Annex 11

Pilot Project
Improvement of
the Waste Collection System

Annex 11 Pilot Project: Improvement of the Waste Collection System

11.1 Objectives

The general objectives of the pilot projects were:

- To strengthen the SWM capability of the PPWM
- To verify the practicability of the master plan
- To execute an operational plan and verify its practicability
- To demonstrate improvement measures to residents and authorities concerned with SWM
- To raise public awareness on solid waste management and gain public cooperation
- To acquire basic data to devise the design outline of the F/S

The specific objectives of the pilot project for improvement of the waste collection system were:

- To verify the efficiency of a container collection system linked with a manual primary waste collection operation.
- To test the effect of a container collection system on the illegal dumping situation.
- To verify the effect of source separation of household waste on existing composting and recycling operations.
- To enhance the institutional and operational capacity of PPWM

11.2 Selection of Study Area

11.2.1 Project Sites

In order to test improved collection methods and assess organizational and planning issues under various conditions, three areas were chosen for the pilot project implementation. Several selection criteria were used to choose pilot areas including:

- At least two areas should lack regular waste collection service
- At least two areas should be unplanned communities or informal settlements
- Areas selected should be mostly low to medium income

Based on the above the following areas were selected:

Konkea Pos Community. This area is located adjacent to the urbanized parts of Phnom Penh, but in the rural Khan of Russey Keo to the north of the city. The community includes parts of Kum Konkea Pos (group numbers 14, 15 and 16) of Sangkat Toul Sangke and parts of Kum Bayab and Tumnoup in Sangkat Phnom Penh Thmey. About 17% of residents report irregular waste collection service, but the majority of the families report no collection service at all.

Parts of Villages 14 and 16 in Sangkat Boeng Salang. This pilot project focused on the area located on the east side of the Boeng Salang drainage canal. The area lacked waste collection service before the pilot project.

Parts of Sangkat Boeng Kang Keng 2 and 3. This area is within the "NIP" zone set-up under the NORAD project in 1997. There is an existing collection scheme operating in this

area under PPWM in cooperation with a local NGO called Community Sanitation and Recycling Organization (CSARO). CSARO has set-up a recycling and composting center run by Self-Help Groups (SHG) of former waste pickers in the center of the zone. This pilot project focused on the northern and southern parts of the NIP zone.

a. Map

The three pilot project areas are shown on the map in the figure below.

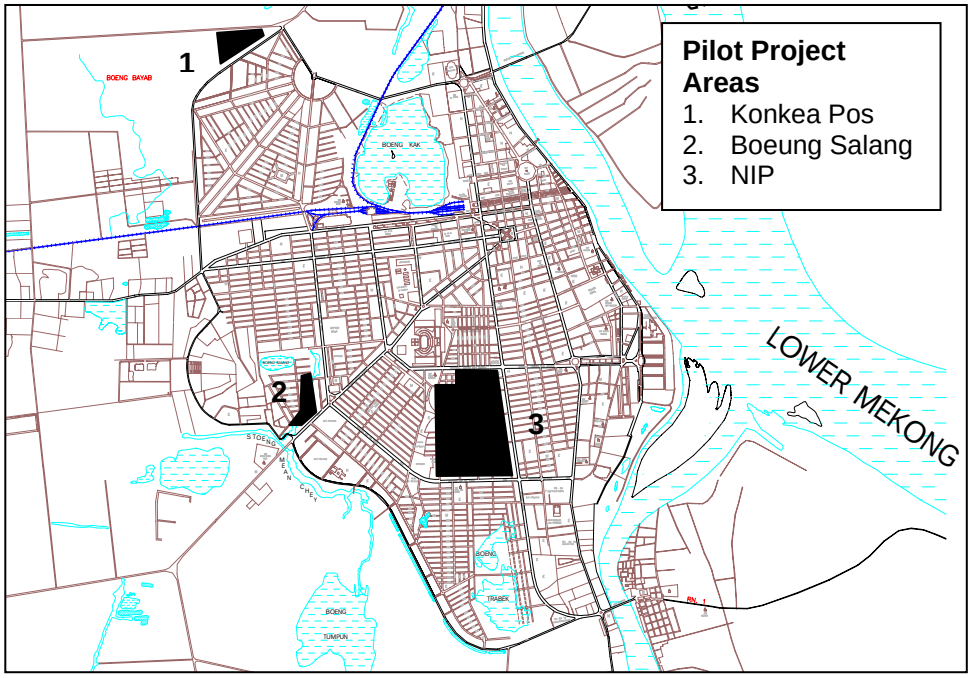


Figure 11-1: Map of Pilot Project Areas

b. Population

Population breakdown for these areas are shown below.

Table 11-1: Population of Pilot Project Areas

Area		Sub-area	Households Within Collection Area	Estimated Population
1	**Konkea Pos**	Group 14 (Sangkat Toul Sangke)	89	516
		Group 15 (Sangkat Toul Sangke)	81	470
		Group 16 (Sangkat Toul Sangke)	106	615
		Tumnoup Village (Sangkat Phnom Penh Thmey)	66	383
		Bayab Village (Sangkat Phnom Penh Thmey)	18	104
Konkea Pos Sub-Total			*360*	*2088*
2	**Boeng Salang**	Village 14	91	528
		Village 16	17	99
Boeng Salang Sub-Total			*108*	*626*
3	**NIP Zone**	Sangkat Boeng Kang Keng 2	703	4077
		Sangkat Boeng Kang Keng 3	869	5040
NIP Zone Sub-Total			*1572*	*9118*
TOTAL WITHIN PILOT PROJECT AREAS			***2040***	***11832***

c. Site Conditions

The conditions within the three areas selected for the pilot project activities are as follows:

Konkea Pos Community. This is an unplanned settlement that was established on vacant government land about 1993. Access is by four unpaved tertiary roads and a network of small alleyways. Residents formed a neighborhood development committee in late 1993. They have set-up a community nursery school that also serves as a community-meeting place. The community had previously installed a simple combined sewerage and drainage system as a community project, however many areas still are plagued by standing water because the area is quite flat. Conditions become very muddy during the rainy season. The majority of households could be classified as lower middle class to poor. The major form of employment appears to be sewing in home workshops (piece work) and making items from cloth waste discharged from the nearby garment factories. Household and workshop waste was typically dumped in vacant land, burned or hauled to heaps along road 578 that runs just south of the community.

Parts of Villages 14 and 16 in Sangkat Boeng Salang. This is an unplanned community almost completely without road access. Residents use a network of small alleyways and wooden bridges to reach their homes. Most alleyways and bridges were in very poor condition with muddy or flooded areas and uneven surfaces. Most of the families in this area would be classified as "very poor". Most rubbish was dumped in the water under people's houses or in the nearby canal.

Parts of Sangkat Boeng Kang Keng 2 and 3. This area is within the planned part of the city with a standard grid pattern of secondary and tertiary roads, but includes some pockets of unplanned settlements. Within these unplanned areas, the only access is by alleyway. Most of the alleyways were paved and drains installed under the previous NORAD project. There is an existing recycling/composting center in the area with data on post-collection (center-based) manual sorting of recyclable and compostable materials from the waste stream, this location offers a good opportunity to test the results of the source separation (in-home sorting) pilot activities.

11.3 Pilot Project Plan

Waste heaps are a common sight in many parts of Phnom Penh. Because of weak or non-existing collection systems, residents in these areas have learned to discharge waste in any convenient place such as vacant land, along side roads and near public areas such as schools, markets or parks. In these areas, residents discharge waste at any time without regard to collection schedule or other rules. Waste from these heaps is left to rot, burned or loaded into trucks manually with shovels (which is a slow and inefficient operation). Most residents recognize that this method of disposal is unsanitary and unsightly, but in the absence of alternatives this condition continues. Even when a new collection system is introduced, existing habits are sometimes difficult to change.

It was recognized that the use of standardized containers with covers to reduce bad odors and waste scattering could offer a great improvement over the existing system in these un-serviced or under-serviced areas. If containers are placed at existing discharge areas or other convenient places and the areas are kept clean and well maintained, little change to resident's discharge habits will be required, only that residents place their waste in the container instead on the ground.

To test this assumption the pilot project imported one "Skip Loader" vehicle and three five-cubic meter steel "Skip" type containers with covers. An additional seven containers were fabricated locally with plans supplied by the project.

11.3.1 Primary/Secondary Collection System

Many parts of the selected pilot project areas are not accessible to standard waste collection vehicles because of the narrow alleyways and passages. This is a common condition in many parts of Phnom Penh, particularly in the unplanned and urban poor settlements where some 62,249[1] households or about one third of the city's population live. As 250 meters is generally regarded as the maximum distance that residents will voluntarily haul their own garbage[2] it was necessary to identify effective collection systems for use in these inaccessible areas.

Primary/Secondary waste collection systems have already been operating successfully in several areas of Phnom Penh where access is difficult. In this type of collection system, workers collect household waste manually with pushcarts by going door to door or picking up at curbside. The waste is then moved by pushcart to a transfer point where it is loaded into vehicles for transport (secondary collection) to the final disposal site.

There are several methods used for the secondary collection. In the NIP area, waste is brought to a centrally located recycling center where it is sorted to remove compostable and recyclable materials, then the remaining waste is loaded into a compactor truck for transportation to the final disposal site. In the Psar Touch area of Sangkat Toul Sangke the waste is transferred into a truck at a roadside meeting point. Both of these methods of secondary collection have some drawbacks. In the center-based model, the truck must standby for several hours during loading. This is an inefficient use of truck time. At the roadside meeting point, coordinating meeting times has been problematic and the workers often must wait several hours for the arrival of the truck for secondary collection. In the JICA sponsored pilot project, the use to "skip" type containers was introduced for the secondary collection needs. The introduction of skip containers is expected improve the efficiency of both the primary and secondary collection activities.

11.3.2 Source Separation

Data from the Waste Composition Survey indicates that up to 93.7% of household waste is potentially recyclable or compostable.

Table 11-2: Waste Composition

	Compostable	Recyclable
Paper		6.4%
Kitchen waste	63.3%	
Plastic		15.5%
Grass and Wood	6.6%	
Metal		0.6%
Bottles and Glass		1.3%
TOTALS	69.9%	23.8%
Grand TOTAL	93.7%	

However, because most waste discharged from households and businesses is un-segregated, sorting and removal of the useful materials is slow and in many cases not economically feasible. At present only 10-15% of the materials are recovered. If a higher percentage of

[1] *Phnom Penh: An Information Booklet on the City's Development and the Settlements of the Urban Poor* published in May 2003 by the Municipality of Phnom Penh and Cities Alliance in association with UNCHS.

[2] *Refuse Collection Vehicles For Developing Countries* published by United Nations Center For Human Settlements (Habitat), Dr. Arcot Ramachandran.

the waste could be removed for recycling or composting it could generate substantial savings in transportation and disposal costs. Household waste separation (called source separation) is the most efficient method for material separation, but to be successful the public must be educated and convinced to change discharge habits. To test the effectiveness of public education and the efficiency of waste separation at the source, the pilot project for the improvement of the waste collection system included a source separation component.

Under this activity, 200 households were selected within the existing NIP zone. Educational materials were prepared and trainings conducted on the importance of proper waste separation. Posters were also put-up in the target area. During a public ceremony, each household was provided two waste bins, a green one for "wet" waste consisting of food and kitchen waste, and another for "dry" waste consisting of recyclables and other types of waste.

11.3.3 Community Infrastructure Improvement

In many areas the alleyways and passages have muddy, flooded or uneven surfaces that make waste collection, even by pushcart difficult or impossible. To improve access and facilitate waste collection, the pilot project for the improvement of the waste collection systems included a community infrastructure improvement component to install or repair concrete paving in the alleyways and drainage pipes in some areas.

11.3.4 Public Education

Public participation is an essential part of any solid waste management system. In order to educate the public on proper waste disposal methods and the problems of littering and illegal dumping, the pilot project for the improvement of the waste collection systems included a public education component. This included preparation of educational materials and public campaigns and training sessions.

11.3.5 Fee Collection

To ensure sustainability of the waste collection system it is necessary to have an effective fee collection system. In the past several waste collection schemes have failed in Phnom Penh, in part because of problems with the fee collection system, particularly non-payment of bills and improper classification of the waste producers. To overcome these problems the study team proposed to have local authorities at the sangkat level participate in the fee collection system. Together with PPWM, procedures were developed wherein PPWM is responsible for maintaining customer lists and issuing monthly bills, and the sangkat authorities are responsible for the door to door fee collection. To test the effectiveness of this system, the pilot project included setting-up and operating a fee collection system in the pilot areas.

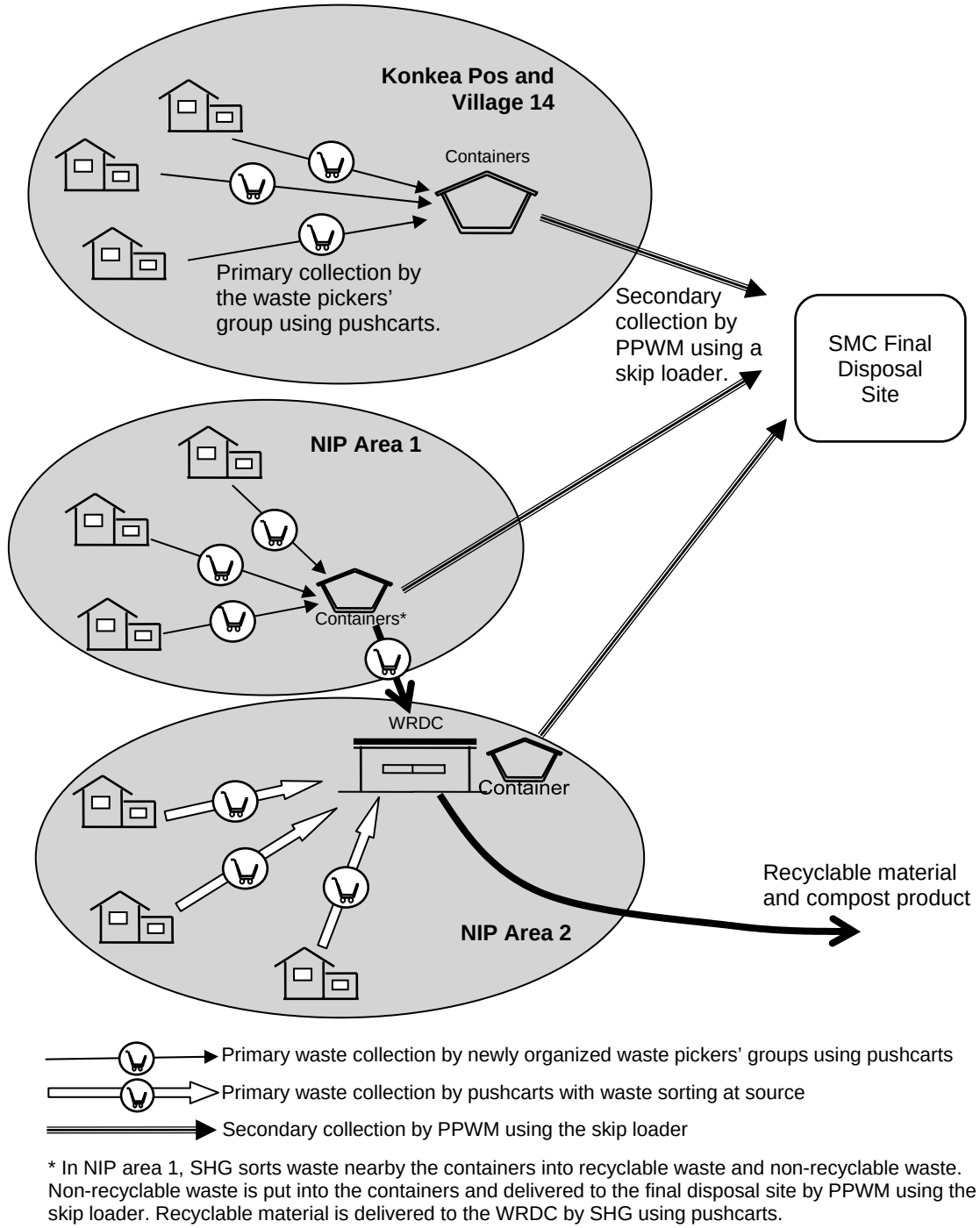
11.3.6 Summary of Pilot Project

A summary of pilot project activities for each area is shown below.

Table 11-3: Summary of Pilot Project Activities

Project Component	Area 1: Konkea Pos	Area 2: Village 14 in Boeung Salang	Area 3	
			NIP area 1	NIP area 2
1. Introduction of the container collection system	✓	✓	✓	
2. Source separation of household waste				✓
3. Public education	✓	✓	✓	✓

The Figure below shows the schematic view of the waste collection system developed in this pilot project.



* In NIP area 1, SHG sorts waste nearby the containers into recyclable waste and non-recyclable waste. Non-recyclable waste is put into the containers and delivered to the final disposal site by PPWM using the skip loader. Recyclable material is delivered to the WRDC by SHG using pushcarts.

Figure 1.2: Schematic View of Waste Collection System

11.3.7 Project Design Matrix

The PDM for the pilot project in Konkea Pos, Village 14 and NIP area 1, and another PDM for the project in NIP 2 are shown in the following pages.

PDM_0 for Improvement of Waste Collection System 1 in Konkea Pos, Village 14 and NIP Area 1

Target area: MPP Period: September, 2003-March, 2004 Date: June, 2003

Narrative Summary	Objective Verifiable Indicators	Means of Verification	External Conditions
Overall Goal • Waste collection rate increases by introducing container collection system.	• Non-collection and limited collection service area.	• Result of a study on non-collection and limited collection service area	
Project Purpose • to verify the improvement of collection efficiency resulted from the introduction of container collection system	• Comparison of working hour between primary and secondary collection workers	• Interview survey	• DPWT/PPWM will expand container collection service system to other areas
Outputs 1. NIP area 1-1 By installing containers, waste is collected in shorter time after it is discharged and piled up on the ground. 1-2 The time needed for waste collection is shortened. 1-3 Waste littered is reduced. 2. Non-collection service area 2-1 Volume of waste, which is dumped illegally in a open space and so on, decrease as a result of container installation	1-1 Comparison between usual manual transfer method and container collection method. 1-2 Comparison of the necessary time for waste collection 1-3 Monitoring of environment around discharge points 2-1 Waste amount that is collected by container collection method	1-1 Survey of the necessary time for waste collection of both usual manual transfer method and container collection method 1-2 Survey of the necessary time for both primary and secondary collection 1-3 Monitoring survey of environment around discharge points 2-1 Data from weighbridge at the disposal site	• Primary collector transfer separate recyclable goods from other waste at the container point without littering waste
Activities 1. NIP area 1 1-1 to install containers 1-2 to adjust primary collection routes dew to the location of containers 1-3 to have a meeting to explain the PP to local residents 1-4 to conduct monitoring of the PP 1-5 to evaluate the PP 2. Non-collection service area (Konkea Pos and Village 14) 2-1 to install containers 2-2 to have a meeting to explain the PP to local residents 2-3 to organize primary collection service workers 2-4 to develop PPWM's fee collection system. 2-5 to monitor the PP 2-6 to evaluate the PP	**Input** **MPP** 1. Operators of a skip loader 2. Personnel for public meetings and campaigns **JICA** 1. Procurement of a skip loader and containers 2. Installation of containers 3. Material for public education 4. Pushcarts with covers 5. Material to improve the road condition 6. Personnel for project coordination		1. Local residents, that bring and put their waste on the ground at present, lent their cooperation to container collection system **Pre-conditions** 1. CINTRI agrees that PPWM is in charge of waste collection service and fee collection in the area of the PP. 2. Local authority or residents agree with the installation of containers 3. SHG (primary collection workers and operators of the WRDC) agree with the introduction of container collection system 4. Recycling activities in the NIP area are not prevented

PDM_0 for Improvement of Waste Collection System 2 in NIP Area 2

Target area: MPP Period: September, 2003-March, 2004 Date: June, 2003

Narrative Summary	Objective Verifiable Indicators	Means of Verification	External Conditions
Overall Goal • Participatory source separation collection systems are applied widely in Phnom Penh.	• Recycling and composting rate in Phnom Penh increases	• Survey of recycling and composting in Phnom Penh	
Project Purpose • To verify the improvement of recycling system resulted from public participation.	• Evaluation of the PP by all the stakeholders such as local residents, collection workers, operators of the WRDC, and PPWM.	• Interview survey	• MPP implement M/P. • DPWT/PPWM expand source separation collection system to other areas
Outputs 1. Recycling rate of compost and other recyclable materials at the WRDC increases. 2. Efficiency of separation work at the WRDC increases. 3. Public awareness of waste management increases.	1. Amount of non-recyclable waste discharged from the WRDC decreases 2. The time needed for waste separation at the WRDC is shortened 3. More than half the residents recognize the importance of recycling.	1. Data of waste brought to the disposal site 2. Operation log of the WRDC 3. Interview survey	1. Waste amount and its composition do not change much during the experiment. 2. Organization of primary collection system such as arrangement of personnel does not change during the experiment period. 3. Organization of the WRDC such as arrangement of personnel does not change during the experiment period
Activities 1. to have a meeting to explain the PP to local residents 2. to distribute necessary equipments for source separation to local residents. 3. to explain the PP to SHG (primary collection workers and operators of the WRDC 4. to conduct monitoring of the PP 5. to evaluate the PP	**Input** **MPP** 1. Personnel for public education **JICA** 1. Material for waste sorting 2. Material for public education 3. Personnel for project coordination		1. Local residents lent their cooperation to the experiment of source separation collection 2. SHG (primary collection workers and operators of the WRDC) lent their cooperation to the experiment of source separation collection **Pre-conditions** 1. Local residents agree with experiment of source separation collection 2. SHG (primary collection workers and operators of the WRDC) agree with experiment of source separation collection

11.4 Pilot Project Implementation

11.4.1 Primary Collection

In the NIP area, the pilot project was able to utilize the existing primary collection system. In the Boeng Salang and Konkea Pos areas there was no existing service. To implement the pilot project in these areas, the ST hired staff from a local NGO with experience in organizing primary/secondary waste collection systems. These project assistants worked under the direction of the ST to conduct community meetings in the pilot project areas. During these meetings residents were informed about the aims of the pilot project. Their roles and responsibilities in improved waste management were explained. Residents expressed full support for the project and agreed to participate in the activities. To prepare for the collection service, specially designed pushcarts were fabricated and tools and equipment purchased. A major challenge was identifying suitable sites for the container stations and obtaining agreement from the local residents and authorities in the Boeng Salang and Konkea Pos areas. In Boeng Salang it was necessary to prepare a temporary station for use until the permanent site adjacent to the new drainage canal is ready (probably February, 2004). Nighttime storage areas were also identified for the pushcarts and other equipment.

11.4.2 Organizing Self Help Group

At the same time as preparation was underway within the communities, the project assistants began preparing teams of workers for the primary collection work. Workers were drawn from the Waste Picker Self-Help Groups (SHG) already organized by CSARO. The group members were trained in their roles and responsibilities as contractors for SWM and procedures of waste collection by pushcarts. They were also introduced to the waste collection areas to understand the boundaries of the zone, where the container stations were located and where pushcarts would be parked after collection activities. After understanding the extent of the work to be done, the SHG members sat down with PPWM to negotiate conditions of their collection contract. There was some concern on the part of the SHG members about the workload and the travel distances involved. In the end it was decided that they would sign an initial one-month contract and then reevaluate the working conditions. This is a fairly common reaction at the beginning of the work because this is a new conception for the waste pickers to enter into a formal working contract. Careful facilitation by the ST assistants was instrumental in resolving these problems. The contract was signed on 10 December 2003.

11.4.3 Improvement of Infrastructure

The ST and project assistants worked with the local authorities and small groups of residents to plan and implement a number of small-scale infrastructure improvement projects aimed at improving access in the alleyways in Boeng Salang and Konkea Pos (access was already adequate in the NIP zone). The ST supplied the materials and the residents contributed at the required labor input. This activity took somewhat longer than planned because of the complexity of building consensus among residents, designing the improvements, coordinating material deliveries and community contributions. The average community input equaled approximately 30% of the project costs. All improvements were complete by 21 December 2003.

Improvements can be summarized as follows.

Table 11-4: Infrastructure Improvement

Area	Alleyway Improvements		Small Road Improvements		Drainage Improvements	
	Length (m)	Area (m^2)	Length (m)	Area (m^2)	Concrete Pipes (m)	Clean-outs (units)
Boeng Salang	528	1,191	-	-	142	10
Konkea Pos	704	1510	180	900	-	-

Originally, 4-6 weeks was planned for the organization and implementation of the small scale community infrastructure improvements required to provide adequate access for waste collection. However, it was found that organizing community participation in this component of the pilot project was a complicated process which required almost 9-10 weeks of intensive effort.

Delays were experienced where passages (alleyways) were especially small, because it was necessary to negotiate with landowners to yield part of their property to improve the access. In other areas existing conflicts over land ownership, drainage or land-use rights must be resolved. Organizing community participation in the cost of construction can also be a time consuming process because of poverty and the need to insure transparency in the use of community funds. These types of issues must be properly dealt with to avoid problems later.

11.4.4 Container Collection System

One Skip loader vehicle with a 6 ton chassis was imported from Isuzu – Japan along with three steel skip type containers with covers of 5 m3 capacity. This equipment arrived in Phnom Penh in September and was demonstrated to municipal authorities on 6 October. In September the ST also tendered for the local fabrication of an additional 7 containers, for the construction of 8 container stations in the selected areas, and for the supply of construction materials required for the local community infrastructure projects. The contract was signed on 8 October and work began on container fabrication and container stations the following day. The first three locally fabricated containers were delivered on 23 October and remainder by 27 November. Seven container stations were completed by mid-November. Construction of the remaining station will be delayed until construction work is completed on the JICA sponsored drainage canal at Boeng Salang, expected in 2004.

Skip containers were brought to their stations in the NIP zone and waste collection began on 16 November. Initially four containers were used within the NIP zone. An additional container was installed on 5 December to handle heavier than expected volume of waste. Containers were installed and collection service began in Boeng Salang area on 10 December and in Konkea Pos on 15 December.

11.4.5 Time and Motion Analysis

Based on the results of the time and motion survey (conducted in May-April and October-December 2003) and additional data collected during implementation of the pilot project, it is possible to compare parameters of several different waste collection systems as shown below.

Table 11-5: Impact of Skip Container Use

Impact of Skip Containers on SWM in NIP Zone

Activities	Units	Primary / Secondary Collection Before Use Of Skip Containers	Primary / Secondary Collection After Use Of Skip Containers	Rate of Change
Total waste collected in Zone	ton/day	19.94	20.97 (Daewoo = 16.25 + Skip = 4.72)	5.2%
Total waste collected in Zone	m3/day	56.97	59.91 (Daewoo = 46.43 + Skip = 13.49)	5.2%
Illegal dumping along canal *1	m3/day	3.3	2.5	-24.2%
Primary collection time required *2	t/pers/hr	0.13	0.19	46.2%
Secondary collection Rate *3	m3/hr	14.25	19.4	47.2%

*1 Waste dumped along the canal was collected and measured over a 14 day period
*2 This is time required for manual collection of waste from all households within the zone
*3 Time required to load the waste into vehicles for secondary transportation to the disposal site, includes actual loading time plus time spent waiting at site for the containers to be filled

Based on the pilot project experience the working efficiency of the Skip Container collection system can also be compared to the manual collection of waste heaps (which is a common collect method in many areas of Phnom Penh today). The results are summarized below.

Table 11-6: Vehicle and Worker Efficiency

Vehicle Type and Collection Method	Average Time (min)	Average Volume (m3)	Vehicle Efficiency (m3/hr)	Average Workers (pers)	Worker Efficiency (m3/pers/hr)
Skip Loader Vehicle with skip container	15.5	5	19.4	2	9.7
Daelus 7t with manual loading of waste heaps	54.4	3.46	3.8	4.2	0.9
Boxer 4.5t with manual loading of waste heaps	82	3.5	2.6	4.8	0.5
Daewoo 11t with manual loading of waste heaps	50	7.6	9.1	4.9	1.9
Kamaz 11t with manual loading of waste heaps	92	4.9	3.2	3.8	0.8

11.5 Experience of Source Separation of Household Waste

The pilot project component on Source Separation of Household waste was conducted in the NIP zone where there is an existing waste collection system that includes manual separation of household waste at the Waste Recycling Development Center (WRDC). In the Source Separation pilot zone, 200 families have agreed to separate their own waste into two categories. These are: “wet waste” that includes food and vegetable materials and “dry waste’ that includes paper, metals, glass and other inert waste. The separated waste is transported by pushcart to the WRDC where it receives a final sorting. By comparing the results of the pilot project with baseline data collected before implementation we can get an idea of the impact of the source separation activity. The results shown below.

Table 11-7: Source Separation Impact on Sorting Efficiency

	Total Recovered	Number of households	Recovery Rate	Workers	Sorting Time	Worker Efficiency
Materials recovered at WRDC without source separation pilot	(ton/day)	(hh)	(kg/hh/day)	(pers)	(hrs/day)	(kg/hr/ worker)
Compost Material	0.41	3800	0.11	2	3.95	51.77
Recycled Materials	0.06	3800	0.02	2	3.95	7.54

Materials recovered at WRDC with source separation pilot						
Compost Material	0.140	200	0.70	2	0.18	396.23
Recycled Materials	0.018	200	0.09	2	0.18	50.94

11.6 Conclusions

a. Primary Collection

The manual collection of waste by SHGs with pushcarts has been successful in collection household waste in areas with difficult access and has resulted in improved sanitation in the pilot areas. However, the cost for this service is higher than curbside collection or stationary collection methods.

Planning and start-up of this service can also be difficult for inexperienced SHGs and communities. Support and facilitation by the ST was very important to ensuring the success for the pilot project experience.

In areas where primary collection service would be a workable option, residents should be given the choice of taking their own waste to a stationary collection point or having SHG's collect the waste for an extra charge. Experience in the pilot projects indicates that the extra fee would be approximately $0.30 to $0.40 depending on conditions in the area and the time required for waste collection. If residents select the primary collection option, PPWM should support for this service option by providing the pushcarts and uniforms. To facilitate the planning and start-up of primary collection service, PPWM will require specially trained staff or the services of a specialized NGO maybe required.

b. Use of Skip Containers

Skip containers where found to be very effective for the efficient collection and transportation of waste from stationary collection points and in areas where primary collection is used. The experience of local fabrication of skip containers was also very positive and resulted in good quality containers at lower cost than the imported units.

Finding suitable sites for the container stations was problematic in some areas because of objections from households near the proposed stations and land ownership disputes. Although this is normally an issue that should be resolved by the local Sangkat officials, ST staff had to spend considerable time and energy to facilitate and assist with problem solving.

If this method is used in the future, the service provider must plan sufficient staff time to assist Sangkat officials in resolving the problems that arise during the identification of suitable sites for container stations.

c. Source Separation

The pilot project experience indicates that the use of source separation resulted in a substantial increase in sorting efficiency at recycling centers. However, the pilot experience was on a very limited scale (only 200 households participated over a one month data collection period).

The source separation pilot area should be expanded and the impact monitored to collect further data on the possible impact of large-scale application of source separation in Phnom Penh.

d. Infrastructure Improvement

Infrastructure improvements conducted during the pilot project were successful in improving access for waste collection and sanitary conditions within the target areas. However, this activity required considerable ST staff time to assist communities in planning the improvements, organizing community participation and resolving problems between residents.

Where infrastructure improvements are planned, communities and local officials may require assistance and facilitation from experiences community organizers and community development workers to overcome problems. Specially trained staff from the service provider or by a qualified NGO should provide facilitation for this activity.

11.7 Summary Data

Summary Data for NIP Primary Collection (Skip Zones)

notes: Pushcart volume = 1 m3

During first week SHG added waste to second container per day instead of hauling to center. This additional waste shows as resident loading for following day.

		Container A and B					Container C						Container D					
Date	No. of crew	Work time (minutes)	Resident loading before 7 am	SHG loading to container	SHG loading to center	Num of Containers	Workers	Work time (minutes)	Resident loading before 7 am	SHG loading to container	SHG loading to center	Num of Containers	Workers	Work time (minutes)	Resident loading before 7 am	SHG loading to container	SHG loading to center	Num of Containers
20/11/03	2	225	1	4	1	2	2	200	0.5	2.5	3	1	2	195	1	2	3	1
21/11/03	2	205	0.5	5.5	0	2	2	250	0.5	2.5	1	1	2	200	0.5	2.5	0	1
22/11/03	2	200	0.5	5.5.	0	2	2	250	2	1	1	1	2	205	2	1	1	1
24/11/03	2	230	6	6	4	2	2	390	3	2	4	1	2	410	3	0	4	1
25/11/03	2	110	6	2	4	2	2	370	0	3	3	1	2	350	3	0	4	1
26/11/03	2	240	4	2	6	2	2	280	0	3	3	1	2	230	3	0	3	1
27/11/03	2	245	1.5	4.5	6	2	2	270	1	2	3	1	2	280	0	3	3	1
28/11/03	2	210	0.5	4	4	2	2	180	0	3	4	1	2	200	0	3	2	1
29/11/03	2	230	1	5	6	2	2	210	1	2	3	1	2	240	2	1	3	1
1/12/2003	2	270	2	4	6	2	2	210	1	2	3	1	2	240	3	3	6	1
2/12/2003	2	270	1.5	4	6	2	2	210	1.5	1.5	3	1	2	240	3	3	3	1
3/12/2003	2	270	0.5	5.5	6	2	2	210	2	4	3	1	2	240	3	2	3	1
4/12/2003	2	240	1	5	6	2	2	230	2	3	3	1	2	200	3	3	3	1
5/12/2003	2	300	1	6	4	2	2	210	3	3	4	1	2	240	2	4	0	2
6/12/2003	2	290	1	3	3	2	2	290	3	3	4	1	2	210	1	5	0	2
8/12/2003	2	450	2	3	6	2	2	405	2	4	6	2	2	440	3	5	2	1
9/12/2003	2	420	2	2	2	2	2	345	3	3	0	2	2	390	3	3	0	1
10/12/2003	2	300.0	1	2	2	2	2	350	3	4	1	2	2	350	3	3	1	1
11/12/2003	2	340	1	5	0	2	2	380	4	2	2	2	2	300	0	8	0	1
12/12/2003	2	290	0	6	0	2	2	370	0	5	0	2	2	300	0.5	2.5	3	1
13/12/2003	2	290	1	5	4	2	2	350	3	6	3	2	2	300	1	2	3	1
14/12/2003	2	300	2	3	4	2	2	360	1	5	6	2	2	290	3	3	2	1
15/12/03	2	300	0	6	6	2	2	300	1	5	6	2	2	270	3	0	4	1
16/12/03	2	300	0.5	5	6	2	2	300	0	6	3	2	2	270	2	7	3	1
17/12/03	2	360	4	2	6	2	2	300	5	1	5	2	2	270	3	2	3	1
18/12/03	2	300	2	4	6	2	2	300	1	2	3	2	2	330	1	5	2	1
19/12/03	2	300	1	4	5	2	2	300	1	5	3	2	2	270	1	5	2	1
20/12/03	2	300	1	5	4	2	2	300	0	3	3	2	2	270	2	4	5	1
22/12/03	2	270	1	5	6	2	2	300	0.5	5.5	6	2	2	360	0.5	8.5	1	1
23/12/03	2	270	3	3	6	2	2	300	0.5	5.5	3	2	2	300	5	3	0	1

23/12/03	2	270	3	3	6	2	2	300	0.5	5.5	3	2	2	300	5	3	0	1
24/12/03	2	270	3	3	6	2	2	270	4	2	6	2	2	300	2	3	0	1
25/12/03	2	330	0.5	5.5	6	2	2	300	0	3	3	2	2	370	3	3	3	1
26/12/03	2	310	1	5	3	2	2	320	0	6	0	2	2	310	3	3	3	1
27/12/03	2	330	1	5	2	2	2	315	2	4	3	2	2	320	3	3	3	1
28/12/03	2	300	3	3	3	2	2	310	5	1	5	2	2	350	2	1	0	1
29/12/03	2	270	2	4	4	2	2	300	0	6	3	2	2	330	1		0	1
30/12/03	2	320	3	3	3	2	2	300	5	4	3	2	2	290	0	3	3	1
31/12/03	2	300	2	4	3	2	2	320	4	2	4	2	2	300	0	3	3	1
6/1/2004	2	330	2	4	0	2	2	310	2	4	1	2	2	320	2	2	1	1
7/1/2004	2	360	2	4	3	2	2	330	1	2	3	2	2	390	2	3	2	1
8/1/2004	2	330	2	4	2	2	2	300	2	1	3	2	2	240	2	3	4	1
9/1/2004	2	390	2	5	0	2	2	360	1	2	0	2	2	240	1	4	0	1
10/1/2004	2	400	2.5	2	2	2	2	350	1	5	1	2	2	360	1	2	1	1
11/1/2004	2	390	2	5	1	2	2	360	2	3	1	2	2	390	3	3	0	1
12/1/2004	2	390	2	6	0	2	2	360	1	4	0	2	2	370	1.5	7	1	1
13/1/2004	2	360	2	4	0	2	2	330	3	4	0	2	2	390	1	3	0	1
14/1/2003	2	360	1	6	0	2	2	330	1	2	0	2	2	330	2	6	0	1
15/1/2003	2	360	1	5	0	2	2	330	2	4	0	1	2	270	1	7	1	2
16/1/2003						2						2						1

Skip Container Data - Boeung Salang Area

			Start time		Stopt time		Container				Condition around container sites		
Sheet Num.	Date	No. of crew	Hours	Minutes	Hours	Minutes	Work time (minutes)	Resident loading before 7am	SHG loading to container	No.of Households	Clean?	Dirty?	Very dirty?
	23/12/03	3	14	0	16	0	120	1.5	3	135	Yes		
	24/12/03	3	13	0	16	0	180	1	2	135	Yes		
	25/12/03	3	13	0	16	0	180	1	2	135	Yes		
	26/12/03	3	14	0	16	0	120	1	2	135	Yes		
	27/12/03	3	13	0	16	0	180	1	2.5	135	Yes		
	28/12/03	3	13	0	16	0	180	1	2.5	135	Yes		
	29/12/03	3	13	0	16	0	180	1	2.5	135	Yes		
	30/12/03	3	13	0	16	0	180	1	2.5	135	Yes		
	31/12/03	3	13	0	16	0	180	1	2.5	135	Yes		
	1/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	2/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	3/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	5/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	6/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	7/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	8/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	9/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	10/1/2004	3	13	0	16	0	180	1	2	135	Yes		
	11/1/2003	3	13	0	16	0	180	1	2	135	Yes		
	12/1/2003	3	13	0	16	0	180	1	2	135	Yes		
	13/1/04	3	13	0	16	0	180	1	2	135	Yes		
	14/1/04	3	13	0	16	0	180	1	2	135	Yes		
	15/1/04	3	13	0	16	0	180	1	2	135	Yes		
	16/1/04	3	13	0	16	0	180	1	2	135	Yes		

Skip Container Data - Konkea Pos Area

			Start time		Stopt time		Container				Condition around container sites		
Sheet Num.	Date	No. of crew	Hours	Minutes	Hours	Minutes	Work time (minutes)	Resident loading before	SHG loading to container	No.of Households	Clean?	Dirty?	Very dirty?
	23/12/03	3	7	30	11	0	210	0	3	330	Yes		
	24/12/03	3	7	30	11	28	238	0	3	320	Yes		
	25/12/03	3	7	30	11	30	240	0	3	320	Yes		
	26/12/03	3	7	30	11	35	245	0	3	320	Yes		
	27/12/03	3	7	30	11	30	240	0	3	320	Yes		
	28/12/03	3	7	30	11	25	235	0	3	320	Yes		
	29/12/03	3	7	30	11	30	240	0	3	320	Yes		
	30/12/03	3	7	30	11	30	240	0	3	320	Yes		
	31/12/03	3	7	30	11	30	240	0	3	320	Yes		
	1/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	2/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	3/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	5/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	6/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	7/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	8/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	9/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	10/1/2004	3	7	30	11	30	240	0	3	325	Yes		
	11/1/2003	3	7	30	11	30	240	0	3	325	Yes		
	12/1/2003	3	7	30	11	30	240	0	3	325	Yes		
	13/1/04	3	7	30	11	30	240	0	3	325	Yes		
	14/1/04	3	7	30	11	30	240	0	3	325	Yes		
	15/1/04	3	7	30	11	30	240	0	3	325	Yes		
	16/1/04	3	7	30	11	30	240	0	3	325	Yes		

Annex 12

Pilot Project for the Data Management System

Annex 12 Pilot Project for the Data Management System for SWM

12.1 Installation of Weighbridge at the SMCDS

12.1.1 Progress of Construction

a. Report of Working Progress

1) Preparation had been completely finished with Excavation, Installation of Pipe, 3 Manholes and Laterite leveling.
2) Control Building had been completely finished with installation of 2 tables, 2 Chairs, 1 set if Cabinet, 1 set of Air Conditioning, Lighting installation, 1 set of weighbridge instrument.
3) Weighbridge foundation had been finished 100% with testing y Dynamic Cone Penetration work.
4) Approach slab had been finished 100% of the work.
5) Electricity had been completely finished and continuous using up to now with safety work.
6) Water Supply work had been completely finished with installation of water meter, 20m of water spraying tube, head for spraying water to clean weighbridge.
7) Weighbridge installation work had been completely finished with installation of 6 load cells, Cable of load cells, Galvanized pipe for load cells cable, 1 set of balance box, Lightning cable and connecting to control building.
8) Calibration work had been completely finished with 2 places of weighbridge comparison work.
   I. Angkor Kasekam Roongroeung around 28km from Phnom Penh on the National Road NO.4;
   -Heavy Dump Truck Weight 35,350kgs
   -Empty Dump Truck Weight 13,689kgs
   II. C.P. Cambodia CO., 25km from Phnom Penh
   -Heavy Dump Truck Weight 35,320kgs
   -Empty Dump Truck Weight 13,660kgs

   Our Weighbridge was 35,340kgs after Calibration work
9) Registration and Training are held on 27, 28 and 29 June, 2003 with the successful of the work.There are 5 training participants from PPWM and 2 from S.O.M Corporation, LTD. Two supervisors from Thailand for instruction of Registration and Training of Weighbridge.
10) .Cleaning work had been completely finished 100 of the work.
11) Handing Over was held on 30 June, 2003 presided over by Mr. Nhem Saran, DPWT of MPP, Mr. Junji Anai, Team leader of JICA study team.

Construction work was delays due to the bad weather conditions, but was completed.

b. Monthly Completed Schedule

Schedule for Control Building and Weighbridge Works

No.	Description	YEAR 2003												Remarks
		April, 2003				May, 2003				June, 2003				
		1st Week	2nd Week	3rd Week	4th Week	1st Week	2nd Week	3rd Week	4th Week	1st Week	2nd Week	3rd Week	4th Week	
1	Preparation Work													
2	Control Building Work													
3	Weighbridge Foundation Work													
4	Approach Slab Work													
5	Electricity Work													
6	Water Supply Work													
7	Weighbridge Installation Work													
8	Calibration Work													
9	Registration and Training Work													
10	Cleaning Work													
11	Handing Over													

1 DCF = Dynamic Cone Penetration Test

12.1.2 Layout Plan of Site

a. Layout Plan of Site

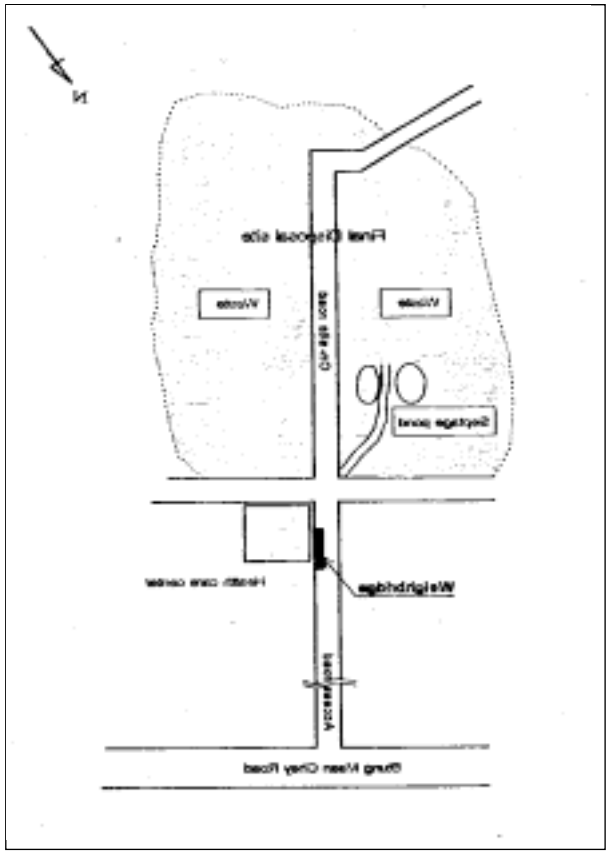


Figure 12-1: Location of Weighbridge

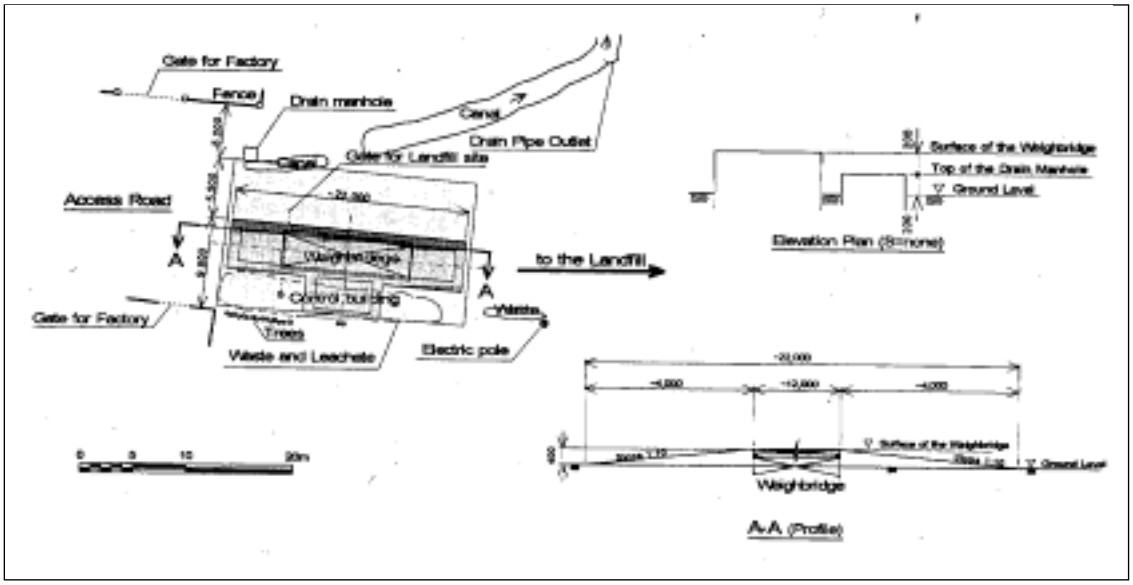
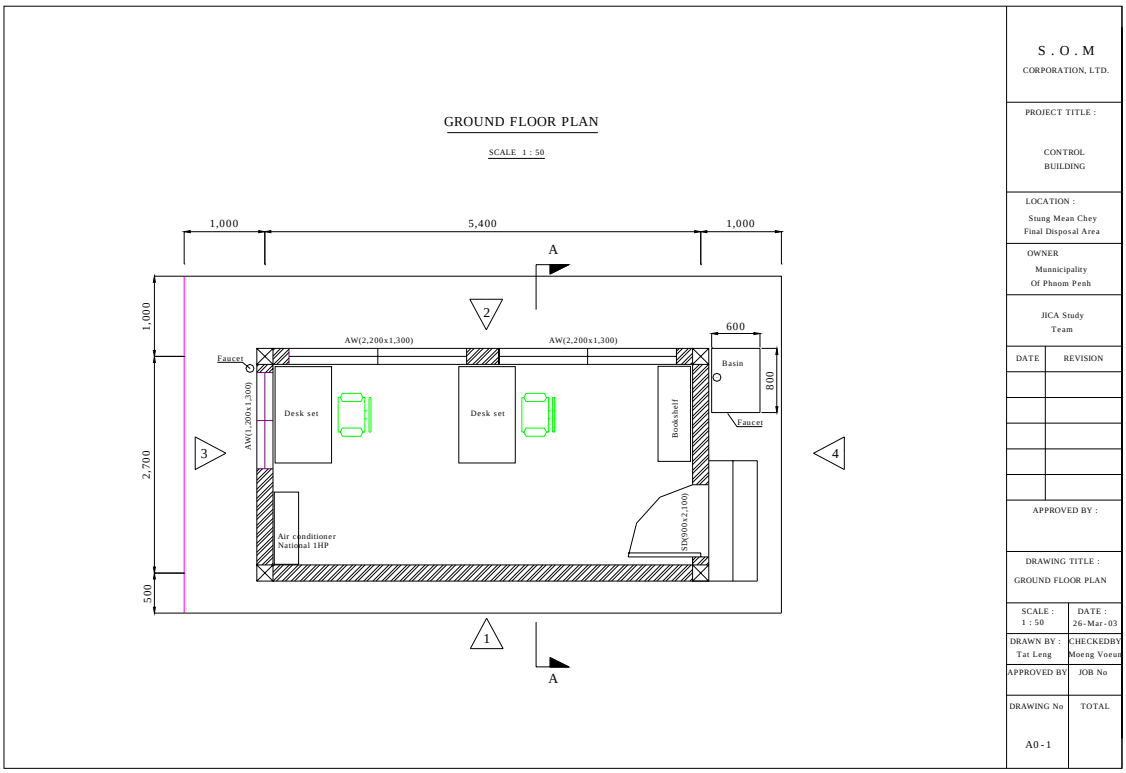


Figure 12-2: Plan of Weighbridge

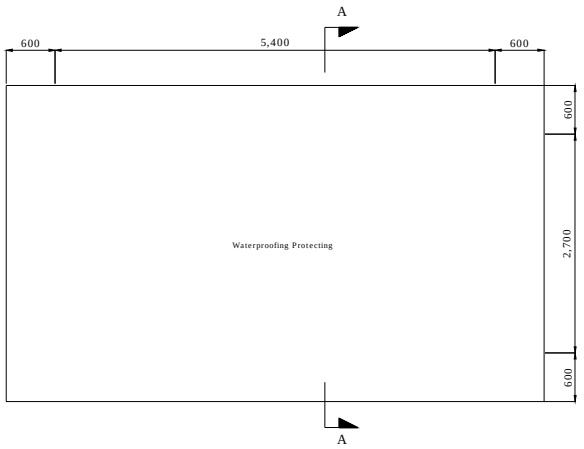
b. Structural Drawing for Complete Work

b.1 Weighbridge Building



ROOF PLAN

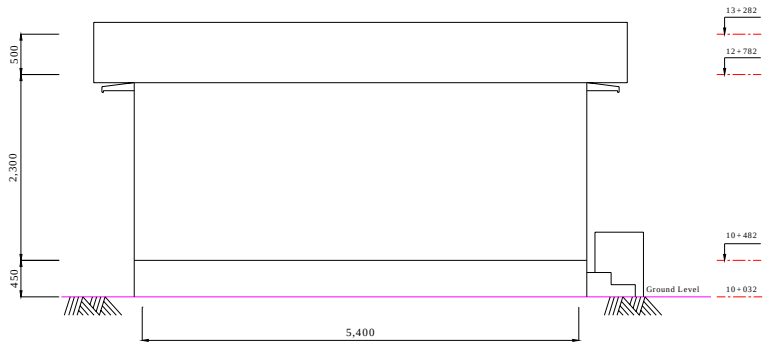
SCALE 1 : 50



S . O . M CORPORATION, LTD.	
PROJECT TITLE : CONTROL BUILDING	
LOCATION : Stung Mean Chey Final Disposal Area	
OWNER Munnicipality Of Phnom Penh	
JICA Study Team	
DATE	REVISION
APPROVED BY :	
DRAWING TITLE : ROOF PLAN	
SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No A0-2	TOTAL

ELEVATION 1

SCALE 1 : 50



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PROJECT TITLE : CONTROL BUILDING	
LOCATION : Stung Mean Chey Final Disposal Area	
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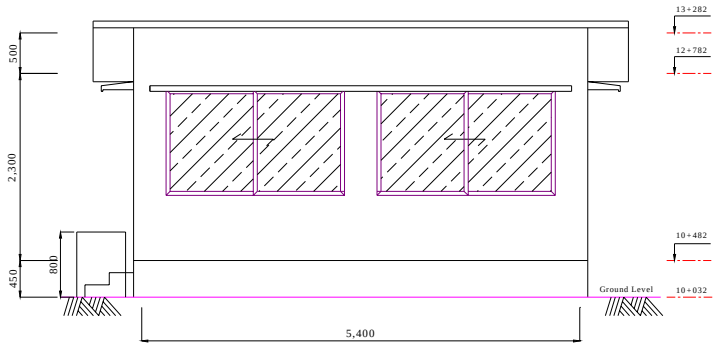
JICA Study Team	
DATE	REVISION
APPROVED BY :	
DRAWING TITLE : ELEVATION 1	
SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No A0-3	TOTAL

ELEVATION 2

SCALE 1 : 50



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PROJECT TITLE :
CONTROL BUILDING

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JICA Study Team

DATE	REVISION

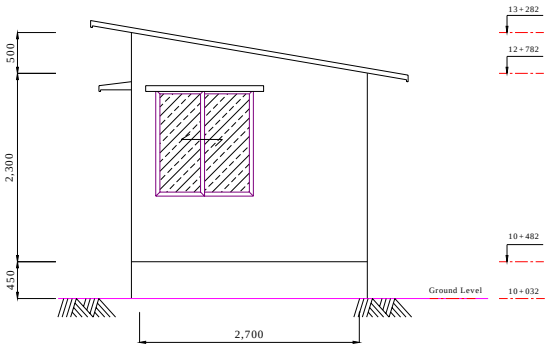
APPROVED BY :

DRAWING TITLE :
ELEVATION 2

SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No A0-4	TOTAL

ELEVATION 3

SCALE 1 : 50



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PROJECT TITLE :
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LOCATION :
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DATE	REVISION

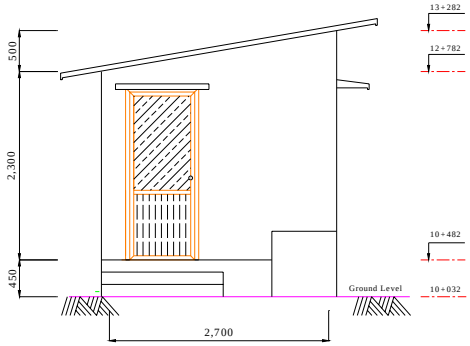
APPROVED BY :

DRAWING TITLE :
ELEVATION 3

SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No A0-5	TOTAL

ELEVATION 4

SCALE 1 : 50



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PROJECT TITLE : CONTROL BUILDING	
LOCATION : Stung Mean Chey Final Disposal Area	
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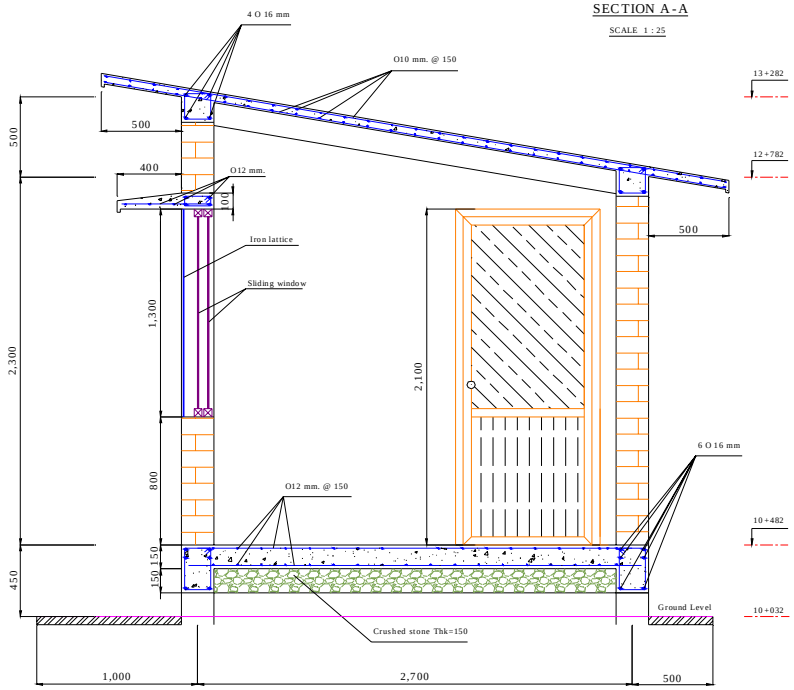
JICA Study Team	
DATE	REVISION
APPROVED BY :	
DRAWING TITLE : ELEVATION 4	
SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No A0-6	TOTAL

SECTION A-A

SCALE 1 : 25



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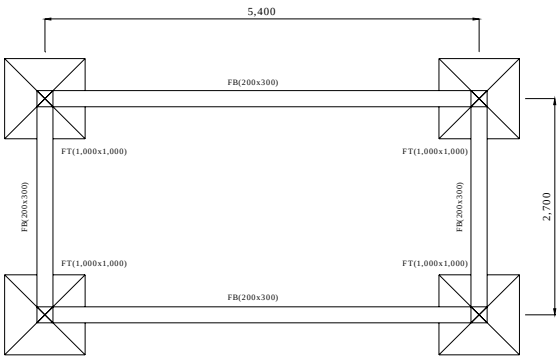
LOCATION : Stung Mean Chey Final Disposal Area	
OWNER Munnicipality Of Phnom Penh	
JICA Study Team	
DATE	REVISION
APPROVED BY :	
DRAWING TITLE : SECTION A-A	
SCALE : 1 : 25	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No A0-7	TOTAL

