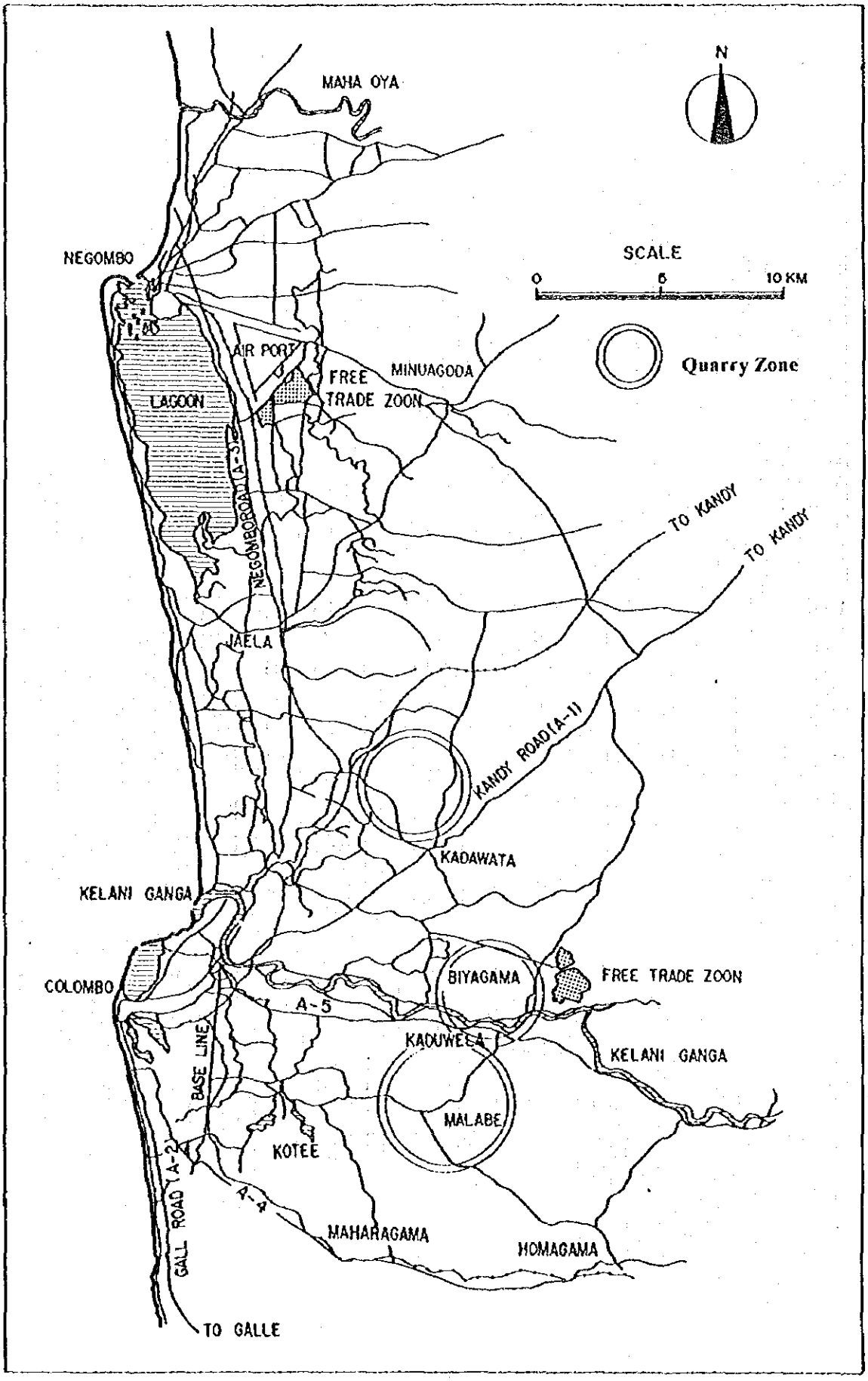
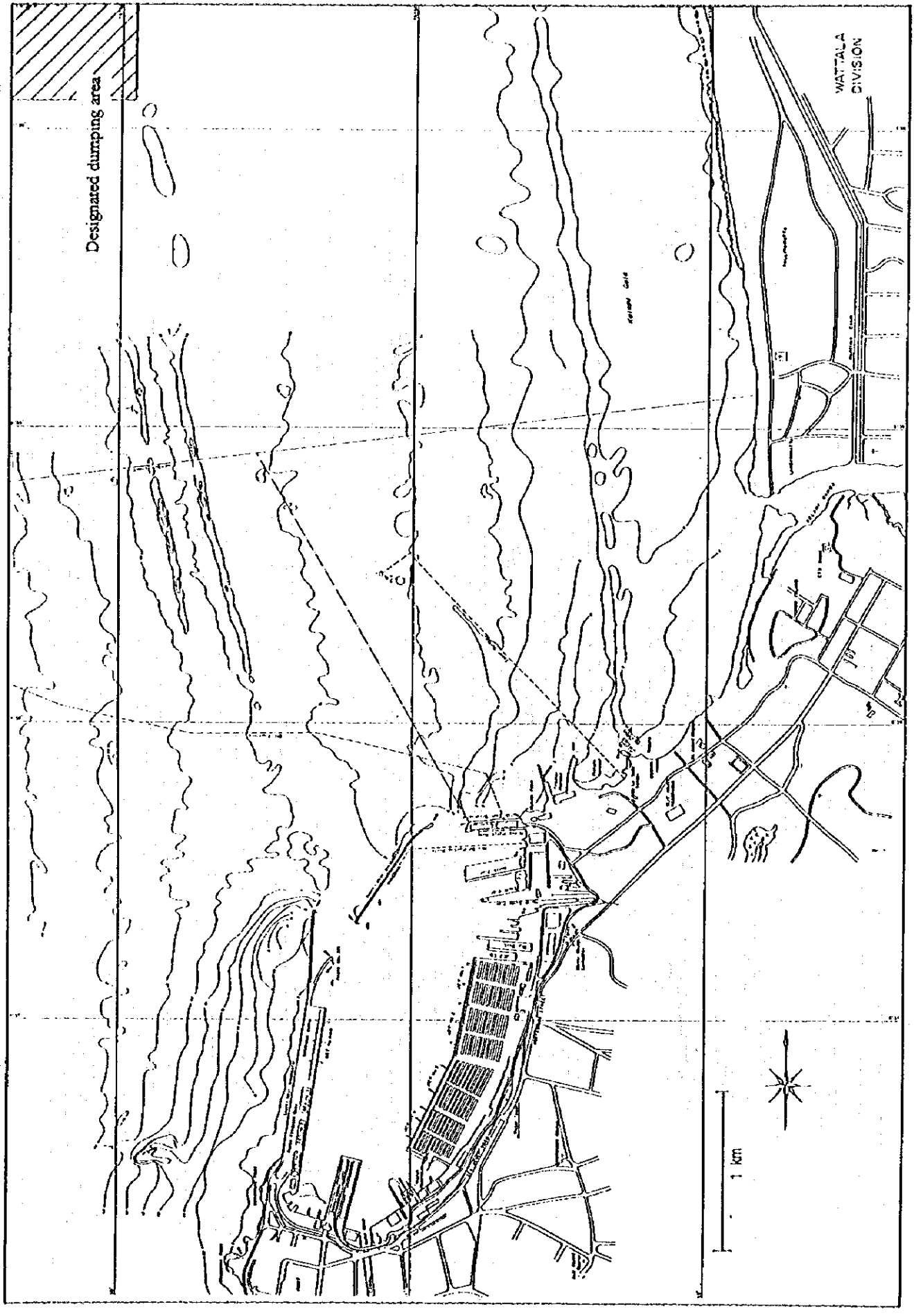


FIGURE 2.2.3 Location of Dumping Area of Dredged Material



3. Initial Environmental Examination

3.1 Coastal and Marine Resources

(1) Environmental Issues

37. Continuous deterioration of Sri Lanka's coastal and marine resources is reportedly a major problem. Key environmental and resource management issues in Sri Lanka are recognized as follows.

Loss of habitats and nursery grounds

38. Beaches, coral reefs, sea grass beds, mangroves, estuaries, lagoons and habitable marine waters comprise important coastal and marine ecosystem in the coast of Sri Lanka. National Economic Action Plan 1995-1998 pointed out that beach erosion along most of the south and west coasts is accelerated, coral reefs are reduced and consequently near shore wave action is increased, mangrove forests are reduced, and so forth.

Over exploitation of coastal resources

39. Over exploitation of fish and other aquatic fauna, sand from beaches and river, and limestone are also indicated in the NEAP. Reduction of fish catch is reported in the near shore areas.

Marine Pollution

40. Marine pollution is reportedly caused by upland erosion, deforestation, industrial effluent, sewage and other discharges and is causing reduced growth rates of coral reefs, other living organisms.

(2) Causes of Degradation

41. The loss of coastal habitat is caused by various reasons, of which coral mining, sand mining, destruction of mangroves, unauthorized industries, bottom trawling, reclamation of wetland, and increasing human population are apparent causes of the degradation. The pollution of coastal and marine areas are mainly caused by the following activities.

- Industrial untreated effluent because of weak Environmental Protection Licensing enforcement.
- Domestic waste from towns and cities which is dumped directly into the sea because municipalities have not yet made the needed treatment investment.
- Solid waste dumped into the sea by shoreline residents and ships because of lacks of regulation and eduction.

TABLE 3.1.1 Polices for Coastal Resources Management

Policies for Improved Coastal and Marine Resources Management	
Policy 1.	The coastal management programme will proceed simultaneously at the national, provisional, district and local levels with the collaboration required to achieve effective and participatory resource management by governmental and nongovernmental agencies.
Policy 2.	Implement a programme to monitor the condition and use of coastal environmental systems and the outcomes of selected development and resource management projects through the collaboration of the Coast Conservation Department, National Aquatic resources Agency, Central Environmental Agency, Irrigation Department, Ministry of Fisheries and Aquatic Resources.
Policy 3.	Implement a research programme of direct relevance to CRM through NARA, national universities and other institutions which will provide a better understanding of ecological processes and social and cultural issues as well as provide information of critical importance to the formulation and implementation of CRM plans.
Policy 4.	Implement a programme to strengthen institutional and human capacity to manage coastal ecosystems.
Policy 5.	Update and extend the scope of the master plan for coastal erosion management.
Policy 6.	Implement a programme to create awareness, both by national and provisional government personnel and NGOs of the strategies for coastal resources management and issues they address.

Source: National Environmental Action Plan 1995 - 1998, Ministry of Environment and Parliamentary Affairs, June 1994

3.2 Initial Environmental Examination

42. Since the Environmental Impact Assessment Regulations entered into forth in 1993, most large projects are subject to EIA studies. The development of new port of Colombo will be required to implement an EIA study focussed on the prediction of changes in the surroundings.

43. Major sources of adverse effects of port development can be categorized into three types: (a) location of port; (b) construction; and (c) port operation, including ship traffic and discharges, cargo handling and storage, and land transport. Location of port connotes the existence of structures or landfills, and the position of the development site. Construction implies construction activities in the sea and on land, dredging, disposal of dredged materials, and transport of construction materials. Port operation includes ship-related factors such as vessel traffic, ship discharges and emissions, spills and leakage from ships; and cargo-related factors such as cargo handling and storage, handling equipment, hazardous materials, waterfront industry discharges, and land transport to and from the port.

44. Environmental facets to be considered in relation to the development of the new port of Colombo are categorized into nine groups: (a) water quality; (b) coastal hydrology; (c) bottom contamination; (d) marine and coastal ecology; (e) air quality; (f) noise and vibration; (g) waste management; (h) visual quality; and (i) socio-cultural impacts.

45. Checklists of adverse effects of port development for IEE have been compiled by several organizations including the World Bank, the Asian Development Bank, the International Association of Ports and Harbors. and Japan International Cooperation Agency. Based on the these checklist potential adverse effects are checked as listed in Table 3.2.1[1].

46. As a result of screening, following factors are selected for a detailed study.
- Changes in current patterns which may be caused by dredging and construction of breakwaters/seawalls;
- Disposal of dredged material;
- Changes in water quality of the inside and outside of harbour;
- Coastal hydrology on the south and north coast of the new port;
- Traffic load on access roads; and
- Air pollution which may be caused by future port traffic.

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[1] Environmental Considerations for Port and Harbor Developments, World Bank Technical Report No.126, 1990

TABLE 3.2.1 Initial Environmental Examination Check List

Factors	Impacts
(1) WATER-RELATED ITEMS	
a. Dredging	
i. Toxic, harmful substances in water column, Sunlight penetration, Smothering bottom biota	Not detected
ii. Influence on tidal flows, Accelerated natural sediment deposition, Attraction of desirable or undesirable fisheries, Altered bottom biota	Influence on Kelani River to be considered
iii. Change in current patterns, Shorezone and beach erosion, Accelerated sediment deposition—shoaling	Impact of the reclamation to be studied
iv. Loss of bottom habitat, shellfisheries, fishery food resources	Bottom habitat of particular importance is not detected
v. Salt water intrusion, Accelerated groundwater flow to estuary	No dredging planned in river area
b. Dredged material disposal	
i. Selection of appropriate disposal site, Methods of dredging and dredged material transfer and related disposal impacts	Dumping site located offshore. No adverse effect reported from dumping in the past.
ii. Characteristics of Dredged Material	Sand and sandy silt
iii. Disposal Methods (Potential or requirements for capping, Alteration of current patterns, Accelerated shoaling)	Dumping from dredgers, No particular adverse effect reported in the past.

c. Landfills and Construction of breakwaters	
i. Loss or displacement of Shellfisheries, Fishery food resources lost or displaced	Significant effect is not identified
ii. Desirable, undesirable species formed by structures (especially pilings and breakwaters)	Not detected in the past
iii. Alter currents, Sediment deposition accelerated, Change required in harbor maintenance dredging practices	Changes in currents to be simulated.
iv. Dispersal of suspended sediments	Limited area near offshore dumping site is affected
d. Alteration of harbor/port ship traffic patterns	
i. Relocation of navigation markers, moorings	Not required
e. Ship discharges — oily ballast; bilge water; sewage	
i. Regulations controlling cleaning procedures, Limitations on release of cargo and machinery space residues (Discharge limitations), Need for facilities to receive waste from ships, Means of storage and ultimate disposal of residual wastes	Majority of calling ships is container and breakbulk ships. International regulations are applied
ii. Importance to fishery resources, Water quality of rivers, bays, harbors	Monitoring is ongoing. Change in Water quality to be studied
iii. Shore facilities for receiving ship generated sewage and garbage waste, Sanitary treatment facilities (Connection to special or municipal systems), Transfer and pumping facilities	No facilities available

f.	Detection and clean-up of spills	
i.	Type of Spills (Oils, Lubricants, Hydraulic oils, Fuels, Liquid and solid chemicals), Frequent spill sources	No significant spill was detected.
ii.	Spill clean-up measures (Regulations, Clean-up equipment available), Spill detection routines, Contingency plan	Oil berth to be equipped with oil fences
iii.	Dry cargo releases (Fugitive emissions, Dust control, Smoke density and effects)	Bulk operations have little dust emission
g.	Waterfront industry discharges	
i.	Sanitary wastes (Sources, Volumes, Special contaminants)	Soil water discharged
1)	Sanitary treatment facilities (Existing, Planned, Proposed, Capacity of each, Locations, Discharge water quality, Ability to handle shipping)	No facility available
ii.	Non-sanitary wastes (Sources, Volumes, Toxins)	Discharges from ship building yard
1)	Discharge/treatment procedures (Capacities, Discharge points, Limitations, Residuals)	Direct discharge in 2 km offshore
2)	Discharges reaching harbor/river waters, Dispersion, Settling tendencies	To be studied
3)	Non-sanitary spillage from non-ship related activities (Types of spills, Frequency, Volumes, How handled, Retention/recovery systems)	No spillage detected
iii.	Heated process water discharges (Electricity generation, Industrial processes, LNG condensation)	Heated water discharges not detected

(2) LAND-RELATED ITEMS	
h. Excavation for fill	
i. Shore sand/gravel excavation, Dust (fugitive emissions), Blasting	Gravel to be obtained from mountain area
ii. Transportation to construction site	Transportation by tracks
i. Wetland damage and filling	
i. Ecological value of wetlands (Use by domestic animals, Use by other fauna, Unique vegetation, Irrigation water source, Damage to flora)	Not detected
ii. Runoff from ports and harbor facilities, Existing contamination input	No contamination detected
j. Loss of usable uplands	
i. Types of land areas likely lost to waterfront use (Residential areas, Market centers, Commercial areas)	Usable land is not lost
ii. Residential relocation, Replacement farmlands, Other replacement/relocation needs	No relocation of residential area, farmlands
k. Noise from ports and harborside industry:	
i. Location of noise sources, Background noise level	Noise from container yard is limited
l. Dust and other airborne emissions	
i. Sources (industrial, construction), Raw material storage	Not detected
ii. Smoke and other combustion products (ships, traffic, industry	Smoke from ships seen temporarily
iii. Projected traffic increases (Roadway additions/improvements, Important routes)	Ship traffic will increase by 1.7-2.6 times in 2005
m. Handling and disposal of solid shore generated wastes	
i. Important sources (Ships, Waterfront industrial areas, Residential areas)	Sewer outfall located in the sea
ii. Means of transport/transfer (Ship-to-shore, Onshore)	
iii. Disposal methods (Incineration, Landfills)	

n.	Traffic related items	
	i. Existing traffic load (Roadway network, Traffic load, Accident data)	To be studied
	ii. Projected traffic increases (Roadway additions/improvements, Important routes)	To be studied
o.	Handling and disposal of solid shore generated wastes	
	i. Important sources (Ships, Waterfront industrial areas, Residential areas)	Not discharged
	ii. Means of transport/transfer (Ship-to-shore, Onshore)	Not discharged
	iii. Disposal methods (Incineration, Landfills)	Landfills
p.	Runoff from raw material storage	
	i. Nature of materials (Salt, Sulfur, Metal ores, Refined concentrates)	Sugar, Fertilizer, Grain
	ii. Typical storage conditions, Locations, Storage time, Health menace to workforce)	Warehouse and Silo
q.	Visual impacts	
	Structure, Painting, Lighting, Attempts to blend with surroundings,	Lighting in container yard seen during night

(3) AIR-RELATED ITEMS	
r. Background information	
i. Meteorological Data (Prevailing winds, Seasonal weather patterns, Storm tracks, frequency and severity, Rainfall records, Wind rose data)	Available in this report
ii. Identify sensitive areas	No detected
s. Gases, smoke, and fumes	
i. Sources, components, controls (Industrial contributions, Ships, Residential background, Vehicle emissions, Background from other areas)	Emission from ships and vehicles
(4) HAZARDOUS MATERIALS/CARGOES	
t. Categories — gases, liquids, solids	
i. How stored, Location of storage areas. Shipping and handling procedures, Disposal of any hazardous wastes generated	Handled at a restricted area in the Port
(5) SOCIO-CULTURAL ITEMS	
Tribal, cultural, ethnic, historical, religious aspects likely impacted by changes, including consequences of modernization and industrialization Preserving traditions with minimum loss and disturbance, Removal of graveyards, churches, etc.	Expansion of port brings no significant change in culture No relocation planned

4. Coastal Features

4.1 Coastal Conservation

47. Sri Lanka, belonging to the Indian subcontinent, originated in the supercontinent Gondwanaland which had been disintegrated into Indian subcontinent, Antarctica, Australia, Madagascar, Africa and South America in Jurassic times (135 - 180 million years ago) (C.M.Madduma Bandara : 1989). In Sri Lanka rocks geologically consists mainly (>90%) of ancient crystalline formations (charnockite, gneiss, granite and metasediment) and have been relatively stable since one billion years ago (Pre-cambrian Era).

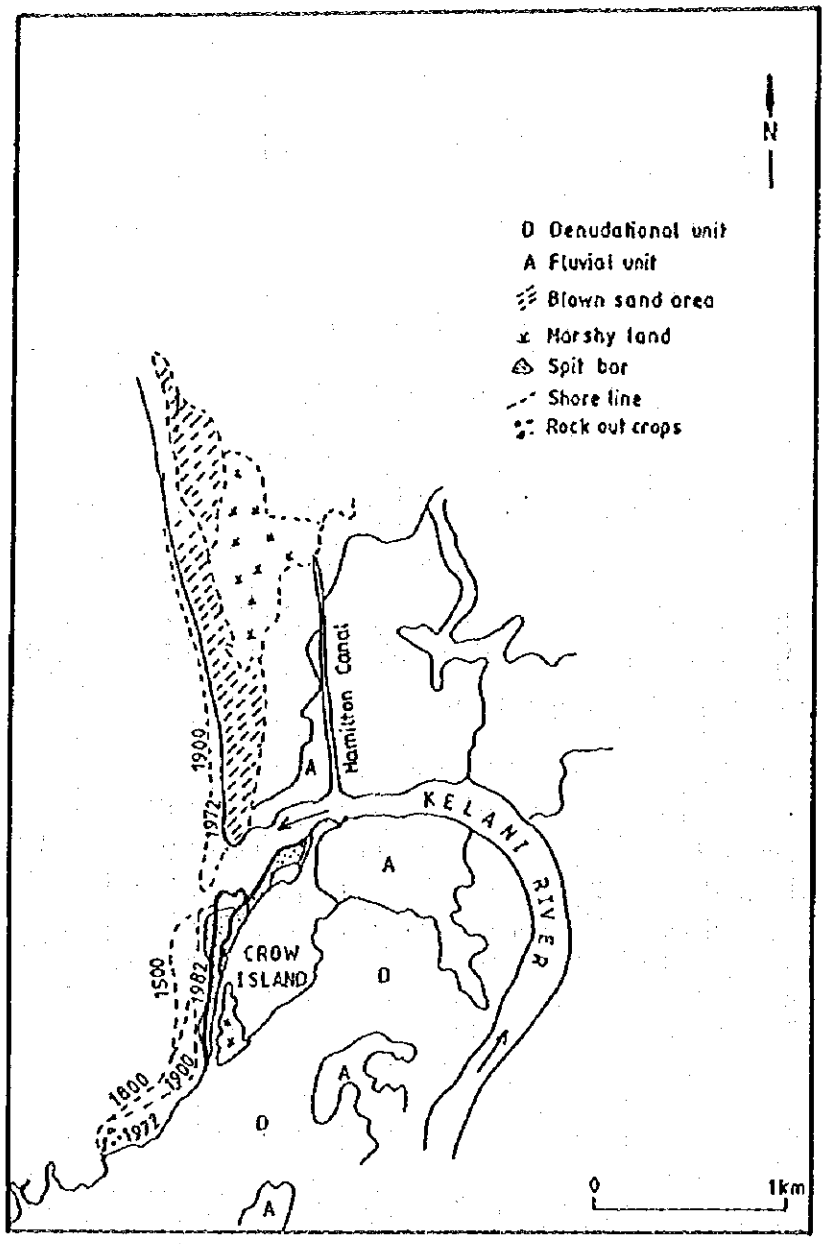
48. The southwest coast mostly consists of Holocene sediments (unconsolidated sand, alluvium and laterites) covering Pre-Cambrian bedrock (granitic gneiss). In the last glacial period (Pleistocene, approx. 10,000 years ago), the coastline was supposed to be the present water depth of 18 m with the most crenelated contour. The sand spits have developed on both sides of Kelani Ganga, Centering in the rivermouth. The southern lagoon was gradually reclaimed naturally and artificially and remained as the water area in Colombo Port. Colombo Port started in Portuguese period and has affected the coastal evolution after the construction of breakwaters in 1875.

49. Along the reach of Kelani Ganga, the second largest river (annual discharge 5,582 million m^3), voluminous sand has been extracted (222,771 m^3/year) as the construction material of many buildings in Colombo City.

50. On both coasts of the rivermouth, the erosive characteristics have been supposedly influenced or accelerated by the structures against floods and saline water intrusion, the excavation of Hamilton Canal and the construction of Colombo Port (FIGURE 4.1.1). The south coast of the rivermouth was partly fostered by the northward sand drift supplied from the Kalu Ganga, deduced from the mineral, roundness and grain size of sand.

51. Along the southwest coast between Colombo and Galle, the shore protection works is said to be effective against beach erosion.

FIGURE 4.1.1 Shore Line Changes at Crow Island Reconstructed From Historical Maps Aerial Photographs



(Source: C.M.MADDUMA BANDARA; Coastal Changes of Crow Island and its Environs, 1989)

4.2 Currents

4.2.1 Currents in Harbour Basin

52. A currents observation in harbour basin was carried out on August, 1993 as part of an Environmental Study of Colombo Port. Currents velocities mostly range from 0.05 m/sec to 0.25 m/sec. Near the northeast entrance there is always observed a current moving from the outer to the inner harbour area. At the center of the harbour the currents commonly flow toward the inner harbour, or to the S or SW direction. FIGURE A.4.3.1, Part 2 shows the typical spatial distribution of the currents in harbour basin.

4.2.2 Offshore currents

53. Field observations of offshore currents were made by means of an electromagnetic current meter installed at a depth of -15 m off the northern shores of the existing Port of Colombo. The currents observation records covering the period between October 1995 and February 1996. The prevailing current directions are NNW to NNE centering around N, and that current velocities below 0.1 m/sec are accounted for 98.7% of the total velocities measurements.

54. Spot current observations of 25-hour duration for 9 different points were made by means of direct-reading current meters on February, 1966 (at spring tide). FIGURE A.4.3.4, Part 2 shows spatial distribution of currents in northern area. The current velocities range from 0.1 m/sec to 0.4 m/sec, and the currents flow toward N direction at nearshore but directions are not apparent.

55. TABLE A.4.2.1 shows the component current velocities of four major constituents (M2, S2, K1 and O1) computed by harmonic analysis. The constituent which gives the maximum velocity is M2 or K1, but the component current velocities are all below 0.1 m/sec.

