Chapter 8

Estimation of Future IW Generation

8 Estimation of Future IW Generation

8.1 Socio-Economic Framework of the Master Plan

8.1.1 Population

The current population in the Bangkok Metropolitan and Vicinity (Bangkok, Samut Prakan, Nonthaburi, Pathun Thani, Samut Sakhon) is approximately 8600 thousand in the year 2000 according to the registration record at the Department of Local Administration, Ministry of Interior. The region-wise distribution of population is shown in Table 8-1 below.

Table 8-1: Population in the Study Area

Region, Changwat	Population		
	Total	Male	Female
Bangkok	5,680,380	2,761,012	2,919,368
Samut Prakan	995,838	485,562	510,276
Nonthaburi	859,607	412,645	446,962
Pathum Thani	654,701	319,014	335,687
Samut Sakhon	428,814	210,494	218,320
Bangkok and Vicinity (Study Area)	8,619,340	4,188,727	4,430,613
Whole Kingdom	61,878,746	30,725,016	31,153,730

Source: Department of Local Administration, Ministry of Interior.
Compiled by: Statistical Data Bank and Information Division, National Statistical Office (NSO).

Regarding the growth of population in the Bangkok and its Vicinity, the higher growth has been found in Vicinity since 1980 while the rate of population growth in Bangkok Metropolis has been lower than 1% since 1980.

Table 8-2: Population growth rate in the Study Area (1995-2000)

Unit: %/annum

Year	Bangkok	Vicinity	Bangkok and Vicinity
1975-80	3.45	2.66	3.22
1980-85	0.80	3.61	1.64
1985-90	0.68	3.85	1.72
1990-95	0.09	2.14	0.82
1995-2000	0.39	2.27	1.11

Source: Department of Local Administration, Ministry of Interior.
Compiled by: Statistical Data Bank and Information Division, NSO.

Taking into account the difference in trend of population growth between Bangkok and Vicinity, the team makes the projection of future population separately by regression analysis of the past trend of population growth. The results are given in Table 8-3 below.

Table 8-3: Population Projection in the Study Area (2000-2010)

Year	Bangkok	Vicinity	Bangkok and Vicinity
2000	5,680,380	2,938,960	8,619,340
2005	5,732,469	3,244,467	8,976,936
2010	5,797,093	3,542,118	9,339,210
Average Growth Rate	0.20%/year	1.88%/year	0.81%/year

The total population in the study area is projected to be around 9.3 million in 2010, of which about 5.8 million in Bangkok and 3.5 million in the Vicinity.

8.1.2 Economy

The latest information about the future economy outlook of Thailand is available at the Industrial Finance Corporation of Thailand. According to its latest future economy outlook, the growth of GDP in Thailand is projected as shown in Table 8-4 below.

Table 8-4: Projection of GDP Growth in Thailand (1999-2002)

	Actual		Projection	
	1999	2000	2001	2002
GDP at 1988 price (billion Baht)	2,859	2,985	3,039	3,139
Growth Rate	4.2%	4.4%	1.8%	3.3%

Source: Economic Outlook 2000, IFCT.

The team followed this IFCT's projection up until 2002. Meanwhile, the medium term economic growth target from 2002 to 2006 is provided in 'Strategy Plan Framework Toward Quality and Sustainability of Thailand Economic Development, which was prepared by the Ministry of Finance (MOF) and the National Economic and Social Development Board (NESDB) in July 2001. Accordingly, the team followed this data for this period (2002-2006) and assumed that the target annual growth rate of 6 % given in the above 'Strategy Plan' will be maintained up until 2010. Table 8-5 show the projected GDP growth in Thailand on the basis of these assumptions.

Table 8-5: Projected GDP Growth in Thailand (2002-2010)

	2002	2005	2010
GDP at 1988 price (billion Baht)	3,139	3,700	4,951
Average Annual Growth Rate (%)	3.3% (2001-2002)	6.0% (2003-2005)	6.0% (2005-2010)

The above projections of population and economy are only used as the background information for the estimation of the future industrial waste generation. In case there are any significant changes in the above figures in the future, the estimation of

the future industrial waste generation to be made in the next section needs to be reviewed.

8.1.3 Number of Employees by Types of Industries

An important variable necessary to be estimated here is the future number of employees for each categorized industry. The reason why the number of employees is chosen as the variable of forecasting the future IW generation is that **the future trend of IW generation is assumed to be more similar to that of number of employees than that of production volume. Generally, the owners of the manufacturing industry make efforts to lower their production cost through increasing productivity while increasing the amount of production itself. Such productivity improvement activities, in this case, include enhancing labor productivity as well as increasing the efficiency of raw material and energy consumption, which will also lower IW generation. Accordingly, based on the above assumption regarding the efforts of industry owners, the IW generation will not increase at the same rate of production increase, but will increase at nearly the same rate of number of employees.** Figure 8-1 below shows the result of forecasting the future trend of growth in production and number of employees in the total manufacturing industry in the Study Area.

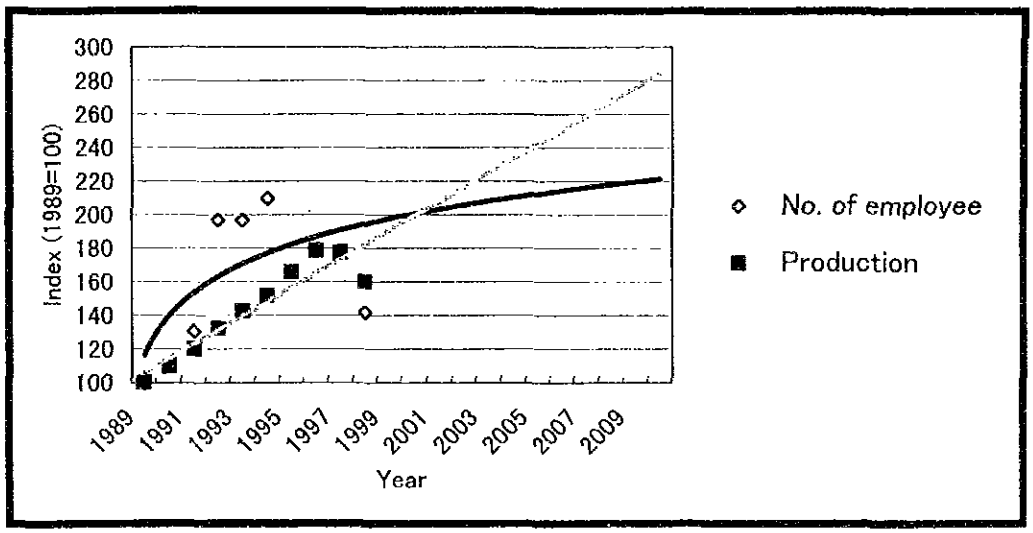

Figure 8-1: Forecast of the Future Growth Trend of Production and No. of Employees in Manufacturing Sector

As shown in the figure above, the growth rate of number of employees has been higher than that of production amount before outbreak of the Asian economic crisis. It indicated that Thai manufacturing industry had been dominated by labor-intensive types. This is also supported by the fact that the number of employees in manufacturing industry showed a sharper drop than production amount during the period of economic crisis in Thailand.

In future, however, the efforts of lowering the cost of production will be further promoted in Thailand by way of increasing labor productivity as well as raw material and energy consumption efficiency. Therefore, the production in manufacturing industry will be recovered in the same way as the recovery of Thai economy while

the growth of employment in manufacturing sector will be less than the growth of production.

Thus, the increase in IW generation is estimated to show the same tendency as the number of employees because of further efforts of productivity improvement in manufacturing industry.

In making the estimation of future number of employees, the team applies the regression analysis of the past trend of the number of employees from 1989 to 1998 by the least square method on the basis of available industrial data obtained from the National Statistical Office (NSO). Therefore, the future number of employees is estimated here by each TSIC code with 3digits (311-390 for manufacturing industry) in accordance with NSO categorization, as shown in Table 8-6 on next page.

However, the team assumed that there would be no change in the number of employees in some types of manufacturing industries. This is mainly due to limited availability of data and large deviation in these data, both of which makes it virtually impossible to estimate reliable future number of employees. Regarding these types of industries, the team took the average of the past data as the future number of employees. If more data becomes available in the future, these figures need to be reviewed.

Table 8-6: The projected future number of employees by types of Industries in accordance with the TSIC Code

Code	Industrial Category (TSIC)	1989	1991	1993	1994	1998	2000	2005	2010
311	Food manufacturing	53,044	72,843	144,692	130,573	154,652	182,152	217,693	248,396
312	Manufacture of food products n.e.c.	9,692	12,208	10,388	9,840	15,031	14,889	15,834	16,247
313	Beverage industries	42,629	13,462	40,970	18,765	13,582	14,906	13,090	11,890
314	Tobacco manufactures	0	10,716	5,448	6,871	no data	8,741	8,955	9,071
321	Manufacture of textiles	205,747	226,412	285,425	320,789	156,727	348,200	352,166	352,764
322	Manufacture of wearing apparel except footwear	3,234	200,246	534,820	649,209	114,625	471,313	524,247	563,431
323	Manufacture of leather and products of leather, leather substitutes and fur except footwear and wearing apparel	9,617	11,460	14,023	19,461	18,614	20,199	22,571	24,506
324	Manufacture of footwear except vulcanized or moduled rubber or plastic footwear	14,421	37,809	40,140	8,949	11,605	9,788	9,324	8,995
331	Manuacture of wood and wood and cork products except furniture	13,164	19,809	22,884	21,050	18,265	17,178	15,393	14,192
332	Manufacture of furniture, fixtures and floorings except primary of metals	29,476	20,308	21,638	17,312	35,911	33,486	36,393	37,960
341	Manufacture of paper and paper products	688	14,095	17,317	13,975	20,474	21,831	26,407	30,984
342	Printing, pulishing and allied industries	30,841	31,543	23,465	29,186	29,408	31,635	34,614	36,998
351	Manufacture of industrial chemicals	8,195	14,984	12,848	8,148	43,316	44,999	47,317	47,608
352	Manufacture of other chemical products	30,079	30,648	33,669	23,105	no data	26,726	26,150	25,731
353	Petroleum refineries	2,907	2,255	12,294	3,456	no data	3,692	3,771	3,793
354	Manufacture of miscellaneous products of petroleum and coal	162	180	no data	no data	812	855	889	893
355	Manufacture of rubber products	13,402	15,265	28,992	20,340	28,100	29,929	31,336	31,739
356	Manufacture of plastic products n.e.c.	9,963	18,616	30,199	44,979	73,306	63,955	72,797	79,342
361	Manufacture of pottery	2,988	140	4,788	10,957	no data	11,927	12,044	12,052
362	Manufacture of glass and glass products	8,355	15,201	8,324	9,733	7,122	8,084	8,004	7,946
369	Manufacture of other non-metallic mineral products	26,751	22,549	15,355	25,470	36,122	34,999	37,742	38,932
371	Iron and steel basic industries	17,802	29,005	50,016	23,828	23,292	25,166	28,370	27,573
372	Non-ferrous metal basic industries	2,969	12,124	5,868	34,411	no data	37,637	37,846	37,852
381	Manufacture of fabricated metal products except machinery and equipment	40,139	57,971	67,439	123,320	86,836	105,320	114,668	121,588
382	Manufacture of machinery except electrical	4,779	55,002	58,712	25,898	48,951	38,594	36,056	34,286
383	Manufacture of electrical machinery, apparatus, appliances and supplies	52,953	45,164	65,433	68,542	143,596	145,114	155,490	157,508
384	Manufacture of transport equipment	798	59,239	72,859	60,931	71,940	73,360	76,912	79,652
385	Mnufacture of professional and scientific and measuring and controlling equipment not elsewhere classified and of photographic and optical goods	6,159	10,220	6,720	8,559	7,000	7,711	7,939	8,112
390	Other manufacturing industries	29,673	58,711	51,018	58,926	55,170	60,256	62,948	63,802
Total	Manufacturing	856,491	1,118,185	1,685,744	1,796,583	1,214,457	1,892,642	2,036,966	2,133,843

8.2 Projection of the Future Industrial Waste Generation

8.2.1 Scope of Projection

a. Industries Covered

The industries covered in the projection of future industrial waste generation here include all the industries located in the study area under the control of the Factory Act B.E. 2535 (1992) or the Industrial Estate Act B.E.2522 (1979). 104 categories of factories are given specific codes (MOI code) and controlled by these acts. The team simplified them into 33 categories (Study Code) and clarified their correspondence with the Thailand Standard for Industrial Classification (TSIC), which is virtually compatible with the International Standard for Industrial Classification (ISIC) as shown in Table 8-7 below.

