7. Feasibility Studies

7 Feasibility Study

7.1 Priority Projects for the Feasibility Study

7.1.1 Priority Projects for the Feasibility Study

Based on the M/P the following three projects were selected as priority projects to be implemented by year 2010 and decided by the St/C held on May 10th, 2006. Following the decision of the St/C feasibility study for the projects was conducted below.

Table 7-1: Priority Project

Priority Project	Contents
1. Improvement of collection system	1.1 Improvement of collection efficiency in the Planned area (Apartment area) 1.2 Provision of a collection service to all the households in UB, including the Unplanned area (Ger area) 1.3 Introduction of a separate collection system in the Planned area 1.4 Construction and management of a central workshop
2. Development of Narangiin Enger Disposal Site (NEDS)	2.1 Construction of a final disposal site for sanitary landfill operation 2.2 Implementation of a sanitary landfill operation
3. Development of Narangiin Enger Recycling Complex	3.1 Construction and operation of a sorting yard 3.2 Construction and operation of a RDF plant 3.3 Development of a industrial site for private recycling businesses and attraction of them

7.1.2 Supplemental Study

a. Topographic Survey

Topographic map of proposed Narangiin Enger Disposal Site (NEDS) is prepared in the scale of 1/1,000 and 1.0m contour interval. The map is used for the development of a new disposal site at Narangiin Enger and a recycling complex next to the NEDS

b. Geological Investigation

b.1.1. Findings of the Investigation

Geological investigation works was conducted by a local company (Engineering Geodesy Co., Ltd.) that was selected through a competitive bidding. Five boreholes in total were drilled for the investigation. The followings are main findings of the investigation:

1. The proposed NEDS and recycling complex site has the following geological features:
   - Geomorphologic form: Investigation site was affected by temporary water activity and human and engineering activity.
   - Water in boreholes: Water discovered only 5th borehole at 3 m deep from surface when drilling. Other boreholes do not have water.
   - Rocks: Investigation site has sandy and pebbles with sandy, decayed cliff soil. Therefore investigation area belongs engineering geological middle difficult condition.
2. The proposed NEDS locates between Khokh Tolgoin and Ulaan Tolgoin hills in west side of Ulaanbaatar City.
3. Geological structures of the proposed site are denudation accumulation of origin alluvial-pluvial and diluvial deposits of age of upper-modern quaternary. And pebble with loam, rock soil widespread in the investigation area.

4. Soil water did not appear when drilling. Temporary stream possibly arises when rainfall and flooding. Spring occurred in bottom of Khokh Tolgoin hill.
5. Investigation area's permeability is ranging from 0.03 cm/min to 0.25 cm/min
6. Investigation area located in 7 ball's seismic zone.
7. Soil permeability is low by result of Naliv test of No. 1, 2 and 3 boreholes. The construction of NEDS and recycling complex will be small impacts on soil, because rocky soil layer exists in 2-3 m deep from surface by boreholes records

b.2 Geological Profiles

Based on the five boring surveys geological profiles of the site were prepared as shown in the following figures.

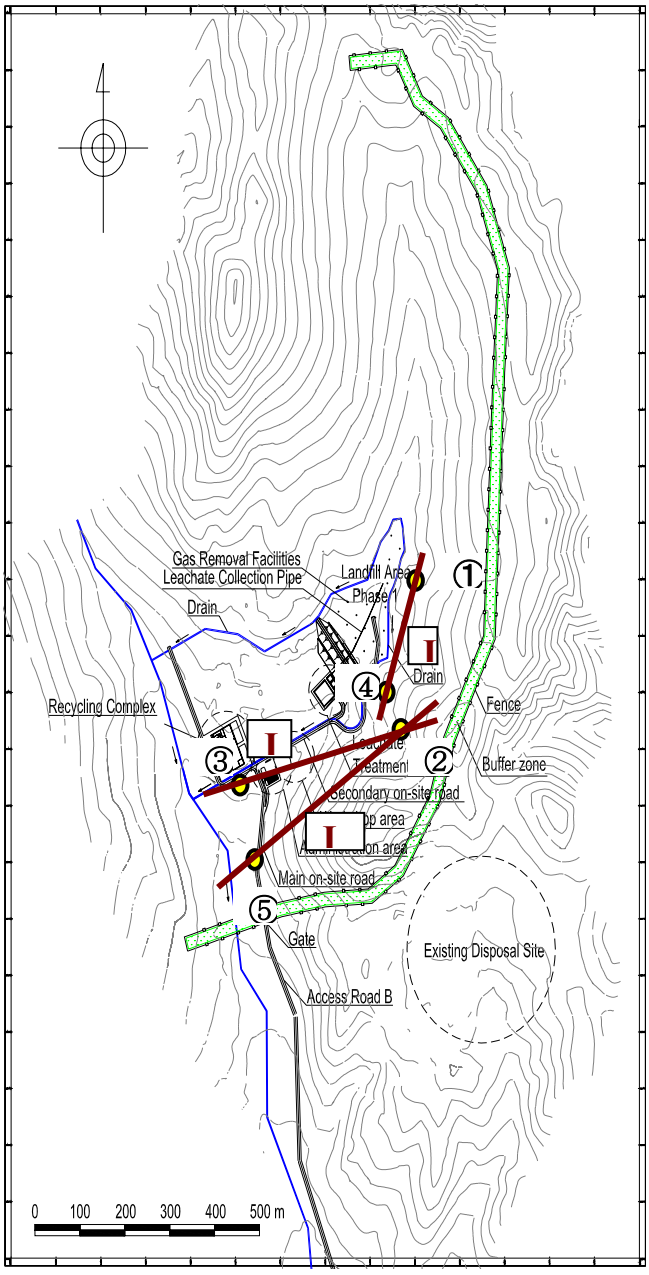


Figure 7-1: Location of Boreholes

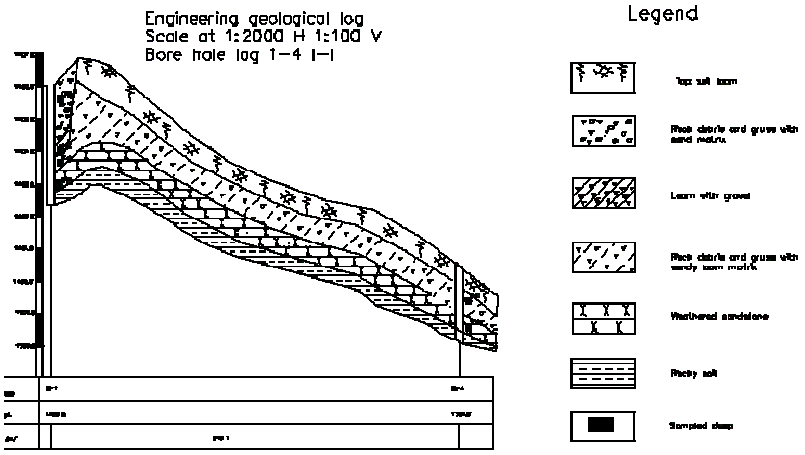


Figure 7-2: Geological Profile of I - I Section

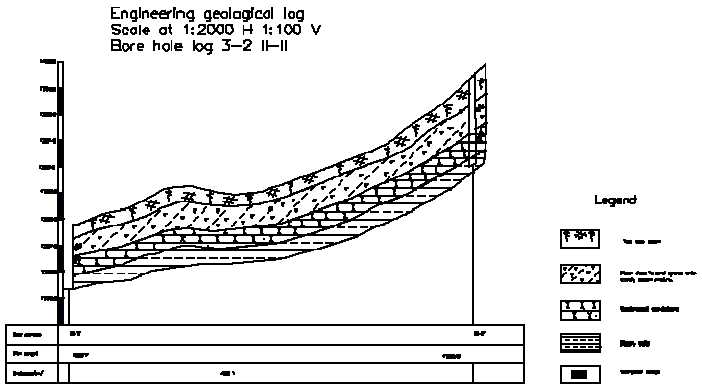


Figure 7-3: Geological Profile of II - II Section

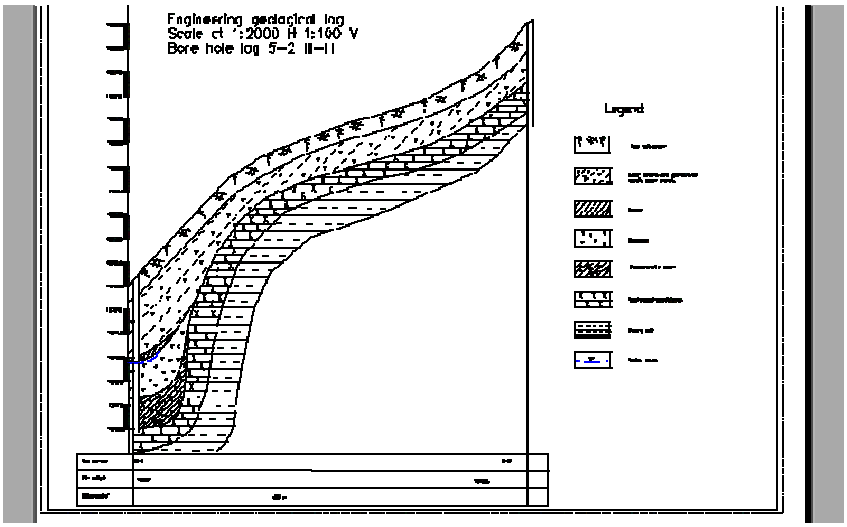


Figure 7-4: Geological Profile of III - III Section

c. Social Survey

The main targets of the social survey can be divided into two groups.

- waste pickers who are working at the UCDS now
- local residents who are living near the project site in Khoroo 3 and 4 of SKhD

In fact, many of residents in the target area are working at the disposal site. Therefore, it can be said that a main target group is waste pickers who are working at the disposal site.

c.1 Waste pickers at the disposal site

At the first phase, a social survey targeting waste pickers was conducted. However, at that time, they tend to be very hostile toward outsiders, and it was impossible to conduct an extensive survey. The number of interviewees and meeting participants were limited.

This survey aimed at obtaining a general view of waste pickers who are working at the disposal site and making a consensus about rules at the current disposal site as well as the plan of the new disposal site.

The survey consists of two parts: Registration and Focus group meetings. The outlines of these parts are described below.

c.1.1. Introduction of the Registration System

(1) Outline of registration system

In order to obtain a whole view of waste pickers, a registration system was tried to be introduced. All the waste pickers are requested to register, applying a family registration sheet, shown below. The registration sheets were accepted at the Nuut Co. office for one week from August 10, 2005. The registration data was compiled and the database was created. According to the site manager of the disposal site, almost all the waste pickers who have worked at the disposal site relatively long were registered.

Regarding the registration of new comers, the details procedure will be finalized later.

Registration Sheet (1 sheet per each family)

Serial No.		Date	

Head of Household

Name	
Duureg	
Khoroo No.	
Heseg No.	
Birth date	
Sex	

Those who work at the disposal site
(All the member who work at the disposal site, including those who work only at weekend, only during summer time, and so on)

						only for those who are 15 years old or under	
Name	birth date	Sex	the year when you started to work at the disposal site	you work … 1. whole the year 2. only winter 3. only summer	working days per week (1-7)	going to school (formal) 1. every day 2. sometimes 3. not going	informal school 1. I attend 2. I attended 3. never

Figure 7-5: Registration Sheet

(2) Result of registration

Even though there are unregistered waste pickers (mainly new comers), the information obtained from the registration data is summarized.

The number of families which were registered was 148. The distribution by Dureg is shown below.

Table 7-2: Distribution of Family by Dureg

Dureg	bayangol	bayanzurh	songinohairhan	suhbaatar	Total
No.	2	3	140	3	148

The majority of waste picker families live in Khoroo 3, 4 and 7 of the Songinohairhan district.

The total number of registered individual waste pickers is 327. The distribution by sex and adult/child is shown.

Table 7-3: Distribution of Registered Waste Pickers

	adult	child	total
Female	138	17	155
Male	136	36	172
Total	274	53	327

Child: those who are 15 years old or below are regarded as children

c.1.2. Focus Group Meetings

In order to discuss about the pilot project and the plan of a new disposal site with waste pickers, two meetings were organized at the disposal site on the 30th of August and 1st of September. In total, 127 families out of 148 attended the two meetings.

Basically, most meeting attendants agreed with pilot project and proposed rules at the disposal site. Their main concerns mentioned at the meetings are summarized below.

- Fair trade with recycle buyers
- Dealing with new comers (how their priority is maintained)
- Impact of the pilot project on their income
- How to stop children's dangerous behaviours such as jumping on collection vehicles

Some waste pickers set their gers inside the disposal site, but after the explanation about the future landfill plan of UCDS, they quickly move their gers to outside the disposal site.

c.2 Local resident living near the site of the new disposal site

After the first public hearing, held on the 9th of August, the follow-up survey was conducted to know how hearing participants think about the development plan and how much they understood the content of the hearing.

c.2.1. Target of the survey

In total, 111 people attended the first public hearing. Among them, the number of people who live very near to the site of the new disposal site was around 45. The samples of the follow-up survey were selected from 45 people. During the survey, samples were selected randomly by interviewers.

c.2.2. Contents of questions

The contents of questions

- Knowledge of the development before the first public hearing
- Level of understanding of explanations about the development plan at the disposal site
- Opinions about the presentation method
- Opinions about the development plan

c.2.3. Execution of the survey

The survey was conducted on the 8th and 10th of September. The number of samples was 15.

c.2.4. Result of the survey

Main findings from the follow-up survey are summarized below.

- Many respondents are confused with pilot project at the disposal site and the NEDS development plan.
- It seems that about half of respondents are working at UCDS (many of residents who live near the site of NEDS are waste pickers). They are concerned about the current pilot project more than the development plan of NEDS.
- Even though respondents reply that they remember or understand presentations, their understanding is very limited. (one respondent understood the content of the public hearing very well)
- Since they are living near UCDS, most of them understood what kind of place a final disposal site is and what kinds of problems could occur. But more than half of them were not concerned about possible problems. They are more interested in job opportunity.
- Most of respondents thought that JICA was responsible organization of the development plan.

7.2 Improvement Collection System

7.2.1 Design Condition

a. Targets

Description	2010	2015	2020
Planned Area (Plan targets the summer.)			
Waste collection coverage rate	100%	100%	100%
Separate collection coverage rate	15%	40%	70%
Waste Generation Amount	29.2t/d	116.9t/d	299.2t/d
Collection amount of non-recyclable waste	16.5t/d	65.2t/d	163.8t/d
Collection amount of recyclable waste	12.7t/d	51.7t/d	135.4t/d
Unplanned Area (Plan target the winter.)			
Waste collection coverage rate	100%	100%	100%
Separate collection coverage rate	0%	0%	0%
Waste Generation Amount	366.4t/d	311.5t/d	227.6t/d
Waste collection amount	366.4t/d	311.5t/d	227.6t/d

b. Waste Haulage Distances

There are 4 disposal sites in the study area. Waste haulage distance in each duureg to each disposal site is different. Following table indicates the name of disposal site to be used by each duureg.

Table 7-4: Name of Disposal Site to be used by each Duureg

Duureg	Khoroo No. to use the local disposal sites
Songinokhairkhan	NEDS and Kh21
Sukhbaatar	NEDS
Bayangol	NEDS
Khan Uul	NEDS and MDDS
Chingeltei	NEDS
Bayanzurkh	NEDS
Nalaikh	NADS

NEDS: Narangiin Enger Disposal Site
MDDS: Morin Davaa Disposal Site
NADS: Nalaikh Disposal Site
Kh21: Khoroo 21 Disposal Site

7.2.2 Collection and Haulage System Design

a. Basic Concept of the Collection and Haulage System

a.1 Principle to be adopted

The causes of the existing waste scattered in the town are as follows.

a) Present irregular waste collection causes waste left outside for many hours and days.
b) People discharge waste any time and any day.
c) Waste pickers scatter waste when they scavenge recyclables from the waste.
d) Stray dogs scatter waste when they scavenge food from the waste.
e) Waste is blown by strong wind.

All the abovementioned problems must be rectified in order to maintain the town`s hygiene and beauty. Therefore, the principle of the collection and haulage system to be used for the design shall be “minimizing the hours of waste which is placed outside”.

a.2 Waste Haulage System

The figure below shows the waste haulage system for the planned areas. In the planned areas, the people have to discharge wastes separately; recyclable waste and non-recyclable waste. In addition, people voluntarily separate recyclables and directly sell them to recyclers.

Non-recyclable waste is directly carried to the disposal site to be used as sanitary landfill. Recyclables collected are carried to the sorting yards for recovering economically valuable recyclables. Residues are carried to the RDF plant for RDF production. RDF produced is either sold or given to the power station plants or heating plants for thermal recovery.

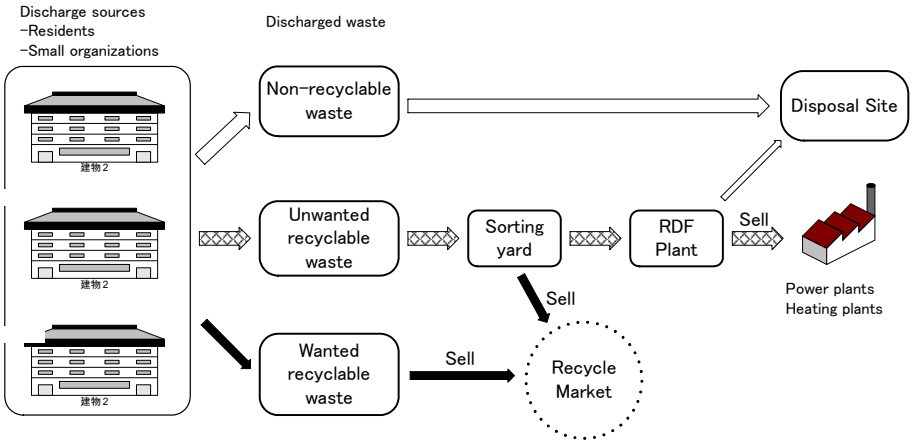


Figure 7-6: Waste Haulage System for the Planned Areas

Figure 7-7 shows the waste haulage system for the unplanned area. In unplanned areas, the people discharge the waste without separation and all the waste collected is directly carried to the disposal site to be used as sanitary landfill. People voluntarily separate recyclables and directly sell them to recyclers.

