4. Siting of Future Final Disposal Sites

4 Siting of Future Final Disposal Sites

4.1 Procedure of the Site Selection

Any MSWM (municipal solid waste management) needs at least one final disposal site (landfill). MSWM in the study area, seven districts of Ulaanbaatar city, is being managed by only collection and final disposal systems.

It is indispensable to decide future disposal site(s) for the formulation of the MSWM master plan (M/P) and to formulate practical M/P with consensus among the stakeholders. The Mongolian counterpart (C/P) and the Study Team discussed and agreed about the procedure/schedule of the site selection for future disposal system as shown in the table below.

Table 4-1: Procedure and Schedule of the Site Selection

December, 2004	➢ 1-10: Explanation of the procedure/schedule of the site selection for future final disposal system and request for the candidate sites by the Team
January, 2005	➢ 11-20: Presentation of the candidate sites by the Mongolian side ➢ 21- 31: Collection of data and reconnaissance of the sites by the Team
February, 2005	➢ 1-20: Screening of the sites by the Team ➢ 21-28: Presentation of the M/P alternatives by the Team according to the 6 candidates
March, 2005	➢ Examination of the alternatives by the Team
April, 2005	➢ 1-10: 2nd Workshop => Recommendation of the optimum alternative, i.e. the most suitable future final disposal site(s), by the Workshop => Selection of the optimum one by the St/C ➢ 11-20: 1st Seminar => Consensus on the optimum alternative => Completion of site selection work
May, 2005	➢ Formulation of a draft M/P

4.2 Presentation of the candidate sites by the Mongolian side

In response to the agreement on the procedure/schedule of the site selection, the Minister for Environment and the Governor of MUB issued joint decree to establish the working group to select a new waste disposal site.

The waste disposal selection process was done in cooperation with specialized organizations and has taken into account the UBC development plan until 2020, the fresh water reserves, borders of the protected areas, the city green area and mineral reserves. The members of the working group are from Ministry of Environment, Ministry of Construction and Urban Planning, Ministry of Health, Institute of Urban Planning, Research and Design, Faculty of the Environment and Geography of Mongolian National University, Land Department and IT Center, UBC Government, Governor's Office, "Nuuts" Company and etc. The UBC has limited land resources and during the selection process the working group faced number of difficulties such as the rapid expansion of the living area, the close location of the Bogduul mountain protected area in the south, the fresh water reserves located in the east and north-east side and the city green area that covers the northern side of the city.

The working group examined 16 candidate and in cooperation with the JICA study team made several site visits to the places such as Bayangiin Khonkhor and coal mining sites located in the area of Nalaikh District, the used coal mine in the Baganuur district, the Uliastai valley, Tsagaan Davaa, valleys located nearby old Dari Ekh Disposal Site, the valley

located in the north of Gants Hudag in the Bayanzurkh District, Khanyn Materialyn Kombinat, Narangiin Enger, vicinities nearby the 22nd autopost in the Sogino-hairhan District, Morin Davaa, Ulziit Horoolol in the Khan-uul district. It was the end of February when the working group finally selected the 6 future candidate sites after careful consideration of the environment impact, social aspects, economic activities, urban planning and others issues of the above mentioned places.

Consequently the schedule was revised as shown in the Figure below.

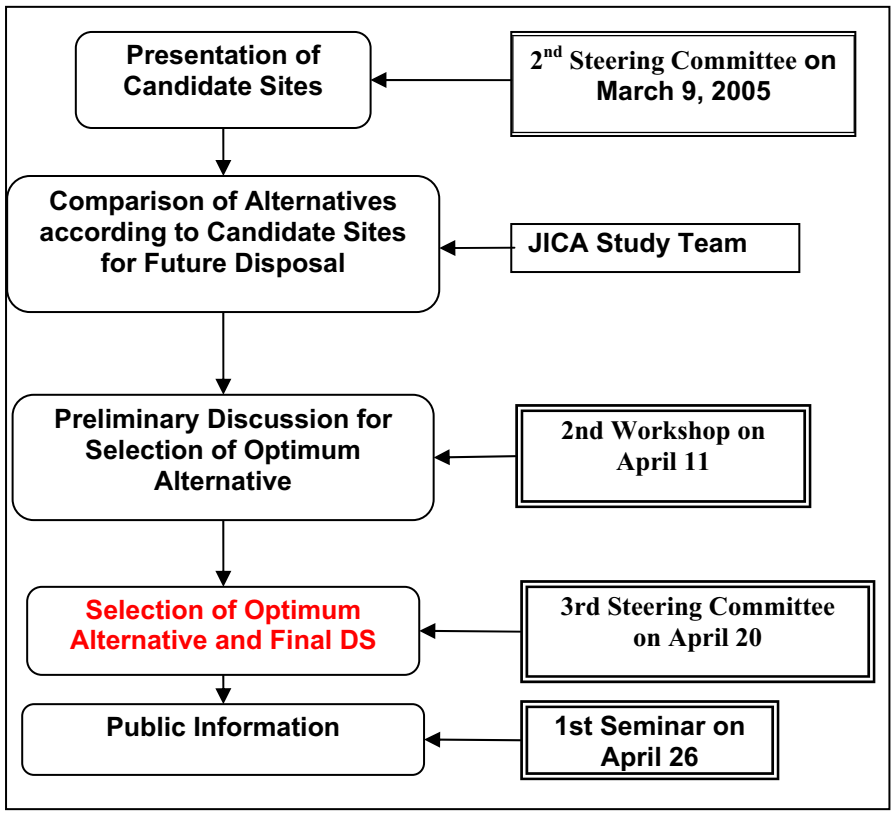


Figure 4-1: Procedure of the Site Selection

4.3 Preliminary Selection by the St/C

- In response to the recommendation made by the Working Group, on March 9 the Steering Committee (St/C) of the Study selected six (6) candidates for the future final disposal site(s) as listed below.
- NECS: Narangiin Enger candidate site located to the north of current Ulaan Chuluut disposal site;
- XMKCS: XMK candidate site of former borrow pit for building material
- MDCS: Morin Davaa candidate site south of current Morin Davaa disposal site;
- BKCS: Bayangiin Khonkhor candidate site in the south of Nalaikh;
- TDCS: Tsagaan Davaa candidate site located north of former Dari Ekh disposal site; and
- BCMCS: Baganuur coal mining candidate site of former coal mining pit.

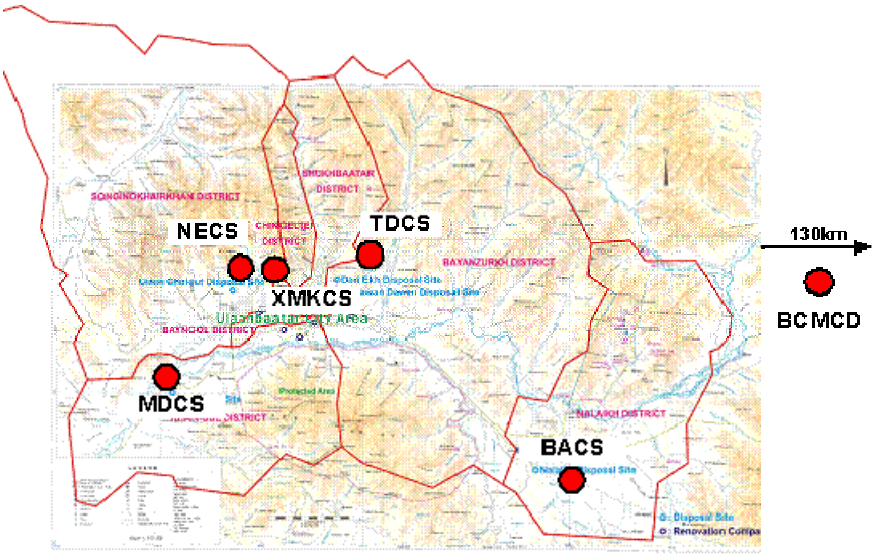


Figure 4-2: Location of Six Candidate Sites

4.4 Preliminary Environmental Study and Financial Analysis

The Study Team examined the six candidate sites focusing on the technical and financial aspects and the National University conducted a preliminary environmental study on the candidate sites. The results of both studies are summarized in the following tables:

4.4.1 Preliminary Environmental Study

The results of the preliminary environmental study on the six candidate sites are presented in the following tables.

Table 4-2: Preliminary Environmental Study on Narangiin Enger Candidate Site (NECS)

Items			Specific Information
Location			The site is located in the Baga Naran valley in the territory of 4th khoroo, Songinokhairkhan District (SKhD), Ulaanbaatar city, to the north of the existing Ulaanchuluut disposal site (UCDS), covering an area of more than 50 hectares.
Social Environment	1	Inhabitants	• Currently, over 250 individuals make a living by trash pick-up at the UCDS area. (1) • Two households of 7 members are dwelling to the west side of the candidate site, where in former time extracted gravels for construction. These dwellers live in 2 gers and 1 trailer and possess over 30 heads of livestock. • The nearest settled area is 4th khoroo with about 9,041 residents and 200 of them are children aging 0-16. The distance from the candidate site to the edge of residential area is 1.3 km. • Households started settling in 2 km distance to the west of the candidate site (on the opposite side of the lower valley of the site) and the new settled area is extending to the range, unless making some further limitation.
	2	Economic Activities	• The candidate site and its surrounding area is not cultivated or mined and currently used only for pasture. • Currently, 2 households and about 30 livestock inhabit in the area.
	3	Transport and Public Facilities	• The candidate site is located 13 km from the city center and can be reached along 9 km of asphalt road, after which on 1.5 km improved road (to the Ikh Naran) and another 3 km on dirt road, (which is wide enough for 2 vehicles to pass through). The dirt road lies along the mountain bed. • For the roads, the site is less prone to flood, however, in case of the new waste site is established, extension of the roads is required to facilitate transportation of large scale vehicles. • No school and kindergartens operating in the territory of 4th khoroo, but the household clinic “Enkh-Undrakh”, located in the khoroo center. (2)
	4	Cultural Heritage	• No any cultural heritages have been revealed in 4 km surrounding of the site. (3)

	5	State of Public Health & Hygiene	• Smoke and emissions drift in case of fire in the existing UCDS, depending on the wind direction and speed. In case of bigger fires with the wind speed of 4-9 m/sec, the smoke drifts approximately 5-10 km along the wind direction. According to a research by the Social Health Institute, cases of diseases originated from solid waste disposal site such as jaundice, intestinal infectious diseases (from bad sanitation) and respiratory diseases are popular, and cases of inflammation of mucous membrane is wide among the children from surrounding areas of disposal site. (4)
	6	Isolation from Energy Resource	• A high voltage line is available for extension, using transformer, 1.5 km to the southwest of the site.
Natural Environment	7	Topography and Geology	• The candidate site is a mountain valley. • As no geological surveys on soil have been conducted in the area, "Gazar-Eco" Company made on-site soil profiling: Section 1: Ao-26 cm. Brown, slightly humid, loam with plant roots and fragile crumbed compositions, and light clay. The next layer comes with the gradual transformation in color. Bk 26-61 cm. (35 cm thick) Light brown colored, humid soil with less plant roots, the structure is fragile crumbed and the next layer comes with the clear change in color. Sk 65-82 cm. (17 cm thick) White and bright colored, humid loam without plant roots. Boils and swirls with hydrochloric acid effect. Section 2. This section was made 500 meters down to the Section 1. The soil surface contains stones. Ao-20 cm. Brown colored, slightly humid, with plant roots, loam stony and fragile crumbed composition. The next layer comes with the gradual transformation in color. AB 20-42 cm. Light brown colored, humid soil with less plant roots, the structure is fragile crumbed, loam and the next layer comes with the clear change is color. BK-42-66 cm. White and bright colored soil with little dry plant roots. Boils and swirls with hydrochloric acid effect. • Soil composition: Mountain loam stony brown soil. In a very small portion of land there is less developed brown, basin soil. (5) Section 1 was made upside side of the Narangiin Enger proposed site and Section 2 was made 600 meters downward along the valley from Section 1.
	8	Ground water	• Nearest groundwater supply or wells located within the Ikh Naran and Baga Naran ger area (6) and there are 4 wells in 2.9-3 km to the south of the site. Results of the water quality analysis determined that water in these ground wells are not conforms to the sanitary requirements. The main polluting ingredients were petroleum products and coliform. • The groundwater stream in this valley is flows from the north to the south. • Extracts from the survey of #3325 borehole in Tolgoit khoroo: - Water was discovered in 3 meters depth. S=1m Q=2l/sec, where S-yield , Q is draw down - Depth of water layer - 3-33m, mantle rock. (7) Latitude 47° 54' 50" Longitude 106° 54' 30"
	9	Hydro-Geological Situation	• There is only one small springs to the west of the site in 6 km distance, which comes up in summer. Except this, there's no other surface water noted. (8)
	10	Fauna and Flora	• The vegetation is mountain steppe vegetation. Mainly there are Festuca Lenensis, Duriuscula, wormwood. The coverage is 70-80% and plant height is 10-15 cm. • No rare animals and plant species recorded in this area. (9)
	11	Meteorology	• The climate in surrounding areas of Narangiin Enger site is similar to Ulaanbaatar city, generally. Annual precipitation is 233mm of which 123-213mm falls in summer and the remaining in winter season. The average air temperature in winter (in December, January and February) is -20 to -27 degrees Celsius and +15 to +16 in summer time (June, July, and August) in Ulaanbaatar area. The average volume of air absolute humidity is 4.3-4.8 hPa, the highest in July at 11.0-12.3 hPa, and the lowest in winter times at 0.5-1.0 hPa. It is observed that the relative humidity is in inverse relation to the air temperature. • Winds from the northwest, north and east dominate in the wind regime in extreme winter – in January – however, direction of the main stream of wind goes from southeast to west depending on topography and geographical patterns. The average wind speed of the area is 4.3 meters per second. (10) • During transportation through the city center and the khoroo territory, trash vehicles can transfer bad smell, as well as micro elements such as bacteria or virus through the wind.

	12	Landscape	• Although there is no specific property to protect landscape, the construction and operation of landfill may affect natural view.
Pollution	13	Air Pollution	• This site is relatively sparse populated compared to other candidate sites, thus the air pollution is less here. • Additionally, the valley is spanning from north to south, protecting the site from the wind. • It is recommended that when establishing waste disposal site here, the wind behavior should be carefully studied and it is recommended to receive wastes when the wind is stable. • When solid waste disposal site is established in a place with constant and extreme wind, significant problems occur like dust in the air and smell, which scatters in populated areas. • Therefore, in case of establishing disposal site in the proposed area, it is necessary to conduct a detailed assessment, taking the mentioned issues into account.
	14	Water Pollution	• Results of water analysis of the nearest 3 wells are attached herewith. According to the results, the drinking water in the well in Ikh Naran does not meet the sanitary requirements and two other wells in Baga Naran also showed bad results, which might be suggested that the current disposal site is affecting the groundwater. (6) There is no information about surface water pollution.
	15	Noise Pollution	• Building new disposal site in the proposed area, a possible physical impact on the area inhabitants and operation of organizations and companies cannot exceed the current level. Because, transportation seemingly will go along the old route to Ulaan Chuluut.
	16	Others	• The newly settled ger areas in the Baga Naran, 4th khoroo, SKHD, where the proposed site locates, is expanding intensively, especially in last 1-2 years to the north. If this process will continue, the area will be approaching close to the proposed site. Therefore, it is necessary to revise the issues on citizens land ownership, in case of choosing the area for new disposal site. • Building landfill in the proposed site might also affect the living of about 250 inhabitants who lives on trash pick-up within the territory of the existing Ulaan Chuluut disposal. As the old disposal site is closed down, the inhabitants possibly affect adversely to the operation of the new landfill (reveal the buried wastes etc.). • In addition, bulk volume of wastes scattered in 500-600 meters surrounding of the present disposal site, as result of wind and also insufficient operation of waste vehicles (as the vehicles dump the wastes not reaching the disposal site). This matter shall be reflected in the plan. The possible negative impacts in case if Ulaanbaatar city solid waste landfill will be established on this site: • If the dam and channel for protecting from flood from snow and rainwater is not constructed, there might occur some difficulties with the wastes flowing with the flood water. Basically, the whole or partial amount of waste can flow to the populated area or Baga Naran valley following the contour of the area. • If the waste is not compacted and pressed immediately after arrival, during the windy times, especially in spring, the waste can scatter to populated area through wind. • During the construction of the landfill, it is necessary to consider the soil and it's needed to protect the layer with waterproof material, otherwise the waste can leachate and pollute the groundwater. • When receiving the waste, it's recommended to distinguish the wastes according to sources, e.g. ger area waste, apartment waste, and industrial waste. Because the ger areas mostly generate ash, which is easily flow with wind. • Current status of the scattered wastes in populated areas from UCDS shows that there was not enough work done about enclosing and protecting the site from the wind. Thus, in building the next disposal site it is necessary to consider these circumstances.

(Sources):

1. BZD 4th khoroo Governor's Office
2. SKHD 4th khoroo Governor's Office
3. UB city information atlas. 2003
4. Enkh Undrakh family hospital and Public Health Institution Research
5. "Gazar-Eco" Co., Ltd Researcher, Soil analyst S. Munkhbat. UB 2005.
6. "Solid waste disposal site groundwater pollution" research by "Gazar-Eco" Co., Ltd. 2005
7. Geo-Ecological Institution and "Gazar-Eco" Co., Ltd researcher PhD. N. Jadambaa
8. UB city surface water research. Science Academy-Geographical Institution
9. UB city Fauna and Floral Study summary. 2002
10. Last 10 year statistics taken from Morin Davaa Meteorological Station. 1995- 2004, Hydro –Meteorological Institute

Table 4-3: Preliminary Environmental Study on XMK Candidate Site (XMKCS)

Items			Specific Information
General Explanation			This site is located in 7th khoroo, Songinokhairkhan district, UB city. Its size is approximately 20 hectares and is located in a populated area.
Social Environment	1	Inhabitant	• The site takes place in the populated area of SKH district 7th khoroo, where 2,800 families -13,000 residents are. The closest family from the site is within 50 meters, and in some areas it is 200 meters.
	2	Economic Activities	• "Mongol Ceramic" factory which owns a license of the land and has seasonal operations is located in the area. • Also, "Voyage", "Gan Khiits", Army Division, and Noodle Factory are located in this khoroo and each has own small scale of heating plant. There are two gas stations. • Besides the entities with permission, there are individuals who obtain clay from the mines.
	3	Transport and Public Facilities	• The distance between the center of UB city and this candidate site is 11km. In order to reach to the site from the center of UB city, you drive 6.7 km on the main paved road, then turn to the right and drive on 14 meters of wide paved road for 3.3km, and 1 km on a supporting small paved road that leads to Gan Khiits factory. From the factory there is another 50 meters of drive way on dirt l road till the point. • 67th High school, 117th kindergarten, and "Enkhiin Urguu" family hospital are located in the center of the 7th khoroo of SKH district as well. (1)
	4	Cultural Heritage	• Within 4 km from the site there is not any cultural heritage or property that is found. (2)
	5	Public Health Condition	• According to the information that is given from the Khoroo's Family Hospital, diseases such as jaundice, abdominal infectious, hypertension, kidney, urethral, and heart diseases occur most commonly among the residents.
	6	Distance from Electricity Supply	• To the west direction from the site there is one high voltage electric tower in 500 meters, and in the middle of the Ger area which is the north of the site, there is another high voltage electric tower with a transformer.
Natural Environment	7	Topography and Geology	• Originally the site was a small hill, but now it has several big holes with average depth of 15-25 meters due to the mining activities. • The soil of the area is greatly damaged. It is a mountain loam soil. The soil section profile study has been conducted by "Gazar-Eco" Co., Ltd : Ao 25 cm. Brown colored, humid, has no plant roots, and loam-silt with crumbed structure. It transfers to the next layer with the gradual change of color. Bk 25-60 cm. /38 cm thick/. Light brown or reddish colored, humid, has no plant roots, largely crumbed, and is silt. The next layer comes with a gradual change of color. BCk 60-89 cm. Reddish, humid, and silt. Boils and swirls in a 10% hydrochloric acid. (3) • It is a construction material mine according to the information from the Mineral Resource and Oil Authority.
	8	Groundwater	• The movement of the groundwater happens less depending on the soil structure and the soil is generally poor in groundwater. (7)
	9	Hydrological Situation	• In 2.8 km to the west from the site, there is a small Bayankhoshuu River that flows in summer time with the direction of north to south, and in some year temporary dryness occurs. Residents of close Ger areas take their drinking water supply from it and some families utilize the water for their cattle. (1)
	10	Fauna and Flora	• There is hardly any fauna and flora on the surface; 1m2 is covered with 20%. The main vegetation is wormwood and wild grass "Luuli". • There is no living condition for animals because of the factories, mines, and human population of the area.
	11	Meteorology	• UB area has a precipitation of 233mm per year; In summer there is 123-213mm of rainfall. In winter time (December, January, and February) the average air temperature of UB city is -20 to -27 degrees Celsius and in summer time (June, July, and August) +15 to +16. The average absolute air humidity of a whole year is 4.3-4.8 hPa: the highest was in July at 11.0-12.3 hPa and the lowest was in winter at 0.5-1.0 hPa. The relative humidity of atmosphere is negatively related to the atmospheric temperature. • The wind direction is mostly from northwest, north, and east in January, however in UB the direction is mainly from southeast to west depending on the land contour and other characteristics. UB mostly receives a northwest and southeast wind. The UB's average wind speed in many years is 4.3 meters per second. (4)
			• This site is located in the middle of the populated area, thus in any wind direction smell and waste can be blown into the residential area. • Through the wind waste collection vehicle can transfer micro elements and bacteria to the residential areas when it travels inside UB city and this khoroo. • On the other hand, the waste will be disposed in a deep hole which might prevent the wind from passing the waste around.