FOOTING & FOUNDATION BEAM

SCALE 1 : 50



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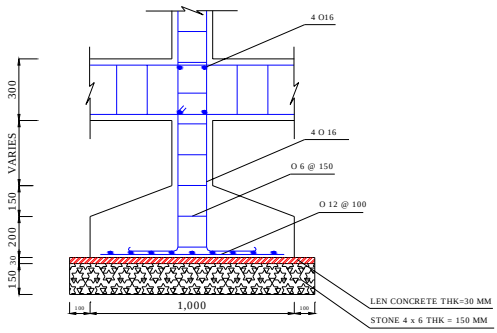
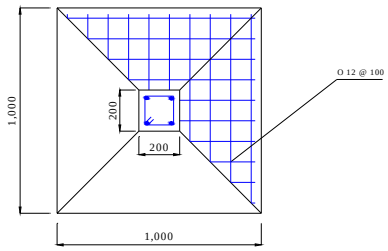
PROJECT TITLE : CONTROL BUILDING	
LOCATION : Stung Mean Chey Final Disposal Area	
OWNER Munnicipality Of Phnom Penh	
JICA Study Team	
DATE	REVISION
APPROVED BY :	
DRAWING TITLE : FOOTING & FOUNDATION BEAM	
SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No S0 - 1	TOTAL

DETAILS FOR FOOTING

SCALE 1/20





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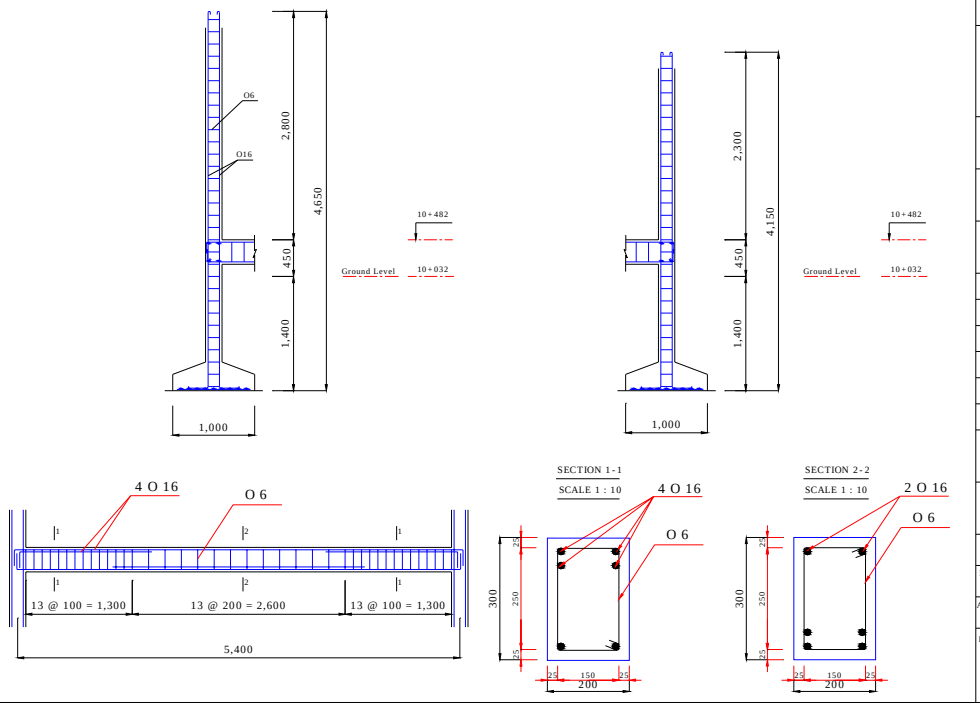
PROJECT TITLE : CONTROL BUILDING	
LOCATION : Stung Mean Chey Final Disposal Area	
OWNER Munnicipality Of Phnom Penh	
JICA Study Team	
DATE	REVISION
APPROVED BY :	
DRAWING TITLE : DETAILS FOR FOOTING	
SCALE : 1 : 20	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No S0 - 2	TOTAL

DETAILS COLUMN & BEAM

SCALE 1/50



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PROJECT TITLE :
CONTROL BUILDING

LOCATION :
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JICA Study Team

DATE	REVISION

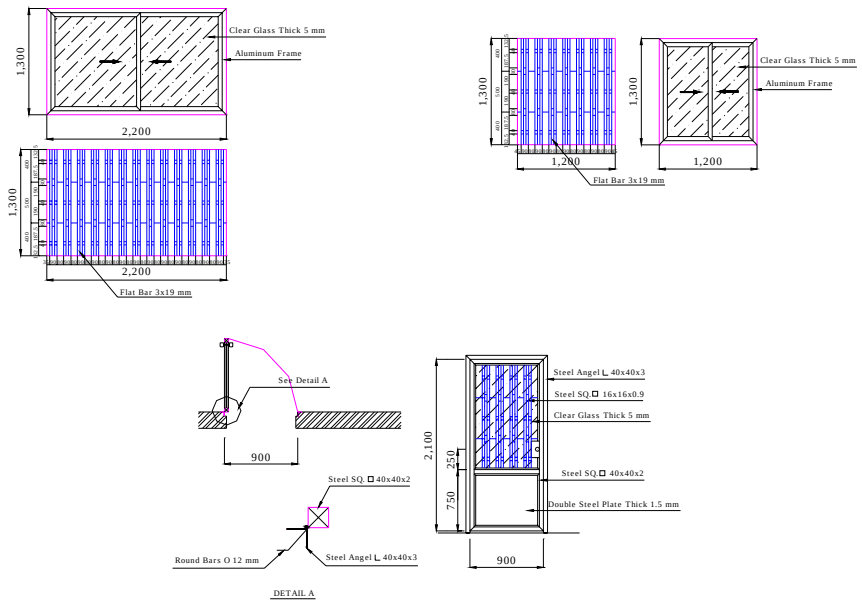
APPROVED BY :

DRAWING TITLE :
DETAILS COLUMN & BEAM

SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No S0-3	TOTAL

DETAIL DOOR & WINDOW

SCALE 1 : 50



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PROJECT TITLE :
CONTROL BUILDING

LOCATION :
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Final Disposal Area

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JICA Study Team

DATE	REVISION

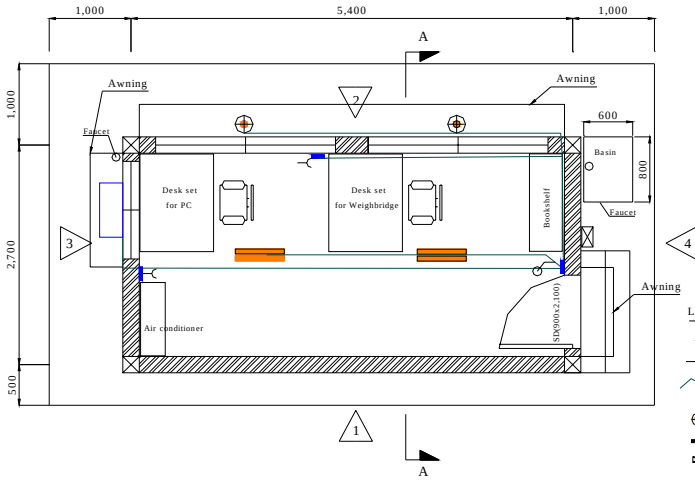
APPROVED BY :

DRAWING TITLE :
DETAIL DOOR & WINDOW

SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No S0-4	TOTAL

GROUND FLOOR PLAN

SCALE 1 : 50



LEGEND ELECTRICITY

- Switch
- Socket
- Line for light, Air Condition, Socket
- Night Light (Bottom awning)
- Double Fluorescent Lamp 60 cm
- Electric Board

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CONTROL BUILDING

LOCATION :
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Munnicipality Of Phnom Penh

JICA Study Team

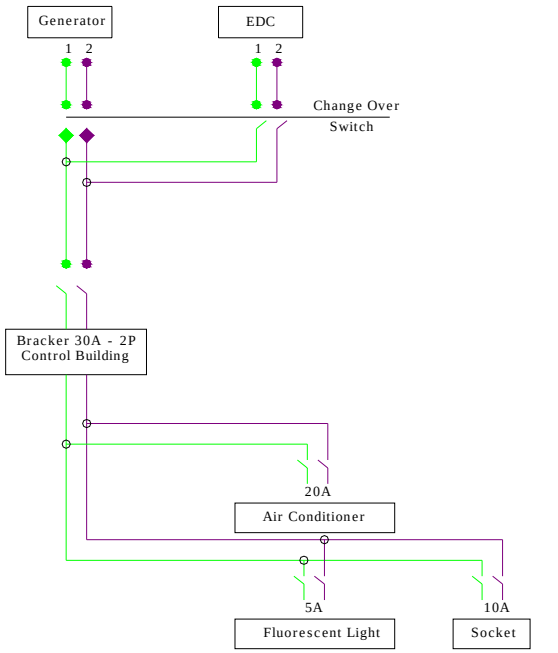
DATE	REVISION

APPROVED BY :

DRAWING TITLE :
LIGHTING WIRING

SCALE : 1 : 50	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No : E0-1	TOTAL

ELECTRIC SYSTEM



S . O . M
CORPORATION, LTD.

PROJECT TITLE :
CONTROL BUILDING

LOCATION :
Stung Mean Chey Final Disposal Area

OWNER
Munnicipality Of Phnom Penh

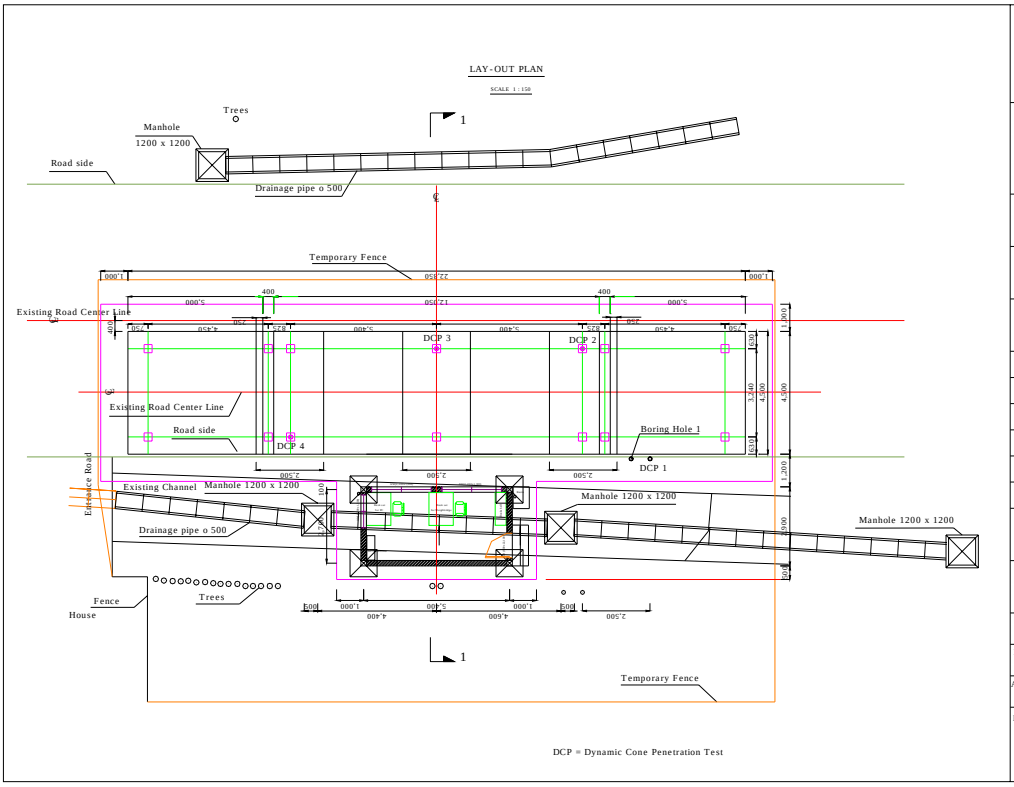
JICA Study Team

DATE	REVISION

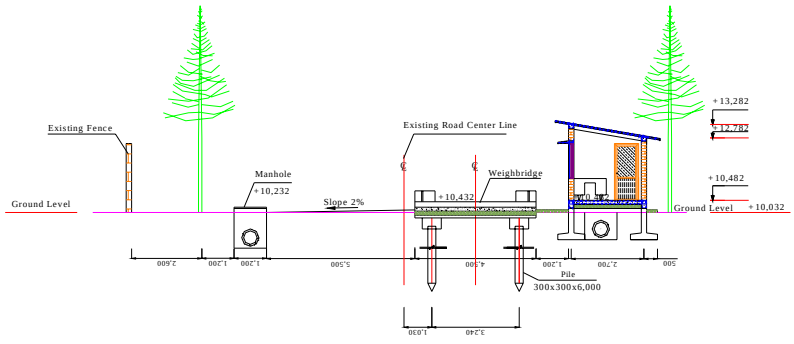
APPROVED BY :

DRAWING TITLE :
ELECTRIC SYSTEM

SCALE :	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No : E0-2	TOTAL

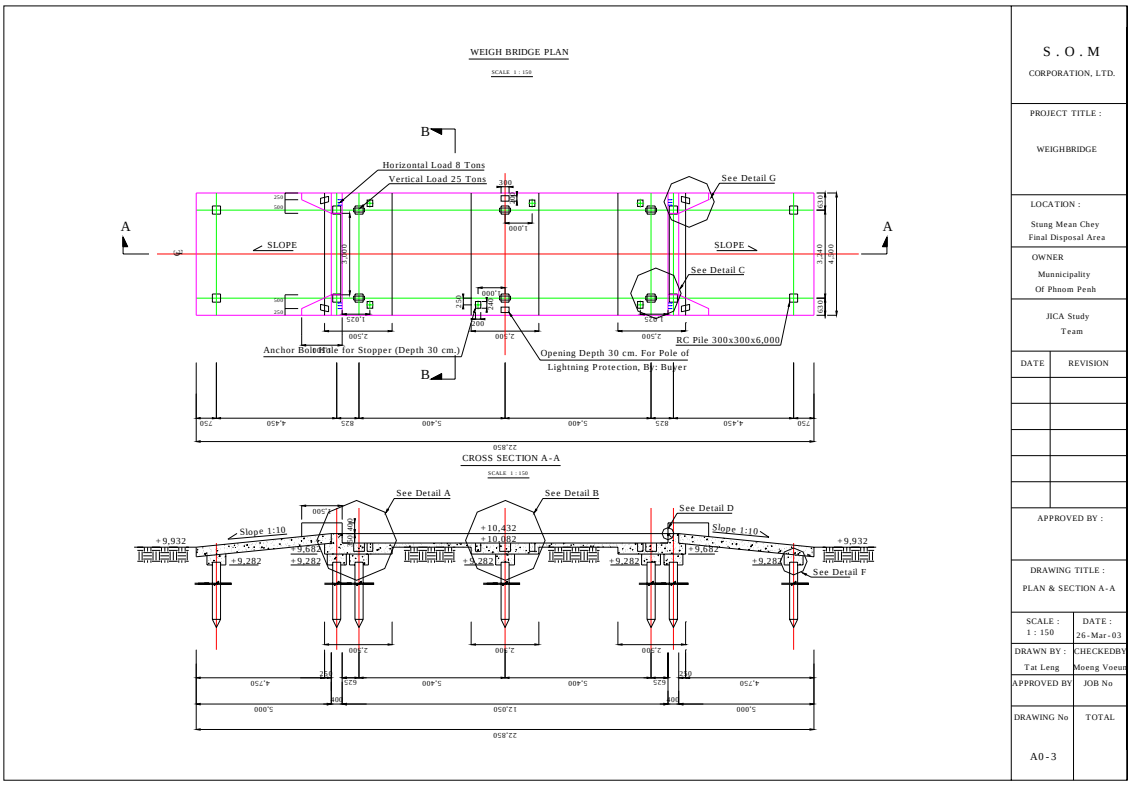


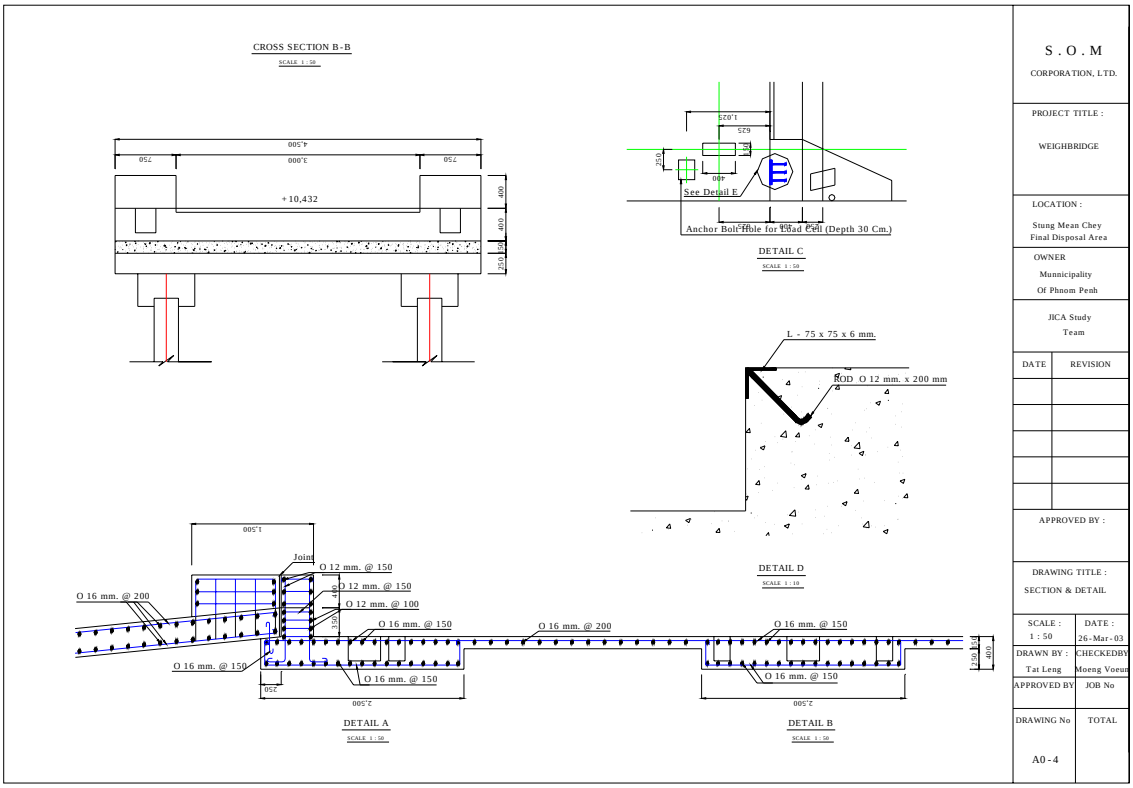
S . O . M CORPORATION, LTD.	
PROJECT TITLE : CONTROL BUILDING AND WEIGHBRIDGE	
LOCATION : Stung Mean Chey Final Disposal Area	
OWNER Munnicipality Of Phnom Penh	
JICA Study Team	
DATE	REVISION
APPROVED BY :	
DRAWING TITLE : LAY-OUT PLAN	
SCALE : 1 : 150	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No A0 - 1	TOTAL

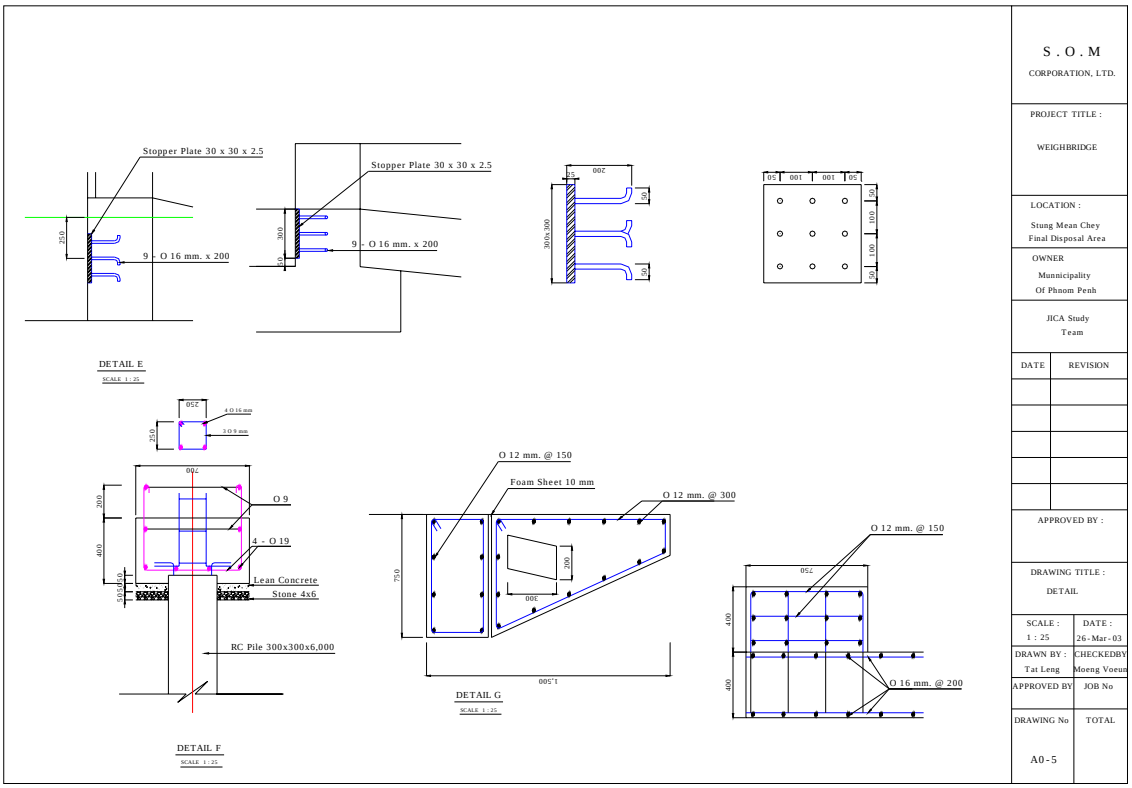


S . O . M CORPORATION, LTD.	
PROJECT TITLE : CONTROL BUILDING AND WEIGHBRIDGE	
LOCATION : Stung Mean Chey Final Disposal Area	
OWNER Munnicipality Of Phnom Penh	
JICA Study Team	
DATE	REVISION
APPROVED BY :	
DRAWING TITLE : CROSS SECTION 1 - 1	
SCALE : 1 : 150	DATE : 26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No A0 - 2	TOTAL

b.2 Weighbridge







S . O . M
CORPORATION, LTD.

PROJECT TITLE :
WEIGHBRIDGE

LOCATION :
Stung Mean Chey
Final Disposal Area

OWNER
Munnicipality
Of Phnom Penh

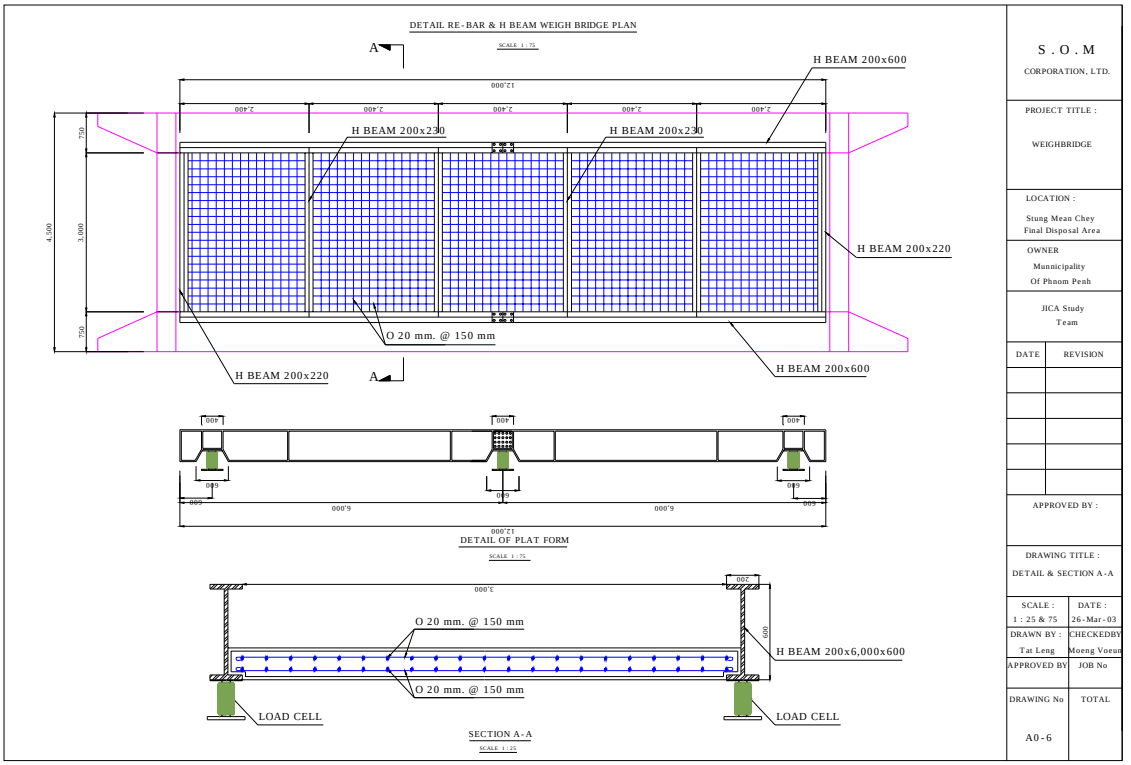
JICA Study
Team

DATE	REVISION

APPROVED BY :

DRAWING TITLE :
DETAIL

SCALE :	DATE :
1 : 25	26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No	TOTAL
A0-5	



S . O . M
CORPORATION, LTD.

PROJECT TITLE :
WEIGHBRIDGE

LOCATION :
Stung Mean Chey
Final Disposal Area

OWNER
Munnicipality
Of Phnom Penh

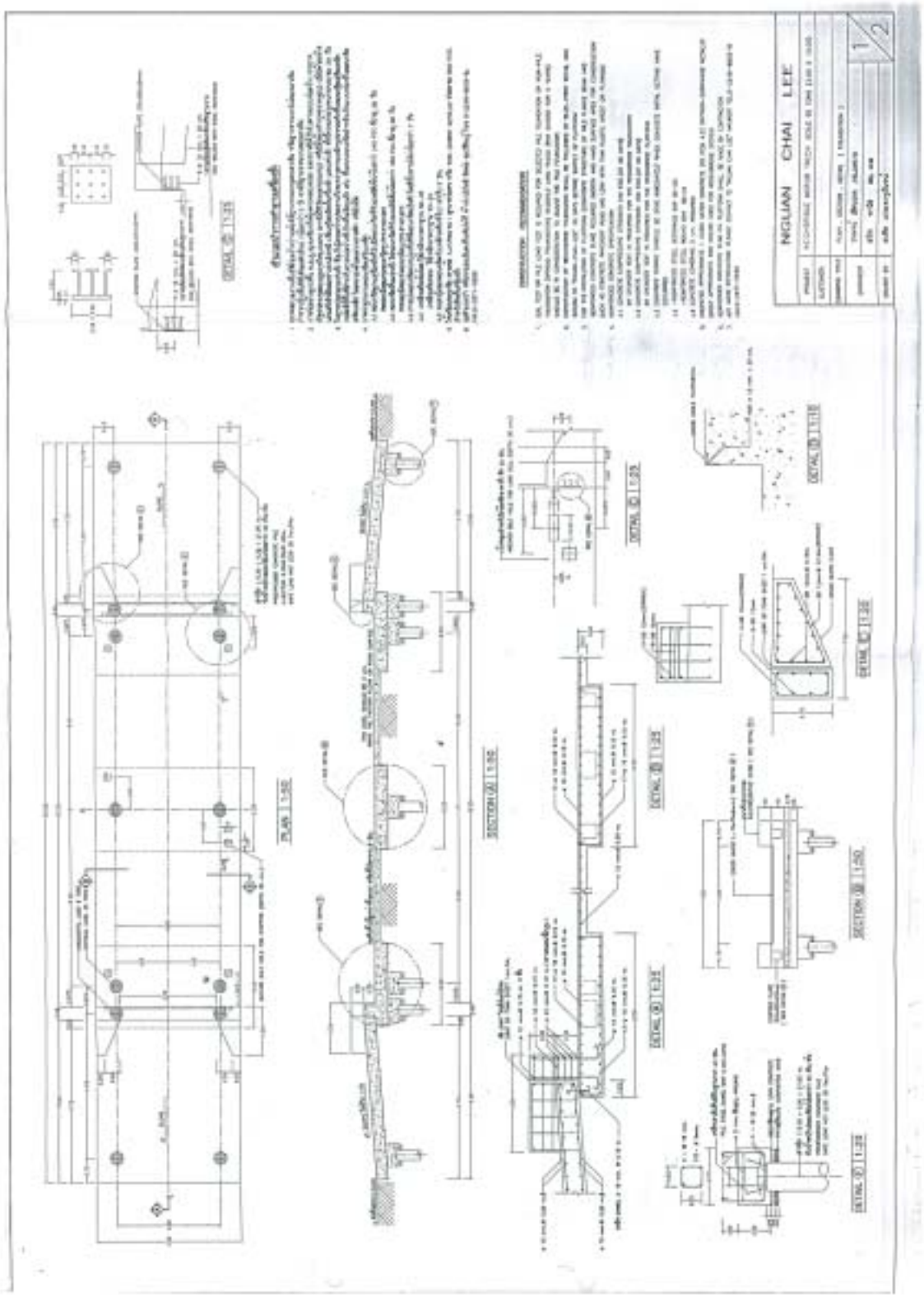
JICA Study
Team

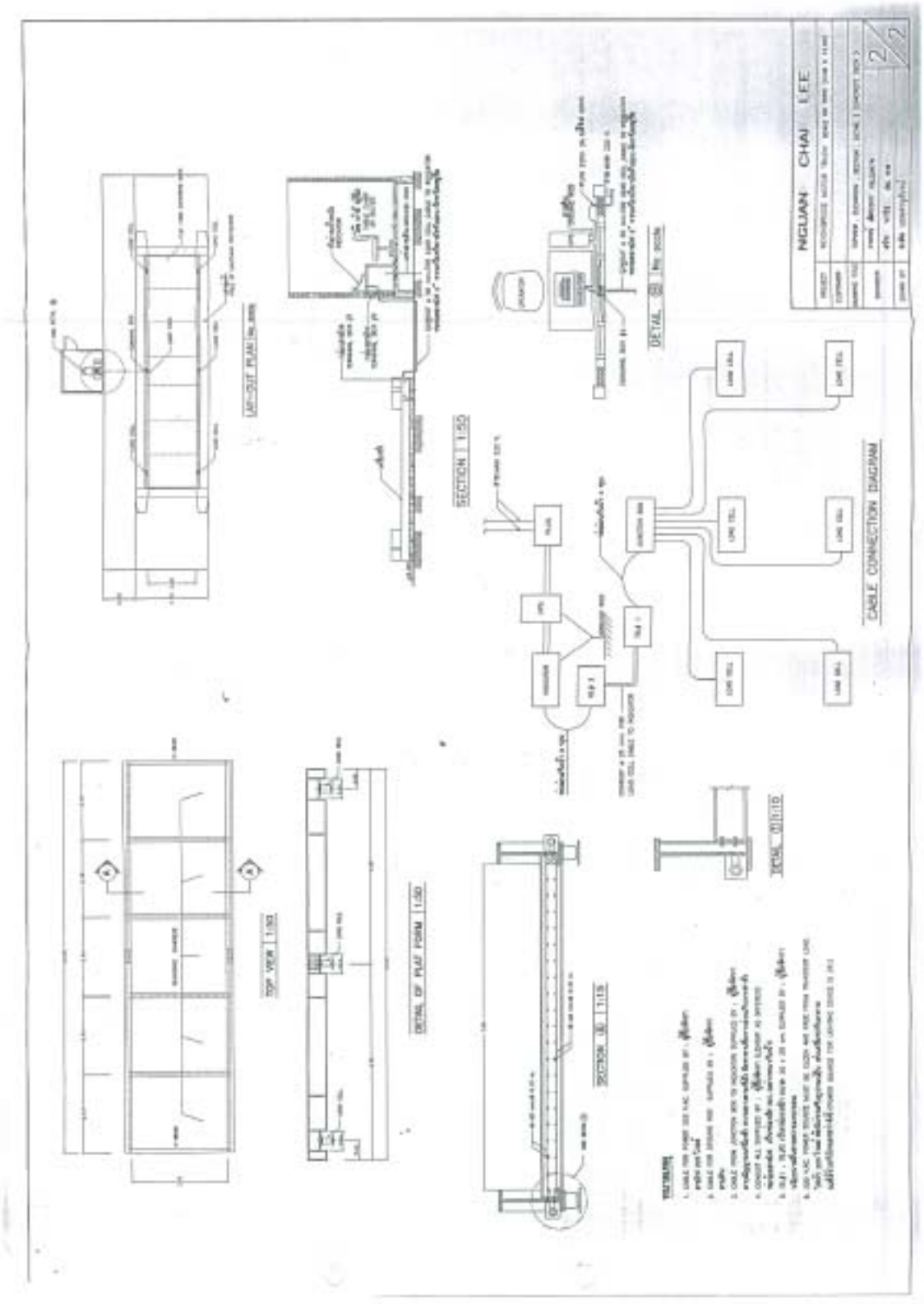
DATE	REVISION

APPROVED BY :

DRAWING TITLE :
DETAIL & SECTION A-A

SCALE :	DATE :
1 : 25 & 75	26-Mar-03
DRAWN BY : Tat Leng	CHECKEDBY Moeng Voeun
APPROVED BY	JOB No
DRAWING No	TOTAL
A0-6	

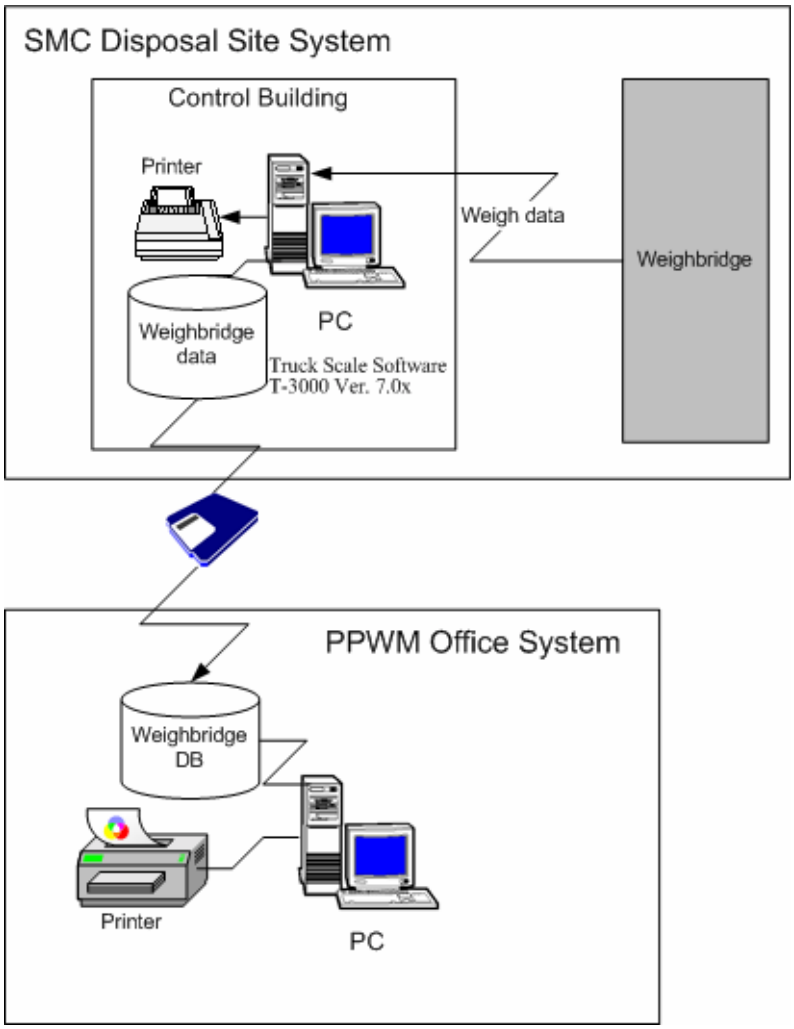

NGUAN CHAI LEE


NGUAN CHAI LEE
CABLE CONNECTION DIAGRAM
SECTION 1:50
DETAIL OF PILE FORM 1:50
TOP VIEW 1:50

12.2 WBDB User Manual

12.2.1 Introduction

WBDB (WeighBridge DataBase) is a system to manage data from weighbridge installed in the SMC disposal site. The WBDB was developed with Microsoft Access and the general specification is as shown in the following figure.



The data from the "T-3000" system are sending from SMC disposal site to the PPWM office by diskette, and then import to the WBDB.

12.2.2 Setup folder

Files	Folder	Detail
WBDB.mdb	**D:¥PPWMDB¥WPDB¥**	Main DB file
Truck Photos	**D:¥PPWMDB¥WPDB¥Photo**	Folder for truck photo that is link with each truck record

12.2.3 Starting WBDB

1. The WBDB system is in the **[WBDB.mdb**] file, and the file located in the next folder **[D:¥PPWMDB¥WBDB¥WBDB.mdb].** Doble click the next icon.

2. The next screen will appear, enter a valid pasword and then click [OK] to start the system or [Cancel] to cancel.

3. The main menu will appear and you are ready to start using WPDB

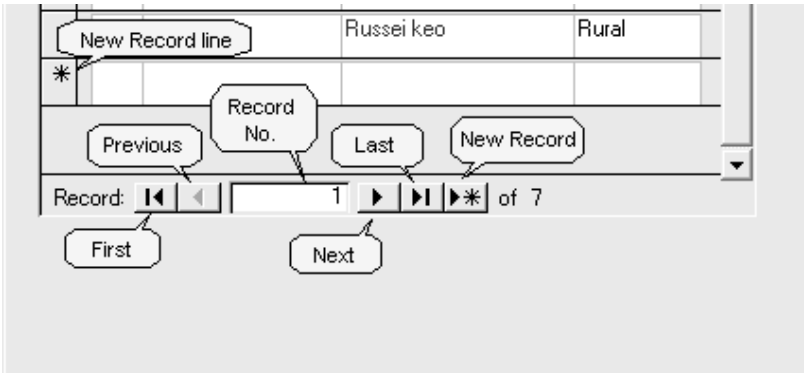
12.2.4 Weighbridge DB

WBDB main page

a. Handling record

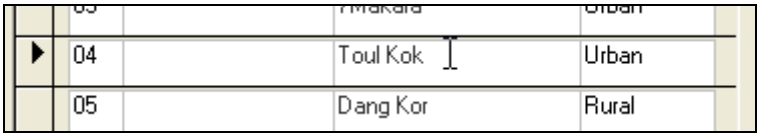
For the handling of the records of the DB, in this section some common steps for the whole DB.

- **Record Navigation**



- **Edit record**

To edit a record, select the field and click the mouse and you can change the selecte field.

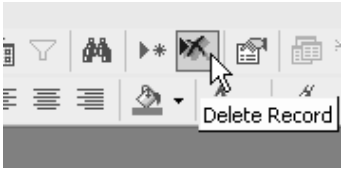


- **New record**

To add a new record, click the [New record] button 

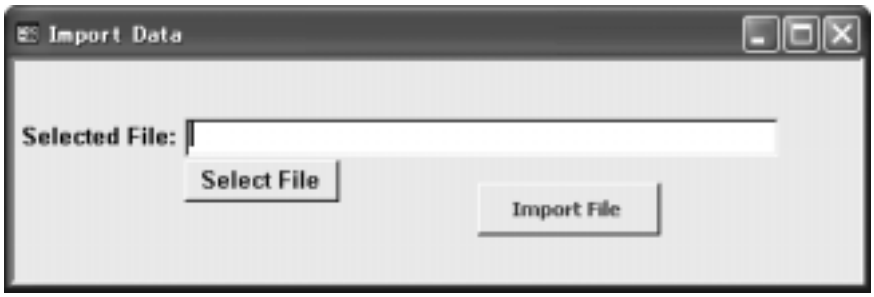
- **Delete record**

To delete a record select the row to delete and click the [Delete button]

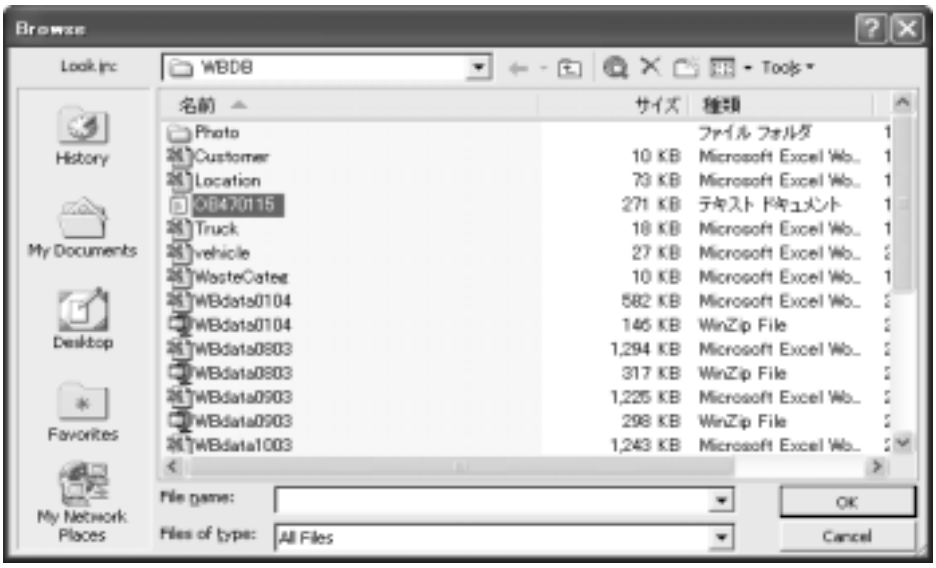


b. Import WB data

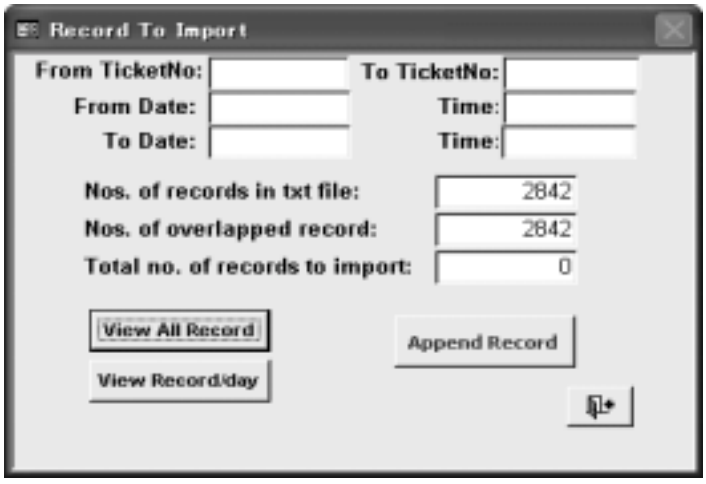
To import weighbridge data to the WBDB, in the main menu click [Import WB data] and the next screen will appear.



- Copy the weighbridge data came from SMC disposal in to the computer hard disk.
- Click [Select file] button and will appear the next dialog box, select the file and click [Ok] button.

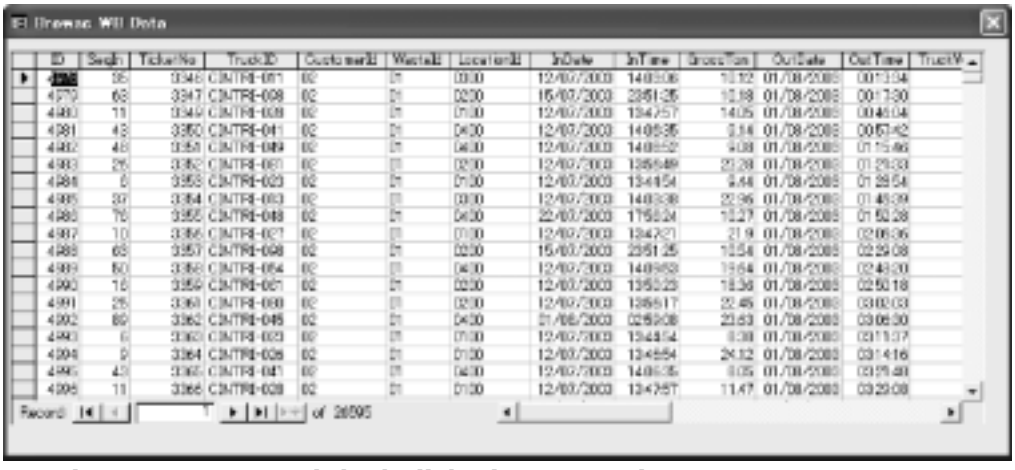


- Click [Import File] and the next screen will appear, with a detail of the content of the source file. Click [Append Record] to import the file to the WBDB.



c. Browse weighbridge data

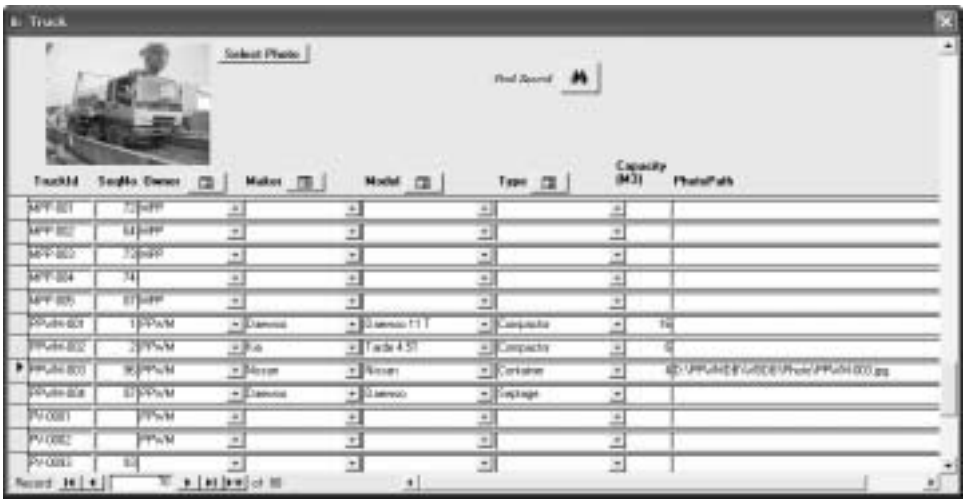
To browse the weighbridge data, in the main menu click [Browse WB data] and the next screen will appear.



In this windows you can see and check all the data imported to WBDB

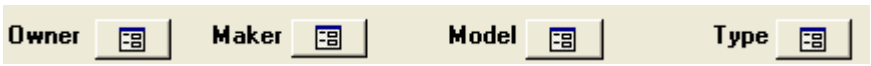
d. Truck data

To browse the truck data, in the main menu click [Vehicle] and the next screen will appear.



In this form you can control all the related data of the truck registered in the weighbridge system.

- To handling truck record, refer to the [Handling record] section
- The owner, Maker, Model and Truck type data it is coded, and to change click in the field and will appear the list of each category. If the data that you want it isnt in the list click the next button



And will appear the form for each category and you can add a new data for the list.

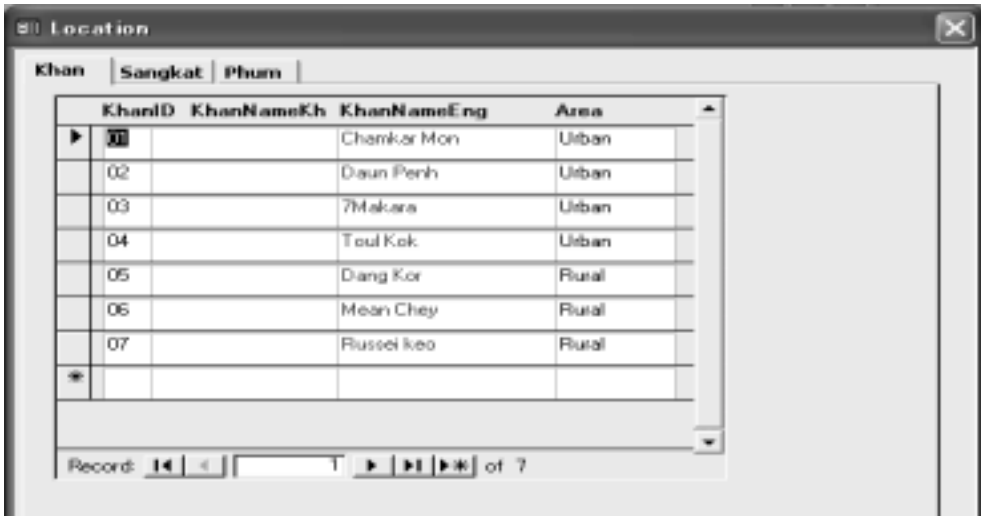
To add a picture of the truck, select the record and click [Select photo] button and the next screen will appear

Select the file and click [Ok] button and the picture of the track will link to the record.

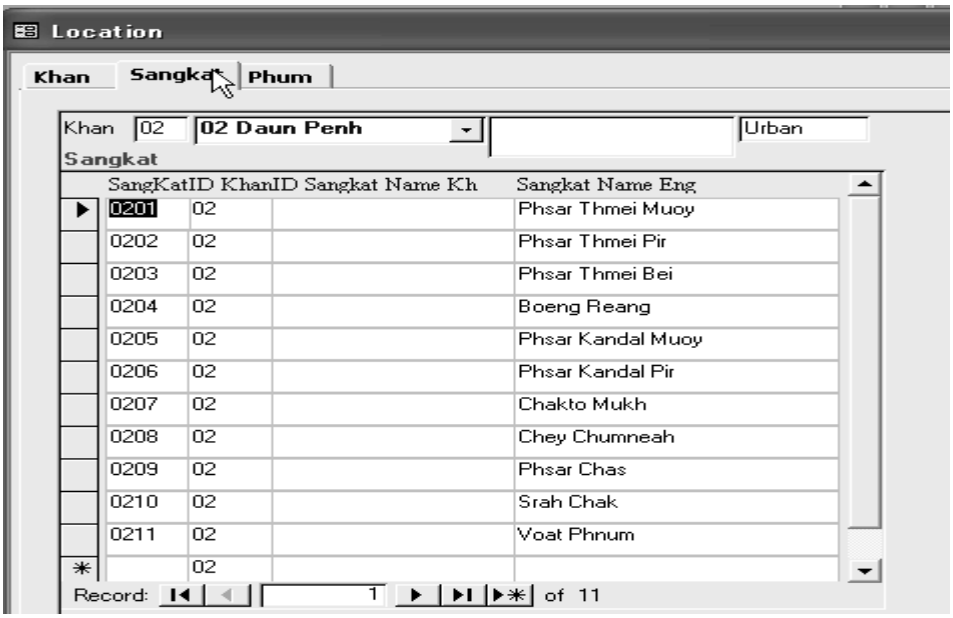
e. Location data (Khan, Sangkat, Phum)

To [Add, Edit, Delete] location data, in the main menu click [Location] and the next screen will appear.

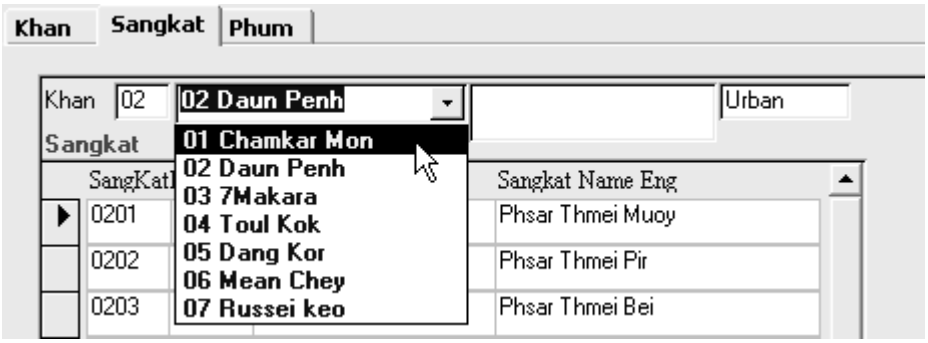
- In this form you can [Add, Edit, Delete] Khan record.



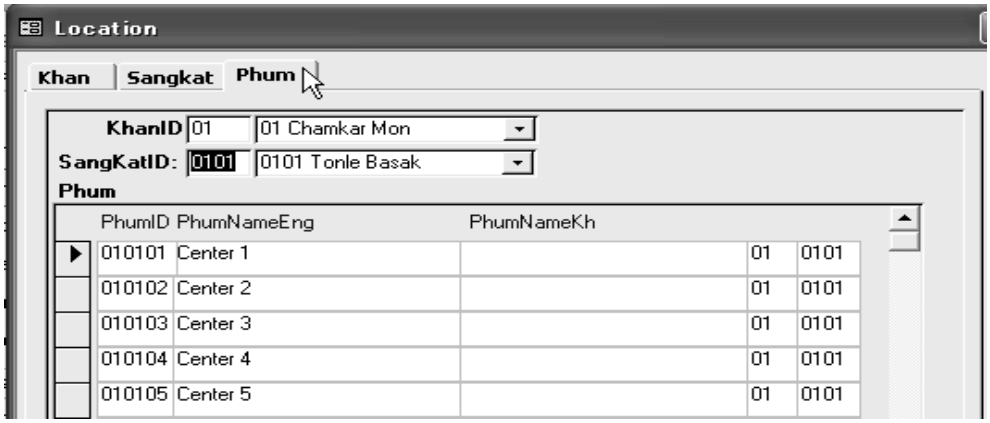
- To [Add, Edit, Delete] Sangkat data, click in the [Sangkat] label and the next screen will appear.



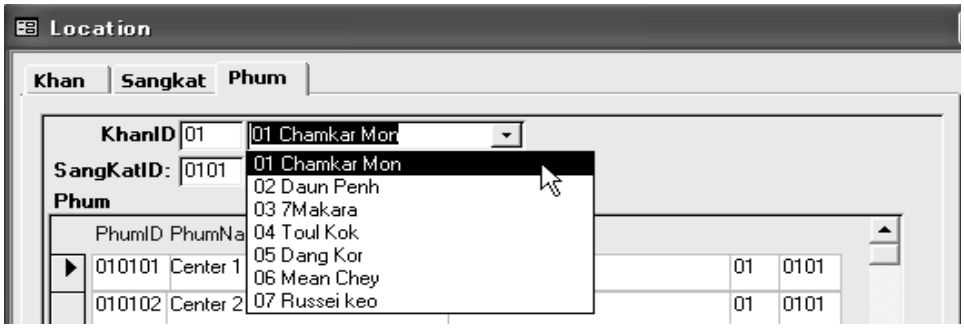
To form is linked to the Khan data, to browse Sangkat of each Khan, select first the Khan and the system will update the list of the Sangkat.

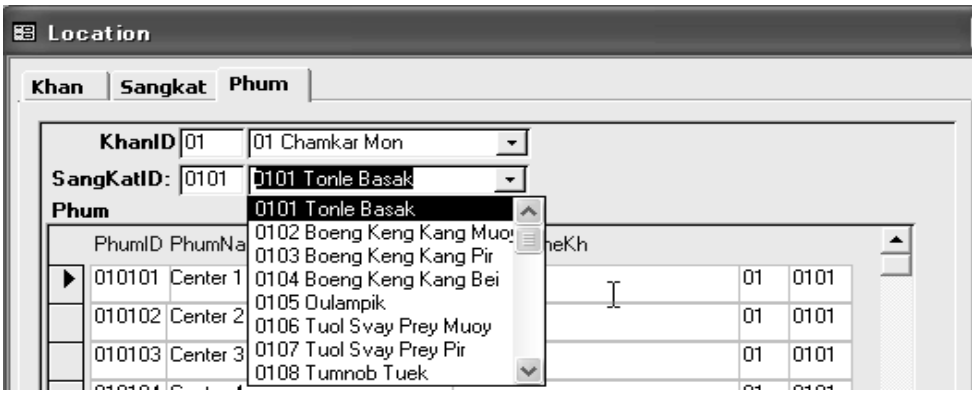


- To [Add, Edit, Delete] Phum data, click in the [Phum] label and the next screen will



This form is linked to the Khan and Sangkat form, first select the [KhanID] and then [SangkatID] and the system will show the Phum linked to the Khan and Sangkat





f. Export WBDB

The system can export weighbridge data to other application. To export in the main menu click [Export data] and the next screen will appear.