Table 8-7: 33 categories of factories and their correspondence with TSIC

Study Code	MOI Code	Description of industrial Category	TSIC
G01	001-002, 004-009	Food (agricultural product, non-aquatic/aquatic animals etc.)	311
G02	010-015	Food (flour, sugar, tea, ice, etc.)	312
G03	016-021	Beverage and tobacco	313,314
G04	022	Textile, thread and fiber	321
G05	023-027	Textile products (clothes, mats, etc.)	321
G06	028	Wearing apparel	322
G07	029-033	Fur dressing, footwear, etc.	323,324
G08	034	Woodwork	331
G09	035-036	Wood, cork, bamboo and other products	331
G10	037	Furniture	332
G11	038-040	Paper, cardboard	341
G12	041	Printing, etc.	342
G13	042-050	Petroleum and chemical products	351-354
G14	051-052	Rubber	355
G15	053	Plastic Products	356
G16	054-058	Glassware, Ceramics, non-metallic mineral products	361,362, 369
G17	059-060	Iron and Steel, non-ferrous basic metals	371,372
G18	061-062	Metal products (tools, appliances, household furniture, building interior, etc.)	381
G19	063	Metal products (construction, installation)	381
G20	064	Metal products (others)	381
G21	065-066	Machines (engines, turbines, machines)	382
G22	067	Machines (for producing metal or wood products)	382
G23	068	Machines (for paper, chemical, food, textile, etc.)	382
G24	069-070	Machines (calculating, accounting, etc.)	382
G25	071-073	Electric products (machines or products under No.70, Radio, electric instruments or appliances, etc.)	383
G26	074	Electric products (electric equipment)	383
G27	075-077	Transport equipment (ship, trains, streetcars, cars, trailers)	384

Study Code	MOI Code	Description of Industrial Category	TSIC
G28	078-080	Transport equipment (motorcycles, tricycles, bicycles, aircraft, etc.)	384
G29	081-084	Precision Machinery	385
G30	085-087	Others (musical instruments, sport, toys, etc.)	390
G31	088-094	Others (electric & gas supply, packaging, cold storage, etc.)	41
G32	095	Others (repair of vehicles, trailers, etc.)	95
G33	003, 096-104	Others (stone, watches, clocks, central waste treatment plant, steam generators, salt production, etc.)	NA

b. Industrial Waste Covered

The projection covers the whole types of industrial waste defined in accordance with the Notification No.1 and 6 of the Minister of Industry pursuant to non-hazardous and hazardous waste generated as the result of factory operation under the Factory Act B.E. 2535 (1992).

c. Projection Period

The projection of industrial waste generation covers the period up until 2010, the target year of the M/P.

8.2.2 Methodology of Estimating the Future Industrial Waste Generation

Future industrial waste generation is given by the equation given below:

$$IWG = \sum_{i=1}^{n} \sum_{j=1}^{m} (Mi \bullet Gij)$$

where,

IWG : Industrial Waste Generation (tons/year)
i : Industrial category (Study Code)
j : Type of waste
M : Number of employees (person)
G : IW generation rate (tons/year/person)
n : Number of industrial categories (33 categories)
m : Number of waste categories

a. IW Generation Rate

IW generation rate is given by each type of wastes for each of the 33 categorized factories in the form of ton per employee per annum on the basis of the waste generation data obtained from the team's factory survey. The team assumes that the estimated IW generation rate will not change during the projection period. Generation rate of hazardous and non-hazardous waste is given below by types of industry for each type of waste.

a.1 Non-HW generation rate per employee

Non-HW generation rate per employee, that was calculated in each 33 categories and each type of waste based on the result of the factory survey, are shown in Table 8-8. Blank cells, including the column 06, indicate that there were no replies about these types of wastes

The average non-HW generation rate of all industries per employee is 1,503.0 kg/year/person. However, there is a significant difference in generation rate among industries.

Table 8-8: Non-HW Generation rate (per employee)

Unit : kg/year/person

Study Code	Descriptions	C01-01	C01-2	C02	C03	C04	C05	C07	C08	C09-01	C09-02	C10	C11	W12	Total
G01	Food (agricultural product, non-aquatic animals, aquatic animals etc.)	16.9	2,987.1		2.8	179.1			1.0				0.1	0.5	3,187.5
G02	Food (flour, sugar, tea, ice etc)			1.6	13.9	18 6	5.1	50.8	12.2					285.0	387.2
G03	Drink, Beverage	1,294.3		0.9	3.4	18.9			4.1		1,212.8			171.2	2,705.6
G04	Textile, Thread, Fibre				8.3	30.6	327.4		62.0				7.0	13 5	448 8
G05	Textile product (Clothes, mats etc.)	577.3		16.4	16.4	259.1	40.8	0.0	0.0						910.0
G06	Wearing Apparel				7.8	0.4	222.3		0 2				58.0		288.7
G07	Hide, Fur, Footwear		443.7		3.4	55.0	134.9	8.9	1.8			8.9		1.1	657.7
G08	Woodwork (any or many items)			5,577.2	0.3				0.2				104.6		5,682.3
G09	Woodwork (bamboo, rattan, straw, cork etc)			3,907.9	11.8								127.2		4,046.9
G10	Furniture			5,231.3	12.7				4.7				98.1		5,346.8
G11	Paper, Cardboard				720.7	58 2			16.2					1,031.6	1,826.7
G12	Printed matter				971.8	1.5			1.4				88.2	1.2	1,064.1
G13	Chemical matter, Petroleum				11.0	27.2			12.4				14.6	21.9	87.1
G14	Rubber			300.8	50 3	200.9	0.3	679 7	0.6			1.6			1,234.2
G15	Plastic product			116.7	36.5	789.7	2.1		4.4				2.7		952.1
G16	Glassware, Ceramics, non-Metallic Matter			0.1	5.1		0.2		61.9	836.1	947.8	702.3		20.1	2,573.6
G17	Steel basic industries, non-ferrous metal basic industries				30.5	30.5			15,128 3			7,623.9	46.4		22,859.6
G18	Metal product (tools, appliances, household furniture, building interior etc)			3.4	9 2		1.4		4,313.1						4,327.1
G19	Metal product (construction, installation)			54.5		5.5			2,501.8						2,561.8
G20	Metal product (others)			2 3	133 2	1.8	4.6		653.2						795.1
G21	Machines (Engines, Turbines, Machinery)			60 2	121.1	5.0			1,928.8			30.1	352.5		2,497.7
G22	Machines (for producing metal or wood products)				10.6				335.1				10.6		356.3
G23	Machines (for paper, chemical, food, textile etc)			2 8	1.7				547.2				21.8		573 5
G24	Machines (calculating machines, Accounting machines, Water pumps, air or gas compressors etc)					56 2			49.9				0.8		106 9
G25	Electric product (Machines or Product under No 70, Radio set, Electric instruments or appliances etc)			2.4	22 4	55.0			229.2				128.0	170.7	607.7
G26	Electric product (Electric Equipment)				78.7	447.9			440.4		458 8	0.6	3.4		1,429.8
G27	Transportation machines (Ship, Trains, Streetcars, Cars or Trailers)			3.8	46.5	15.0			61.3			1.1			127.7
G28	Transportation machines (Motorcycles, Tricycles, Bicycles, Aircraft, Wheeled vehicles etc)				0.8	1.9	441.7	23.5	627.0		4.7	47.0		0.6	1,147.4
G29	Precision machinery				3.4	0.7			13.8			6.6			24.5
G30	Others (Musical instruments, Sport, Toys etc)		1.1	6.4	45.7	277.5	1.3		6.4				2 9		341.3
G31	Others (Electric power, Gas, Packaging, Cold storage etc)		70 4	0.2	115.7	7.3						1,270.8			1,464.4
G32	Others (Engine-driven for vehicles or motorcycles etc				4.7	7.6			27.2						39.7
G33	Others (Store, Watches or Clocks, Central waste treatment plant, Generating steam, salt etc)					2.5			11.9				2.1		16.5

Study Code	Descriptions	C01-01	C01-2	C02	C03	C04	C05	C07	C08	C09-01	C09-02	C10	C11	W12	Total
All Category of Factories		86.5	205.1	351.2	66.4	70.9	50.5	17.8	296.2	6.3	75.7	209.4	29.5	47.5	1,503.0

a.2 HW generation rate per employee

HW generation rate per employee, that was calculated in each 33 categories and each type of waste based on the result of the factory survey, are shown in Table 8-9. Blank cells indicate that there were no replies concerning these types of wastes.

The average HW generation rate per employee of all industries is 345.7kg/year/person. However, there is a significant difference in HW generation rate among industries.

Table 8-9: HW generation rate per employee

Unit : kg/year/person

Study Code	Descriptions	W01	W02	W03	W04	W05	W06	W07	W08	W09	W10	W11	W12	Total
G01	Food (agricultural product non-aquatic animals, aquatic animals etc.)								0.1					0.1
G02	Food (flour, sugar, tea, ice etc.)								0.2			39.5		39.7
G03	Drink, Beverage		139.8						10.4			20.7	1,553.1	1,724.0
G04	Textile, Thread, Fibre								8.2			2.4	0.3	10.9
G05	Textile product (Clothes, mats etc.)							0.0	0.0			0.8	1.8	2.6
G06	Wearing Apparel								0.1					0.1
G07	Hide, Fur, Footwear						0.5		0.0				3.2	3.7
G08	Woodwork (any or many items)						4.9		0.1			80.1	4.4	89.5
G09	Woodwork (bamboo, rattan, straw, cork etc.)								2.4				0.7	3.1
G10	Furniture						11.0		1.8			35.7	146.9	195.4
G11	Paper, Cardboard						0.4						8.1	8.5
G12	Printed matter								80.5				188.4	268.9
G13	Chemical matter, Petroleum			29.3	62.2		21.9	27.7	36.6	0.3		286.8	309.3	774.1
G14	Rubber							0.3	37.0				0.6	37.9
G15	Plastic product						73.7	141.6	94.3				132.6	442.2
G16	Glassware, Ceramics, non-Metallic Matter								0.2				6.7	6.9
G17	Steel basic industries, non-ferrous metal basic industries								4,256.0					4,256.0
G18	Metal product (tools, appliances, household furniture, building interior etc.)								4.5			68.8		73.3
G19	Metal product (construction, installation)								85.1			14.7		99.8
G20	Metal product (others)		5.5		458.2		13.6		38.2		9.1	8.8	306.5	839.9
G21	Machines (Engines, Turbines, Machinery)			46.0	5.0				72.5			29.2	3.3	156.0
G22	Machines (for producing metal or wood products)								60.5				136.7	197.2
G23	Machines (for paper, chemical, food, textile etc.)						1.7		52.7					54.4
G24	Machines (calculating machines, Accounting machines, Water pumps, air or gas compressors etc.)			0.2	61.7		0.7	17.6	2.6			8.8	13.0	104.6
G25	Electric product (Machines or Product under No.70, Radio set, Electric Instruments or appliances etc.)			1.7	12.1				0.6			1,121.6	96.2	1,232.2
G26	Electric product (Electric Equipment)	61.6		78.5					12.7		22.6		75.5	250.9
G27	Transportation machines (Ship, Trains, Streetcars, Cars or Trailers)					10.7	1.7		28.1			185.5	96.9	322.9
G28	Transportation machines (Motorcycles, Tricycles, Bicycles, Aircraft, Wheeled vehicles etc.)	11.1		0.2			104.8	28.2	4.7			20.4	54.2	223.6
G29	Precision machinery						4.3	17.0	20.2			8.1	0.0	49.6

Study Code	Descriptions	W01	W02	W03	W04	W05	W06	W07	W08	W09	W10	W11	W12	Total
G30	Others (Musical Instruments, Sport Toys etc.)											1.1	1.3	2.4
G31	Others (Electric power, Gas Packaging, Cold storage etc.)								0.6					0.6
G32	Others (Engine-driven for vehicles or motorcycles etc.						43.6		324.0			373.8	4.7	746.1
G33	Others (Stone, Watches or Clocks, Central waste treatment plant, Generating steam, salt etc.)	6.0							1.0			46.6	50.1	102.7
All Category of Factories		1.6	7.0	2.9	19.6	0.6	4.6	5.0	56.4	0.0	0.8	125.3	121.7	345.7

b. Estimation of future number of employees

The future number of employees by industrial type, which were simplified to 33 industrial codes for this survey, was estimated in the following way.

- The number of employees in 2001 is obtained from such data as DIW factory data, which the team used for the factory survey. The total number of employees in the study area in 2001 is 1,584,782.
- If study codes agree with individual TSIC codes, TSIC increase rates in the number of employee, which were calculated in the previous chapter, is used to estimate the future number of employees.
- If study codes include plural TSIC codes, weighted average of employee increase rates of these TSIC codes is used to estimate the future number of employees.
- The rest of study codes, G31, G32 and G33, do not fall under any of TSIC codes. The increase rate in the total number of employees is used to calculate the future number of employees.

The number of employees in 2001 in each study code is shown in Table 8-10, along with the ratio of the estimated number in 2005 and 2010 to the current number.

