- The two DB use different waste classification. DIW is strongly recommended to define its solid waste classification system to be applied to both. .
- The team in cooperation with IT Center attempted to link the Samae Dam manifest data with the DIW factory registration DB by referring to the name of factories and assigning a corresponding DIW registration code. Out of 599 customers registered at the Samae Dam Center only 275 were found in the DIW factory registration DB, and furthermore, some of their names were not correct. It will be difficult to check all the factories. Therefore, from now on, the treatment center must be enforced to use the DIW registration code.

2.4 Current Issues on IWM

2.4.1 Present IW Generation and IW Flow

a. IW Generation

Based on the generation data of the 206 factories that gave the team valid answers about waste generation, generation rates (ton/employee/year) of each category of non-HW/HW generated from each study code of industry are calculated. Annual generation amount is simply calculated by multiplying the generation rates by the number of total employees. The amounts of non-HW and HW are estimated at about 2,365 thousand ton and 557 thousand ton in a year, respectively. The tables below present IW generation of each code of industries, non-HW generation of each non-HW category and HW generation of each HW category.

Table 2-4: IW Generation of Each Study Code of Industries

Study Code	Descriptions	Non-HW (ton/year)	HW (ton/year)	Total (ton/year)
G01	Food (agricultural product, non-aquatic animals, aquatic animals etc.)	295,015	9	295,024
G02	Food (flour, sugar, tea, ice etc.)	11,881	1,218	13,099
G03	Drink, Beverage	47,208	30,079	77,287
G04	Textile, Thread, Fibre	64,299	1,562	65,861
G05	Textile product (Clothes, mats etc.)	53,513	153	53,666
G06	Wearing Apparel	54,835	19	54,854
G07	Hide, Fur, Footwear	42,163	243	42,406
G08	Woodwork (any or many items)	143,705	2,264	145,969
G09	Woodwork (bamboo, rattan, straw, cork etc.)	61,848	48	61,896
G10	Furniture	159,222	5,820	165,042
G11	Paper, Cardboard	48,735	227	48,962
G12	Printed matter	36,232	9,156	45,388
G13	Chemical matter, Petroleum	5,107	45,395	50,502
G14	Rubber	44,213	1,357	45,570
G15	Plastic product	93,787	43,559	137,346
G16	Glassware, Ceramics, non-Metallic Matter	105,949	284	106,233
G17	Steel basic industries, non-ferrous metal basic industries	668,620	124,484	793,104
G18	Metal product (tools, appliances, household furniture, building interior etc.)	60,446	1,024	61,470
G19	Metal product (construction, installation)	47,439	1,848	49,287
G20	Metal product (others)	74,770	78,984	153,754
G21	Machines (Engines, Turbines, Machinery)	35,982	2,248	38,230
G22	Machines (for producing metal or wood products)	2,346	1,298	3,644
G23	Machines (for paper, chemical, food, textile etc.)	2,985	283	3,268
G24	Machines (calculating machines, Accounting machines, Water pumps, air or gas compressors etc.)	6,086	5,954	12,040

G25	Electric product (Machines or Product under No.70, Radio set, Electric instruments or appliances etc.)	72,951	147,919	220,870
G26	Electric product (Electric Equipment)	35,599	6,247	41,846
G27	Transportation machines (Ship, Trains, Streetcars, Cars or Trailers)	6,986	17,663	24,649
G28	Transportation machines (Motorcycles, Tricycles, Bicycles, Aircraft, Wheeled vehicles etc.)	30,774	5,997	36,771
G29	Precision machinery	1,426	2,878	4,304
G30	Others (Musical instruments, Sport, Toys etc.)	13,929	98	14,027
G31	Others (Electric power, Gas, Packaging, Cold storage etc.)	35,605	15	35,620
G32	Others (Engine-driven for vehicles or motorcycles etc.	963	18,114	19,077
G33	Others (Stone, Watches or Clocks, Central waste treatment plant, Generating steam, salt etc.)	163	1,009	1,172
Total	---	2,364,782	557,456	2,922,238

Table 2-5: Non-HW and HW Generation of Each Waste Category

Waste Type	Non-HW Code for the Study	Descriptions	*Total Generation* Amount (ton/year)
Non-HW	C01-01	Parts of plants such as roots, barks and leave	58,096
	C01-02	Parts of animals such as bones, skins, hair and excreta	306,668
	C02	Parts of wood	382,775
	C03	Paper waste	91,307
	C04	Plastics or synthetic rubbers	163,704
	C05	Cloth, thread and fabric	112,911
	C06	Animal's fat and oil and vegetable oil	---
	C07	*Natural rubbers*	27,109
	C08	Metals and metal alloys (not in salt form)	720,592
	C09-01	Ceramics	34,421
	C09-02	Glasses	71,729
	C10	Stone, cement, sand or materials consisting of clay, sand or stone e.g. tile, brick gypsum and concrete	285,583
	C11	Mixed waste	45,917
	C12	Others	63,970
Total Non-HW			2,364,782
HW	W01	Acid	1,881
	W02	Alkalis	2,956
	W03	Heavy Metal Compounds	4,555
	W04	Liquid Inorganic Compounds	51,774
	W05	Solid Inorganic Compounds	585
	W06	Organic Compounds	14,579
	W07	Polymer Materials	18,331
	W08	Fuel, Oil and Grease	159,690
	W09	Fine Chemicals and Biocides	18
	W10	Pickling Waste	1,419
	W11	Filter Materials, Treatment Sludge	180,238
	W12	Other Toxic substance (besides W01-W11)	121,430
Total HW			557,456

b. Present IW Flow

The team estimated current IW flow in the study area based on valid relies of 206 factories on IW generation and on-site/off-site IW disposal method, i.e. on-site storage, on-site treatment, on-site reuse/recycling, on-site final disposal, collection/transportation, off-site reuse/recycling, off-site treatment and final

disposal. The table below shows current non-HW flow and HW flow in the study area.

Table 2-6: Non-HW Flow and HW Flow in the Study Area (2001)

IW / Items	Non-HW		HW	
	Amount (ton/year)	Rate to Total (%)	Amount (ton/year)	Rate to Total (%)
1. Generation	2,364,782	100.0	557,456	100.0
On-site Disposal*1	707,574	29.9	313,903	56.3
Off-site Disposal*2	1,657,208	70.1	243,553	43.7
2.Reuse/Recycling	1,853,964	78.4	101,337	18.2
On-site	321,414	13.6	22,455	4.0
Off-site	1,532,550	64.8	78,882	14.2
3. On-site Storage	42,081	1.8	3,842	0.7
4. On-site Treatment	20,405	0.9	182,994	32.8
(Reduction) *3	(8,493)	(0.4)	(123,935)	(22.2)
5. On-site Final Disposal	335,526	14.1	120,063	21.6
6. Off-site Treatment and Final Disposal	124,718	5.3	208,279	37.4
7. Collection by Waste Buyers*4	1,147,738	48.5	47,472	8.5

1. The term of disposal covers storage, discharge, collection, transportation, treatment and final disposal of waste. In concrete term on-site disposal covers IW long-term storage, reuse/recycling, treatment and final disposal at the generation sources, i.e. factories.
2. Off-site disposal covers IW collection/transportation, reuse/recycling, treatment and final disposal outside of the factories.
3. Reduction refers to the lost amount of waste through treatment such as dewatering, drying, incinerating, etc.
4. Waste buyer in Thai is Por Kha Khong Gao.

The following figures illustrate the above-mentioned non-HW Flow and HW Flow in 2001 respectively. In addition IW flows of 13 categories of non-HW (206 valid reply did not report C06: Animal's Fat and Oil and Vegetable Oil) and 12 categories of HW as well as non-HW/HW flows of 33 categories of industry are prepared and presented in Annex 4.1.