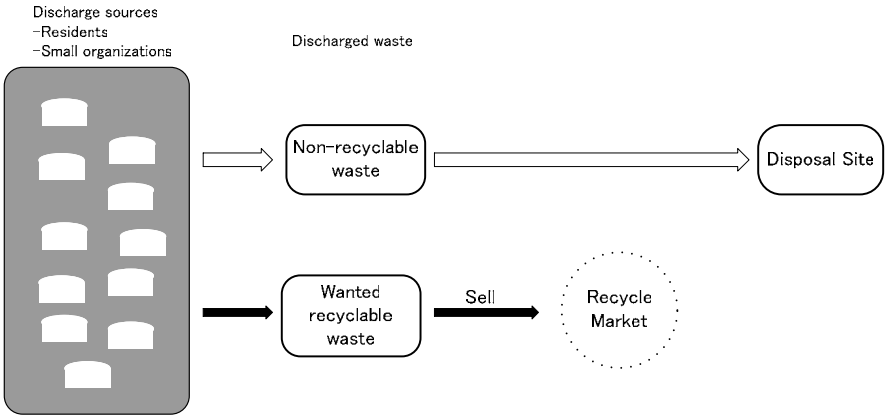


Figure 7-7: Waste Haulage System for the Unplanned Areas

a.3 Collection Frequency

Considering the quite low temperature, the low waste moisture content ratio, and the very high percentage of inert materials contained in the waste throughout the year, only one waste collection per week is enough in terms of sanitation.

In planned area, however, there is not enough space for residents in apartments to store waste for a week unless they store waste outside which causes waste scattering, a waste collection frequency of more than twice a week is necessary for apartments and business entities located in apartment buildings to keep their waste properly within their premises.

As for the collection frequency of recyclable waste, collection once a week is adequate because the percentage of recyclable waste in all waste is about 40% in maximum and all of them are inert.

Therefore, the waste collection frequency for the planned area is proposed as follows.

- General waste: twice a week
- Recyclable waste: once a week

As for the unplanned area, the waste collection frequency should be, ideally, once a week. However, considering the present maximum collection frequency is only once a month and enough space is owned by each premise, fortnightly collection is proposed.

As for the non-residential waste which some organizations discharge a large amount of, the collection frequency should be variable and the timing should be flexible for the dischargers' convenience.

a.4 Waste separation

In planned areas, the introduction of separate collection is proposed in order to recover recyclable materials from the waste because the percentage of recyclable materials in waste in planned areas is very high ranging from 40 to 50% which is similar to that of developed countries.

As for the unplanned areas, the separate collection to recover the recyclable materials will not be introduced because the percentage of recyclable materials in waste is too small.

The items to be separately collected for resource recovery are plastic, paper, metal and textile.

The other items are collected as general waste.

Returnable bottles are collected by private recyclers at generation sources.

a.5 Storage

In general, the system of storing waste outside is not suitable for the study area due to the waste often frozen, waste scattered by waste pickers, etc. The system to keep waste outside can be appropriate only for waste which some of organizations discharge a large amount of.

The dust chute system is proposed to be banned to keep hygiene condition and to raise residents' awareness of recycling.

It is proposed that the waste is kept within the apartment buildings until the collection truck comes to collect it. The proper storage for this system should be any kind of plastic bag.

As for the storage of the waste which organizations discharge a large amount of, it should vary depending on the waste quality and waste discharge pattern.

a.6 Collection Trucks

Planned area

The compaction truck which can compact light waste is adopted because the density of waste discharged from the planned area is very light, less than 200 kg/m^3.

There are two kinds of compaction trucks adopted as follows.

- Compactor truck with the capacity 15m^3 is used where traffic is not congested.
- Compactor truck with the capacity 8m^3 is used where traffic is congested.

Unplanned area

The dump truck is adopted for the unplanned area because the density of waste discharged is heavy, more than 300 kg/m^3.

The specification of the standard dump truck shall be as follows.

- Loading weight capacity: 6 ton
- Loading volume capacity: 10 m3
- Carrier: closed type

Large amount of waste which organizations discharge

The type of collection truck depends on the waste type and waste discharge pattern. The following trucks are adopted for the standard trucks for these wastes.

- Dump truck, 6 ton.
- Skipper with skip 5m3 container.
- Compactor truck with 1m3 container.

a.7 Collection method

Planned Area

Regardless of whether the dischargers are residents or organizations, if the waste is generated from the apartment buildings, the dischargers themselves are responsible of discharging the waste outside of their ground floor door.

The collection days, which are fixed, are informed to the dischargers in advance. The waste collection is executed according to the fixed schedule and music is played to inform its arrival to dischargers when they go to collect the waste.

Dischargers are obliged to discharge waste only on collection days.

Dischargers are obliged to discharge waste in plastic bags or light and hygienic containers.

Guards which are responsible for the doors shall be actively involved to cooperate with this system.

Unplanned area

The waste discharged from a house in ger areas is generally too heavy to carry by dischargers themselves. Therefore, the door to door collection system which requires minimum haulage required by dischargers is adopted.

The station collection system which dischargers carry their waste to a collection point for discharge will not be adopted due to the following reason.

- Waste is too heavy for dischargers to manually carry.
- Waste is too difficult to be manually carried due to frozen road for several months.
- Placing communal collection points disturbs the fee collectors from doing their work.
- They cannot maintain communal collection points clean most probably due to the lack of ownership.

Large amount of waste which organizations discharge

The system should be customary made to fit with the dischargers' situation and convenience. To place a container can be a good option and the size of container to be placed should be decided depending on the amount of waste discharged.

a.8 Collection Hours

In order to get the public cooperation for the waste discharge, the waste should be collected during the daytime unless the traffic is too congested. Considering the people's quite late lifestyles in Ulaanbaatar

The proposed collection hours should keep a one hour time gap with the disposal operation hours.

Period	Disposal operation	Collection operation	
		Residential	Non-residential
Winter (Oct. to Mar.)	8:00 to 20:00	9:00 to 18:00	7:00 to 19:00
Summer (Apr. to Sep.)	6:00 to 24:00	9:00 to 19:00	5:00 to 23:00

Note: The collection operation hours does not mean the working hours. It means the hours which waste is actually collected.

b. Outline of the Collection and Haulage System

Table 7-5 summarizes the collection haulage system plan.

Table 7-5: Collection and Haulage System

Type of area	Source of waste	Frequency	Waste separation	Storage	Collection equipment	Collection method	Collection hours
Planned Area	Residential waste	3 times per week on fixed days (twice for non-recyclable, once for recyclable)	Separate collection Recyclable → Sorting yard Non-recyclable → Landfill site	Plastic bag	Compactor 15m3 Compactor 8m3	Entrance (of apartment) collection with bell system	Winter: 9am to 6pm Summer: 9am to 7pm
	Non-residential waste (small dischargers)	3 times per week on fixed days (twice for non-recyclable, once for recyclable)	Separate collection Recyclable → Sorting yard Non-recyclable → Landfill site	Plastic bag	Compactor 15m3 Compactor 8m3	Door to door collection with bell system	Winter: 9am to 6pm Summer: 9am to 7pm
	Bulky waste	Depending on customers' needs	N.A.	N.A.	2 ton truck	Door to door collection	Winter: 9am to 6pm Summer: 9am to 7pm
Unplanned Area	Residential waste	Twice per month on fixed days	Mixed collection	Less than 200 liter container (drum), Bags	Dump trucks 6m3	Door to door collection with bell system	Winter: 9am to 6pm Summer: 9am to 7pm
	Non-residential waste (small dischargers)	Twice per month on fixed days	Mixed collection	Less than 200 liter container (drum), Bags	Dump trucks 6m3	Door to door collection with bell system	Winter: 9am to 6pm Summer: 9am to 7pm
Both area	Non-residential waste (large dischargers)	Depending on customers' needs	Mixed collection	On-site container. 1m3 container, 5m3 container, Etc.	Depending on the waste type and waste discharge pattern. 6 ton dump truck 5m3 container with skipper 1m3 container with a compactor with lifting device	Door to door collection based on the contract condition or by telephone order.	Winter: 7am to 7pm Summer: 5am to 11pm

7.2.3 Collection and Haulage System by the Type of Waste Generation Source

a. Planned Areas

Type of Area	**Planned Area**
Type of Waste	**Residential Waste**
Frequency	3 times per week on fixed days. • Twice for non-recyclable waste (other than recyclables, including bottles.) • Once for recyclable waste (plastic, papers, textile, ferrous metal, non-ferrous metal)
Waste separation	Separating waste into the following two kinds. • Non-recyclable. It is carried to the landfill site. • Recyclable. It is carried to the sorting yard.
Storage	Plastic bag
Equipment	Compactor 15m3 for the less traffic area Compactor 8m3 for the traffic congested area
Collection method	Residents carry their waste downstairs and place it near the inside of the entrance on the collection days. Collection vehicles come to collect the waste with playing music (bell collection) to inform of their arrival to residents.
Schedule	Winter: 9am to 6pm Summer: 9am to 7pm

Type of Area	**Planned Area**
Type of Waste	**Non-residential Waste (small dischargers)**
Frequency	3 times per week on fixed days. • Twice for non-recyclable waste (other than recyclables, including bottles.) • Once for recyclable waste (plastic, papers, textile, ferrous metal, non-ferrous metal)
Waste separation	Separating waste into the following two kinds. • Non-recyclable. It is carried to the landfill site. • Recyclable. It is carried to the sorting yard.
Storage	Plastic bag.
Equipment	Compactor 15m3 for the less traffic area Compactor 8m3 for the traffic congested area
Collection method	Dischargers keep the waste within their premises. Collection vehicles come to collect the waste with playing music (bell collection) to inform of their arrival to dischargers. And then, dischargers carry their waste to the collection vehicles for discharging.
Schedule	Winter: 9am to 6pm Summer: 9am to 7pm

Type of Area	**Planned Area**
Type of Waste	**Bulky Waste**
Frequency	Depending on customers' needs
Waste separation	N.A.
Storage	N.A.
Equipment	2 ton truck
Collection method	Door to door collection The customer telephone to the Duureg office for the collection.
Schedule	Winter: 9am to 6pm Summer: 9am to 7pm

b. Unplanned Area

Type of Area	**Unplanned Area**
Type of Waste	**Residential Waste**
Frequency	Twice per month on fixed days
Waste separation	Mixed collection
Storage	Container such as a drum. (The capacity must be less than 200 liters.). Bags
Equipment	Dump trucks 6m3
Collection method	Door to door collection with bell system
Schedule	Winter: 9am to 6pm Summer: 9am to 7pm

Type of Area	**Unplanned Area**
Type of Waste	**Non-residential Waste (small dischargers)**
Frequency	Twice per month on fixed days
Waste separation	Mixed collection

Storage	Container such as a drum. (The capacity must be less than 200 liters.). Bags
Equipment	Dump trucks 6m3
Collection method	Door to door collection with bell system
Schedule	Winter: 9am to 6pm Summer: 9am to 7pm

c. Both Areas

Type of Area	**Both Areas**
Type of Waste	**Non-residential Waste (large dischargers)**
Frequency	Depending on customers' needs
Waste separation	Mixed collection
Storage	On-site container, 5m3 metal container, 1m3 metal container, etc.
Equipment	Depending on the waste type and waste discharge pattern. 6 ton Dump truck 5m3 container with a skipper*1 1m3 container with a compactor with lifting device*1, etc.
Collection method	Door to door collection based on the contract condition or by occasional telephone order.
Schedule	Winter: 7am to 7pm Summer: 5am to 11pm

*1:Existing trucks to be used until its life period.

7.2.4 Collection and Haulage Equipment Design

a. Selection of Collection Equipment

The following waste collection equipment is selected based on the examination made in the former sections and the O&M cost calculated.

Table 7-6: Proposed Collection and Haulage Equipment

Type of equipment	Area
15 m3 compactor	Residential and non-residential waste in planned area where traffic is not congested
8 m3 compactor	Residential and non-residential waste in planned area where traffic is congested
10 m3 dump truck	Residential and non-residential waste in unplanned area. Construction waste and Industrial waste
5.5 m3 skipper truck*1	Large amount of waste discharged by a business entity

*1:Existing trucks to be used until its life period.

b. Productivity Determination of Collection Equipment

b.1 Productivity of Refuse Collection Vehicles

This section compares four different waste collection trucks in terms of unit collection cost.

Equation for Calculating Productivity

The following equations were adopted for calculating productivity.

$$Tr = \frac{(60 \times t1 - t2) \times E}{D \div V + t3 + t4}$$

Tr: Number of trips per day (trips)
D: Travel distance per trip (km)
V: Velocity of a vehicle (km/h)
t1: Working hours per day (hours)
t2: Time of daily service for inspection and fuelling, etc. (min)
t3: Time of loading waste (min)
t4: Time of unloading waste (min)
E: Efficiency of loading capacity

$$Qd = q \times d \times f \times Tr$$

Qd: Waste carried per day
q: Volume capacity of a skip container or a tipping truck (m^3)
d: Density of waste when being transported (ton/m^3)
f: Efficiency of working time

b.2 Determination of Waste Collection Truck Productivity

The table below shows the determination of waste collection trucks' productivity in accordance with the equation shown above.

Table 7-7: Determination of Waste Collection Truck Productivity

Description	unit	Compactor truck				
Capacity in weight	t	10.00	10.00	6.00	6.00	6.00
Capacity in volume	m3	15.00	15.00	8.00	8.00	8.00
Half way distance	km	0.50	18.80	7.40	16.60	35.00
One trip distance	km	1.00	37.60	14.80	33.20	70.00
Velocity of vehicle	km/h	35.00	35.00	35.00	35.00	35.00
Specific gravity of waste	t/m^3	0.20	0.20	0.20	0.20	0.20
Density of waste when hauled	t/m^3	0.45	0.45	0.45	0.45	0.45
t1:Working hour	h	7.50	7.50	7.50	7.50	7.50
t2:Daily service time	min	30.00	30.00	30.00	30.00	30.00
t3:Loading time per trip	min	120.00	120.00	64.00	64.00	64.00
t4:Unloading time	min	5.00	5.00	5.00	5.00	5.00
E: Efficiency of loading capacity		0.90	0.90	0.90	0.90	0.90
f: Efficiency of working time		0.90	0.90	0.90	0.90	0.90
Nos of trips per day	times	2.98	2.00	4.01	3.00	2.00
Adjusted Nos of trips per day	times	3.00	2.00	4.00	3.00	2.00
Waste carried per trip	t/trip	6.08	6.08	3.24	3.24	3.24
Waste carried per day	t/d	18.23	12.15	12.96	9.72	6.48
Waste carried per month	t/month	430	286	305	229	153
Waste carried per year	t/year	5,155	3,437	3,666	2,749	1,833

Description	unit	Dump Truck			Skipper truck
Capacity in weight	t	6.00	6.00	6.00	6.00
Capacity in volume	m3	10.00	10.00	10.00	5.50
Half way distance	km	0.40	18.50	74.00	15.00
One trip distance	km	0.80	37.00	148.00	30.00
Velocity of vehicle	km/h	35.00	35.00	35.00	35.00
Specific gravity of waste	t/m3	0.30	0.30	0.30	0.30
Density of waste when hauled	t/m3	0.30	0.30	0.30	0.30
t1:Working hour	h	7.50	7.50	7.50	7.50
t2:Daily service time	min	30.00	30.00	30.00	30.00
t3:Loading time per trip	min	120.00	120.00	120.00	5.00
t4:Unloading time	min	5.00	5.00	5.00	5.00
E: Efficiency of loading capacity		0.90	0.90	0.90	0.90
f: Efficiency of working time		0.90	0.90	0.90	0.90
Nos of trips per day	times	2.99	2.01	1.00	6.15
Adjusted Nos of trips per day	times	3.00	2.00	1.00	6.00
Waste carried per trip	t/trip	2.70	2.70	2.70	1.49
Waste carried per day	t/d	8.10	5.40	2.70	8.91
Waste carried per month	t/month	191	127	64	210
Waste carried per year	t/year	2,291	1,527	764	2,520

c. Required Number of Collection Equipment in 2010

Based on the above mentioned productivity of each type of equipment, the following number of vehicles is required for the collection system in the study area in 2010.

Type of equipment	Number of Vehicle Required
15 m3 compactor	23 units
8 m3 compactor	7 units
10 m3 dump truck	100 units.
5.5 m3 skipper truck	To be decided after consensus made on the managing organization for collection.

7.2.5 Maintenance Plan

Proper maintenance such as periodical, general, and back-up services will help the actual economic life and operation efficiency of the waste collection vehicle and landfill equipment. At present MUB does not have an organization, equipment, nor facilities for the maintenance of the waste collection vehicle and landfill equipment. If the vehicle and equipment are procured, MUB office should manage equipment taking the responsibility and should have their own management section and facilities.

a. Organization

Effective organization and preparation of preventive maintenance system will be ease to monitor and making an operation schedule economically for the collection and landfill equipment. MUB should have the established organization as proposed in the Figure below. The organization scale is planned referring to the number of vehicles and equipment to be procured.

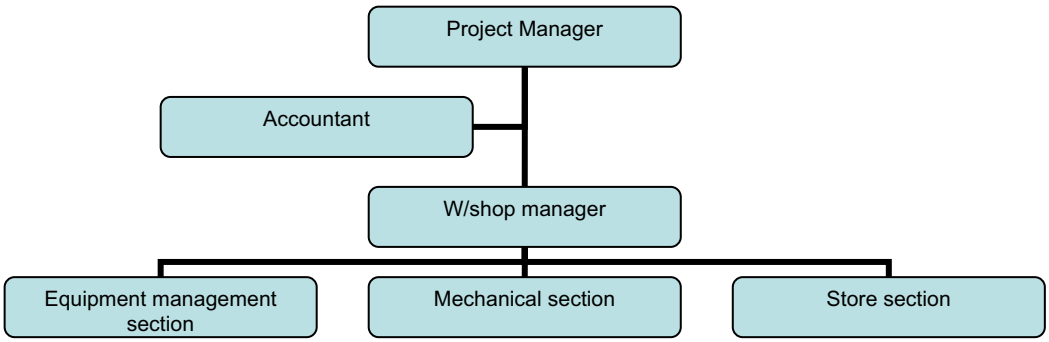


Figure 7-8 Proposed Organization

b. Facilities

MUB dose not have any maintenance workshops. When the equipment is arranged in MUB, it is necessary to have a workshop that has a main repair bay, parts and material storage and washing yard etc. Moreover, it is necessary to arrange the tools and equipment to do these effectively.

b.1 Workshop / Warm garage

Proper equipment maintenance requires proper maintenance facilities especially the existence of a workshop is very important, thereby ensuring their sufficient equipment availability.

The workshop consists of a service shop for vehicles, tire, welding, battery shop, parts/material storage, equipment management/store office, shop office and washing yard as shown in the following figure. Moreover, MUB should prepare warm garage at the final disposal site for daily and light scale maintenance for landfill equipment especially heavy duty machine such as bulldozers, wheel loaders, excavators, etc. and considering the starting problem in winter at the site as shown in the Figure below. These workshop and warm garage are assumed to be a specification with the roof in consideration of the work in winter. The inside of the workshop assumes a simple, a concrete finish of cement and gravel and carwashes are to be a concrete finish.