4.2.3 Littoral currents

56. During the September-October 1995 and the January-February 1996 littoral current observations were carried out using floats at the depth of approximately -2 m, to the 8 points with the interval length of approximately 300 m. Off the southern shore near the fishery harbour the littoral currents flow toward S or SW direction (toward Colombo port) and along the coast north of Kelani river mouth currents flow northward. The maximum current velocity was 0.3 m/sec and the velocity measurements were mostly less than 0.1 m/sec.

TABLE 4.2.1 Component Current Velocities (Tidal Ellipses)

Point	Layer	CO.	Ellipse of Tidal Current						Constant Current	
			Long Axis			Short Axis				
			Dir. (deg)	Vel. (m/s)	Lag. (deg)	Dir. (deg)	Vel. (m/s)	Lag. (deg)	Dir. (deg)	Vel. (m/s)
Offshore Depth -15m	Middle	M2	7	0.074	328	97	0.019	238	13	0.151
		S2	7	0.050	14	97	0.013	284		
		K1	359	0.024	329	89	0.008	239		
		O1	359	0.010	358	89	0.003	268		
	Bottom	M2	24	0.003	236	114	0.001	326	10	0.024
		S2	272	0.003	150	2	0.002	60		
		K1	329	0.006	271	59	0.003	181		
		O1	354	0.004	308	84	0.000	218		
Near Outside the Main Entrance Depth -10m	Middle	M2	41	0.020	318	131	0.003	228	236	0.011
		S2	41	0.013	4	131	0.002	274		
		K1	36	0.032	110	126	0.009	20		
		O1	36	0.014	139	126	0.004	49		

5. Description of the Environmental Conditions

5.1 Water Quality

5.1.1 Existing Survey Data

57. In Colombo Port, a water quality survey was carried out by the SLPA from April to December 1993 as part of its Environmental Monitoring Study. During the survey the water samples collected from different points in the port and neighboring waters were analyzed to determine the principal water pollution indices (pH, SS, DO and COD). The water quality of the port as investigated may be summarized as follows:

58. pH shows slight monthly variations, ranging from 6.8 to 8.7. DO is sub-saturated, fluctuating between 1.3 and 8.3 mg/ℓ and SS reaches its maximum during rainy season supplied with wastes. COD shows limited variations between 0.6 and 10.0 mg/ℓ except the excessive values up to 37.4 mg/ℓ in April, presumably polluted with organic solvent, oil, during rainy season supplied with wastes.

5.1.2 Water Quality Survey during SW Monsoon Season

(1) Harbour Basin

59. During the SW monsoon season a water quality survey was conducted with the following details:

Time and date of sampling:	0930 to 1145, 29 August, 1995
Point of sampling:	5 points H1 - H5 (see FIGURE A.5.1.1)
Layers of sampling:	Surface, middle and bottom

60. TABLE A.5.1.1 presents the outcome of sample analysis in terms of the key water pollution indices. As seen from this table, DO has values of 5.0 mg/ℓ or higher except the samples taken from Point H4 which exhibited smaller values. The largest COD value is 11.7 mg/ℓ. Samples from Point H1 in front of JCT 3 showed higher COD values than those collected from the other sampling points. With respect to SS, samples obtained from the bottom layers of Points H3 and H4 in the central part of the harbour basin showed much higher values than those collected from the other sampling points. Generally, the values presented in TABLE A.5.1.1 do not vary appreciably from the data derived from the aforesaid water quality survey performed over the April-December 1993 period.

(2) Area Off North Shore of the Port and Kelani River Mouth

61. In view of the lack of existing water quality data pertaining to this sea area, water sampling and laboratory analyses were undertaken as part of the first series of field surveys. The sampling days were listed in TABLE 5.1.1

TABLE 5.1.1 Water Sampling Days (SW monsoon season)

Month	Date	Sampling Points	Remarks
September 1995	19th Sep.	O1 - O5 & F1 - F3	Outer Harbour & Fishery Harbour
	20th Sep.	N1 - N3, C1 - C3 & R1 to R5	North of the River Mouth & Kelani River

62. FIGURE A.5.1.2 indicates the sampling points in the Outer Harbour, Fishery Harbour and On the north of the river mouth which are marked as O1 - O5, F1 - F3 and N1 - N3. FIGURE A.5.1.3 indicates the sampling points in the Kelani River marked as R1 - R5 and C1 - C3. Sampling was carried out at each point from the depths indicated below:

Outer Harbour, Fishery Harbour & North of the Kelani River Mouth	Kelani River
*Surface layer	*Surface layer
*Middle layer	*Bottom layer
*Bottom layer	

63. TABLES A.5.1.1 and A.5.1.2 present the analysis results of the water samples collected in the outer harbour, fishery harbour, on the north of the Kelani River mouth and in the river, respectively. The analyses involved the eight key water pollution indices: salinity, temperature, pH, DO, COD, SS, T-P and T-N.

64. For the outer harbour area, DO values ranged form 5 to 7 mg/ℓ and COD values were in the range of 3 to 6 mg/ℓ. SS values, on the other hand, were generally much smaller than those for the other areas surveyed. T-N and T-P values were also generally lower than for the remaining areas investigated.

65. For the fishery harbour, the samples collected showed higher COD, SS and T-P values than for the outer harbour. The SS values for the middle and bottom layers were much higher than in the outer harbour area.

66. For the area north of the Kelani River mouth, the COD values were at substantially comparable level to those for the fishery harbour. Samples obtained from the bottom layer of Point N-2 showed an exceptionally large value. This may be attributable to disturbances induced by waves. The sampling activities were carried out during the SW monsoon season and much difficulty was experienced in collecting samples at predetermined points because of higher waves generated in the area off the north shores of Colombo Port.

67. For the Kelani River, the COD values were in the 5-9 mg/ℓ range. Samples collected from the bottom layer showed SS values ranging from 10 to 200 mg/ℓ.

(3) Well Points

68. A well water quality survey was undertaken in a fishing community near the fishery harbour and in another community on the north of the Kelani River mouth. Details of the survey are as follows:

Time and date of sampling	:	0945 to 1150 hours, 10 October, 1995 (The weather was rainy.)
Point of sampling	:	6 points W-1 to W-6 (see FIGURE A.5.1.4)
Layer of sampling	:	Sampling was made from the bottom layer since the wells investigated except W-2 were all less than 1 m deep. At W-2 samples were obtained from both surface and bottom layers.

69. TABLE A.5.1.2 also gives the analysis results of the samples in terms of the eight key indices of water quality. Well water is clean with minimal pollutant.

5.1.3 Water Quality Survey during NE Monsoon Season

70. During the NE monsoon season, the water quality survey was conducted in the same manner as that in the SW monsoon season (TABLES A.5.1.3 and A.5.1.4). The sampling days were listed in TABLE 5.1.2. The overall characteristics of water quality is similar in both monsoon seasons and needless to repeat their explanation. In NE monsoon season, 2 physical items (colour and transparency) were additionally measured for the convenience of sensible apprehension.

71. In the inner harbour, salinity is generally lower than in SW monsoon season (TABLE A.5.1.3). Water colour (yellow green) and transparency (2 to 5 m) reflect medium pollution in the outer and inner harbours. Transparency (1.2 to 1.8 m) indicates severe pollution in the Fishery Harbour and the north area of Kelani river mouth. River water is somewhat polluted with some COD (around 5 to 10 mg/ℓ) and causes its low transparency of 1.0 to 1.4 m.

TABLE 5.1.2 Water Sampling Days (NE monsoon season)

Date	Time	Location	Sampling Points
11th January 1996	am	Inner Harbour	H1 to H5
25th January 1996	pm	Kelani River (Con. Mate)	C1 to C3
26th January 1996	am	Well Water	W1 to W6
08th February 1996	am	Outer Harbour	O1 to O5
		Fishery Harbour	F1 to F3
09th February 1996	am	North of River Mouth	N1 to N3
	pm	Kelani River	R1 to R5

72. Well water is naturally clean and potable with little pollution except some salinity near the coastline. Summarizing the survey results during SW and NE monsoon seasons, fresh water quality is naturally best in the wells (potable), followed by the Kelani river (for water supply).

73. Sea water quality is best, even though somewhat polluted, in the outer harbour which can be tentatively regarded as the background level (Salinity 1.8%, COD 4 ~ 5 mg/ℓ, SS 1.5 ~ 2.0 mg/ℓ, DO 6 ~ 7 mg/ℓ). Sea water is fairly polluted in the fishery harbour and the innermost area of the inner harbour. For harbour water, the tolerance limits for marine coastal waters (SLS 775 : 1987) are prescribed as TABLE 5.1.3. Referring to the colour and odour, sea areas seem to be polluted to some extent.

TABLE 5.1.3 Tolerance Limits for Water Quality

Determinant	Tolerance Limit
Colour	No noticeable colour
Odour	No offensive odour
Floating Material	No visible floating matter
SS	Not specified
pH	6.5 to 9.0
BOD (mg/ℓ)	5
Oils and greases (mg/ℓ)	10
Phenolic OH (mg/ℓ)	Not specified
As (mg/ℓ)	Not specified
Hg (mg/ℓ)	Not specified
Free ammonia N (mg/ℓ)	Not specified
DO	3
Pesticides CL (mg/ℓ)	Not specified
Coliform bacteria (MPN/100 mℓ)	2500
Bio-assay test	Not specified

TABLE 5.1.4 Water Quality (SW : upper, NE : lower)

Area	Point	Salinity (%)	PH	DO (mg/l)	COD (mg/l)	SS (mg/l)	T-P (mg/l)	T-N (mg/l)	Color	Transp
Inner Harbour	H1-5	1.36-2.40	7.99-8.31	2.3-6.5	2.71-11.69	3.0-103.0	0.07-0.41	0.01-0.24	-	-
		1.58-1.88	7.99-8.36	1.3-12.1	2.85-12.26	6.5-29.5	0.07-0.33	0.02-0.09	Yellow Green	-
Outer Harbour	O1-5	0.82-2.20	8.20-8.60	5.4-6.7	1.83-8.92	1.5-13.0	0.05-0.10	0.01-0.08	-	-
		-	7.20-8.50	6.3-13.7	3.96-9.97	4.5-22.0	0.04-0.21	0.03-0.09	Vivid Green	1.8-5.6
Fishery Harbour	F1-3	0.74-2.25	8.10-8.38	2.1-6.8	3.43-19.44	6.0-128.0	0.08-0.85	0.01-0.05	-	-
		-	7.60-8.10	6.6-13.5	5.95-12.46	7.0-29.5	0.07-0.19	0.04-0.15	Yellow Green	1.2-1.4
North of Kelani River	N1-3	0.98-1.98	-	2.0-7.0	6.41-14.18	5.0-48.5	0.05-0.41	0.01-0.09	-	-
		-	6.90-8.00	6.5-15.3	4.98-9.06	3.5-16.5	0.07-0.14	0.03-0.05	Yellow Green	1.4-1.8
Kelani River	R1-5	0.00	-	3.5-7.2	4.58-16.93	3.0-26.5	0.05-0.54	0.01-0.02	-	-
		-	6.50-7.70	4.2-7.5	5.44-12.23	1.0-3.0	0.06-0.28	0.05-0.23	Yellow Green	1.0-1.4
	C1-3	0.00	-	7.2-7.3	5.26-8.01	5.0-31.5	0.05-0.10	0.01-0.01	-	-
		0.00	6.10-6.60	7.7-8.0	3.99-10.83	2.6-4.4	0.03-0.01	0.01-0.17	Yellow Green	1.0-1.4
Well	W1-6	0.00-0.02	6.94-7.75	1.3-4.6	3.47-8.68	0.4-0.8	0.03-0.08	0.01-0.11	-	-
		0.01-0.02	6.53-7.08	2.0-5.3	2.05-5.47	0.4-1.4	0.02-0.06	0.01-0.06	Clean	-
Tolerance Limit			6.5-9.0	3		Not Specified			No Notice-able Colour	

5.2 Sediment Quality

5.2.1 Sediment Sampling during SW Monsoon Season

74. Sediment samples were collected twice at a total of 22 different points in the outer harbour area, fishery harbour, on the north of the Kelani River mouth, and in the river to determine the characteristics of sediments in both SW and NE monsoon seasons. Details of the first survey are as follows:

Date sampling:	19 September, 1995 (outer harbour and fishery harbour) 20 September, 1995 (on the north of Kelani River mouth and in the river)	
Points of Sampling:	Outer harbour:	5 points O-1 to O-5
	Fishery harbour:	6 points F-1 to F-6
	North of Kelanai River mouth:	6 points N-1 to N-6
	Kelani River:	5 points R-1 to R-5 (see FIGURES A.5.1.2 and A.5.1.3)

75. TABLE A.5.2.1 shows the characteristics of sediment samples collected, and TABLE A.5.2.2 their chemical compositions. Sediments vary widely from coarse sand in Kelani River to silty clay in the outer harbour and the north coast of Kelani river mouth.Natural colour (brown) turns into blackish or green in the polluted sea area with organic material (T-N, T-P and O-P), coral fragments and heavy minals.

5.2.2 Sediment Sampling during NE Monsoon Season

76. Sediment samples were collected in NE monsoon season as the second survey. Overall characteristics of sediments are similar to the first survey (TABLES A.5.2.3 and A.5.2.4). Prevalent green in the first survey was replaced by black in the second survey. No tolerance limits are prescribed for sediment quality yet.

5.3 Sewage Discharge

77. In Colombo City, there are 13 pumping stations as sewerage systems (TABLE 5.3.1). The total sewerage (max. 190,000, min. 117,000, average 142,000 m^3/day) discharges into 2 outfalls (Mutual and Wellawatta) and a treatment plant.

78. Mutwalla outfall discharge from only Madampitiya pumping station into the offshore of the fishery harbour. The discharge (max. 61,113 and min. 36,070 m^3/day) accounts for 32% and 30% (average 31%), respectively, of the total discharge from the whole area.

TABLE 5.3.1 Pumping Stations (m³/day)

No.	Station	Maximum	Minimum	Average
1	Madampitiya	61,113	36,070	47,096
2	Vystwyko	3,487	2,170	2,472
3	Harbour	9,225	7,886	7,936
4	Maligawatta	13,517	7,445	9,638
5	Borella	13,525	8,201	9,637
6	Thimbirigasayaya	9,116	4,985	6,333
7	S-8	50,193	31,499	34,726
8	Wallawatta	9,385	6,931	8,644
9	Bambalapitiya	1,976	1,312	1,670
10	Polwatta	11,603	5,929	8,243
11	Slave Island	4,745	3,298	3,630
12	Wanathmilla	1,564	1,128	1,415
13	Pettah (negligible amount)	-	-	-
Total		approx. 190,000	117,000	142,000

(Source: NWS & DB, 1994)

79. Then the average discharge can be estimated as

142,000 m³/day × 0.31 = 44,000 m³/day = 0.51 m³/s from Mutwalla outfall.

80. Water quality has never been measured for the sewage at Mutwalla outfall. However we can apply the reliable survey results (BOD 66 to 209 and SS 36 to 130 mg/ℓ) at sewer inlets into Beira Lake (NBRO, 1989). Here pollutants can be estimated as

44,000 m³/day × 209 mg/ℓ = 9.2 t/day = 106 g/s (BOD) and

44,000 m³/day × 130 mg/ℓ = 5.7 t/day = 66 g/s (SS).

81. In this estimation, we use the upper values corresponding to ordinary weather condition without raining, for the lower values can be regarded under heavy shower.

5.4 Air Quality

82. Air samples were collected twice (weekday and weekend) in each SW and NE monsoon season at about 1.5m above the ground of 12 locations (R1 to 13 except 10) around Colombo Port (TABLE 5.4.1 and FIGURE A.5.4.1).

5.4.1 Air Sampling during SW Monsoon Season

83. The first air sampling was done in 4 to 19 November 1995. During the survey period, SW wind blew at daily average speed of 1.5 to 2.0 m/s. SO_2, NO_x, SPM, P_b and CO_{max} range 5.3 - 231.2, 10.7 - 141.9, 108.4 - 1957.5, 0.2 - 2.9 (mg/m^3) and 5 - 130 (ppm), respectively (TABLE 5.4.2). Air quality seems to be better in a holiday than in a weekday. SPM and NO_x always show the values above and below its permissible level SO_2(R-7 and R-13), respectively (TABLE 5.4.3). Pb (R-8) and CO (R1, 2, 12 and 13) are partly and temporarily exceed their permissible limits.

TABLE 5.4.3 Maximum Permissible Level

Pollutant	Averaging Time	Maximum Permissible Level	
		$\mu g/m^3$	ppm
SO_2	8 hr	120	0.05
NO_x	8 hr	150	0.08
SPM	8 hr	350	-
LEAD	24 hr	2	-
CO	1 hr	30,000	26.00

Souce: Sri Lanka Central Environmental Authority

5.4.2 Air Sampling during NE Monsoon Season

84. Air quality is considerably better than in the first survey, for most SPM and all CO values are below their permissible limits (TABLE 5.4.4). In short, SO_2 and NO_x vary spatially in the same manner as the road traffic and generally increase in the northern area.

TABLE 5.4.1 Description of Locations of Road Traffic and Air Quality Survey

Location	Description
R-1	Nearby - Gate No. 1
R-2	Nearby - Gate No. 3 (LB Gate)
R-3	Near the gate to the Colombo Port's car park near the Sri Bodhiraja Viharaya
R-4	Nearby - Gate No. 4
R-5	Inside the Port; On the railway track; About 50 m north-east to Gate No. 5 (closed)
R-6	Inside the Port; About 30 m west to Gate No. 6; In front of SLPA medical centre
R-7	Nearby - Gate No. 7; Just opposite the Ceylon Tobacco Company at Srimath Ramanathan Mawatha
R-8	In front of Sri Kanthi Traders building, Olcott Mawatha; Opposite the Fort Railway Station
R-9	At the main entrance to Hotel Taj Samudra, Colombo
R-11	Major junction No. 2, near the Auto Court Atomobille & General Engineers building; towards the port access road.
R-12	In front of the Livingstone Pharmacy Groceries, 129/2C, Sri Pannanda Mawatha, Colombo - 15; about 5 m away from the major junction No. 3
R-13	Nearby - De Seram Gate

TABLE 5.4.2 Air Quality (SW monsoon season)

Location	Date	Duration (hours)	(µg/m³)				CO (ppm)	
			SO_2	NO_x	SPM	Pb	max	ave
R-1	04/11/95 (Sat)	10 15 - 17 15	58.3	30.5	443.6	1.0	20	<5
	* 07/11/95 (Tue)	10 40 - 17 35	05.3	19.6	161.4	0.4	70	<5
R-2	06/11/95 (Poya)	10 05 - 17 20	12.9	29.5	353.2	0.2	20	<5
	09/11/95 (Thu)	10 50 - 17 45	46.3	53.4	506.1	0.7	40	<5
R-3	06/11/95 (Poya)	10 50 - 17 45	16.4	27.9	574.1	0.5	-	<5
	09/11/95 (Thu)	10 35 - 17 35	47.5	40.3	672.9	1.9	25	<5
R-4	* 04/11/95 (Sat)	11 00 - 18 00	39.7	35.6	342.0	0.8	10	<5
	07/11/95 (Tue)	11 35 - 17 50	06.2	10.7	108.4	0.2	20	<5
R-5	17/11/95 (Fri)	10 45 - 17 30	23.0	47.4	484.8	0.8	-	<5
	18/11/95 (Sat)	11 10 - 17 20	14.6	45.8	570.5	1.1	-	<5
R-6	17/11/95 (Fri)	10 30 - 17 20	31.2	43.2	501.3	0.7	-	<5
	18/11/95 (Sat)	10 50 - 17 30	27.0	31.5	416.6	1.0	-	<5
R-7	10/11/95 (Fri)	11 30 - 18 00	231.2	54.4	1302.3	1.4	20	<5
	18/11/95 (Sun)	09 45 - 16 05	71.9	58.7	1041.7	1.1	25	<5
R-8	17/11/95 (Fri)	11 20 - 18 00	91.8	40.6	1583.7	2.9	10	<5
	18/11/95 (Sat)	09 30 - 18 00	85.9	52.8	1084.7	2.5	5	<5
R-9	16/11/95 (Thu)	11 40 - 18 00	73.0	53.2	698.8	0.7	10	<5
	19/11/95 (Sun)	10 20 - 17 20	21.2	27.4	586.2	0.4	-	<5
R-11	16/11/95 (Thu)	10 25 - 17 15	69.7	81.5	1189.3	1.1	-	<5
	19/11/95 (Sun)	10 15 - 17 15	65.3	85.9	768.6	0.5	15	<5
R-12	16/11/95 (Thu)	10 55 - 17 35	66.7	57.8	1090.9	1.2	130	<5
	19/11/95 (Sun)	09 50 - 17 35	61.1	27.0	432.9	1.0	10	<5
R-13	10/11/95 (Fri)	11 55 - 18 30	173.2	141.9	1957.3	1.3	60	<5
	11/11/95 (Sat)	09 55 - 15 55	98.5	68.8	1054.1	1.5	20	<5

Note: **Heavy rains were experienced for about two hours continuously, during sampling*

Remarks:

- Gate No. 5 and 8 were closed at the time of monitoring; therefore, sampling were carried out inside the ports, closer to the gates.
- Since the Gate No. 7 (JCT) was very busy and congested, and also due to security reasons, sampling were carried out just outside the gate (outside the ports premises)
- For security reasons, sampling at Gate No. 7 and 13 on the 11/11/95 (phase 1) were confined to six hours as a bomb blast took place in Colombo in the same day. (the mininum number of observations required to determine the average over eight hours is six hours)
- the peak values obtained for the CO concentrations were due to direct vehicular emissions during sampling.
- The permissible ambient air quality standards stipulated by the Central Environmental Authority are as follows:

TABLE 5.4.4 Air Quality (NE monsoonseason)

Location	Date	Duration (hours)	(µg/m³)				CO (ppm)	
			SO_2	NO_x	SPM	Pb	max	ave
R-1	05/01/96 (Poya)	10 05 - 18 00	01.7	16.0	152.1	0.6	-	<5
	11/01/96 (Thu)	09 40 - 17 40	29.8	16.6	221.5	1.2	10	<5
R-2	05/01/96 (Poya)	10 25 - 18 25	05.2	60.8	186.3	0.2	-	<5
	11/01/96 (Thu)	10 20 - 18 20	47.2	50.8	340.3	1.2	15	<5
R-3	05/01/96 (Poya)	11 00 - 19 00	76.6	34.6	222.2	0.3	-	<5
	11/01/96 (Thu)	10 20 - 18 00	83.2	75.1	333.6	0.6	10	<5
R-4	07/01/96 (Sun)	10 00 - 18 00	27.2	29.2	204.4	0.6	-	<5
	09/01/96 (Tue)	09 45 - 17 45	136.6	88.9	166.2	0.6	5	<5
R-5	07/01/96 (Sun)	11 00 - 19 00	12.5	16.9	110.1	0.1	-	<5
	09/01/96 (Tue)	10 20 - 18 20	71.8	59.6	152.5	0.5	-	<5
R-6	07/01/96 (Sun)	11 05 - 18 10	07.8	24.6	104.6	0.5	-	<5
	09/01/96 (Tue)	10 00 - 18 00	60.7	55.2	451.3	0.6	-	<5
R-7	21/01/96 (Sun)	09 55 - 16 55	59.1	64.9	404.1	0.8	25	<5
	25/01/96 (Thu)	10 45 - 17 15	239.1	89.7	546.1	2.7	10	<5
R-8	13/01/96 (Sat)	09 55 - 17 55	67.1	39.6	299.9	0.2	5	<5
	16/01/96 (Tue)	10 45 - 18 55	138.9	80.1	326.8	0.3	10	<5
R-9	13/01/96 (Thu)	09 25 - 17 30	42.5	06.8	82.3	1.3	15	<5
	16/01/96 (Tue)	10 15 - 18 15	54.5	47.4	113.4	1.5	-	<5
R-11	18/01/96 (Thu)	10 00 - 18 00	80.3	75.6	464.0	2.1	5	<5
	20/01/96 (Sat)	09 25 - 17 10	177.7	77.5	233.3	0.5	15	<5
R-12	18/01/96 (Thu)	10 40 - 18 30	81.3	35.9	363.3	2.3	10	<5
	20/01/96 (Sat)	09 45 - 17 50	91.3	41.4	283.6	1.6	30	<5
R-13	21/01/96 (Sun)	10 10 - 18 10	06.6	38.5	80.4	0.3	20	<5
	25/01/96 (Thu)	11 00 - 18 00	212.3	111.9	340.4	0.1	5	<5

5.5 Road Traffic

5.5.1 Road Traffic Survey during SW Monsoon Season

85. The road traffic surveys were carried out at 12 stations (R1 to 13 except 10) in SW and NE monsoon seasons with respect to the air quality survey. The 12 stations and the counting directions are indicated in FIGURE A.5.4.1. All vehicles are categorized into the following 5 types.

i) Container trailers
ii) Large heavy vehicles - lorries and tankers
iii) Other heavy vehicles - other small lorries etc.
iv) Automobiles - cars, buses and vans, etc.
v) Two wheeled vehicles - motor cycles and scooters

86. The surveys were conducted twice (weekday and weekend) in each season. The 5 categorized vehicles were counted along the in-out directions at the port gates and circumferential directions (N-S or E-W) outside the port. TABLE A.5.5.1 tabulates the results of the first surveys conducted on 10,11,17 and 18 November 1995, when winds were typical of the SW monsoon with the daily maximum speeds as 5 to 6 m/s and daily average of 1.5 to 2 m/s.

