Part II

The Solid Waste Management Master Plan

Chapter 5

Planning Framework for SWM Master Plan

5 Planning Frameworks for SWM Master Plan

5.1 Siting of Future SWM Facilities

5.1.1 Review of the Previous Report for Siting of Disposal Site

Two studies on the selection of the candidate site for the new disposal site after closure of the Stung Mean Chey disposal site were conducted. One is the "Report on searching for new landfill" (DPWT No. 634, 11 August 1995) and the other is "Dump Site Construction" in Phnom Penh (April 1997). According to the minutes of meeting on the Inception Report of this study signed on the 10th of March, 2003, the Study Team reviewed the above-mentioned studies to verify the appropriateness of the site where the MPP had already acquired 11 ha of land as a part of the proposed area based on the results of these studies.

a. Review of "Report on searching for new landfill" (DPWT No.634, 11 August 1995)

The following four candidate sites for the new disposal site were nominated for the study.

Candidate 1: Prey Sala Village, Sangkat Kakoy, Khan Dang Kor
Candidate 2: Sam Rong Village, Khan Dang Kor
Candidate 3: Pray Speu Village, Khan Dang Kor
Candidate 4: Choeung Ek Village, Sangkat Choeung Ek, Khan Dang Kor

The characteristics are summarized in Table 5-1 and their locations are shown in Figure 5-2.

At the time of this study, it was presumed that an area of about 10 ha was to be considered as a candidate site. There are more than two landowners for three of the four sites and the fourth has only one landowner. This report only introduces the possible sites and does not conclude which is the most appropriate site.

Table 5-1: Comparison of Candidates for a New Final Disposal Site

Candidate site	Descriptions
Candidate 1	• The land area is 6.5-10 hectares. • It is farmland (i.e. rice fields) and people are growing crops. • The land is sandy and far away (about 3,000 m) from any national road. • We have not met the landowner for price discussion. • We will spend money for access road construction.
Candidate 2	• The land area is about 10 hectares. • The villagers are already planting rice. • It is low-lying land and there is flooding in the rainy season. The road is not passable by vehicles. • We have not met the landowner for price discussion.
Candidate 3	• About 1,000 m to the village • It is farmland. Sixty per cent of the land is used by the villagers to grow rice. • There are several vacant spaces, of which the soil is sold. • It is sandy soil. • It is 17 km from Stung Mean Chey by National Road No.3.
Candidate 4	• The land is not good for growing rice. • There is a concrete road from Stung Mean Chey to the intersection. It is about 1,000 m from the intersection. • The site covers about 7 hectares near the Prey Sor temple.

	• Far away from people's homes, does not impact the environment. Construction of a dike around the dumpsite is possible for waste disposal. • Mr. Vear Snar, the landowner, works in the port. The land is officially issue ownership by MPP. • Not so far from Stung Mean Chey. Will not disturb important roads, spend an appropriate amount of time for waste disposal. • The cost of land will be discussed next time.

b. Final Report of the Workgroup "Dump Site Construction" in Phnom Penh (April 1997) (Referred to as 1997 report)

The report was mainly prepared by a German consultant.

The report indicates the area for the future disposal site should be 100 ha considering the waste generation amount estimated. To select the candidate site, the following were considered.

- Examination of the geological conditions of Greater Phnom Penh (height level of the site, permeability of the ground.
- Evaluation of the groundwater and surface water situation with special regard to seasonal fluctuations in precipitation (flood areas, maximum water level in the rainy season)
- Estimation of the climatic situation (wind direction, amount of precipitation)
- Considering the settlement structure and other necessary exclusion criteria.

As a result of the evaluations, three out of the four sites as shown below were examined. However, the reason for excluding the fourth site is not explained in the report.

- The area northwest of Pochentong Airport (Candidate 2)
- The area south of Pochentong Airport between RT303 and RN3 (Candidate 3)
- The area in the southern extension of RT303 before the area boundary of Dang Kor, which was determined for further planning (Candidate 4)

As a result, this report concluded that Candidate Site 4, which was located furthest downstream and seemed to have the least environmental impact among the four candidates, was the most suitable. Site No.4 is the current candidate site of PPWM.

5.1.2 11 ha of Land Acquired by the MPP

Based on the conclusion of the above report, MPP purchased 11 ha of land at Site No. 4 in 2001.

5.1.3 Study by the JICA Study Team

a. 25ha of Land (Original plan)

The Study Team visited and observed the candidate sites with the vice governor of PPWM, Mr. Leng Simen who was one of the writers of the 1997 report, as a guide.

The team compared the four candidates for the new final disposal site by reviewing the DPWT document and the 1997 report, studying the current land use, accessibility, soil condition through visual observation and interview, surrounding environment and area size.

According to the comparison table shown in Table 5-2 prepared based on the site reconnaissance, the Study Team concluded that Site No.4 in Dang Kor was the most appropriate site for the future disposal site.

The study team compared the four candidate sites that had been nominated in the previous study from the viewpoint of accessibility, soil condition by visual observation, development in the surroundings, and possibility of future expansion. However, the study team did not compare the development cost required for each candidate, because it would be different according to the operation period which was decided by the possible area.

According to the results of the comparison study, the study team concluded the site in Khan Dang Kor was the most suitable and the land that had been acquired by MPP located in this site was appropriate.

The proposed site is located at the southern edge of the municipal area under jurisdiction of Phnom Penh, which is in the downstream area in the plain spread out across the diluvial upland. This area is used as a paddy field and there are no houses in the planned area. This area used to be flooded by the Prek Thnaot river, but it has not been since 2002 when the bank was constructed.

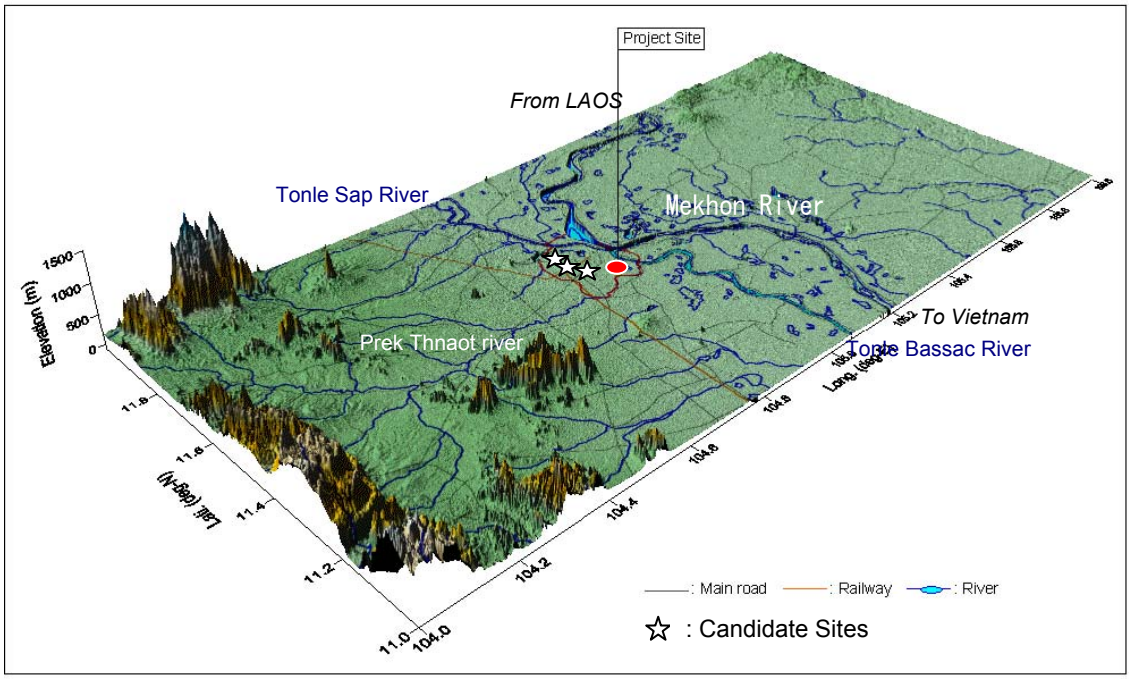


Figure 5-1: Candidate Sites in the Geographical Feature

At first, the study team proposed an area of about 100 ha, which was enough for more than 20 years of landfill operation, in the Dang Kor district by using aerial photos. Then, within the 100ha mentioned above, the study team proposed a 25ha area including the 11ha of land MPP had already acquired, which could be used for about 5 years.

MPP approved this proposal in the steering committee meeting held on the 3rd of July, 2003 and applied to the central government for this land acquisition. The ministry of council ministers approved the application submitted by MPP on the 29th of October, 2003 and notified the Governor of Phnom Penh and the Minister of Economy and Finance of this decision.

MPP organized the land evaluation committee in the municipality for the new disposal site development after this notification, and started to acquire the land.

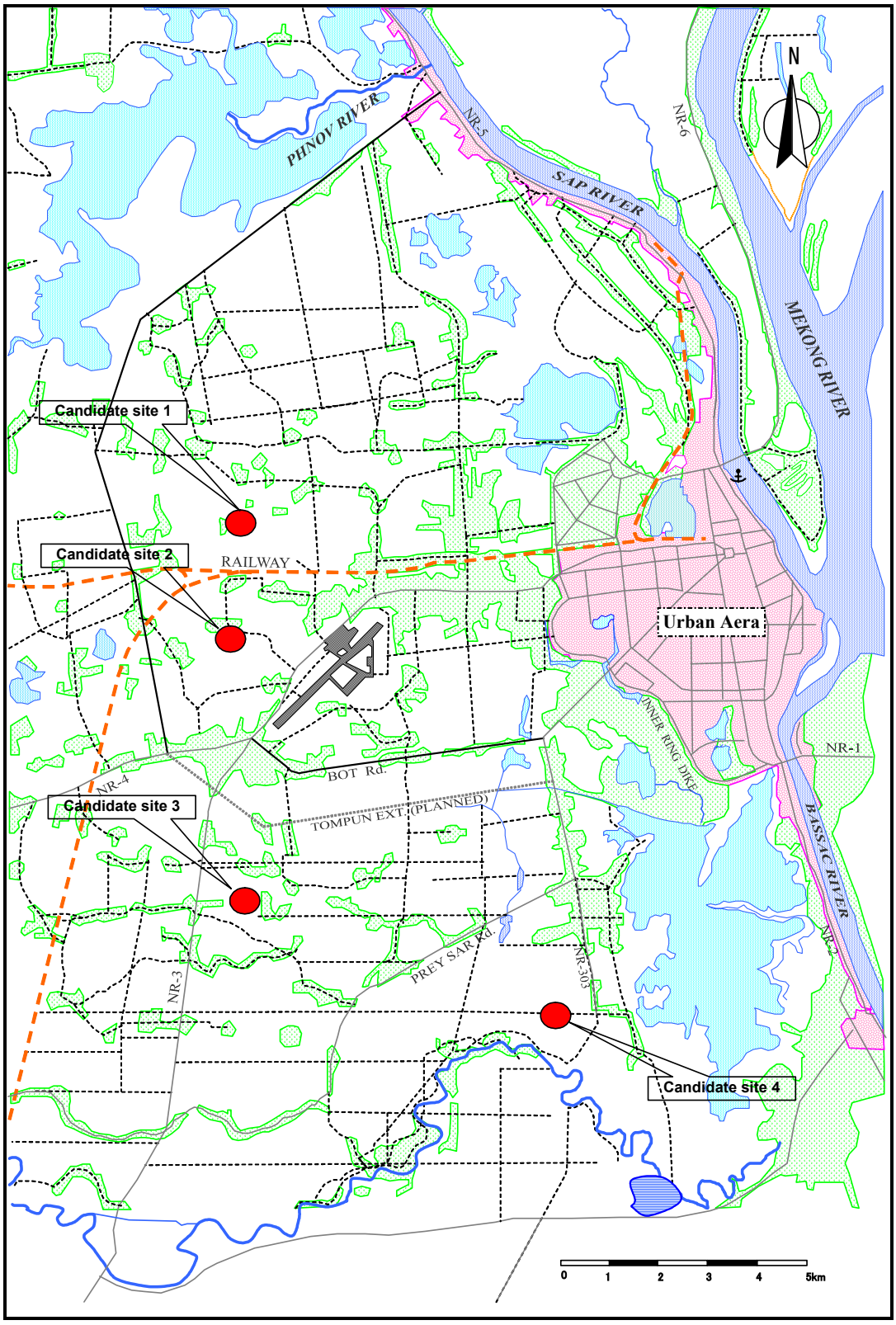


Figure 5-2: Location of Four Candidates for a New Final Disposal Site

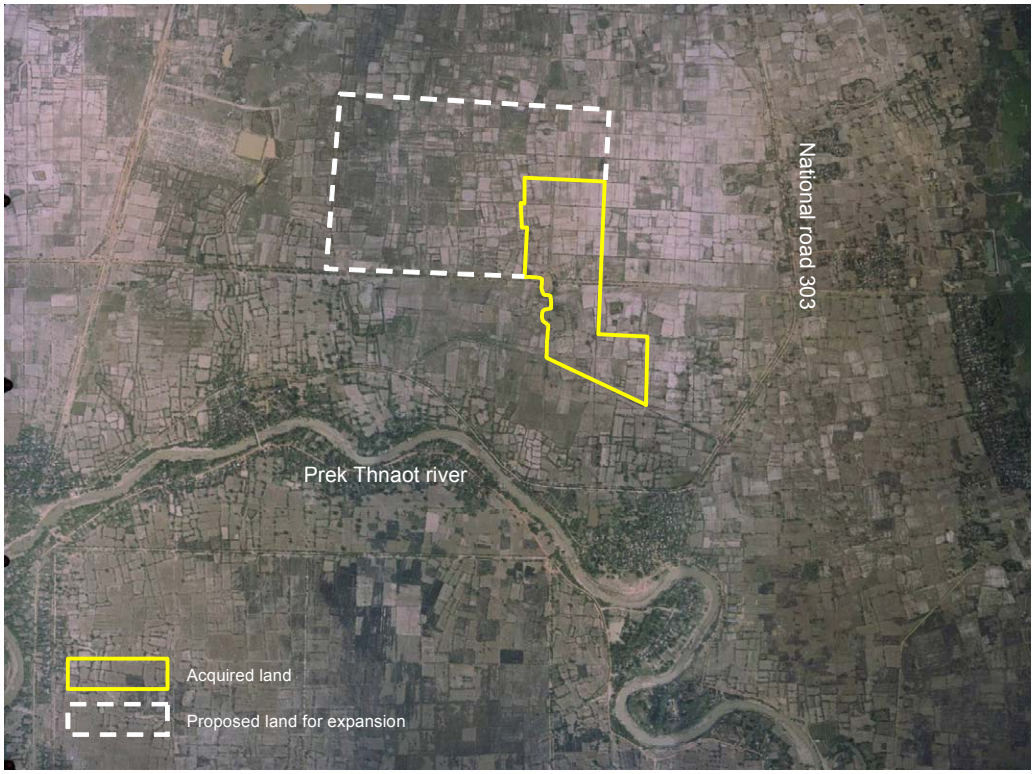


Figure 5-3: Aerial Photo of the Candidate Site and Surrounding Area

b. 31.4ha of Land (Amended plan)

Although the land evaluation committee tried to acquire the land according to the development plan prepared by the study team, the price of land along national route 303 rose suddenly. It became difficult to acquire the proposed area within the budget. Therefore, the land evaluation committee decided to change the area and acquired about 20ha of land adjacent to the 11 ha, located about 800 m on the western side from national route 303. According to this change, MPP had to acquire additional land, which area was estimated as 5,500 m^2 for the access road from national route 303.

Figure 5-4: Change of the Land for the New Disposal Site

Table 5-2: Comparison of the Candidate Sites by JICA Study Team

Items	Candidate 1	Candidate 2	Candidate 3	Candidate 4
Location (Address)	Prey Sala village,Sangkat Kakoy	Choeung Ek village, Sangkan Choeung Ek	Chunlun Malou village	A land near the road to Prey Sor temple
Present land use	• Rice field	• Rice field	• Mainly rice field, but also ponds, trees, and probably a road to a temple near the site	• Rice field
Access road	• 1.3 km to the north along the road that connects with a national highway running near the airport, and 1.1 km to the west. • There are many houses along the roads.	• 1.8 km to the north along the road that connects with a national highway running near the airport, and 1.3 km to the west along a railway. • The road along a railway is not wide enough and its road surface condition is poor, requiring substantial rehabilitation work.	• 4 km to the south along the national highway Route 3 from the point where Route 4 starts, and 1.2 km to the east. • The access road from Route 3 should be newly constructed.	• The access road is not wide enough and its road surface condition is poor at present. • It is to be upgraded by 2007.
Soil condition (interview with PPWM and visual observation)	• As the ground is principally sand, permeability is estimated as high and the bearing power small.	• The ground is sandy and the groundwater table seems to be high as a water spring was found at a height of 2-3 m in a sandpit.	• Permeability seems to be low as there is a pond in the site.	• Permeability seems to be low as there is a pond and an irrigation canal in the site.
Surrounding environment	• Only 2 km from the airport. • The site is rice field but houses and factories are situated nearby.	• Vehicles must go across the railway. • The site is rice field but an industrial park is under construction nearby. There are also houses in the surrounding area.	• There is a temple nearby leeward from the site and another at a small distance. • There is a house on the pond. The areas near the temples have not been studied yet.	• The site is rice field. There is a residential area on the southern side including military facilities. There is a pagoda worth visiting on the north-east side. • Rice fields spread in the other directions.
Possibility to secure 100ha	• Low due to the location of houses and factories.	• Low due to the location of the industrial park and houses.	• High.	• High
Others	• There are no rivers to which treated leachate can be discharged.	• There are no rivers to which treated leachate can be discharged.	• Careful attention should be paid to the temples. • There are no rivers to which treated leachate can be discharged.	• Careful attention should be paid to the temple. • There is a river to which treated leachate can be discharged.
Evaluation	No good	No good	Good	Very good

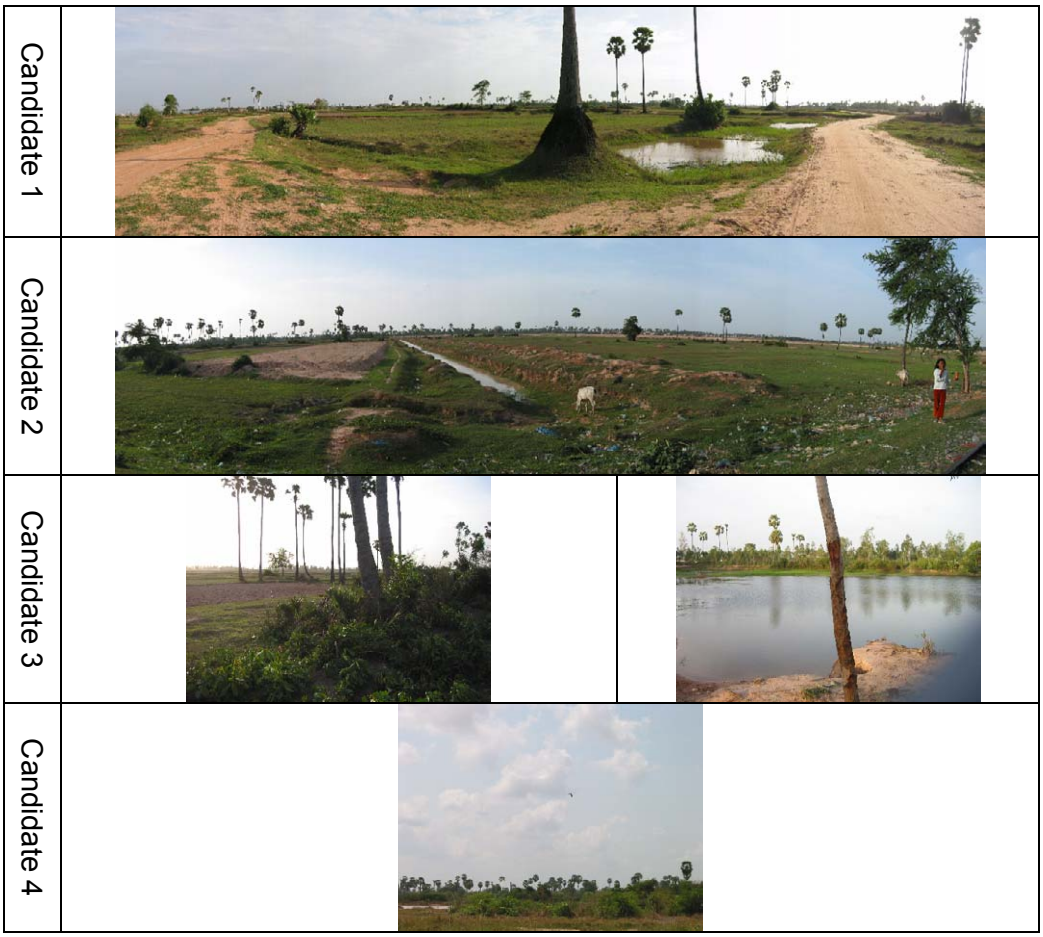


Figure 5-5: View of Four Candidates

5.1.4 Final Disposal Site and Future Expansion

Finally, MPP acquired 314,446 m^2 of land altogether with 11 ha where had been acquired already by July 12, 2004. In addition to the land for disposal site, MPP also acquired 5,500 m^2 of land for access road 800m from National route 303.

The Study team amended the development plan based on the shape of land acquired. Therefore, the Study team also proposed that MPP should expand the site necessary for future operation as shown in the Figure 5-3.

5.1.5 Site Selection for Other Facilities

As described later, the M/P recommends that PPWM provide waste collection services in the rural area. In order to strengthen PPWM's capability for waste collection, the provision of collection equipment is essential, and such equipment requires depots and maintenance workshops.

Therefore, the Study Team held discussions with the C/P, and MPP decided to add 1 ha to the new final disposal site of 25 ha, to be utilized for the depots and maintenance workshops.

5.2 Socio-Economic Framework

5.2.1 Population[1]

a. Population of the Study Area

In addition to the Population Census in 1998, available population data for the past years were collected from the Department of Planning, the Municipality of Phnom Penh. As there is no future population estimate for the Study Area, a regression model, based on past trends, was applied for the population projection of the Municipality of Phnom Penh (Figure 5-6). The population projection incorporates the population of a part of Kandal Province, which is included in the Study Area. The results are summarized in Table 5-3. The projection results show that population growth rates in the Study Area are higher than the national rates. The national growth rate of the whole country is considered to give the natural increase in the Study Area, while the difference between the growth rate of the whole country and that of the Study Area provides the social increase due to migration, etc.

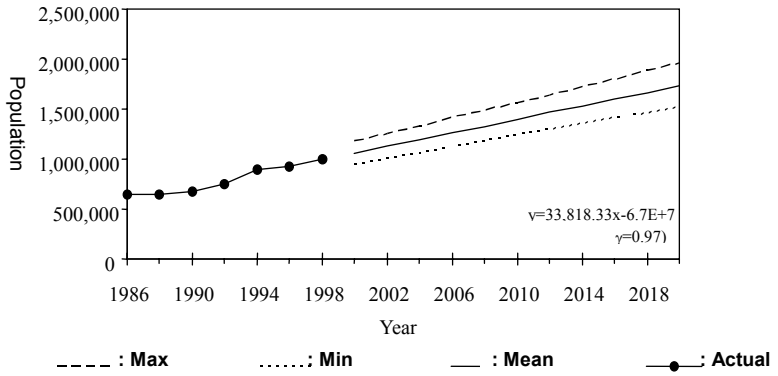


Figure 5-6: Population Forecast of Municipality of Phnom Penh

Table 5-3: Population of the Study Area

	2003	2008	2012	2015
Population of Phnom Penh (in Thousand)	1,199	1,416	1,581	1,702
Population Growth Rate (%)	-	3.24	2.32	2.57
Population Growth (year 2003 as 1.00)	1.00	1.18	1.32	1.42

Table 5-4: Estimated Population for Urbanized Area and Suburban Area

	2003	2008	2012	2015
Study Area Population (in 1,000)	1,199	1,416	1,581	1,702
Urban Area Population (in 1,000)	628	692	731	750
Rural Area Population (in 1,000)	571	724	850	952
Population Growth Rate (%)				
Study Area	-	3.26	2.47	2.47
Urban Area	-	1.87	0.87	0.87
Rural Area	-	4.47	3.68	3.68
Population Growth (year of 2003 as 1.00)				
Study Area	1.00	1.18	1.32	1.42
Urban Area	1.00	1.10	1.16	1.19
Rural Area	1.00	1.27	1.49	1.67
Population Increase from year 2003 (in 1,000)				
Study Area	-	217	382	503
Urban Area	-	64	103	122
Rural Area	-	153	279	381

[1] Data are quoted from the report of "the Study on Transport Master Plan in the Phnom Penh": Nov. 2001 JICA

b. Allocation of Population

The total increase of population in the Study Area from year 2000 to year 2015 is estimated at 343,000 based on the present trend. Out of 343,000, the population growth in the urban area is estimated to be limited to 159,000 (46.3% of 343,000) by adoption of the population control policy for the urban area. Accordingly, the remaining 184,000 of population growth is assumed to be displaced to the rural area supplementing the population increase based on the present trend. (See Figure 5-7). The estimated population for the urbanized area and the rural area were allocated in due consideration of the following:

Urban Area

- Existing floor area of residential building and their occupancy rate;
- Additional floor area, which can be built within the limit of building regulation.

