CHAPTER7: SEWERAGE SYSTEM

7.1 General

Increasing water consumption in domestic, business and industrial activities generated a large amount of water pollutants, especially in the densely populated areas and caused of water pollution in the klongs as well as in the Chao Phraya river.

Water pollution problems in the khlongs has been pointed out in the core area of Bangkok since 1960's. In spite of the recommendations in many studies and the reports in early stages of water pollution problem, implementation of the sewage projects were not materialized until the Sipraya Sewage System started operation in the end of 1994.

The Sewage Master Plan, "Bangkok Metropolitan Region Wastewater Management Master Plan" issued in March, 1993 by the Pollution Control Department(PCD), MOSTE, formulates the sewage systems in BMA Area and the municipalities in the vicinity areas.

Decentralization policies and plans of the Government and the Bangkok Plan, the city planning for BMA Area, prepared by MIT, EC consultant teams and the Department of Policy and Planning, BMA towards the 5th BMA Five Year Development Plan, 1997-2001, and other infrastructure projects by government agencies including mass transit and roads projects, would influence the changes of future land use pattern, population distribution, etc. Accordingly, the sewage master plan shall be proposed in line of the restructuring plans for the city of Bangkok to improve the deteriorated environmental quality and retrieve nature to the Chao Phraya river and the klongs in the area.

7.2 Assessment on Present Condition

(1) Current Sewage System

1) Implementing Agency

At present, Wastewater Quality Control Division of DDS, BMA take charge from planning to operation and maintenance of the sewage systems within the administration boundary of Bangkok.

2) On-going Sewage Projects

As of December, 1995, there are 6 sewage projects including 7 sewered areas have implemented in the central area of Bangkok. Locations of each projects and some more detail information is shown in Figure 7.1 and Table 7.1 respectively. After completion of the projects, the total sewage treatment capacity will reach at 992,000 cum/day in terms of dry weather flow for the sewered population of approximately 2.86 million. Comparing with the water consumption records of the whole water service area of MWA in the fiscal year 1995, which is 870.3 million cum. per year, the coverage of sewered area reaches at about 41 percent.

Table 7.1 On-going Sewage Projects in BMA Area

Project Name	Progress of Works	Plant Capacity (cum/day)
1. Sipraya	plant operation	30,000
2. Rattanakosin	under construction	40,000
3. Bangkok (Stage 1)	under construction	350,000
4. Yannawa (Stage 2)	under construction	200,000
5.1 Nong Khaem & Phasicharoen (Stage 3)	construction started	157,000
5.2 Ratburana (Stage 3)	construction started	65,000
6. Chatuchak (Stage 4)	preparation of TOR	130,000

Note : Reference shall be made to " Environmental Atlas " for location of the project
Source : Department of Drainage ans Sewerage, BMA

(2) Wastewater Management Authority (WMA)

The Royal Decree to establish the new organization "Wastewater Management Authority(WMA)" was enacted on 20 July, 1995 to control wastewater projects within the "Waste Water Management Area (WWM Area)" in Bangkok Metropolis, Nakhon Province, Nonthaburi Province, Pathum Thani Province, Samut Prakarn Province and Samut Sakhorn Province. Since then, a close coordination is required among the sewage works agencies such as PCD, MOSTE, Public Work Department (PWD), and DDS, BMA for budgeting and implementing towards coordination for implementing the future wastewater projects in the WWM Area under the WMA administration.

Objective of the WMA stipulated in the Royal Decree is comprehended that the WMA realize a common/combined/central/regional wastewater treatment system in the WWM Area and provide and conduct the services and activities continuously and economically for establishment of the efficient wastewater treatment system.

Authorized power for management and other important roles were cited from the Royal Decree and attached to APPENDIX :"WATER-RELATED ENVIRONMENT" (separate cover).

7.3 Policy Direction and Planning Issues

Sewage system in Thailand is designed not only for the facilities to reduce water pollution loading to the public water courses but also for the function to support drainage because of the sewer system designed in most of the municipalities by the combined sewer system. However, the primary role of the sewage system shall be designed for the facilities to contribute toward water quality conservation in the public water course.

Tendency of the society and the advanced technology of recent years has come to require the sewage system to consider the worldwide tendency for establishing the energy-saving society into design. Accordingly, reuse of treated sewage, treatment and resource recovery of sludge and low-energy-consumption design of overall sewage system are the important factors to formulate the development plan in respect of energy-saving concept in mind. Considering these factors, the major five issues were selected and described in the following sections.

This section also include the strategic plan drafted by DDS for The 5th BMA Five Year Development Plan and the prediction of sewage amount in 2011 putting together with every issues related with future planning.

(1) Sewage Master Plan and Stage Development

The Sewage Master Plan by PCD determined the sewered area in BMA into 24 zone and formulated the 3 phase implementation plan for the remaining 18 zones including Chatuchak and Lad Phrao districts as shown in the followings. Table 7.2 and Figure 7.1 shows a basic information for stage development of each sewage zone proposed in the Sewage Master Plan by PCD.

Table 7.2 Stage Development in Sewage Master Plan

Phasing	Design	Sewer Construction	STP Construction
First Phase(5-10 years)			
First Group :	X	X	X
Second Group:	X	X	
Second Phase(10-15 years)			
Second Group:	X		X
Third Group :	X		
Third Phase(15-20 years)			
Third Group :		X	X

Note: First Group include 8 zones Zone 14, 15, 4, 6, 6, 7, 3 and 2
Second Group include 4 zones Zone 1, 10, 16 and 8
Third Group include 6 zones Zone 9, 11, 17, 18, 12 and 13
Source : "Bangkok Metropolitan Region Wastewater Management Master Plan", 1993, PCD, MOSTE,

The Master Plan shall be updated, reviewed and modified considering the current and future conditions related such as the new Bangkok city plan, direction of urban growth in future, coordination with drainage plans, available construction sites, administration issues concerned with MWA, etc.

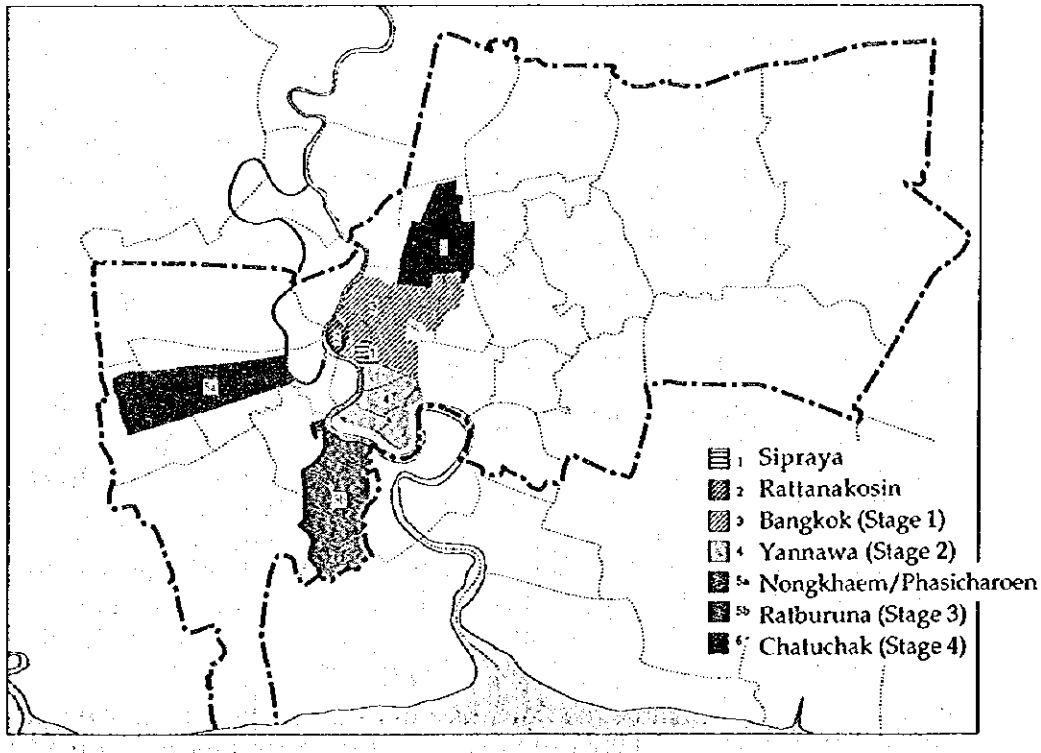


Figure 7.1 Sewage Development Zones in Sewage Master Plan (GIS Map reduce to A3, Sewage Zoning Proposed by PCD)

(2) Procurement of Construction Sites

Every on-going sewage projects procured the public land for construction of the wastewater treatment plants. However, the land area of each site is too small to layout the facilities with standard design for easy operation and maintenance, except for the construction site of Nong Khaem - Phasicharoen Project secured at a corner of Nong Khaem Final Disposal Site. The following data indicates the plant area of the on-going projects to unit sewage treatment capacity.

Table 7.3 Plant Site Area per Treatment Capacity

Treatment Plant	Plant Capacity (m3/day)	Site Area (m2)	Per Unit Area (m2/m3/day)
1. Sipraya	30,000	1,600	0.053
2. Rattanakosin	40,000	6,400	0.160
3. Bangkok (Stage 1)	350,000	27,200	0.078
4. Yannawa (Stage 2)	400,000*	32,000	0.080
5.1 Nong Khaem & Phasicharoen (Stage 3)	157,000	83,200	0.530
5.2 Ratburana (Stage 3)	65,000	14,400	0.222
6. Chatuchak (Stage 4)	130,000	11,200	0.086
7. Tokyo(10 Plants)	6,233,000	2,890,693	0.464

Note : The mark * indicates the plant capacity after completion of Phase 2 construction

Securing the construction sites will become a key factor for BMA to develop the sewage system in future. Investigation to inquire into ownership of the public lands being carried out recently will result a great effort in advance as the sewage project will begin with the planning to locate the construction site. In other words, it should give the priority for implementation of the sewage system development depending upon the zones where the construction sites are procured. Land procurement is an important and urgent matter for BMA to implement the sewage projects on schedule. Moreover, it should be noted again that securing the construction site with a sufficient area will enable the operation and maintenance wise treatment process design.

(3) Installation of New Stormwater Drains by District Offices

Main Drains have been installed along the most of the major roads in BMA Area and the branch drains are installed in sois under the responsibility of each District Office. These drain pipes are to be used as a combined sewers to collect and convey stormwater to the nearby interceptors before discharged into the klongs. Judging from the on-going sewage projects adopting the combined sewer systems, the future sewer system will also be designed to make use of the existing stormwater drainage system as a combined sewer system although required to study the economic and technical soundness for searching the possibility of the separate sewer system in the area where the drainage facilities are not installed up to present days.

Size of the pipe, direction of the flow, location of outfalls, etc. are the major factors require collaboration work between the District Offices and the head office, DDS, BMA and the other authorities concerned.

(4) Saving Water to Reduce Loading to the Nature and Economize Plant Capacity

Wastewater generates as people use water. Reducing water consumption will bring about discharge of pollutants to the public water courses to the minimum extent and

possibly reduce the capacity of the wastewater treatment plant and increase economic feasibility of the projects.

Water pollutants for example, detergents and food oil are commonly consumed in home and discharged to the public water course every day. Excessive amounts of Phosphate, ABS, etc., are the major possible cause of eutrophication in ponds and the slow-flow khlongs. Increase of water pollutants has been carried in with improvement of quality of life and the people take it for granted.

"Saving Water" and "Reducing Water Pollutants" are the key phrase for betterment of life in comfortable urban environment. Water quality conservation need participation of individual people and the social change in awareness to the value of the nature. If the sewage flow increase continuously, the infrastructures such as the sewage system always need expansion of the facilities with a large amount of expenditure for investment forever.

Accordingly, the public campaigns to inspire the consciousness of the people that "Saving Water" and "Reducing Water Pollutants" are essentially required for establishing the water-environment friendly city of Bangkok.

(5) Khlong Water Quality Improvement Project (Clean and Green Khlongs Project or CGK Project)

After completion of the on-going sewage projects, wastewater being discharged into the klongs will be collected, conveyed and treated at the wastewater treatment plant in each sewered area. The systems will be able to collect more than 95% of wastewater and it is expected to improve the state of water pollution in the klongs considerably. However, here is a very pessimistic viewpoint about the improvement of water quality in the klongs caused by the water pollutants carried from the up-stream sections, discharge of the water pollutants remained in the treated sewage discharge to the klongs, sediments in the klongs, etc. Consequently, water quality improvement in the klongs could be realized after the most part of the built-up area will be have been covered in the sewage project area, which will be probably wider than 60 to 70% of the built-up area in BMA Area.