87. The traffic is most and least active around noon and midnight, respectively (FIGURES 5.5.1 and 5.5.2). Over the weekend, the traffic decreases to 70% to 75% of that of a week day, although it was heavily controlled as follows for administrative and security reasons.

i) R1 : 10^h30^m - 13^h00^m main approach road (Chaithya Road) to this point was closed for security reasons after the bomb explosion (10^h30^m) at Slave Island near Army Headquarters.

ii) R2 : Only for exit vehicles excluding carriers. Normally closed 18^h to 8^h, but 11th Nov. closed at 15^h because of the bomb explosion.

iii) R4 : Normally not used by container carriers

iv) R7 : Normally not used by container carriers. After 14^h on 11 Nov. closed for the same reason as for R2.

v) R11 : All vehicles allowed but mainly used for container carriers

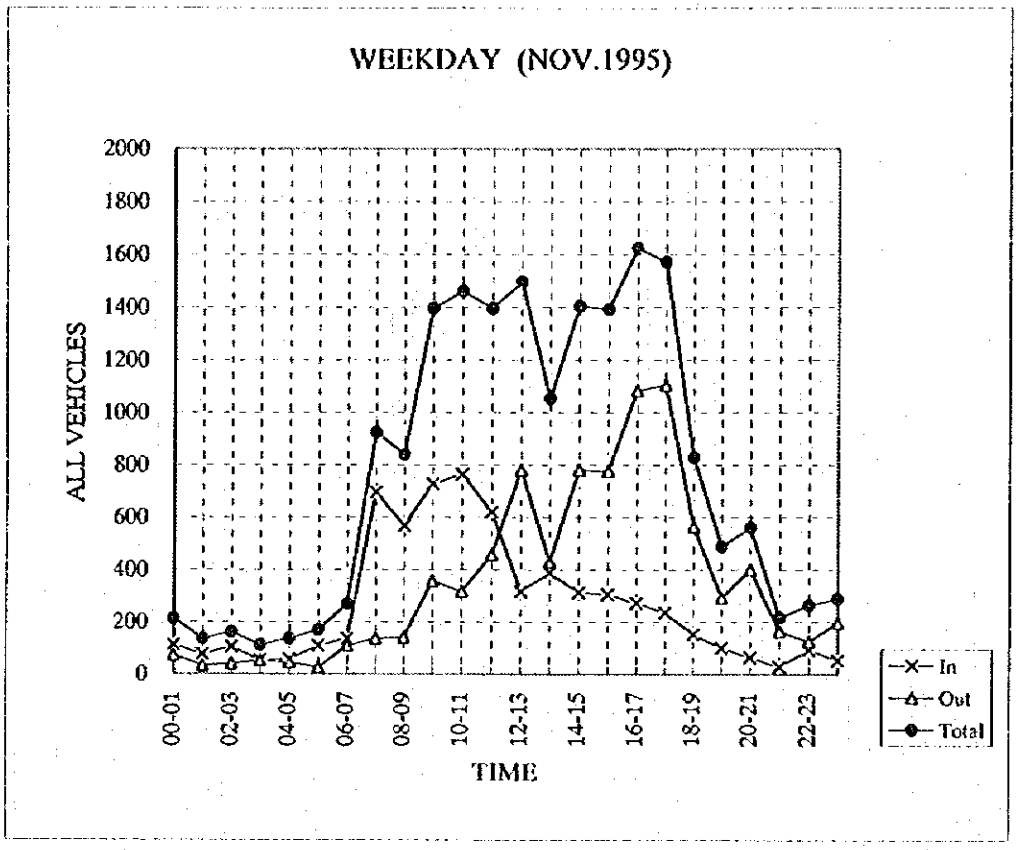
vi) R12 : At this junction, Sri Pannananda Mawatha closed during night time

vii) R13 : Normally not used by container carriers

88. The traffic is most and least active around noon and midnight, respectively (FIGURE 5.5.1). The vehicles, going into/out of the port, are summed up at all gates (R1, 2, 4, 7, 11 and

13). All vehicles show a typical commuting characteristic on a weekday, but all vehicles on a weekend and trailers quickly go out after entering. The vehicles going N-E and S-W are summed up outside the port at R3, 5, 6, 8 and 12. All vehicles equilibrate on both northbound and southbound; however, trailers reflect some daily trend (FIGURE 5.5.2).

FIGURE 5.5.1 In-Out Vehicles (all)



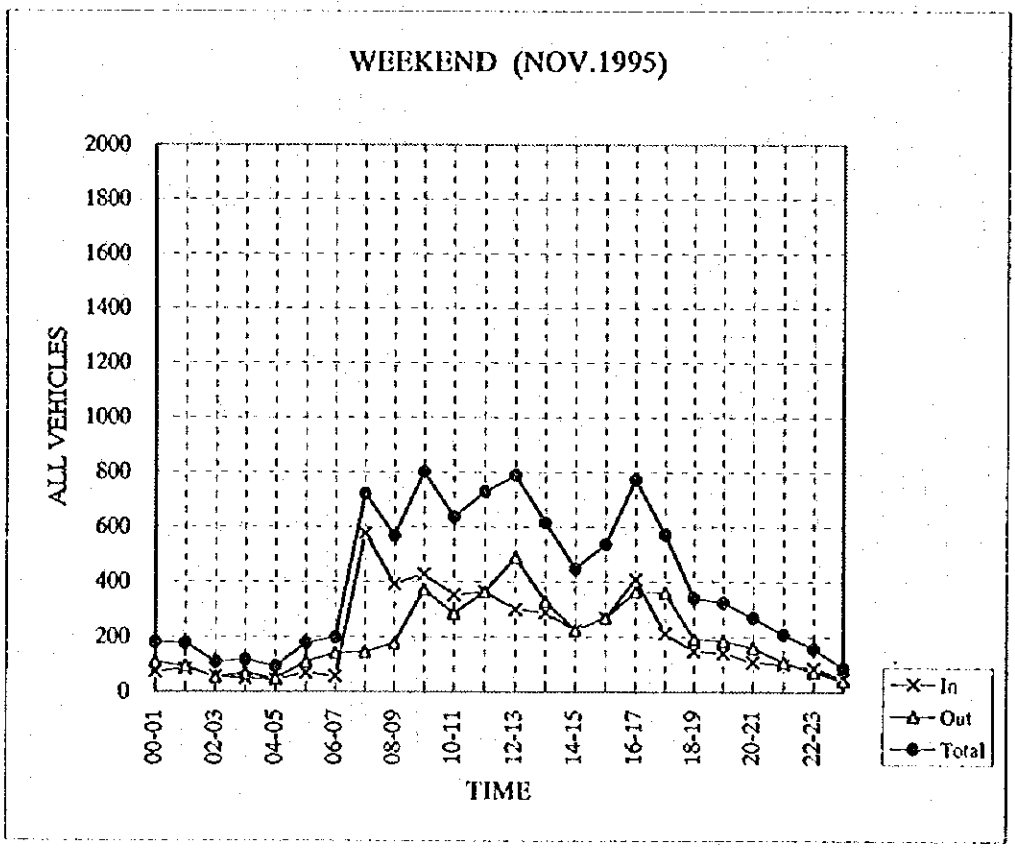
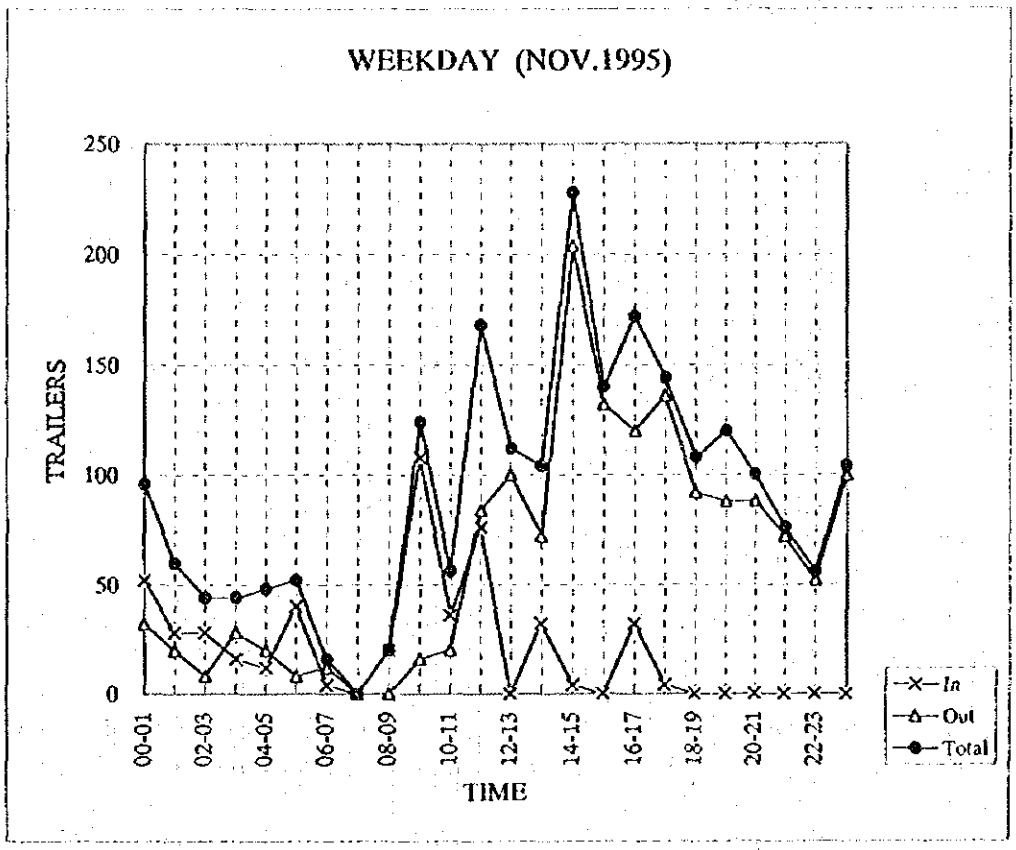
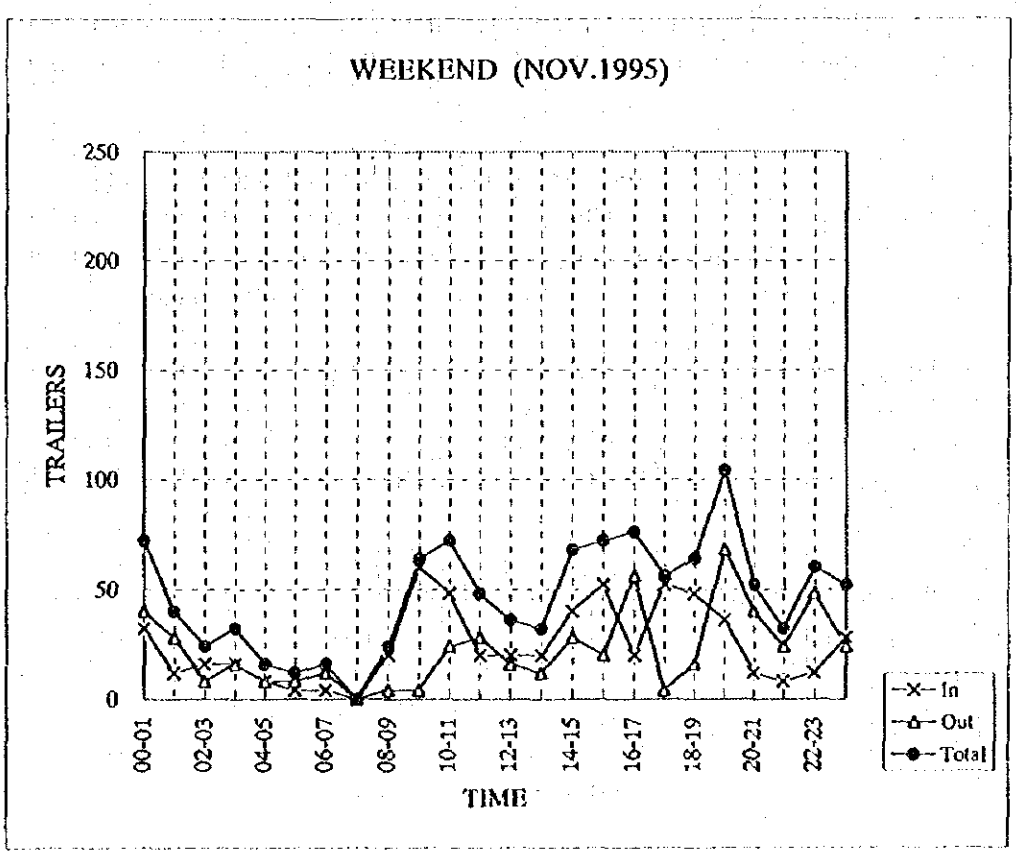


FIGURE 5.5.2 In-Out Vehicles (trailer)





5.6 Biological Survey

5.6.1 Plants

(1) Terrestrial Plants

89. Biological surveys were carried out in the area Shown in FIGURE A5.6.1. The coastal vegetation is mostly confined to the Kelani river mouth without human habitation. Species encountered were identified and enumerated and vegetation profiles were made. Three major vegetation communities could be identified from the area below.

1) Seashore vegetation, 2) Mangrove vegetation, 3) Riverain / canal vegetation

1) Seashore Vegetation

90. The sandy strip of about 10 m wide along the waterfront is covered with the creepers such as *Ipomoea Pes-caprae* and *Spinifex spp.* and *Heliotropium anomalum.* Short herbs grow scatterd among these creepers. The most commonly found emergent herbs include species of *Tridax, Vernonia, Crotolaria Osbekia* and *Lantana.*

91. Towards the river mouth, these creepers were not found, may be due to the continuously eroding shoreline with relatively less amount of sand for the plants to grow.

92. The area behind (inland) this zone the grass *Imperata sp.* grows along with *Cymbopogon sp.*, upto 1.5 m and occurs in patches. The average height of the vegetation in this zone is about 2 m. The other shrub species that occur with the grasses are *Dodonia sp. Lantana sp. Osebekia species.*

93. The seaward portion of the shore at the river mouth is covered with a thicket of *Scaevola tacada*, a shrub that grows upto 2-3 m in height. The riverain portion (area by the side of the river banks) of the coast is dominated by tall trees of *Cerbera mangahs, Thespesia populnea, Peltophrum dessirachis, Samanea saman, Anona glabra* and *Terminalia catappa.*

2) Mangrove vegetation

94. Mangroves are poorly represented at the river mouth. The only species that found to occur was *Sonneratia caseolaris* and isolated trees were observed around the canal and the water hole.

95. Approximately 0.5 km away from the river mouth, a thin fringe of *Sonneratia caseolaris* occurred around a water hole. About 1 km away from the river mouth, another fairly extensive patch of mangroves occurs, at a location parallel to the Hamilton canal. This is highly disturbed as it is already filled up in small lots for homesteads. Depending on the presence of pockets of remaining vegetation, it appears that the area must have been a well developed mangel, dominated by *Bruguiera sexangula* and *Sonneratia caseolaris.* Isolated trees of *Ceriops tagal*

and shrubs of *Acrostichum aureum* are found growing scattered in the area.

96. Besides these remnants of once thriving mangroves, no mangrove areas were found in the study area.

3) Riverain and canal vegetation

97. Natural riverain vegetation, i.e.plants that grow on the banks and the associated area, are mostly replaced with crops such as coconut. However, at the river mouth low grasses such as *Cyanodon sp. Panicum sp.* tend to grow in patches. Isolated shrubs / trees of species of *Dillenia* were found among the predominant tree species such as *Cerbera manghas, Anona glabra and Thespesia populnea.*

98. The canals and the water holes in the hinterland to the shore and the estuary are fringed with *Phragmites karka* and *Cerbera manghas* along with *Sonneratia caseolaris.* The shallow parts of the water holes area covered with aquatic plants such as *Ipomoea aquatica.* (TABLE 5.6.1).

TABLE 5.6.1 Terrestrial Plants

Seashore vegetation	Riverain and canal vegetation	Mangrove vegetation
Cerbera mangahs,	Anona glabra	Acrostichum aureum
Crotolaria sp.	Cerbera manghas	Bruguiera sexangula
Cymbopogon sp.	Cyanodon sp.	Ceriops tagel
Dodonia sp.	Dillenia	Lumnitzera racemosa
Heliotropium anomalum.	Ipomoea aquatica	Sonneratia caseolaris
Imperata sp.	Panicum sp.	
Ipomoea pes-caprae	Peltophorum	
Lantana sp.	dessirachis,	
Osbekia sp.	Phragmites karka	
Pandanus sp.	Samanea saman,	
Scaevola tacada	Terminalia catappa.	
Spinifex spp.	Thespesia populnea	
Terminalia catappa		
Thespesia populnea,		
Tridax sp.		
Vernonia zeylanica		

(2) Marine Plants

99. Marine plants, i.e.the macro seaweeds were collected from the 'outer-shore' reef area which is about 9-10 m deep. These samples were collected from the same line transacts used across the reef, to collect data on reef invertebrates and benthic fauna. The algal (seaweed)

growth was found to be very poor and only 4 species algae were encountered. The specimens were poorly grown and very small in size. Two out of these 4 algae were calcarious algae. *Halimeda opuntia* (green algae) and *Amphiroa sp.* (red algae).

100. The high silt content in the water column that reduces light penetration in water may be a major reason, among others, for this low abundance and diversity of seaweeds in the area. Besides, the absence of rocks and other emergent substrata for the algae to grow also may have contributed to this situation.

TABLE 5.6.2 Marine Plants

Class : Phaeophyceae **Order :** Dictyorales **Family :** Dictyotaceae Stoechospermum sp.	**Class :** Rhodophyceae **Order :** Nemalionaceae **Family :** Chantransiaceae Acrochaetium	**Class :** Rhodophyceae **Order :** Cryptomeniales **Family :** Corallinaceae Amphiroa sp.	**Class :** Chlorophyceae **Order :** Siphonales **Family :** Codiaceae Halimeda opuntia

5.6.2 Animals

(1) Birds

101. The areas demarcated as B-3 to 5 were surveyed for bird species and records of birds sighted in these areas within the past five years were also collected (TABLES A.5.6.1, A.5.6.2 and 5.6.3).

102. Section B-3 and B-4 contained many terrestrial species water birds and seabirds and few nesting sites. Nests of sunbirds, Red vented bulbul, Magpie robin, house crow and Alexandrine parakeet were observed in these areas. Most of the birds and nesting sites were concentrated in the area containing shrubs and mangrove vegetation. Many roosting sites were also observed.

103. Section B-3 contained different habitats i.e. home gardens sea beach, area with high density of vegetation, shrubland and mangroves, water holes, river mouth and estuary and therefore provided shelter to a diverse group of birds. No previous records were available for section B-3.

104. Many species of sea birds have been recorded from the B-5 (Modara) area among them are some very rare wintering visitors (sea birds) to Sri Lanka. i.e. Brown noddy, Sooty gull, Flesh footed shearwater. Gadfly petrel, Barau's petrel, Philippine noddy, Great frigate bird and Christmas frigate bird. The only records of sighting some of these birds in Sri Lanka are from Modara. However not many terrestrial birds were recorded from this area may be due to the lack of vegetation.

TABLE 5.6.3 Birds (B5)

*Common tern	Brahmini Kite	*Wilson's stompetrel
Little tern	House crow	*Flesh footed shearwater
*Lesser crested tern	Common mynah	*Barau's petrel
Large crested tern	House sparow	*Great frigate bird
Gull billed tern	*Whiskered tern	Barn owl
*Briddled tern	Koel	*White winged black tern
*Large sand plover	Little cormorant	Golden backed woodpecker
*Lesser snad plover	Alexandrine parackeet	*Red winged crested cuckoo
*Black headed gull	Indian shag	*Phillipine noddy
*Brown headed gull	Domestic pigeon	*Blyths reed warbler
*Common sand piper	Magpie robin	*Sooty tern
*Turnstone ruddy	Purple sunbird	*Gadfly petrel
*Bain swallow	Tailor bird	Blue breasted quail
Little swift	Indian pitta	*Dunlin
Median egret	*White bellied sea	*Chrismtas frigate bird
Little egret	eagle	*Banded crake
Pond heron	Shatin falcon	*Brown noddy
White breasted	*Lesser frigate bird	
Kingfisher	*Herring gull	
Shaheen falcon	*Scooty gull	

105. Indian Pitta is also a rare bird in this area and there is only one record of having sighted the white bellied sea eagle in this area (although it is a common breading resident of the dry zone).

106. The most common birds recorded from B-5 area were House crow, Little cormorant, Median egret, Whiskered tern, and Gull billed tern. In B-3 and B-4 area the most common birds species were House crow, Little cormorant, House sparrow, Purple sunbird, Lotens sunbird, Median egret and Alexandrine parakeet.

107. However no threatened bird species were recorded from the area except for the Indian shag - *Phalacrocorax fuscicollis*. The only endemic species found in the area was the Layard's parakeet - *Psittacula calthopae*.

TABLE 5.6.4 Ecological Status of Birds

Section	B3	B4	B5
Total no. species	39	59	55
No. migrant species	07	10	28
% of migrants	18%	17%	51%
No. endemic species	0	01	0
No. threatened species	01	01	01

(2) Insects

108. Samples ware collected from sites B-3 to 5 which were found to be highly residential areas except for certain areas where vegetation was observed. The insects found in the area are listed in TABLE 5.6.5.

TABLE 5.6.5 Insects (Order Lepidoptera)

B3	Crimson rose butterfly, Glassy tiger butterfly, Common tiger butterfly, Tawny coster butterfly, Tailed jay butterfly, Brown king crow butterfly, Dark-brand bushbrown butterfly, Common grass yellow butterfly, Three spot grass yellow butterfly, Lesser grass blue butterfly, Common Albatross, Psyche
B4	Common tiger butterfly, Tawny coster butterfly, Tailed jay butterfly, Common grass yellow butterfly
B5	Plan tiger butterfly, Common Jezebel butterfly, Indian skipper butterfly, Crimson rose butterfly, Glassy tiger butterfly, Common tiger butterfly, Tawnu jay butterfly, Drown king crow butterfly, Dark brand bushbrown butterfly, Common grass yellow butterfly, Three spot grass yellow butterfly, Lesser grass blue butterfly, Psyche

109. In some or all sections among B3 to 5, the following insects were also found: Dragonflies, Damsel flies, Paddy bug, Cicada, Tiger beetle, Ladybird beetle, Housefly, Malaria mosquito, Dengue mosquito, Encephalitis mosquito, Ants, Tailor ant, Carpenter Bee, Honey Bee, Wasp, Praying Mantis and grasshopper. All the species of butterflies found in B3 to 5 were either listed as common or very common by John and Judy Banks (1985). The ladybird beetle (*Coccinella*) is considered a very important natural predator as a biological control agent. *Aulacophora* is considered a pest of vegetables especially of Cucurbitaceae. *Chilocorus* has been introduced as a biological control agent for pests of vegetables such as Malvaceae and Cucurbitaceae. *Xylocopu trenuviscapa,* the Carpenter Bee is considered a good pollinator.

110. Under Odonata, 11 species of Dragonflies and 5 pieces of Damsel flies have been recorded from Colombo. During the period of investigation, only three species were observed belonging to Order Odonata. Even though moths of various hues were observed within the area, these could not be identified as no information is available for identification of moths in Sri Lanka. Comparatively fewer species of insects were found in area B-5.

111. Most insects are recorded to be migratory and, therefore, the above record is restricted to the period of investigation. None of the threatened species of insects listed by the IUCN in its Red Data List (1988) was observed in the area during the period of investigation.

(3) Terrestrial Fauna

112. Survey was conducted in sites referred in the terms of reference. Site B-3 - Highly urbanized area. There is no natural habitats for the mammals. Domesticated animals such as

dogs. (Canis canis), Pigs (*Sus*), Cats (*Felis catus*) and Goats (*Capra*) were observed.

113. Site B-4 - The site is relatively undisturbed. Following reptiles were abundant in this area.

* Calotes ceylnensis * Varanus sepadinus * Geradia prevostiana
* Varanus salvator * Natrox piscator

114. This site is covered with *Ipomia* species and *Spinifex* species which are typical sandy shore vegetative and forms a habitat for most of the above animals.

115. Site B-5 - Highly domesticated area. But there are undisturbed marshy areas and patches. Animals observed were domesticated species. Animals observed were similar to site B-3.

(4) Coral Reefs

116. The site investigations were conducted on Kalapugala in front and on the northern side of the Kelaniya river outfall. Investigations were not carried out on the southern side of the Kelani River outfall due to very low visibility. The sea around the Kelani River remains turbid during most of the year. The investigations revealed that the organisms found in the area are well adapted to silty conditions with low levels of light intensity. The visibility during the investigations was as low as 1.5 meters from the surface to a depth of 4 meters and below it was less than 1 metre. In some areas the visibility was around 0.5 metres, as a result the abundance of reef fish species such as snappers (Lutjanidae), Emperors (Lethrinidae), Barracuda (Sphyraenidae) could not be accurately estimated. Since fish migrate between different reef areas a single list has been included for sites.

117. The information on biodiversity of the second reef (deeper site) is also provided. This information is provided from previous surveys conducted by NARA in 1990. This site could not be investigated during the present study due to extreme turbidity on the southern side of the Kelani River outfall.

118. Investigated reefs are composed of sandstone and coralline material, they are very similar to other reefs on the west coast around Colombo. The profile consists of a shallow side (Shoreside), reef crest, reef slope and a deep ledge that extend on to a sandy sea bed on the seaward side. The width of the reef is approximately 100 to 150 metres. In some areas it is less than 50 metres wide. The depth of the first reef (nearshore) varied from 1.5 to 7 meres. The profile of the second reef is somewhat different to the first reef as there is no difference in depth on the shoreward and seaward sides. The reef crest is about 1.5 to 2 metres higher than the surrounding seabed. The depth of the reef varies from 8 to 12 metres. Due to high sedimentation the surface of the deeper sections of the first reef (Kalapugala) was covered by a layer of fine sediment and sand whilst the upper sections had less sediment due to wave action along the reef crest. A greater part of the surface of the second reef was also covered with a thicker layer of

sediment. As a result the coral cover on both reefs was less than 1%. Only the silt tolerant species were seen. The shallow sections of Kalapugala contained extensive areas of sand tubes constructed by Sabellaried worms (Polychaete worms). Fish life appeared to be low, however for a proper assessment of fish abundance a survey has to be conducted during a period with better water clarity. Sponges were relatively common. A few colonies of soft corals were also recorded from both sites. Sea urchins (Stomopneustes) were abundant in the shallow sections of Kalapugala. Spiny lobsters (Panulirus spp.) were not seen during the surveys although they are caught by divers and fishermen using bottom-set nets.