	12	Landscape	• The environmental protection issue does not have a serious problem, and because it is a populated region maintaining the area clean and protected is necessary. • In case of having a disposal site, the site has to be enclosed with barriers or walls. It cannot be open.
Pollution	13	Air Pollution	• The wind might transfer the unpleasant smell to UB city as well as residential areas around the site. • Also, Bayankhoshuu and Zuunsalaa Ger area chimneys' smoke pollutes the air very much.
	14	Water Pollution	• Burying waste at this location might pollute the small Bayankhoshuu River, underground drinking water and surface wells nearby where residents live.
	15	Noise and Vibration	• Consequent noise and vibration might affect and distract people because the site is right in the middle of where they live.
	16	Others	• The site land is owned by "Mongol Ceramic" and other factories that own mineral mine licenses. • This is a residential area with the settlements and service entities. • In chapter 3, statement 15 of Mongolian Environmental Protection Law's specific ruling about "Household and Industrial Waste", it states that the populated area, land that has been specified as a mining licensed area, and/or area with mineral resources cannot be used as a final disposal site. Therefore, if this site will be chosen, two articles of the Environmental Law will be violated. (5.6)

(Sources):

1. SKH District 7th khoroo Governor's Office
2. UB city information atlas 2003.
3. Steppe Profile by "Gazar-Eco" Co., Ltd Examiner and Soil researcher S. Munkhbat. 2005
4. Last 10 year statistics taken from Morin Davaa Meteorological Station. 1995- 2004 Hydro-meteorological Institute
5. Mineral Resource and Oil Authority. 2005
6. Mongolian Environmental Law publication. 2004
7. Academy of Science Geo-ecology Institution water expert, Professor, PhD N. Jadambaa. 2005.

Table 4-4: Preliminary Environmental Study on Morin Davaa Candidate Site (MDCS)

Items			Specific Information
General description			The site is located to the south of the Morin Davaa disposal site (MDDS) in a valley (to the south of Bio-combinat), in the territory of 12th khoroo, Khan-Uul District, Ulaanbaatar city, covering an area of more than 50 hectares.
Social Environment	1	Inhabitants	• About 40 peoples make a living by trash pick-up within the MDDS. (1) • A household of 5 members are dwelling 2kms to the northeast of the candidate site and possess 10 heads of cattle. They have a ground well with depth of 42 meters. The JICA study team conducted a water quality analysis of the well. The result of laboratory analysis indicates there is no impact to the water quality of the well by MDDS. (2) • The nearest settlement area is Khoroo 12 of Khan Uul district (Bio-combinat) and population is about 4,000, locating in 2.6 km from the proposed site. (3) Khoroo 12, which is the closest area to Morin Davaa Disposal Site, is located within surroundings by low hills and isolated from the centre of Ulaanbaatar.
	2	Economic Activities	• There is a Bio-combinat about 2km from the site, which is producing medicines for livestock • No any projects for production and services implemented in the proposed site and its surrounding area, so far. However, one of the three official disposal sites of Ulaanbaatar city, MDDS, is located in the area.
	3	Transport and Public Facilities	• The candidate site is located 25 km from the centre of Ulaanbaatar, with 23 km of asphalt road to the site. The remaining 2 km are unpaved road. This road passes along the east valley of the site and in comparison to other proposed sites as the Tsagaan Davaa and Narangiin Enger candidate sites, it is slightly damaged. • With the establishment of the future disposal at the Morin Davaa, the traffic of the waste dump trucks will increase than the current traffic and it may affect the traffic to the International Airport. There are two airport access roads from the city center and the roads cross each other nearby the Tsagaan Haalga (1.5 km from the airport). The traffic increases significantly at the above 1.5 km section from the road intersection until the airport. The first road or the Yarmag Highway is the main airport access road from the city center and its traffic higher than the second one or the Sonsoglon Highway. Thus, the Sonsoglon Highway is to be more appropriate road for the waste trucks to use. On the other hand, foreign visitors and tourists use the Yarmag Highway regularly, and the view of the waste dump trucks is not appropriate. • "Songino" Resort place. There are 2 resorts located on the north bank of Tuul River. The "Songino" is located 3 kms to the north from the centre of Bio-combinat and at 6 kms distance from the Disposal Site. • Secondary School No.10 is located in Khoroo 12, Khan Uul • District, to the north of the proposed site and it has about 600 students. • In the territory of Khoroo 12, there is also kindergarten No 121 is operating, as well as a household clinic. • The clinic, school and kindergarten are located in the centre of the settlement area.(4)
	4	Cultural Heritage	• No any cultural heritage has not been discovered around 4 km of proposed site.(5)
	5	State of Public Health & Hygiene	• In accordance with the medical survey taken from the household clinic in Khoroo12, the most common diseases are the jaundice, respiratory disease, cold and coughs among children. • It is possible that the wastes at Disposal Site can spread with wind, especially in spring and summer seasons, and also the wastes can contaminate the settlement due to the wastes fell down from the waste collection trucks on the road to disposal site.
	6	Distance from Electricity Supply	• There is a high voltage line at 1.7 km to the north of proposed site, and available for extension by transformer.
Natural Environment	7	Topography and Geology	• Hollow with low hills. • Any geologic resources have not been found according to the information of Mineral Resources and Oil Authority, Mongolia. The detailed soil analysis was not conducted in this area. However, eye observation tells that steppe soil is dominated and a meadow soil might be occurred near the Tuul River. Therefore, detailed soil analysis should be conducted. The soil structure is more important for the place to be chosen as candidate site. Because the ground water and even Tuul river might be contaminated through the soil depending on soil structure and defrosting. • The existing soil of Morin Davaa Disposal Site might be contaminated by chemicals generated by wastes, therefore a detailed analysis required to be conducted.
	8	Groundwater	• The result of analysis in water samples taken from the ground well that locates 2 km from the site, and the Tuul river water, located about 4 km from the candidate site are shown in the Report of the Water Quality Analysis around Final Disposal Sites. (2) • The depth of the ground well that the water was sampled and tested was 42 m. This well might be connected to Tuul river underground. The family members of this well and cattle have been using this ground water taken from the well. (2)

	9	Hydrological Condition	• Tuul River flows from the east to the west on the north side of candidate site. Tuul River is one of the biggest rivers in Mongolia and it provides Ulaanbaatar city with clean water. As well as, some households living in ger area around Bio-combinat are using this water for drinking.
	10	Fauna and Flora	• The vegetation of this area is mostly steppe plants. Poa Pratensis and Caragana grass occur widely in the mountain steppe area. • There is a bush grove in Tuul river valley. • Brandt's Vole spreads widely in some occurrences because of steppe rodents are living there and due to this condition birds of prey can be occurred sometimes. Within the 4-5 km around the candidate site, no endangered species of fauna and flora have not been discovered. (6)
	11	Meteorology	• Annual precipitation is 233mm of which 123-213mm falls in summer and the remaining in winter season. The average air temperature in winter (in December, January and February) is -20 to -27 degrees Celsius and +15 to +16 in summer time (June, July, and August) in Ulaanbaatar area. The average volume of air absolute humidity is 4.3-4.8 hPa, the highest in July at 11.0-12.3 hPa, and the lowest in winter times at 0.5-1.0 hPa. It is observed that the relative humidity is in inverse relation to the air temperature. • Winds from the northwest, north and east dominate in extreme winter – in January – however, direction of the main stream of wind goes from southeast to west depending on topography and geographical patterns. The average wind speed of the area is 4.3 meters per second.(7) • Due to the wind direction in April and May (windy season), which is mostly from northwest to north, the probability of wastes to contaminate the Bio-combinat area is relatively low and the wastes can not be spread by wind. Dominated wind direction in December, January and February is from southeast to east side. Therefore, the wastes will be less spread by wind because it snows heavily during these months. However, it is required to take some measures considering these conditions.
	12	Landscape	• Although there is no specific property to protect landscape, the construction and operation of landfill may affect natural view.
Pollution	13	Air Pollution	• Air pollution is relatively less in the area of Bio-combinat, which is located to the north of the proposed site, comparing to other sites in Ulaanbaatar. Because this place is located relatively far from the ger area in Ulaanbaatar, Power Station, and other factories. (source: Biochemistry and Microbiology Department, Mongolian National University, 1999) • Smoke from waste burning in Morin Davaa Disposal Site pollutes the air around Bio-combinat in winter season to some extent. Because during this time (winter season) the wind direction flows toward the Bio-combinat. As well as, the bad smell of this disposal site can be spread in Bio-combinat area.
	14	Water Pollution	• It is required to conduct a detailed water analysis, as it might contaminate the water of Tuul River while the wastes will be disposed of at the proposed site. Also it might penetrate into the soil and might contaminate the ground water in further.
	15	Noise and Vibration	• Noise and vibration can be less for the settled population in this area. Because the road to this site will be passed by the end of the settlement, thus the effect will be less.
	16	Others	• The Morin Davaa disposal site, which located in the south of Bio-combinat, 12th Khoroo of Khan-Uul District, causes a lot of contamination to the surrounding environment. It has negative impact on the population of the Bio-combinat. Thus, the closure of the current waste disposal site and opening new less impact disposal site will create basis for the reduction of the current contamination affects. On the other hand, the opening of the new disposal site will increase the traffic of dump trucks by two times, which will affect negatively population and environment of the Khoroo 12. • As we have closed the current disposal site to set up the new landfill, the wastes that are being used by about 40 waste pickers will be eliminated. In this regard, these 40 waste pickers may show adverse effects to the operation of the planned landfill, by trying to get recyclables from the wastes which has been buried and compacted. • There is one open dumping just behind the candidate site, which is being used currently, might contaminate the environment of Tuul River. Even though, the endangered species of fauna and flora have not been found in this area, we can stop using this disposal site to set up up-to-date landfill. Doing so, contamination of this area and environmental adverse effects will be reduced certainly.

(Source):

1. Information taken from Khoroo No. 12, Khan –Uul District
2. Results of Lab analysis from Institutes of Chemistry and Physics of Academy of Science and Lab of SGS Co.
3. Ulaanbaatar Statistics Book, 2004.
4. Ulaanbaatar city atlas,
5. Ulaanbaatar city Enquire Atlas, 2003.
6. Fauna and Flora Research Book, Ulaanbaatar city, 2002.
7. Last 10 year statistics taken from Morin Davaa Meteorological Station. 1995- 2004 Hydro meteorological Institute

Table 4-5: Preliminary Environmental Study on Tsagaan Davaa Candidate Site (TDCS)

Items			Specific Information
General Explanation			Candidate site is located in the Khoroo No.2 of Bayanzurkh District. The area which is called "Gants Khudgiin Am". The area of candidate site is more than 50 hectares.
Social Environment	1	Inhabitant	• The economic entities, business enterprises and the location of households at the candidate site and the distance from the proposed Disposal Site is as follows: • The population of Khoroo No.2 of Bayanzurkh district is currently 5000 in total. (1). Khoroo No.2 is a ger area. Khoroo No.2 is the nearest settlement area located at 3 km from candidate site. • Temporary Criminal Detention Center is located 2.6 km to the southwest of the candidate site and about 250 people are there. This is a restricted place so detailed information can not be obtained. (2) • The "Bum Arvai Invest" Co., Ltd is located 1.9 km to on the west side of the candidate site. This company established a brick manufacturing factory which has a license for mineral resource use for 30 hectares for 60 years starting from April 30, 1998. (3) About 10 people in 2 households are working and living at the brick factory. • A brick manufacturing factory is located 1.8 km to southwest of the candidate site under the jurisdiction of the Judicial Decision Implementing Authority. About 200 prisoners are employed by this factory and live there. They have permission to use 25 hectares of area. (4) • The Scorpion Service Co ltd. is located 1.2 km to the west of the candidate site. This company has a license to extract yellow clay on 330 hectares since November 11,1999 and has established a brick manufacturing factory.(5) About 10 people are working at this factory and a security guard and 3 family members live nearby. They engage in cattle breeding with 12 large cattle and about 50 small cattle.
	2	Economic Activities	• Brick manufacturing factories such as Scorpion Service Co., Ltd., Bum Arvai Invest Co ltd., and a brick manufacturing factory under the jurisdiction of Judicial Decision Implementing Authority operate their business on seasonal base around the candidate site. The brick manufacturing factory of Scorpion Service Co., Ltd. produces 27,000 bricks a day and net income is 661,454 MNT. (6) • According to the data of Scientific Technical Committee of Geological Authority of Mongolia (old name) the entire reserve of yellow clay is 5,530 thousand m3. This number is also confirmed by Ye. Silkeni / Russian Senior Geologist. (7)
	3	Traffic and Public Facilities	• This candidate site is located 10 km from the centre of Ulaanbaatar (Intersection at Post office). 6.0 km of 10 km is an asphalt-paved road and 4.0 km is an unpaved road branching from the main road. This unpaved road is located by the mountain foothills and valley and therefore it is hard to reach this candidate site using the other way. Some of this unpaved road has already been damaged with abundant erosion. Due to some potential risk of water flow from melting snow and flood water damage the road can be slippery in winter. Heavy snow in the valley area will make it difficult for the waste collection truck to deliver the waste. 2.1km of the asphalt road is located in an apartment area and 3 km of the asphalt road is in ger area of Dari Ekh. Traffic density on this asphalt road is classified as high and medium load pressure. • In Khoroo No.2, Bayanzurkh District called "Gants Khudgiin Am". There are no kindergartens or schools and only "Domnokhui and Surakhui" khoroo hospitals.
	4	Cultural Property	• No cultural heritage site is located within 4 km of this candidate site. There is Dari Ekh cairn (pass) located at 5 km southwest of the candidate site and there is a Stupa constructed by "Mamba Datsan" temple. There is a Dambadarjaa temple located at 8 km to northwest. (8)
	5	Public Health Condition	• When previous Dari Ekh Disposal Site was in operation, an air pollution survey has been conducted by Public Health Institute in the area of Khoroo No.2, Bayanzurkh District. (9) Air quality was shown to be quite bad and has affected the environment so much. Therefore, that this disposal site was closed by the State Specialized Inspection Agency. • According to the survey conducted in soil of previous Dari Ekh Disposal Site, there exist hazardous chemicals like dioxin and furan. They have adverse impact on humans health and might be kept in human's body and transferred genetically The wastes at this Disposal Site had been burnt openly at low temperature thus these hazardous chemicals are contaminating the air and soil.(10) • Some diseases such as, jaundice, infectious intestinal disease, abdominal diseases and respiratory diseases can be generated by the previous disposal site.
	6	Distance from Electricity Supply	• There is a high voltage line 1.2 km to southwest from the candidate site. Electricity of "Scorpion Service" Co., Ltd, is being supplied by this high voltage transformer.

Natural Environment	7	Topography and Geology	• This candidate site is situated in a low mountain and valley area. Surveys have previously been conducted only in some parts of this area. This survey was conducted by Mr.E. Silkieny Russian Geologist in 1964. (7) The geologic formation is deluvi-proluvial sandy and clayey, clayey coarse breccia deposit. The top stratum of surveyed area belonged to Cretaceous period rocks. The top and foot of mountain area belonged to a quaternary geology deposit. The result of drilling borehole shows that there is sand stone in clay stratums and weak cohesive supes 0.1-6.0%. Also partially graveled layer may be occurred. • This area is an important place to for raw materials of brick. (Information taken from Mineral Resource and Oil Authority) • The clay color is dark beige. The clay content of this area includes different kinds of clay density. The clay structure is powder. The mineral content is watery glittering, kaolinit, non clayey. There are also silicon, feldspar and lime mineral in non clay layer. The mineral content is as follows: - Clayey mineral – 27% - Silicon mineral – 85% - Feldspar – 38% Since there is no data on soil survey and soil structure analysis in the candidate site "Gazar-Eco" has conducted some study there. Section 1. • This section has done in the area which is called "Gants Hudgiin Am". • Ao-40 cm dark brown colored, humid, has some vegetation roots, fragile crumb, which is abundant with vegetation roots. It has a light clayey stone and transfers to the next layer with a clear change of color. • BK-40-97 cm light beige colored humid, fragile crumb, which is abundant with vegetation roots. Light clayey and the color changes gradually to the next layer. • CK97-150 cm Light beige colored, a bit dry. Boils in a Hydrochloric acid. Soil content: • Mountain dark brown soil with light clayey stones. Mountain less dark brown soil and valley soil has spread only in a small area. (11).
	8	Groundwater	• According to the survey results done by the drilling team of the Soviet geologist E.Sylken, the groundwater reserves and permafrost soil were not found in the area. (7) •
	9	Hydrological Situation	• At the candidate site area called "Gants Khudgiin Am" intensive land surface erosion by water and damage by erosion now occurred. There is a deep gully into which the rain water flows in a south foot area. • There is "Dambadarjaa" spring water about 6 km northwest of the candidate site. The Selbe River is 6 km from candidate site to the west and flows in spring and summer. In dry and hot weather sometimes the river dries up. Residents near Dambadarjaa spring and sometimes people from UBC spring water to use as a medical treatment. • Selbe river water is used by the residents of the ger area. People come to the river to wash cars, carpets and rugs.
	10	Fauna and Flora	• Fine grass and mountain steppe plants are the dominant vegetation. The plant covering is 70-80% and Festuca Lenensis, Agropyron Repens, Artemisia and Carex dominated this area. The height of the plants will be 15-20 cm. • Some of steppe rodents live here. No endangered species of animals or plants have been found. (12)
	11	Meteorology	• The weather condition of this area is similar to Ulaanbaatar city climate. The annual precipitation in Ulaanbaatar is about 233 mm. It is 123-213 mm in summer and the average air temperature in winter season (December, January, February) is -20° to -27°C and +15° to +16° in the summer season (June, July, August) The annual average of absolute humidity is 4.3 to 4.8 hPa. The highest is in July 11.0-12.3 hPa and the lowest is 0.5-1.0 hPa in winter. The relative humidity rate has inverse relation with air temperature. • The wind direction in January is mostly from northwest and west. However, the wind from southeast dominates in summer. Many years of annual surveys show the average wind speed in Ulaanbaatar is 4.3 m/sec. (13) • This candidate site is in a valley of east UB. The wind direction in summer (July, August, and September) is from the northeast. It has a low risk that the wastes will be spread by wind. • There is a potential risk of the bad smell of wastes and bacteria may spread by wind because of waste collection trucks will be going into the city center and in a Khoroo area. • A proper waste compacting and disposal technology can not be applied without considering watershed and water collection issues in the area. There is a risk that water flow from melting snow will collect. There is a probability wastes collected in the valley will be exposed by heavy rain water or floods. Disposed waste in the valley may be brought into the city by flood or heavy rain water.
	12	Landscape	• Although there is no specific property to protect landscape, the construction and operation of landfill may affect natural view.

Pollution	13	Air Pollution	• Wind characteristics and wind direction should be well analyzed. Collected waste should be received on site when wind is low. • The disposal site will be thus there will be lots of dust bad waste smell throughout the area. • The wind direction in January is mostly from the northwest and west. Wind from southeast dominates in summer. In warm seasons, especially in spring there will be an adverse effect for households, economic entities and business enterprises. The nearest place to this candidate site is a brick manufacturing factory at 1.2-1.9 km away. This area will be directly affected. Currently there are about 5,000 residents in this area. If a disposal site is set up half of the residents will be affected directly by air pollution. Because households are located on the northern and southern foothills of this valley. • An air pollution survey conducted in this Khoroo identified hazardous gases SO2 sulfuric dioxide NO2 nitrogen dioxide and SO3 sulfuric oxide (these are third degree of hazardous chemicals). Results show that hazardous gases are 12 to16 times greater than the allowed standard limit, which is already the most hazardous limit. Analyzed dust content was 24.7, much higher than the standard. It will be considered as most hazardous limit. Sulfuric oxide was shown the 5 times greater than the standard which belongs to more hazardous limit. (9)
	14	Water Pollution	• There is a possibility that leachate from wastes at this candidate site will penetrate the soil and contaminate surface and ground water.
	15	Noise and Vibration	• Noise and vibration will occur at this candidate site affecting people and business enterprises in the area. Noise and traffic movement will increase contamination undoubtedly at this candidate site.
	16	Others	Compacting and disposing the wastes in the candidate site may have the following adverse effects and consequences: • Due to the absence of rain water and flood protection dams and culverts in this site the water can flow through the waste area. There is a probability that these wastes which can be compacted and disposed will flow into river and flood water and thus to settlement areas depending on the ground level.
			• Unless proper solid waste compaction happens every time the wastes will be spread by wind especially in the spring. • Detailed analysis of soil structure and soil density requires that the bottom layer of this site should be lined with waterproof materials to prevent leachate from penetrating into the soil and ground water. Rain water collected in “Gants Khudgiin Am” basin provides some water to the Selbe River during spring and summer. If the disposal site is set up this area it might affect surface and ground water. Therefore, the environmental impact assessment should be accurate and a proper method of solid waste disposal system should be implemented.
			• Solid waste should be classified from ger area, apartment area and business enterprises. Waste generated in ger areas is mostly ash, which can be spread easily by wind. • Khoroo No.2 Authority stated that the number of households in the ger area has dramatically increased. The settlement area spread by 500 m last year. The area will likely spread very close to the candidate site. • From the settlement area to candidate site much domestic and construction waste has left by trucks along the valley and river bed area. • The previous Dari Ekh Disposal Site had many adverse effects in this area and thus it was closed. Even if a Disposal Site in this area had a less adverse affects the local residents would probably not like it. • According to the Article 3, Chapter 15 of the Law on Household and Industrial Waste, it is prohibited to set up the Disposal Site in a mining license area or mineral resource reserve area • The candidate site probably is coincides (selected) with a mining license belonging to the other company’s property. We were unable to get detail information about location and boundary of the mining license area except the organization name and the total square meter of area. . /This information was taken form the Mineral Resource and Oil Authority and Mongolian Environmental Law, 2004/

(Sources):
1. Information taken from Khoroo No.2, Bayanzurkh District
2. Information taken from Temporary detention of criminals
3. Information taken from Brick Manufacturing factory of “Bum Arvai Invest Company”
4. Information taken from Brick Manufacturing factory of Judicial Decision Implementing Authority
5. Information taken from Brick Manufacturing factory of Scorpion Service Co ltd.,
6. Information taken from Environmental Impact Assessment Report of Brick Manufacturing factories of “Scorpion Service” Co ltd., and “Bum Arvai Invest” Co ltd., made by “GazarEco” Company
7. Study Survey Report leaded by Mr. Ye Silkiny, Russian Geologist
8. Ulaanbaatar city enquiry atlas, 2003
9. (Report written by N.Sanjaa) Hygiene and Atmospheric pollution Assessment survey conducted in Khoroo No.2, Bayanzurkh District of Ulaanbaatar city, 2000
10. Research work of “Soil contaminated by chemicals of Ulaanbaatar city”,2004 made by Mr. Kamo Yashiaki, Visitor Professor of Mongolian National University
11. Mr. S. Munkhbat / Soil Investigator of “Gazar Eco” Co ltd., UB 2005
12. Fauna and Flora Research work of Ulaanbaatar city, 2002
13. Last 10 year statistics taken from Morin Davaa Meteorological Station. 1995- 2004 Hydro-meteorological Institute, Ulaanbaatar