Rural Area

- Natural increase of population of each area
- Characteristics of zone, such as rural and urban, with or without development projects, area by land use and vicinity to transport facilities, etc.

The population in the rural area will sharply increase with high population growth rates ranging from 5.06% (in year 2005) to 3.68% (in year 2015). In order to cope with high population growth in the rural area, sound urbanization must be achieved with the proper support of the transport system.

Figure 5-7 shows the population of each area for the years 2000 and 2015.

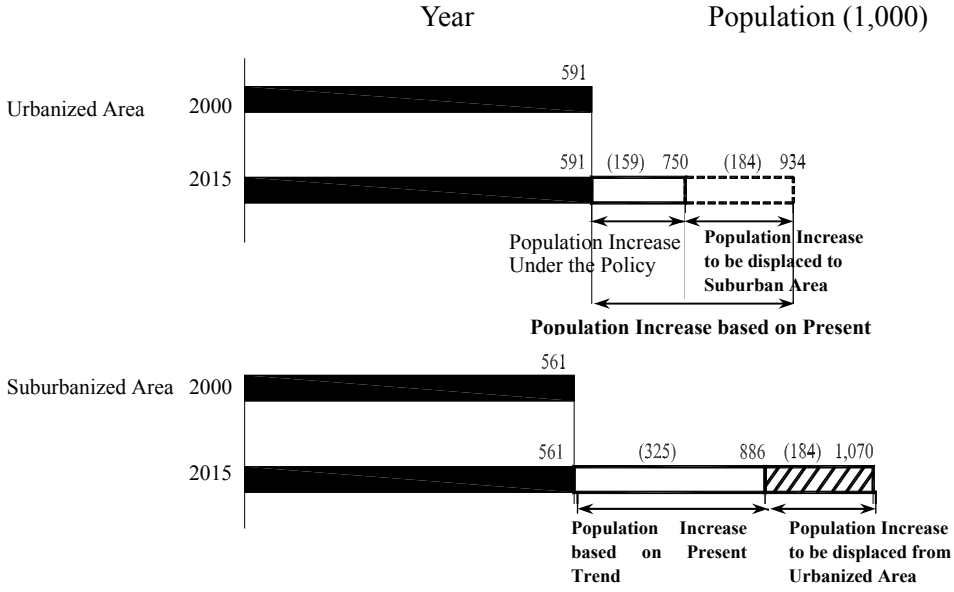


Figure 5-7: Population Increase in Urbanized Area and Suburban Area

5.2.2 Economic Framework

Since there is no available data on the regional economic growth of Phnom Penh, the Study set up the economic framework of the Study Areas based on the national economic framework of Cambodia.

In setting up the national economic framework, the Study followed the target economic growth and inflation rates given in the latest National Economic Plan of Cambodia up until

2005 while the growth rates between 2005 and 2015 are based on the scenario developed by the Cambodia Development Research Institute (CDRI) in the ADB Study on Enhancing Governance for Sustainable Development in October 2000. There were two kinds of expectancy in the ADB report; one was predicted with a Non-Reform Scenario and the other was with a Reform Scenario. The study team adopted the predicted value with the reform scenario to take priority avoiding any harmful effects, such as a change for the worse of environmental sanitation due to a delay in development of the new disposal site and/or collection system, caused by a low estimate. The Cambodian government was promoting administrative reform basically in line with the Reform scenario. Thus, the economic framework of the study area is established as shown in the table below.

Table 5-5: Economic Framework of the Study Area

	2003	2004	2005	2005-2010	2010-2015
Economic Growth Rate (%/year)	6.0	6.5	7.0	8.4	6.8
Inflation Rate (%/year)	3.7	3.7	3.7	3.4	3.5

5.3 Forecast of Future Waste Amount and Composition

5.3.1 Population Forecast

The future population estimated in the transport study[2] is adopted in this study, as confirmed in the IT/R meeting. The population of 1.7 million in 2015 projected is almost 200 thousand less than that of NSO's. This difference is rather big so the Study Team will estimate the waste disposal amount and operation period of the new disposal to confirm the worst scenario. However, there are several projections but each one is forecasted based on the census data in 1998. The Study Team recommends reforecasting the population when the second census giving a more reliable trend was done.

Table 5-6: Population Forecast

Khan	2003	2007	2012	2015
1. Chamkar Mon	208,750	227,664	246,777	253,935
2. Daun Penh	137,186	141,744	146,320	148,028
3. Prampir Makakra	104,013	110,815	117,681	120,253
4. Toul Kork	178,373	199,115	220,109	227,941
Urban area	**628,322**	**679,338**	**730,887**	**750,157**
5. Dang Kor	114,333	126,904	161,871	208,136
6. Mean Chey	210,027	258,336	307,295	325,489
7. Russei Keo	246,732	307,403	381,379	418,384
Rural area	**571,092**	**692,643**	**850,545**	**952,009**
Whole Phnom Penh	**1,199,414**	**1,371,981**	**1,581,432**	**1,702,166**

5.3.2 Economic Forecast

The economic growth rate and inflation rate during the target year are shown below.

Table 5-7: Economic Indicator of the Target Area

	2003	2004	2005	2005-2010	2010-2015
Economic Growth Rate (%/year)	6.0	6.5	7.0	8.4	6.8
Inflation Rate (%/year)	3.7	3.7	3.7	3.4	3.5

[2] The study on the transport master plan of the Phnom Penh metropolitan area in the Kingdom of Cambodia: by JICA November, 2001

5.3.3 Waste Discharge Amount Forecast

The future waste generation amount was forecasted to increase in proportion to the increase in number of generation sources such as population, number of stalls in case of markets, etc.

a. Waste discharge ratio

The future waste generation ratio was deemed to increase in proportion with economic growth. The waste generation ratio of households may increase in proportion to the growth of GDP per capita. Japanese statistics, recorded from 1963 to 1988, which were the only available data of its kind in the world, show the trend of the rate due to development of the economy as follows:

- Period of high economic growth (1963-1970):
- Period of developed economy (1975-1988):

In the case of this study, considering the efforts to be made on the 3Rs, the Study Team adopted 50% of the growth rates from 1963 to 1970, which was a period of high economic growth without any measures for waste reduction, etc. Based on the above figure, the team concluded the increase in waste discharge per capita per year was as follows:

2003-2005 : 1.7-2.0 %/year
2006-2010 : 2.3 %/year
2011-2015 : 1.9 %/year

However, the increase in the waste discharge ratio per year as shown above will not apply to public cleansing services such as street sweeping and cleaning parks but their amount will be implicitly increased in accordance with the growth of population, expansion of the city, etc.

Table 5-8: Forecast Waste generation ratio

Generation source		Unit	2003	2007	2012	2015
Household		g/person/day	487	529	588	622
Commercial	Restaurant	g/table/day	1,664	1,807	2,020	2,127
	Other shop	g/shop/day	4,502	4,889	5,438	5,754
Market		g/stall/day	1,823	1,980	2,202	2,330
School		g/student/day	20	22	24	26
Street sweeping		g/km/day	53,373	53,373	53,373	53,373
Hotel		g/room/day	231	251	279	295
Office		g/office/day	3,560	3,866	4,300	4,550

b. Number of waste generation sources

The number of generation sources are forecasted based on the assumption that it will increase in proportion to the growth rate of GDP.

Table 5-9: Number of waste generation sources

Generation souce		Unit	2003	2007	2012	2015
Household	Urban area	Person	623,322	679,338	730,887	750,157
	Rural area		571,092	692,643	850,545	952,009
	Whole area		1,199,414	1,371,981	1,581,432	1,702,166
Commercial	Restaurant	Table	27,808	32,285	39,070	43,186
	Other shop	Shop	33,524	38,921	47,101	52,063
Market		Stall	51.766	60,100	72,731	80,393
School		Student	385,013	447,000	540,943	597,925
Hotel		Room	13,385	15,540	18,806	20,787
Office		Office	368	427	517	572

c. Future Waste Generation Amount

Therefore, the waste generation amount forecast was calculated by multiplying the generation rate at that point by the future number of generation sources.

Table 5-10: Waste Generation Amount Forecast

Area	Unit	2003	2007	2012	2015
Whole Phnom Penh	Ton/day	927.8	1,158.7	1,511.9	1,739.3
Urban area	Ton/day	556.1	659.4	808.4	894.2
Rural area	Ton/day	371.7	499.3	703.5	845.1

5.3.4 Waste Composition Forecast

The waste composition forecast is mainly based on the following assumptions:

- Significant changes in dietary habit and living environment are not anticipated. Therefore, the discharged amount of kitchen waste, garden waste (grass, ceramic, stone and others) is assumed to remain the same.
- The discharge amount of wastes used for wrapping, e.g., paper, plastics, bottles and glass, is assumed to increase in accordance with economic growth.

Table 5-11: Waste Composition Forecast

Classification			2003	2007	2012	2015
Combustible waste	Paper	(%)	6.4	8.7	9.9	10.9
	Rubber and Leather	(%)	0.1	0.1	0.1	0.1
	Kitchen waste	(%)	63.3	55.6	51.4	47.9
	Textile	(%)	2.5	3.4	3.8	4.2
	Plastic	(%)	15.5	20.7	23.7	25.9
	Grass & wood	(%)	6.8	6.0	5.5	5.2
	Sub-合計	(%)	94.6	94.5	94.4	94.2
Incombustible waste	Metal	(%)	0.6	0.9	1.0	1.1
	Bottle & Glass	(%)	1.2	1.6	1.8	2.0
	Ceramic & Stone	(%)	1.5	1.2	1.1	1.1
	Others	(%)	2.1	1.9	1.7	1.6
	Sub-合計	(%)	5.4	5.5	5.6	5.8
合計		(%)	100.0	100.0	100.0	100.0

5.3.5 Waste Flow

In developed nations, the MSW collection rate is generally close to 100%, and the collection amount is equivalent to the generation amount.

However, collection services in developing nations are mostly insufficient. The waste amount generated, discharged, collected, and disposed of often differ significantly due to self-disposal methods (e.g. burning in the open) and recycling (e.g. feeding food waste to domestic animals) at the generation source, and the recycling by collection workers, waste pickers, etc.

There is a big difference between the estimated generation amount and the actual disposal amount.

a. Methodology

The waste flow was analyzed in the following surveys by determining the waste amount at every relevant phase:

- Unit generation/Discharge rate survey to measure generation or discharge amount from generation sources like households, restaurants, shops, etc.
- Interview at generation sources, e.g. every household, shop, hospital, etc.
- Survey on actual recycling conditions based on interviews with recycling enterprises/individuals.
- Survey on actual illegal dumping conditions
- Survey on final disposal amount based on weighbridge records, etc.
- Survey on transfer/intermediate treatment amount based on weighbridge records, etc.

b. Waste Flow

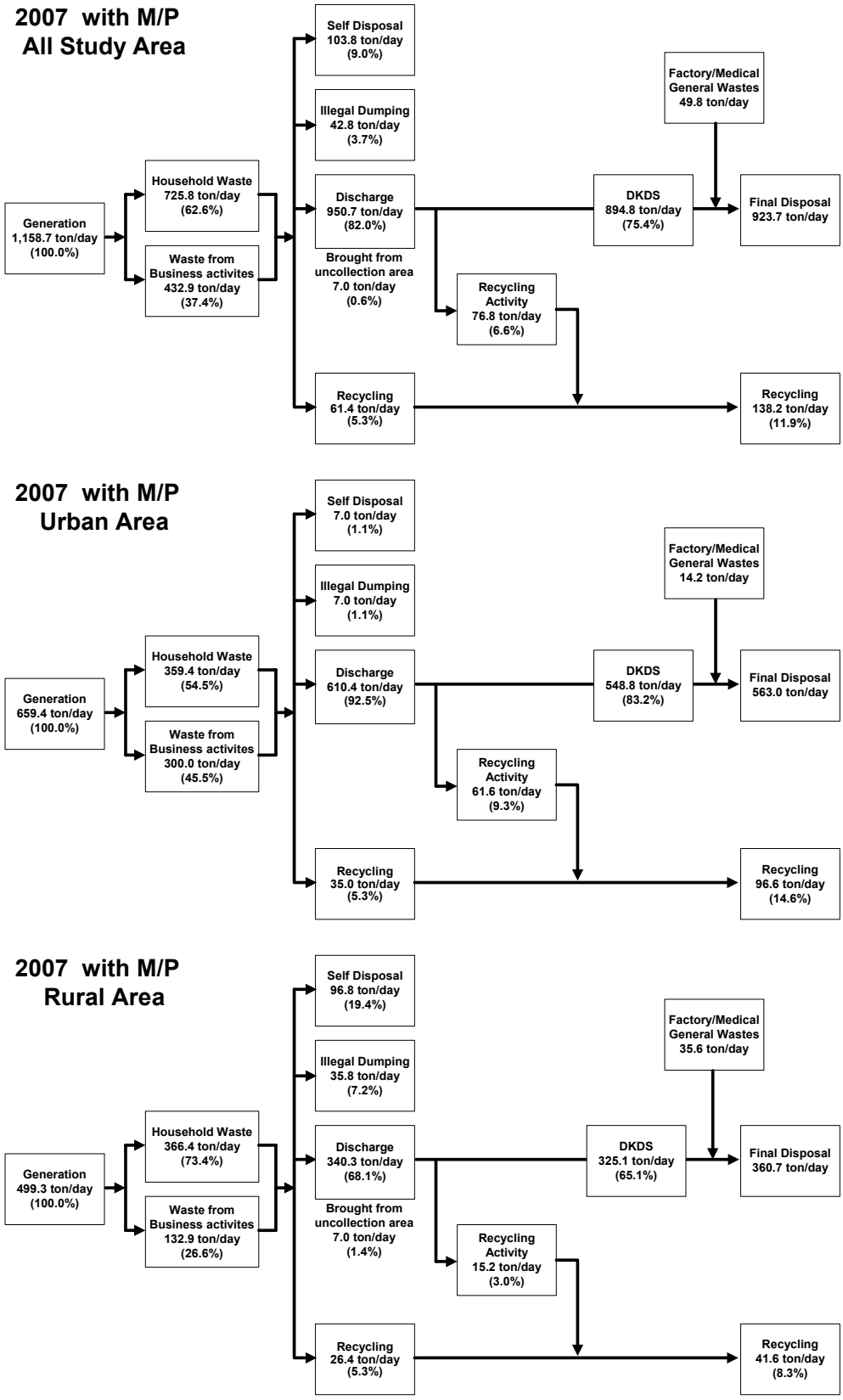


Figure 5-8: Waste Flow in 2007

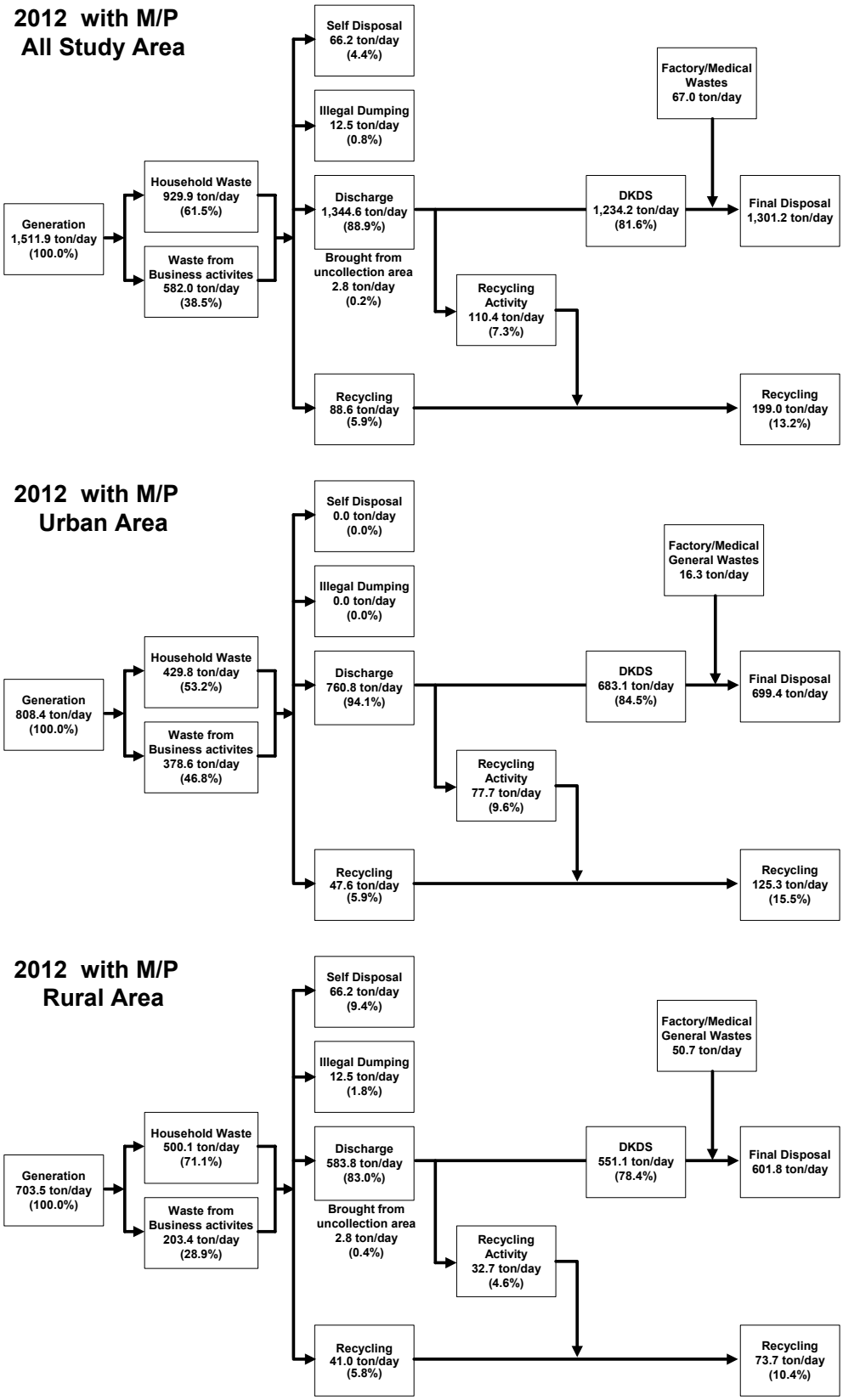


Figure 5-9: Waste Flow in 2012

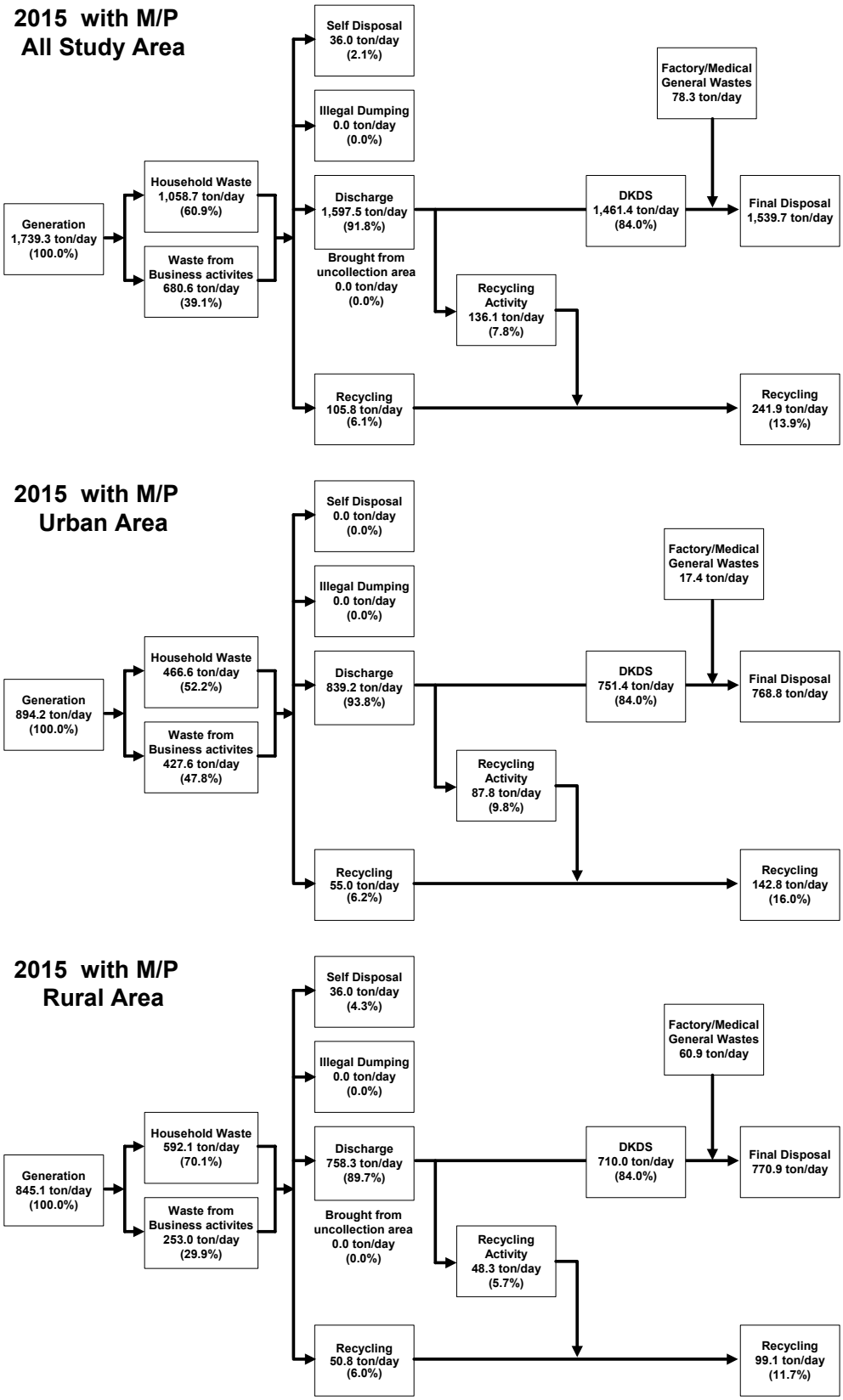


Figure 5-10: Waste Flow in 2015

5.4 Other Pre-conditions

5.4.1 Economic Conditions

a. Financial Conditions

The future municipal revenue is revised as shown in Chapter 7, in accordance with the 2002 and 2003 financial data obtained.

5.4.2 Conditions for Cost Estimation

a. Design Conditions

a.1 The Period and Projects in the SWM Master Plan to be examined

The period and projects in the SWM Master Plan to be examined here are all projects which are planned to be implemented or operated from the year 2003 until 2015.

Key Design Data

- Apparent Specific Gravity (ASG) of waste without compaction: 300 kg/m^3
- ASG of waste with compaction: 500 kg/m^3
- ASG of waste when it is compacted at a disposal site: 800 kg/m^3
- Average waste transportation distance: 5.0 km
- Operation efficiency of waste collection vehicles: 0.8
- Operation time of waste collection vehicles: 7.5 hours/day
  6 days/week

a.2 Depreciation Period and Residual value

Table 5-12 Depreciation Period of Facilities and Equipment

Items	Depreciation period (year)	Residual value (%)
Vehicle & Heavy equipment	7	10
Container	7	10
Machinery:	15	0
Buildings and Civil works:	20	0

Chapter 6

Selection of an Optimal System

6 Selection of an Optimum System

6.1 Selection of Optimum Technical Systems

The selection of a technical system should be based on the following criteria:

- Equipment selected should be appropriate to local operating conditions.
- Equipment should be designed to provide reliable service under expected condition for the service life of the equipment.
- The collect system should be able to expand to meet future SWM needs.
- The collection system must provide a collection service that meets established standards for service delivery, hygiene and convenience for customers.
- The collection system selected must provide service at a reasonable cost.
- Where possible, the collection system should maximize use of local equipment, materials and expertise.