119. One endemic species of Damsel fish (*Pomacentrus proteus* - Colombo Damsel) was common on Kalapugala. TABLE 5.6.6 contains the coral species recorded for both reefs whilst TABLE A.5.6.3 contains a list of fish species recorded for both reefs. Total live coral cover for the first and second reefs was less than 1%

TABLE 5.6.6 Corals

First reef		
Order : Scleractinia	Family : Fviidae	Family : Poritidae
Family : Pocilloporidae	*Favia speciosa*	*Goniopora spp.*
Pocillopora verrucosa	*Favia favus*	*Porites spp.*
Pocillopora damocornis	*Favites complanata*	
	Favites abdita	Family : Acroporidae Acropora spp.
Family : Agariciidae	*Favites spp.*	
Pavona varians	*Plesiastrea versipora*	
Leptoseris explanata		

Second reef		
Order : Scleractinia	Family : Faviidae	Family : Poritidae
Family : Pocilloporidae	*Favia speciosa*	*Goniopora spp.*
Pocillopora verrucosa	*Favia favus*	*Porites spp.*
	Favites complanata	Family : Acroporidae
Family : Agariciidae	*Favites abdita*	*Acropora spp.*
Pavona varians	*Favites flexuosa*	Family : Mussidae
Leptoseris explanata	*Favites spp.*	*Symphyllia spp.*
	Plesiastrea versipora	*Acanthastrea echinata*
		Family : Pectiniidae
		Echinophyllia spp.

(5) Benthic Fauna

120. Benthic fauna was investigated by analyzing the benthic samples that ware collected during the coral reef survey. Samples were collected using a grab as well as manually from a known area of the sea bed.

121. Since the divers (sample collectors) could not operate at the first (shallow) reef, due to poor visibility, benthic samples from this reef were not available for the analysis. Samples obtained from the 'outer-shore' reef which has been reported to be with less sediment than the near-shore reef were fixed, isolated and identified, in most instances, to the generic level using taxonomic keys and descriptive literature.

122. The abundance of the organisms was relatively low, however the benthic community was well represented by tube-dwelling sedentary polychaetes, bivalves and echinoderms. The fauna that apparently could withstand high sediment environments. This location, i.e. near the Kelani river outfall, receives river-borne sediment constantly. Hence, relatively a high proportion filter-feeders are found along with some carnivorous species. Although fewer in numbers, 25 species of gastropods were found to occur in this area. Being filter-feeders of particularly, detritus they play a significant role in the foodwebs of these waters, through which some of the commercially important fisheries such as shrimps, are sustained.

123. TABLE 5.6.7 presents the benthic organisms encountered in the bottom sediment of the study area.

(6) Finfish, Shellfish and Fisheries

124. Seven trips were made so far to the study area to collect information with respect to marine animals. During the survey fishermen operating their nets in the vicinity of the study area were interviewed at sea to collect more information and also to fill the gaps of the species list. Fishermen from Mutwal and adjacent areas operate approximately 60 Theppams in the study area on a normal fishing day. They go out for fishing daily around 4.00 am and return around 7.30 am. Most of the fishermen having traditional crafts operate their drift gillnets closer to harbour mouth and in the adjacent areas. Fishermen having 17'-22' FRP boats also operate in the same area as well as deeper area off harbour mouth. Drift gillnet fishermen use 3.715 cm and 3.810 cm meshed 2 ply nets and their catch mainly consist of Sardines, Leiognathids, Half beeks, White fish and Carangids. In most cases, two people are involved in fishing in a traditional craft and FRP boat where as 4-5 people in 3.5 ton prawn trawler. Catch rates and daily income values of the three categories of fishing crafts are shown in TABLES 5.6.8 and 5.6.9.

125. There seems to be a seasonality in some of these fisheries such as sardine fishery and white fish (Pulunna) fishery etc. Bottom set net fishery for rock fish around target rocks, trawling for shrimp and drift gillnets for sardines are regular fisheries in the study area (TABLES 5.6.10 and 5.6.11).

TABLE 5.6.7 Benthic Organisms on/around the 'Outer-shore' Reef

Class : Crustacea
Order : Brachyura
Family : Paguridae
Pagurus sp.

Class : Polychaeta
Order : Errantia
Family : Glyceridae
Glycera sp.

Class : Polychaeta
Order : Sedentaria
Family : Polynoidae
Lepidonotus sp.

Family : Spionidae
Unidentified species

Family : Sabellidae
Unidetified species 1
Unidetified species 2
Arenicola sp.

Family : Aphroditidae
A prodita sp.

Phylum : Echinodermata
Class : Crinoids
Family : Comasteridae
(brittle star)

Class : Echinoidea
Family : Echinidae
Unidentified genus

Phylum : Coelenterata
Class : Anthozoa
Sub class: Octocorallia

Phylum : Mollusca
Hexabrancus sp.

Phylum : Arthropoda
Class : Crustacea
(Hermit crab)

Class : Gastropoda
Family : Trochidae
Tegula aureotincta
Trochus erythraeus

Family : Cerithiidae
Terebralia palustris

Family : Cypraeidae
Cypraea cellata
Cypraea marginalis

Family : Cymatiidae
Gyrineum natator

Family : Muricidae
Chicoreus banksii
Thais echinata
Lataxiena fimbriata

Family : Olividae
Oliva reticulata

Family : Conidae
Conus balteatus
Conus miles

Class : Bivalvia
Family : Arcidae
Anadara antiquata
Barbatia reeveana
Larkinia rhombea

Family : Mytilidae
Modiolus auriculatus
Perna Perna

Family : Pteriidae
Pinctada radiata
Pinctada vulgaris
Pteria penguin

Family : Pectinidae

TABLE 5.6.8 Fishing Gear-types and Target Species

Fishing Gear	Target species	Craft Type
Trawling	Penaeid prawns	3.5 ton IB boats
Drift gillnets	Sardines	17'-22' FRP boats / Theppam / Orus
Hand lining	Groupers / Carangidis	17'-22' FRP boats / Theppam / Orus
Bottom set nets	Lobsters	17'-22' FRP boats / Theppam
Bottom long line	Groupers	17'-22' FRP boats

TABLE 5.6.9 Catch Rates and Daily Income by Craft-type

Craft Type	Average catch rate (Kg/Day)	Date average gross income of a Craft (Rs.)
Theppam	6-10	200-400
17'-22' FRP boat	7-10	250-500
3.5 ton boat (Prawn trawler)	7-12	1000-2000
Oru	6-10	200-400

TABLE 5.6.10 Daily Fish Production of the Area according to Major Groups

Group	Production (Kg.)
Small pelagic fish	120
Rock fish	50
Prawn (Based on few visits)	40

TABLE 5.6.11 Numbers of Different Craft-types operated in the Study Area

Craft type	Number operated	
	During the study period	*During the peak season**
Theppam	50	70
17'-22' FRP boats	30	50
3.5 Ton IB boats	8-10	20-25
Oru	02	10

* *Based on interviews made with fishermen*

126. A short distribution about the commercially important crustaceans are given below:

1) Shrimp

127. Prawn trawlers ranging in number from 6-8 (3.5 ton boats) operating from Mutwal Fisheries Harbour engage in prawn trawling activities. In addition to this fishermen from Handala area (10-15, 3.5 ton boats) also enter to this fishing ground through the Kelani river mouth. During peak season, the number of prawn trawlers increase upto 20-25 per day. The trawlable area extends from galle face to Dickowita.

128. The prawn species caught in this area belongs to two main groups:
(i) Large prawns (ii) Small prawns

129. Large prawns consist of four main species and small prawns consist of two main species. Their species composition values are as follows:

Common name	Large prawns	%	Small	%
White prawn	P. indicus	60.5	M.dobsoni	56
Bannana prawn	P.merguiensis	34.0	P.stylifera	40
Giant tiger prawn	P.monodon	3.5	M.monoceros	04
Green tiger prawn	P.semisulcatus	2.0		

2) Lobsters

130. Four species of spiny lobsters were recorded from the area during the study period and their abundance is as follows:

Panulirus homarus	86%	P. ornatus	05%
P. versicolor	08%	P. penicillatus	01%

131. According to a previous study (Jayawickrema, 1991) the species composition of the above species in the Mutwal areas is as follows:

P. homarus	92%	P. ornatus	04%
P. versicolor	03%	P. penicillatus	01%

132. Fishermen use bottom set gill nets (mesh size 90-180 mm) for catching lobsters and berried female percentage is high just before and after the south-west monsoon April and August (Jayawickrema, 1991).

133. Fishermen use 17'-22' FRP boats, canoes and Theppam for catching lobsters in the area between Galle face, just out of the harbour and the area toward Ona-Gala. The general depth range use for setting lobster nets is 5 m-20 m.

3) Crabs

134. Although there is no aimed fishery for crabs, four species of crabs are also recorded from this area entangled to gillnets. They are:

Portunus pelagicus	-	Blue swimming carb
Portunus sanguinolentus	-	Three spotted swimming crab
Grapus albiliniatus	-	Painted stone crab
Scylla serrata	-	Serratud mud crab

5.7 Residents, Buildings and Cultural Assets

135. Survey was conducted by collecting available data from government and other relevant Authorities and cross checking by visiting subjected area.

136. It was firstly decided to contact mainly government organization to collect available data. The team members visited following government establishments.

1) Colombo Municipal Council
   A. Assets Department
   B. District engineer Colombo North Area
2) Urban Development Authority
3) Senses & Statistics Department
4) Police stations
   A. Modara B. Mattakyliya C. Wattala
5) Wattala Provincial Council
6) National Housing Development Authority
7) Housing Development Cooperation
8) Sri-Lanka Land Reclamation Cooperation
9) Gramasevka Divisions Heads (Village Headman)
   A. Alth Mawatha D. Mattakuliya F. Palliyawatta - South
   B. Lunupokuna E. Palliyawatta- North G. Dikowita
   C. Modara

137. The survey groups visited following non government and Village committees, except government establishments.

1) Gramodya Mandala & Defense Committees in above mention Gramasevaka Divisional.
2) Chief Priests of several Temples, Churches, Mosque and Kovils

138. Critical discrepancy in every item were noticed in both sides of Kelani river. Considering this matter the subjected area secondly could be diverted into two parts such as Colombo North Provincial Council (CNCA) and Wattala Provindial Area (WPCA).

139. The comprehensive amount of factories, populations, government & private organizations are located in CNCA and Tourist and fishery's industry disseminate in the WPCA. Here one could notice people from all kinds of religions and communications are well developed in both areas.

140. There are a number of unpermitted shanties slumps constructed on Lunupokuna and Palliyawatta-North Gramasevaka divisions. To collect information from them during the field visits used questioner.

141. During the survey, the team faced the following limitations and problems

1) During the field visits the Residents of survey area given variable cost estimates to their lands and to the properties (Buildings). To avoid this situation utilized government evaluation scheme which is currently using in many other organizations.

2) There are several momentous historical and cultural places located in project area. Here the survey crew faced little difficulty on evaluation of these places. It was decided to mention separately these places in the map.

3) Inability of evaluation and economical and social interrelationships and it's social values of the Residencies of subjected area.

142. For the simplifications, collected information illustrates with following diversions.

1) Population
2) Buildings; Total, ownership, etc.
3) Land; Ownership, Values
4) Historical & cultural Buildings
5) Economical relationship

5.7.1 Population

143. The total number of houses were 4268. This number distributes within the all study area which equal to the 814.5 acres. The average density of this area is 68 people per acre. Comparing all Gramasevaka divisions the maximum population were noticed in the Aluth Mawatha area. The population of Aluth Mawatha is 29,914 people and it was 54% of the total. TABLE 5.7.1 illustrates population in all Gramasevaka divisions.

TABLE 5.7.1 Population

No.	Gramasevaka division	population	%
1	Lunupokuna	5,045	9
2	Aluth Mawatha	29,914	54
3	Modara	5,890	11
4	Mattakuliya	7,250	13
5	Palliyawatta North	3,310	6
6	Palliyawatta South	2,802	5
7	Dikowita	1,217	2
	TOTAL	55,428	100

5.7.2 Building

144. There are 4,268 number of buildings spreading over the survey area. The government as well as private structures includes to this number. Additional to that, there are different type of permanent, temporary, single story, upstairs buildings, metal constructions, shanties, unpermitted constructions were included to the this number. From this number 91% belongs to the private owners and around 4.2% is government properties. TABLE 5.7.2 illustrates buildings coverage per Gramasevaka divisional wise.

TABLE 5.7.2 Building by Gramasevak Division

No.	Gramasevaka division	# of Buildings	Private	Government	% (from # of Buildings)
1	Lunupokuna	672	582	53	16
2	Alth Mawatha	1,118	1,031	38	26
3	Modara	1,143	1,088	33	27
4	Mattakuliya	85	64	45	2
5	Palliyawatta North	562	502	5	13
6	Palliyawatta South	633	568	3	15
7	Dikowita	55	49	2	1
	TOTAL	4,268	3,884	179	100

145. According to the population and buildings rates the maximum percentages ware reported from the Aluth Mawatha and Modara Gramasevaka divisions. That is from total population 65% and from buildings 53%. The other important fact is even though Aluth Mawatha gives the maximum populations, the total number of building is less than the Modera division. The most of Aluth Mawatha residents lives in the upstairs buildings.

146. Due to the heavy density of buildings in Aluth Mawatha Gramasevaka, they were categorized into several types during the field visits. This was helpful to evaluate Buildings and other structures. The evaluations take into account, their locations, dimensions, the purpose of the structure, Social and Cultural values, Government standards etc. By considering these reasons outcomes could be summarized as TABLE 5.7.3.

TABLE 5.7.3 Building (Aluth Mawatha)

No.	Type of Structure	# of Buildings	Approximate estimate Rs. mill.
1	Single story	1,042	750.4
2	Flats	36	43.2
3	Shanties (temporary)	401	14.0
4	Fatories (Private-Large)	08	150.0
5	Factories (Private-Small)	14	78.0
6	Government establishments	07	3,500.0
7	Companies (Larage scale)	03	1,050.0
8	Companies (Medium scale)	53	855.0
9	Companies (Small scale)	96	588.0
10	Hotels (tourists)	03	900.0
11	Buildings along the coast	03	75.0
12	Harbours	02	400.0
13	Schools	07	42.0
	TOTAL	1,675	8,445.6

147. Even though results show a large number of Single story houses, yet more number of people lives in flats and compartments. Also a moderate number of factories and garments situated in the survey area. The Government and private establishment cost estimates given here very tentatively and some of them were plotted in the annexed map.

5.7.3 Historical and Cultural Assets

148. During the evaluation of Cultural and Historical properties of survey area, it is very essential to consider their Historical placement of society. Some of cultural properties in the project area which opulent from the Colonial Architectures and their relationship to the foreign culture makes invaluable contribution to the country. Here should be considered non material value of these properties. These properties are mentioned in the attached map. TABLE 5.7.4 illustrates number of cultural properties of survey area.

149. Among the Churches Mattakuliya Church with seminary is very sacred place to the Roman Catholic people of the country. This situated in Lunupokuna area. Palliyawatta Church is also considered as a Historical place by the people.

5.7.4 Land Value

150. Due to the urbanization, improvement of economical activities, the land values rapidly rise up. The land value of survey area is varies from 40,000.00-125,000.00 of Sri-Lankan Rupees per perch. Here in CNCA average value of per perch is around Rs. 108,635.60 and in WPCA is Rs. 51,425.40. These figures vary due to the many reasons. TABLE 5.7.5 is approximate average value per perch in all Gramasevaka divisions and total land values.

TABLE 5.7.4 Cultural Asset

No.	Type of Cultural Property	Number
1	Temples	07
2	Churches	07
3	Kovils (Hindu Temple)	04
4	Mosque (Muslims)	02
	TOTAL	**20**

TABLE 5.7.5 Land Value

No.	Gramasevaka division	Average value (Rs.)	Land area (perches)	Average value (Rs./perch)	Total land value (million Rs.)
1	Lunupokuna	238,185.00	21,120	120,000.00	2,534.4
2	Alth Mawatha	100,000.00	27,360	100,000.00	2,736.0
3	Modara	85,000.00	22,080	115,000.00	2,539.2
4	Mattakuliya	80,000.00	25,600	103,000.00	2,636.8
5	Palliyawatta North	42,000.00	11,920	62,000.00	739.1
6	Palliyawatta South	45,000.00	13,920	48,000.00	668.2
7	Dikowita	35,000.00	8,324	42,000.00	349.6
	TOTAL		130,324		12,203.3

6. Assessment of Environmental Impacts

151. Reclamation and dredging have the most potentially adverse effects. As shown in the Figure 6.1.1, the expansion of QEQ is designed within the extended coastal line along the Galle Face Road. It will minimize the effects on the south coast of the port.

152. Landfill in the north site is designed in consideration of the mouth of Kelani River. In case of the PVQ North Development, the front of landfill is about 1.5 km offshore from the river mouth. In case of the Crow Island Offshore Development, the edge of landfill is designed at 200 meters south of the river mouth and two groins are planned to lead the flow.

6.1 Current Flow

153. To assess the impact of the port development in the short-term development plan and master plan, tidal currents are identified by means of computer simulation. The simulation area encompasses 42 km^2 of surface water, about 9 km in south-north direction and 3.8-6.4 km offshore.

154. A single layer differential model is adopted for the simulation. Equations of the model are shown in Equation 6.1.1. Grid size of the simulation is 200 meters and the tidal component used is M_2. Volume and location of freshwater discharges are shown in Figure 6.1.1 and Table 6.1.1

155. Simulation was carried out in the case of northward tide and southward tide, in both cases the current flows from south to north due to the fact that the constant flow in the sea dominates the tidal flow so that the residue of current velocity is always headed north. Simulation cases are as follows:

Case 1: Present Geometry, Northward tide with the constant flow
Case 2: - ditto -, Southward tide with the constant flow
Case 3: Short-term Development, Northward tide with the constant flow
Case 4: - ditto -, Southward tide with the constant flow
Case 5: Master Plan (Crow Island Offshore Dev.), Northward tide with the constant flow
Case 6: - ditto -, Southward tide with the constant flow

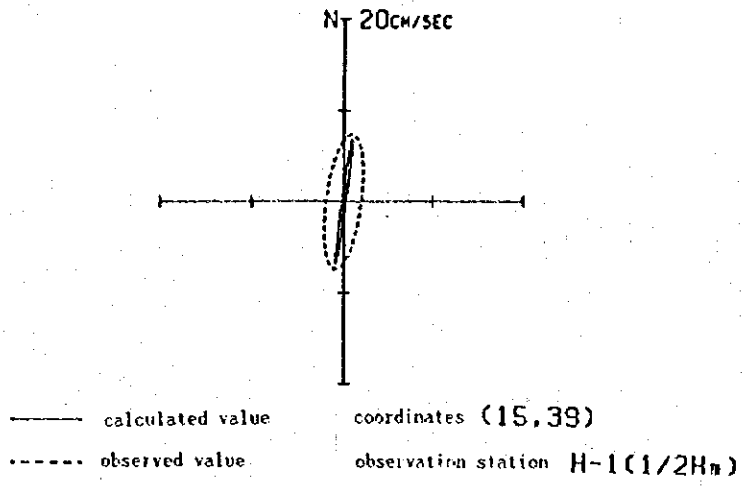
156. Calibration of the model was carried out in line with the current data observed at the point 3.5 km offshore Crow Island. (See Figure 6.1.2). The component of tidal portion is less than 10 cm/s and the constant portion is about 15 cm/s.

157. The simulation has shown that the tidal current in the offshore area flows along the coastline in the direction of N-NE, while the clockwise counter current appears near the river mouth of Kelani River. Current velocity is much smaller in the port area than outside. An

incoming flow is shown from the North Entrance and outgoing flow from the West Entrance. (Figures 6.1.3 and 6.1.4).

158. Results of the calculation (Short-term development plan and M/P Crow Island Offshore Development case) are shown in Figures 6.1.5 and 6.1.6, in which current direction and velocity are indicated with vector array. Differences in current velocity between the present geometry and the future are presented in Figures 6.1.7 and 6.1.8. In both future cases, changes in current velocity of more than 10 cm/s are limited to the adjacent area while a slight decrease is shown in the north coast of Kelani River.

FIGURE 6.1.2 TIDAL CURRENT ELLIPSE



EQUATION 6.1.1

Equation of continuation :

$$\frac{\partial \zeta}{\partial t}+\frac{\partial}{\partial x}[(\zeta+D)u]+\frac{\partial}{\partial y}[(\zeta+D)v]=0$$

Equations of motion :

$$\frac{\partial u}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial u}{\partial y}=fv-g\frac{\partial \zeta}{\partial x}+Ax\frac{\partial^2 u}{\partial x^2}+Ay\frac{\partial^2 u}{\partial y^2}-\gamma_b^2\frac{u\sqrt{u^2+v^2}}{(\zeta+D)}$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-fu-g\frac{\partial \zeta}{\partial y}+Ax\frac{\partial^2 v}{\partial x^2}+Ay\frac{\partial^2 v}{\partial y^2}-\gamma_b^2\frac{v\sqrt{u^2+v^2}}{(\zeta+D)}$$

where,

x,y	: Orthogonal cartesian coordinates
u,v	: Velocity components in x-, y- directions, respectively
t	: Time
ζ	: Elevation of water surface from the still water level positive upward
D	: Water depth
f	: Coriolis parameter
g	: Gravitational acceleration
γ_b^2	: Bottom friction factor
Ax, Ay	: Horizontal eddy viscosity

TABLE 6.1.1 Freshwater discharge into the sea

Point	Source	Discharge (m^3/day)
1	Kelani River	7,000,000
2	Harbour P1	1,980
3	Harbour P2	5,340
4	Harbour P3	2,730
5	Harbour P4	2,890
6	Harbour P5	1,100
7	Beira Lake	20,400
8	Sewer Outlet	Present 44,000 (2005) 52,800 (2015) 52,800

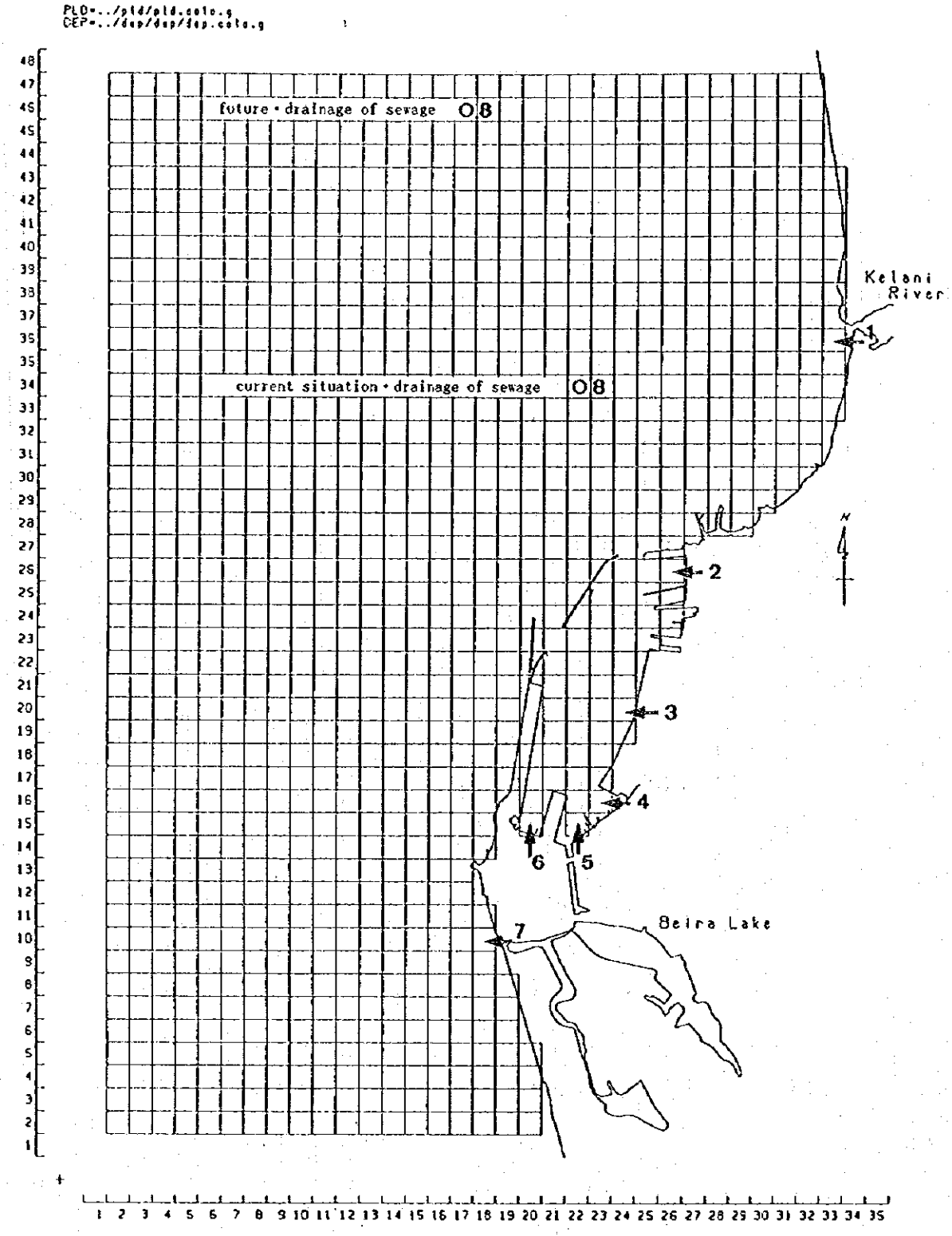


FIGURE 6.1.1 Location of fresh water discharge into the sea

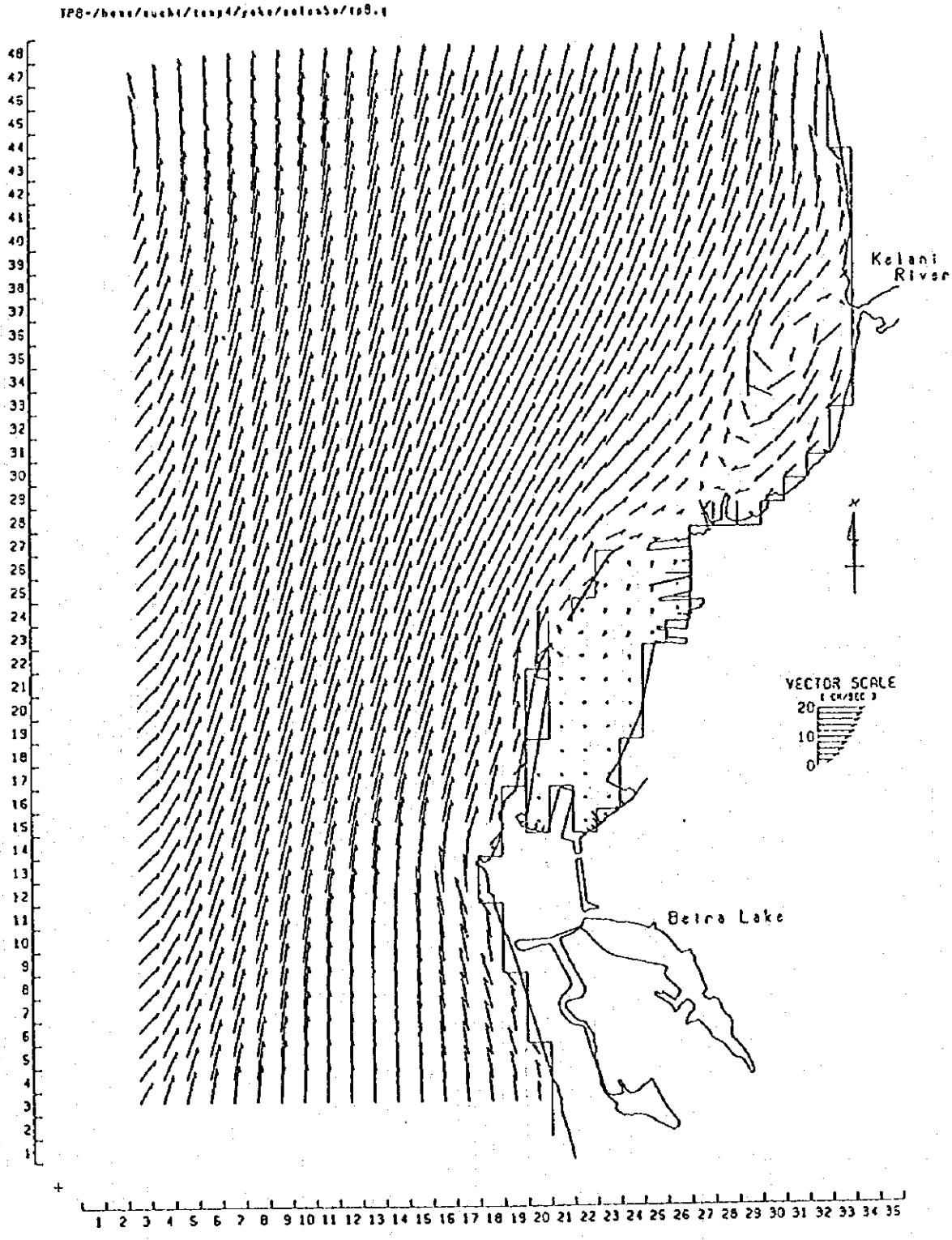


FIGURE 6.1.3 Fastest northward current
Current direction and velocity indicated with vector array
(constant flow + tidal flow, current situation)

