PREPARATORY SURVEY
FOR
INTEGRATED SOLID WASTE MANAGEMENT
IN NAIROBI CITY
IN
THE REPUBLIC OF KENYA

FINAL REPORT

VOLUME 3

SUPPORTING REPORT

SECTION E

FINAL DISPOSAL

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FINAL DISPOSAL

1. INTRODUCTION

The Dandora Dumpsite is the only official dumpsite currently operating in Nairobi and where the waste collected in the city is dumped. However, there are also approximately 70 illegal dumpsites scattered throughout the city and waste collected by private collectors is dumped at those sites. Also, in slum areas and low income residential districts, waste is dumped on roadsides and in vacant spaces. The Kayole dumpsite acts as a temporary site managed by National Environment Management Agency (NEMA) for disposing wastes picked up from the Nairobi River, etc. Wastes from Nairobi City are not supposed to be dumped there, but in reality the private collectors dump the wastes collected by them at this facility.

The Dandora Dumpsite is an open dumping disposal site; however, because landfill management is not adequately conducted, negative impacts are imparted on the local environment due to generation of landfill gas. Accordingly, it is necessary to close the Dandora Dumpsite and to build a new landfill site that applies the sanitary landfill method as quickly as possible.

Under the above circumstances, this report discusses the following points:

- Present condition and evaluation of final disposal
- Future plans for final landfill site
- Closure plan of Dandora Dumpsite
- Clean-up and closure of illegal dumpsites

Finally, the action plan up to 2030 is divided into the Short-Term (2011~2015), the Mid-Term (2016~2020) and the Long-Term (2021~2030).

The current condition of illegal dumping sites is described in **Section C of Volume 3, Supporting Report**.

2. PRESENT CONDITION AND EVALUATION OF FINAL DISPOSAL

2.1 Introduction

In Nairobi City, there are three kinds of dumpsite: the official Dandora dumpsite, the Kayole temporary dumpsite managed by NEMA, and the illegal dumpsites. In this chapter, the current condition of the Dandora Dumpsite and the Kayole temporary dumpsite are gauged with a view to identifying the problems and issues that confront final disposal in Nairobi. Details regarding the condition of illegal dumpsites are given in the section on collection and transportation.

2.2 Description and Evaluation of Dandora Dumpsite

2.2.1 Outline of the Situation

(1) Location of Dandora Dumpsite

The Dandora Dumpsite is located in the northeast side at about 7.5 km away from the central part of Nairobi. Before the Dandora dumpsite area used, there was a quarry of approximately 2 ha in the north-western part. The depth of the quarry was about 20 to 30m. Other portions of the ground inclined gently toward the Nairobi River.

The Wangu Primary School, Dandora Secondary School and James Gichuru Primary School are located in the South. Nairobi River flows in the North, and the East and West sides serve as the residential areas in Dandora. The opposite side of the Nairobi River also serves as a residential area. The Location Map of the Dandora Dumpsite is shown in **Figure E.2.1**.