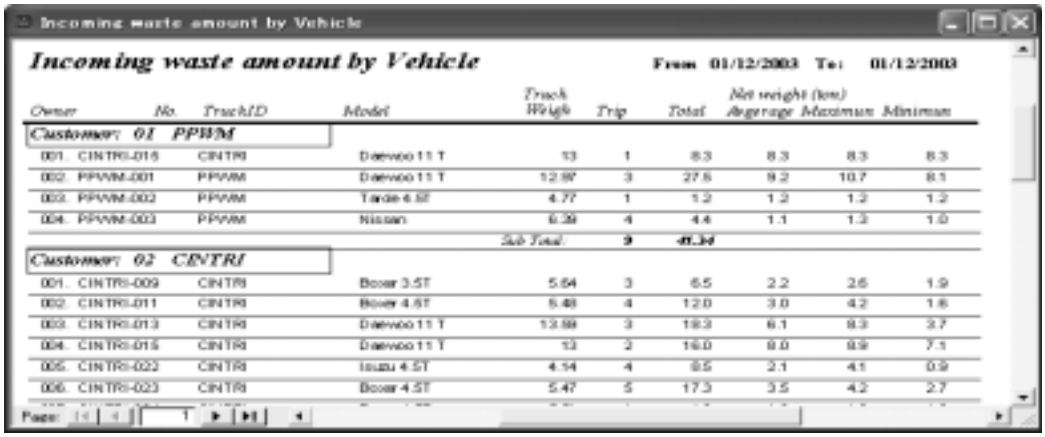
- To export weighbridge data, select [Weighbridge] and then select the period of date, and click [Export Data]. The system will copy the data to D:¥PPWMDB¥WBDB.
- To export other data, just select the type of data and then click [Export Data]. The system will copy the data to D:¥PPWMDB¥WBDB.

g. Report

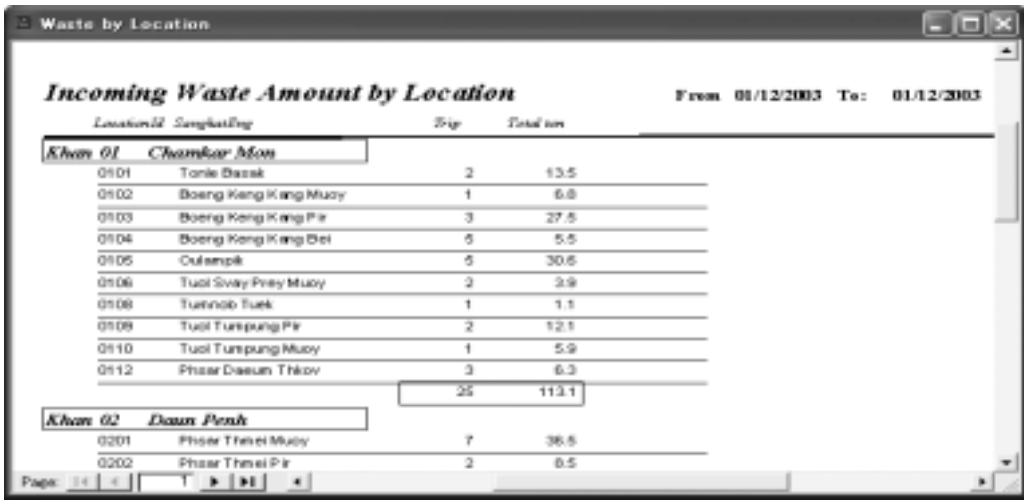
To print a report in the main menu click [Report] and the next screen will appear.

Select the period of date and then select the type of report and click [Preview] button.

- Incoming waste by vehicle

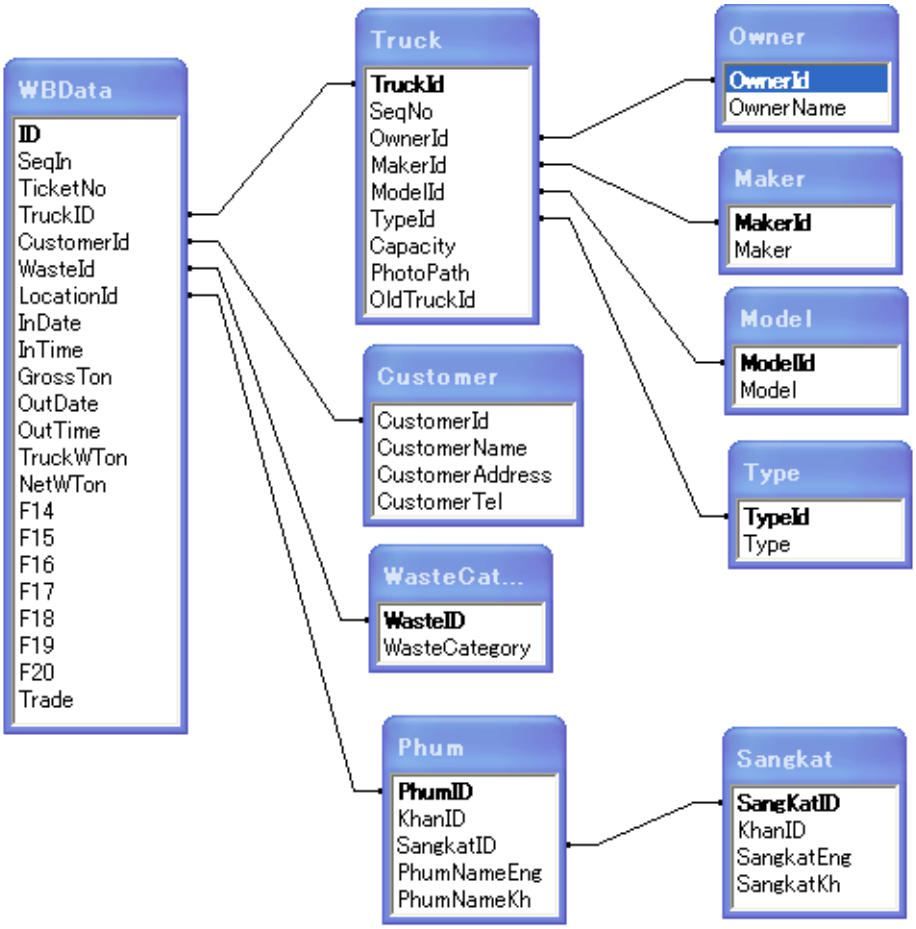


- Incoming waste by location



To print the report click the [Print] button

h. Relations of tables



i. Structure of Tables

WBTmpTxt	***Temporary WB data to import to the WeighbridgeDB***		
Name	**Type**	**Size**	**Property**
F1	Text	255	
F2	Text	255	
F3	Text	255	
F4	Text	255	
F5	Text	255	
F6	Text	255	
F7	Text	255	
F8	Text	255	
F9	Long Integer	4	
F10	Text	255	
F11	Text	255	
F12	Long Integer	4	
F13	Long Integer	4	
F14	Long Integer	4	
F15	Long Integer	4	
F16	Long Integer	4	
F17	Double	8	
F18	Double	8	
F19	Long Integer	4	
F20	Text	255	
F21	Text	255	

WBData	***Imported WB data***		
Name	**Type**	**Size**	**Property**
ID	Long Integer	4	Running number ID
SeqIn	Double	8	Sequential truck registration number
TicketNo	Long Integer	4	Sequential Weighbridge ticket number
TruckID	Text	12	Truck ID
CustomerId	Text	16	Customer ID
WasteId	Text	16	Waste Category ID
LocationId	Text	16	Location ID (Phum ID)
InDate	Date/Time	8	Truck enter date
InTime	Date/Time	8	Truck enter time
GrossTon	Double	8	Gross ton
OutDate	Date/Time	8	Truck out date
OutTime	Date/Time	8	Truck in date
TruckWTon	Double	8	Truck registered weigh
NetWTon	Double	8	Waste net ton
F14	Long Integer	4	Not use
F15	Long Integer	4	Not use
F16	Long Integer	4	Not use
F17	Double	8	Not use
F18	Double	8	Not use
F19	Long Integer	4	Not use
F20	Text	10	Not use
Trade	Text	1	Not use

Truck	***Truck type***		
Name	**Type**	**Size**	**Property**
TruckId	Text	12	Truck ID
SeqNo	Double	8	Sequential truck registration number
OwnerId	Long Integer	4	
MakerId	Long Integer	4	
ModelId	Long Integer	4	

TypeId	Long Integer	4	
Capacity	Double	8	Capacity of the truck
PhotoPath	Text	50	Truck picture file path
OldTruckId	Text	12	

Table	***Truck owner***		
Name	**Type**	**Size**	**Property**
OwnerId	Long Integer	4	
OwnerName	Text	30	

Maker	***Truck maker***		
Name	**Type**	**Size**	**Property**
MakerId	Long Integer	4	
Maker	Text	30	

Model	***Truck model***		
Name	**Type**	**Size**	**Property**
ModelId	Long Integer	4	
Model	Text	30	

Type	***Truck type***		
Name	**Type**	**Size**	**Property**
TypeId	Long Integer	4	
Type	Text	255	

Customer	***Waste transporter owner***		
Name	**Type**	**Size**	**Property**
CustomerId	Text	16	
CustomerName	Text	30	
CustomerAddress	Text	50	
CustomerTel	Text	50	

Waste	***Waste type***		
Name	**Type**	**Size**	**Property**
WasteID	Text	16	
WasteCategory	Text	50	

Khan	***Khan***		
Name	**Type**	**Size**	**Property**
KhanID	Text	2	
KhanNameEng	Text	30	
KhanNameKh	Text	30	
Area	Text	15	

Phum	***Phum***		
Name	**Type**	**Size**	**Property**
PhumID	Text	255	
KhanID	Text	2	
SangkatID	Text	4	
PhumNameEng	Text	30	
PhumNameKh	Text	30	

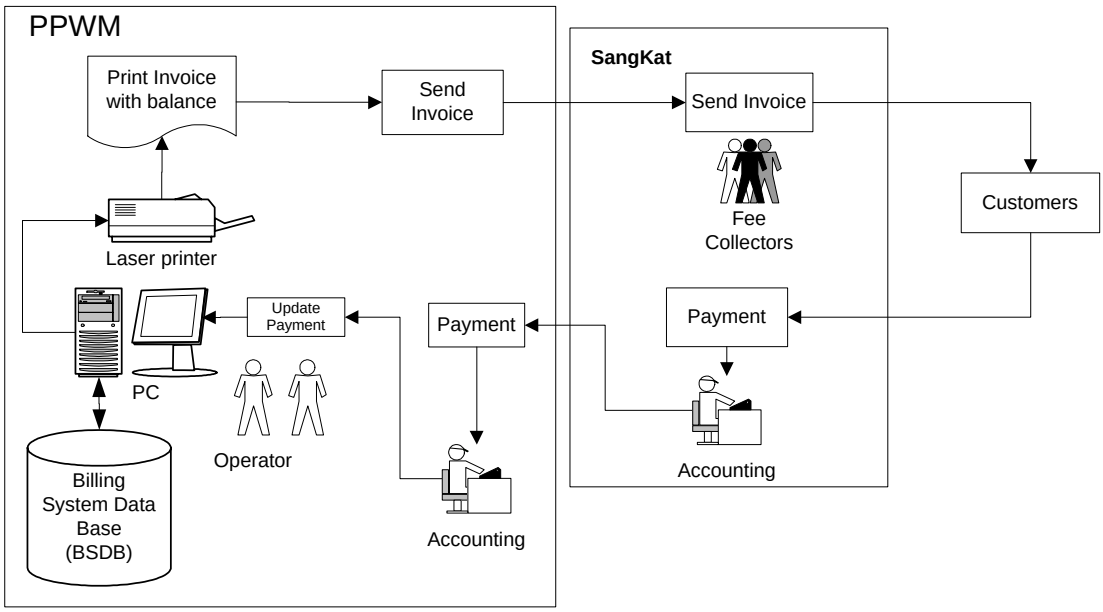
Sangkat	***Sangkat***		
Name	**Type**	**Size**	**Property**

SangKatID	Text	4	
KhanID	Text	2	
SangkatEng	Text	30	
SangkatKh	Text	30	

12.3 Billing System DB User Manual

12.3.1 Introduction

The Billing System Database (BSDB) is a system to manage all data about the billing for waste collection from PPWM. The BSDB was developed with Microsoft Access and the general specification is as shown in the following figure.



The BSDB print a bill for all the customer each month and these printed bill are send to the Sangkat office. Sangkat fee collectors delivery each bill to the customer in their area and receive the payment and the send the payment to the PPWM. All the payment of the customer are update in the BSDB.

12.3.2 Setup folder

Files	Folder	Detail
BSDB.mdb	**D:¥PPWMDB¥BSDB¥**	Main DB file

12.3.3 Starting BSDB

1. The BSDB system is in the **[BSDB.mdb**] file, and the file located in the next folder **[D:¥PPWMDB¥BSDB¥WSDB.mdb].** Doble click the next icon.

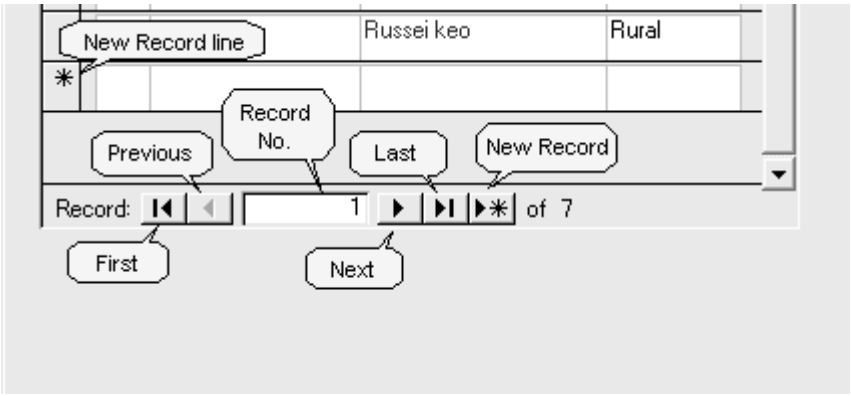
2. The next screen will appear, enter a valid password and then click [OK] to start the system or [Cancel] to cancel.

3. The main menu will appear and you are ready to start using WPDB

12.3.4 Handling record

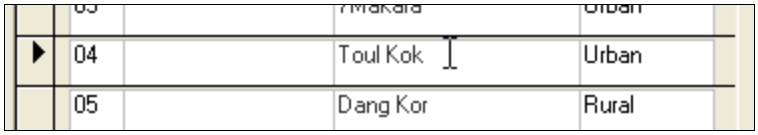
For the handling of the records of the DB, in this section some common steps for the whole DB.

- **Record Navigation**



- **Edit record**

To edit a record, select the field and click the mouse and you can change the selected field.

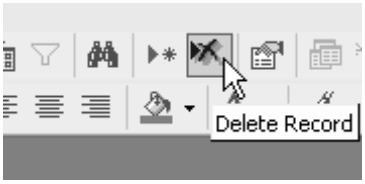


- **New record**

To add a new record, click the [New record] button 

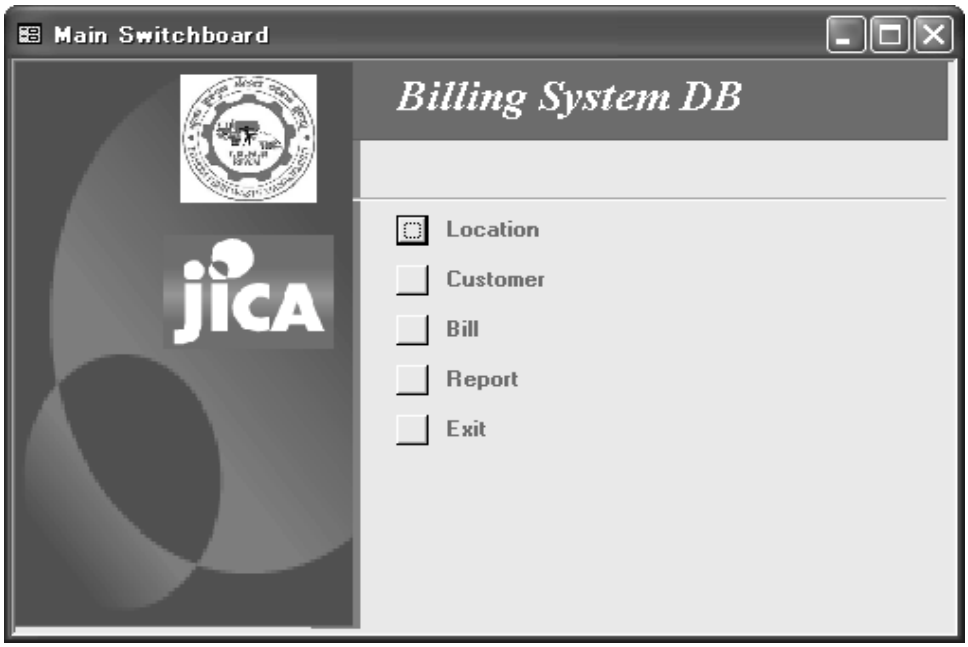
- **Delete record**

To delete a record select the row to delete and click the [Delete button]



12.3.5 Billing System Database (BSDB)

BSDB main menu



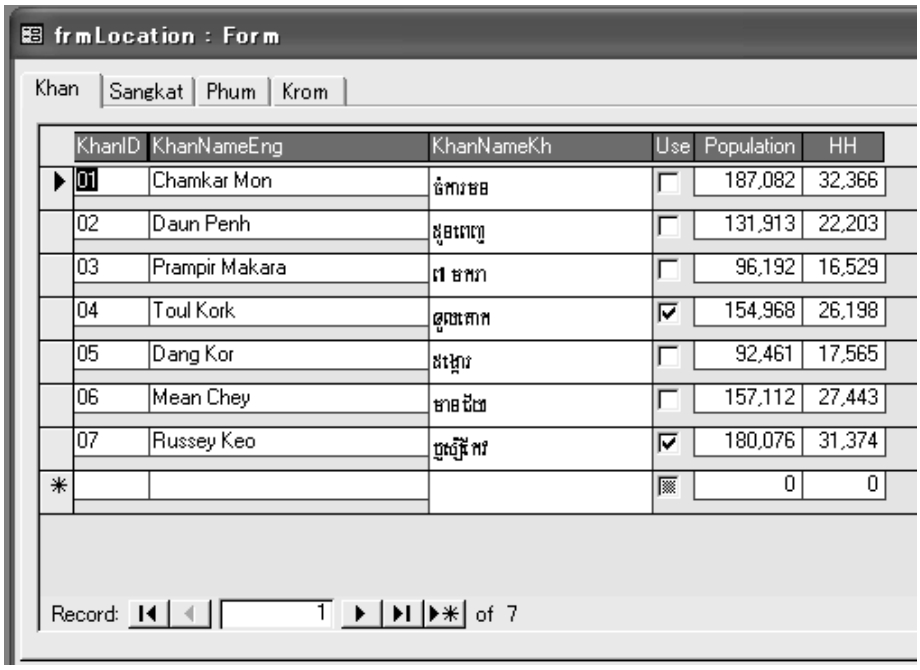
a. Location Data

Location data is referring to the information about Khan, Sangkat, Phum and Krom. To handle the location data, in the main menu click [Location] and the next form will appear.

All the location data have a [Use] column, this will use for select the location data to use in the billing system, if the location data [Use] column is off, this data you cannot use in the system.

a.1 Khan

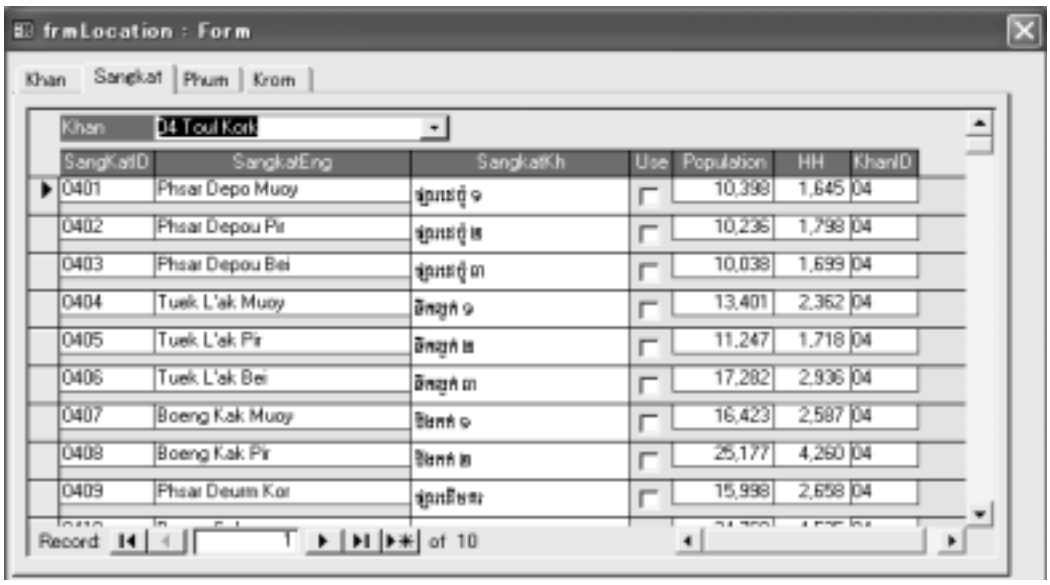
In the next screen click [Khan] and will appear all the registered Khan



- You can add/edit/delete Khan data
- To use the Khan record in the system click in the [Use] column.

a.2 Sangkat

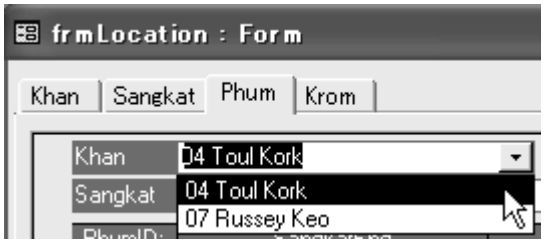
In the next screen click [Sangkat] page and then select [Khan] and will appear all the registered Sangkat in the selected Khan.



- In this screen you can add/edit/delete Sangkat data
- To use the Sangkat record in the system click in the [Use] column.

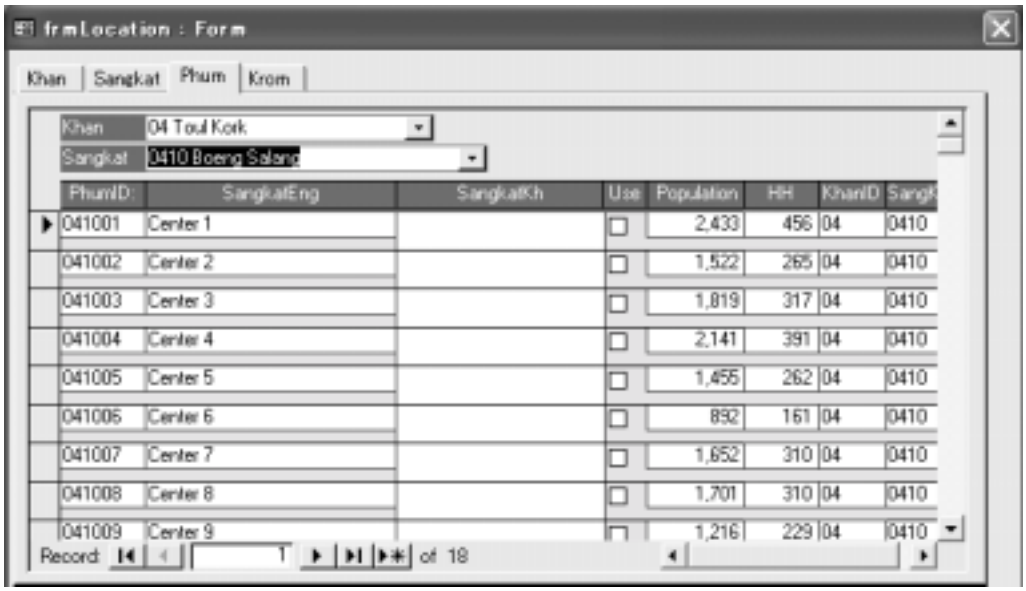
a.3 Phum

- In the location main form click [Phum] page
- Select [Khan]



- Select [Sangkat].

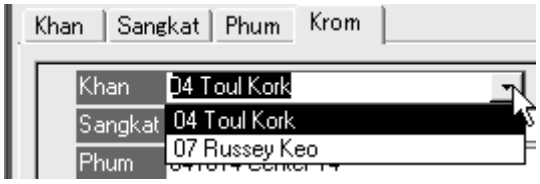
- All the Phum registered in the selected Khan and Sangkat will appear in the next form



- In this screen you can add/edit/delete Phum data
- To use the Phum record in the system click in the [Use] column.

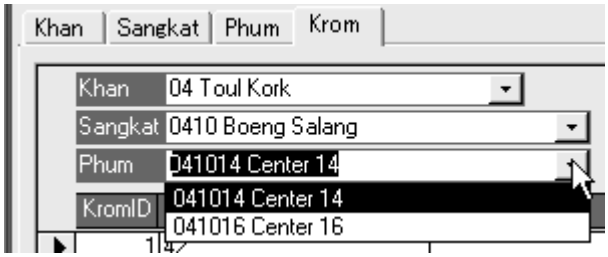
a.4 Krom

- In the location main form click [Krom] page
- Select [Khan]

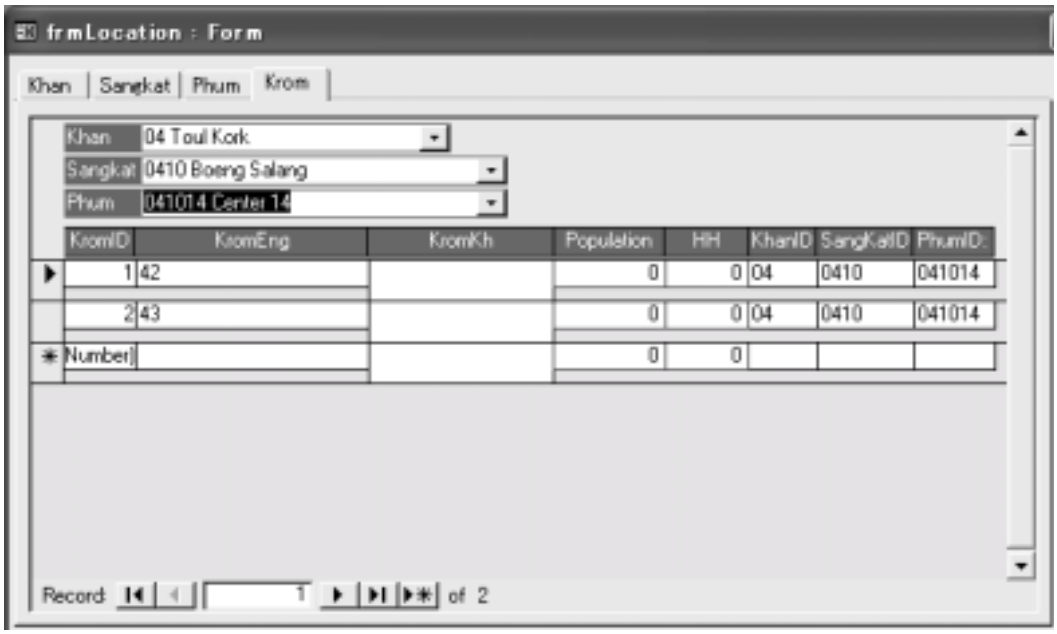


- Select [Sangkat]

- Select [Phum]



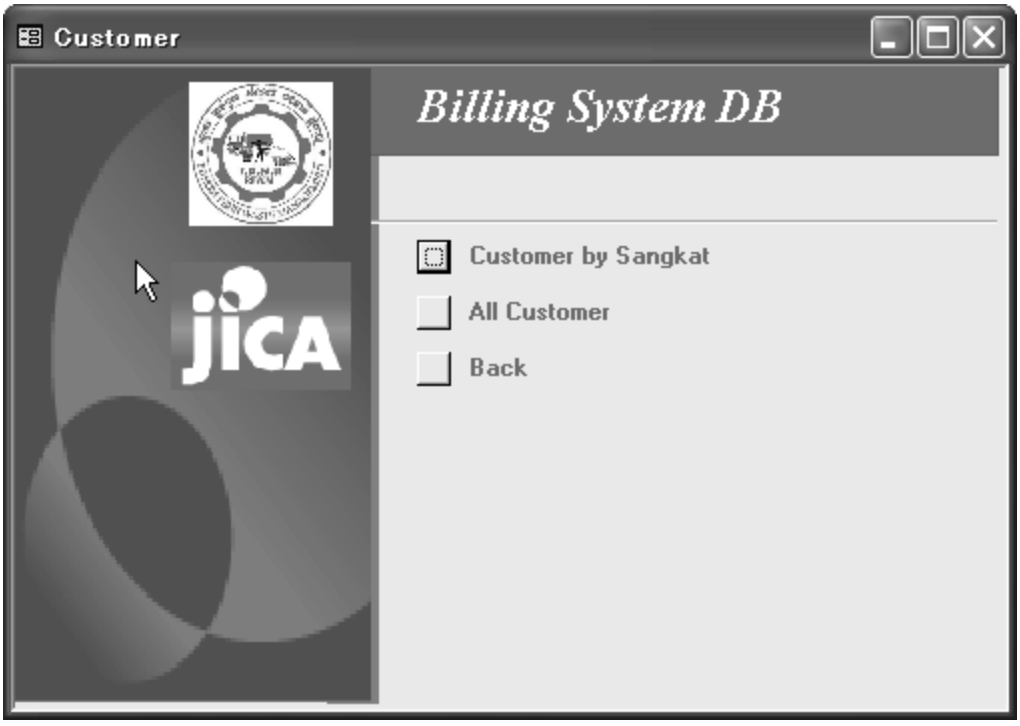
- All the Krom registered in the selected Khan, Sangkat and Phum will appear in the next form



- In this screen you can add/edit/delete Krom data
- To use the Krom record in the system click in the [Use] column.

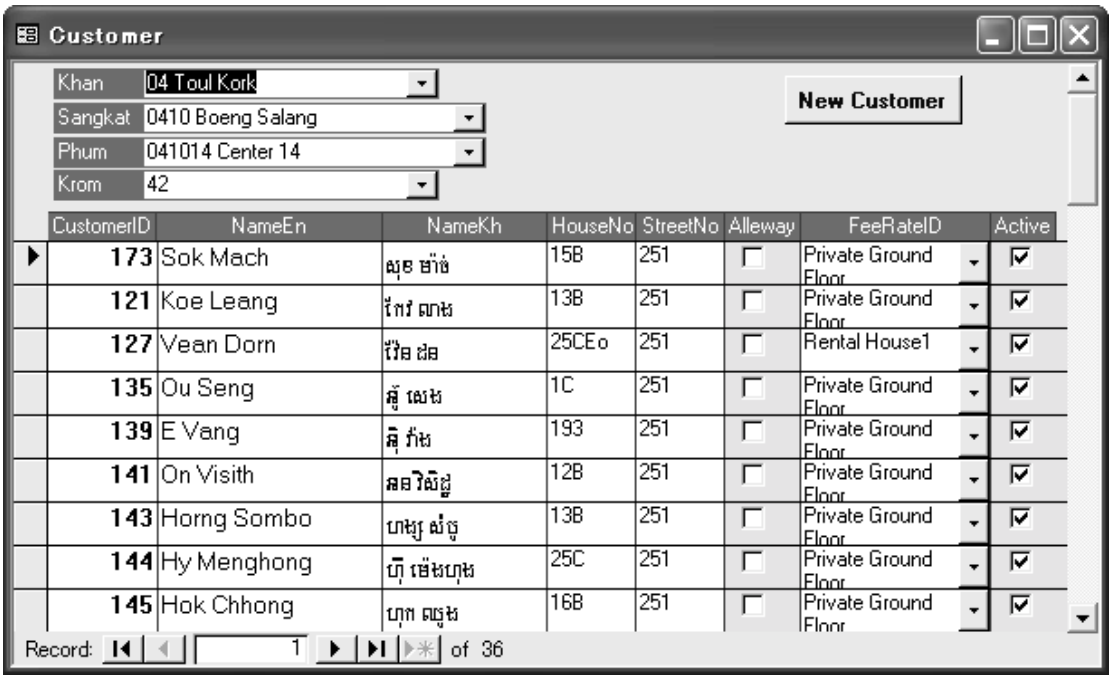
b. Customer

To handle customer data, in the main menu click [Customer] and the next customer menu will appear.



b.1 Customer by Sangkat

To view customer data by Sangkat in the [Customer Menu], click [Customer by Sangkat] and the next form will appear.

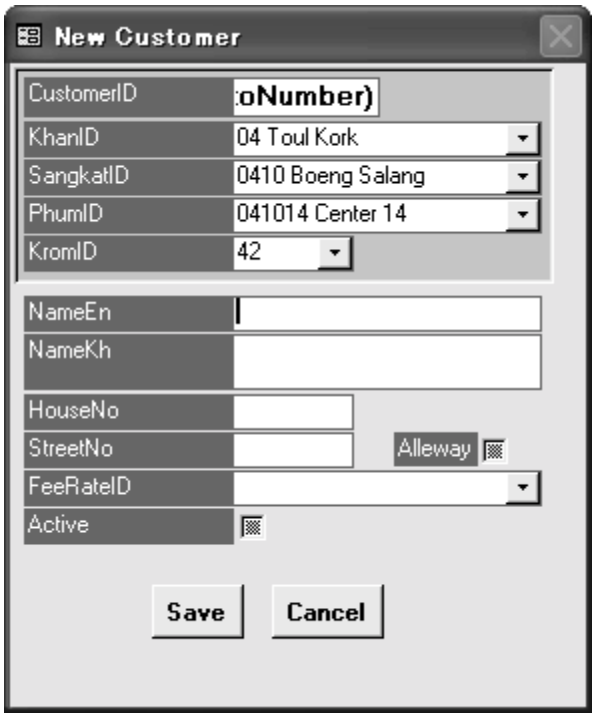


a) Select customer list

Select Khan, Sangkat, Phum and Krom and the registered customer for selected location will appear

b) Add new Customer

1. Select customer list
2. Click [New Customer] button and the next form will appear.



3. Input the customer data and click [Save] button to add the new customer for this location or click the [Cancel] button to cancel and exit.

c) Edit customer data

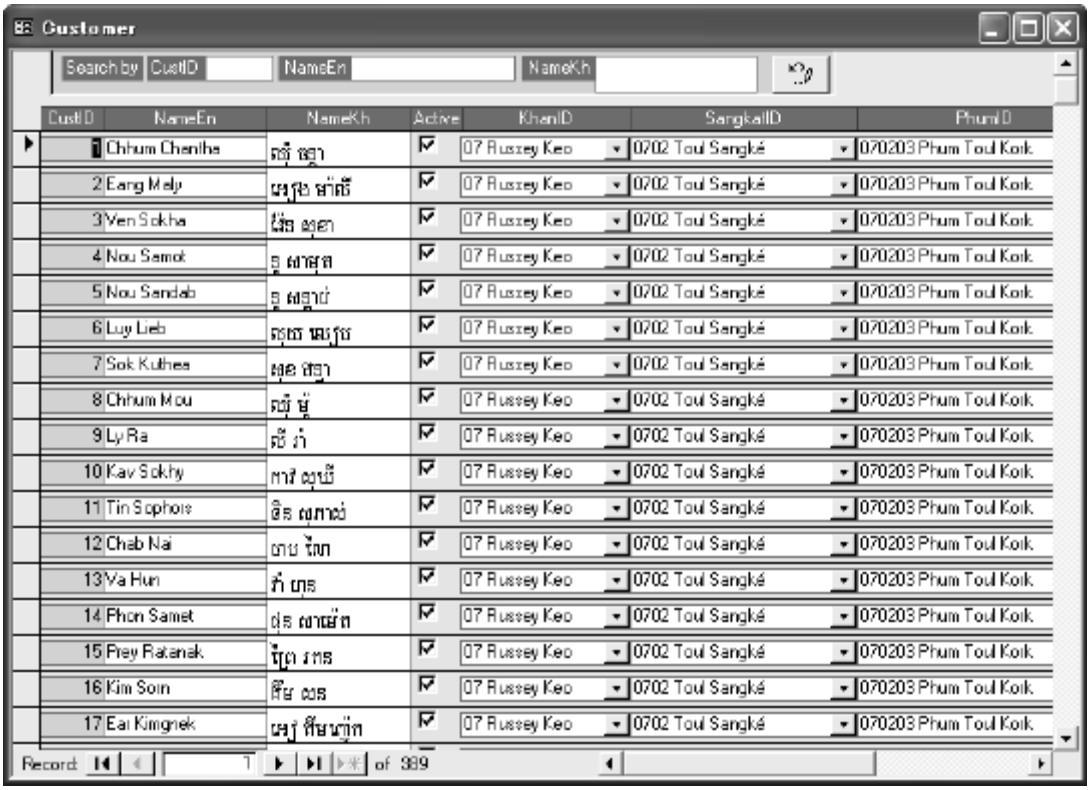
1. Select customer list
2. Click the customer record that you want edit, and you can change or update customer data.
3. In this form you can change the customer general data but you can't change the customer location data. To change the customer location data see the [All Customer] section

d) Activate or Deactivate Customer

1. Select customer list
2. Select the customer to activate or deactivate.
3. Click in the Active column, turn on if you want to use the customer in the system or turn off if you don't.

b.2 All Customer

To view the entire customer registered in the system, in the main menu click [All Customer] and the next form will appear with all the customer record.



a) Search Customer

1. You can search customer by Customer ID, Name in English or Name in Khmer
2. In the top of the form input the search criteria and press [Enter], the form will show all the customer match with the search criteria.

3. To clear the search criteria click 

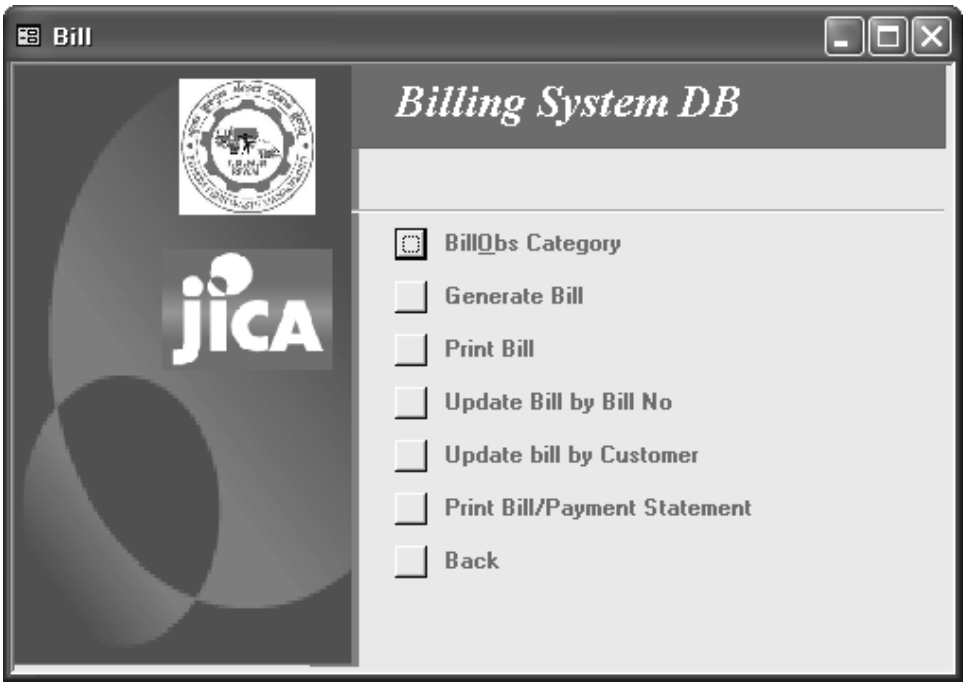
b) Edit Customer data

1. Search the customer and then double click in the customer ID, and the next form will appear.

2. In this form you can change the customer general data and customer location data
3. Click the [Save] button to update the changes or click the [Cancel] button to cancel the changes.

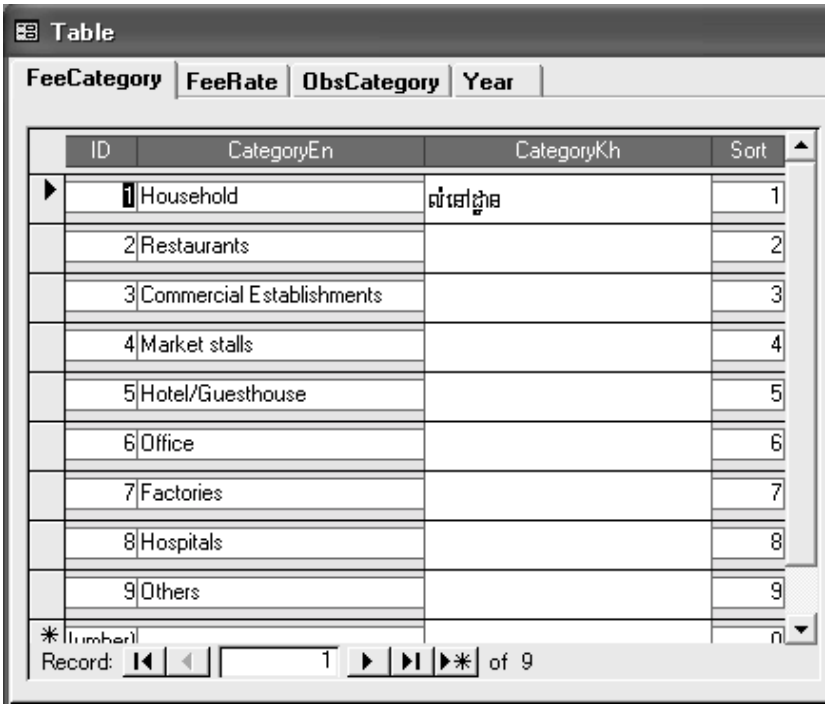
c. Bill

In the main menu click [Bill] and the next Bill Menu will appear



c.1 Bill Obs Category

In the Bill Menu click [Bill Obs Category] and the next form will appear.



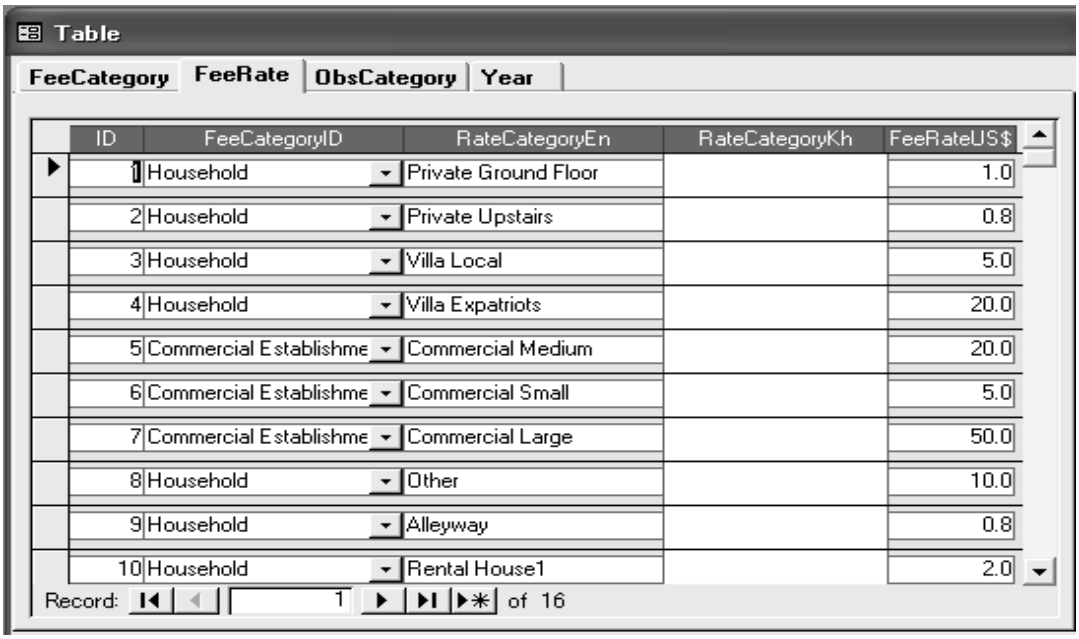
a) Fee Category

Fee category is the main category of the fee rate of the customer

1. Click in the [FeeCategory] page
2. In this form you can add/edit/delete Fee Category

b) Fee Rate

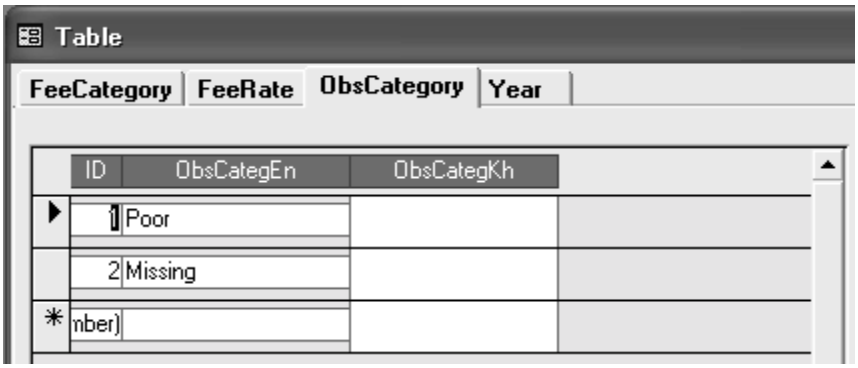
In this form will define all the fee rate of each category of the customer



1. Click in the [FeeRate] page
2. In this form you can Add/edit/delete the fee rate of the customer

c) Obs Category

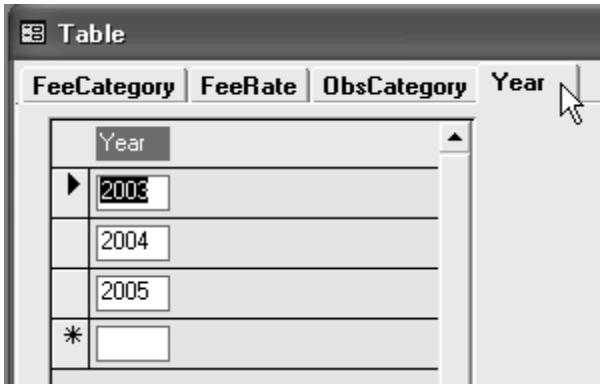
Obs category is the category for the non payment bill



1. Click in the [Obs Category] page
2. In this form you can Add/edit/delete the Obs category

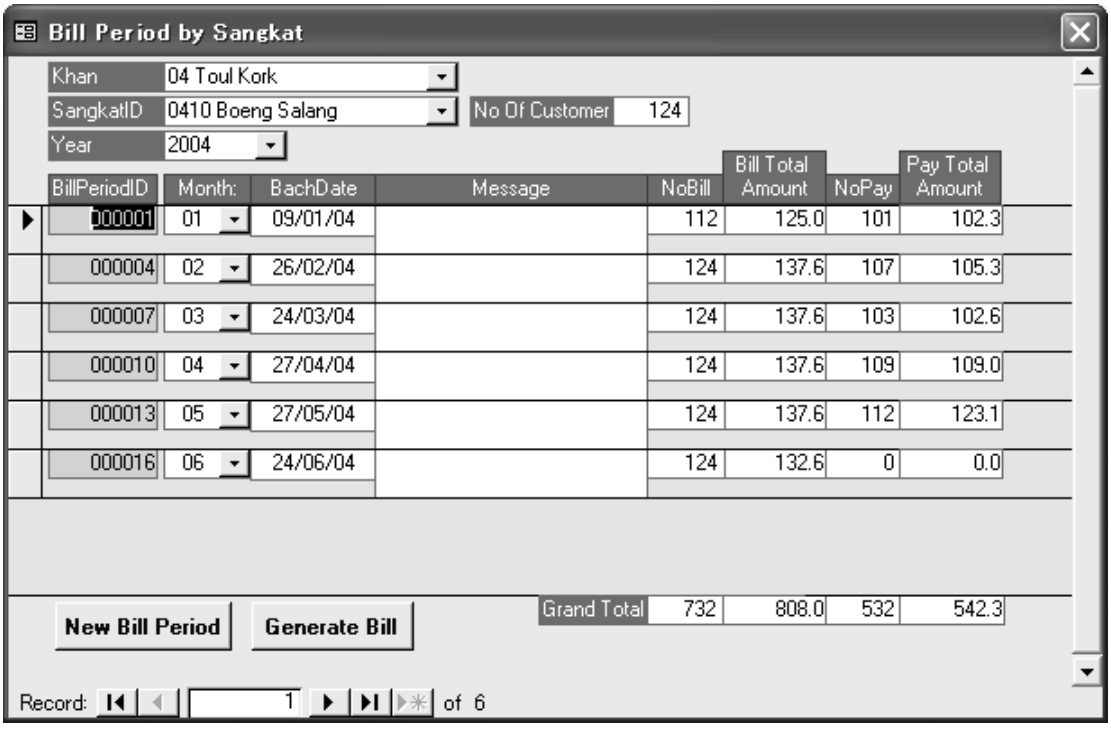
d) Year

In this form will input all the year use in the billing system, click the [Year] page.



c.2 Generate Bill

In the Bill Menu click [Generate Bill] and the next form will appear.



a) Select Location

Select Khan, Sangkat and the year of the bill and will appear all the bill period generated for the selected location

b) New Bill Period

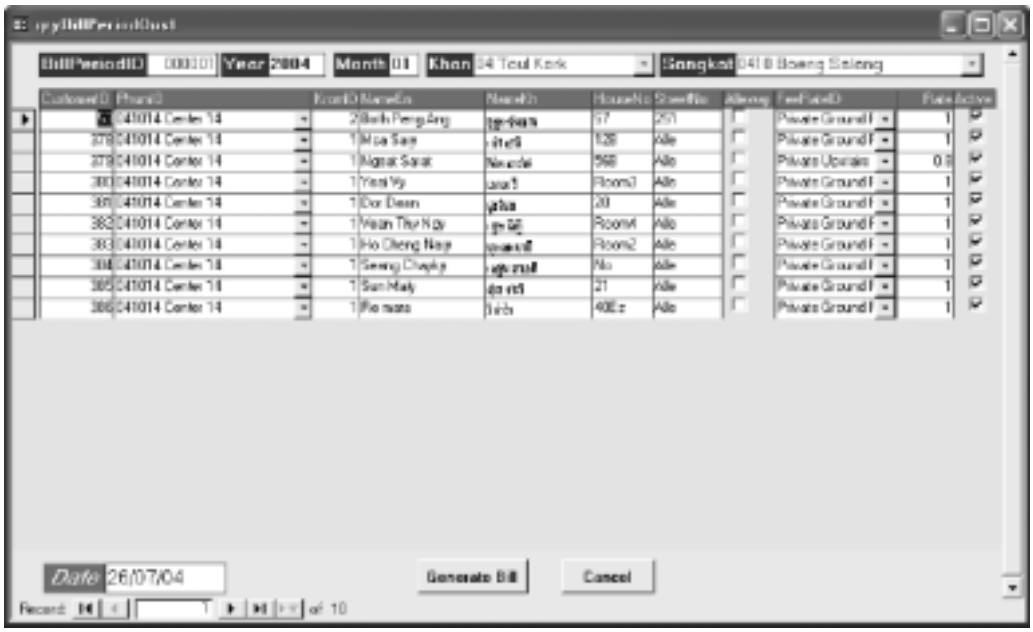
1. To add new bill period for the selected location, click [New Bill Period] button and the next form will appear

2. Select the month for the new period and input the message for this period
3. Click [Ok] button to add new bill period or click the [Cancel] button to cancel.

c) Generate bill

Once create the new period for the selected location, you can generate the bill for all the customer in the selected location

1. To generate bill for the selected location and period, click [Generate Bill] button and the next form will appear with the list of the customer

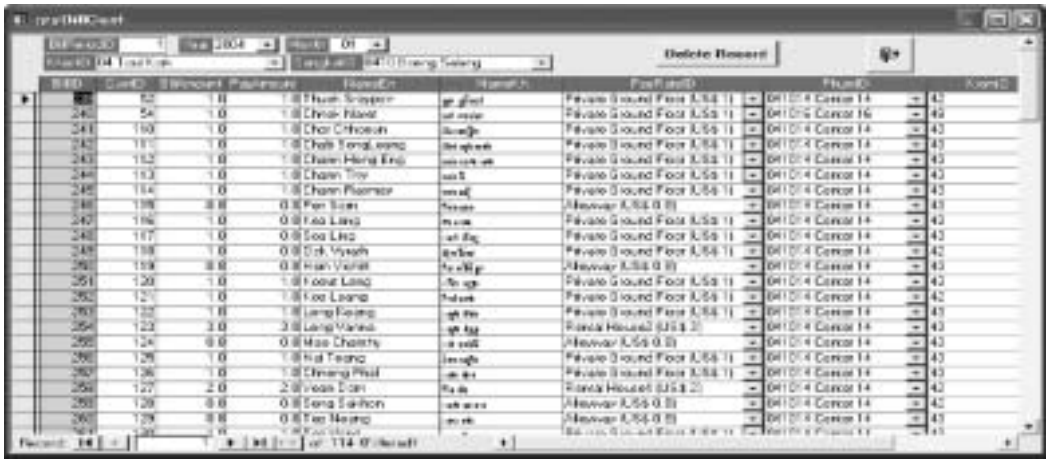


2. Check the customer list and click [Generate Bill] button to generate the bill for the entire customer in the list or click [Cancel] button to cancel.

3. Once generated the bill, will appear the number of bill generated and will close this form.

d) Browse Bill Period data

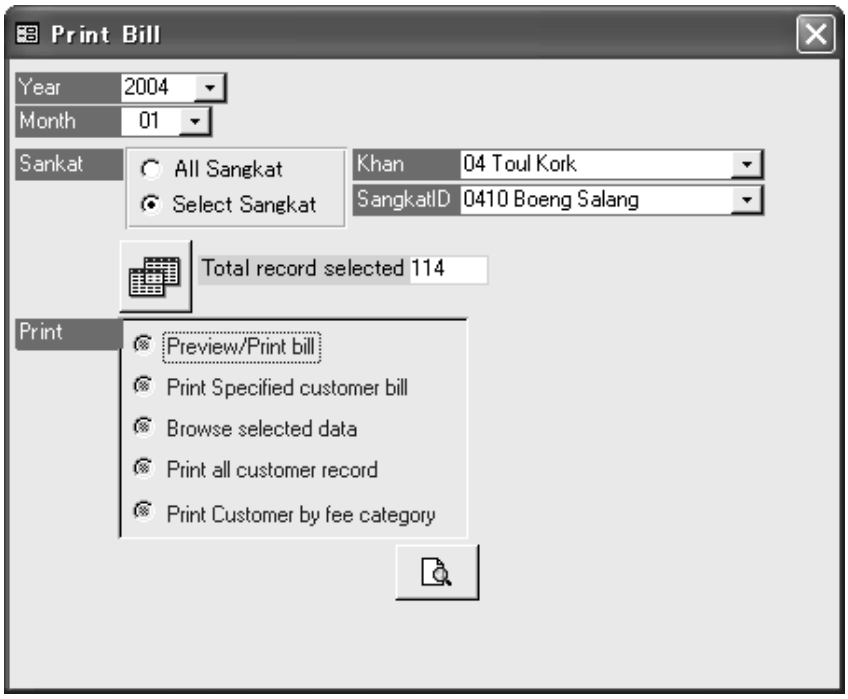
To view the entire generated bill for specific period, select the period and double click the [BillPeriodID] column, and the next form will appear with the list of customer.



If you want to delete a bill for specific customer, select the customer bill to delete and click in the [Delete] button

c.3 Print Bill

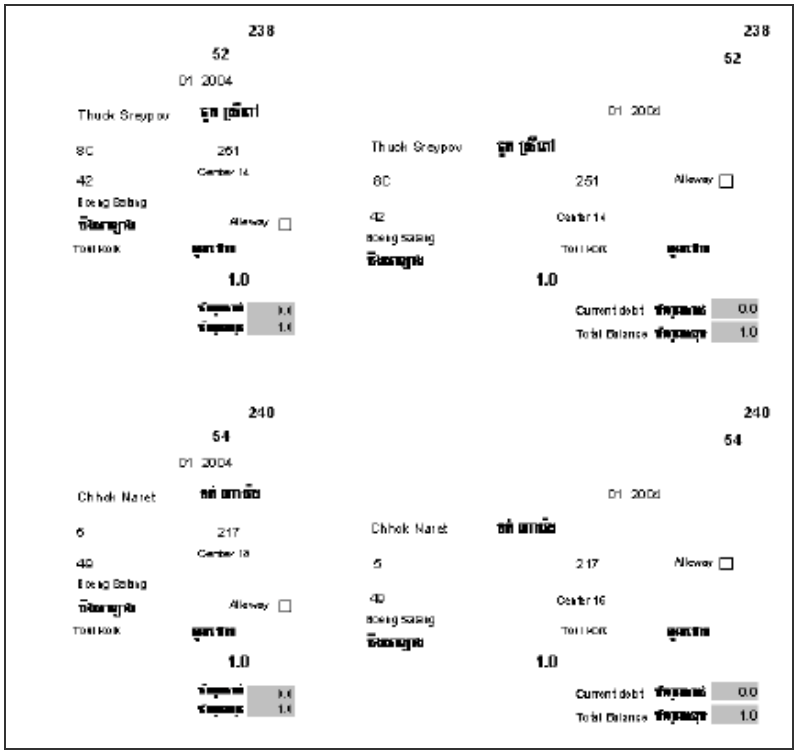
In the Bill Menu click [Print Bill] and the next form will appear.