Table 4-6: Preliminary Environmental Study on Bayangiin Khonkhor Candidate Site (BKCS)

Items			Specific Information
General Explanation			This site is in khoroo 1 of Nalaikh District of Ulaanbaatar city with area of 73.2 thousand hectares. The area, where the candidate site is located, is called Bayangiin Khonkhor. It is in the south of the district and has land area of more than 50 hectares.
Social Environment	1	Inhabitant	• From the site within 600 meters distance there is Department for Protection from Air strike which of population number is kept secret. Also, in 1 km distance to the east there are 2 cattle breeding families and in 1.4 km to the south there is one family. All the 3 families have 10 members in total and 600 cattle. • Overall population of Nalaikh district is 25000. (1)
	2	Economic Activities	• The area between the site and the settled area is used as a pasture. • Department for Protection from Air strike has 1 hectare land surrounded with barbed wire where there are armed facilities against air strike. • In 2 km to the east of the site, there are 2 Chinese-Mongolian joint coal mines which operate half-manually.
	3	Traffic and Public Facilities	• The candidate site is located in 38 km from UB city center. It is 38 km drive way on paved road and another 600 meters on the dirt l road to reach to the site. The 38 km long main road is medium loaded and is less packed in comparison to the west side roads of the city. There is no problem concerning with roads. • The major concentration of the UBC activities is in the western part of the city and the traffic out and into the city is mostly from the west and central part of the city that cause high traffic on the west road. While the traffic in the eastern part of the city is comparatively low and with less traffic jams. • The closest border of Nalaikh district from the candidate site is in 3.2 km. In Nalaikh district there is a school-complex and 2 kindergartens with 6000 students and children, which are located in the apartment area of the district. There is a District hospital and maternity hospital in the apartment area, and each of 4 Khoroos has family hospitals. (2)
	4	Cultural Property	• In 4 km distance around the candidate site there was no cultural property found.
	5	Public Health Condition	• According to the information obtained from the Nalaikh District Hospital, the district population suffers from mine accidents and gets poisoned by coal fumes, which is different from other place population illness tendencies. There is no specific contagious disease that is popular among this population. (4)
	6	Distance from Electricity Supply	• In 600 meters to the north direction from the north border of the candidate site, there is a high voltage pole and a transformer.
Natural Environment	7	Topography and Geology	• The land is open concave area with low hills. • The area mainly has dark brown soil but some areas are saline and stony, and valleys have frozen soil.
	8	Groundwater	• The site is considered to be a part of the Tuul river catchments basin. • There was no previous groundwater survey undertaken in the Bayangiin Khonkhor area of Nalaikh District. However, it is clear the future disposal site will affect groundwater in that area.
	9	Hydrological Situation	• In 7 km from the north of the candidate site, there is a Tuul River flowing from the east to the west. In 6 km distance, there is Nalaikh River flowing from south to north direction. • The Nalaikh district hydrological condition is composite depending on the land's physiographical conditions, geological formation, groundwater movements, spread of the stratum containing water, condition of obtaining nourishment, and many years of old frost contained in it. Thus it is divided into the following layers: - Neogene's or water containing in quaternary period "active layer" holes. - Later cretaceous period or water containing in crack and clefts. • Later carboniferous age water containing in metamorphic rocks layer. (3)
	10	Fauna and Flora	• The vegetation is steppe kind. The popular plant is stipe, Caragana grass. The plantation coverage is 70-80 in 1m2 area. The damage of vegetation is not significant. There are no important or rare fauna and flora registered. (3)
	11	Meteorology	• The average mean of precipitation of Nalaikh district is 248-300 mm per annum. The 70-80 percent of annual precipitation falls in summer, precisely in July and August. The relative air humidity ranges between 50-70% and 60-65% is viewed to be average. 70% of 365 days can be counted as windy. The average wind speed is 3.9 m per second in winter, 4.5 m per second in spring, 3.8 m per second in summer, and 3.4 m per second in autumn. • The average snow cover is 6 cm and the highest is 15cm. (3) • There is a big chance of wind scattering the waste because there are not high hills around the site and less protection by the higher hills.
	12	Landscape	• The candidate site is the beginning of the steppe ecosystem that is located in the southwest of Nalaikh district; it is located in 7km from the sanctuary Bogdkhan mountain's protected area. The candidate site has a land that is not damaged or influenced by negative forces, thus it may be unsuitable to establish a waste disposal site here.

Pollution	13	Air Pollution	• There are some negative factors such as Nalaikh coal mine dusts, ger area chimney fume, and heating plant pollution.
	14	Water Pollution	• There is no water pollution information of the area in 3km distance surrounding the area. • If there is a groundwater reserve will be discovered the disposal site may contaminate the water.
	15	Noise and Vibration	• The noise and vibration might affect the daily lives of the surrounding population.
	16	Others	• The site is located fairly far from the city but the wind may scatter the waste along the paved road. The permission to establish a disposal site might be hard to obtain because of the near located UB city Air Strike Protection Division.

(Sources):
1. Ulaanbaatar city Statistics book. 2004
2. Nalaikh District Governor's Office
3. Nalaikh District Environmental Research Report. 2000
4. Nalaikh District Hospital

Table 4-7: Preliminary Environmental Study on Baganuur Coal Mining Candidate Site (BCMCS)

Items			Specific Information
General Explanation			This site is located in Baganuur District of Ulaanbaatar city with an area of 63,000 hectares. The site was previously used as a coal mining quarry and has more than 100 hectares land area.
Social Environment	1	Inhabitant	• The nearest settlement area to this candidate site is Baganuur district with about 22,000 residents. It is 3 km from the candidate site to the settlement area. (1). • Administration office of Baganuur Coal Mine in 2 km distance from the candidate site. • Around the candidate area there is a constant coal mining procedures being done.
	2	Economic Activities and Current land use	• The candidate site is located in the mining area. Rehabilitation has started on abandoned mining sites. There is a new exploration and topsoil removal at new mining sites.
	3	Traffic and Public Facilities	• To reach the candidate site it needs to drive 130 km on asphalt road and about 3 km on gravel road. There is a gravel road to the Baganuur Mine site. • A railway reaches this candidate site. It is 150 km on railway and will take 5-6 hours to reach by train. It is about 4 km from the center of Baganuur district to mine site pit and there is an available railroad. (2) • There are 4 high schools with 800 students each and one district hospital, and they are located in the centre of Baganuur district. There is one resort and Gun Galuutai tourist camp on the east side of the site, in about 14 km distance.
	4	Cultural Property	• There is a Natural Reserve of Gun Galuutai in 20 km distance to southwest from the candidate site. (3)
	5	Public Health Condition	• No special infectious disease is endemic to this region. However, there might be some risk for infectious diseases such as, foot and mouth disease spread through the cattle and cattle skin transportation from east aimags. Marmot meat and skin can spread plague.
	6	Distance from Electricity Supply	• There are high voltage poles and transformers at used pits and coal mine sites. It is about 300 m from the candidate site.
Natural Environment	7	Topography and Geology	• The Baganuur District is located in a low valley. The deep mine pit is 30-40 meters deep at the candidate site. • Coal Mining Area (5) • The soil characteristic and soil pH of survey area for candidate site is neutral around 2nd block on the area of 1st pit, and for other areas the pH is about 8.0, some what alkaline. Heavy metals, such as lead and copper are high. (6)
	8	Groundwater	• The groundwater has a hydraulic connection with the surface water, becoming a zone of an integrated hydrodynamic system. Hydrological deposits are divided into the following water layers: 1. Groundwater with excessive supply or water contained in a quaternary period deposit. It spreads from Kherlen river valley and acts as the main source for Baganuur's water supply. 2. Groundwater with medium supply in the Khujirt and Khutsaa river "alluvi-prolluvi-deluvi" deposit basically has dried up due to leakagecausing the quaternary period coal deposit to dry up. The study shows that in 1991 the borehole water level was 9.4-22 meters deep. In 2000 it decreased to 43.8-74.5 meters deep. The decreasing level of the groundwater is causing the falling level of Bagagun lake and Khujirt, Khutsaa rivers. (8)

	9	Hydrological Condition	• The most important part of the Baganuur area surface and ground water system is Kherlen river which is located 12 km to east side from candidate site. In 2000 the average flow rate was 28.7m3/sec. In the year with least water level reached which is 1980, its yearly average rate reached 11.4m3/sec. Its water is mineralized fluctuating between 45-190 mg/l. Khujirt and Khutsaa rivers take origin from Baga Khentii mountain south valley. Khujirt river flows 30 km and flows into Bagagun lLake and flows out of it to salty lakes and into the Khutsaa river and then into the Kherlen river. In the center of Baganuur coal mine two tectonic faults join. From here a Nuurent mineral spring flows into small river that leaks into a salty lake. Bagagun Lake has an area of 0.27 km2 and it is fed from a layer under the coal layer. Ayagan lake has an area of 0.16 km2 and and is located 6 km to the southeast of Ikhgunii Lake and Bagagun Lake. (1) The outflow of 1st and 2nd section of the mountain has 2-3 times higher mineral content than in the Hutsaa river. Outflow and sewage water from the Sewage Treatment Facility flows through the riverbed and flows into the Kherlen river during the winter season. (8) • Bagagun Lake is located 6 km to southwest and flows into the Khujirt river. It connects to filtered water from the 5th mining section and flows into Kherlen river. This water is unusable because of its high mineralization. (6, 7)
	10	Fauna and Flora	• The topsoil has been removed at the candidate site. As a result of the mining exploration and operation there is no vegetation. • There are endangered plants and animal species in Gun Galuut Natural Resource Reserve in 20 km to southwest from candidate site. (3)
	11	Meteorology	• The climate of this area is slightly humid and cool. Average annual precipitation is 250 mm. Wind direction is from northeast to southwest. Average wind speed is 2 m/sec on the ground surface. During spring the wind flows from west northwest and the north. The wind effect will lesser because waste will be stored in deep hole (6)
	12	Landscape	• There is no impact on landscape of the area. Because the original view of the site is already damaged by coal mining.
Pollution	13	Air Pollution	• The bad smell of the waste may have an adverse effect on the people and environment in the area. • Baganuur district's source of air pollution includes coal mining, power and other heating plants, ger area smoke, vehicle emission, and wastes. (8)
	14	Water Pollution	• The candidate site is relatively rich in hydraulically connected surface and ground water. Thus the landfill might cause some groundwater and Kherlen river pollution. • If we disposed the wastes of at the candidate site, there is a potential risk of leachate leaching into the soil and ground water. It might contaminate Gaga Gun Lake, Khutsaa river, Khujirt river and Kherlen river. It is necessary to protect the waste from leaching.
	15	Noise and Vibration	• This candidate site is located in a mine site. There might be noise and vibration effects. Because the mine operation has lots of noise.
	16	Others	• The candidate site is located in Baganuur Coal Mining area and is included in the Coal Mining Licensed area. • According to the Article 15, Chapter 3 of the Law on Household and Industrial Waste, areas where waste disposal site is prohibited to be established include mining area, proven mineral deposit site and residential area. (5, 9)

(Source):

1. Statistical book of Ulaanbaatar city, 2004
2. Baganuur Coal Mining Authority
3. Information booklet of Gun Galuutai Resort and a Tourist Camp
4. Public Health Institution
5. Mineral Resource and Oil Authority
6. Baganuur Coal Mining Environmental Impact Assessment Report. 1995
7. Map of Baganuur district land integrated fund and Administration map published from State Geodesy and Cartography Authority
8. "Gazar-Eco" Co., Ltd detailed Environmental Impact Assessment report of "Baganuur-Us" State owned treatment facility. 2002
9. Mongolian Environmental Law. 2004

4.5 Cost Estimation for Collection of Wastes

4.5.1 General

a. Waste Amount

Waste amounts needed to be collect from each district in 2010 are summarized as follows.

Table 4-8: Waste Collection Amount in Year 2010

District	Category	Daily amount ton/d	Yearly amount ton/y
Bayangol	Planned Area	59.7	21,791
	Gel Area	17.3	6,315
Bayanzurkh	Planned Area	51.4	18,761
	Gel Area	40.2	14,673
Nalaikh	Planned Area	4.7	1,716
	Gel Area	8.4	3,066
Songinokhairkhan	Planned Area	32.1	11,717
	Gel Area	67.7	24,711
Sukhbaatar	Planned Area	26.8	9,782
	Gel Area	37.2	13,578
Chingeltei	Planned Area	25.0	9,125
	Gel Area	47.3	17,265
Khan Uul	Planned Area	16.7	6,096
	Gel Area	29.2	10,658
Total		463.7	169,251

Planned Area: Developed area such as apartment, business, industry area
Gel area : Undeveloped area such as Gel Area

b. Haulage Distance

Haulage distance from each district to the 6 candidate sites is summarized as follows. In order to make calculation simple, the haulage distance from each district is simplified as one point at centre of the district shown in the drawing.

As for the BKDS, haulage distance will exceed 30 km and transfer station with 2nd haulage with bigger trailer will be more economical rather than transport by single truck. Therefore, 1st haulage will be 5 km to 18 km depend on the collection point and 2nd haulage will be 30.7 km from transfer station to the disposal site.

As for the BCMDS, it is around 130km far away from UB city and there is a railway which transports mining coal from Baganuur to UB City. Therefore, transportation by the train is investigated in this cost estimation. One loading facility is located at east of UB city and one unloading facilities is located at Baganuur Coal Mining site.

Table 4-9: Haulage Distance from Each District to the 6 Candidate Sites

unit: km

	Haulage	NEDS	TDDS	XMDS	MDDS	BKDS	BCMDS
Bayangol	1st	11.7	12.8	8.3	24.0	11.3	11.3
	2nd	-	-	-	-	30.7	128.4
Bayanzurkh	1st	17.9	10.7	14.5	25.3	5.3	5.3
	2nd	-	-	-	-	30.7	128.4
Nalaikh	1st	2.0	2.0	2.0	2.0	8.0	2.0
	2nd	-	-	-	-	-	-
Songinokhairkhan	1st	7.3	20.1	1.0	21.2	18.7	18.7
	2nd	-	-	-	-	30.7	128.4
Sukhbaatar	1st	18.1	8.0	15.4	27.0	10.4	10.4
	2nd	-	-	-	-	30.7	128.4

Chingeltei	1st	15.6	9.7	12.2	25.0	10.9	10.9
	2nd	-	-	-	-	30.7	128.4
Khan Uul	1st	14.8	17.3	11.4	15.0	15.7	15.7
	2nd	-	-	-	-	30.7	128.4

Note: Nalaikh will utilise his own disposal site which is abondoned coal mining pit except transporting to the New NAKH disposal site.

c. Type of Vehicle

Type of vehicle which used for collection of wastes at planned area is compactor because of the nature of the wastes collected. And the vehicle which is used for Ger area is a dump truck because the composition of the wastes which contain a lot of ash especially in winter season.

The machinery cost will be depreciated in 7 years and 10% of the initial cost will be remain at the end. Depreciation cost per minutes is calculated as follows.

Table 4-10: Depreciation Cost of Dump Truck (10m3, 6 ton)

Basic price	Tg	72,000,000	60,000US$
Life year	years	7	
Salvaged value	10%	7,200,000	Value after using 7 years
Cost per 7 years		64,800,000	
Life hours	hours	14,053	5.5 working days per week, 7hrs a day
Life minutes	min	843,150	
Depreciation per minute	Tg	77	

Table 4-11: Depreciation Cost of Compactor, (15m3, 10ton)

Basic price	Tg	120,000,000	100,000US$
Life year	years	7	
Salvaged value	10%	12,000,000	Value after using 7 years
Cost per 7 years		108,000,000	
Life hours	hours	14,053	5.5 working days per week, 7 hrs a day
Life minutes	min	843,150	
Depreciation per minute	Tg	128	

Labor cost is as follows.

Table 4-12: Labor Cost

Description	unit	Amount
Driver	Tg/month	96,000
Waste collector	Tg/month	76,800

4.5.2 Haulage Cost

a. Calculation method

Required duration per trip of haulage can be calculated based on the following table.

Table 4-13: Calculation of Required Duration

no	Item	Unit	Calculation Formula
①	Capacity in weight	t	data input:10 for compactor, 6 for dump truck
②	Capacity in volume	m3	data input:15 for compactor, 10 for dump truck
③	Half way distance	km	data input
④	One trip distance	km	③ x 2
⑤	Velocity of vehicle	km/h	data input : 35
⑥	Specific gravity of waste	t/m3	data input : 0.2 for planned area, 0.3 for Ger area

⑦	Density of waste when hauled	t/m3	data input : 0.4 for compactor, 0.3 for dump truck
⑧	t1:Working hour	h	data input : 8.0
⑨	t2:Daily service time	min	data input : 30
⑩	t3:Loading time per trip	min	data input : 120
⑪	t4:Unloading time	min	data input : 5
⑫	E: Working efficiency of haulage		data input : 0.9
⑬	f: Work efficiency of haulage		data input : 0.9
⑭	Nos of trips per day	times	(60x⑧-⑨)x⑫／(④/⑤x60+⑩+⑪)
⑮	Adjusted Nos of trips per day	times	adjusted to integral figure
⑯	Waste carried per trip	t/trip	data input : 5.4 for compactor, 2.7 for dump truck
⑰	Waste carried per day	t/d	⑯x ⑮
⑱	Waste carried per month	t/month	⑰x30daysx5.5days/7days
⑲	Waste carried per year	t/year	⑱× 12 months
⑳	Required duration per trip	min	(④/⑤x60+⑩+⑪)/⑫+⑨/⑮

Note:
Secondly, required cost per trip is calculated as follow.

Table 4-14: Cost Estimation per trip

no	Item	Unit	Calculation Formula
a	Diesel quantity for traveling	liter/trip	④ ÷ 2km/liter:fuel consumption during traveling
b	Diesel quantity for collection	liter/trip	(⑨+⑩)÷ 15min/liter: Fuel consumption during collection
c	Total consumption quantity of diesel	liter/trip	a + b
d	Rate of diesel	Tg/liter	data input : 800Tg/Liter
e	Diesel cost	Tg/trip	d x c
f	Lubricant (5% of diesel)	Tg/trip	5% x e
g	Depreciation of a Compactor truck	Tg/trip	⑳ x 128Tg for Compactor, 77 for Dump Truck
h	Spare parts & repair (30% of Depreciation)	Tg/trip	30% of g
i	Wage for a driver	Tg/trip	data input : wage÷⑮
j	Wage for 2 waste collector	Tg/trip	data input : wage÷⑮× 2 men
k	Toll gate fee	Tg/trip	data input if necessary
l	sub total		e+f+g+h+i+j+k
m	Indirect Cost	35%	35 % x i
n	Cost per trip	Tg/trip	l+m
o	Unit cost per ton (5.4 ton per trip)	Tg/ton	n ÷ ⑯

Indirect Cost(m) includes: Social insurance tax, real estate depreciation, machinery tax, heating and electricity cost, department cost, administration cost, sales tax and profit

Required annual haulage cost will be calculated as follows.

Annual waste amount ÷ waste carried per trip (5.4ton for compactor and 2.7 ton for dump truck) x cost per trip (figure n in above table)

b. Result of Haulage Cost

Thus calculation result of each step will be summarized as follows.

Table 4-15: Cost per Trip from Each District to 6 Disposal Sites (Compactor)]

Type of Vehicle Compactor Tg/trip

District	Dispose to					
	NEDS	TDDS	XMKDS	MDDS	BKDS	BCMDS
Bayangol	71,744	73,934	64,977	96,901	70,948	70,948
Bayanzurkh	84,085	69,754	77,317	99,488	59,006	59,006
Nalaikh	58,409	58,409	58,409	58,409	58,409	58,409
Songinokhairkhan	62,987	88,463	50,447	91,328	85,677	85,677
Sukhbaatar	85,876	64,380	79,109	102,872	69,157	69,157
Chingeltei	79,507	67,763	72,739	98,891	70,152	70,152
Khan Uul	77,914	82,890	71,147	78,987	79,706	79,706

Table 4-16: Cost per Trip from Each District to 6 Disposal Sites (Dump Truck)

Type of Vehicle Dump Truck Tg/trip

District	Dispose to					
	NEDS	TDDS	XMKDS	MDDS	BKDS	BCMDS
Bayangol	42,692	44,045	38,509	58,500	42,200	42,200
Bayanzurkh	50,320	41,462	46,137	60,099	34,818	34,818
Nalaikh	34,449	34,449	34,449	34,449	34,449	34,449
Songinokhairkhan	37,279	53,027	29,528	55,055	51,304	51,304
Sukhbaatar	51,427	38,140	47,244	62,191	41,093	41,093
Chingeltei	47,490	40,231	43,307	59,730	41,708	41,708
Khan Uul	46,506	49,582	42,323	47,427	47,613	47,613

Table 4-17: Haulage Cost per Ton of Waste (Compactor)

Cost per ton of waste 5.4ton Tg/ton

District	Dispose to					
	NEDS	TDDS	XMKDS	MDDS	BKDS	BCMDS
Bayangor	13,286	13,691	12,033	17,945	13,139	13,139
Bayanzurkh	15,571	12,917	14,318	18,424	10,927	10,927
Nalaikh	10,816	10,816	10,816	10,816	10,816	10,816
Songinokhairkhan	11,664	16,382	9,342	16,913	15,866	15,866
Sukhbaatar	15,903	11,922	14,650	19,050	12,807	12,807
Chingeltei	14,723	12,549	13,470	18,313	12,991	12,991
Khan Uul	14,429	15,350	13,175	14,627	14,760	14,760

Table 4-18: Haulage Cost per Ton of Waste (Dump Truck)

Dump Truck 2.7ton Tg/ton

District	Dispose to					
	NEDS	TDDS	XMKDS	MDDS	BKDS	BCMDS
Bayangor	15,812	16,313	14,263	21,667	15,630	15,630
Bayanzurkh	18,637	15,356	17,088	22,259	12,896	12,896
Nalaikh	12,759	12,759	12,759	12,759	12,759	12,759
Songinokhairkhan	13,807	19,639	10,936	20,391	19,002	19,002
Sukhbaatar	19,047	14,126	17,498	23,034	15,219	15,219
Chingeltei	17,589	14,901	16,040	22,122	15,447	15,447
Khan Uul	17,224	18,364	15,675	17,566	17,635	17,635

c. Transfer Station and 2nd Haulage

In case the disposal site is located in BKDS, haulage distance will exceed 30km and to construct transfer station and 2nd haulage by bigger trailer become more economical. Transfer cost including second haulage is 1,091million Tg annually.