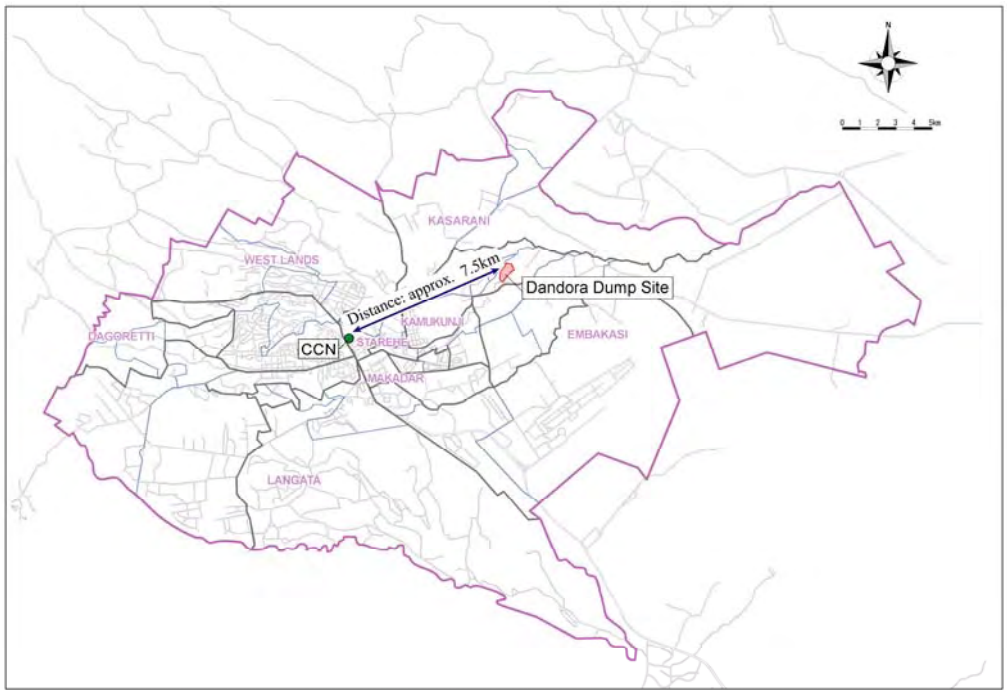
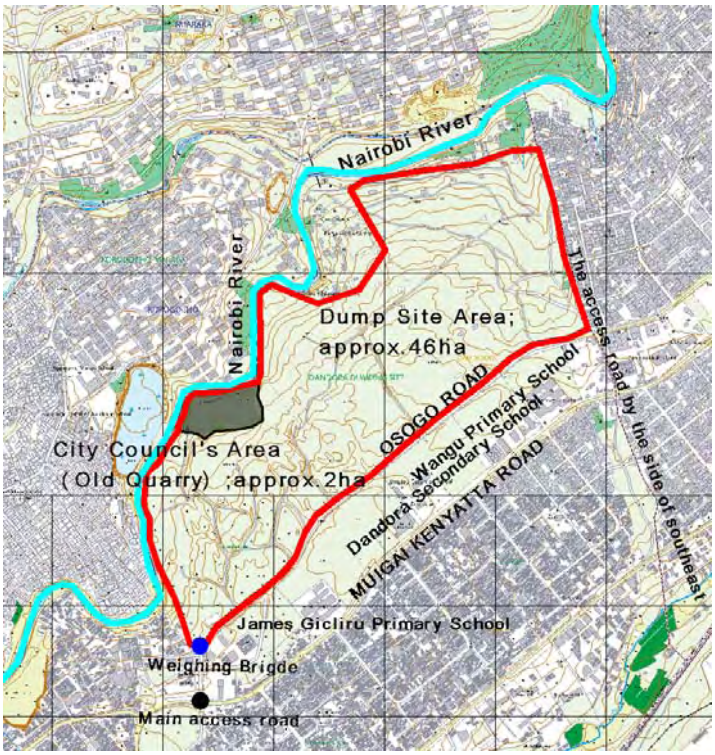


Figure E.4.1 Location Map of Dandora Dumpsite

(2) Range of Reclamation



The total area covered by waste in Dandora is about 46 ha. Approximately 2 ha or the quarry at the western part is the City Council's disposal site, while the remaining portions are in private lands.

The overall area of the Dandora dumpsite is shown in **Figure E.2.2**.

Figure E.4.2 Detailed Location of Dandora Dumpsite

2.2.2 Current Condition

(1) Current Condition of Waste Disposal in Dandora Dumpsite

(a) Waste Amount

The landfill at the Dandora dumpsite began in 1981, and it is still currently being used. Since 2006 the weighing bridge has been used to measure the amount of waste brought into Dandora, as shown in **Figure E.2.2**. The total amount of waste brought in 2009 was about 220,000 tons/year. (For details, refer to **Supporting Report Section A.**)

From the analysis on the actual measurement of weight from 2006 to 2009, the total amount of reclaimed waste was estimated with respect to the population transition from 1981 to 2009. Approximately 3,550,000 tons of waste were reclaimed from 1981 to 2009, a total of 29 years. Estimated results are shown in **Table E.2.1**.

The total area of the Dandora Dumpsite is 46 ha. Additionally, according to the measurements undertaken during the present study, the average height of waste landfill is around 3 m. Also, part of Dandora Dumpsite was an old quarry and the average height of landfill in that area is estimated to be around 20 to 30 m.

Making an estimation based on the characteristics of Dandora Dumpsite (total area and average height of the landfill) the total waste amount in the dumpsite is assumed around 1,800,000 m^3 (20,000m^2 x 25m + 440,000m^2 x 3m = 1,820,000m^3).