The "Khlong Water Quality Improvement Project" implemented by DDS, BMA in the East Bank shall be maintained for the time being until the water quality in the klongs will have been improved to the satisfactory level.

The system consists of the facilities and works to withdraw dilution water from the Chao Phraya river into the khlongs, dredging of sediments in the klongs, construction of retaining wall on both sides of the klongs, and installation of direct aeration system. For better functioning of the system, installation of more numbers of direct aeration stations will be effective since diffusing air into the khlongs will enable decomposition and purification of pollutants at the sites.

Khlong Water Quality Improvement Project is not yet implemented in the West Bank, Tonburi side up to now. With respect to the successful results performed in the East Bank, the similar system shall be introduce in the East Bank to improve water quality in the klongs in main area of Tonburi side.

Installation of automatic water quality monitoring stations will be beneficial to monitor water quality in the khlongs and in the Chao Phraya River. Recent technology in water quality measuring device, data transmission, processing and analysis make it easier to monitor water quality in the office by installing the automatic monitoring system.

Water quality monitoring play a very important role in conservation of water environment to inform us the degradation of water quality in the public water course so that the monitor can take immediate action to investigate the cause and take proper measures against the wastewater sources. Initially, the study shall be conducted with the water quality monitoring parameters and the location of the monitoring stations in consideration of the locations of the water level monitoring stations maintained by

DDS, BMA and the monitoring stations maintained by PCD, MOSTE.

(6) Strategic Plan Proposed in The 5th BMA Five Year Development Plan

Department of Drainage and Sewerage drafted the strategic plan for development of sewage system in the 5th BMA Five Year Development Plan implemented during 1997 to 2001. The strategic plan consists of four programs as indicated below. These plans are duly examined as the action plans of the Study are proposed to improve urban environmental quality in BMA Area.

Program 1 : Construction of 4 Wastewater Projects Invested by BMA and the Government
Program 2 : Improvement Work for NHA Wastewater Treatment Plants
Program 3 : Administration and Management Preparation
Program 4 : Public Relations

1) Activities of the Programs

Program 1 : BMA and Government Investment 4 Projects

- Implementation of the Stage 4 Project
  Wastewater Treatment Site at Bang Sue :site area 7 rais
  Plant Capacity :130,000 cum/day
  Sewered Area :Dusit, Phaya Thai, Huay Khwang,Chatuchak
  Starting in :1996

- Implementation of the Bangkok Yai - Bangkok Noi Project
  Wastewater Treatment Site at :site area 60 rais
  Plant Capacity :173,400 cum/day
  Sewered Area :Bangkok Yai, Bangkok Noi
  Starting in :1997

- Implementation of the Stage 5 Project
  Wastewater Treatment Site : site area 20 rais
  Plant Capacity :320,000 cum/day
  Sewered Area :Phra Khanong, Khlong Toei, Pravet
  Starting in :1998

- Implementation of the Nong Bon Project
  Wastewater Treatment Site : site area 45 raise
  Plant Capacity :125,400 cum/day
  Sewered Area :Pravet, Phra Khanong
  Starting in :1998

Program 2 : Improvement Work for NHA Wastewater Treatment Plants

Six (6) plants including, Huay Khwang, Bang Na, Khlong Chan, Ram Intra, Tung Song Hong 1, Tung Song Hong 2

Program 3 : Administration and Management Preparation Study of a sewage charge system

Program 4 : Public Relations

- Public relations to follow effluent quality standard
- Effluent water quality control for buildings

(7) Prediction of Sewage Amount

1) Method of Prediction

Prediction of future sewage amount was conducted on the basis of prediction of water consumption, the rate of wastewater entering to the collection pipes and the rate of groundwater infiltration into the pipes. Water consumption prediction is generally predicted by water consumption per capita per day in consideration of domestic, commercial, industrial and other water use in business activities.

In respect of a specific feature in this Study made available to use GIS system for urban environmental improvement planning, water consumption was predicted in proportion to the relation between the land use type and the water consumption to unit area. Sewage amount was estimated by 80 % of water consumption entering to the pipes and by another 20 % infiltration of groundwater in flowing down to the plant. Thus, future sewage amount prediction is practicable for the city planner by estimating the area of future built-up and land use area.

Sewage amount in the Study was predicted in accordance with the following sequence.

Step 1 :	Calculation of unit area water consumption to residential area and business area in each water service block for 1995.
Step 2 :	Calculation of population density increase ratio between 1995 and 2011 for built-up area in proposed sewage zones
Step 3 :	Assumption of unit area water consumption to residential and business area for 2011 from the results of Step 1 & 2.
Step 4 :	Obtain the future built-up area and land use from the city planning data
Step 5 :	Prediction of amount of water consumption each sewage zone from the results of Step 3 & 4
Step 6 :	Convert amount of water consumption to the amount of sewage in each sewage zone
Step 7:	Evaluate the unit sewage amount and adjust if necessary.

2) Sewage Amount in 2011

Result of sewage amount prediction was summarized in Table 7.4 for each sewage zone. Total sewage amount reached at 2.7 million m3/day in 2011 in the built-up area of BMA. The current sewage projects construct 6 sewage treatment plants having total capacity of 972,000 m3/day, which is equivalent to 36 % as against for the year 2011. The remaining sewage amount 64 % or about 1.75 million m3/day need construction of the facilities hereafter.

Total plant capacity predicted in the Sewage Master Plan by PCD in together with that of the on-going project indicate approximately 2 million m3/day. Although difference in target year, sewage amount predicted by the Study exceeded by 35 % or 0.7 million m3/day comparing with the plant capacity in the current planning.

In Tokyo, 10 plants treat sewage 5.1 million m3/day in average for the sewered area and population approximately 545 km2 and 8.1 million respectively as of 1993. From these data, the sewage plant capacity to unit area is obtained at 9,400 m3/day/km2. In case of Bangkok, sewage amount at plant sites was estimated at 2.7 million m3/day for the future built up area 715 km2 and the sewage generation rate to unit area was calculated with 3,800 m3/day/km2. Assuming the plant capacity by 1.2 times of the inflow, the sewerage plant capacity to unit built-up area is estimated at 4,600 m3/day/km2 and the ratio to Tokyo become about 50 %.

Meanwhile, water supply in Tokyo and the neighboring area supply 4.8 million m3/day for the served area 1,150 km2 in Tokyo. From these data the water supply ratio per

unit area is estimated at 4,200 m3/day/km2 whereas water service area in MWA 890 km2 consume water 2.4 million m3/day and the water consumption ratio per unit area is obtained at 2,700 m3/day/km2.

Difference of sewage generation and water supply ratio per unit area is because of the sewage service area covers densely populated area against the water supply service area cover more wider low-density area. Difference of the figures between Tokyo and Bangkok may be caused of water consumption in business activities.

BOD loading in each sewage zone was predicted based on the sewage flow at the plant site and shown in Table 7.5. Average unit BOD loading obtained from the field survey conducted in connection with the Study show 130 g/m3 and 105 g/m3 for residential and business area respectively. Future unit BOD loadings were assumed to increase by 20 % respectively as the betterment of life. Total BOD loading in 24 sewage zone reached at 382 tons per day in 2011 which is equivalent to29 grams per capita per day.

Table 7.4 Prediction of Wastewater Amount in Sewage Zones (2011)

No.	Sewage Zone Name	Water Consumption (m3/day)	Generated Sewage Amount (m3/day)	Ground Water Infiltration (m3/day)	Sewage Amount at WWTP (m3/day)	Estimated Sewage Amount at WWTP (m3/day)	Required Construction Site Area per Unit Flow (m2/m3/day)	Required Construction Site Area (ha)	Phasing Plan
1	SiPhraya	27,743	22,194	4,439	26,633	27,000	0.059	1,600*1	Phase1
2	Rattanakosin	29,713	23,771	4,754	28,525	29,000	0.221	6,400*1	Phase1
3	DinDaeng	253,803	203,042	40,608	243,651	244,000	0.111	27,200*1	Phase1
4	Yanawa	181,961	145,569	29,114	174,682	175,000	0.183	32,000*1	Phase1
5.1	NongKhaem/Phasicharoen	107,012	85,610	17,122	102,731	103,000	0.808	83,200*1	Phase1
5.2	Ratburana	93,354	74,683	14,937	89,620	90,000	0.160	14,400*1	Phase1
6	Chatuchak	164,174	131,339	26,268	157,607	158,000	0.071	11,200*1	Phase2
7	Tonburi	119,317	95,454	19,091	114,545	115,000	0.300	34,000	Phase2
8	KhlongToey	254,236	203,388	40,678	244,066	244,000	0.300	73,000	Phase2
9	SuanLuang	133,721	106,977	21,395	128,372	128,000	0.300	38,000	Phase2
10	BangKhaen/DonMuang	271,755	217,404	43,481	260,885	261,000	0.300	78,000	Phase3
11	BangKhaen/Minburi	37,312	29,850	5,970	35,820	36,000	0.300	10,000	Phase4
12	DonMuang/BangSue	144,871	115,896	23,179	139,076	139,000	0.300	41,000	Phase3
13	HuayKhwang	133,278	106,622	21,324	127,947	128,000	0.300	38,000	Phase3
14	BangKapi/LatPhrao	164,127	131,302	26,260	157,562	158,000	0.300	47,000	Phase3
15	BungKum	165,905	132,724	26,545	159,269	159,000	0.300	47,000	Phase3
16	Pravet	168,415	134,732	26,946	161,678	162,000	0.300	48,000	Phase4
17	Latkrabang	6,209	4,968	994	5,961	6,000	0.500	3,000	Phase4
18	NongChok	3,541	2,833	567	3,400	3,400	0.500	1,700	Phase4
19	TalingChangWest	58,306	46,645	9,329	55,973	56,000	0.300	16,000	Phase4
20	TalingChangEast	43,216	34,573	6,915	41,488	41,000	0.300	12,000	Phase4
21	NongKhaem	40,334	32,267	6,453	38,720	39,000	0.300	11,000	Phase4
22	ChomThong	198,789	159,031	31,806	190,837	191,000	0.300	57,000	Phase3
23	BangKhunTien	33,758	27,006	5,401	32,408	32,000	0.300	9,000	Phase4
	Total	2,834,85(	2,267,88(	453,57(	2,721,45(	2,724,40(		739,70(	
								176,000*2	
								563,700*3	

Bangkok VS Thonburi					
Bangkok	2,140,765	1,712,612	342,522	2,055,134	2,057,400
Tonburi	694,086	555,268	111,054	666,322	667,000
Bangkok(%)	75.5	75.5	75.5	75.5	75.5
Tonburi(%)	24.5	24.5	24.5	24.5	24.5

Sewage Amount In Stage Development		
Phase1	668,000	24.5%
Phase2	645,000	23.7%
Phase3	1,036,000	38.0%
Phase4	375,400	13.8%
Total	2,724,400	100.0%

Note: *1 indicate the sites procured already
*2 indicate total site area procured already
*3 indicate the total site area required in future

Table 7.5 Prediction of BOD Loading in Sewage Zones (2011)

Sewage Zone No.	Sewage Amount (m 3/day)			BOD Loading (kg/day)		
	Domestic Use	Businesss Use	Total	BOD Loadingby Domestic Use	BOD Loading by Business Use	Total
1	166	26,467	26,633	26	3,335	3,361
2	3,719	24,805	28,525	580	3,125	3,706
3	72,873	171,022	243,896	11,368	21,549	32,917
4	70,609	104,073	174,682	11,015	13,113	24,128
5.1	51,538	51,193	102,731	8,040	6,450	14,490
5.2	45,551	44,069	89,620	7,106	5,553	12,659
6	76,789	80,818	157,607	11,979	10,183	22,162
7	61,185	53,359	114,545	9,545	6,723	16,268
8	116,270	127,796	244,066	18,138	16,102	34,240
9	88,387	39,986	128,372	13,788	5,038	18,827
10	102,018	158,867	260,885	15,915	20,017	35,932
11	22,158	13,662	35,820	3,457	1,721	5,178
12	74,161	64,915	139,076	11,569	8,179	19,748
13	51,788	76,159	127,947	8,079	9,596	17,675
14	60,406	97,156	157,562	9,423	12,242	21,665
15	86,502	72,767	159,269	13,494	9,169	22,663
16	71,945	89,734	161,678	11,223	11,306	22,530
17	3,989	1,972	5,961	622	249	871
18	3,400	0	3,400	530	0	530
19	48,874	7,099	55,973	7,624	895	8,519
20	32,988	8,500	41,488	5,146	1,071	6,217
21	24,816	13,904	38,720	3,871	1,752	5,623
22	112,161	78,676	190,837	17,497	9,913	27,410
23	23,469	8,939	32,408	3,661	1,126	4,787
Total	1,305,763	1,415,938	2,721,701	203,699	178,408	382,107
Bangkok VS Thonburi						
Bangkok	905,180	1,150,199	2,055,379	141,208	144,925	286,133
Tonburi	400,583	265,739	666,322	62,491	33,483	95,974
Bangkok(%)	69.3	81.2	75.5	69.3	81.2	74.9
Tonburi(%)	30.7	18.8	24.5	30.7	18.8	25.1