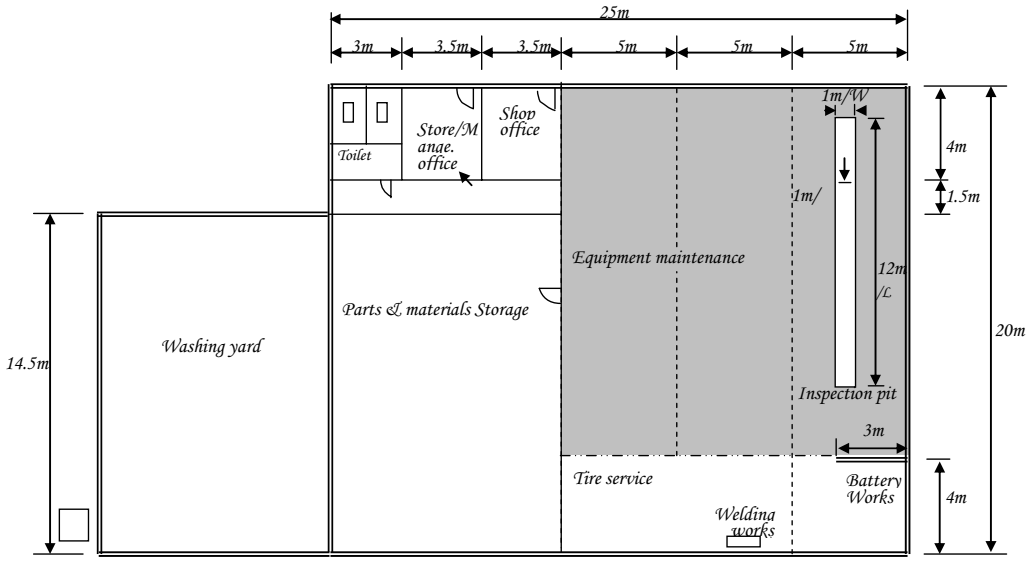


Figure 7-9: Proposed Workshop for Collection Equipment

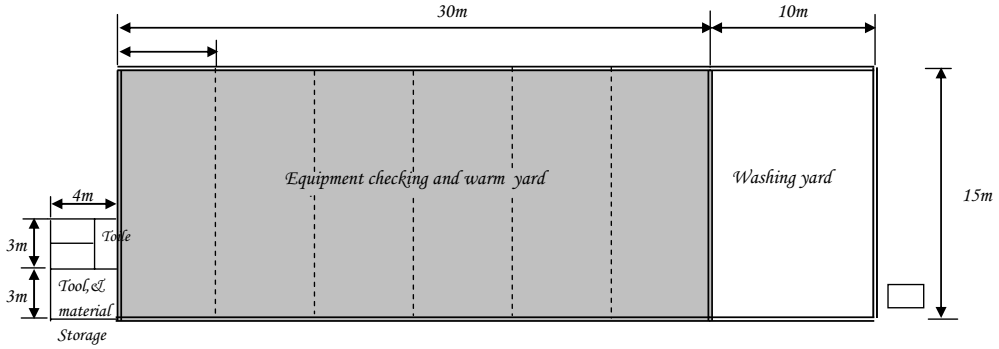


Figure 7-10: Proposed Warm Garage at the NEDS

b.2 Workshop equipment and Tools

Workshop equipment (washing, welding machine, battery charger, etc.) and tools (hand tools, lubricant refill tools etc.) for periodical and miner repair works both for collection and landfill equipment will be furnished. It made it necessary to have minimum tools and equipment in consideration of content of the maintenance and repair work. Desirable, portable types of equipment and tools are selected to assure the convenience of the works.

c. Duties

c.1 Overall duties

Actual economic life and operation efficiency of waste collection and landfill equipment depend on the degree of maintenance. However, it is difficult for the city office to do all maintenance works due to lack of technical knowledge and human resources. Considering this situation, all the management duties (such as equipment ledger, equipment arrangement, record etc.) is done directly (MUB through Nuuts) and maintenance duties are divided into 3 stages, the first stage such as daily checking and miner repair works should be done by the equipment responsible (using) person (company/institution) and the next stage such as 1, 3month periodical maintenance of vehicles, 50, 100, 250 hrs periodical maintenance of heavy equipment and medium repair works are done directly (MUB through Nuuts workshop) and other periodical and heavy repair works are done by authorized dealers or professional workshops (private). According to investigation, some authorized dealers and professional

garages have sufficient technical support capability and systems. Intensive periodical maintenance (6, 12 month or 500, 1000, 2000 hrs) and heavy (overhaul) works shall be done in those workshops or professional garages (or suitable institutions). It is outlined as follows.

Table 7-8: Overall Duties of Organizations Concerned Maintenance

	Vehicle Compactor, Skip loader, Dump truck, Truck, Pick-up	**Heavy equipment** Bulldozer, Wheel loader, Excavator
Collection Company	• Daily: Oil, grease, cooling water refilling. working condition of engine, battery, brake, suspension Clutch, etc. • Checking before& after working: Condition of brake, clutch, engine starting, and suspension to be checked by driver.	• Daily checking: Oil, grease, cooling water refilling, working devices, track, etc. • Before & after working checking Brake, clutch, engine, suspensions condition check by operator
MUB/Nuuts workshop or warm garage	• 1 month period maintenance: Engine oil/filter change, brake clutch check & adjustment, T/M, D/F oil check, etc. • 3 month period maintenance: Engine oil/filter, fuel filter change, brake, clutch check & adjustment, etc. • Medium repair works: Clutch plate, brake lining change, battery charge, welding works, tire service, etc.	• 50,100 hrs periodical maintenance: Lubricant check & refill, brake check & adjustment, transmission check, track check & adjustment, etc. • 250 hrs periodical maintenance: Engine oil & filter change, lubricants check & refill, track check & adjustment (including bucket), etc. • Medium repair works: Track shoe, end bit, tooth change, minor electrical & welding service, etc.
Sub contract garage.	• 6 month period. maintenance: Engine oil/filter, fuel filter change, gear oil change, lubricant check & refill, brake lining check, replace & adjustment, clutch check replacement & adjustment, suspension lubrication check & refill, etc. • 12 month (1year) period maintenance: Engine oil/filter, fuel filter change, gear oil change, air element change, coolant change and all 6 month period services. • Normal repair works: All repair works other than Nuuts duties (all over haul works)	• 500 hrs period. maintenance: Engine oil/filter, fuel filter change, T/M oil /filter change. Air element change including all 250hrs period maintenance. • 1000 hrs period maintenance: 500hrs+antifreeze, hydraulic oil change including all 500 hrs period maintenance (250 hrs period maintenance depend on contents of works.) • Normal repair works: All repair works other than Nuuts duties (all over haul works)

c.2 Duty of each section

Each section needs to take the following duties:

Mechanical section

Maintenance Vehicle Heavy equipment	-1 & 3 month periodical maintenance -Minor repair works -50,100, (250)*1 hrs periodical maintenance -Minor repair works
Record	-Periodical maintenance record -General repair record -Daily work sheet

*1: depend on contents, sometimes send subcontractor

Equipment management section

Equipment	-Periodic service management -Equipment ledger management -Repair record management
Others	-Subcontract management -Allocation of equipment

Store section

Daily	-Spare parts and materials in-out management -Materials ledger(issue voucher) -Order and purchase of spare and materials
Monthly	-Stock taking
Yearly	-Stock taking

Account section

In project	-Purchasing(payment) of spare parts and materials -All payment duties in project -Budget planning
Outside project	-Payment to subcontract (to private workshop)

Driver/Operator

Daily	-Daily before and after checking sheet -Log sheet

d. Personnel

MUB/Nuuts should arrange experienced and skilled personnel for the maintenance section. At least engineers, technicians (or senior mechanics), mechanics and store keepers and equipment management officers are required .The recommended necessary qualifications and the numbers are as follows.

Table 7-9: Personnel Plan

Title	Number	Qualification
Engineer/Workshop manager	1	More than 10 years experience of workshop management, both heavy and light duty equipment. Applied mechanical engineer by recognized authorities.
Technician (or senior mechanic)	1	More than 15 years experience of site duties of equipment maintenance or 7 years experience of applied technician.
Mechanic	3	More than 5 years experience of site duties of light or heavy duty equipment.
Mechanic helper	3	More than 3 years experience of site duties of light or heavy duty equipment.
Store keeper	1	More than 7 years experience of store management. Knowledge of computer is necessary.
Equipment management officer	1	More than 10 years experience of head driver or transport officer.
Office clerk	1	More than 3 years experience of office duties and knowledge of computer is necessary.
Accountant	1	More than 15 years experience of account duties. Applied accountant by recognized authorities.

e. Training

Preparation of the training is the improvement of the basic knowledge of the Nuuts equipment maintenance personnel, not only mechanics but also operators, drivers. Staff training will improve their equipment operation and maintenance capabilities. Skills might contribute in the improvement of the Nuuts equipment and maintenance system in general. It is recommended that this training is organized by the private workshop to be subcontracted the heavy repair works (on the job training).

7.3 Development of Narangiin Enger Disposal Site (NEDS)

7.3.1 Development Concept

a. Need for a Sanitary Landfill

It is generally recognized that a sanitary landfill is the basic element of modern SWM (solid waste management). Thus, it is acknowledged that the majority of waste has to be disposed of at a landfill even if best efforts are made to the 3Rs (reduce, reuse and recycle). As a priority step towards modern SMW, the Municipality of Ulaanbaatar (MUB) is recommended to strengthen the final disposal system which minimizes environmental impact.

b. The New Disposal Site in Narangiin Enger

This section presents the preliminary design for a new final disposal site in Narangiin Enger, which has been selected by the Steering Committee (St/C) of the Study on April 26, 2005 to be its future landfill site. The distance from the city center of Ulaanbaatar to the disposal site is approximately 10 km and the site comprises of an area of approximately 82 ha in total, as shown in the following figure.

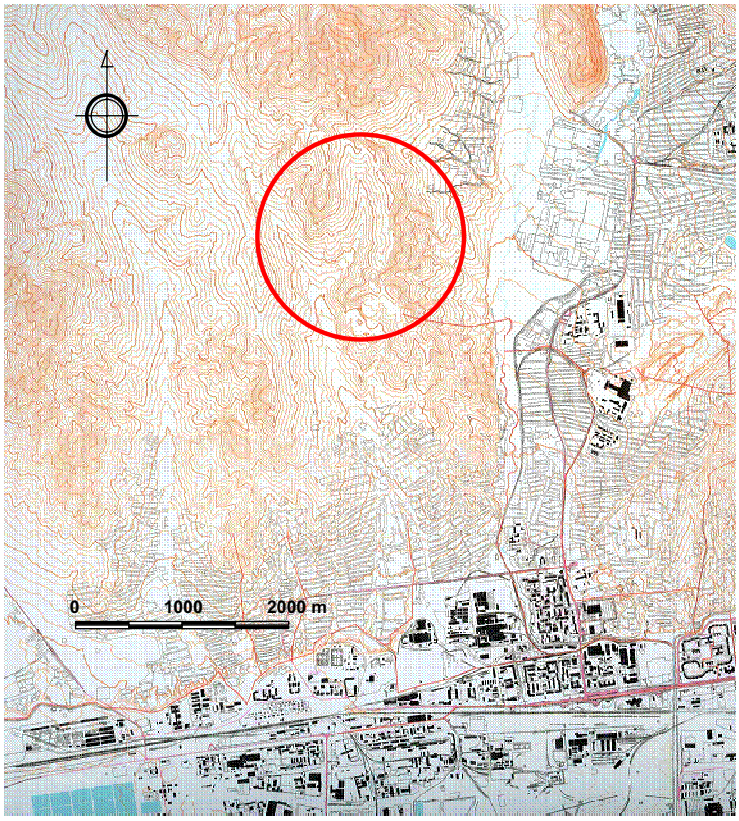


Figure 7-11: Location of Narangiin Enger Disposal Site

c. Design Concept of the Narangiin Enger Disposal Site

The facilities of Narangiin Enger Disposal Site to be constructed in Phase 1 include the Nuuts/MUB site office, the landfill area, a leachate treatment facility (pond), a recycling complex (a sorting yard with RDF equipment), and a warm garage. A sorting yard with RDF equipment will be constructed on a pilot scale in 2010 and will be upgraded to full scale in year 2014. The site comprises of an area of approximately 20 ha, as shown in the figure below. The disposal site is to be expanded to approximately 82 ha in total in future. According to the operation plan, the 82 ha site will be developed in seven phases. The conceptual design of the site is presented in the following table.

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 height of the enclosing dam of the landfill area by phase1 was designed to be 1,401m (Altitude) and the final height of the landfill was determined considering the NEDS land form. The slope of the completed landfill was designed to be 1:3. The excavated soil can be used as cover material for land filled sections.

Although the leachate generation is very limited due to the climatic conditions (high evaporation and low precipitation) and characteristic of waste to be disposed of (less water contents), the new disposal site will be equipped with a leachate treatment facility (evaporation method). The facility will not discharge treated waste water outside the disposal site, so that it is possible to prevent environmental degradation of the surrounding area.

The landfill section will be developed first until 1,401 m. In the next phase, Nuuts/MUB is supposed to develop the landfill areas according to the operation plan. An important issue of this plan is to minimize the initial investment cost and O&M expenditure.

The main features of the proposed disposal site are mentioned above, and 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.

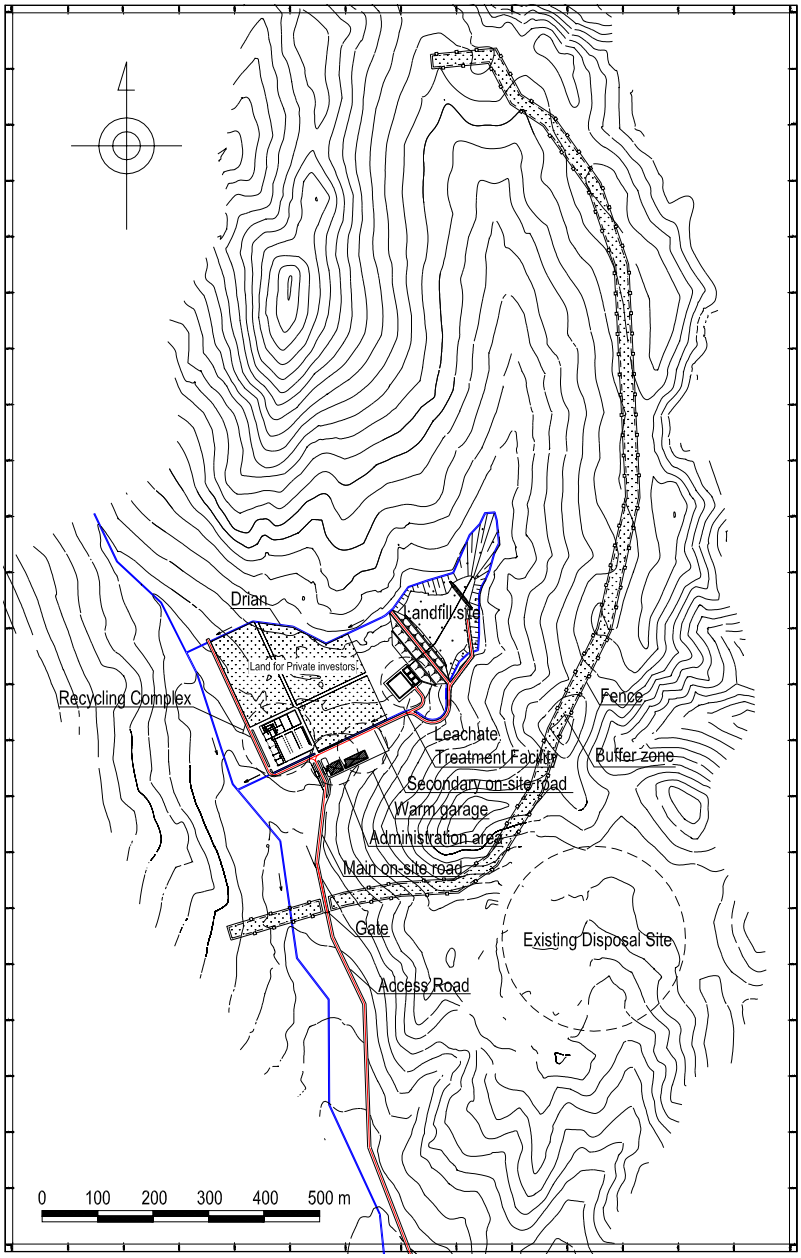


Figure 7-12: Layout Plan of Narangiin Enger Disposal Site (Phase1)

Table 7-10: Design Concept of the Narangiin Enger Disposal Site (Phase1)

Item			unit	Qty
The area of disposal site		Total	ha	approx.82
		Phase 1	ha	approx.20
Administration area				
Area			ha	approx. 0.7
Site office			L.S..	1
Weighbridge house			no.	1
Warm garage			no.	1
Tire washing pit			no.	1
Security and safety facility	Gate		no.	1
	Fence (Fixed type)		L.S.	1
Landfill and leachate treatment facilities				
Landfill Area (final phase)			ha	approx. 27.8
Landfill Capacity			m^3	3,176,000
Life span			years	11
Level	Top of the enclosing Dam by Phase1		m (Altitude)	1,401
	Level of Landfill bottom from top of Enclosing Dam		m	- 10
	Level of Landfill top from top of Enclosing Dam (final phase)		m	+ 30
Gradient of Slope	Enclosing Dam (inside)		---	1:2
	Enclosing Dam (outside)		---	1:3
Sanitary waste disposal facility	Main access road (asphalt concrete paved)		L.S.	1
	Main On-site road (asphalt concrete paved)		L.S.	1
	Secondary On-site road (gravel)		L.S.	1
	Fence (Movable type)		L.S.	1
Leachate collection facility -Perforated reinforced concrete pipe with rubble stone -Bottom layer as natural liner instead of artificial liner			L.S.	1
Leachate treatment facility -Evaporation ponds + Recirculation facilities + Regulation ponds			L.S.	1
Rain water drainage	Perimeter drain along the waste filling slope		L.S.	1
	Earth drain along the waste filling slope		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
Recycling Complex facility				
Area			ha	0.7
Sorting facility	Capacity 2.5 ton/hour		Line	1
	Type : Hand sorting yard			
RDF facility	Capacity 2.2 ton/hour		Line	2
	Compressing type RDF production			

7.3.2 Preliminary Design of the Narangiin Enger Disposal Site

a. Administration Section

a.1 Conceptual Design

Nuuts/MUB site office is to be located in the administration area.

The administration section is to consist of the following buildings and accessories:

- Entrance area (common use)
- Nuuts/MUB site office
- Weighbridge house
- Warm garage
- Tire washing pit
- Safety facilities (common use): gates, fences, handrail and street lights
- Others: parking lot, etc.

a.2 Layout

The Administration section is to be designed in the Narangiin Enger Disposal Site. The area is approximately 0.7 hectares.