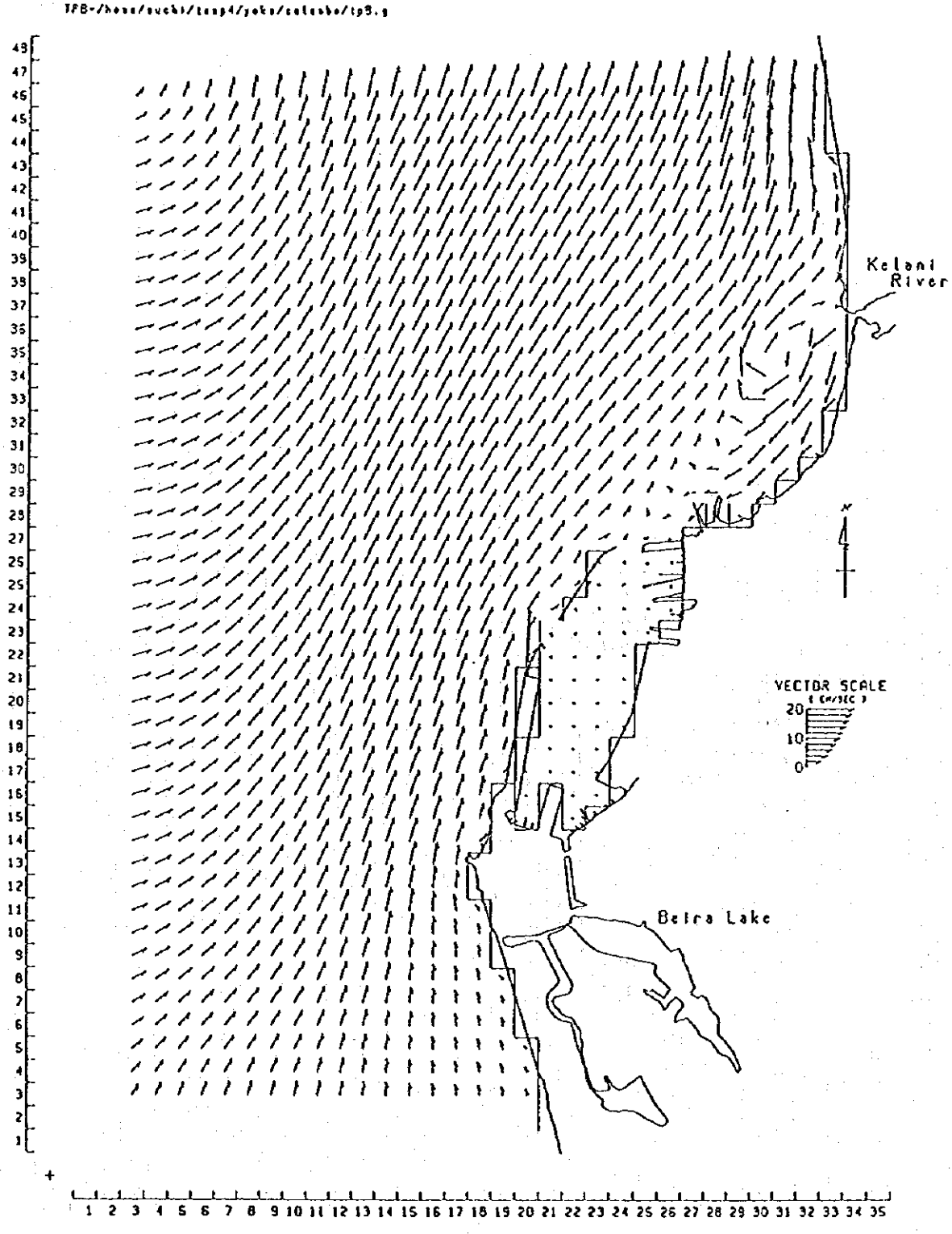


FIGURE 6.1.4 Fastest southward current
Current direction and velocity indicated with vector array
(constant flow + tidal flow, current situation)

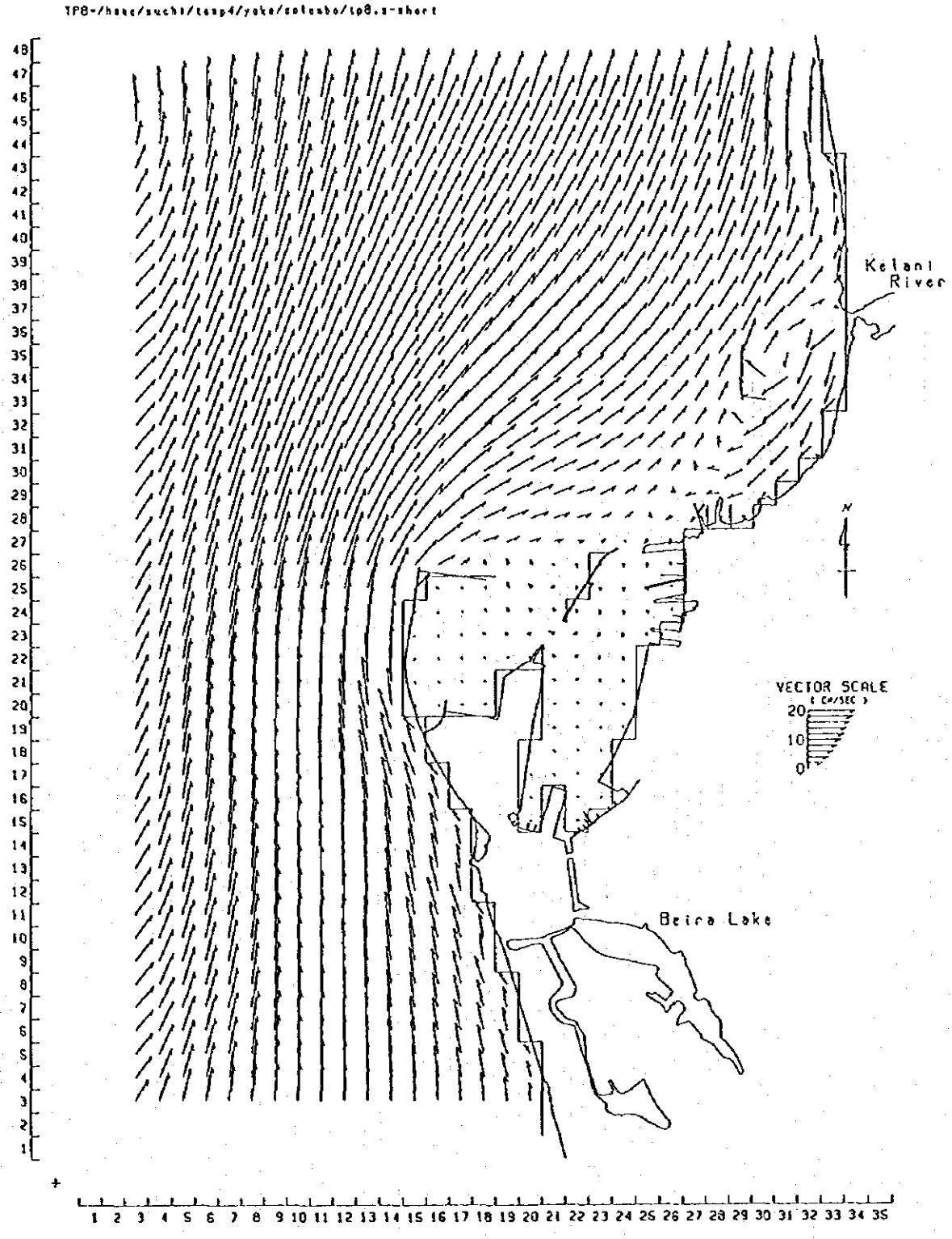


FIGURE 6.1.5 Fastest northward current
Current direction and velocity indicated with vector array
(constant flow + tidal flow, short-term development)

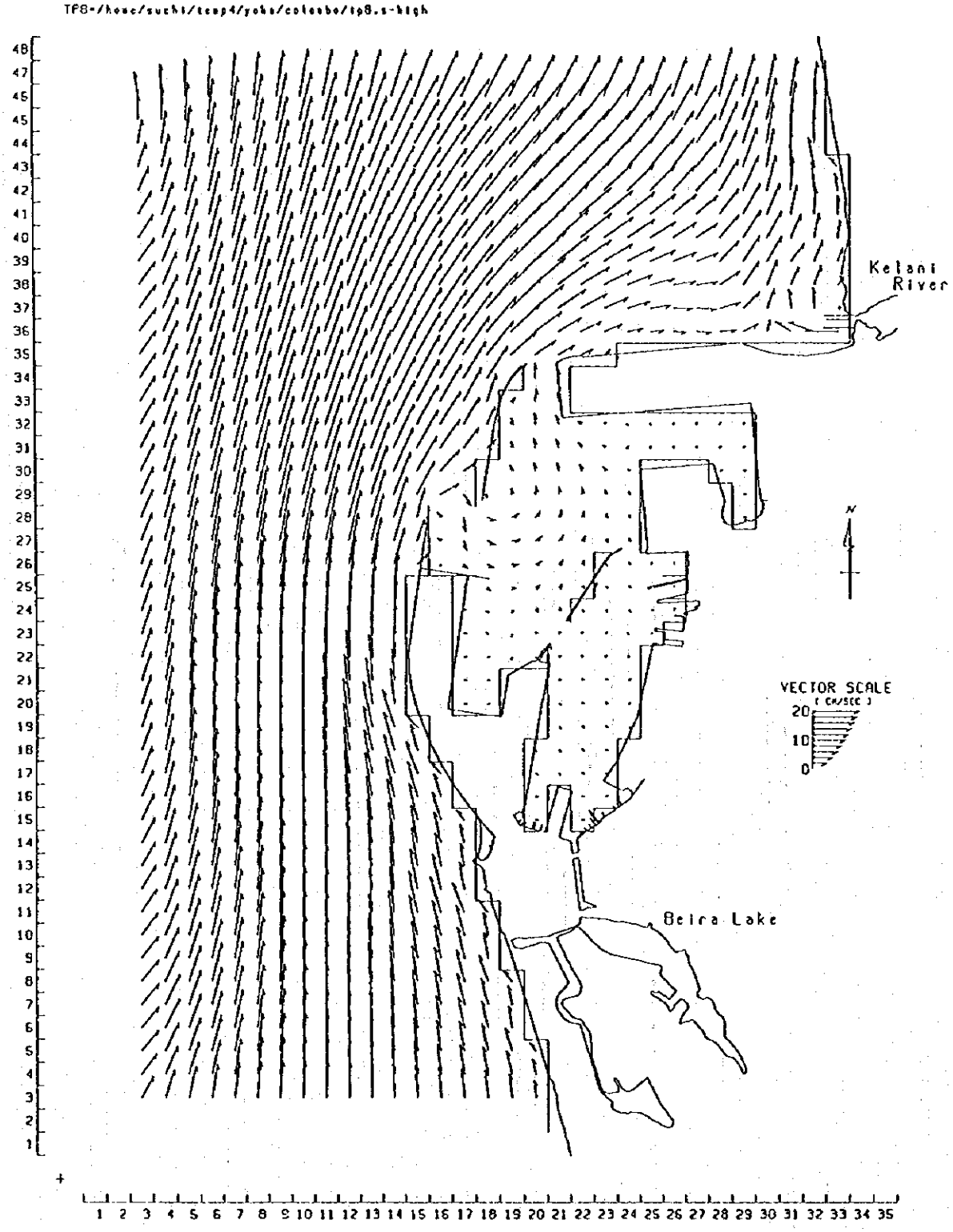


FIGURE 6.1.6 Fastest northward current
Current direction and velocity indicated with vector area
(constant flow + tidal current, M/P high growth case)

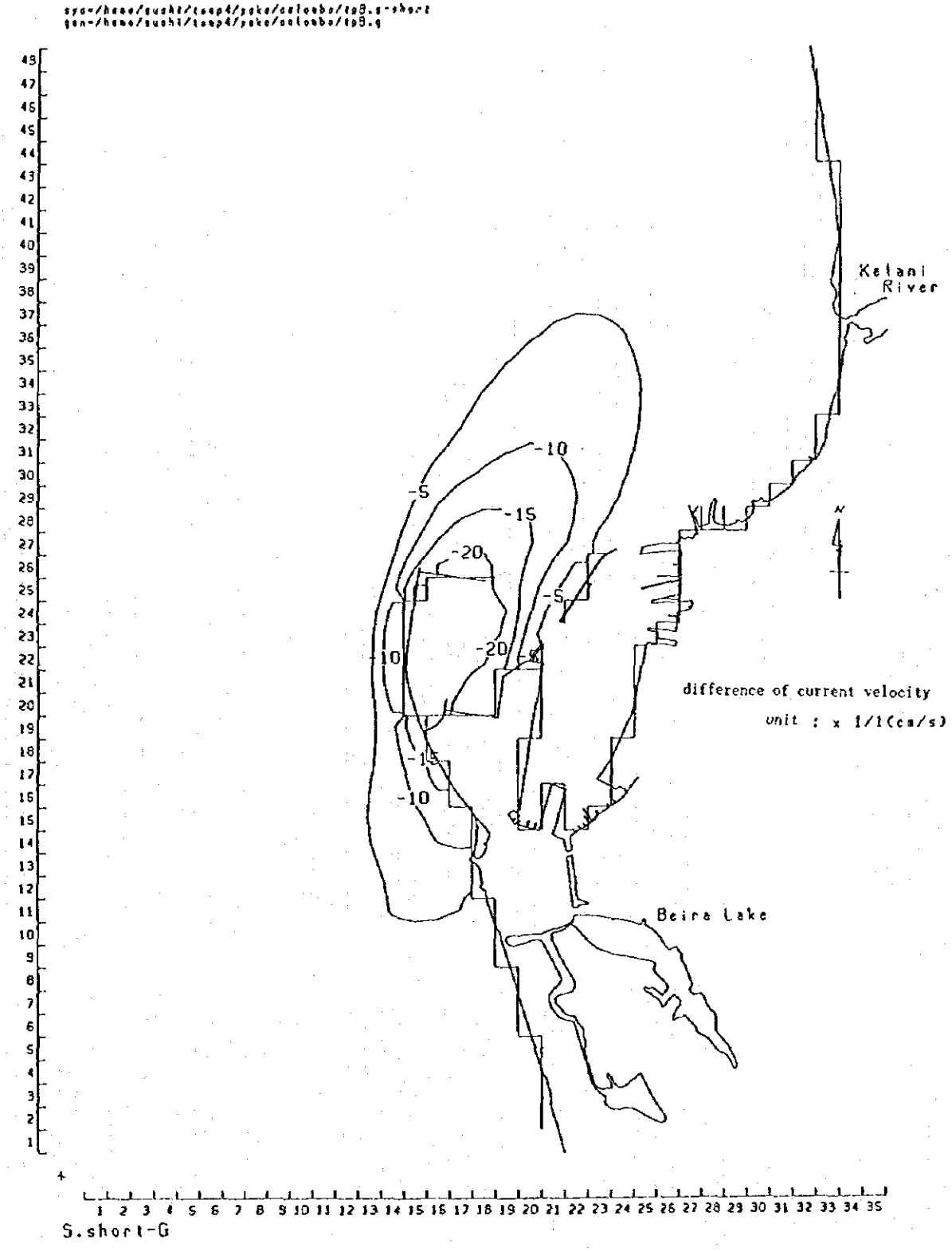


FIGURE 6.1.7 Fastest northward current
Difference of current velocity
(constant flow + tidal current, short-term development)

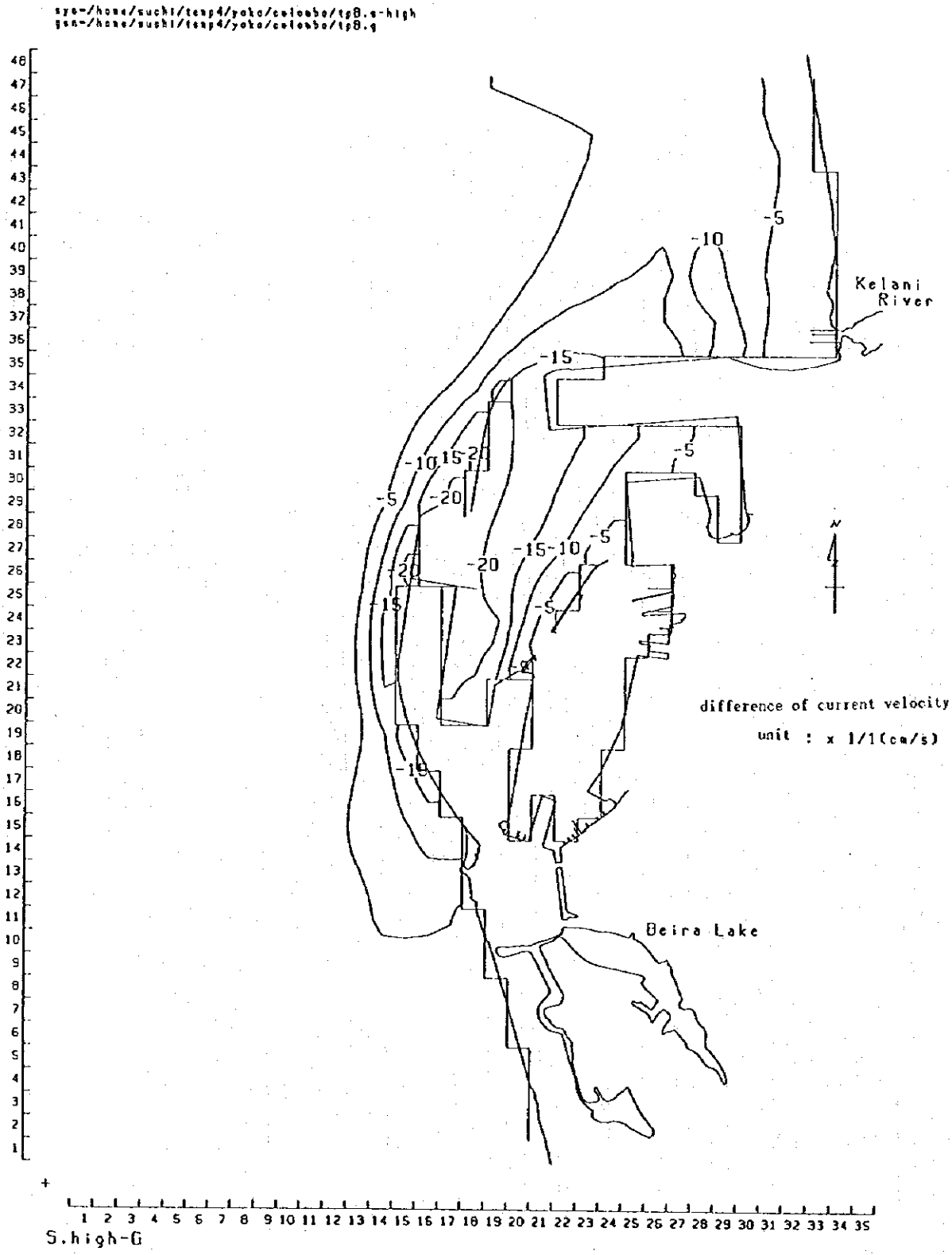


FIGURE 6.1.8 Fastest northward current
Difference of current velocity
(constant flow + tidal flow, M/P-high growth case)

6.2 Water Pollution

(1) Changes in Water Quality (COD)

159. Water quality is mainly measured by five elements: (a) general features such as temperature, salinity, pH, colour, transparency, oil and grease, and organic material concentration measured by chemical oxygen demand (COD) or biochemical oxygen demand (BOD); (b) turbidity measured by suspended solids (SS); (c) eutrophication-related factors measured by dissolved oxygen (DO), nitrogen (N) and phosphorus (P); (d) harmful or toxic substances including heavy metals such as mercury, cadmium, lead, and pesticides; and (e) sanitation-related factors determined by measuring the amount of coliform bacteria.

160. Since COD is usually used for an indicator of the dispersion of water pollution, water quality is assessed by COD dispersion model on tidal currents. The model used is a single layer differential model and its equations are indicated in Equation 6.1.2.

161. The amount of COD load is shown in Table 6.2.1. The location of discharge points is the same as Figure 6.1.1. New sewer outlet is planned at a point about 3 km north east due to the development plan of North Port. (See Figure 6.1.1)

162. A computer simulation was carried out for two cases, one to assess the present water quality and the other to assess water quality after completion of master plan. As the short-term development plan is part of the master plan, which consists of the South Port and North Port, impacts of the short-term development are less than that of the master plan.

163. Based on water quality survey shown in chapter 5, COD concentration at the boundary of the simulation area is assessed at 5 ppm. The simulation was carried out under the following conditions and the result of the present case is compared with the COD concentration observed. (See Figure 6.2.1).

Diffusion factor:	10^4 cm^2/s
Time step:	300 sec
Simulation period:	120 tide cycles

164. A result of the simulation is shown in Figure 6.2.3 indicating contour lines of COD dispersion. Fairly high concentration is seen at the inner harbour between Bandaranaike Quay and the JCT south end. No significant difference in COD concentration is shown between the offshore and QEQ outer harbour or North harbour. A slight increase is seen inside the harbour as shown in Figure 6.2.4, however, it is within 10 % of the present COD concentration and has no substantial adverse effect.

165. COD concentration adjacent to the new sewer outlet shows an increase of 0.1 mg/l, however, the area of higher concentration is very much limited and the increase of 0.1 mg/l is deemed to have no substantial effect.