Table 8-10: Number of employees in 2001 and its increase

Study Code	Descriptions	TSIC Code	Nos. of Employee (2001)	Increase Rate (2005)	Increase Rate (2010)
G01	Food (agricultural product, non-aquatic animals, aquatic animals etc.)	311	92,554	1.147	1.309
G02	Food (flour, sugar, tea, ice etc.)	312	30,685	1.046	1.073
G03	Drink, Beverage	313+314	17,448	1.005	1.008
G04	Textile, Thread, Fibre	321	143,267	1.007	1.009
G05	Textile product (Clothes, mats etc.)	321	58,807	1.007	1.009
G06	Wearing Apparel	322	189,939	1.084	1.165
G07	Hide, Fur, Footwear	323+324	64,105	1.057	1.117
G08	Woodwork (any or many items)	331	25,290	1.000	1.000
G09	Woodwork (bamboo, rattan, straw, cork etc.)	331	15,283	1.000	1.000
G10	Furniture	332	29,779	1.064	1.110
G11	Paper, Cardboard	341	26,679	1.161	1.362
G12	Printed matter	342	34,049	1.072	1.146
G13	Chemical matter, Petroleum	351-354	58,642	1.019	1.023
G14	Rubber	355	35,823	1.032	1.045
G15	Plastic product	356	98,506	1.103	1.202
G16	Glassware, Ceramics, non-Metallic Matter	361,362, 369	41,168	1.037	1.058
G17	Steel basic industries, non-ferrous metal basic industries	371+372	29,249	1.017	1.036
G18	Metal product (tools, appliances, household furniture, building interior etc.)	381	13,969	1.067	1.131
G19	Metal product (construction, installation)	381	18,518	1.067	1.131
G20	Metal product (others)	381	94,039	1.067	1.131
G21	Machines (Engines, Turbines, Machinery)	382	14,406	1.000	1.000
G22	Machines (for producing metal or wood products)	382	6,584	1.000	1.000
G23	Machines (for paper, chemical, food, textile etc.)	382	5,204	1.000	1.000
G24	Machines (calculating machines, Accounting machines, Water pumps, air or gas compressors etc.)	382	56,926	1.000	1.000
G25	Electric product (Machines or Product under No.70, Radio set, Electric instruments or appliances etc.)	383	120,045	1.046	1.060
G26	Electric product (Electric Equipment)	383	24,898	1.046	1.060

Study Code	Descriptions	TSIC Code	Nos. of Employee (2001)	Increase Rate (2005)	Increase Rate (2010)
G27	Transportation machines (Ship, Trains, Streetcars, Cars or Trailers)	384	54,702	1.037	1.074
G28	Transportation machines (Motorcycles, Tricycles, Bicycles, Aircraft, Wheeled vehicles etc.)	384	26,821	1.037	1.074
G29	Precision machinery	385	58,164	1.023	1.045
G30	Others (Musical instruments, Sport, Toys etc.)	390	40,818	1.029	1.048
G31	Others (Electric power, Gas, Packaging, Cold storage etc.)	41	24,314	1.058	1.111
G32	Others (Engine-driven for vehicles or motorcycles etc.	95	24,278	1.058	1.111
G33	Others (Stone, Watches or Clocks, Central waste treatment plant, Generating steam, salt etc.)	NA	9,825	1.058	1.111
All Category of Factories		---	1,584,782	---	---

8.2.3 Estimation Results of the Future Industrial Waste Generation

The product of waste generation rate (by types of industry for each category of waste) and the future number of employees for each 33 industrial categories is the future amount of industrial waste generation. The results of the estimation are shown below.

a. Non-HW generation

Non-HW generations by type of industry and waste in 2010 were obtained by multiplying non-HW generation rate by the estimated number of employees in 2010[1]. Non-HW generations by the type of industry and waste are shown Table 8-11 and Table 8-12 respectively.

The total non-HW generation is estimated at 2,601,993 ton/year in 2010, which is 1.1 times more than 2,364,782 ton/year in 2001.

Table 8-11: Non-HW generation by type of industry in 2010

Unit : ton/year

Study Code	Descriptions	C01-01	C01-2	C02	C03	C04	C05	C07	C08	C09-01	C09-02	C10	C11	W12	Total
G01	Food (agricultural product, non-aquatic animals, aquat c animals etc)	2,047	361,897		339	21,698			122				12	60	386,175
G02	Food (flour, sugar, tea, Ice etc.)			53	458	613	167	1,673	401					9,383	12,748
G03	Drink, Beverage	22,764		16	59	333			73		21,330			3,011	47,586
G04	Textile, Thread, Fibre				1,200	4,423	47,328		8,963				1,012	1,951	64,877
G05	Textile product (Clothes, mats etc)	34,255		973	973	15,374	2,421	0	0						53,996
G06	Wearing Apparel				1,727	89	49,190		44				12,834		63,884
G07	Hide, Fur, Footwear		31,771		244	3,939	9,660	638	128			638		79	47,097
G08	Woodwork (any or many items)			141,047	8				5				2,645		143,705
G09	Woodwork (bamboo, rattan, straw cork etc.)			59,724	180								1,944		61,848
G10	Furniture			172,919	420				155				3,242		176,736
G11	Paper, Cardboard				26,189	2,115			588					37,485	66,377
G12	Printed matter				37,920	58			55				3,441	47	41,521
G13	Chemical matter, Petroleum				660	1,632			744				876	1,314	5,226
G14	Rubber			11,261	1,883	7,521	11	25,445	22			60			46,203
G15	Plastic product			13,818	4,321	93,504	249		520				320		112,732
G16	Glassware, Ceramics, non-Metallic Matter			4	222		8		2,696	36,417	41,282	30,589		875	112,093
G17	Steel basic industries, non-ferrous metal basic industries				924	924			458,418			231,919	1,406		692,691
G18	Metal product (tools, appliances household furniture, building interior etc)			53	146		23		68,143						68,365
G19	Metal product (construction, installation)			1,141		115			52,397						53,653
G20	Metal product (others)			244	14,167	191	490		69,473						84,565
G21	Machines (Engines, Turbines, Machinery)			867	1,745	72			27,786			434	5,078		35,982
G22	Machines (for producing metal or wood products)				70				2,206				70		2,346
G23	Machines (for paper, chemical, food, textile etc.)			15	9				2,848				113		2,985
G24	Machines (calculating machines, Accounting machines, Water pumps, air or gas compressors etc)					3,199			2,841				46		6,086
G25	Electric product (Machines or Product under No 70, Radio set, Electric instruments or appliances etc.)			305	2,850	6,998			29,165				16,288	21,722	77,328
G26	Electric product (Electric Equipment)				2,077	11,821			11,623		12,108	16	90		37,735

[1] The team assumes that the non-HW generation rate is constant until 2010.

Study Code	Descriptions	C01-01	C01-2	C02	C03	C04	C05	C07	C08	C09-01	C09-02	C10	C11	W12	Total
G27	Transportation machines (Ship, Trains, Streetcars, Cars or Trailers)			223	2,732	882			3,601			64			7,502
G28	Transportation machines (Motorcycles, Tricycles, Bicycles, Aircraft, Wheeled vehicles etc)				23	55	12,724	677	18,061		135	1,354		23	33,052
G29	Precision machinery				207	43			839			401			1,490
G30	Others (Musical instruments, Sport toys etc)		47	274	1,955	11,870	56		274				124		14,600
G31	Others (Electric power, Gas, Packaging, Cold storage etc.)		1,902	6	3,125	197						34,328			39,556
G32	Others (Engine-driven for vehicles or motorcycles etc				127	210			733						1,070
G33	Others (Stone, Watches or Clocks, Central waste treatment plant Generating steam, salt etc)					28			130				23		181
All Category of Factories		59,086	395,617	402,943	106,960	187,904	122,327	28,433	763,054	36,417	74,855	298,903	49,564	75,950	2,601,993

Table 8-12: Non-HW generation by type of waste in 2010

Unit : ton/year

Non-HW Code for the Study	Descriptions	Generation Amount (2001)	Generation Amount (2005)	Generation Amount (2010)	Rate to Total (2010) (%)
C01-01	Parts of plants such as roots, barks and leave	58,096	58,677	59,066	2.3
C01-02	Parts of animals such as bones, skins, hair and excreta	306,668	349,030	395,617	15.2
C02	Parts of wood	382,775	394,397	402,943	15.5
C03	Paper waste	91,307	98,867	106,960	4.1
C04	Plastics or synthetic rubbers	163,704	176,273	187,904	7.2
C05	Cloth, thread and fabric	112,911	117,794	122,327	4.7
C06	Animal's fat and oil and vegetable oil	---	---	---	---
C07	Natural rubbers	27,109	28,016	28,433	1.1
C08	Metals and metal alloys (not in salt form)	720,592	742,297	763,054	29.3
C09-01	Ceramics	34,421	35,695	36,417	1.4
C09-02	Glasses	71,729	73,809	74,855	2.9
C10	Stone, cement, sand or materials consisting of clay, sand or stone e.g. tile, brick gypsum and concrete	285,583	292,330	298,903	11.5
C11	Mixed waste	45,917	48,034	49,564	1.9
C12	Others	63,970	69,845	75,950	2.9
All category of Non-HW		2,364,782	2,485,064	2,601,993	100.0

b. HW generation

Same as the non-HW generation, HW generations by type of industry and waste in 2010 were obtained by multiplying HW generation rate by the estimated number of employees in 2010[2]. HW generations by the type of industry and waste are shown in Table 8-13 and Table 8-14.

The total HW generation is estimated to be 580,909 ton/year in 2005 and 598,278 ton/year in 2010, which is 1.07 times more than 557,456 ton/year in 2001.

Table 8-13: HW generation by type of industry in 2005

Unit : ton/year

Study Code	Descriptions	W01	W02	W03	W04	W05	W06	W07	W08	W09	W10	W11	W12	Total
G01	Food (agricultural product, non-aquatic animals, aquatic animals etc)								10					10
G02	Food (flour, sugar, tea, ice etc)								6			1,268		1,274

[2] The team assumes that the HW generation rate is constant until 2010.

G03	Drink, Beverage		2,451						182			363	27,233	30,229
G04	Textile, Thread, Fibre								1,183			346	43	1,572
G05	Textile product (Clothes, mats etc.)							1	0			48	105	154
G06	Wearing Apparel								21					21
G07	Hide, Fur, Footwear						36		2				219	257
G08	Woodwork (any or many items)						124		3			2,026	111	2,264
G09	Woodwork (bamboo, rattan, straw cork etc.)								37				11	48
G10	Furniture						349		57			1,131	4,655	6,192
G11	Paper, Cardboard						13						251	264
G12	Printed matter								2,938				6,877	9,815
G13	Chemical matter, Petroleum			1,751	3,717		1,308	1,655	2,187	18		17,139	18,483	46,258
G14	Rubber							11	1,387				22	1,400
G15	Plastic product						8,008	15,385	10,246				14,407	48,046
G16	Glassware, Ceramics, non-Metallic Matter								8				286	294
G17	Steel basic industries, non-ferrous metal basic industries								126,600					126,600
G18	Metal product (tools, appliances household furniture, building interior etc.)								67			1,025		1,092
G19	Metal product (construction, installation)								1,682			290		1,972
G20	Metal product (others)		552		45,976		1,365		3,833		913	883	30,751	84,276
G21	Machines (Engines, Turbines, Machinery)			663	72				1,044			421	48	2,248
G22	Machines (for producing metal or wood products)								398				900	1,298
G23	Machines (for paper, chemical, food, textile etc.)						9		274					283
G24	Machines (calculating machines, Accounting machines, Water pumps, air or gas compressors etc.)			11	3,512		40	1,002	148			501	740	5,954
G25	Electric product (Machines or Product under No.70, Radio set, Electric instruments or appliances etc.)			213	1,520				75			140,836	12,079	154,723
G26	Electric product (Electric Equipment)	1,605		2,044					331		589		1,966	6,535
G27	Transportation machines (Ship, Trains, Streetcars, Cars or Trailers)					607	96		1,594			10,522	5,497	18,316
G28	Transportation machines (Motorcycles, Tricycles, Bicycles, Aircraft, Wheeled vehicles etc.)	309		5			2,915	784	131			567	1,508	6,219
G29	Precision machinery						253	1,012	1,201			479	0	2,945
G30	Others (Musical instruments, Sport, Toys etc.)											46	55	101
G31	Others (Electric power, Gas Packaging, Cold storage etc.)								16					16
G32	Others (Engine-driven for vehicles or motorcycles etc						1,120		8,322			9,601	121	19,164
G33	Others (Stone, Watches or Clocks Central waste treatment plant, Generating steam, salt etc.)	52							11			485	521	1,069
All Category of Factories		1,966	3,003	4,687	54,797	607	15,636	19,850	163,974	18	1,502	187,977	126,892	580,909

Table 8-14: HW generation by type of waste in 2001, 2005 and 2010

Unit : ton/year

HW Code for the Study	Descriptions	Generation Amount 2001	Generation Amount 2005	Generation Amount 2010	Rate to Total (2010) (%)
W01	Acid	1,881	1,966	2,000	0.3
W02	Alkalis	2,956	3,003	3,044	0.5
W03	Heavy Metal Compounds	4,555	4,687	4,724	0.8
W04	Liquid Inorganic Compounds	51,774	54,797	57,590	9.6
W05	Solid Inorganic Compounds	585	607	628	0.1
W06	Organic Compounds	14,579	15,636	16,632	2.8
W07	Polymer Materials	18,331	19,850	21,286	3.6
W08	Fuel, Oil and Grease	159,690	163,974	168,340	28.1
W09	Fine Chemicals and Biocides	18	18	18	0.0
W10	Pickling Waste	1,419	1,502	1,565	0.3
W11	Filter Materials, Treatment Sludge	180,238	187,977	191,057	31.9
W12	Other Toxic substance (besides W01-W11)	121,430	126,892	131,394	22.0
All category of HW		557,456	580,909	598,278	100.0

Chapter 9

Non-HW Management Master Plan

9 Non-HW Management Master Plan

9.1 Goal, Target and Strategy

9.1.1 Goal

The primary goal of the non-HW Master Plan (M/P) is to develop a proper management system of non-HW by the target year 2010 in the Bangkok Metropolitan Area and its vicinity where the Kingdom centers industries and economic activities.

By the development of the non-HW management system, it is expected:

- to preserve the environment and public health in the area and facilitate the sound economic and social development of the area, and
- to promote the growth of internationally competitive industries in Thailand complying with the strict ISO standard and the environmental requirements in the international market.