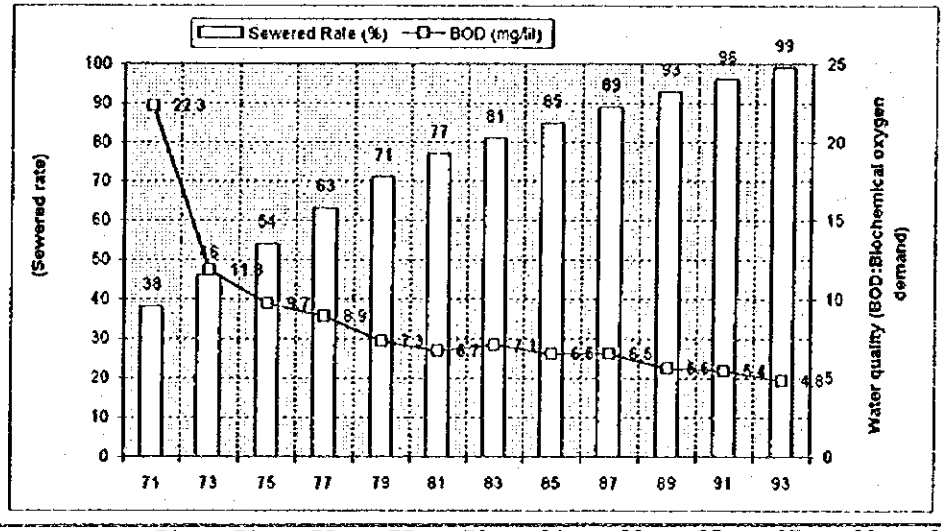
7.4 Planning Targets and Framework

(1) Planning Target

Creation of "Water-Friendly Eco-City" which is the planning issue No. 6 , denotes that environmental improvement on water in rivers, canals and ponds is an essential matter to achieve the objectives. Municipality water use such as domestic use, business use, commercial use etc. are the major wastewater sources and industrial water use is a minor source of water pollutants in BMA Area as described in the Section of " Water Supply ". Accordingly, environmental quality deterioration on water pollution mainly caused of pollutants from urban activities can improved considerably by development of sewage systems.

For an example of the phased development of sewage system in Tokyo, water quality in the rivers running across the downtown was evidently improved as the coverage ratio of sewered area reached at 60 to 70 % range as shown in Figure 7.2. Completion of the on-going sewage projects can cover the treatment capacity of 972,000 cum/day or approximately 40 % of water consumption as of 1995 in MWA service area. Therefore, referring to the experience in Tokyo, the target sewage development capacity for the next phase shall be set in the range of 1 to 1.3 million m3/day by 2011 in total for creation of "Water-Friendly Eco City" in early stage.

In addition, the Study Team set a target to the on-going Khlong Water Quality Improvement Project which shall support the sewage development projects for improvement of water quality in major khlongs. The first step target level is proposed to Level 3, less than 15 mg/lit in BOD, which is aiming at retrieving the nature in central urban area back to 1960's when people could enjoy playing with water in the city khlongs.



Year	71	73	75	77	79	81	83	85	87	89	91	93
Sewered Rate (%)	38	46	54	63	71	77	81	85	89	93	96	99
BOD (mg/lit)	22.3	11.8	9.7	8.9	7.3	6.7	7.1	6.5	6.5	5.6	5.4	4.8

Remarks
1.Sewered rate : sewered area against area of the Sumida River Basin (the wards of Itabashi, Kita and Nerima)
2. BOD: BOD measured through the year at Odaibashi bridge (75% of the standard value, prepare by the Bureau of Sewerage from the data of the Bureau of Environmental Protection)
Source: Bureau of Sewerage, Tokyo Metropolitan Government

Figure 7.2 Water Quality of the Sumida River and Sewage Construction

(2) Proposed Action Plans to Achieve the Targets

Considering the planning issues discussed in the previous section, most of the tasks to be tackled during the first 5 years are covered in the Strategic Plan for the 5th Five Year Plan proposed by DDS but the following five action plans included some key issues of the 5th Five Year Plan as for the major factors to play a important role for improvement of urban environmental quality in BMA Area.

1) Action Plan 1 : Formulation of Sewage Master Plan and Stage Development

Action Plan 1 consist of the works to review, correct, modify, alter and add the existing Sewage Master Plan to meet with the current and future urbanization conditions and construct the system based on the stage development plan to be formulated in the Master Plan. The Sewage Master Plan has to be formulated not only construction of the wastewater treatment plants but also it should include at least the items for sludge treatment, recycling and disposal, reuse of treated sewage, improvement of the existing drain pipes, sewage fee, project financing, sewage system data and information center, etc. which will be required sooner or later to complete development of the high-efficiency and comprehensive sewage system for BMA in future. In addition, the action plan require the measures for strengthening operation and maintenance of the completed sewage systems to meet satisfactorily with the function of the plant and the system as intended in the design.

The Study proposed stage development as shown in Table 7.6 and Figure 7.4. Proposed stage development plan was formulated to perform the target coverage of sewered area with 60 to 70 % in view of forwarding improvement of water pollution in early stage therefore the plan shall be reviewed again carefully from the angle of availability of the financial sources.

Table 7.6 Sewered Area Coverage Ratio UnderProposed Stage Development

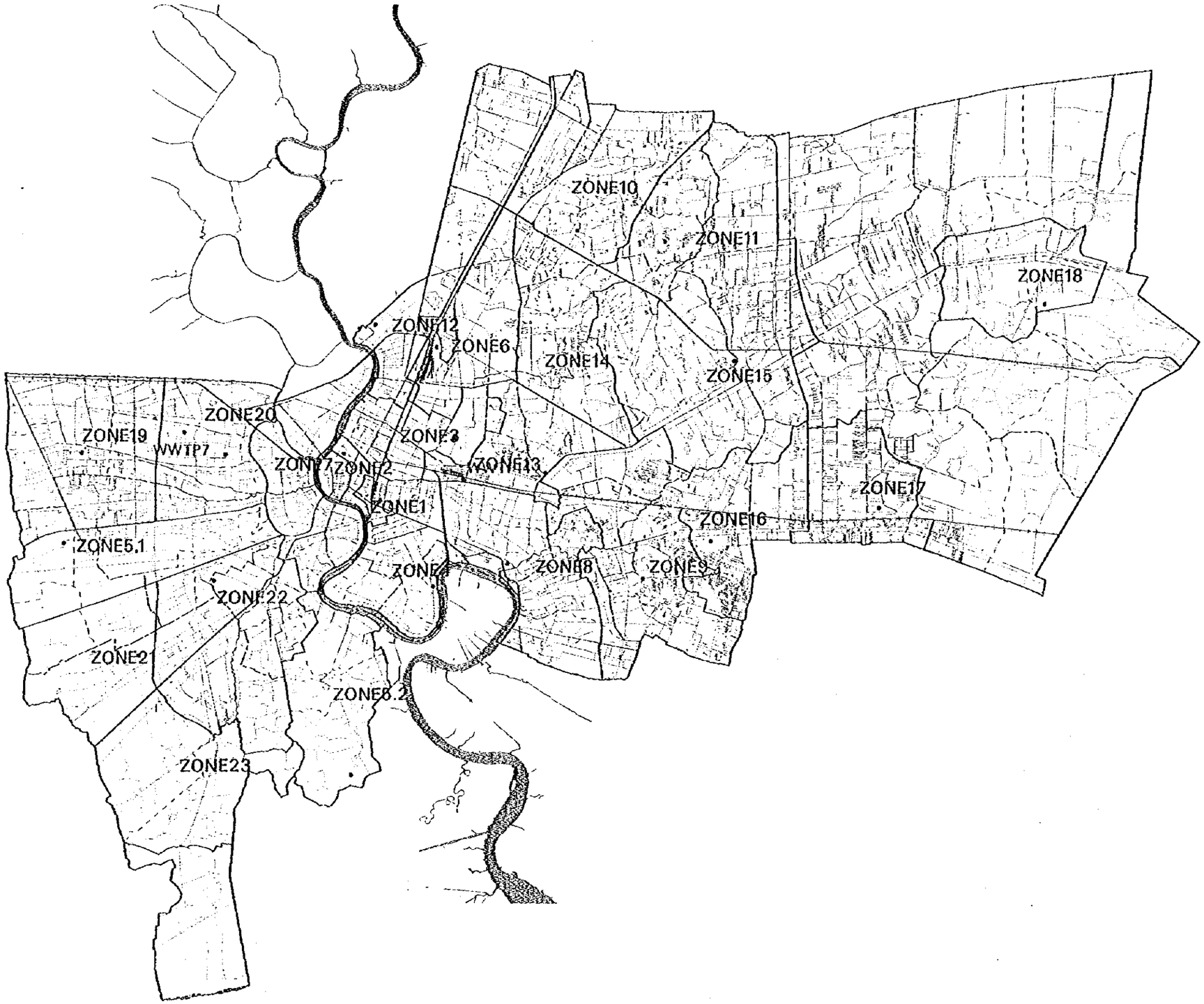
Stage Development	Sewage Amount (x 1,000 m3/day)	Coverage Ratio (%)	
On-going Project Zones (To 2001 AD)	668	24.5	
2nd Development Zones (1997 - 2001)	645	23.7	48.2
3rd Development Zones (2002 - 2006)	1,038	38.0	86.2
4th Development Zones (2007 - 2011)	375	13.8	100
Total	2,724	100	

Present Situation as of 1996

- Six projects for seven sewered areas have been implemented to construct the plants with a capacity of 972,000 cum/d.
- Sewage Master Plan proposed by PCD needs coordination with the urban restructure plan of BMA

Action Plan during 1997 - 2001

- Completion of the on-going sewage projects
- Completion of the on-going sludge treatment and disposal project
- Review of the Swage Development Master Plan in coordination with the BMA City Plan
- Planning, design and bidding for the projects in 2nd Sewage Development Zone
- Securing skillful O&M staff for sewer systems and treatment plants
- Improvement of NHA sewerage system



On-going Sewerage Projects and Planned Sewerage Zones

Legend

- Under Operation
- Under Construction
- Planning in 5th BMA
- Third Sewage Development
- Fourth Sewage Development
- Proposed WWTP Site
- Proposed Sewage Zone
- Chaopraya River
- River
- Railways
- Road
- BMA Boundary
- District Boundary
- Sub-district Boundary

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KILOMETERS

THE STUDY
ON
URBAN ENVIRONMENTAL IMPROVEMENT PROGRAM
IN
BANGKOK METROPOLITAN AREA (BEIP)

BANGKOK METROPOLITAN ADMINISTRATION(BMA)
THE GOVERNMENT OF THE KINGDOM OF THAILAND

JICA JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

Action Plan during 2002 - 2006

- Completion of the projects for the 2nd Sewage Development Zone
- Planning, design and bidding for the projects in 2nd Sewage Development Zone
- Implementation of sewage and solid waste corroboration project(s)

Action Plan during 2007 - 2011

- Completion of the projects for the 3rd Sewage Development Zone
- Planning, design and bidding for the projects in 4th Sewage Development Zone

2) Action Plan 2 : Procurement of Construction Sites

Based on the proposed sewage zoning and future sewage amount, the remaining 17 sewage zones require the construction site area about 62 ha. or 390 rai in minimum. Due to a foreseeable difficulties to acquire the plant sites disliked by the neighboring residents, a task team shall be established to accelerate procurement of the land to be proposed in the revised Sewage Master Plan. The site area shall be wide enough to layout buffer zone surrounding the plant to avoid probable influence to the neighboring area. Action Plan 3 was proposed to call the authority's attention to recognize importance of land acquisition as implementing the project on schedule.