In case of the disposal site is located in BCMDS, the railway transport will be required. The total cost for railway transport including 2nd haulage at Baganuur is estimated at 2,226million Tg annually.

d. Haulage cost in year 2010.

Haulage cost in year 2010 is summarized as follows based on above explanation.

Table 4-19: Haulage Cost in Year 2010

Unit: million

District	Area	NEDS	TDDS	XMDS	MDDS	BKDS	BCMDS
Bayangol	Planned	290	298	262	391	286	286
	Gel	100	103	90	137	99	99
Bayanzurkh	Planned	292	242	269	346	205	205
	Gel	273	225	251	327	189	189
Nalaikh	Planned	5	5	5	5	5	5
	Gel	39	39	39	39	39	39
Songinokhairkhan	Planned	137	192	109	198	186	186
	Gel	341	485	270	504	470	470

District	Area	NEDS	TDDS	XMDS	MDDS	BKDS	BCMDS
Sukhbaatar	Planned	156	117	143	186	125	125
	Gel	259	192	238	313	207	207
Chingeltei	Planned	134	115	123	167	119	119
	Gel	304	257	277	382	267	267
Khan Uul	Planned	88	94	80	89	90	90
	Gel	184	196	167	187	188	188
Transfer haulage		-	-	-	-	1,091	-
Railway haulage		-	-	-	-	-	2,226
Total cost	million Tg	2,600	2,560	2,323	3,270	3,564	4,700
Unit cost	Tg/ton	15,364	15,123	13,727	19,323	21,058	27,767
Unit cost	$/ton	12.8	12.6	11.4	16.1	17.5	23.1

4.5.3 Cost Estimation for 6 candidate sites for future disposal

a. General

Final disposal amount shall be calculated as follows in order to estimate required capacity of future landfill site. Insitu density of wastes after compaction at disposal site shall be 0.85 to 0.92 depend on which year landfilled. Volume of soil cover is allowed 20 % of the disposal amount.

Table 4-20: Estimated Annual Disposal Amount up to year 2020

Year	Daily Volume			Annual Amount				Disposal to New Disposal Site
	Final Disposal Amount (1) per day	Insitu Density after compaction	Final Disposal Amount (2) per day	Annual Final Disposal Amount	Annual Final Disposal Amount	Volume of Cover Soil (20% of Wastes)	Total	
	Ton/day	Ton/M3	m3/day	t	m3	m3	m3	m3
2006								
2007								
2008	409.2	0.92	444.8	149,358	162,346	32,469	194,815	194,815
2009	426.8	0.92	463.9	155,782	169,328	33,866	203,194	203,194
2010	445.1	0.90	494.6	162,462	180,513	36,103	216,615	216,615
2011	461.7	0.90	513.0	168,521	187,245	37,449	224,694	224,694
2012	477.7	0.90	530.8	174,361	193,734	38,747	232,481	232,481
2013	496.7	0.90	551.9	181,296	201,439	40,288	241,727	241,727
2014	510.5	0.90	567.2	186,333	207,036	41,407	248,443	248,443
2015	524.5	0.88	596.0	191,443	217,548	43,510	261,058	261,058
2016	536.3	0.88	609.4	195,750	222,443	44,489	266,931	266,931
2017	548.0	0.88	622.7	200,020	227,295	45,459	272,755	272,755
2018	557.8	0.88	633.9	203,597	231,360	46,272	277,632	277,632
2019	567.0	0.88	644.3	206,955	235,176	47,035	282,211	282,211
2020	574.2	0.85	675.5	209,583	246,568	49,314	295,882	295,882
Total	6535.5			2,385,458	2,682,032	536,406	3,218,439	3,218,439

According to the calculation above, required capacity of new disposal site which can accommodate up to year 2020 is around 3,300,000 m3 in the condition that the existing final disposal site can be used up to year wpp7.

b. Construction Cost of Final Disposal Site

There are 6 candidate sites recommended by Mongolian side as future final disposal site.

site	location
NEDS	North valley adjacent to the Ulaan Chuluut Disposal Site
XMKDS	Former soil pit operated by XMK company
MDDS	West valley to the Morin Davaa Disposal Site
TDDS	Tsagan Davaa which is located north of former Dari Ekh disposal site
BKDS	South of Nalaikh Disposal Site
BCMDS	Baganuur former coal mining pit

Following facilities are considered to be built as an initial investment.

1. Clearing site
2. Construction of cut off drain to prevent rainfall water to inflow into landfill area

3. Construction of boundary fence along the boundary to prevent any animals, waste pickers to enter.
4. Leachate treatment facilities
5. Embankment dam which height is 10m initially and extend further according to the landfill operations.
6. Paved access road from nearest paved main road to the entrance of the disposal site.
7. Weighbridge and control building
8. Electricity supply from nearest tapping point.

Preliminary designs at 6 candidate sites are shown in the following drawings.

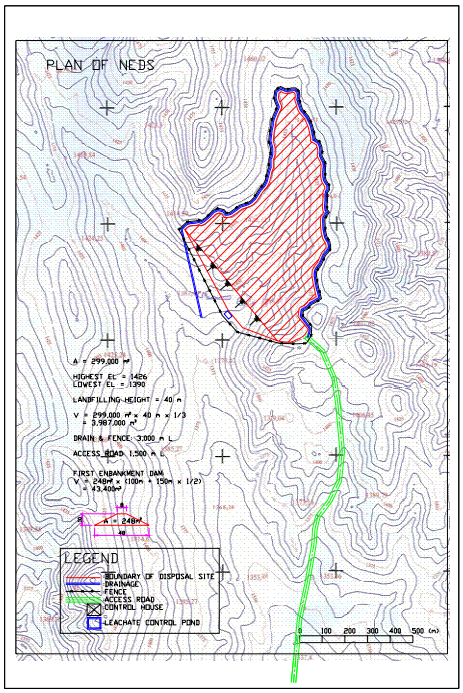


Figure 4-3: Preliminary Design for NEDS

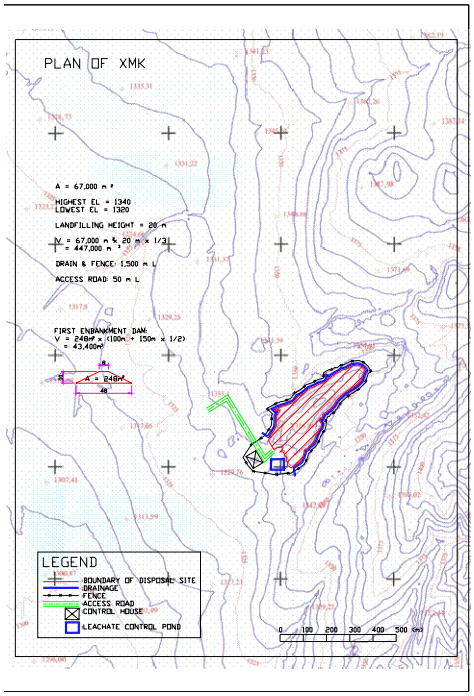


Figure 4-4: Preliminary Design for XMKDS

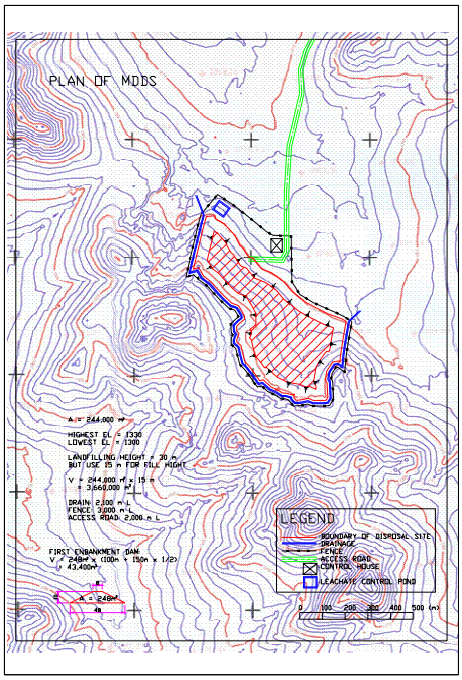


Figure 4-5: Preliminary Design for MDDS

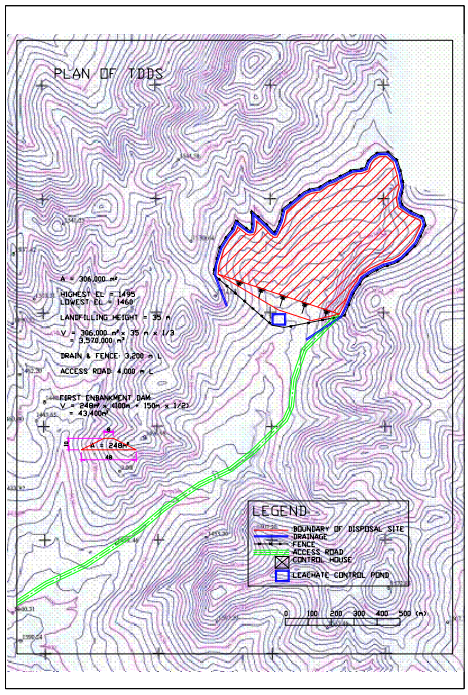


Figure 4-6: Preliminary Design for TDDS

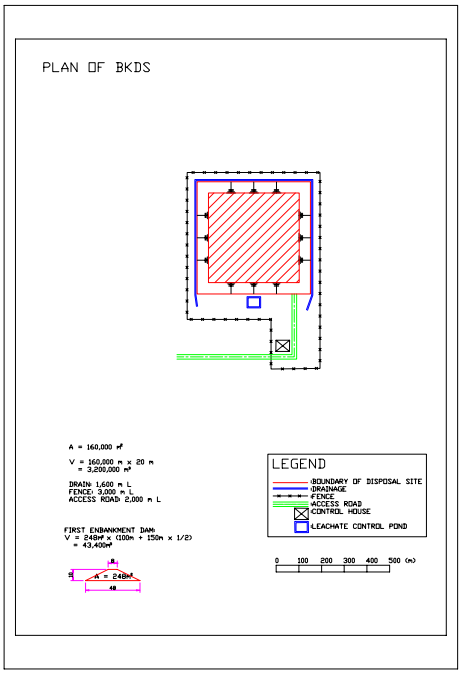


Figure 4-7: Preliminary Design for BKDS

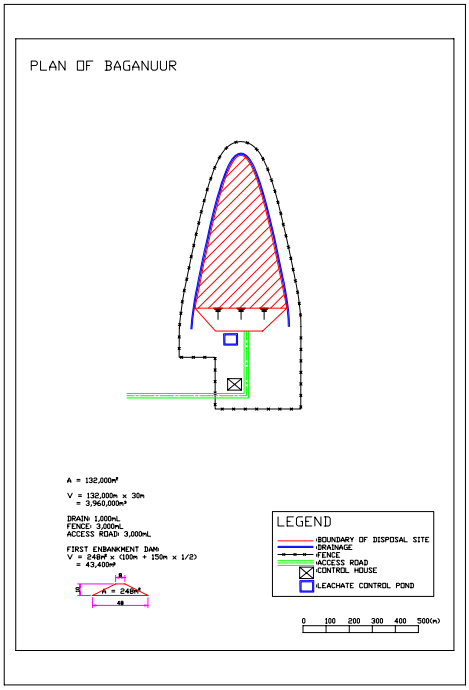


Figure 4-8: Preliminary Design for BMDS

Base on the above design, each quantities for 6 candidate sites are summarized as follows.

Table 4-21: Summary of Quantities for 6 candidate sites

Description	Unit	Quantity					
		1.NEDS	XMKDS	MDDS	TDDS	BKDS	BCMDS
Area	ha	30	7	25	31	16	14
Landfill Capacity	m3	3,987,000	875,000	3,660,000	3,570,000	3,200,000	3,960,000
	ton	2,954,000	648,000	2,712,000	2,645,000	2,371,000	2,934,000
Expected Service Life	year	16	4	15	14	13	16
Clearing Site	ha	30	7	25	31	16	14
Cut Off Drain	m	3,000	1,500	2,100	3,200	1,600	1,000
Boundary Fence	m	3,000	2,000	3,000	3,200	3,000	3,000
Leachate Treatment Facility	ls	1	1	1	1	1	1
Embankment Dam	m3	43,400	0	224,000	63,000	140,000	70,000
Access Road from main paved road	m2	10,500	350	14,000	28,000	4,200	21,000
Weighbridge and Control Building	no	0	1	1	1	1	1
Electricity Supply	km	1.5	0.5	1.7	1.0	0.6	3.0

Accordingly, construction cost is calculated as follows.

Table 4-22: Cost Calculation for Construction of Final Disposal Site

Description	Unit	NEDS	XMKDS	MDDS	TDDS	BKDS	BCMDS
Area	ha	30	7	25	31	16	14
Landfill Capacity	m3	3,987,000	447,000	3,660,000	3,570,000	3,200,000	3,960,000
	ton	2,954,000	331,000	2,712,000	2,645,000	2,371,000	2,934,000
Expected Service Life	year	16	2	15	14	13	16
Construction Cost		Amount (US$)					
Clearing Site		9,000	2,100	7,500	9,300	4,800	4,200
Cut Off Drain		30,000	15,000	21,000	32,000	16,000	10,000
Boundary Fence		60,000	40,000	60,000	64,000	60,000	60,000
Leachate Treatment Facility		10,000	10,000	10,000	10,000	10,000	10,000
Embankment Dam		173,600	0	896,000	252,000	560,000	280,000
Access Road from main paved road		178,500	5,950	238,000	714,000	71,400	357,000
Weighbridge and Control Building		0	50,000	50,000	288,000	50,000	50,000
Electricity Supply		15,000	5,000	17,000	50,000	6,000	30,000
Total	$	476,100	128,050	1,299,500	1,419,300	778,200	801,200
Cost per ton of waste	$/ton	0.16	0.39	0.48	0.54	0.33	0.27

4.6 Operation Cost of Sanitary Landfilling

Sanitary landfill cost shall consist of followings;

1. Planning Daily Operation: The cost for a planner who will make plan of daily operation such as where to fill, when to fill and give direction to the supervisors. One planner is allowed.
2. Sanitary Landfill: the cost for heavy machinery such as bulldozer, excavator, dump truck which will spread and compact wastes delivered and cover with soil after compaction. One water lorry also allowed to extinguish fire, in case happen, and spray water in order to control dusts.
3. Collection Control: the cost includes the operation of weighbridge, analysis of collected data, education to the collection company, monitoring illegal dump.
4. Monitoring and Safety Control: the cost includes setting up and functioning o f monitoring committee, safety control of landfill operations.

Above operation cost is presented as follows.

Table 4-23: Monthly Operation Cost of Sanitary Landfilling

Unit : US$

	Description of Work	Monthly Cost ($/Month)	Remarks
1	Planning Daily Operation	150	Planner
2	Sanitary Landfilling	31,490	Bulldozer, Excavator, Dumptruck, Water Truck, Supervision, Control Traffic, Control Waste Pickers
3	Collection Control	930	Weighbridge Operation, Analysis of Data, Education, Monitoring Illegal Dump
4	Monitoring/Safety Control	45	Monitorig Committee, Safety Control
	Sub Total	32,615	
	Operation Cost per ton of wastes	2.44	$/ton

Monthly Landfill Amount in 2010 445.1ton/day x 30days = 13,353 ton

Table 4-24: Detailed Breakdown of the Cost Calculation

	Description of Work	Specification	Unit	Qty	Rate	Amount	Remarks
1	Planning Daily Opeartion	Planner	man-month	1	150	150	1man × 1 month
2	Sanitary Landfill					31,490	
	2.1 Leveling and Compaction	Bulldozer	nos-month	2	5,000	10,000	2no x 8 hr/day x 1 month
	2.2 Shaping and Cover Soil	Excavator	nos-month	1	6,250	6,250	1no x 8hrs/day x 1 month
		Bulldozer	nos-month	1	5,000	5,000	1no x 8hrs/day x 1month
		Dump Truck	nos-month	2	3,300	6,600	1no x 8hrs/day x 1 month
		Water Lorry	nos-month	1	3,300	3,300	1no x 8hrs/day x 1 month
	2.3 Supervision	Supervisor	man-month	1	100	100	1man x 1 month
	2.4 Control Traffic	General Labour	man-month	2	80	160	2 men x 1 month
	2.5 Control Waste Pickers	General Labour	man-month	1	80	80	1 man x 1 month
3	Collection Control					930	
	3.1Operation of Weigh bridge	WB Operator	man-month	3	100	300	3 men x 1 month
	3.2 Control and Analyze Data	Data Controller	man-month	1	100	100	1 man x 1 month
	3.3 Control, Regulate, Educate Collecting Company	Control Officer	man-day	8	5	40	1man x 2 days/week
	3.4 Monitoring and Regulation of Illegal Dump	Inspector	man-month	4	100	400	4 men x 1 month
4	Monitoring/ Safety Control					45	
	4.1 Monitoring Committee	Monitoring Committee	man-day	5	5	25	5 men x 0.5 day/2week
	4.2 Safety Control	Safety Controller	man-day	4	5	20	1man × 1 day/week

Table 4-25: Unit Rate of Machinery and Manpower used for calculation

Unit Rate (US$)

	daily	monthly
Manager	7.5	150
Engineer	5	100
Supervisor	5	100
General Labour	4	80
Bulldozer	200	5,000
Excavator	250	6,250
Dump Truck	132	3,300
Water Lorry	132	3,300

Total monthly cost for sanitary landfilling is US$32,525. In the year 2010, monthly disposal amount is estimated at 13,353 ton. Therefore, the unit cost of operation per ton of wastes disposed is $32,525 ÷ 13,353ton = 2.44 $/ton

4.7 Second Workshop

The Second Workshop was held on April 11 in order to examine, discuss and make recommendation regarding future final disposal site(s) for MSWM in the City of Ulaanbaatar. 55 persons from relevant organizations and communities were invited and in total 45 participated including administrative officers of Khoroos where the 6 candidates are located. The participants discussed on the subject based on the report of the technical and financial study and the preliminary environmental study. Then the Workshop recommended the two sites, Narangiin Enger and Tsagaan Davaa, to the St/C for final decision.

The 3rd St/C meeting including visits to the recommended two sites was held on April 26 and made decision on the future disposal site. Narangiin Enger site was finally selected.

In response to the decision, the Study Team will conduct a feasibility study for development of new landfill at Narangiin Enger site including preliminary design with mitigation measures against adverse impacts, cost estimation, etc. in Phase 2 of the Study from July 2005. The Environmental Impact Assessment (EIA) will be conducted by MUB, the proponent of the project.

4.8 First Seminar

The First Seminar was held on April 26 to present decision on the selection of Narangiin Enger candidate site for the future final disposal site in order to achieve consensus among the stakeholders. 95 persons from relevant organizations and communities were invited and in total 61 participated including 13 persons in total from residents and administrative officers of Khoroo No. 4 of SKhD where the Narangiin Enger candidate site is located. In the seminar the following issues are presented by the C/P with the assistant of the Team:

1. Explanation of background and objectives of the first seminar
2. Explanation of sanitary landfill and pilot project for the improvement of UCDS
3. Explanation of six (6) candidates as future disposal site(s), selection process and decision

After the explanation of the above aspects the participants actively asked many questions to clarify the decision, etc. and the C/P replied to every question with little assistance of the Team. The record of questions and answers are presented in the Annex 7.

5. Selection of an Optimum System

5 Selection of an Optimum System

5.1 Selection Method

5.1.1 Policy of Master Plan

An SWM technical system consists of various technical subsystems of a Discharge and Storage system, Collection and Haulage system, Public Area Cleansing system, Intermediate Treatment and Recycling system, Final Disposal system, and Maintenance system for Vehicles and Equipment. There are many potential technologies in each sub-system. Consequently, a number of alternatives can be formed for an optimum technical system from a combination of these various subsystems.

In order to screen the potential technologies and select an optimum technical system, the C/P and JICA Study team have set up the policies of the M/P as described below.

- Collection service will cover all residents by 2010. The waste collected will be disposed of at the final disposal site by sanitary landfill in order to minimize the negative effects on the environment.
- The fundamental goal of the M/P for SWM in MUB (Municipality of Ulaanbaatar) is to establish an environmentally sound SWM system in MUB by the target year 2020. To achieve this goal, the 3Rs (Reduce, Reuse, Recycle) will be actively promoted firstly to reduce waste generation, then to reuse and recycle generated waste as a resource as much as possible in order to reduce the amount of solid waste to be disposed of at the landfills.

5.1.2 Policies for Selection

Taking the current situation and background of SWM in the study area into account, the policies for the selection of an optimum technical system are as follows:

- Technical system proposals have to contribute to the implementation of the above-mentioned M/P policy.
- The implementation of technical system proposals have to be afforded by MUB and District governments and be justified in terms of national economy.
- The systems and technologies to be adopted should be simple so that operation and maintenance will be easy and inexpensive.
- The foreign currency requirements for the purchase, operation and maintenance of systems should be minimized. The use of locally available materials and services should be maximized.
- The proposed technical system should be consistent with the existing conditions and existing practices, in order to easily cope with the system.

5.1.3 Method of Selection

The SWM system consists of a collection and haulage system to remove generated waste from the living area and a final disposal system to suitably dispose the removed waste.

Incinerating and composting is part of a processing system, called the intermediary system, between the collection and haulage system and final disposal system in order to ① reduce volume (to reduce the final disposal amount), ② stabilize (to stabilize the final disposal waste), and ③ detoxify (to make the final disposal waste non-hazardous) the waste. In the event that sufficient capacity and a suitable location is secured for the final disposal site, it is possible to develop a sustainable SWM system even if there is no intermediary system.

An optimum discharge and storage system, and collection and haulage system are largely related in particular to the necessity of introducing separated collection and whether or not an intermediate treatment facility is introduced. Moreover, the necessity of introducing an intermediate treatment facility is greatly influenced by the capacity and location of the final disposal site. Therefore, the optimum system was selected in this study by the following process.

- Site selection work was carried out for the final disposal site and a disposal site was selected which can be used until the M/P target year of 2020. Accordingly, it was determined that the previously mentioned four disposal sites could be used until the year 2020.
- The necessity of introducing an intermediate treatment system was examined using the selected final disposal site as a base. Consequently, it was decided to plan the introduction of a valuables sorting yard and RDF production facility in order to promote the 3Rs for environmental conservation.
- As the introduction of a valuables sorting yard and RDF production facility was decided, optimum discharge and storage systems, and collection and haulage systems were examined for the introduction of separated collection necessary for the operation of the facility.

5.2 Identification of Potential Technologies

Each technical sub-system has potential technologies as shown in the table below.