6.1.1 Selection of an Optimum Technical System

a. Collection and Haulage

Primary/Secondary collection was seen as the only option for service provision in the difficult to access areas.

A container waste handling system was selected for use in about 50% of the new coverage area because of the flexibility of the system, ease of maintenance and because it is well adapted to primary/secondary collection, communal collection and also market and commercial collection needs. Containers and the pushcarts needed for primary collection can be easily made locally in Cambodia.

The size of the skip loader truck was determined considering the accessibility to the unserviced area and the size of the skip containers was selected to fit the skip loader truck. The containers are to be covered because the covers limit waste scattering and make the unit more attractive and sanitary.

For curbside collection two styles of compactor trucks were recommended. 14 ton rear loading compactors should be used in areas with large roads and easy access. 10 ton rear loading vehicles were recommended for areas where access problems or smaller waste volumes made the large vehicles inappropriate.

b. Public Area Cleansing

It is recommended that PPWM be assisted to develop the required capacity to do this work as a public service. PPWM should set up a section dedicated to providing this service with the required staff and equipment appropriate to the amount of surface to be cleaned. To ensure a degree of service flexibility and easy maintenance, haulage should be done with open topped dump truck(s). Smaller sized vehicles should be considered because their lower height makes them easy to load manually.

Waste collection from schools and administrative buildings should be carried out as part of the regular collection service. If volumes are large, special containers maybe considered. However, with proper education and management these institutions should be able to organize waste reduction policies to keep the problem manageable.

For gardens and parks, the DPWT section responsible for this should continue to carry out this work as they already have the skills required and the public mandate. The equipment and staffing needs of this section should be evaluated to determine future needs.

c. Recycling

The Study Team concluded to propose that the MPP related recycling system as described below should be established.

1) In order to minimize the waste generation amount, it is first necessary to manufacture products that can be easily recycled, taking such factors into account in the design process of products. Therefore, it is necessary to establish a proper administrative system which helps to forward the change of the socio-economic system.

2) Secondly, a technical system which maximizes the recycling amount of generated waste should be established. In concrete terms, the essential measures are to establish an efficient source segregation system, to collect separated waste at a minimal cost, and to promote recycling waste.

The MPP should be greatly involved in forwarding the society to the establishment of such a recycling system for the following reasons.

1) The Study Team estimates the increase in GRDP in 2015. Since solid waste problems are ordinarily related to economic growth, it is forecasted that MPP will have similar solid waste problems as currently seen in developed countries, such as shortage of disposal sites, high cost for waste treatment and disposal, etc. Therefore, in order to avoid such problems, it is necessary to create a “closed loop society” regarding solid waste.

2) The present recycling system is mainly dealing with commonly recyclable wastes. However, in order to increase the recycling rate, it is necessary to establish a system to recycle non-recyclable wastes such as putrescible wastes. To materialize such a system, the MPP has to take the initiative for the promotion of separate discharge and separate collection systems.

Based on the above, the Study Team proposes that the recycling system, as described below, for the target area be established by 2015.

1) To establish a separate discharge and collection system which deals with putrescible wastes and non-putrescible wastes separately.

2) To utilize as much putrescible wastes as possible to produce compost after removing impurities.

d. Intermediate Treatment

d.1 Conclusion (appropriate intermediate treatment methods in MPP)

In this section, various intermediate methods such as incineration, biogas and composting are introduced. Considering the construction and operation cost, composting is the most appropriate intermediate treatment method. However, centralized large-scale mechanical composting plants, which are widely used in Japan, Europe, and the US, are not appropriate because these plants also need skilled engineers and have high operation cost.

There are the following preconditions to apply the compost method as an effective intermediate treatment method.

- There is demand for compost products
- Organic-rich waste such as market waste is available.
- The transportation cost of the input and products is low.

The following issues are also important, regarding the plant facilities:

- Low construction cost
- Easy operation/management and low operation cost

The demand for compost is the most decisive factor in the introduction of compost production as an intermediate treatment method. Surveys both on the compost market and on the effect of compost on harvests were conducted as a pilot project in the phase 2 study.

As CONPED already demonstrates, it is possible to produce high quality compost using organic rich waste selected from market waste.

Considering the construction and operation cost, it is preferable to construct a small-scale compost plant at the source (markets), rather than to transport organic rich waste from the markets to a compost plant in other areas. However, in the urban area it is difficult to secure enough space for a compost plant; hence, it is necessary to have an alternative plan for constructing a relatively large-scale compost plant that receives waste from various markets.

d.2 Experience with Composting in MPP

In MPP, the following two compost plants are currently in operation.

- SCARO compost plant (Waste Recycle Development Center)
- CONPED compost plant (SMC dump site)

SCARO produces compost with the windrow method at a place partitioned by concrete wall, using organic matters sorted from household waste. On the other hand, COMPED produces compost with the windrow method, using organic rich waste generated from two markets. Both the plants input a large volume of labor and produce high quality compost.

It is necessary to remove non-compostable materials such as metal, plastics, glass, and stone at any stage of the production process in order to produce high quality compost.

It is preferable to remove non-compostable materials at the source. Therefore, it is reasonable to use market and restaurant waste, which is generally rich in organic matters and less likely to be mixed with impurities.

Non-compostable materials can be removed at the time of receiving the waste, at the time of turning the waste during the fermentation process, or at the finishing stage.

d.3 Waste Quality in MPP with reference to Composting

The most important factors that determine the quality of the finished compost are:

- The C/N ratio (carbon/nitrogen ratio) of the waste to be composted.
- The contents of unwanted materials (heavy metals, glass, and plastics) in the waste to be composted.
- Aeration and water content of the waste during the composting process.

These factors are briefly discussed as follows.

<C/N-ratio>

Experience has shown that the most favorable C/N-ratio of waste to be composted lies between 15 and 35.

According to the result of the WACS, the C/N-ratio of the kitchen waste of households (middle), restaurants and markets, along with grass/wood, almost fell in this range. Since the C/N-ratio is a very important factor in producing good quality compost, it is necessary to conduct a more detailed study and to examine how to control the C/N-ratio.

<Contents of Unwanted Materials>

The result of the WACS showed that the waste generated from households, restaurants and markets contained a large volume of plastics, but there were relatively small amounts of metal and glass mixed in the waste.

However, to produce high quality compost with a low content of heavy metals and without bits and pieces of glass and plastics, these unwanted materials have to be removed before the waste is composted.

<Aeration and Water Content>

These are factors that have to be regulated during the composting process.

The objective of aeration is to supply the aerobic micro-organisms with sufficient oxygen and to permit the maximum exhaustion of carbonic gas. To allow sufficient aeration, “chimneys” can be arranged in the heap and, especially during the initial period of fermentation when most carbonic gas is liberated, the heap must be opened and turned over.

After ventilation, the most important factor is water. An excess of it in the waste will cause the fermentation to be anaerobic especially in the lower part of the waste heap. It is estimated that in order to avoid this, the waste must not contain more than 60 - 65 % of water. The ideal amount is around 55 %. Aerobic fermentation, however, cannot take place when the water content of the waste is lower than 30 %.

e. Final Disposal

Consequently, the first priority should be to construct a sanitary disposal site which complies with the legal requirement of the Ministry of Environment.

f. Operation and Maintenance of Vehicles and Equipment

To ensure reliability of the collection service in the rural areas, PPWM must establish a vehicle management system and develop the skills to plan optimum collection routes. This will require a detailed understanding of the catchments areas.

g. Selection of an Optimum Technical System

Following the examination of SWM technical sub-systems, the optimum SWM technical system was selected as shown in the table below.

Table 6-1: Optimum Technical System

Work	Proposed System
Storage & Discharge	• Storage method: Plastic bags • Introduction of discharge rule: Standardized discharge method, discharge time • Discharge method: Popularize the use of containers such as bamboo basket to prevent waste scattering. • Source separation (in the area where the recycle centre will be introduced): Separation of compostable and non-compostable waste
Collection	<u>PPWM service area</u> • Collection frequency: More than three times a week (every day for commercial waste) • Collection method: Mixed collection Separate collection (in the area where the recycling centre will be introduced) • Collection system: Combined primary and secondary collection system Communal container collection system (point collection) Curb/bell collection system • Collection time: Daytime • Collection vehicle: Skip loader trucks Compactor trucks (15m^3, 8m^3,4 m^3) • Haulage system: Direct haulage from collection points Transfer station should be considered in accordance with the disposal site location and work efficiency <u>CINTRI service area</u> Collection system is provided by CINTRI
Street Sweeping	• Manual sweeping in the PPWM service area • Both manual sweeping and machinery street sweeping in the CINTRI service area • Park waste is basically collected by communal container.
Recycling	• Recycling activities are encourages through PPWM support and educational programmes.
Intermediate Treatment	<u>Composting and sorting at recycling center</u> • Non-compostable waste: Manual sorting • Compostable waste: Composting plant • Residue from sorting plant and composting plant: Sanitary landfilling <u>Composting at the disposal site</u> • Compostable waste: Composting plant • Residue from the composting plant: Sanitary landfilling
Final Disposal	• Promote as the first priority project the construction of a sanitary landfill site. • Sanitary landfill with leachate treatment system is adopted.
Equipment & Facility O/M	• Building of a small workshop for preventive maintenance. • Major repairs will be entrusted over to private workshops.
Medical SWM	• Disposal of infectious and hazardous medical SW shall be allowed at the municipal landfill and strictly controlled from generation to final disposal. • All of the infectious and hazardous medical SW generated in the target area shall be treated at the generations or disposal of the HW landfill..
Industrial WM	• Disposal of industrial hazardous waste shall be allowed at the municipal landfill and strictly controlled from generation to final disposal. • All of the industrial hazardous waste generated in the target area shall be disposed at the HW site approved by the MOE.

6.2 Institutional Requirements

Institutional consideration such as correction of the monopolistic system of the waste collection service; strategies to strengthen the PPWM as an executing agency; and development of the legal system and standards for establishing an appropriate SWM is indispensable to formulate a master plan for SWM in the municipality of Phnom Penh.

In this chapter, institutional requirements for the implementation of the proposed M/P are presented, but all of them need further elaboration. The Team will carefully examine the requirements presented here in the Second Study Work in Cambodia through the discussion with the C/P as well as relevant authorities. The following sections present concepts, procedures or recommendations for the preparation of such improvement plans.

6.2.1 Legal System

a. Development of Detailed Solid Waste Classification

The Sub-decree on SWM classifies solid waste (SW) into non-hazardous waste (non-HW) and hazardous waste (HW) and the classification is reasonable. However, a more detailed classification is necessary for proper SWM, especially identification of the responsible body (producer) for disposal (storage, collection, transport, recycling, treatment and final disposal) of the SW in accordance with the PPP (Polluter Pay Principle). Some of the ministerial declarations and decisions (*Prakas and Sechdei Samrech*) uses terms of industrial waste or medical waste, but definitions of them are not specified. It is obviously necessary to define these wastes officially in order to clarify the responsibility of the waste producer. The Team prepared a detailed classification of SW for the study as shown in the table below.

Table 6-2: Solid Waste Classification

Category in Sub-decree	Waste Category by Source	Sub-Waste Category	Detailed Waste Category or Description
Household Waste (Non Hazardous Waste)	Municipal Waste	Domestic Waste	1. Household waste 2. Institutional (school, government office, etc.) waste 3. Public area (road, drain, etc.) cleaning waste 4. Septage
		Commercial Waste	5. Commercial (shop, office, restaurant, hotel, etc.) waste 6. Market waste 7. Construction waste
	Industrial (Factory) Waste	Non-hazardous Industrial Waste (Non-HIW)	8. Non-HIW from non-production sources 9. Non-HIW from production process
	Medical Waste	General Medical Waste	10. Non-infectious and non-hazardous medical waste
	Agricultural Waste*1	Agricultural Waste	11. Non-hazardous Agricultural Waste
Hazardous Waste (HW)	Municipal Waste	Hazardous Municipal Waste	12. Domestic HW 13. Commercial HW
	Industrial (Factory) Waste	Hazardous Industrial Waste (HIW)	14. Hazardous Factory Waste
	Medical Waste	Medical Waste	15. Infectious waste 16. Hazardous medical waste
	Agricultural Waste*1	Hazardous Agricultural Waste	17. Hazardous Agricultural Waste

(Note) *1: This study does not cover agricultural waste.

b. Preparation of Municipal Regulation on SWM

The Sub-decree on SWM stipulates MOE shall establish guidelines on non-hazardous waste management (Non-HWM). The MOE in collaboration with Ministry of Interior (MOI) made "the Inter-ministerial Declaration (*Prakas*) on SWM (non-HWM) in Provinces and Cities in the Kingdom of Cambodia" on February 25, 2003. In response to the *Prakas,* DOE of MPP prepared a "Draft Instruction for Conducting the Inter-ministerial Declaration, Interior-environment, No. 80 Dated on February 25, 2003 on SWM in Phnom Penh". The Team concluded that the following issues need further discussions:

1. The team understands that the purpose of the Draft Instruction is to establish a municipal regulation on SWM in Phnom Penh, which aims to guide how SWM shall be organized and carried out. If so, it obviously requires further discussions with representatives from relevant organizations. Those organizations shall include at least relevant departments and PPWM of MPP, preferably *Khans, Sangkats* and some NGOs.

2. The team, however, could not agree with Chapter IV, which stipulates the DOE would have whole responsibility on SWM in Phnom Penh instead of DPWT/PPWM. This is because PPWM had been authorized as a responsible agency on the SWM by the municipality.

3. The team recommends the MPP to clarify and integrate its roles and functions on SWM in the municipality, which are dispersed and/or duplicated in the several departments and organization under the MPP.

c. Guidelines for SWM

Although MOE is establishing several guidelines for proper SWM, the following guidelines need to be gradually prepared in collaboration with relevant organizations:

- Technical guidelines for landfill design and operation
- Detailed regulations and guidelines for collection and treatment of medical waste
- Detailed regulations and guidelines for management of hazardous waste other than medical waste
- Regulations and guidelines for environmental impact analyses and public hearings
- Guidelines for establishing appropriate waste collection systems in urban poor areas that cannot afford the regular waste collection services
- Guidelines for establishing, introducing and collecting service fees and tipping fees
- Procurement regulations and guidelines for contracting out the different types of SWM service, including model contracts

The Team recommends MOE and other responsible organizations to request foreign technical cooperation for the preparation of the above guidelines.

6.2.2 Administration and Organization

Regarding the administration and organization, the following issues needs to be improved:

a. Clarification and Integration of Roles/Responsibilities on SWM

At present, the roles and responsibilities on SWM in Phnom Penh are dispersed and/or duplicated in the several departments and organization under the MPP. Although the integration is highly a matter of municipal (political) decision, the Team proposes the following alternatives for further discussion in MPP:

Alternative 1: Separation of Service Provision and Monitoring/Control

- PPWM is the SWM service provider under MPP
- DPWT is the SWM service facilitator and the supervisor for PPWM
- DOE is the enforcer responsible for monitoring and control of SWM services to be provided by both PPWM and private contractor(s)
- Municipal Cabinet is the regulator

Alternative 2: No Separation of Service Provision and Monitoring/Control

- PPWM is a SWM service provider under MPP and the enforcer responsible for monitoring and control of SWM services to be provided by both PPWM and private contractor(s)
- DPWT is the SWM service facilitator and the supervisor for PPWM
- Municipal regulation is issued by the council of ministers based on the request of the municipality.

It is not clear from the statute how the PPWM operations will be financed, but it may be assumed that PPWM's revenues will come from service fees and treatment/disposal fees levied on private contractors, and that the intention is to make PPWM self-financing. This may work if PPWM is a service provider like CINTRI, but not if PPWM will become an authority that controls and monitors the contracted private service provider(s). In this case MPP will have to allocate the necessary funds to run PPWM, or the private contractors will have to pay a management or license fee to PPWM.

b. Independence and Powers of PPWM

Although the Statute of PPWM was not approved by the Central Government, PPWM lacks the necessary independence and powers in certain areas to carry out its mandate as described in it. The Governor of MPP appoints and determines the remuneration of the management team (Governor and Deputy Governors of PPWM), and is himself the Business Committee Chairman though he appointed a vice Governor as the chairman instead of him. The Municipal Cabinet appoints the other Business Committee members. It would be more appropriate that the Business Committee be responsible for nominating a candidate for the Governor of PPWM position, with the Municipal Cabinet making the final appointment. The governor of PPWM should in-turn select his Deputies with the appointments approved by the Business Committee. This would make the Governor of PPWM more responsible and accountable for the management performance of the Authority.

The present low levels of salaries tend to corrupt the work force and reduce performance, effectiveness and efficiency. Under these circumstances, PPWM may find it difficult to compete with the private contractors. The Business Committee should have the power to set appropriate salary levels based on a sustainable business plan.

c. Strengthening Human Resources of PPWM

PPWM is weak in terms of property (machinery and facility), human resources (quality and quantity of personnel) and finance. In order to implement the proposed M/P, PPWM shall be strengthened in every aspect. Regarding human resources, the following personnel will be needed in the target year of the M/P, 2015.

Table 6-3: Number of Staff for Solid Waste Management of PPWM in2015

	Number of staff
Manager	3
Engineer	4
Specialist	19
Clerk	10
Driver/operator	74
General worker	101
Temporary worker	55
Total	266

6.2.3 Public-Private Partnership

The public-private partnership approach means a sharing of responsibilities and tasks for providing services, financing the services using a blend of public and/or private funds, design and construction of facilities, and operation and maintenance of the service facilities. Therefore, the division of responsibility and roles needs to be clearly established.

a. Delineation of Responsibilities and Roles between PPWM and Private Service Contractors

In principle the public (municipality) is the service regulator, enforcer and facilitator and the private sector the service supplier.

The practices of entering into direct negotiations for long-term franchise agreements, and the lack of competition and contestability in providing services need to be reviewed. MPP should give careful consideration to working arrangements in order to arrive at a more workable and appropriate delineation of responsibilities and roles between PPWM and private service contractors, i.e. CINTRI at present. The Strategic SWM Plan and Action Plan formulated in the ICB/NIP by NORAD concluded that MPP would need to consider more carefully the future responsibilities and roles of PPWM and the private contractor(s). Presently, the contractual terms of the franchise agreements and the PPWM statute are conflicting and overlapping.

The Team agrees on the conclusion of the Strategic SWM Plan. There are, however, hardships for cancellation of the current franchise agreement such as:

- Compensation for the cancellation
- Finding someone to take over collection and cleansing works from CINTRI
- Very limited possibility of having replacer(s) for CINTRI

The private sector (CINTRI), which has the right to provide the service to the whole city based on the concession agreement, cannot provide it to economically unfeasible areas. Therefore, the public sector should provide the service to those areas the private cannot cover. According to the present situation acknowledged through surveys, the team proposed that the private sector provide the service to the four urban Khans in which the collection coverage rate has already reached more than 90 % and that the collection coverage rate in this area should be raised to 100% by 2012. On the other hand, it was found through the surveys that the collection coverage rate in the three rural Khans was almost 50% and that there were many unserviced areas. However, it may be difficult for the private sector to provide the service due to the fact that it is not economically feasible, as the settlements are scattered and the majority of residents living in most of the unserviced areas are low income. Accordingly, the team proposed that the public and private sector eliminate the unserviced areas in the

three rural Khans in collaboration with each other. The study team amended the area-wise responsibilities and roles of PPWM and CINTRI as shown in Table 6-4. PPWM and CINTRI have to make efforts to achieve the targets given in Chapter 3.5 in the areas allocated to them respectively.

PPWM and CINTRI have to make efforts to achieve the targets given in chapter 3.5 in the areas allocated to them respectively. MPP/DOE should check whether the service provider achieves the targets or not. If one does not achieve the target verified by DOE, the other party should provide the service to eliminate the non-serviced area or insufficiently serviced area.

Table 6-4: Area-wise Responsibilities and Roles between PPWM and CINTRI

Area / Work Items	Four Urban Khans	Three Rural Khans
Monitoring and Control	MPP/DOE	
Collection and Transport	CINTRI	PPWM/CINTRI
Treatment and Recycling	CINTRI	PPWM/CINTRI
Final Disposal	MPP/PPWM	
Public Area Cleaning	CINTRI	PPWM/CINTRI
Service Fee Collection	CINTRI	PPWM/CINTRI

Based on the above responsibilities and roles, MPP and CINTRI organized the working group in the middle of January, 2005, and it has identified the unserviced area, where CINTRI would not provide the service for the time being. However, the both parties did not reach an agreement on the area demarcation as of the end of February, 2005.

b. Contract Management for Private Companies

b.1 Basic Consideration

The Strategic SWM Plan by INTERCONSULT/NORAD presented that the justifications for engaging the private sector to carry out SWM services are cheaper and more efficient services, and the reasons for this are:

1. **Open and transparent competitive** bidding and pricing of the contracted services lead to lower costs for the users.
2. Service performance and costs of the private contractor's work is **contested and monitored** by the municipal cleansing department, encourages the contractor to maintain high service standards and low costs.
3. The contractor will be **accountable to the client and customers** for the standards and manner in which his service is provided. The customers' satisfaction will influence the service charges that can be levied on the customers, and he will be fined for not meeting the contract performance specifications, which encourages the contractor to meet the performance specifications.
4. Finally, auditing of the contractor's account by an accredited independent auditing firm will **ensure transparency and avoid corrupt practices**.

However, most of the basic conditions for the justifications for engaging the private sector are not secured under the current SWM.

b.2 Contract Management for Private Companies

As described above, the supply of SWM services will be contracted out to the private sector through a transparent, open and fair bidding procedure. Services should be carried out under conditions of competition and contestability. The responsibility and role of the private sector will be to supply the services in accordance with the contractual conditions, applicable laws, regulations and obligations. Therefore, the most important issue for the contract management for private companies is to establish appropriate performance contracts through competitive and transparent tender procedures. The tender document specifies:

- Service regulations (Municipal Regulation on SWM, etc.) and rules
- Contents of the services such as service area, target wastes, population to be served, cleansing service length and/or area, frequency of the services, etc.
- Payments and penalties against breach of contract
- Others necessary

Once the contract is made, the Public (MPP) shall establish monitoring and control the performance of the private companies in accordance with conditions set in the contract.

6.2.4 Capacity Building

Following the Strategic SWM Plan and Action Plan, several programs were carried out by ADB and NORAD for five years in order to strengthen the capabilities of MPP targeting DPWT and PPWM. However, in all aspects the MPP capabilities for proper SWM are weak.

As described before, in principle the public (municipality) is the service regulator, enforcer and facilitator and the private sector the service supplier. Therefore, the capacity building for the MPP needs to include the following:

- Capability for establishing policy and regulation on SWM
- Capability for facilitating the construction of SWM facilities, such as landfills
- Capability for enforcement, which includes supervision, monitoring and control of the SWM services

In addition to the above, the M/P proposes to strengthen the operational capability of PPWM in order to phase out the monopoly of collection and cleansing services.

a. Operational Capability

Although the structure of PPWM has been developed, its collection service covered only 2.1 % of the population in MPP and the SMC final disposal site they operate is nothing but an open dump. It can hardly supervise or control the SWM work in the city carried out by the private company.

Under such circumstances, the Team concludes:

- The acquisition of the know-how on the provision of waste collection and cleansing services and the operation of a sanitary landfill is especially urgent for the existence of the organization.
- The acquisition of such know-how would provide PPWM, or any other organization in MPP responsible for SWM, with the capability for supervision and control of proper SWM works, which are main responsibility of the public sector.
- Therefore, in regard to the capacity building of PPWM, the priority should be placed on the acquisition of the know-how of SWM service operation.