1. Select the period of the bill
2. Select specific Sangkat or all Sangkat
3. Click [Select] button to select the customer bill to print
4. Select the print type

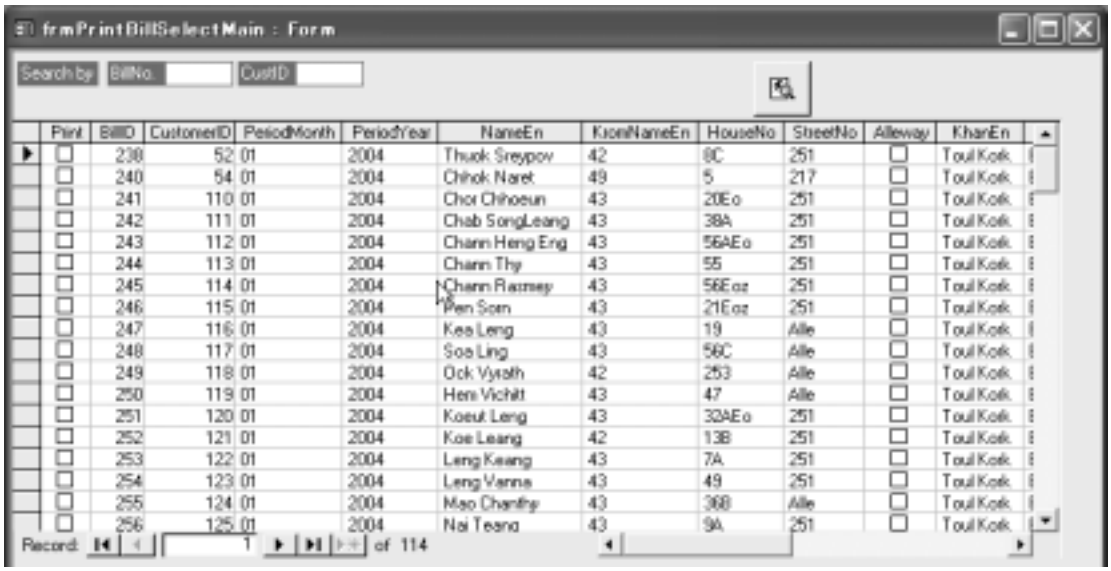
■ Preview/Print bill

Select this option to print the bill of all the customer for selected period and location



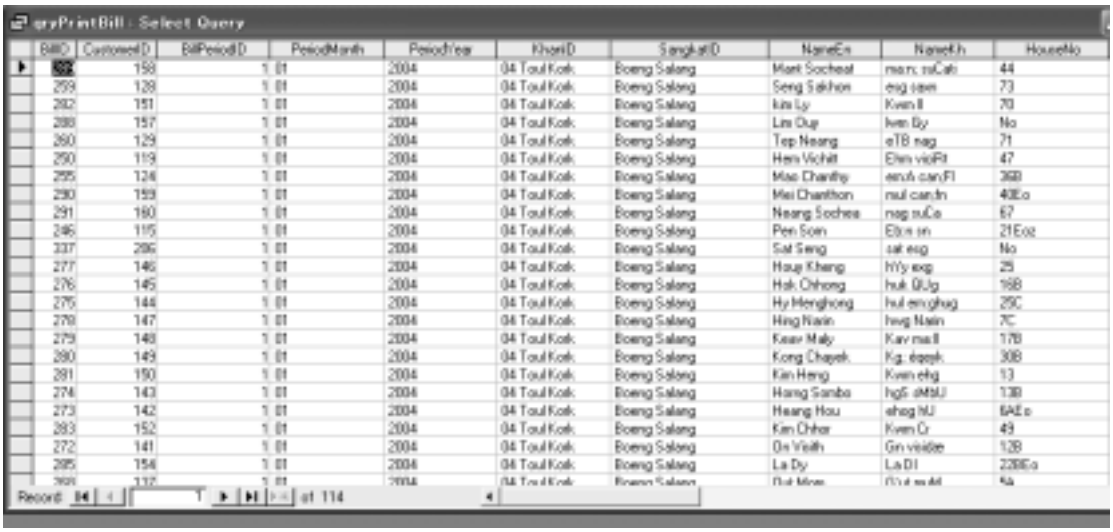
- Print Specified customer bill

  Select this option to print the bill of specific customer for selected period and location. In the next form select the customer and click [Print] column, check on all the customer that you want to print and click the [Preview] button and print



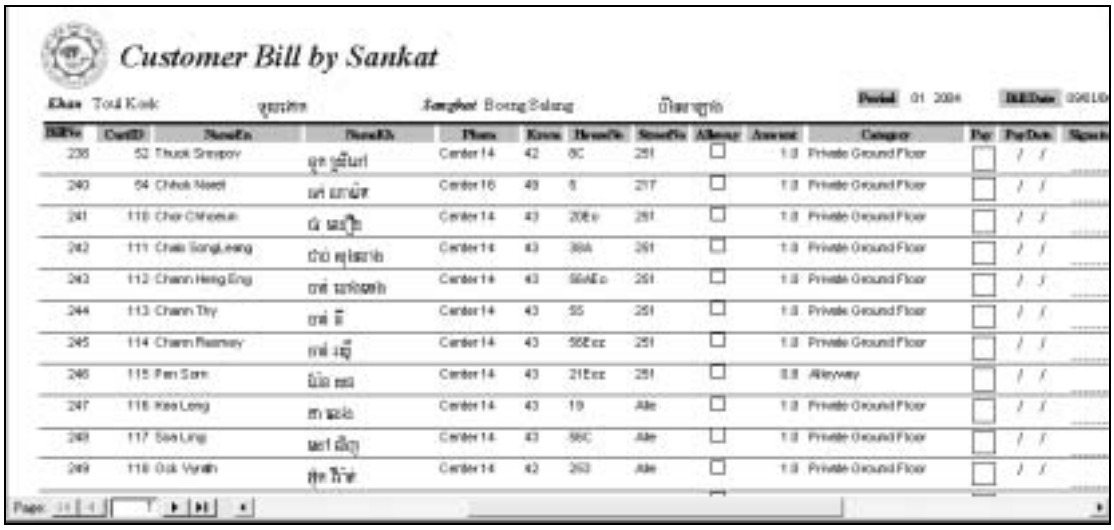
- Browse selected data

  Select this option to browse the list of customer selected



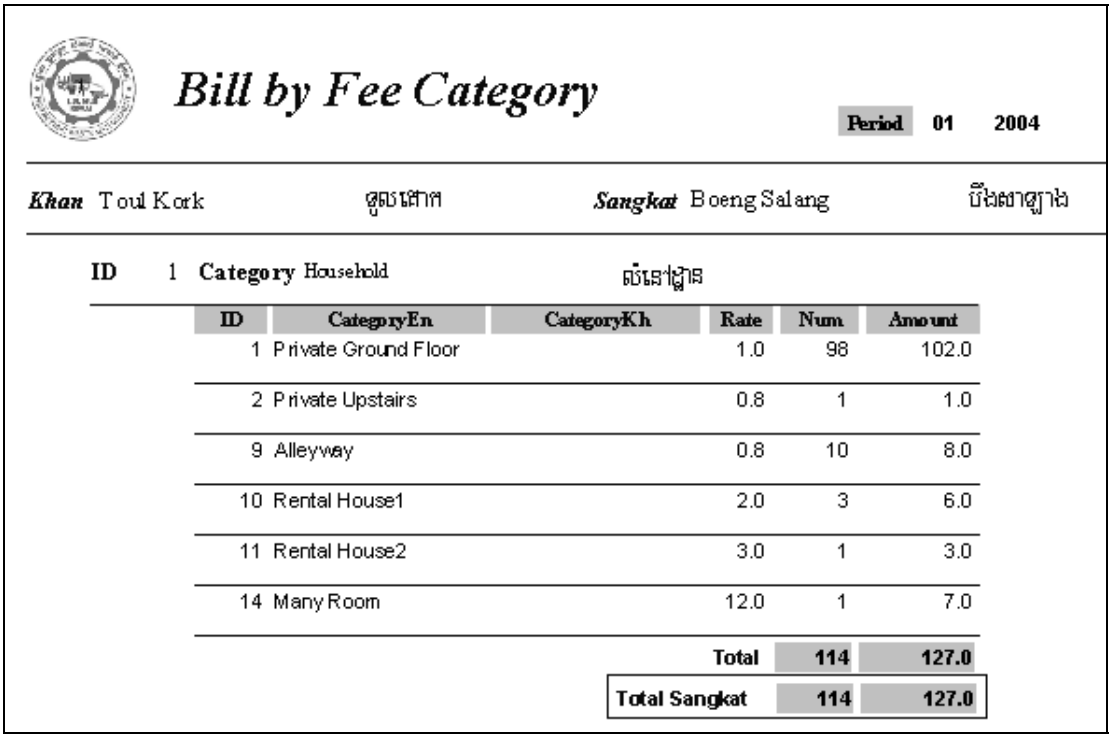
- Print all customer record

  Select this option to print the list of the customer for the selected period and location



- Print customer by fee category

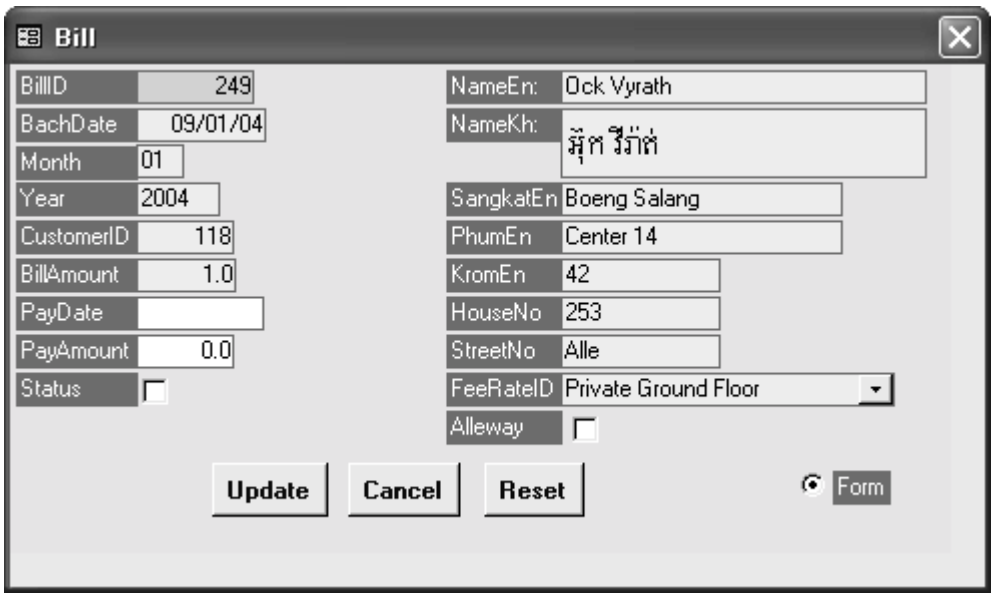
  Select this option to print the detail of bill by fee category of the customer for the selected period and location



c.4 Update Bill by Bill No

To update the payment of the bill by bill number, in the Bill Menu click [Update Bill by Bill No] and the next form will appear.

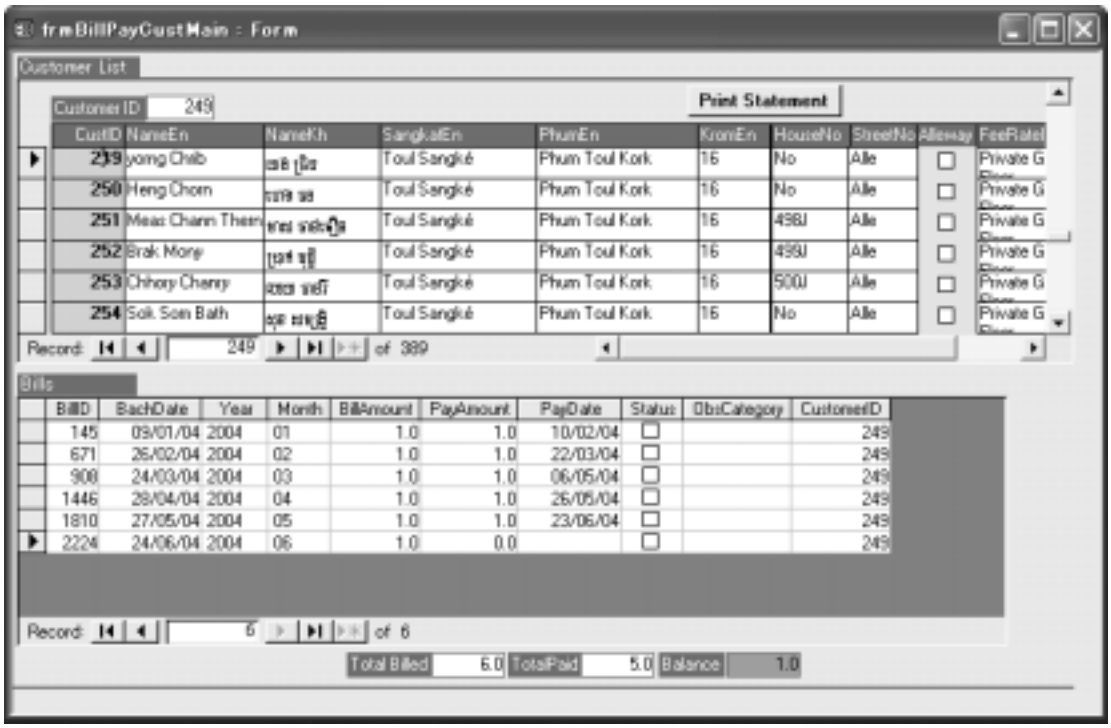
1. Input the bill no and then press [Enter], and the next form will appear



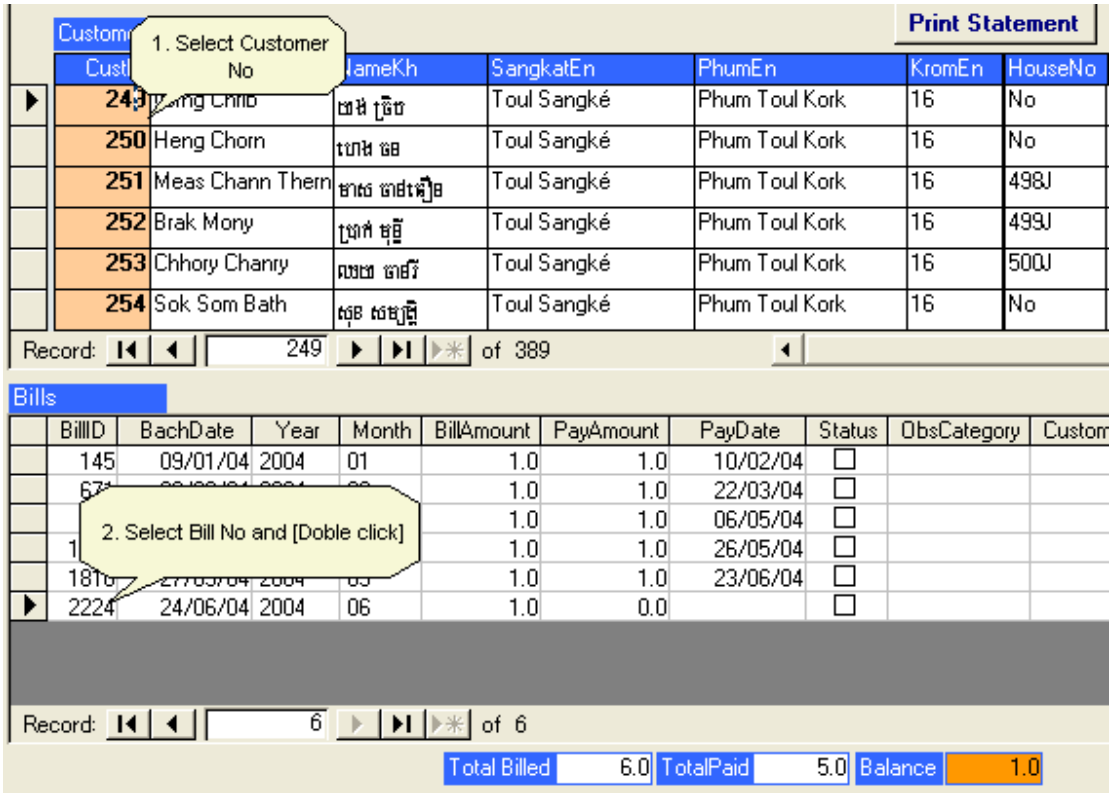
2. Input the pay date and the pay amount
3. Click [Update] button to update or click [Cancel] button to cancel
4. To Update the next bill, repeat step 1 to 3

c.5 Update Bill by Customer

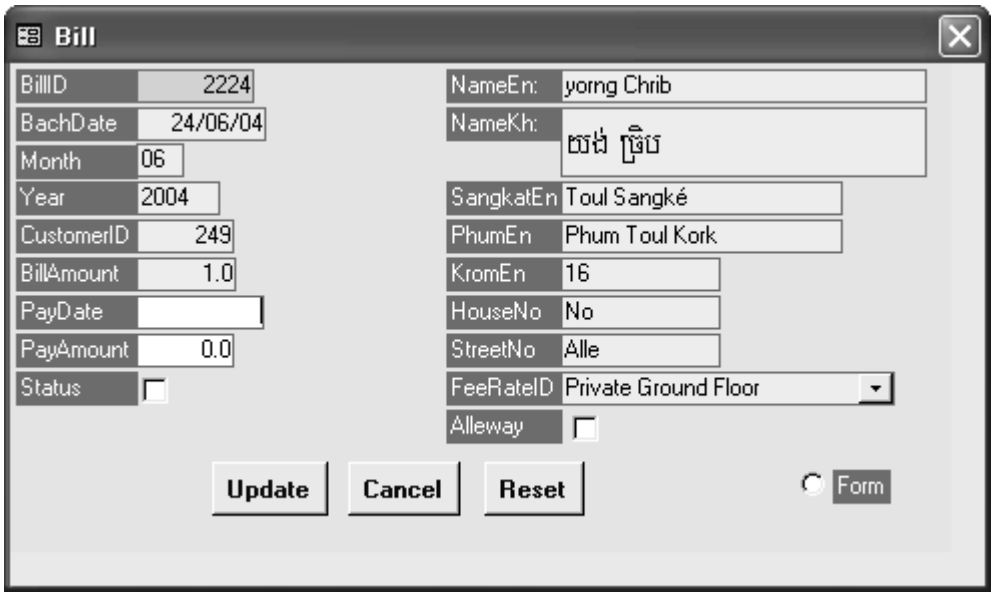
To update the payment of the bill by customer, in the Bill Menu click [Update Bill by Customer] and the next form will appear.



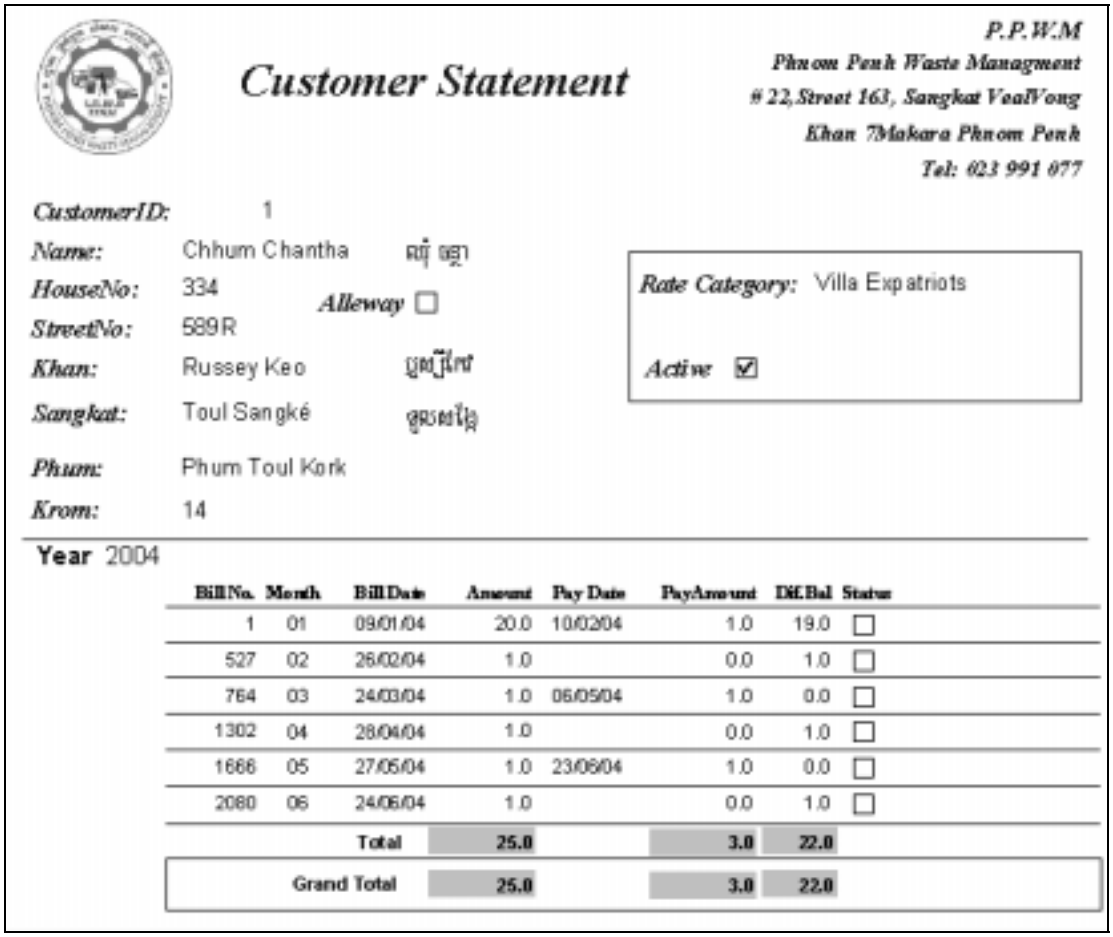
1. In the customer section of the form, select the customer that the bill belong



2. In the bill section of the form, select the bill number to update and double click in the [BillID], and the next form will appear



3. Input the pay date and the pay amount
4. Click [Update] button to update or click [Cancel] button to cancel
5. To Update the next bill, repeat step 1 to 4
6. To print the statement for selected customer, select the customer and click [Print Statement] button and the system will print next statement of the customer



Customer Statement

P.P.W.M
Phnom Penh Waste Managment
 # 22,Street 163, Sangkat VealVong
Khan 7Makara Phnom Penh
Tel: 023 991 077

CustomerID: 1
Name: Chhum Chantha
HouseNo: 334
StreetNo: 589R
Alleway ☐
Khan: Russey Keo
Sangkat: Toul Sangké
Phum: Phum Toul Kork
Krom: 14

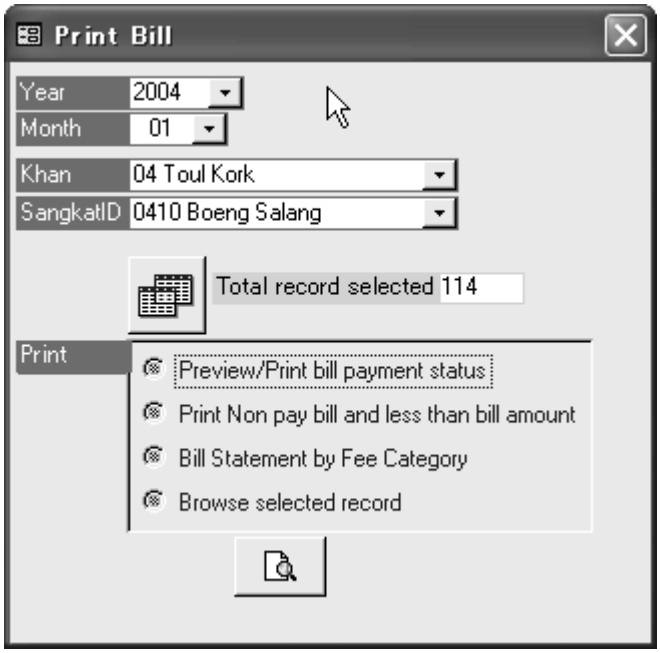
Rate Category: Villa Expatriots
Active ☑

Year 2004

Bill No.	Month	Bill Date	Amount	Pay Date	PayAmount	Dif.Bal	Status
1	01	09/01/04	20.0	10/02/04	1.0	19.0	☐
527	02	26/02/04	1.0		0.0	1.0	☐
764	03	24/03/04	1.0	06/05/04	1.0	0.0	☐
1302	04	28/04/04	1.0		0.0	1.0	☐
1666	05	27/05/04	1.0	23/06/04	1.0	0.0	☐
2080	06	24/06/04	1.0		0.0	1.0	☐
		Total	**25.0**		**3.0**	**22.0**	
		Grand Total	**25.0**		**3.0**	**22.0**	

c.6 Print Bill / Payment Statement

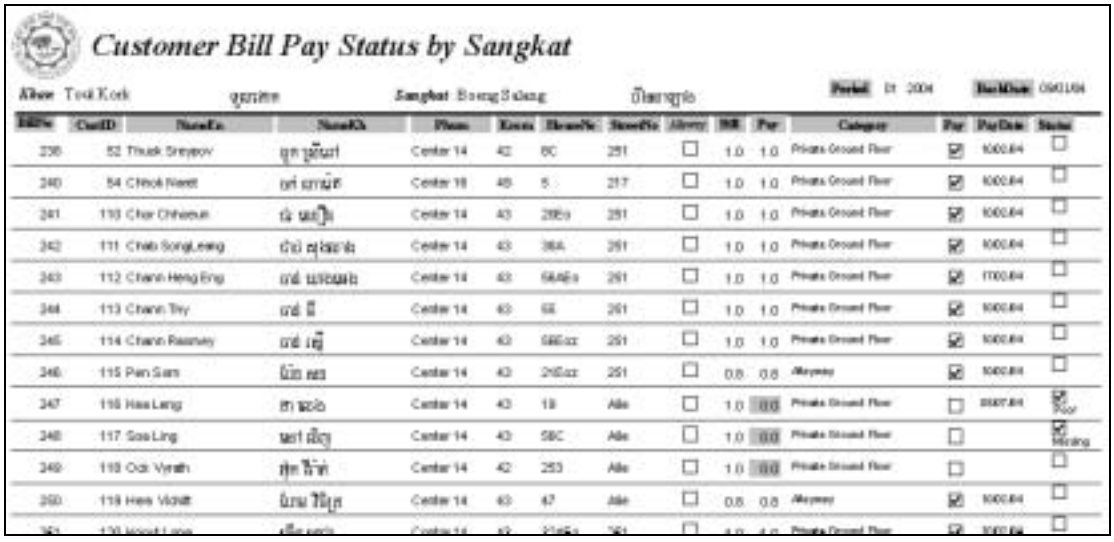
In the Bill Menu click [Print Bill/Payment Statement] and the next form will appear.



1. Select the period (Year and Month)
2. Select Khan and Sangkat
3. Click the selection button
4. Select the type of report

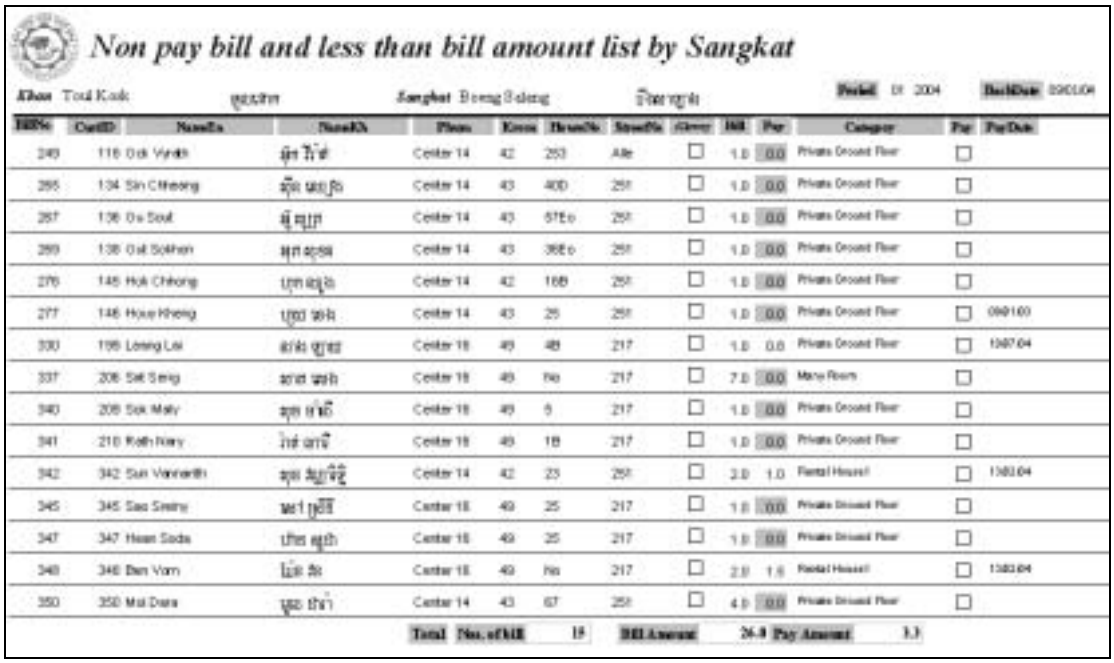
- Preview/Print bill payment status

  Select this option to print the detail of payment of the bill by selected period and location



- Print Non pay bill and less than bill amount

  Select this option to print the list of the customer that they don't pay the bill or pay less than bill amount for selected period and location



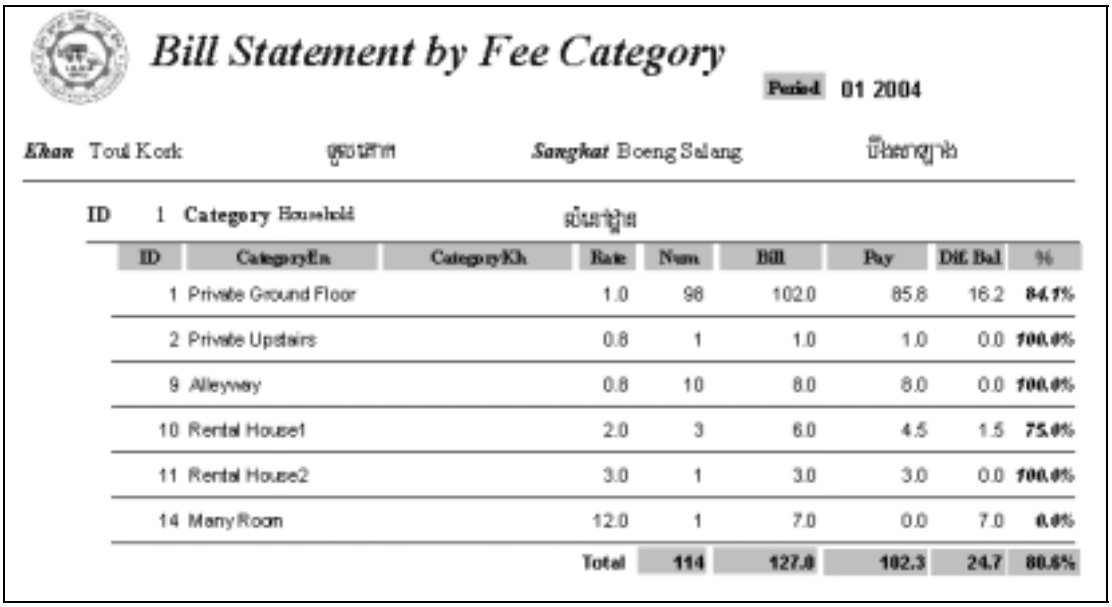
Non pay bill and less than bill amount list by Sangkat

Khan Toul Kork ចូលលាក់ Sangkat Boeng Salang បឹងសាឡាង Period 01 2004

HHNo	CustID	NameEn	NameKh	Phum	Room	HouseNo	StreetNo	Cover	Bill	Pay	Category	Pay	PayDate
249	116	Ouk Vanith	ឈុក វ៉ានិត	Center 14	42	253	Alle	☐	1.0	0.0	Private Ground Floor	☐	
255	134	Sin Chheang	ស៊ីន ឆេង	Center 14	43	400	251	☐	1.0	0.0	Private Ground Floor	☐	
257	136	Ou Soul	អ៊ូ សូល	Center 14	43	575	251	☐	1.0	0.0	Private Ground Floor	☐	
259	138	Oat Sokhon	អុត សុខុន	Center 14	43	398	251	☐	1.0	0.0	Private Ground Floor	☐	
276	145	Huk Chheng	ហ៊ុក ឆេង	Center 14	42	168	251	☐	1.0	0.0	Private Ground Floor	☐	
277	146	Houe Kheng	ហ៊ូ ខេង	Center 14	43	25	251	☐	1.0	0.0	Private Ground Floor	☐	090103
330	196	Leang Lai	លាង លៃ	Center 18	49	48	217	☐	1.0	0.0	Private Ground Floor	☐	1307.04
337	206	Sat Seng	សាត សេង	Center 18	49	No	217	☐	7.0	0.0	Many Room	☐	
340	209	Sok Maly	សុខ ម៉ាលី	Center 18	49	5	217	☐	1.0	0.0	Private Ground Floor	☐	
341	210	Keth Nary	កែត នារី	Center 18	49	18	217	☐	1.0	0.0	Private Ground Floor	☐	
342	342	Sun Vannarith	សុន វ៉ណ្ណរិទ្ធ	Center 14	42	23	251	☐	2.0	1.0	Rental House1	☐	1303.04
345	345	Sao Sreiny	ស្រ ស្រីនី	Center 18	49	25	217	☐	1.0	0.0	Private Ground Floor	☐	
347	347	Hean Sida	ហ៊ន សុធា	Center 18	49	25	217	☐	1.0	0.0	Private Ground Floor	☐	
348	348	Ban Vorn	ប៊ុន វ៉ន	Center 18	49	No	217	☐	2.0	1.0	Rental House1	☐	1303.04
350	350	Mol Dara	ម៉ុល តារា	Center 14	43	67	251	☐	4.0	0.0	Private Ground Floor	☐	
				Total	No. of bill	18			Bill Amount	26.0	Pay Amount	3.3	

- Bill Statement by Fee Category

  Select this option to print the detail of payment by fee category for selected period and location



Bill Statement by Fee Category

Period 01 2004

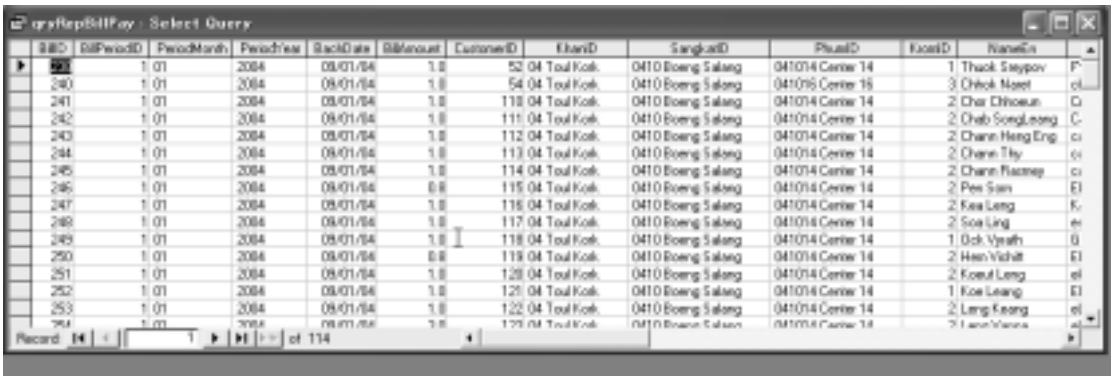
Khan Toul Kork ចូលលាក់ Sangkat Boeng Salang បឹងសាឡាង

ID 1 Category Household លំនៅដ្ឋាន

ID	CategoryEn	CategoryKh	Rate	Num	Bill	Pay	Dif. Bal	%
1	Private Ground Floor		1.0	98	102.0	85.8	16.2	**84.1%**
2	Private Upstairs		0.8	1	1.0	1.0	0.0	**100.0%**
9	Alleyway		0.8	10	8.0	8.0	0.0	**100.0%**
10	Rental House1		2.0	3	6.0	4.5	1.5	**75.0%**
11	Rental House2		3.0	1	3.0	3.0	0.0	**100.0%**
14	Many Room		12.0	1	7.0	0.0	7.0	**0.0%**
		Total		**114**	**127.0**	**102.3**	**24.7**	**80.6%**

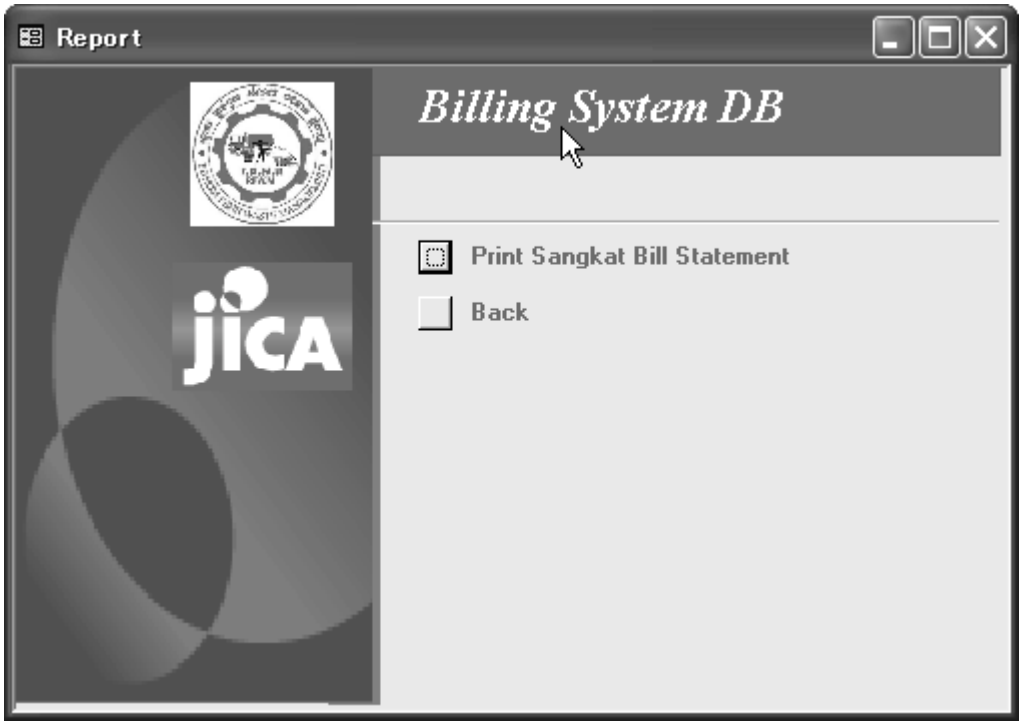
- Browse selected record

  Select this option to view the list of customer selected for selected period and location



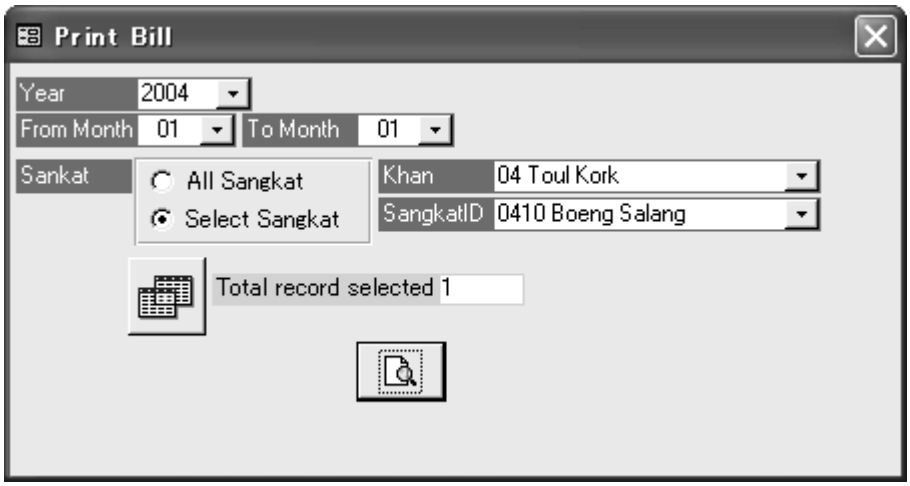
d. Report

In the main menu click [Report] and the next Report Menu will appear

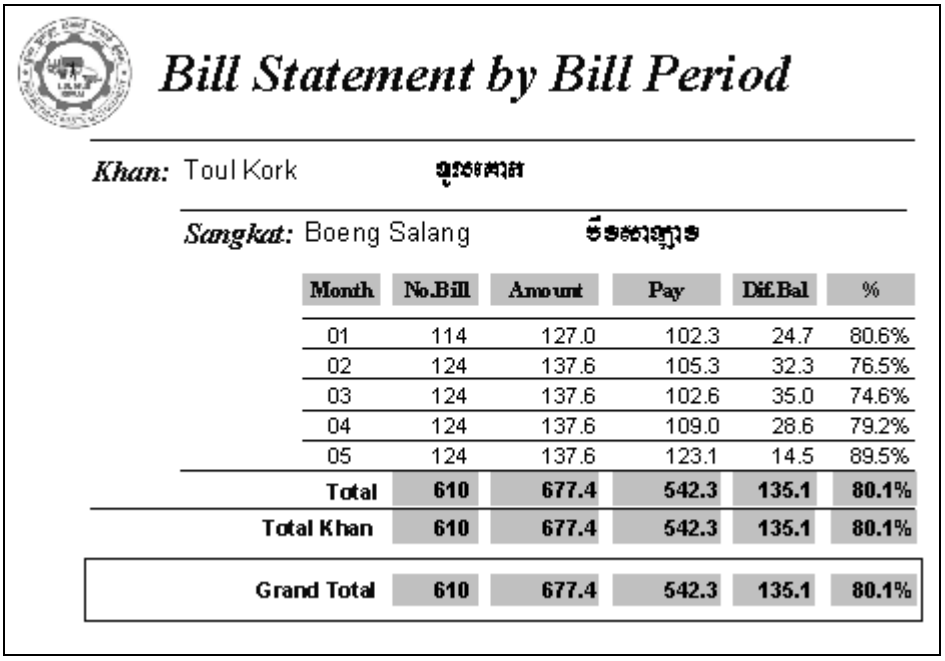


d.1 Print Sangkat Bill Statement

To print a report of Sangkat bill statement in the Report Menu click [Print Sangkat Bill Statement] and the next form will appear



1. Select the period year
2. Select the period month from to
3. Select Khan and Sangkat
4. Click the selection button
5. Click the preview button



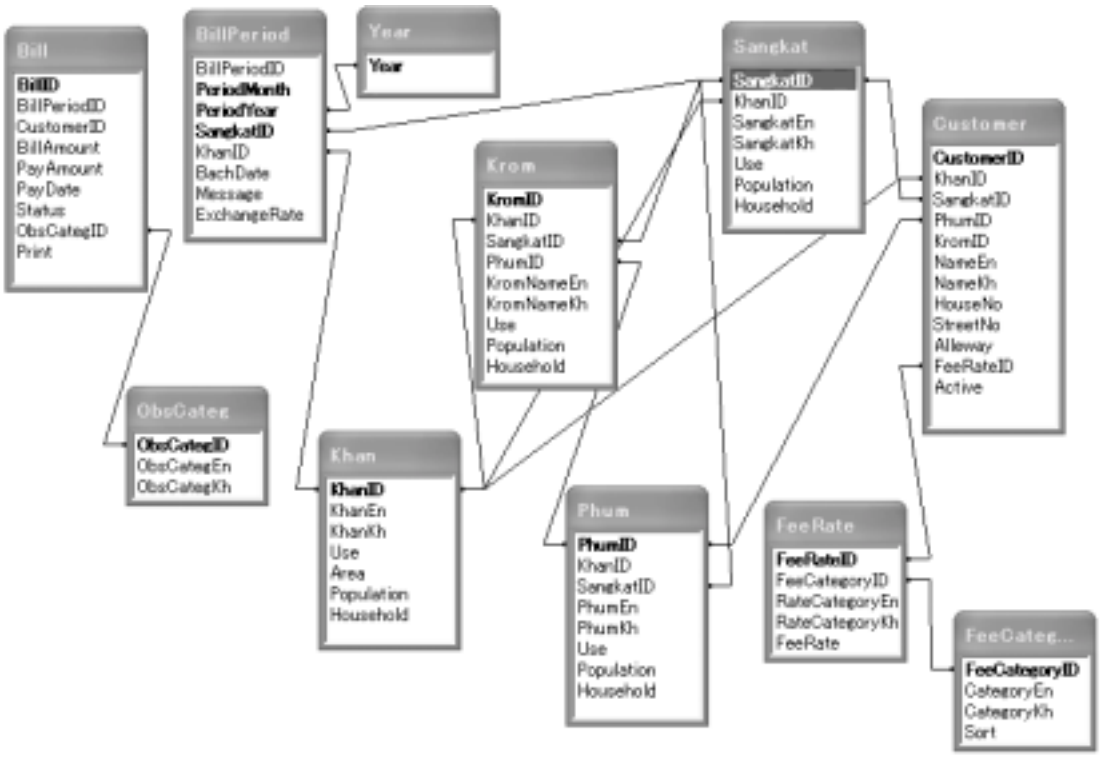
Bill Statement by Bill Period

Khan: Toul Kork

Sangkat: Boeng Salang

Month	No.Bill	Amount	Pay	Dif.Bal	%
01	114	127.0	102.3	24.7	80.6%
02	124	137.6	105.3	32.3	76.5%
03	124	137.6	102.6	35.0	74.6%
04	124	137.6	109.0	28.6	79.2%
05	124	137.6	123.1	14.5	89.5%
Total	**610**	**677.4**	**542.3**	**135.1**	**80.1%**
Total Khan	**610**	**677.4**	**542.3**	**135.1**	**80.1%**
Grand Total	**610**	**677.4**	**542.3**	**135.1**	**80.1%**

e. Table Relationships



f. Tables Structure

Bill	All bill record		
Name	Type	Size	Property
BillID	Long Integer	4	
BillPeriodID	Long Integer	4	
CustomerID	Long Integer	4	
BillAmount	Single	4	
PayAmount	Single	4	
PayDate	Date/Time	8	
Status	Yes/No	1	
ObsCategID	Long Integer	4	
Print	Yes/No	1	

BillPeriod	Bill Period data		
Name	Type	Size	Property
BillPeriodID	Long Integer	4	
PeriodMonth	Text	2	
PeriodYear	Text	4	
SangkatID	Text	4	
KhanID	Text	2	
BachDate	Date/Time	8	
Message	Text	30	
ExchangeRate	Integer	2	

Customer	Customer data		
Name	Type	Size	Property
CustomerID	Long Integer	4	
KhanID	Text	2	
SangkatID	Text	4	

PhumID	Text	6	
KromID	Long Integer	4	
NameEn	Text	30	
NameKh	Text	30	
HouseNo	Text	10	
StreetNo	Text	10	
Alleway	Yes/No	1	
FeeRateID	Long Integer	4	
Active	Yes/No	1	

FeeCategory	Main Fee category		
Name	Type	Size	Property
FeeCategoryID	Long Integer	4	
CategoryEn	Text	30	
CategoryKh	Text	30	
Sort	Long Integer	4	

FeeRate	Fee rate by category		
Name	Type	Size	Property
FeeRateID	Long Integer	4	
FeeCategoryID	Long Integer	4	
RateCategoryEn	Text	30	
RateCategoryKh	Text	30	
FeeRate	Single	4	

Khan	Khan data		
Name	Type	Size	Property
KhanID	Text	2	
KhanEn	Text	30	
KhanKh	Text	30	
Use	Yes/No	1	
Area	Text	10	
Population	Long Integer	4	
Household	Long Integer	4	

Krom	Krom		
Name	Type	Size	Property
KromID	Long Integer	4	
KhanID	Text	2	
SangkatID	Text	4	
PhumID	Text	6	
KromNameEn	Text	20	
KromNameKh	Text	20	
Use	Yes/No	1	
Population	Long Integer	4	
Household	Long Integer	4	

ObsCateg	Obs Category of Non pay bill		
Name	Type	Size	Property
ObsCategID	Long Integer	4	
ObsCategEn	Text	20	
ObsCategKh	Text	20	

Phum	Phum data		
Name	Type	Size	Property
PhumID	Text	6	
KhanID	Text	2	
SangkatID	Text	4	
PhumEn	Text	30	
PhumKh	Text	30	
Use	Yes/No	1	
Population	Long Integer	4	
Household	Long Integer	4	

Sangkat	Sankat data		
Name	Type	Size	Property
SangkatID	Text	4	
KhanID	Text	2	
SangkatEn	Text	30	
SangkatKh	Text	30	
Use	Yes/No	1	
Population	Long Integer	4	
Household	Long Integer	4	

Year	Year of bill period		
Name	Type	Size	Property
Year	Text	4	

Annex 13

Pilot Project for Development and Promotion of the Urban Waste Compost Market

Annex 13 Pilot Project for Development and Promotion of the Urban Waste Compost Market

13.1 Background

In Phnom Penh, compostable organic waste such as kitchen waste and grass/wood waste is approximately 70% of total waste generation. The disposal of such waste is an increasingly difficult problem. Landfill disposal is done in SMCDS, however have been almost filled up. Even though new disposal site, Dang Kor disposal site, will be developed in the future, it is very important to discover treatment methods which reduce the volume of such waste to be accommodated on scarce landfill site. Therefore, it is natural that possibility of converting urban waste into compost.

If composting can be operated successfully, it achieves the following desirable results.

- Conservation of resources by recycling
- Support for nature's cycle by returning to the earth organic waste.
- Reduction of landfill space requirement in Dang Kor disposal site.

This pilot project aims to develop a market for the urban waste compost as a soil conditioner by demonstrating its effectiveness to farmers and investigating the marketability of urban waste compost.

13.1.1 Project Outline

The main components of the pilot project are following.

- Physical/chemical analysis of urban waste compost
- A market survey of the urban waste compost
- A PR field trial using the urban waste compost
- Field trips to PR field trial farmland
- Production of promotional material

13.2 Chemical analysis of urban waste compost

The aim of composting is to convert organic waste, a major proportion of solid waste generated from Phnom Penh into a soil conditioner as a marketable product. It is necessary to understand the quality of the urban waste compost. Therefore, chemical analysis of the urban waste composts produced by NGOs was done. Following table shows the comparison between analysis results of urban waste compost and the main parameters of the compost standard in Thailand.

Table 13-1: Physical/compost standard in Thailand and analysis results of composts

Parameters	Standard	Analysis results	
		COMPED	SCARO
C/N ratio	less than 20	16.6	9.8
pH	5.5-8.5	9.08	9.18
N content	1.0% or more	1.32	1.98
P2O5	0.5% or more	1.2	1.8
K2O	0.5% or more	0.8	2.7
Contamination	10% or less	27	7.9
Glass and Metals	None	Glass0.3% Metal0.1%	Glass0.4% Metal0.2%

As	50ppm	1.9	0.7
Cd	5ppm	1.3	2.2
Cr	300ppm	14	0
Cu	500ppm	44	108
Pb	500ppm	132	132
Hg	2ppm	0.1	0.4

- The contents of N, P, K and C/N ratio are acceptable and clear the Thai standard. Though the results of K2O are deferent between COMPED's and CSARO's, it seems because of the deferent of row materials. COMPED uses market waste, and CSARO uses household waste as row materials.
- The pH results exceeded the standard. It can be said that ammonia may be generated from the compost because aging of both compost is insufficient. Enough aging can improve it.
- COMPED compost exceeded the standard of contamination. It is because the compost is stored in open yard. When it is turned, the contamination may be occurred.
- Both compost exceeded the standard of "Glass and Metal". Row material sorting should be done more.
- Other parameters such as heavy metals clear the Thai standard.

13.3 A market survey of urban waste compost

13.3.1 General

If the organic materials are separate from municipal solid and subjected to bacterial decomposition, the product remaining after composting process is a dark-brown substance referred to as humus or compost.

In general, the beneficial use of compost is the soil improving, while its values as fertilizer are of minor importance. By adding compost, the capability of the soil to keep the moisture and nutrients will be improving. As fertilizer regarded, compost contents micronutrients that is not available in chemical fertilizer. Thus, the risk of failure of crops due to lack of nutrients that will be reducing.

The municipal solid waste generated in Phnom Penh municipality is suitable for composting due to its high content of organic matters. However, unlike recyclable items such as aluminum, paper, plastics and glass no national markets for compost product are available in Cambodia.

13.3.2 Objectives of the Survey

Once the solid waste have been converted to a humus, they are ready for the final step of composting operation, marketing. The study team, therefore, investigates end-uses for the compost product and price to find the feasibility of new compost plant. As for the compost market survey, a questionnaire to the farmers in and around Phnom Penh in order to:

- identify potential users and their location, and
- find out a seasonal variation of the compost demand, total estimated demand in the area, and an expected price of the compost.

- Find out existing compost users and its possibility of expansion

13.3.3 Method of the Survey

a. Selection of Villages and farmers

The study team planned to select 10 villages from the targeted area, nine villages were selected in the range within 20km of the border of Phnom Penh at random, one was selected in Phnom Penh. From each village, 5 farmers were selected at random for a questionnaire survey. In total 50 farmers were selected for the survey.

The list of villages surveyed is shown in the tables below. All the results in the tables were obtained by the questionnaire survey to the farmer. The location map of selected village in targeted area is shown in the figures below.

Table 13-2: List of Surveyed Villages in Targeted Area

No.	Villages	Communes	Districts	Province and Municipality
01.	Prek Thom	Kbal Koah	Kien Svay	Kandal
02.	Por Thom	Arey Ksart	Lvea Em	Kandal
03.	Orn Loung	Prek Tameak	Ksarch Kondal	Kandal
04.	Sambork Meas	Bak Kheng	Mork Kampol	Kandal
05.	Dam Nark Ampil	Dam Nark Ampil	Ang Snoul	Kandal
06.	Siem Reap	Siem Ream	Kandal Steung	Kandal
07.	Wat Kondal	Teak Vil	S'Ang	Kandal
08.	Trapang Veng	Trapang Korng	Samrong Tong	Kampong Speu
09.	Kliang Pram	Viang Chas	Oudong	Kampong Speu
10.	Kork Bonteay	Prey Sar	Dang Kor	Phnom Penh

Table 13-3: List of types of crop distribution in Surveyed Villages

No	Village Name	District	Type of Crop	Total No. 0f Farmer	Total Farm Area (ha)	Average Farm Area (ha/Farmer)
Kandal Province						
01	Prek Thom	Kean Svay	Rice, Cucumber, cauliflower, Chinese cabbage	800	456	0.57
02	Por Thom	Lvear Aem	Herbs, papaya, String been, cucumber, French bean, corn, banana	278	481	1.73
03	Orn Loung	Ksach Kandal	Water melon, corn, rice, Chinese radish, Yum bean, cucumber	290	259	0.89
04	Sambork Meas	Mukompul	Rice, Chinese cabbage, Salad, cucumber,	312	240	0.77
05	Dam Nark Ampil	Ang Snoul	Rice, Chinese cabbage, water melon	120	150	1.25
06	Siem Reap	Kondal Steung	Rice, cucumber, cauliflower, Yard long been, Chinese	212	242	1.14
07	Wat Kondal	Sa ang	Rice, Mustard green, Ginger, Papaya, chili, leaf onion, radish, Sugar cans	110	67	0.61
Kampong Speu						
08	Trapang Veng	Samroung Tong	Rice, red pepper, Sponge gourd, cucumber, pumpkins, water melon	150	189	1.26
09	Kliang Pram	Oudong	Rice	170	221	1.30
Phnom Penh city						
10	Kork Bonteay	Dangkor	Rice, Cucumber, Tomatoes, Yard long been, sponge gourd	63	35	0.55
Total				**2505**	**2340**	**1.01**

Source: Market survey, 2003

In total 347,962 of households were estimated in the targeted area. Number of village households to be interview red is 50. Therefore, the sample size was 0.014% of total. The following table shows the estimated number of households in the target area.

Table 13-4: The estimated number of households in the target area

No.	Provinces	Districts	Estimated number of households in the target area*
1.	**Kondal province**	Kien Svay	17,121
2.		Ksarch Kandal	16,702
3.		Lvea Em	7,637
4.		Muk Kampoul	14,003
5.		Kandal Steung	16,212
6.		Ang Snoul	16,974
7.		S' Ang	16,228
8.		Ponhea Leau	16,131
9.		Takmao	6,160
10.	**Kampong speu province**	Korng Pisey	19,014
11.		Oudong	9,412
12		Samrong Tong	8,986
13.	**Takeo**	Bati	4,510
14.	**Kampong cham**	Srey Santhor	1,456
15.		Batheay	1,228
16.	**Kampong chhnang**	Kampong Tralach	288
17.	**Prey veng**	Pear Riang	2,222
18.	**Phnom Penh Municipality**	Chamkar Morn	32,366
		Doun Penh	22,203
		Prampi Makara	16,529
		Toul Kork	26,198
		Dang Kor	17,565
		Mean Chey	27,443
		Russei Keo	31,374
Total			347,962

* Estimated by the proportion of the target area in each districts

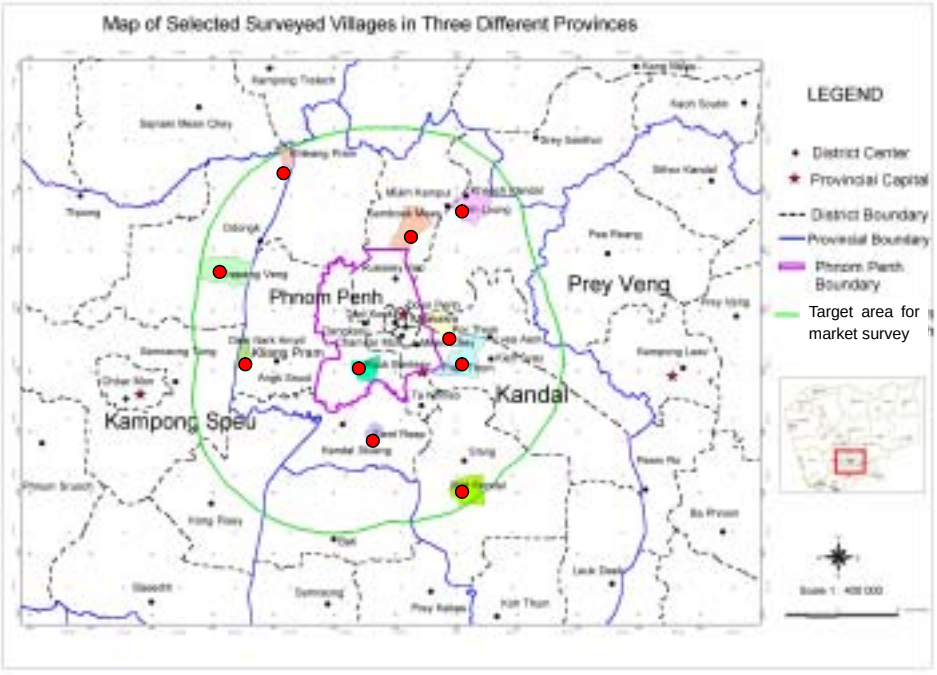


Figure 13-1: Map of Selected Surveyed Villages

b. Questionnaire Survey

A questionnaire sheet for the survey was prepared by the Study Team as shown below. The survey was conducted from 3rd to 19th November 2003 by visiting farmers in the targeted area.

Questionnaire Survey

Survey Date.....
Name of farmer.....
Village No. .....
Name of Village.....Commune.....
District .....
Province / City …….....

Question on farm land

1. How many farmers are there in your village?
.....
2. How many hectare of farmland do you have?
.....
3. What type of crop do you plant?