Present Situation as of 1996

- On-going projects procured the site owned by the public agencies
- Layout plans of the on-going projects are too narrow for convenient O&M and better environmental installation to the neighboring

Action Plan during 1997 - 2001

- Inventory investigation of vacant lands in BMA Area
- Procurement of construction sites approximately 19 hectares for 3 plants in the 2nd Sewage Development Zone

Action Plan during 2002 - 2006

- Procurement of construction sites approximately 31 hectares for 6 plants in the 3rd Sewage Development Zone
- Provisional utilization of the sites for public services

Action Plan during 2007 - 2011

- Procurement of construction sites approximately 12 hectares for 8 plants in the 4th Sewage Development Zone

3) Action Plan 3 : Installation of New Stormwater Drains by District Offices

Prior to proceed to the Action Plan 3, it is required to formulate the Sewage Master Plan in each sewage zone indicating the sewage amount, plant site, type of sewer system, route of interceptor mains and collection trunk mains, etc. With the information of the Sewage Master Plan, drain system in soi shall be designed to match with the overall sewer system.

Coordination is required not only with the Sewage Master Plan but also required for road pavement work to avoid duplication construction work in narrow sois. Technical guidance and assistance also should be made available from the authorities concerned.

Present Situation as of 1996

- District offices are responsible for installation of drain pipes in sois
- Existing drain pipes are not always designed properly in sizing, slope and flow direction

Action Plan during 1997 - 2001

- Establishment of a technical coordination system among the agencies concerned
- Installation of drain pipes linking with main drains and sewer systems
- Implementation of regular cleaning of drain pipes

Action Plan during 2002 - 2006

- Continuous collaboration work among the agencies concerned

4) Action Plan 4 : Saving Water to Reduce Pollution Loading to the Nature and Economize Plant Capacity

Water pollution problem arise from where people use water. Saving water in daily life in home, office, and business activities will be useful to reduce generation of water pollutants discharged to the public water course as well as saving energy.

Excessive use of synthetic detergent for washing and cleaner for washing dishes are the a habit of urban dwellers and the have been spread to all over the country nowadays. Solution of water pollution problem can be found not only by the administrative officials but realized by the consumer

Intention of Action Plan 4 is to set up project team and prepare public campaign program to forward the movement of environmental conservation from the water environmental view point. The campaign shall be implemented with two main subject which are "Saving Water" and "Reducing Water Pollutants".

Public campaigns through mass media, school curriculums, circulation notice in workplace, visiting sewage plant open for the public, etc., will be helpful to arouse awareness of the people to participate in the campaign. National level saving water campaign in collaboration with MWA, PWA, PCD and other government agencies will be more effective way.

Present Situation as of 1996

- Average water consumption reaches at 480 liter per capita per day in MWA service area in 1995
- Betterment of life discharging more water pollutants into the public waters

Action Plan during 1997 - 2001

- Set up Project Team and preparation of public campaign program
- Start public campaigns "Saving Water" and "Reducing Water Pollutants" by reforming the current energy-consuming life style
- Public campaigns to reduce generation of water pollutants in daily life

Action Plan during 2002 - 2006

- Continuous public campaigns for saving water and for reducing water pollutants in daily life

5) Action Plan 5 : Khlong Water Quality Improvement Project (Clean and Green Khlongs Project or CGK Project)

The main activities in Action Plan 5 consist of a) operation and maintenance of the CGK Project in the East Bank, b) set up CGK Project in the West Bank, and c) preparation of automatic water quality monitoring system. Stage-wise activities of Action Plan 5 is proposed in the followings.

Present Situation as of 1996

- Khlong water quality improvement project is being implemented for 390 km2 in the East Bank

Action Plan during 1997 - 2001

- O&M for CGK System in the East Bank
- Planning for formulation of CGK Project in the West Bank
- Investigation for establishment of automatic water quality monitoring system

Action Plan during 2002 - 2006

- Implementation of the CGK Project in the West Bank
- Construction of on-line automatic water quality monitoring stations and a monitoring center and start monitoring operation

Action Plan during 2007 - 2011

- O & M for CGK systems in the East and West banks

CHAPTER 8: SOLID WASTE MANAGEMENT SYSTEM

8.1 General

Public services on solid waste management in BMA Area have become an important problem caused by the increasing amount of solid wastes, insufficient capacities of collection vehicles, treatment facilities, final disposal sites, etc. In other words, rapid growth of the city brought about the increase of solid wastes amount at the level exceeding the capacity of the facilities provided by the city authority.

The amount of solid wastes collected in 1995 from 38 districts of BMA reaches at 6,540 tons/day in average. Comparing with the solid waste collected in 1985, which was 3,260 tons/day in average, the solid waste amount required for treatment and disposal become double in the past 10 years and the rate of annual increase reach at 7-8 % which is almost the same rate of economic growth in the same period in Thailand.

Economic growth is bringing prosperity in exchange for many problems including traffic, floods, air pollution, water pollution, etc. and a heap of garbage produced every day. A very simple method of numerical prediction shows that the daily average solid waste amount to be collected in 2011 reaches at the range from 14,000 to 18,000 in BMA Area.

Despite pressing problem to improve the solid waste management situation in the city of Bangkok, BMA could not provide effective facilities and manpower for years. However, recently, the projects for construction of solid waste incineration plants, etc. have started to cope with the chronic problems.

In 1995, there were many topics reported frequently on news papers over the solid waste projects implemented such as the cases in Chiang Mai Incineration Plant Project, Lad Krabang Final Disposal Project, Hazardous Wastes Treatment Center in Rayong, etc. opposed by the neighboring residents of the construction sites for fear of environmental degradation after the plant operation started. Any kind of the development projects probably containing the elements to influence environmental degradation to the people and to nature require the primary consensus from the people reside in the project site and the surrounding areas.

Department of Public Cleansing(DPC), BMA is now practicing the separation of wastes into dry waste and wet waste in several districts, which may be intended for the compost plant in operation in On Nut Landfill Site and the forthcoming incineration plant construction project. This is one way of participation of the people to the public services to make one aware that the individual resident shall be responsible for the solid waste management through the garbage generated from his house, collection, treatment and disposal for the purpose of keeping a sanitary living environment in the society.

The study review the contents of the on-going projects and policy of public cleansing services in respect of future urban development policies and the points of urban environmental improvement in BMA Area.

8.2 Assessment on Present Condition

(1) Current Solid Waste Management

1) Implementing Agency

Department of Public Cleansing(DPC) undertake services of solid waste management from planning to operation and maintenance. Collection work is carried out under the management of each district office.

2) Existing Facilities

Existing facilities in operation under DPC is listed as follows. Figure 22.1 shows the location of each plant site.

Nong Khaem Landfill Site

- Landfill Site 375 rai
- Transfer Station 1,500 ton/day

On Nut Landfill Site

- Landfill Site 590.86 rai
- Transfer Station 1,200 ton/day
- Compost Plant 1,200 ton/day

Ram Intra Landfill Site (Tha Raeng)

- Landfill Site 59 rai
- Transfer Station 1,500 ton/day

Collection Vehicles

- Compactor, 10 cum 929 units
- Compactor, 2 tons 73 units
- Sided Loader , 12 cum 171 units
- Container Truck, 8 cum 139 units

(2) On-going Solid Waste Projects

DPC has implemented the projects for construction of the intermediate treatment facilities summarized in the followings.

1) Nong Khaem Compost Plant

Compost plant of 1,000 tons/day is now under construction at Nong Khaem Landfill site and expected to start operation in 1999.

2) On Nut Incineration Plant by Turn Key

Construction project of an incineration plant at On Nut Landfill Site with the capacity of 1,350 tons/day (450 x 3 furnaces) is in the process of bidding to start construction in 1997. The plant is expected to start operation in 2000.

3) Nong Khaem Incineration Plant by Turn Key

Turn key project will be implemented at Nong Khaem Landfill site to construct incineration plant of the capacity likely 1,350 tons/day (450 x 3 furnaces). However, the details have not decided yet.

4) Incineration Plant by BOT

Construction project for incineration plant by BOT is expected to start soon. The plant capacity is likely more than 1,000 tons/day ,however, the details have not decided yet.

5) Central Sludge Treatment Plant

The project is implemented at Rama Intra Landfill site by turn key base contract. Sludges from the wastewater treatment plants of BMA, fat and greases collected from greases traps from the wastewater treatment plants in restaurants, hotels, etc. shall be treated by the following facilities.

- Liquid Waste Max. 300 m3/day
- Sludge, Grease & Fat Max. 480 m3/day

The project is expected to start in 1996 and complete in 1999.

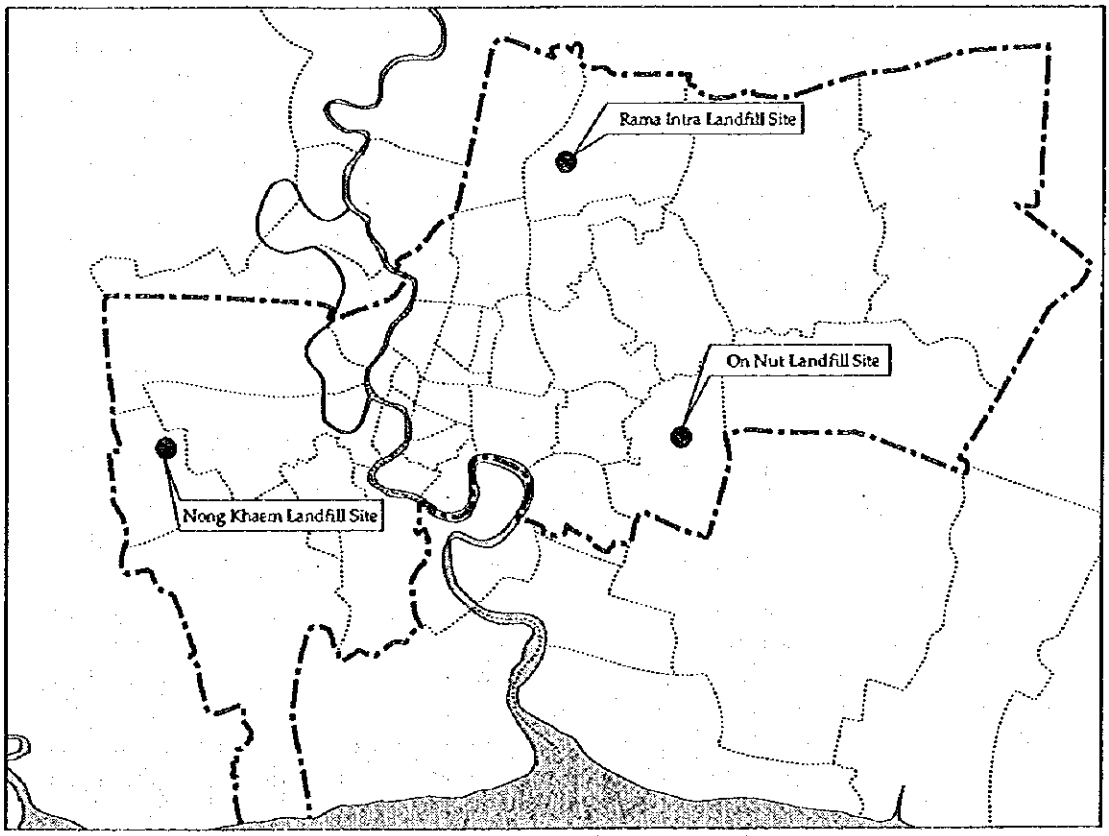


Figure 8.1 Location of Solid Waste Treatment and Disposal Facilities

(3) Solid Waste Amount in BMA Area

1) Solid Waste Amount in 1990 - 1995

Solid waste amount generated in BMA Area increase from 4,513 tons/day in 1990 to 6,539 tons/day in 1995 as shown in Table 8.1. Annual increase rate reached at 7.7 % in the last 6 years. Increase rate is more or less the same rate with the economic growth in Thailand. Meanwhile, population in the same period increase from 6.9 million to 8.1 million in BMA with the increase rate at 3.4 % per annum, which mean that the increase

rate of solid waste is higher than the population increase rate and the solid waste generation rate per capita in the same period increase from 657 grams/day in 1990 to 805 gram/day in 1995 which is increasing about 4.1 % annually. Meanwhile, solid waste generation amount in Tokyo recorded the peak in 1989 and tend to decrease since 1990. Total collected solid waste amount ranges approximately 13,400 ton/day in 1989 to 11,800 ton/day in 1994. Per capita generation rate also shows decrease from 1,625 to 1,493 g/c/day in the same period.