In order to develop the operational capabilities of PPWM, the Team and the C/P will conduct the following pilot projects (PPs):

- Improvement of the SMC Disposal Site
- Improvement of the Waste Collection System
- Development of the Urban Waste Compost Market and Promotion
- Development of the Data Management System for SWM

Through the planning and implementation of the PPs, the operational capabilities of PPWM will be enhanced. The Team and the C/P will also develop several tools necessary for proper operation through the PPs such as operational planning and management of the SMC disposal site, planning and operation of primary and secondary waste collection and cleansing services, establishment of a fee collection system, etc.

b. Capability for Establishing Policy and Regulation on SWM

At present, the roles and responsibilities on SWM in Phnom Penh are dispersed and/or duplicated in the several departments and organizations under the MPP. The MPP is requested to clarify and integrate the roles and responsibilities on SWM including those between PPWM and CINTRI within the study period.

The DOE of MPP is preparing a "Draft Instruction for Conducting the Inter-ministerial Declaration, Interior-environment, No. 80 Dated on February 25, 2003 on SWM in Phnom Penh", which is considered as a municipal regulation on SWM.

Through the decision making and establishing of the regulation, the Team expects the capability of MPP for establishing policy and regulation on SWM will be enhanced. The Team will provide the findings as well as recommendations on the enhancement of these capabilities through the above-mentioned experiences.

c. Capability for Facilitating Construction of SWM Facilities

The M/P proposes to construct a new disposal site and its feasibility study (F/S) was conducted in the study. The F/S provided a good opportunity for the capacity building of MPP on this subject because the F/S includes:

- Acquisition of the initial environment evaluation (IEE)
- Planning of a sanitary landfill including cost estimation of both investment and operation & maintenance (O&M)
- Conduct of environmental impact assessment (EIA) including explanatory meeting(s) with neighborhood community
- Application of financial assistance to the foreign lending agencies

Through the implementation of the above works, the Team has expected the capability of MPP for facilitating construction of SWM facilities would be enhanced. The Team provided the findings as well as recommendations on the enhancement of these capabilities through the above-mentioned works.

d. Enforcement Capability

The MPP can hardly supervise, monitor or control the SWM work in the city carried out by the private company in place of PPWM. The Team considers these problems come from:

- Very limited operational experience since for a decade the SWM services has been conducted under franchise contracts.

- Lack of base line data necessary for SWM, such as data on rate of population without waste collection service and data on waste disposal quantity from each generation source, from each district, or of each collection company or organization.
- Due to a lack of base line data, the unit cost of each sub-component of SWM (i.e. waste collection, septage collection, final disposal) is not known

The enforcement capability, which includes supervision, monitoring and control of the SWM services, will be strengthened mainly through the PPs as mentioned above. In particular, the compilation of basic data on SWM by the weighbridge and the development of a database will be useful in strengthening these capabilities. Through the implementation of the PPs, the Team and C/P will develop the method and procedure for supervision, monitoring and control of the SWM services.

Chapter 7

The SWM Master Plan

7 The SWM Master Plan

7.1 Outline of the Master Plan

7.1.1 Goal

As mentioned in Chapter 2, the current capability for SWM of the municipality of Phnom Penh is very weak, placing an extreme burden on the urban environment and civil life. The situation is very serious.
The fundamental goal of the M/P for SWM in MPP is:

"To establish a sustainable SWM system in MPP by the target year 2015".

The establishment of such a system will:

- Maintain the urban environment and public health in MPP, which is the center of the economic and industrial activities of Cambodia and has 8.7% of the national population (1998 census), and contribute to the sound development of urban life.
- Motivate foreign investment whereby the economic development of Cambodia will be promoted.

In the sustainable SWM system, the following situation should be established.

- Waste reduction is encouraged at the generation source such as households and offices.
- Waste generated after the attempt of waste reduction is reused or recycled as much as possible.
- Only after the effort of waste reduction, reuse or recycling, waste is properly collected, treated, and finally disposed of in a proper manner without negative environmental impacts.
- Such a SWM system will be established by requiring adequate responsibilities of the governmental sector, private sector and general public under a transparent and fair rule.

The specific approaches to achieving the goal are summarized as follows.

7.1.2 Target year

The target year of the M/P is 2015. In order to achieve the goal of the M/P step by step, the planning period is divided into the following three phases:

1st Phase : 2005 to 2007 (urgent improvement)[1]
To develop the new disposal site as SMCDS is improved. The waste collection system under public and private partnership is established.

2nd Phase : 2008 to 2012 (short term improvement)
The new disposal site and waste collection system established in the Phase are operated properly.

3rd Phase : 2013 to 2015 (middle term improvement)

[1] Since the proposed 6.0 ha of expansion area was changed to 3.6ha the capacity of the SMCDS was reduced almost for one year operation. Therefore, the inaugural year of the urgent improvement is hastened from 2008 to 2007.

The target of the Master Plan is achieved and the preparation works for the next plan targeting a higher grade of management will be started.

7.1.3 Numerical Target

To achieve the target of the Master Plan step by step, phased targets are set as shown in the below table.

Table 7-1: Numerical Targets of the Master Plan for SWM in Phnom Penh

Technical Component	Present (2004)	Phase 1 (2007)	Phase 2 (2012)	Phase 3 (2015)
Service coverage of waste collection including recyclable waste collection*1 (*2)				
4 Urban Khans	95.6% (90.7%)	97.8% (92.5%)	100% (94.1%)	100% (93.8%)
3 Rural Khans	53.4% (48.2%)	73.4% (68.1%)	88.8% (83.0%)	95.7% (89.7%)
Generation reduction				
Growth rate of household waste *3	1.00 (63.0%)	1.14 (62.6%)	1.32 (61.5%)	1.42 (60.9%)
Growth rate of commercial waste *4 (proportion of commercial waste to the total waste generation)	1.00 (37.0%)	1.16 (37.4%)	1.41 (38.5%)	1.55 (39.1%)
Proportion of recycled waste to the total waste generation *5				
4 Khans in the urban area	11.1 %	14.6 %	15.5 %	16.0 %
3 Khans in the rural area	6.8 %	8.3 %	10.4 %	11.7 %
Proportion of composted waste (intermediately treated waste) to the total waste generation (amount treated, tons/day)	0.1% (1.3)	2.4% (26.3)	2.0% (29.3)	1.9% (32.3)
Proportion of waste illegally dumped by households to the total waste generation				
4 Urban Khans	2.2 %	1.1 %	0.0 %	0.0 %
3 Rural Khans	13.8 %	7.2 %	1.8 %	0.0 %
Street Sweeping				
4 Urban Khans	46km	46km	46km	46km
3 Rural Khans	10km	14km	19km	24km
Final disposal method of municipal waste	Control tipping/ Open Dumping	SLF level 1 (Control tipping)	Sanitary landfill (SLF) Level 4	
Final disposal method of hazardous waste	A system for reduction of the waste generation, recycling, proper treatment and disposal will be established in phases.			

Note:*1: The collection service coverage rate is, in general, expressed by the rate of served population to the total population. In this study, however, the rate is expressed by the rate of collected waste to the total waste because it is not possible to obtain data of population who receive waste collection service.
*2: This excludes waste that is collected by recyclers at generation source.
*3: The number of generation sources is assumed to increase in proportion with population. The increase in unit generation is assumed to be half of that in Japan, and figures in the table are the growth rate of unit generation with letting that in 2003 be 1.
*4: The number of generation sources is assumed to increase in proportion with GNP. The increase in unit generation is assumed to be half of that in Japan, and figures in the table are the growth rate of unit generation with letting that in 2003 be 1.
*5: The recycling rate in Japan in 1999 was 13.1%.
*6: A part of self disposal is an appropriate disposal. Therefore, it is considered that the rate of illegal

7.1.4 Strategies to Achieve the Target

The strategies for the three phases to be taken in order to achieve the goal of the M/P are shown below.

Table 7-2: Strategies to Achieve the Targets of the SWM M/P

Items	Four Khans in the Urban Area	Three Khans in the Rural Area
Phase 1 (2005-2007) Technical aspects		
1. Generation and waste management at source	• DOE carries out public education campaign in cooperation with PPWM and CINTRI to encourage a reduction of illegal dumping and instill proper discharge rules. • The campaign also promotes waste reduction. • DOE gives guidance and popularizes a proper storage method according to the collection frequency.	
2. Discharge, collection and transport	• Operation of secondary collection in NIP area is transferred to CINTRI. • CINTRI fixes waste collection routes and time and keeps these services. • CINTRI introduces a primary collection system or establishes a point collection system based on public cooperation in areas where collection vehicles cannot access in order to eliminate unserviced areas. (The collection system is decided by CINTRI) • CINTRI charges a fee based on a service agreement signed between the client and CINTRI. • Transfer stations may be introduced according to the CINTRI's decision.	<u>PPWM</u> • PPWM strengthens it's capability to provide the waste collection service to the 3 rural Khans by the end of 2006 and starts providing service from the beginning of 2007. ① PPWM decides which areas will be serviced by curbside/bell collection and by container collection, considering area conditions. ② PPWM decides whether to adopt point collection or primary collection in each area where the container system applied. ③ PPWM works in cooperation with NGOs and communities to organize primary/secondary collection schemes where appropriate to maximize collection efficiency and employment creation. ④ Expenses for the primary collection provided by collectors are borne by the community in principle, and the fee is decided based on the agreement among PPWM, Sangkat and community. • PPWM makes a service agreement with the clients in cooperation with Sangkat. • PPWM examines the introduction of transfer stations for the areas that are farther than 20 km from the final disposal site.
		<u>CINTRI</u> • Same as left column
	• MPP supports the communities that decide to introduce primary collection.	
3. Street sweeping and park cleansing	• The present cleansing system of public places, which is labor oriented, should be maintained from the viewpoint of job creation. • DOE carries out a public education campaign and regulates illegal practices such as illegal dumping in order to stop waste scattering in the city center. • MPP commits resources in 2006 so that PPWM can prepare the material and human resources required to take over cleansing services in the PPWM service area from the private provider by 2007.	

Items	Four Khans in the Urban Area	Three Khans in the Rural Area
4. Intermediate treatment and recycling	• PPWM develops a compost plant to reduce and recycle organic waste collected from the markets at the new final disposal site in Dang Kor. • MPP through PPWM secures surplus government or other land and equips it with simple facilities for use by NGO, SHG or community groups to operate recycling and composting activities to increase waste recycling and employment creation. • MPP through PPWM develops rules and policies to promote private recycling and regulate inappropriate or dangerous practices. • MPP develops a scheme to support private long-established recycling systems to maintain and conserve the existing recycling system. • MPP in collaboration with MOI, etc. encourages local recycling activities for the valuable resources collected. • MOE in collaboration with ministries concerned encourages reusable and recyclable products and promotes the 3Rs infusing an extended producer responsibility (EPR).	
5. Final disposal and O&M of machinery	• PPWM improves the existing SMC disposal site based on the experience of the pilot project implemented during the study, and uses the site as long as possible. • PPWM organizes the waste pickers and makes them work according to rules. Furthermore, PPWM encourages waste pickers to become primary or secondary waste collectors after closure of the SMCDS in 2006. • PPWM constructs a new final disposal site at Dang Kor, and purchases the necessary vehicles and machinery with its own funds and external assistance by 2005, and starts the operation of the new site in 2007. It prohibits waste picking at the new site. • The plan of facilities should consider avoiding a leachate spillage, while measures for minimizing outflow of leachate which may be caused by an unexpected large scale flood should be prepared. • PPWM constructs a maintenance workshop with its own funds and external assistance where preventive maintenance is carried out for the vehicles and machinery of PPWM. • PPWM should utilize landfill gas. • A closure plan for SMC disposal site is formulated.	
6. Septage management	• PPWM studies and understands the current situation of septage disposal and the use of septic tanks in the city. • PPWM formulates a septage management plan and an action plan, which is in line with public and private sector partnership and should include a plan for the development of a new septage treatment and disposal facility. • MPP allocates a budget for the implementation of the action plan, and PPWM puts it into action involving the private sector. • PPWM sets a guideline for the appropriate management of septic tanks. • MOE examines a legal system to prevent illegal septage dumping.	
Institutional aspects		
7. Legal system	• MOE clarifies the uncertainty of the Sub-Decree on SWM, adds a supplemental explanation, and develops regulations, standards or guidelines that are suitable for priority issues. • MOE encourages the municipalities to develop municipal regulations that complement the legal system at the national level.	
7. Legal system	• MOE diffuses the methodology of SWM plan development to other major cities in Cambodia in cooperation with MPP/PPWM based on the result of the study. • MOE promotes the construction of proper waste treatment and disposal facilities and strictly regulates inappropriate waste treatment and disposal. • MPP approves a draft municipal regulation on SWM prepared by DOE and establish an enforcing system of improper disposal. • MPP develops municipal rules on SWM and guidelines for waste discharge and other activities in order to ask for people's cooperation.	

Items	Four Khans in the Urban Area	Three Khans in the Rural Area
8. Administration and organization	• MPP clarifies the organization(s) responsible for SWM of MPP as follows. ✓ MPP/Cabinet formulates a comprehensive SWM policy and enforces it. ✓ DPWT supervises the construction of the disposal site and waste collection service to be carried out by PPWM. ✓ DOE monitors and controls SWM operated by PPWM and takes charge of public education. ✓ PPWM operates and maintains the SWM under their jurisdiction. ✓ MPP/Cabinet constitutes the coordination committee consisting of the above four agencies to coordinate each function and manages smoothly through a regular meeting. • MPP strengthens PPWM in terms of property (machinery and facility), human resources (quality and quantity of personnel) and finance by utilizing international assistance programs as much as possible so that PPWM can operate and control the technical system proposed above.	
9. Public-private partnership	• MPP amends the contract with CINTRI, and transfers the waste collection and public cleansing work in the area where CINTRI will not provide waste collection service to PPWM by the end of 2006. • MPP develops a system for systematic monitoring and data control. The system should make it possible to evaluate the unit cost for each component of SWM by which MPP can evaluate cost/benefit, cost/efficiency and cost/impact. In parallel to the above, MPP should also establish a database of all activities of SWM and make PPWM and the private company to continuously check the performance of their services and costs.	
10. Capacity building	• PPWM establishes a human resource development program to build the capacity of staff in each of the key activity areas (management, accounting and administration, SW collection, equipment maintenance and operation of sanitary landfill site.) • DOE establishes a monitoring and control system to ensure that PPWM's performance is in accordance with the PPWM Statute. • DOE establishes a monitoring and control system to ensure the private company(s)'s performance is in accordance with the contract.	
11. Finance	• CINTRI employs external financial auditors who audit the revenue and expenditure of waste collection and public cleansing services, discloses the result of audit, and shows the justification of the waste fee.	<u>PPWM</u> • MPP draws finances from bilateral and multilateral donors to strengthen the SWM service capability of PPWM. • PPWM establish a fee collection system involving Sangkat, based on the result of the pilot project implemented in the present study. • MPP allocates a budget for PPWM to start public area cleansing work in 2007. <u>CINTRI</u> Same as left column
12. Public education and cooperation	• DOE raises public awareness through basic education such as the necessity of public hygiene and environmental conservation. • DOE in collaboration with PPWM and CINTRI carries out a public education campaign to obtain public participation. It promotes cooperation with NGOs. • PPWM and CINTRI carry out public education and PR activities to ask for public cooperation in order to gain the understanding of the people. In doing so, they work closely with NGOs.	

Items	Four Khans in the Urban Area	Three Khans in the Rural Area
13. Hazardous waste management	• MOE studies the real situation of hazardous waste generation in cooperation with generation sources such as factories, and examines the appropriate treatment and disposal measures by taking account of the size of the economy and the total generation amount. • MOE promotes the construction of appropriate treatment and disposal facilities for hazardous waste and strengthens the control on improper hazardous waste management. • MOE develops a code of practice for medical waste management in cooperation with the Ministry of Health (MOH). MOE strengthens its relevant unit to establish a proper control/supervision system for medical waste management. • DOH (Department of Health) and PPWM introduce a separate collection system for infectious waste, and regulate its disposal at the municipal waste disposal site. • DOH examines the integration of existing incinerators or the introduction of new treatment facilities that receive waste from several medical institutions in consideration of the efficiency improvement of treatment and operation. • PPWM strictly controls the hazardous waste incoming to the disposal site.	
Phase 2 (2008-2012) Technical aspects		
1. Generation and waste management at source	• PPWM, in cooperation with CINTRI, carries out a public education campaign and regulates illegal dumping and improper disposal at households. Finally, illegal dumping and improper self disposal is eliminated in 2012. • The campaign also promotes waste reduction.	PPWM • PPWM carries out a public education campaign and regulates illegal dumping and improper disposal at households to reduce the rate of these up to 1.8% in 2012. • The campaign also promotes waste reduction. CINTRI Same as left column
2. Discharge, collection and transport	• DOE supervises the collection works by CINTRI. • CINTRI, in cooperation with NGOs, organizes waste pickers as primary waste collectors and achieves a collection rate of 100% in 2012. • Separate collection is continued in the NIP area.	PPWM • PPWM, in cooperation with NGOs, organizes former waste pickers as primary or secondary waste collectors. • PPWM improves its collection efficiency and increases the collection rate up to 88.8% in proportion to the population receiving services. • PPWM introduces separate collection in part of the area. • Following the result of examination in Phase 1, PPWM introduces the transfer stations if necessary. CINTRI Same as left column
3. Road and park cleansing	• The labor oriented cleansing system of public places should be maintained as long as it has an economical advantage over machinery cleansing. • PPWM continues to carry out a public education campaign and to regulate illegal practices such as illegal dumping in order to stop waste scattering in the city center.	
4. Intermediate treatment and recycling	• PPWM operates a composting facility on the Dang Kor disposal site. • PPWM promotes recycling by constructing small-scale recycling centers, where groups of former waste pickers, organized by NGOs, carry out waste sorting and composting under the simple structure with a roof, when it acquires land. • PPWM promotes the improvement of recycling activities by individual recyclers and regulates improper recycling.	

Items	Four Khans in the Urban Area	Three Khans in the Rural Area
5. Final disposal and O&M of machinery	• PPWM continues to operate the sanitary landfill at the Dang Kor disposal site. • PPWM constructs the second stage disposal site by the end of 2012. • PPWM carries out preventive maintenance of its vehicles and machinery regularly. • Installation of gas removal pipes and soil covering works are executed at the SMCDS after closure at the beginning of 2007.	
6. Septage management	• PPWM and the private sector follow the septage management plan and the action plan formulated in Phase 1. • PPWM appropriately manages the septage disposal facility. • PPWM and the private sector carry out public campaigns to enforce the guideline issued in Phase 1. • MOE develops legislation and enforcement measures to prevent the illegal dumping of septage.	
Institutional aspects		
7. Legal system	• MOE develops regulations, standards or guidelines following the Sub-Decree. • MOE encourages the municipalities to develop municipal regulations. • MOE encourages other major cities in Cambodia to develop a SWM plan. • MOE and MOH more strictly regulate inappropriate waste treatment and disposal. • MOE together with MPP diffuse the municipal regulations on SWM and guidelines for waste discharge and other activities in order to ask for people's cooperation to other major cities in the country.	
8. Administration and organization	• MPP further strengthens PPWM. • MPP monitors the progress of the M/P.	
9. Public-private partnership	• MPP reviews the contract with CINTRI and examines amendments necessary to introduce a market mechanism. • MPP/DOE enforces the system for systematic monitoring and data control. Through the system, MPP/DOE regularly evaluates the performance of PPWM and the private contractor by checking the unit cost for each component of SWM and the key performance indicators. The result of the evaluation should be disclosed to the public.	
10. Capacity building	• PPWM carries out the training program suitable for the different jobs of all the personnel engaged in SWM.	
11. Finance	• CINTRI improves the transparency of financial information, and raises its fee collection rate.	PPWM • PPWM strengthens its fee collection system in its service area to totally cover the cost. • MPP allocates a budget for PPWM to execute public area cleansing from 2007. CINTRI Same as left column
12. Public education and cooperation	• PPWM and CINTRI continue to carry out public education and PR activities to ask for public cooperation in order to gain the understanding of the people, working closely with NGOs.	

Items	Four Khans in the Urban Area	Three Khans in the Rural Area
13. Hazardous waste management	• MOE promotes the construction of appropriate treatment and disposal facilities for hazardous waste and further strengthens the control on improper hazardous waste management. • MOE studies the real situation of hazardous waste generation and instructs relevant organizations to take the most suitable treatment and disposal measures. • Each medical institution follows the code of practice for medical waste management. • DOH and DOE instruct medical institutions to separately discharge infectious/hazardous waste, and control them to pay the necessary cost for the management (including collection and final disposal) of medical waste. • DOH promotes the integration of small incinerators for infectious waste and hazardous medical waste and minimizes the number of facilities.	
Phase 3 (2013-2015) Technical aspects		
1. Generation and waste management at source	• DOE, in cooperation with PPWM and CINTRI, carries out a public education campaign and regulates illegal dumping and improper disposal at households. • The campaign also promotes waste reduction.	
2. Discharge, collection and transport	• DOE supervises the collection works by CINTRI. • CINTRI continues to provide 100% of collection services. • CINTRI examines the introduction of separate collection systems in the area other than the NIP area.	PPWM • PPWM improves its collection efficiency and increases the collection rate up to 95.7% in proportion to the population in 2015. • PPWM expands the area of separate collection. • Following the result of examination in Phase 1, PPWM introduces the transfer stations if necessary. CINTRI Same as left column
3. Road and park cleansing	• The labor oriented cleansing system of public places should be maintained as long as it has an economical advantage over cleansing by machine. • DOE continues to carry out a public education campaign and to regulate illegal practices such as illegal dumping in order to stop waste scattering in the city center.	
4. Intermediate treatment and recycling	• PPWM operates a composting facility on the Dang Kor disposal site. • PPWM continues to promote NGOs' recycling activities. • PPWM promotes the improvement of recycling activities by individual recyclers and regulates improper recycling. • PPWM attempts to coordinate the separate collection system and the private recyclers' activities.	
5. Final disposal and O&M of machinery	• PPWM continues sanitary landfill at the Dang Kor disposal site. • PPWM properly maintains its vehicles and machinery.	
6. Septage management	• PPWM and the private sector follow the septage management plan and the action plan.	
Institutional aspects		
7. Legal system	• MOE encourages other major cities in Cambodia to develop a SWM plan. • MOE and MOH more strictly regulate inappropriate waste treatment and disposal. • MOE in cooperation with MPP diffuses the municipal regulations on SWM and guidelines for waste discharge and other activities in order to ask for people's cooperation to other cities in the country.	
8. Administration and organization	• MPP further strengthens PPWM. • MPP evaluates the progress of the M/P and formulates a new M/P starting 2016.	

Items	Four Khans in the Urban Area	Three Khans in the Rural Area
9. Public-private partnership	• MPP amends the contract with CINTRI and develops a private-public partnership based on the market mechanism. • DOE maintains the system for systematic monitoring and data control. Performance evaluation work and its publication should be continued.	
10. Capacity building	• PPWM carries out the training program suitable for the different jobs of all the personnel engaged in SWM.	
11. Finance	• CINTRI improves the transparency of financial information, and raises its fee collection rate.	PPWM • PPWM keeps the collection system financially sustained by collecting a fee from the residents. • MPP continues to allocate a budget for PPWM to execute cleansing work._ CINTRI Same as left column
11. Human resources development	• PPWM carries out the training program suitable for the different jobs of all the personnel engaged in SWM.	
12. Public education and cooperation	• DOE, in cooperate with PPWM and CINTRI, continues to carry out public education and PR activities to ask for public cooperation in order to gain the understanding of the people, working closely with NGOs.	
13. Hazardous waste management	• MOE promotes the construction of appropriate treatment and disposal facilities for hazardous waste and further strengthens the control on improper hazardous waste management. • The relevant organizations carry out their roles in hazardous waste management. • MOE and DOE regulate and supervise the medical waste management system. • MOE and DOE regulate small incinerators for infectious and hazardous medical waste.	