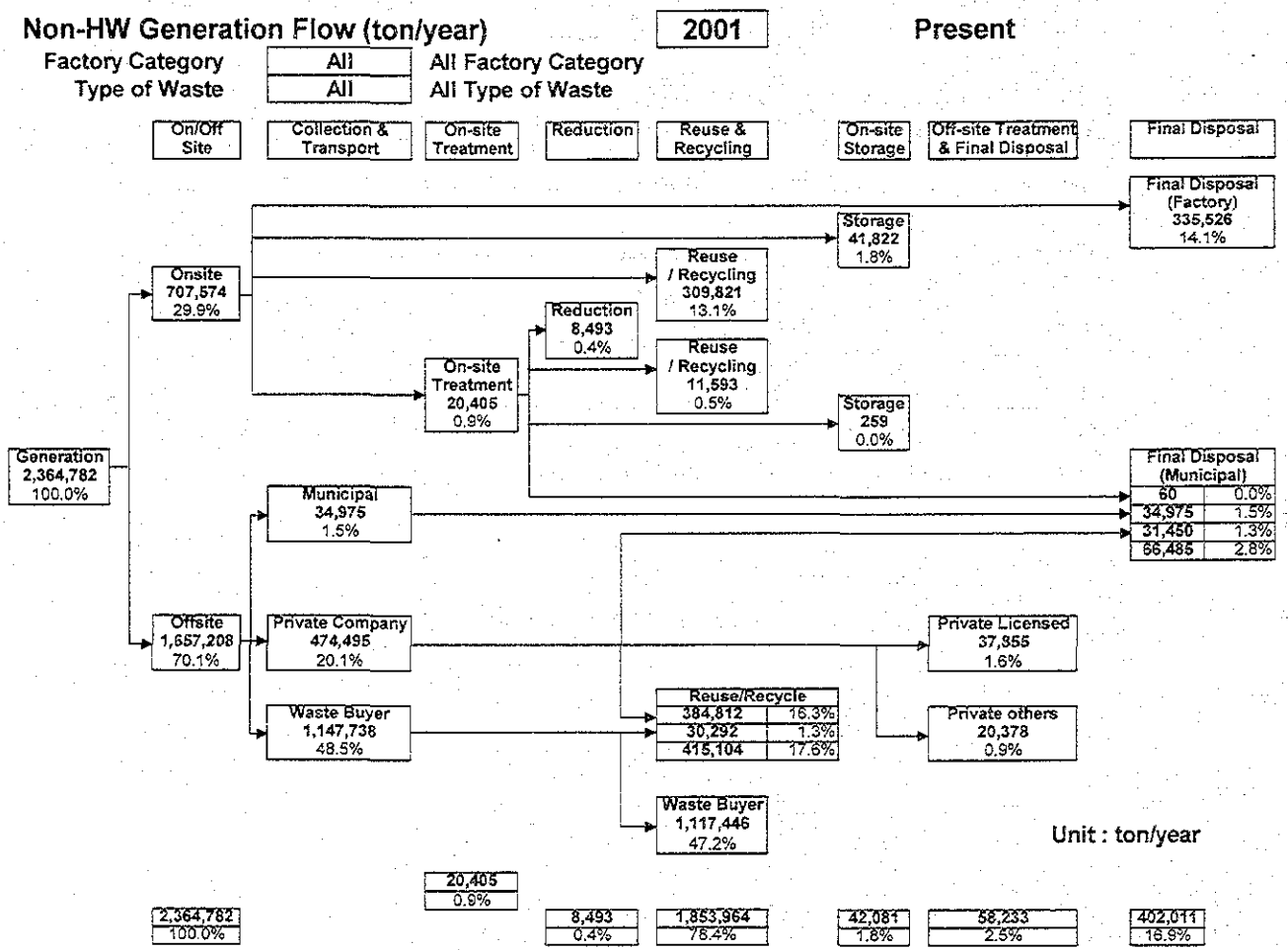

Figure 2-6: Non-HW Flow in the Study Area (2001)

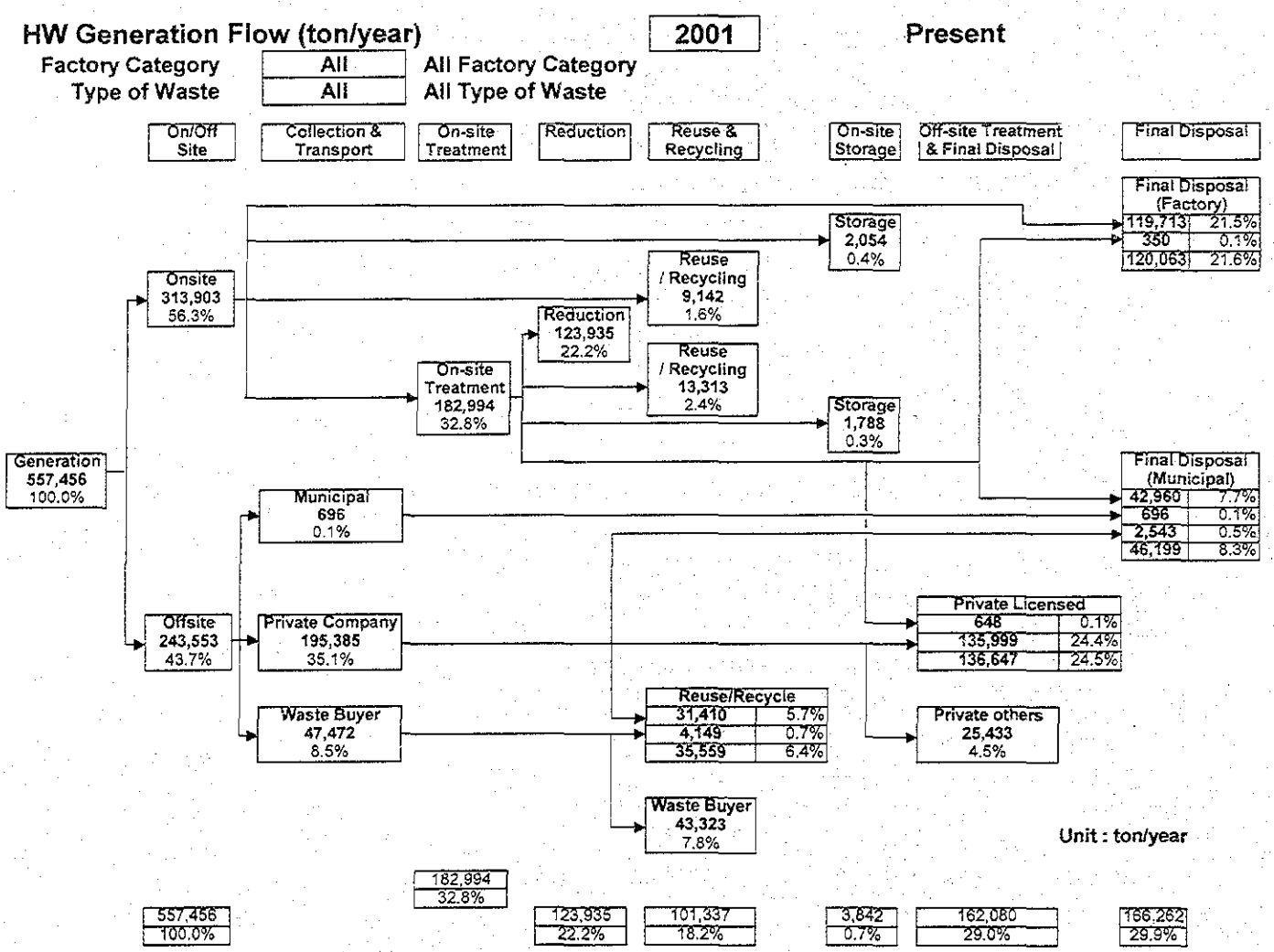

Figure 2-7: HW Flow in the Study Area (2001)

c. Limitations in the Use of the IW Flow

Though the team developed the IW flows, there are following limitations for the application of them. The team, therefore, recommends DIW to conduct additional factory surveys continuously in order to eliminate the limitations.

1. The flows are deduced from data obtained from the limited number of factories as shown in the table below.

Table 2-7: Rate of Factory Survey Data to Total of Study Area

	Factory Survey Data		Total		Rate to Total (%)
	Number	Unit	Number	Unit	
Number of Factories	206	Factory	33,092	Factory	0.62
Number of Employees	79,113	Employee	1,584,782	Employee	5.0
Non-HW Generation	118,904	ton/year	2,364,782	ton/year	5.0
HW Generation	27,349	ton/year	557,456	ton/year	4.9

2. As the estimation of IW generation requires the following basic data of the factories registered in the DIW and IEAT factory database, those factories that do not have the data are not counted in the study.
   - MOI factory code number; and
   - Number of employees.
3. Since the actual number of employees informed by the factories was 18 % more than that in the DIW factories registration database, the database seems not to be well updated. In addition the database does not have the factory registration data of industrial zones, industrial communities and industrial parks.
4. If 33 codes of industry generate each code of wastes (14 non-HW and 12 HW), theoretically there should be 858 (26 x 33) IW generation rates. However, from the factory survey the team obtained 288 IW generation rates.

2.4.2 IWM at Factories (Generation Sources)

a. Current Issues

In general, factories in the study area well manage the production lines and work environment by keeping the work areas in good order. The factory survey that the team carried out by visiting 215 factories, however, suggests that IWM at factories is not adequate from the following findings. These are particularly observed at small-to-medium-sized factories.

- Waste is often discharged without separation. 17.2% of 215 factories mix non-HW and HW, and 24.6% mix non-HW from production and non-HW from the other part of the factory.
- One third of 215 factories do not have storage facilities for industrial waste in their premises.

- Three fourths of the factories replied that the amount of their industrial waste will not increase in future, but factories, which have a plan of waste reduction and/or waste reuse/recycling, are only 8%.

b. Scheme for Improvement

In order to establish a proper IWM the important issues 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 be reused/recycled (Proper Treatment/Final Disposal).

The fundamental of IWM is that the waste sources, i.e. factories, reduce their waste, reuse/recycle IW generated and subcontract waste treatment and final disposal, if necessary, in an appropriate way. For this purpose, factories should have a clear mechanism to place responsibility for waste management and a technical control system. It is therefore recommended for factories to appoint a technical manager who comprehensively oversees IWM. On the other hand, the government will be required to encourage human resource development by, for example, establishing training programs and a certificate system and legally enforcing the appointment of the technical manager of IWM at every factory.

2.4.3 Non-HW Management

a. Current Issues

a.1 Limitation of the Study Results

The status of non-HW management had not been studied and was unknown. The present JICA study is the first trial to understand it from generation to final disposal by interviewing 215 factories using a questionnaire. Out of 215, 206 factories provided necessary data for the team to analyze the waste flow. However, they are merely 0.62% of the total number of factories in the study area, 33,092. It should be noted, therefore, that the analysis of the status of non-HW management is merely derived from the answers of such a small group of factories.

a.2 High Waste Reuse/Recycling Rate and Unclear Reuse/Recycling Activities

According to the non-HW flow in 2001 developed using the factory survey result, more than 78% of non-HW is reused or recycled. This rate is two times more than that in Japan (37% in 1996). The high reuse/recycling rate in the study area is not, however, extraordinary, because:

- the waste flow in Japan takes account of sludge, which is hard to recycle (only 7% of generated sludge is recycled in Japan) but generated in large volume (its generation amount accounts for 47.7% of total IW generation amount, 405 million tones a year), but sludge in the waste flow in the study area is only a little (55.5% of the mixed waste (category C11) equivalent to 1.1% of the total of non-HW), and
- cost for raw materials is comparatively expensive than personnel cost and there is an economic incentive to reuse/recycle waste.