2) Unit Solid Waste Generation Rate in District in 1995

Table 8.2 indicate solid waste generation rate in each district converted to the unit generation rate per resident population and per built-up area. Per capita solid generation rate ranges from 296 to 1,947 grams/day. Average of whole BMA indicate 805 grams per capita per day. Districts of the higher per capita generation rate are Phra Nakhon, Huai Khwang, Khlong Toei, Chatuchak, Sathon, etc. and the lower per capita generation rate districts locate in Nong Chok, Bang Sue, Talling Chan, Bang Phlad, Pom Phrap Sattru Phai, etc. Districts of the higher population density shows rather lower per capita generation rate.

Table 8.2 also show the solid waste generation rate to built-up area in each district. Per built-up area generation rate ranges from 4.1 to 50.8 ton per square kilometer. The higher generation rate to built-up area consists of Sam Phanthawong, Phra Nakhon, and Pom Prap Sattru Phai districts in Rattanakosin, Bang Rak and Patthunwan in business districts etc. Districts of the lower generation rate locate in Talling Chan, Pravet, Nong Chok, etc. districts in the suburbs. Average of whole built up area discharge solid waste about 12.1 ton/km2/day in BMA which include solid waste discharge rate of 0.4 tons/km2/day from hospitals, clinics and fresh foods market. Solid waste generation rate to area in Tokyo in 1994 is 19.3 ton/km2 obtained from the collected amount 11,835 ton/day and area 613 km2.

3) Numbers of Collection Vehicles and Loading Capacity

Table 8.3 shows numbers of collection vehicles in service in each districts. Total numbers of collection vehicles, 1,268 units, are in service for 38 districts and for collection of garbage from fresh foods markets and infectious waste from hospitals and clinics. Most of the collection vehicles 6 ton compactor and/or side loader, the smaller 2 ton compactors are introduced in service recently to collect garbage in narrow streets.

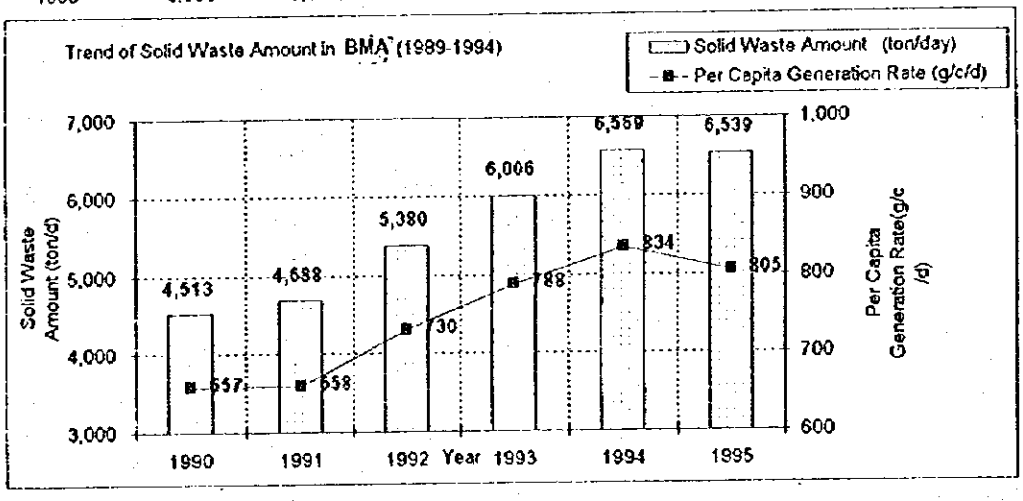
As a whole, total loading capacity of the collection vehicles in BMA meet with the solid waste generation amount by 1 trip in a day. However, there are 18 districts run short of the collection vehicles and required to operate 2 trips in a day in heavy traffic condition in BMA Area. Those districts include Bung Kum, Latkrabang, Bang Khaen, Phasicharoen, Bang Khun Tien, etc. where are expanding urban area in recent years. Excess amount of 272 tons per day need collection operation 2 trips in a day as of 1995. Meanwhile, 62 units of collection vehicles with the loading capacity of 290 ton are in service to collect solid wastes 193 tons per day from hospitals and markets. Figure 8.2 was prepared using the data in Table 8.3 to show visually the loading ratio between the amount of solid waste and the total loading capacity of the collection vehicles in each district.

DPC has started the Khlong Beautification Program since 1991 to collect floating garbage from the khlongs in Tonburin and Bangkok by the budget of 6 million Baht for 35 units of boats. Later 17 units of boats were added by spending budget about 3.7 million. The Program collect garbage about 25 to 30 tons/day from 38 khlongs in total. Table 8.4 shows the list of collection boats in service as of 1995.

Table 8.1 Trend of Solid Waste Generation Amount in BMA 1990-1995

Trend of Solid Waste Generation Amount in BMA 1990 - 1995

Year	Solid Waste Amount (ton/day)	Population	Per Capita Generation Rate (g/c/d)	Solid Waste Increase Ratio (%)	Population Increase Ratio (%)	Per Capita Generation Rate Increase Ratio (%)
1990	4,513	6,873,300	657	100	100	100
1991	4,688	7,123,864	658	104	104	100
1992	5,380	7,374,429	730	119	107	111
1993	6,006	7,624,995	788	133	111	120
1994	6,569	7,875,560	834	146	115	127
1995	6,539	8,126,125	805	145	118	123



Trend Solid Waste Generation Amount in Tokyo Metropolitan Area (1989 -1994)

Year	Solid Waste Amount (ton/day)	Population	Per Capita Generation Rate (g/c/d)	Solid Waste Increase Ratio (%)	Population Increase Ratio (%)	Per Capita Generation Rate Increase Ratio (%)
1989	13,429	8,111,731	1,625	281	118	247
1990	13,178	8,129,377	1,597	275	118	242
1991	12,898	8,154,404	1,519	264	119	231
1992	12,390	8,059,267	1,496	257	117	228
1993	12,057	8,111,731	1,486	257	118	226
1994	11,835	7,927,084	1,493	252	115	227

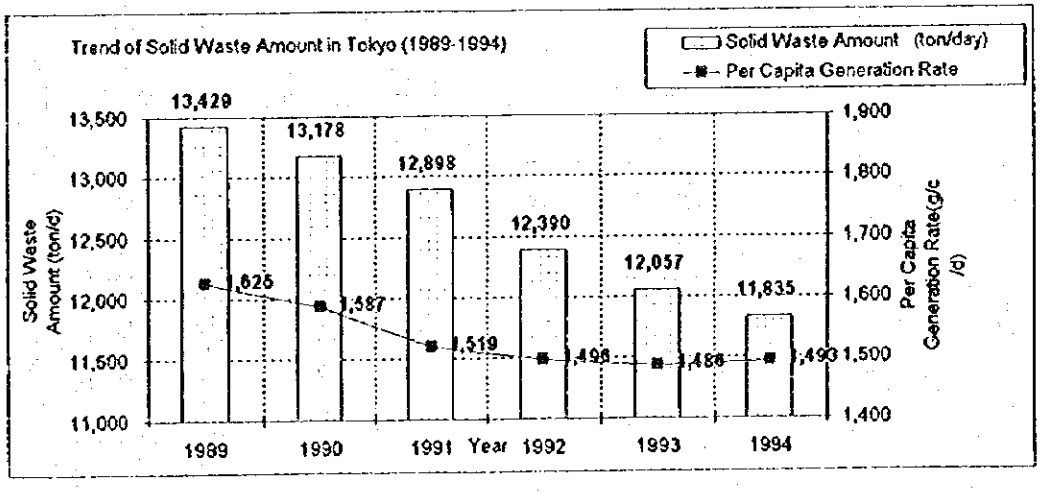


Table 8.2 Solid Waste Amount and Unit Generation Rate in 1995

District	Population	Built-up Area	Solid Waste Amount		Unit Generation Rate	
		km2	ton/year	ton/day	per capita per day	per km2 per day
1 PhraNakhon	106,334	4.139	75,551	207.0	1,947	50.0
2 KhlongToei	306.56[illegible]	26.141	138.91[illegible]	380.6	1.241	14.6
3 KhlongSan	144.40[illegible]	5.420	47.63[illegible]	130.5	904	24.1
4 Chatuchak	227.70[illegible]	29.064	100.157	274.4	1.205	9.4
5 ChomThong	199.28[illegible]	12.954	59.337	162.6	816	12.5
6 DonMuang	298.65[illegible]	38.28[illegible]	92.87[illegible]	254.5	852	6.6
7 Dusit	283.04[illegible]	8.832	75.14[illegible]	205.9	727	23.3
8 TalingChan	171.70[illegible]	21.69[illegible]	32.18[illegible]	88.2	513	4.1
9 ThonBuri	296.43[illegible]	7.456	68.10[illegible]	186.6	629	25.0
10 BangkokNoi	251.53[illegible]	9.751	65.30[illegible]	178.9	711	18.3
11 BangkokYai	103.961	5.399	32.45[illegible]	88.9	855	16.5
12 BangKapi	388.381	30.05[illegible]	122.68[illegible]	336.1	865	11.2
13 BangKhunThian	229.97[illegible]	22.00[illegible]	65.20[illegible]	178.7	777	8.1
14 BangKhen	377.261	25.08[illegible]	76.63[illegible]	210.0	557	8.4
15 BangKhoLaem	144.22[illegible]	6.865	50.214	137.6	954	20.0
16 BangSue	338.73[illegible]	11.28[illegible]	58.657	160.7	474	14.2
17 BangPhlad	247.00[illegible]	9.456	46.39[illegible]	127.1	515	13.4
18 BangRak	164.41[illegible]	3.904	53.494	146.6	891	37.5
19 BungKhum	251.24[illegible]	28.051	71.77[illegible]	196.6	783	7.0
20 PathumWan	290.93[illegible]	6.675	62.912	172.4	592	25.8
21 Prawet	163.34[illegible]	26.28[illegible]	40.401	110.7	678	4.2
22 PomPrapSattruPhai	198.73[illegible]	2.370	40.16[illegible]	110.0	554	46.4
23 PhayaThai	254.02[illegible]	8.868	58.10[illegible]	159.2	627	18.0
24 PhraKhanong	258.07[illegible]	29.28[illegible]	80.23[illegible]	219.8	852	7.5
25 PhasiCharoen	314.86[illegible]	23.161	89.46[illegible]	245.1	779	10.6
26 Minburi	185.83[illegible]	13.37[illegible]	44.387	121.6	654	9.1
27 YanNawa	152.80[illegible]	10.281	54.20[illegible]	148.5	972	14.4
28 Ratchatavee	259.641	6.859	61.36[illegible]	168.1	648	24.5
29 RatBurana	264.72[illegible]	15.27[illegible]	68.93[illegible]	188.9	713	12.4
30 LaKrabang	123.69[illegible]	11.614	40.05[illegible]	109.7	887	9.4
31 LatPhrao	164.07[illegible]	17.42[illegible]	46.68[illegible]	127.9	780	7.3
32 SamPhanthawong	73.47[illegible]	1.237	22.93[illegible]	62.8	855	50.8
33 Sathon	136.96[illegible]	7.004	51.74[illegible]	141.8	1.035	20.2
34 NongKhaem	144.12[illegible]	16.33[illegible]	45.70[illegible]	125.2	869	7.7
35 NongChok	93.244	6.108	10.09[illegible]	27.6	296	4.5
36 HuaKhwang	78.93[illegible]	10.42[illegible]	46.10[illegible]	126.3	1.600	12.1
37 DinDaeng	275.86[illegible]	8.350	75.367	206.5	748	24.7
38 SuanLuang	161.91[illegible]	14.25[illegible]	44.75[illegible]	122.6	757	8.6
Subtotal (38 Districts)	8,126,12[illegible]	541.02[illegible]	2,316,31[illegible]	6,346.1	781	11.7
Hospitals & Markets	8,126,125	541.020	70,486	193.1	24	0.4
Total (BMA)	8,126,12[illegible]	541.02[illegible]	2,386,80[illegible]	6,539.[illegible]	805	12.1
OtherPlaces	8,126,125	541.020	33,519	91.8	11	0.2
Grand Total	8,126,12[illegible]	541.02[illegible]	2,420,32[illegible]	6,631.[illegible]	816	12.3

Table 8.3 Operation Condition of Solid Waste Collection Vehicles (1995)