EQUATION 6.1.2

COD diffusion.

$$\frac{\partial S(D+\zeta)}{\partial t} = -\frac{\partial}{\partial x}[Su(D+\zeta)] - \frac{\partial}{\partial y}[Su(D+\zeta)] + \frac{\partial}{\partial x}[K(D+\zeta)\frac{\partial S}{\partial x}] + \frac{\partial}{\partial y}[K(D+\zeta)\frac{\partial S}{\partial y}] + Ls$$

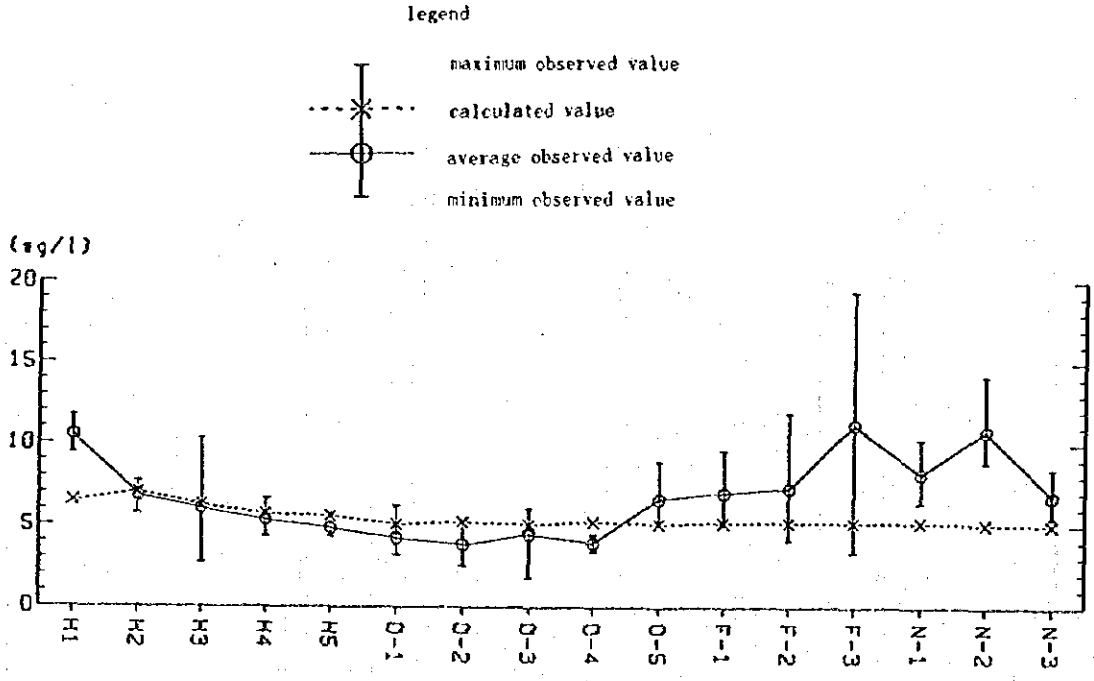
where,

x, y	:	Orthological cartesian coordinates
u, v	:	Velocity components in x-, y- directions, respectively
t	:	Time
D	:	Water depth
ζ	:	Elevation of water surface from the still water level positive upward
K	:	Horizontal diffusion coefficient
S	:	Concentration of COD
Ls	:	Load

TABLE 6.2.1 Amount of COD load

Point	Source	COD (kg/day)
1	Kelani River	36,400
2	Harbour P1	277
3	Harbour P2	748
4	Harbour P3	273
5	Harbour P4	231
6	Harbour P5	121
7	Beira Lake	1,020
8	Sewer Outlet	Present 6,160 Future 7,392

FIGURE 6.2.1 COD Concentration Estimated and Observed



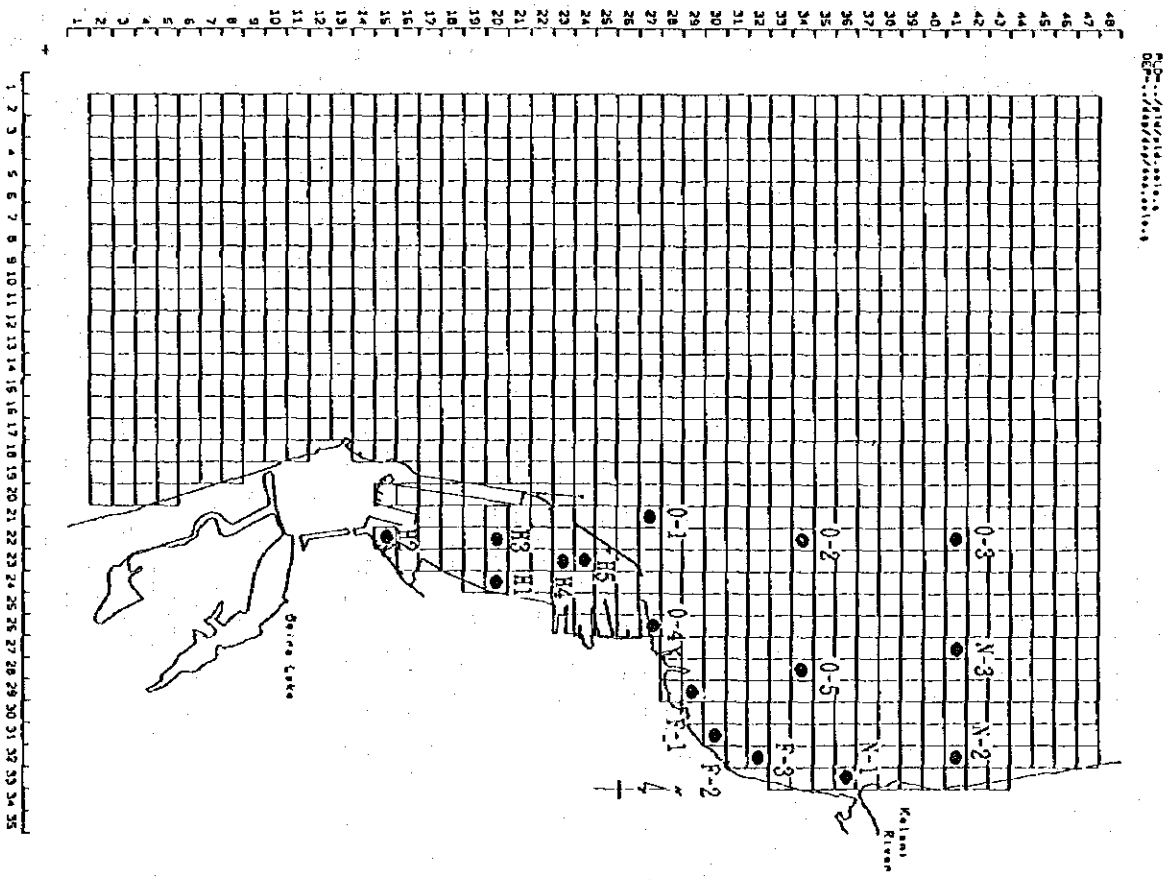


FIGURE 6.2.2 Sampling Points

(2) Dispersion of Suspended Solids (SS)

166. Deposition of rubble, dredging, pile driving and other construction works in water cause resuspension of sediments and turbid water. Resuspension of sediments in water leads to an increase in the level of suspended solids (SS) and in the concentration of organic matter, possibly to toxic or harmful levels. It also reduces sunlight penetration.

167. Disposal of dredged material has also potential adverse effects on the level of SS. The master plan and short-term development plan proposed in this report have larger volume of reclamation than dredging. Consequently, dumping of dredged material will only be necessary at the first stage of seawall construction and most of the dredged material can be filled in land reclamation. Dumping is therefore deemed not to cause serious adverse effects.

168. Whilst the adverse effects of dredging and dumping are limited to working hours, a possible area of turbid water dispersion is assessed by computer simulation using SS as an indicator. The model used for the simulation is the same as the model for current flow simulation.

169. SS loads of typical construction work sites are supposed to be 2-6 ton/day as shown in Figure 6.2.5. While all construction works are not carried out simultaneously, the simulation was carried out supposing a case that all of them generate SS at the rate indicated in Figure 6.2.5.

170. Parameters used in the simulation is the same as that of COD dispersion simulation. Results of the simulation are shown in Figure 6.2.6 (Daily average of SS concentration) and in Figure 6.2.7 (Max SS concentration). Since the particle size of sediments in this area is rather large and the velocity of tidal currents is small, SS dispersion is limited to the area adjacent to work site. Taking into account that a temporary limit of SS is set under 2 mg/l for the cultivation of fish, estimated level of SS will not have significant impacts on fishery resources.

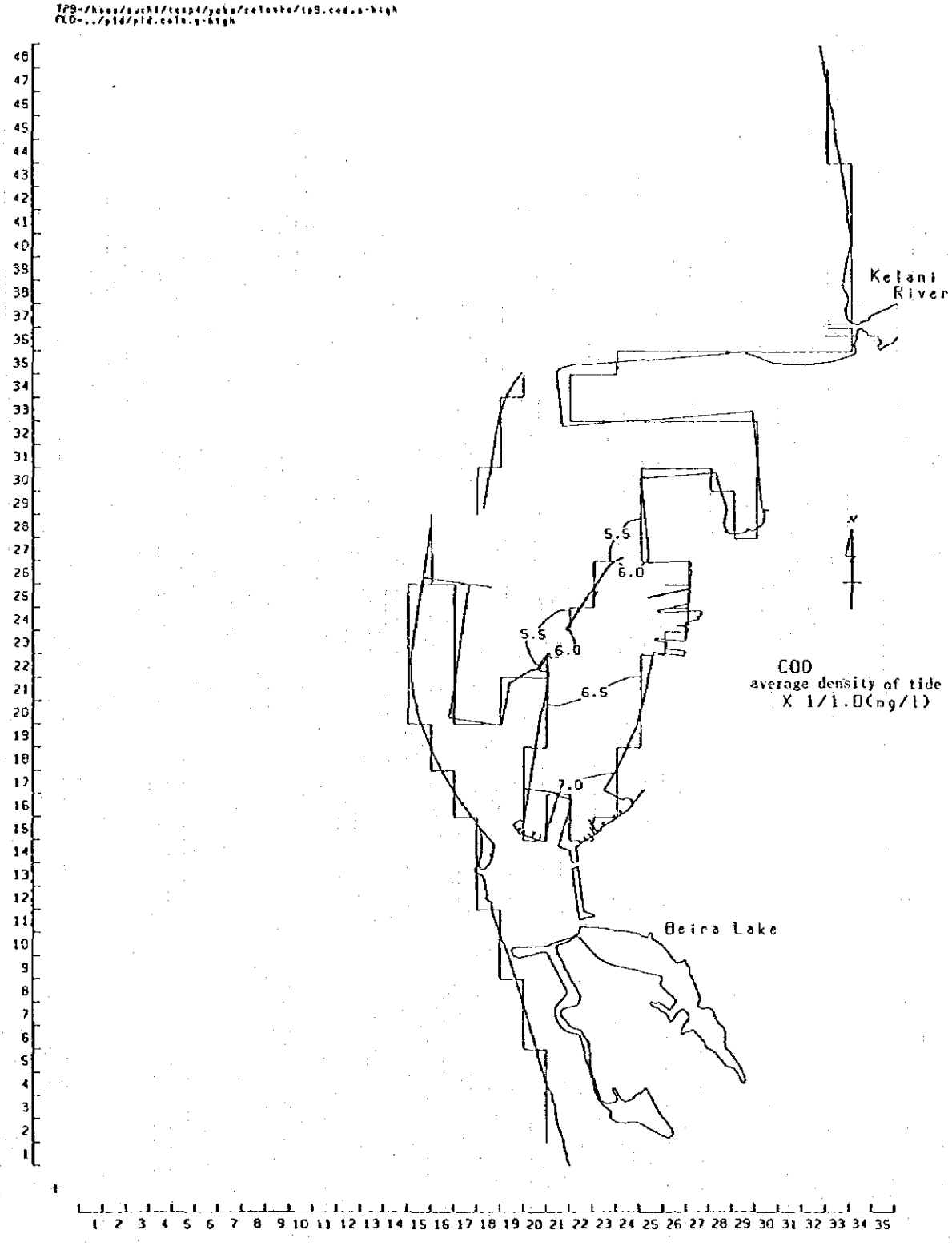


FIGURE 6.2.3 Distribution pattern of COD concentration in future (constant flow + tidal current, high growth case)

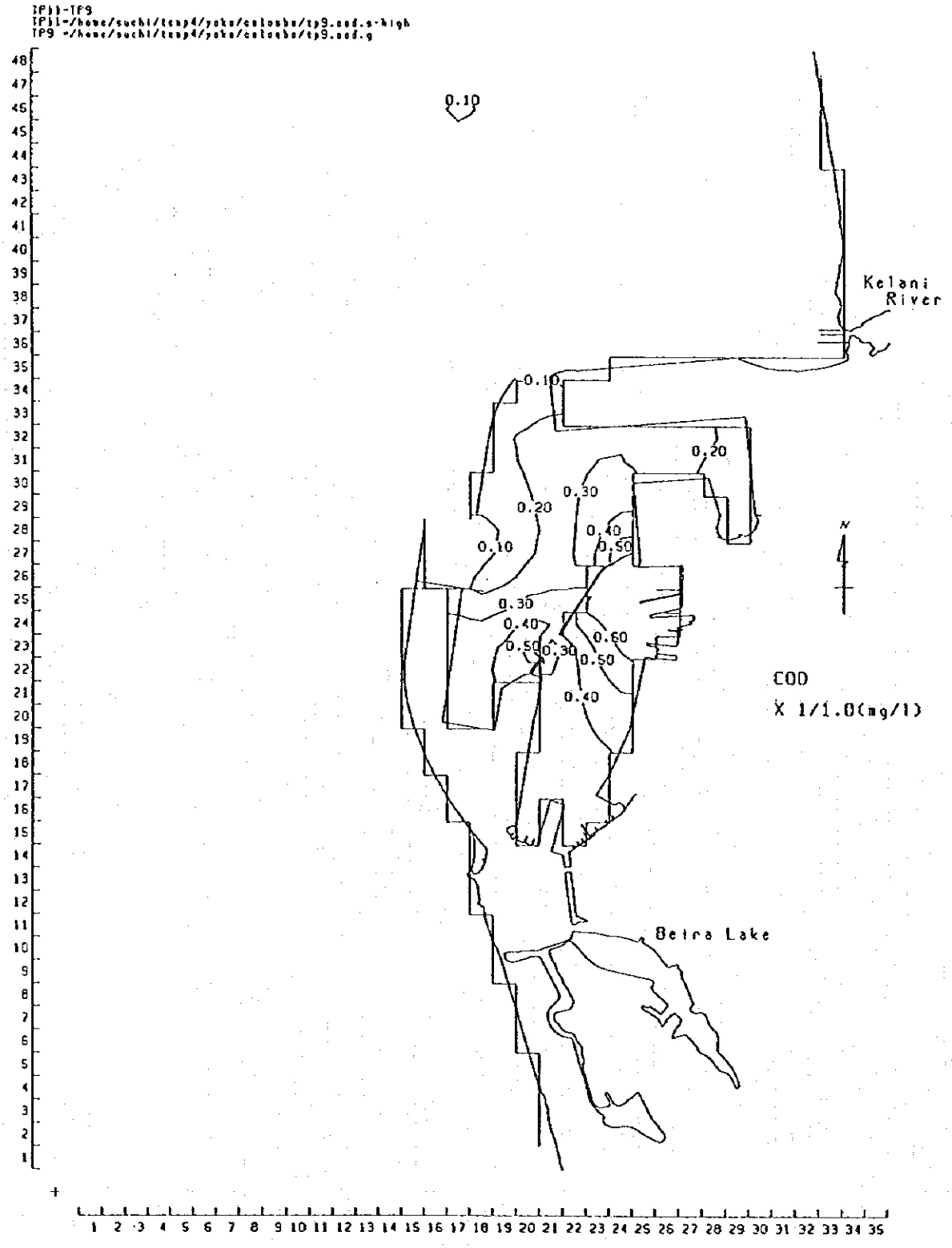
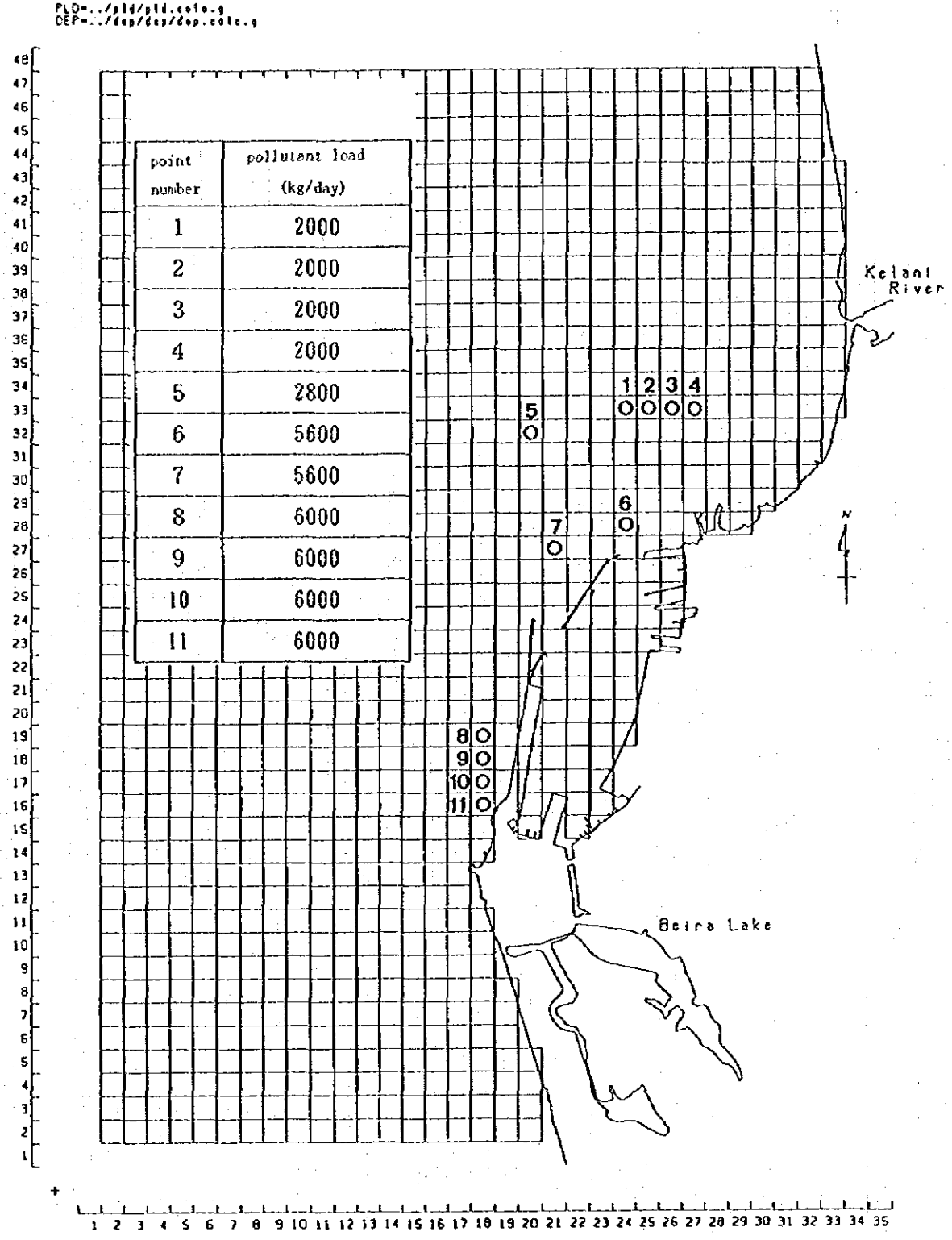


FIGURE 6.2.4 Difference of COD concentration between the current condition and the future(constant flow + tidal current, high growth case)



point number	pollutant load (kg/day)
1	2000
2	2000
3	2000
4	2000
5	2800
6	5600
7	5600
8	6000
9	6000
10	6000
11	6000

FIGURE 6.2.5 Ponts of SS generation

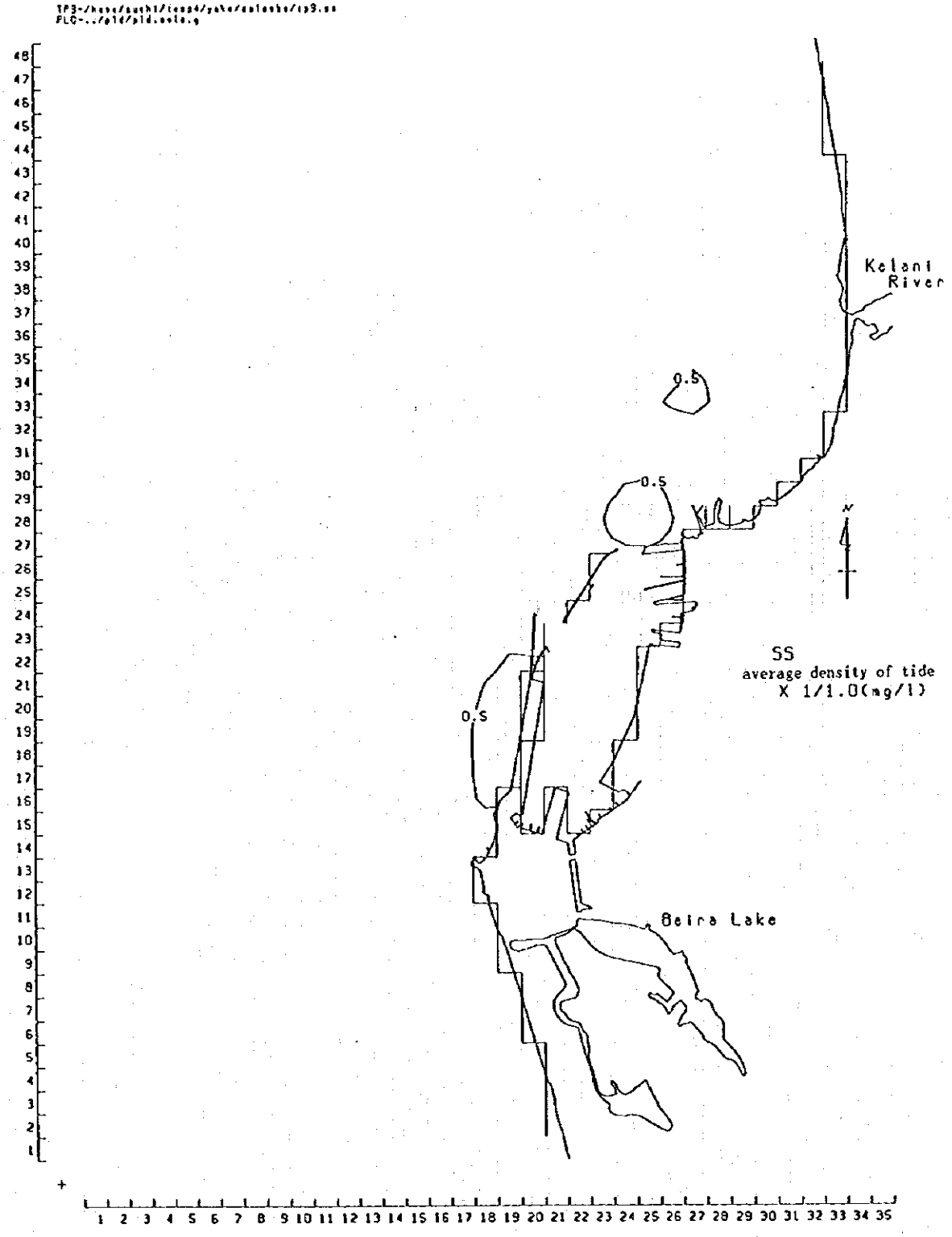


FIGURE 6.2.6 SS distribution of the average concentration

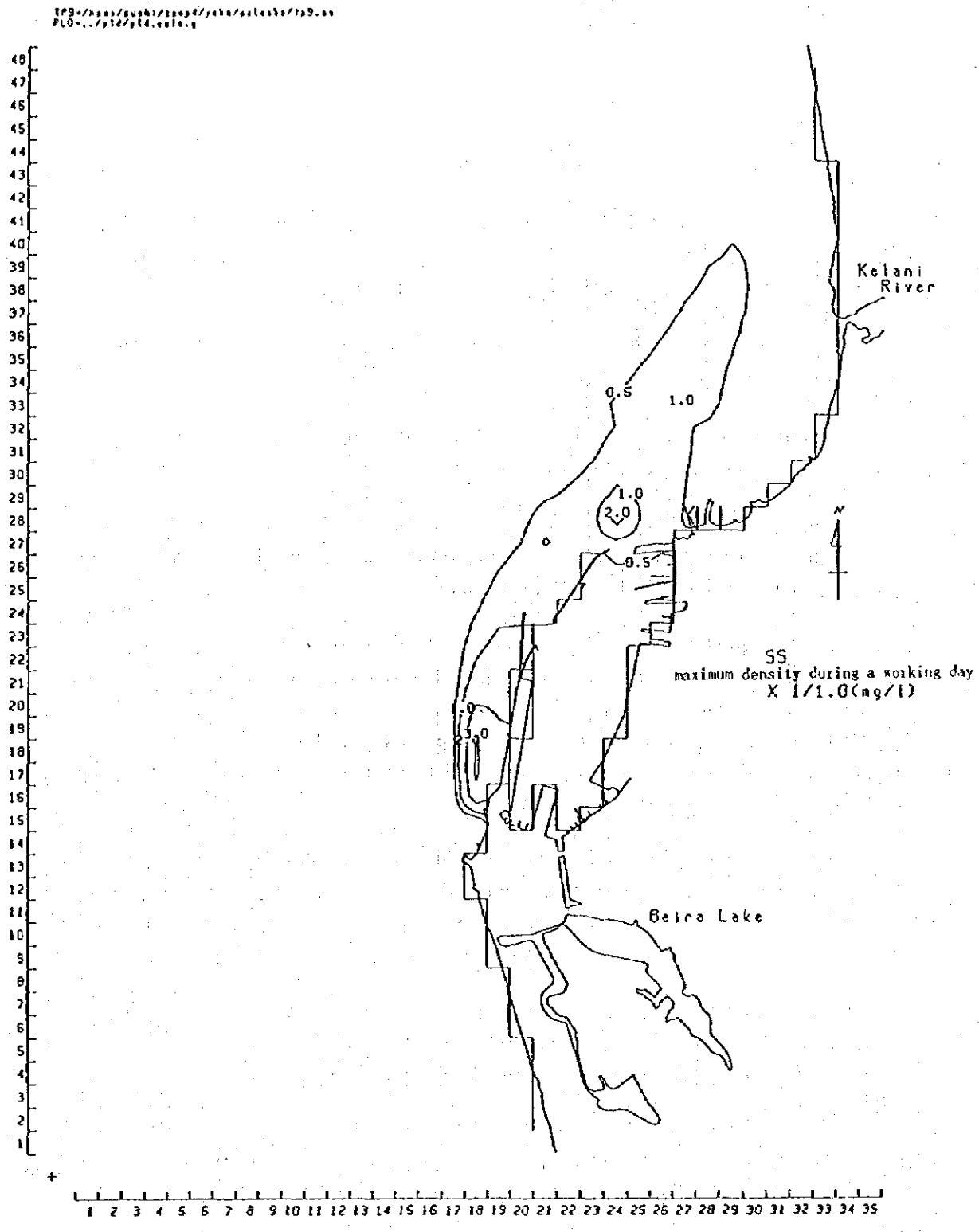


FIGURE 6.2.7 Maximum concentration of SS during a working day

6.3 Shoreline change

171. Marine structures or land reclamation usually cause changes in currents and wave movements, which may result in changes in the shoreline configuration (e.g. beach erosion or accretion). Erosion and accretion take place alternately due to the change of onshore-offshore littoral transport and longshore littoral drifts.