Type of Crop	Farm Area (Acre)	Farm Area (ha)
1.Rice crop Wet Dry		
2.Trees of citrus Sour orange Lemon Grape fruit Mandarin Other		
3.Vegetables Onion Lettuce Green broccoli Cabbage Ginger Cucumber Other		
4.Fruits Mango Watermelon Papaya Banana Logan Other		
5.Cereals Corn Wheat Black and White Bean Bean Crop Other		
6.Herbs Chilli Smelly Plant Other		
7.Others.....		

4. What months are your farm cultivation and harvesting? How much does the price of crop?

Type of Crop	Period		Price (Riel/Unit)
	Cultivation	Harvesting	
1.Rice crop Wet Dry Other			
2.Trees of citrus Sour orange Lemon Grape fruit Mandarin Other			

3.Vegetables Onion Lettuce Green broccoli Cabbage Ginger Cucumber Pumpkin Other			
4.Fruits Mango Watermelon Papaya Banana Logan Other			
5.Cereals Corn Wheat Black and White Bean Bean Crop Other			
6.Herbs Chilli Smelly Plant Other			
7. Others.....			

5. Do you have your own transportation (Truck, van, car, motorbike or other)?
.....

Question on fertilizer

6. What fertiliser do you use for your farm? How mucht is the price?

Type of fertiliser	Price (Riel / kg or /ton)	Price including transportation (Riel /kg or /ton)
1. Organic Fertilizers Cow manure Buffalo manure Horse manure Pig manure Goat manure Chicken manure Duck manure Other		
2.Inorganic Fertilizers (Chemical) Urea (N: 46 P:00 K:00) De-Ammonium Sulphate (N: 18 P: 46 K:00) N:15 P:15 K:15 KCL (N:00 P:00 K:60) Other		
3.Fresh or Green manure Leaf of litter Pieces of Plant Grass Other		
4.Fertile Soil Humus Cal care (soil) Other		
5.Compost Liquid (Fine compost) Dry (Coarse compost) Other		

Type of fertiliser	Amounts per ha	Times per year
1. Organic Fertilizers Cow manure Buffalo manure Horse manure Pig manure		

Goat manure Chicken manure Duck manure Other		
2.Inorganic Fertilizers (Chemical) Urea (N: 46 P:00 K:00) De-Ammonium Sulphate (N: 18 P: 46 K:00) N: 15 P: 15 K: 15 KCL (N:00 P:00 K: 60) N: 16 P: 20 K:00 Other		
3.Fresh or Green manure Leaf of litter Pieces of Plant Grass Other		
4.Fertile Soil Humus Cal care (soil) Other		
5.Compost Liquid (Fine compost) Dry (Coarse compost)		

7. How much do you use fertilisers per ha? How many times do you apply them per year?
……..
8. What month do you fill the fertiliser to your farm?
……..
9. Where do you buy the fertiliser (Local market, District Market, Phnom Penh market/Other)? .....
10. Why do use this fertiliser?
.....
11. Is this fertiliser available whenever you want? Yes …….No ……

Question on Compost Market

12. Have you ever used "compost" for your farmland? Yes ….....No…….
.....if Yes, When? .....….
13. Do you know qualification of compost? Yes .....……..No ……..
14. If compost is good quality and available, will you use it? Yes …..No …..

If not, please proceed to Q. 22

15. Do you know how much amount used to apply compost on your farmland?
.....
16. How much of compost will you use per ha/year?
.....
17. How often and when do you use compost for your farmland?
.....
18. How much are you willing to pay at most for compost?
…….
19. Why do you not use compost?
…….……

c. Results of Survey

c.1 Agricultural situation

Based on Landsat survey in 1992 in Cambodia, approximately 58% of land use was forest. Farmland was 22%, rice field accounted for 14% in the 22%. The rice field are distributed in the central area of Cambodia like the target area of the marketing survey. Agriculture is main industry and approximately 70% of workers are farmers. It can be said that main crop is rice, followed by vegetable in the target area.

Rice field

The Almost farmers interviewed were rice farmer. Many of them cultivate vegetable but it is for side work. Normally farmer can cultivate rice two times per year, which are rainy and dry season. Based on the results of the marketing survey, the rice yield was less than 3 tons/ha. All Interviewees used chemical fertilizer because the supply of chemical fertilizer is stable. This is the prime reason for use of it. On the other hand, the interviewees answered that they know the problem of chemical fertilizers due to overuse (i.e. soil hardening) and they want apply organic fertilizer such as compost. The chemical fertilizers used are DAP, 15 15 15, Urea, 16 20 00 and the prices are from 45,000 to 60,000 riel/50kg. In case of rice farming, the application rate of those chemical fertilizers is 202kg/ha in average.

Almost half (26 farmers of 50) of farmers uses organic fertilizer with chemical fertilizers. Cow manure is normally used. However it is not always available because the number of cattle farmers is very few, and so such organic fertilizer is always short. As a result, rice farmers have to rely on the chemical fertilizers more and more. The prices are from 20 to 60 riel/kg. In case of rice farming, the application rate of those organic fertilizers is 250 to 7,500kg/ha. The application rates were varied according to the supply condition. An average application rate is 2,800kg/ha in total.

c.2 Vegetable field

31 framers of 50 cultivate vegetables. Same as rice, chemical fertilizers are normally used. Usually vegetable cultivation is side work for supporting their living. However, there is no interviewee of vegetable farmer in 2 villages, which are Dam Nark Ampil and Kliang Pram both located in the west of Phnom Penh.

Same as rice farmers, vegetable farmers use chemical fertilizer because the supply of chemical fertilizer is stable. This is the prime reason for use of it. On the other hand, the vegetable farmers answered that they know the problem of chemical fertilizers due to overuse (i.e. soil hardening) and they want apply organic fertilizer such as compost. The chemical fertilizers used are DAP, 15 15 15, Urea, 16 20 00 and the prices are from 45,000 to 60,000 riel/50kg. In case of vegetable farming, it is notable that the application rate of those chemical fertilizers is 410kg/ha in average.

15 vegetable farmers of 31 use organic fertilizer with chemical fertilizer. Cow manure is normally used. However it is not always available because the number of cattle farmers is very few, and so such organic fertilizer is always short. Organic fertilizer is used only in 3 villages, which are Orn Long, Wat kandal and Kork Bonteay. However 93% of vegetable farmers are using them in the 3 village. It can be said that vegetable farmers always want to apply organic fertilizer if it is available. The price of the organic fertilizer is from 20 to 60 riel/kg. In case of vegetable farming, the application rate of those organic fertilizers is 250 to 7,500kg/ha. The application rates were varied according to the supply condition. It is notable that an average application rate is 3,100kg/ha in total and it is higher than rice cultivation.

c.3 Compost Producers

In Cambodia, there are two NGOs, COMPED and CSCARO, which process waste into the compost fertilizer, but almost did not know about the urban waste compost fertilizer available in Phnom Penh. COMPED has been supported by Germany's fund, and it sells compost fertilizers somewhere around six tons per month. The price per kilogram is 200 riel per kilogram. The customers of COMPED are vegetable and fruits farmers and the number of the customers are limited. The consumers of these products are mainly classy restaurants or hotels for foreigners.

As for CSARO, it was supported by NORAD organization in cooperation with MPP. CSARO can produce from one to two tons per month and the price is 350 riel per kilogram and it is higher than compost fertilizer produced by COMPED.

13.4 A PR field trial using the urban waste compost

13.4.1 Background

The field trial of compost application was conducted on farmland in Svay Rieng by International Volunteers of Yamagata (IVY), and the farmers under the instruction of IVY to verify the effect of urban waste compost. In the trial, the yields of rice on farmland with and without compost were reported to the team via IVY and compared. The implementation structure of the field trial is shown in the figure below. The results of the experiment will be utilized for the development of the urban waste compost market and the wide use of compost for rice cultivation.

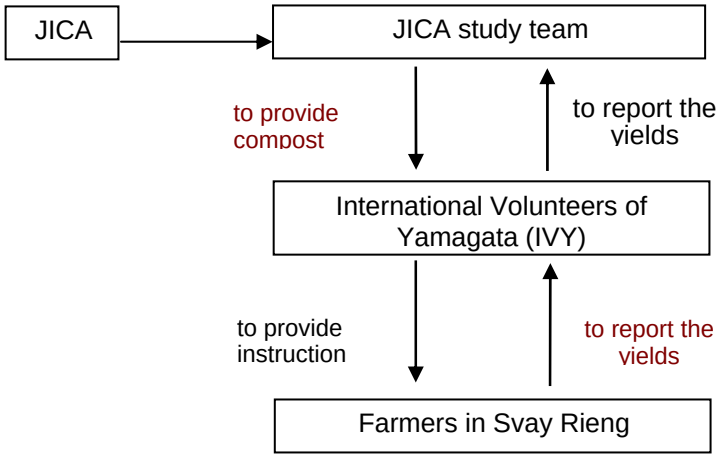


Figure 13-2: System to Conduct the Field Trial

13.4.2 Method of the Field Trial

The field trial was done in five sites. From site 1 to 3 were the farmers' farmland and compost was applied with chemical fertilizer. Site 4 and 5 were in the IVY pilot farm and compost was applied without chemical fertilizer. The detail conditions were shown in below table. In each sites, three types of trial were done which were without compost, with 10t/ha of compost and 30t/ha of compost.

Table 13-5: Conditions of the field trial

Name of villages	Site 1	Site 2	Site 3	Site 4	Site 5
	Prey Chambok	Nearea Tean	Pon Kok	IVY 1	IVY 2
Variety of rice	Chrosan Teap	Chrosan Teap	Son Com	Phkar Rumdull	Neang Ourk
Fertilizer application	Urea 54.8kg/ha	Urea 51.5kg/ha	Urea 100kg/ha	None	None
Date of sowing	1-Jun	2-Jun	15-Jul	10-Jul	10-Jul
Date of transplanting	15-19 - July	16-18 - July	10-11 - Aug	1-Aug	6-Aug
Date of yield survey	13-Nov	13-Nov	17-Dec	20-Nov	6-Dec

13.4.3 Results of the Field Trial

Following table shows the results of the field trial.

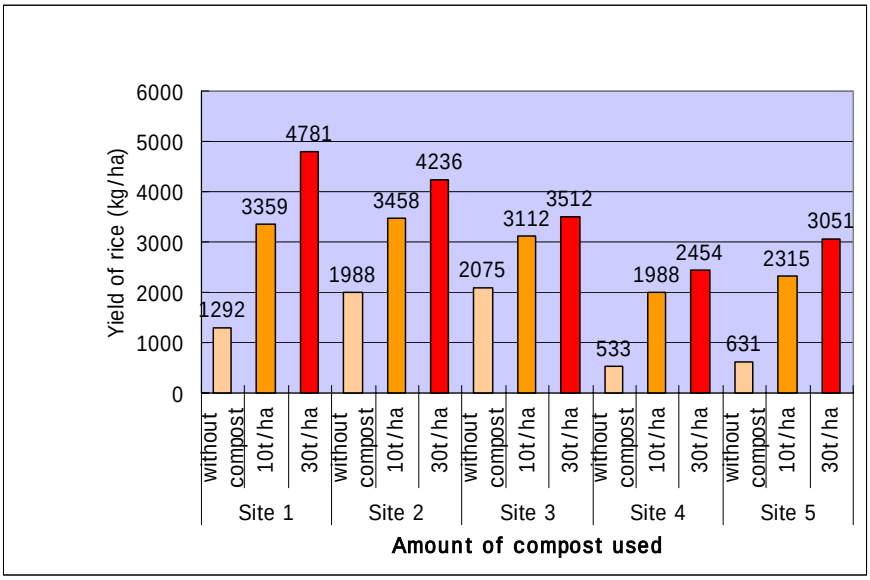


Figure 13-3: Effectiveness of urban waste compost

All the sites show that the urban waste compost is effective both with and without chemical fertilizer. Especially, site 4 and 5 showed the increase of yield by 3.4 to 3.7 times between without compost and with 10t/ha of compost.

As compared with application rate of compost, all sites show that the yields of rice with 30t/ha of compost were higher than 10t/ha of that however were lower than 3 times of 10t/ha of that. Therefore, in the viewpoint of cost effectiveness, most suitable application rate for compost can be said under 10t/ha. For example, based on the analysis results mentioned before, the nitrogen content of the compost was 1.3 to 2%. As nitrogen application rate is 50kg/ha in average in Cambodia, necessary compost application rate is 2.5 to 3.8t/ha to satisfy the nitrogen application rate.

13.5 Field trips to PR field trial farmland

Two field trips were arranged, once during the growing period and once at harvesting time, targeting farmers in Svay Rieng to demonstrate the effect of compost. Another field trip was arranged at harvesting time targeting related persons in Phnom Penh for the same purpose. In addition, a promotional video, panels and leaflet, showing the production process of urban waste compost, how to use compost and the cultivation process of rice, were made.

13.5.1 Field trip targeting farmers in Svay Rieng

Date:	12th of November 2003
Attendants:	50 farmers in Svay Rieng
Time:	10:00 ～ 15:00 am
Venue:	Agricultural hall in Svay Rieng and experimental farmland of IVY and farmers

1. Workshop for urban waste compost
2. Field visit to observe the growing condition of the rice

13.5.2 Second trip targeting farmers in Svay Rieng

Date: 9th of December 2003
Attendants: 50 farmers in Svay Rieng
Time: 10:00 ～ 15:00 am
Venue: Agricultural hall in Svay Rieng and experimental farmland of IVY and farmers

1. Workshop for urban waste compost

2. field visit to observe the rice at harvesting time, and demonstrate the compost production

13.5.3 Field trip targeting farmers in Svay Rieng

Date: 26th of November 2003
Attendants: 44 attendants (16 farmers in Phnom Penh, 2 NGO, 23 MPP/local officers and 3 PPWM)
Time: 8:00 ～ 19:00 am
Venue: Experimental farmland of IVY and farmers in Svay Rieng

1. Workshop for urban waste compost

2. Field visit to observe the growing condition of the rice

13.5.4 Findings

Regarding the results of the compositional analysis of the urban waste compost produced by COMPED and CSARO in Phnom Penh, although the lead content was slightly high, all the parameters were found to be within the permissible limit. Though some parameters exceeded the Thailand compost standard, these can be recovered by improvement of composting operation. Therefore, the compost can be marketed.

The results of the field trials conducted in Svay Rieng demonstrated that the use of urban compost can increase rice yields. The study team made a promotional video showing the production process of compost and the field trials that were conducted. At the second seminar, the video was shown to the participants along with a presentation of compost using panels in order to demonstrate the effectiveness of urban waste compost. The videos were also lent out to NGOs producing urban waste compost to further promote its use.

In the marketing survey conducted in the villages, the farmers were found to fully appreciate the importance of organic farming. However, the supply of compost is not steady so they have to rely on chemical fertilizers. This shows that if a system for providing a steady supply of compost at a reasonable price is established, there will be an increase in demand.

In the field trial, in order to produce 2000 kg of rice, 50kg of chemical fertilizer and 10,000 kg of urban waste compost were required. The chemical fertilizer costs 900～1,200 riel/kg while the compost costs 200～500 riel/kg. Therefore, the investment to produce the same yield is 45 to 80 times greater for compost. Even taking into account the effect of soil improvement, if cost is not reduced to one tenth of the current amount, the farmers will have no choice but to rely on chemical fertilizers.

COMPED sells compost at 200 riel/kg to fruit farms and farmers who grow vegetables in the suburbs of Phnom Penh, while CSARO sells compost at 350 riel/kg for home gardens and horticulture. Although both are small scale markets, for limited purposes there is a demand. Therefore, although urban waste compost cannot compete with chemical fertilizers in terms of cost, a demand for high value crops can be expected.

Annex 14

Initial Environmental Examination on the Development of the New Disposal Site

Annex 14 Initial Environmental Examination on the Development of the New Disposal Site

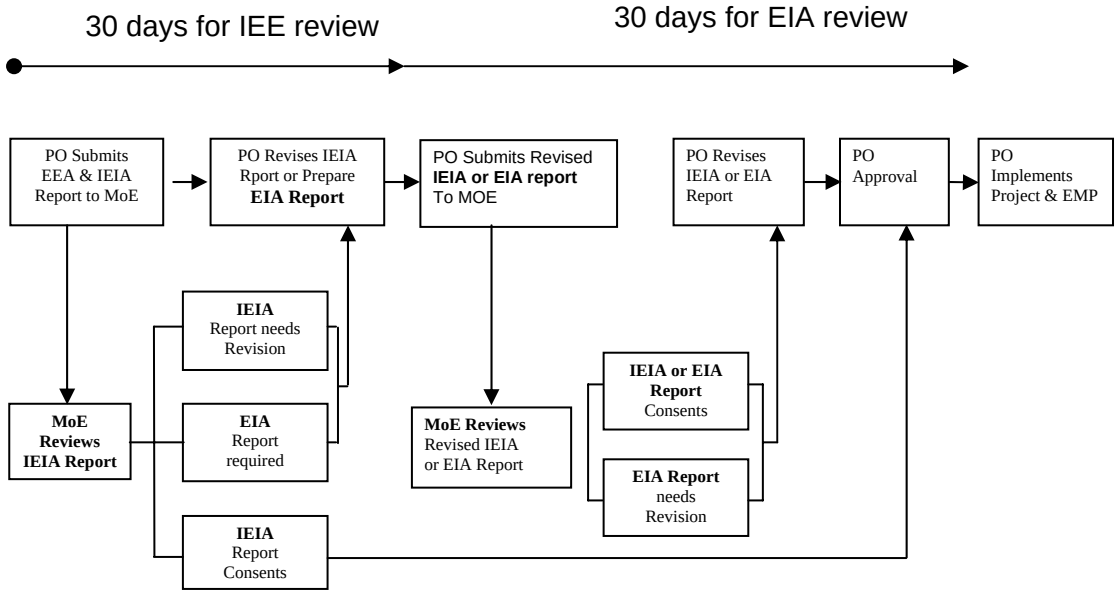
14.1 IEE/EIA system

The development of environment related laws began in 1994. Since then, the Law on Environmental Protection and Natural Resources Management, the Sub-decree on Environmental Impact Assessment Process, the Sub-decree on Water Pollution, and the Sub-decree on Solid Waste Management have been established. The Sub-decree on Environmental Impact Assessment Process came into effect in August 1999, based on the Law on environmental Protection and Natural Resources Management. This Sub-decree requires an IEE/EIA for the following projects including all proposed and existing activities, either publicly or privately owned.

A. Industrial
- A-1 Foods, drinks, tobacco
- A-2 Leather tanning, garment and textile
- A-3 Wooden production
- A-4 Paper
- A-5 Plastic, rubber and chemical

B. Agriculture
C. Tourism
D. Infrastructure

The waste disposal site is listed in the D.Infrastructure in the event that the disposed population is more than 200,000. The procedures for IEE/EIA are shown in Figure 14-1.



Note: PO: Project Owner
IEIA: Initial EIA (same as IEE)
EMP: Environmental Management Plan
EEA: Environmental Examination Application

Figure 14-1: IEE/EIA process for proposed project

The Project's owner must prepare and submit the EEA and IEIA reports to the MOE. The MOE reviews the IEIA report and gives comments and suggestions to the project owner within 30 working days counting from the IEIA report submission day. If MOE concludes that the environmental impact of the proposed project is acceptable and a full EIA is not necessary, MOE gives approval for implementation to the project owner. If MOE concludes that the IEIA report is insufficient or the project will have a serious environmental impact, MOE requires an EIA. The project owner must revise the IEIA report or prepare a full EIA report, and must submit it. MOE reviews the revised IEIA report or the full EIA report, and gives comments and suggestions to the project owner within 30 working days counting from the revised IEIA report or the full EIA report submission day. The project owner reviews the revised IEIA report or the full EIA report, and then the project is approved for implementation.

As for final disposal sites, there is no EIA application. The draft guideline for EIA is prepared by MOE, pending approval by the Cambodian cabinet. As for an IEE report, there is no guideline in Cambodia as of yet.

14.2 Scope of the IEE/EIA work

14.2.1 Target projects

In the master plan, the following projects are targeted for IEE/EIA.

a SMC existing final disposal site

b Dong Kor proposed disposal site (includes a vehicle depot and a maintenance work shop)

a. SMC existing final disposal site

According to the Sub-decree on Environmental Impact Assessment Process, the existing disposal site is subject to an IEE/EIA. However, MOE approved the implementation of the SMC improvement project on the following conditions.

A fence is installed around the dump site to prohibit people and animals from entering.

The access road to the dump site is improved to avoid the dumping of solid waste outside the disposal site due to lack of accessibility.

The burning of solid waste in the SMC disposal site is stopped in all situations.

The disposal of industrial and medical waste in the SMC disposal site is prohibited under any circumstance.

Leachate drains are established and the leachate is treated.

Regular underground water analysis is carried out.

The project is implemented in cooperation with MOE technical staff

The SMC disposal site is covered after its operation.

The MPP (project owner) accepted these conditions. Therefore, an IEE/EIA is not necessary for the SMC improvement project.

b. Dong Kor proposed new disposal site

According to the Sub-decree on Environmental Impact Assessment Process, the proposed disposal site is subject to an IEE/EIA. Therefore, the Study Team conducted the IEE survey, and the MPP (project owner) submitted the IEIA report to the MOE.

14.3 The results of IEE for the Dong Kor proposed new disposal site

The work scope for the environmental impact survey for EIA is to be planned from the results of the IEE shown in Table 14-1. The study area of the IEE covered the area within 1 km from the center of the Dang Kor disposal site, which was originally 25ha. Although the MPP decided to purchase an additional 1 ha for the vehicle depot and the maintenance workshop and 26ha should be subject to EIA, the study area of EIA (i.e. the area within 1km from the center of 26ha of the site) is almost the same as the study area of IEE. The location of the Dang Kor disposal site and the IEE study area are shown in Figure 14-2.

Environmental parameters were evaluated using the JICA guideline for "waste disposal" sector projects. As Table 14-1shows, the project is expected to have a serious negative impact on two environmental items, and some negative impact on eleven environmental items. It seems that there will be no impact on the other parameters so IEE/EIA are not necessary for them. Though some impacts are shown in the construction phase, most of the impacts will occur in the operation phase.

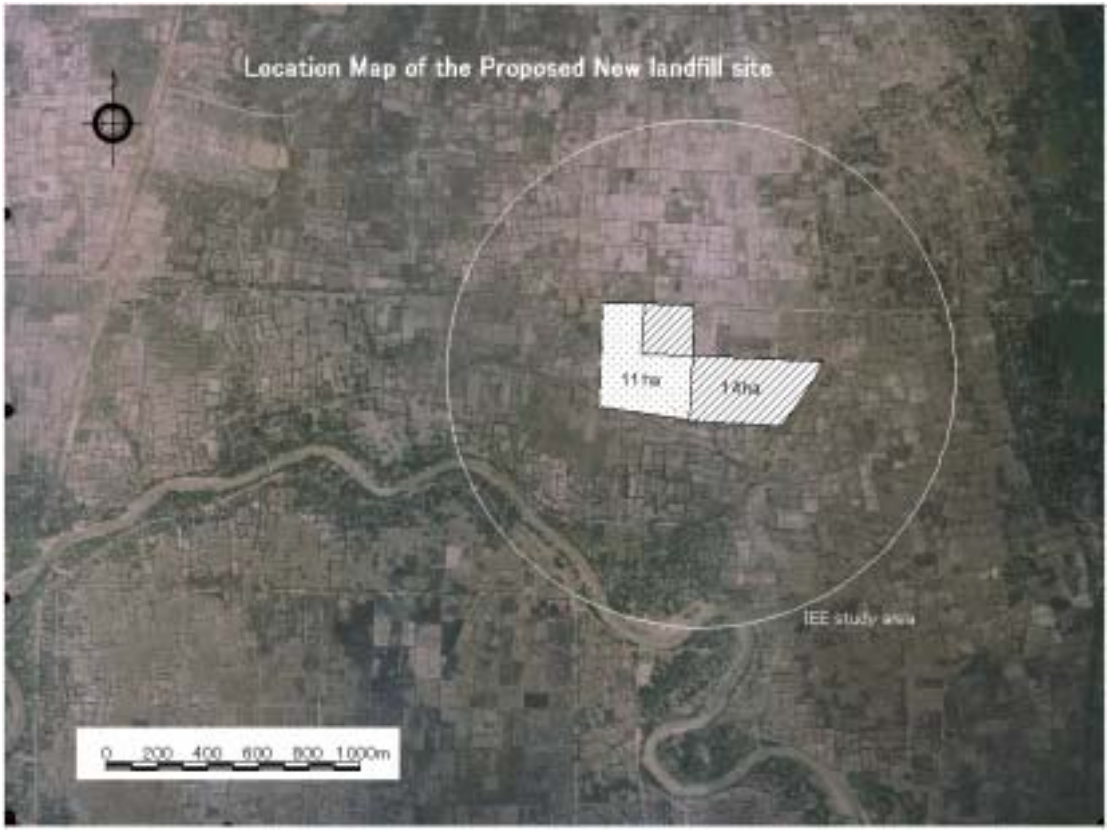


Figure 14-2: Location map of the Dong Kor disposal site

Table 14-1: Results of the scoping using a matrix

Environmental Items / Activities which may cause impacts			Overall Evaluation	Construction Phase (include Pre-construction phase)		After Operation			
				Reclamation and Spatial Occupancy	Operation of Construction, Equipment and Vehicles	Spatial Occupancy	Operation of Vehicles	Operation and Maintenance of Facilities	Accumulation of people and Goods
Social Environment	1	Resettlement							
	2	Economic Activities	B		B				
	3	Traffic and Public Facilities	B		B		B		
	4	Split of Communities							
	5	Cultural Property	B			B			
	6	Water Rights and Fishing Rights							
	7	Public Health Condition	B					B	B
	8	Waste							
	9	Hazards(Risk)							
Natural Environment	10	Topography and Geology							
	11	Soil Erosion							
	12	Groundwater	A	B				A	A
	13	Hydrological Situation	B					B	
	14	Coastal Zone							
	15	Fauna and Flora	B	B	B	B	B	B	B
	16	Meteorology							
	17	Landscape	B			B			
Pollution	18	Air Pollution	B		B		B		
	19	Water Pollution	A					A	B
	20	Soil Contamination	B					B	B
	21	Noise and Vibration	B		B		B	B	
	22	Land Subsidence							
	23	Offensive Odor	B					B	B

Note: Evaluation categories:

A: Serious negative impact is expected

B: Some negative impact is expected

C: Extent of impact is Unknown (Examination is needed, Impacts may become clear as study progresses.).

No Mark: The environmental items requiring no impact assessment since the anticipated impacts are, in general, not significant.

The Policy for the Environmental Impact Survey for EIA is concluded in Table 14-2 from the results of the scoping. The environmental items that need to be monitored are air pollution, water pollution (surface water and groundwater) and noise level. Monitoring should be appropriately planned. For example, water quality monitoring should be carried out at least once a year after starting operation. The schedule and items of the monitoring activities will be determined during the EIA phase.

Table 14-2: Scope of Work of Environmental Impact Survey

Assessment items		Assessment method	Remark
Social / Cultural Impacts			
Economic Activities		Literature survey Interview survey	
Traffic and Public Facilities		Literature survey Field survey	
Cultural Property		Literature survey Field survey	
Public health		Literature survey Interview survey	
Environmental impacts			
Air pollution		Monitoring (CO, NO_2, SO_2, Pb, TSP)	
Water pollution	Surface water	Monitoring (Temperature, pH, Electric Conductivity, Turbidity, Color, Alkalinity, Oil Content, Total Coliform, BOD, COD, SS, NH_3-N, Na^+, K^+, SO_4^{2-}, Cl^-, Total P, Mn, Fe, Cd, Pb, Total Cr, Cr^{6+}, As, Cu, Zn, *HCO_3^-, CN, Total N, Total Hg, PCBs**)	
	Groundwater		
Hydrological Situation		Field survey Interview survey	
Soil contamination		Literature survey Interview survey	
Noise		Monitoring (noise level)	
Offensive odor		Literature survey Interview survey	
Fauna and Flora		Field survey	200ha of in and around the site
Landscape		Field survey	
Neighborhood People's Consensus			
POS on the development of the new landfill site.(citizen, local authority, village chief, etc)		Literature survey Interview survey	To be consider the timing of conduct

***** *HCO_3^-, CN, Total N, Total Hg, PCBs* are impossible to be analyzed in Cambodia.

14.4 Conclusion of IEE for the Dong Kor proposed new disposal site

The evaluation of the IEE shows that the location of the project site is basically suitable from the point of view of environmental conservation. In generally, minor negative impacts are expected and they can be mitigated through a series of countermeasures. However, as some environmental items should be monitored and a baseline survey is necessary, an EIA will need to be conducted.

Annex 15

Environment Impact Assessment Report

Annex 15 Environment Impact Assessment Report

15.1 Introduction

15.1.1 Background

The Municipality of Phnom Penh (MPP) faces various problems related to solid waste management, ranging from scattered waste on the streets and illegal dumping of waste in canals to serious pollution problems caused by the final disposal site in Stung Mean Chey. Hence, the Government of Cambodia (GOC) requested the Government of Japan (GOJ) to carry out a development study in 2000. In response to this request, JICA decided to conduct the Study on Solid Waste Management in the Municipality of Phnom Penh (the JICA study), starting in February 2003, after the preliminary study, and entrusted the study to Kokusai Kogyo Co. Ltd. (hereinafter called the JICA study team).

One of the most important items of the study was the improvement of the existing final disposal site. In MPP, there is only one disposal site operated by Phnom Penh Waste Management (PPWM) under the supervision of Department of Public Works and Transportation (DPWT) of MPP. The disposal site that is located in Stung Mean Chey causes serious environmental problems due to improper operation by PPWM and the lack of pollution control facilities. More than 500 waste pickers are working at the disposal site, and this makes it more difficult for PPWM to do its landfill operation. Moreover, before the study started, the Stung Mean Chey disposal site (SMCDS) was almost full.

The JICA study team expanded the landfill area during the second phase of the JICA study, from September 2003 to January 2004, as part of a pilot project, aiming at improving the SMC disposal site. The remaining life of the SMCDS, however, could be extended only three years because of the limited land available for its expansion.

According to the result of the first and second phase of the study, in the whole area of Phnom Penh with a population of 1.2 million, 927.8 tons of waste was generated everyday in 2003 and 70% of it was brought to the SMCDS for the final disposal. The total amount of waste generation is determined by the average waste generation amount per capita and the total population. Due to a high birth rate as shown in Table 15-1 and a continuous migration from rural areas to the city, Phnom Penh expects a high population growth rate. In addition, the per capita waste generation amount generally increases as economic development progresses. Therefore, the total amount of waste generation is expected to grow rapidly, as shown in Table 15-2.

Table 15-1: Population Projection in MPP

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

Population Increase from year 2003 (in 1,000)				
Study Area	-	217	382	503
Urban Area	-	64	103	122
Rural Area	-	153	279	381

Table 15-2: Expected Waste Generation Amount

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

On the other hand, MPP has a plan to widen the waste collection service area in the three rural Khans. As a result, the amount of municipal waste brought to the SMCDS in 2007 and 2015 is expected to be 894.8 tons (a 40% increase from the current level) and 1,461.4 tons (more than double the current amount) respectively.

Table 15-3: Expected Waste Amount Disposed of at Final Disposal Site

Area	Unit	2003	2007	2012	2015
Whole Phnom Penh	Ton/day	668.6	923.7	1,301.2	1,539.7
Urban area	Ton/day	479.5	563.0	699.4	768.8
Rural area	Ton/day	189.1	360.7	601.8	770.9

Therefore, it is urgent for MPP to construct a new disposal site, which has enough capacity to accept the growing amount of waste for a certain period, by 2007. Moreover, it is necessary for MPP to design a development plan of the new disposal site very carefully in order to prevent or mitigate serious pollution problems, because a final disposal site could have an enormous environmental and social impact on surrounding areas, as shown in the case of the SMCDS.

MPP requested JICA to select the development plan of the Dang Kor Disposal Site (DKDS) as a priority project of the JICA study, and JICA agreed to conduct a feasibility study of the development plan of DKDS during the second phase of the JICA study. The EIA survey was conducted as part of the feasibility study.

15.1.2 Legislation and Regulation Consideration

In accordance with the "Law on Environmental Protection and Natural Resource Management", an environmental impact assessment shall be done for all projects and activities, private or public, and shall be reviewed and evaluated by the Ministry of Environment (MOE) before being submitted to the Royal Government for decision.

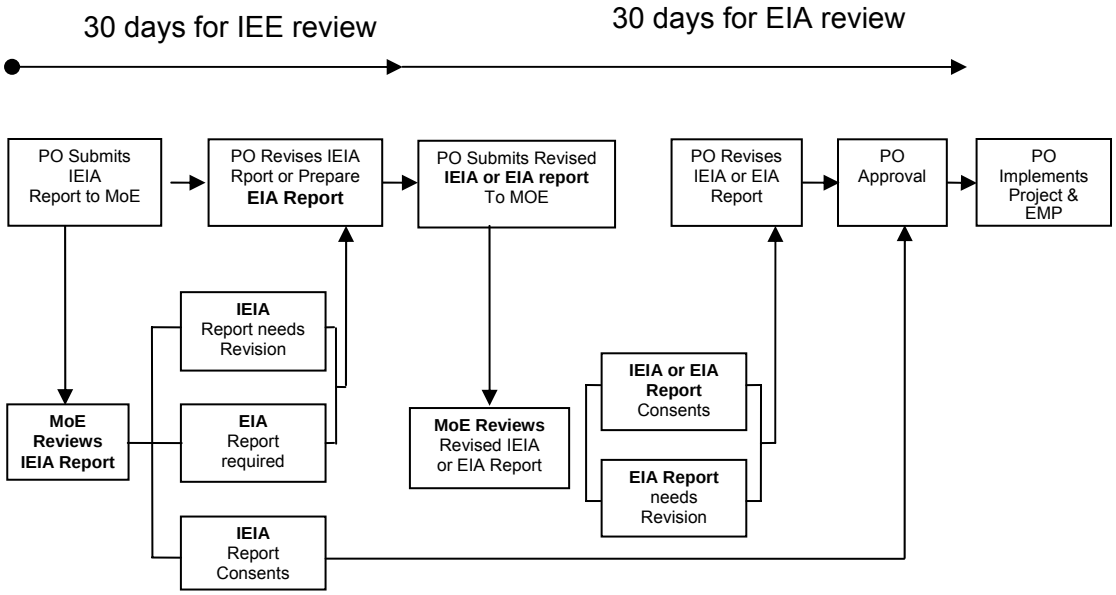
This Sub-decree requires an Initial Environmental Impact Assessment (IEIA) or Environmental Impact Assessment (EIA) for the following projects including all proposed and existing activities, either publicly or privately owned.

A. Industrial
- A-1 Foods, drinks, tobacco
- A-2 Leather tanning, garment and textile
- A-3 Wooden production
- A-4 Paper
- A-5 Plastic, rubber and chemical

B. Agriculture

C. Tourism
D. Infrastructure

The waste disposal site is listed under "D. Infrastructure" in the event that the disposed population is more than 200,000. The procedures for IEE/EIA are shown in Figure 15-1. If MOE judges that an Environmental Impact Assessment (EIA) study is necessary for its final decision after reviewing the IEIA report, the EIA study shall be conducted according to "Declaration on Guidelines for Conducting Environmental Impact Assessment Report"



Note: PO: Project Owner
IEIA: Initial EIA (same as IEE)
EMP: Environmental Management Plan
EEA: Environmental Examination Application

Figure 15-1: IEIA/EIA process for proposed project

The EIA report should state public participation, assessment of alternatives and mitigation measures, as well as the details of the project, the current environmental quality at the location where the proposed project will be sited, the result of the assessment of the environment, and the social impact of the proposed project.

On the other hand, JICA has its own guideline, "JICA Guidelines for Environmental and Social Considerations", which was modified and put into effective on April 1, 2004. JICA encourages the recipient government to give appropriate environmental and social considerations through cooperation activities. Even though the Guidelines had not yet been effective when the EIA survey started, the JICA Guidelines were applied in the EIA survey procedure as much as possible.

This environmental impact assessment (EIA) report was prepared on the first phase of the Dong Kor disposal site development project as part of the study on solid waste management in the municipality of Phnom Penh in the Kingdom of Cambodia.

15.2 Project Summary

15.2.1 Overall Structure of the Strategic Framework

a. Goals of the development plan

As mentioned in the previous chapter, because the existing final disposal site in Stung Mean Chey will be full in 2007, MPP has to prepare for a new disposal site as soon as possible. Otherwise, MPP will face various environmental and hygienic problems.

On the other hand, the SMCDS was constructed without any consideration for environmental conservation and has been operated and managed without any plans since it was opened. This has resulted in serious pollution problems in and around the disposal site. Therefore, it is very important for MPP to develop the new disposal site plan considering its environmental and social impacts on surrounding areas.

Therefore, the main goal of the development plan of the DKDS is to construct a disposal site that can deal with the growing amount of solid waste while minimizing the environmental impact and to start its operation in 2007. The DKDS will be the first sanitary landfill site with pollution control facilities in Cambodia and the plan also aims to modernize the solid waste management system of MPP by introducing the sanitary landfill method. The following policies are considered for developing the new disposal site plan.

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

Enhancing PPWM's ability to conduct landfill operation is also a key element for the prevention of pollution problems. Before the start of its operation, the staff of the operation department of PPWM will acquire operational skills through the pilot project at the SMCDS.

b. Conceptual Design

As mentioned in the previous chapter, the amount of waste brought to the proposed DKDS for final disposal is expected to grow rapidly. Therefore, the DKDS has to have enough capacity to receive the growing amount of waste.

In the long term plan, the DKDS will have a total land area of 100 ha with an expected life span of 20 years. However, the JICA study team recommended that the whole plan be divided into four phases, as shown in Figure 15-2, and that MPP acquire the necessary land according to the long term plan. This DKDS Development Plan covers only the first phase, starting in 2007 and ending in 2012. The landfill area will accept waste for two more years after the second phase starts in 2013.

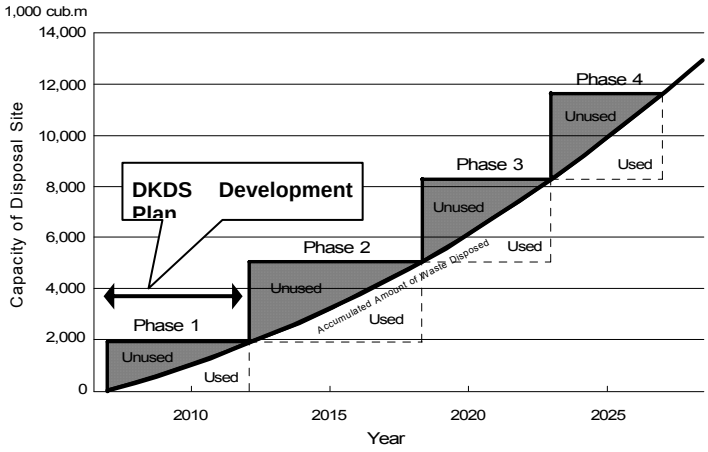


Figure 15-2: Long Term Plan of DKDS

The development plan aims to construct a disposal site with a capacity of more than five years in an area of 26ha, which was secured by MPP for Phase 1 of the development plan of the new disposal site. The Dang Kor disposal site will be the first sanitary landfill site with leachate treatment systems and other pollution control facilities in Cambodia.

During Phase 1, PPWM has to consider the renewal or purchase of new facilities and equipment necessary for Phase 2. Therefore, when the technical and financial assessment is done, the target period covers from 2007 to 2015, which is longer than Phase 1.

b.1 Schedule

Phase 1: From January 2007 to 2012

b.2 Target Waste of Landfill

The target waste of the landfill is all municipal waste, except hazardous waste, collected from the entire city of Phnom Penh. The expected waste amount to be treated at the DKDS after the start of its operation is shown in the table below.

Table 15-4: Estimated Annual and Accumulated Amount of Waste Disposal in Dang Kor Disposal site

Year	Waste Amount Disposed of	
	Yearly Amount (tons/year)	Accumulated Amount (ton)
2007	337,151	337,151
2008	361,350	698,501
2009	388,616	1,087,117
2010	416,319	1,503,436
2011	439,825	1,943,261
2012	474,938	2,418,199
2013	498,955	2,917,154
2014	524,688	3,441,842
2015	561,991	4,003,833

b.3 Facilities

The following facilities are included in the development plan:

- Administration Section (PPWM office, the weighbridge facility, and so on)
- Landfill Section and Leachate Treatment Facilities
- Compost Plant (target of organic waste is market waste)
- Maintenance Workshop and Vehicle Depot (for collection vehicles and landfill equipment)

In Phnom Penh, compostable organic waste such as kitchen waste and grass/wood waste is approximately 70% of total waste generation, and the disposal of such waste is an increasingly difficult problem. Composting is a measure with high potential to reduce organic waste and the SMCDS has experience in producing compost from market waste. The development plan aims at enhancing the capability for producing compost to reduce organic waste.

If the composting plant can be operated successfully, it will achieve the following desirable results:

- Conservation of resources by recycling
- Support for nature's cycle by returning organic waste to the earth.
- Reduction of landfill space requirement in Dang Kor disposal site.

One trammel with hopper and conveyer, and one wheel loader are to be installed for the compost plant.

As for the maintenance workshop for collection and final disposal site vehicles, it is essential because MPP plans to start the collection service in the three rural Khans in 2007, while CINTRI continues to provide the collection service in the four urban Khans. Therefore, the maintenance workshop will be installed in the Dang Kor disposal site. The daily maintenance work of collection vehicles will be done at the maintenance workshop at the disposal site. Major maintenance such as overhauls will be contracted out. Repair facilities and vehicle washing facilities are to be installed for the maintenance workshop.

b.4 Equipments

The following equipments for landfill operation are arranged according to the plan.

Table 15-5: List of Landfill Equipment

Equipment	Specification	Number	Use
1 Bulldozer	21ton	4	To level and compact waste
2 Wheel loader	1.2m^3	1	To level waste and maintain on-site road
3 Water Tank truck	6,000 liter	1	To maintain on-site road and extinguish fire
4 Dump truck	11 ton	2	To transport soil
5 Pickup truck	4WD	2	To make a tour of on-site inspection
6 Excavator	0.7m^3	2	To excavate soil and maintain drains

b.5 Organization Structure and Management System

The Landfill Operation Section under PPWM is in charge of disposal site management. The personnel of the disposal site is shown in the table below.

Table 15-6: Organization Structure of Landfill Operation section

Section	At present	2007	2012	2015
1. Section Chief	1	1	1	1
2. Engineer	-	1	1	1
3. Clerk	-	2	2	2
4. Truck scale operator	2	3	3	3
5. Supervisor	-	4	4	4
6. Operator	-	22	25	29
7. Worker	1	12	12	12
total	4	45	48	52

The proposed personnel for operation of the compost plant in 2007 are shown in the following table.

Table 15-7: Organizational Structure of Compost Plant

Section	Number
1. Section Chief	1
2. Clerk	1
3. Supervisor	2
4. Operator	2
5. Worker	25
Total	31

b.6 Monitoring and Information Management

Monitoring for underground water, surface water, landfill gas, noise, subsidence, fire, and odor is conducted on site regularly.

c. Siting of proposed disposal site

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

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

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

Table 15-8: Comparison of Candidates for a New Final Disposal Site

Candidate site	Descriptions
Candidate 1	• The land area is 6.5ha-10 hectares. • It is farmland (i.e. rice fields) and people are growing crops. • The land is sandy and far away (about 3,000 m) from any national road. • We have not met the landowner for price discussion. • We will spend money for access road construction.
Candidate 2	• The land area is about 10 hectares. • The villagers are already planting rice. • It is low-lying land and there is flooding in the rainy season. The road is not passable by vehicles. • We have not met the landowner for price discussion.
Candidate 3	• About 1,000 m to the village • It is farmland. 60% of the land is used by the villagers to grow rice. • There are several vacant spaces, of which the soil is sold. • It is sandy soil. • It is 17 km from Stung Mean Chey by national road No.3.
Candidate 4	• The land is not good for growing rice. • There is a concrete road from Stung Mean Chey to the intersection. It is about 1,000 m from the intersection. • The site covers about 7 hectares near the Prey Sor temple. • Far away from people's homes, does not impact the environment.

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

The four candidates for the proposed final disposal site were compared by reviewing the DPWT document and the 1997 report, studying the current land use, accessibility, soil conditions through visual observation and interviews, surrounding environment and area size. According to the comparison table (prepared based on the site reconnaissance) shown in the table above, site No.4 in Dang Kor was selected as the most appropriate site for the proposed disposal site.

15.3 Description of the DKDS Development Project

15.3.1 Location of the Dang Kor Disposal Site

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

This section presents the preliminary design and cost estimates for a new final disposal site in Dang Kor, which has been selected by the MPP to be the future location for an inter-municipal landfill. The distance from city centre to the disposal site is approximately 10 km and the site comprises an area of approximately 26 ha as shown in following figure.

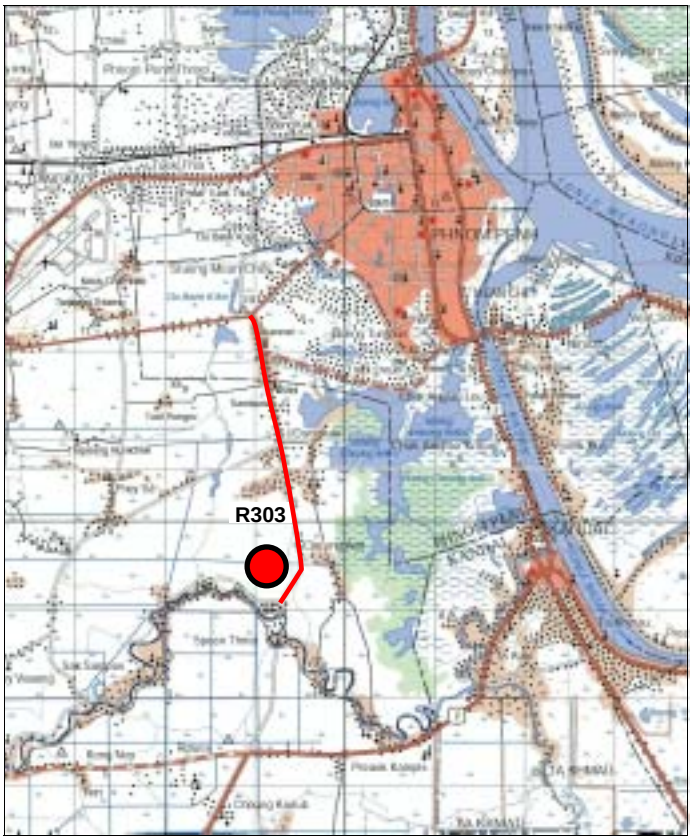


Figure 15-3: Location of Dang Kor Disposal Site

15.3.2 Conceptual design of the Dong Kor Disposal Site

The JICA study team recommended that an area of 26 ha, including the land possessed by MPP, be secured for construction of the new disposal site. Furthermore, the disposal site is to be expanded to approximately 100 ha in total in the future. According to the construction plan, the landfill area will be developed 25 ha at a time in four phases. Therefore, this can be regarded as the first stage of development.

The facilities of Dang Kor Disposal Site to be constructed in phase 1 include PPWM's head office, the landfill area, a leachate treatment pond, a compost plant, a vehicle depot, and a maintenance workshop. The site comprises an area of approximately 26 ha as shown in following figure. The conceptual design of the site is shown in the following table.

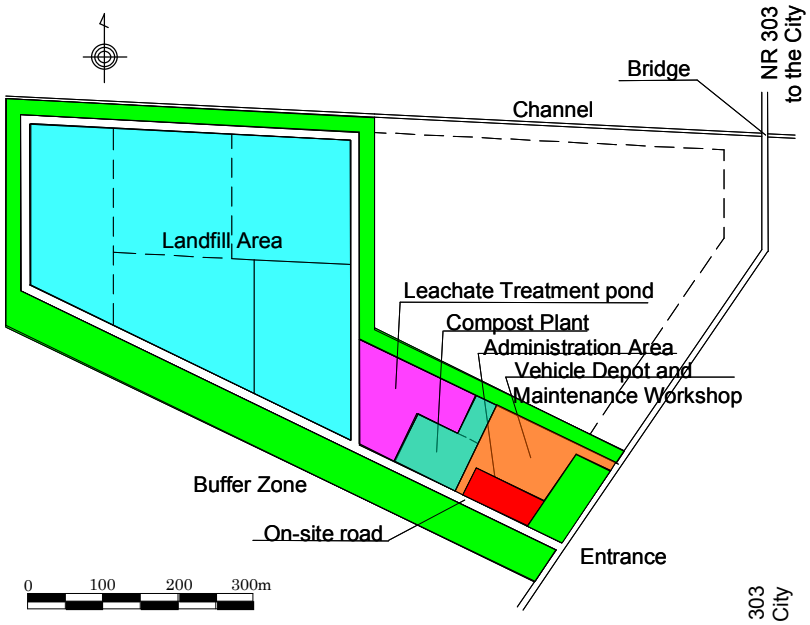


Figure 15-4: Layout plan of Dang Kor Disposal Site

Table 15-9: Conceptual Design of the Dang Kor Disposal Site (Phase 1)

Item		unit	Qty
Total area of disposal site		ha	approx. 26
Administration area			
Area		ha	approx. 0.4
PPWM head office		no.	1
Weighbridge house		no.	1
Security and safety facility	Gate	no.	1
	Fence (Fixed type)	L.S.	1
Landfill and leachate treatment facilities			
Area		ha	approx. 23.5
Extent Capacity		m3	2,300,000
Life span		years	6
Level	Level of landfill bottom	m	GL -9
	Level of landfill top	m	GL +11
Sanitary waste disposal facility	Main access road (asphalt paved)	L.S.	1
	On-site road (gravel)	L.S.	1
	Fence (Movable type)	L.S.	1
Leachate collection facility -Perforated drainage with rubble stone -Bottom layer as natural liner instead of artificial liner		L.S.	1
Leachate treatment facility -Wetland ponds + evaporation ponds (dry season) -Reservoir ponds + Recirculation facilities (wet season)		L.S.	1
Rain water drainage	Rubble stone type along the waste filling slope	L.S.	1
	Earth drain type along the road	L.S.	1
Gas ventilation facility –Perforated steel pipe with rubble stone		L.S.	1
Monitoring well		L.S.	1
Buffer zone (Green belt etc.)		L.S.	1
Compost facility			
Area		ha	approx. 0.8
Capacity		ton/day	20
Type		-	Windrow
Maintenance workshop for Heave vehicle			
Area		ha	approx. 1.2
Maintenance house		no.	1
Tire wash pit		no.	1
Parking area		L.S.	1

15.3.3 Facilities

a. Conceptual Design

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

The features of the proposed disposal site plan are as follows:

The investigation conducted on the soil of the disposal site area revealed that the permeability of the natural soil is low. The study team concluded that the existing ground could be used as a natural liner to control leakage. Therefore, it is possible to avoid the high cost of installing a plastic or rubber liner.

In order to maintain the view of the surrounding area, the height of the landfill is to be 11m. Soil will be excavated to a depth of about 9 m in order to secure a layer of low permeable soil of more than 2 m at the bottom of the disposal site. The excavated soil can be used as cover material for landfilled sections and the extra soil can be sold.

The new disposal site will be equipped with a leachate treatment system (wetland ponds and evaporation ponds), which will not discharge treated water outside the site in order to prevent environmental degradation of the surrounding area. In addition, the treatment systems include a pumping system that returns the excess leachate back to the landfill section in case the rainfall exceeds the expected maximum amount.

As already mentioned, the DKDS will be developed up to 100 ha at the end of the forth phase, and in the first phase 26 ha will be developed. An important issue of this plan is to minimize the initial investment cost and the volume of the leachate to be treated. The peripheral road of the disposal site will also be constructed in the first phase.

The landfill area is to be developed in accordance with the basic concept of mitigating the impact on the surrounding environment as much as possible.

For the administration section, PPWM's head office is to be located in the administration area.

The administration section consists of the following buildings and accessories:

- Buildings and accessories

- Entrance area (common use)
- PPWM head office
- Weighbridge house
- Safety facilities (common use): gates, fences, handrail and street lights
- Others: parking lot etc.

b. Administrative section

b.1 Layout

The Administration section is to be designed in the Dang Kor Disposal Site. The area is approximately 0.4 hectares.

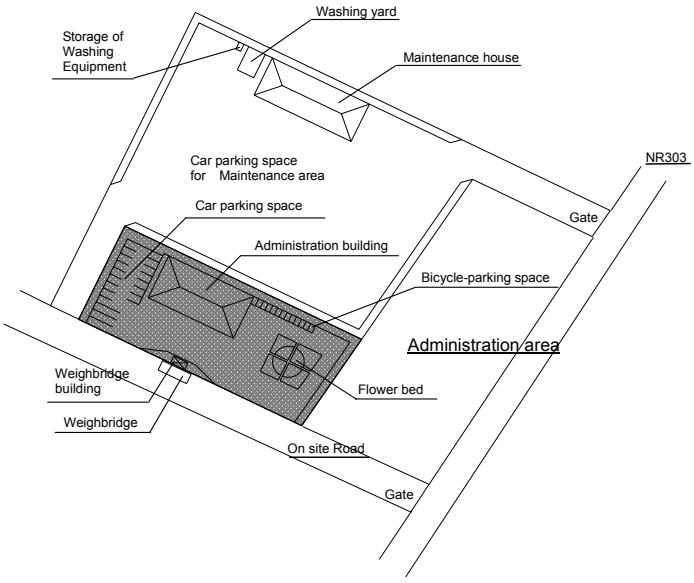


Figure 15-5: Location of the Administration Section

b.2 Cost Estimation of the Administration Section

The investment cost and schedule for the administration section are shown in Table 15-10 and Table 15-11 respectively. The cost includes the following components: the study for detailed design, facility construction and operation equipment. It should be noted that the cost for land preparation is not included.

Table 15-10: Investment Cost of the Landfill Section

Item	Cost (US$)
Facility Construction of Administration section	1,086,000
Total cost	1,086,000

Table 15-11: Investment Schedule of the Administration Section (2005-2015)

unit : US$ 1,000

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
D/D	65	44	---	---	---	---	---	---	---	---	---	109
Civil	---	1,086	---	---	---	---	---	---	---	---	---	1,086
O&M	---	---	132	132	132	132	134	134	134	137	139	1,206
Total	65	1,130	132	132	132	132	134	134	134	137	139	2,401

Note: D/D : Detailed design, Civil : Civil works, O&M: Operation and Maintenance

c. Landfill Section

c.1 Design Conditions

c.1.1. Target Operation Level of Landfilling

- Target Level : Level 4
- Requirement of Level 4

The requirements for landfill operation in level 4 are as follows:

- to prevent infiltration of leachate;
- to cover waste with soil daily;
- to screen working areas from outsiders;
- to release gas promptly;
- to minimize the leachate quantity to be discharged outside;

- to have an adequate drainage system;
- to have a proper access road; and
- to have a leachate collection and evaporation system.

Commencement of Sanitary Landfill Operation

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

Estimated Amount of Waste Disposal in the Dang Kor Disposal Site

The proposed disposal site in Dang Kor Disposal Site is designed to receive waste discharged from the following 7 Khans. The type of waste to be received will include MSW and general waste from medical institutions and factories.

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

Table 15-12: Estimated Daily Amount of Waste Disposal in the Dang Kor Disposal site

Year	All Phnom Penh (Total) (ton/day)	Description			
		MSW		Medical Waste (general waste) (ton/day)	Industrial waste (general waste) (ton/day)
		Urban area (ton/day)	Rural area (ton/day)		
2007	923.7	548.8	325.1	12.3	37.5
2008	990.0	577.3	359.7	13.1	39.9
2009	1,064.7	606.6	401.6	13.9	42.6
2010	1,140.6	636.7	443.6	14.9	45.4
2011	1,205.0	659.7	481.8	15.7	47.8
2012	1,301.2	683.1	551.1	16.5	50.5
2013	1,367.0	705.9	590.6	17.4	53.1
2014	1,437.5	728.3	635.0	18.3	55.9
2015	1,539.7	751.4	710.0	19.3	59.0

c.1.2. Required Capacity of Landfill Sections

The final disposal site in phase 1 is designed to receive waste for a period of six years from 2007 to 2012.

The estimated annual amounts of waste disposed of in the Dang Kor Disposal site are presented in the following table.

Table 15-13: Estimated Annual Amount of Waste Disposal in Dang Kor Disposal site

Year	Waste Disposal		
	Annual Total (ton/year)	Accumulate Amount (ton)	Phase
2007	337,151	337,151	Phase 1
2008	361,350	698,501	
2009	388,616	1,087,117	
2010	416,319	1,503,436	
2011	439,825	1,943,261	
2012	474,938	2,418,199	
2013	498,955	2,917,154	Phase 2
2014	524,688	3,441,842	
2015	561,991	4,003,833	

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

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

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

- The required amount of soil for covering the waste dumped daily is 10 % of the waste dumped in volume, excluding it for final cover.
- The unit weight of the waste just after dumped in a landfill is 0.5 ton/m^3.
- The unit weight of waste in a stable (i.e. after half a year) state after filling is 0.8 tons/m^3.
- The water content of waste when discharged is 68.3wt% (according to WACS study), the content of decomposable matter is 24.2wt%, non-decomposable matter is 7.5wt% and when in a stable state it is 50wt%
- The decomposition rate of organic material is 10%.
- Therefore, if the weight of the waste just after discharged in a landfill is 1 ton, the waste weight after half a year which is calculated in accordance with the above mentioned condition is 0.586 ton.

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

Table 15-14: Required Capacity of Landfill

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

c.2 Preliminary Design

c.2.1. Landfill Capacity

The landfill capacity of the proposed landfill site is designed to be 2,300,000 m^3 as wastes to be processed at this site in 2007.

c.2.2. Working Time

The work schedule of the site is as follows.