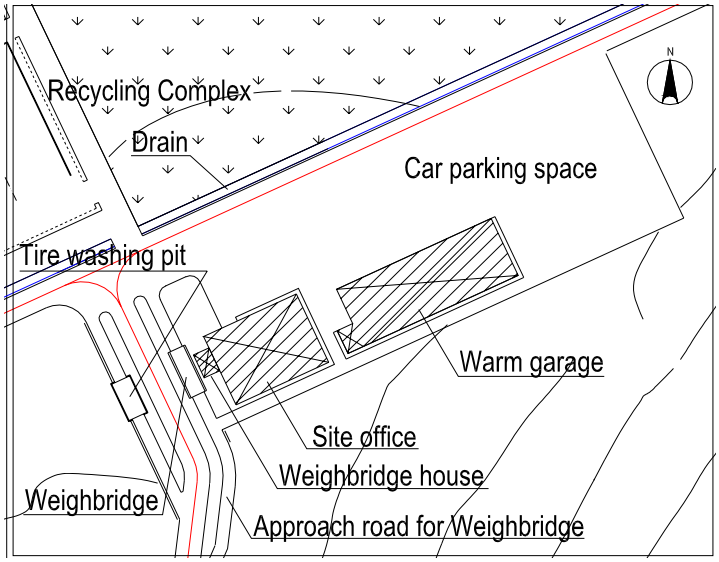


Figure 7-13: Layout of the Administration Section

b. Calculation of Required Landfill Capacity

b.1 Commencement of Sanitary Landfill Operation

The operation of the new sanitary landfill is planned to commence in August 2008.

b.2 Estimated Amount of Waste Disposal at the Narangiin Enger Disposal Site

The proposed landfill in Narangiin Enger Disposal Site is designed to receive waste discharged from the following 6 Duuregs. The type of waste to be received will include MSW and general waste from medical institutions and factories.

- Bayangol
- Bayanzurkh
- Songinokhairkhan
- Sukhbaatar
- Khan-Uul
- Chingeltei

Table 7-11: Estimated Daily Amount of Waste Disposed in the Narangiin Enger Disposal Site

Year	NEDS (Total) (ton/day)	Description				
		MSW (ton/day)	RDF facility Residue (ton/day)	Construction waste (ton/day)	Non-HIW (ton/day)	GWMI (ton/day)
2009	555.0	373.8	0.0	92.1	72.4	16.7
2010	592.2	392.0	4.7	103.4	76.4	15.7
2011	614.7	403.7	5.2	109.1	80.6	16.1
2012	638.9	416.6	5.6	115.1	85.1	16.5
2013	664.1	430.0	6.1	121.5	89.7	16.8
2014	691.0	444.5	6.7	128.0	94.6	17.2
2015	698.7	427.0	19.2	135.1	99.8	17.6
2016	725.3	438.5	21.0	142.6	105.3	17.9
2017	754.6	452.1	22.8	150.4	111.1	18.2
2018	785.2	466.0	24.7	158.7	117.2	18.6
2019	817.6	481.1	26.5	167.4	123.7	18.9
2020	815.5	439.0	50.1	176.6	130.5	19.3

note : Figures are the average amount in winter and summer

b.3 Change in Unit Weight

The unit weight of waste changes as the stages of waste management system progresses from generation and storage to disposal. The estimated changes are shown in the table below.

Table 7-12: Unit Weight at each Stage

Step		Unit Weight (ton/m^3)
Discharge	UWw	0.11～0.2
Collection (compactor or container)	UWc	0.45
Final disposal	UWd	0.40
Half a year after final disposal	UWd6m	1.00
A year after final disposal	UWd1y	1.20

b.4 Required Landfill Capacity

The final disposal site is designed to receive waste for a period of 11 years from 2009 to 2020.

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 = 0.4 ton/m^3)
V2 : volume of soil required for covering waste dumped
V3 : volume of waste in a stable state (apparent density = 1.0 ton/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 8 % of the waste dumped in volume, including it for final cover.
- The unit weight of the waste just after dumped in a landfill is 0.4 ton/m^3.
- The unit weight of waste in a stable state after filling is 1.2 ton/m^3.

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

Table 7-13: Required Landfill Capacity

Year	Weight of Discharged Waste	V1 Volume of Waste Just Dumped	V2 Cover Soil	V3 Volume of Waste by stable state	V Total Volume	Accumulated Volume	Required Capacity
	Wd	V1= Wd / 0.4	V2= V1 x 0.08	V3= Wd / 1.2	V= V2+V3		
	ton/year	m^3/year	m^3/year	m^3/year	m^3/year	m^3	m^3
2009	202,575	506,438	40,515	168,813	209,328	209,328	
2010	216,153	540,383	43,231	180,128	223,359	432,687	
2011	224,366	560,915	44,873	186,972	231,845	664,532	
2012	233,199	582,998	46,640	194,333	240,973	905,505	
2013	242,397	605,993	48,479	201,998	250,477	1,155,982	3,151,000
2014	252,215	630,538	50,443	210,179	260,622	1,416,604	
2015	255,026	637,565	51,005	212,522	263,527	1,680,131	
2016	264,735	661,838	52,947	220,613	273,560	1,953,691	
2017	275,429	688,573	55,086	229,524	284,610	2,238,301	
2018	286,598	716,495	57,320	238,832	296,152	2,534,453	
2019	298,424	746,060	59,685	248,687	308,372	2,842,825	
2020	297,658	744,145	59,532	248,048	307,580	3,150,405	

b.5 Landfill Capacity

The landfill capacity of the proposed landfill site is designed to be 3,176,000 m^3 as waste is to be disposed of at this site by the end of 2020.

c. Design of Facilities

c.1 Target Operation Level of Landfilling

The target operation level of the landfill is set as Level 4, which treats leachate generated in the disposal site and minimizes adverse impacts as much as possible. The requirements for operation of a Level 4 landfill are as follows:

- to cover waste with soil daily;
- to prohibit waste picking activities at the disposal area;
- to release gas promptly;
- to minimize the leachate quantity to be generated;
- to have an adequate drainage system;
- to have a proper access road; and
- to have a leachate collection and treatment system.

c.2 Main facilities of landfill facilities

The proposed landfill site is designed to be composed of the following facilities. The landfill section comprises an area of approximately 2.4 ha in Phase 1.

- Main Facilities
  - Enclosing structure:
    enclosing dam and divider
  - Drainage system:
    open side drain, etc.
  - Road:
    Access road , main on-site road, secondary on-site road
- Environmental protection facilities
  - Buffer zone
  - Litter scattering prevention facilities
  - Gas removal facilities
  - Leachate collection facilities
  - Leachate evaporation facilities
  - Monitoring well

c.2.1. Enclosing Dam Structure

The role of the enclosing dam provided, which is banked with earth around the filling area, is to prevent the 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 2.0 for inside the site
- Crest of dam: 8.0 m
- Height of dam: 10.0 m
- Material of dam structure: Excavated soil at the site

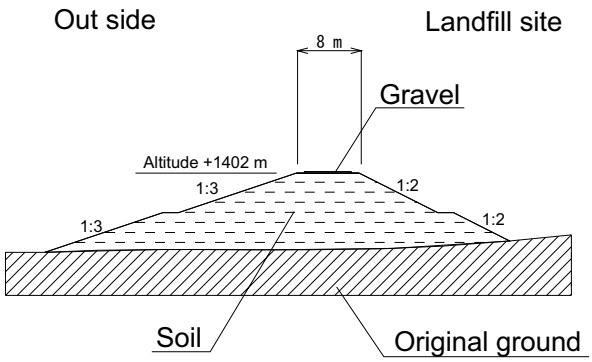


Figure 7-14: Structure of Enclosing Dam (Phase 1)

c.2.2. Divider

The role of the divider, which is made of soil (original ground) and provided inside the enclosing dam, 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 are set as follows.

- Gradient of slope: 1 in 1.0
- Crest of dike: 1.5 m
- Height of dike: 1.5 m
- Material of dike structure: Original Ground (No lining)

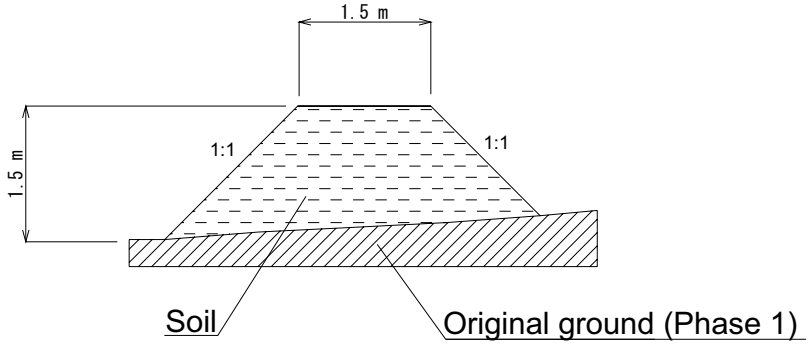


Figure 7-15: Structure of Divider

c.2.3. Drainage System (Open side drain)

The drainage system has a very important role in maintaining the site and waste filling slope 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 the side drain are as follows.

- Top width: 2.0m
- Bottom width: 1.0m
- Gradient of side slope: 1 in 1.0
- Depth: 0.5m
- Surface of drain: Original Ground (No lining)

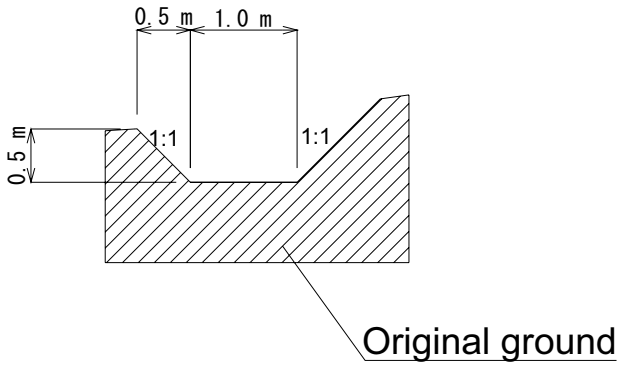


Figure 7-16: Structure of Drain

c.2.4. Access road and On-site road

Access road

The asphalt concrete-paved road is constructed from City Asphalt Road (Tolgoit road) to the gate of the landfill site so that the waste collection vehicles can access the disposal site easily. The access road will be constructed as shown in the figure below.

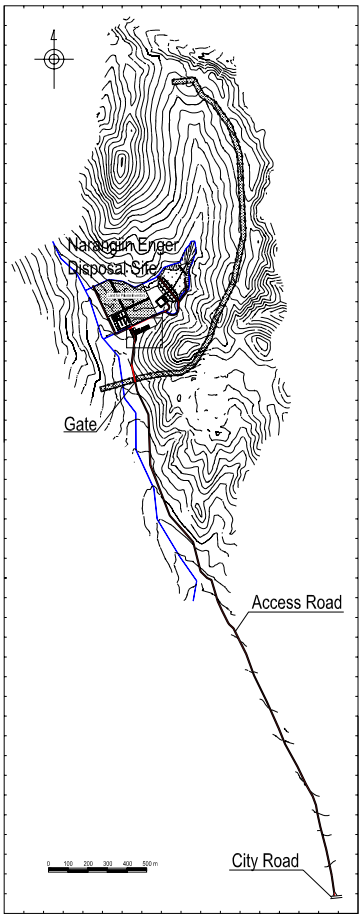


Figure 7-17: Location of Access Road

The dimensions of the Access road are shown below.

- Carriageway width: 6.0m
- Shoulder width: 0.5m both sides
- 2 paved layer in the carriage way

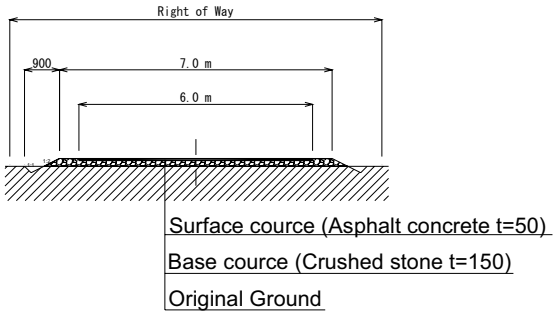


Figure 7-18: Structure of Access road

Main On-site Road

The road from the entrance of the Narangiin Enger Disposal Site to the landfill section is to be paved with asphalt concrete because this segment of the road is expected to be used for more than 12 years. The dimensions of the main on-site roads are shown below.

- Carriageway width: 6.0m
- Shoulder width: 0.5m both sides
- 2 paved layer in the carriage way

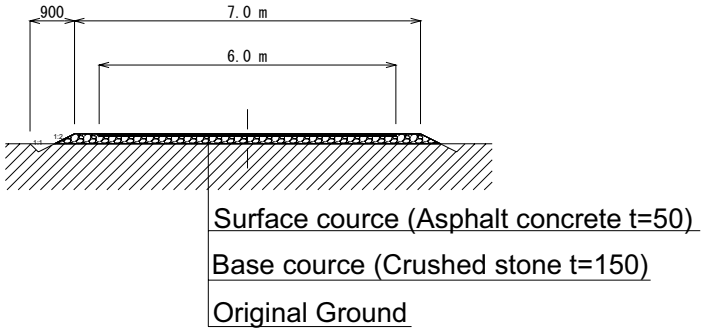


Figure 7-19: Structure of Main On-site Road

Secondary On-site Road

Secondary on-site roads are the roads for landfill works provided on the site. The dimensions of secondary on-site roads are shown below.

- Thickness of pavement: 0.15m
- Width of paved road: 6.0m
- Shoulder width0.5m
- Material: Gravel 0-40mm

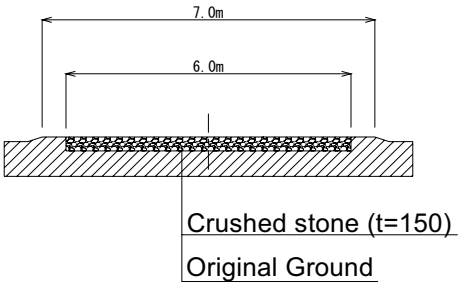


Figure 7-20: Structure of Secondary On-site Road

c.2.5. Buffer Zone (Green belts, etc.)

A buffer zone with trees is constructed 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; and
- balancing the site with the natural surroundings in a harmonious fashion.

Basically, the width of the buffer zone is 20m. The density of trees should be approximately 1,600 trees per hector.

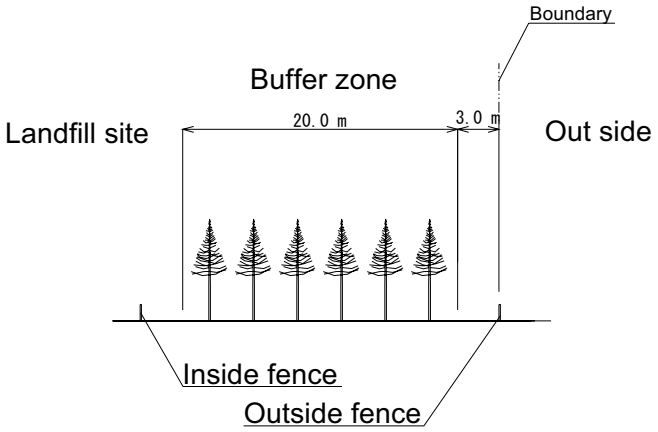


Figure 7-21: Structure of Buffer Zone

c.2.6. Litter Scattering Prevention Facilities

Litter scattering during the 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 be closed with nets

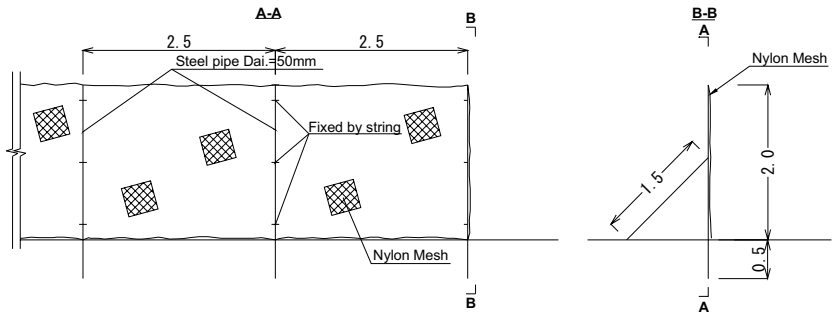


Figure 7-22: Temporary Fence

c.2.7. Gas Removal Facilities

For the organic matter present during landfill 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, outbreaks of gas in landfill sites 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 natural release, by pumping, and by ventilation. Within these designs, the most economical gas removal facility, by evacuation, has been selected.

The completed landfill site gas removal facilities have been designed at 1 position per 900m^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.

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. The vertical removal pipe will be extended upward as the landfill operation makes progress. After completion of the filling of the waste the vertical gas removal pipe extends above ground to vent the gas. A cap is installed at the top of the gas collection pipe in order to prevent rainwater from entering the pipe. The structure is shown below.

Horizontal Gas Removal

After waste filling is completed, the horizontal gas removal system is constructed.

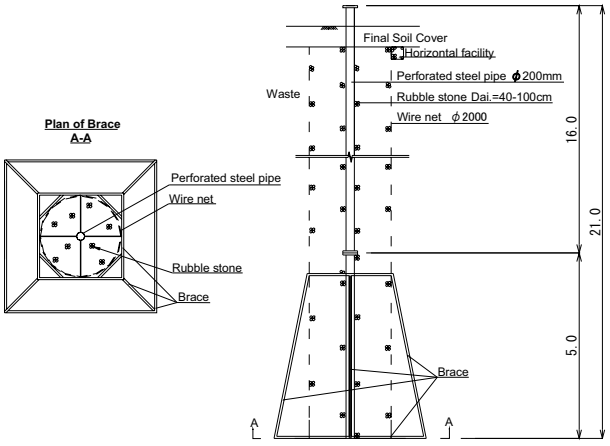


Figure 7-23: Structure of Vertical Gas Removal Facility

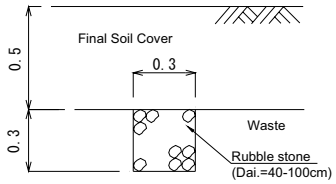


Figure 7-24: Structure of Horizontal Gas Removal Facility

c.2.8. Monitoring Well

To confirm whether leachate is contaminating groundwater resources, monitoring well approximately 5 m in depth with a diameter of more than 100mm will be installed in the site.

c.2.9. Final Soil Cover

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

Soil for coverage was planned to be obtained within the Narangiin Enger Disposal Site.

c.3 Building and Accessories

These facilities include a Nuuts/MUB site office, a weighbridge, a warm garage, tire washing pit, safety facilities, fire prevention facilities, a storage building, monitoring facilities, a car wash, etc.