Although such high reuse/recycling rate should be appreciated, the reality of reuse/recycling activities is not yet clearly understood. Recycling of waste is mostly done off-site (64.8% in 78.4%) and 48.5% of non-HW is sold to Por Kha Khong Gao

(Waste Buyer) for off-site recycling. Whether waste collected by Por Kha Khong Gao is properly recycled is open to question.

a.3 Inadequate Capacity of Treatment/Final Disposal Facilities

The number of treatment facilities for non-HW except those for municipal waste is only three in the study area. They are small incineration plants installed in industrial estates under IEAT, each of which has the capacity of less than 0.5 ton/hour. They receive waste only within the industrial estate in which they are located, are not registered at DIW, and are not fully operated. DIW gave a license of Code 101 to a private non-HW incinerator operator in Samut Prakarn, but there is no facility yet. The study area does not have any private-own waste disposal site authorized by DIW.

There are four private incineration plants for intermediate treatment with DIW registration. They are, however, also small and intended to accept non-HW only from factories within the industrial estate to which each of them belongs. The non-HW final disposal sites with DIW registration are three. As of June 2002, one of them located in Saraburi, 1.5-hour drive from Bangkok, and another in Chonburi, 1 hour drive from Bangkok, are operated, and the other, located in Sakaeo, 3 hours drive from Bangkok is under construction.

According to the non-HW flow developed in the present study, the fate of non-HW, which is not reused or recycled, is on-site final disposal (14.1%), final disposal together with municipal waste (2.8%), and treatment/final disposal by the private sector (2.5%) in a descending order. As these figures show, treatment/final disposal facilities have not been sufficiently developed by the private sector, which should be primarily responsible for non-HW treatment/final disposal.

b. Scheme for Improvement

b.1 Understanding the Status of Non-HW Management in Detail

Improvement should be started with the full understanding of the status of non-HW management. In the present study, the team developed the non-HW flow using the valid replies of 206 factories out of 215. The team also established the non-HW database containing data of those 206 factories. This database should be further expanded for proper non-HW management.

In order to obtain necessary data for database expansion, it is necessary to carry out a factory survey as conducted by the team should be repeated regularly (In Japan, every five year such survey is conducted.). For the efficient execution of regular factory survey, it will be effective to issue a ministerial announcement, which obligates factories to disclose data on request by the authorities of industrial waste. Database development will enable the renewal of the estimation of current and future waste generation amount and the waste flow.

b.2 Improvement of Reuse/Recycling System and Maintenance of High Reuse/Recycling Rate

The prime issue in non-HW management for the future is the quality improvement of current reuse and recycling activities by which nearly 80% of non-HW is dealt with, and maintenance of such a high reuse/recycling rate even along with the increase in personnel cost. The achievement of this requires to urgently investigate the actual conditions of the reuse/recycling system that the present study could not explore in

depth, to detect problems, and to formulate an improvement plan. Moreover, it is needed to establish a system to supervise and control waste recycling business enterprises including waste buyers.

b.3 Promotion of Construction of Treatment/Final Disposal Facilities by the Private Sector and the Examination of Continuous Use of Municipal Waste Final Disposal Site

The off-site treatment amount and off-site final disposal amount of non-HW is only 125,000 ton/year, or 5.3% of total generation. More than half of that is disposed of at municipal landfills and the rest is treated and disposed of at private-own facilities which is limited in number and in capacity. Therefore, it is important to examine how to promote the construction of treatment/final disposal facilities by the private sector, but whether investment can be recovered is critical since the construction of such facilities costs the private sector significantly. In order to make the private waste treatment/final disposal business profitable, it is highly important to strictly control and eliminate the inappropriate or illegal waste routes.

The types of waste which is mostly disposed of off-site without reused/recycled are C09-01 Ceramics (reuse/recycle rate: 0%), C10 Stone, sand, etc. (reuse/recycle rate: 18.7%), and C11 Mixed waste (reuse/recycle rate: 0%). As far as the social and economic situation of the study area does not dramatically change, non-HW, which is not reused or recycled, should be disposed of at sanitary landfills, which is a cheap disposal option. Even if non-HW, which is currently disposed of on-site, is to be treated and/or disposed of off-site, the off-site treatment/final disposal amount is merely 460,000 ton/year. This is only 11.6% of the treatment/final disposal amount of municipal waste (3.97 million ton/year, mostly landfilled) and is presumably small enough to be received at the municipal waste landfills. Therefore, it is one possible way to continue using the municipal waste landfills to dispose of non-HW as today, in parallel with the promotion of private sector's participation in the non-HW treatment/final disposal business.

2.4.4 HW Management

a. Current Issues

a.1 Difference between the GTZ HW Study and the Present JICA Study

Different organizations have been studied HW since the study of MOI[1] in 1984. Some studies cover not only HW from factories but also infectious waste and HW from households, and there is no common definition of HW among the previous studies. HW from factories, which the present study deals with, was most recently studied in Samut Prakarn Province by GTZ[2], which carried out a factory survey and estimated the generation amount of HW. The result of this GTZ HW study was used by DIW to estimate the generation amount of HW in the whole country.

In order to be consistent to the GTZ HW study, the team carried out the factory survey applying the HW categorization used in the GTZ HW study, and estimated not

[1] "Pre-feasibility Study for the Construction of Inorganic Waste Treatment Facilities in Thailand", 1985, Department of Industrial Plant, MOI

[2] "Preparation of Register on Hazardous Waste Generation and GIS Application for the Province Samut Prakarn", November 1999, DIW, MOI.

only generation amount but also a HW flow, which was not analyzed in the GTZ HW study.

As a result, the figures of total HW generation estimated by the two studies were close, but data of each industrial sector or each waste type were diverse. This will be because GTZ selectively studied industrial sectors, which were highly likely to generate HW in Samut Prakarn Province while the present study distributed the limited number of questionnaires to factories in all the industrial sectors in the five provinces since the team also aimed to study the status of non-HW and non-HW can be generated in every sector.

a.2 Low Reuse/Recycling Rate and High On-site Treatment/Final Disposal Rate

According to the HW flow in 2001 developed from the factory survey, the reuse/recycling rate of HW is 18.2%, only one fourth of that (more than 78%) of non-HW. By contrast, more than half (54.4%) of HW is treated on-site (32.8%) or disposed of on-site (21.6%), while on-site treatment and on-site final disposal of non-HW amount is only 15% of total generation.

The residue of on-site HW treatment is, however, mostly disposed of at municipal waste landfills. The safety of on-site final disposal is also questionable.

a.3 Shortage of Off-site Treatment/Final Disposal Facilities

The number of HW treatment/final disposal facilities is two in the study area and eight outside of the study area (GENCO's Map Ta Phut plant, which has a treatment facility and a final disposal site, is counted as single facility). as of April 24, 2002. These ten facilities are not adequate to meet all the demand for HW treatment/disposal of the country.

Table 2-8: Off-site HW Treatment/Final Disposal Facilities

	Name	Location	MOI Code	Target Waste	Capacity, etc.
Treatment	GENCO, Samae Dum Center	Bangkok	101	Wastewater from factories, sludge	110,000 ton/year 30,000 ton/year
	GENCO, Map Ta Phut Plant	Rayong	101	Waste oils and waste solvents Sludge	200 ton/day 600 ton/day
	Technochem Co., Ltd.	Chachoengsao	101	Waste solvents	15,000 ton/year
	Recycle Engineering Co., Ltd.	Chonburi	101	Waste solvents	10,000 ton/year
	Siam Cement Kaeng Koi Plant	Saraburi	101	Waste oils, waste solvents and others	46,000 ton (actual amount during Jan-Sep 2001)
	Siam City Cement	Saraburi	101	Waste oil, Wax oil, Fly ash, others	192,029 ton (actual amount during Jan -Apr 2002)
	Refine Tech Co., Ltd.	Samut Prakarn	106	Isopropyl alcohol	5 m^3/day

	Asian PVS Chemical Co., Ltd.	Chachoensao	106	Acid pickling waste (Iron chloride $FeCl_2$ solution)	1,000 ton/month
Final Disposal	GENCO, Map Ta Phut Plant	Rayong	101	Solid HW	Remaining capacity is scarce and a new disposal site is under construction
	Rachaburi Landfill	Rachaburi	101	Sludge treated at the Samae Dum Center	Remaining capacity is sufficient and expansion is also possible.
	Professional Waste Technology Co., Ltd.	Sakaeo	101, 105	Solid HW	Under construction

As of October 2001, Code 101 is the only code specified in waste business and there were only five facilities registered as Code 101. Codes 105 and 106 were newly established in December 2002 and the number of waste related facilities increased to ten, as the table above shows. The situation seems improved, but ten is still a too small number. In Japan, the number of treatment/final disposal facilities receiving HW and/or non-HW is 16,883 (in 1999). In Thailand, in reality, there are many recycling factories but they are registered as other codes depending on what they produce (e.g. thinner recyclers are categorized as chemical manufacturers). Since they have not attained codes of waste related facilities, it is not easy for waste generators to obtain transport permits if they are to deliver waste to such recyclers.