Table 5-1: Technical Sub-systems and Potential Technologies

Technical Sub-systems	Items to be Examined	Potential Technologies
Discharge and Storage	Storage system	• Dust chute • Disposable containers • On-site waste storage • Small containers • Medium containers • Large containers
	Discharge system	• Mixed discharge • Separate discharge • Bring to the drop-off stations or buy-back stations
Collection and Haulage	Primary collection	
	Collection frequency	
	Mixed or separate collection	• Mixed collection • Separate collection
	Collection system	• Point collection • Communal container collection • Bell collection • Curbside collection • Door-to-door collection
	Collection Schedule	• Day collection • Night collection

	Collection equipment	• Compactor trucks • Non-compaction trucks • Tractors and trailers • Tipper trucks • Skip trucks • Railway transportation • Transfer of waste
Street Sweeping	Sweeping method	• Manual street sweeping • Mechanical sweeping • Vacuum sweeping • Flushing
Recycling	Material recycle	• Direct reuse • Raw materials for remanufacturing and reprocessing • Feedstock for production of biological and chemical conversion product • Land reclamation
	Thermal recycle	• Heat recovery • Fuel recovery
Intermediate treatment	Pre-treatment system	• Size reduction • Manual and mechanical sorting
	Treatment system	• Incineration • Refuse Derived Fuel (RDF) • Composting • Biogas Production • Size reduction • Manual and mechanical sorting
Final Disposal	Location of final disposal sites	• Mining pit, flat land or valley
	Landfill structure	• Anaerobic, Semi-aerobic or aerobic
	Level of sanitary landfill development and operation	• 4 sanitary landfill level
Maintenance of Vehicles and Equipment		• Preventive Service Workshop • Full Service Workshop

5.3 Screening Potential Technology

5.3.1 Collection and Haulage

a. Storage System

Waste is generated on a somewhat continuous basis. However, collection occurs intermittently, a few times a week or even once a month, depending on the quantity generated at a specific location and climatic conditions. Therefore, it is necessary to provide proper storage for waste until it is collected. Storage is quite important because it can have a significant effect on:

- Public health and aesthetic conditions.
- Subsequent functional elements such as collection.
- Public attitudes concerning the operation of the system.

Public Health and Aesthetic Conditions

Public health concerns are related primarily to the infestation of storage areas for solid wastes with vermin and insects that often serve as potential vectors of disease. By far the most effective control measure for both rats and flies is proper sanitation. Typically, this involves the use of paper, plastic bags, or containers with tight lids, the periodic washing of the containers as well as of the storage areas, and the periodic removal of biodegradable materials, which is especially important in areas with a warm climate such as DSM.

Aesthetic considerations are related to the production of odors and the unsightly conditions that can develop when adequate attention is not given to the maintenance of sanitary conditions. Most odors can be controlled through the use of containers with tight lids and with the maintenance of a reasonable collection frequency, or through the timely discharge of refuse by dischargers with punctual refuse collection services. To maintain aesthetic conditions, the container should be scrubbed and washed periodically.

Subsequent Functional Element

Storage and collection are separate operations but must be closely coordinated. The type, size and location of containers are very important factors in determining the most efficient collection system. Large size public containers are favorable in terms of public health and aesthetic conditions but difficult to load manually. Small containers are quite convenient for loading wastes but reduce waste collection efficiency because they require more frequent stops for loading.

Public Attitudes in the Operation of the System

It is necessary to pay sufficient attention to the security of equipment including waste containers, to be installed in DSM. There is always a risk that dustbins and containers could get stolen because they are handy and can be used for other purposes.

The effects on these aspects vary depending on the generation source, i.e., residences, shops, office buildings, etc.

Accordingly, this section deals with on-site handling and storage systems available for the study area

The applicability of the use of the following storage systems, which are used in many countries, in Ulaanbaatar City are discussed below.

- Dust Chute
- Disposable containers (Paper or plastic sacks)
- On-site refuse storage
- Small containers (about 0.2 m^3)
- Medium containers (1 to 2 m^3)
- Large containers (5 to 10 m^3)

There are a wide range of issues to be considered in the selection of the most appropriate storage system for Ulaanbaatar City. The examples are as follows.

- The amount and composition of waste discharged.
- Waste composition and components.
- The collection frequency, most often determined by climate and waste composition.
- The space available near the source and the accessibility of the area to collection vehicles.
- Environmental and occupational health hazards.
- Suitability to the actual environment, i.e., functions suitable for the actual user.
- The ability to stand misuse, very cold climate, and waste pickers scavenging.
- The total investment and operational costs over a given period.
- The habits and traditions of users and collection crews.

a.1 Dust Chute

Many buildings in Ulaanbaatar have the dust chute system for discharging waste. In this system, there is a lid of the dust chute

in every floor. Dischargers can drop off waste into the dust chute after opening the lid. Waste are dropped to a waste chamber on the 1st floor and stored there until waste is collected.

Advantages

a) It is very convenient for dischargers because they are able to discharge their waste anytime.
b) A waste collection crew is able to collect waste anytime because the collection doesn't require any public cooperation. In actual, in Ulaanbaatar City, waste from dust chute chambers is very irregular and often collected even in night.
c) The frequency of waste collection can be few because the waste chamber can store waste.
d) The factors of b) and c) make the waste collection cost cheap.

Disadvantages

a) The minimum required waste collection frequency is often ignored.
b) Vermin such as flies and mosquitoes and offensive odor are often generated from waste stored in the waste chamber and spread to every floor through the openings of the chute installed every floor.
c) The dust chutes are often clogged.
d) Waste in the chamber often fire and smoke is spread to every floor through the chute.
e) Collection and loading work of waste from the chamber to the truck is very labor intensive and unsanitary.
f) People lose their consciousness to waste issue because the system is too convenient for them.
g) Difficult to apply separate collection.

Applicability

One of the biggest problems associating with the dust chute system is unsanitary condition caused by lack of people's consciousness because it is too convenient for both dischargers and collectors. In addition, considering the fact that the many countries which once introduced the dust chute system have already prohibited its use, it should be prohibited in Ulaanbaatar City.

a.2 Disposable containers (Sackcloth, paper sacks or plastic sacks)

The paper or plastic sack system generally entails the use of 20 to 80 liters sacks for the storage and handling of wastes which are later collected for further haulage and disposal. They are expendable. This system can be used by any discharger, i.e., residents, shop owners. In addition, sackcloth used as packing coal is often used in unplanned area for discharging ash.

Advantages

a) The system is very sanitary because the sacks are disposable.
b) The system is labor and time saving because the sacks are light in weight and expendable thereby requiring less time and effort for haulage.
c) The system does not require any initial investment.

Disadvantages

a) The system requires the continuous purchase of sacks. However, shopping bags used for packing items can be used for its purpose.
b) The use of expendable sacks increases the waste generation amount.
c) The contents of sacks when left outside may scatter widely at pick-up points due to scavenging by waste pickers.

Applicability

For planned areas

If no dust chute system, this system is essential because it is too difficult for people who live upstairs to bring back to their homes after discharging waste to the 1st floor.

For unplanned areas

Sackcloth is suitable for discharging ash and soil which occupy majority of waste discharged from the unplanned areas.

a.3 On-site waste storage

The on-site waste storage is commonly made of bricks or steel and mainly used to store communal waste. With this storage system, it is possible to keep different types of wastes separately in different compartments.

Advantages

a) This system maintains aesthetic conditions if it is properly maintained.
b) This system is durable enough to last more than 10 years.
c) This system is applicable to separate collection if it has a few compartments.

Disadvantages

a) This system requires an investment.
b) This system requires close monitoring for the maintenance of sanitary conditions.
c) This system requires space.
d) It is difficult to select a location for on-site waste storage because it is a permanent fixture and it might cause public nuisance.
e) This system makes loading of waste onto waste collection trucks difficult if the design of the structure is improper.

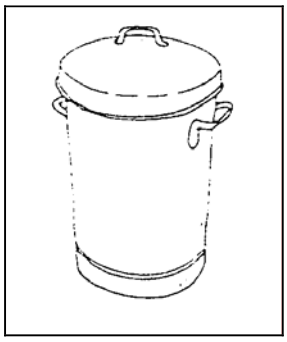
Applicability

This system requires close maintenance services, therefore, it is only applicable in markets and high income residential areas where people can afford the cost it incurs.

This system is unsuitable for the unplanned area because the communal on-site storage system requires the primary haulage and the individual on-site storage require an investment which exceeds majority of residents' financial affordability.

This system requires an investment but increased efficiency in collection works does not lead to cost-effectiveness. Therefore, this system is not recommended unless users are willing to bear the extra costs.

a.4 Small containers (about 0.2 m^3)



Dustbins herein refer to all small-size containers with lids, ranging from 30 liters to about 120 liters in size. One man can reasonably lift and empty containers weighing up to about 28 kg (70 liters), while two men are required to lift a 48 kg (120 liters) container. Dustbins of the former size may be used at individual premises or as communal dustbins for 6 to 12 families either on or farther from the collection points. They can also be used as litter bins for street sweepers or the general public. The dustbins may be made of galvanized steel or high density polyethylene and must be weather resistant.

A small container without a lid can be a simple empty drum.

Advantages

a) This system provides sanitary conditions because wastes stored can be completely covered.
b) This system maintains aesthetic conditions.
c) This system lasts for more than several years.
d) It can stand for heavy waste.

Disadvantages

a) This system requires a large initial investment for the purchase of dustbins.
b) Dustbins require periodical washing to maintain their sanitary condition.
c) Dustbins are easily stolen because of their usefulness.
d) Heavy and difficult to carry waste in dustbins for a long distance.

Applicability

For Planned Areas

This is unsuitable for residential waste in apartments because too difficult to carry and too large for the waste amount. However, it is suitable for non-residential waste generated from entities which locates in the 1st floor.

For Unplanned Areas

People can't afford to pay for dustbins with lids but can afford to pay for dustbin without lids which made of an empty drum. Drum dustbin is durable for ash but the size should be limited to a half drum because it is the maximum size for people to carry without difficulties.

a.5 Medium containers (1 to 2 m^3)

The container (1 m^3) system is used for the planned are in Chingeltei duureg.

Containers of any size may be used for the temporary storage of waste, but there are two main constraints. One is weight limitation for consistent manual haulage and transport to avoid undue fatigue and bodily injuries. Containers may be fitted with wheels and moved by a small hand truck from the storage stands to the collection vehicle or to an intermediate storage point. However, the use of containers exceeding the weight limitation for manual haulage and transport require that the surfaces over which these containers are to be placed and wheeled must be reasonably even, hard and without steps or steep inclines.

It is very important to wash the containers and clean its surroundings. The frequency of cleansing would depend largely upon the kind of waste stored in the containers. The cleansing of containers is difficult, exhausting, and costly. Cleansing is usually more satisfactory if it is undertaken in the central maintenance depot where steam sweeping equipment or high pressure jets can be installed.

Advantages

If these are properly maintained, there are following advantages.

a) This system provides sanitary conditions.
b) This system maintains aesthetic conditions.
c) This system is durable enough to last several years.

Disadvantages

a) This system requires a huge capital.
b) This system requires even concrete floorings and equipment for lifting containers.
c) Waste pickers scatter waste when they collect recyclables from waste.
d) Waste pickers often burn waste in containers for warming and it causes damages.
e) Waste in containers is frozen and strongly adhered to containers during winter.
f) This system requires periodical washing to maintain sanitary conditions.
g) This system requires daily cleaning of surroundings.
h) Nobody take care of containers because of they are communal.
i) The operation of this system is considerably expensive.

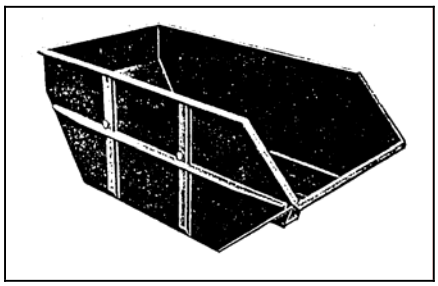
Applicability

Due to the above mentioned disadvantages, more than a half of 150 number of $1m^3$ communal containers purchased in 2002 which have used in Chingeltei duureg have been damaged before 2005. In addition, the surroundings of most containers are always very dirty due to lack of users' interest and scavenging by waste pickers. Considering the experience of the use of these containers in last two years, this is considered unsuitable for residential waste for both planned and unplanned areas.

However, this can be suitable for non-residential waste of which dischargers can take care of waste and the containers.

a.6 Large containers (5 to 10 m^3)

Containers measuring 5 - 10 m^3 are suitable for areas generating large quantities of waste. Special purpose vehicles are required for lifting, transporting and emptying such containers. A constraint to the use of such containers would be the need for room at the storage location for the vehicle to maneuver, to complete the container collection or exchange process.



Advantages

a) This system provides sanitary conditions.
b) This system maintains aesthetic conditions.
c) This system is durable enough to last more than several years.
d) This system can curtail collection and transportation costs because it minimizes loading time.

Disadvantages

a) This system requires a huge capital.
b) This system requires special vehicles for lifting, transporting and emptying containers.
c) This system requires space for placing and lifting containers.
d) This system requires people's care for maintaining clean.
e) Waste pickers scatter waste when they collect recyclables from waste.
f) Waste pickers often burn waste in containers for warming and it causes damages.
g) Waste in containers is frozen and strongly adhered to containers during winter.
h) Irregular collection can cause hazards as the huge amount of waste stored in these containers is left for a considerable period of time.

Applicability

Although the operation cost of this system is one of the cheapest in terms of collection and haulage, this system associate with many problems mentioned above in the study area in particular. For this system, therefore, how to use it should be considered very carefully in order to highlight the advantages with minimizing disadvantages. In general, it is suitable for construction waste and bulky or large amount waste which are discharged from specific generation sources.

a.7 Conclusion

	Residential waste in Planned Area	Residential waste in Unplanned Area	Other waste
Dust Chute	Unsuitable	Not applicable	Unsuitable
Disposable containers (Paper or plastic sacks)	Suitable	Suitable	Suitable
On-site refuse storage	Suitable	Unsuitable	
Small containers (about 0.2 m3)	Unsuitable	Suitable	Suitable
Medium containers (1 m3)	Unsuitable	Unsuitable	Suitable
Large containers (5 to 10 m3)	Unsuitable	Unsuitable	Suitable

b. Discharge System

The appropriate discharge system is closely related to the storage system and the collection system which is applied and in addition to the people's cooperation level.

b.1 Mixed Discharge System

People discharge their waste without any separation.

Advantages

a) It is the simplest and the easiest for both the dischargers and the collectors to do.

Disadvantages

a) Difficult to recover the recyclables from waste.

b.2 Separate Discharge System

People separately discharge waste. The number of waste kinds to be sorted has to be properly determined to get the public cooperation.

Advantages

a) It is easy to recover the recyclables from waste.

Disadvantages

a) Dischargers have to make certain efforts to separate waste for discharging.

b.3 Bring to the Drop-Off Stations or Buy-Back Stations by Dischargers

In order to recover recyclables, people separate recyclables and take them to buy-back stations for selling or to the drop-off stations for discharging without any return.

Advantages

a) It is easy to recover the recyclables from waste.
b) The collection cost is cheap.
c) Dischargers can get some return if they take them to buy-back stations.

Disadvantages

a) Dischargers have to make certain efforts to separate and carrying recyclables for discharging.

c. Collection and Haulage System

c.1 Primary Collection

In areas with inaccessible roads, waste has to be carried to designated points for collection. People living near collection points find it easy to discharge waste by them, but those further away have difficulties doing so. Therefore, a primary collection service, which is the haulage of waste from residences to collection points, should be established for the latter.

In the study area, most roads are accessible except in a few khoroo in Chingeltei where the roads are too steep.

c.2 Collection and Haulage System

The objective of waste collection and haulage system is to collect and to haul waste from specific locations to a disposal site at regular intervals, with minimal cost and in a reliable manner, with due considerations of sanitary conditions. It is very important to always bear in mind that the cost for the collection and haulage of waste is by far the most expensive part of the overall waste management system.

The collection and transportation system is mainly affected by the following aspects:

a) collection frequency
b) collection method (mixed or separate)
c) collection system
d) collection schedule
e) collection vehicle
f) haulage distance
g) haulage method
h) transfer system

c.2.1. Collection Frequency

Collection frequency is determined in view of sanitary conditions, operation and maintenance cost. As for organic waste, the more frequent collection is carried out the better in terms of sanitation. However, because this would mean higher costs, collection frequency should be minimized as long as sanitation is maintained.

Considering its climate, low humidity, waste composition including low percentage of organic fractions, and high population density, etc., a twice or thrice weekly collection is recommended for the planned areas.

Considering the population density lower than the planned areas, and waste composition including high percentage of ash in winter and garden waste with soil in summer, etc., a twice

monthly collection is recommended for the unplanned areas.

c.2.2. Mixed or Separate Collection

A separate collection system is required by introducing intermediate treatment technologies. Introduction of incineration technology requires separate collection of combustibles and noncombustible. Composting requires separate collection of organic and inorganic materials, while recycling requires separate collection of recyclable and non-recyclable materials.

The separate collection system requires additional costs because it necessitates more storage space, and reduces waste collection and transportation efficiency.

Another issue to be kept in mind is people's willingness to cooperate in source segregation. Because this necessitates the conduct of public education and motivation programmes, it would take time before it is adequately implemented.

In principle, separate collection may be targeted in planned areas if the intermediate treatment technologies will be adopted, while mixed collection should be implemented in unplanned areas because the waste generated from unplanned areas can't be targeted by any intermediate treatment technologies due to high percentage of ash or soil in the waste.

c.2.3. Collection System

To consider the appropriateness of the collection system, the collection efficiency, the town structure, and the land use of the area are the main factors to consider.

Table 5-2: Summary of Collection Systems

Collection System		Summary
Point Collection		Dischargers carry their own waste to specified waste collection points; discharged wastes are later collected by trucks. The dust chute system is also categorized in this.
Communal Container Collection		Residents discharge waste regardless of collection day. This collection method produces high collection efficiency.
Bell Collection		The collector calls out to the residents to discharge their waste upon the arrival of collection vehicle at a given collection point. Then people bring the waste to trucks.
Curb Side Collection		Discharger is responsible for placing the waste at the curb on collection day.
Door to Door Collection	Set-out - Set-back	Containers are set out from the premises and set back after being emptied by additional crews that work in conjunction with the operators responsible for loading the collection vehicle.
	Setout	Set out collection is essentially the same as set-out-set-back collection, except that residents are responsible for returning the containers to their storage location.
	Backyard Collection	The collection crew enters the premises and collects wastes from their storage location.

In Ulaanbaatar City, point collection, communal container collection, bell collection, and door to door collection systems are used.

The following collection systems are recommended for further examination:

- Point collection system for planned areas
- Door to door collection system for unplanned area, commercial, institutional areas
- Bell collection system together to supplement the other collection system.

c.2.4. Collection Schedule

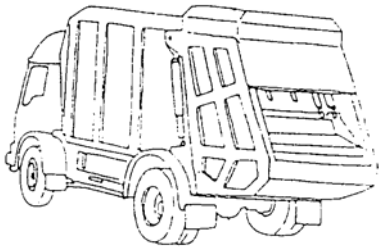
Setting a proper collection time is important to achieve an effective collection system. The factors to be considered are capacity of collection equipment resource, traffic, current town structure, etc.

The day collection is essential to get cooperation from dischargers. Only areas where traffic is too congested for a collection crew to collect waste, the night collection should be carried out. Considering the present congested condition of traffic, the necessity of the night collection isn't so high. In addition, the night collection is too hard and too dangerous for collection workers to do during winter.

The collection work, therefore, should be carried out basically from 9 a.m. until 6 p.m. for the entire city area.

c.2.5. Collection Equipment

Compactor Trucks



The use of rear end loading compaction trucks have become the norm in many industrialized countries, where they are designed specifically for the following purposes:

- Maximization of productivity of highly paid labor force.
- Compaction of low density wastes such as packaging waste to achieve higher payloads.

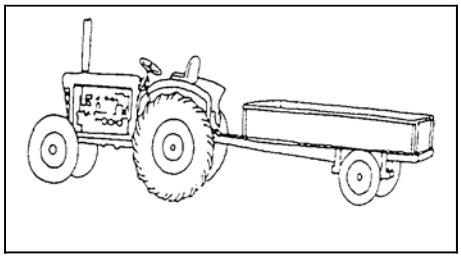
These compaction trucks are used to haul a waste density of 100 to from the collection points. The density of waste discharged from the planned area is less than 200 kg/m^3, while it from the unplanned area is more than 300 kg/m^3 according to the waste composition survey. Therefore, the compaction trucks are suitable only for the planned area.

One of the potential problems associated with using compactor trucks will be maintenance. The maintenance of compactor trucks requires a higher level of technological skill. According to our investigation, all TUK are not capable for the maintenance of the compactor trucks in terms of human resources, repair equipment, etc.

Non-Compaction Trucks

There are many types of non-compaction trucks, and these are generally distinguished by loading form.

Tractors and Trailers



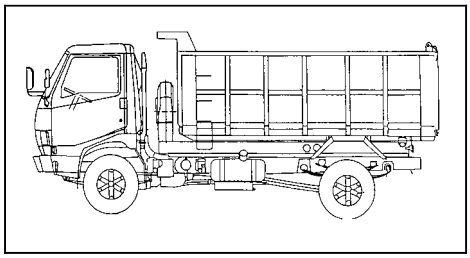
Tractors and trailers can be useful in certain areas close to the landfill. They can be useful when traveling over relatively rough terrain and can be used in connection with street sweeping services. The trailer can be parked at fixed locations where significant amounts of waste have accumulated over a certain period. For example, in areas where wastes produced from pruning trees have accumulated. One tractor could on this basis service several trailers in the course of a day.

These tractors and trailers, however, are only suitable for Nalaikh duureg in the study area because they will disturb other traffic in the other duureg in the study area due to the congested traffic condition.

Tipper Trucks

Tipper trucks are fairly basic and do not incur excessive maintenance costs.

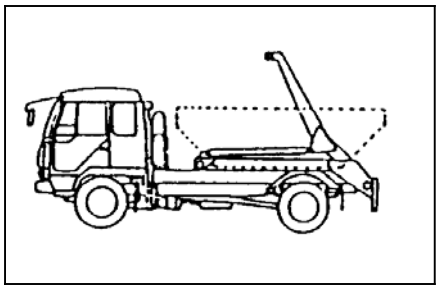
Loading is normally carried out manually; hence it is extremely slow and tiring due to the considerably high loading elevation. When loading, waste is handed over from the ground to the workers inside the truck who pack the load. Furthermore, the loading operation is unhygienic.