The facilities are to be shared by recycling complex (sorting yard with RDF equipment).

c.3.1. Entrance area

The entrance area starts from the access road to the Nuuts/MUB site office. It has an area of 0.5 ha and is paved with concrete.

c.3.2. Nuuts/MUB Site Office

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

The weighbridge 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 weighbridge control room furnished with a computer for the weighbridge.
- a changing room
- toilets
- waste picker's welfare room.
- a storeroom etc.

c.3.3. Weighbridge

A weighbridge shall be constructed on weighing load 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 40tons.

c.3.4. 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.

c.3.5. Gate

A 6m wide gate should be installed at the entrance of the site.

c.3.6. Fence (Outside and Inside)

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

- to control waste pickers, outsiders, animals 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:

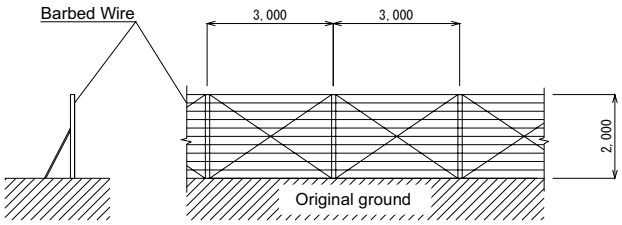


Figure 7-25: Structure of Fence (Outside)

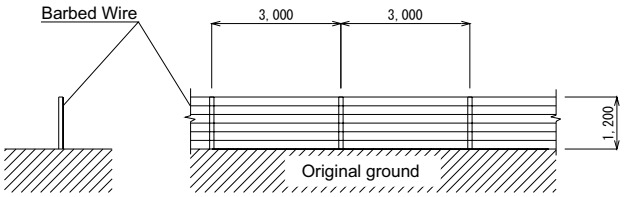


Figure 7-26: Structure of Fence (Inside)

c.3.7. Parking area

A parking lot for the disposal site staff and heavy vehicles such as landfill equipment and collection vehicles will be arranged.

c.3.8. Warm garage

A warm garage for heavy vehicles such as landfill equipment and collection vehicles will be arranged.

c.3.9. Power supply, water supply and heating generation plant

A power supply should be installed at the entrance area, site office, weighbridge, warm garage, recycling complex, etc.

Since there is no water source around the site and it locates very far from water supply pipe line, water tank shall be constructed and water shall be delivered from water kiosk by the water truck.

The site office, warm garage, and other facilities shall have proper heating system.

c.4 Design and supervision

Prior to the commencement of constructing the disposal site, a detailed design study including detailed 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.

d. Leachate Recirculation Treatment Plan

d.1 Weather

In order to formulate leachate recirculation treatment plan, following weather conditions are considered.

1. Annual average temperature is -0.3℃ and the earth is frozen in 7 months of the year. So that there is no evaporation data exists from October to April. There is no outflow of leachate from October to April since the earth is frozen during those periods.

2. Evaporation is much more than precipitation through the year. Average precipitation record of 5 months from May to September shows 210.8 mm, hence average evaporation is 645.1 mm and is three times of precipitation.
3. Average evaporation is more than average precipitation even in August, which average precipitation records the largest in the year.
4. According to the above conditions, generation of leachate due to precipitation is considered very limited.
5. Furthermore, leachate from wastes itself will not be generated due to the characteristic of the waste as described later. (Both portion of kitchen waste and water content are very low.)

Table 7-14: Average Temperature

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(℃)	-21.0	-15.6	-5.4	1.5	9.5	14.5	16.9	15.3	7.8	0.9	-10.1	-17.7

Institute of Hydro-Meteorology, 1988 to 1997

Table 7-15：Average Precipitation and Evaporation

Unit : mm/month

month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1. Average Precipitation	2.5	1.6	2.6	8.9	21.8	43.3	57.8	71.2	30.6	8.7	6.5	4.0	259.5
2. Average Evaporation	NA	NA	NA	NA	165.7	212.1	175.0	173.0	124.0	NA	NA	NA	NA
1 - 2	NA	NA	NA	NA	-143.9	-168.8	-117.2	-101.8	-93.4	NA	NA	NA	NA

Source: Institute of Hydro-Meteorology, from 1994 to 2003 for Precipitation, and 1996 and from 1998 to 2002 for Evaporation
Note: NA: data is not available

d.2 Estimated Leachate Amount

Leachate is generated by ①consolidation of wastes itself and ②precipitation. Followings are the calculations by both causes of leachate:

d.2.1. Estimation of Leachate Amount Generated from Waste Itself

i. Formula

Wastes transported to a landfill are unloaded and compacted. On the wastes disposed of at the landfill newly coming wastes are unloaded and compacted. By these works the wastes will be consolidated in long time. Due to this consolidation, the water of the wastes themselves will be discharged as a leachate. On the other hand, landfilled wastes require water in order to decompose organic matters. Therefore, following formula will be used to calculate the amount of leachate generated from waste itself.

$$Lw = Lc - Ld$$

Lw: Leachate Amount generated from waste itself（ton/day）
Lc: Leachate Amount generated due to consolidation（ton/day）
Ld: Water consumption required to decompose organic matter.（ton/day）

ii. Formula to Calculate Leachate Amount Generated due to Consolidation

Following is the formula to calculate leachate amount generated due to consolidation:

$$Lc = Wa \times (Whw - Wlw)$$

Wa: Landfilled Waste Amount（ton/day）
Whw: Waster content of the landfilled wastes（ton-H_2O/ton-DS）
Wlw: Water content of the waste after consolidation（ton-H_2O/ton-DS）

iii. Water Consumption Required to Decompose Organic Matter

Following is the formula to calculate waster consumption required to decompose organic matter:

Whw = Wds x Rdw x Rwc

Wds: Weight of Dry Solid in Waste (ton-DS)
Rds: Ratio of substance which is decomposable (%)
Rwc: Ratio of water consumption by decomposing organic matter in wastes (ton-H_2O/ton-decomposable matter)

iv. Characteristic of the Wastes

Generation of the leachate from landfilled wastes is occurred in summer time because wastes are not frozen. Therefore, leachate amount will be calculated using WACS data obtained during summer. Following table shows the forecast of composition of MSW in summer. The data in 2020 will be adopted for calculation of leachate amount because leachate generation will be max. both due to a precipitation (as explained later) and a consolidation in year 2020.

Table 7-16：Forecast on Composition of MSW in Summer for the Study Area (2005-2020)

Waste Composition of MSW	2005 (%)	2010 (%)	2015 (%)	2020 (%)
Kitchen Waste	33.8	34.5	35.2	35.8
Paper	18.9	19.3	19.7	20.0
Textile	4.8	4.6	4.3	4.1
Grass and Wood	4.8	4.2	3.7	3.3
Plastic	15.2	15.5	15.8	16.1
Leather and Rubber	0.6	0.6	0.6	0.5
Combustibles	**78.1**	**78.7**	**79.3**	**79.8**
Metal	3.5	3.6	3.6	3.7
Bottle and Glass	10.5	10.7	11.0	11.2
Ceramic and Stone	6.8	6.0	5.3	4.6
Miscellaneous	1.1	1.0	0.8	0.7
Non-combustibles including ash	**21.9**	**21.3**	**20.7**	**20.2**
Other Weight (%)	100.0	100.0	100.0	100.0
Ash Weight (%)	0.0	0.0	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**

v. Conditions of Calculation

Following figures were used for the calculation except for the characteristic of the waste.

① Landfilled Waste Amount（Wa）:

598.4 ton/day [waste amount in 2020]

② Water content of the wastes:

40.5 % [based on the WACS result in summer 2005]

③ Weight of Dry Solid (Wds）:

356.0 ton-DS（Dry Solid）/day [= 598.4 x (1 – 40.5/100)]

④ Waster Content of the Wastes after Consolidation:

45% [Actual Data obtained in Stung Mean Chey Disposal Site in the Previous Study[1]]

⑤ Water Amount per kg of DS（Whw）:

0.68 kg-H_2O/kg-DS [=40.5/100 / (1 – 40.5/100)]

⑥ Water Amount per kg of DS after consolidation（Wlw）:

0.82 kg-H_2O/kg-DS [= 45/100 /(1 – 45/100)]

⑦ Water consumption amount per kg of decomposable substance（Rwc）:

0.165kg-H_2O/kg-decomposable substance [literature data[2]]

⑧ Ratio of decomposable substances in wastes（Rds）:

39.1 % [percentage of kitchen wastes and grass and woods in Table 7-16]

⑨ Leachate from landfilled wastes is considered to be generated immediately after the wastes are spread. In other words, the time required for consolidation and decomposition is not considered for the calculation.

vi. Leachate generated from landfilled wastes

① Leachate due to consolidation

Lc = 356.0 x (0.68 – 0.82) = - 49.8 tons/day

② Water consumption due to decomposition of organic substances

Ld = (356.0 x 39.1/100) x 0.165 = 23.0 tons/day

③ Leachate generated from landfilled wastes

Lw = - 49.8 – 23.0 = - 72.8 tons/day

vii. Conclusion

Based on the above calculation, it is concluded that **the leachate by consolidation of wastes disposed of at NEDS is not generated** considering current and future characteristic of the wastes. The reasons are:

1. Water content of the incoming wastes is as low as 40.5 % even in summer and 21.5 % in winter. Leachate will not be generated due to consolidation even though the water content of the landfill wastes after consolidation is set to 38 %.
2. The reason is that the water content of the incoming wastes is very low comparing with the other countries such as Adana-Mersin in Turkey is 63.3%[3] and Phnom Penh in Cambodia is 69.5 %[4].
3. Therefore, the characteristic of the wastes in the study area is that, in order to accelerate decomposition of the organic substances, it requires a water to be supplied in stead of generating excess waster as a leachate.

[1] The Study on Solid Waste Management in the Municipality of Phnom Penh in the Kingdom of Cambodia, Final Report, March 2005
[2] Integrated Solid Waste Management, Irwin/McGraw-Hill, 1993
[3] The Study on Regional Solid Waste Management for Adana-Mersin in the Republic of Turkey, Final Report, January 2000
4 The Study on Solid Waste Management in the Municipality of Phnom Penh in the Kingdom of Cambodia, Final Report, March 2005

4. In the leachate treatment facilities, which were constructed in the existing Ulaan Chuluut Disposal Site as a pilot project, there is no leachate observed even in August 2005 when precipitation is the largest in the year.

d.2.2. Leachate generated due to Precipitation

i. Formula

The leachate amount originating from rainfall is estimated according to the following equation, which is widely used in Japan. The equation estimates the amount of rainwater likely to percolate through the waste layers of the landfill.

$$Q = 1/1000 \times I \times (C_1A_1 + C_2A_2) \quad \text{..... (1)}$$

Q:	Daily leachate generation	(m^3/day)
I:	Daily precipitation	(mm/day)
C_1:	Percolation rate at the active working landfill area	(-)
C_2:	Percolation rate at the completed landfill area	(-)
A_1:	Area of the active working landfill area	(m^2)
A_2:	Area of the completed landfill area	(m^2)

ii. Pre-conditions

Following pre-conditions are set in order to calculate leachate amount:

- There is no inflow from outside of the disposal site.
- Data on precipitation and evaporation is obtained from the meteorological station in MUB as shown in Table 7-15.
- As there is no data available in Mongolia regarding evaporation amount in the disposal sites after rainfall, coefficient of 0.7, which is used in Japan in case of without such data, is applied to calculate the percolation rate.

iii. Percolation Rate

<Formula>

Following formula is applied to calculate percolation rate.

$$C_1 = 1 - (E \times 0.7) / I$$
$$C_2 = C_1 \times 0.6$$

C_1:	Percolation rate at the active working landfill area	(-)
C_2:	Percolation rate at the completed landfill area	(-)
E:	Possible evaporation amount	(mm/day)
I:	Daily precipitation	(mm/day)

Average monthly precipitation amount in 10 years from 1994 to 2003 and average monthly evaporation amount in 6 years in 1996 and from 1998 to 2002 are applied to calculate percolation rates of C_1 and C_2 are shown in Table 7-17.

Table 7-17: Precipitation, Evaporation and Percolation Rate

month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1. Average Precipitation		2.5	1.6	2.6	8.9	21.8	43.3	57.8	71.2	30.6	8.7	6.5	4.0	259.5
2. Average Evaporation		NA	NA	NA	NA	165.7	212.1	175.0	173.0	124.0	NA	NA	NA	NA
Percolation Rate	C1	-	-	-	-	-	-	-	-	-	-	-	-	NA
	C2	-	-	-	-	-	-	-	-	-	-	-	-	NA

Note: 1.Average Precipitation：10 years average from 1994-2003
2.Average Evaporation：6 years average in 1996、and from 1998-2002

Based on the above calculation using average precipitation and evaporation, percolation rate in every month become negative and as a result, no leachate will be generated.

Then, among available data of evaporation in 6 years, only in August 1998 and 2000, percolation rate will be positive and others are all negative. Following table shows the percolation rate in those months.

Table 7-18: Percolation Rate in 1998 and 2000

Unit : mm/month

1998		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1. Average Precipitation		2.4	0	0	18.6	3.1	45.9	35.6	79.5	46.7	15.4	10.4	2.3	259.9
2. Average Evaporation		NA	NA	NA	NA	167.4	143.4	154.7	102.1	77.5	NA	NA	NA	NA
Percolation Rate	C1	-	-	-	-	-	-	-	0.10	-	-	-	-	NA
	C2	-	-	-	-	-	-	-	0.06	-	-	-	-	NA
2000		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1. Average Precipitation		3.4	2.8	3.5	16.0	16.2	59.2	59.9	102.7	4.3	7.7	11.8	6.3	293.8
2. Average Evaporation		NA	NA	NA	NA	NA	164.1	84.7	132.9	74.6	NA	NA	NA	NA
Percolation Rate	C1	-	-	-	-	-	-	-	0.09	-	-	-	-	NA
	C2	-	-	-	-	-	-	-	0.05	-	-	-	-	NA

<Conclusion>

As a result of above calculations, there is no leachate outflow under normal conditions and, only in August of some years, there is a possibility of leachate outflow by precipitation. Therefore, percolation rates, C_1=0.10, C_2=0.06 in 1998 August, are used to calculate leachate amount estimation as they are the biggest figures in 6 years.

- All percolation rates become negative in case using average precipitation on 10 years and average evaporation in 6 years.
- Therefore, percolation rates are calculated in all the months in 6 years which evaporation record are available and it was found that all the percolation rate except in August 1998 and 2000 is negative.

iv. Projected Leachate Amount (daily leachate treatment capacity)

<Pre-conditions>

The leachate generation amount will reach a peak when the landfill operation is done under the following conditions.

- Landfilling Phase 7; and
- Starting at final landfilling section (Area 7-6) as shown in the following drawing.

Area is calculated as follows.

- Area of completed fill: 214,500 m^2
- Area of active working fill (Area 7-6): 31,500 m^2

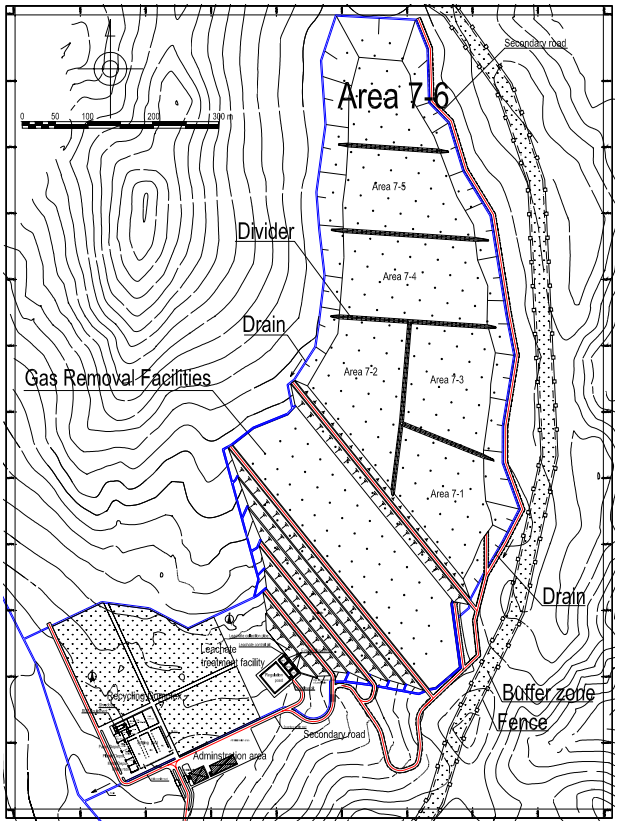


Figure 7-27: Area 7-6 of Landfill Section

<Precipitation Data>

Projected leachate amount is obtained for the following precipitation data.

- Annual mean daily precipitation: 0.70 mm/day
- Average daily precipitation in the largest precipitation month (79.5 mm/month: August in 1998): 2.56 mm/day
- Maximum daily precipitation in 10 years (4th August 1995): 49.8 mm/day

<Calculation of Leachate Amount>

Leachate Amount for the annual daily precipitation (0.70 mm/day）:

substituting I = 0.70 mm/day, C_1 = 0.10, C_2 = 0.06, A_1＝31,500m^2 and A_2= 214,500m^2 for the equation:

$$Q = 1/1000 \times I \times (C_1A_1 + C_2A_2)$$
$$= 1/1000 \times 0.70 \times (0.10 \times 31,500 + 0.06 \times 214,500)$$
$$= 11.2\ m^3/day$$

Leachate Amount for the average daily precipitation in the largest precipitation month （79.5 mm/month(2.56 mm/day)）:

substituting I = 2.56 mm/day, C_1 = 0.10, C_2 = 0.06, A_1＝31,500m^2 and A_2= 214,500m^2 for the equation.

$$Q = 1/1000 \times I \times (C_1A_1 + C_2A_2)$$
$$= 1/1000 \times 2.56 \times (0.10 \times 31,500 + 0.06 \times 214,500)$$
$$= 41.0\ m^3/day$$

Leachate Amount for the maximum daily precipitation in 10 years （49.8 mm/day）:

substituting I = 49.8 mm/day, C_1 = 0.10, C_2 = 0.06, A_1＝31,500m^2 and A_2= 214,500m^2 for the equation.

$$Q = 1/1000 \times I \times (C_1A_1 + C_2A_2)$$
$$= 1/1000 \times 49.8 \times (0.10 \times 31,500 + 0.06 \times 214,500)$$
$$= 797.8 \text{ m}^3/\text{day}$$

d.3 Leachate Recirculation Treatment System

d.3.1. Flow Sheet of Leachate Recirculation Treatment System

All the leachate from Narangiin Enger Disposal Site is circulated inside the facilities after treated on site. Therefore, leachate will not be discharged outside the site.

Leachate is collected from landfill area and flow into leachate collection & control pit. An excess leachate is flowed into regulation pond through collection & control pit in case of much inflow due to rain. Recirculation pump will be installed at leachate collection and control pit.