The shortage of the capacity of treatment/final disposal facilities and consequent rise in treatment/final disposal fee is a serious problem by which the manufacturers are confronted. The questionnaire survey of the Japanese manufacturing companies conducted by Japan Chambers and Commerce in Bangkok in August 2001 revealed that 91 out of 148 replies (61.5%) stated that the treatment and final disposal of industrial waste is the most serious environmental problem of the manufacturers.

The urgent construction of treatment/final disposal facilities for HW which is difficult to recycle is strongly required, but the strong public opposition against the construction plan is highly anticipated. Therefore, the development of treatment/final disposal facilities in a short term will be significantly difficult.

b. Scheme for Improvement

b.1 Understanding the Status of HW Management in Detail

The importance to understand the status of HW management can not be emphasized. As in the case of non-HW management, the periodical execution of a factory surveys as in the present study and the review of present and future generation amount and waste flow are necessary. In visiting factories for the survey, the manner of on-site disposal may need inspection since on-site disposal is applied more than half of HW. In order to trace the waste flow outward from factories, the comprehensive implementation of the manifest system is desired.

b.2 Promotion of Urgent Construction of Treatment/Final Disposal Facilities

The principal cause of the on-site treatment and final disposal of more than half of HW is that appropriate treatment/final disposal facilities are limited. Accordingly,

competitive pricing does not work, and off-site treatment/final disposal cost exceeds on-site treatment/final disposal cost. Therefore, it is necessary to promote the urgent construction of treatment/final disposal facilities and to encourage competitive pricing. When improper on-site waste disposal, particularly final disposal, is found from the factory survey, inspection, annual report, or other occasions, it is important to require improvement and, if necessary, to divert waste to off-site facilities.

According to the result of the public opinion survey (POS), large part of the respondents pointed out that the most desired condition to agree a plan of waste treatment/final disposal facilities is the participation of the local residents or their representatives from the planning process. It is therefore necessary to consider how to involve the public from the planning stage of treatment/final disposal facilities.

Such participatory planning, however, requires substantial time before the construction plan is finally agreed and proceeded. Meanwhile, it will be more practical to feed waste as raw material or fuel to cement plants, which exist at this very moment and leave little residue.

b.3 Promotion of Reuse/Recycling

In addition to the promotion of urgent construction of treatment/final disposal facilities, the reuse/recycling rate of HW, which is less than one fourth of that of non-HW, should be raised. The utilization of cement plants is an effective measure to compensate the shortage of treatment/final disposal facilities and to forward reuse/recycling.

When waste is received at cement plants, however, waste quality must be well analyzed and adjusted, and different types of waste may need compounding in order not to impair product quality. It is desirable to raise and guide a new intermediary business, which provides a service of waste quality control. Some types of waste cannot be simply put into cement production process, and it is also needed to investigate how the existing plants should be improved and how much investment is required. Waste Utilization Data Center that the team has established should be a useful system to support such business enterprises including the cement plants, which play an important role in the reuse/recycling of HW and non-HW.

2.4.5 Institutional System

a. Current Issues

a.1 Lack of a System to Control Industrial Waste Collection/Transport Business

In Thailand, industrial waste means waste from factories, and is under the control of MOI in conformity with the Factory Act. According to the Factory Act, facilities with certain conditions in terms of the number of employees and horsepower are registered as factories, and MOI controls factories through the processes of registration, permission, reporting, and/or inspection. MOI controls IWM by taking sanctions such as fines, administrative directives, factory closure, and the cancellation of licenses against factories, which violate the relevant stipulations in the Factory Act. Therefore, factories, which generate waste, and factories that receive waste for treatment or final disposal are controlled by MOI.

Waste collection and transport from the generation source is to be controlled by the transport permit system, which is defined by MOI Notification No.6 B.E. 2540 (1997) as for HW and MOI Notification No.1 B.E. 2541 (1998) as for non-HW applied only in 14 provinces including the study area, to require waste generating factories to be permitted when bringing their waste out. In fact, however, small parts of factories actually apply for and obtain the permit. Comparing the total amount of waste to which transport permits were issued in 2000 and the waste amount of off-site disposal (i.e. waste brought out from factories) in 2001 estimated by the team, the former is far below the latter. The amount of non-HW with transport permit is 94,000 ton or 5.7% of its off-site disposal amount: that of HW is merely 6,400 ton or 2.6% of its off-site disposal amount.

On the other hand, there is no regulation to register, permit, control and monitor waste collection/transport business. One who is going to start waste collection/transport business has to firstly register the company with Ministry of Commerce, and secondly apply for a transporter license to Land Transport Department of Ministry of Transport and Communication in accordance to the Land Transportation Act B.E.2522 (1979). However, only major transport companies have licenses and the rest execute their collection/transport business without licenses. The said act does not stipulate the penalty to waste collectors/transporters for dumping waste entrusted to illegal waste dumps done by them. If a waste collector/transporter who illegally dumped waste is arrested, he/she will be fined only a small amount by applying acts other than the Land Transportation Act. For example, in local administration areas, i.e. areas under the control of local administration such as BMA, the highest fine will be only 2,000 Bahts according to Cleanliness and Orderliness Act B.E. 2535 (1992). Moreover, the generators of waste that was illegally dumped by transporters are not accused of for illegal dump.

In conclusion, there is no sufficient legal tool to supervise waste collectors/transporters, to prevent illegal dumps, and to strictly control wicked collectors/transporters who repeat illegal dumps. Even the number of IW collectors or transporters is not known. In Japan, the number of collection/transport enterprises of non-HW and HW are 117,507 and 14,494, respectively in 1998.

a.2 Inadequate Control over IW Reuse/Recycling Business

The Factory Act had categorized factories into 104 until very recent. Factories that run waste treatment or final disposal facilities were categorized as code 101: Centralized waste disposal or treatment factory, but waste reusing/recycling factories were not categorized as a single code of reuser/recycler, but were categorized as relevant codes according to their final output. To solve this issue, MOI created new codes 105 for waste separation and landfill and 106 for waste reuse and recycling in December 2001, but the registration process has not been well proceeded.

Moreover, most waste buyers who play important roles in IW reuse/recycling are not registered as factory since they do not meet the conditions of horsepower or the number of employees. Not only the Factory Act but also any other acts do not control nor regulate waste buyers (Por Kha Khong Gao). Therefore, if they illegally treat or finally dispose of waste that they bought from factories, they are punished with only a

small fine, as in the case of waste collectors/transporters. The study of PCD/MOSTE[3] reported that there are 2,231 waste buyers, but details of their business are still not known.

a.3 Lack of Unified Control over IWM

The administration and management on IW is not under the unified control. As stated earlier, MOI controls the factories that generate waste and those to which waste is brought for treatment and/or final disposal since factories with certain scale need licenses and registration that enable DIW to control them. The area between the generation source and treatment/final disposal is, however, beyond the jurisdiction of MOI. Moreover, there are only three non-HW final disposal sites authorized by MOI in and around the study area, and the majority of non-HW from factories is disposed of at municipal landfills. The municipal landfills are managed by local administration, and industrial waste control by MOI does not reach them.

a.4 Inadequate Data Management

DIW has Information Technology Center that keeps a database of factory registration and other data concerning factories. Part of data is open to the public at DIW's website. However, the data in the database is not adequately updated.

In the present study, the team obtained the basic factory data such as the number of factories and the number of employees in the study area using this database. It found, however, that the number of factories and the number of employees in the DIW database are smaller than those in the database of IEAT. It was also found that the database does not contain sufficient data of factories located in the industrial zones, industrial communities and industrial parks.

As for the database on industrial waste, there are only two: the database on HW developed in the GTZ HW study, and the other on HW and non-HW developed in the present study. However, the number of factories covered by those databases is not large. DIW has data on IW in transport permits and in manifest forms from factories every year and from treatment/final disposal enterprises, but these data are kept only in a paper form in files not being digitized in a database.

a.5 Public Opposition against the Construction of Waste Treatment/Final Disposal Facilities

Today, as environmental awareness develops in Thailand, the general public has become concerned in development projects which may give negative impacts on human health and the environment. Especially the construction of any types of waste treatment/final disposal facilities faces strong opposition of the public, because the people have heard troubles at open waste dumps and have developed recognition that waste related facilities damage the environment by such problems as offensive odor and fires. As stated in Section 3.5, the operation of some of municipal waste landfills which were constructed after the successful EIA procedure have been stuck due to the public opposition in the study area. Therefore, it is highly anticipated that IW treatment/final disposal facilities can not be constructed and/or operated due to the

[3] Final Report of the Study on Guideline to Reduce Pollution by Recycling, Pollution Control Department, Ministry of Science, Technology and Environment, March 1998

public resistance, even with the approval of EIA by MOSTE and the authorization of DIW.

b. Scheme for Improvement

b.1 Examination of the Introduction of Consistent Manifest System

Whether waste taken out of the factories are properly dealt with is controlled by the transport permit system of DIW and IEAT and the manifest system. However, only part of factories apply for and obtain transport permits. The current manifest system only covers industrial waste that is treated or disposed of at treatment/final disposal enterprises with DIW authorization. In summary, neither of the systems can trace nor control the majority of waste that is discharged by factories.

Thorough industrial waste control covering every aspect of disposal including discharge, collection/transport, reuse/recycling, and final disposal necessitates the introduction of a complete manifest system. The system should use an unified format which is used by all the relevant organizations across the country.