Tipper trucks are effective for loading large heaps of waste and carrying heavy density waste such as ash and soil. Considering the majority of waste discharged from unplanned areas is ash in winter and garden waste with soil in summer, tipper trucks are suitable for the collection of waste from unplanned areas.

Skip Trucks

A wide range of skip trucks are available, handling containers from 1 to 10 m^3. These trucks are highly productive since they were able to collect about two tones of waste filled containers with each lift within a few minutes.



With the relatively short distance (10 km from City Centre), this system can accomplish between five and eight loads per day.

The skip truck itself is cheaper than a compaction truck and can achieve a higher payload in the course of a day than any non-compaction vehicles.

The containers may be manufactured locally; the system is robust and can handle a wide range of wastes. The vehicles are easy to maintain provided spare parts are available, especially for the container hoist system.

Container trucks have faster average road speed than tractor-trailers, and shall hardly affect the normal flow of traffic.

As well as providing a regular service from fixed collection points, this system is also equipped with functions that can deal with water accumulating at specific locations (markets) or resulting from particular public events. It, therefore, offers considerable flexibility in terms of dealing with the various wastes generated across the City.

The system is recommended for the future waste collection services for non-residential waste.

c.2.6. Railway Transportation

There are railway lines running the study area and it is possible to use it for carrying waste. However, because the waste has to be transferred twice at a loading station and an unloading station, this is the factor to increase the total haulage cost expensive. Therefore, it will be effective for the long distance transportation and it highly depends on the location of disposal site.

c.2.7. Water Transportation

Waste is transported to transfer stations for loading onto boats and is hauled to disposal sites. This method is frequently used for the disposal of residual soil of land reclamation works but cannot be adopted for the study area due to no watercourses which has enough water for boats to access through the seasons.

c.2.8. Transfer of Waste

Wastes discharged in transfer stations are hauled to the final disposal sites using large trucks (about 20 to 40 tones in capacity) to minimize overall transport costs. A transfer station is where wastes from collection vehicles of limited capacity are loaded into trucks (or rail cars for rail transfer stations) of larger capacity for haulage to a disposal site.

The main purpose of using a transfer station is to reduce the net cost of transporting waste from collection areas to the final disposal site. The issue of whether or not to build and operate a transfer facility almost entirely depends on economic factors.

Although this system reduces transportation expenses, it requires additional cost for the construction of a transfer station, as well as for dumping and loading work. Accordingly, this system is not financially beneficial unless the disposal site is located far away. A simplified transportation system would be more reliable and productive, hence beneficial.

As long as disposal sites are located within 20 km from the weighted centre of their respective collection areas, in compliance with this master plan, a transfer station will be unnecessary.

5.3.2 Public Area Cleansing System

a. Introduction

Street sweeping is one of the most visible of all government services. Consciously or not, residents allow their opinions of the effectiveness of street sweeping programs influence their assessment of the credibility of their municipal leaders and local officials. Visitors instinctively rate municipalities based on their external conditions, i.e., cleanliness. Dirty cities cannot attract foreign tourists and investors. These opinions should be positively used to stimulate the residents to build a better city.

Street sweeping programs were conducted mainly to remove litter and dirt so that streets appear presentable, and traffic will not create dust. In some areas particularly, regular street sweeping is necessary to prevent sewers from becoming clogged. It is also recognized that dirt is a potential pollutant.

Municipalities must balance the costs for adequate street sweeping and effective litter control programs, sewer improvement operations, projects to ensure safety of pedestrians and vehicle occupants, air and water pollution countermeasures, and economic development. Public education programs alone, however, will not help eliminate street litter. Debris also accumulates from air pollution fallout, animal excreta, oil drippings, parts dropped from vehicles, spillage from solid waste collection, as well as mud tracked onto pavements.

b. Street Sweeping Methods

As practiced today, street sweeping methods may be grouped conveniently under these general headings:

- manual sweeping
- mechanical sweeping
- vacuum sweeping
- flushing

b.1 Manual Street Sweeping

Manual street sweeping is by far the oldest method. However, it still retains certain advantages as follows:

Advantages

a) low capital
b) great flexibility of operation
c) applicable to cleansing of areas where debris accumulation is most frequent
d) makes cleaning beneath parked vehicles possible
e) makes cleaning rough cobble stone pavements possible
f) produces less noise
g) creates more job opportunities
h) requires minimum equipment repair and maintenance costs

Disadvantages

a) difficulty in supervision
b) dangerous under heavy traffic conditions

The equipment required for manual sweeping is simple and inexpensive. Sweepers use stiff bristled push brooms, containers with wheels, shovels, and few other tools for special tasks.

b.2 Mechanical Sweeping

Mechanical sweeping entails the use of as many machines as possible, usually of various sorts. Three or four-wheel sweepers are mainly used for wide main roads. Self-propelled sweepers and water sprinkling-trucks are also used for mechanical sweeping.

Advantages

a) great productivity
b) low manpower requirement
c) ensures safe operation

Disadvantages

a) huge capital
b) high maintenance cost
c) low flexibility of operation
d) difficult to conduct in narrow areas
e) produces lots of noise
f) difficult to conduct under heavy traffic

Mechanical Sweeping is generally the cheapest sweeping method for wide roads. This method is generally suitable for roads exceeding 6m in width.

b.3 Vacuum Sweeping

Vacuum street sweeping is becoming increasingly popular in developed countries because it removes fine materials as well as larger debris without using water, thereby curtailing water-use expenses. The flicking action of the broom is not as effective on fine materials as is the vacuum.

Vacuum units can also pick up larger debris, ranging from cigarette butts to beer bottles at operating speeds of 20 km per hour. With the help of gutter brooms, this unit is able to loosen and deflect debris so it can be picked up. It is also equipped with an additional broom, which may or may not be used in picking up debris, to windrow dirt. This second broom loosens the street dirt and pushes it toward the vacuum nozzles where it is drawn into the storage compartment. A filter system traps the dust and confines it to the sweeper hopper.

Advantages

a) high sweeping capability

b) no harm to sewage pipes by dust
c) produces only a very small amount of dust

Disadvantages

a) requires huge capital
b) requires high maintenance cost
c) low flexibility of operation
d) difficult to conduct in narrow areas
e) produces lots of noise
f) difficult to conduct under heavy traffic

b.4 Flushing

Street flushers hydraulically move debris from the street surface to the gutter. Since the disposal of street dirt in sewers and catch basins is regarded with increasing disfavor because it pollutes the environment, several municipalities now flush only to aid sweeping and not as the sole method of sweeping.

Flushing before sweeping washes street dirt to the curb for collection by motorized sweepers. This type of flushing ordinarily employs smaller quantities of water and lower nozzle pressures to keep the dirt from flowing into the inlets as well as minimize the risk of getting pedestrians and vehicles wet. The benefits of flushing after sweeping are: cleaner pavements and the discharge of only small quantities of dirt into inlets and catch basins.

Advantage

a) produces no dust

Disadvantages

a) needs a large amount of water
b) may clog sewage pipes
c) requires high maintenance cost
d) low flexibility of operation
e) difficult to conduct in narrow areas
f) difficult to conduct under heavy traffic

c. Current Street Sweeping System

All TUKs currently employs the manual sweeping method. The sweepers collect and heap up litters with a broom and scrape it and put it into a wheel bin. The waste is later collected by waste collection vehicles. Sometimes after strong wind blow, water is sprayed with a water tanker onto roads to wash out dust.

d. Applicability

To use the flushing system is sometimes necessary because the strong wind carry lots of fine sands especially in spring and autumn; however the fully mechanical flushing system is not necessary because the frequency of the necessity of the flushing system is low.

The mechanical and vacuum sweeping systems are also not suitable for the study area because they require large capital, and incur high operational and maintenance costs.

Conclusively, the present manual sweeping is most suitable for the study area because of an abundant and inexpensive supply of labor force. The jobs that are produced by this sweeping system can contribute, albeit to a smaller degree, to the betterment of poor people. This system is also flexible and can cope with waste containing lots of sand.

5.3.3 Recycling

a. Introduction

The commonly accepted definition of solid waste recycling would be to utilize one or more waste components in such a way that they are not deposited in a landfill. Materials commonly recycled or recyclable wastes are paper, cardboard, glass, bottle, aluminum, ferrous metal, and plastic.

The primary benefits of recycling are conservation of natural resources and landfill space; however, the collection and transport of materials requires substantial amounts of energy and labor, and historically, most recycling programs are subsidized economically[1]. The requirements for a successful program are that a strong demand exists for recovered materials and that the market value of the materials be sufficient to pay for collection and transportation costs. Uses for materials that have been recovered from MSW are shown in Table 5-3.

Table 5-3: Uses for Materials that have been recovered from MSW

Use/application	Remarks
Material Recycle	
➢ Direct reuse	Many of the materials separated from MSW can be reused directly. Examples of such materials include lumber, wooden pallets, 200 liters drums, furniture, etc. Whenever possible, direct reuse should be encouraged.
➢ Raw materials for Remanufacturing and Reprocessing	Typical specifications for eight different materials derived from municipal wastes are presented in next table. Specific details, such as product purity, density, and shipping conditions, must be worked out with each potential buyer. Whenever possible, it is beneficial to develop a range of product specifications and product prices. In this way, processing costs to achieve a higher-quality product can be evaluated with respect to the higher market price obtainable for the higher-quality product.
➢ Feedstock for production of biological and chemical conversion products.	Many communities have elected to meet their diversion goals by producing compost that can be marketed directly, given to the residents of the community, used on city property (e.g., greenbelts, highway dividers, etc.), or used as intermediate land fill cover. Each of these uses requires a different quality of compost, especially with respect to the type and amount of contaminant materials that may be present (e.g., plastic, pieces of metal, etc.). The production of methane in controlled reactors, ethanol, and other organic compounds will require that the materials that make up the organic fraction of the MSW be separated from the mixed MSW.
➢ Land reclamation	Applying wastes to land is one of the oldest and most used techniques in solid waste management. Land disposal technology has developed to the point that communities can now plan land reclamation projects without fear of the development of health problems. Typically, land reclamation will be accomplished with clean or processed demolition wastes. Land reclamation using wastes should not be started until a final land use has been designated.
Thermal Recycle	
➢ Heat recover / Fuel recover	Energy can be derived from municipal wastes in two forms: (1) by combusting (burning) the organic fraction of MSW and/or yard wastes and recovering the heat that is given off and (2) by converting the wastes to some type of fuel (oil, gas, pellets, etc.) that can be stored and used locally or transported to distant energy markets. Specifications for direct use of wastes for the production of steam are usually not so restrictive as those for the production of a fuel. However, as firing and storage techniques improve, specifications for direct use may become more stringent. Note that in many states the use of waste materials as a fuel source is not considered an appropriate means of waste diversion or recycling.

Recycling can be classified by the location of implementation: recycling carried out at the source and at the place where recyclables are got together.

The recycling system the government is in charge of is defined as the latter, and there are the following preconditions to implement it.

[1] Integrated Solid Waste Management, Engineering Principles and Management Issues, G. Tchobanoglous, et al, McGraw-Hill, 1993

- Source separating collection system of recyclable material
- Separate transportation system of recyclable material
- Centre where recycling is carried out

In order that the government implements and promotes recycling, it is necessary to examine the whole system from waste discharge to construction of recycling center. In addition, the target materials of recycling have to be determined. Typical materials specifications that affect the selection and design of processing operations for MSW are summarized below.

Table 5-4: Typical materials specifications that affect the selection and design of processing operations for MSW

Reuse category and materials components	Typical specification items
Material Recycle	
Direct reuse	Must be usable for original or related function. Degree of cleanliness (e.g., bicycles, processed construction and demolition wastes)
Raw material for remanufacturing and reprocessing	
Aluminum	Particle size; degree of cleanliness; moisture content; density; quantity, shipment means, and delivery point
Paper and cardboard	Source; grade; no magazines; no adhesives; moisture content; quantity; storage; and delivery point
Plastics	Type (e.g., PETE, HDPE, PVC, LDPE, PP, PS, and multilayer); degree of cleanliness, moisture content
Glass	Amount of cullet material; color, no labels or metal; degree of cleanliness; freedom from metallic contamination; no non-container glass; no broken crockery; quantity, storage and delivery point
Ferrous metals	Source (domestic, industrial, etc.); specific weight; degree of cleanliness; degree of contamination with tin, aluminum, and lead; quantity; shipment means; and delivery point
Nonferrous metals	Vary with local needs and markets
Rubber (e.g., waste tires)	Recapping standards; specifications for other uses not well defined
Textiles	Type of material; degree of cleanliness
Feedstock for bioconversion products	
Yard wastes	Composition of material, particle sizes, particle size distribution, degree of contamination
Organic fraction of MSW	Composition of material, degree of contamination
Land reclamation	
Construction and demolition waste	Composition; degree of contamination. Local and state regulations; final land-use designation
Thermal Recycle	
Heat recover / Fuel recover	
Yard wastes	Composition, particle size, moisture content
Organic fraction of MSW	Composition, calorific value; moisture content; storage limits; firm quantities; sale and distribution of energy and/or by-products
Plastics	Depends on application and design of combustion equipment
Wastepaper	Use as fuel will vary with local needs and markets
Wood	Composition, degree of contamination
Tires	Tire-to-energy plants; or pulp and paper mills and cement manufacturing facilities that use tire fuel
Waste oil	Depends on application and design of combustion equipment

b. Waste composition from the viewpoint of recycling

The following table shows the surveyed composition of waste in the study area. The Team evaluates the current waste composition from the viewpoint of recycling as follows:

- The proportion of ash is overwhelming; 60.2 %. Especially in the unplanned area ash comprises 82.9 % by weight, the other components shares are small. The proportion of kitchen waste and recyclable matters such as metals, papers, plastics,

bottles and glass is only 5% and 8.1 % respectively. Consequently, collection of recyclables in this area is not promising.

- On the contrary, in the planned area although the proportion of kitchen waste is low (32.4 %) compare to the other economically comparative countries, the proportion of recyclable matters is very high 51.6 % all together. Of that, the proportion of plastic is 22.4%, which is strikingly high. Consequently, collection of recyclables in this area is very promising.

Table 5-5: Comparison of Waste Composition

Waste Composition of MSW	Whole Study Area (%)	Planned Area (%)	Unplanned Area (%)
Kitchen Waste	12.5	32.6	5.0
Paper	5.2	12.8	2.4
Textile	2.0	4.6	1.0
Grass and Wood	0.5	1.1	0.2
Plastic	7.8	22.4	2.2
Leather and Rubber	0.2	0.7	0.1
Combustibles	28.2	74.2	10.9
Metal	1.5	4.0	0.6
Bottle and Glass	5.5	12.4	2.9
Ceramic and Stone	1.9	4.4	0.9
Miscellaneous	2.7	5.0	1.8
Non-combustibles	11.6	25.8	6.2
Ash Weight (%)	60.2	---	82.9
Total	100.0	100.0	100.0

c. Alternatives

c.1 Government Related Recycling System

Government related recycling system is carried out as a means of economically controlling solid waste generation. This system obliges dischargers to conduct waste segregation and sorting, as well as separate discharge, collection and transportation. These activities incur additional costs and their success is heavily dependent on public cooperation. The government related recycling system is considered to be more productive and they reduce the amount of waste for final disposal.

c.2 Private Sector Centered Recycling System

The government has an indirect and limited role in the promotion of this recycling system that is the conduct of public education programs on recycling. This system does not impose separate collection and any risk encountered is solely the responsibility of the private entities involved.

d. Conclusions of Screening for Recycling Systems

Although the current recycling activities are limited due to the demand for recovered materials and the market value of the materials, the private sector is conducting material recycling as much as possible. Furthermore, in view of the limited financial capability of the MUB and Duureg governments, in principle SWM shall be as financially independent as possible and recycling is not exception though the promotion of 3Rs is the goal of M/P. The Team, therefore, sets the following policies for the recycling:

1. Recycling activities shall be conducted by the private sector in principle.
2. The role of public sector (MUB) shall be limited to:

- Promote, support and regulate the recycling activities of private sector.

- Develop technologies to recycle the wastes that the private sector can not deal with

5.3.4 Intermediate Treatment

a. Intermediate Treatment System

This section considers the possible options for:

- The treatment of wastes by improving or removing some of its undesirable characteristics (e.g., to reduce waste volume, to render waste inert)
- The recovery of some of the wastes either as energy (gas, steam or electricity) or as reusable materials (e.g., waste paper, ferrous scrap, compost)

Several criteria of prime importance in assessing the suitability and viability of any system of waste handling, treatment or recovery are as follows.

Technical feasibility

- **The degree to which the technology of the system is proven,** i.e., "are these plants actually in operation elsewhere?".
- **The reliability of the system and similar issues.** (These questions are particularly important when considering latest technologies since, for example, many recovery systems are of relatively recent development).
- **Its financial and economic implications**: how much will the system cost to construct and operate; what are the potential benefits from savings in transport and disposal costs and from the sale of recovered products; what other economic benefits does the system offer in terms of foreign exchange savings, employment, etc. Of special importance here is the scope for actual selling and using any recovered products as this can frequently be less than is estimated.
- **Its management requirements**: how much qualified management and skilled labor will the system require to operate properly; how much co-operate will be obtained from the public, etc. Unless the necessary resources and skills are available, the system may be much less attractive than it initially appears.

Our assessment of the various operations below takes into account the prevailing conditions and problems in the target area, evaluating in broad terms the technical suitability and economic implications of different systems for handling, treatment and recovering solid wastes in the study area.

The following intermediate technologies are discussed in this section:

- Incineration
- Production of Refuse-Derived Fuel (RDF)
- Composting
- Biogas Production
- Size Reduction
- Mechanical and Manual Sorting

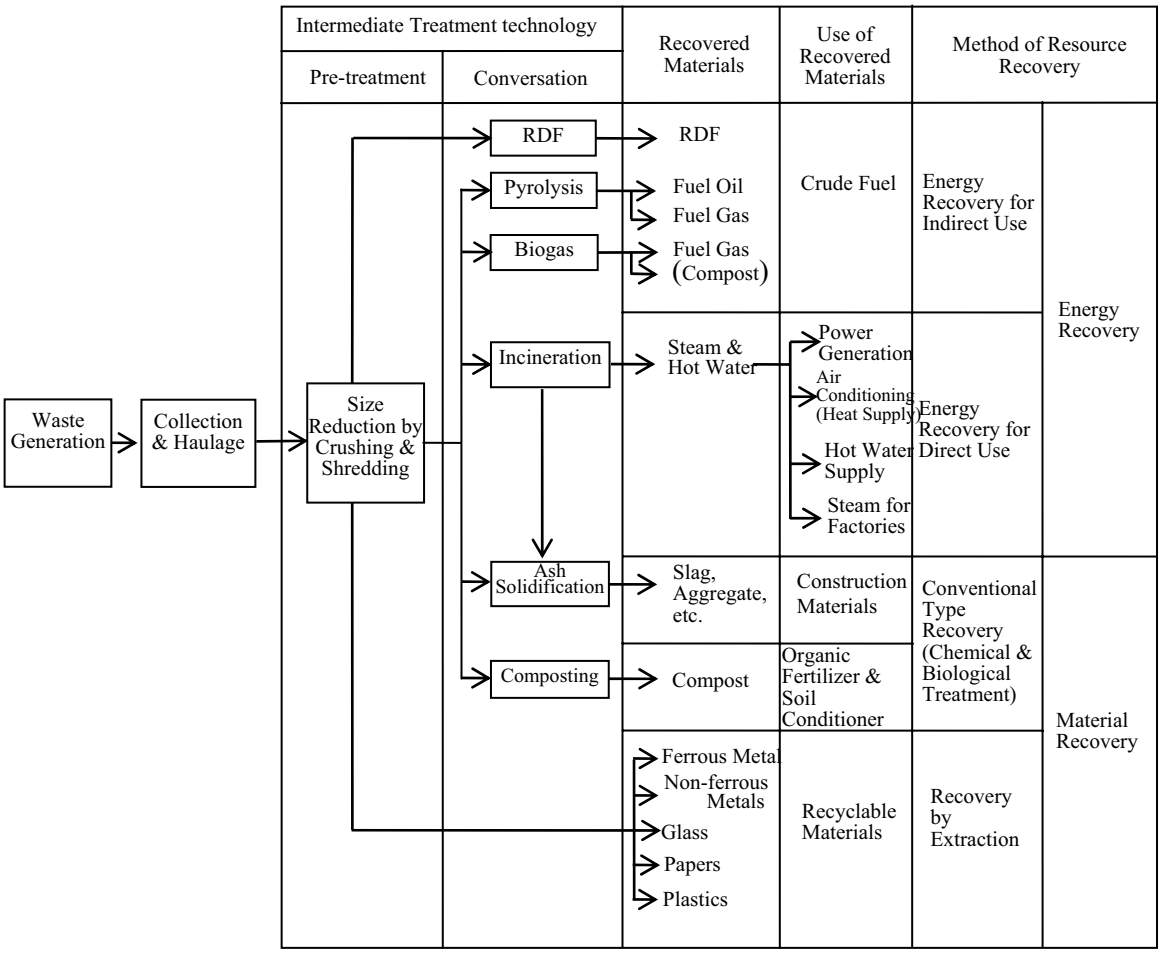


Figure 5-1: Intermediate Treatment Technologies and Resource Recovery Method

a.1 Incineration

Incineration of municipal solid wastes is one of the most popular methods recently adopted for processing wastes in developed countries. Waste is mainly converted into stable oxidized gases and partly into stable inorganic matters by high temperature combustion. Of the various intermediate treatment technologies, incineration generally reduces waste volume to a large degree. It also stabilizes putrescible organic wastes. Energy from waste incineration can be utilized for the production of electricity and/or district heating, and the income from the sale of energy may contribute to the economics of the plant.

A general observation would indicate that incinerators may be feasible where land for land filling is scarce, expensive or very remote from the actual solid waste generation centre. Modern incineration and flue gas treatment technology makes waste incineration an environmentally acceptable form of waste treatment; it is, therefore, possible to locate such plants even in densely populated areas. Accordingly, incineration has played a role in municipal waste management for more than 50 years in many major cities in Japan, Europe and the USA.

A modern incinerator consists of a number of basic components. Typically they include an unloading area, refuse feeding device, burning grate area, combustion chamber, air supply system, residue quench and disposal system, flue gas treatment equipment and water treatment system, and stack. Selection and design of these basic components will be the deciding factor in differentiating one incinerator from another.