The important issues in establishing a proper non-HW management system are (i) to reduce IW generation as much as possible (Reduction), (ii) to reuse/recycle IW generated as much as possible (Reuse/Recycling) and (iii) to properly treat/dispose of IW, which could not reused/recycled (Proper Treatment/Final Disposal).

With such recognition, the goal of the M/P set above can be interpreted in practical terms as follows.

1. An appropriate on-site IWM system is established. That is, factories minimize IW generation as much as possible, and reuse/recycle generated IW within the factories to a maximum extent. Factories discharge only waste that they can not reduce nor reuse/recycle by themselves, and subcontract its collection/transportation, reused/recycling, and/or final disposal to waste business enterprises with authorization to render such services.
2. An appropriate off-site IWM system is also established. In the system, waste that is once discharged by factories is reused/recycled as much as possible. Waste that is difficult to be reused/recycled is properly treated and/or disposed of without environmental negative impacts.
3. The off-site IWM system is established by the private sector. It provides appropriate and adequate off-site IWM services. The services include collection/transport, reuse/recycling, intermediate treatment and final disposal with properly controlled equipment and facility.
4. A sound market of IWM services is established. In the market, the service providers compete in price and service quality, and waste generators bear the cost for appropriate service.

9.1.2 Targets

The M/P will be implemented in two phases for the accomplishment of the above goal.

Short-term: 2002-2005

Mid- and long-term: 2006-2010

In setting targets for the goal of the M/P, the team took account of the following views.

1. By the promotion of waste reduction at factories, the total generation amount in 2010 is only 10% more than that in 2001.
2. The quality of current reuse and recycling activities is improved and the reuse/recycling rate as high as 80% is maintained even along with the increase in personnel cost.
3. The waste amount of on-site final disposal is reduced to half by the enforcement of strict control on on-site final disposal in consideration of the fact that on-site final disposal is often affecting the environment.
4. Part of waste that is currently disposed of on-site is diverted to off-site treatment/final disposal facilities. The waste amount treated and/or disposed of off-site in 2010 will be 13.5% of the total generation amount, which is 2.55 times more than the figure in 2001, i.e. 5.3%.

Table 9-1: Targets of Non-HW Management

Item	Present (2001)	Short-term (2005)	Mid- and Long-term (2010)
Generation (ton/year)	2,364,782	2,485,064	2,601,993
Reuse/recycling rate (%)	78.4	78.9	79.5
On-site (%)	13.6	13.4	13.2
Off-site (%)	64.8	65.5	66.3
On-site final disposal (%)	14.1	9.7	6.7
Off-site treatment and final disposal (%)	5.3	11.1	13.5
Reduction (%)	0.4	0.3	0.3
On-site storage (%)	1.8	0	0

Note: % in Brackets is the rate to the total generation amount.

The non-HW flow in 2005 and 2010 will be as shown below, assuming that these targets are achieved.

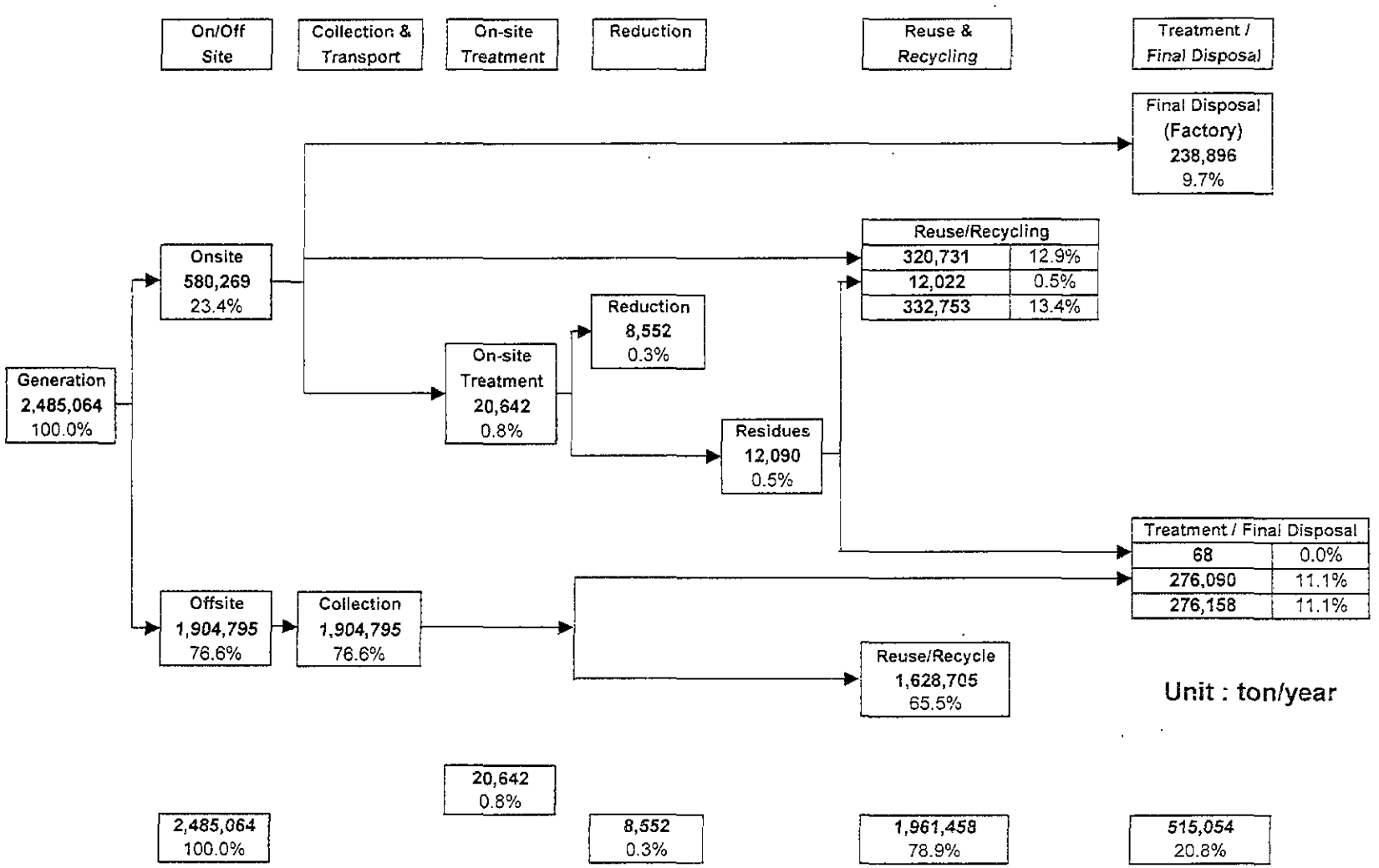

Figure 9-1: Non-HW Flow (2005)

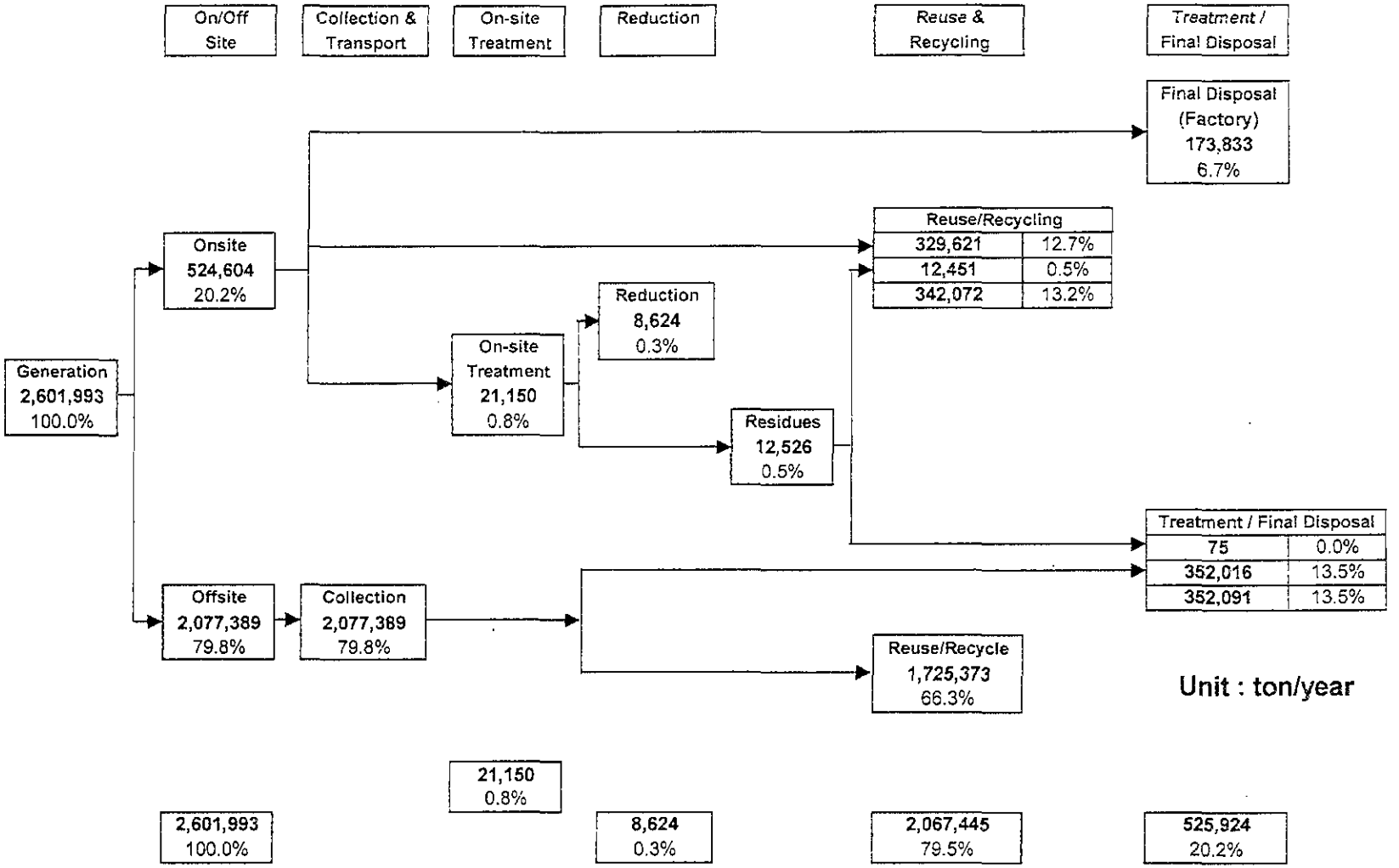

Figure 9-2: Non-HW Flow (2010)

9.2 Master Plan

The targets of the M/P shown earlier can be summarized by three terms: generation reduction, the maintenance of reuse/recycling rate and the shift from on-site disposal to off-site disposal. In addition to these, the M/P should contain activities for the purpose of smoothly carrying the M/P into action. The team proposes the M/P consisting of eight elements as shown below. The next table summarizes the proposed M/P.