- The proposed plant operates 365 days a year.
- Mondays – Sundays: 4:00 - 22:00 (18 hour/day).

c.3 Design of Facilities of Landfill

c.3.1. Main facilities of landfill facilities

The proposed landfill site is planned to be composed of the following facilities. The landfill section comprises an area of approximately 13 ha.

- Main Facilities

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

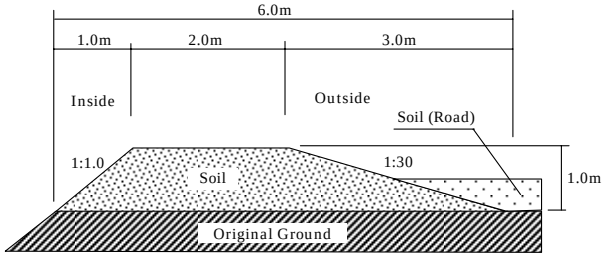
- Environmental protection facilities

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

Enclosing Bank Structure

The role of the enclosing bank provided, which is banked with earth around the filling area, is to prevent seepage of rainwater and leachate and to store dumped waste stably. The dimensions of the enclosing structure are set as follows.

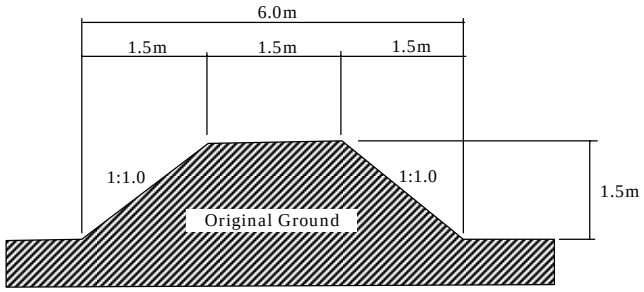
- Gradient of slope: 1 in 3.0 for outside the site
  1 in 1.0 for inside the site
- Crest of bank: 2.0m
- Height of bank: 1.0m
- Material of bank structure: Soil



Divider

The role of the divider, which is made of soil and provided inside an enclosing dike, is to reduce the quantity of leachate by blocking rain water and to separate the working face for landfill work. The dimensions of the divider structure are set as follows.

- Gradient of slope: 1 in 1.5
- Crest of dike: 1.5m
- Height of dike: 1.5m
- Material of dike structure: Original Ground

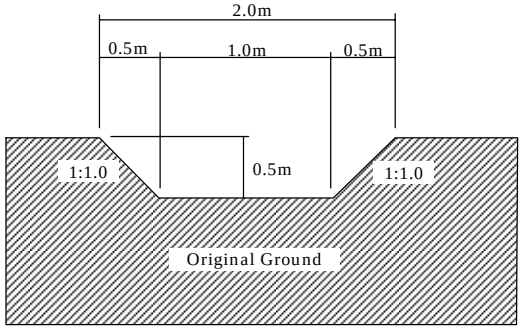


Drainage System (Open site drain)

The drainage system has a very important role in maintaining the site and peripheral roads in good condition and also to minimize the influx of rainwater to leachate control facilities.

The side drain is generally provided around the landfill to intercept all the runoff water from the landfill area and to remove the fluid from the site. The dimensions of side drain are as follows.

- Top Width: 2.0m
- Bottem width: 1.0m
- Gradicnt of slope: 1 in 1
- Depth: 0.5m
- Surface of drain: No lining

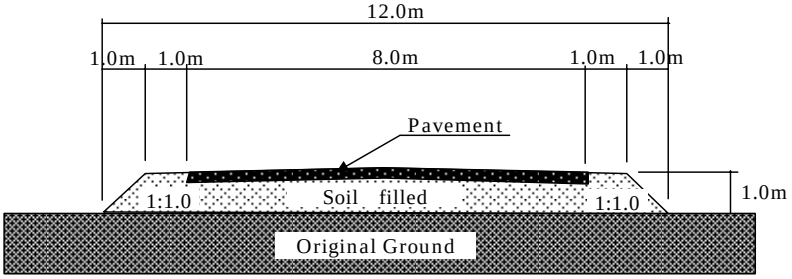


Access

(1) Main Approach Road

The asphalt paved road is provided at the entrance of the landfill site so that the waste collection vehicles can enter and leave the site without disturbing the public traffic. In addition, the road from the entrance to the landfill section is planned to be paved with asphalt for the Dang Kor Disposal Site because this segment of the road is expected to be used for more than 20 years. The dimensions of the approach roads are shown below.

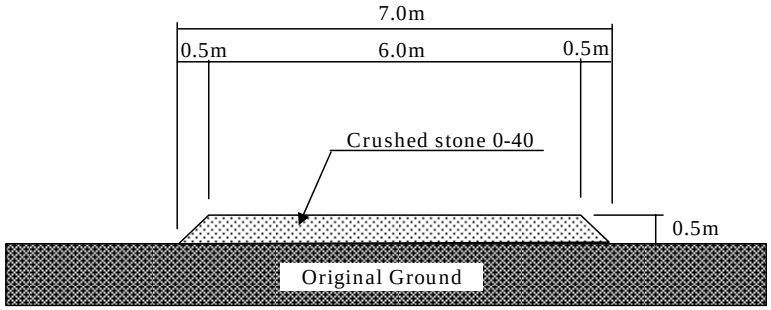
- Carriageway width: 8.0m
- Shoulder width: 1.0m both sides
- 3 paved layer in the carriage way



(2) On-site Road

The on-site road is a road for landfill works provided in the site. The dimensions of the on-site roads are shown below.

- Thickness of paved road: 0.5m
- Width of raved road: 6.0m
- Material: Crushed stone 0-40



c.3.2. Environmental Protection Facilities

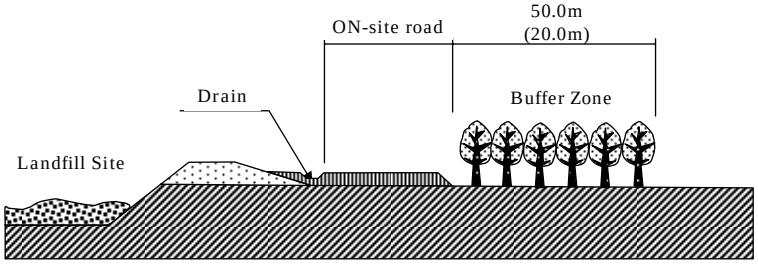
The environmental protection facilities are provided to prevent primary and secondary pollution outbreaks during and after completion of landfill operations.

Buffer Zone (Green belts etc.)

A buffer zone is provided between the disposal site and outside areas for the purpose of:

- screening the landfill site from outside,
- reducing the noise and vibrations emitted during landfilling operation,
- balancing the site with the natural surroundings in a harmonious fashion.

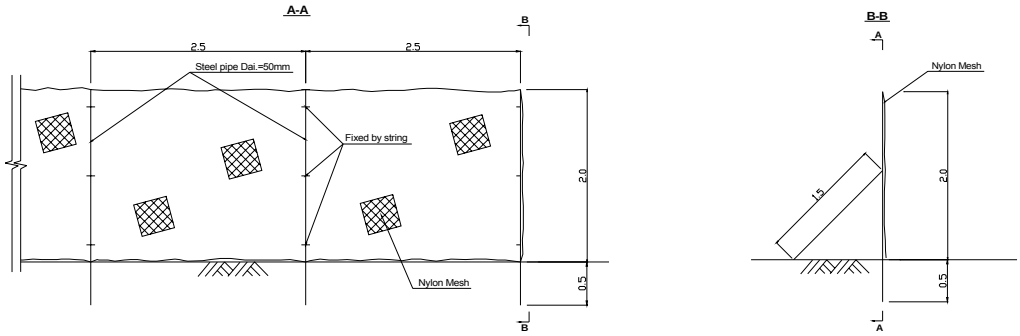
The buffer zone is formed with a green belt made of plants and its width is 20-50 m. A 50 m buffer zone will be established along the national road and adjacent to residential areas. The side that is to be expanded in the future will have a 20 m buffer zone. The density of trees should be approximately 500 trees per hector.



Litter Scattering Prevention Facilities

Litter scattering during landfill operation, before the waste is covered with soil, will be inevitable. Therefore, as a means of prevention, a temporary fence made of materials available locally like wood, and with nets to catch flying litter is constructed.

- Height: 2.0m
- Material of post: Steel pile
- Distribution density: The landfill working face shall closed with nets



Gas Removal Facilities

For the organic matter present during landfilling operations, microbial decomposition occurs and results in the production of water, gas and inorganic chlorides. If the landfill structure houses aerobic matters, this gives rise to aerobic bacterial activity. Therefore, decomposition is fast; carbon dioxide, water, ammonia etc. are produced, without a problem. On the other hand, if the structure houses anaerobic matter, this gives rise to anaerobic bacterial activity with slow decomposition; thus, odors and combustible gases, such as methane, carbon dioxide, hydrogen sulfide and ammonia, badly affect the environment.

Generally, as for the outbreak of gas in landfill sites, gushing and exhausting are common at weak points on the boundary surface between the landfill site and surrounding structures. Disaster prevention measures, which are represented by gas removal facilities, are necessary at points where gas pockets burst unexpectedly and thus produce fires, odors, etc.

As for gas removal facilities, there are three types under consideration: by evacuation, by pumping and by ventilation. Within these designs, the most economical gas removal facility, the one by evacuation, has been selected.

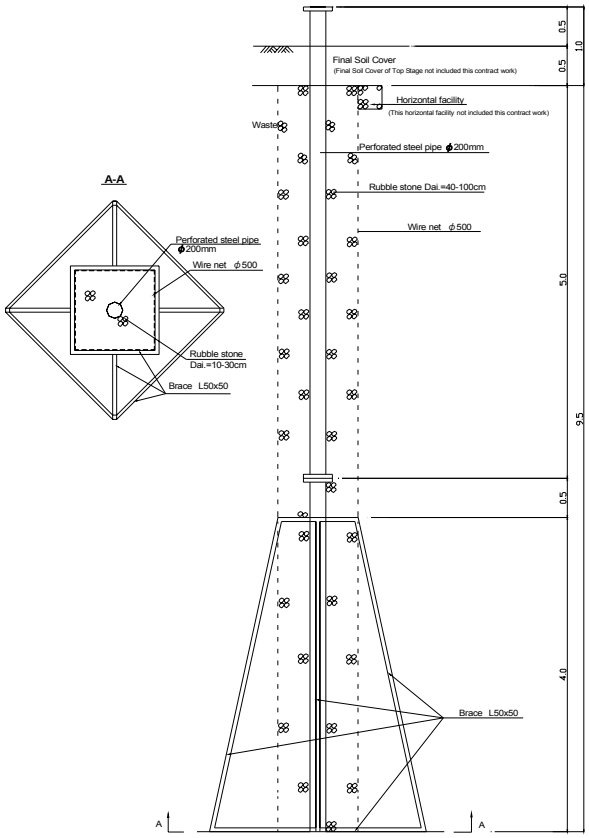
The completed landfill site gas removal facilities have been designed at 1 position per 1,000m^2. As for disaster prevention measures, the gas removal facilities make counteraction quite possible. However, the covering material is the most important factor, as it is necessary to not leave waste exposed over a long time.

(1) Vertical Gas Removal

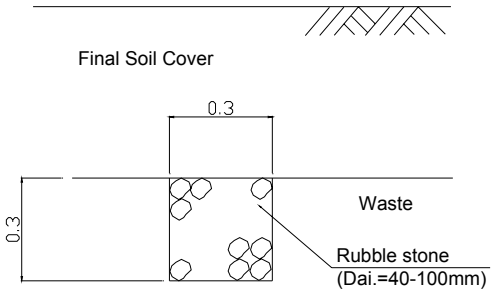
Before starting the filling of waste, 5 meters of the vertical gas removal system is constructed and is extended as the waste is filled. After completion of filling the waste the vertical gas removal pipe extends above ground to exhaust the gas. The structure is shown below.

(2) Horizontal Gas Removal

Before starting the filling of waste, the horizontal gas removal system is constructed. The structure is shown below.



Vertical Gas Removal



Horizontal Gas Removal

Leachate Collection Facilities

The purpose of leachate collection facilities is to collect only contaminated water with waste and decomposed polluted water, and carry it to the leachate treatment facilities without allowing it to infiltrate the ground.

The facility ordinary consists of the following components.

- A low permeable bottom liner
- A leachate collection pipe network

(1) Low permeability of bottom liner

The permeability of the bottom liner must be sufficiently low in order to protect groundwater from infiltration of leachate into the ground. However, the provision of an artificial liner is always the largest conflict in the construction cost. The best solution is, therefore, the full utilization of the natural conditions. In order to examine whether the natural ground can be utilized for the low permeable layer for the landfill site, a geological survey was conducted at the site from October to December 2003 in the Study. The result of geological survey is as follows. (refer to Appendix)

1) Although the 4 m section directly below the ground surface contains a fine sand layer with a thickness of 0.8 m- 3.2 m, the ground generally consists of clay soil with a permeability of 10^{-8} m/sec.

2) The deeper section contains a sand layer at a depth of approximately 11 m.

Although the 4m layer directly below the ground surface has the required permeability for the landfill site, it may crack due to the construction work. Therefore, the underlying section

should be used as the impermeable layer of the site. However, the upper sand layer needs to be covered with bottom clay soil of low permeability as shown in the diagram.

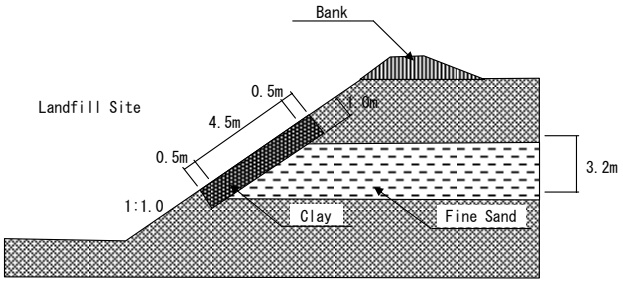


Figure 15-6: Structure of Soil condition

(2) Leachate collection pipe net work

- Horizontal leachate collection

The purpose of a horizontal leachate collection facility, which is installed on the bottom of a disposal site, is to collect leachate and to drain it out quickly. In this plan, two types of horizontal leachate collection facilities were adopted depending on the flow capacity.

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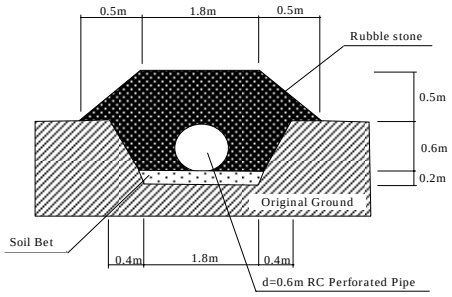

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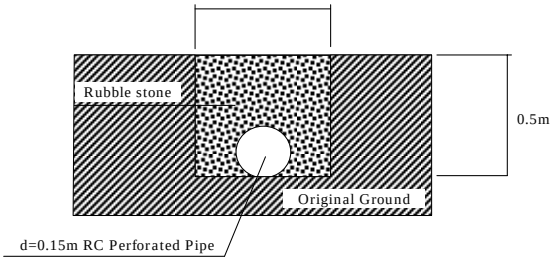


- Vertical leachate collection

The purpose of a vertical leachate collection facility is to quickly drain contaminated water contained in the waste layer downwards. In this plan, the vertical gas removal facility is also utilized as the vertical leachate collection facility.

Monitoring Well

To confirm whether leachate has contaminated groundwater resources, monitoring wells approximately 15m deep with a diameter of more than 80mm will be installed in the site.

Final Soil Cover

After waste filling is completed, soil having certain thickness should be filled on the top of landfill so that the land can be utilized for other purposes without any impact by waste dumped. Although the required thickness of the final soil cover depends on the ultimate use, in this design the thickness of final cover of soil was assumed to be 50 cm.

Soil for coverage was planned to be obtained within the Dang Kor Disposal Site.

c.3.3. Building and Accessories

These facilities include a PPWM head office, a weighbridge, safety facilities, fire prevention facilities, a storage building, monitoring facilities, a car wash, etc.

The facilities are to be shared by the maintenance work shop and compost facility.

Entrance area

The entrance area starts from the approach road to the PPWM head office. It has an area of 0.4 ha and is paved with asphalt.

Site Office

The site office shall have a control room and facilities for staff and management.

The control room shall be constructed and equipped with facilities that enable easy control and registration of incoming vehicles. The computerized weighbridge system enables detailed registration, which is indispensable for appropriate SWM.

The facilities are as follows;

- a staff office
- a control room furnished with a computer for the weighbridge.
- a changing room
- toilets and showers
- cooking facilities
- a storeroom

Weighbridge

A weighbridge shall be constructed on weighing cells in a concrete structure. The recorded weight of a full vehicle will be transmitted to the computer in the site office. The capacity of the weighbridge shall be 60tons.

As for the weighbridge to be constructed at the poposed disposal site, the weighbridge at the SMC disposal site which is constructed in June 2003, is to be relocated to the proposed disposal site.

Tire Washing Pit

The waste collection vehicles should pass the tire washing pit before leaving the site to avoid carrying the dirt back into the city. The pit should be of a concrete structure.

Gate

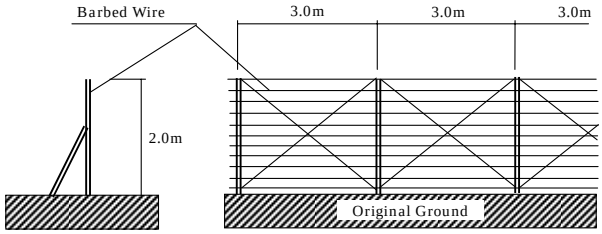
An 8m wide gate should be installed at the entrance of the site.

Fence

Fencing is necessary to control the disposal site properly for the following reasons:

- to control waste pickers, outsiders, etc.
- to protect the equipment, spare parts, etc.
- to protect the disposal site from illegal dumping

The dimension of the proposed fence is as follows:



Parking for Heavy Vehicles

The parking area for heavy vehicles should be mainly for heavy equipment for landfill operation. This area should also be available for the waste collection vehicles.

Power supply and water supply

A power supply should be installed at the entrance area, site office, weighbridge, maintenance workshop, compost plant, etc. Wells are to be constructed on-site to supply water. A water supply should be installed at the site office, maintenance workshop, compost pant, tire washing pit. etc.

c.3.4. Design and supervision

Prior to the commencement of constructing the disposal site, a detailed design study including investigation of site conditions has to be carried out. During construction of the site, supervision work has to be carried out to maintain the required quality of work.

c.4 Operation and Maintenance Plan

c.4.1. Landfill Plan

Basic Policy

The following basic policies were sustained for the preparation of the landfill plan:

- to spread and compact solid waste sufficiently;
- to minimize scattering of solid waste;
- to minimize the diffusion of offensive odor; and
- to stabilize wastes as early as possible.

Compaction of solid waste is necessary to prolong the service life of the landfill site, which is also helpful in reducing settlement after the completion of the landfill. Furthermore, the prevention of solid wastes scattering and diffusion of offensive odor is required in order to conserve the surrounding environment. In order to use the completed landfill site for other purposes, such as recreational or agricultural, early stabilization is necessary during landfill operation.

Landfill Structure

The improved semi-aerobic sanitary landfill method was adopted for the landfill structure.

Landfill Method

The landfill methods are divided into three types; open dumping, sandwich and cell method. The open dumping method cannot abate offensive odors, the generation of disease vectors and noxious insects and does not compact waste well either.

With the sandwich method, soil is spread to cover solid wastes filled horizontally. If the landfill site is narrow, this method is effective, but if the site is big, solid waste is left uncovered for a couple days, resulting in the generation of offensive odors, etc.

With the cell method, soil is spread daily or weekly to cover solid waste dumped. Through this method, a highly compacted landfill can be obtained and this prevents the scattering of solid waste, the generation of offensive odor and the breeding of disease vectors and noxious insects. Therefore, the cell method should be applied.

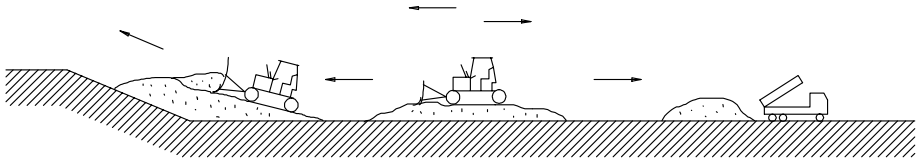


Figure 15-7: Conception of Landfill Operation

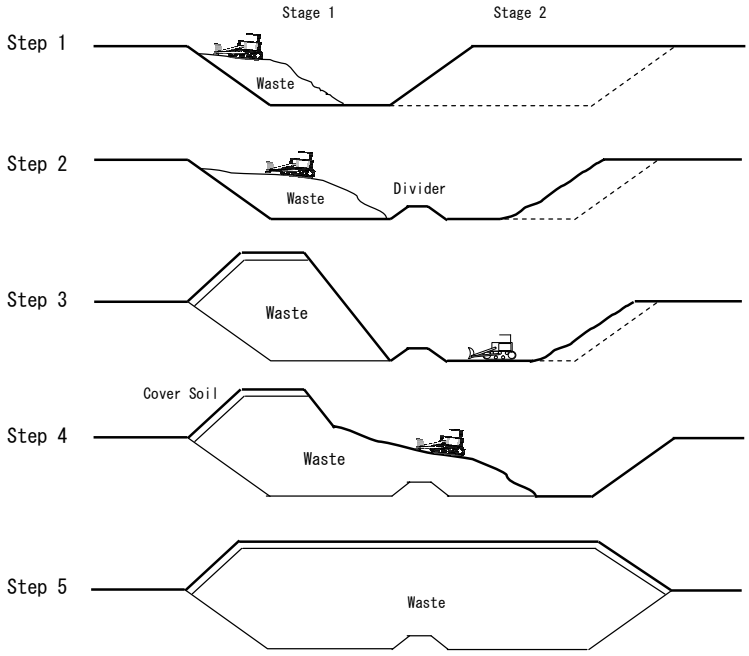


Figure 15-8: Each Step of Landfill Operation

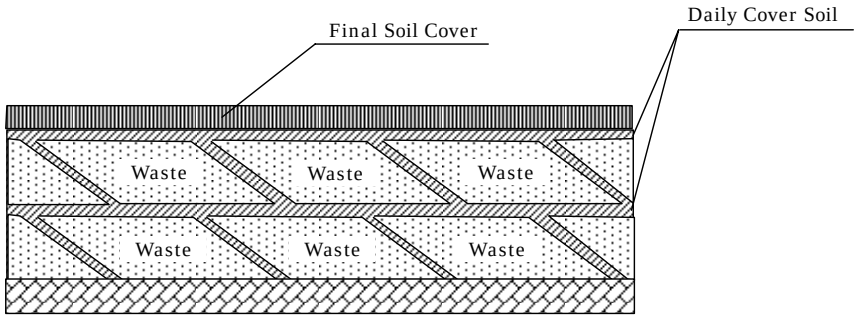
Cover Soil

Cover soil is to be placed as in the method shown above and the thickness of each layer is as follows:

- daily or weekly covering soil: 15 cm
- final covering soil: 50 cm (depending on the ultimate use)

Accordingly, the ratio of cover soil to the disposal volume of waste will be 10 %, excluding final covering soil.

Soil for coverage was planned to be obtained within the Dang Kor Disposal site because its area is large enough.



c.4.2. Equipment Planning

Planning Conditions

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

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

Equipment Selection

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

	Equipment	Specification	Quantity	unit
1	Bulldozer	21ton	4	nos
2	Wheel loader	1.2m^3	1	nos
3	Water Tank truck	6,000 liter	1	nos
4	Dump truck	11 ton	2	nos
5	Pickup truck	4WD	2	nos
6	Excavator	0.7m^3	2	nos

c.4.3. Landfill Operations

The landfill operations are outlined below.

- Waste is dumped directed by the landfill operation staff.
- The dumped waste is spread, crushed, leveled and compacted by bulldozers.
- The covering operations after the landfill operations will be performed daily or weekly using the cell method.
- A second layer will be laid on the first in the same manner, extending to the divider.
- Covering material will be laid on top of the second layer of landfill.
- A divider as well as gas and leachate removal facilities will be constructed in the adjacent area for the next landfill operations.

c.4.4. Monitoring Plan

During construction, operation and closure stage, regular monitoring is to be conducted on the items shown in the table below. The monitoring locations are shown in the following figure.

Table 15-15: Monitoring plan of the Dang Kor Disposal Site

Items	Facility and equipment	Measuring Items	Stage		
			construction	Operation	Closure
Underground Water	Monitoring well	Electric conductivity, Cl^-, pH		√	
Surface Water	Water sampling	Electric conductivity, Cl^-, pH		√	√
Landfill gas	Gas removal pipe	CH_4, CO_2, H_2O, Temperature		√	√
Noise	Noise level meter	Odor, Noise	√	√	
Settlement	Settlement board	Settlement level		√	√
Landfill fire	Personal check,	Landfill fire		√	√
Offensive odor	Personal check,	Offensive odor		√	√

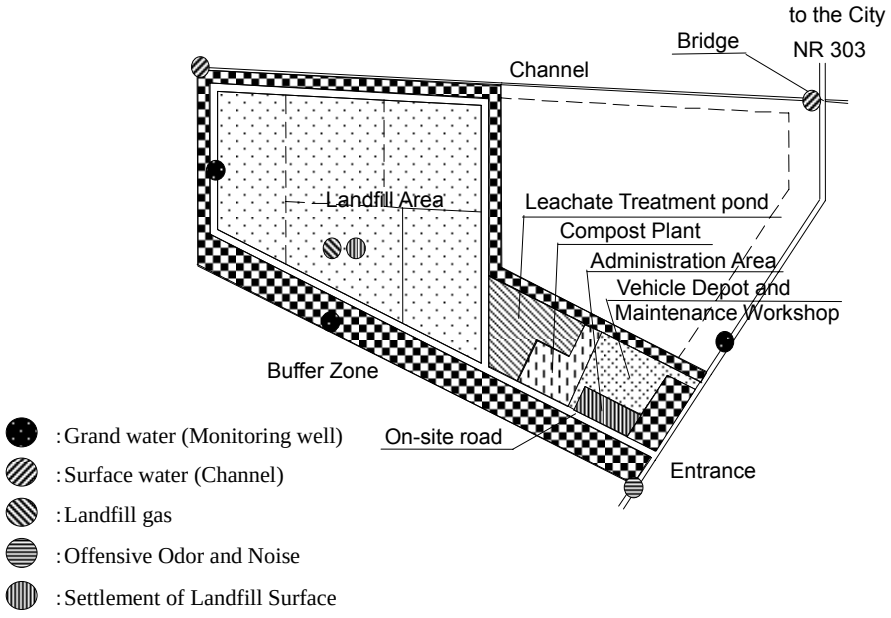


Figure 15-9: Location of Monitoring Plan

c.4.5. Personnel Plan

Organization structure

The organization structure for the operation of the Dang Kor Disposal Site in 2007 is proposed as shown in following table. The stuff will consist of PPWM stuff and new employment such as landowners who will loss their agricultural income.

Table 15-16: Organization Structure of Landfill Operation section in 2007

Landfill Operation section	Section chief	1 person
	Engineer	1 person
	Clerk (include Weighbridge staff)	5 person
	Supervisor	4 person
	Operator	22 person
	Worker	12 person
Total		45 person

c.5 Cost Estimation of the Landfill Section

The investment cost and schedule for the landfill section are shown in Table 15-17 and Table 15-18 respectively. The cost has two components: facility construction and operation equipment. It should be noted that the cost for land preparation is not included. The table also includes the cost of leachate treatment facilities which are mentioned in the next section.

Table 15-17: Investment Cost of the Landfill section

Item	Cost (US$)
Facility Construction of Landfill Section	5,051,000
Equipment (Machine and V&E)	1,341,000
Total cost	6,392,000

Note: V&E : Vehicles and Equipment

Table 15-18: Investment Schedule of the Compost Plant (2005-2015)

unit : US$ 1,000

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
D/D	303	202	---	---	---	---	122	81	---	---	---	708
Civil	---	5,051	---	---	---	---	---	2,032	---	---	---	7,083
V&E	---	1,341	---	---	---	175	---	---	1,724	---	---	3,240
O&M	---	---	398	398	398	398	427	427	427	442	561	3,876
Total	303	6,594	398	398	398	573	549	2,540	2,151	442	561	14,907

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

d. Leachate Treatment Section

d.1 Examination of Technical Alternative

d.1.1. Leachate Treatment Process

The selection of the most suitable leachate treatment system for the site is very important in the project planning because there are many available systems which have different advantages and disadvantages. The following two points are mainly considered in the selection of the system.

- - Required operation and maintenance cost
- - Required technical skill for the operation

The leachate treatment methods are compared in the following table.

As you can see, the evaporation method is the most suitable system for the Dong Kor disposal site, as the operation and maintenance cost is low and it is easy to operate. As Phnom Penh has both rainy and dry seasons, the evaporation method is to be combined with the wetland method and recirculation method. Furthermore, as the residents living the downstream of Prek Thnot river are drinking this river water, if the leachate is discharged into the river, required water quality is very high and it is very difficult to clear it. Therefore, in order not to discharge the leachate, the evaporation method is the most suitable system for the Dong Kor disposal site

Table 15-19: Comparison of Leachate Treatment Method for the Dang Kor Disposal Site

	Activated Sludge system	Aerobic Pond Systems	Rotating Disk Contactor System	Recirculation System	Evaporation System and wetland
Description	The activated process is a continuous-flow, aerobic biological process for the treatment of domestic and biodegradable industrial wastewaters. The process provides a high-quality effluent and is characterized by the suspension of microorganisms, which are maintained in a relatively homogeneous state with the wastewater by mixing induced by the aeration system. The overall treatment process will include preliminary, and often primary, treatment before the aeration basin(s). The mixed liquor is discharged to a secondary clarifier where the microorganisms settle out and are recycled to the aeration basin. Excess sludge is piped to separate sludge-handling processes. The clarifier overflow proceeds to disinfection and final discharge or to supplemental treatment, if required.	Historically, aerobic wastewater stabilization pond systems have been a principal biological treatment method for a variety of wastewaters ranging from residential domestic to complex industrial. They may be used alone or in combination with other treatment processes. The advent of aeration via mechanical sources added yet a broader use of pond systems. The three principle types of aerobic ponds are 1. Aerobic 2. Facultative 3. Aerated Furthermore, pond systems are characterized hydraulically as discharge, controlled discharge or retention (no discharge to surface waters).	A rotating biological contactor (RBC) is an attached-growth process wherein the media are rotated through a basin of wastewater. The microorganisms are attached to large-diameter synthetic mounted on a horizontal shaft and placed at about 40% submergence in a contoured-bottom tank. Generally, the media are some 10 to 12 ft (3-3.5 m) in diameter and rotate at a peripheral velocity of 60 ft/min (0.3 m/s). The preferred temperature range for an RBC system is 55 to 90°F (13 to 32°C). Thus, in colder climates the units are enclosed for climatic control.	The process of recirculation is as follows. 1. Leachate collection by perforated pipe at the landfill site 2. Retention of leachate at a pond 3. Pumping up leachate for landfill site 4. Distribution of leachate at the landfill site The leachate is treated by contacting with waste and evaporated through the recirculation process. Advantages: 1. The process of landfill stabilisation is accelerated 2. The constituents of the leachate are attenuated by biological, chemical and physical changes occurring with the landfill. Disadvantages: 1. Not applicable for the area having low evaporation 2. Poor operation makes the disposal area muddy and inaccessible.	This system is adopted in areas with high evapotranspiration and relatively little rainfall. The greatest feature of the evaporation method is that waste water is not generated、However, treatment by evaporation requires a large land area and is not effective in projects with small sites. In regard to technical aspects, to use the site effectively, it is necessary to consider the distribution of drainage. To improve the efficiency of wetland treatment, the treated water can be recirculated. When adopting the wetland system, it is also necessary to conduct thorough studies on vegetation in the area surrounding the facilities. The wetland method can be easily combined with the evaporation method. The BOD and TSS in the waste water is treated by the wetland method、and the treated water is treated by evaporation.
Required technical skill for operation	High degree of technical skill required.	A simple technical skill required.	A simple technical skill is required.	A simple technical skill is required.	A very simple technical skill required.
O&M cost	Very expensive	Cheap	Expensive (material can not obtain in Sri Lanka)	Cheap	Cheap
Area	Enough for the facility.	Enough for the facility.	Enough for the facility.	Enough for the facility.	Enough for the facility.
Evaluation of treatment	It is too difficult for PPWM to operate the treatment facility with a high degree of technical skill due to lack of engineer. In addition the required O&M cost is too expensive	To maintain aerobic ponds, it is necessary to construct an aeration device, which increases the O&M cost.	It is difficult for PPWM to maintain the treatment facility because rotated disk can not obtained in Cambodia, when it is required to replace.	Recirculation system is suitable at Dang Kor due to quite high evaporation and low precipitation.	O&M cost is very cheap and operation technology is simple. Therefore it is easy to operate and maintained the system with technical knowledge.
Result	Not suitable	Not suitable	Not suitable	Suitable	Very suitable

d.1.2. Description of Proposed Leachate Treatment Process

All the leachate from Dang Kor Disposal site is to be treated on site year-round and will not be discharged outside the site. The leachate treatment process will vary in the wet and dry seasons as described below. The systems are comprised of the same facilities although referred to by different names.

Dry season : When the leachate quantity is small, it is to be treated with subsurface flow wetland ponds and evaporation ponds. Any overflow of treated leachate is to be returned to the regulation pond by recirculation pump.

Wet season : If the quantity of leachate exceeds the capacity of the wetland ponds, the wetland ponds and evaporation ponds are to be used as reservoir ponds. In case the leachate exceeds the expected amount, an emergency line is to be constructed to return excess leachate to the landfill site via the overflow pit.

The flow sheet of the leachate treatment facilities is shown in the following diagram.

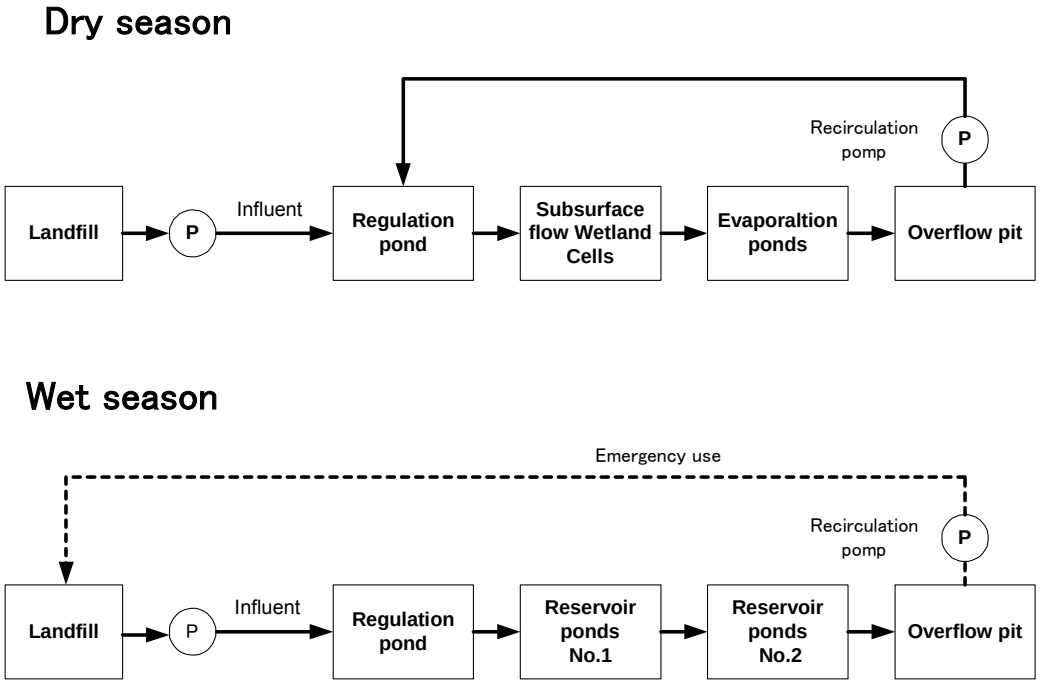


Figure 15-10: Flow sheet of Leachate Treatment Facilities

d.2 Preliminary Design

d.2.1. Layout

The leachate treatment facility is to be designed at the Dang Kor Disposal Site. The area is approximately 0.8 hectares.

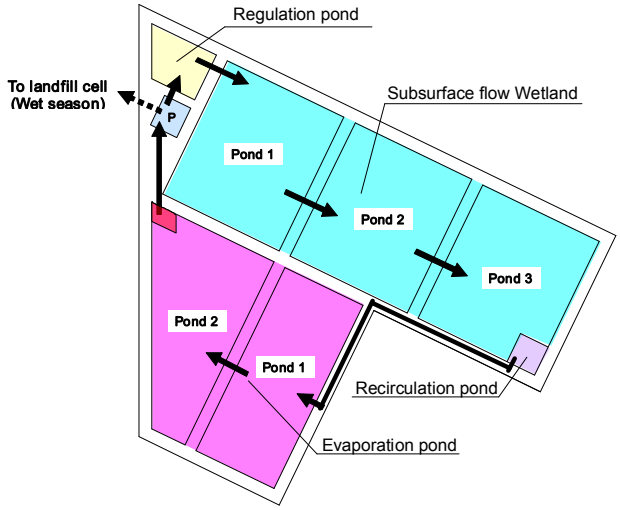


Figure 15-11: Layout of the Leachate Treatment Facility

d.2.2. Precipitation and Evaporation

The following table presents monthly values and annual values for average precipitation and evaporation. At the sanitary landfill, the average annual precipitation and evaporation is 1,721 mm/year and 1,560 mm/year respectively.

Table 15-20: Average Precipitation and Evaporation

unit : mm/month

month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Precipitation	65.5	4.4	67.5	69.1	134.8	178.0	183.0	171.8	228.3	385.0	110.3	122.8	1,721
Average Evaporation	126	146	179	177	146	131	115	108	100	96	110	126	1,560
Precipitation – Evaporation	-60.5	-141.6	-111.5	-107.9	-11.2	47	68	63.8	128.3	289	0.3	-3.2	160.5

Source: Department of Meteorology, Office of Climate, Station Pochentong

d.2.3. Calculation of Leachate Quantity

The landfill area is divided into five sections. Rainwater from the landfill sections that have not been filled is to be drained by a system other than the leachate collection pipe network. Therefore, the leachate quantity will be at a maximum in the final stage of landfill operation when four of the five landfill areas are complete.

The leachate quantity at that time will be determined by the following equation:

$$V = A1 \times L + A2 \times (L \times (1- Lr) – E \times - Er))$$

where ;
V : Leachate quantity (m^3/day)
A1 : Area of the completed landfill (ha)
A2 : Area of the operating landfill (ha)
L : Precipitation (m/day)
Lr : Runoff rate (= 70%)
E : Evaporation (m/day)
Er : Evaporation rate (=70%)

The leachate quantity calculated using the average precipitation and evaporation of each month is shown in the following table. The results show that leachate is generated only in the wet seasons in July, September and October. Although leachate is also generated by

compaction immediately after the waste is filled, that will be covered by the leachate treatment facility design.

Table 15-21: Leachate quantity of phase1 landfill site

month	Leachate quantity		month	Leachate quantity	
	m^3/day	m^3/month		m^3/day	m^3/month
Jan.	-261	-	Jul	2	62
Feb	-452	-	Aug	-14	-
Mar	-401	-	Sep	138	4,140
Apr	-399	-	Oct	421	13,051
May	-182	-	Nov	-127	-
Jun	-63	-	Dec	-147	-

d.2.4. Leachate Evaporation Facilities

The Dang Kor Disposal site will be equipped with a leachate treatment system that does not discharge treated waste outside the site. All leachate is to be collected in a regulation pond and conveyed to evaporation ponds for treatment. In case the rainfall exceeds the expected amount, a pump system will be installed to return the leachate to the evaporation ponds.

The leachate evaporation system consists of:

- A regulation pond

This is to hold leachate temporarily. The leachate quantity fluctuates, depending highly on rainfall; the capacity of the pond should be big enough to hold 7 days worth of liquid during the wettest month.

- Evaporation ponds (include wetland method)

The leachate from the regulation pond is to be conveyed to the evaporation ponds through drains placed in several locations. The sludge that accumulates in the regulation pond and evaporation ponds is to be removed in the dry season.

- A recirculation system

The recirculation system consists of a water pump and pipe for returing leachate to the landfill section in times of very heavy rainfall.

d.2.5. Calculation of Leachate Reservoir Volume

As adequate evaporation is not expected in the wet season, the plan will take into consideration a leachate reservoir. The reservoir volume is to cover the total amount of leachate generated in September and October. The margin of safety ratio shall be 1.2.

Reservoir Volume (m^3) = (4,140 + 13,051) x 1.2 = 20,630 m^3

d.2.6. Effluent Standards

The effluent standards for leachate generated from waste recycling plants and disposal areas are set in Cambodia. Please refer in the section “Description of Environmental resources”.

e. Compost section

e.1 Conceptual Design of the Compost Plant

e.1.1. Examination of Technical Alternative

Composition of Compostable Waste

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

- Foreign materials (non-compostable wastes) in the compostable wastes account for 10%.
- According to the result of the WACS, the moisture content of market waste was 64.4 %. Therefore, the moisture content of the market waste for this plan was assumed to be 65%.

Table 15-22: Composition of the Compostable Waste

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

(1) Compost Process

There are basically two types of composting processes for the organic fraction of municipal solid wastes: the “aerobic process” (the so-called compost plant) and the “anaerobic process” (in general terms, a biogas plant). The following table shows the comparison of the two processes.

Table 15-23: Comparison of Aerobic and Anaerobic Composting for Organic Fraction of MSW

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

Source: Integrated Solid Waste Management, McGraw-Hill

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

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

(2) Selection of Composting System

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

- The construction and operation cost is low.

- Both the two existing compost plants in MPP adopted this system, which proves the acceptability of this system.

Four composting methods are compared in the table below.

Table 15-24: Comparison of Composting Method

	Minimal technology windrow	High-rate windrow	Static pile	In-vessel
Outline	The minimal windrow technology approach involves forming large windrows (e.g. around 3.5m high by 7.3m wide) that are turned only once a year with a front-end loader.	A high-rate windrow composting system employs windrows with smaller cross sections, typically 1.5 to 2.0 m high by 4 to 5m wide. The actual dimensions of the windrows depend on the type of equipment that will be used to turn the composting waste. Waste is turned twice per week while the temperature is maintained at around 55 Centigrade.	An aerated static pile system consists of a grid of aeration or exhaust piping over which the processed organic fraction of MSW is placed. Typical pile heights are 2 to 2.5 m. A layer of screened compost is often placed on top of the newly formed pile for insulation and odor control.	In-vessel composting contains an enclosed container vessel inside. The system can be divided into two major categories: plug flow and dynamic (agitated bed). In the plug flow system, the relationship between particles in the composting mass stays the same throughout the process, and system operates on first-in, first-out principle. In the dynamic system, the composting material is mixed mechanically during the processing.
Odors	Probably emit objectionable odors	Often release offensive odors (accompanied turning)	Controllable	Less than static pile and controllable
Degradation period	Three to five weeks	Three to four weeks (composting) Three to four months (curing)	Three to four weeks (composting) Three to four months (curing)	One to two weeks (composting) Four to twelve weeks (curing)
Required area	Very large	Large	Large	Small
Construction cost	Very cheap	Cheap	Intermediate	High
O & M cost	Very cheap	Cheap	Intermediate	High

(3) Non-compostable Material Mixed in the Raw Materials

It is propsed that the following pre-treatment system be adapted, based on the analysis of the COMPED plant and the production process of the windrow system.

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

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

(4) Size Reduction

The compostable waste discharged from markets contains hardly any large-sized items mixed in such as general household yard waste. PPWM will also instruct all shops at markets to reduce the size of waste when separating it for collection. For such reasons, large sized items can be sorted out manually and the installation of machines for size reduction will not be necessary.

(5) Pre-treatment Process

The proposed composting plant needs a pre-treatment process for the following reasons:

- The raw materials separated at the source as compostables can still contain non-compostable materials. To prevent product quality deterioration, they should

be removed. The removal method may allow material recovery from the removed materials.

- Size reduction will result in a larger surface area of waste fractions. The larger the surface area is, the more oxygen can be supplied, and aerobic decomposition is facilitated.

Screening Section

The proposed compost plant is planned to be equipped with the following separators:

- trommel screen (size separation for raw compost and mature compost)
- ballistic inertial separator (density separation for small glass cullet and gravel)

e.1.2. Preliminary Design

Location

The compost plant is to be designed in the Dang Kor Disposal Site. The area is about 0.8 hectares.

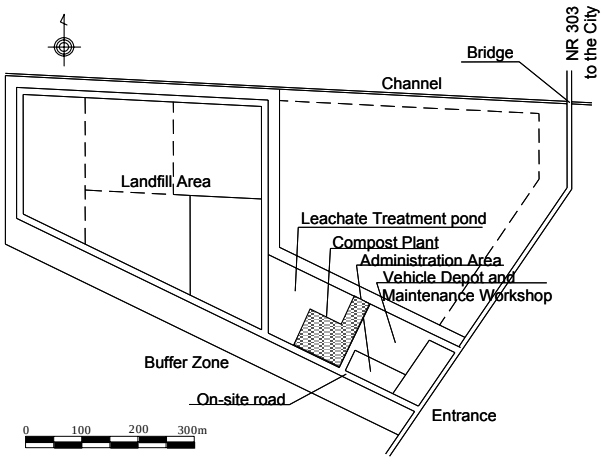


Figure 15-12: Location of the Compost plant

Treatment Capacity

The treatment capacity of the proposed compost plant is designed to be 20 tons/day as the compostable wastes to be processed at this plant in 2007, the target year of the F/S, is projected at 43,435 tons/year (market waste : 119.0 tons/day).

Working Hours

The work schedule of the plant is as follows:

- The proposed plant operates 350 days a year.
- Monday - Sunday 7:00 - 16:00 (9 hours/day).
- National holidays Closed.
- Waste receiving time 7 hours/day
- Equipment operation hours 8 hours/day

Main Process Components of the Plant

The main components of the proposed plant operation are as follows:

- pre-treatment process
- composting process
- maturating process
- screening process

For the purpose of the preliminary design, the process times are assumed to be 28 days for composting and 60 days for maturation. Auxiliary facilities of the plant comprise the following:

- weighbridge (for common use)
- waste reception areas
- temporary storage areas
- compost product storage areas
- water supply facility
- drainage facility
- machine/equipment maintenance workshop (for common use)
- site office and laboratory (for common use)

e.1.3. Compost Plant Design Parameters

Design Principals

- The plant capacity is calculated to be 20 tons/day by assuming that about 17% of market waste will be separately collected and that the plant operates 350 days a year.
- The compost plant is to start operating in the year 2007.
- The compost plant will be constructed at the Dang Kor Disposal Site, among the landfill area and maintenance workshop. The site will be surrounded by a buffer zone (green belt).
- The composting area is to be covered, and every effort will be made to prohibit the generation of leachate. The area will be equipped with side trenches to collect leachate generated from the piles, which will be treated at the leachate treatment facilities.

Design Assumption

The design assumptions made for the preliminary design are described below.

- **Composting Period**: In general practice, the composting period is in the order of 20 to 30 days. This preliminary design proposes a period of 28 days including a margin of safety that allows adjustment for variations in moisture content of the raw materials.
- **Turning Frequency**: Five turnings in total are carried out during the 28-day composting period, with an interval between turnings of 5 or 6 days. Transferring the raw compost to the maturation area on the 28th day is counted as the 5th turning. The initial temperature of the static piles should be maintained at 55-60 ºC, which is the determinant of the timing of turning.
- **Maturation Period**: This is generally in the order of 30 to 90 days. The preliminary design assumes a 60 day period in order to provide sufficient maturation time.
- **Bulk Density and C/N ratio**: Bulk density and the C/N ratio obtained by the WACS by the JICA study team are employed as the figures for the raw material. Meanwhile, the corresponding figures for the raw compost and mature compost are derived from empirical values obtained in Japan.
- **Moisture Content**: According to the result of the WACS, the moisture content of market waste was 64.4 %. Therefore the moisture content of the market waste for this plan was assumed to be 65%.

- **Compostable Content**: The compostable content in the raw material is assumed to be 90%. Therefore, the foreign material (non-compostable wastes) in the raw material accounts for 10%.

Summary of Design Parameters

The table below summarises the design parameters based on the design assumptions established above.

Table 15-25: Design Parameters of Compost Plant

Composting section				
	Type	High-rate Windrow		
	Raw Material (Compostable Waste)	Amount	20 ton/day	
		Compostable Content	27.4 % by Dry weight	*1
		Moisture Content	65 %	
		Apparent Specific Gravity (ASG)	250 kg/m^3	
	Operation		350 day/year	
			8 hour/day	
	Treatment Capacity		20 ton/day	
	Composting Period		28 days	
	Pile Temperature		> 55 ^{o}C	
Maturation (Curing) section				
	Operation		350 day/year	
			8 hour/day	
	Treatment Capacity	Mature compost product	~ 3.8 ton/day	
		Moisture Content	~ 40 %	
		Apparent Specific Gravity (ASG)	600 kg/m^3	
	Maturation Period		60 day	
Final Separation section				
	Type	Trommel screen		
	Operation Time		350 day/year	
			8 hour/day	
	Treatment Capacity	Fine compost product	~ 3.5 ton/day	
		Coarse compost product	~ 0.3 ton/day	
		Moisture Content	~ 40 %	
		Apparent Specific Gravity (ASG)	400-700 kg/m^3	

*1 : Obtained from WACS (composition of kitchen waste and grass/wood)

e.1.4. Quantity and Quality of Compost Product

Table 15-26 shows the target quality and quantity of the compost product in the preliminary design.

Table 15-26: Quantity and Quality of Compost Product in Cimsa

Quantity	Fine Compost	~ 3.5 ton/day
		~ 1,225 ton/year
Quality	Moisture Content	40 %
	Apparent Specific Gravity (ASG)	400-700 kg/m^3
	C/N ratio	< 25

e.1.5. Flow of Compost Plant Process

The figure below shows the flow of the proposed compost plant process.

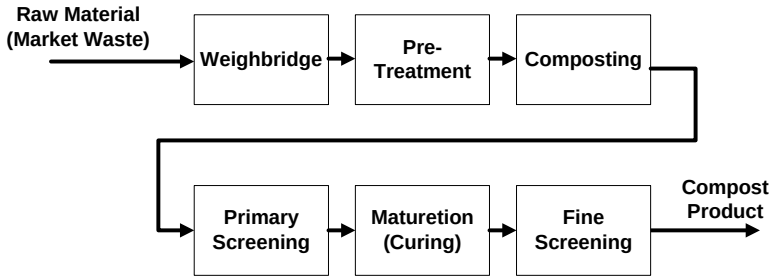


Figure 15-13: Process Flow Diagram of the Compost Plant

e.1.6. Material Balance

The figure below shows the material balance in the proposed plant process in the case of 65 % moisture content.

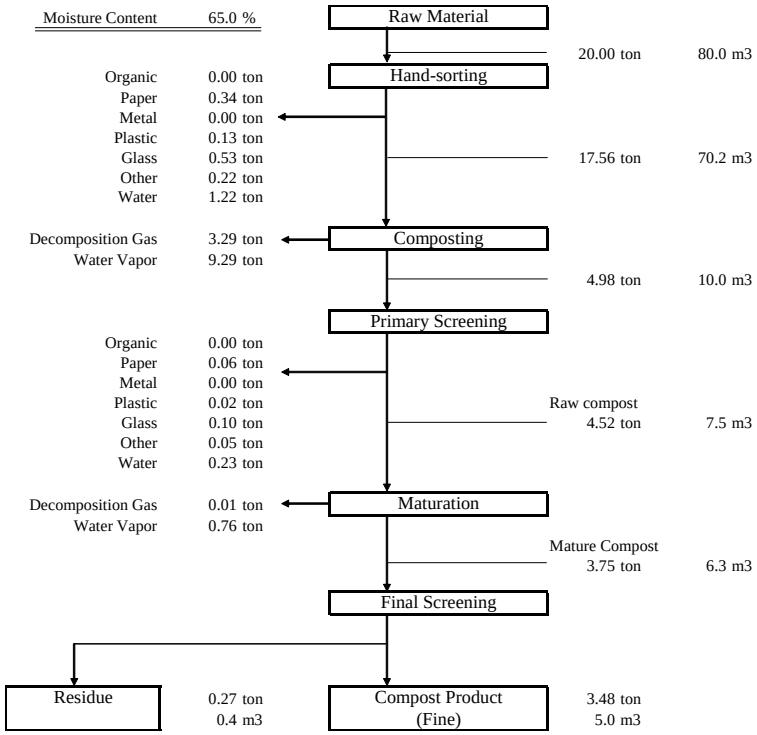


Figure 15-14: Material Balance of the Compost Plant

e.1.7. Layout of Proposed Compost Plant

Figure 15-15 shows the proposed layout of the compost plant.

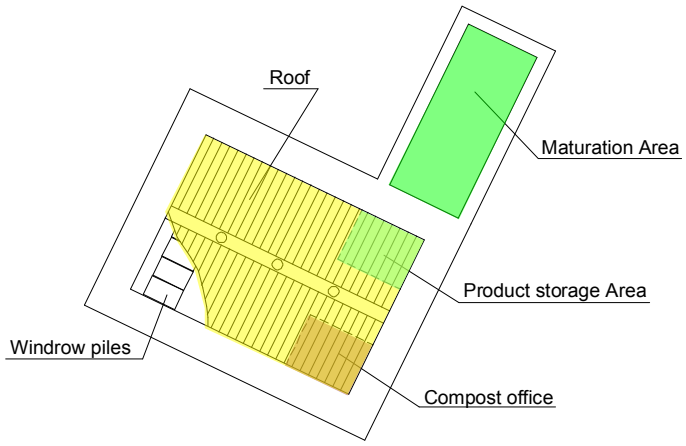


Figure 15-15: Layout of Proposed Compost Plant in Dang Kor Disposal Site

e.1.8. Equipment Planning

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

Table 15-27: Equipment plan of Compost Plant

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

e.1.9. Personnel Plan

The organization for the operation of the compost plant in 2007 is proposed as shown in the following table.

Table 15-28: Organizational Structure of Compost Plant in 2007

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

e.1.10. Staff and Job Descriptions

Table 15-29 shows the staff allocation schedule for the proposed compost plant. The number of operators and manual workers is derived from the volume of materials to be processed and plant operation capacity.

Supervisor

Supervisory work will be executed by a director, who will supervise the operation and management of the plant.

Operation

Operation is managed by a supervisor of the plant and involves two parts: the pre-treatment section and composting section. Both consist of sections, each of which is headed by one supervisor for one shift. The job description of the sections is as follows.

Pre-treatment

(1) Waste Reception Section

Compostable wastes is received by this section and transferred to the pre-treatment space.

The section has workers who reject wastes unsuitable for the process and a wheel loader operator who feeds the other wastes to windrow. These works are controlled by the reception supervisor.

(2) Facility Operation Section

The facility operators, under the supervisor, operate the wheel loader and pile windrow.

This section is in a key position coordinating the preceding waste reception section. The capability to assess the entire pre-treatment section is required.

Composting

(1) Windrow Section

The supervisor of this section directs the loader operators to pile pre-treated materials in an appropriate place. He/she is responsible for the maintenance of the aerobic environment in the piles by wheel loader to be turning. Further, he/she gives instructions to the workers about turning and water supply to the piles.

(2) Screening Section

There are two stages of screening: primary screening for raw compost and final screening for mature compost. The primary screening line and the final screening line is operated alternately by the same operators and workers. They also operate the packaging machine of the final compost product.

(3) Maturation Section

The screened raw compost from the screening section is matured in this section. Although it is usual to mature the materials to ensure stabilisation, market demand for the screened raw compost without maturation may rise. On such occasions, the section chief has to give necessary instructions to the supervisor and the workers of this section.

Table 15-29: Staff Allocation Schedule in the Compost plant

Position			person
ADMINISTRATION OF COMPOST SECTION			
	Section chief		1
	Clerk		1
		sub-total	2
OPERATION			
	Pre-treated section		
		Supervisor	1
		Reception section	
		Loader operator	1
		Worker	5
		sub-total	7
	Composting section		
		Supervisor	1
		Windrow section	
		Loader operator	1
		Worker	10
		Separate section	
		Worker	5
		Curing section	
		Worker	5
		sub-total	22
	Total		31

e.2 Cost Estimation of the Compost plant

The investment cost and schedule for the compost plant are shown in Table 15-30 and Table 15-31 respectively. The cost has two components: facility construction and operation equipment. It should be noted that the cost for land preparation is not included.

Table 15-30: Investment Cost of the Compost Plant

Item	Cost (US$)
Facilities Construction of Compost Plant	698,000
Equipment Machine	10,000
V&E	100,000
Total cost	808,000

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

Table 15-31: Investment Schedule of the Compost Plant (2005-2015)

unit : US$ 1,000

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
D/D	42	28	---	---	---	---	---	---	---	---	---	70
Civil	---	698	---	---	---	---	---	---	---	---	---	698
Machine	---	10	---	---	---	---	---	---	10	---	---	20
V&E	---	100	---	---	---	---	---	---	100	---	---	200
O&M	---	---	56	56	56	56	56	58	58	61	63	522
Total	42	836	56	56	56	56	58	58	168	61	63	1,510

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

f. Maintenance Workshop Section

f.1 Introduction

As of 2004, the number of collection vehicles possessed by MPP/PPWM is 5. However, to improve waste collection services in the rural area and enhance MPP/PPWM's waste management capacity, the M/P proposes that MPP/PPMW collect waste in the rural area. It is therefore necessary to increase the number of vehicles to 50 and to construct a parking space and maintenance workshop for such vehicles by the year 2007, when the collection service is planned to start.