Major differences in typical modern incinerators are noted in both refuse feed systems and grate designs. Feeding of refuse may be accomplished by either batch or continuous mode. Batch feed of refuse has experienced a decline in use over recent years in favor of continuous feed methods.

Applicability

One of the most important factors that would determine whether incineration is feasible is the calorific values of the waste being generated. It is said that the required calorific value of waste to burn without supplementary fuel is 900 cal/kg. According to the result of the waste composition survey, the calorific value of the waste generated in the study area could be estimated far below 900 cal/kg due to large composition of ash from unplanned area (more than 64.1 % of MSW). It will therefore require supplement fuel for burning. However, if waste excluding ash can be separately collected, the calorific value of waste in the study area is estimated to far exceed 900 cal/kg.

The income from the sale of energy generated by incineration of waste, either by the form of heat or electricity, is often expected when it is introduced. To generate electricity by incineration of waste is not appropriate for the study area because it requires considerable amount of costs not only for installation but also for operation and maintenance. As for recover of heat by waste incineration, it requires a simple technology which is popular in the study area. A large income from sale of energy can be expected by recovery of heat from waste incineration because there is enough demand for heat throughout a year in the study area.

A purpose-built automated incineration facility involves very high capital outlay. The technology is sophisticated and requires high levels of technical expertise to operate. Appropriate gas treatment equipment needs to be installed, and operational and maintenance costs are high. In addition, it requires continuous spending for support fuel therefore, both the investment cost and O & M cost is too expensive.

It is accordingly believed that incineration is inappropriate in the study area for technical and economic reasons, except for the purpose of hazardous waste including infectious medical waste treatment. However, it is effective to prepare the future plan of waste incineration in coordination with the existing three power plants.

a.2 Production of Refuse-Derived Fuel (RDF)

In this system the combustible fraction of the waste is separated by some mechanical or manual means primarily to extract the paper and plastic fractions which is then either used as its raw state or compacted into pellets.

The production of refuse-derived fuel can be done in several ways. In some of the earlier systems, raw refuse was first shredded to a nominal particle size of about 40 mm. More recent systems employ a rotary trammel before shredding. This trammel allows for prior separation of heavy, larger materials. After shredding, ferrous metals are separated magnetically for recycling. The remainder is then separated into a lighter, mostly combustible fraction and a heavier, mostly non-combustible fraction using an air classifier.

The lighter fraction is then further processed to produce the RDF through secondary shredding and screening. The RDF that is produced can be burned as a coal or a primary fuel in a specially designed boiler.

Today, RDF systems are mainly adopted in Japan, the United States and Canada. The extensive use of this technology in the developing countries requires to overcome the

following problems.

- There is a need to alter the combustion conditions of conventional boilers and burners if a significant amount of RDF is to be burnt.
- The pre-treatment plant is capital intensive leading to high waste disposal prices in order to make the pellets competitive with coal.
- The pellets still have a high content of pollutants (heavy metals and chloride) which conventional coal fired plants are not equipped for filtering.
- Occupational health problems at the plants specially at manual sorting lines.

Advantages

- Combustibles in municipal waste can be converted to substitute fuel which can be stored and is easy to handle.

Disadvantages

- Waste which can be converted to RDF is very limited, and their availability can be found only in waste with a high plastics and paper content.
- The market for RDF will be limited due to the necessity of a special burner which can burn hard solid fuel such as coal.
- Some technical difficulties such as explosions in crusher, clogging in storing silo, etc., have to be solved.

Applicability

- Because RDF technology produces the solid fuel which can replace coal, it is an attractive technology in the study area where huge amount of coal is consumed for heating and electricity. As for one of problems which have to be solved, i.e. the necessity of conventional boilers and burners, it can be overcome by using furnaces in the existing power plants, although it may requires the trial test to verify the impacts to the facility and the ambient.
- A few accidents of explosion of RDF have occurred recently in Japan. This can be avoided by using only plastic and paper as raw material for RDF excluding putresible material such as kitchen waste and grass/wood.
- The other issue to be solved is how to collect huge amount of plastic and paper waste separately. In order to maximize the benefits by RDF, the economical separate collection system for plastic and paper wastes should be established.

a.3 Composting

Waste composting is a method to achieve microbiological degradation of organic matter (household and vegetable wastes, garden wastes, etc.), to produce a recycled organic product for use in agriculture, gardens, parks, etc.

The most important technical issue about composting concerns the precise nature of the product. Compost is not a fertilizer but a soil conditioner. It does contain some plant nutrients but its value lies primarily in that it improves the soil structure by introducing humus, promotes microbial activities, and can help to retain fertilizers and moisture in the soil. Before being offered for sale, it is important that the product is sterile and free from pathogens that could be harmful to crops and people. To achieve this, it is important to control the temperature and moisture content to enable the necessary stages of decomposition to take place correctly, in order to sterilize the product.

Most essential for achieving success when composting municipal waste is that the waste is sorted into a "green" fraction (i.e. organic waste) and a fraction that is not appropriate for composting (plastics, glass, metals, etc.). Sorting may be conducted at a central compost plant (which would require mechanical equipment as well as manual sorting with due consideration of workers' hygienic conditions) or at the source (i.e. at the householders which would require a good deal of education).

The technology of composting municipal waste is well-established and operating experience and information is available in great detail. In spite of this wealth of experience, few of the refuse compost plants around the world are economically successful. The drawbacks commonly experienced with composting are its high cost and the low value of the compost products.

<Alternative Composting Methods>

Despite the incessant announcements of breakthrough innovations in the technology of composting, all major economically feasible advances are thought to have been made. The so-called breakthroughs are either a minor modification of existing systems or the utilization of mechanical devices unrealistically expensive either in capital or in operating costs, or in both. Four composting methods are compared in Table 5-6:

Table 5-6: Comparison of Composting Method

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

Disadvantages

- Transportation costs
- Requires separation of organic wastes by source or pre-sorting.

Applicability

Composting technology is judged unsuitable for the study area due to the following reasons.

- There is no large market for compost product. This statement can be supported by the fact that even cow dung which has better quality than compost is disposed of in the study area.
- Composting under the very cold climate in the study area requires the expensive investment for the facility and the expensive operation method. Therefore, the project will be financially difficult.

a.4 Biogas Production

Biogas is the combustible gas developed when organic matter is degraded under anaerobic conditions, i.e., without the presence of oxygen. The energy will be bound in the hydrocarbon combination methane, which is the main element of natural gas. Anaerobic degradation of organic matter, resulting in biogas production, is an efficient means of degrading organic wastes, and making it hygienic.

Anaerobic waste treatment is a well known process relating to treatment of farmyard manure, sewage sludge and industrial waste water and other sludge. In the process, part of the organic material is transformed into carbohydrates, proteins, and fat by means of micro organisms. First the material is decomposed by certain bacteria to organic acids and carbon dioxide, after this process other bacteria decompose the organic acids and convert hydrogen to methane. Biogas can be utilized both for heat and power production. First certain bacteria decompose the material to organic acids and carbon dioxide, after this process other bacteria decompose the organic acids including hydrogen to methane. Biogas can be utilized both for heat and power production. The residues are sludge, which can be utilized as compost (a soil-improving agent) when not contaminated with non-organic matter.

In Denmark several biogas plants has been established within the last 5 – 10 years. Only a few of these plants process organic waste from households and gained experience is still limited. Whilst experimental plants have been built to anaerobically digest municipal solid waste, to date these have not all proved successful.

A large-scale plant (capacity: 80 ton per day, price: US$ 10 mill.) constructed in Helsingor, Denmark was operated for 4 years. It was closed in 1996 because of complaints from neighbors due to nuisance from bad smells and because the required separation of municipal waste into organic waste and material not appropriate for the process was too expensive.

Grindsted biogas (price: US$ 15 mill.) plant handles approximately 2,000 ton of organic household waste per year together with approximately 20,000 ton of sewage sludge. Herning biogas plant (price: US$ 7.5 mill.) handles approximately 1,300 ton of organic household waste per year together with approximately 5,200 ton of sewage sludge. In the cities of Herning and Grindsted organic waste has been processed in their biogas plants in the last few years.

These 2 biogas plants has experienced that the following conditions must be present to ensure the operation of the plant and to produce reusable residues:

- To ensure the operation of the plant without breaking down and to avoid problems with neighbors due to nuisance of bad smells the organic waste from households must only contain organic matter. It is particularly important that the organic matter is free from plastics in the waste because such contamination often causes a break down of the plant. Due to these problems some household waste has been rejected from the plant in the city of Herning. In the city of Grindsted a plant has been established based on source separation of waste by every household. Organic waste is collected in bio degradable paper bags and is therefore free of contamination.

- To secure reusable residues from the biogas plant the organic matter used in the plant must be free from non organic matter to avoid pollution when using residues as soil improvement agent.
- To insure an optimal quality of organic waste from households the experience in Denmark is, that it is of the greatest importance to establish a collection system for organic waste based on source separation at each household.

It is possible to add the following wastes to biogas producing waste treatment plants:

- organic wastes from households, including meat and vegetables
- flowers, including herb wastes from gardens
- coffee grounds - tea leaves including paper filters
- fruit wastes
- paper kitchen towels and tissues
- organic sludge and waste water from industry, including the food industry
- sewage sludge (activated)

However, one should exclude waste water and wastes containing heavy metals, and wastes from some branches of the chemical industry.

From a practical point of view, it is an advantage to place the biogas producing plant near a waste water treatment plant, in order to supply the biogas plant with water to dilute incoming wastes, and to supply power to the waste water treatment plant and achieve useful synergy.

Its advantages and disadvantages are summarized as follows:

Advantages

- resource recovery of wastes into potentially useful products, i.e., methane gas and compost (sludge for soil improvement purposes
- minimal potential soil, water and ground water pollution

Disadvantages

- high investment cost
- only few years operational experience of municipal wastes
- transportation costs
- requires pre-sorting of organic wastes.
- not possible to locate near urban areas because of nuisance from offensive odor, unless expensive technical measures are taken.

Applicability

The process of anaerobic digestion of animal manure and sludge from treatment of wastewater has a relatively long history (1,000 years or more). Plants based on this kind of raw material are being operated all over the world. However, a biogas production applying MSW as the raw materials does not appear to be an appropriate technology for adoption in the study area for time being due to the following reasons:

1. The operation technology has not been established because the requirements are very high and complicated. Even in Japan, which is one of countries having advanced solid waste technologies, it is still on the stage that only pilot plants have started operation in order to realize commercial plants in future.
2. This technology is more appropriate for liquid waste rather than for heterogeneous waste like those MSW because of high demands for organic waste not contaminated with non-organic matter.

3. The required investment for facilities is very high. （Note: The construction cost of the Helsing or plant with the capacity of 80 ton per day is US$10 million)

a.5 Size Reduction (Crushing and Shredding)

A size reduction facility is normally equipped with crushing and shredding functions, and is generally used as a pre-treatment facility of an incineration plant, composting plant and other intermediate treatment facilities. It is also used to improve sanitary landfill operations.

Shredding reduces the volume of waste to be transported to the final disposal site for sanitary landfill operations. Shredded waste settles more quickly than unshredded waste, making the landfill sanitary and less subject to complaints from nearby residents. This condition also ensures fewer spontaneous combustion during landfill operations. Because this condition produces fewer rodents and insects, less insecticides and pesticides shall be required.

Shredded wastes cause less damage to the landfill equipment and trucks than unshredded waste, and has a high compaction rate.

The term "crush" has various meanings, i.e., shredding, milling, pulverizing, grinding, cutting, tearing, ripping, etc., for which appropriate machines are developed.

An ordinary hammer mill with a swing hammer attached to the horizontal or vertical shaft rotates very fast. Waste is dumped from above, and discharged from the opening at the bottom after it is pulverized by the shearing force of the cutting board.

The grindability of a machine depends upon the substances to be crushed and the size required by the treatment system. The pulverizing process will be accompanied with sieving, if necessary.

Advantages

Advantages of shredding and crushing are listed below.

- Shredding and crushing (size reduction) contribute to the work efficiency of other intermediate treatment facilities.
- It is well adapted to the local conditions and intended plans because (1) shredding reduces volume by about 50%, thus making transportation easier and more efficient, and (2) shredded waste spreads more easily. Shredded waste is compacted better in the sanitary landfill and takes up less space making the landfill area last longer.
- Shredding and crushing produce a more compact and ultimately more stable sanitary landfill, hence raising the post-closure value of the land.
- Since shredding and crushing facilitate waste compaction, ensures fewer spontaneous combustion and propagation of fewer flies and rodents during landfill operations, particularly if solid waste disposed receives a final cover.
- Shredding and crushing definitely increase compaction, making landfills denser and reduce the percentage of settlement.

Disadvantages

- The use of the rotary type hammer crusher consumes large amount of electricity as it usually requires a high powered electric motor.
- Damage due to explosion caused by flammable matters in waste might occur frequently. Therefore, strict checking and sorting out of dangerous matters have to be done.

- Frequent repair works or replacement of damaged parts shall be necessary for the tremendous wear and tear of mechanical parts such as hammer beaters, shear blades, etc.

Applicability

Crushing and shredding targeting bulky waste is infeasible in the study area due to expensive cost and little amount of bulky waste. However, because these technologies will be often required as pre-treatment technology for the other technology, the economical crushing and shredding system, there is a possibility to adopt these technologies.

a.6 Mechanical and Manual Sorting

Mechanical sorting and manual sorting are inexpensive technologies used to recover as much valuable materials as possible from waste generated without causing any secondary environmental pollution.

Metals, non-ferrous metals, papers, cardboard, glass, plastics, rags, leather are separated manually or by use of an air classifier or a magnetic separation equipment, depending on their respective characteristics. Air for the operation of an air classifier can be supplied by low-pressure blowers or fans.

Advantages

- With the existence of various sorting devices such as pneumatic, mechanical, and magnetic separation equipment, sorting is effectively executed under hygienic conditions.
- Many sorting systems are relatively simple and easy to operate.
- These sorting systems require comparatively cheaper investment, utility cost, and maintenance cost.

Disadvantages

- This system does not contribute to the compaction of waste as its use is generally limited to relatively dry wastes with rich inert material content.
- Objects rejected after usable materials are sorted have to be re-hauled to the landfill site.
- The materials obtained by mechanical separation are generally of inferior quality in comparison to materials manually sorted out. For example, with the pneumatic device, materials recovered are usually a combination of light fractions, e.g., plastic and paper. Each fraction cannot be completely separated because the specific gravity of both materials is almost equal to the specific weight.
- Manual sorting puts the workers at risk due to the possible inclusion of infectious or hazardous wastes.

Applicability

Mechanical sorting facility to recover recyclables is financially infeasible in the study area. However, the economical manual sorting as recovery of recyclables or as pre-treatment of intermediate treatment may be financially feasible.

a.7 Summary of Screening Work for Intermediate Treatment Technology

The above-mentioned screening work for intermediate treatment technology is summarized in the table below.

Table 5-7: Characteristics of Possible Intermediate Treatment System

Intermediate Treatment Technology	Recovered Material	Main Target of System	Contribution to Landfill		Special Cautions							***Evaluation of Applicability***
			Volume Reduction	Stabilization	Stability of Technology	Pre-treatment	Rejected Substances	Acceptability of Refuse Quality	Construction Cost (US$/ton)	Marketability of recovered Material	Environmental Impact	
Incineration	Heat or Electric Power	Volume Reduction & Energy Conversion	A	A	A	Not Necessary	Non-combustibles (Ash)	A	High	B	B	It is not applicable because of • High initial/running cost and cheap sanitary landfill cost estimated by the Team
RDF	Solid Fuel	Conversion to Fuel	B	A	B	Necessary (size reduction, sorting)	Kitchen waste, Metal, Glass, Stone, Ash etc.	A	Low	A	B	It may be applicable if the following issues are cleared: • Stability of supplier and user • Measures to avoid air pollution
Biogas	Gas & Compost	Conversion to Fuel & Soil Conditioner	B	B	C	Necessary (size reduction, sorting)	Ash, Metal, Glass, Stone, Plastic, etc.	C	High	Gas : B Compost : C	C (Odor)	It is not applicable because of • Unproven technology • Requirement of strict segregation of waste and treatment of huge waste water
Composting	Compost	Conversion to Soil Conditioner	B	B	A	Necessary (size reduction, sorting)	Non-combustibles (Glass, Stone, Plastic, etc.)	B	Middle (Vessel type)	C	C (Odor)	It is not applicable because of • Lack of demands of the product (compost) • Unsuitable composition of waste, few compostable wastes
Size Reduction (Crushing & Shredding)	Ferrous etc.	Volume Reduction of Bulky Waste	C	A	A	Extraction of Explosive Object	Discarded Material	C	Low	B	C (Noise & Dust)	It is not applicable because of • No bulky waste
Sorting (Mechanical or Manual sorting)	Ferrous, Glass, Paper, Plastic, etc.	Recycling	B	A	A	Occasionally Necessary	Discarded Material	C	Low (Manual) Middle (Mechanical)	A	B	In addition to promotion of 3Rs, manual sorting system is recommended to provide job opportunities to waste pickers who will loose job when the new disposal site will open.

Note: A: Excellent B: Good C: Fair

5.3.5 Final Disposal Site

Possible Alternative Systems

Upon consideration of the possible alternative systems for final disposal the following aspects are to be taken into account:

- final disposal methods
- landfill structure
- level of sanitary landfill development and operation

a. Final Disposal Methods

The final disposal methods can be divided into the following three types:

- open dumping
- controlled tipping
- sanitary landfill

Although the open dumping method is generally employed in the disposal sites in the study area, this operation shall be terminated in view of its adverse effects on landscape, public health and the environment.

Sanitary landfill should be adopted as it has been proven to be the most economical final disposal method in terms of controlling environmental impacts within the acceptable level.

The advantages of sanitary landfill are as follows.

- Where land is available, sanitary landfill is usually the most economical solid waste disposal method.
- Sanitary landfill is not investment intensive compared with other disposal methods, i.e., composting and incineration.
- In contrast to incineration and composting, sanitary landfill does not require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.
- A sanitary landfill can receive all types of solid wastes, eliminating the necessity for separate collections.
- A sanitary landfill is manageable; increased quantities of solid wastes can be disposed of with a minimum number of personnel and equipment.
- Submerged land may be reclaimed for use as parking lots, playgrounds, golf courses, botanical gardens, etc.

b. Landfill Structure

There are five types of landfill structure as shown below.

- anaerobic landfill
- anaerobic sanitary landfill
- improved anaerobic sanitary landfill
- semi-aerobic sanitary landfill
- aerobic sanitary landfill

Either of the above landfill structures contribute to the mitigation of environmental pollution. Figure 5-2 illustrates each of the above landfill structures.

Anaerobic landfill

As leachate generated in landfill layers is hardly drained, the landfill layers constantly maintain anaerobic condition. The quality of leachate is very poor, causing bad odour and propagating vectors and vermes.

Anaerobic sanitary landfill

Covering soil is applied on each layer of waste thereby preventing the outbreak of bad odour and incidental fires, and the propagation of harmful insects to a certain extent. However, leachate and gas generation problems remain.

As in anaerobic landfill the landfill layers maintain anaerobic conditions.

Improved anaerobic sanitary landfill

In addition to covering soil this landfill structure is constructed with a leachate drainage facility at the bottom of the disposal site. Leachate quality is improved and anaerobic conditions are maintained.

Semi-Aerobic sanitary landfill

Leachate quality is favourably improved with constant drainage. Drainage pipes stimulate natural ventilation, achieving aerobic conditions in the landfill layers and consequently accelerating solid waste decomposition.

Aerobic sanitary landfill

In addition to the drainage pipes used in semi-aerobic landfills, air supply pipes are introduced for forced air injection to achieve aerobic conditions in the layers, thereby accelerating solid waste decomposition and stabilisation and improving leachate quality.

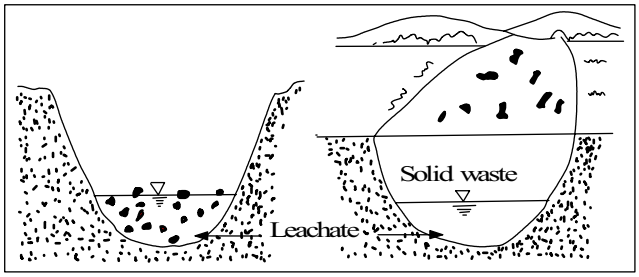
Applicability

The semi-aerobic sanitary landfill or aerobic sanitary landfill methods are generally adopted aiming at the improvement of leachate quality. When the utilisation of biogas by using anaerobic digestion is planned in the region, the improved anaerobic sanitary landfill with liner is generally adopted.

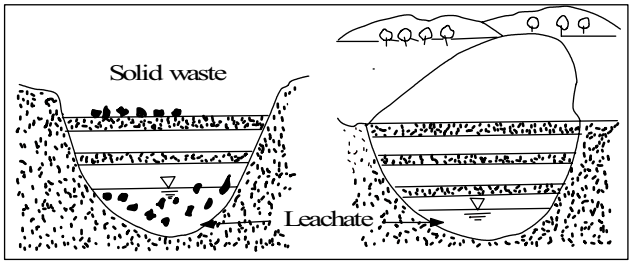
The best landfill method depends on many factors such as the total solid waste management system, especially the type of processing and treatment method adopted, the climate, the natural condition of the disposal site, the available budget for solid waste management, etc. Therefore, these all factors have to be taken into account to select the best landfill method so that its own advantages can be effectively utilised.

In the study area, there is less precipitation and the wastes contain a lot of ash, therefore, the possibility of generating leachate is very low. Hence, the possibility of generating biogas also very low due to the composition of wastes that biodegradable wastes especially contents of kitchen wastes are very low. Therefore, semi aerobic sanitary landfill method is recommended as future landfill structure in the study area.