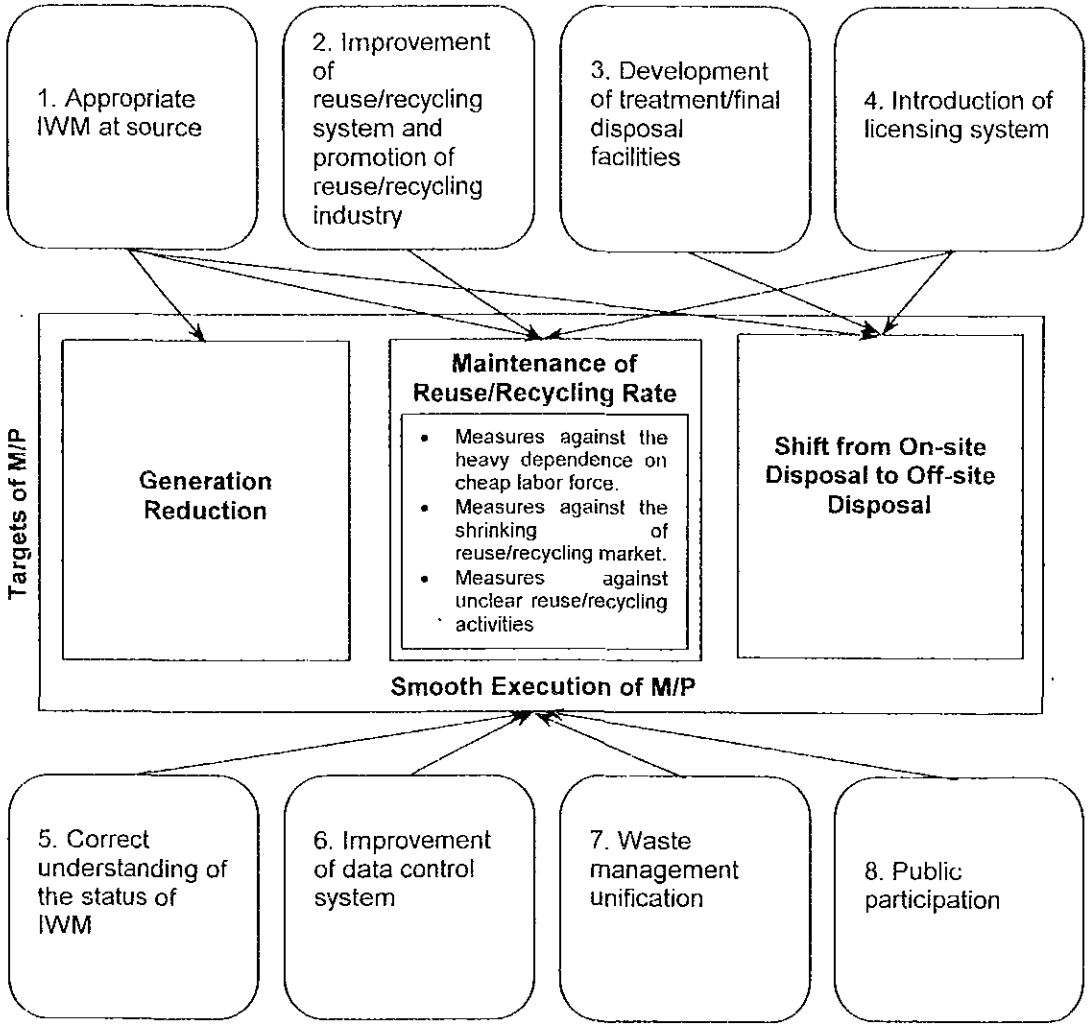

Figure 9-3: Structure of the Non-HW M/P

Table 9-2: Summary of the Non-HW M/P

Subject	Short-term	Mid- and Long-term
1. Appropriate IWM at Source		
a. Establishment of IWM system	• DIW directs factories to have a clear mechanism to place responsibility for waste management and a technical control system at factories. • DIW, in cooperation with other authorities, introduces training programs and certificate systems for human resources development. • DIW provides technical services to factories.	• DIW obliges factories to appoint a general manager who comprehensively oversees IWM at factories and a technical manager to establish a clear IWM system. • DIW promotes factories' preparation of environmental reports.
b. Promotion of waste reduction and reuse/recycling	• DIW prioritizes industrial sectors that need waste reduction and reuse/recycling according to the nature of waste in terms of quality and quantity. • DIW promotes waste reduction and reuse/recycling to the industrial sectors with high priority.	• DIW continues to promote waste reduction and reuse/recycling to industrial sectors in the order of priority.
c. Realization of appropriate on-site treatment/final disposal and appropriate off-site discharge	• DIW strengthens its control over inappropriate on-site waste treatment and final disposal by the factory inspections and on other occasions. • DIW directs factories to separate non-HW waste from HW, and separate non-HW into that from production lines and the other, and separate waste into further categories. • DIW promotes the construction of appropriate waste treatment/disposal facilities. • DIW examines the introduction of a licensing system in accordance with the legislation of the manifest system by PCD.	• DIW strictly controls inappropriate on-site waste treatment and final disposal by the factory inspections and on other occasions. • DIW regulates factories to separate waste. • DIW obliges factories to entrust their off-site waste disposal to licensed enterprises.
2. Improvement of Reuse/Recycling System and Promotion of Reuse/Recycling Industry		

a. Improvement of Reuse/Recycling System	• DIW investigates the actual conditions of the reuse/recycling system that the present study could not explore in depth and detects problems,. • DIW establish a system to control waste reuse/recycling business including waste buyers (Por Kha Khong Gao).	• Based on the result of the investigation done in the short-term, DIW formulates an improvement plan. • DIW puts the plan into effect.
b. Promotion of Reuse/Recycling Industry	• DIW regulates inappropriate reuse/recycling activities and promotes appropriate reuse/recycling by preparing technical and financial support. • DIW promotes waste recycling at cement factories. • DIW nurtures waste analysis, adjustment and blending industries. • DIW studies and promotes the use of existing facilities for the waste recycling purposes. • DIW promotes R&D of various waste recycling technologies.	• DIW continues to regulate inappropriate reuse/recycling activities and promote appropriate reuse/recycling. • DIW promotes R&D of various waste recycling technologies.
3. Development of Treatment/Final Disposal Facilities		
a. Promotion of Treatment/Final Disposal Facilities Construction	• DIW promotes the construction of non-HW final disposal facilities by the private sector.	• DIW continues to promote the construction of non-HW final disposal facilities by the private sector.
b. Control over Inappropriate Waste Management	• DIW strengthens its control over illegal waste dumping and regulates illegal non-HW treatment/final disposal facilities by developing a facility design and operation standard.	• DIW continues to strengthen its control over illegal waste dumping and regulate illegal non-HW treatment/final disposal facilities by developing a facility design and operation standard.
c. Co-use of Facilities for Municipal Waste	• Before non-HW final disposal facilities are developed by the private sector, DIW allows the final disposal of non-HW to be continued at municipal landfills by mutual consent between MOI and local administrations including BMA. • If waste disposal at municipal landfills is continued, DIW, in cooperation with local administrations, develops reception conditions to be applied to non-HW.	• DIW put the reception conditions set in the short term into effect. • As for the intermediate treatment not for reuse/recycling purpose, DIW promotes the use of facilities for municipal waste, if they are available.
4. Introduction of Licensing System		

	• DIW examines the introduction of a licensing system, by which waste collectors/transporters andwaste buyers are required to register. DIW also review the present factory registration system to regard it as a licensing system of the enterprises engaged in waste reuse/recycling, intermediate treatment and final disposal. • Before the introduction of the licensing system, DIW enforces the present transport permit system thoroughly.	• DIW regulates improper waste business enterprises even by withdrawing licenses. • Enterprises without license are strictly regulated, and factories are legally enforced to subcontract off-site waste disposal to licensed enterprises. • DIW provides licensed enterprises with benefits such as technical and financial support and information of waste exchange, so that proper waste business enterprises are encouraged.
5. Correct Understanding of the State of IWM		
a. Development of a Monitoring System	• DIW reviews the present control measures executed on such occasions as factory registration, registration revision, and factory inspections and examines which control procedures *should be strengthened for* waste management. • DIW directs factories to follow the manifest system of PCD when it is legally established.	• Following the result of examination done in the short-term, DIW strengthens its control over factories. • DIW strictly execute the manifest system.
b. Establishment of information control system	• As for information DIW currently collects, DIW reviews and improves the data storage method. • As for information DIW does not currently collect, DIW examines what sorts of information should be *collected and how. Especially,* DIW examines the implementation of a regular factory survey and arranges legislation. • DIW starts to disclose information on waste management as a tool to promote public participation.	• DIW commences the new methods of information collection examined in the short-term. • DIW makes further efforts to ease information access for the public and factories.
6. Improvement of Data Control System		
	• DIW appoints the necessary number of personnel who control and update the databases, and arranges necessary equipment. • DIW makes a procedure thoroughly understood and executed so that data and	• DIW maintains and develops the database adequately.

	information necessary for the database update can gather from bureaus within DIW, DIW regional offices, IEAT, and other relevant offices. DIW prepares software and hardware for this purpose. * • DIW develops procedures to share the data in the databases such as waste classification by code numbers. • DIW attempts to open its data on waste management.	
7. Waste Management Unification		
	• Governmental organizations relevant to waste management examine the introduction of a new umbrella act which regulates every issue of not only industrial waste but also municipal waste and hospital waste.	• Thai government introduces the umbrella act under which waste management is unified. • Relevant organizations modify their acts and organizational structures to promote the execution of the new act.
8. Public Participation		
	• DIW, in cooperation with other government organizations concerned, takes effort to regain confidence of public by tightening control on illegal dumping and strengthening monitoring/inspection of existing treatment/disposal facilities. • DIW and other government organizations concerned open necessary information to public and promote environment education to deepen people's understanding of waste management issues. • DIW examines how to ask for public cooperation for the establishment of appropriate waste management system and how to involve people into the planning process of waste treatment/disposal facilities. • DIW develops a site selection standard for waste treatment/disposal facilities that satisfies people's requirement.	• DIW and other government organizations concerned ask the general public to cooperate for illegal waste dump prevention. • DIW, in cooperation with other organizations, develops a public cooperation system for the establishment of proper IWM and a system to involve the public from the planning stage of IW treatment/final disposal facilities.

9.2.1 Appropriate IWM at Source

a. Establishment of IWM System

In recent years, it is more and more important for manufactures to establish an appropriate IWM system, which control the total process from generation of waste to final disposal. In particular, export oriented companies are forced to improve environment management further and to adapt global standards such as ISO to compete in the global market.

The basic ideas to establish a proper IWM system are (1) to minimize IW generation amount as much as possible, (2) to reuse/recycle generated IW as much as possible, and (3) to treat/dispose of the rest of IW (discharged IW) by appropriate ways to prevent environment degradation by IW. Therefore, the first step for the establishment of total IWM system is to establish a proper IWM system at individual factories to minimize waste generation. And then, it is necessary to promote reuse/recycling system, followed by improvement of on-site treatment/disposal system and contract treatment/disposal system.

Here, improvement plans to establish a proper IWM system at individual factories are proposed. To establish a proper IWM system, each factory is expected:

1. to establish comprehensive waste management and technical control system;
2. to appoint general manager and technical manager of IWM;
3. to study the state of on-site IWM;
4. to grasp IW generation amount and the flow of on-site treatment;
5. to formulate improvement plans concerning waste prevention, reuse/recycle, on-site treatment/disposal, collection and transportation, and off-site treatment/disposal; and
6. to establish the IWM system, by implementing improvement plans.

DIW need to support factories to promote the establishment of a proper IWM system at individual factories. The most important task of DIW is to support small and medium scale industries, which often face difficulties to establish the system by themselves. The necessary measures DIW need to take are as follows.

[Short Term]

1. DIW directs factories to have a clear mechanism to place responsibility for waste management and a technical control system at factories.
2. DIW, in cooperation with other authorities, introduces training programs and certificate systems for human resources development.
3. DIW provides technical services to factories.

[Mid and Long Term]

1. DIW obliges factories to appoint a general manager who comprehensively oversees IWM at factories and a technical manager to establish a clear IWM system.

2. DIW promotes factories' preparation of environmental reports.to obligate factories to establish a waste management and technical control system and to arrange the post of general manager and technical manager of IWM.

b. Waste Reduction and Thorough Reuse/recycling of Waste

As the IWM system mentioned above is established, it will enable factories to understand the state of waste discharge. It is important that they go further steps of reducing waste and reusing/recycling waste.

It is almost impossible to hold waste generation zero, but it is possible to reduce the generation amount. In the case of lubricating oil, the appropriate usage makes it possible to extend the life cycle, and this could bring about waste reduction.

In addition, it is important to reconsider production process including raw materials to achieve waste minimization and to promote reuse/recycling of wastes. Utilization of raw materials that do not contain hazardous substances could make it easier to reuse/recycle generated wastes. Utilization of recycled materials, which might require modification of production process, could bring about waste reduction and the promotion of reuse/recycling.

DIW should support factories and lead them into waste reduction and reuse/recycling. The possible approaches can be different from sector to sector, and DIW should take the following actions.

[Short Term]

1. DIW prioritizes industrial sectors that need waste reduction and reuse/recycling according to the nature of waste in terms of quality and quantity.
2. DIW promotes waste reduction and reuse/recycling to the industrial sectors with high priority.

[Mid and Long Term]

1. DIW continues to promote waste reduction and reuse/recycling to industrial sectors in the order of priority.

c. Relization of Appropriate On-site Treatment/final disposal and Off-site Discharge

c.1 Control over Inappropriate On-site Treatment/final disposal

According to the result of the factory survey, non-HW such as paper waste, metal scrap, concrete, sand, and sludge are disposed of on-site. Even though there is limited number of observation during the factory survey, most of disposal methods observed were close to open storage. Some types of waste could affect surrounding environment. In addition, incinerations of wastes in the oil drum were often observed. In many of developed countries, such simple waste burning is prohibited due to the fear about the generation of Polychlorinated-dibenzo-p-dioxines (PCDDs). Even as for the other methods, it is in general not possible to expect adequate environmental control to waste generators, on-site treatment/final disposal should be regulated and factories should be directed to discharge waste to off-site facilities.

Therefore, DIW should strengthens its control over inappropriate on-site waste treatment and final disposal by the factory inspections and on other occasions throughout the short term and mid- and long-term.

c.2 Thorough Waste Separation

According to the factory survey, the rate of factories that (i) does not separate waste into non-HW and HW and (ii) does not separate non-HW into that from production lines and others are 17.2% and 24.6%, respectively. These figures should go down to halves (8.6% and 12.3%) in 2005, and to zero in 2010.

Moreover, it is desirable to separate waste not simply (i) non-HW and HW, or (ii) waste from production lines and others, but into more small categories for the following reasons.

- Separation of waste could make a part or the whole of discharged wastes recyclable.
- Separated waste of high purity could be a target of the waste exchange program and reused or recycled at other factories.
- It is considered that the current reuse/recycling through waste buyers largely depends on the current cheap labor force. Such a system will not sustain as labor cost rises in future. Waste separation at source will output waste that is easy to reuse/recycle and raise the efficiency of the reuse/recycling system.
- Separation of waste also makes it easier to treat discharged wastes.

When factories try to improve their IWM systems, they should try to implement waste minimization and separation simultaneously. It is important for factories to give priorities over what can be done right away and to put them into practice as soon as possible. Stressing that the improvement of IWM systems could bring about the decrease in production cost, DIW should direct factories to separate waste throughout the short term and mid- and long-term. In doing so, following the PCD's manifest system which requires the waste dischargers to put markings to the containers of HW, DIW should also instruct the factories to mark their HW.

c.3 Discharge of Waste to Proper Contractors

If factories discharge wastes, they should bear the responsibility of making sure of proper off-site treatment/disposal. It is necessary for them to choose proper contractor such as collector, transporter, and theater carefully. In the short term, DIW should promote the construction of appropriate waste treatment/disposal facilities and examine the introduction of a licensing system. In the mid- and long-term, DIW should oblige factories to entrust their off-site waste disposal to licensed enterprises.