To improve waste management efficiency and reduce costs, the maintenance workshop is to be constructed on the compound of the new Dang Kor Disposal Site scheduled to begin operations in 2007. That way the workshop can also be used to maintain the heavy vehicles planned for the landfill section and compost plant.

f.2 Conceptual Design of the Maintenance Workshop

f.2.1. Preliminary Design

Layout

The maintenance workshop is to be designed in the Dang Kor Disposal Site. The area is approximately 1.2 hectares.

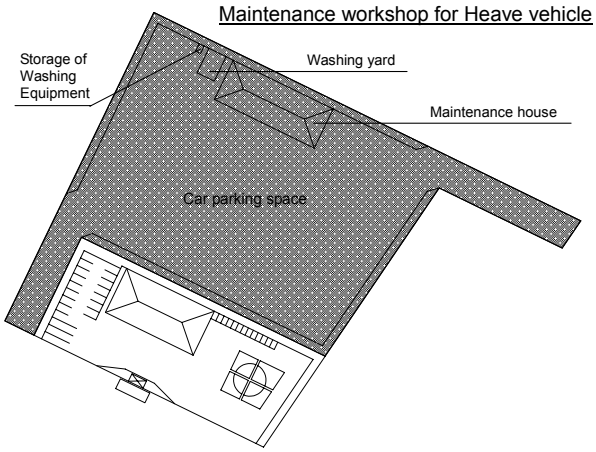


Figure 15-16: Location of the Maintenance Workshop

Working Hours

The work schedule of the workshop is as follows:.

- The proposed plant operates 300 days a year.
- Mondays - Saturdays 7:00 - 16:00 (9 hours/day).
- National Hholidays Closed.
- Equipment operation hours 8 hours/day

Maintenance facilities and Equipment

(1) Maintenance Facilities

The establishment of facilities to carry out maintenance and minor repairs will help to use the collection vehicles and landfill equipment effectively. The maintenance work shop is planned to be constructed on the compound of the new landfill site. The major components of the facilities are as follows:

- Building
  - Main building
  - Storage for washing equipment

(2) Equipment

Equipment and tools will be furnished for the maintenance and mineminorr repair of the vehicles and heavy equipment, thereby ensuring their sufficient equipment availability. It is desirable, that periodical maintenance and repairs at an appropriate interval be carried out using those equipment and tools.

Basically , the maintenance and repair of vehicles and heavy equipment can be largely done by with ordinary tools. Particular emphasis is planned on theose which can be used to disassemble and, assemble and major component parts of the engine and power train. In addition, portable type of equipment and tools are selected to assure the convenience of the works.

Consequently, the following equipment is planned for the maintenance of collection and landfill equipment.

i . for periodical/repair maintenance
- general hand tools for both vehicles and heavy equipment
- hydraulic garage jack
- axle adjusting tool
- nozzle tester

- others

ii . for tire / wWelding works
- air compressor
- arc/gas welding machine
- tire pressure gage
- service tool set for tire and welding
- others

iii . for battery works
- quick battery charger
- booster cable
- battery tester
- others

iv . for store
- tool & parts rack
- computer
- others

v . for spare parts and data control works
- computer

vi . for washing and inspection pit
- steam combination washer

vii . for washing equipment storage

f.2.2. Main Facility Components of the Workshop

The maintenance workshop facilities and their functions are shown in the table below.

Table 15-32: Function of Maintenance Shop at Dang Kor Disposal site

Item	Facilities	Function
Maintenance shop	・Service shop 4bay (Vehicle)	General & miner service both vehicle and heavy equipment -Periodical(1month,3month,6mouth,1year) service Oil change(Engine, Transmission, Differential) Brake adjustment Clutch adjustment etc. -Miner service Brake lining replacement Clutch plate replacement Front & rear axle adjustment. etc. -Final Inspection
	1bay (Heavy Equipment)	-Periodical(250hr,500hr,1000hr,2000hr,3000hr) service Oil change (Engine, Transmission, final drive, Swing drive etc.) Check Water separator Undercarriage oil leaking check Hydraulic system -Miner service Brake adjustment Fan belt Replacement etc. -Final Inspection Brake adjustment Fan belt Replacement etc. -Final Inspection
	・Tire service	-Tire services for collection and landfill site vehicles & equipment Tire replacement service Tire puncture service
	・Battery service 1pit	-Battery service for all equipment Battery replacement Battery charge service Generator inspection
	・Welding service	-Welding service for equipment & iron works. Equipment body welding Container welding
	・Washing service 1yard	-Cleaning service for before service and disposal site equipment.
	・Storage room	-Storage of spare part and tools (including tire and battery)
	・Parts & data Control room	-Entire equipment ledger, working sheet and Lubricant spare and tools control
	・Meeting & Training	-Training and meeting of the staff

	room	
	・Lubricant storage room	-Storage of oils, Grease
	・W/shop manager room	- Management office for Mechanical engineer
Parking	・Parking space	- for Vehicles - for Landfill equipments and other vehicles

f.2.3. Periodical Maintenance

The Periodical maintenance schedule and works is are as follows:,

f.2.4. General services

Collection and light duties vehicles

For Skip loader, Compactor truck, Dump truck Water tanker, Pick-up truck are as follows;

Periodical maintenance every 3,000 km or Monthly periodical maintenance
Periodical maintenance every 10000 km or every 3 months periodical maintenance
Periodical maintenance every 18,000 km or every 6 month periodical maintenance
Periodical maintenance every 36,000 km or Yearly periodical maintenance

Table 15-33: Periodical Maintenance (light and heavy duty vehicles)

	3000km /month	10000km /3month	18000km /6month	36,000km /year
Engine oil	●	●	●	●
Oil filter	●	●	●	●
Fuel filter	●	●	●	●
Air element		▲	▲	●
Gear oil				●
Grease	▲	▲	▲	▲
Hydraulic oil				▲
Coolant				●

● : Change ▲ : Lubricant or Chang

Heavy Landfill Equipment

For Bulldozer, wheel loader, and excavator are as follows;

Initial 100 hr
Periodical maintenance every 250 hrs or monthly periodical maintenance
Periodical maintenance every 500 hrs or every 3 months periodical maintenance
Periodical maintenance every 1000 hrs or every 6 month periodical maintenance
Periodical maintenance every 2000 hrs or 1yearly periodical maintenance

Table 15-34: Periodical Maintenance (Heavy Equipment)

	Initial100hr /month	Initial 50hr	250hr /month	500hr /3month	1000hr /6month	2000hr /1year
Engine oil	●		●	●	●	●
Oil filter	●		●	●	●	●
Fuel filter	●			●	●	●
Grease	▲	▲	▲	▲	▲	▲
Hydraulic oil						●
Hydraulic filter						●
Swing drive oil		●			●	
Final drive oil		●				

● : Change ▲ : Lubricant or Change

Other preventive maintenance works;

Table 15-35: Other Preventive Maintenance Works

Equipment	Preventive maintenance
Collection equipment Light and Heavy duties trucks	・Clutch overhaul, propeller shaft repair works, Brake overhaul, miner axle repair works etc ・Battery charges & change, miner wiring works etc ・All tire repair works.
Landfill equipment Heavy equipment-Tractor, Wheel loader, Excavator	・Track ,Clutch, brake adjustment, Fuel nozzle adjustment ・Minor track repair works such as track adjustment. ・Battery charges & change, minor wiring works, etc

f.2.5. Maintenance Plan

Organization

It is proposed that the organization of the workshop is as follows:

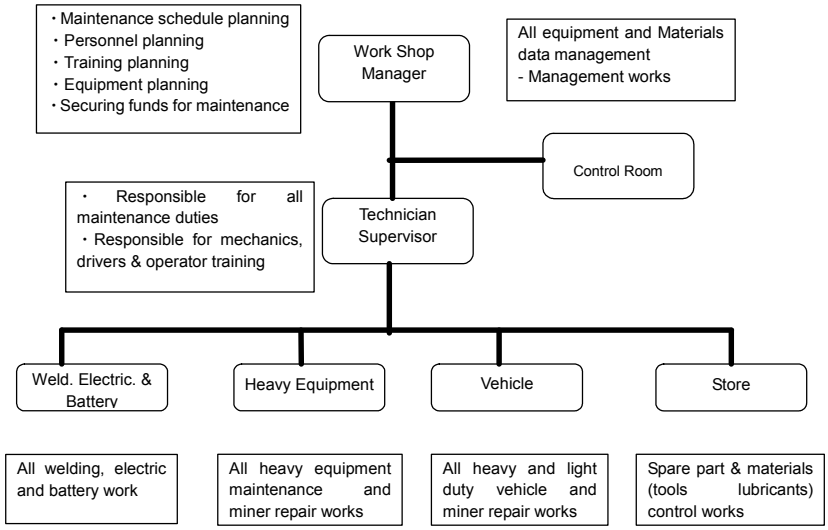


Figure 15-17: Proposed of Organization of Workshop

Maintenance Facilities and Tools

The maintenance workshop is to be equipped with the facilities and tools shown in the table below.

Table 15-36: Maintenance Facilities and Tools of Workshop

Duties	Facilities and tools
Preventive maintenance	・Hand tool set for medium and heavy duties ・Truck wheel repair tools ・Brake system repair tools ・Tool tray, Tool box, Grease pump, grease gun, Oil bucket pump etc. ・Working bench ・Hydraulic jack etc.
Minor service	・Hand tool set for heavy equipment ・Tools for replacement of hydraulic hose and pipe ・etc
General facilities	・Welding machine(Elect. & Gas.) set ・Battery charger ・Washing machine ・Compressor ・Generator (if necessary) ・computer

Maintenance Plan

Outline of maintenance plan is as following.

Table 15-37: Outline of Maintenance Plan

Items	Descriptions
Facilities	・New w/shop at new disposal site for Collection & landfill equipment maintenance ・General & Middle range of w/shop tools and equipment are prepared.
Duties	・All periodical maintenance both collection and landfill equipment ・Back-up service ・Normal repair works ・Heavy repair ,overhauls are made by private w/shop ・All working sheets are prepared and filled properly
Record System	・All necessary systems are established -Preventive maintenance -Recording -Store stock management
Training	・Own preventive maintenance training system is established ・Skilled drivers and operators are prepared ・Skilled office management staff are prepared
Other	・Material security system is established

f.2.6. Personal Plan

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

Table 15-38: Personal Plan of Workshop

Workshop section	Engineer/Workshop manager	1
	Technician/Supervisor	1
	Mechanics	12
	Store keeper	2
	Office clerk	2
Total		18

f.2.7. Cost Estimation of the Workshop

The Investment cost and schedule for the maintenance workshop are shown in Table 15-39 and Table 15-40respectively. The cost has two components: facility construction and operation equipment. It should be noted that the cost for land preparation is not included.

Table 15-39: Investment Cost of the Workshop

Item	Cost (US$)
Facility Construction of Workshop	1,648,000
Equipment (Machinery)	181,000
Total cost	1,829,000

Table 15-40: Investment Schedule of the Workshop (2005-2015)

unit : US$ 1,000

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
D/D	99	66	---	---	---	---	---	---	---	---	---	165
Civil	---	1,648	---	---	---	---	---	---	---	---	---	1,648
Machine	---	181	---	---	---	---	---	---	---	---	---	181
O&M	---	---	36	36	36	36	36	36	36	36	36	324
Total	99	1,895	36	36	36	36	36	36	36	36	36	2,318

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

g. Waste Collection and Transportation System

g.1 Overview

For the period 2007-2015, a mixed collection and transportation system is proposed. In the 4 urban Khans the private sector will continue to provide collection service. In the 3 rural

Khans, MPP/PPWM will introduce a new service using several collection methods to meet waste collection needs. The new collection service will employ 8 m^3 and 15 m^3 compactor trucks and "Skip Loader" type container handling vehicles. A single open top dump truck will be used to collect and transport from street sweeping.

Waste amounts and number of trips required can be summarized as follows (full details are contained in the Master Plan document):

	Urban*		Rural		Total	
	Amount (tons/day)	**Trips** (trips/day)	**Amount** (tons/day)	**Trips** (trips/day)	**Amount** (tons/day)	**Trips** (trips/day)
2007	549	112	377	210	926	322
2008	571	116	416	233	987	349
2009	593	120	462	252	1055	372
2010	615	125	510	269	1125	394
2011	637	129	551	292	1188	421
2012	659	134	626	329	1285	463
2013	681	138	672	348	1353	486
2014	703	143	723	362	1426	505
2015	751	153	811	404	1562	557

* Based on assumption that urban waste amount will be collected and transported with 8 m3 compactor trucks (1/3 of daily amount) and 15 m3 compactor trucks (2/3 of daily amount).

To minimize waste scattering, the waste compartment of the compactor trucks are completely enclosed, skip containers are full covered and the single open dump truck will employ a cargo cover. Waste scavenging during collection and transport will be prohibited to prevent materials from vehicles.

15.4 Description of Environmental Resources

This chapter describes the dimensions of the site and relevant physical, biological, and socioeconomic conditions, including any changes anticipated before the project commences. It also takes into account current and proposed development activities within the project area but not directly connected to the project. These are relevant to decisions about project location, design, operation, and mitigation measures.

15.4.1 Meteorological Conditions

The closest meteorological station to the proposed disposal site in Dang kor is Pochentong station located near the Phnom Penh airport. The climate of this specific area and most of the Mekong river basin is characterized by two monsoons from the southwest and northeast, and occasional periods of cold weather caused by winds from Siberia and China. The following table shows the monsoon seasons throughout the year:

Table 15-41: Monsoon seasons of the Mekong River Basin.

Cold season		Summer season		Rainy season						Cold season	
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Northeast monsoon		*(1)*		Southwest monsoon					*(1)*	Northeast monsoon	
Little precipitation				Heavy and frequent rains						Little precipitation	
Low humidity				High humidity						Low humidity	
Minimal cloudiness				Cloudiness						Minimal cloudiness	

Concerning the other climatic variables such as temperature, precipitation, relative humidity and wind movement of the area, they were interpreted using long term records in Figure 15-18 and Figure 15-24. Meteorological data from 1999 to 2003 are presented in Annex 1.

The hottest month is April with a maximum mean temperature of 35.2 °C, and the coldest month is January with a minimum mean temperature of 21.8 °C.

The average relative humidity varies from 73 % during the dry season to 85 % during the wet season. This high relative humidity combined with a high temperature level will favor the decomposition of organic waste.

The yearly average precipitation in the area is about 1,700 mm. Over 70 % of the annual rainfall is received from May to October.

Concerning wind speed and wind direction, the wind direction is mainly influenced by the two monsoons. From November to March, the northeast monsoon brings strong northeast winds varying between 3.3 and 4.6 m/s. From May to September, the southwest monsoon brings even bigger southwest winds varying between 3.8 and 5.2 m/s.

The annual mean amount of sunshine is 29 % of the total daytime. From November to March the mean daily sunshine duration is 33 % of the total daytime while it is only 25 % of the total daytime during the rainy season from May to October.

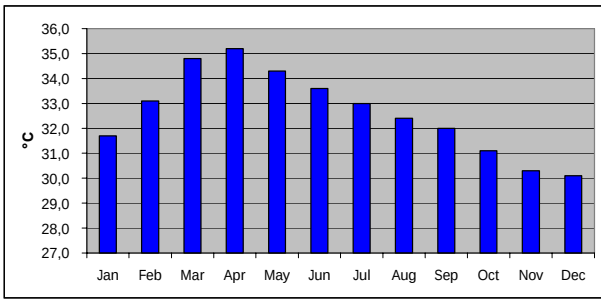


Figure 15-18: Monthly maximum average temperatures (Pochentong Meteorological Station 1994 – 2002)

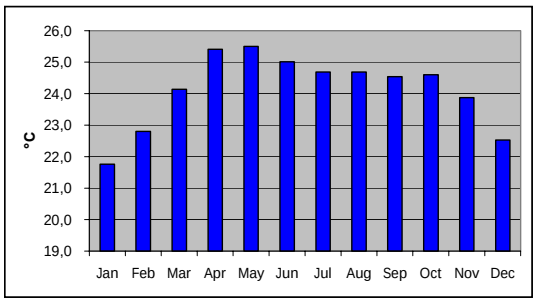


Figure 15-19: Monthly minimum average temperatures (Pochentong Meteorological Station 1994 – 2002)

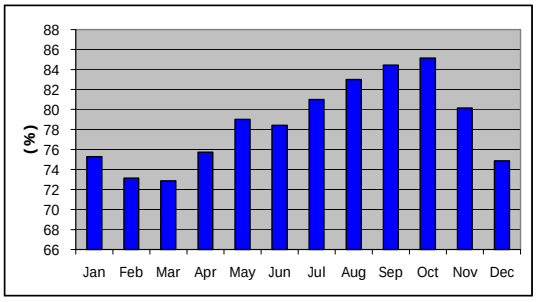


Figure 15-20: Monthly relative humidity (Pochentong Meteorological Station 1996 - 2002).

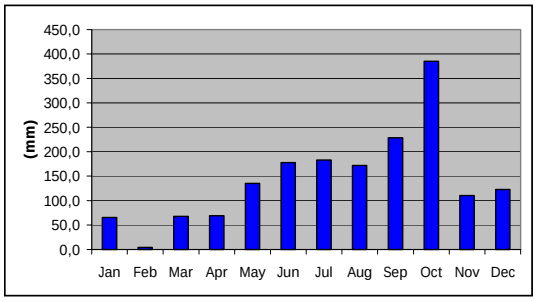


Figure 15-21: Monthly average precipitation (Pochentong Meteorological Station 2000 – 2003)

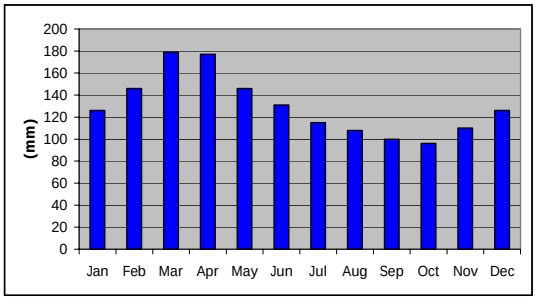


Figure 15-22: Monthly average evaporation (Pochentong Meteorological Station 1990 – 1999).

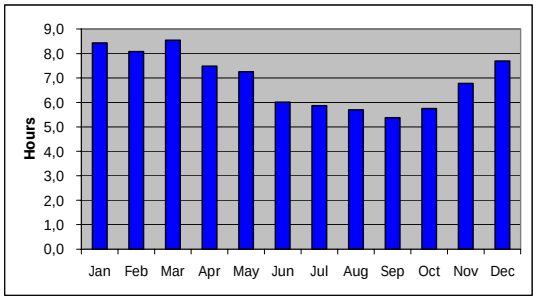


Figure 15-23: Mean daily sunshine duration (Pochentong Meteorological Station 1985 – 2002).

Concerning wind speed and wind direction data, the database available is quite incomplete. The only year for which all the information was available is for the year 2001, which explains

that for the following Figure this year only was considered. Only wind speed data are available from 1995 to 2002.

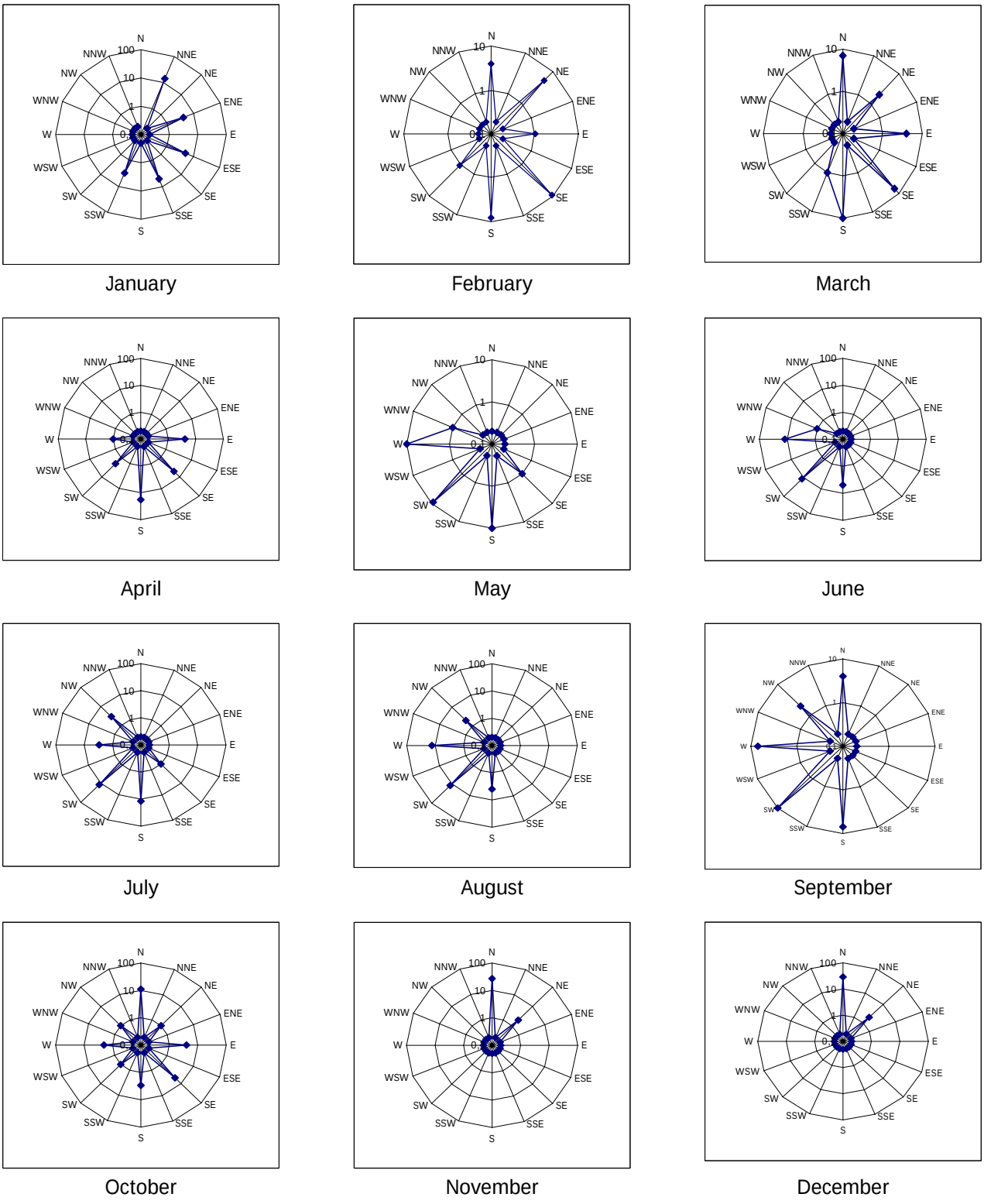


Figure 15-24: Total number of blows
(Pochentong Meteorological Station 2001).

15.4.2 Socio – cultural Characteristics

a. Economic activities

The economic activities survey was done using the data collected by the Ministry of Planning for the 1998 population census. The survey was of three communes (19 villages in total) and targeted the following items:

- The population structure: number of households, people, percentage of women;
- The standard of living per village and the average per commune, based on household amenities; and
- The main economic activities per village and per commune.

a.1 Land use

In the three concerned communes, there are six types of land use. (See following table). Agriculture land occupied most of the area in the three communes.

Table 15-42: Current land use

Land use	Dang kor		Cheung Aek		Spean Thma	
	ha	%	ha	%	ha	%
Residential	147.5	16	260.4	21	201	29
Institution	9.2	1	19.5	1	10	1
Agriculture	682.3	74	651.0	50	497	70
Pagoda	9.2	1	19.5	1	2	0
Parks and open space	73.8	8	65.1	5	-	-
Surface water	-	-	286.4	22	-	-
Total	922.0	100	1301.9	100	710	100

The land in the study area, within a 1 km radius from the proposed site, is mainly used for rice fields and ponds. No population resettlement will be needed in this zone.

The villages in the study area are: Bakou (Dang kor commune), Choeung Ek and Rolous (Cheung Aek commune), and Doung and Ha (Spean Thma commune).

There are 351 households in the study area and the population is estimated to be 1509[1].

[1] Estimated figure based on an average of 4.64 persons per household

Figure 15-25: Present land use of the project area.

a.2 Population structure

a.2.1. 3 communes

The following table summarizes the population structure for each of the 19 villages of the three communes based on the 98 census.

Table 15-43: Population structure of the villages in Dang kor, Cheung Aek and Spean Thma communes.

Commune	Village	Households	Population	Total population
Dang kor	Thmey	293	1531	10462
	Bakou	170	815	
	Sambo	281	1628	
	Ta Ley	351	1622	
	Mol	444	2246	
	Khvar	486	2620	
Choeung Ek	Choeung Ek	575	2787	5170
	Rolous	185	792	
	Chek	173	773	
	Prey Pranak	50	224	

	Prek Thloeung	131	594	
Spean Thma	Anhchanh	78	354	2190
	Kouk Ovloek	50	243	
	Meun Tra	74	340	
	Spean Thma	80	340	
	Svay Mean Leak	45	212	
	Ha	68	324	
	Doung	29	138	
	Preak Chrey	48	239	

In terms of total population, Dang kor commune is by far the most populated in comparison with the other two communes. The total population of Dang kor commune is 10462, followed by Cheung Aek with 5170 and finally Spean Thma commune with only 2190.

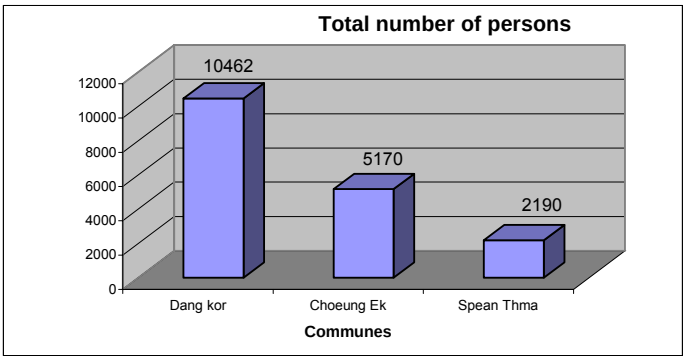


Figure 15-26: Total number of population per commune

a.2.2. Target Area

The following table summarizes the population structure surveyed in the study area. The number of households was based on the interview survey conducted at each village on November 2003. The population was calculated by using the average of 4.3 persons per household.

Table 15-44: Population structure in the target area

Commune	Village	House hold	Population
Dang kor	Bakou	168	721
Choeung Ek	Choeung Ek	65	280
	Rolous	85	366
Spean Thma	Ha	16	69
	Doung	17	73
TOTAL		351	1509

a.3 Standard of living

a.3.1. Methodology

In order to get an idea of the standard of living in the villages, a multi-criteria analysis was done to classify these villages. For example, a family which owns its house can be considered as having a higher standard of living in comparison with a family which only rents its house. Or, for instance, a family using electricity for cooking can be considered as having a higher standard of living than the one using only firewood for fuel.

In the population census of 98, a series of data concerning household amenities is available per village. The following table gives all the parameters that have been considered to assess

the average standard of living in each village and the coefficient that has been given for each parameter.

Table 15-45: Coefficients used for the multi-criteria analysis

Parameters		Coefficient
Tenure (%)	Owner	4
	Rent	3
	Rent free	2
	Other	1
Light (%)	City + Gene	6
	City	5
	Gene	4
	Battery	3
	Kerosene	2
	Candle	1
Fuel (%)	Lpg	6
	Electricity	6
	Kerosene	4
	Charcoal	3
	Firewood	2
	None	0
Toilet	Yes	2
	No	0
Water	Piped water	2
	Tubed well	0
	Dug well	0
	Spring, river	0
	Bought	0
Rooms	8 +	8
	7	7
	6	6
	5	5
	4	4
	3	3
	2	2
	1	1

At the end of the process, each village receives a final mark that can be compared with the other villages and which allowed us to classify these villages per standard of living. The higher the mark is, the higher the standard of living is supposed to be.

The results of this analysis are given in the tables below.

Table 15-46: Results of the multicriteria analysis for the standard of living on the villages of the project area (1/2).

Sangkat	Village	Tenure (%)				Coeff.	Light (%)						Coeff.	Fuel (%)						Coeff.
		Owner	Rent	Rent free	Other	Subtotal	City + Gene	City	Gene	Battery	Kerosene	Candle	Subtotal	Lpg	Electricity	Kerosene	Charcoal	Firewood	None	Subtotal
Dangkao	Thmey	93.1	2.76	3.45	0.69	**3.9**		82.07	0.34	0.34	17.24		**4.5**	0.34		0.69	7.93	91.03		**2.1**
	Bakou	97.6	1.2	1.2		**4.0**		1.2			98.8		**2.0**					100		**2.0**
	Sambo	90.18	1.09	2.55	6.18	**3.8**		71.64		1.82	26.18	0.36	**4.2**	1.09			6.18	92.36		**2.1**
	Ta Ley	99.15		0.85		**4.0**	19.94	24.5	1.99	2.28	51.28		**3.6**			0.57	1.71	97.72		**2.0**
	Mol	88.15	1.98	9.88		**3.8**	0.49	69.14	0.74	2.72	26.91		**4.1**	0.99		0.25	14.07	84.69		**2.2**
	Khvar	86.84	0.85	11.25	1.06	**3.7**	1.49	78.56	2.12	1.27	15.07	1.49	**4.5**	1.91	0.21	0.64	6.58	90.23		**2.2**
Cheung Aek	Choeung Ek	91.96	0.7	6.99	0.35	**3.8**	4.37	34.97	1.75	0.17	58.57	0.17	**3.3**	0.87		1.22	5.59	92.31		**2.1**
	Rolous	99.45		0.55		**4.0**					100		**2.0**				0.55	99.45		**2.0**
	Chek	96.53		3.47		**3.9**			1.73	4.62	93.64		**2.1**			1.73		98.27		**2.0**
	Prey Pranak	91.84		8.16		**3.8**		4.08			95.92		**2.1**					100		**2.0**
	Prek Thloeung	96.9		3.1		**3.9**			0.78	1.55	97.67		**2.0**	0.78			0.78	98.45		**2.0**
Spean Thma	Anhchanh	100				**4.0**		2.56		3.85	93.59		**2.1**					100		**2.0**
	Kouk Ovloek	100				**4.0**				2	98		**2.0**					100		**2.0**
	Meun Tra	98.63		1.37		**4.0**			2.74	1.37	95.89		**2.1**				2.74	97.26		**2.0**
	Spean Thma	100				**4.0**		7.5		1.25	91.25		**2.2**					100		**2.0**
	Svay Mean Leak	100				**4.0**		11.11			88.89		**2.3**					100		**2.0**
	Phum Ha	98.53		1.47		**4.0**		4.41		1.47	94.12		**2.1**					100		**2.0**
	Doung	100				**4.0**					100		**2.0**					100		**2.0**
	Preaek Chrey	100				**4.0**		2.08		2.08	95.83		**2.1**					100		**2.0**

Table 15-47: Results of the multicriteria analysis used for the assessment of the standard of living on the villages of the project area (2/2).

Sangkat	Village	Toilet (%)		Coeff.	Water (%)					Coeff.	Rooms (%)								Coeff.	Coeff.	Aver.
		Yes	No	Subtotal	Piped water	Tubed well	Dug well	Spring, river	Bought	Subtotal	8 +	7	6	5	4	3	2	1	Subtotal	TOTAL	
Dangkao	Thmey	53.1	46.9	**1.1**	4.83	5.86	74.14		15.17	**0.1**					0.34	1.72	17.24	78.97	**1.2**	**12.8**	**11.9**
	Bakou	10.78	89.22	**0.2**		88.02		11.98		**0.0**						0.6	11.98	86.83	**1.1**	**9.3**	
	Sambo	50.55	49.45	**1.0**	1.09	28.73	31.64	0.73	37.82	**0.0**					0.36	7.27	17.09	74.18	**1.3**	**12.4**	
	Ta Ley	22.22	77.78	**0.4**	0.28	59.83	15.1	0.57	24.22	**0.0**	0.28		0.57		1.71	7.98	41.6	47.58	**1.7**	**11.7**	
	Mol	54.81	45.19	**1.1**	2.72	22.22	17.78	1.73	55.56	**0.1**				0.25	0.99	3.7	18.02	76.05	**1.3**	**12.5**	
	Khvar	42.04	57.96	**0.8**	6.37	42.89	13.38	0.21	37.15	**0.1**		0.21		0.42	1.27	4.67	23.35	69	**1.4**	**12.7**	
Cheung Aek	Choeung Ek	20.8	79.2	**0.4**	0.17	12.76	39.16	0.17	47.73	**0.0**				0.7	1.22	3.32	22.9	70.98	**1.4**	**11.0**	**9.5**
	Rolous	2.2	97.8	**0.0**		75.82	24.18			**0.0**						2.2	20.33	76.37	**1.2**	**9.3**	
	Chek	3.47	96.53	**0.1**		16.18	76.88	1.16	5.78	**0.0**				0.58		4.62	10.98	46.82	**0.9**	**9.0**	
	Prey Pranak	6.12	93.88	**0.1**	2.04			97.96		**0.0**							2.04	97.96	**1.0**	**9.1**	
	Prek Thloeung	3.88	96.12	**0.1**	1.55	2.33		96.12		**0.0**							7.75	89.92	**1.1**	**9.2**	
Spean Thma	Anhchanh	3.85	96.15	**0.1**		82.05		17.95		**0.0**						3.85	11.54	78.21	**1.1**	**9.3**	**9.3**
	Kouk Ovloek	4	96	**0.1**		98	2			**0.0**								100	**1.0**	**9.1**	
	Meun Tra	4.11	95.89	**0.1**		8.22		91.78		**0.0**							4.11	95.89	**1.0**	**9.2**	
	Spean Thma	5	95	**0.1**				100		**0.0**						2.5		97.5	**1.1**	**9.4**	
	Svay Mean Leak		100	**0.0**				100		**0.0**						2.22		97.78	**1.0**	**9.4**	
	Phum Ha	2.94	97.06	**0.1**				97.06	2.94	**0.0**							2.94	97.06	**1.0**	**9.2**	
	Doung	3.45	96.55	**0.1**				100		**0.0**						6.9	17.24	75.86	**1.3**	**9.4**	
	Preaek Chrey	2.08	97.92	**0.0**			4.17	95.83		**0.0**							2.08	97.92	**1.0**	**9.1**	

It shows that the commune of Dang kor has an average standard of living related to household amenities higher (11.9 points) than Cheung Aek and Spean Thma communes with 9.4 and 9.3 points respectively.

These communes are considered to be rural areas. That is because when they are compared with other urban areas in Phnom Penh such as Phsar Thmey 1 commune, the standard of living of these urban areas are even higher (19 points) as shown below.

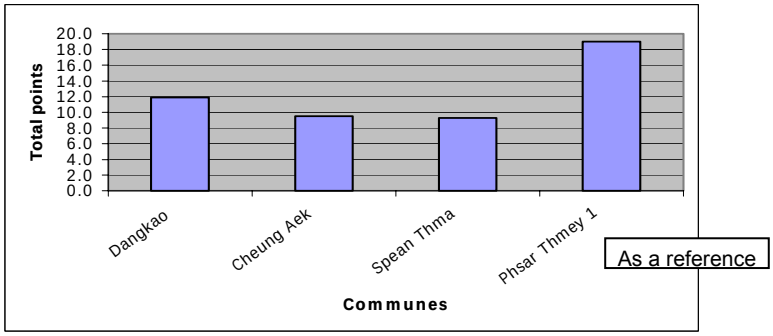


Figure 15-27: Standard of living average score per commune.

The results of the standard of living score per villages show the following:

- The village of Bakou has the lowest standard of living (9.3 points) in Dang kor commune. The other villages range between 11.7 and 12.8 points.
- In Cheung Aek commune, Chek has the lowest standard of living with a score of 9.0 points.
- In Spean Thma commune, Kouk Ovloek has the lowest standard of living with a score of 9.1 points.

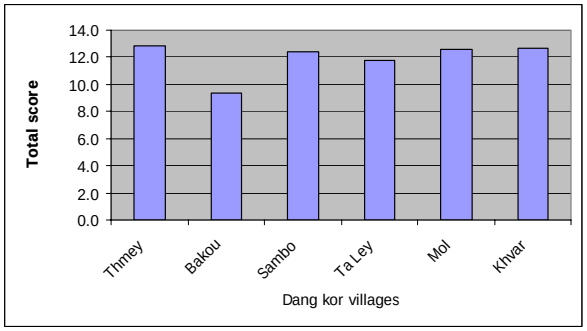


Figure 15-28: Standard of living score obtained for each village of Dang kor commune.

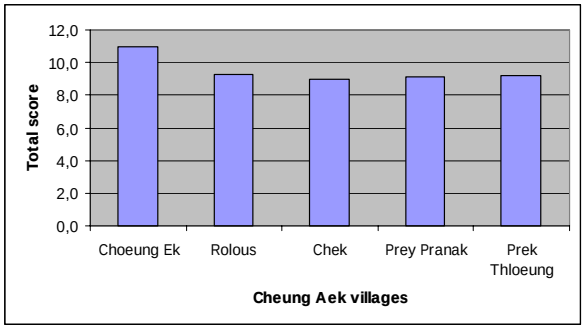


Figure 15-29: Standard of living score obtained for each village of Cheung Aek commune.

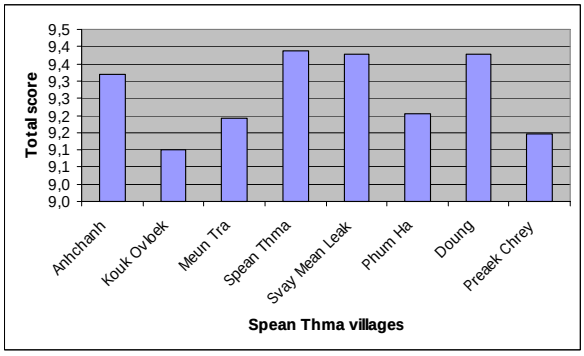


Figure 15-30: Standard of living score obtained for each village of Spean Thma commune.

The following set of pictures illustrates the difference types of houses in the communes of Dang kor, Cheung Aek and Spean Thma.

Dang kor residential house

Dang kor traditional house (Bakou)

Cheung Aek traditional house

Spean Thma traditional house

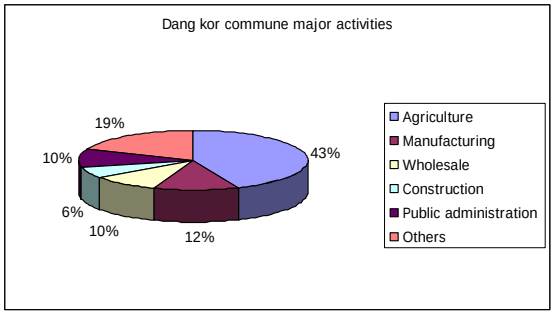
Figure 15-31: Houses of Dang kor, Cheung Aek and Spean Thma.

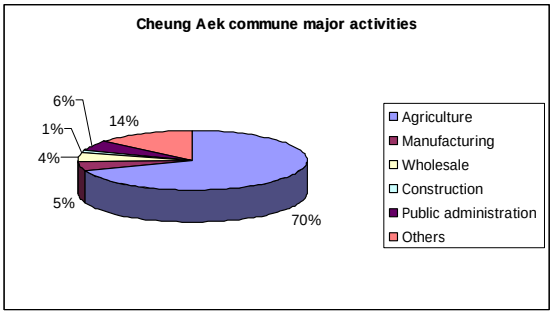
b. Industries

Figure 15-25shows that the study area is mainly cultivated land (more than 90% of land use) with some residential areas (6 %) and water surface areas (2.2 %). This tendency can be observed in the statistics from the population census of 1998 for the percentage of major occupation of each village (see following Table and Figure).

Table 15-48: Major activities per village.

Commune	Village	Persons	Employed		Village Occupation (%)					
			Persons	%	Agriculture	Manufacturing	Wholesale	Construction	Public administration	Others
Dang kor	Thmey	1531	637	41.61	26.28	19.44	20.84	3.89	10.42	19.13
	Bakou	815	333	40.86	84.08	5.41	0.9		3.9	5.71
	Sambo	1628	613	37.65	49.7	9.17	8.14	8.58	7.4	17.01
	Ta Ley	1622	790	48.71	67.34	7.72	4.68	3.16	6.2	10.9
	Mol	2246	768	34.19	33.38	11.51	8.28	14.75	10.87	21.21
	Khvar	2620	1062	40.53	27.31	14.69	11.11	4.61	13.94	28.34
Cheung Aek	Choeung Ek	2787	1193	42.81	53.81	7.46	6.79	2.01	8.8	21.13
	Rolous	792	412	52.02	87.62	0.97	1.7	0.24	2.67	6.8
	Chek	773	377	48.77	85.3	1.05	3.15	0.79	3.41	6.3
	Prey Pranak	224	120	53.57	75.83	6.67	4.17	3.33	5	5
	Prek Thloeung	594	282	47.47	82.11	7.37	0.7	0.35	0.7	8.77
Spean Thma	Anhchanh	354	169	47.74	91.81	3.51	0	1.17	2.92	0.59
	Kouk Ovloek	243	118	48.56	83.9	2.54	1.69	0.85	3.39	7.63
	Meun Tra	340	158	46.47	87.97	1.27	0.63	0	1.9	8.23
	Spean Thma	340	151	44.41	84.11	4.64	5.3	1.99	1.32	2.64
	Ha	212	107	50.47	83.18	5.61	2.8	0	3.74	4.67
	Svay Mean Leak	324	153	47.22	81.94	3.23	3.23	0.65	3.23	7.72
	Doung	138	62	44.93	84.13	1.59	0	0	6.35	7.93
	Preaek Chrey	239	99	41.42	84.85	5.05	0	2.02	4.04	4.04





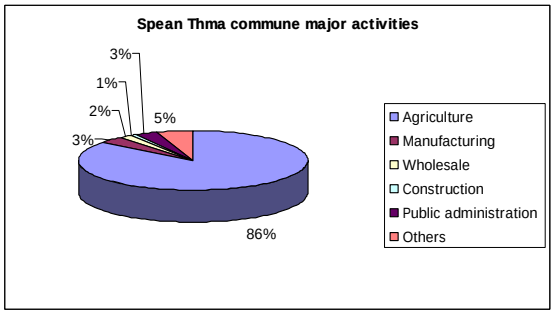
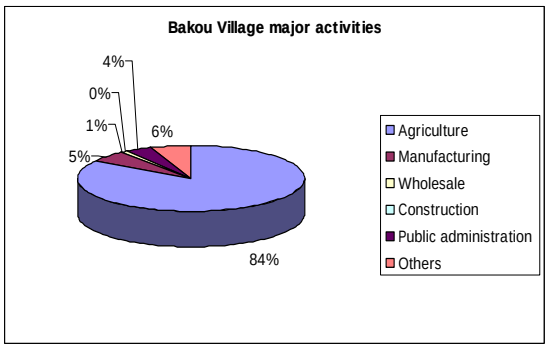
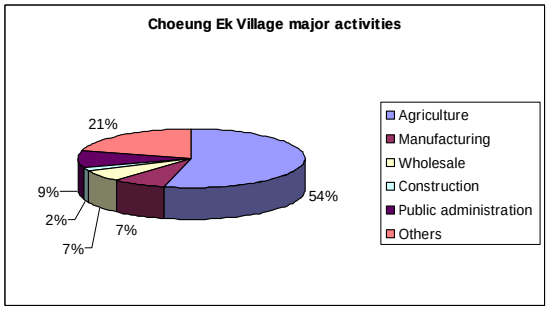
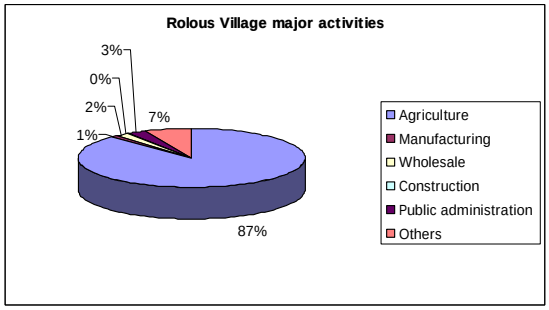
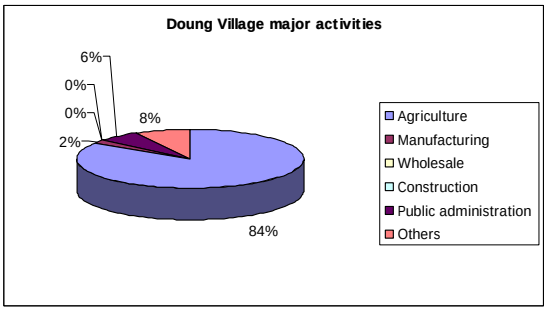


Figure 15-32: Major activities per commune.









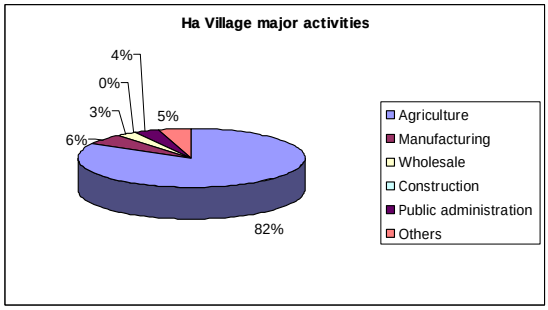


Figure 15-33: Major activities per Target Aerea villages.

b.1 Results for the 3 communes

In general, agriculture is the major occupation of the people living in the communes of Dang kor, Cheung Aek and Spean Thma, followed by people working in public administration, in manufacturing industries of the area and finally arrives the sale activity.

Even though agriculture represents the major activity in each of the three communes, their relative importance differs from one commune to another. For instance, Cheung Aek and Spean Thma communes are typically rural communes as respectively 70% and 86 % of the work force is directly making a living from agriculture. On the other hand, only 43 % of the work force of Dang kor commune is making a living from agriculture.

It is notable that Dang Kor commune is the least involved in agriculture and has the highest standard of living of the three communes. However, Bakou village in Dang kor commune has the lowest score in the standard of living survey, and 84 % of the work force in the village is in agriculture.

b.2 Results for the five villages

When the five villages that belong to the study area are compared, the same trend can be observed.

Figure 15-33 shows that the main activity in all villages is agriculture, but with a slightly less importance for Cheoung Eak village, which has the highest standard of living of the five villages.

b.3 Fishing

It is notable that in general, a lot of people working in agriculture are both farmers and fishermen. These fishermen are either fishing in the ponds nearby their farmland or in Prek Tnot River (see following Figure). The farmers from Dang kor communes are not fishing so much; they fish mainly in the rainy season. 80 % of the farmers of Cheung Aek and 50 % of the farmers of Spean Thma fish the whole year (mainly in the river and the big ponds located in the East of Cheung Aek). It can be considered that fishing is not a major activity but allows people to get a supplementary source of protein.

Figure 15-34: Fishermen in the study area.

c. Traffic and Public facilities

The access road to the proposed disposal site from the center of Phnom Penh is the arterial road, national road 303. This road links and collects all the traffic headed towards Phnom Penh from the communes of Dang kor, Cheung Aek and some of the traffic from Mean Chey and Prey Sa communes (see Figure 15-37).

c.1 Current traffic condition and facility

c.1.1. Road Condition

The road is a 6-7 m wide, gravel and earth road. Therefore, during the rainy season it is badly damaged by traffic especially trucks. Many big holes are present (see) and the road traffic flow capacities are drastically reduced. Because of the bad road conditions, the traffic speed is reduced to 10-15 km/h, which makes transportation very difficult. The only advantage is that there are nearly no accidents due to the low traffic speed.

During the dry season, a lot of dust is created by the traffic, which affects people's health along the road (mainly respiratory problems) (see Figure 15-36).

Moreover, traffic jams are always occurring in the morning and the evening at the entrance of steel bridge No. 1 (Phum Mol bridge) located at the border between commune Dang kor and Mean Chey. YYY

Figure 15-35: Damaged road during rainy season

Figure 15-36: Cloud of dust during dry season

c.1.2. Traffic volume count

Roadside traffic counts were conducted to monitor the comprehensive traffic volume tendency and its indicators, such as peak hours and volume by vehicle classifications. Three stations were located along the road. These survey stations were selected to establish the traffic volume chart every hour and the transport mode distribution on each survey station.

- Three survey stations were set on road 303 (see the following figure). The first station was located about 100 meters south of the 303-A9 intersection.
- The second station was located about 10 meters south of the 303-Prey Sar Road intersection
- The third station was located on road 303 and 600 meters north from the proposed disposal site

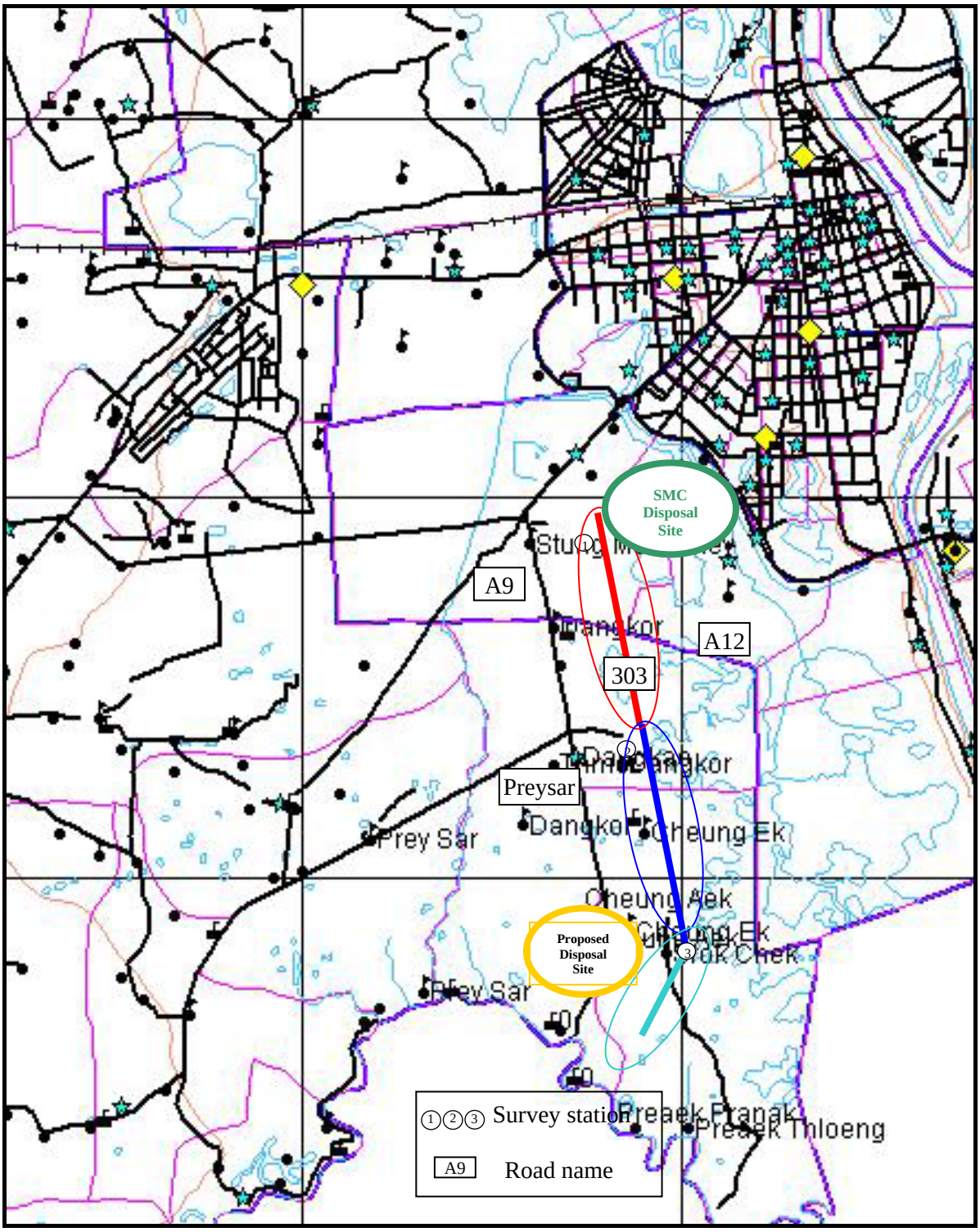


Figure 15-37: Location of the traffic survey stations.

The vehicle count was conducted on the 11th of November 2003. The types of vehicle considered were bicycles, motorcycles, motorumoks, passenger cars, pick up and minibuses, large buses, large trucks and tractors with semi-trailers, tractors with full trailers and others.

PCU methodology

In order to compare the traffic volume of the three stations, all the transport modes were converted into Passenger Car Unit (PCU), using the PCU methodology (Ref.: Bent Thagesen,

Highway and Traffic Engineering in Developing Countries, 1996). This method multiplies the number of each type of vehicle by the coefficients below. The following table gives the coefficients applied to each transport mode

Table 15-49: PCU coefficients.

Transport mode	PCU coefficient
Bicycle	0.3
Motorcycle	0.4
Motorumok	0.6
Passenger car	1.0
Pick up truck and minibus	1.3
Large bus	2.25
Large truck and tractor with semi-trailer	2.3
Tractor with full trailer	4.5
Others	1.5

The details of the survey are given in Annex 2. The following Table gives the traffic volumes from 6:00 am to 7:00 p.m at the three monitoring stations.

Table 15-50: Passenger Car Unit (PCU) of the 13 hour survey.

Time	Station 1	Station 2	Station 3
6h00-7h00	1187	451	182
7h00-8h00	1155	212	118
8h00-9h00	1076	240	87
9h00-10h00	1026	167	100
10h00-11h00	925	205	92
11h00-12h00	823	220	116
12h00-13h00	642	262	105
13h00-14h00	769	182	92
14h00-15h00	886	208	62
15h00-16h00	789	198	89
16h00-17h00	1092	354	98
17h00-18h00	1053	336	96
18h00-19h00	814	255	89
Total (PCU)	**12,237**	**3,290**	**1,323**

From this, it can be said that Station 1 is the station which has the highest total traffic volume, nearly four times the total volume of Station 2 and nearly nine times the total volume of Station 3.

The following figure compares the traffic volume of each monitoring station by time.

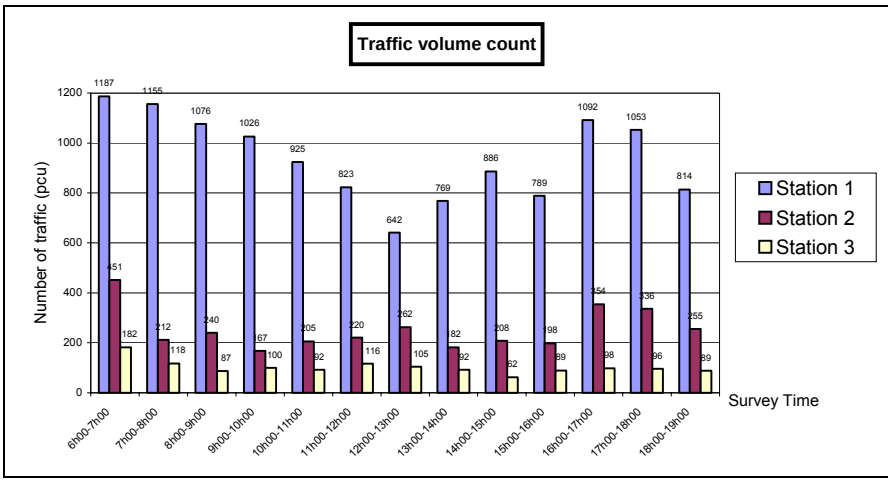


Figure 15-38: Trafic volume comparison.

The peak hours of traffic at each station are in the morning between 6:00 am and 8:00 am and in the afternoon between 4:00 p.m and 6:00 p.m.

Finally, to get an idea of the Average Daily Traffic (ADT) over 24 hours, the 13 hour traffic volumes have to be converted into 24 hour traffic volumes.

Based on the study on the transport master plan of the Phnom Penh metropolitan area conducted by JICA, the ratio of 13 hour traffic volumes to 24 hours varies from 1.2 to 1.3. In this case, the factor is set at 1.25.

Therefore, the Avery Daily Traffic (ADT) is:

- For Station 1 15,296 PCU
- For Station 2 4,112 PCU
- For Station 3 1,853 PCU

Transportation mode distribution

The following table and figures give the transportation mode distribution for each monitoring station. By far, motorcycles are the vehicles that were observed most frequently, followed by bicycles and pick-up trucks.

Table 15-51: Transportation mode distribution

Type	Station 1		Station 2		Station 2	
	PCU	%	PCU	%	PCU	%
Bicycle	678	6	537	16	348	26
Motorcycle	7696	63	2228	68	739	56
Motorumok	136	1	39	1	14	1
Passenger car	782	6	259	8	73	6
Pickup truck and Minibus	1529	12	155	5	56	4
Large Bus	439	4	63	2	83	6
Large Truck and tractor with semi-trailer	957	8	0	0	0	0
Tractor with full trailer	18	0	9	0	0	0
Others	3	0	0	0	11	1
Total	**12237**	**100**	**3290**	**100**	**1323**	**100**

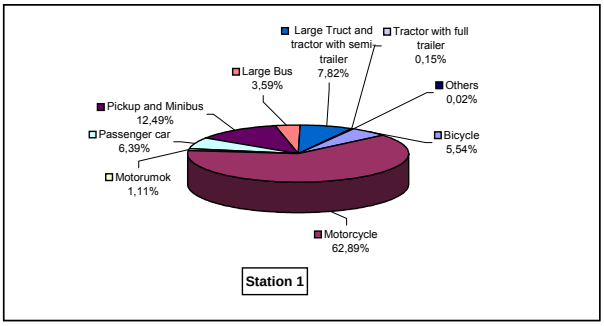


Figure 15-39: Transportation mode distribution for monitoring station 1.