District	Solid Waste Amount		1-4 Year Vehicles			5-6 Year Vehicles			More than 7 Year Vehicles		Total Number of Vehicles	Total Loading Capacity	Loading Capacity Ratio *1	Loading Balance *2	Urgency Ranking *3
	ton/year	ton/day	2ton	3.5to 6ton		3.5to 6ton			3.5to 6ton		units	ton	ton/ton	ton	
Bang Kapi	122,686	336.1	2	5	35	1	1	1	4		49	252	1.332	-84	5
Bang Khen	76,638	210.0	2	2	19	0	5	0	1		29	151	1.395	-59	5
Bang Kho Laem	50,214	137.6	2	2	16	2	0	0	4		26	124	1.107	-13	3
Bang Khun Thian	65,209	178.7	1	5	18	0	0	0	2		26	134	1.338	-45	5
Bang Phlad	46,390	127.1	2	2	21	1	0	0	2		28	146	0.873	19	1
Bang Rak	53,494	146.6	2	1	21	0	2	0	7		33	164	0.896	17	1
Bang Sue	58,657	160.7	2	2	25	1	0	0	4		34	176	0.915	15	1
Bangkok Noi	65,300	178.9	2	2	23	1	3	0	0		31	165	1.083	-14	2
Bangkok Yai	32,452	88.9	2	2	14	0	0	2	1		21	102	0.876	13	1
Bung Khum	71,775	196.6	1	3	15	0	0	1	3		23	113	1.736	-83	6
Chatuchak	100,157	274.4	2	5	30	2	0	0	6		45	225	1.221	-50	4
Din Daeng	75,367	206.5	2	4	25	0	0	0	10		41	198	1.043	-8	2
Don Muang	92,876	254.5	1	5	25	1	0	1	7		40	195	1.306	-60	5
Dusit	75,149	205.9	2	2	29	0	4	0	3		40	212	0.971	6	1
Huai Khwang	46,105	126.3	2	3	23	2	3	0	0		33	171	0.738	45	1
Jomthong	59,337	162.6	1	2	23	1	0	0	3		30	159	1.025	-4	2
Khlong San	47,630	130.5	2	1	20	1	0	0	4		28	142	0.918	12	1
Khlong Toei	138,918	380.6	2	2	57	2	1	1	0		65	365	1.044	-16	2
Lat Phrao	46,685	127.9	2	3	21	1	0	0	0		27	143	0.894	15	1
Latkrabang	40,050	109.7	1	5	7	1	1	0	2		17	75	1.470	-35	6
Minburi	44,387	121.6	2	3	14	1	0	1	5		26	118	1.032	-4	2
Nong Chok	10,090	27.6	1	3	4	1	0	0	10		19	69	0.400	41	1
Nong Khaem	45,703	125.2	1	4	12	1	1	0	0		19	95	1.316	-30	5
Pathum Wan	62,912	172.4	1	4	25	2	1	0	4		37	188	0.918	15	1
Phasi Charoen	89,469	245.1	2	3	23	2	2	1	3		36	178	1.381	-68	5
Phaya Thai	58,103	159.2	2	3	28	2	0	0	5		40	203	0.785	44	1
Phra Khanong	80,239	219.8	2	6	22	1	0	0	6		37	178	1.238	-42	4
Phra Nakhon	75,551	207.0	2	5	31	3	0	0	4		45	227	0.910	20	1
Pom Prap Sattru Phai	40,163	110.0	2	1	19	0	1	0	2		25	132	0.834	22	1
Prawet	40,401	110.7	2	2	17	1	0	0	1		23	119	0.933	8	1
Rat Burana	68,936	188.9	1	3	21	1	1	2	4		33	161	1.172	-28	3
Ratchatavee	61,363	168.1	2	2	21	2	0	0	9		36	169	0.993	1	1
Sam Phanthawong	22,933	62.8	2	0	12	0	2	0	0		16	85	0.739	22	1
Sathon	51,742	141.8	2	2	24	2	0	0	3		33	169	0.838	27	1
Suan Luang	44,753	122.6	2	2	17	1	0	0	3		25	125	0.984	2	1
Taling Chan	32,180	88.2	2	1	12	1	1	0	0		17	87	1.018	-2	2
Thon Buri	68,103	186.6	2	1	30	1	2	1	2		39	207	0.902	20	1
Yan Nawa	54,200	148.5	1	3	17	3	3	0	7		34	157	0.947	8	1
Sub-total	2,316,317	6,345	65	106	618	42	34	11	131		1,205	6,075	1.045	-272	2
Hospitals & Markets	70,486	193.1	4	13	33	3	4	2	3		62	290	0.866	97	1
Total(BMA)	2,386,803	6,539	70	119	649	45	38	13	134		1,268	6,364	1.027	-173	

Note*

*1 indicate that the figures larger than 1.000 run short of loading capacity of the collection vehicles

*2 obtained the balance by subtracting the solid waste generation amount from the loading capacity in each district

*3 shows the ranking based on the following standard;

Rank 1 : smaller than 1.00 Rank 2 : 1.00 to 1.10 Rank 3 : 1.11 to 1.20 Rank 4 : 1.21 to 1.30 Rank 5 : 1.31 to 1.40

Figure 8.2

Disparities between Solid Waste Collection and Generation

Legend

- Smaller than 1.00
- 1.00 to 1.10
- 1.11 to 1.20
- 1.21 to 1.30
- 1.31 to 1.40
- Larger than 1.41
- Build-up Area
- Chaopraya River
- Main Roads
- Railways

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SCALE 1:235000

5 0 2 4 6 8 10

KILOMETERS

THE STUDY
ON
URBAN ENVIRONMENTAL IMPROVEMENT PROGRAM
IN
BANGKOK METROPOLITAN AREA (BEIP)

BANGKOK METROPOLITAN ADMINISTRATION(BMA)
THE GOVERNMENT OF THE KINGDOM OF THAILAND

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

Table 8.4 List of Collection Boats

DistrictOffice	Nos. of Boat	Name of Khlong In Service
Existing Boat		
TalingChan	2	K.Chakphra,K.BangRamard
	4	K.BangPhrom
BangkokNoi	3	K.BangkokNoi
BangKhunThian	2	K.HuaKrabue,K.SanamChai
ChomThong	2	K.SanamChai,K.Dan,K.BangMod
Thonburi	1	K.BangLuang,K.BangkokYai
PhasiCharoen	4	PhasiCharoen,PhrayaRatchamontri, BangWeak,BangChuaknung,BangLuang, K.Dan,SanamChai
BangkokYai	1	K.BangkokYai
BangKapi	1	K.SaenSaep
Pravet,SuanLuangBranch	1	K.PhraKhanong
LaKrabang	2	Pravetburirom,HuaTakei,NongBrue
Ratburana	2	K.ChaengRon,K.SaphanKhwai
Pravet	1	K.Pravetburirom
DonMuang	3	K.Premprachakhorn
HuaiKhwang	3	K.LatPhrao,K.BangSue
BangKhen	3	K.ThomK.Song
Sub-total	35	
New Boat		
ChomThong	2	K.BangKhunThian,K.DaoKhanong, K.Shednah,K.BangMod,K.BangRanaeNoi
BangKapi	1	K.SaenSaep,K.LatPhrao
Ratburana	2	K.BangPakaew,K.BangMod
Pravet	1	
DonMuang	2	K.Premprachakhorn
BangKhen	2	K.SongtoK.Hokwa
Chatuchak	1	K.Premprachakhorn
Minburi	2	K.SaenSaep,K.Samwa
BungKhum	2	K.SaenSaep
PomPrab	2	K.Mahanak
Sub-total	17	
Total	52	

8.3 Policy Direction and Planning Issues

Changes of the society in recent years burden the administrative officials with the varieties of the problem arising out of the public services on the solid waste management likely as listed in the followings.

- Increase of solid waste amount
- Increase of undegradable waste and scattering of waste
- Difficulty to secure suitable landfill sites due to expansion of urban area
- Request for sanitary and comfortable living environment
- Difficulty to implement projects due to awareness of the people to participate in assessment of the projects in aspect of environmental conservation
- Request for resource recovery and recycling of waste in energy-saving society
- Increase of investment, operation and maintenance cost

Pollutes Pay Principle (PPP) is a topic in argument recently among the people concerned with the environmental conservation activities. PPP is not a slogan to put every responsibility on to the consumer side but to share the responsibility to the central government, local government bodies, enterprises and the consumers.

In solid waste management, the role of the central government is to provide financial sources for development of the facilities and technology in addition to prepare legislative measures. The role of the local government bodies is to install adequate facilities and public services in time whenever needed in addition to carry out an administrative guidance. The enterprises should have the role to take measures for reduction, reuse and recovery of waste and production of harmless consumable easily decomposed in the treatment and disposal processes. The consumers, or the beneficiaries should cooperate with the public cleansing services to attain the role to minimize generation of garbage, recycling, and bear for the due garbage fee.

Considering the planning direction in view of the role of local government bodies in solid waste management, BMA have to accelerate installation of necessary facilities and the measures to reduce solid waste amount supported by the enterprises and the beneficiaries who are also responsible to play their role in environmental conservation.

Three issues were picked out in consideration of the current installation of the solid waste management facilities with reference to the subjects mentioned above. Followings are the planning issues to be discussed for implementing the plan and program to the satisfactory manner to search the way for contributing to provide a healthy and sanitary urban environment through establishment of a adequate public cleansing services.

(1) Reduction of Rate of Solid Waste Generation and Recovery of Resources

Primary purpose of this subject is to economize the future development project in the long run by means of the benefits of reduction of raw waste amount from the sources of generation, the residuals generated from the treatment system for treatment and the final disposal site area.

In fact, control of discharge, recovery of valuables and separation of garbage at home will be the most effective way for treatment of garbage by types at the plants. Through participation of the people to the public services, a mind of saving-resources shall be inspired to the individuals so that the people shall take a glance at the garbage to think it over whether it is really an unusable, valueless, or still keeping a state of reusable in home.

In addition, recovery of resources from the treatment process is beneficial on both sides of the post treatment processes and the recovery of valuables. Resource recovery process or recycling process shall be installed at transfer stations, incineration plants or

compost plants.

The more reduction of solid waste through the processes of garbage discharge sources, collection, treatment and disposal processes will lesser the plant scale of the implementation projects. In other words, BMA have to provide all her land for construction of landfill sites unless taking measures to establish recycling society through cooperation from the people and application of suitable technology.

(2) Construction of Intermediate Treatment Facilities

Only one compost plant is in operation at On Nut Landfill Site to treat 1000 to 1200 tons of municipal solid waste every day. Construction of the second compost plant of the rated capacity of 1,000 tons/day is in progress to start operation in 1999. Details of operation condition was not available, however, the final products of the plant is 30 % with the rejects from the process become 70 %. This is to say that large amount the rejects from the compost plant must be disposed at the landfill site. Municipal solid waste contain varieties of garbage and garbage should be segregated in the composting processes or controlled collection of compostable garbage from the sources of discharge. Without practicing proper separation, composting is not an effective treatment process of municipal solid waste.

The major objectives of intermediate treatment facilities of solid waste are intended 1) to reduce volume, 2) to stabilize and 3) to make harmless before disposed at the landfill site. Incineration of urban solid waste is one of the best method to meet with the objectives of solid waste treatment in technical and economic point of view.

The recent incineration technology has developed in combustion process, energy recovery, environmental protection, etc. including the conventional stoker type incinerator, fluidized bed incinerator, pyrolysis furnace, etc. The most feasible type shall be selected in combination with the total process of the treatment facilities suitable for Bangkok taking account of the characteristic of garbage, energy recovery and environmental conservation aspects.

(3) Procurement of Final Disposal Sites

At present, the existing three disposal sites are filled with raw refuse piled up on the garbage hills, raw refuse is transferred to the sanitary landfill sites provided outside of the city boundaries of Bangkok by the hauling & disposal contractors. One solid waste disposal contractors have provided newspaper articles several times before due to the claim from the neighboring residents suffering environmental deterioration caused by hauling garbage and landfill operation in Ladkrabang District. The other contractor haul garbage generated in Bangkok to the landfill site procured in Kanchanaburi Province. There will remain potential news sources in landfill operation without strict control and moral of the contractors.

With the concept of garbage treatment and disposal in the source of generation as a basic rule, BMA should procure the suitable landfill sites within own administration boundaries. Due to a hike of land price in recent years, it would be a hard jobs for officials concerned to find the suitable final disposal sites. Without a final disposal site, intermediate facilities nor public cleansing services itself will not work properly.