9.2.2 Improvement of reuse/recycling system and Promotion of reuse/recycling industry

a. Improvement of reuse/recycling system

The result of the factory survey reveals the aggregate flow of wastes. According to the waste flow, more than 78% of non-HW is reused/recycled. Among reused/recycled non-HW, more than 65% of total generation amount is reused/recycled outside waste sources, and 48.5% of total generation amount is

discharged to waste collector (Por Kha Khong Gao) for value. This survey could not make clear if waste collector (Por Kha Khong Gao) treat wastes, 48.5% of total generation amount, properly or not.

The most important point of non-HW management is to make reuse/recycling system more appropriate while keeping high reuse/recycling rate. In order to achieve this, necessary measures DIW has to take are:

[Short Term]

1. to conduct a study on waste collector to understand the detailed process of reuse/recycling of non-HW by waste collector and to identify problems.
2. to prepare a system to control waste reusers/recyclers including Por Kha Khong Gao and to promote reusers/recyclers to register on factory registration code 105 (waste sorting and disposal facilities) or 106 (waste reuse/recycling), which were newly added on the list of factory code in December 2001.

[Mid and Long Term]

1. to analyse problems based on the registration data and result of the fact finding survey and to examine the basic plan to improve situations.
2. to make action plans to improve reuse/recycling systems and to implement the plans according to priority.

b. Promotion of reuse/recycling industry

In order to keep the current active reuse/recycling market and to maintain the high reuse/recycling rate close to 80% in the future when labor cost is expected to increase, the following is required.

[Short Term]

1. DIW regulates inappropriate reuse/recycling activities and promotes appropriate reuse/recycling by preparing technical and financial support.
2. DIW promotes waste recycling at cement factories.
3. DIW nurtures waste analysis, adjustment and blending industries.
4. DIW studies and promotes the use of existing facilities for the waste recycling purposes.
5. DIW promotes R&D of various waste recycling technologies.

[Mid and Long Term]

1. DIW continues to regulate inappropriate reuse/recycling activities and promote appropriate reuse/recycling.
2. DIW continues to promote R&D of various waste recycling technologies.

9.2.3 Development of Treatment/Final Disposal Facilities

Disposal fees of non-HW, which municipal waste disposal facilities set, are inexpensive, as shown below.

- 323-354 Bahts/ton including transportation fee in BMA

- 200 Bahts/ton in Samut Prakarn
- About 100 Bahts/ton in other provinces

Due to the low disposal cost, non-HW reduction by intermediate treatment is rarely observed in the study area, while 74% of non-HW is get intermediate treatment in Japan (in 1998). In the case of non-HW, there is little need for waste reduction. Therefore, in developing treatment/final disposal facilities, sanitary landfills should be promoted, as long as disposal sites can be secured.

a. Promotion of Treatment/Final Disposal Facilities Construction by the private sector

There are only three disposal sites with DIW's approval as of April 2002: one in Saraburi owned and operated by Better World Green, another in Chonburi by Eastern Seaboard Environmental Complex, and the other under construction in Sakeao by Professional Waste Technology (1999). On the other hand, there are many disposal sites, which have attained authority from provincial or municipal governments and dispose of non-HW along with municipal wastes. Even though many of these facilities have some problems such as insufficient cover soil, it is not a large problem to dispose of non-HW and municipal wastes together and they are prepared to receive non-HW to a certain extent.

The targets of the M/P for the year 2010 state that on-site final disposal should be halved from the present level and the rate of off-site final disposal to total generation should increase from the present 5.3% to 13.5%. This value, 13.5%, corresponds 350,000 tons/year and is equivalent to merely 9% of the present amount of municipal waste that is treated and disposed of (3.8 million tons/year). This implies that receiving non-HW at the municipal landfills is, not only at present but also in future, fairly possible.

However, the fundamental idea is that the private sector should bear primary responsibility to prepare non-HW disposal facilities. Furthermore, there is some possibility that an increase in the amount of municipal wastes tighten the capacity of municipal waste disposal sites in the future, and this could make municipal waste disposal sites reject IW or raise the disposal fee. Therefore, it is better for the government to examine the construction of new non-HW final disposal facilities. Therefore, DIW has to promote the construction of non-HW final disposal facilities by the private sector throughout the short term and mid- and long-term.

b. Control over Inappropriate Waste Management

The public opposition against the construction of waste treatment/final disposal facilities is nearly unavoidable. This is led by the fact that illegal waste dumps and improperly managed waste treatment/final disposal facilities have been negatively affecting the natural and living environment. The lax control over illegal waste treatment/final disposal operations can obstruct the existing appropriate waste service providers with environmental care and block new entrants into the waste business.

Therefore, DIW should strengthen its control over illegal waste dumping and regulate illegal non-HW treatment/final disposal facilities by developing a facility design and operation standard throughout the short term and mid- and long-term.

c. Co-use of Facilities for Municipal Waste

As explained in Item a. above, it is not a large problem in terms of both quality and quantity to dispose of non-HW at the municipal waste landfills, and it is practically reasonable to do so, while the construction of new facilities by the private sector is promoted.

However, it is not totally free from problems. Unlike non-HW, municipal waste tends to contain much water and organic compounds, and when disposed of with municipal waste, part of non-HW such as metal waste can be degraded and deteriorated more easily than when disposed of alone. Not only proper IWM at factories through waste separation into HW and non-HW and execution of the manifest system, but also regular monitoring of such items as leachate and groundwater at the landfills are necessary. Therefore, DIW, in cooperation with local administrations, should develop reception conditions to be applied to non-HW in the short term. Specifically, the conditions will be as below.

1. Local governments which operate and manage municipal waste disposal sites or private companies which is authorized by local governments to dispose of municipal wastes should require waste generators to submit an application and confirm the types of wastes before they decide to accept wastes newly. Moreover, when they receive wastes, they have to check the wastes by observation, and if necessary sampling and analysis are carried out. If the wastes are different from what applications wrote, they should reject to receive wastes.
2. Local governments and DIW work together to examine necessary measures and proper procedures in order to eliminate HW from non-HW and municipal wastes. The items discussed are:
    - a displaying method of vehicle which transport IW;
    - items mentioned in a written application;
    - measuring methods of quality and quantity of wastes received by municipal waste disposal sites;
    - inspection methods of wastes received by municipal waste disposal sites, paying attention to mixture of HW;
    - monitoring method of leachate and underground water surrounding disposal sites.
3. Technical supports for local governments to enhance the ability of analyzing HW should be provided. It is necessary to examine the possibility to use DIW's laboratory to analyze HW from municipal waste disposal sites for a while.

In the mid- and long-term, DIW should put the reception conditions set in the short term into effect, and as for the intermediate treatment not for reuse/recycling purpose, DIW may need to promote the use of facilities for municipal waste, if they are available.

9.2.4 Introduction of a Licensing System

a. Control by the Licensing System

It should be remarked that although the transporters and the waste buyers play important roles in recycling business, the current Factory Act can not control hem,

and the transporters' license system by Ministry of Transportation and Communication does not regulate the collection and transportation of waste, either. Therefore, it is necessary to develop a certain control over them to manage the proper movement of industrial waste, and to prevent illegal dumping of the waste.

To cope with such situation, the team recommends that a licensing system should be developed to complement the current legislation so as to establish comprehensive control over all the phases of non-HW management after factories discharged it, and to prevent illegal dumping or improper treatment. The system also can be effectively applied to HW control if the manifest system is combined together.

c. Introduction Plan of the Licensing System

The introduction of the licensing system will follow the steps as below. The details of the licensing system is explained in Section 9.4.2.

[Short Term]

1. DIW examines the introduction of a licensing system, by which waste collectors/transporters and waste buyers are required to register. DIW also review the present factory registration system to regard it as a licensing system of the enterprises engaged in waste reuse/recycling, intermediate treatment and final disposal.
2. Before the introduction of the licensing system, DIW enforces the present transport permit system thoroughly.

[Mid and Long Term]

1. DIW regulates improper waste business enterprises even by withdrawing licenses.
2. Enterprises without license are strictly regulated, and factories are legally enforced to subcontract off-site waste disposal to licensed enterprises.
3. DIW provides licensed enterprises with benefits such as technical and financial support and information of waste exchange, so that proper waste business enterprises are encouraged.

9.2.5 Correct Understanding of State of IWM

It is necessary to grasp the state of IWM correctly in order to monitor the progress of the M/P and properly put the plan into effect.

The most important elements to do so are monitoring system and information system. Since these two systems are complementary each other, both systems are indispensable for correct understanding of the state of treatment.

a. Development of a Monitoring System

Targets to be monitored are three. Monitoring at waste sources is the most important one. The main purpose of the monitoring at sources is to know the type, quality and quantity of wastes generated and the state of on-site treatment/final disposal, paying special attention to hazardous substances.

The second target is IW treatment/final disposal facilities. To control and monitor their operation of treatment/disposal facilities, periodical analysis of emission gas and effluent by operator and on-site inspection by government organizations are needed.

It is also necessary to check if the treatment/disposal facilities receive approved type and quantity of wastes or not. To check these matters, on-site inspection, manifest system, and analysis of submitted reports are needed.

Finally, the entire flow of waste from from collection/transportation to final disposal should be monitored. it is indispensable to establish the manifest system, which makes it possible for all the 3 parties, waste generators, waste receivers, and the government organization (DIW), to check whether waste is appropriately collected, transported, reused/recycled, treated and/or finally disposed of.. To make the manifest system work, the government has to strictly direct both waste generators and receivers to follow the rules.

Under such recognition, the team proposes the following actions to be taken by DIW.

[Short Term]

1. DIW reviews the present control measures executed on such occasions as factory registration, registration revision, and factory inspections and examines which control procedures should be strengthened for waste management. Examples will be:
   - the possibility to discharge HW should be examined using Ro Ngo 5 on which factories describe raw materials that they use, and the result should be utilized in the authorization system of transport permit (or manifest system after legislated) (and a copy of Ro Ngo 5, that is submitted to the Office of Industrial Economies of MOI, should be submitted to DIW).
   - whether on-site treatment/final disposal is appropriately carried out should be checked more strictly on factory inspection.
2. DIW directs factories to follow the manifest system of PCD when it is legally established. Checking whether factories follow the manifest system should be added to the factory inspection process.

[Mid and Long Term]

1. Following the result of examination done in the short-term, DIW strengthens its control over factories.
2. DIW strictly execute the manifest system.

b. Establishment of Information Control System

The establishment of an information control system requires examination about what kinds of information should be obtained from which sources and how to store it.

Necessary information to establish information systems is:

1. the state of generation, storage, and treatment/disposal of wastes at sources and the form of contract of off-site treatment/disposal;
2. the state of generation process, storage, treatment and disposal of HW at sources;
3. IWM plans at sources;

4. information on discharged wastes which are, collected, transported, reused/recycled, or treated/disposed of outside factories;
5. information on wastes which are received, reused/recycled or treated/disposed of by waste disposal company and reuser/recycler;
6. information on waste treatment/disposal facilities owned and operated by waste disposal company and reuser/recycler, including state of operation;
7. state of improper route such as illegal dumping; and
8. information on technology, reuse/recycling, amount of waste requiring off-site treatment/final disposal and capacity of such facilities, and so on.

Information sources will be as follows. Numbers in the parenthesis correspond to numbers of above items.

- Fact finding study such as factory survey (1-6)
- Reports submitted by generators (factories) (1,2,3)
- Reports submitted by waste disposal companies and reusers/recyclers (4,5,6)
- On-site inspection by government organizations (1～7)
- Registration applications of waste treatment/disposal facilities (2,6)
- Reports from local people, local administrations, and police (7)
- Exchange of information with research institutes such as universities and national/ foreign organization concerned (8)

The factory survey that the team carried out is a model of the first item, fact finding study. The target of the factory survey should, preferably, cover all the factories in the area, but it is not necessary to conduct the survey every year, because the survey makes a heavy burden for both the government and factories and IWM at factories is not expected to change drastically every year. It can be said that factory survey every 5 years could provide enough data for the government to grasp the state correctly. Since the factory survey by questionnaire tends to have a low rate of valid replies because it is troublesome for factories to fill in and they are not well aware of IWM, it is necessary for the government to consider legalizing the factory survey and obliging factories to answer to the questionnaire.

The storage methods of information obtained depend on the needs for information and the cost to gather, store and renew the data. The team proposes that DIW should improve its data control system in the following way.

- Information on factories that were the target of factory survey, reuse/recycling and treatment/final disposal facilities, state of management/treatment, and improper treatment routs are stored as individual information based on their questionnaire sheets. In addition, the data will need to be digitized to be stored as a database which is linked with the factory registration database.
- The aggregate flow of wastes and overall problems are kept as aggregate information.

- Information such as manifest data, which cover the whole flow of waste, should be saved as electronic and shared data as much as possible. If those data cannot be saved as electronic data, manifest forms are kept in a certain period as a reference.

It is necessary for the government to standardize all the data systems for example by setting a coding rule and unifying data formats.

To establish the information control system, DIW should take the following actions.

[Short Term]

1. As for information that DIW have been collecting, the storage methods should be reviewed and improved if necessary. For instance, types of waste generated from factories may well be stored using a coding system that the team used or the other coding system to facilitate statistical analysis.
2. As for information that DIW is not collecting, DIW should examine what kinds of information they should collect and how. Particularly, the regular factory survey will be needed, together with necessary legislative measures.
3. DIW should start to disclose information on waste management as a tool to promote public participation.