7.1.5 SWM Master Plan

Phase / Components	Present (2004)		Phase 1 (2007)		Phase 2 (2012)		Phase 3 (2015)	
1. MSW Generation								
Population in Phnom Phne	Rural:	601,449	Rural:	724,409	Rural:	850,545	Rural:	952,009
	Urban:	642,392	Urban:	692,036	Urban:	730,887	Urban:	750,157
	Total:	1,242,841	Total:	1,416,445	Total:	1,581,432	Total:	1,702,166
MSW Amount (ton/day)								
Generation		977.6		1,158.7		1,511.9		1,739.3
Discharge		716.6		950.7		1,344.6		1,597.5
Collection	Rural:	189.8	Rural:	325.1	Rural:	551.1	Rural:	710.0
	PPWM:	29.9	PPWM:	156.5	PPWM:	281.1	PPWM:	404.4
	Private:	159.9	Private:	168.6	Private:	270.0	Private:	305.6
	Urban:	502.8	Urban:	548.8	Urban:	683.1	Urban:	751.4
	Total:	692.6	Total:	873.9	Total:	1,234.2	Total:	1,461.4
MSW Composition (%)								
Non-compostable		29.9		38.4		43.1		46.9
Compostable		70.1		61.6		56.9		53.1
2. Waste Collection & Transportation								
Collection rate (%)	Rural:	48.2	Rural:	68.1	Rural:	83.0	Rural:	89.7
	Urban:	90.7	Urban:	92.5	Urban:	94.1	Urban:	93.8
	Total:	73.3	Total:	82.0	Total:	88.9	Total:	91.8
Ratio of improper disposal to generation (%)	Rural:	13.8	Rural:	7.2	Rural:	1.8	Rural:	0.0
	Urban:	2.2	Urban:	1.1	Urban:	0.0	Urban:	0.0
	Total:	6.9	Total:	3.7	Total:	0.8	Total:	0.0

Phase / Components	Present (2004)	Phase 1 (2007)	Phase 2 (2012)	Phase 3 (2015)
Separate collection rate to refuse collection (%)	Rural: 0 Urban: 0.7 Total: 4 ton/day	Rural: 1.8 Urban: 0.7 Total: 6 ton/day	Rural: 1.6 Urban: 0.7 Total: 9 ton/day	Rural: 1.7 Urban: 0.7 Total: 12 ton/day
Collection system	PPWM Curb side/bell collection Stationary collection with container Primary + container collection Private Curb side/bell collection Container collection	PPWM Curb side/bell collection Stationary collection with container Primary + container collection CINTRI Depend on the plan of the private collector contracted out	PPWM Curb side/bell collection Stationary collection with container Primary + container collection CINTRI Depend on the plan of the private collector contracted out	PPWM Curb side/bell collection Stationary collection with container Primary + container collection CINTRI Depend on the plan of the private collector contracted out
Major type of vehicles (units) CT: Compactor Truck SL: Skip Loader CO: Container	CT (18m^3): 1 CT (4.5 m^3): 1 CT (4 m^3): 2 SL: 1 CO (5 m^3): 10	PPWM CT (15 m^3): 8 CT (8 m^3): 3 CT (4 m^3): 3 SL : 5 CO (5 m^3): 37 WL: 1	PPWM CT (15 m^3): 14 CT (8 m^3): 4 CT (4 m^3): 5 SL : 8 CO (5 m^3): 61 WL: 1	PPWM CT (15 m^3): 19 CT (8 m^3): 6 CT (4 m^3): 8 SL : 11 CO (5 m^3): 86 WL: 1
Number of staff (collection workers)	PPWM: 21(16)	PPWM: 75 (48)	PPWM: 108 (74)	PPWM: 142 (100)
Transportation system	Direct haulage	Direct haulage	Direct haulage	Direct haulage
Executing organisation	PPWM: 4 Sangkats Private: Whole Phnom Penh other than PPWM area	Rural: PPWM CINTRI Urban: CINTRI	Rural: PPWM CINTRI Urban: CINTRI	Rural: PPWM CINTRI Urban: CINTRI
Unit cost (US$/ton)	6.73 (in 2003)	8.14 (PPWM area)	6.98 (PPWM area)	7.07 (PPWM area)
3. Public Area Cleansing				
Method of sweeping	Manual sweeping by private	Rural: PPWM: Manual CINTRI: Private plan Urban: CINTRI	Rural: PPWM: Manual CINTRI: Private plan Urban: CINTRI	Rural: PPWM: Manual CINTRI: Private plan Urban: CINTRI
Type of collection vehicles in Rural area	-	Dump truck: 1	Dump truck: 1	Dump truck 1
Length of served road (km)	Rural: 10km Urban: 46 km	Rural: 10 km PPWM: 4 km CINTRI: 6 km Urban: 46 km	Rural: 13 km PPWM: 7 km CINTRI: 6 km Urban: 46 km	Rural: 16 km PPWM: 8 km CINTRI: 6 km Urban: 46 km
Operation by	Rural: PPWM CINTRI Urban: CINTRI	Rural: PPWM CINTRI Urban: CINTRI	Rural: PPWM CINTRI Urban: CINTRI	Rural: PPWM CINTRI Urban: CINTRI
No of Staff (Sweepers)	PPWM: 0	PPWM: 28 (25)	PPWM: 47 (44)	PPWM: 53 (50)
Unit cost (US$/ton)	-	238.8 (PPWM area)	183.0 (PPWM area)	153.9 (PPWM area)
4. Recycling Intermediate Treatment				
Compost plant 1 Site	SMCDS	DKDS	DKDS	DKDS
Treated amount (ton/year)	365	7,300	7,300	7,300
Unit cost (US$/material -ton)	N/A	10.3	10.3	10.3
(US$/Product-ton)	N/A	51.4	51.4	51.4
Recycling at generation	Market waste etc.	Market waste etc.	Market waste etc.	Market waste etc.
Overall recycling rate	0.6	1.8	1.4	1.2
Recycling system	Windrow	Windrow	Windrow	Windrow
Compost plant 2	Rural: - Urban: Waste Recycle	Rural: Waste Recycle Centre (WRC)	Rural: WRC	Rural: WRC

Phase / Components	Present (2004)	Phase 1 (2007)	Phase 2 (2012)	Phase 3 (2015)
	Development Centre in NIP (WRDC)	Urban: WRDC	Urban: ERDC	Urban: ERDC
Treated amount (ton/year)	110	110+2,190= 2,300	110+3,285= 3,395	110+4,380= 4,490
Unit cost (US$/ton)	N/A	N/A	N/A	N/A
Recycling at generation	MSW	MSW	MSW	MSW
Overall recycling rate (%)	0.1	0.6	0.7	0.8
Recycling system	Windrow	Windrow	Windrow	Windrow
5. Final Disposal				
Method of operation	Open-dumping	Sanitary landfill level 4	Sanitary landfill level 4	Sanitary landfill level 4
Final disposal site	SMCDS	DKDS	DKDS	DKDS
Distance from city (km)	5	10	10	10
Operation by	PPWM	PPWM	PPWM	PPWM
Disposal amount (ton/day)	715	924	1,301	1,540
Nos. of workers	9	51 (include Administration staffs)	54 (include Administration staffs)	61 (include Administration staffs)
Unit cost (US$/ton)	0.43			
With grant	-	5.92	5.92	5.92
Without grant	-	4.40	4.40	4.40
Main equipment	Bulldozers (leased) 2	Bulldozer 4 Wheel loader 1 Water tank truck 1 Dump truck 2 Pickup truck 2 Excavator 2	Bulldozer 5 Wheel loader 1 Water tank truck 1 Dump truck 2 Pickup truck 2 Excavator 2	Bulldozer 6 Wheel loader 1 Water tank truck 1 Dump truck 3 Pickup truck 2 Excavator 3
6. Maintenance & Repair (for PPWM)				
Preventive Maintenance	By private	By PPWM	By PPWM	By PPWM
Major repair	By private repair shop	By private work shop	By private work shop	By private work shop
Operation by	PPWM	PPWM	PPWM	PPWM
Maintenance staffs		WS Manager: 1 Technician: 2 Mechanics: 6 Store keeper: 1 Office clerk: 2	WS Manager: 1 Technician: 2 Mechanics: 8 Store keeper: 1 Office clerk: 2	WS Manager: 1 Technician: 2 Mechanics: 9 Store keeper: 1 Office clerk: 2
7. Financial Matters of PPWM (present data are in 2003)				
Unit SWM Cost (US$/ton)	7.16	12.54	11.38	11.47
Revenue Source	MPP Budget 0 SW collection 39 Tipping fee 104 Selling of soil 0	MPP Budget 35 SW collection 663 Tipping fee 1,483 Selling of soil 0	MPP Budget 47 SW collection 1,191 Tipping fee 2,090 Selling of soil 133	MPP Budget 51 SW collection 1,714 Tipping fee 2,473 Selling of soil 66
Total revenue (US$ 1,000)	143	2,181	3,461	4,304
Collection rate of waste collection fee	Household 80% Business 0%	Household 80% Business 100%	Household 80% Business 100%	Household 80% Business 100%
Budget allocation from general finance to the total income from SWM	0%	2%	2%	2%
Coverage rate of waste collection fee to the total income from SWM	27%	30%	34%	40%
Tipping fee to the total income from SWM	73%	68%	60%	57%
Selling soil to the total income from SWM	0%	0%	4%	2%
Total revenue per capita (US$/year)	0.12	1.54	2.19	2.53
Municipal Budget estimated (thousand US$)	5,811	8,435	11,305	13,772

Components \ Phase	Present (2004)	Phase 1 (2007)	Phase 2 (2012)	Phase 3 (2015)
Share of SWM budget	0%	0.4%	0.4%	0.4%
8. Medical SWM				
Generation (ton/day)	General : 9.7 Medical: 1.0	General: 12.3 Medical: 1.2	General: 16.5 Medical: 1.6	General: 19.3 Medical: 1.9
Treatment at generation	General: Landfill Medical: Incineration	General: Landfill Medical: Incineration	General: Landfill Medical: Incineration	General: Landfill Medical: Incineration
Final disposal	General Waste : Open dumping	General Waste :Sanitary landfill at DKDS Medical waste without treatment is not allowed to dispose in the DKDS	General Waste :Sanitary landfill at DKDS Medical waste without treatment is not allowed to dispose in the DKDS	General Waste :Sanitary landfill at DKDS Medical waste without treatment is not allowed to dispose in the DKDS
Final disposal operation	PPWM	PPWM	PPWM	PPWM
9. Industrial SWM				
Generation (ton/day)	General: 29.7 IW: 28.5	General: 37.5 IW: 36.0	General: 50.5 IW: 48.5	General: 59.0 IW: 56.6
HW treatment	N/A	Landfill	Landfill	Landfill
Final disposal	Open dumping	Prohibit and control HW disposal at DKDS and oblige disposal at HW landfill site	Prohibit and control HW disposal at DKDS and oblige disposal at HW landfill site	Prohibit and control HW disposal at DKDS and oblige disposal at HW landfill site

7.2 Technical System

7.2.1 Discharge and Storage

a. Waste Storage

Waste should be stored on the premises of the waste producer until discharge in the recommended manner. Household waste should be in placed plastic bags that are tied at the top when full. Small commercial waste producers should use plastic bags for waste storage or suitable containers such as bamboo baskets and half oil drums with handles. Major waste generators should lease containers from PPWM for waste storage until collection. Waste from street sweeping should be placed in plastic bags and stored at the curbside until collection. Waste from other public areas such as parks and sidewalks should be placed in suitable public containers. PPWM should supply large covered containers (for use in parks where space is available) that are suitable for use with its collection equipment. Small public containers suitable for placement on sidewalks and other public areas (such as the half oil drums with handles currently in use) should be supplied by PPWM, the local government or requested as donations from the private sector. PPWM should coordinate placement of these containers.

b. Waste Discharge

The discharge of waste in heaps on the ground should be prohibited in all cases. Sangkat authorities should ensure that residents are informed about the proper discharge method used in their area.

In areas where curbside collection is used, households and small waste generators should have a bamboo basket or other suitable container to store their bags at the curbside. On the day when collection is scheduled, waste producers should move their baskets to curbside to await collection. Where stationary containers are used for waste collection, waste producers

should bring their waste to the container station and place the waste inside the container. Local authorities should organize residents to maintain the area around the container. Alternatively, local authorities can use part of the collection fee commission to employ a part-time worker or retired person to monitor and maintain the area around the container.

In areas where stationary collection is used, residents can choose to contract the so-called "Self-Help Groups" to transport waste from the house to the container station. The local authorities should organize this and a separate primary collection fee should be collected.

Large waste producers that use leased container collection should discharge their waste directly into the container provided. The container should be placed on the producer's premises in an area that can be easily accessed by collection vehicles.

c. Discharge Rules

The collection plan proposed in this Master Plan uses a mixed collection approach to provide service under a variety of conditions as found in Phnom Penh. The existing rules for waste discharge will need to be revised to reflect the requirements of the mixed collection system. Specific rules proposed are shown in the text box below.

Waste Discharge Rules

To meet the needs of the mixed collection approach used in the Master Plan 2007-2015, the following discharge rules are proposed for all household and small waste generators:

- The Sangkat authorities should ensure that all residents are informed about the collection schedule and discharge rules for their areas.
- To avoid scattering, all loose waste (such as household, commercial and office waste) must be placed in plastic bags (with the top tied closed) or placed in an appropriate waste container (made from bamboo, plastic or metal) with a cover.
- Containers used for curbside collection must be no larger than 120 liters and not weigh more than 30 kg (container plus waste).
- All larger waste (such as garden waste, wood, construction materials, etc.) should be cut into pieces not longer than 1.2 meters and securely tied with cord or wire into bundles weighing not more than 30 kg.
- Where the separate collection service is provided, residents must separate their waste into the appropriate categories and discharge it in separate bags or containers.
- Waste must be stored on the customer's premises until the scheduled collection day. At the designated date and time, the waste should be placed at the curbside for collection.
- In areas with the container collection system, waste should be placed inside the container. Waste must never be placed on the ground or discharged in a place not designated for that purpose. If containers are full, waste should be stored on the customer's premises until containers are available.

All waste producers regularly discharging more than $1m^3$ or 300 kg of waste per day are required to discharge waste in standard "skip" type containers for mechanized collection. To insure high collection efficiency and standardization of equipment, waste producers are required to lease the appropriate container from PPWM. Non-PPWM containers are not permitted.

7.2.2 Collection and Transport System

a. Target Areas Characteristics

Selection of a collection system and related collection vehicles must be based on several factors. These include appropriateness of the equipment to physical conditions in the

collection area, system flexibility and ability to expand to meet future needs, system efficiency and ease of maintenance, sanitation and convenience for customers, and investment and operating cost.

Conditions within the proposed collection area include several general patterns of development and land-use densities.

b. Collection System Considerations

To meet the waste collection requirements of these areas, several types of collection systems were considered. These include the following:

Curbside collection
Container collection - Stationary
Container collection - Leased
Primary / Secondary Collection, with or without recycling center
Street sweeping

c. Vehicle Considerations

To meet the waste collection requirements several types of vehicles and collection systems were considered. These include the following:

- Large size, rear hopper type compactor trucks with 10 to 20 m^3 capacity.
- Medium size, rear hopper type compactor trucks with 6 to 10 m^3 capacity.
- Small size, rear hopper type compactor trucks with 2 to 6 m^3 capacity.
- Skip Loader collection vehicles with containers with capacities of 4 to 8 m^3.
- Open top dump trucks with capacity of 4 to 8 m^3.

d. Selection of Vehicle and Collection System

To meet the diverse collection needs for the target area, a mixed waste collection system is proposed. The collection system will have the following components:

- Curbside collection with compactor trucks
- Leased container system
- Stationary container collection
- Primary / Secondary collection with container
- Primary / Secondary collection with recycling center
- Street sweeping

Collection frequency has been calculated to provide an adequate level of service and at same time reduce operating costs and maximize use of collection equipment. The collection frequency has been planned as shown in the table below.

Table 7-3: Combination of Equipments

Waste Generation Sources		Collection Method	Equipment / Facilities	Frequency
Household Waste	Inaccessible Areas	Primary / Secondary Collection	Skip loader trucks, containers, container station, pushcarts, recycling centers	3 times per week
		Stationary container collection	Skip loader trucks, containers, container station	3 times per week
	Accessible area	Curbside collection	Compactor trucks (4 m^3,8 m^3 and 15 $m^{3)}$, baskets or containers	Everyday
Businesses	Small generators	Curbside collection	Compactor trucks (4 m^3,8 m^3 and 15 m^3), baskets or containers	Everyday
	Large generators	Leased container system	Skip loader trucks, containers	As required

Public Cleansing	Streets	Manual sweeping, collection with dump truck	Dump truck (8 ton)	2 times per week
	Parks	Stationary container collection	Skip loader trucks, containers, container station	2 times per week

e. Planned Waste Amount

The table below shows the expected waste amount for various sources based on population and waste generation projections.

Table 7-4: Collection Amount (t/day)

Collection amount	2007	2008	2009	2010	2011	2012	2013	2014	2015
Households	82.6	100.2	116.7	132	145.9	158.5	188.2	216.2	242.1
Commercial-Restaurants	8.1	8.5	9.3	9.9	9.9	13.3	13.5	13.6	17.5
Commercial-Others	20.6	22.1	24.5	26.5	26.7	36.3	37.2	38.1	49.1
Markets	14.1	15	16.5	17.8	17.9	24.2	24.7	25.2	32.4
Hotels	0.4	0.5	0.5	0.6	0.6	0.8	0.8	0.8	1
Offices	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4
Schools	1.4	1.4	1.6	1.7	1.7	2.3	2.3	2.3	3
Factories	15.9	16.5	17.9	19	18.8	25.1	25.4	25.6	32.8
Hospitals	2.7	2.8	3	3.2	3.1	4.2	4.3	4.3	5.5
Slaughter House	1.9	2	2.1	2.2	2.2	2.9	2.9	2.9	3.7
Unidentified source	8.4	9.2	10	10.9	11.8	12.7	13.7	15	16.2
Street Sweeping	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.7
TOTAL	156.5	178.7	202.7	224.4	239.2	281.1	313.8	344.8	404.4

f. Planning Collection Method

A mixed collection system is planned to meet the needs of the various conditions within the collection area. Several collection methods will be used.

The table below shows a breakdown of waste collection amounts for each collection method.

Table 7-5: Collection Amount (tons per day)

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Curbside collection with 4m3 truck	24.78	30.06	35.01	39.60	43.77	47.55	56.46	64.86	72.63
Curbside collection with 8m3 truck	25.93	29.48	33.48	37.01	39.20	47.25	52.23	56.92	67.87
Curbside collection with 15m3 truck	69.13	78.51	88.74	98.04	104.05	123.46	136.86	149.57	176.39
Stationary collection	8.33	9.61	10.84	12.05	13.20	14.28	16.26	18.31	20.21
Leased Containers	19.78	20.73	22.58	24.10	24.00	32.23	32.68	33.03	42.40
Stationary container in a recycling center with primary collection service	4.13	5.01	5.84	6.60	7.30	7.93	9.41	10.81	12.11
Stationary container with primary collection service	4.13	5.01	5.84	6.60	7.30	7.93	9.41	10.81	12.11
Collection of street sweeping waste by dump truck	0.30	0.30	0.40	0.40	0.40	0.50	0.50	0.50	0.70
TOTAL	24.78	30.06	35.01	39.60	43.77	47.55	56.46	64.86	72.63

g. Equipment and Other Inputs Required

The number of vehicles and other equipment required for operations is shown in the table below.

Table 7-6: Summary of Equipment Required for Collection Needs

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Equipment									
Compactor Truck - 4m3	3	4	4	5	5	5	6	7	8
Compactor Truck - 8m3	3	3	3	3	4	4	5	5	6
Compactor Truck - 15m3	8	9	10	12	12	14	16	17	19
Skip Vehicle	5	6	7	7	7	8	9	10	11
Skip Container	37	45	51	51	52	61	67	74	86
Dump truck	1	1	1	1	1	1	1	1	1
Wheel Loader	1	1	1	1	1	1	1	1	1
Pushcarts	12	15	16	19	19	22	25	29	32
Pick-up Truck	2	2	2	2	2	2	2	2	2
Other									
Container Station	11	14	15	17	18	19	22	26	28
Recycling Center	1	1	1	1	1	1	1	1	1

h. Equipment Schedule

The procurement schedule can be summarized as shown in the table below.

Table 7-7: Equipment purchase schedule

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Totals
Compactor Truck - 4m3	3	1	0	1	0	0	1	4	2	0	12
Compactor Truck - 8m3	3	0	0	0	1	0	1	3	1	0	9
Compactor Truck - 15m3	8	1	1	2	0	2	2	9	3	1	29
Skip Vehicle	5	1	1	0	0	1	1	6	2	1	18
Skip Container	37	8	6	0	1	9	6	44	20	6	137
Dump truck	1	0	0	0	0	0	0	1	0	0	2
Wheel Loader	1	0	0	0	0	0	0	1	0	0	2
Pick-up Truck	2	0	0	0	0	0	0	2	0	0	4
Pushcarts	12	3	1	15	3	4	18	7	7	18	88
Container Station	11	3	1	2	1	1	3	4	2	0	28
Recycling Center	1	0	0	0	0	0	0	0	0	0	1

i. Personnel Plan

The number of workers and drivers has been based on the amount of waste to be collected and the number of vehicles used. An administrative and management structure including clerks, supervisors, engineers and section chiefs is also required to operate the collection system. Details of this structure are contained in chapter 11.6. Personnel needs are summarized in the table below.

Table 7-8: Personnel Required for Waste Collection Service

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Section Chief	1	1	1	1	1	1	1	1	1
Collection Engineer	1	1	1	1	1	1	1	1	1
Supervisor	2	2	2	2	2	3	3	3	3
Cleck	3	3	3	3	3	4	4	4	5
Driver	22	25	27	30	31	34	39	42	47
Operator	1	1	1	1	1	1	1	1	1
Worker	43	49	53	59	61	69	78	84	95
Worker in Center	5	5	5	5	5	5	5	5	5
Sweeper	25	32	32	38	38	44	44	50	50
TOTAL	103	119	125	140	143	162	176	191	208

7.2.3 Intermediate Treatment

a. Design of Compost Plant

This plan aims at constructing a plant that produces compost using organic rich waste collected from various markets.

a.1 Examination of Technical Alternative

a.1.1. Composition of Compostable Waste

Based on the result of the WACS, the composition of compostable waste applied to the plant design is assumed as shown in the table below.

- Foreign materials (non-compostable wastes) in the compostable wastes account for 10%.
- According to the result of the WACS, the moisture content of market waste was 60.2%. Since organic rich waste tends to contain more moisture, the moisture content of the waste for this plan was assumed to be 65%.

Table 7-9: Composition of the Compostable Waste

Composition		Market Waste Composition	Compost material
Compostable	Kitchen	66.4%	82.0%
	Grass	6.5%	8.0%
	Sub-total	72.9	90.0%
Non-Compostable	Paper	8.0%	3.0%
	Textile	0.9%	0.3%
	Plastic	11.6%	4.4%
	Leather	0.1%	0.0%
	Metal	0.0%	0.0%
	Glass	2.0%	0.7%
	Stone	1.2%	0.4%
	Others	3.3%	1.2%
	Sub-total	27.1%	10.0%
Total		100.0%	100.0%

a.1.2. Examination of Technical Alternative

There are basically two types of composting processes for the organic fraction of municipal solid wastes: the “aerobic process” (the so-called compost plant) and the “anaerobic process”

(in general terms, a biogas plant). The following table shows the comparison of the two processes.

Table 7-10: Comparison of Aerobic and Anaerobic Composting for Organic Fraction of MSW

Characteristic	Aerobic process	Anaerobic process
Energy use	Net energy consumer	Net energy producer
End products	Humus, CO_2, H_2O	Sludge, CO_2, CH_4
Volume reduction	Up to 50%	Up to 50%
Processing time	20 to 30 days	20 to 40 days
Curing time	30 to 90 days	30 to 90 days
Primary goal	Volume reduction	Energy production
Secondary goal	Compost production	Volume reduction, waste stabilisation

Source : Integrated Solid Waste Management, McGraw-Hill

As the compost plant is selected as one of the priority projects in the Study with the prime objective of "recovery of organic waste, especially kitchen waste", the aerobic process is selected for the design of this project.

Aerobic composting can be operated by either windrow composting, static pile composting or in-vessel composting. Furthermore, windrow composting has two types: minimal technology windrow and high-rate windrow.

a.1.3. Selection of Composting System

The team recommends that the new compost plant adopt the windrow system of minimal technology for the following reasons.

- The construction and operation cost is low.
- The two existing compost plants in MPP adopted this system, which proves the acceptability of this system.

a.1.4. Pre-treatment system to remove Non-compostable Material

The team proposed to adapt the following pre-treatment system, based on the analysis of the COMPED plant and the production process of the windrow system.