The enforcement of the manifest system is conditioned on a register and permit system of waste collectors and transporters. Furthermore, intensive examination will be required to demonstrate a legal basis of DIW to control waste collectors and transporters. Meanwhile, it is important to strongly put into effect the present control measures including the submission of annual report by the factories to report about their waste management at the end of every year, transport permits, and filling in the manifest form by the treatment/final disposal enterprises as a receipt of waste and sending the copy from them to the factories in the annual report every year.

b.2 Examination of the Introduction of a License System

In order to practically implement the manifest system, it is necessary to examine the introduction of a license system, in which all the enterprises engaged in waste management including waste collectors/transporters, waste buyers, waste reusers/recyclers, and treatment/final disposal facility owners are required to register and obtain a license to run their business. The license should be issued to every type of business and every type of waste dealt with.

If the license system is established, it should possible to strictly control the waste business by withdrawing the license, ordering facility closure, etc. At the same time, it is also possible to provide the registered enterprises with benefits such as technical and financial assistance and the information of waste exchange, and to promote the waste treatment/final disposal business which is at present too small to meet demand. The license system is therefore has the carrot and the stick.

In December 2001, the amendment of a ministerial regulation pursuant to the Factory Act was enacted. By this amendment, new factory codes 105 and 106 will be newly set up by which facilities of waste segregation and waste reuse/recycling should be licensed prior to the facility installation under the Factory Act.

The critical point in the license system is to stringently regulate illegal operation by applying severe control and punishment on enterprises that operate without licenses. In parallel, tt is also necessary and probably more efficient to legally force waste generators to entrust off-site waste disposal only to licensed enterprises.

b.3 Unifying Waste Management

Covering all the aspect of IWM as addressed above will be difficult for the IWM system under the Factory Act. To overcome this deficit, it will be worth examining to establish a new act which regulates every issue of not only industrial waste but also municipal waste and hospital waste. The waste-relevant acts such as the Factory Act, Public Sanitation Act and others will be linked together under this new act.

b.4 Improvement of Data Control System

The establishment of the database is merely a starting point: it should be always functioning. Therefore, the maintenance of the current databases, and the development of a system to foster the database are required. Especially, it is urgently needed to develop an interface system to link the database of provincial industrial offices and the database of the IT Center, so that the IT Center's database is regularly updated.

The following measures should be further attempted.

- To appoint the necessary number of personnel who control and update the databases.
- To make a reporting rule thoroughly understood and executed so that data and information necessary for the database update can gather from bureaus within DIW, DIW regional offices, IEAT, and other relevant offices.
- To develop procedures to share the data in the databases such as waste classification by code numbers.

b.5 Public Consensus Making for the Construction of Waste Treatment/Final Disposal Facilities

The team carried out a public opinion survey (POS) which covered 400 people in the study area. According to the result of POS, more than 60% of the respondents recognize the pressing need to construct IW treatment/final disposal facilities. It was also found that the condition to agree a plan of waste treatment/final disposal facilities is, firstly, the participation of the local residents or their representatives from the planning process; secondly, careful site selection; and thirdly, strengthened measures to prevent illegal dumps. The majority of the respondents pointed out the necessity of the government to strengthen its control and punishment of illegal dumps followed by the development of public control as an effective measure to prevent illegal dumps.

With such understanding, it should be considered how to cooperate with the public and how to involve the public from the planning stage of IW treatment/final disposal facilities. In other words, it is necessary to make the construction of IW treatment/disposal facilities understood by disclosing information to the public as much as possible and by PR activities to the residents.

For the purpose of attaining public consensus, a company which recently started the operation of non-HW final disposal site discloses necessary information to the residents, grants a "community fund" to them in proportion to the waste disposal amount, and reserves a closure fund and a post closure fund to be used at the termination of the use of the site. The another company whose disposal site is under construction has openly explained the work to the residents since the planning stage

for their right understanding, and intends to establish a public relation center for the publicity to the residents and NGOs.

Careful site selection requires the formulation of site selection standards. MOSTE have the only site selection standard which is simple and is applied to the treatment/final disposal facilities for municipal waste. It is recommended to develop as early as possible a site selection standard for IW treatment/final disposal facilities which satisfies the requirement of the public.

3 Non-HW Master Plan and HW Action Plan

3.1 Estimation of Future IW Generation

3.1.1 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

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.**

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 by each TSIC code obtained from the National Statistical Office (NSO).

The other important element of the equation above is the waste generation rate. Since the waste generation rate is obtained using the result of the factory survey, it follows the 33 industrial categories that the team developed for the study (study code). Therefore, the estimation of future number of employees also should follow the study code by converting the estimation based on TSIC. The team clarified the correspondence of the study code with TSIC code as shown in Table 3-1 below.

Table 3-1: 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
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

Referring to this table, the conversion was done 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 is used to estimate the future number of employees of the study codes.
- 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 3-2, along with the ratio of the estimated number in 2005 and 2010 to the current number.

Table 3-2: Number of employees in 2001 and its increase

Study Code	Descriptions	TSIC Cod	Nos. of Employee (2001)	Increase Rate	
				(2005)	(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	361,362,3	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 o gas compressors etc.)	382	56,926	1.000	1.000
G25	Electric product (Machines or Product under No.70, Radio set, Electri instruments or appliances etc.)	383	120,045	1.046	1.060
G26	Electric product (Electric Equipment)	383	24,898	1.046	1.060
G27	Transportation machines (Ship, Trains, Streetcars, Cars or Trailers)	384	54,702	1.037	1.074
G28	Transportation machines (Motorcycles, Tricycles, Bicycles, Aircraft, Wheele 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	40,816	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

Study Code	Descriptions	TSIC Cod	Nos. of Employee (2001)	Increase Rate (2005)	Increase Rate (2010)
G33	Others (Stone, Watches or Clocks, Central waste treatment plant, Generatin steam, salt etc.)	NA	9,825	1.058	1.111
All Category of Factories		---	1,584,782	---	---

b. 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 factory survey. The team assumes that the estimated IW generation rate will not change during the projection period, i.e. up to the year 2010. Generation rate of hazardous and non-hazardous waste is given below by types of industry for each type of waste.

Table 3-3: 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	C12	Total
G01	Food (agricultural product non-aquatic animals, aquali animals etc.)	16.	2,987.1		2.	179.1			1.				0.1	0.	3,187.
G02	Food (flour, sugar, tea, ice etc.)			1.	13.	18.	5.1	50.	12.					285.	387.
G03	Drink, Beverage	1,294.		0.	3.	18.			4.1		1,212.			171.	2,705.
G04	Textile, Thread, Fibre				8.	30.	327.		62.				7.	13.	448.
G05	Textile product (Clothes, mats etc.)	577.		16.	16.	259.1	40.	0.	0.						910.
G06	Wearing Apparel				7.	0.	222.		0.				58.		288.
G07	Hide, Fur, Footwear		443.		3.	55.	134.	8.	1.			8.		1.1	657.
G08	Woodwork (any or many items)			5,577.	0.				0.				104.		5,682.
G09	Woodwork (bamboo, rattan, straw cork etc.)			3,907.	11.								127.		4,046.
G10	Furniture			5,231.	12.				4.				98.1		5,346.
G11	Paper, Cardboard				720.	58.			16.					1,031.	1,826.
G12	Printed matter				971.	1.			1.				88.	1.	1,064.1
G13	Chemical matter, Petroleum				11.	27.			12.				14.	21.	87.1
G14	Rubber			300.	50.	200.	0.	679.	0.			1.			1,234.
G15	Plastic product			116.	36.	789.	2.1		4.				2.		952.1
G16	Glassware, Ceramics, non-Metalli Matter			0.1	5.1		0.		61.	836.1	947.	702.		20.1	2,573.
G17	Steel basic industries, non-ferrou metal basic industries				30.	30.			15,128.			7,623.	46.		22,859.
G18	Metal product (tools, appliance household furniture, buildin interior etc.)			3.	9.		1.		4,313.1						4,327.1
G19	Metal product (constructio installation)			54.		5.			2,501.						2,561.
G20	Metal product (others)			2.	133.	1.	4.		653.						795.1
G21	Machines (Engines, Turbine Machinery)			60.	121.1	5.			1,928.			30.1	352.		2,497.
G22	Machines (for producing metal o ood products)				10.				335.1				10.		356.
G23	Machines (for paper, chemical food, textile etc.)			2.	1.				547.				21.		573.
G24	Machines (calculating machine Accounting machines, Wate pumps, air or gas compressor etc.)					56.			49.				0.		106.
G25	Electric product (Machines o Product under No.70, Radio set Electric instruments or appliance etc.)			2.	22.	55.			229.				128.	170.	607.
G26	Electric product (Electri Equipment)				78.	447.			440.		458.	0.	3.		1,429.
G27	Transportation machines (Shi Trains, Streetcars, Cars or Trailers)			3.	46.	15.			61.			1.1			127.
G28	Transportation machine (Motorcycles, Tricycles, Bicycle Aircraft, Wheeled vehicles etc.)				0.	1.	441.	23.	627.		4.	47.		0.	1,147.
G29	Precision machinery				3.	0.			13.			6.			24.
G30	Others (Musical instruments, Sport Toys etc.)		1.1	6.	45.	277.	1.		6.				2.		341.