172. The coast between Colombo and Negombo is a barrier beach with ledges of beach rock and the coastline is only keeping its present position due to the abundant presence of beach rock. This coast is characterized by erosion, which is accelerated for a number of reasons[1]:

- Sediment supply from south ceased long ago, when proto-historical coast erosion increased the headland effects of Colombo;

- Sediment supply from south has also been cut off due to the heavy coastal protection of the beach between Mount Lavenia and Colombo;

- Sand mining in the Kelani River resulted in a lack of sand which left the coast undernourished. The volume of the mining has reached 750,000 m^3, which is estimated at 25 times the littoral drift in the area;

173. Impacts of the South Port Development and North Port Development on the shoreline configuration are mainly caused by changes in littoral current flow and wave actions on the coast. Littoral current flow is simulated by a computer model as shown in section 6.1 of this chapter and it is concluded that no significant change will take place except the area adjacent to breakwater and reclamation. In the case of North Port Development, a slight decrease in the current speed is predicted along the coast north of Kelani River.

174. Changes in wave action to be caused by South and North Port Development were studied by a computer simulation model. Wave refraction, shoaling and reflection from the structures are simulated in the model. As the wave energy throughout a year affects littoral drifts, averaged wave height and period are used in the simulation (Table 6.3.1)

175. Wave refraction and shoaling pattern in SW wave is shown in Figure-6.3.1(1) and all other patterns in other directions are shown in Figure A6.3.1(1)-(4) Differences in wave height between the case of the present geometry and the case of the master plan are shown in Figure 6.3.2(1) and Figure A6.3.2(1)-(4).

176. A result of simulation has shown no effect on the coast of Galle Face in any wave direction. A considerable decrease in wave height is predicted in the limited area offshore of Kelani River in cases of SW and WSW waves, which will ease coastal erosion in the area. It is also predicted that wave height increases in the same area in a case of NW waves, which may

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[1] Master plan, Coast Erosion Management, West Coast, by coast Conservation Department, 1986

bring coastal erosion. However, as frequency of NW waves are very small and waves from SW to W are predominant, a certain area offshore of Kelani River will experience an accumulation of sand to some extent.

177. Groins will therefore be necessary to keep the river mouth open. The coast between Colombo and Negombo will also need groins to trap sand and protect the beach from erosion. Adverse effects of the implementation of the master plan are deemed to be limited to a certain area and not to be so serious.

TABLE 6.3.1 Averaged wave height and period

Case	Wave direction	Wave period (sec)	Wave height (m)	Frequency of occurrence (%)
1	SW	6.0	1.8	48.74
2	WSW	6.0	1.8	14.62
3	W	6.0	1.8	2.58
4	WNW	6.0	1.8	0.26
5	NW	4.9	1.5	0.88

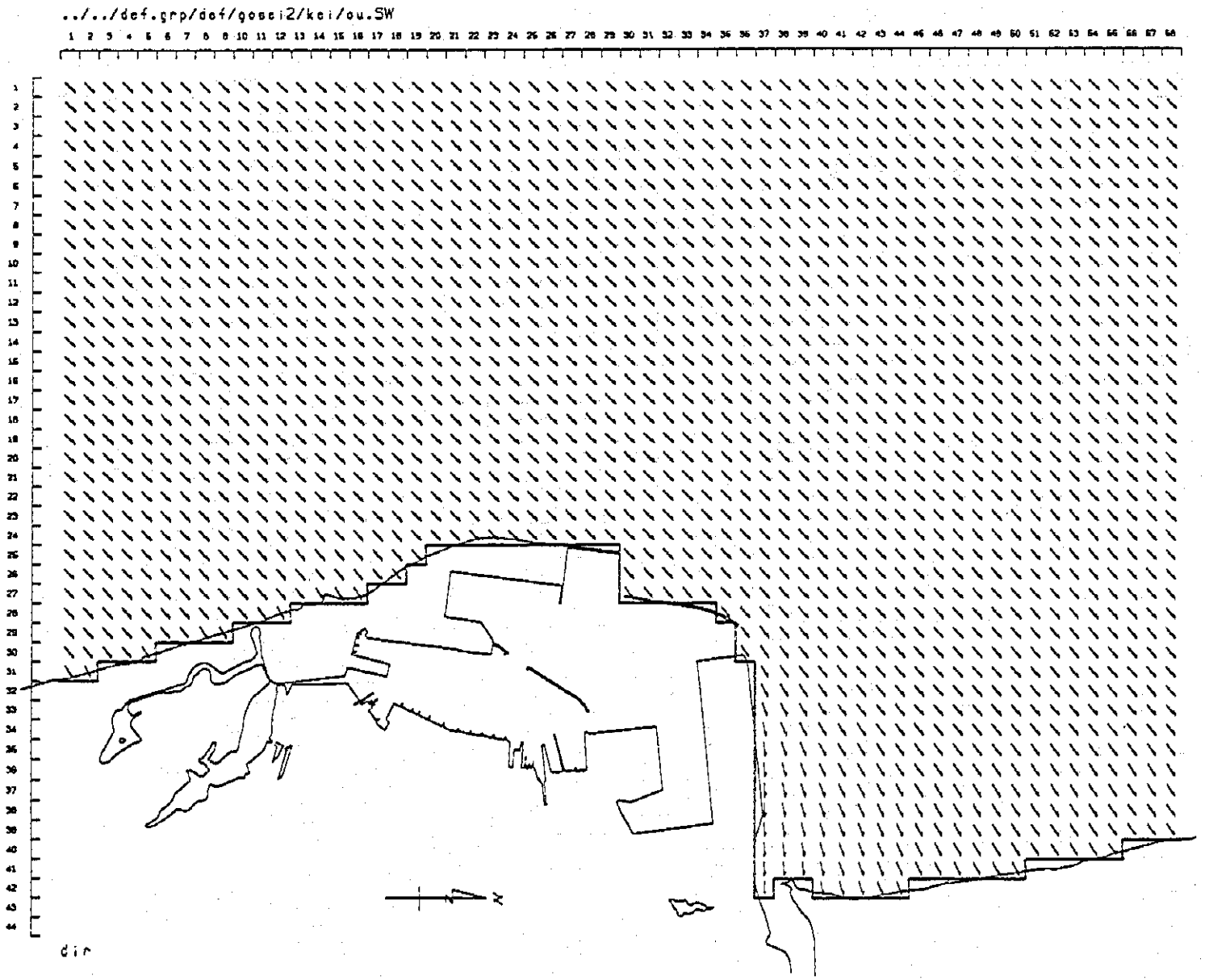

FIGURE 6.3.1(1)
Wave Refraction and Shoaling (SW)

Title	The future wave condition
Wave direction	SW
Wave period	6.00sec
smax	25

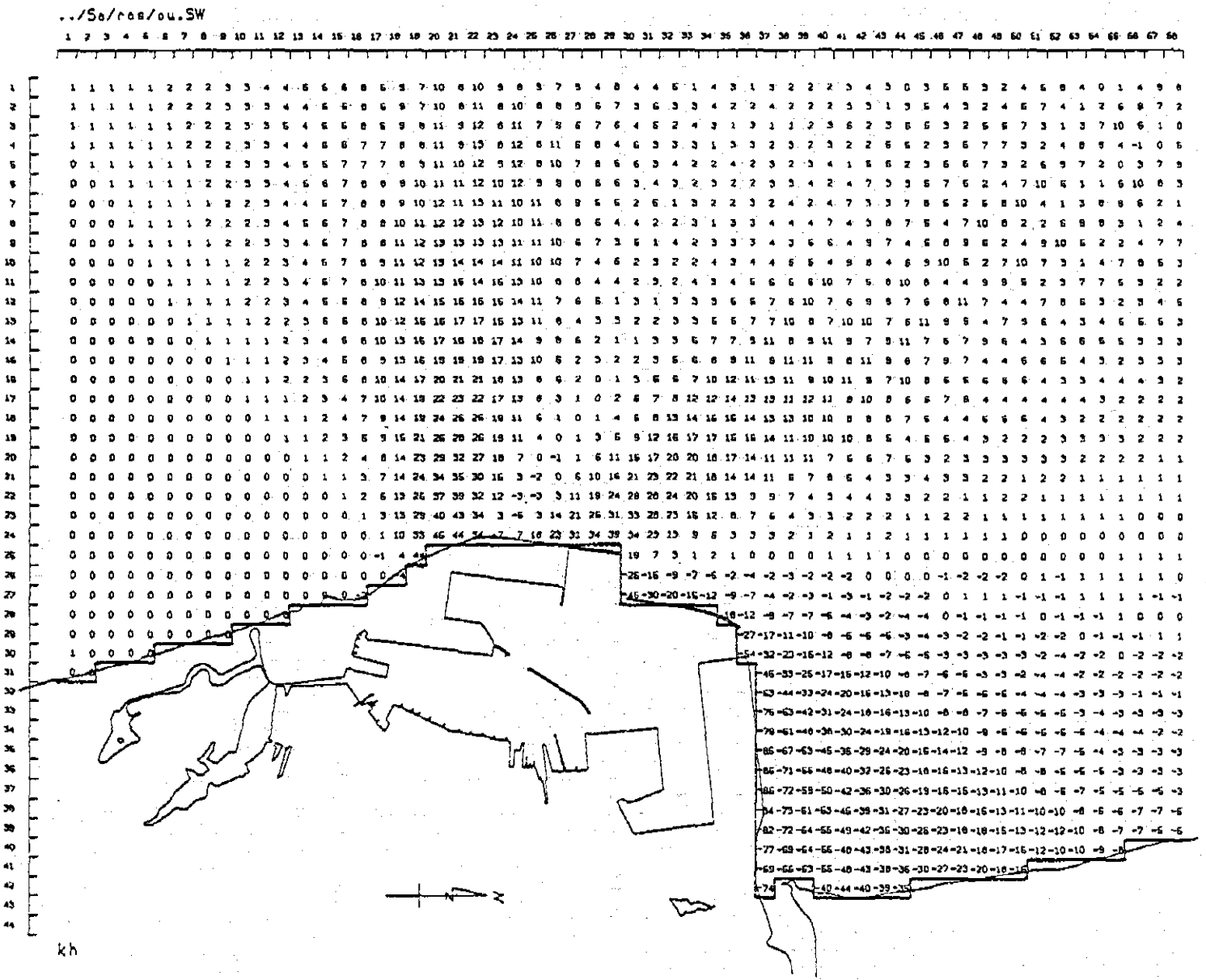

FIGURE 6.3.2(1)
Wave Height Changes (SW)

Title	difference in wave height between the conditions of existing and future situation
Wave direction	SW
Wave period	6.00sec
smax	25
unit	cm

6.4 Vehicle Emissions

178. Air quality consists of two main elements: (a) soot and dust, measured by suspended particulate matter (SPM), which originate from road traffic, dry bulk cargo handling and storage, construction works; and (b) concentration of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and hydrocarbons (HC) emitted from ships, vehicles and various equipment used for port activities.

179. As indicated in section 3 of Part 5, SPM showed higher concentration than the permissible level during SW monsoon season, particularly on points R7-R13 (major cross sections outside of the port; See Figure 5.4.1). SPM concentration on the inter-terminal road in the port showed rather low concentration. In NE monsoon season, SPM showed lower concentration than the permissible level except three points, R7, R11, and R12, where city traffic is much larger than port-related traffic.

180. Sulfur dioxide level is rather low compared with the permissible level, however three points, R7, R11 and R13 showed slightly higher concentration. Diesel trucks are deemed to be main sources of SO_2 due to the fact that lower SO_2 levels were recorded at weekends while higher levels were recorded on weekdays.

181. Nitrogen dioxide and monoxide (NOx) showed very low concentration level compared with the permissible level. Among the points observed, R7, R11 and R13 have a rather high concentration due to vehicle traffic, which is the main source of air pollution in Colombo.

182. Total SOx and NOx emissions from port related vehicle traffic and ships are estimated in the medium growth case, in which incoming and outgoing port related traffic is assessed at about 18,000 in 2005 and 27,000 in 2015 and ship calls at about 6,700 in 2005 and 9,700 in 2015.

TABLE 6.4.1 Port Related SOx NOx Emissions

(ton/day)

Year	1994		2005		2015	
Source	SOx	NOx	SOx	NOx	SOx	NOx
Ships	0.2	0.9	0.4	2.0	0.6	3.0
Vehicles	0.01	0.2	0.02	0.3	0.03	0.4
Total	0.2	1.1	0.4	2.3	0.6	3.4

183. Total emissions in Colombo city are not assessed in details, however, total consumption of oil products suggests that SOx emissions may be about 5-6 tons/day and NOx emissions about 20-25 tons/day. Present concentration level of NOx is very low compared with permissible level and future port related NOx emissions will be 10-15% of the total in Colombo. Present concentration level of SO_2 is not so high except some road side points and future port related SOx emissions will be less than 10 % of the total. Though impacts of port development on air

pollution are deemed not so serious, careful routing of port related lorry traffic will be effective to mitigate air pollution in the city, which may be caused by a rapid increase in city traffic in the future.

184. In this connection, there is a plan for heavy lorries to use Gate No.11 or new Crow Island Access Road to be developed in the future while small lorries will use Gate Nos.7,11,13. All other gates are for the use of port-related passenger cars and not for lorries. Expansion of the inter-terminal road is therefore planned to accommodate all lorries to/from QEQ.

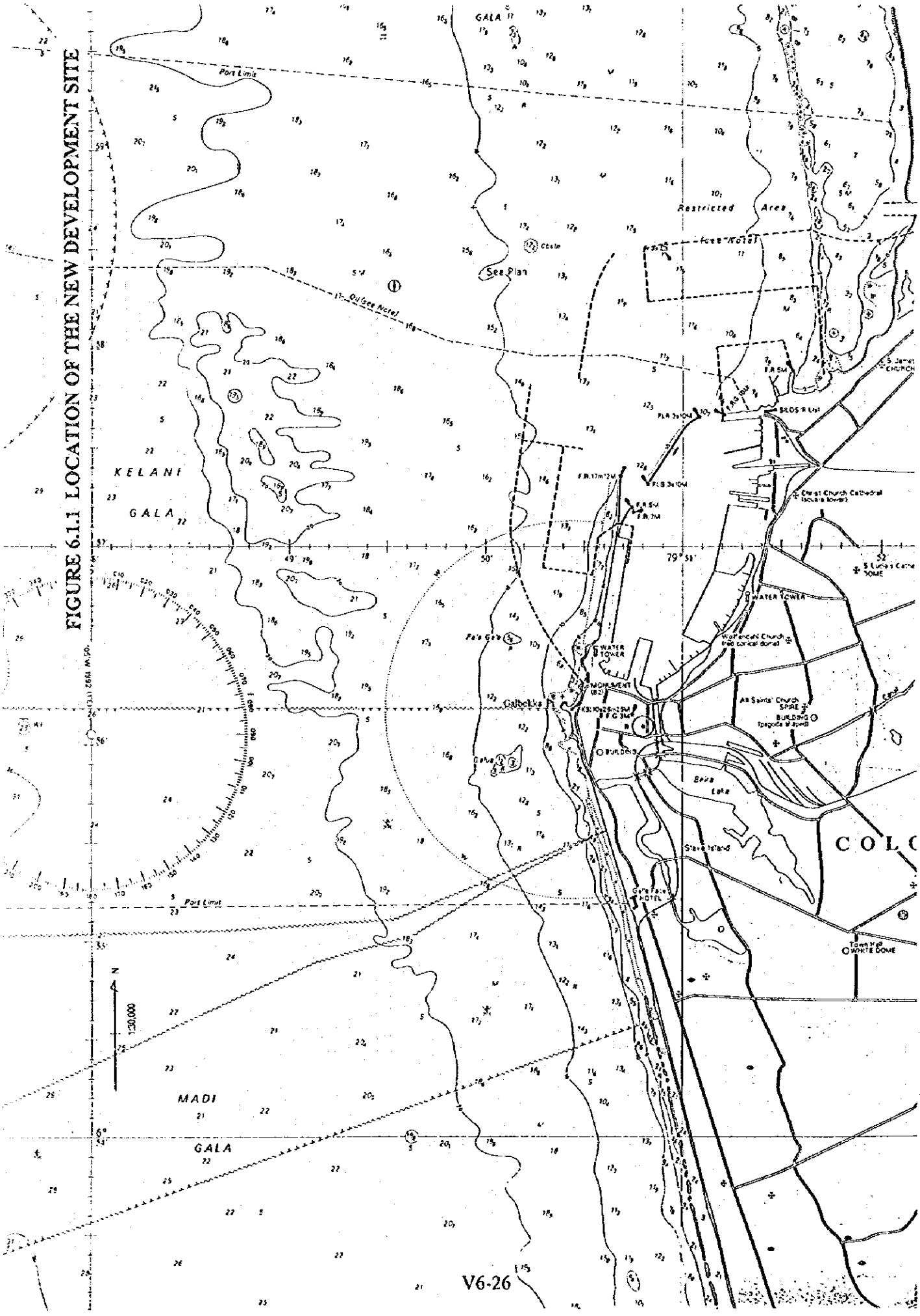

FIGURE 6.1.1 LOCATION OF THE NEW DEVELOPMENT SITE

7. Conclusions of preliminary EIA

185. Initial Environmental Examination is carried out based on a checklist of adverse effects of port development and the following are screened for detailed study: 1) Changes in current patterns which may be caused by dredging and construction of breakwaters/seawalls; 2) Disposal of dredged material; 3) Changes in water quality of the inside and outside of harbour; 4) Coastal hydrology on the south and north coast of the new port; 5) Traffic load on access roads; and 6) Air pollution which may be caused by future port traffic.

186. Current observation showed that the predominant direction of the currents are from south to north and the speed is 30 cm/s at a maximum and mostly less than 10 cm/s. As a result of simulation on the new port development, changes in current velocity are limited to the area adjacent to the new port and no significant change is seen in the offshore area. Current speed is reduced slightly along the north coast of Kelani River.

187. Water quality survey showed that the background level of the salinity is about 1.8 %, COD 4-5 mg/l, SS 1.5-2.0 mg/l, and DO 6-7 mg/l. Pollution is observed in the inner harbour and in the Mutwal Fishery harbour to some extent. As a result of computer simulation, no significant deterioration is predicted in the project area. Simulation also showed that the dispersion of suspended solids being generated by construction will be in a tolerable range, under 2 mg/l near construction work site.

188. The coast between Colombo and Negombo has been eroded by the lack of sediment supply from south and sand mining in the Kelani River. Changes in wave action were checked by a computer simulation. No change in wave action is seen on the shoreline of Galle Face coast and a decrease in wave height is predicted to some extent in the limited area of the north of Crow Island reclamation. It will bring sand accumulation in the limited area in front of the mouth of Kelani River so that two groins are planned to keep the mouth clear from siltation and sand accumulation.

189. Air pollution is not so serious in Colombo. Though field survey showed that suspended particulate matter exceeds the permissible limit at some major cross sections in SW monsoon season and sulfur dioxide level exceeds the permissible limit temporarily at some major cross sections, pollution level is generally low in this stage. Port related emissions of SOx and NOx are deemed low compared with total emissions in Colombo. Careful routing of port related lorry traffic is recommend to mitigate air pollution, which may be caused by a rapid increase in city traffic. It will also be necessary to mitigate noise and vibration being generated by road traffic.

190. Consideration is given to disposal of dredged material. Disposal site is designated in the sea about 4 km offshore from the north coast of Kelani Ganga and 6 km north west of the port. Since the volume of landfill is larger than the dredging, most of the dredged material can be filled in land reclamation, dumping is therefore deemed not to cause serious adverse effects.

191. Biological survey showed that mangroves are poorly represented at the Kalani river mouth and are not found anywhere else in the study area. Marine plants survey found that the algal (seaweed) growth was very poor in the offshore sea about 9-10 m deep. Coral reefs are composed of sandstone and coralline mineral and covered with a thick layer of sediment. As a result the coral cover on the reef is less than 1 %. It was found that the quantity of the marine organisms was relatively low in the study area.

192. The area behind the coast of Crow Island has a population of 168 per hectare and is mainly used for private houses. About 400 shanties are identified in the area and all of them are illegal settlement. Colonial architectures are located in the area including temples and churches, some of them are historically important buildings. Since the master plan is to develop firstly the South Port and secondly the North Port on land reclamation, relocation of these assets is not required. A buffer zone behind the Crow Island reclamation will be able to separate the new port from residential area.

PART 6

CONCLUSIONS AND RECOMMENDATIONS

1. Policy Alternatives for the New Port

1.1 Basic Concept of Public Port

1. The Port of Colombo has been developed and operated as a pubic port by the Sri Lanka Port Authority, which is a government organization. The port has provided the required facilities and services which are vital for the seaborne cargo flow of the nation. In the last decade in particular, the port has made a large contribution to national economic development by providing international container transhipment function as a major hub port in South-Western Asia. Now, the presence of the port is essential in creating an efficient world port network and in promoting the global shipping economy as well.

2. In this sense, the port should continue to be considered as a so called public port. In general, public ports should be considered as economic infrastructure, or social capital, or as a national asset which is vital in promoting the national economy and upgrading the total welfare of citizens. Under this concept, ports should be owned by the public sector (national or regional government), and basic policy of port development and management and provision of basic facilities should be controlled by the government. For countries like Sri Lanka in particular, where the national economy is greatly dependent on foreign trade or international container transshipment operation, it is very important for the government to have competence over the particular functions of the ports and to establish a national port policy based on the public port concept.

3. The above concept may seem to ignore the positive effects of free competition among private entities for port development/operation business, but it does not necessarily preclude introduction of the free market system when required. Actually, many western countries have succeeded in utilizing financial, human or technical resources of the private sector for effective port development and operation projects. It should be noted however, that the very nature of a port, as a basic infrastructure, does neither allow nor accept full privatization of its core function.

4. Under the above public port concept, it is very important to understand that the port facilities and its services are just for providing private business entities with well cultivated fields in which they can promote their economic activities freely under a liberalized competitive market. The government as owner of the port should take full responsibility in securing effective provision of such a field ready for open public use.

1.2 Basic Policy Alternatives for New Port Development

5. Since the New Colombo Port Development has several unique factors, basic policy of the port development should carefully be considered as described here below;

(Potential Demand of Cargo Flow and Target Level of Port Capacity)

6. The major component of target cargo demand will most likely be international container transshipment traffic of which future demand is highly sensitive to future capacity of international hub port service network and actual service level to be provided by the New Colombo Port

project. It should clearly be understood, therefore, that a certain level of uncertainty may creep into cargo traffic forecasts, and that there must be a certain gap between forecasted potential cargo traffic demand and actual future cargo traffic to be served by the project port facilities.

7. Under the situation, it is not proper to consider that maximum potential demand of cargo traffic should always be fully accommodated within the capacity of the port facilities/services to be developed under the project. In other words, the scale of port development needs to be decided not simply by the forecasted cargo demand but on the basis of low risk and high net return consideration.

(Evaluation Policy for Selection of Alternative Plans)

8. Since the port area sheltered by the existing breakwaters cannot provide adequate space for port expansion, the now port development needs to be considered at the site outside of the breakwaters, which entails high construction cost. On the other hand, substantial economic benefits can be expected from the project because of its wide-ranging contribution to various economic aspects of the nation. Financial viability of the project may therefore be poor compared with its economic viability, which means that the project alternative needs to be selected at the sacrifice of better financial position of the project to some extent.

(Financing Policy Alternatives)

9. How to mobilize the considerably large amount of required funds for the project is one of the most critical issues for successful development of the port. There may be several ways to procure funds for the project. Mobilization of construction funds from private sector through privatization of core function of the port is one possible alternative. This selection, however, is not always appropriate from the public port development concept point of view.

10. If the purpose of privatization is to improve efficiency of port operation through competition, this selection may be allowed generally for any type of port development including a port of highly public function. However, if the government wants (mainly because of heavy shortage of original funds) to get instant money for the project by simply selling a vital part of the port site and its function to private sector, such a policy should not be applied. Considering the aspect pointed out in the above paragraph, it may be better for the government to use its own funds for the project (at least for the initial stage of the project) including utilization of possible soft foreign loan or combination of both public and private financing sources.

(Consideration of External or Contradictory Effects of the Project)

11. Addressing possible external or contradictory effects accompanied by the New Port Development is equally vital for securing total economic return and smooth implementation of the project. Improvement in port operation efficiency and labour problems, large scale of functional requirement of the port and conservation of better environment, substantial amount of investment and severe shortage of available pubic funds, requirements for safe operation and maximum utilization of the port facilities, maximization of total return and cost/benefit ratio of the project, are the typical sets of conflicting factors characterizing such a project.

12. In many cases, such conflicting factors tend to be ignored mainly due to the difficulty

of analysis as these external effects are often intangible or uncertain. However, planning and selection of the most preferable alternative of a project full of contradictory requirements needs to be considered carefully to keep reasonable balance between such sensitive factors. In such a case, project evaluation should not be made simply based on the indices such as FIRR, EIRR or other quantitative analyses on the engineering factors. It should be noted, in this sense, that the available ways of theoretical analyses are not almighty.