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

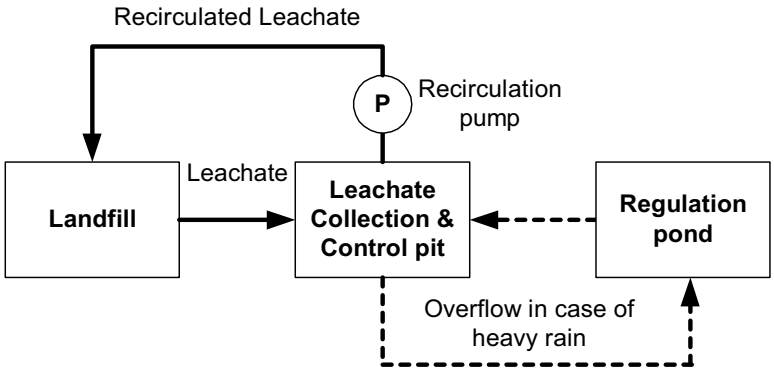


Figure 7-28: Flow sheet of Leachate Recirculation Treatment Facilities

d.3.2. Required Leachate Recirculation Treatment Capacity

Following table summarizes the leachate amount calculations under three conditions.

Table 7-19: Leachate Amount under the Conditions

	Conditions	Leachate Amount
(1)	Leachate Amount for the annual daily precipitation (0.70 mm/day) （Average Leachate Amount）	11.2 m^3/day
(2)	Leachate Amount for the average daily precipitation in the largest precipitation month（79.5 mm/month(2.56 mm/day)） （Max. Leachate Amount）	41.0 m^3/day
(3)	Leachate Amount for the maximum daily precipitation in 10 years （49.8 mm/day）	797.8 m^3/day

Based on the above results, leachate recirculation treatment capacity will be calculated under the conditions between (1) 11.2m^3/day and (2) 41.0m^3/day.

Calculation under the condition of (3) 797.8 m^3 / day might be over design. Regulation pond will be constructed to cater for the maximum daily precipitation in 10 years so leachate will not outflow to the outside of the disposal site.

d.3.3. Leachate Recirculation Treatment Facility Plan

i. Leachate Collection and Control Pit

Leachate collection and control pit is designed based on the capacity that can store the leachate amount of 41.0 m^3/day which is generated under the average daily precipitation in the heaviest precipitation month.

① Capacity of Leachate Collection and Control Pit : Q	45 m^3

ii. Leachate Regulation Pond

In order to cater for maximum leachate amount (797.8 m^3/day) for the maximum daily precipitation in 10 years (49.8 mm/day), leachate regulation pond will be designed not to overflow the leachate to the outside of the disposal site. Volume of this regulation pond is 800 m^3 to store the maximum leachate amount and locates next to the leachate collection and control pit.

① Capacity of Regulation Pond : Q	800 m^3

d.3.4. Leachate Recirculation Treatment Facilities

Based on the above examinations, leachate recirculation treatment facilities are summarized as follows:

Table 7-20: Outline of Leachate Recirculation Treatment Facilities

Capacity of leachate collection and control pit	Volume	45.0 m^3
	Area	25 m^2
Capacity of regulation pond	Volume	800 m^3
	Area	465 m^2

d.3.5. Leachate Collection Facilities Plan

In order to prevent leachate from penetration into underground, the following measures are made.

- No specific lining is laid.
- Leachate collection pipe as shown in the following drawing will be installed at the lowest point of the valley from enclosing dam to the top of the landfill.
- Leachate collection pit will be installed on the impermeable layer of bed rock.
- Leachate collection and control pit and regulation pond shall be made of reinforced concrete.
- Submersible pump will be installed in the leachate collection & control pit and, in case level of leachate reach to the 60 cm above bed rock , pump up leachate to the existing landfill site to minimize leachate pressure in order to prevent it from penetration to the underground.

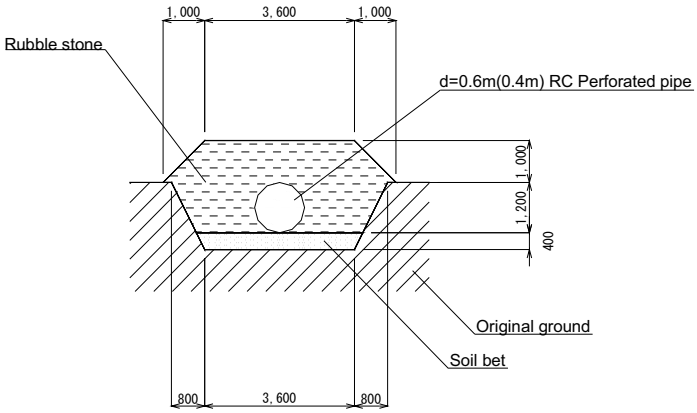


Figure 7-29: Structure of Leachate Collection Pipe

The reasons why above design is adopted are explained as follows.

1. Water content of the wastes is very low compared with other countries. Furthermore, evaporation is three times much than precipitation. As a result, leachate generation is very limited. Based on the examination above, possibility of outflow of the leachate from disposal site is limited only in August and once in three years according to the available data.
2. Construction of liner to prevent leachate penetration might be very expensive under such a cold weather (mean temperature in January is less than -20℃) and it is still questionable that the liner will maintain those function permanently or not.
3. There is a firm bed rock under 2 to 3 meters below the ground in the proposed disposal site. The layer above this bed rock is made of weathered stone and sand and its permeability is relatively high. But the permeability of the said bed rock is anticipated very low. Based on the consideration of the topographic and geological features, very limited leachate will gather in the lowest point naturally and this can be collected at collection & control pit safely without penetrating into underground.
4. The majority of source of drinking water for UB city locates in the eastside of the city and usage of underground water at downstream of NEDS is very limited. Furthermore, the result of the underground water survey conducted for the downstream of UCDS which locates next to the NEDS shows there is no underground pollution caused by the leachate of disposal site.
5. For the safety of very limited people who use underground water at downstream of NEDS, piped water, which will be laid under development of NEDS, will be recommended to use.

d.3.6. Layout of Proposed Leachate Recirculation Treatment System

The layout plan of leachate recirculation treatment facility is prepared as shown in the figure below.

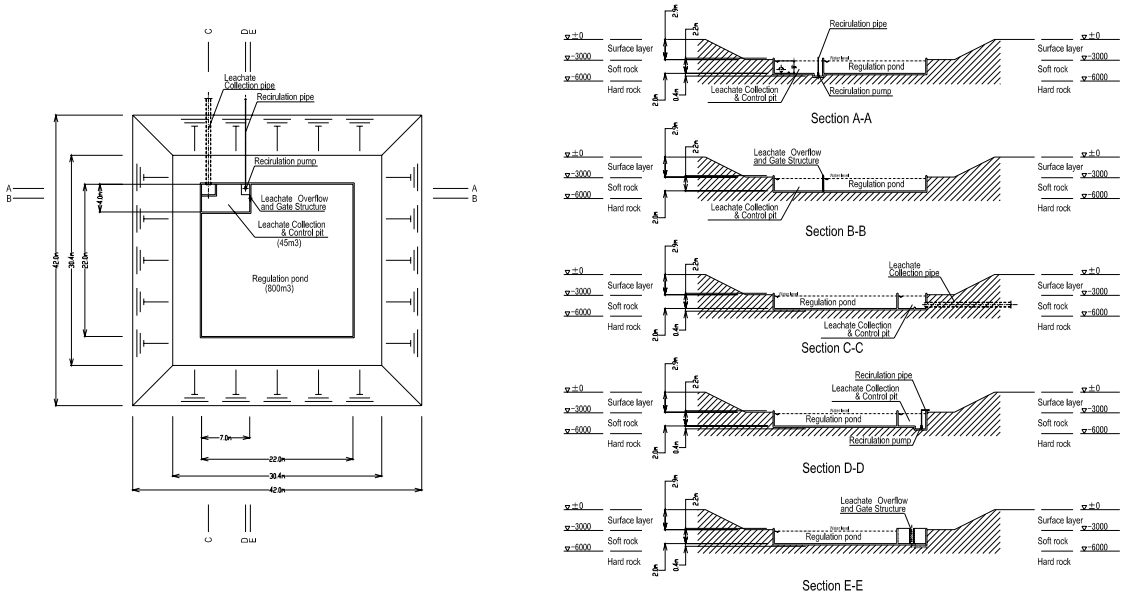


Figure 7-30: Layout of the Leachate Recirculation Treatment Facility

7.4 Development of Narangiin Enger Recycling Complex (NERC)

7.4.1 Background

The fundamental goal of the M/P for SWM in MUB is to establish an environmentally sound SWM system in MUB by the target year 2020. To achieve this goal, 3Rs (Reduce, Reuse, Recycle) will be actively promoted to reduce waste generation at first, then to reuse and recycle generated wastes as a resource as much as possible in order to reduce the amount of the solid waste to be disposed of at the landfills.

As for the promotion of 3Rs, recycling activities shall be conducted by the private sector in principle. The role of public sector (MUB) shall be limited to:

- Promote, support and regulate the recycling activities of private sector.
- Research, introduce and disseminate technologies to recycle the waste that the private sector can not deal with.

The development project of a recycling complex next to the NEDS is identified to pursue the role of public sector (MUB) mentioned above. The project is divided into the following phases:

Phase 1 (Target year 2010):

Construction of a sorting yard and a RDF (Refuse Derived Fuel) plant and development of basic infrastructures (such as access road, electricity, water, etc.) for new private investors of recycling business

Phase 2 (Target year 2020):

Promotion of investment by private recycling enterprises

The Phase 1 of the project is subject to the feasibility study, which examines the viability of the project.

7.4.2 Policy of Development of Recycling Complex

The policy of the development of Recycling Complex Phase 1 is established as follows:

1. Main purposes of the project are:
   - To promote the recycling activities of the private sector and introduce technologies to recycle the waste that the private sector can not deal with; and
   - To create job opportunities to the residents around the new NEDS and waste pickers working at current UCDS in order to obtain consensus on the development of it from them.
2. The MUB shall develop a site for the recycling complex next to the NEDS and to invite the private enterprises to locate their facilities there. Because it has the following advantages:
   - Recycling facilities require a basic infrastructure such as access and on-site roads, electricity and water which will be provided by the development of the new NEDS.
   - The recycling complex will develop cooperation in a mutually complementary form if various kinds of recycling factories locate on the site. For instance, a plastic bag production company will be able to purchase their raw materials from sorting yards, an enterprise exporting scrap metal to China can purchase their materials from sorting yards and also use compaction machine provided at the yard.
   - Recycling facilities need a disposal site for residue to be generated by processing raw materials (waste).
3. Objectives of the sorting yard are:
   - To provide work opportunities to current waste pickers in UCDS in order to prevent the NEDS from their entering and to ensure sanitary landfill operation at the NEDS. Therefore, the facility shall limit the use of machinery as much as possible;
   - To promote reuse/recycle of waste; and
   - To pre-treat waste for RDF production.
4. Purposes of the RDF plant are:
   - To mitigate problems for the sanitary landfill operation; i.e. scattering waste and spoiling the stability of landfill, by reducing problems-some waste such as plastics and papers; and
   - To introduce and disseminate a thermal recycling technology of RDF that the private sector can not deal with at present and can recycle problem some waste.

7.4.3 Outline of the Recycling Complex

a. Development of Basic Infrastructures

a.1 Basic Infrastructures

As shown in the drawing, the asphalt paved access road from the existing asphalt paved trunk road to the recycling complex will be constructed. In addition to the access road, the following basic infrastructure will be provided to the private investors of the recycling business:

- Electricity
- Water

- Central heating system
- Waste water treatment facility
- Car washing facility
- On-site road
- Land for private investors of recycling business

a.2 Land for private investors of recycling business

Next to the sorting yard and RDF plant, 4.2 ha of land for private investors of recycling business will be developed as shown in the Figure below. The land will be divided into building plots in accordance with the requests from private investors.

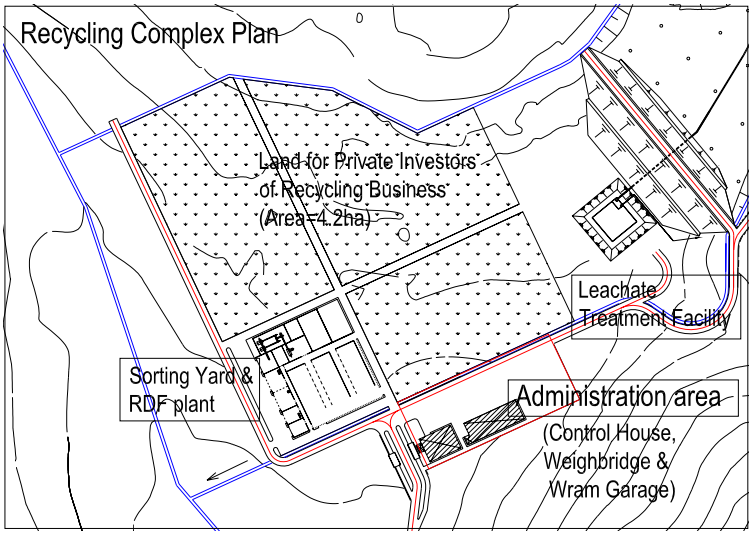


Figure 7-31: Layout of Recycling Complex

b. Sorting Yard and RDF Plant

b.1 Target Waste

Target waste of the sorting yard is the recyclable waste separated at residential sources and small scale non-residential sources in the Planned Area. The recyclable waste consists of paper, plastic, textile and metal, but excludes bottles and glass since bottles are mainly reused at the generation sources and glass (cullet) is not recycled in the study area.

b.2 Waste Amount and Composition

Waste amount and composition of the study area significantly differs from summer and winter. The table below shows a forecast of waste generation amount in planned area.

Table 7-21: Forecast of Waste Generation Amount in Planned Area

		2006	2010	2015	2020
Winter season	Residential Sources	127.0	181.9	273.9	397.4
	Non-residential Sources	36.7	51.0	77.2	116.6
	Total	163.7	232.9	351.1	514.0
Summer season	Residential Sources	113.0	161.7	243.6	352.6
	Non-residential Sources	48.2	67.1	101.4	153.4
	Total	161.2	228.8	345.0	506.0

The tables below show forecasts of waste composition in planned area in winter and summer respectively.

Table 7-22: Forecast of Waste Composition in Planned Area in Winter

Waste Category	2005	2010	2015	2020
Paper	12.7	12.9	13.3	13.7
Textile	4.6	4.4	3.9	3.3
Plastic	22.4	22.8	23.5	24.4
Metal	4.0	4.1	4.2	4.4
Recyclable Waste Total	**43.7**	**44.2**	**44.9**	**45.8**
Kitchen Waste	32.7	33.3	34.3	35.5
Grass and Wood	1.1	0.9	0.7	0.5
Rubber and Leather	0.7	0.7	0.6	0.5
Bottle and Glass	12.4	12.6	13.1	13.4
Ceramic & Stone	4.4	3.9	3.0	2.0
Others	5.0	4.4	3.4	2.3
Non-Recyclable Waste Total	**56.3**	**55.8**	**55.1**	**54.2**
Total	100.0	100.0	100.0	100.0

Table 7-23: Forecast of Waste Composition in Planned Area in Summer

Waste Category	2005	2010	2015	2020
Paper	21.7	22.1	22.9	23.8
Textile	4.1	3.9	3.5	2.9
Plastic	14.5	14.8	15.3	15.9
Metal	1.8	1.8	1.9	2.0
Recyclable Waste Total	**42.1**	**42.6**	**43.6**	**44.6**
Kitchen Waste	35.7	36.4	37.7	39.2
Grass and Wood	5.3	4.7	3.6	2.4
Rubber and Leather	0.4	0.4	0.4	0.3
Bottle and Glass	9.5	9.7	9.9	10.3
Ceramic & Stone	6.5	5.8	4.5	3.0
Others	0.5	0.4	0.3	0.2
Non-Recyclable Waste Total	**57.9**	**57.4**	**56.4**	**55.4**
Total	100.0	100.0	100.0	100.0

b.3 Amount of Separated Waste coming to Sorting Yard

In order to estimate the possible recyclable waste amount coming to the sorting yard, the following assumptions are set:

- Portion in waste amount of small scale non-residential sources to that of large scale, where separate collection is not planned, is 70 %.
- Separate collection service will cover all residential and small scale non-residential sources in the planned area from 2010.
- However, since the rate of public cooperation with the separate collection system will gradually improve and some portion of recyclables will be reused and recycled at generation, collection rate of recyclable waste to is assumed at 15% in 2010, 40% in 2015 and 70% in 2020 in this Study.

Accordingly the amount of separated waste coming to the sorting yard is calculated as shown in the table below.

Table 7-24: Amount of Separated Waste coming to Sorting Yard

Season	Items	Unit	2006	2010	2015	2020
In Winter	Residential Sources	ton/day	127.0	181.9	273.9	397.4
	Small Scale Non-residential Sources	ton/day	25.7	35.8	54.0	82.3
	Total Waste Generation Amount in Separate Collection Area	ton/day	152.7	217.7	327.9	479.7
	Portion of Recyclable Waste	%	43.9	44.2	45.1	45.8
	Maximum Separated Recyclable Waste	ton/day	67.0	96.2	147.9	219.7

	Collection Rate of Recyclable Waste	%	0	15	40	70
	Amount of Separated Waste coming to Sorting Yard	**ton/day**	**0**	**14.4**	**59.2**	**153.8**
In Summer	Residential Sources	ton/day	113	161.7	243.6	352.6
	Small Scale Non-residential Sources	ton/day	33.7	47.0	71.1	107.6
	Total Waste Generation Amount in Separate Collection Area	ton/day	146.7	208.7	314.7	460.2
	Portion of Recyclable Waste	%	42.7	42.6	43.6	44.6
	Maximum Separated Recyclable Waste	ton/day	62.6	88.9	137.2	205.2
	Collection Rate of Recyclable Waste	%	0	15	40	70
	Amount of Separated Waste coming to Sorting Yard	**ton/day**	**0**	**13.3**	**54.9**	**143.6**

b.4 Process Flow of the Plant

- Recyclable waste, which is separately collected from apartment area, is transported into sorting yard.
- Recyclable materials such as paper, textile, plastics and metal will be sorted in the sorting yard.
- Residues after sorting will be transported to the RDF plant.

The important issues for designing sorting yard and RDF plant are set as follows:

- Three sorting yards are provided to let collection vehicles unload collected waste (No.1 Yard), to allow workers to collect recyclables (No.2 Yard) and to enable wheel loaders to clean up residues after sorting and bring them to RDF plant (No.3 Yard).
- Three sorting yards will rotate their functions every hour. The working hours of a day will be 8 hours. Then each sorting yard will have area of 250 m^2 (20 ton/8 hour/0.1 ton/m^3/0.1 m thick).

Based on the above setting a process flow of the sorting yard and RDF plant is presented in following figure.