(4) Strategic Plan Proposed in The 5th BMA Five Year Development Plan

Department of Public Cleansing (DPC) drafted the proposals for The 5th BMA Five Year Development Plan to tackle with the solid waste problems. The programs are composed of the plans to improve and construct solid waste facilities and equipment for collection, treatment and disposal in participation of public sectors and public campaigns to cope with current and future solid waste management. Proposed programs of DPC for the next 5 year plan are presented as follows.

Program 1 : Promotion for Reduction of Solid Waste Generation Amount

Program 2 : Improvement of Collection Efficiency

Program 3 : Improvement of Disposal Efficiency

Program 4 : Improvement of Night Soil Management Efficiency

Program 5 : Supporting Services for Solid Waste, Night Soil and Hazardous Waste Management

Activities of the Programs

Program 1 : Promotion for Reduction of Solid Waste Generation Amount

- Public campaign for reduction of solid waster generation rates
- Educational campaign for knowledge about hazardous waste
- Public campaign for solid waste recycling and recovery

Program 2 : Improvement of Collection Efficiency

- Collection services for construction wastes
- Collection services for floating matters in waterways
- Provision of extra equipment and vehicles for supporting collection services
- Improvement of efficiency of collection vehicles
- Development of cleaning systems by mechanization in substitution of manpower
- Improvement of collection systems for infectious wastes
- Collection of hazardous wastes for communities
- Upgrading of public cleansing services by staff training and workshop

Program 3 : Improvement of Treatment and Disposal Efficiency

- Privatization of solid waste transfer and disposal services for On Nuch with a capacity not less than 2,000-2,500 t/day
- Privatization for O&M of the compost plant in On Nuch for a capacity not less than 1,000 t/day
- Construction of an incineration plant in On Nuch for a capacity not less than 1,000 t/day at On Nuch
- Privatization of solid waste transfer and disposal services for Nong Khaem with the capacity not less than 1,500-2,000 t/day
- Construction of a compost plant in Nong Khaem for a capacity not less than 1,000 t/day
- Construction of an incineration plant in Nong Khaem for a capacity not less than 1000 t/day
- Privatization of solid waster transfer and disposal services for Tha Raeng with a capacity not less than 2,000 t/day
- Construction of a compost plant in Bang Khaen for a capacity not less than 1000 t/day
- Provision of 5 waste transfer stations for nearby districts

Program 4 : Improvement of Night Soil Management Efficiency

- Privatization for treatment and disposal services for sludge from wastewater treatment plants of BMA, night soil, oil and grease residues at Tha Raeng

- Privatization for operation of the night soil treatment plant at Nong Khaem
- Collection services for oil and grease residues from restaurant and waste oil from gas stations and garages
- Provision of vacuum boats for night soil collection services for the area along waterways
- Provision of night soil vacuum trucks
- Investigation for exemption of night soil collection service fee to support the central wastewater treatment system for Phase I

Program 5 : Supporting Services for Solid Waste, Night Soil and Hazardous Waste Management

- Study for tendency of administration and management of generation, collection, recycle and disposal of solid waste, night soil and hazardous waste
- Feasibility study for utilization of swamp areas for sanitary landfill sites
- Feasibility study for privatization for management of construction and demolish wastes
- Feasibility study on large amount solid waste transportation and disposal at deforest areas

(5) Prediction of Solid Waste Amount

1) Method of Prediction

Generally, prediction of solid waste amount is carried out based on the per capita generation rate for domestic waste and the ratio of solid waste from business activities etc. However, in respect of the aspect to improve urban environment form the city planning to point of view, future solid waste amount was predicted based on the generation rate to built-up area analyzed from the relation between the existing built-up area and the collected solid waste amount in each District. By this method, it will be made available for the city planner to predict future solid waste amount through prediction of future development area. The applied procedures for prediction is indicated in the following steps

Step 1	:	Calculation of unit area generation rate to built-up area for 1995
Step 2	:	Calculation of the increase rate of population density from the data 1990 - 1995
Step 3	:	Calculation of annual increase rate of per capita generation rate from the data 1990 - 1995
Step 4	:	Pre-assumption of per capita generation rate in 2011 from the results of Step 3 and 1995 data
Step 5	:	Adjust the higher per capita generation rate of the Districts to limit the average of whole BMA ,1,501 g/c/d
Step 6	:	Calculation of increase rate of per capita generation rate from the results of Step 5 and 1995 data
Step 7	:	Obtain the future built-up area from the city planning data
Step 8	:	Calculation of unit area generation rate to built-up in 2011 from the results of Step 1, 2 and 6
Step 9	:	Prediction of solid waste amount in each district from the results of Step 7 and 8
Step 10	:	Evaluate the unit generation rate and the predicted amount and adjust if necessary.

2) Solid Waste Amount in 2011

Result of prediction was summarized in Table 8.5. Total solid waste amount generated in BMA Area will reach at approximately 14,700 ton/day in 2011 of which about 97 % is generated from residential and business area and the remaining 3 % is collected from hospitals, clinics and fresh foods markets. Increment compared with 1995 will be 8,100 ton/day in 2011. Department Public Cleansing, BMA predict future solid waste amount in the range of 18,800 and 14,400 ton/day hence the Study predicted the lower side.

An annual rate of increase become 3.4 % and the increase rate compared with 1995 become 2.2 times in 16 years. Intensity or generation rate to built up area was estimated at 23.0 ton/km2/day which is higher than the rate of 1994 data in Tokyo by about 20 %.

Due to increase of solid waste amount, public services in solid waste management will be a burden to the administration officials unless the projects shall implement in accordance with the schedule.

Table 8.5 Prediction of Solid Waste Amount (2011)

District	Solid Waste Amount in 1995 (ton/day)	Solid Waste Generation Rate 1995 (ton/km2/day)	Solid Waste Amount in 2011 (ton/day)	Solid Waste Generation Rate 2011 (ton/km2/day)	Solid Waste Amount Increment (2011-1995) (ton/day)	Increase Rate (2011/1995)(%)
Bang Kaol	33E	11.2	81Z	18.E	476	24Z
Bang Khen	21C	8.4	63C	21.E	420	30C
Bang Kho Laem	13E	20.0	254	35.4	116	18E
Bang Khun Thian	17E	8.1	73Z	17.3	553	41C
Bang Phlad	127	13.4	207	19.1	80	16З
Bang Rak	147	37.5	171	43.E	25	11Z
Bang Sue	161	14.2	60E	48.З	444	37E
Bangkok Noi	17E	18.4	464	40.1	285	25E
Bangkok Yai	89	16.5	16E	27.E	80	19C
Bung Khum	197	7.0	76E	15.E	572	391
Chatuchak	274	9.4	40E	13.E	131	14E
Din Daeng	20E	24.7	43E	52.E	232	21З
Don Muang	254	6.6	694	12.7	439	27З
Dusit	20E	23.3	20E	23.7	3	10Z
Huai Khwang	12E	12.1	23E	14.З	110	18Z
Jomtong	16З	12.5	44C	20.E	277	27C
Khlong San	13C	24.1	15Z	27.E	21	11E
Khlong Toei	381	14.6	55З	20.7	173	14E
Lat Phrao	12E	7.3	361	13.4	234	28З
Latkrabang	11C	9.4	24C	18.1	131	21E
Minburi	12Z	9.1	407	19.З	285	33E
Nong Chok	28	4.5	14C	22.E	112	50E
Nong Khaem	12E	7.7	25E	15.З	131	204
Pathumwan	17Z	25.8	21E	32.Z	45	12E
Phasi Charoen	24E	10.6	667	19.1	422	27Z
Phaya Thai	15E	18.0	16E	19.C	10	10E
Phra Khanong	22C	7.5	48E	15.З	269	22З
Phra Nakhon	207	50.0	16C	38.E	-47	77
Pom Prap Sattru Phai	11C	46.4	121	50.E	11	11C
Prawet	111	4.2	51E	12.E	407	46E
Ratburana	18E	12.4	487	23.E	299	25E
Ratchathewi	16E	24.5	19E	28.E	30	11E
Samphanthawong	63	50.8	68	54.E	5	10E
Sathon	14Z	20.2	23E	33.E	96	16E
Suan Luang	12З	8.6	34Z	16.E	219	27E
Taling Chan	88	4.1	42E	14.4	337	48Z
Thonburi	187	25.0	48E	63.4	299	26C
Yan Nawa	14E	14.4	27Z	25.Z	124	18З
Subtotal	6,34E	11.7	14,20‹	22.З	7,858	224
Hospitals & Markets	19З	0.4	437	0.E	244	227
Total	6,53E	12.1	14,64'	23.C	8,102	224

Remarks : For reference, prediction by DPC, BMA for the year 2011 is presented as follows.

Upper Value: 18,760t/day Average Value : 16,60C Lower Value: 14,400t/day

8.4 Planning Targets and Framework

In this section, the target for implementing the plans and programs of individual key issue is proposed to solve the problem. Continuously, the framework and contents of the proposed action plans are presented in the manner of phased development planning. Cost of the projects will be estimated in the final section just for reference to know the scale of the project.

(1)Planning Targets

Daily activities of the human being generate a huge amount of wastes exceeding the permissible level left to the natural decomposition process especially in urban area. Difficulties in implementation of the solid waste projects such as impact on the neighboring area, procurement of land and budget, etc. likely cause of insufficient installation of the solid waste facilities in BMA Area. However, the heaps of garbage of the existing disposal sites can not wait any more delay of the solid waste projects now. Littering of garbage in living environment make the citizens feel uncomfortable, and its insanitary condition eventually caused degradation of quality of life.

The planning targets are set out as follows to achieve by the year 2011.

- Reduction of solid waste amount by 10 %
- Providing intermediate treatment facilities to process two-thirds or 60 - 70 % of solid waste prior to final disposal.
- Procurement of landfill site in BMA Area to serve for 20 -30 years

For contribution to achieve "Up-grading of Quality of Living", the action plans based on the planning targets are formulated in the following sections. Time does not wait now to declare "The Bangkok Garbage War".

(2) Proposed Action Plan to Achieve the Targets

Proposed programs of solid waste management in the 5th Five Year Development Plan has been reviewed on the stand point that the programs are properly selected to solve the current problem and prepared for the foreseeable future problem as well. In conclusion, the proposed programs are covered widely to take measures for the problems arising from solid waste management for BMA. Formulation of the action plans to be proposed in BEIP study will have duplication necessarily with those proposed in the 5th Five Year Plan. Accordingly, the proposed action plans are highlighted to the necessary minimum points effective to improve the situation toward up-grading of "Quality of Life" in consideration of the planning issues described earlier and divided into three phases plan.

Action Plan 1 : Reduction of Solid Waste Generation Rate and Recovery of Resources

Action Plan 1 is intended to materialize reduction of solid waste generation amount for treatment and disposal through participation of the communities, enterprises, District Offices and BMA to achieve reduction amount of 10 % by 2011.

Present Situation as of 1995

- Rate of municipal solid waster generation reached at 805 grams per capita per day in BMA
- Valuable wastes are recovered by collection staff and picked up by squatters at the disposal sites.
- Separation of garbage is practiced with dry and wet in several Districts

Action Plan during 1997 - 2001

- Investigation of solid waste component, generation amount, etc.
- Investigation of amount of recyclable in garbage such as paper, bottles, steel and aluminum cans, plastics, etc. and market research.
- Study on legislative measures to clarify responsibility and role of the government, local government bodies, enterprises, and consumers.
- Study on conversion waste, compost, heat, electricity, solid fuels, etc.
- Study on searching for organizing recycling activities in communities, schools, temples, election districts, NGO, etc. for domestic solid waste
- Study on possible collaboration activities with enterprises for reducing waste, reuse, resource recovery, and produce degradable consumable
- Formulation of resource recovery and recycling plan in total flow of solid waste management system and relevant facilities
- Public campaigns to control discharge of waste by changing the prevailing energy-consuming life style

Action Plan during 2002 - 2006

- Selection and training of recycling leaders in Districts and recycling groups
- Establishment of Recycling Campaign Center in BMA and in District Offices
- Promotion of recycling activities in pilot area
- Construction of recycling plant(s) and Establishment of Recycling Market
- Public campaign to participate in recycling activities

Action Plan during 2007 - 2011

- Establishment of recycling activities and continuous operation
- Enforcement of regulations or new Decree for recycling and recovery of solid wastes
- Review of the recycling activities during 2002-2006 and necessary improvement

Action Plan 2 : Construction of Intermediate Solid Waste Treatment Facilities

Action Plan 2 is formulated to develop intermediate facilities to meet with the target to realize ratio of solid waste treatment with 60 to 70 % by 2011. To achieve the target, the following facilities must be developed by the year 2011.