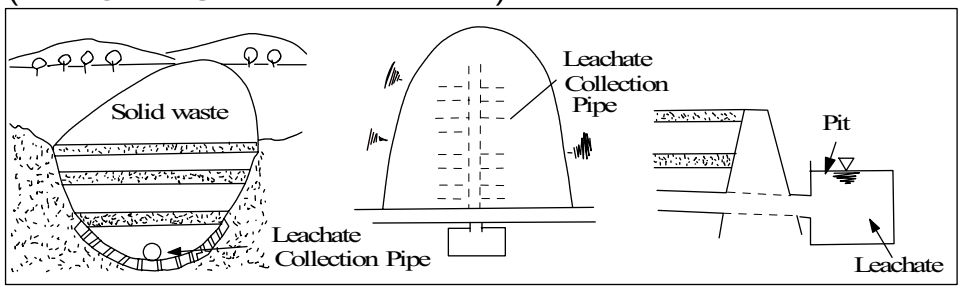
ANAEROBIC LANDFILL



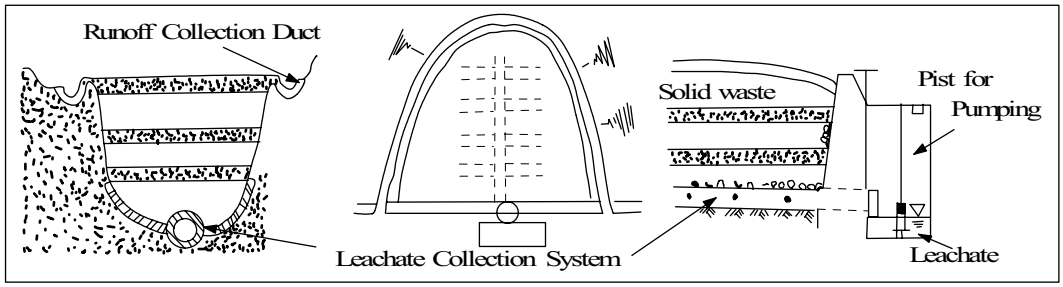
ANAEROBIC SANITARY LANDFILL



IMPROVED ANAEROBIC SANITARY LANDFILL
(IMPROVED SANITARY LANDFILL)



SEMI-AEROBIC LANDFILL



AEROBIC LANDFILL

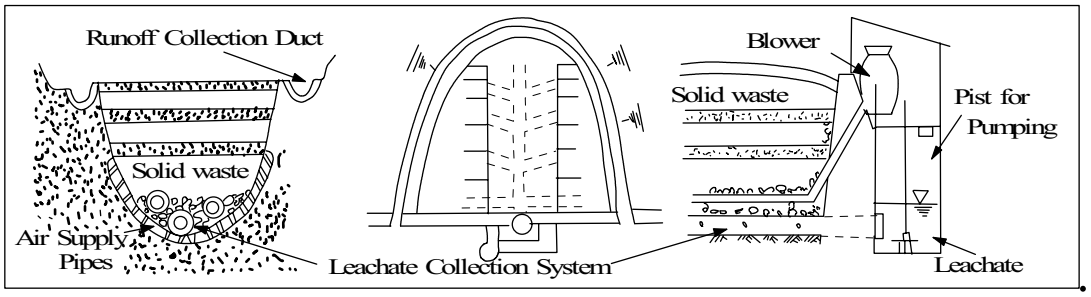


Figure 5-2: Landfill Structures

c. Level of Sanitary Landfill Development and Operation

The sanitary landfill development and operation levels are classified as follows:

- Level 1, Controlled tipping
- Level 2, Sanitary landfill with dike and daily soil covering
- Level 3, Sanitary landfill with primary leachate circulation system
- Level 4, Sanitary landfill with leachate treatment system

The prospective sanitary landfill development and operation levels are illustrated in Figure 5-3.

The above mentioned sanitary landfill development and operation levels are described below.

Level 1: Controlled Tipping

Introduction of controlled tipping through:

- Establishment of access to site.
- Provision of cover materials for the prevention of fire outbreaks and the dispersion of rank odour.
- Establishment of inspection, control and operational recording system for incoming waste.

Level 2: Sanitary Landfill with Dike and Daily Soil Covering

Introduction of sanitary landfill through:

- Establishment of disposal site boundary to eliminate scavenging and to avoid light waste scattering by wind.
- Execution of sufficient cover over waste disposed.
- Enclosing the disposal area with a dike.
- Construction of a divider between present and future landfill areas.
- Establishment of a drainage system in order to divert storm water flow from surrounding areas away from the disposal site and to reduce leachate.
- Construction of environmental protection facilities, such as buffer zone, litter control and gas removal facilities, to abate direct impact on surroundings.
- Installation of gas removal facilities to achieve the conditions necessary for a semi-aerobic sanitary landfill.
- Introduction of amenities for staff

Level 3: Sanitary Landfill with Leachate Circulation

Establishment of leachate control through:

- Installation of leachate collection, circulation and monitoring facilities.
- Installation of liners for seepage control.
- Construction of semi-aerobic sanitary landfill to accelerate waste decomposition and facilitate stabilisation.
- Introduction of water sprinkling for dust prevention.

Level 4: Sanitary Landfill with Leachate Treatment

Establishment of leachate treatment through:

- Installation of an oxidation pond.

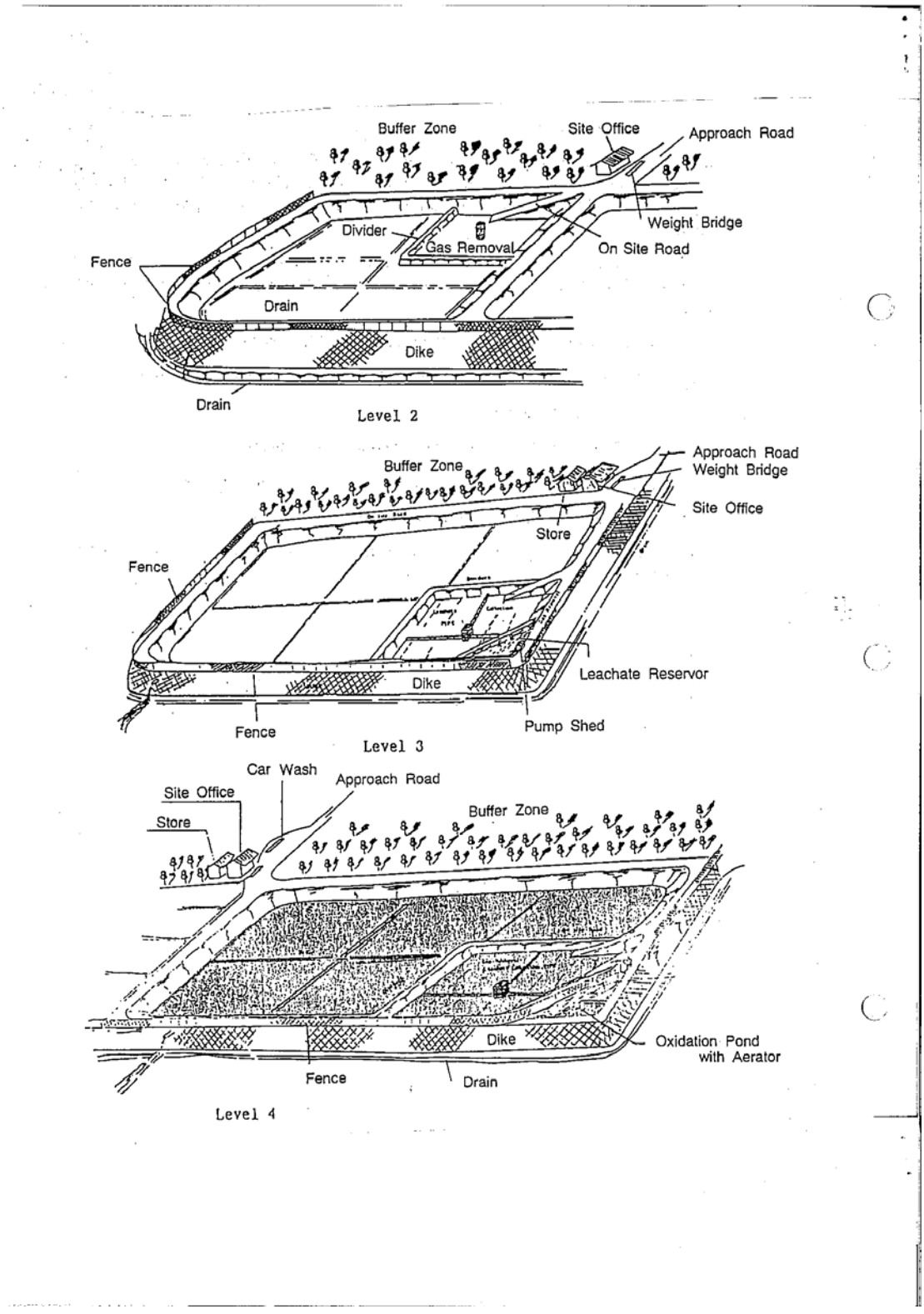


Figure 5-3: Illustration of Prospective Sanitary Landfill Development and Operation Levels 2, 3 and 4

The above mentioned sanitary landfill development and operation levels are described and tabulated in the table below. Table 5-9 shows the environmental standard each landfill level has to meet.

Table 5-8: Outline of Sanitary Landfill Development and Operation

Items		Level of Sanitary Landfill				Remarks
		1	2	3	4	
1	**Site Development**					
1.1	*Main Facilities*					
a.	Enclosing Structures					
	• Enclosing dikes		A	A	A	
	• Dividers		B	A	A	B means a dike made of refuse and soil
b.	Drainage System					
	• Surrounding drains		A	A	A	
	• On-site drains (surface water)		A	A	A	
	• On-site drains (spring)		A	A	A	If necessary
	• Drains for reclaimed area		A	A	A	
c.	Access					
	• Approach roads	A	A	A	A	
	• On-site roads	A	A	A	A	
	• Others	A	A	A	A	Improvement of existing road network to access the sites
1.2	*Environmental Protection Facilities*					
	Buffer zones		A	A	A	
	Litter control facilities		B	A	A	Movable fences, etc.
	Gas removal facilities		B	A	A	
	Leachate collection facilities			A	A	
	Leachate circulation facilities			A	A	
	Seepage control facilities			B	A	
	Leachate treatment facilities				A	
1.3	*Building and accessories*					
	Site office	B	A	A	A	
	Weighbridge	A	A	A	A	
	Store			A	A	
	Safety facilities		A	A	A	Gate, fence, lights, etc.
	Fire prevention facilities		B	A	A	Water tank, extinguisher, etc.
	Monitoring facilities			A	A	Monitoring well, etc.
	Car washer			A	A	
2	**Equipment**					
	Landfill Equipment	A	A	A	A	
	Others			A	A	Water truck, inspection vehicles, etc.
3	**Operation and Maintenance**					
3.1	*Operation*					
	a. Personnel	A	A	A	A	
	b. Cover material	B	A	A	A	B means insufficient soil cover.
	c. Utility					
	• Fuel tank	A	A	A	A	
	• Water		A	A	A	
	• Electricity	B	A	A	A	
	d. Chemicals					
	• Insecticide	A	A	A	A	
	• Monitoring chemicals			A	A	
	e. Others		A	A	A	Divider, drain for reclaimed area, leachate collection pipes, etc.
3.2	*Maintenance*					
	• Main facilities		A	A	A	
	• Environmental protection facilities		A	A	A	
	• Building and accessories	A	A	A	A	
	• Equipment	A	A	A	A	

A: necessary
B: necessary under certain conditions, or may be omitted when budget is not enough

Table 5-9: Environmental Standards for Each Sanitary Landfill Development and Operation Level

Items		Sanitary Landfill Development and Operation Level			
		Level 1	Level 2	Level 3	Level 4
1	**Landfill Structure**				
1.1	Landfill Structure	Anaerobic Sanitary Landfill	Improved Anaerobic Sanitary Landfill	Semi-aerobic Sanitary Landfill	Semi-aerobic Sanitary Landfill
1.2	Achieved Condition	• Leachate generated in solid waste layers is seldom drained; an anaerobic state is maintained. Generally, the quality of leachate is poor. • Because of inactive decomposition of wastes, stabilisation is slow.	• Through gas removal facilities, the quality of leachate is slightly better than in Level 1; an anaerobic state is maintained. • The rate of decomposition is slightly improved.	• Leachate accumulated at the bottom of landfills is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit natural ventilation. • This structure facilitates decomposition of solid waste because a semi-aerobic condition is maintained. The quality of leachate is much improved and generation of offensive odour is further reduced. • Water content of solid wastes is lower than Level 2	• Leachate accumulated at the bottom of landfills is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit natural ventilation. • This structure facilitates decomposition of solid waste because a semi-aerobic condition is maintained. The quality of leachate is much improved and generation of offensive odour is further reduced. • Water content of solid wastes is lower than Level 2
2	**Leachate and it's Impacts on Surroundings**				
2.1	Leachate Generation Amount	• Leachate is freely discharged outside of both landfilling and reclaimed areas because of the absence of an enclosing structure. • Rain water flows into the landfill from catchment area and increases leachate amount.	• As for reclaimed areas, surface water is drained and discharged outside. • Rain water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.	• As for the reclaimed areas, surface water is drained and discharged outside. • Rain water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.	• As for the reclaimed areas, surface water is drained and discharged outside. • Rain water from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.
2.2	Leachate Control Facilities	• None	Enclosing dike and divider prevents direct discharge of leachate.	• In addition to the facilities for Level 2 are leachate cycling and monitoring facilities. • Leachate is discharged only during heavy rain from regulating pond. Leachate discharged is therefore, diluted.	• Conditions are similar to Level 3 except for effluent which is constantly treated and discharged from oxidation pond.
2.3	Leachate Treatment Facilities	• None	• None	• Retention and regulation ponds may work as oxidation pond.	• Leachate is treated in an oxidation pond with aerator.

Items		Sanitary Landfill Development and Operation Level			
		Level 1	Level 2	Level 3	Level 4
2.4	Leachate Quality	• High leachate content, and the quality is the poorest of all the landfill levels. The quality is also not expected to improve much even after a long period of time.	• Amount of leachate is limited because of dike and divider. However, leachate quality does not improve even after a certain period of time.	• Amount of leachate is limited as in Level 2. • The quality of leachate improves because of the semi-aerobic condition of the landfill. • Leachate circulation facilitates waste purification • Since leachate is discharged only during heavy rain, it is therefore, diluted.	• Amount of leachate is limited as in Level 2 • The quality of leachate will be treated in order to meet the effluent standards.
2.5	Leachate Impact				
a.	Impacts on Underground water	• The degree of the impact varies depending on the permeability of bottom soil. • If bottom soil is permeable, the impacts on underground water will be immense because of high pressure head and large amount of leachate.	• The degree of the impact varies depending on the permeability of bottom soil. • The amount of leachate is much less than Level 1. However, leachate would still have immense impact if bottom soil is permeable.	• Liner is laid to protect underground water from leachate seepage. • There is very little underground water contamination	• Liner is laid to protect underground water from leachate seepage. • There is very little underground water contamination.
b.	Impacts on Surface Water	• Because leachate is freely discharged from the landfill site, the impacts on surrounding water area is very high.	• Discharge of leachate may occur when the divider is submerged and through seepage. • Although leachate amount is limited, impacts on surrounding water area is high because of uncontrolled and unimproved leachate.	• Discharge of leachate occurs only during heavy rain. • Leachate can be monitored. In case leachate to be discharged would affect the surroundings, the construction of leachate treatment facility is encouraged.	• Effluent from landfill site will satisfy the required effluent standards.
3	**Others**				
3.1	Vector control	• Generates a large amount of flies, insects and rodents. • entices the huge gathering of crows • constant generation of rank	• Vector control is achieved and at a much improved level compared to Level 1.	• Vector control is achieved and at a much improved level compared to Level 1.	• Vector control is achieved and at a much improved level compared to Level 1.
3.2	Odours and Gas Production	• Occasional fires occur due to spontaneous ignition	• Conditions are much better than Level 1. • No fire outbreaks	• Due to semi-aerobic landfill structure, conditions are better than Level 2.	• Due to semi-aerobic landfill structure, conditions are better than Level 2.
3.3	Others	• scattering of wastes, dusty condition. • Deterioration of Landscape. • Noisy • Presence of scavengers.	• It is improved in all aspects.	• In addition to the condition achieved at Level 2, dust problems are mitigated with the use of a water sprinkler.	• Same as Level 3.

Applicability

In fact the sanitary levels of 3 existing disposal sites in UBC are worse than the first sanitary level which is the poorest.

Since it is difficult to improve the existing disposal site to fourth sanitary level in a short period, it is recommended that part of UCDS shall be improved through the pilot project and this improvement methods shall be applied to other disposal sites in a later stage.

New final disposal site is strongly recommended to be constructed and operated under forth sanitary level.

5.4 Selection of Optimum Technical System

5.4.1 Comparison of Alternatives

a. Selection of Final Disposal Site

The six potential disposal sites selected in the previously mentioned final disposal site selection work were presented in the St/C. Accordingly, the counterpart (C/P) and the study team compared the alternative six proposed disposal sites. In short, the waste collection and haulage including transfer station (T/S) and disposal cost was calculated for each site and the alternatives were assessed on how they fit in with the initial environment.

Table 5-10: Six Alternative M/P Technical Systems

Alternative (Site)	System
Alternative 1: Narangiin Enger disposal site (NEDS)	6 Districts => NEDS Nalaikh District => Nalaikh Coal Mining disposal site (NCMDS)
Alternative 2: XMK disposal site (XMKDS)	6 Districts => XMKDS Nalaikh District => NCMDS
Alternative 3: Morin Davaa disposal site (MDDS)	6 Districts => MDDS Nalaikh District => NCMDS
Alternative 4 : Tsagaan Davaa disposal site (TDDS)	6 Districts => TDDS Nalaikh District => NCMDS
Alternative 5: Bayangiin Khonkhor disposal site (BKDS)	6 Districts => Transfer Station (T/S) => BKDS Nalaikh District => BKDS
Alternative 6 BCMDS: Baganuur coal mining disposal site (BCMDS)	6 Districts => T/S => Railway => T/S => BCMDS Nalaikh District => NCMDS

From the results of the comparison of the alternative sites, the workshop participants assessed the pros and cons of the alternatives, based on the six proposed final disposal sites. The St/C decided upon the proposed Narangiin Enger site as the future disposal site for the main six districts of Ulaanbaatar City based on the results of the workshop investigation.

Therefore, waste generated in Ulaanbaatar City in 2020 is scheduled to be disposed of at the following four disposal sites.

Table 5-11: Final Disposal Site and Disposal Amount in 2020

Landfill site	Ratio (%)	Final Disposal Amount (ton/day)	
		Winter season	Summer season
NEDS	91	935.4	911.2
MDDS	5	51.3	50.1
NDS	3	30.8	30.1
KH21DS	1	10.3	10.0
Total	100	1027.8	1001.4

b. Introduction of Intermediate Treatment System

Comparative work for the intermediate treatment system was carried out in accordance with the selection policies and the details are described in the Annex Report. Introduction of a valuables sorting yard and RDF production facility was decided based on the results of the study and the main reasons for this decision are listed below.

b.1 Valuables Sorting Yard

- Waste Picker (WP) activity will be prohibited because sanitary landfill will be conducted at the new Narangiin Enger disposal site (NEDS). Therefore, the WPs who are making a living at the current Ulaan Chuluut disposal site (UCDS) will lose their livelihoods. Thus it is essential for securing their workplace.
- It will be possible to utilize the RDF production facility as a pre-processing facility.

b.2 RDF Production Facility

- Plastic and paper waste is a significant obstacle to the conservation of the environment of the final disposal site (waste scattering) and smooth operation (compaction).
- The proportion of plastic and paper waste in the municipal solid waste (MSW) of Ulaanbaatar City is extremely high. The combined percentage of plastic and paper waste in household waste in the Apartment area, which does not produce ash, is 36.1% in all year average and in the summer season it accounts for 34.1% of all MSW. As the density of this waste is low, the volume becomes several times higher than that of food waste and the above problems occur at the disposal site.
- On the other hand, the percentage of food waste which is generally a main cause of the deterioration of disposal site environments (generation of leachate and bad smells) is very low. It accounts for 37.3% of the household waste in the Apartment area, which does not produce ash, and in the summer season it does not account for more than 33.8% of all MSW. Furthermore, as cattle manure is discarded at the disposal site if the disposal fee is paid, it was decided that there is almost no demand for compost made from the MSW.
- There is extremely low domestic demand for plastic and paper waste materials and recycling and because most of the consumers are in China which is thousand of kilometers of transport away, it is limited to high cost PET bottles. Moreover, strict separation is essential for ensuring a prescribed quality for material recycling but it is difficult to implement separation.
- There is significantly high demand for waste to be used as fuel because the calorific value plastic and paper waste is extremely high (9,000 and 5,000 kcal/kg) and it is a cold climate. However, it is necessary to homogenize the size in order to use it as fuel, and the RDF production facility is an essential to do this.
- If the size is homogenized and it is possible co-combust with coal, it is possible to use the RDF produced from using plastic and paper waste at existing power plants or large-scale heat supply plants thus there is an enormous demand for it.

5.4.2 Selection of an Optimum Technical System

The optimum technical system was selected, as shown below, in accordance with the results of the comparison of alternatives.

Table 5-12: Optimum Technical System

Sub-system	Plan System
Discharge and Storage	● **Source Separation:** Waste will be separated into recyclable and non-recyclable waste in the Apartment area but it will be mixed discharge in the Ger Area. ● **Storage Container:** Public containers for bulk dischargers and other individual containers (generally, plastic bags)
Collection	● **Collection Frequency:** Twice a week in the Apartment Area (non-recyclable waste), once a week (recyclable) and twice a month in the Ger area. ● **Collection Method:** Point collection (Entrance Collection) and curb sude collection in the Apartment Area. Door to door collection in the Ger Area. ● **Collection Time:** Daytime collection ● **Collection Vehicle:** Compactor truck in the Apartment Area and dump truck in the Ger Area. ● **Haulage Method:** Directly transported to each disposal site.
Public Area Cleansing	Combination of manual and machine use. Revised taking into consideration future costs and manpower from the viewpoint of the cost benefit of the proportion of manual labour and machinery.
Recycling	The following public participation recycling systems will be established. ● A plan will be established to promote and develop private sector recycling activities. One plan for this is to construct a recycling complex adjacent to NEDS in order to attract private enterprises. ● A separate discharge system will be established at the source and recycling of the separately discharged waste will be promoted.
Intermediate Treatment	A valuables sorting yard and RDF Production facility will be constructed and will operate within the Narangiin Enger Recycling Complex (NERC) to recycle the recyclable waste discharged separately from the Apartment Area.
Final Disposal	Suitable landfill will be carried out at the following 4 disposal sites. ● NEDS: Sanitary landfill ● Morin Davaa disposal site, Nalaikh disposal site, Khoroo 21 disposal site: semi-sanitary landfill.
Maintenance for Vehicles	● Carry out preventative maintenance and establish a small-scale repair shop and entrust large-scale repairs to private companies.