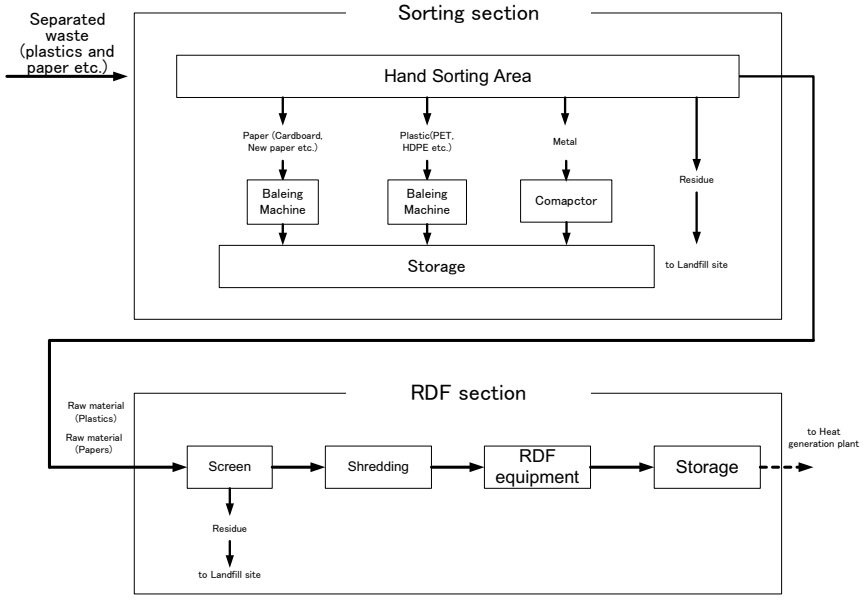


Figure 7-32: Process Flow Diagram of the Recycling Complex

b.5 Material Balance for Recycling Complex

The figure below shows the material balance at the proposed Recycling complex.

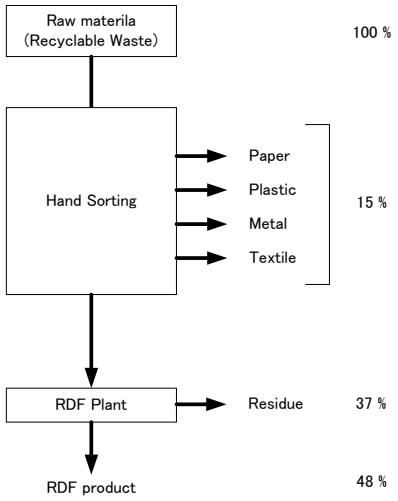


Figure 7-33: Material Balance of the Recycling Complex

b.6 Layout of Sorting Yard and RDF Plant

The layout of the proposed recycling complex is presented in the figure below.

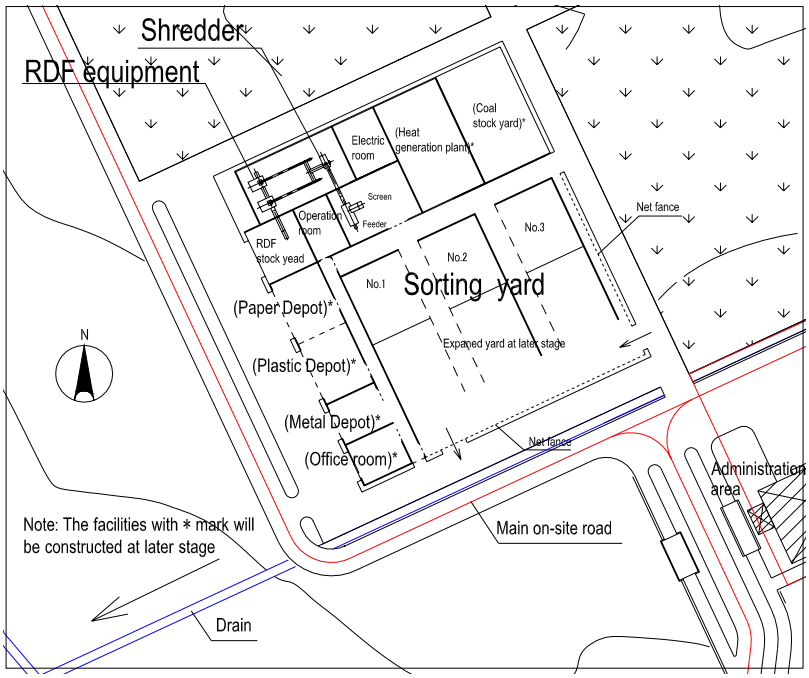


Figure 7-34: Layout of Sorting Yard and RDF Plant

c. Outline of Sorting Yard

c.1 Sorting Methods

The sorting yard is planned to recover every materials by manual sorting on a filed. In order to raise the work efficiency of manual sorting, large baskets of mesh are provided.

c.2 Outline of Sorting Yard

The table below summarises the outline of the sorting yard.

Table 7-25: Outline of Sorting Yard

Items	Description
1. Raw Material (Recyclable waste)	
Raw Materials (Waste)	paper, plastic, textile and metals
Amount	12.1 tons / day in summer and 13.2 tons / day in winter for weekdays in 2010
Moisture Content	10 - 20 %
Bulk Density	100 kg / m^3
2. Yard Specification	
Method	Hand-sorting yard
Sorting Yard	3 yards with concrete paved floor of 500 m^2 and surrounded by fence
Processing Capacity	20 tons / day
Operation	8 hours / day for weekdays 4 hours / day for Saturdays
3. Recovered Material	
Recovered Items	(1)Paper (mainly Cardboard), (2) Plastics (Film, PET bottles and HDPE), (3) Ferrous metal, (4) Non-ferrous metal (mainly Aluminum cans)
Recovered Amount	1.8 tons / week in summer and 2.0 tons / week in winter
4. Machinery	
Wheel Loader	
Baling machine	One for papers and one for plastics
Compaction machine	One for metals

d. Outline of RDF Plant

The RDF plant will receive recyclable waste after recovery of recyclables done by the sorting yard. The waste to be received by the RDF plant will contain a large portion of papers and plastics which are not subject to material recycling due to their quality.

The table below summarizes the outline of the RDF plant.

Table 7-26: Outline of RDF Plant

Items	Description
1. Raw Material	
Raw Materials (Waste)	Recyclable waste after recovery of recyclables
Amount	10.3 tons / day in summer and 11.2 tons / day in winter for weekdays in 2010
Moisture content	< 10 %
Bulk density	100 kg / m^3
2. Plant Specification	
Type	Compressing type RDF production
Treatment line	Two line for RDF production
Treatment Capacity	11 tons / day (2.2 tons / hour)
Operation	300 days / year 5 hours / day by one shift
3. Recovered Material	
RDF Production Amount	5.8 tons / day in summer and 6.3 tons / day in winter for weekdays in 2010
Residue Amount	4.5 tons / day in summer and 4.9 tons / day in winter for weekdays in 2010
4. Machinery	
Feeder	Apron conveyor
Screen or Conveyor	Rotary screen or Flat conveyor
Shredder	Screw type shredder
Magnetic separator	Permanent magnet type
RDF machine	Compressing type

7.5 Operational Plan of NEDS and NERC

7.5.1 Final Disposal Site (NEDS)

a. Fundamental Issues

This operational plan shall be applied for the proposed disposal site in NEDS.

b. Working Hours

The work schedule of the site is as followings.

- The proposed plant operates : 365 days a year.
- Mondays - Sundays Collection vehicle: 5:00-23:00 (April – September)
  7:00-19:00 (October – March)
  Landfill operation: 6:00-24:00 (April – September)
  8:00-20:00 (October – March)

c. Types of Solid Wastes

The disposal site will receive the following types of waste.

- Mixed municipal solid waste such as households and commercial enterprises.
- Rejected waste from the Recycling Complex.
- Other waste (general waste from factories and medical institutions)

d. Landfill Plan

d.1 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 waste as early as possible.

The compaction of solid waste is necessary to prolong the service life of the landfill site, and is also helpful in reducing settlement after the completion of the landfill. Furthermore, the prevention of solid waste 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.

d.2 Landfill Structure

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

d.3 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 waste 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 of days, resulting in the generation of offensive odors, etc.

With the cell method, soil is spread daily 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.

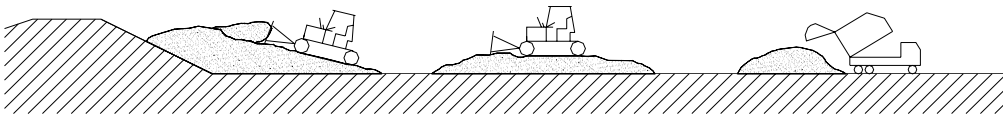


Figure 7-35: Conception of Landfill Operation

The outline of the landfill plan is summarized below.

- Step 1: After the enclosing dam and the divider (bank) are constructed, landfill operation at Area 1 starts.
- Step 2: After the completion of the landfill operation at Area 1, the landfill operation at Area 2 starts.
- Step 3: Before the completion of the landfill operation at Area 2, the enclosing dam for Phase 2 is constructed.
- Step 4: By the repetition of works from step 1 to step 3, the Phase 2 landfill operation is conducted.

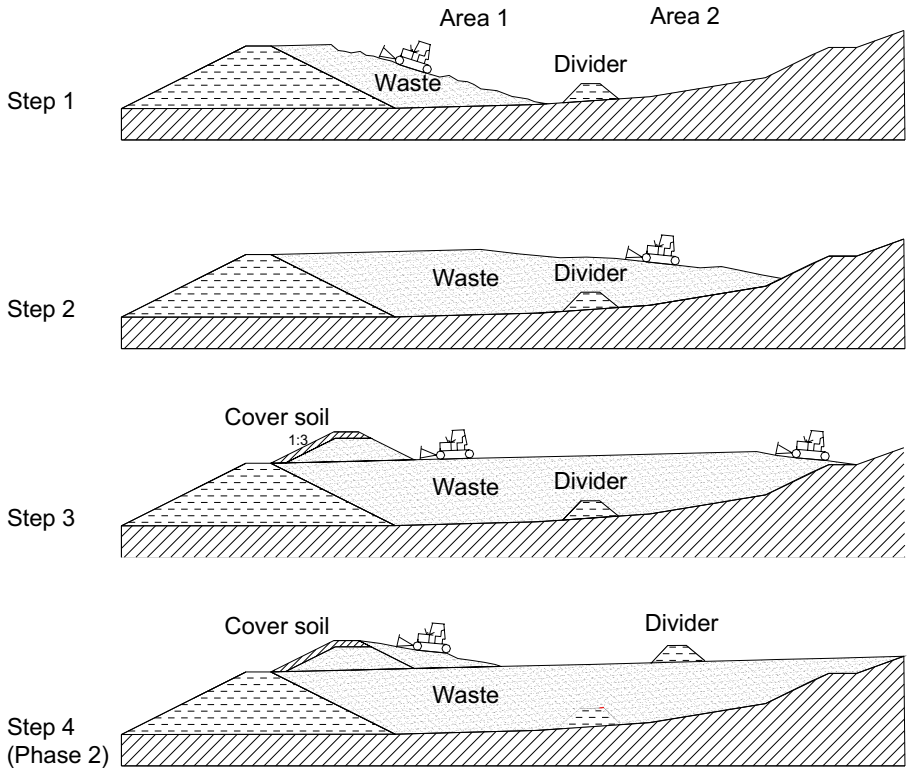


Figure 7-36: Each Step of Landfill Operation

d.4 Landfill Procedure

The landfill operations are outlined below.

1) Waste is dumped by the collection vehicle driver with the instruction of landfill operation staff.
2) The dumped waste is spread, crushed, leveled and compacted by bulldozers.
3) After the landfill operations, the covering operations will be performed daily using the cell method.

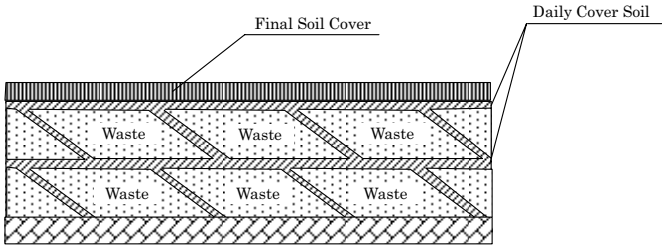
4) A second layer will be laid on the first in the same manner, extending to the divider.
5) A covering material will be laid on top of the second layer of landfill.
6) A divider as well as gas and leachate removal facilities will be constructed in the adjacent area for the next landfill operations.

d.5 Cover Soil

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

- daily cover soil : 15 cm
- intermediate cover soil : 30 cm
- final cover soil : 50 cm

Accordingly, the ratio of cover soil to waste disposal volume will be 8 %, including final cover soil. The cover soil is to be obtained within the Narangiin Enger Disposal Site because its area is large enough.



d.6 Phased Landfill Plan of NEDS

The phased landfill plan of NEDS is proposed as shown in Table 7-27.

Table 7-27: Phased Landfill Plan of NEDS

Items	Description		
Land Area and Proposed Land Use	Total Area : 24.6 ha		
Landfill Volume	Phase	Capacity	Disposal Period
	Phase 1	84,981m^3	2009-2009
	Phase 2	164,298 m^3	2009-2010
	Phase 3	294,865 m^3	2010-2011
	Phase 4	433,090 m^3	2011-2013
	Phase 5	603,840 m^3	2013-2015
	Phase 6	805,650 m^3	2015-2018
	Phase 7	789,660m^3	2018-2020
	Total	3,176,384m^3	2009-2020

e. Operation of Weighbridge

The final disposal site and recycling complex, which are to be sited in the same land plot, will share one weighbridge.

The weighbridge will be used to measure the following.

- MSW directly delivered to the landfill.
- General waste from medical institutions and factories directly delivered to the landfill.
- Recyclable waste.
- Recycle material and residue from the recycling complex.

f. Equipment Planning

f.1 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 sufficient capacity to crush and compact combustibles and non-combustibles.
- Equipment which can carry out daily soil covering.
- 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.

f.2 Equipment Selection

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

Table 7-28: Equipment for Landfill Operation and Maintenance

	Equipment	Specification	Quantity	Unit
1	Bulldozer	21 ton	3	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	1	nos
6	Excavator	0.7m^3	1	nos

g. Personnel Plan

The organization structure for the operation of the Narangiin Enger Disposal Site in 2008 is proposed as shown in following table.

Table 7-29: Organization Structure of Landfill Operation section in 2008

Landfill Operation section	Section chief	1	person
	Engineer	2	person
	Clerk (include Weighbridge staff)	5	person
	Supervisor	3	person
	Operator	8	person
	Mechanic	1	person
	Worker	2	person
Total		22	person

7.5.2 Recycling Complex Operation (NERC)

a. Fundamental Issues

This part describes the operation plan of the sorting yard and RDF plant.

The operation plan will cover the work flow from waste reception to recycled materials storage.

b. Working Hours

This sorting yard and RDF plant is open the following hours.

<Sorting yard>

- Mondays - Saturdays 9:00 - 18:00 (8 hour/day)
- Sundays and National Holidays Closed
- Design capacity Sorting section 2.5 ton/hour

<RDF plant>

- Mondays - Saturdays 10:00 - 16:00 (5 hour/day)

- Sundays and National Holidays Closed
- Design capacity RDF section 2.2 ton/hour

Table 7-30: Work Schedule

	6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Waste Received Time	Mondays-Fridays Saturday
Sorting Equipment Operation	Mondays-Saturdays
RDF Plant Operation	Mondays-Saturdays

c. Equipment Plan

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

Table 7-31: Equipment for Recycling Complex

	Equipment	Specification	Quantity	Unit
	Common section			
1	Dump truck	4 ton	1	nos
2	Wheel loader	1.0 m^3	1	nos

d. Operation of NEDS

d.1 Sorting Section

The sorting section has three sorting yards and each yard will be rotated as unloading, waste sorting and cleanup activities.

- Unloading yard: this yard will be used for unloading incoming waste and sorting activities are prohibited.
- Waste sorting yard: this yard will be used for sorting valuables and any machinery operation will be prohibited.
- Cleanup yard: this yard will be used for cleaning up residue after sorting operation.

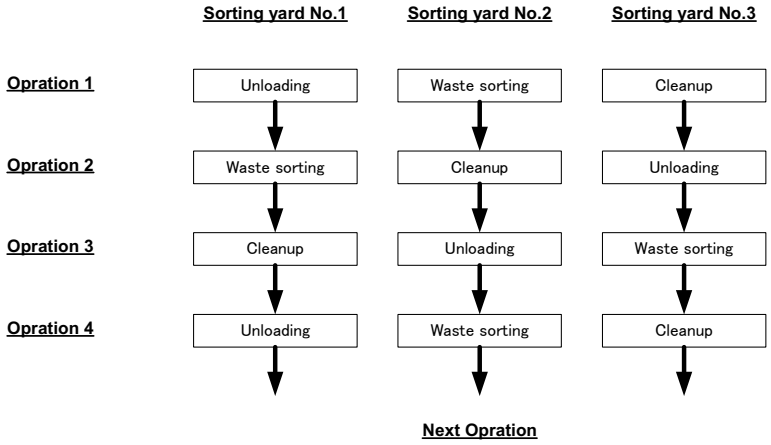


Figure 7-37: Rotation at Sorting yards

d.2 RDF section

Following operation will be required under RDF section

Section	Operation
Waste reception section	This section is in charge of receiving residue from the sorting yard after cleaning up the yard. And material which is not suitable for RDF production will be removed using screening.
Equipment operation section	This section is in charge of operation of RDF equipment. The main equipment are feeders, screens, conveyors, shredders, magnetic separator and RDF equipment.
RDF product section	This section is in charge of the storage of the RDF product and control of forwarding the products.

e. Personnel Plan

e.1 Staff and Job Description

e.1.1. Operation and Control System for Recycling Complex

Operation and control system shall be planned as follows.

- Sorting yard: CMPUA shall be responsible for operation and maintenance of plant and facilities, collection and transportation of separated waste, disposal of residue after sorting. Sorting operation of valuable waste shall be done by the private sector which will be formed from existing waste pickers.
- RDF plant: CMPUA shall operate and control all the facilities.

e.1.2. Administration (Plant Office)

Administrative work will be executed by the plant manager (Nuuts), who overseas the operation and management of the recycling complex, and supporting staff including an accountant and secretary.

e.2 Personnel Plan

The staffing structure for the operation of the recycling complex in 2010 is proposed as shown in following table.

Table 7-32: Staffing Schedule of Recycling Complex (2010)

Position			total
ADMINISTRATION			
	Section chief		1
	Clerk		2
	Accountant		1
	sub-total		4
OPERATION			
	RDF equipment section		
		Supervisor	1
	Operation		
		Equipment operator	2
		Worker	8
	Transport section		
		Truck driver	2
		Worker	2
	sub-total		15
Total			19

7.5.3 Monitoring Plan of NEDS and NERC

a. Monitoring Plan

a.1 Monitoring Items and Frequency

In the monitoring system, the measurement of hazardous chemical substances such as heavy metals is very important. However, these measurements are very costly and the budget and human resources of Nuuts/MUB are quite limited.

Therefore, in the monitoring system of NEDS, only limited analytical parameters such as pH, EC and chloride were set for water quality. These parameters are inexpensive and easy to measure, and can monitor the leachate leakage. As for the frequency of monitoring, the same matters mentioned above had to be considered and the frequency was set as monthly.