1.3 Port Development Planning Policy

13. While there may be many key policy requirements of development planning for public infrastructure, the following three points are the most basic (though easily forgotten) requirements:

(Clear Identification of Planning Purpose)

14. For the master plan of the New Colombo Port Development, the planning purposes can be summarized as follows:

1) to be a guideline for long-term investment and operational improvement scheme of the port.
2) to be a base for short-term/urgent development plan of which contents are required to be consistent with total development scheme.
3) to provide port users, investors, and other business entities concerned with future prospect of business environment and thus to guide the business behaviour of private sector in proper direction consistent with the port development.
4) to promote harmonized development of other infrastructures necessary to realize the proposed port development scheme.
5) to be a component of national port plan so that the New Colombo Port Development can appropriately be coordinated with the overall concept of national port development.
6) to be a base for consideration of various financing agencies in their investment or financial assistance plan.

(Appropriate Timing of Initial Planning and Periodical Review)

15. Appropriate selection of timing of planning and decision is extremely important for the Port of Colombo in particular, because of its vital role in serving the rapidly increasing container transhipment traffic. The initial planning for expansion of container handling capacity of the port was completed quite timely in 1981 and second planning works for further expansion of container facilities was done also well in time, which was followed by timely construction of the terminals to catch up with the sharply increasing cargo traffic.

16. However, the third development planning works (namely this Study) was started only in 1995 due to various procedural reasons and lack of understanding of the parties concerned on the importance of early commencement of the Study. It is quite regrettable for the port that due to late commencement of the Study, SLPA could have only limited lead time for realizing timely expansion of container handling capacity, which may jeopardize the port's advantage in attracting

potential transshipment container traffic. Considering the above situation, more importance should be attached to the timing of planning.

17. In this connection, necessity of periodical review of the existing port plans should also be stressed. As already pointed out, container cargo traffic demand in this region is and will be increasing rapidly, and total container handling capacity and its distribution in the region are expanding and changing year by year according to aggressive policies of the countries concerned in attracting cargo to their own ports. Under the situation, it is very important to understand that the original plan might lead the development policy of the port in an undesirable direction. In this sense, constant review of the plans is essential to meet any contingency in the surrounding situation. For the Port of Colombo, the recommended plan should be carefully reviewed and adjusted at least every two years after its completion.

(Authorization of the Recommended Plan)

18. How to utilize the recommended development plan of the port is another important point for effective implementation of the project. There are many cases observed in developing countries where the project development as recommended in the studies fails to be successfully realized. The major reasons (apart from apparent failure in planning) for this type of failure can be summarized as follows:

1) Lack of practicability, applicability or flexibility in the proposed schemes
2) Basic change in the government's policy for the target port development
3) Shortage of funds for the development
4) Failure in developing other port related infrastructure and facilities
5) Lack of proper control of the government on the private sector activities concerned

19. In order to avoid the above mentioned cases, the plan should officially be authorized through proper procedure by the laws, regulations or any other form applicable to the country concerned. This is quite effective in particular in securing public expenditure on a long-term time basis for the project itself as well as for other public works necessary for the project. The plan also needs to be open to the public so that any business activities concerned could be guided properly along the line of concept of the plan.

2. Conclusions

(Findings on the present port)

20. Owing to the economic boom in the Indian Subcontinent, cargo throughput at the port of Colombo has rapidly increased since 1990 and reached one million TEUs in 1995. However, the port of Singapore is attracting more transhipment containers from the Indian Subcontinent and the port of Colombo is therefore required to develop a competitive transhipment terminal with enough capacity, deeper berths, efficient productivity and quality services.

(Bottlenecks)

21. Sheltered basin of the port of Colombo is very narrow to accommodate post Panamax vessels as the port was originally developed at the end of the 19th century to provide an anchorage for lighterage and the breakwaters have remained unchanged for a century. Consequently, many bottlenecks are identified to develop a modern container port such as 1) curved fairway and very narrow entrance; 2) short stopping distance; 3) little under keel clearance in the approaching channel and basin; 4) shallow North Channel; 5) wave disturbance to smaller vessels; 6) poor equipment for ship traffic control; 7) slender container yard (QEQ); and so forth. Operational problems are also recognized such as 8) extra cost for inter-terminal transportation between JCT and QCT; 9) less priority to feeder vessels; 10) berthing arrangements for mother vessels; 11) hidden cost besides the tariff; 12) productivity of cargo handling; 13) customs clearance procedure; 14) capacity of inland container depots.

(Natural Conditions)

22. Wave observation performed at a northern offshore point with a depth of minus 15 m has shown that the predominant wave direction is SW and some waves are from NNW-NW with a maximum height of 1.5 meters. Maximum wave height for the structural design is determined at H=5.7 m, T=10 sec, with a 50 year return period through statistical processing of previous wave observation records. The predominant wave direction through the year was SW and 46 % of waves exceeds 1.0 m in height. Offshore currents observation has revealed that the current velocity in this area is very low and littoral currents flow mainly from south to north except the shore near fishery harbour where the littoral currents flow toward S or SW. Soil boring survey, carried out at five offshore points and six onshore points, revealed hard bed rock in the north area of PVQ.

(Environmental conditions)

23. Off the northern shore of the port of Colombo, water is most transparent with some pollutant from the sewerage outfall and the land surface. In the inner harbour, water is considerably polluted due to discharges into the port. Near the fishery harbour, water is least transparent with pollutant from sewerage outfall. Kelani river water contains some inorganic and organic SS without saline intrusion. Water samples from nearby wells were clean with minimal pollutant. Variety of sediments were observed from coarse sand in Kelani river to silty clay in the outer harbour.

24. Air quality is rather deteriorated in the north of the port but better in the south. Marine

plants or macro seaweeds grow poorly in species and sizes. Besides benthic fauna, coral fish are identified around the reefs. Coastal vegetation is mostly confined to Kelani river without human activity. Mangrove vegetation only grows in some patches along the river mouth and Hamilton canal. Many species of birds and seabirds including migrants are recorded in uncultivated land homesteads. In Colombo North, there are many factories, government and private organizations as well as a large population. The study area is rich in historical and cultural assets dating back to the colonial period.

(Role of the Port of Galle)

25. The port of Galle can be a supplement to the port of Colombo serving vessels with cargo from/to the Southern Province. At the first stage, the port of Galle should cater to bulk and breakbulk carriers. It will be necessary to accommodate pleasure boats and fishing vessels. As far as transhipment services are concerned, efforts should be placed on the development of Colombo so as to enable the port to enjoy economies of scale.

(Demand Forecast)

26. A considerable increase in the container traffic, both in the transhipment and in the country's imports/exports, is envisaged owing to the economic boom in the Indian Subcontinent and the economic growth of Sri Lanka. (2.3-3.6 million TEUs in the year 2005, 3.8-6.7 million TEUs in 2015). Cargo growth rate is estimated at about 12.7 % in the high case and 8.5 % in the low case for the period of short-term development and at about 4.7-6.5 % for the period of 2005-2015.

Year		2005			2015		
Cargo Type		High	Med.	Low	High	Med.	Low
Transhipment Containers		2,616	2,145	1,684	4,641	3,835	2,670
Domestic Containers		929	767	660	2,096	1,444	1,110
Total	('000 TEU)	3,545	2,912	2,344	6,737	5,279	3,780
Conventional Cargo	('000 ton)	7,458	6,669	6,013	9,926	8,268	6,978
Coastal Trade	('000 ton)	376	277	179	376	277	179

(Capacity of the Present Port)

27. The annual container handling capacity of the JCT, QCT and NP terminals amounts to approximately 1,500,000 TEU as of the end of 1995 when JCT No. 4 terminal was completed. The annual capacity in the year 2000 is estimated to reach about 1,900,000 TEU subject to the rehabilitation and redevelopment of QCT and NP and to the procurement of additional cargo handling equipment at JCT.

(Requirements for the new port)

28. To meet the requirements for a competitive hub port, the port needs to accommodate post Panamax vessels of 6,000 TEU class and to assure safe manoeuvring at the entrance. Reliable operations are essential for further development.

(Master Plan for 2015)

29. Master Plan for 2015 has two development scenarios. In the low/medium growth case, South Port Development will be able to cover the demand anticipated in 2015 but in the high growth case, North Port Development will be necessary in addition to the South Port Development. North Port has two optional plans, Crow Island Offshore Development and PVQ North Development, which will be reviewed following a series of wave and current observations.

Facilities	High Growth Case		Low/Medium Growth Case
	PVQ North Development	Crow Island Offshore Dev.	
Terminal Area	236 ha	340 ha	120 ha
Additional Berths	Main CT: 10 Feeder: 7	Main CT: 11 Feeder: 5	Main CT: 6 Feeder: 3
Handling Capacity	7.7 mil. TEUs	7.7 mil. TEUs	4.9 mil. TEUs
Breakwater/Seawall	6,350 m	7,010 m	3,610 m
Dredging	12.5 mil. m^3	13.3 mil. m^3	5.3 mil. m^3

(Short-term Development Plan)

30. The proposed projects for the short-term development and details of the QEQ Outer Terminal Development are as follow:

1) QEQ Outer Terminal as a part of South Port Development;
   - Breakwater/Seawall: 3,130 m,
   - Berths: Main 3, Feeder 3
   - Terminal Area: 73 ha
   - Capacity: 2.0 million TEUs
   - Estimated Cost: US$840 million
2) Redevelopment of Bandaranaike Quay (US$17 million);
3) Widening the West Entrance (US$27 million);
4) North Channel dredging (US$6 million);
5) Inter-terminal road expansion (US$18 million);
6) Navigation Aids (US$33 million); and
7) Renovation of JCT Cargo Handling Equipment (under E/S).

QEQ Outer Terminal

Facilities	Quantity
Breakwater/Seawall	3,130 m
Berths	Main: 3 (6)[1]; Feeder: 3 (3)[1]
Terminal Area	73 ha (120.4 ha)[1]
Capacity	2.0 (3.5)[1] million TEUs

Note: ()[1] indicates the final stage of the development.

(Stage Plan)

31. The development of the South Port enables the expansion of QEQ container terminal to the outside as well as the construction of deeper berths behind the new South-west Breakwater. North Port can be economically developed after the offshore area of Crow Island is sheltered from rough waves by the South Port. The development of the North Port will be flexible in accordance with the demand for cargo throughput. Priority was given to the South Port Development from the viewpoint of construction cost and period. By the year 2005, three full-size container berths will be completed in the QEQ Outer Terminal and the capacity of QEQ Outer Terminal will be increased to 2 million TEUs.

(Urgent Development Plan)

32. In order to cope with the demand in the near future, some rehabilitation projects are selected for urgent implementation. Urgent plan comprises 1) QEQ No.6 extension; 2) rehabilitation of QEQ Nos.2-3; 3) reinforcement of JCT container handling equipment; 4) redevelopment of North Pier; 5) redevelopment of Bandaranaike Quay; 6) dredging North Channel; 7) encouraging installation of Inland container depots; and 8) upgrading tug boats and other port service facilities.

(Structural Design)

33. Economic and rapid construction of breakwater plays a key role in the outer port development. After comparing possible structural types of breakwater, it was concluded that caisson structure will be the best for breakwater and seawall in the deep water from the viewpoint of stability and construction period.

(Construction Procedure)

34. Construction works start with the new South-West seawall and the extension of QEQ No.6 berth. Shortly after the commencement of construction, back yard of QEQ can be expanded and be utilized as a container yard. After the completion of QEQ No.6 extension and the rehabilitation of QEQ Nos.2-3 with outer container yard (five years after commencement of construction), cargo handling capacity of QEQ will reach 0.9 million TEUs.

35. Development of the new S-W seawall and breakwater makes the approach channel calm, which allows easy manoeuvring to the present port. After the completion of the new S-W seawall, the present S-W Extension Arm can be removed and the West Entrance can be widened

accordingly.

(Cost Estimates)

36. Project cost of Master Plan 2015 is estimated at about US$1.1-1.4 billion in case of the South Port Development. Estimated cost of the North Port Development is about US$1.1-1.4 billion in case of Crow Island Offshore Development and at about US$1.0-1.2 billion in case of PVQ North Development including all other projects and relocation of oil pipeline and sewer outfall.

37. Project cost of the short-term development plan is estimated at about US$940 million for a period of 10 years, of which estimated cost for the urgent plan is about US$500 million. Estimated cost of major components is as follows:

Project	Estimated Cost (US$)
South Port Development	840 million
Civil Works	(500)
Equipment	(180)
Buildings & Others	(160)
Bandaranaike Quay Rehabilitation	17
Widening Main channel	27
North Channel Dredging	6
Inter-terminal Road Expansion	18
Navigation Aids	33
Total	940

(Economic Analysis)

38. EIRR of the short-term development plan is assessed at 20.5% in the high growth case, 18.7% in the medium growth case and 11.5% in the low growth case. The short-term development plan has sufficient economic viability. After conducting a sensitivity analysis, the EIRRs are still in a feasible range as shown below.

Development Case	EIRR	Sensitivity*
High Growth Case	20.5%	18.5%
Medium Growth Case	18.7%	17.0%
Low Growth Case	11.5%	10.5%

**Sensitivity: Benefits-10%, Costs+10%*

39. Container handling business brings the port benefits of more than US$13 million per 100,000 TEUs. Benefits incurred by transhipment business spread across a wide area of commercial activities including not only the port and shipping agents but also truck operators, ship chandlers and other downstream companies. Construction work also brings considerable

economic benefit to the country.

(Development Scenarios)

40. The following scenarios are considered for the development of the new port:

Scenario 1) All breakwaters/seawalls will be developed by SLPA and land reclamation/terminal facilities of the Berths Nos.6,7,8 be developed by SLPA while land reclamation /terminal facilities of the Berths Nos.9,10,11 be developed by private sectors;

Scenario 2) All breakwaters/seawalls will be developed by SLPA and land reclamation/terminal facilities of the Berths Nos.6-11 be developed by SLPA;

Scenario 3) All breakwaters/seawalls will be developed by SLPA and land reclamation for the Berths Nos.6,7,8 be carried out by SLPA while terminal facilities of the Berths Nos.6-11 be developed by private sectors.

In case that private sectors develop terminal facilities, the operations of their terminal(s) shall be carried out by the developer. In case that the SLPA develops terminal facilities, the operations shall be carried out by the SLPA or by private sectors given an SLPA's mandate.

(Financial Analysis)

41. Owing to the large initial investment in the civil works, the proposed short-term development plan is infeasible if cargo handling productivity is not improved and construction cost exceeds the estimates. FIRR is calculated based on three scenarios, all of which are based on the stage plan that QEQ short-term development (Berth Nos.6,7,8 and breakwaters) will be completed in 2005 and cargo throughput will increase as projected in the medium growth case (290 million TEUs in 2005).

42. FIRR is assessed at 4.8%-5.3% in the first scenario according to the cargo growth case, and at 7.2% in the second scenario. FIRR in the third scenario is estimated at 4.2% based on the assumption that the rent of terminal is determined to cover the construction cost of infrastructure.

	Scenario 1		Scenario 2	Scenario 3
Cargo Growth	Medium case	Low Case	Medium Case	Medium case
FIRR	5.3 %	4.8 %	7.2 %	4.2 %
Sensitivity	3.8 %	3.7 %	5.8 %	3.5 %

Note/ Scenarios: See the above paragraph "Development Scenarios"

(EIA)

43. Field surveys covered waves, currents, water pollution, shoreline configuration, sediment contamination, port-related road traffic and air pollution, terrestrial flora and fauna, and local residents and cultural assets. Biological survey showed that the project area is rather poor in terms of the biological abundance as it has already been urbanized.

44. Initial environmental examination is adopted to study changes in current patterns, disposal of dredged material, impacts on water quality, coastal hydrology, traffic load on access roads, and air pollution. To assess the impact of the port development, tidal currents and the dispersion of water pollution are identified by means of computer simulation. Adverse effects on air pollution and shoreline configuration are also studied. As a result no significant adverse effect is shown in the preliminary EIA.

(Overall Evaluation of the Project)

45. Economic benefits borne by the port have greatly contributed to the Sri Lankan economy in terms of foreign currency earnings, job opportunities, trade promotion and industrial development. However, the development of a new port requires a large capital investment in breakwaters and reclamation work in the deep sea area, so that financial feasibility is very critical in connection with construction cost and port revenues. EIRR is estimated at 11.5% and 18.7% in the low and medium growth cases respectively, but FIRR is at 4.8% and 5.3% in the same cases. In this regard, Master Plan for 2015 is economically a very important project to Sri Lanka but difficulties are envisaged in the financial management of the project.

46. Since the project needs large investment and is not so profitable for the private sector, it will only be feasible in case that the public sector develops all port facilities or in case that the public sector develops the port infrastructure and invites the private sector to invest in and to operate port superstructures, subject to the payment of royalty to SLPA for the use of port infrastructure. Soft loans or other financial assistance to the private sector can encourage their participation. In both cases, cargo handling productivity plays a key role in the feasibility of the project.

3. Recommendations

(Basic Concept of Public Port)

47. Port is a basic infrastructure for a nation's imports and exports so that the public sector should administer the port from the viewpoint of people's welfare. However, commercial activities related to the port are basically supported by private sectors in the field of terminal operations, stevedoring, harbour services and other ancillary services. Participation of the private sectors in these fields needs to be encouraged under the administration of SLPA.

(Participation of Private Sectors)

48. In view of privatization of a part of SLPA functions, following schemes can be applied to the new terminals. These alternatives should be selected appropriately according to the financial situation of the project and the prospect of terminal operations.

Scheme 1: SLPA develops all port infrastructures and superstructures, and requests the private sector to operate a terminal.

Scheme 2: SLPA provides only basic port infrastructures and invites the private sector to build superstructures and to operate its own terminal.

Scheme 3: SLPA prepares only the breakwater and basin, and invite the private sector to build and operate a terminal.

(Port Development Policy)

49. There should be a legal scheme in which SLPA proposes a master plan for the development of the port of Colombo and seeks authorization from the Government. It would be helpful to coordinate all related development projects such as the road development project or oil pipeline project. It would also be useful to encourage private sector's participation in port development. SLPA should be given a mandate to consent to the development plan proposed by the private sector in accordance with the authorized master plan. Periodical review of the master plan is important to cope with changes in shipping environment and the demands for the port.

(Necessities for a Competitive Hub)

50. Factors required for a successful hub port are 1) Strategic Location; 2) Excellent Infrastructure; 3) Reliable Operations; 4) Skilled and Disciplined Work Force; 5) Good Banking and Financial Services; 6) Efficient Telecommunications; and 7) Stable Government. Though the port of Colombo is located in a strategic position, the port fails to meet most of the other requirements. Efforts should be made to satisfy all of the requirements.

(New Port Development)

51. Development of the outside of the present breakwaters is a possible means to increase the capacity of the Port to the required level, however, difficulties are anticipated in the high cost and the lengthy period of breakwater construction. It is essential to the development that the construction period and cost be reduced to the minimum level through a careful engineering study on the structural design.

(QEQ Redevelopment)

52. To meet the urgent demand for main/feeder berths and additional container yard in QEQ area, it will be helpful to develop the inner side of QEQ. However, QEQ expansion to the inner harbour should be minimized from the viewpoint of ship maneuvering in the harbour, interalia berthing at the Bandaranaike Quay and QEQ Nos.1-2 Berths and turning of lengthy Panamax vessels in the restricted basin between JCT and QEQ.

(Widening the West Entrance)

53. The navigable width of the present entrance channel is 125 meters for a Panamax vessel with a draft of 13 meters, which is far below the internationally accepted standard, i.e. more than 5-6 times of the breadth of the maximum ship entering the port, namely 160-200 meters in case of a Panamax. The present entrance should therefore be widened as soon as possible.

(Ship Traffic Separation)

54. As a result of the proposed development, future ship traffic will increase by 1.7-2.6 times in 2005. Daily in/out traffic will reach 31-46 moves so that separation between incoming and outgoing vessels becomes necessary. Short-term Development Plan includes a project to dredge North Channel to minus 12 meters. Installation of Vessel Traffic System (VTS) is recommended to control the approaching and outgoing vessels.

(Wave Observation)

55. With a view to economical design of port structures, a considerable series of wave data is essential so that the wave observation at the offshore point of Crow Island should be continued for more than five years, preferably ten years.

(Project Implementation)

56. On-site work period for the construction of outer seawall and breakwater is limited to the NE monsoon season so that it will take more than eight years to complete the first berth on the outside of the present breakwaters. With a view to filling the gap between demand and capacity foreseen, the development of the new terminal shall be started as soon as possible.

(Construction Cost/Period)

57. In order to build the new port within a limited budget and time frame, the supply of quarry will play a key role in saving the cost and time for construction, as it is an indispensable material for the construction of breakwater and seawall. It is also important to undertake an in-depth study on the design of breakwater and quaywall from the view point of economical construction following the result of wave observation.

(Improving Cargo Handling Productivity)

58. To improve container handling productivity, it is recommended that 1) container handling facilities be augmented; 2) crane operator's skill be enhanced by training at an advanced terminal; and 3) container terminal planning/operation system be established so that the simulation of and preparation for terminal operations (ship and yard) can be completed before ship arrival.

59. It is also important to introduce a proper incentive system (preferably linked to work

productivity) to speed up cargo operations. Introduction of private operators into terminal operations will also encourage efficient cargo handling. Urgent improvements should be made in berth assignment to feeder vessels, in priority berthing to regular mother vessels, in reducing inter-terminal container transportation.

(Harbour Services)

60. It is recommended to take certain countermeasures to prevent possible sea accidents and to promote efficiency of port activities in a heavily congested situation, namely, introducing a VTS, updating the traffic regulations, reinforcing the tug fleet, and retraining pilots. The stuff training is particularly important for the prosperous port of Colombo.

(Port Management and Operations)

61. To cope with changes in the demand for the port, SLPA should be given the power to operate the port in its own capacity, particularly in terms of investment, procurement, decision of labour wages, and other financial management with the responsibility for the balance.

(Financial Assistance)

62. Bearing in mind that the project is economically propitious to the country but financially not so profitable, public sector should play an important role in developing the port infrastructure and efforts should be placed to encourage the participation of private sectors in terminal development and operations by preparing soft loans or through other financial assistance.

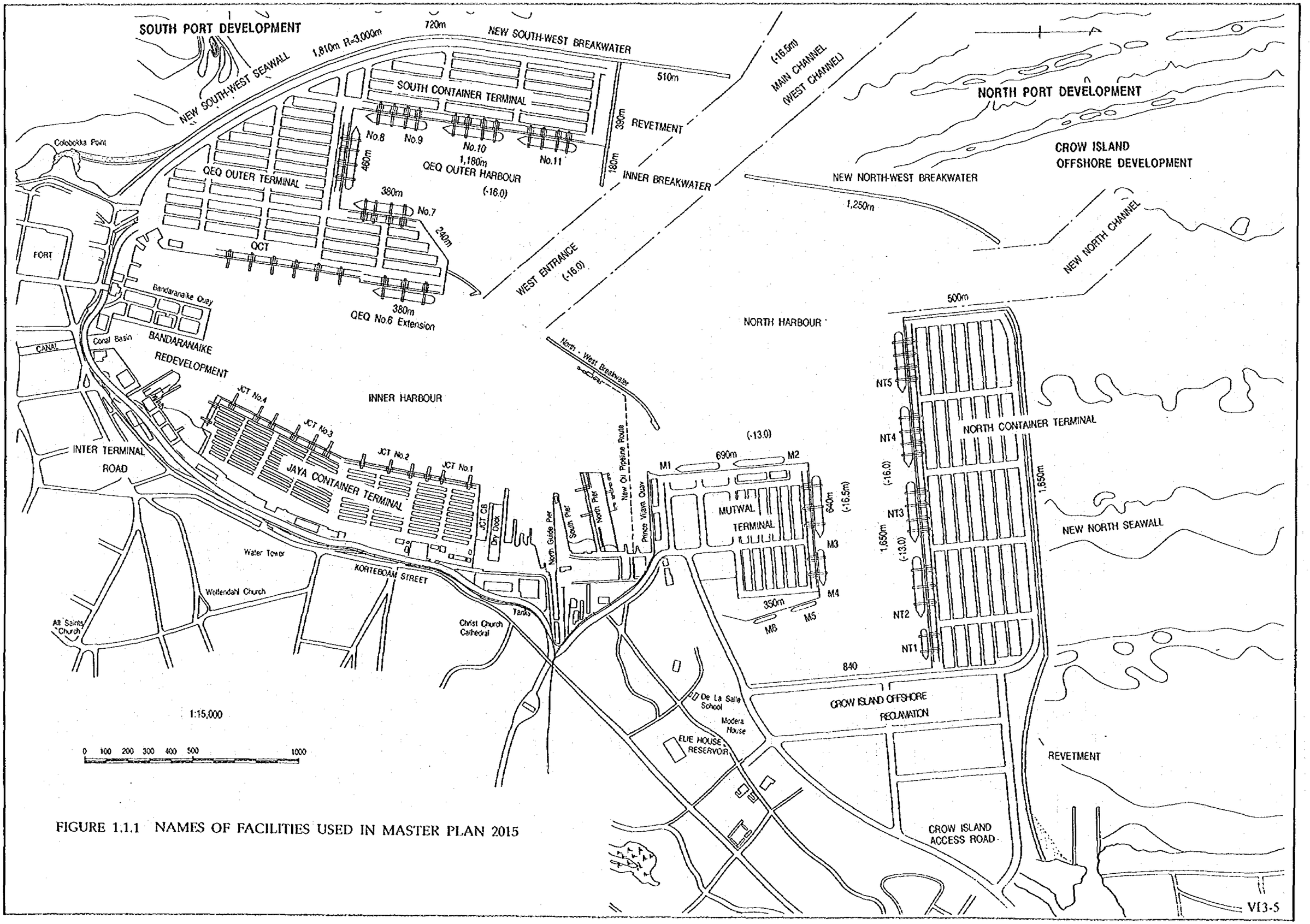

FIGURE 1.1.1 NAMES OF FACILITIES USED IN MASTER PLAN 2015

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