[Mid and Long Term]

1. DIW should commence the new methods of information collection examined in the short-term.
2. DIW should make further efforts to ease information access for the public and factories.

9.2.6 Improvement of Data Control Systems

a. Improvement of Data Control Systems

Since DIW has a special section, Information Technology Center, which in charge of data control, various kinds of data such as factory registration data are well stored as DB. In addition, a part of DB is open to public on the Web site of DIW. However, the DB is not updated systematically. Since DB cannot fulfill its function without proper management, DIW needs to take the following measures to control DB properly and to expand its functions.

1. Rules to gather data from each section of DIW headquarter, regional industrial offices and IEAT to the IT center are made clear and observed thoroughly, while improving computer systems (both hardware and software) to make it possible for all the organizations concerned to share the data.
2. Necessary measures to improve DA system such as standardizing waste codes are taken to make DB shared by all the organizations.
3. Necessary personnel and equipments are allocated to manage DB properly.

All of these should be commenced in the short term. In the mid- and long-term, some of them may need to be continued, and DIW should maintain and develop the

database so that data can be efficiently processed and the general public can access useful information.

b. Action Plan (A/P) for Item 1. in the Short Term

Recognizing that the incompatibility between the database of DIW managed by the IT Center and the database of DIW's regional industrial offices is the biggest problem of the DB systems that DIW faces now, the team proposes a specific action plan (A/P) below.

b.1 Background

At present, 120,000 factories in the whole country are registered on factory registration DB at DIW. On-site inspection of theses factories, checking and updating of DB, and registration of new factories are carried out by 600 inspectors at 74 regional industrial offices. Newly registered data and renewed data are transferred and processed at DIW in the following steps.

1. Newly registered factory data and renewed data are saved as electronic data and compiled as DB at regional industrial offices;
2. These data are sent to DIW as the form of documents and to MOI as the form of electronic DB monthly;
3. Since the DB systems of DIW and regional industrial offices are different, Oracle DBMS and Foxpro respectively and DB made by regional industrial offices cannot be converted to DB system at DIW, DB sent by regional industrial offices cannot be used as electronic data at DIW.
4. DIW enter newly registered and renewed data sent by regional industrial offices into DIW DB by itself, after checking data.

In this way, DIW and regional industrial offices are doing the same input work. Since a huge volume of data are sent and accumulated at the IT center, DIW is badly behind with updating work of factory registration DB. This problem can be attributed to the incompatibility of the 2 DB systems. In order to link and convert DB of regional industrial offices directly to DIW DB, advanced equipments and computer/database experts are needed.

DIW has to take necessary measures to solve this compatibility problem, so that it can save labour for data input work and update DB systematically.

b.2 A/P

Since the both DB systems of DIW and regional industrial offices are well developed, the team makes a proposal to establish a DB convert system between the 2 DB systems, using W2000 server which has wider purposes, as shown in Figure 9-4.

The establishment of DB convert systems makes it possible for DIW to check data in the form of electronic data, not in the form of document, to obtained new data entered by regional industrial offices at any time it want, rather than one a month, and to update DB promptly after checking the content of new data. On the other hand, this makes it possible for regional industrial offices to have easy access to DIW factory registration DB.

This A/P was taken up as a pilot project which was carried out from May 2002. The details and lessons learned are found in Chapter 13.

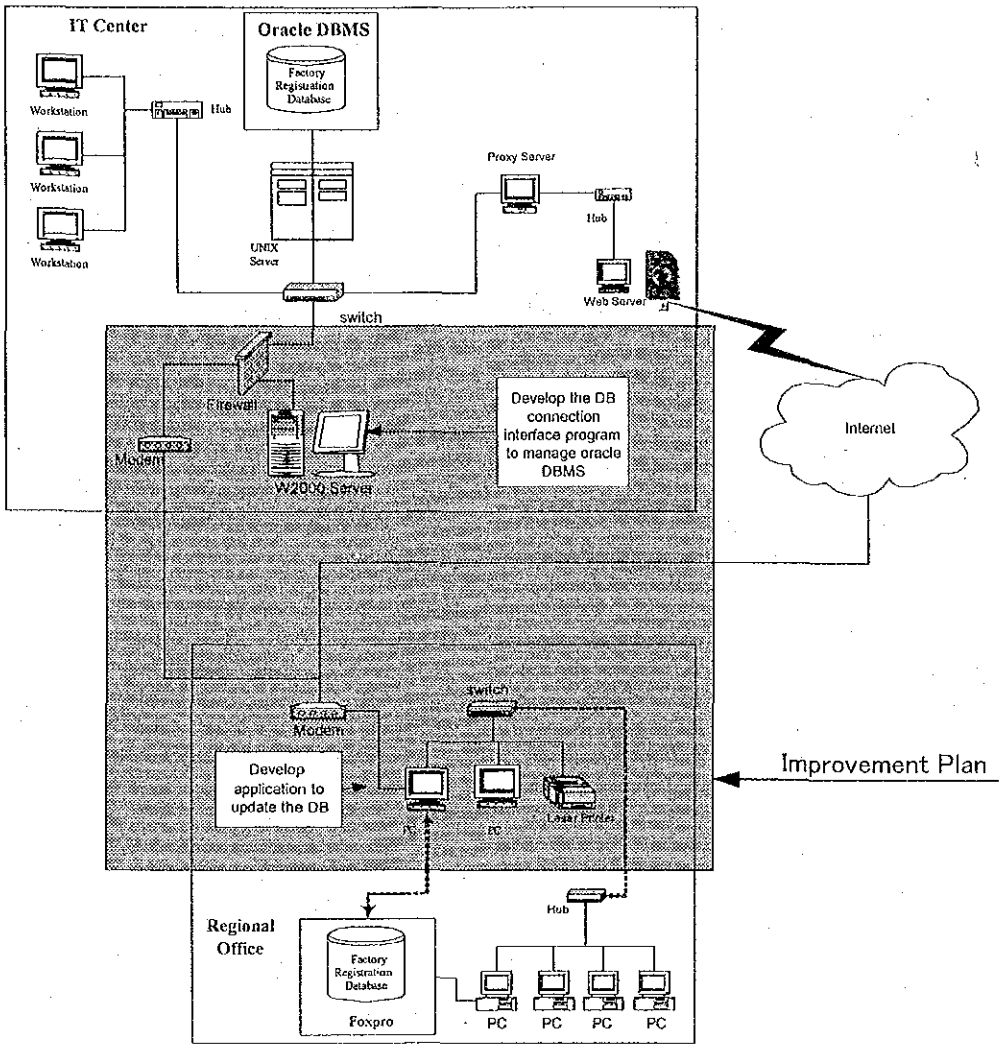

Figure 9-4: Improvement of DB management systems

9.2.7 Integration of the Waste Management Administration

It is natural that administration over waste management may be inter-ministerial matter involving Ministry of Public Health, Ministry of Industry, Ministry of Science, Technology and Environment, and Local Administrations. However, at present each ministry and local administration performs their duty as defined in the individual relevant laws. They have not been well coordinated.

Notification No.1 (B.E.2541, 1998) of MOI is one of examples. Since the Notification was issued under the Factory Act, the DIW became a responsible organization for management of non-HW which the Local Administration used to collect following to the Public Health Act. However, private collectors and treaters for IWM have not yet appeared in spite of expectation, and the Local Administration

still collects non-HW inevitably. Prior to the issue of Notification No. 1, MOI and BMA entered the agreement providing that BMA should collect non-HW for the time being. The agreement intended that BMA collect non-HW tentatively until the private sector become ready to collect waste, but the situation is still unchanged.

The responsibility of local administration to collect waste is provided in the Public Health Act. The Ministry of Public Health is going to amend the Act. The draft of the amended Act was already presented to the Cabinet and now is waiting for approval. The draft amendment stipulates three types of waste to be managed by the Local Administration with its responsibility.

- Type 1 Municipal Waste
- Type 2 Infectious Waste
- Type 3 Non-hazardous Industrial Waste

The Local Administration can collect and treat the waste by itself or can contract out the work, but it must take a whole responsibility. It should be noted that the new act will have a conditional clause that Notification No.1 precedes the act as for waste the handling method of which is defined by the notification. The Ministry of Public Health expects that the local administration contracts out the services to the private contractors and supervise the their performance.

It seems that the Ministry of Public Health does not intend to coordinate the responsibilities of them and DIW but just respect specification of Notification No.1. Under such a condition, it is hardly expected to develop national policy common to all the ministries related to waste management.

Therefore, to improve the situation, a comprehensive law on waste management involving all the relevant agencies and integrated national policy based on the law should be established.

In the mid- and long-term, Thai government should enact the Waste Management Act under which waste management is unified, and relevant organizations should modify their acts and organizational structures to promote the execution of the new act.

9.2.8 Public Participation

As people's political awareness is growing due to the democratization process, there are oppositions in increasing numbers against big-scale government projects, which usually ignore the opinion of local people and do not pay enough attention to environment conservation. The result of public opinion survey shows that a lot of people in the study area want to participate in decision-making process of projects, which could affect their lives. Therefore, in order to ask people to understand and support government IWM policies, it is necessary for the Thai government to establish a system in which government policies reflect people's opinion. Public participation in the decision-making process is to be the core of the system in the future.

The team therefore considers that in the short term, conflicts between the governmental bodies and the general public should be dissolved through mutual communication, and in the mid- and long-term, the people's participation should be

encouraged recognizing that they are necessary members to support the IWM system. The specific actions required are proposed below.

a. Short Term (2002 – 2005): bridging the gap between people and the authorities

a.1 Regaining confidence of the public (control over illegal dumps and improperly managed waste disposal facilities)

According to the result of POS, a lot of people recognize environmental problems caused by inappropriate IWM such as illegal dumping and improper operation and management of waste treatment/disposal facilities including municipal waste disposal facilities. In order to ask public to understand government IWM policies, it is necessary for all the government agencies concerned including DIW to regain confidence of people, by taking efforts to solve above problems. In particular, it is urgent issues for all the government agencies concerned to tighten control on illegal dumping and strengthen monitoring/inspection of existing waste treatment/disposal facilities.

a.2 Promotion of better understanding of people in government basic IWM policies and plans (information disclosure)

As the first step of consensus formulation, it is necessary for the government to develop people's understanding in IWM issues and government policies and plans such as waste minimization plan and waste treatment/disposal plan, by opening necessary information to public. It is important to select appropriate media, which are easy of access for ordinal people, considering a huge discrepancy in income and living standards between Bangkok and rural areas. Internet is one of possible choices in cities.

According to the result of POS, even though people are interested in IWM, their level of knowledge is not high enough. It is necessary to emphasize environment education further in order to deepen and broaden people's knowledge on IW and increase awareness of IWM.

If possible, the public comment system is introduced to promote communications about IWM policies between the government and public, by providing opportunities for the public to express their opinion about the government policies. It is important for the government to reply to public comments without delay and to try to incorporate their idea to government policies in order to make the system work.

a.3 Exploration of a mechanism to involve the public into the planning process

The general public has deep discontent with a closed planning process of waste disposal facility projects. In order to establish the IWM system which is supported by the general public, it is necessary to explore a mechanism to involve people into the early stages of project planning, and to make decisions through mutual consent among three parties, i.e. the general public, the government organizations and the waste business entities.

Specifically, the practical way for DIW to take for this purpose will be the improvement of the EIA system in cooperation with OEPP and other relevant bodies. This is because EIA will be the most advanced tool in present Thailand for people

and NGOs to join the decision making process, and the main function of EIA is to promote communication among the three parties, as well as to avoid, mitigate or compensate negative impact of the project on surrounding environment.

First of all, the guideline of public participation in EIA study, which was prepared by OEPP, should be utilized more positively. It is necessary for the government to make public participation in the early stage of EIA study, e.g. at the stage of preparing draft of scoping, obligatory for all project owners. Since OEPP has not have a clear idea about public participation procedure yet, it is necessary for both the government and public to work together in order to search for an appropriate procedures through trial and error.

On the other hand, in order to realize public participation in the early stage of EIA study, it is essential for the public and NGOs to increase the level of knowledge and abilities. It is necessary for the government, in particular MOSTE, to improve supporting systems for the public and NGOs.

a.4 Development of site selection standard

The critical point with which the people are not satisfied in many cases of waste facility plans is site selection. DIW is strongly recommended to prepare a site selection standard for IW treatment/final disposal facilities as a means to show the rationale of selected sites. If the standard is developed through the intensive discussion with people, the construction of the treatment/final disposal facilities based on the standard should proceed smoothly.

b. Mid- and long-term (2006 – 2010): Public participation in IWM system

b.1 Public participation in illegal dump control

DIW should continue and strengthen the control over illegal dumps in the mid- and long-term, but it depends to a certain extent on report given by people. The public, who tends to always require the government to bear responsibility of IWM, should notice that IWM is the issue that the society as a whole has to deal with. DIW and other government organizations concerned need to ask them to cooperate for illegal waste dump prevention.

b.2 Involvement of the general public into waste facilities planning

The mechanism to involve the general public into the planning process of waste facility projects, that would have been explored in the short term as mentioned above, should be put into force. Furthermore, DIW, in cooperation with other organizations, should develops a system where the general public can participate in the establishment of proper IWM, a higher level than the planning process of individual projects.