If the results of monitoring change significantly, it means that leachate may have leaked to the outside area. So full-scale measurement parameters, including heavy metals, shall be measured and the frequency of monitoring increased.

As with water quality monitoring, practicable measurements for air quality monitoring are also limited. Therefore, CH_4, CO_2, H_2O and temperature, which can be measured by portable meters, as well as landfill fire and offensive odor, which can be monitored by visual checking, are the set measurement parameters for air quality.

Table 7-33: Monitoring plan of the Narangiin Enger 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	Noise	√	√	
Settlement	Settlement board	Settlement level		√	√
Landfill fire	Personal check	Landfill fire		√	√
Offensive odor	Personal check	Offensive odor		√	√

The matters mentioned above shall be considered in the detailed design of NEDS. However, it should be noted that if the situation concerning the budget and human resources of Nuuts/MUB improves, measurement parameters and frequency of monitoring must be re-considered immediately.

The monitoring locations are shown in the following figure.

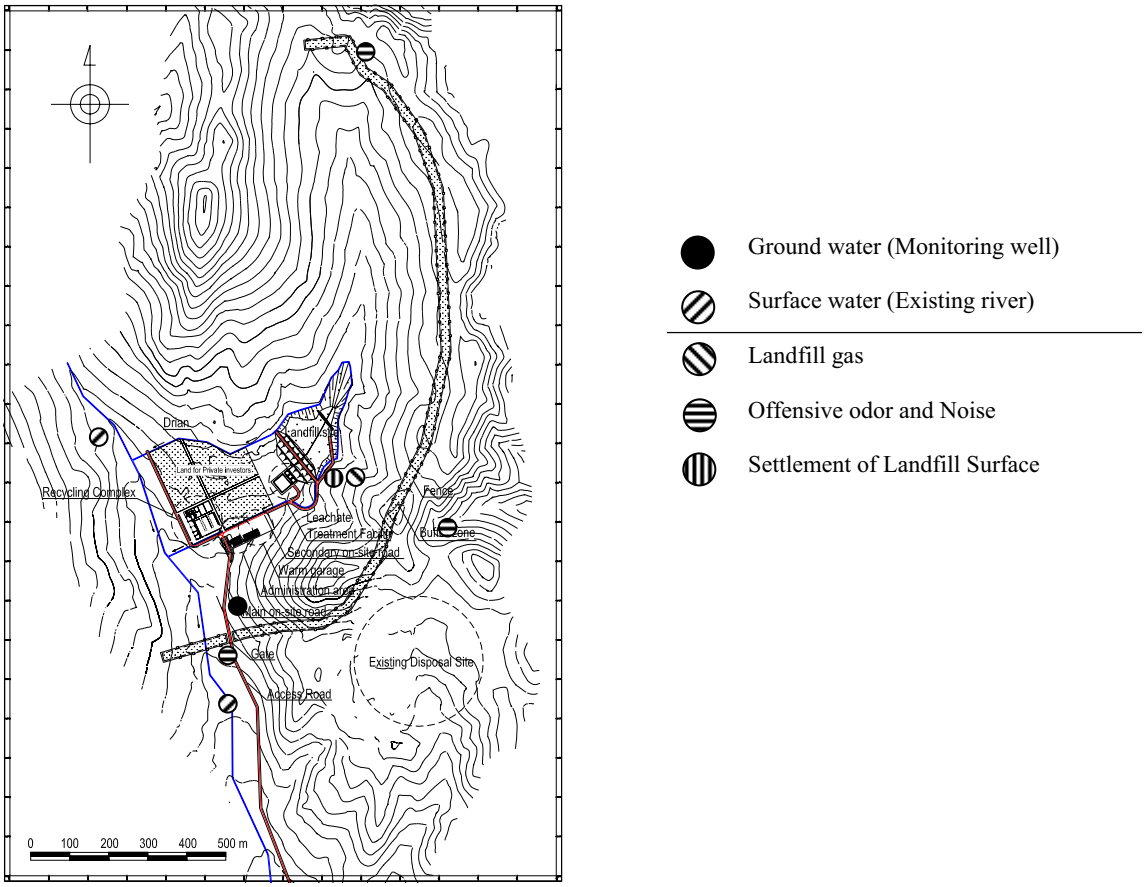


Figure 7-38: Location of Monitoring Plan

a.2 Public Communication

The result of the regular monitoring will be communicated to local residents through the monitoring committee, while other citizens will be able to access the data through the web site of MUB.

b. Monitoring Committee

In order to strengthen a monitoring system, a monitoring committee for the Project is proposed. The monitoring committee will have the following function.

- The committee members shall join in the monitoring and observe the environmental condition of the site and its surroundings.
- If the operation is suspected of having an effect on environmental conditions, the committee members shall be able to request a survey for it and be able to join on-site inspection.
- In order to properly operate the disposal site, the committee and Nuuts/MUB shall hold discussions whenever necessary.

The committee may include:

- City Specialized Inspection Agency
- Nuuts/MUB
- MOE
- NGOs
- Representatives from local authorities and residents

7.6 Cost Estimation

7.6.1 Condition of Cost Estimation

a. Basic Conditions

- Design of project will start in 2008 and implementation of the project will be in 2009. Operation and Maintenance (O&M) will start from 2010.
- Exchange rates are : 1 US$ = 1,200 MNT, 1 MNT = 0.095 Japanese Yen
- Cost estimation was done in Mongolian Currency which is MNT

b. Costing Item

- Initial investment cost and Operation & Maintenance cost
- 15 % of O&M cost of collection services is added as an overhead of collection company.
- On top of it, 2% of all the O&M cost (Collection, Disposal, Recycling) is added as an management cost for overall SWM.
- Collection and transportation cost was calculated in Duureg by Duureg.
- Annual Cost was calculated considering 6 months in summer time and 6 months in winter time because the quantity and quality of waste are totally different.

c. Improvement of Collection System

- Initial investment to improve collection system involves;
  - ✓ Compactor trucks, both 15m^3 and 8 m^3, which will be used for planned area
  - ✓ One wheel loader, one excavator and 2 dump trucks which will be used for cleaning remote area and at small landfill sites.
- Collection for unplanned area shall be done by dump trucks due to the quality of the waste and no investment is considered since dump trucks are available in the market.
- Costing shall be done separately on initial investment and O&M.
- Costing for dump trucks used for unplanned area shall be done depreciation basis and no initial investment is considered.

d. Life Period and Residual Value of Assets

Life period and residual value of the assets are calculated based on the following conditions.

Table 7-34: Life Period and Residual Value

Assets	Life Period	Residual Value
Waste Collection Vehicle Compactor (15 & 8 m^3) Dump Truck	8 years	10 % of Initial Cost
Heavy Equipment 21ton Bulldozer 1.2 m^3 Wheel Shovel 0.7 m^3 Excavator	12 years	10 % of Initial Cost
Building and Civil Structure Office, Depot, Road, etc.	20 years	0
Machinery RDF machine Bailing Machine	15 years	0

7.6.2 Improvement of Collection System including Development of a Central Workshop

a. Collection System

a.1 Investment: Collection Equipment

Compactor trucks will be procured and invested for collection of waste in planned area. And the waste in unplanned area will be collected by Dump trucks which are currently available in the market. Initial investment will be in 2009 and operation and maintenance will be commenced from 2010. Following are the number of compactor trucks to be owned in each year at each duureg.

Table 7-35: Required Compactor Trucks in each year at each duureg

Number of Equipment Owned			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BGD	Compactor 15m3	nos	7	8	8	9	9	10	11	12	13	14	14
	Compactor 8m3	nos	0	0	0	0	0	0	0	0	0	0	0
BZD	Compactor 15m3	nos	6	7	7	8	8	9	10	10	11	12	13
	Compactor 8m3	nos	0	0	0	0	0	0	0	0	0	0	0
SKhD	Compactor 15m3	nos	4	4	5	5	5	6	6	7	7	8	8
	Compactor 8m3	nos	0	0	0	0	0	0	0	0	0	0	0
SBD	Compactor 15m3	nos	3	3	3	3	3	3	4	4	4	4	5
	Compactor 8m3	nos	2	2	2	2	2	3	3	3	3	3	3
KhUD	Compactor 15m3	nos	3	3	3	3	3	3	4	4	4	4	5
	Compactor 8m3	nos	0	0	0	0	0	0	0	0	0	0	0
C h D	Compactor 15m3	nos	0	0	0	0	0	0	0	0	0	0	0
	Compactor 8m3	nos	4	4	5	5	5	6	6	7	7	7	8
NAD	Compactor 15m3	nos	0	0	0	0	0	0	0	0	0	0	0
	Compactor 8m3	nos	1	1	1	1	1	1	1	1	1	1	1
Cleaning Team for Remore Area	Wheel loader	nos	1	1	1	1	1	1	1	1	1	1	1
	Wheel backhoe	nos	1	1	1	1	1	1	1	1	1	1	1
	Dump truck	nos	2	2	2	2	2	2	2	2	2	2	2
Total	Compactor 15m3	nos	23	25	26	28	28	31	35	37	39	42	45
	Compactor 8m3	nos	7	7	8	8	8	10	10	11	11	11	12
	Wheel loader	nos	1	1	1	1	1	1	1	1	1	1	1
	Wheel backhoe	nos	1	1	1	1	1	1	1	1	1	1	1
	Dump truck	nos	2	2	2	2	2	2	2	2	2	2	2
	Total	nos	34	36	38	40	40	45	49	52	54	57	61

The following are the prices of the equipment used for the cost estimation.

Table 7-36: Basic Price of Equipment

	Basic price	Basic price	Life year	Residual Value
	USD	Tg	years	Tg
Compactor truck 15m3, 10ton	95,000	114,000,000	8	11,400,000
Compactor truck 8m3, 6ton	80,000	96,000,000	8	9,600,000
Dump truck 10m3, 6ton	65,000	78,000,000	8	7,800,000
Wheel loader	130,000	156,000,000	12	15,600,000
Wheel backhoe	100,000	120,000,000	12	12,000,000

Based on the consideration of above prices, depreciation period, residual value, necessary investment for the equipment is calculated and summarised in the following table.

Table 7-37: Investment for the Equipment in each Year

Unit : 1 million MNT

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	RV	Total
BGD	798	0	114	0	114	0	114	114	832	114	217	0	-1032	1385
BZD	684	0	114	0	114	0	114	114	616	114	217	114	-995	1206
SkhD	456	0	0	114	0	0	114	0	524	0	114	114	-654	782
SBD	420	0	114	0	0	0	96	0	300	0	103	0	-370	663
KhUD	342	0	0	0	0	0	0	114	308	0	0	114	-403	475
ChD	384	0	0	96	0	0	96	0	442	0	0	192	-562	648
NAD	96	0	0	0	0	0	0	0	86	0	0	0	-64	118
CT	624	0	0	0	0	0	0	0	281	0	0	0	-261	644
Total	3804	0	342	210	228	0	534	342	3389	228	651	534	-4341	5921

RV: Residual Value
CT: Cleaning Team

a.2 O&M

Operation and maintenance will commence from 2010 using procured equipment. Manpower cost for operating a collection crew is assumed as follows.

Table 7-38: Manpower Cost for a Collection Crew

	Nos of persons	Salary per person (MNT/Month)	Total (MNT/ Month)
Driver	1	200,000	200,000
Collection Worker	2	150,000	300,000
			500,000

Price of the fuel to calculate operation cost is as follows.

Table 7-39: Fuel Cost

	Unit	Price
Diesel	MNT/Liter	1,020
Gasoline	MNT/Liter	850

Required number of dump trucks is as follows.

Table 7-40: Required Number of Dump Trucks

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BGD	10	10	10	10	11	11	11	12	11	11	11
BZD	24	24	24	24	23	23	23	22	21	20	19
SK h D	21	20	20	19	20	20	18	18	18	17	17
SBD	13	13	13	13	13	13	13	12	12	11	11
KhUD	23	23	23	23	24	22	24	24	22	22	23
ChD	16	15	15	15	14	14	14	14	13	13	12
NAD	4	3	3	3	3	3	3	3	3	3	3
Total	111	108	108	107	108	106	106	105	100	97	96

Since investment for dump trucks is not included, depreciation cost for dump trucks was added for the calculation of O & M cost for each duureg.

Table 7-41: O&M Cost for Collection at each Duureg

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BGD	546	562	596	629	645	695	745	795	795	828	845
BZD	799	837	837	890	894	913	951	970	974	997	1,019
SK h D	622	606	637	637	652	698	667	682	698	697	728
SBD	498	534	534	534	552	578	596	615	615	597	628
KhUD	495	495	513	513	530	549	585	602	585	585	622
ChD	528	541	554	554	566	579	579	623	605	618	595
NAD	109	95	109	109	109	109	109	109	109	109	109
CT	92	92	92	92	92	92	92	92	92	92	92
Total	3,689	3,762	3,872	3,958	4,040	4,213	4,324	4,488	4,473	4,523	4,638

b. Central Workshop

b.1 Investment: Civil and Building Works and Tools

Table 7-42: Investment Cost for Central Workshop

Unit : 1,000MNT

No	Description	Amount	Remarks
1	Design and Supervision	21,600	
2	Civil and Building Work	208,800	
3	Tools and Equipment	102,000	
	Total Cost	332,400	

b.2 O&M

The O&M cost for central workshop consists of replacement of tools, electricity, heating and salary for the staffs. Replacement of tools shall be considered that 50 % of the tools will be replaced in every three years.

Table 7-43: O&M Cost for Central Workshop

Unit : 1,000 MNT

Year	Total
2010	85,680
2011	44,064
2012	44,064
2013	85,680
2014	44,064
2015	44,064
2016	85,680
2017	44,064
2018	44,064
2019	85,680
2020	44,064

7.6.3 Development of NEDS

a. Construction of Final Disposal Site

a.1 Investment: Civil and Building Works

Design will be commenced in 2008 and construction work will be commenced in 2009.

Table 7-44: Investment Cost of Civil and Building Works for NEDS

Unit : 1 Million MNT

Description	Amount
Design and SV	347
Civil Work	
Common Facility	1902
Administration Facility	960
Final Disposal	469
Leachate Control	122
Total	3800

a.2 Investment: Machinery

In 2009 following machinery will be purchased and invested for NEDS landfill site starting operation from 2010.

Table 7-45: Investment of Machinery for NEDS

Equipment	Spec	Unit Price US$	Quantity	Amount US$	Amount 1000MNT
Bulldozer	21ton	220,000	3	660,000	792,000
Wheel loader	1.2m3	70,000	1	70,000	84,000
Water Tank truck	6000 liter	84,000	1	84,000	100,800
Dump truck	11 ton	82,000	2	164,000	196,800
Pickup truck	4WD	20,000	1	20,000	24,000
Excavator	0.7m3	105,000	1	105,000	126,000
Othe minor Ewuip.				17,000	20,400
Total				1,120,000	1,344,000

In year 2015, one bulldozer will be purchased in order to cope with increased amount of incoming waste

No	Description	Unit	Amount (US$)
1	Bulldozer 21 ton	1 nos	220,000

b. Operation and Maintenance (O&M)

The O&M costs for NEDS consists of Parts for equipment, maintenance and fuel costs for machinery, electricity and heating for the building, salary for the staff and are summarized as follows.

Table 7-46: O&M Costs for NEDS

Unit : 1,000 MNT

Year	Total
2010	500,616
2011	516,528
2012	529,992
2013	462,672
2014	588,744
2015	532,195
2016	538,315
2017	635,011
2018	532,195
2019	679,075
2020	532,195

7.6.4 Development of NERC

a. Construction of Recycling Complex

a.1 Investment: Civil and Building Works

Following table shows the investment for the pilot scale operation starting from 2010 to 2014.

Table 7-47: Investment of Civil and Building Works for Recycling Complex

Unit : 1,000MNT

No	Description	Amount	Remarks
1	Civil and Building Works	120,000	Sorting bed
2	RDF equipment	300,000	Second hand
3	Equipment	168,000	Wheel Loader 1.0 m^3 x 1 Dump Truck 4 ton x 1
	Total	588,000	

Further investment will be required for scale up the capacity of the RDF plant and Sorting yard in year 2014 and 2019.

b. O&M

The O&M costs for the Recycling Complex consists of parts for the equipment, maintenance and fuel for machinery, electricity for buildings and equipment, heating for buildings, and salary of the staff.

Table 7-48: O&M Costs for Recycling Complex

Year	Total
2010	190,944
2011	190,944
2012	190,944
2013	190,944
2014	195,840
2015	430,848

2016	430,848
2017	430,848
2018	430,848
2019	440,640
2020	861,696

7.6.5 Summary

a. Collection

Collection costs consist of collection cost itself and workshop cost which is necessary for maintenance of the collection vehicles are summarised as follows.

Table 7-49: Collection Cost

Unit : Million MNT

	Collection			Workshop				Total
	Investment	O & M	Sub Total	Design and SV	Investment	O & M	Sub Total	
2008	0		0	13	0	0	13	13
2009	3,804	0	3,804	8	311	0	319	4,123
2010	0	4,114	4,114			84	84	4,198
2011	342	4,224	4,566			43	43	4,610
2012	210	4,362	4,572			43	43	4,615
2013	228	4,479	4,707			84	84	4,791
2014	0	4,577	4,577			43	43	4,620
2015	534	4,813	5,347			43	43	5,390
2016	342	4,969	5,311			84	84	5,395
2017	3,658	5,183	8,841			43	43	8,884
2018	228	5,189	5,417			43	43	5,460
2019	673	5,284	5,957			84	84	6,041
2020	534	5,465	5,999			43	43	6,042
RV	-4,319		-4,319		-84		-84	-4,402
Total	6,234	52,659	58,893	22	227	638	887	59,780

RV: Residual Value

b. NEDS

Final disposal costs at NEDS including design and supervision, investment and O&M are summarised as follows. Investment in 2017 is required for replacement of equipment due to its service life.

Table 7-50: Final Disposal Cost

Unit : Million MNT

	Design and SV	Investment	O&M	Total
2008	209	0	0	209
2009	138	4798	0	4936
2010		0	501	501
2011		0	517	517
2012		0	530	530
2013		0	463	463
2014		0	589	589
2015		0	463	463
2016		0	469	469
2017		289	565	855
2018		0	463	463
2019		0	610	610
2020		0	463	463
RV		-1535		-1535
Total	347	3552	5630	9529

c. NERC

Investment for sorting yard and RDF plant will be done in 2009 at pilot scale and these plant will be upgraded further in 2014 and 2019. Investment cost and O&M cost are summarised as follows.

Table 7-51: Recycling Cost

Unit : Million MNT

	Investment	O&M	Total
2008	0	0	0
2009	588	0	588
2010	0	191	191
2011	0	191	191
2012	0	191	191
2013	0	191	191
2014	3,245	196	3,441
2015	0	431	431
2016	0	431	431
2017	76	431	506
2018	0	431	431
2019	1,580	441	2,021
2020	0	862	862
RV	-3,578		-3,578
Total	1,910	3,985	5,896