Table E.4.1 Total Waste Amount of Dandora Dumpsite

	Waste Amount (ton)	Remarks
1981 ~ 2005	2,800,000	Estimated
2006	145,000	Actual
2007	187,000	Actual
2008	193,000	Actual
2009	222,000	Actual
TOTAL	3,547,000	

(b) Waste Composition

Different types of waste have been transported to Dandora Dumpsite. Almost half of the waste generated in Nairobi City is Food Waste according to the WACS and hence it can be said that around half of the waste transported to Dandora Dumpsite is composed of Food Waste.. The other half of the waste could be composed of paper, plastics etc., and a small amount of medical waste with some intermediate treatment.

For details of waste composition, refer to **Volume 3, Supporting Report Section A**, Waste Generation and Composition Analysis.

(2) Current Condition of Landfill Operation

(a) Landfill Method

At the Dandora dumpsite, after weighing at the weighing bridge which is located at the entrance to the landfill, dumping is done at any possible location. After dumping, no action to flatten the waste by bulldozer is carried out. Moreover, no gas exhaust equipment and leachate drain are installed in the landfill area. From the above description, the landfill method at the Dandora dumpsite is said to be an open dumping system.

(b) Soil Cover

Wastes of approximately 610 tons are brought in one day. However, no covering of soil is done and the waste at the site is left in a bare state.

(c) Situation of Leachate Management

At the Dandora dumpsite, there is no proper soil cover and drainage facilities have not been installed to remove rainwater from the landfill area. Therefore, the stagnating rainwater at places where waste has been dumped becomes leachate which flows downstream into the Nairobi River excluding the evaporation amount. Since this situation becomes an index to judge the condition of the reclaimed waste and the influence on the Nairobi River, it is essential to measure the water quality and amount of water in the leachate. However, water quality and the amount of water in the leachate are not managed.

(d) Situation of Landfill Gas Emission

Hazardous landfill gas (e.g., methane gas) is produced by wet organic wastes decomposing under anaerobic condition in a landfill. The waste is covered and mechanically compressed by the weight of the material that is deposited from above. This material prevents oxygen exposure thus allowing anaerobic microbes to thrive. With regard to the Dandora dumpsite, because no gas exhaust equipment and leachate drains are installed, it is assumed that there is lack of air circulation in the dumped waste, a circumstance where methane gas could be easily generated. Under the present condition, around the west side of the Old Quarry, the occurrence of landfill gas has to be verified in areas where waste is highly stocked. On the east side, no landfill gas emission has occurred.

The present situations of landfill at the Dandora dumpsite are as shown in **Photo E.2.1**.

West Side

East Side

Landfill Gas Emission

Waste Pickers

Photo E.4.1 Situations of Dandora Dumpsite

(3) Management Condition

(a) Management Organisation and Administrative Staff

The management of Dandora dumpsite is done under the Solid Waste Management Section of the Department of Environment (DoE). As for the personnel involved, refer to the portions

encircled in red in the personnel organisation chart shown in **Figure E.2.3**. The list of management personnel is shown on **Table E.2.2**.

As the table shows, there are 12 management personnel including the Dumpsite Manager for Dandora Dumpsite. According to the field survey findings, weighing of waste is carried out and the records are consolidated in the Dumpsite Manager's office. Moreover, waste dumping positions are instructed at the entrance gate. However, no evidence of waste compacting and so on could be confirmed.

Table E.4.2 Work Allocation for Dandora Dumpsite

Scale	Position	Work Allocation	Number
8	Env. Officer I	Dumpsite Manager	1
9	Env. Officer II	Deputy Dumpsite Manager	1
13	Env. Assistant III	Clerk (Operating the Computer)	2
16	Artisan III	Supervision of machines operating at the site	4
17	Ungraded Artisan	- Washing of weighbridge, cleaning of office, controlling trucks - Control of illegal dumping along access roads	1 2
18	Labourer II	Messenger, Dandora-Kaloleni-City Hall	1