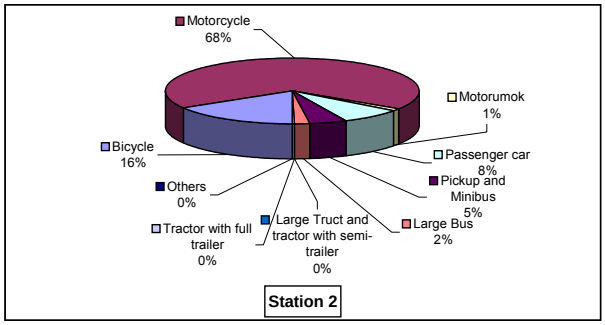


Figure 15-40:: Transportation mode distribution for monitoring station 2

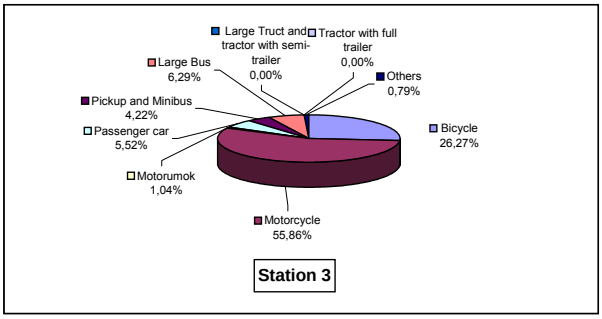


Figure 15-41: Transportation mode distribution for monitoring station 3

c.1.3. Public facilities

Around the study area, ten schools, one health center and one correctional center (prison) have been identified (see following Figure). However, there are no public facilities in the study area.

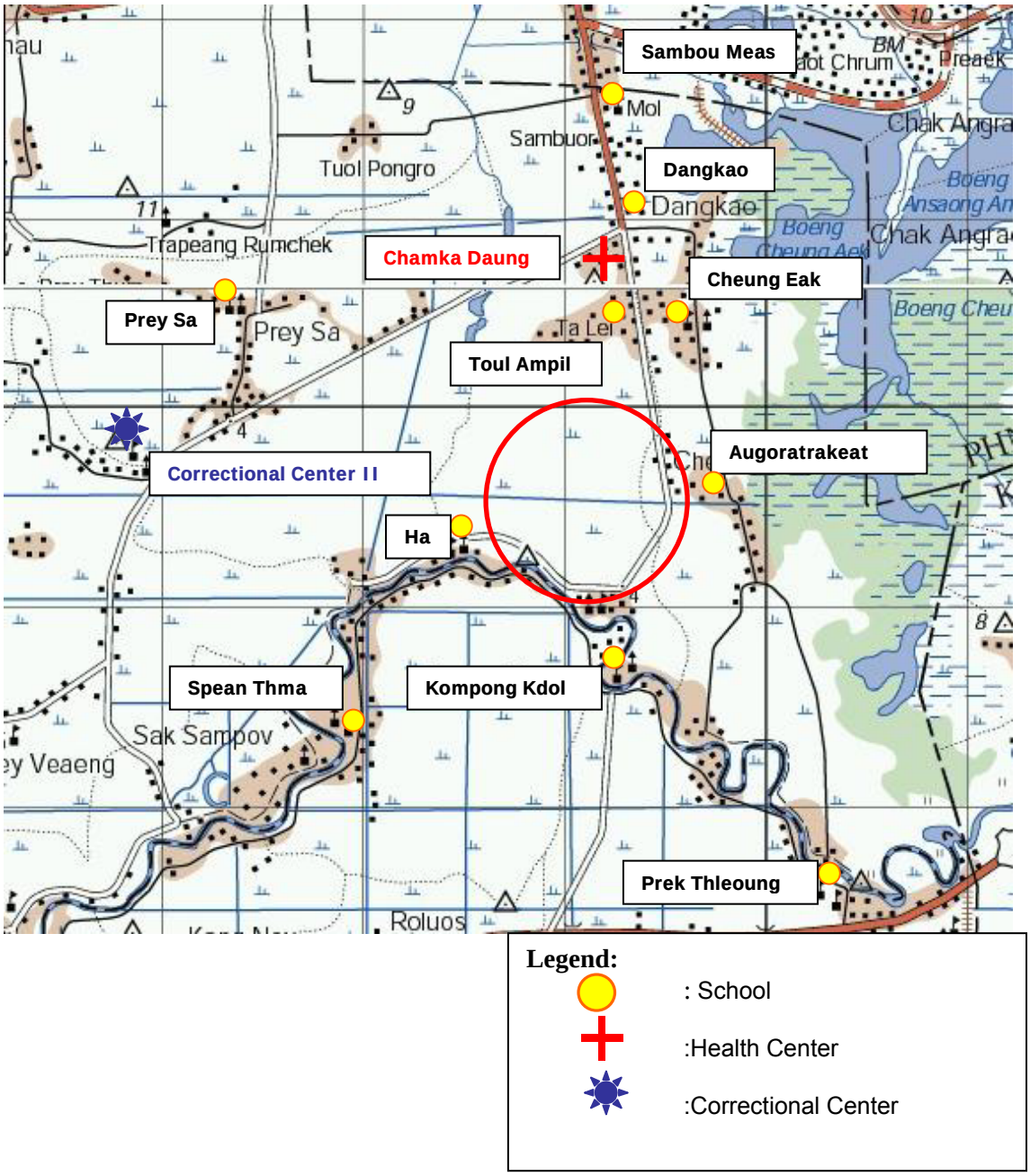


Figure 15-42: Map of the public facilities in the study area.

d. Cultural Property

Concerning cultural property, one memorial site (Killing Fields), nine pagodas and three archeological sites (pagodas) are located around the proposed disposal site. However, none of them is directly located on the site (see Figure 15-43).

The Killing Fields Memorial site is the most important site around the study area. Between 20,000 and 30,000 persons per year visit this genocide memorial and the number might become bigger when road 303 is rehabilitated.

Concerning the nine pagodas, five are located in the commune of Dang kor (Sambour Meas, Thou Dong, Har, Prek Chrey and Ang Meatrey), two in Prey Sar commune (Russey Sagne and Thom Matray) and two in Cheung Aek commune (Cheung Ek and Kok Ampol). Three of the pagodas were recently reconstructed (Thom Matray, Prek Chrey and

Cheung Aek) as they had been destroyed during the Khmer Rouge period, and one pagoda was built recently (Kok Ampol – 2002). The others are between 25 (Thou Dong) and 50 years old (Har, Russey Sagne, Ang Meatrey and Sambour Meas).

It is notable that the Ecole Française d'Extrême-Orient (EFEO)[2] has identified three of the pagodas (Wat Sambour Meas, Wat Har and Wat Cheung Aek) as being built on archeological sites, where some ancient objects have been found.

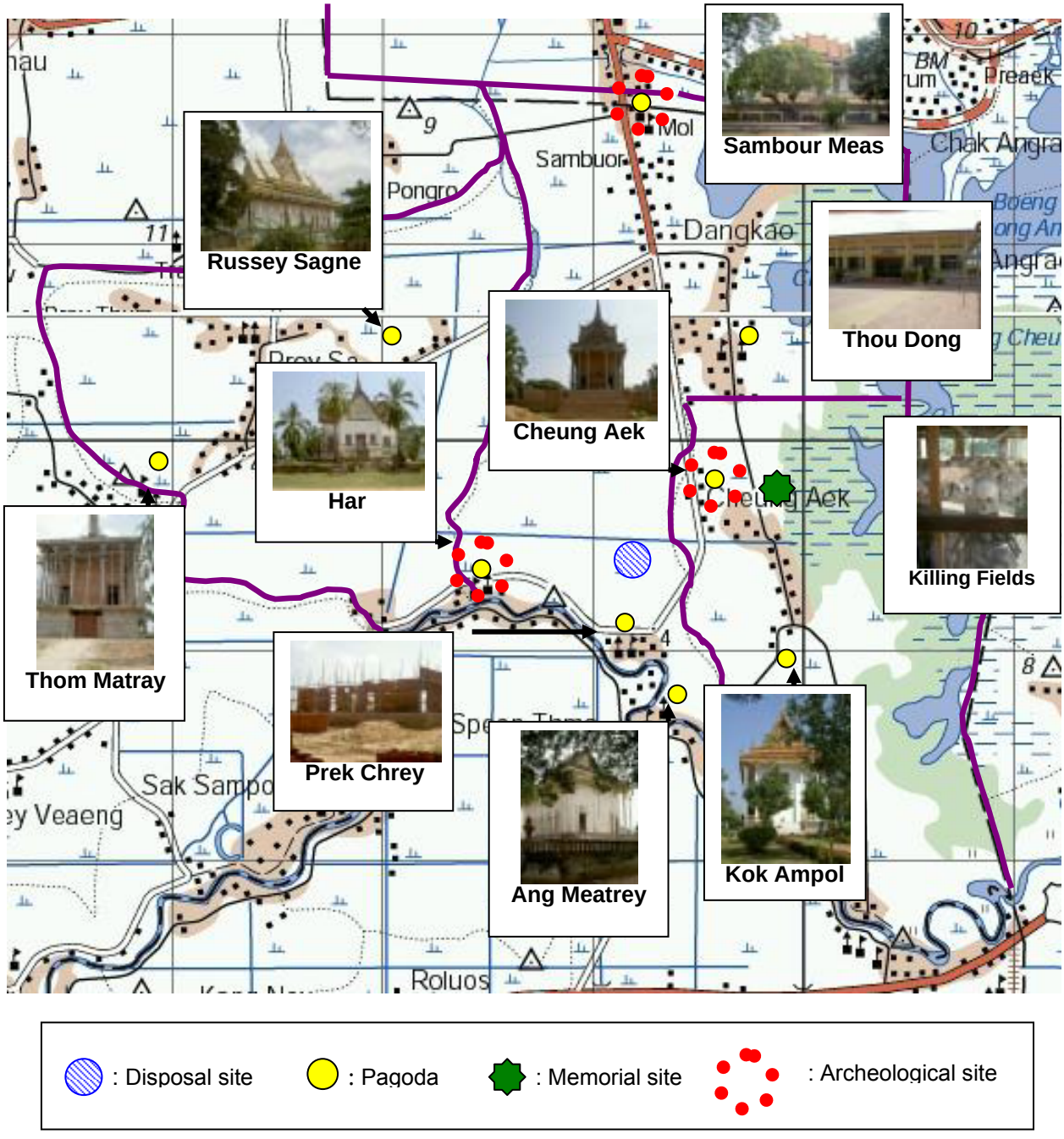


Figure 15-43: Location map of the identified cultural properties in the project area

e. Public health

[2] The EFEO is a worldwide famous French organisation involved with the cultural heritage protection in the Far East area.

In order to get information on public health in and around the study area, an interview survey of the Chamka Daung Health Center (the only health center for the three communes) was conducted. Moreover, at least four people from each of the 15 villages in Dang kor, Prey Sa and Cheung Aek communes were also interviewed.

e.1 Interview with the health center

According to the Health Center, around 550 persons visit the health center per month.

- 122 persons are between 0 and 4 years old
- 98 persons are between 5 and 14 years old
- 242 persons are between 15 and 49 years old
- 89 persons are 50 years old and more

Concerning the major diseases, dengue (30 %), diarrhea (20 %), cough (10 %) and acute respiratory infection (ARI) are the most frequent diseases.

As for life expectancy in and around the study area, that of males is around 54 years old and for females it is around 58 years old.

e.2 Interview with the residents

The following table shows the results of the interview survey in the 15 villages of Dang kor, Spean Thma and Cheung Aek communes.

Table 15-52: Public health information for the 15 villages in Dang kor, Cheung Aek and Spean Thma communes in 2003.

Village	# car accidents	# mine accidents	Presence of Rats/Harmfull insects	# of birth	# of death	# of death below 5 years old	Medicine expenditure (USD) per year
Thmey	1	0	Snake	10	3	0	2,5 - 5
Bakou	0	0	Snake	18	5	1	5 - 25
Sambo	0	0	0	5	6	2	1
Ta Ley	0	0	Snake, centipede	8	2	1	7.5
Mol	0	0	0	19	11	0	
Khvar	0	0	0	20	10	5	
TOTAL	***1***	***0***		***80***	***37***	***9***	
Choeung Ek	0	0	Snake	15	6	0	5
Rolous	0	0	Snake	6	3	0	5
Chek	0	0	Snake	10	2	0	5
Prey Pranak	0	0	Snake	4	0	0	3
Prek Thloeung	0	0	Snake, centipede	16	0	0	10
TOTAL	***0***	***0***		***51***	***11***	***0***	
Spean Thma	0	0	Snake	10	4	0	
Svay Mean Leak	0	0	Snake	4	1	0	
Phum Ha	0	0	Snake	4	0	0	3
Doung	0	0	Snake	1	0	0	
TOTAL	***0***	***0***		***19***	***5***	***0***	

From this survey, it can be said that:

- Very few car accidents have been reported (only 1);
- No mine accidents at all have been reported;
- Concerning the presence of vermin in the project area, none have been reported, with the exception of some snakes and centipedes;
- The total number of births in the three communes is 150 in 2003 (80 in Dang kor, 51 in Cheung Aek and 19 in Spean Thma).
- The total number of deaths in children below 5 years old is 9.
- The total number of deaths in the three communes is around 53 in 2003.

15.4.3 Environmental Characteristics

a. Air pollution

In order to assess the air quality of the project area, monitoring was carried out and three monitoring stations for air pollution were selected:

- A1 was located almost at the center of the proposed disposal site area
- A2 was located south of the site, at the northern end of the residencial area in Bakou village
- A3 was located north of the site, on road 303, 50 meters north of the main entrance to the Killing Fields Memorial.

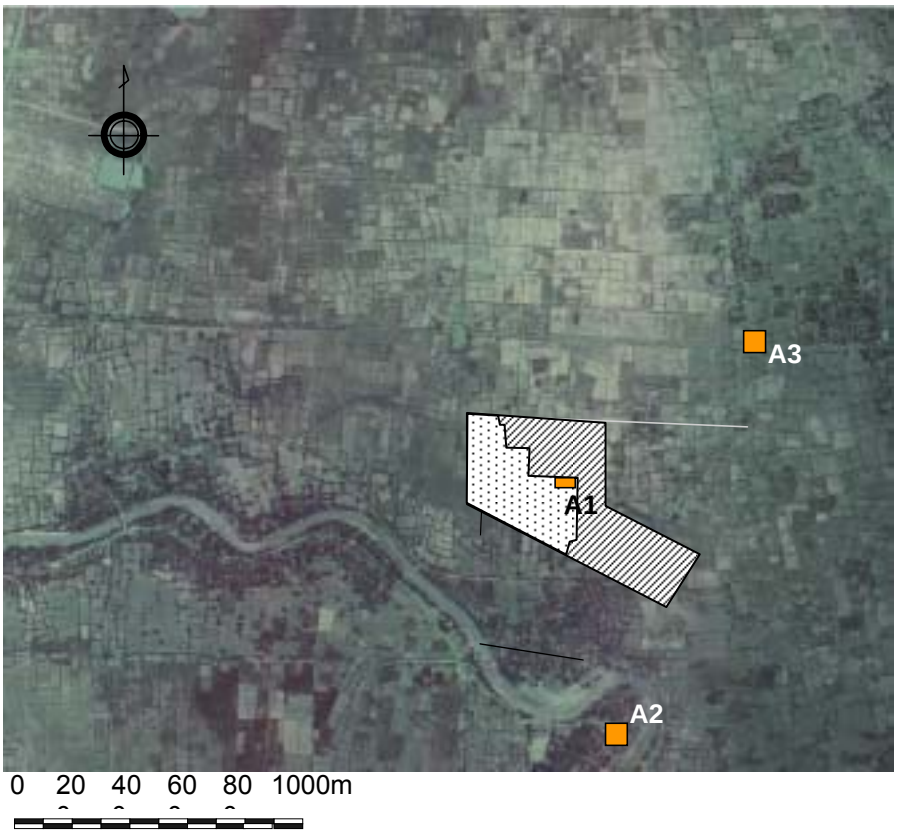


Figure 15-44: Location of the air monitoring stations.

These three stations were monitored for seven days and CO, NO_2, SO_2, TSP and Pb were analyzed. NO_2 and SO_2 analysis required four hours of sampling with 0.4 L/min and 2 L/min pumps respectively, while TSP and Pb required a bigger pump (30L/min pump) and eight hours of sampling (see the following figure). In the case of CO, passive sampling (24 hours) was done.

NO2, SO2 air sampling instrument

TSP and Pb air sampling instrument

Filter for TSP and Pb sampling

CO air sampling instrument

Figure 15-45: Air sampling instruments used for monitoring

The following table gives the results.

Table 15-53: Air quality standard and monitoring results.

		NO_2 µg/m^3	SO_2 µg/m^3	CO mg/m^3	TSP mg/m^3	Pb µg/m^3
Standard	Cambodia	100	300	20	0.33	5
Station	Date					
A1	24/10/03	9.70	9.60	0.16	0.09	< 0.04
	25/10/03	10.4	7.00	0.26	0.15	< 0.04
	27/10/03	4.55	1.17	0.31	0.40	< 0.04
	30/10/03	3.88	1.49	0.16	0.071	< 0.04
	04/11/03	13.00	7.60	0.21	0.146	< 0.04
	05/11/03	3.07	1.25	0.31	0.31	< 0.04
	06/11/03	4.34	2.36	0.21	0.67	< 0.04
A2	24/10/03	3.00	8.70	0.63	5.23	0.21
	27/10/03	11.70	7.00	1.04	1.19	0.07
	28/10/03	15.50	10.20	0.73	0.44	0.08
	29/10/03	8.60	4.30	1.07	0.47	0.04
	30/10/03	15.40	11.90	0.94	0.14	0.08
	31/10/03	6.90	5.60	0.63	4.44	0.07
	05/11/03	17.50	6.00	0.78	13.85	1.51
A3	28/10/03	5.70	10.90	0.94	2.80	0.71
	29/10/03	18.00	10.40	0.78	2.68	0.05
	30/10/03	25.8	4.60	1.46	0.18	0.96
	31/10/03	14.9	5.10	1.04	1.25	0.73
	04/11/03	20.5	16.50	1.46	3.06	0.68
	05/11/03	14.0	4.70	1.56	2.90	0.13
	06/11/03	28.0	5.30	1.56	13.42	0.13

Comparing the results of the three stations with the Cambodian standards, NO^2, SO^2, CO and Pb concentrations are well below the standards. However, a number of TSP results exceeded the standard (highlighted results). The TSP results which exceeded the standard are

distributed in stations A2 and A3. Therefore, it was caused by traffic since A1 is located far from road 303 due to the unpaved road (road 303).

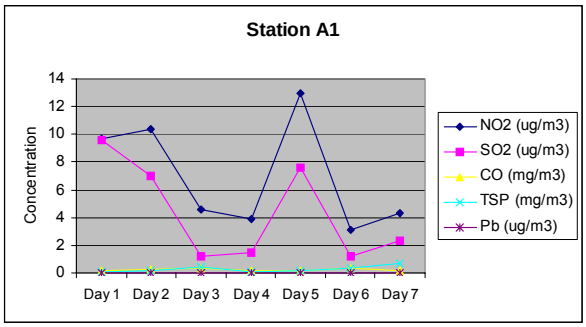


Figure 15-46: Station A1 air pollution results.

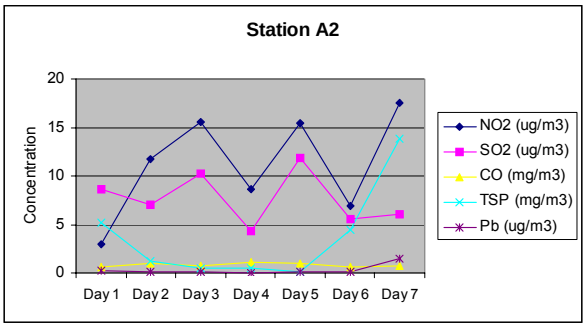


Figure 15-47: Station A2 air pollution results.

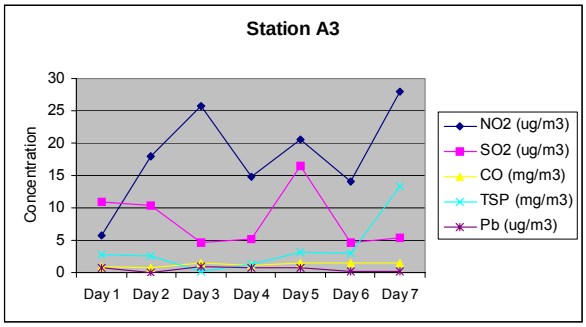


Figure 15-48: Station A3 air pollution results

The following figure shows the results of the average and maximum concentrations for each station. Station A3 shows the highest concentration, followed by station A2; A1 has the lowest results of all. This is because the air pollution is caused by vehicle traffic, and A2 and A3 were located on road 303. A3 in particular was located on the way to the "killing fields" and a number of sight-seeing vehicles passed in front of it.

- Station A1 was located in the middle of a rice field, with therefore less chance to detect air pollution mainly caused by the traffic
- Station A2 was located nearby the road but the traffic condition is not so heavy in the location
- Station A3 was located on the main road, 50m north of the entrance to the Killing Fields Memorial where the traffic is much heavier than the other stations

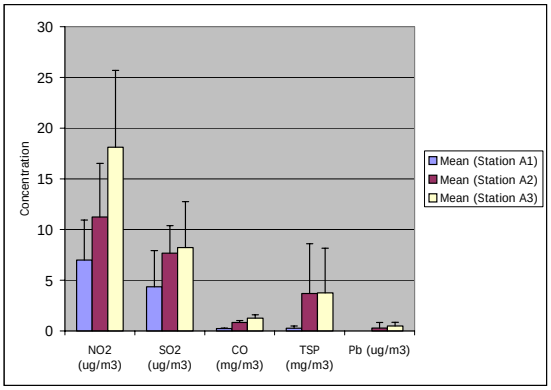


Figure 15-49: Average and maximum concentrations for NO_2, SO_2, CO, TSP and Pb.

b. Water quality

b.1 Sampling

In order to assess the water quality of the project area, monitoring was carried out. Twelve water quality monitoring stations were selected. Five surface water (SW) sampling stations were located on ponds, a river, and a canal in or around the proposed disposal site, and seven groundwater (GW) sampling stations were located in the proposed disposal site and in the villages surrounding the site.

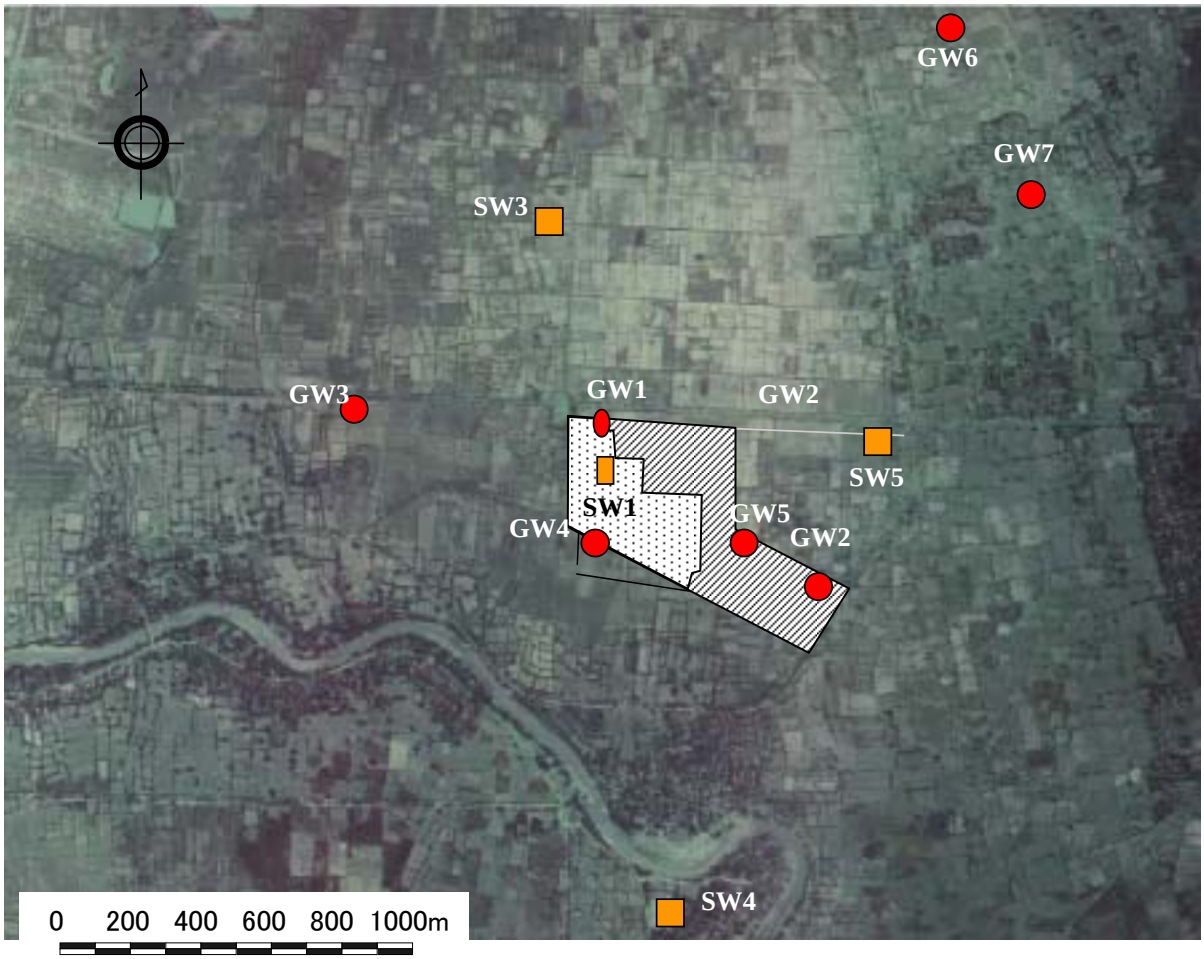


Figure 15-50: Water quality sampling stations.

The samples from SW1, SW2, SW3 and all GW were collected on the 18th of November 2003. The samples from SW4 and SW5 were taken two times for the dry and rainy seasons, on the 23rd of April and on the 28th of October 2003.

The surface water samples were directly taken from the ponds, river and canal. The groundwater samples were collected from existing wells or from boreholes that the Study Team had made for the geological survey (see following Figure).

SW3 sampling station

GW3 sampling station (Anlong Kong village)

GW2 sampling station (Study Team borehole)

On site analysis

Figure 15-51: Photographs of the water quality monitoring survey.

b.2 Groundwater analysis results

The following table shows the results of the groundwater analysis to compare with the Cambodian Standards for public areas.

Table 15-54: Groundwater analysis results

		Date	2003/11/18	2003/11/18	2003/11/18	2003/11/18	2003/11/18	2003/11/18	2003/11/18
		Station Name	Landfill 1	Landfill 2	Anlong Kong Cha	Bakou 1	Bakou 2	Khvav	Rolous
		Station Code	GW1	GW2	GW3	GW4	GW5	GW6	GW7
		GPS position	N 11°28'46.2"	N 11°28'38.5"	N 11°28'27.4"	N 11°28'16.3"	N 11°28'16.9"	N 11°30'24.3"	N 11°28'56.9"
			E 104°53'25.8"	E 104°53'53.2"	E 104°52'14.9"	E 104°53'28.5"	E 104°53'40.1"	E 104°53'59.1"	E 104°54'06.0"
Parameters	**Unit**	**MoE Standard**							
Temperature	**(°C)**		31.8	31.6	30.6	30.1	29.8	29.7	29.3
pH		**6.5-8.5**	6.8	7.2	7.8	6.8	6.8	6.8	7.2
Turbidity			161.0	2.1	1.9	57.0	1.6	1.5	1.1
Color			157.0	7.0	11.0	19.0	29.0	13.0	8.0
Electric Conductivity	**(us/cm)**		573	533	831	425	985	471	1700
DO	**(mg/L)**		2.83	2.79	1.68	0.98	1.15	1.24	1.15
Alkalinity (as CaCO3)	**(mg/L)**		181	248	399	186	202	144	594
Oil content	**(mg/L)**		< 5	< 5	< 5	< 5	< 5	< 5	< 5
Total Coliforms	**(#/100 mL)**	**<5000**	0	160	0	0	0	0	0
BOD5	**(mg/L)**	**1-10**	6.54	1.52	0.89	5.43	1.96	0.82	1.05
COD Mn	**(mg/L)**		1.96	1.28	0.92	0.8	1.08	0.72	0.92
SS (TSS)	**(mg/L)**	**25-100**	467	16	2	267	4	11	4.0
Ammonium - N (NH4-N)	**(mg/L)**		0.0732	0.0225	0.0142	0.039	0.063	0.028	0.0124
Na^+	**(mg/L)**		5.029	4.425	7.716	3.417	4.761	3.535	11.142
K^+	**(mg/L)**		0.587	0.060	0.056	0.026	0.041	0.046	0.014
$SO4^{2-}$	**(mg/L)**		75.4	15.19	26.123	16.35	190.69	21.89	117.87
Cl^-	**(mg/L)**		0.287	0.328	0.287	0.369	0.697	0.328	0.205
Tot-P	**(mg/L)**		3.42	0.0276	0.0089	0.2796	0.0146	0.0112	0.0236
Cd	**(ug/L)**	**<1**	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50
Pb	**(ug/L)**	**<10**	14	< 5,0	< 5,0	7	< 5,0	< 5,0	< 5,0
Cr total	**(ug/L)**		29	< 2,0	< 2,0	9.6	< 2,0	< 2,0	< 2,0
Cr6+	**(ug/L)**	**<50**	< 0,15	< 0,15	< 0,15	< 0,15	< 0,15	< 0,15	< 0,15
Cu	**(ug/L)**		12	< 5,0	< 5,0	< 5,0	< 5,0	< 5,0	< 5,0
Zn	**(mg/L)**		< 0,10	< 0,10	< 0,10	< 0,10	< 0,10	< 0,10	< 0,10
Fe	**(mg/L)**		5.4	0.5	0.11	6.3	0.56	0.29	0.12
Mn	**(mg/L)**		< 0,10	0.93	< 0,10	0.49	1	0.83	0.54
As	**(mg/L)**	**<0.01**	0.0046	0.0005	< 0,0003	< 0,0003	< 0,0003	< 0,0003	0.0008
Tot-N	**(mg/L)**		0.5745	0.0709	0.0496	0.0638	0.1667	0.1241	0.1702
HCO3-	**(mg/L)**		346.5	485.7	277.2	138.6	381.3	311.8	831.6
CN-	**(ug/L)**	**<0.005**	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2
Hg	**(mg/L)**	**<0.0005**	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001	< 0,0001
PCB 28	**(ug/L)**	**0**	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006
PCB 52	**(ug/L)**		< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006
PCB 101	**(ug/L)**		< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006
PCB 138	**(ug/L)**		< 0,003	< 0,003	< 0,003	< 0,003	< 0,003	< 0,003	< 0,003
PCB 153	**(ug/L)**		< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006
PCB 180	**(ug/L)**		< 0,003	< 0,003	< 0,003	< 0,003	< 0,003	< 0,003	< 0,003

Generally, the results of groundwater showed good water quality. Although the SS concentration of GW1 and GW exceeded the standard, it was caused by precipitaion in the borehole and well. Pb of GW1 slightly exceeded the standard.

b.3 Surface water analysis results

The following table shows the results of the surface water analysis to compare with the Cambodian Standards for drinking water.

Table 15-55: Surface water analysis results (1/2)

			Date	18/11/2003	18/11/2003	18/11/2003	28/10/2003	28/10/2003
			Station Name	Boeng 1	Boeng 2	Boeng 3	River	Canal
			Station Code	SW1	SW2	SW3	SW4	SW5
			GPS position	N 11°28'46.8"	N 11°28'42.9"	N 11°28'51.4"	-	-
				E 104°53'27.0"	E 104°53'17.1"	E 104°53'23.2"	-	-
Parameters	**Unit**	**MoE Standard**						
Temperature	**(°C)**			34.7	32	32.6	26.5	30
pH		**6.5-8.5**		7.7	7.2	7.0	6.9	7.0
Turbidity				976.0	15.9	152.0	42.1	117.0
Color				849.0	58.0	465.0	400.0	470.0
Electric Conductivity	**(us/cm)**			97.6	98.9	82.9	39	35
DO	**(mg/L)**			5.83	4.48	3.74	-	-
Alkalinity (as CaCO3)	**(mg/L)**			127.5	219	144	8.85	9.84
Oil content	**(mg/L)**			< 5	< 5	< 5	2	3
Total Coliforms	**(#/100 mL)**	**<5000**		1900	900	1600	130	510
BOD_5	**(mg/L)**	**1-10**		6.14	5.27	4.48	13.7	9.5
COD Mn	**(mg/L)**			4.6	6.4	6.2	27.4	23.5
SS (as TSS)	**(mg/L)**	**25-100**		1935	24	184	107	99
Ammonium - N	**(mg/L)**			0.0723	0.017	0.0308	0.46	0.10
Na^+	**(mg/L)**			1.452	0.495	0.546	<0.05	0.050
K^+	**(mg/L)**			0.063	0.020	0.023	<0.1	<0.1
$SO4^{2-}$	**(mg/L)**			25.83	3.323	3.41	8.3	6.0
Cl^-	**(mg/L)**			0.574	0.369	1.311	5.43	6.9
Tot-P	**(mg/L)**			0.1968	0.0429	0.1912	0.80	1.41
Cd	**(ug/L)**	**<1**		0.63	< 0,50	< 0,50	<50	<50
Pb	**(ug/L)**	**<10**		47	< 5,0	14	<1000	<1000
Cr total	**(ug/L)**			192	< 2,0	13	<200	<200
Cr6+	**(ug/L)**	**<50**		0.29	< 0,15	< 0,15	<5	<5
Cu	**(ug/L)**			60	< 5,0	5.4	<200	<200
Zn	**(mg/L)**			0.19	< 0,10	< 0,10	0.273	0.235
Fe	**(mg/L)**			64	1.2	6.7	0.62	1.03
Mn	**(mg/L)**			0.16	0.89	0.12	<0.1	<0.1
As	**(mg/L)**	**<0.01**		0.0042	< 0,0003	< 0,0003	<0.01	<0.01
Tot-N	**(mg/L)**			1.7375	0.8475	0.2447	1.53	2.29
HCO3-	**(mg/L)**			311.8	173.2	103.9	63.9	65.1
CN-	**(ug/L)**	**<0.005**		< 0,002	< 0,002	< 0,002	<1	<1
Hg	**(mg/L)**	**<0.0005**		< 0,0001	< 0,0001	< 0,0001	<5	<5
PCB 28	**(ug/L)**			< 0.006	< 0.006	< 0.006		
PCB 52	**(ug/L)**			< 0.006	< 0.006	< 0.006		
PCB 101	**(ug/L)**	**0**		< 0.006	< 0.006	< 0.006	<0.2	<0.2
PCB 138	**(ug/L)**			< 0.003	< 0.003	< 0.003		
PCB 153	**(ug/L)**			< 0.006	< 0.006	< 0.006		
PCB 180	**(ug/L)**			< 0.003	< 0.003	< 0.003		

Table 15-56: Surface water analysis results (2/2)

No.	Parameters	Unit	Standard for in public	Sample No			
				SW4		SW5	
				Dry season	Rainy season	Dry season	Rainy season
1	Temperature	°C		24.5	26.5	25.5	30
2	pH		6.5-8.5	7.00	6.87	7.00	6.95
3	Electric Conductivity	mS/cm		83	39	153	35
4	Turbidity	NTU		19.8	42.10	410	117
5	Color	Pt/Co		440	400	24000	470
6	Alkalinity	mg/l		22	8.85	104	9.84
7	Oil Content	mg/l		0.02	2	0.03	3
8	Total Coliform	MPN/100ml	<5000	150	130	430	510
9	BOD_5	mg/l	1-10	1.72	13.72	0.05	9.56
10	COD	mg/l		15.08	27.44	18.86	23.52
11	SS	mg/l	25-100	355	107.6	5551	98.5
12	Ammonium-N	mg/l		18.5	0.46	6.5	0.10
13	Na^+	mg/l		<0.1	<0.05	4.61	0.05
14	K^+	mg/l		17.04	<0.1	2.78	<0.1
15	SO_4^-	mg/l		45.61	8.3	533.3	6.0
16	Cl^-	mg/l		9.87	5.43	79.01	6.91
17	HCO_3^-	mg/l		21.68	63.9	59.93	65.1
18	Total Phosphorus	mg/l		0.323	0.80	0.126	1.41
19	Cadmium	μg/l	<1	<100	<50	<100	<50
20	Cyanide	μg/l	<0.005	6	<1	<1	<1
21	Lead	μg/l	<10	<1000	<1000	<1000	<1000
22	Total Chromium	mg/l		<0.1	<0.2	<0.1	<0.2
23	Hexavalent Chromium	μg/l	<50	<5	<5	<5	<5
24	Arsenic	μg/l	<10	<10	<10	<10	<10
25	Copper	mg/l		<0.1	<0.2	0.127	<0.2
26	Zinc	mg/l		<0.1	0.273	<0.1	0.235
27	Iron	mg/l		13.730	0.617	0.132	1.028
28	Manganese	mg/l		<0.1	<0.1	0.376	<0.1
29	Total Nitrogen	mg/l		2.17	1.53	6.52	2.29
30	Total Mercury	μg/l	<0.5	2	<5	12	<5
31	PCB	μg/l	0	<0.2	<0.2	<0.2	<0.2

Generally, the quality of surface water was found to be good though some parameters such as SS and BOD concentrations of SW1 and SW4 exceeded the standard.

It is notable that Pb concentrations of SW1 exceeded the standard, and GW1 which is located near SW1 also exceeded the standard for Pb. As the location of SW1 and GW1 are very close, some matrial containing Pb, such as batteries, might have been dumped there before.

As for total mercury (Hg), it is notable that samples from SW4 and SW5 in the dry season exceeded the standard in Cambodia in public water areas. Hg does not exist in normal environments except for volcanos, etc. The Study Team searched the upstream areas of these points, but could not find any factories or facilities which discharge Hg. One possibility is contamination by pesticides. Pesticides that contain mercury were widely used throughout the world and are still being used in developing countries even though their use has been banned. According to FAO, although there is no data on the use of Hg containing pesticides in Cambodia, the possibility is quite high. Although it is out of the scope of work, this should be clarified.

As for cyanide, a sample from SW4 in the dry season showed concentrations exceeding the standard in Cambodia for public water areas. However, as with mercury, cyanide does not exist in natural environments. No reason for cyanide contamination has been determined so

far. Even if the points are contaminated by cyanide, the results are below the WHO guideline for drinking water quality.

c. Hydrological situation

c.1 Ponds and rivers

Several ponds are located in and around the study area. However almost all exist only in the rainy season except one pond, which is located northwest of the proposed disposal site. It is an irrigational regulation pond.

The Prek Thnot river, a tributary of the Bassac river, also runs through the South of the proposed disposal site.

The water quality of the ponds and river are shown in the section on "Water quality".

However, as mentioned in the section on "Water Quality", the total mercury (Hg) concentration in samples from Prek Thnot river and an irrigation canal near the site exceeded the Cambodian standard for public water areas. One possibility is contamination by pesticides. Pesticides that contain mercury were widely used throughout the world and are still being used in developing countries even though their use has been banned. According to FAO, although there is no data on the use of Hg containing pesticides in Cambodia, the possibility is quite high. Although it is out of the scope of work, this should be clarified.

c.2 Wells and Aquifer

Based on the geological survey in the study area and interview survey to the residents living in and around the study area, ground aquifer exists and the people who live in the study area drink the groundwater. The people who live on Prek Thnot river use the river water for drinking purposes.

The water quality of the groundwater is shown in the section on "Water Quality Monitoring".

Concerning water quality, it is notable that Pb concentrations in the pond and groundwater at the site exceeded the standard. As the location of the pond and groundwater are very close, some material containing Pb, such as batteries, might have been dumped there before.

d. Soil contamination

The proposed disposal site is mainly rice fields. Therefore, very low soil contamination is expected, partly perhaps from some pesticides. However, as mentioned in the section on "Water Quality Monitoring" and "Hydrological Situation", in the dry season mercury (Hg) concentrations in samples from Prek Thnot river and the irrigation canal near the site exceeded the Cambodian standard for public water areas. As with river and pond water quality, soil in the study area also might be contaminated by Hg. As with Hg, it is notable that Pb concentrations in the pond and groundwater at the site exceeded the standard. As the location of the pond and groundwater are very close, some material containing Pb, such as batteries, might have been dumped here before.

Based on the geological survey, the site and its surroundings consist of silty clay from the ground surface to a depth of 10-15 meters.

e. Noise

For the noise monitoring survey, 7 stations were selected in and around the proposed disposal site. The noise level was monitored per station for 24 hours. The location of the stations is as follows:

Figure 15-52: Noise monitoring stations

Figure 15-53: Instrument used for the noise monitoring survey.

The following figures give the results of the noise level for each of the seven stations over 24 hours. On each graph, the minimum, maximum, average and standard noise levels are represented.

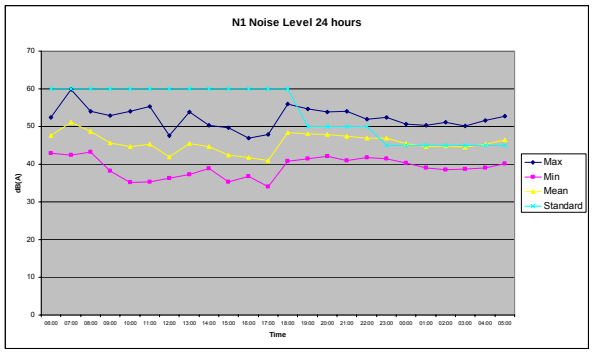


Figure 15-54: Station N1 24 hours noise level

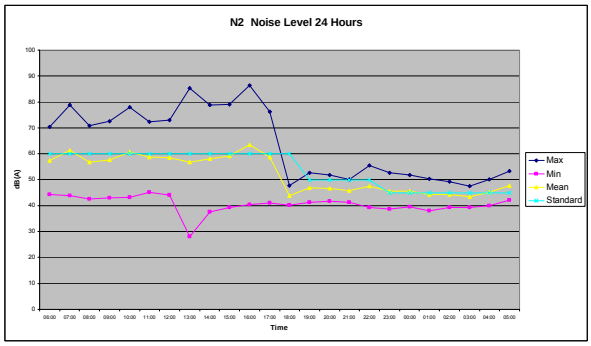


Figure 15-55: Station N2 24 hours noise level

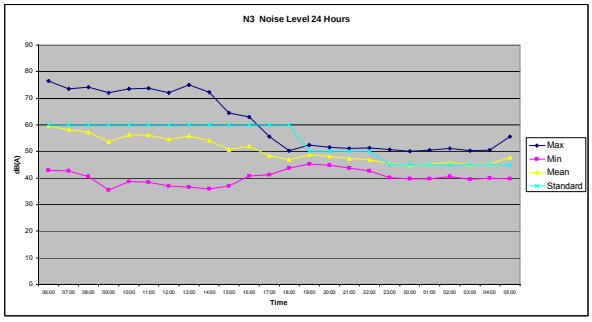


Figure 15-56: Station N3 24 hours noise level

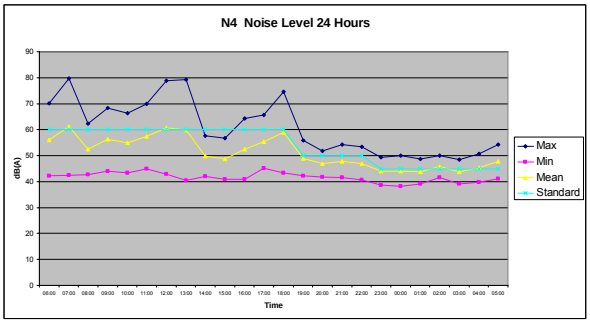


Figure 15-57: Station N4 24 hours noise level.

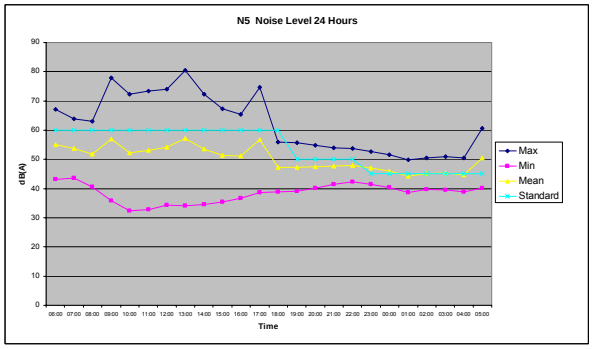


Figure 15-58: Station N5 24 hours noise level

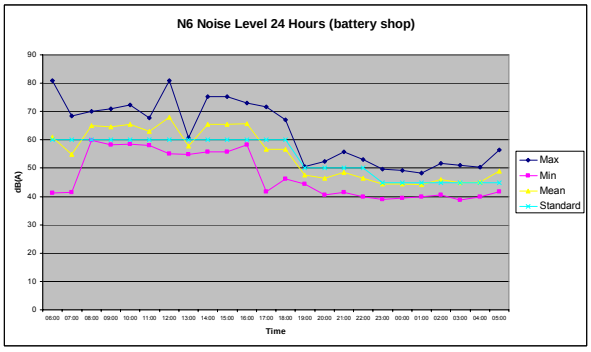


Figure 15-59: Station N6 24 hours noise level

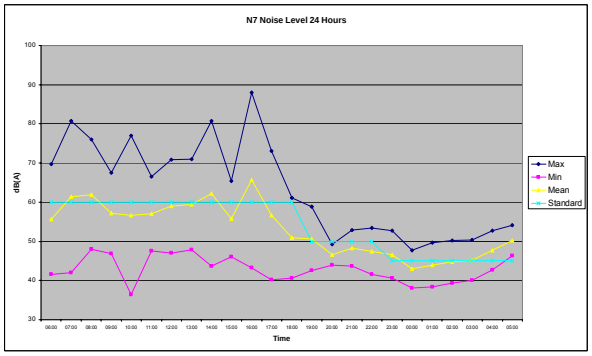


Figure 15-60: Station N7 24 hours noise level.

From these graphs, it can be said that the average noise level is in general below the Cambodian standards (see following table), except for station N6 which was located on the way to the “killing fields”.

Table 15-57: Maximum permitted noise level in public and residential areas (dB(A))

Cambodian standards

N°	Area	From 6h to 18h	From 18h to 22h	From 22h to 6h
1	Quiet areas: Hospitals, Libraries, School, Kindergarden	45	40	35
2	Residential area: Hotels, Administration offices, House	60	50	45
3	Commercial and service areas and mix	70	65	50
4	Small industrial factories intermingling in residential	75	70	50

The following table compares the noise level results for each station with the standard.

It can be seen that the noise is in general caused by traffic, mainly during the day. Station N1 is located far from the road and showed a lower noise level than the other stations (45.3 dB in the range from 06:00-18:00). This noise mainly came from animals and birds in the rice fields. The other stations (N2-N7) show a higher noise level during the day time.

Compared with the Cambodian standard, noise levels are generally lower than the standard. From 6:00 to 22:00, almost all the average results, except N6 from 6:00 to 18:00, were below the standard. The average level at N6 from 6:00 to 18:00 shows to be 62.3dB, which slightly exceeds the standard (60dB). This was due to the heavy traffic volume as N6 is located on the way to the "killing fields".

In the period from 23:00 to 5:00, all average results slightly exceeded the standard.

Table 15-58: Comparison of the average noise level results for each station with the standard

STATION	06:00-18:00		18:00-22:00		22:00-06:00	
	Ld (Average)	Ld (Standard)	Ls (Average)	Ls (Standard)	Ln (Average)	Ln (Standard)
N1	45.30	60	47.60	50	45.50	45
N2	57.80	60	46.72	50	45.20	45
N3	54.10	60	47.90	50	45.60	45
N4	55.70	60	47.70	50	45.20	45
N5	53.40	60	47.60	50	46.10	45
N6	62.30	60	47.30	50	45.40	45
N7	58.40	60	61.00	50	45.90	45

f. Offensive odor

There is nothing that would cause an offensive odor in the study area as it is mainly rice fields. When the public health survey was conducted in the different villages, an interview survey for offensive odor was also done if the residents had any complaints about offensive odor in and around the proposed disposal site. As a result, no one had any complaints about offensive odor.

g. Fauna and Flora

The study of the fauna and flora in the study area was done in the following way:

- For domestic animals (cows, pigs and poultry), the study was based on field work and questionnaires to the villagers and the chiefs of the villages.
- For birds, the work was based on field work (observations and listening to the bird songs) and questionnaires to the villagers. The identification of the scientific names of the species observed was based on Wildlife Conservation Society (WCS) documents. This institution has been studying most of the bird species in Cambodia.
- For fish, the work was based on field work and questionnaires to fishermen. The identification of the species in scientific name was done based on World Food Program (WFP) documentation;
- For reptiles, amphibians and insects, the study was mainly based on field work and questionnaires. However, some of the species were not identified by scientific names due to the lack of documents available on species in Cambodia.

For details of the data, see Data 10

g.1 Fauna

g.1.1. Domestic animals

Villagers breed cows to work in their rice fields, and pigs as a supplementary source of revenue. The poultry includes chicken, ducks and geese.

The distribution of the domestic animals in and around the proposed new disposal site is given in the following table:

Table 15-59: Distribution of domestic animals in the villages of the study area.

Village	# of cows	# of pigs	# of poultry
Cheung Ek	300	120	
Ba Kou	115		
Sroc Chek	163	295	700
Ro Lours	98	183	2872
Peam	75	40	270
Svay Mean Lak	45		
Khvar	75	185	

Cow

Buffalo

Pig

Goat

Figure 15-61: Some pictures of domestic animals

g.1.2. Birds

Concerning the birds, only the domestic ones were counted. The wild species were mainly observed early in the morning or late at night. A total of 60 species have been identified.

g.1.3. Fish and other aquatic species

In and around the study area, many species of fish and fresh water shellfish are found in the Prek Thnot river (see below for the detail list). During the rainy season, many fish, crab, shrimp and snail species can be found in the rice fields and the ponds of the study area. Amphibians (frogs and toads) are also found in the area as in most of the rural areas of Cambodia.

A total of 59 species of fish have been identified, two species of shrimp, two of crabs, two of frogs, two of toads, two of bivalve mollusc, one of leech, one cockchafer, three species of snail and one of worm.

Trey Chhlaing – Mystus nemurus

Trey Cha kèng – Puntionplites waanders

Trey Kampleigne – Trichogaster microlepis

Trey Kachoss – Heterobagrus bocourti and
Trey Linh – Thynnithys thynnoides

Trey Roass – Channa marulius

Trey Linh – Thynnithys thynnoides

Figure 15-62: Some pictures of fishes

g.1.4. Mammals

A total of 11 species of mammals have been identified in and around the study area, mainly three species of mice, two species of squirrels, one species of rabbit, and one species of monkey.

g.1.5. Reptiles

Concerning the reptiles, geckos, certain lizards and certain snakes were found. Information on other species were also given by the villagers.

g.1.6. Insects

Concerning insects, many species were found; for example, dragonflies, grasshoppers and butterflies were observed in the rice fields.

Red ant

Butterfly

Figure 15-63: Photographs of insects encountered in the study area.

g.1.7. Flora

In the study area, the flora is mainly a big rice field area with some fruit trees, vegetable areas, bloom trees and small bush trees planted by the villagers. In the fields, these trees and plants give the typical atmosphere of rural areas in Cambodia. In addition, the villagers are also cultivating green beans, tomatos, courgettes, eggplants, cucumbers, pumpkins and soja.

Figure 15-64: Typical landscape of rural areas in Cambodia

Other wild plants found in the area (trees, shrubs and other types of plants) are shown in Annex. In total, approximately 380 different species of trees and plants have been identified in the study area.

h. Landscape

The following aerial photograph shows the general landscape of the study area.

The picture shows that the topography of the study area is flat, containing mainly rice fields with some palm trees and ponds. There are not many roads in the area, the biggest one being road 303. The scenic potential of the study area is special as it is mainly rice fields with scattered palm trees. It can be said that it is a typical landscape of rural areas in Cambodia.

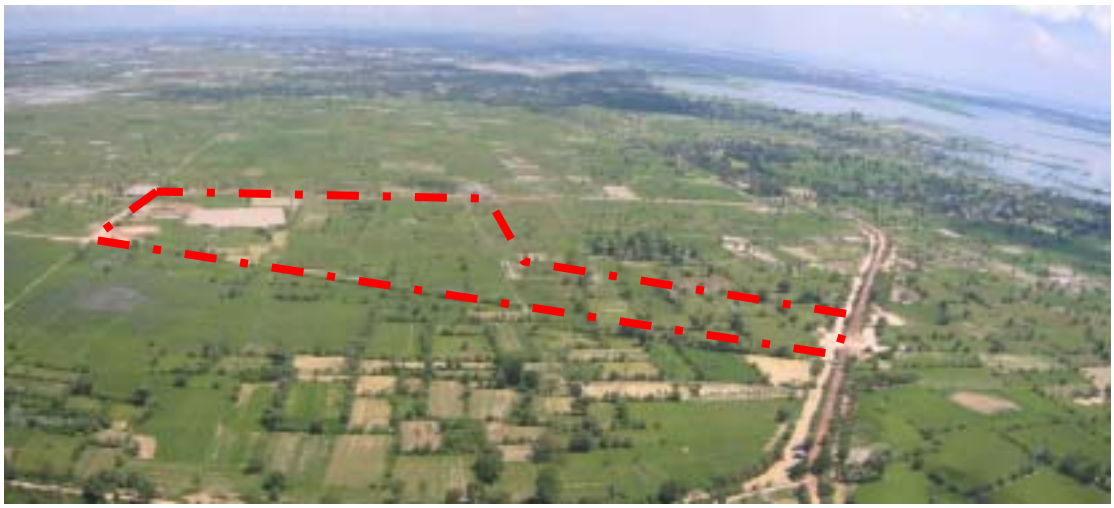


Figure 15-65: Project area aerial photograph.

The landscape survey proved that the future disposal site could be seen from road 303 and from Cheung Aek village and Bakou village.

As palm trees are located between the villages and the proposed disposal site, the view from the villages will not be much affected.

(See map and panoramic pictures hereby attached)

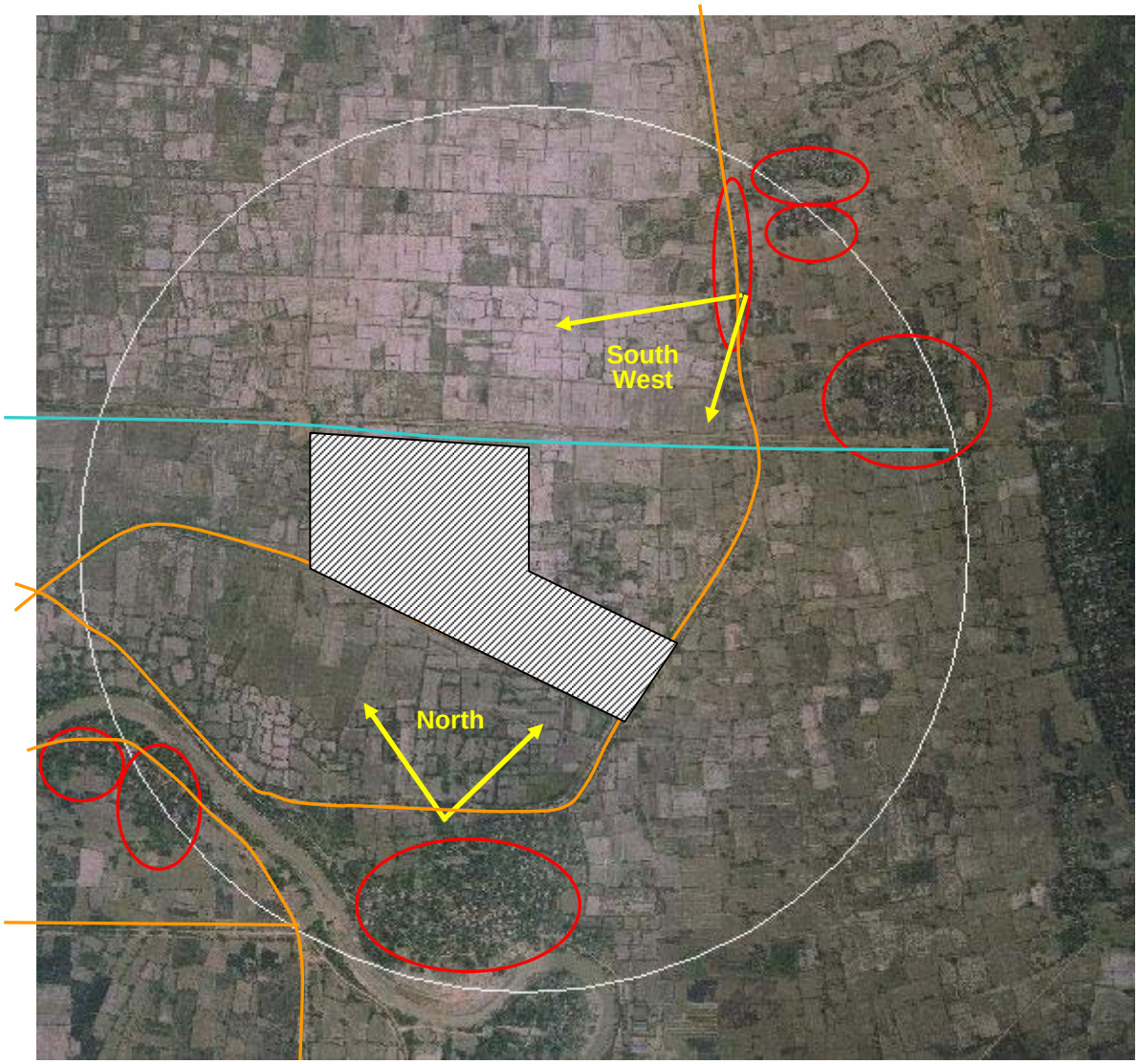


Figure 15-66: Panoramic pictures - location and view range of the camera

Figure 15-67: View of the proposed disposal site from Cheung village (to South West)