Flow of Solid Waste Treatment and Disposal in 2011

Solid Waste Generation Amount	:	14,700	t/day
Compost Plant (1 plant)	:	1,000	t/day
Incineration Plant (5 plants)	:	7,050	t/day
Recycling	:	1,500	t/day
Landfill (Raw Refuse)	:	5,150	t/day
Landfill (Ashes and Rejects)	:	1,550	t/day

Figure 8.3 shows overall solid waste management system proposed for treatment and disposal in 2011 based on the amount shown above.

Intermediate facilities shall be designed to improve efficiency of post-coming final disposal, recover usable materials and to recover conversion products and energy. Because of large energy consumption by the intermediate facilities itself, the design have to consider about efficiency of each component and the total system and it is strongly emphasized that the plants must be equipped with the devices to minimize the secondary pollution.

Action Plan 2 is composed of installation of the facilities listed as follows.

- 2,000 t/day incineration plant in the East Bank (No. 3 Bangkok Incineration Plant)
- 1,000 t/day incineration plant in the East Bank(No. 4 Bangkok Incineration Plant)
- 1,000 t/day recycling/verge transfer plant in the East Bank river side area (Bangkok Recycling Center)
- 500 t/day recycling/verge transfer plant in the West Bank river side area (Tonburi Recycling Center)

Present Situation as of 1995

- Only one 1,000 t/day plant is in operation at On Nut Landfill Site
- Second compost plant of 1,000 t/day is under construction at Nong Khaem Landfill Site
- Turnkey incineration plant of the capacity expected at 1,350 t/day is to be prepared for bidding soon.
- BOT incineration plant of the capacity expected to be larger than 1,000 t/day will be prepare for bidding soon.

Action Plan during 1997 - 2001

- Completion of on-going four projects, 3 incinerators and 1 compost plant, expected to have the total capacity of 5,050 t/day
- Review and formulation of solid waste Master Plan and Feasibility Study for the next 5 Year Plan
- Planning and design of 2,000 t/day incineration plant in the East Bank
- Planning and design of the recycling/transfer plant in the East and the West banks having the capacity of 1,000 t/day and 500 t/day respectively.
- Study for collection of selected waste to increase efficiency of compost plant

Action Plan during 2002 - 2006

- Review of the incineration plants and compost plants constructed in the previous 5 Year Plan and Formulation of the nest 5 Year Plan
- Construction of 2,000 t/day No. 3 Bangkok Incineration Plant
- Planning and design of 1,000 t/day No. 2 Tonburi Incineration Plant
- Construction of recycling/verge transfer plants of 1,000 t/day and 500 t/day in the East and the West banks
- Experimental carry in the selected compostable waste and test operation

Action Plan during 2007 - 2011

- Construction of No. 2 Tonburi Incineration Plant
- Actual operation of the compost plant with selected compostable waste
- Abandon 1,000 t/day On Nut Compost Plant
- Review of the Master Plan and implementation for the next projects

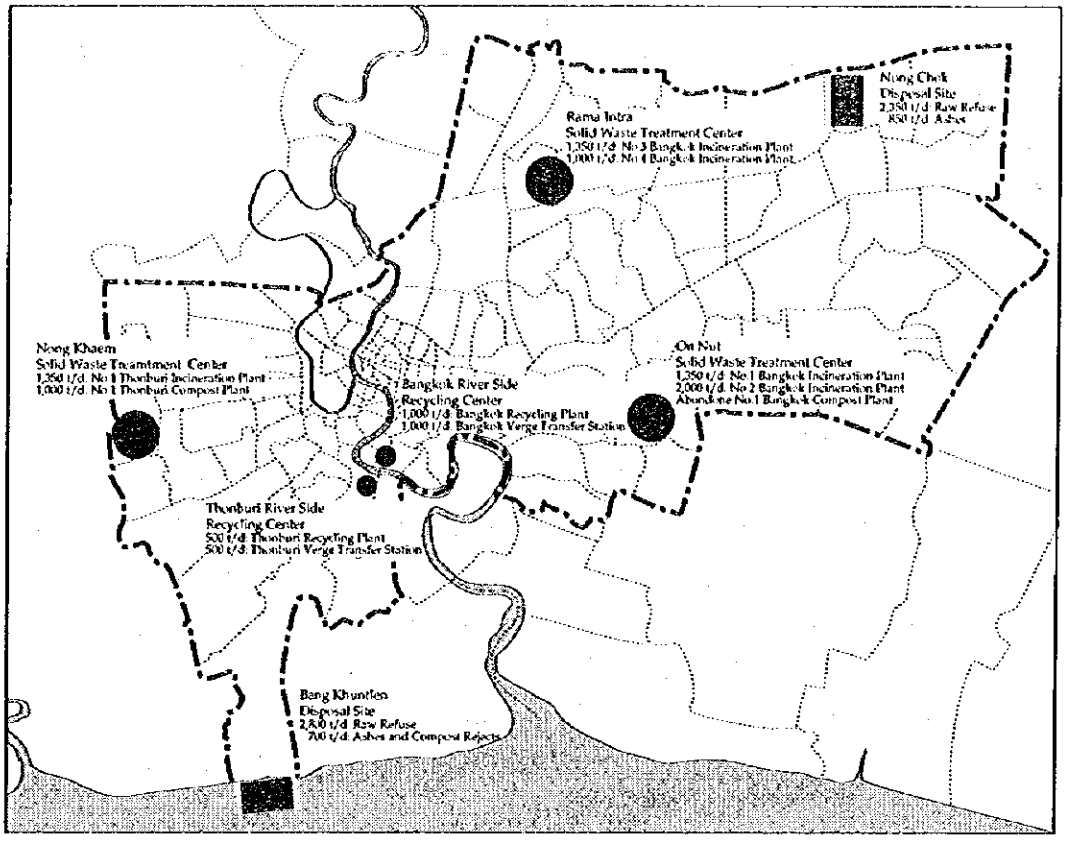

Figure 8.3 Proposed Solid Waste Treatment and Disposal System in 2001

Action Plan 3 : Procurement of Final Disposal Site

In view of no landfill site in BMA Area, Action Plan 3 is proposed to secure the landfill sites within the city boundary in Bangkok and Tonburi sides respectively for operation in the next 20 -30 years. Disposal of solid waste in flat terrain area is generally practiced by sanitary landfill in wet area such as swamp, marsh area, ponds, etc. Investigating the entire BMA Area, the candidate landfill sites are proposed at inland of Nong Chok District in Bangkok side and tidal area in Bang Khuntien District in Tonburi side.

Landfill in wet area or water area as well is associated with the water pollution problem caused by leachate from the filled material therefore suitable protective measures have to be studied prior to start implementation of the project.

For the proposed landfill site in Bang Khuntien, transportation of solid waste shall be made by both ways by land and by sea through the verge transfer station to be located in the river side area in Bangkok and Tonburi side respectively. The verge transfer station shall be designed to have the facilities for unloading and loading of compactor containers and resource recovery process to function also as the recycling center.

Procurement of landfill site in the eastern provinces supported by the railway transportation will be useful as consider the long term plan or as the final alternative sites replacing the landfill sites in Nong Chok and/or Bang Khuntien. In this case, solid waste disposal plan have to be formulated with regional level scheme to collaborate with the provincial governments, municipalities, The State Railways of Thailand, Department of Forestry, Department of Public Works, etc.

Considering the issues mentioned above, Action Plan 3 is proposed as follows. As for reference, conceptual design for landfill site in Bang Khuntien was shown in Figure 8.4.

Present Situation as of 1995

- Three existing disposal sites have no space anymore to receive wastes
- Solid waste transfer and disposal is privatized and operate the landfill sites in the neighboring provinces

Action Plan during 1997 - 2001

- Investigation of available vacant land for final disposal
- Site selection, planning and design of landfill facilities for Bangkok and for Tonburi
- Procurement of landfill sites for Bangkok and for Tonburi
- Start construction of landfill facilities for Bangkok and for Tonburi
- Study for regional solid waste disposal plan

Action Plan during 2002 - 2006

- Construction of landfill facilities for Bangkok and for Tonburi
- Start operation and maintenance of landfill sites for Bangkok and for Tonburi
- Site selection, planning and design of regional disposal plan
- Procurement of landfill site for regional solid waste disposal plan

Action Plan during 2007 - 2011

- Construction of regional disposal facilities
- Start operation and maintenance of the regional disposal facilities

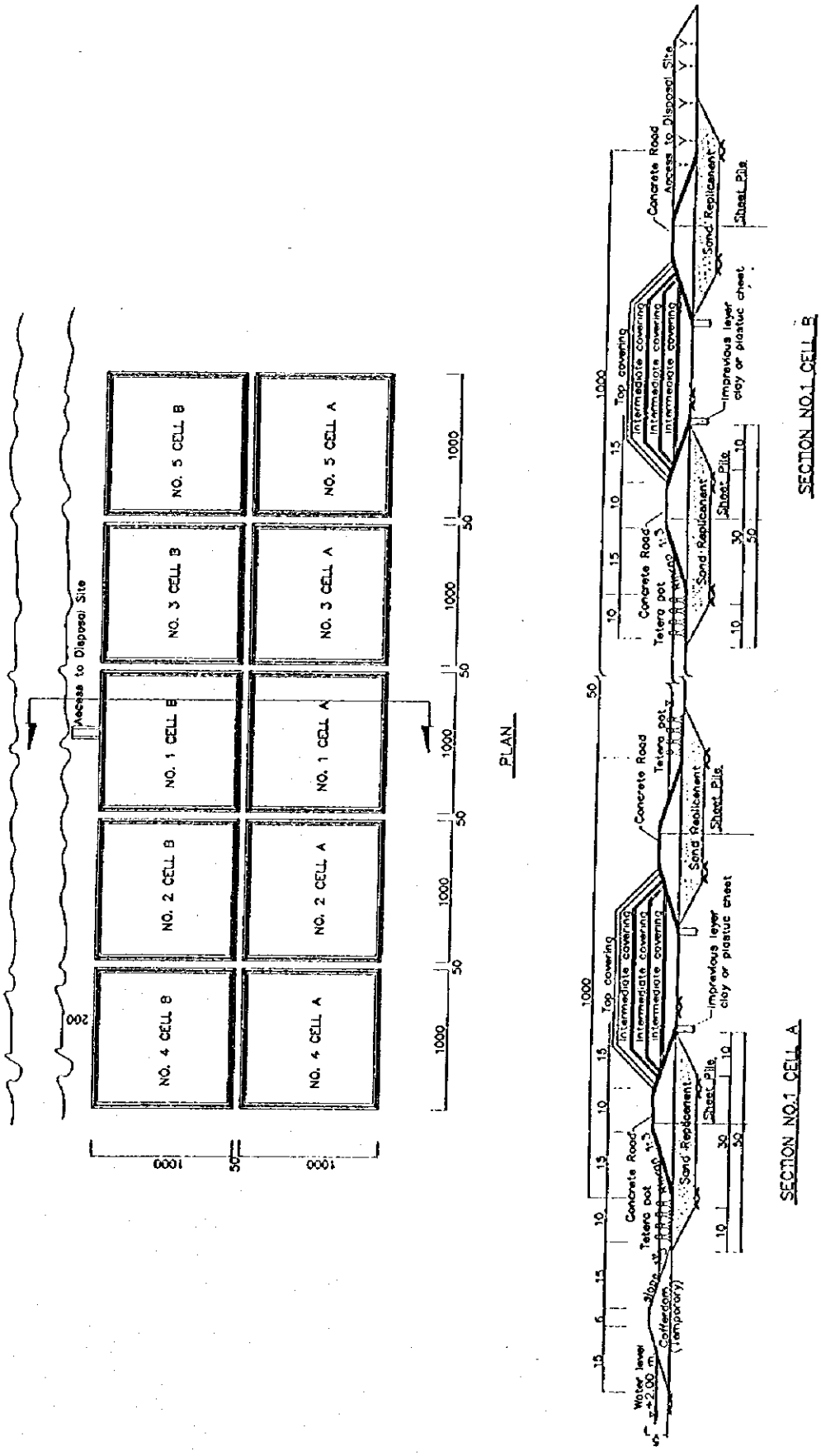

Figure 8.4 Conceptual Design of Bang Khun Thian Off-shore Disposal Site