Study Code	Descriptions	C01-01	C01-2	C02	C03	C04	C05	C07	C08	C09-01	C09-02	C10	C11	C12	Total
G31	Others (Electric power, Ga Packaging, Cold storage etc.)		70.	0.	115.	7.						1,270.			1,464.
G32	Others (Engine-driven for vehicle or motorcycles etc.				4.	7.			27.						39.
G33	Others (Stone, Watches or Clock Central waste treatment plant Generating steam, salt etc.)					2.			11.				2.1		16.
All Category of Factories		86.	205.1	351.	56.	70.	50.	17.	298.	6.	75.	209.	29.	47.	1,503.

Table 3-4: 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-aquati animals, aquatic animals etc.)								0.1					0.1
G02	Food (flour, sugar, tea, ice etc.)								0.			39.		39.
G03	Drink, Beverage		139.						10.			20.	1,553.1	1,724.
G04	Textile, Thread, Fibre								8.			2.	0.	10.
G05	Textile product (Clothes, mats etc.)							0.	0.			0.	1.	2.
G06	Wearing Apparel								0.1					0.1
G07	Hide, Fur, Footwear						0.		0.				3.	3.
G08	Woodwork (any or many items)						4.		0.1			80.1	4.	89.
G09	Woodwork (bamboo, rattan, straw, cork etc.)								2.				0.	3.1
G10	Furniture						11.		1.			35.	148.	195.
G11	Paper, Cardboard						0.						8.1	8.
G12	Printed matter								80.				188.	268.
G13	Chemical matter, Petroleum			29.	62.		21.	27.	36.	0.		286.	309.	774.1
G14	Rubber							0.	37.				0.	37.
G15	Plastic product						73.	141.	94.				132.	442.
G16	Glassware, Ceramics, non-Metallic Matter								0.				6.	6.
G17	Steel basic industries, non-ferrous metal basi industries								4,256.					4,256.
G18	Metal product (tools, appliances, househol furniture, building interior etc.)								4.			68.		73.
G19	Metal product (construction, installation)								85.1			14.		99.
G20	Metal product (others)		5.		458.		13.		38.		9.1	8.	306.	839.
G21	Machines (Engines, Turbines, Machinery)			46.	5.				72.			29.	3.	156.
G22	Machines (for producing metal or woo products)								60.				136.	197.
G23	Machines (for paper, chemical, food, textile etc.)						1.		52.					54.
G24	Machines (calculating machines, Accountin machines, Water pumps, air or gas compressors etc.)			0.	61.		0.	17.	2.			8.	13.	104.
G25	Electric product (Machines or Product unde No.70, Radio set, Electric Instruments o appliances etc.)			1.	12.1				0.			1,121.	96.	1,232.
G26	Electric product (Electric Equipment)	61.		78.					12.		22.		75.	250.
G27	Transportation machines (Ship, Train Streetcars, Cars or Trailers)					10.	1.		28.1			185.	96.	322.
G28	Transportation machines (Motorcycle Tricycles, Bicycles, Aircraft, Wheeled vehicle etc.)	11.1		0.			104.	28.	4.			20.	54.	223.
G29	Precision machinery						4.	17.	20.			8.1	0.	49.
G30	Others (Musical instruments, Sport, Toys etc.)											1.1	1.	2.
G31	Others (Electric power, Gas, Packaging, Col storage etc.)								0.					0.
G32	Others (Engine-driven for vehicles o motorcycles etc.						43.		324.			373.	4.	746.1
G33	Others (Stone, Watches or Clocks, Centr aste treatment plant, Generating steam, sal etc.)	5.							1.			46.	50.1	102.
All Category of Factories		1.	7.	2.	19.	0.	4.	5.	56.	0.	0.	125.	121.	345.

3.1.2 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 the type of industry and waste are shown Table 3-5 and Table 3-6 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 3-5: 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	C12	Total
G01	Food (agricultural product non-aquatic animals, aquati animals etc.)	2,04	361,89		33	21,69			12				1	6	386,17
G02	Food (flour, sugar, tea, ice etc.)			5	45	61	16	1,67	401					9,38	12,74
G03	Drink, Beverage	22,76		1	5	33			7		21,33			3,011	47,58
G04	Textile, Thread, Fibre				1,20	4,42	47,32		8,96				1,01	1,951	64,87
G05	Textile product (Clothes, mats etc.)	34,25		97	97	15,37	2,421								53,99
G06	Wearing Apparel				1,72	8	49,19		4				12,83		63,88
G07	Hide, Fur, Footwear		31,771		24	3,93	9,68	63	12			63		7	47,09
G08	Woodwork (any or many items)			141,04									2,64		143,70
G09	Woodwork (bamboo, rattan, straw cork etc.)			59,72	18								1,94		61,84
G10	Furniture			172,91	42				15				3,24		176,73
G11	Paper, Cardboard				26,18	2,11			58					37,48	66,37
G12	Printed matter				37,92	5			5				3,441	4	41,521
G13	Chemical matter, Petroleum				66	1,63			74				87	1,31	5,22
G14	Rubber			11,261	1,88	7,521	11	25,44	2			6			46,20
G15	Plastic product			13,81	4,321	93,50	24		52				32		112,73
G16	Glassware, Ceramics, non-Metalli Matter				22				2,69	36,41	41,28	30,58		87	112,09
G17	Steel basic industries, non-ferrou metal basic industries				92	92			458,41			231,01	1,40		692,691
G18	Metal product (tools, appliance household furniture, buildin interior etc.)			5	14		2		68,14						68,36
G19	Metal product (constructio installation)			1,141		11			52,39						53,65
G20	Metal product (others)			24	14,16	191	49		69,47						84,56
G21	Machines (Engines, Turbine Machinery)			86	1,74	7			27,78			43	5,07		35,98
G22	Machines (for producing metal o ood products)				7				2,20				7		2,34
G23	Machines (for paper, chemical food, textile etc.)			1					2,84				11		2,98
G24	Machines (calculating machine Accounting machines, Wate pumps, air or gas compressor etc.)					3,19			2,841				4		6,08
G25	Electric product (Machines o Product under No.70, Radio set Electric instruments or appliance etc.)			30	2,85	6,99			29,16				16,28	21,72	77,32
G26	Electric product (Electri Equipment)				2,07	11,821			11,62		12,10	1	9		37,73
G27	Transportation machines (Shi Trains, Streetcars, Cars or Trailers)			22	2,73	88			3,601			6			7,50
G28	Transportation machine (Motorcycles, Tricycles, Bicycle Aircraft, Wheeled vehicles etc.)				2	5	12,72	67	18,061		13	1,35		2	33,05
G29	Precision machinery				20	4			83			401			1,49
G30	Others (Musical instruments, Sport Toys etc.)		4	27	1,95	11,87	5		27				12		14,60
G31	Others (Electric power, Ga Packaging, Cold storage etc.)		1,90		3,12	19						34,32			39,55
G32	Others (Engine-driven for vehicle or motorcycles etc.				12	21			73						1,07
G33	Others (Stone, Watches or Clock Central waste treatment plant Generating steam, salt etc.)					2			13				2		181
All Category of Factories		59,06	395,61	402,94	106,96	187,90	122,32	28,43	763,05	36,41	74,85	298,90	49,56	75,95	2,601,99

Table 3-6: 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 Categories 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. HW generations by the type of industry and waste are shown in Table 3-7 and Table 3-8.

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 3-7: 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, aquati animals etc.)								1					1
G02	Food (flour, sugar, tea, ice etc.)											1,26		1,27
G03	Drink, Beverage		2,451						18			36	27,23	30,22
G04	Textile, Thread, Fibre								1,18			34	4	1,57
G05	Textile product (Clothes, mats etc.)							1				4	10	15
G06	Wearing Apparel								21					21
G07	Hide, Fur, Footwear						3						21	25
G08	Woodwork (any or many items)						12					2,02	111	2,26
G09	Woodwork (bamboo, rattan, straw cork etc.)								3				11	4
G10	Furniture						34		5			1,131	4,65	6,19
G11	Paper, Cardboard						1						251	26
G12	Printed matter								2,93				6,87	9,81
G13	Chemical matter, Petroleum			1,751	3,71		1,30	1,65	2,18	1		17,13	18,48	46,25
G14	Rubber							11	1,36				2	1,40
G15	Plastic product						8,00	15,38	10,24				14,40	48,04
G16	Glassware, Ceramics, non-Metalli Matter												28	29
G17	Steel basic industries, non-ferrou metal basic industries								126,60					126,60
G18	Metal product (tools, appliance household furniture, buildin interior etc.)								6			1,02		1,09
G19	Metal product (constructio installation)								1,68			29		1,97
G20	Metal product (others)		55		45,97		1,36		3,83		91	88	30,75	84,27
G21	Machines (Engines, Turbine Machinery)			66	7				1,04			421	4	2,24
G22	Machines (for producing metal o ood products)								39				90	1,29
G23	Machines (for paper, chemical food, textile etc.)								27					28
G24	Machines (calculating machine Accounting machines, Wate pumps, air or gas compressor etc.)			11	3,51		4	1,00	14			501	74	5,95
G25	Electric product (Machines o Product under No.70, Radio set Electric instruments or appliance etc.)			21	1,52				7			140,83	12,07	154,72
G26	Electric product (Electri Equipment)	1,60		2,04					331		58		1,96	6,53
G27	Transportation machines (Shi Trains, Streetcars, Cars or Trailers)					60	9		1,59			10,52	5,49	18,31
G28	Transportation machine (Motorcycles, Tricycles, Bicycle Aircraft, Wheeled vehicles etc.)	30					2,91	78	131			56	1,50	6,21

G29	Precision machinery						25	1,01	1,201			47		2,94
G30	Others (Musical Instruments, Sport Toys etc.)											4	5	101
G31	Others (Electric power, Ga Packaging, Cold storage etc.)								1					1
G32	Others (Engine-driven for vehicle or motorcycles etc.						1,12		8,32			9,601	121	19,16
G33	Others (Stone, Watches or Clock Central waste treatment plant Generating steam, salt etc.)	5							11			48	521	1,06
All Category of Factories		1,96	3,00	4,68	54,79	60	15,69	19,85	163,97	1	1,50	187,97	126,89	580,90

Table 3-8: 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 Categories of HW		557,456	580,909	598,278	100.0

3.2 Non-HW Management Master Plan

3.2.1 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.