The pre-treatment system of the proposed compost plant is to remove non-compostable materials manually. There is no need to install large-scale machines for the purpose of size reduction and size separation. In addition, at the time of turning waste, some non-compostable material such as plastic and large-sized paper can be removed manually.

The only machine used to remove non-compostable material is a trommel, which is installed at the production stage. The trommel is indispensable to increase the quality of compost.

a.2 Preliminary Design

a.2.1. Outline

Location

The compost plant is to be located in the Dang Kor Disposal site (31.4ha) shown in theFigure 7-1.

Treatment Capacity

The treatment capacity of the proposed compost plant is designed to be 20 tons/day as the compostable wastes to be processed at this plant in 2007, the target year of the F/S, is projected at 18,323 tons/year (Market waste: 50.2 tons/day).

a.2.2. Equipment Schedule

The following equipment was selected for the operation and maintenance of the composting operation.

Table 7-11: Equipment Required

	Equipment	Specification	Quantity	Unit
1	Wheel loader (Fork lift type)	Capacity 0.7 m^3	1	nos
2	Trommel	1 ton/hour with hopper and conveyer	1	nos

a.2.3. Personnel Plan

The organization for the operation of the compost plant is proposed as shown in the following table.

Table 7-12: Required Staff for Compost Plant

Compost section	Section chief	1	person
	Clerk	1	person
	Supervisor	2	persons
	Operator	2	persons
	Worker	25	persons
Total		31	persons

7.2.4 Final Disposal System

a. Introduction

It is generally recognized that a sanitary landfill is the basic element of modern solid waste management. Thus, it is acknowledged that the majority of waste has to be disposed of even if efforts are provided to reuse the waste. As a priority step towards modern solid waste management, the city of Phnom Penh is recommended to strengthen the final disposal activity, which minimizes the environmental impact.

This section presents the preliminary design and cost estimates for a new final disposal site in Dang Kor, which has been selected by the MPP to be the future location for an inter-municipal landfill. The site comprises an area of approximately 31.4 ha as shown in the following figure.

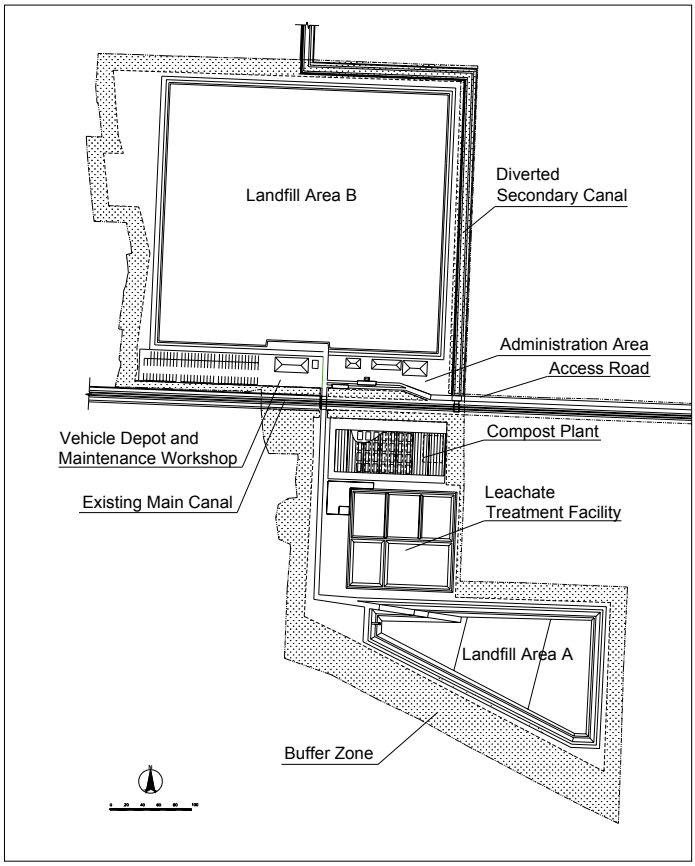


Figure 7-1: Layout Plan of the New Final Disposal Site in Dang Kor

b. Conception of Design

An area of about 26 ha was already acquired by MPP for the construction of the new disposal site. According to the plan formulated by MPP, the disposal site will be expanded to 100 ha in total in the future, and the area for the landfill operation will be developed every 25 ha. Therefore, the new disposal site construction plan of the JICA study can be regarded as the first phase of the whole project consisting of four phases.

The basic concept of the disposal site design is to arrange the necessary facilities and equipment, while considering its environmental impact on the surrounding areas. For sustainable management, it is preferable to keep the unit cost of the waste disposal (the construction cost per 1 ton of waste) as low as possible.

The features of the new disposal site plan are summarized below.

i. The new disposal site is located in a paddy field area. The result of the geological survey on the soil of the disposal site and its surrounding areas showed that the permeability of the natural soil is low, and the team came to the conclusion that the existing ground can be used as a natural liner of the bottom of the disposal site. This makes it possible to omit the installation of a liner, which usually increases the construction cost considerably.

ii. The new disposal site will be equipped with leachate treatment systems, which do not discharge treated wastes outside the site in order to prevent environmental degradation of the surrounding areas. In addition, the treatment systems include a pumping system that returns the excess leachate back to the landfill section in case the rainfall exceeds the expected maximum amount.

iii. The whole landfill area is divided into five sections, and in this plan one of these sections will be developed. The other four sections will be developed one by one in the future according to the operation plan. An important issue for this plan is to minimize the initial investment cost and the volume of the leachate to be treated. The peripheral road of the disposal site will be constructed during the first phase.

The most important concept of this plan is that each facility should be designed with a mind to minimize the environmental impact on the surrounding areas.

c. Design Conditions

The design conditions are summarized below.

c.1 Target Operation Level of Landfilling

The target level of sanitary landfill operation is set as level 4. The requirements for landfill operation at Level 4 are as follows:

- To prevent the infiltration of leachate;
- To cover waste with soil daily;
- To screen working areas from outsiders;
- To release gas promptly;
- To minimize the leachate quantity to be discharged outside;
- To have an adequate drainage system;
- To have a proper access road; and
- To have a leachate collection and evaporation system.

c.2 Commencement of Sanitary Landfill Operation

The operation of the new sanitary landfill is to commence at the beginning of 2007.

c.3 Estimated Amount of Waste Disposal in the Dang Kor Disposal Site

The new disposal site in the Dang Kor Disposal site is designed to receive waste discharged from the following seven Sangkats, along with general waste from medical institutions in MPP.

Table 7-13: 7 Khans in Phnom Penh

Urban Area	Chamkar Mon
	Daun Penh
	Prampir Makara
	Toul Kork
Rural Area	Dang Kor
	Mean Chey
	Russei Keo

Table 7-14: Estimated Daily Amount of Waste Disposal in the Dang Kor Disposal Site

Year	All Phnom Penh (Total) (ton/day)	Description			
		MSW		Medical Waste (general waste) (ton/day)	Industrial waste (general waste) (ton/day)
		Urban area (ton/day)	Rural area (ton/day)		
2007	923.7	548.8	325.1	12.3	37.5
2008	990.0	577.3	359.7	13.1	39.9
2009	1,064.7	606.6	401.6	13.9	42.6

2010	1,140.6	636.7	443.6	14.9	45.4
2011	1,205.0	659.7	481.8	15.7	47.8
2012	1,301.2	683.1	551.1	16.5	50.5
2013	1,367.0	705.9	590.6	17.4	53.1
2014	1,437.5	728.3	635.0	18.3	55.9
2015	1,539.7	751.4	710.0	19.3	59.0

c.4 Required Capacity of Landfill Sections

The landfill site should be constructed section by section, and the duration of the operation at each section is expected to be from three to five years. In the disposal site construction plan, the team assumed that the disposal site of 26 ha could receive waste for six years from 2007 to 2012.

The estimated annual amount of waste disposed at the Dang Kor Disposal Site is presented in the following table.

Table 7-15: Estimated Annual Amount of Waste Disposal in Dang Kor Disposal Site

Year	Waste Disposal		Disposal Site
	Daily Total (tons/day)	Daily Total (tons/day)	
2003	668.6	244,039	SMCDS
2004	715.1	261,012	
2005	769.0	280,685	
2006	827.2	301,928	
2007	923.7	337,151	DKDS
2008	990.0	361,350	
2009	1,064.7	388,616	
2010	1,140.6	416,319	
2011	1,205.0	439,825	
2003	668.6	244,039	
2004	715.1	261,012	
2005	769.0	280,685	

The required capacity of the landfill was determined by the following equation.

V= V2 + V3
V2=V1 x 0.1
V : required volume
V1 : volume of waste to be dumped (apparent density=0.5 tons/m^3)
V2 : volume of soil required for covering waste dumped
V3 : volume of waste in a stable state (apparent density = 0.8 tons/m^3)

In order to calculate the required capacity of the landfill sections, the following assumptions are made.

- The required amount of soil for covering the waste dumped daily is 10 % of the waste dumped in volume, excluding that for final cover.
- The unit weight of the waste just after dumped in a landfill is 0.5 ton /m^3.
- The unit weight of waste in a stable state after filling is 0.8 ton /m^3.

- The water content of waste when discharged is 68.3wt% (according to WACS study), the content of decomposable matter is 24.2wt%, non-decomposable matter is 7.5wt% and when in a stable state it is 50wt%
- The decomposition rate of organic material in a stable state is 10%.
- Therefore, if the weight of the waste just after discharged in a landfill is 1 ton, the waste weight after half a year calculated in accordance with the above mentioned conditions is 0.586 tons.

The required capacity of landfill sections are presented in the following table.

Table 7-16: Required Capacity of Landfill

year	Weight of Discharge waste	V1	V2	Waste Weight in Stable State	V3	V	Accumulate Volume	Required Capacity
		Volume of just dumped waste	Cover Soil		Waste Volume in Stable State	Total Volume		
	Wd	V1= Wd / 0.5	V2= V1 x o.1	Ws= Wd x 0.586	V3= Ws/0.8	V=V2+V3		
	ton/year	m^3/year	m^3/year	ton/year	m^3/year	m^3/year	m^3	m^3
2007	337,151	674,302	67,430	197,570	246,963	314,393	314,393	
2008	361,350	722,700	72,270	211,751	264,689	336,959	651,352	
2009	388,616	777,232	77,723	227,729	284,661	362,384	1,013,736	Phase 1
2010	416,319	832,638	83,264	243,963	304,954	388,218	1,401,954	2,300,000
2011	439,825	879,650	87,965	257,737	322,171	410,136	1,812,090	
2012	474,938	949,876	94,988	278,314	347,893	442,881	2,254,971	

d. Design of Facilities

The proposed disposal site is to be composed of the following facilities:

- Main Facilities

- Enclosing structure: enclosing bank and divider
- Drainage system: open side drain, etc.
- Access: main access road, on-site road

- Environmental protection facilities

- Buffer zone
- Litter scattering prevention facilities
- Gas removal facilities
- Leachate collection facilities
- Leachate evaporation facilities
- Monitoring well

- Buildings and accessories

- Entrance area
- Site office
- Weighbridge
- Tire washing pit
- Gate
- Safety facilities: gates, fences and street lights
- Others: parking lot, etc.

d.1 Equipment Planning

d.1.1. Planning Conditions

It is essential to consider the following conditions to plan the landfill equipment to be acquired.

- Equipment that can work well on poor ground is required.
- Equipment with a big capacity to crush and compact combustibles and non-combustibles is required.
- Equipment that can carry out daily or weekly soil covering is required.
- Equipment with a high capacity for compaction is necessary not only for the ultimate use of the site when completed, but also for the preservation of sanitary conditions as well as the lengthening of the life span of the disposal site.

d.1.2. Equipment Schedule

The required equipment for operation and maintenance of the landfill operation are shown in the below table.

Table 7-17: Required Landfill Equipment Purchase Schedule

Equipment		Specification	unit	2007	2012	2015
1	Bulldozer	21tons	nos	4	5	6
2	Wheel loader	1.2m3	nos	1	1	1
3	Water Tank truck	6,000 liters	nos	1	1	1
4	Dump truck	11 tons	nos	2	2	3
5	Pickup truck	4WD	nos	2	2	2
6	Excavator	0.7m3	nos	2	2	3

d.2 Personnel Schedule

The staffs for landfill operation of the Dang Kor Disposal Site are scheduled as follows.

Table 7-18: Required Staffs for Dang Kor Disposal Site Operation

Staff	Unit	2007	2012	2015
Section chief	person	1	1	1
Engineer	person	1	1	1
Clerk (include Weighbridge staff)	person	5	5	5
Supervisor	person	4	4	4
Operator	person	22	25	29
Worker	person	12	12	12
Total		45	48	52

7.2.5 Maintenance Workshop

a. Introduction

PPWM has a plan to increase the number of collection vehicles from two to 43 in order to start the collection service in the three rural Khans in 2007. In order to provide collection service continuously in a wider area, PPWM needs a depo for the proper management of collection vehicles and a workshop for regular inspection and the service and minor repair of vehicles.

MPP has a plan to acquire an additional 1 ha of land for the construction of a depo and maintenance shop, along with the land for the new disposal site in Dang Kor.

b. Design Conditions

b.1 Land and layout plan

b.1.1. Land

The maintenance workshop is planned to be constructed inside the Dang Kor disposal site.

b.1.2. Layout plan of facilities

The layout plan of the maintenance workshop in the Dang Kor Disposal site is shown in the Figure 7-1. The maintenance shop will share the office with the landfill section and compost facility.

The list of facilities of the maintenance workshop is shown below.

Table 7-19: Facilities in the Maintenance Workshop

Shops
Service shop
Lubricant shop
Battery & tire shop
Spare parts & tools storage
Maintenance Administration Unit
Car wash

b.2 Facilities plan

The major functions of the facilities in the maintenance workshop are shown in the following table.

Table 7-20: Function of Maintenance Workshop at Dang Kor Disposal Site

Items	Facilities	Major function
Maintenance shop	- Service shop	- regular inspection and maintenance oil change valve adjustment change of fuel elements minor repair - final inspection after repair - issuance of the repair record
	- Storage of lubricant	- lubricant dispenser, tool shelf
	- Battery & tire shop	- inspection and charge of battery
	- Storage of parts & tools	- control and storage of spare parts and tools
	- Inspection pit	- inspection of vehicles - washing vehicles and equipment
Parking	- Parking space for compactor	- for 30 large vehicles
	- Parking space for Skip loader	- for 50 light vehicles
	- Parking space for visitors	- for 5 pick up and 5 cars of visitors
	- Parking space for motorcycles	- for 30 motorcycles

c. Personnel Requirement

The organizational structure for operation of the maintenance workshop at Dang Kor Disposal Site is proposed as shown in the following table.

Table 7-21: Required Staff for Maintenance Workshop

Staff	Unit	2007	2012	2015
Director	person	1	1	1
Chief mechanic	person	2	2	2
Mechanic	person	6	8	9

Clerk	person	3	3	3
Total	person	12	14	15

7.3 Administration and Organization

7.3.1 Administration

Regarding the administrative framework of MPP, the roles and responsibilities of the relevant organizations are not clear and the respective organizations are not qualitatively or quantitatively suited to promote sound SWM services. In order to solve this problem, the following measures are recommended.

- The roles and responsibilities of the organizations concerned with SWM in Phnom Penh should be clarified. Fundamentally, from the standpoint of securing a clean and healthy environment for all citizens living in the city, the Municipal Cabinet, in compliance with the Mayor's wishes, should establish and enforce comprehensive SWM policy. DPWT should be responsible for supervising the disposal site construction work and collection services conducted by PPWM. DOE should be responsible for the monitoring and control of the waste disposal services provided by PPWM and the private contractor (CINTRI) and for educating and informing the public. PPWM should be the service provider responsible for operating and managing the waste disposal work under its jurisdiction (collection, intermediate treatment, final disposal, etc).
- Using the M/P as a basis, the four bodies mentioned above should establish their respective systems in order to promptly carry out their respective roles, and implement the M/P quickly and efficiently by strengthening cooperation and making the necessary adjustments. The Municipal Cabinet should set up a coordinating committee and hold regular meetings to control the functions of the four bodies responsible for solid waste management services.

7.3.2 Organization

The PPWM will eventually be developed into an autonomous organization directly under MPP, and it shall be strengthened to provide the SWM services proposed in the M/P. The proposed organization structure of it is presented in Figure 7-2.

The **Business Committee** will act as a Board of Directors, and its members are appointed by the MPP. The **DPWT** will continue to supervise and support the PPWM, especially development of the new landfill, construction of recycling facilities and procurement of vehicles and equipment. The Governor will be the top of the PPWM and under him there will be an **Office of Governor.** There will be three Deputy Governors, each responsible for two departments. Under them there will be six operational departments as follows:

a. Office of Governor

The Office of Governor is responsible for the overall management of PPWM, acting as a liaison with MPP and the public, and formulating development strategies and operational plans for PPWM. The office will consist of a **Policy Planning Section** and a **Public Relations Section**. The Policy Planning section will make a policy for the overall management of PPWM, and formulate development strategies and operational plans. The

Public Relations section will be responsible for public awareness and information campaigns, providing information to the public, customers and contractors that PPWM is doing business with. It will also be responsible for receiving and processing complaints from the public and the customers.

b. Collection and Cleansing Department

The **Collection and Cleansing Department** is responsible for the services of waste collection and transportation, and public area cleansing. The proposed organization structure is presented in the Figure 7-3. Five sections should be established within the Department to meet the requirements. They include three Collection Sections (one for each Khan), a Fleet Management Section and a Public Area Cleansing Section. As the service area and quantity of waste to be collected increases, the workforce and managerial staff also have to increase correspondingly.

c. Liquid Waste Operation Department

The **Liquid Waste Operation Department** is responsible for the services of liquid waste (sludge from septic tank) collection, transportation and final disposal. The proposed organization structure is presented in the Figure 7-4.

d. Treatment, Maintenance and Disposal Department

The **Treatment, Maintenance and Disposal Department** is responsible for the operation of the compost plant, maintenance shop and final disposal site. The proposed organization structure is presented in the Figure 7-5.

e. Planning and Monitoring Department

The **Planning and Monitoring Department** is responsible for long-term and short-term planning activities; development of sector strategies (such as 3Rs); preparing and implementing research and development; preparing plans for construction of new facilities and expansion of service areas; setting up tender documents for contracting out services, construction and procurement of equipment; reviewing and updating service area zoning and collection routing; collecting performance data and maintaining the management information system (MIS); and preparing periodic service performance reports to the Governor.

f. Finance and Accounting Department

The **Finance and Accounting Department** will be responsible for the financial aspects of billing and revenue collection; payments to contractors and suppliers, budgeting and accounting, preparing tariff structures and annual adjustments of tariffs; recommending new financial instruments relevant to recycling and resource recovery systems; maintaining and updating a customer database; etc. The Department will prepare periodic status reports for the Governor.

g. Administration and Human Resources Department

The **Administration and Human Resources Department** will be responsible for all personnel related matters, salaries and benefits; the legal aspects of contracting out collection and disposal services, supply, technical assistance and construction of facilities; and issuing fines and penalties to enforce compliance with contract conditions, operating permits, illegal littering, etc.

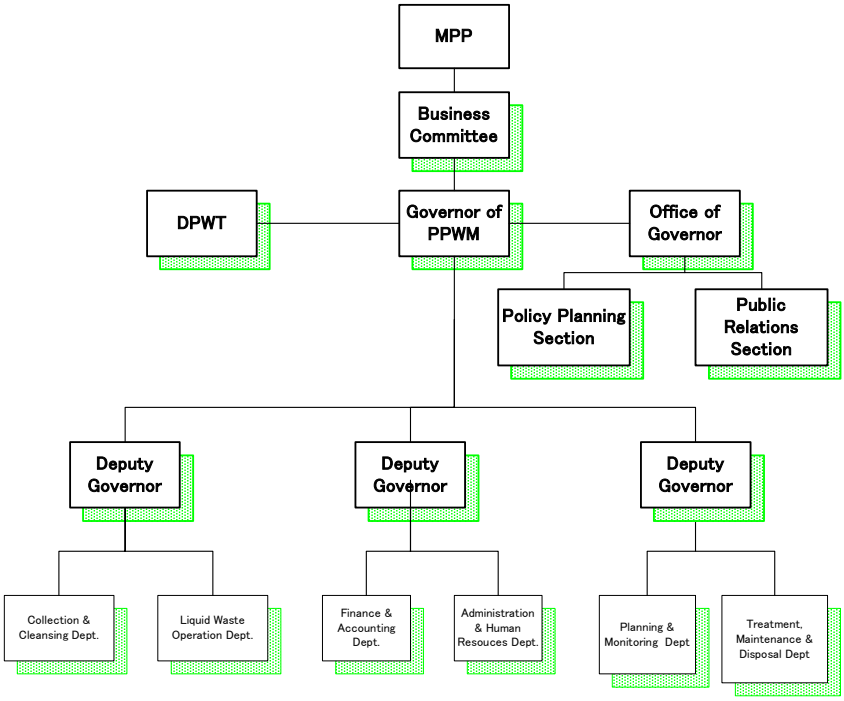


Figure 7-2: Proposed Organization Chart of PPWM in 2015

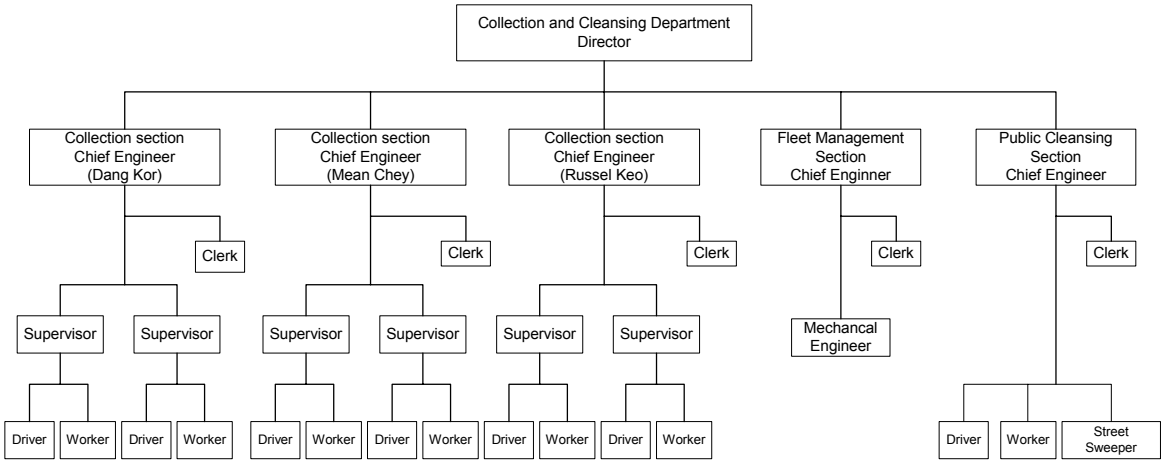


Figure 7-3: Proposed Organization Chart of Collection and Cleansing Dept. in 2015

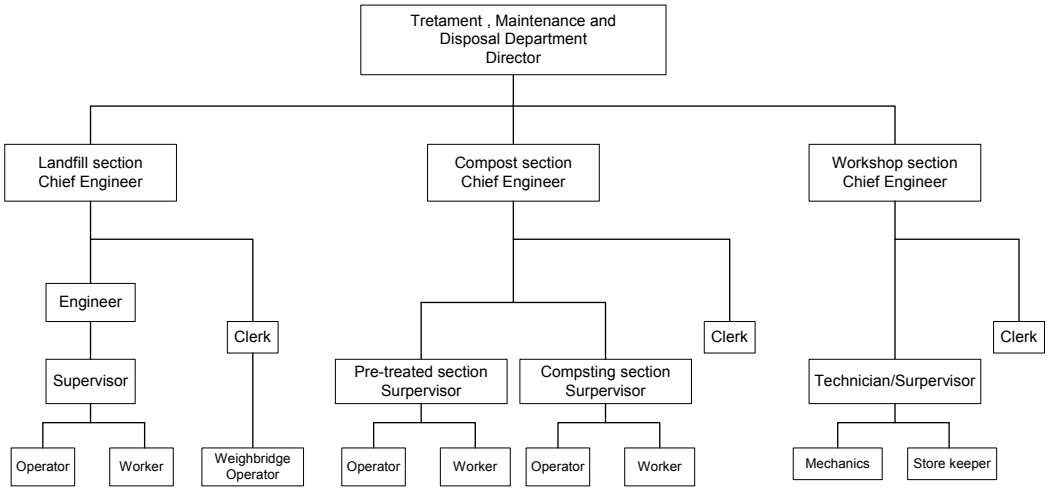


Figure 7-4: Proposed Organization Chart of Treatment, Maintenance and Disposal Dept.