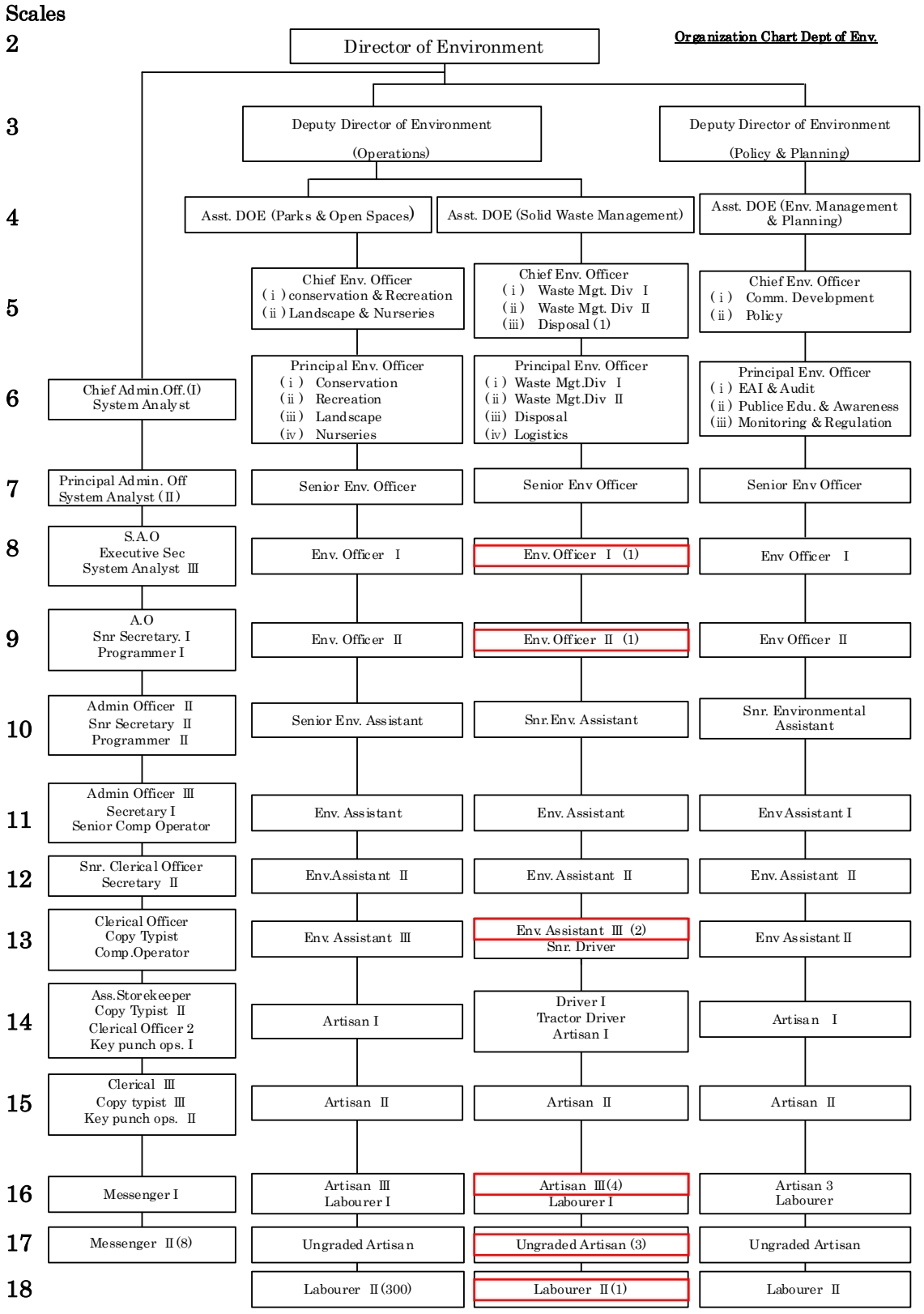


Figure E.4.3 Personnel Organisation Chart – Department of Environment

(b) Current Condition of Machinery for Landfill Operation

The city council owns 4 units of bulldozers. However, since 2007, these have been grounded and only 1 unit was repaired in 2010. The present landfill activity is being managed by two subcontracted corporations. Operation is carried out using 2 bulldozers and 1 excavator.

(c) Annual Administrative and Maintenance Expenditures

For the maintenance and management of the Dandora dumpsite, the expenses shown below are necessary:

- Salary of administrative staff
- Heavy machine fuel and maintenance
- Weighing bridge maintenance fee
- Road maintenance fee

Annual maintenance expenses were incurred for the city's machinery used in the landfill operation up to the year 2006. Since the landfill operation has been subcontracted to private enterprises starting in 2007, two sorts of annual maintenance expenses are as shown in **Tables E.2.3 and E.2.4** where in the first case two units of the city's heavy machinery were operational while in the other case, two heavy machinery of the private subcontractor were operational.