3.2.2 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 3-9: 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
On-site 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.

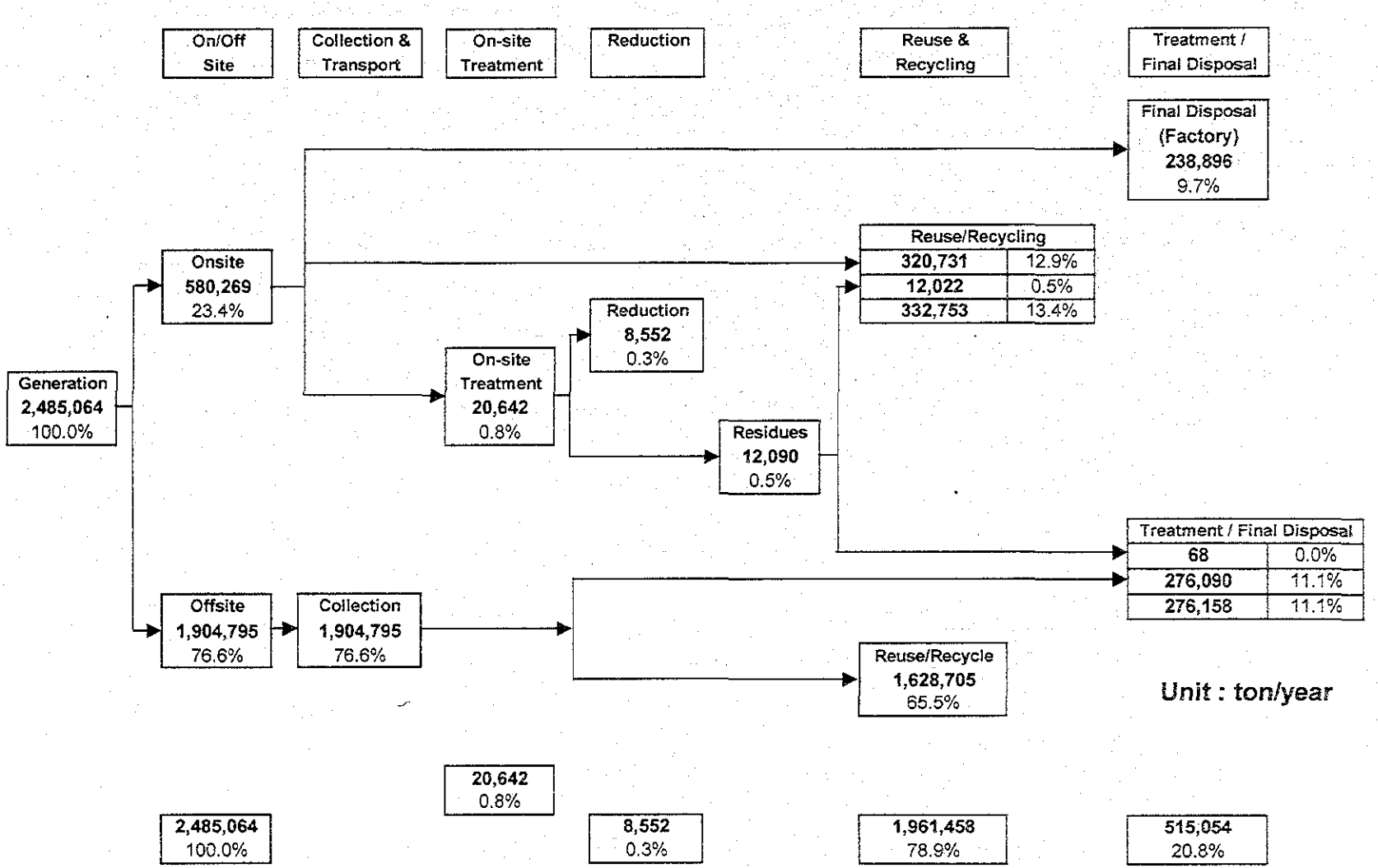

Figure 3-1: Non-HW Flow (2005)

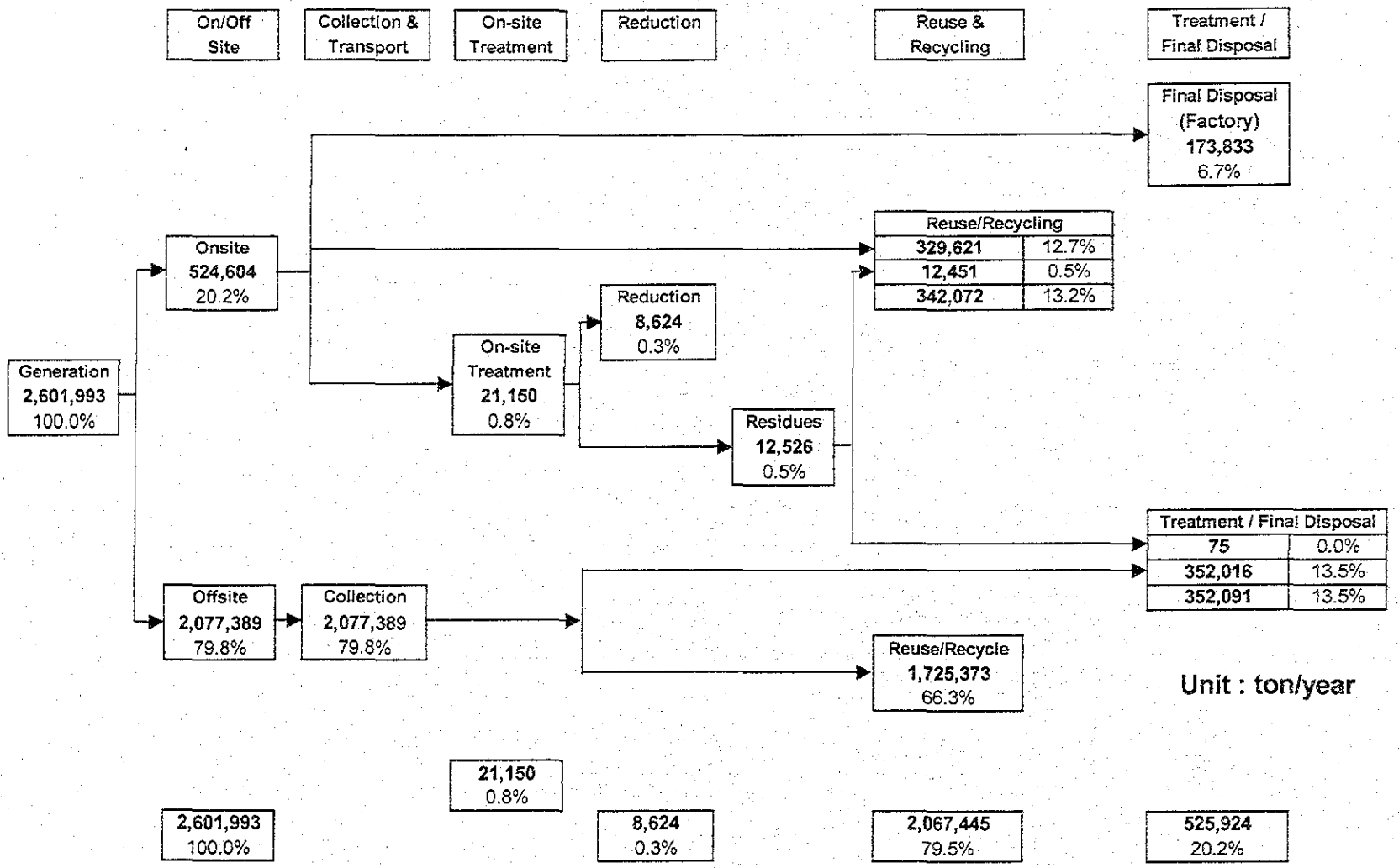

Figure 3-2: Non-HW Flow (2010)

3.2.3 Master Plan (M/P)

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 following table summarizes the proposed M/P.