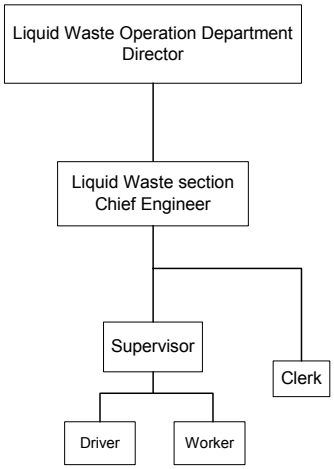


Figure 7-5: Proposed Organization Chart of Liquid Waste Operation Dept in 2015

7.4 Cost Estimation

7.4.1 Collection and Transport System

a. Investment Schedule

Based on the number of units required and the unit prices, the investment requirements have been calculated as shown below.

Table 7-22: Investment Required (1,000 $US)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Collection Equipment	1,746	193	140	195	59	219	320	1,601	521	144
Construction of facilities	58	2	1	2	1	1	2	3	2	-
Total	1,804	195	141	197	60	220	322	1,604	523	144

b. Operation and Maintenance Cost

Operation and maintenance costs are summarized below.

Table 7-23: Summary of Operations and Maintenance Cost (1,000US$)

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fuel	169	191	207	220	225	248	275	298	332
Personnel	83	94	99	110	112	127	138	149	163
Other (uniform etc.)	3	3	4	4	4	5	5	5	6
Maintenance	61	71	77	83	86	97	108	118	133
TOTAL ($US)	316	359	387	417	427	477	526	570	634

c. Depreciation Costs

Depreciation costs have been calculated based on the expected life of vehicles and facilities. At the end of their useful life, vehicles and equipment will be sold as "scrap equipment". The value of scrap equipment is calculated as 10% of the purchase price.

The total depreciation costs are summarized below.

Table 7-24: Summary of Depreciation Costs (1,000 US$)

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Depriciation	185	210	228	253	260	288	329	354	397
Return scrap valie	0	0	0	0	0	0	0	141	19
Adjusted Total	185	210	228	253	260	288	329	495	416

d. Summary of Waste Collection Costs

The total operating costs are summarized in the table below. Investment costs have not been included in the operating cost calculation because initial investment is expected to be from grant aid and not part of the operating costs. Eventual vehicle replacement costs are covered by depreciation.

The costs for street sweeping and the cleansing of parks and public areas are not income generating activities. The cost of this service should be funded from the municipal budget. For this reason, public cleansing costs have not been included in the overall operating costs for the waste collection costs shown below.

Table 7-25: Waste Collection Costs (1,000 US$)

	2007	2008	2009	2010	2011	2012	2013	2014 *	2015	Total
O & M	286	325	352	379	390	434	485	524	588	3,763
Depreciation	178	203	221	245	253	281	322	210	369	2,281
Total Costs	464	528	573	624	643	715	807	734	957	6,044

Table 7-26: Unit Costs

	2007	2008	2009	2010	2011	2012	2013	2014 *	2015	Total
Waste collected per day (tons)	156.2	178.4	202.3	224.0	238.8	280.6	313.3	344.3	403.7	
Waste collected per year (1000 tons)	57	65	74	82	87	102	114	126	147	855
Cost per ton ($US)	8.14	8.10	7.76	7.64	7.37	6.98	7.05	5.84	6.50	7.07

* Depreciation costs in 2014 were off set by sale of scrap vehicles, resulting in a significant reduction of unit costs for that year

e. Summary of Public Cleansing Costs

Public cleansing consists of street sweeping and collection of waste from public parks. For the period 2007-2015, the streets targeted for sweeping will start at 15 km and increase yearly to a total of 24 km by the end of the period. Labor inputs for sweeping are summarized below.

Table 7-27: Inputs for Public Cleaning

		2007	2008	2009	2010	2011	2012	2013	2014	2015
Road Cleaning *	km	4.00	5.00	5.00	6.00	6.00	7.00	7.00	8.00	8.00
Labor input**	pers/km	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25
Sweepers Required	pers	25	32	32	38	38	44	44	50	50
Waste Generation	kg/km/day	53.37	53.37	53.37	53.37	53.37	53.37	53.37	53.37	53.37
Waste Amount	ton/day	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4

* Figures shown are daily sweeping requirements based on cleaning all streets twice per week with a 6-day per week work schedule

** Based on data from CINTRI (350 sweepers / 56km = 6.25 sweepers/km)

In addition to sweepers inputs, this section will have one dump truck with one driver and one worker for collection of the swept waste.

7.4.2 Final Disposal System

a. Administration Facilities

The investment cost and schedule for the administration section are shown in Table 7-28 and Table 7-29, respectively. The cost includes the following components: facility construction and operation equipment. It should be noted that the cost for land preparation is not included.

Table 7-28: Investment Cost of the Landfill Section

Item	Cost (US$)
Facility Construction of Administration section	1,748,000
Total cost	1,748,000

Table 7-29: Investment Schedule of the Administration Section (2005-2015)

unit : US$ 1,000

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
D/D	95	64	0	0	0	0	4	3	0	0	0	166
Civil	0	1,589	0	0	0	0	0	72	0	0	0	1,661
O&M	0	0	132	132	132	132	137	134	192	139	139	1,269
Total	95	1,653	132	132	132	132	141	209	192	139	139	3,096

Note: D/D : Detailed design, Civil : Civil works, Machine :Machinery

b. Disposal Facilities

The investment cost and schedule for the landfill section are shown in Table 7-30 and Table 7-31, respectively. The cost has two components: facility construction and operation equipment. It should be noted that the cost for land preparation is not included. The table also includes the cost of leachate treatment facilities, which are mentioned in the next section.

Table 7-30: Investment Cost of the Landfill section

Item	Cost (US$)
Facility Construction of Landfill Section	5,801,000
Equipment (Machine and V&E)	1,341,000
Total cost	7,142,000

Note: V&E : Vehicles and Equipment

Table 7-31: Investment Schedule of the Compost Plant (2005-2015)

unit : US$ 1,000

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
D/D	316	211	0	0	0	0	193	129	0	0	0	849
Civil	0	5,274	0	0	0	0	0	3,220	0	0	0	8,494
V&E	0	1,341	0	0	0	175	0	0	1,724	0	0	3,240
O&M	0	0	1,322	1,304	1,304	1,304	1,344	1,334	1,342	1,357	1,468	12,079
Total	316	6,826	1,322	1,304	1,304	1,479	1,537	4,683	3,066	1,357	1,468	24,662

Note: D/D : Detailed design, Civil : Civil works, Machine :Machinery
V&E : Vehicles and Equipment, O&M : Operation and maintenance

c. Compost Plant

The investment cost and schedule for the compost plant are shown in Table 7-32 and Table 7-33, respectively. The cost has two components: facility construction and operation equipment. It should be noted that the cost for land preparation is not included.

Table 7-32: Investment Cost of the Compost Plant

Item	Cost (US$)
Facilities Construction of Compost Plant	1,084,000
Equipment & Machine	220,000
Total cost	1,304,000

Note: Machine : Machinery, V&E : Vehicles and Equipment

Table 7-33: Investment Schedule of the Compost Plant (2005-2015)

unit : US$ 1,000

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
D/D	59	40	0	0	0	0	0	0	0	0	0	99
Civil	0	985	0	0	0	0	0	0	0	0	0	985
E & M	0	110	0	0	0	0	0	0	110	0	0	220
O&M	0	0	56	56	56	56	62	58	61	63	63	531
Total	59	1,135	56	56	56	56	62	58	171	63	63	1,835

Note: D/D : Detailed design, Civil : Civil works, Machine :Machinery
V&E : Vehicles and Equipment, O&M : Operation and maintenance

7.4.3 Overall Cost Estimation

The annual project cost for implementing the Master Plan is estimated, as shown in the below table, according to the implementation schedule.

Table 7-34: Project Cost for M/P

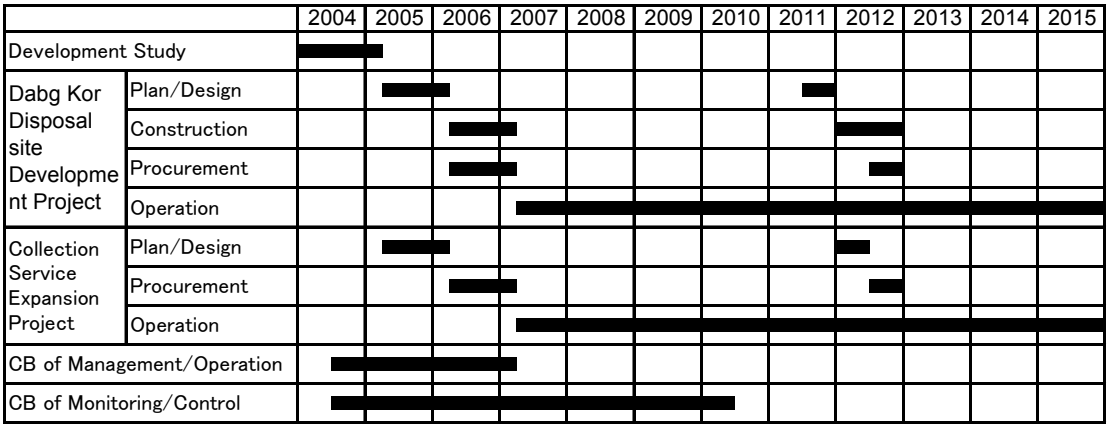
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Collection	Collection vehicles	Invest.	0	1,804	195	141	197	60	220	322	1,604	523	144	5,210
		O&M	0	0	316	359	386	417	428	475	527	569	634	4,111
Intermediate treatment	Compost plant	Invest.	59	1,135	0	0	0	0	0	0	110	0	0	1,304
		O&M	0	0	56	56	56	56	62	58	61	63	63	531

Final disposal	Admin.	Invest.	95	1,653	0	0	0	0	4	75	0	0	0	1,827
	Landfill	Invest.	316	5,485	0	0	0	0	193	3,349	0	0	0	9,343
	Landfill	Invest.	0	1,341	0	0	0	175	0	0	1,724	0	0	3,240
	Workshop	Invest.	76	1,498	0	0	0	0	0	0	0	0	0	1,574
	Landfill	O&M	0	0	795	777	777	777	844	820	897	871	984	7,542
SMCDS closure project		Invest.	0	75	745	0	0	0	0	0	0	0	0	820
		O&M	0	0	24	14	14	24	14	14	24	14	14	156
Total			546	12,991	2,131	1,347	1,430	1,509	1,765	5,113	4,947	2,040	1,837	35,656

7.5 Implementation Plan

The implementation schedule for the priority projects is shown in the following table.

Table 7-35: Implementation Schedule



7.6 Selection of Priority Projects

The following three projects were selected as priority projects to be targeted in the feasibility study and implemented urgently in the first phase of the Master Plan.

1. Dang Kor Disposal Site Development Project

As the SMCDS will reach full capacity by end of 2006, the development of a new disposal site to continue landfill operation from the beginning of 2007 is an urgent and serious issue. To deal with this issue, the Study team will make a development plan for the new disposal site in Dang Kor, which has been verified as a suitable candidate site in this study.

2. Waste Collection Service Expansion Project

This project is to strengthen the PPWM's capability of waste collection to eliminate unserviced and insufficiently serviced areas from the city in collaboration with the private sector according to Table-6-5: Area-wise Responsibilities and Roles between PPWM and CINTRI.

The service area of each will be decided through negotiations between MPP and CINTRI. However, because both parties did not reach an agreement on area demarcation as of the end of February 2005, the Study team estimated the waste amount to be collected by PPWM based on the site reconnaissance and the weighbridge data, and planned the waste collection system required to collect it according to the request of MPP.

3. SMCDS Closure Project

SMC disposal site can be used until early 2007 due to the 3.6 ha area that was expanded through the study. By carrying out the aged waste to the neighbouring barrow pit requested by its owner, the remaining life of the SMC disposal site is prolonged. Therefore, PPWM can have additional time for managing waste disposal until the new disposal site is opened.
Preparation of a plan to smoothly transfer the landfill operation from the existing site to the new site must be carried out simultaneously with the planning of the new disposal site development. It is also important to plan countermeasures to minimize possible environmental impacts of the landfilled waste on the surrounding area.

7.7 Financial Analysis

The Projects subject to financial appraisal here include:

- Waste Collection Expansion Project
- Dan Kor New Final Disposal Landfill Project

As to MSW collection and haulage in the remaining area of PPWM service area, the Study proposes that it will be carried out by CINTRI, which currently provides it in Phnom Penh. However, due to insufficient financial and cost data disclosed by CINTRI, the Study does not make financial appraisal of its operation.

a. Current cost of MSW

According to the data provided by PPWM, the cost of MSW collection/haulage in NIP zone per ton of waste collected and SMC disposal operation per ton of waste received are estimated as shown in the table below.

Table 7-36: The Cost of MSW Collection/Haulage and Operation of SMC Disposal Site by PPWM

Year / SWM	Unit	2002	2003
Collection and haulage	US$/ton	6.93	6.73
Final disposal	US$/ton	0.57	0.43
Total	US$/ton	7.50	7.16

Remark: The above cost does not include the depreciation cost of the buildings, vehicles and equipment. The cost of MSW collection and haulage by CINTRI is not included in the above estimation.

b. Financial appraisal of the M/P

The following preconditions are established for financial appraisal of the M/P.

Table 7-37: Preconditions of the Project

Implementation Body	PPWM
Project Period	12 years from 2005 to 2015
Project Income	(Income from MSW collection and haulage by PPWM) • Income from user fee from the service area of PPWM from 2007 to 2015. (Income from Dang Kor final disposal landfill) • Income from tipping fee from CINTRI and PPWM. • Income from selling the excavated soil (The average annual income

	of 279,000 US dollars is assumed to be earned during its operation period from 2007 to 2015.). • Income from selling compost materials produced in the compost plant at the rate of 200 riel per kilogram (The average annual income of 61,250 US dollars is assumed during its operation period from 2007 to 2015.
Investment Cost	**1. MSW collection and haulage** Initial investment is made in 2006 for the following purposes. (Purchase of vehicles) • Compactor Truck (loading capacity of 4m^3, 8m^3 and 15m^3) • Skip Loader Truck • Skip Containers (5 m^3) • Wheel Loader • Pushcarts • Pick-up Trucks • Dump truck (Construction) • Container Stations • Vehicles Maintenance Workshop Collection and haulage vehicles and equipment will be purchased in accordance with the increase in the number of service users and expansion of the service areas while the end-of-life vehicles and equipment will also be replaced. **2. Dang Kor final disposal site** The following investment and actions will be made from 2005 to 2012. • 2005 - 2006: Design and construction of landfill and compost plant • 2006 - 2007: Closure of SMCDS • 1 Jan. 2007: Starting operation of the New disposal site • Phase II development of landfill will start in 2012 for its operation from 2013.
O/M Cost	O/M cost is estimated for each year from 2007 to 2015 based on the determined unit cost and amount.
Depreciation	**1. MSW collection and haulage** 20, 15 and 7 years of depreciation period are set for building and equipment and vehicles respectively. The scrap value is set at 10% for all vehicles and equipment while the buildings are assumed completely depreciated. **2. Dang Kor final disposal landfill** The site development and building for common use including road, administration building, leachate treatment facility, compost plant and so forth in the final disposal landfill are completely depreciated in 20 years while the landfill area itself is completely depreciated in the same years of possible landfill operation. Vehicles and equipment used in landfill are depreciated in 7 years with a scrap value of 10%.
Price	All the cost is estimated based on the current price of 2003. No price escalation is included.
Discount rate	Discount rate is set up at 10%, taking into account inflation and market rate in Cambodia.

Based on the preconditions above, the Study analyzes the required fee rate MSW collection and final disposal to make the above projects financially feasible.

b.1 Financial Analysis of MSW Collection by PPWM

Financial analysis of MSW collection in the area shown in the scenario 2 by PPWM (hereunder described as PPWM-MSW Collection) is made in two cases. One is the case with normal public investment project with no grant assistance and the other is the case with

grant assistance to initial development cost. The Study analyzes the required fee rate of MSW collection to make PPWM-MSW Collection financially feasible in these 2 cases. In the case of normal public investment project with no grant assistance, the Study established the financially feasible level of the project at 10 % of financial internal rate of return (FIRR), taking account the discount rate set above. In the case with grant assistance to initial investment, financial feasibility of the project is secured at the level of fee rate which assures enough income to cover the whole cost (depreciation, additional investment cost, and operational expenses) required during the project period.

b.1.1. Financial Analysis of Case 1 (Normal public investment with no grant assistance)

Based on the estimated amount of MSW generation from household and business establishment and the total cost of PPWM-MSW collection in the M/P, the Study here estimated the required level of SWM collection fee rate to meet FIRR of more than 10%. The fee rate is estimated in US dollar per ton of waste collected. As the baseline case, the fee collection ratio for household and business establishment is set at 80%, which is equal to the fee collection ratio of PPWM at NIP Zone in 2003, and 100 % for business establishment while the same fee rate is applied to household and business establishment. The fees per ton of waste collected from the households and business establishment are assumed as equal in the case of baseline.

The result of estimation under the assumptions above showed that the required fee rate of MSW collection to reach FIRR of 10% was 13.94 US dollars per ton of waste collected. In the case of applying this fee rate, the average monthly fee of MSW collection for household will be as shown in the table below.

Table 7-38: Estimated Fee Rate of MSW Collection for Household

	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015
Amount of MSW collected	Kg/month/ household	102	107	113	118	124	113	119	125	113
Fee rate	US$/month/ household	1.42	1.49	1.58	1.64	1.73	1.68	1.66	1.74	1.58

Remark: The decrease of MSW collection amount in 2012 and 2015 comes from the increase in reduction of MSW generation at source by recycling, etc., which is assumed in the M/P.

b.1.2. Financial Analysis of Case 2 (with grant assistance to initial investment)

The Study here analyzes the fee rate of MSW collection in the case of providing grant assistance to fully cover the initial investment cost arising in 2005 and 2006. Financial feasibility of PPWM-MSW collection in this case is secured if it earns enough income to cover the whole project cost including depreciation, additional equipment investment and operational expenses arising during the project period. The result of estimation showed that the required fee rate of MSW collection were able to be lowered to 11.61US dollars per ton of waste collected in the case with grant assistance. The average monthly fee rate of MSW collection per household in this case is shown in the table below.

Table 7-39: Estimated Fee Rate of MSW Collection for Household

	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015
Amount of MSW collected	Kg/month/ household	102	107	113	118	124	113	119	125	113
Fee rate	US$/month/ household	1.18	1.24	1.31	1.37	1.44	1.31	1.38	1.45	1.31

b.1.3. Financial Analysis of PPWM-MSW Collection

The results of financial analysis above indicated that the required fee rate of MSW collection was different as shown in the table below between the case with and without grant assistance.

Table 7-40: Comparison of MSW collection fee rate between the cases with and without grant assistance

	Fee Rate (US$/ton)	Household Fee Rate (US$/month/household)				
		2007	2009	2011	2013	2015
Without grant assistance	13.94	1.42	1.58	1.73	1.66	1.58
With grant assistance	11.61	1.18	1.31	1.44	1.38	1.31

The reduction rate of MSW collection rate in the case with grant assistance remains at comparatively low level of 17%. It is mainly due to the low ratio of initial investment cost to the total project cost. The project requires replacement of MSW collection vehicles within the project period as well as additional investment for purchasing new vehicle to meet the expansion of collection area and increase in number of household subject to MSW collection. Furthermore, ration of the operation and maintenance cost such as fuel cost etc. to the project cost is comparatively high as 44%. All of these factors lower the effect of grant assistance upon financial viability of the project.

Even in the case with grant assistance, the required fee rate of MSW collection is higher by approximately 80% than the current collection cost of 7US dollars per ton of waste collected by PPWM in NIP Zone while it is more than two-fold in the case without grant assistance. Moreover, the above fee rate is estimated with the comparatively higher assumption of fee collection ratio for household (80%) as well as business establishment (100%). The fee collection ratio may be lowered if the fee rate increases as shown above. However, the result of business establishment survey done by the Study showed that the current fee rate for business establishment is established at more than double of the household's one. Further investigation and analysis will be required for establishment of fee rate and collection ratio for household and business establishment.

b.2 Financial Analysis of Dang Kor Final Disposal Landfill

The Study here makes a financial analysis of Dang Kor new final disposal landfill, which is responsible for sanitary landfill disposal of MSW collected in Phnom Penh. Similar with the case of PPWM-MSW Collection above, the analysis is made for the cases with and without grant assistance.

In analyzing the tipping fee at Dang Kor final disposal site, the Study assumes that the same fee rate is applied to CINTRI as well as PPWM. The required tipping fee rate for financially feasible operation of Dang Kor final disposal landfill is estimated in per ton of waste disposal. The tipping fee is collected on weight basis while its collection rate is assumed 100% for PPWM as well as CINTRI.

b.2.1. Case with no grant assistance

Similar with the case of PPWM-MSW Collection, the required financial feasibility level in the case of normal public investment with no grant assistance is set at 10% of FIRR. The income from tipping fee collection is estimated as a result of multiplying the estimated

amount of MSW disposed by PPWM and CINTRI by the tipping fee rate per ton of waste disposal.

Table 7-41: Estimated Amount of MSW Disposal by PPWM and CINTRI

Unit: thousand tons/year

	2007	2008	2009	2010	2011	2012	2013	2014	2015
CINTRI	280	296	315	334	353	372	384	399	414
PPWM	57	65	74	82	87	103	115	126	148
Total	337	361	389	416	440	475	499	525	562

Besides the tipping fee collection above, the income from selling excavated soil and compost materials produced in the compost plant is included as the revenue of the project. The total cost of the project is taken from the estimation in the M/P. The result of financial analysis based on these assumptions showed that the required fee tipping fee rate to reach 10% of FIRR in the case with no grant assistance was 5.92 US dollars per ton of waste disposal, which was more or less nine-fold of the current final disposal cost at SMC disposal site in 2002.

b.2.2. Case with grant assistance

The Study analyzes the required tipping fee rate in the case with grant assistance to fully cover initial investment cost arising in the year from 2004 to 2006. Similar with the case of PPWM-MSW Collection, financial feasibility in this case is secured if the total project cost including depreciation, additional investment, and operational expenses arising during the project period is fully covered by the income. The result of analysis showed that the required tipping fee rate in this case was lowered to 4.4 US dollars per ton of waste disposal. Although the tipping fee rate can be reduced by about 25% in comparison with the case with no grant assistance, the project still requires seven to eight-fold of current disposal cost at SMC disposal site.

However, such low cost of final disposal at SMC disposal site stands at sacrifice of human health and environment by unsanitary open dumping of waste. The above estimation indicated the minimum cost required for the operation of waste landfill with proper consideration of human health, sanitation and environment.

Therefore, the Study concluded that the tipping fee rate of 4.4 US dollars per ton of waste disposal was the minimum cost required for proper operation of waste landfill to be equally collected from PPWM as well as CINTRI.

b.3 Analysis of Fee Rate for MSW Collection and Disposal and Its Impact Upon Household

Based on the estimated fee rate for MSW collection and disposal above, the total fee rate of MSW management for household is analyzed here.

b.3.1. MSW Service Fee in the PPWM Collection Area

The total MSW service fee in the PPWM service area is estimated as follows:

i) MSW Collection Fee

The fee rates of MSW collection for household are estimated as follows in the case with and without grant assistance.

Table 7-42: Household Fee Rate for MSW Collection by PPWM

Unit: US dollar/month/household

	2007	2015
Case with no grant assistance	1.42	1.58
Case with grant assistance	1.18	1.31

ii) MSW Disposal Fee

The tipping fee to be paid by household is estimated as the result of dividing the product of the tonnage of MSW disposal collected from household and tipping fee rate per ton of waste disposal by the number of household subject to MSW collection by PPWM. The result of estimation is shown in the table below.