In practice, the government organizations including DIW should promote, for example, (i) the amendment of Administrative Procedure Act by putting a planning procedure and public participation in the stipulated form, and (ii) the introduction of the basic concept of Strategic Environmental Assessment, SEA, which makes the policy itself the target of environment impact assessment before going down to individual projects.

9.3 Measures for Promoting the Implementation of the Master Plan

The projects proposed in the M/P are various involving several organizations of different fields. Therefore, cost estimation necessary for considering how to promote M/P implementation requires further in-depth studies. For example, "IWM at the Waste Sources", the important element of M/P, has three components, (a) establishment of waste management system, (b) waste generation reduction and reuse/recycling and (c) appropriate on-site waste disposal and appropriate waste discharge, and the implementation of each component requires the involvement of authorities and factories, whose approaches for improvement can be diverse depending on their sectors and their individual circumstances.

Therefore, the team put focus on the construction of off-site treatment/disposal facilities that is necessary for relevant authorities and factories to fulfill their roles and for the goal of the M/P, i.e. the development a proper management system of non-HW, to be achieved. Among several options for the construction of off-site treatment/disposal facilities such as reuse, recycling and incineration for quantity reduction, the team picked up the final disposal facility development project and examined its feasibility. This is because reuse and recycling of non-HW have already been enough developed to cover the future increase of generation while quantity reduction by incineration will never be financially feasible as an option of non-HW treatment due to its much higher cost than other options.

9.3.1 Estimation of the Cost of Implementing the Master Plan

a. Preconditions for Cost Estimation of Landfill Facility Development and Operation

In estimating the cost of landfill facility development and operation, the team established the preconditions as given Table 11-1 below.

Table 9-3: Preconditions for Cost Estimation of Landfill Facility Development

Items	Preconditions	Remark
Types of wastes landfilled	All the non-HW subject to treatment or disposal outside the factories	
Amount of wastes landfilled	1,884,862 tons (2,356,079 m^3)	- The total amount of non-HW that is estimated to be generated and subject to treatment or disposal outside factories between 2005 and 2010 in the M/P. - Volume (m^3) of the wastes is estimated at the apparent density of 0.8 tons per m^3.
Landfill method	Sanitary landfill	
Amount of soil cover used	471,217 m^3	- The amount of soil cover used is assumed to be 20% of the volume of wastes landfilled.
Landfill capacity	2,830,000 m^3	- It is estimated based on the sum of the volume of waste

Items	Preconditions	Remark
		landfilled and soil cover used.
Landfill area	292,000 m^2	- It is estimated based on the landfill capacity above.
Project period	- Starting construction in 2004. - Starting landfill operation in 2005. - Completion of landfill operation in 2010. - 6 years' landfill operation	- Starting year of landfill operation is set up at 2005 considering the time needed for construction and preparations for operation. - Completion year of Landfilll operation is set up at 2010, i.e. target year of the M/P.

b. Estimation of the Construction Cost of Landfill Facility

b.1 Estimation Methods

Estimation of the construction cost of landfill facility is made by calculating the unit cost of construction per ton of waste landfill based on the cost estimation data in "F/S Summaries and Pre-Appraisal Khon Kaen Municipality Solid Waste Disposal Project" (hereinafter mentioned as OEPP Report), which was prepared by the Office of Environmental Policy and Program: OEPP). The estimated construction cost of landfill facility wass given by calculating the product of unit construction cost per ton of waste landfilled and the total amount of waste landfilled.

b.2 Outline of the Landfill Facility Plan in OEPP Report

The landfill facility development plan in OEPP Report aims at prolonging the life of the existing landfill for another 4 years. The total development cost is estimated at 49,190 thousand bahts.

Table 9-4: Outline of Landfill Facility Plan and Estimated Construction Cost in OEPP Report

Project ID Number	OEPP-SW-G41006	
Project Title	Solid Waste Management Systems fro Khon Kaen Municipality (Phase 1)	
Executing Agency	Khon Kaen Municipality	
Purpose	To upgrade the existing solid waste disposal systems so that it will have a capability to serve the municipality up to the next 4 years.	
Location	The vicinity of Khon Kaen Municipality, Khon Kaen	
Type of Waste Handled	Municipal Waste	
Landfill Method	Sanitary Landfill	
Landfill Area	112,000 m^2	
Project Period	Year of starting operation: 1998 Completion of operation: 2001 Period of operation: 4 years	
Construction Cost (thousand bahts)	**Total cost**	**49,190**
	Construction of waste disposal system (landfill)	33,289
	Construction of buildings and other civil works	1,287
	Operation equipment	13,750
	Construction supervision (2.5%)	864

Based on the landfill area of 112,000 m^2 given above, the team estimated that its total landfill capacity would be approximately 800,000 m^3, of which 663,401 m^3 (431,212 tons) would be the possible waste landfill capacity.

b.3 Estimation of the Construction Cost of the Landfill Facility

Based on the cost estimation data in the OEPP Report, the unit construction cost per ton of waste landfilled is calculated by the following formula:

> Unit construction cost per ton of waste landfilled =
>
> (Total construction cost of the landfill facility)/(Capacity of Landfilling waste)

Therefore, the unit construction cost per ton of waste landfilled is given as the result of dividing the total construction cost of 49,190 thousand bahts by the estimated landfill capacity of 431,212 tons. The unit construction cost is finally estimated as 114.1 bahts per ton of waste landfilled.

Finally, construction cost of the final disposal facility to landfill the total amount of 1,884,862 tons that is estimated to be generated between 2005 and 2010 in the M/P is given by the following formula:

Unit construction cost (bahts/tons of waste) X Landfill capacity (tons) =

Construction cost of the final disposal facility

or

141.1(bahts/ton of waste) X 1,884,862 (tons of waste) =

215.1 (million bahts)

(Land acquisition and facility plan/design costs are excluded.)

c. Estimation of the Operation cost of Landfill Facility

Table 9-5 below shows the result of estimating the operation cost of landfill facility by items with the assumptions applied for the estimation. All the operation cost is given in the form of unit cost per ton of waste landfilled in Table 9-5 below. The sum of all the operation cost is estimated as 182.7 bahts per ton of waste landfilled.

Table 9-5: Unit Operation Cost of Landfill Facility

Item	Unit cost (Baht/ton)	Assumptions
Facility construction cost	114.1	Based on the estimation above
Soil cover	37.5	Unit cost of soil cover: 150bahts/m3-soil Total amount of soil cover: 471,217m3 Total soil cover cost = (471,217 X 150)/1,884,862 tons of waste
Fuels for heavy equipment	19.5	Types and numbers of heavy equipment Type | Number

Item	Unit cost (Baht/ton)	Assumptions
		Bulldozer: 2 Excavator: 1 Dump truck: 3 Water Tanker: 1 Average fuel consumption: 200 liter/vehicle/day Unit cost of fuel: 12 bahts/liter Average daily fuel consumption: 16,800 bahts/day (=7 X 200 X 12) Average daily amount of waste landfilled: 861 tons/day (=1,884,862/(365 X 6))
Manpower cost	11.6	Number of workers: 20 persons/day Average wage of workers: 500 bahts/day Average daily manpower cost per ton of waste = (20 X 500/861)
Total	**182.7**	

9.3.2 Measures to Promote Proper Non-HW Treatment and Disposal in terms of their financial viability

a. Use of Municipal Waste Landfill

According to the estimation in the M/P, the total amount of non-HW to be generated for treatment and disposal outside factories will be approximately 352 thousand tons in the year 2010, which is three times as much as the current amount in 2001, 125,000 ton/year.

However, it is only more or less 10% of the disposal amount of municipal waste in 2001, which is about 3.8 million tons. Therefore, it is the most cost-efficient method to utilize municipal waste landfill for final disposal of non-HW if separation of hazardous and non-hazardous waste is properly made, the final disposal sites are appropriately managed by sanitary landfill, and the landfills have enough capacity to accept non-HW.

Many of the municipal waste landfills are managed by local administrations. Even though private operators manage them, they are required to obtain official permission by the local administrations concerned. In this respect, the use of municipal waste landfill for final disposal of non-HW is expected to make the current non-HW management more transparent and control its improper and illegal dumping.

b. Possibility of Non-HW Treatment and Disposal by Private Sector

There are some private municipal and non-hazardous industrial waste treaters authorized by local governments while the Department of Industry also issues permissions of non-hazardous industrial waste treatment and disposal to private treaters. Therefore, if a new landfill facility operator comes into the current market, he has to compete with the existing treaters in terms of its quality of services, cost efficiency, etc. According to the interview surveys and data collection by the team, tipping fees of non-HW at municipal landfills or private treaters are as follows:

Table 9-6: Treatment and landfill fees of non-HW at the existing treatment facilities and landfills

Treatment/landfill facility	Fee (bahts/ton)	Remark
Final Disposal (Landfill)		
On Nuch-Rachathewa*1	323 (Municipal Waste)	Collection and haulage included. Open dumping.
Nongkhaen-Kampangsaen*1	354 (Municipal Waste)	Collection and haulage included. Open dumping.
Tharaeng-Kampangsaen*1	351 (Municipal Waste)	Collection and haulage included. Open dumping.
Samut Prakarn Landfill*2	200 (non-HW)	Collection and haulage not included. Sanitary Landfill
Better World Green*3	900 (non-HW)	Sanitary Landfill
Incineration (Thermal Treatment)		
Hi-Tech Industrial Estate*4	2,500	Low operation ratio
Bang-Pa-In Industrial Estate*4	3,000	Low operation ratio
Borwin Industrial Estate*4	3,000	Low operation ratio

*1: SAPROF Team - JBIC Special Assistance for Project Formation (SAPROF – Phase1) for Solid Waste Management at On-Nuch, Final Report, Feb. 2001
*2: Interview Survey by the JICA Study Team
*3: Questionnaire and Interview Survey by the JICA Study Team
*4: "Survey Report, Feasibility Study of Industrial Waste Utilization Model Plant for Industrial Estate in Thailand", NEDO, April 1999.

As shown in the table above, the cost of incineration is much higher than the cost of landfill in the case of non-HW. If a new treater comes into this non-HW market, tipping fee needs to be established at the same level of the existing landfills.

Taking such current situation into account, the team carried out a preliminary financial feasibility appraisal of the landfill development and operation project by making use of the costs of facility construction and operation estimated in the previous section. In appraising financial feasibility project, the team established several tipping fees as shown below.

Case 1: 200 bahts/ton

Case 2: 250 bahts/ton

Case 3: 300 bahts/ton

Case 4: 350 bahts/ton

Other conditions of the project are assumed as shown Table 9-7 below for all the above cases.

Table 9-7: Preconditions of the Project for Preliminary Financial Appraisal

Project Period	From 2004 to 2010 2004: Start landfill facility construction 2005: Start landfill operation 2010: Landfill completed

<table>
<tr><td>Project Income</td><td>Collection of tipping fees for final disposal of non-HW.
Tipping fee: established for each case (from 200 to 350 bahts/ton).
Amount of non-HW landfilled:
Established based on the estimation of the future non-HW generation from 2005-2010 in the M/P
Amount of non-HW accepted at the landfill
<table>
<tr><td rowspan="2">Year</td><td colspan="2">Amount of non-HW accepted at the landfill</td></tr>
<tr><td>ton/year</td><td>m^3/year</td></tr>
<tr><td></td><td>A</td><td>B = A/0.8</td></tr>
<tr><td>2005</td><td>276,158</td><td>345,198</td></tr>
<tr><td>2006</td><td>291,418</td><td>364,273</td></tr>
<tr><td>2007</td><td>306,620</td><td>383,275</td></tr>
<tr><td>2008</td><td>321,695</td><td>402,119</td></tr>
<tr><td>2009</td><td>336,880</td><td>421,100</td></tr>
<tr><td>2010</td><td>352,091</td><td>440,114</td></tr>
<tr><td>Total</td><td>1,884,862</td><td>2,356,079</td></tr>
</table></td></tr>
<tr><td>Project Expenses</td><td>Assumed as follows based on the cost of facility construction and operation estimated in the previous section.
Construction cost: 215.1 million bahts (excluding land and facility plan & design cost)
Operation cost:
Soil cover (floating): 37.5 (bahts/ton of waste) X landfill amount (tons/year)
Fuels for equipment: 12 (bahts/liter) X 16,800 (liters/day) X 365 (days) = 6,132 (thousand bahts/year)
Manpower cost: 20 (persons/day) X 500 (bahts/day) X 365 (days) = 3,650 (thousand bahts/year)</td></tr>
<tr><td>Discount Rate</td><td>10% (assumed taking into account commercial interest rate, inflation, etc.)</td></tr>
</table>

The results of estimating NPV (net present value) and FIRR (financial internal rate of return) based on the above assumptions are shown in Table 11-6 below.

Table 9-8: Results of Estimating the Financial Feasibility indicators

	Tipping Fee (bahts/ton)	NPV (bahts)	FIRR (%)
Case 1	200	-34,857,774	3.97%
Case 2	250	26,501,607	14.28%
Case 3	300	87,860,987	23.45%
Case 4	350	149,220,368	31.91%

As shown in the table above, the project will not be financially feasible as a private sector business if the tipping fee is not more than 200 bahts per ton of waste (FIRR is only about 4%). On the other hand, if the tipping fee is established more than 250 bahts per ton of waste, the project will be financially feasible in consideration of the current interest rate of short-term commercial lending, which is ranging from 7 to 12%. Although the assumption above does not include the cost of land and facility