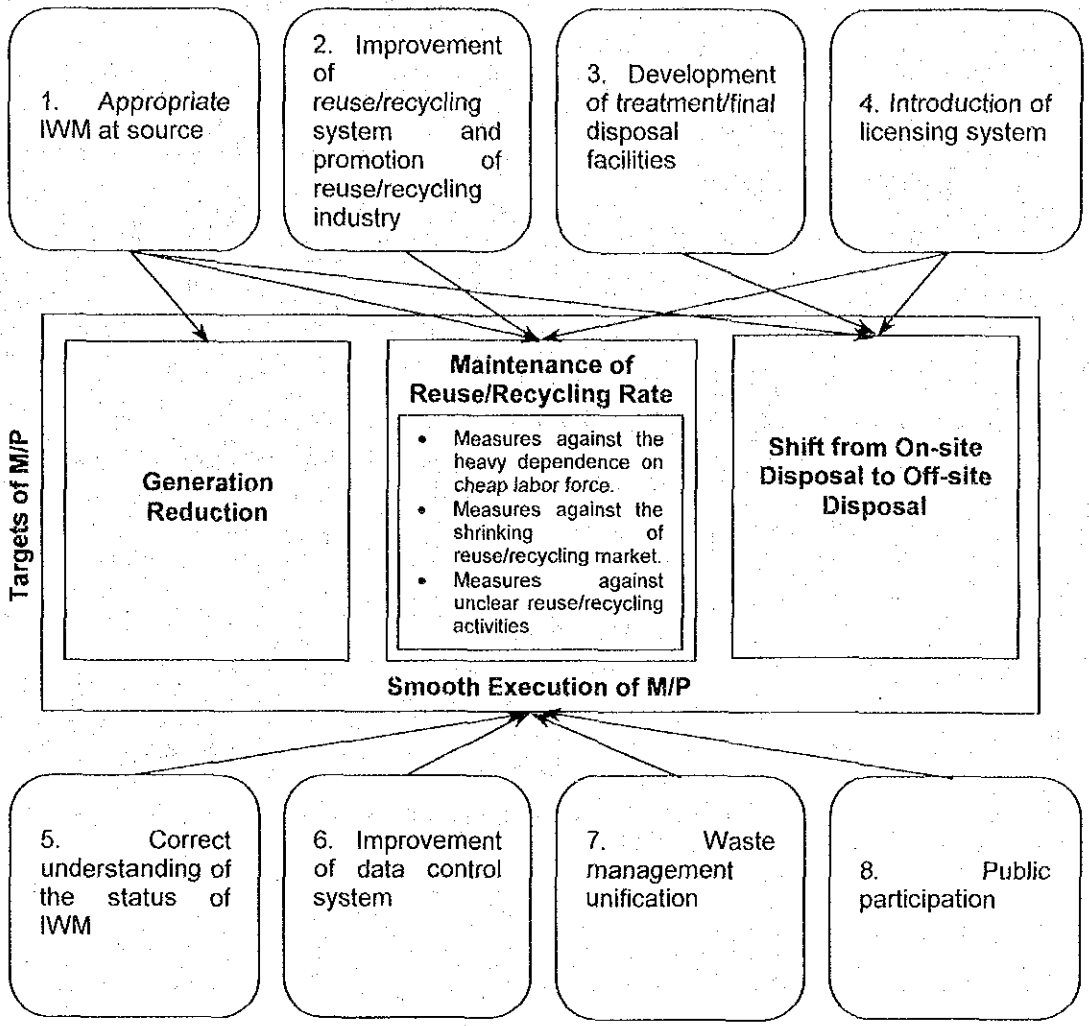

Figure 3-3: Structure of the Non-HW M/P

Table 3-10: 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.

It is to be noted that in regard to the second item with an asterisk (*) of "6. Improvement of Data Control System" in the short term, the team recognized that the incompatibility of the database of the provincial industrial offices, which collect information of factories in their areas, and the database of the IT Center, which should collect factory information from the industrial provincial offices across the country, is a highly critical problem. Therefore, the team proposes an action plan to develop a data transfer system which will be as in the figure below. This action plan was taken up as Pilot Project 3, and its content and lessons learned can be found in Section 4.3.3 of the Main Report.

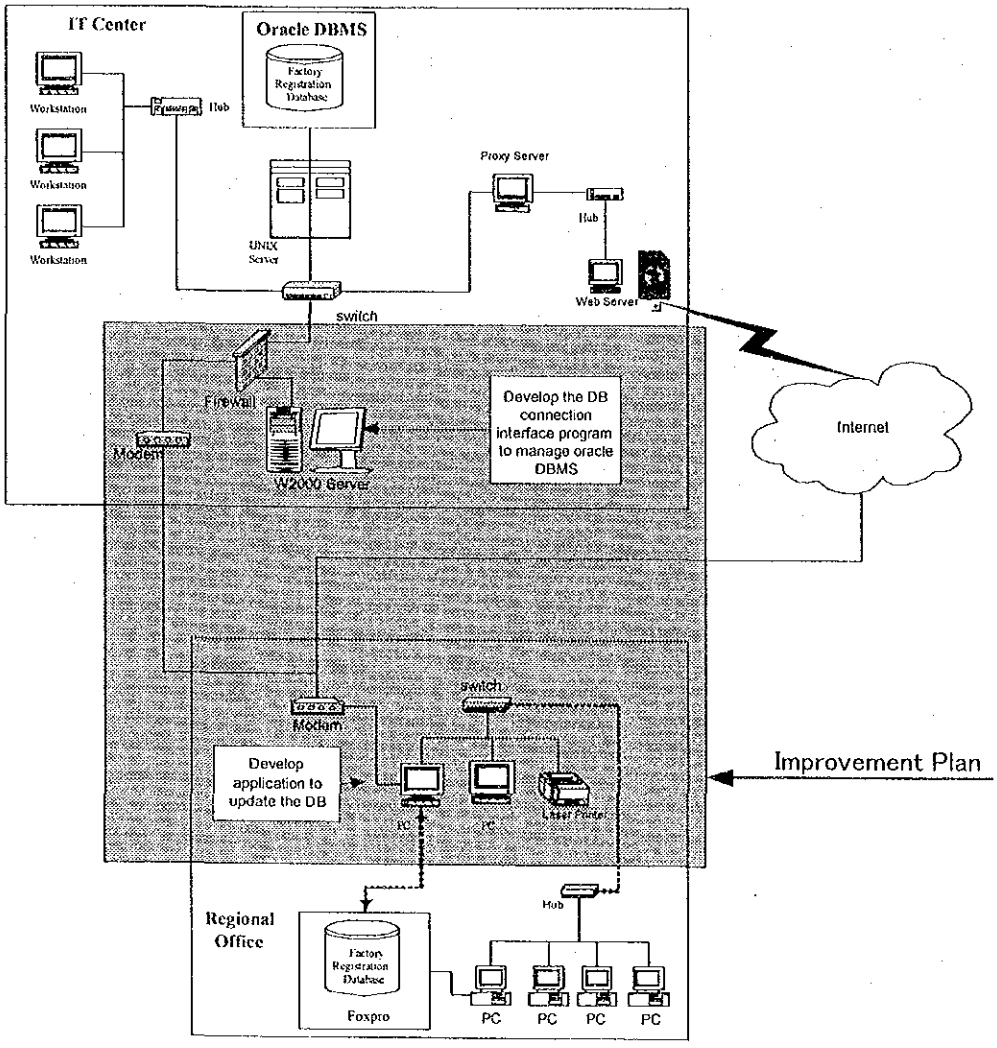

Figure 3-4: Action Plan for Factory Data Control Improvement

3.2.4 Promotion of the Project Implementation (Financial Viability of Construction of a Non-HW Landfill)

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. Although various non-HW treatment/disposal options can be considered e.g. reuse, recycling, and quantity reduction by incineration, the team estimated the cost of final disposal facility development and operation. 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.

a. Cost Estimation

a.1 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 3-11 below.

Table 3-11: 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 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.	- Starting year of landfill operation is set up at 2005 considering the time needed

Items	Preconditions	Remark
	- *Completion of landfill operation* in 2010. - 6 years' landfill operation	*for construction and* preparations for operation. - Completion year of Landfilli operation is set up at 2010, i.e. target year of the M/P.

a.2 Estimation of the Construction Cost of Landfill Facility

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 OEPP, Office of Environmental Policy and Program. The estimated construction cost of landfill facility was given by calculating the product of unit construction cost per ton of waste landfilled and the total amount of waste landfilled.

Consequently, the unit construction cost per ton of waste landfilled is calculated by the following formula based on the OEPP report:

Unit construction cost per ton of waste landfilled =

(Total construction cost of the landfill facility)/(Capacity of Landfilling waste)

This gives,

49.190 (million bahts) / 431,212 (tons) =

Unit construction cost: 114.1 (baths/ton)

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 as below.

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

Construction cost: 215.1 (million bahts)

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

a.3 Estimation of the Operation cost of Landfill Facility

Table 3-12 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 the table. The sum of all the operation cost is estimated as 182.7 bahts per ton of waste landfilled.

Table 3-12: 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

<table>
<tr><th>Item</th><th>Unit cost (Baht/ton)</th><th>Assumptions</th></tr>
<tr><td></td><td></td><td>Total amount of soil cover: 471,217m3
Total soil cover cost =
(471,217 X 150)/1,884,862 tons of waste</td></tr>
<tr><td>Fuels for heavy equipment</td><td>19.5</td><td>Types and numbers of heavy equipment
<table><tr><th>Type</th><th>Number</th></tr><tr><td>Bulldozer</td><td>2</td></tr><tr><td>Excavator</td><td>1</td></tr><tr><td>Dump truck</td><td>3</td></tr><tr><td>Water Tanker</td><td>1</td></tr></table>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))</td></tr>
<tr><td>Manpower cost</td><td>11.6</td><td>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)</td></tr>
<tr><td>Total</td><td>182.7</td><td></td></tr>
</table>

b. Financial Viability of Construction of a Non-HW Landfill

b.1 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.2 Possibility of Non-HW Treatment and Disposal by Private Sector

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 3-13 below for all the above cases.

Table 3-13: Preconditions of the Project for Preliminary Financial Appraisal

<table>
<tr><td>Project Period</td><td>From 2004 to 2010
2004: Start landfill facility construction
2005: Start landfill operation
2010: Landfill completed</td></tr>
<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="3">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>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 3-14 below.