Table 7-43: Tipping Fee Rate to be Covered by Household

	Unit	2007	2015
Amount of waste disposal collected from household	ton/year	74,460	176,259
Number of household subject to MSW collection by PPWM	Number of household	64,530	135,731
(1) Case with no grant assistance	US$/ton	5.92	
	US$/month/household	0.57	0.64
(2) Case with grant assistance	US$/ton	4.40	
	US$/month/household	0.42	0.48

iii) The Total Cost of MSW Service for Household

As the result of estimation made in i) and ii) above, the total cost of MSW service for household is estimated as follows:

Table 7-44: Total Cost of MSW Service for Household

		2007	2015
With no grant assistance	MSW collection	1.42	1.58
	Final disposal	0.57	0.64
	Total	1.99	2.22
With grant assistance	MSW collection	1.18	1.31
	Final disposal	0.42	0.48
	Total	1.60	1.79

On the other hand, the result of the Study shows the willingness and affordability to pay of the household as shown in the table below.

Table 7-45: Household's Willingness and Affordability to Pay in 2003

1. Current fee rate	0.8~1.0US$/month
2. Willingness to pay per household (Result from the Public Opinion Survey)	0.47US$/month
3. Affordability to pay per household (average of semi-urban 3Khans (0.5% of the average per household monthly income of US$ 216.)	1.08US$/month

Although the current fee rate for household ranges from 0.8 to 1.0 Us dollar per household per month, the Study predicted the future affordability to pay of household based on the

affordability to pay of 1.08 US dollars per month estimated above, assuming that it will increase with the rate of economic growth, as shown in the table below.

Table 7-46: Prediction of the Affordability to Pay of Household

Year	2003	2007	2008	2009	2010	2011	2012	2013	2014	2015
GDP	3.8	5.1	5.5	6.0	6.5	6.9	7.4	7.9	8.4	9.0
Growth rate	6.0	8.4	8.4	8.4	8.4	6.8	6.8	6.8	6.8	6.8
Minimum fee rate	0.80	1.07	1.16	1.26	1.36	1.46	1.56	1.66	1.78	1.90
Maximum fee rate	1.00	1.34	1.45	1.57	1.71	1.82	1.95	2.08	2.22	2.37
Affordable rate	1.08	1.45	1.57	1.70	1.84	1.97	2.10	2.24	2.40	2.56

The result of analysis on willingness to pay and affordability to pay of household above indicates that the increase in fee rate of MSW services for household needs to be minimized so that every household can afford to pay. The required household fee rate for the MSW services proposed in the M/P is 1.99 US dollars per month per household in the case with no grant assistance while it is 1.60 US dollars in the case with grant assistance, ranging from 1.1 to 1.4 fold of the estimated minimum fee rate in 2007 given in the table above.

b.4 Financial Appraisal of PPWM's MSW Services and Sensitivity Analysis

The result of financial analysis made above indicates that the PPWM's MSW Services proposed in the M/P is difficult to implement in a financially viable manner without application of considerably higher fee rate for household even in the case with grant assistance.

In addition, the cases established for financial analysis above made comparatively optimistic assumptions on fee collection of 80% for household and 100% for business establishment. If they are lowered, higher fee rate is required for financially feasible operation of PPWM's MSW Services.

On the other hand, the fee rate for business establishment, which was set up at the same rate as household's in the analysis above, can be increased, taking into account its current fee rate, relatively higher benefit to obtain, and actual fee payment identified by business establishment survey.

Considering these conditions, the Study here made a sensitivity analysis of MSW services fee rate for household with the variables of fee rate and fee collection ratio of business establishment so as to examine possibility of lowering the fee rate for household by increasing the fee rate for business establishment.

In this sensitivity analysis, the Study selected the case with grant assistance as the baseline case of the project. Selection of grant assistance case is based on the Study's recognition that grant assistance is essential for the project to be financially feasible. It is also made for simplification of analysis itself by taking only one baseline case.

i) Baseline Case

The baseline case established here used the same preconditions applied in the financial analysis of the M/P. The fee rates for MSW collection and disposal is commonly applied to household and business establishment on weight basis while the fee collection ratio is set at 80% for household and 100% for business establishment. As mentioned above, the required fee rates for MSW collection and disposal in the case with the grant assistance is estimated as follows:

Table 7-47: MSW Service fees in the Baseline Case (with grant assistance)

		2007	2015
Fee Rate per ton (US$/Ton)	Collection	11.61	
	Disposal	4.40	
Household Fee rate (US$/month/household)	Collection	1.18	1.31
	Disposal	0.42	0.48
	Total	1.60	1.79

Remark: Fee rate on weight basis will not change during the project period.

ii) Establishment of Variables

The variables established here for sensitivity analysis are the fee rate of MSW collection for business establishment on tonnage basis and its fee collection ratio. As to the fee for final disposal, the Study assumed that the same rate is applied for household as well as business establishment. Sensitivity analysis is made on the combinations of fee rate and fee collection ratio given in the table below. The required household fee rate (MSW collection and disposal) is estimated for each of those combinations.

Table 7-48: Establishment of Variables

Variables		Fee Collection Ratio for Business Establishment			
		100%	90%	80%	70%
Fee Rate of MSW Collection for Business Establishment (multiplying factor of household fee rate is established by cases)	1	Baseline	-	-	-
	1.5	○	○	○	○
	2	○	○	○	○
	2.5	○	○	○	○
	3	○	○	○	○

The cells with a blank circle in the table above indicate the combinations subject to sensitivity analysis here. The required household fee rate is estimated for each of such combinations. The result of analysis is shown in the tables below.

Table 7-49: Result of Sensitivity Analysis (Required Household Fee Rate for Household in 2007 for each combination)

Variables		Fee Collection Ratio for Business Establishment			
		100%	90%	80%	70%
Fee Rate of MSW Collection for Business Establishment (multiplying factor of household fee rate is established by cases)	1	1.60	-	-	-
	1.5	**1.38**	**1.44**	1.50	1.58
	2	**1.23**	**1.28**	**1.35**	**1.42**
	2.5	**1.12**	**1.17**	**1.23**	**1.30**
	3	**1.04**	**1.08**	**1.14**	**1.21**

Remark:

- The figures in the table shows the required household fee rate for MSW services (collection and disposal) is US dollars per household per month.
- Bold numbers indicate lower fee rate than the estimated affordability to pay of household (US$1.45) in 2007.

Table 7-50: Result of Sensitivity Analysis (Required Household Fee Rate for Household in 2015 for each combination)

Variables		Fee Collection Ratio for Business Establishment			
		100%	90%	80%	70%
Fee Rate of MSW Collection for Business Establishment (multiplying factor of household fee rate is established by cases)	1	**1.79**	**1.86**	1.94	2.02
	1.5	**1.55**	**1.61**	**1.68**	**1.76**
	2	**1.38**	**1.44**	**1.51**	**1.59**
	2.5	**1.26**	**1.31**	**1.38**	**1.45**
	3	**1.16**	**1.21**	**1.28**	**1.35**

Remark:
- The figures in the table shows the required household fee rate for MSW services (collection and disposal) in US dollars per household per month.
- Bold numbers indicate lower fee rate than the estimated minimum fee rate of household (US$1.90) in 2015.

As shown in the tables above, the increase in the fee rate for business establishment, even though it causes a considerable decrease in fee collection ratio, can lower the household fee rate for MSW services. It indicates that PPWM-MSW Services proposed in the M/P can be implemented in a financially feasible manner if proper fee rate is established for business establishment based on the result of sensitivity analysis above.

b.5 Recommendations regarding the implementation of the M/P from financial viewpoint

Based on the result of financial analysis above, the Study makes the following recommendations regarding the implementation of the M/P from financial viewpoint.

- **Use of grant type assistance to cover initial investment for implementation of the M/P**

The result of financial analysis clearly shows that the M/P will not be financially feasible as a normal public investment since it requires the increase of current fee rate for household that cannot afford to be paid. The tipping fee rate for CINTRI also needs to be increased by about nine-fold.

Taking these into account, the Study strongly recommends that MPP should make its best effort of obtaining grant type assistance to cover the initial investment cost required in the M/P so that the household fee rate and tipping fee rate for CINTRI can be minimized.

- **Reduction of household fee rate**

To make PPWM-MSW Services financially feasible, the household fee rate needs to be increased by 1.5 to 2 fold. Such increase in the fee rate is difficult to accept for the average household in Phnom Penh since its income is not expected to grow by such rates. The increase in fee rate has to be minimized so that the M/P can be well accepted by household as well as fee collection can be maintained at high ratio.

The Study examined the possibility of raising the fee rate for business establishment as an option of minimizing the increase in fee rate for household based on the following rationales:

- Business establishment will receive higher quality MSW services than household, e.g. high frequency of MSW collection, door-to-door collection, etc.)
- Street sweeping and public cleansing services provided by PPWM will provide not only the benefit business establishment in terms of health and sanitation as well as improvement of its business environment.

- The current fee rate is set up higher than the required fee rate in the M/P in most of the types of business establishment. In addition, the business establishment survey done by the Study showed that the average monthly payment of business establishment for MSW services is about 14.6 US dollars per establishment. Although we have to consider the difference in type and scale of business establishment, it can be estimated that business establishment has a considerably higher affordability to pay than household.

The result of sensitivity analysis above showed that the increase in the fee rate for business establishment could lower the household fee rate even though it decreases fee collection ratio from business establishment to a certain extent. The Study strongly recommends that MPP should review the current fee rate system for household and business establishment based on the analysis results shown in the Table 7-46, Table 7-49 and Table 7-50 above so that every MSW service users can well accept them.

- **Revision of current tipping fee rate for CINTRI**

The currently applied tipping fee rate for CINTRI is below 1 US dollar per ton of waste received. The required tipping fee rate for financially feasible operation of Dang Kor Final Disposal Landfill is 4.40 US dollars per ton of waste disposal even in the case with grant assistance. This cost is the minimum requirement for proper operation of MSW disposal landfill with proper consideration of human health and environment, replacing the currently operating unsanitary open dumping in SMC disposal site. The Study recommends that the above cost should be equally covered by PPWM and CINTRI based on the amount of MSW disposal.

- **Establishment of the new fee rate system for MSW services**

To make the M/P financially feasible, the current fee rate system needs to be improved to best reflect the actual cost arising from providing new MSW services proposed in the M/P. In the financial appraisal above, the Study estimated the required fee rate to cover the total cost of MSW collection and disposal per ton of waste collection and disposal on the basis of prediction of MSW generation by household and business establishment. The current fee rate system should also be improved so that the cost of MSW collection and disposal can be equally covered by service users based on the amount of MSW they generate. Establishment of the weight/volume-based fee rate system is the foundation of sound and equal share of the cost by service users. It should be studied in detail in the F/S.

- **Maximizing fee collection ratio through better understanding of MSW services by users and establishment of reasonable fee rate**

To make the M/P financially feasible, the fee collection ratio has to be maximized to stabilize the project income. The key of high fee collection ratio is the people's understanding of the improved MSW services and establishment of reasonable and transparent fee rate system based on the actual cost arising from provision of MSW services.

- **MPP Budget allocation for street sweeping and public cleansing**

Since the above cost estimation does not include street sweeping and public cleansing expenses, they need be covered by MPP budget allocation. According to our estimation, it will annually cost 35,400 – 51,200 US dollars for providing such services in the PPWM service area.

7.8 Environmental consideration

From an environmental point of view, the M/P is evaluated in the following respects:

- Expansion of collection service
- Prevention of waste scattering
- Promotion of the 3Rs
- Improvement of the final disposal site
- Environmental Impact Assessment (EIA) for Dang Kor Disposal Site Development Project
- Industrial waste management
- Septic sludge management

7.8.1 Expansion of collection service

MPP contracts out the MSWM service to a private company based on a franchise agreement. However, because the collection service by the private contractor is limited to areas that are profitable, there are many unserviced areas. Many of those areas are unplanned settlements that are home to the cities poor, and access is difficult because the roads are narrow. Otherwise, they are located in rural areas where the population density is low and waste collection cannot be carried out efficiently.

From the standpoint of conserving the urban environment, the unserviced areas and areas where the collection service is not adequate have to be eliminated. All Phnom Penh residents have an equal right to public services and MPP is obligated to ensure they are covered.

Looking at the waste flow in the city's Urban Area (four Urban Khans) and Rural Area (three Rural Khans), the amounts of waste disposed of by self disposal and by illegal dumping in the Urban Area are both 2.5%, while in the Rural Area they are extremely high at 34.5% and15.1%, respectively. This means that at present, half of the waste generated is not being collected by the collection service. Moreover, the waste that is collected is improperly disposed of at the SMC disposal site (open dumping).

Waste collection is an essential public service for securing a sanitary and sound environment for the people living in the city. MPP has a duty to provide the collection service to all the citizens of the city. However, due to restrictions based on its agreement with CINTRI and a lack of equipment and personnel, MPP is currently not able to fulfill this duty.

In order to solve this environmental problem, the following measures are recommended in the M/P:

In the unserviced and inadequately serviced areas, access by collection vehicle is often difficult. Therefore, the collection system should be divided into

- Curbside/bell collection by compacter truck; and
- Public container collection by skip loader truck, depending on whether the collection vehicle can approach the collection site. PPWM should apply the respective systems according to the area features.

7.8.2 Prevention of waste scattering

In Phnom Penh, even in the central part where the collection service is adequately provided, garbage heaps and scattered waste is ubiquitous, not only causing a decline in the urban sanitary environment but also having a negative impact on the tourist industry due to the

spoiled scenery. The beauty of Phnom Penh is maintained by street cleaning services, which are carried out somewhat to excess

In order to solve this environmental problem, the following measures are recommended in the M/P:

- In order to eliminate waste heaps and scattered waste, the collection service providers (PPWM and CINTRI) should establish the waste discharge rules proposed in the M/P in accordance with area features. The discharge rules should clearly provide information such as the disposal containers, times, days, and place, and should be adequately publicized to the residents to obtain their cooperation. Furthermore, the collection service should be reliable and provided according to schedule.
- The administrative side (MPP) should raise public awareness by educating the residents (the beneficiaries of the service) about the need for public sanitation and environmental conservation so that they strictly adhere to the rules. The public education should include the required programs to eliminate the scattering of waste and littering. If such practices are stopped, the cost required for street cleaning can be reduced. As long as the high unemployment rate and cheap labor cost continue, the street cleaning service should be conducted manually.

7.8.3 Promotion of the 3Rs

Reduce, reuse, and recycle (3Rs) are basic environmental policies that are promoted throughout the world. The capacity of the final disposal site in Phnom Penh is not adequate, and securing of a new disposal site is a serious issue. Reducing the generation amount even by a small amount in order to extend the life of the existing site is important under the tight financial conditions. Furthermore, studies found that 70% of the waste in the city is compostable waste, such as household and yard waste, and 24% is recyclable waste, such as paper, plastic, metals, and glass. Therefore, it is necessary to reduce the volume of waste by actively promoting recycling activities.

In this study, it was found that the amount of waste generated per person is small (487g/person/day), and the traditional private material recovery system is very active and well established (recycling rate is 9.3 %). However, the majority of the valuables recovered are recycled in Thailand and Vietnam. Based on that, in order to promote the 3Rs (Reduce, Reuse, Recycle), the following measures are recommended in the M/P.

- In order to maintain and preserve the existing recycling system, the MPP should establish a support mechanism (the provision of education and information to dischargers and collectors of valuable materials, small loan system, etc.) for Et Chhay (recycler) and WPs. Furthermore, the recycling of recovered materials within Cambodia should be promoted with the support of the Ministry of Technology, etc.
- In order to increase the recycling rate, degradable organic waste (kitchen wastes, grass and wood), which currently accounts for 70% of the waste composition by weight, must be adequately recycled. Therefore, the composting of waste should be promoted. Judging from the profitability of compost activities and product marketability, it is important to target wastes that can be converted into good-quality compost at a low cost, such as market waste, yard waste, etc; target customers who will buy high cost products, such as fruit and vegetable farmers;

and promote community level composting activities in order to progressively increase production according to the increase in demand.

- In cooperation with the relevant ministries and agencies and based on examples in developed countries, the Ministry of Environment (MOE) should promote the 3Rs by encouraging products that are easy to reuse and recycle and the introduction of the extended producer responsibility (EPR) system in the future.

7.8.4 Improvement of the final disposal site

The SMC disposal site is essentially an open dump and the environment at the site is poor. Offensive odor, smoke from fires, and the scattering of waste are daily problems. In order to gain public understanding for development of the new disposal site, it is urgent that the environment be improved. Furthermore, the design and construction of the new disposal site will require three to four years and the remaining service life of the existing SMC disposal site is inadequate. Therefore, measures must be taken as soon as possible to extend the life of the existing site.

With the exception of the mere 0.5% (5.3 tons/day) of waste that is treated by composting, all of the waste collected is disposed of at the SMC dump site, which is the only disposal site in the city. The SMC disposal site is a typical open dump, and the negative impact on the surrounding environment by fire outbreaks, the discharge of untreated leachate into public waters, etc, is a serious problem. Furthermore, there is rapid urbanization in the surrounding area and the disposal site has nearly reached its capacity. In order to improve the final disposal system, which is vital for SWM, the following measures are recommended.

- Construction of a new disposal site is an urgent issue but a preparation period of at least a few years is required. MPP should, therefore, try to utilize the SMC disposal site as long as possible by continuing the pilot projects implemented with the study team and properly operating the SMC disposal site as a sanitary landfill
- Seventy percent (by weight) of the waste landfilled at the SMC disposal site is degradable organic waste. PPWM should make plans to effectively use the landfill gas (production of charcoal, briquette, etc.) using the gas collection pipes installed for safety measures.
- In Cambodia, the main method of waste disposal is and will be landfilling. In the case of waste disposal by landfilling, plastic is a big obstacle in respect to landfill operation and use of the site after closure. An effective way to solve this environmental problem is through the promotion of biodegradable plastic. In order to address the high cost of biodegradable plastic, which is an obstacle to its promotion, it is recommended that the Cambodian government create a mechanism that makes users of non-biodegradable plastic shoulder the additional costs in consideration of the environmental load in the future.

7.8.5 Environmental Impact Assessment (EIA) for Dang Kor Disposal Site Development Project

Based on the IEE implemented in advance, the EIA for the Disposal Site Development Project, which includes the construction of a final disposal site, compost plant, and maintenance workshop, was carried out to assess the impacts of the project on the following:

economic activity, traffic and public facilities, cultural property, public health, the socially vulnerable, hydrological conditions, fauna and flora, landscape, air pollution, water pollution, soil contamination, noise and vibration, offensive odour.

Consequently, the implementation of the plan is expected to bring about various positive and negative impacts. The adverse impacts may be mitigated through the various countermeasures to be taken at the time of implementation. Accordingly, it has been concluded that the allowable limit can be maintained by preparing suitable countermeasures based on the results of the EIA. However, special consideration will be needed for the following items in order to develop the new disposal site in Dang Kor.

- Proper implementation
  Even if the proposed disposal site is planned, designed and constructed as a sanitary landfill, the monitoring of the landfill at all stages is the key to securing environmentally sound landfill operation. Therefore, regular monitoring during the construction, operation and closure stage is essential. In order to establish a monitoring system, a monitoring committee for the Project is proposed. The committee members shall join in the monitoring and observe the environmental condition of the site and its surroundings.

  The committee may include MPP, MoE, DoE, NGOs, representatives from local authorities and residents.

  As for the interval of monitoring, internal monitoring by PPWM shall be done every month and monitoring by the monitoring committee shall be carried out twice a year.

- Road improvement
  Based on the waste collection and transportation system in the M/P, the collection vehicles will make a total of 322 trips per day in 2007. So the number of trips made by collection vehicles is not so large. However, the current road conditions are bad because it is not unpaved. The following environmental items would be seriously affected:

  Noise, traffic jams, air pollution

  As for countermeasures, the most effective countermeasure is to pave the road. The ADB will implement the “Mekong Tourism Development Project”. In this project, National Road 303 will be paved in order to create better access from the center of Phnom Penh to the Killing Field Memorial. The section of the road from there to the entrance of the proposed disposal site is also to be paved in the Project. Therefore, noise, traffic jams and air pollution will be negligible.

- Alternative jobs
  When the existing disposal site, SMCDS, is closed at the end of 2006, almost 500 waste pickers who are working there will lose their jobs. In addition, the land owners of the new disposal site in Dang Kor will lose agricultural income as the proposed site is mainly rice fields and will be bought by the Cambodian Government. Therefore, alternative jobs for them are considered. As for waste pickers in SMCDS, PPWM will support them by providing them the opportunity to work as waste collectors. As for the landowners of the Dang Kor disposal site area, PPWM will support them by providing them the opportunity to work at the Dang Kor disposal site.

These alternative jobs are a very important issue for social consideration. They are proper countermeasures for social consideration and in order to maintain a trusting relationship with the stakeholders.

7.8.6 Medical Waste Management

The generation amount of infectious and hazardous medical wastes, estimated on the basis of the medical waste survey results, is 0.96 tons/day, or 350 tons/year. A technical system (separation of infectious and hazardous medical wastes at the source for separate collection, transport and treatment/disposal) for such wastes needs to be established as quickly as possible. Because the amount of hazardous medical waste generated is very limited compared to municipal solid waste, the disposal of such waste will not be such a big burden; that is, on the condition that it is strictly separated from non-hazardous medical waste (general medical waste : 9.7 tons/day, 35,400 tons/year). Therefore, the Ministry of Health (MOH), which is responsible for supervising waste disposal at medical institutions, must ensure the strict separation of hazardous medical waste at the source, at every stage including collection, intermediate treatment, storage, and discharge.

As for non-hazardous medical waste, after strict separation from hazardous waste, it can be collected and disposed of as general waste, as is done at present.

Regarding non-hazardous medical waste, disposal at individual medical institutions by small-scale incinerators has difficulties in respect to air pollution and operation and maintenance. On the other hand, with the construction of large-scale incinerators, it is necessary to overcome problems in terms of size and investment cost recovery.

Hence, as a provisional method, the study team recommends disposal at individual medical institutions by small scale incinerators along with disposal by sanitary landfilling at disposal sites approved by the Ministry of Environment as being suitable for hazardous industrial waste. In the future, hazardous medical waste should be treated en masse at appropriate incineration plants along with other hazardous wastes. When the hazardous waste incineration plants are in operation, strict air pollution controls should be applied to existing small scale incinerators.

This kind of improvement work is accompanied by a rise in expenses. By law, medical institutions must bear all costs for handling hazardous medical waste, from collection to final disposal. Therefore, the Ministry of Environment, with the cooperation of the MOH, should examine ways in which medical institutions should cover the rise in costs.

7.8.7 Industrial waste management

According to the factory survey, the generation amount of hazardous industrial waste (1.9 tons/day, 694 tons/year) is very limited compared to that of non-hazardous industrial waste (56.3 tons/day, 20,550 tons/year). Furthermore, an industrial waste disposal site that has been approved of by the Ministry of Environment as being suitable for hazardous industrial waste is located in the neighboring of Kandal province. Therefore, DOE and PPWM should establish a strict monitoring system for incoming vehicles to prevent hazardous industrial waste from being disposed of with general waste at the municipal disposal site. As for industries categorized as highly potential hazardous industrial waste generators, the industries will not be permitted to dispose waste at the municipal disposal site until they have proven their waste is not hazardous.

As for non-hazardous industrial waste, after strict separation from hazardous industrial waste, it should be collected and disposed of as general waste, as is done at present.

7.8.8 Septic sludge management

According to the septic sludge survey, the amount of sludge disposed of in the treatment ponds installed at SMC disposal site is a mere 6m^3 a day on average (based on 2003 data). Supposing that 30% of Phnom Penh' population of 1,200,000 are using sludge treatment tanks, the generation amount estimated based on Japanese data would be 288m^3 per day, which is 48 times more sludge than is generated at present.

Judging from this result, septic tanks are not working because the majority of them are full with sludge, or if the sludge is being collected, it is being improperly disposed of somewhere other than the treatment ponds at SMC disposal site.

In order to improve this environmental situation, MPP should take the following measures:

- Investigate the condition of the installation of tanks and the collection of sludge and based on the findings, formulate a management plan for septic tanks and septic sludge.
- Examine standards for septic tank management and establish laws for septic tanks and clamp down on the improper disposal of septic sludge.
- Based on the management plan for septic tanks and septic sludge, establish a collection system and install new sludge treatment facilities.
- While the new sludge treatment facilities are being installed, maintain and use the existing treatment ponds at the SMC disposal site.