Table E.4.3 Annual Expenditure for Dandora Dumpsite Operation (2006)

	Expenditure	Amount (KSh)
1	Total Salary	3,100,000
2	Heavy Machine Fuel and Maintenance	8,600,000
3	Weighing Bridge Maintenance Fee	3,000,000
4	Road Maintenance Fee	10,000,000
5	Heavy Machine Repair Fee	1,600,000
	Total Expenditure	26,300,000

Source: Department of Environment and City Council of Nairobi

Table E.4.4 Annual Expenditure for Dandora Dumpsite Operation (2009 Machine Hiring)

	Expenditure	Amount (KSh)
1	Total Salary	3,100,000
2	Machine Hiring Fee	35,000,000
3	Weighing Bridge Maintenance Fee	3,000,000
4	Road Maintenance Fee	10,000,000
	Total Expenditure	51,100,000

Source: Department of Environment and City Council of Nairobi

The comparison of costs of heavy equipment between 2006, when CCN equipment was used, and 2009, when equipment was leased from the private sector, shows that the latter case was around three times more expensive at KSh 35 million. Furthermore, looking at monthly payments to the private sector in 2009, the ability to pay is thought to be inadequate because there were months when zero payments were made. (See **Table E.2.5**).

The inability to pay could be due to the fact that the cost of maintaining heavy machinery accounts for roughly one-tenth of the DoE SWM budget. Accordingly, in order to properly operate heavy machinery without causing pressure on the budget, it will be necessary to repair the four heavy machines owned by the CCN and to stop leasing machinery from the private sector as quickly as possible.

Table E.4.5 Heavy Equipment Expenditures for Year 2009 (in KSh)

Month	Contractor A	Contractor B	Total Amount
January	2,083,791.67	1,693,000.00	3,776,791.67
February	1,944,888.89	894,833.33	2,839,722.22
March	2,858,625.00	1,523,000.00	4,381,625.00
April	3,114,166.67	1,395,333.33	4,509,500.00
May	4,012,375.00	2,066,666.67	6,079,041.67
June	1,619,500.00	2,066,083.33	3,685,583.33
July	803,833.33	382,750.00	1,186,583.33
August	594,000.00	0.00	594,000.00
September	218,000.00	162,250.00	380,250.00
October	406,250.00	231,416.67	637,666.67
November	2,520,833.33	1,025,250.00	3,546,083.33
December	1,370,125.00	2,588,333.33	3,958,458.33
Total Amount	21,546,388.89	14,028,916.66	35,575,305.55

Source: Department of Environment and City Council of Nairobi

(4) Environmental Situation of Dumpsite and Surrounding Area

The landfill gas produce by waste decomposition has ill effect on the workers as well as the residents nearby the dumpsite. The leachate water from the dumpsite is estimated to be one of the causes of the water pollution of Nairobi River. With regard to the environmental condition of the final disposal site and the surrounding area, reference is made to **Volume 3, Supporting Report Section G**.

(5) Current Situation of Waste Pickers

As shown in **Photo E.2.1,** approximately 1,500 Waste Pickers active in Dandora dumpsite extract "valuables" from the waste. As for the current situation of waste pickers, reference is made to **Volume 3, Supporting Report Section G**.

2.2.3 Evaluation of Current Condition

The following problems were identified in the survey of Dandora Dumpsite:

- Covering of soil to maintain the dumpsite in a sanitary condition has not been made.
- Large amounts of landfill gas have been generated in some parts of the dumpsite because no gas exhaust equipment or leachate drain has been installed.

In addition, the following maintenance issues were also identified:

- Enough payment has not been made to subcontractors of landfill works due to the breakdown of CCN's heavy machinery.
- Accordingly, sufficient landfill works has not been done.

Therefore, the measures such as soil covering, provision of heavy machinery for landfill works and protection from gas emission will be required urgently.

2.3 Description and Evaluation of Kayole Temporary Dumpsite

The present condition of the Kayole temporary dumpsite, which is receiving cleansing wastes and some parts of the municipal solid waste of Nairobi, is as described below.

2.3.1 Outline of the Situation at Kayole

The Kayole temporary dumpsite is located in the east side at about 13 km from the central part of Nairobi and south of the Dandora dumpsite. There are 9 quarries located along the southern reaches of the Ngong River and one of them is currently being used as the dumpsite. Land-filling at the dumpsite began in 2009. For this project it is planned to use 3 pre-established quarries located in that area as temporary dumpsites. However, during the site inspection it was noted that 2 of them had a great amount of accumulated water, rendering the area not suitable for waste disposal. There are some residential areas located in the northern side of the Ngong River, and to the south of the Quarry Area the Embakasi Garrison is located.

The dumpsite's location is indicated in **Figure E.2.4**. The range with which waste is filled is encircled by the red line which serves as the Quarry in **Figure E.2.5** whose area is approximately 4 ha and 23 m in depth.

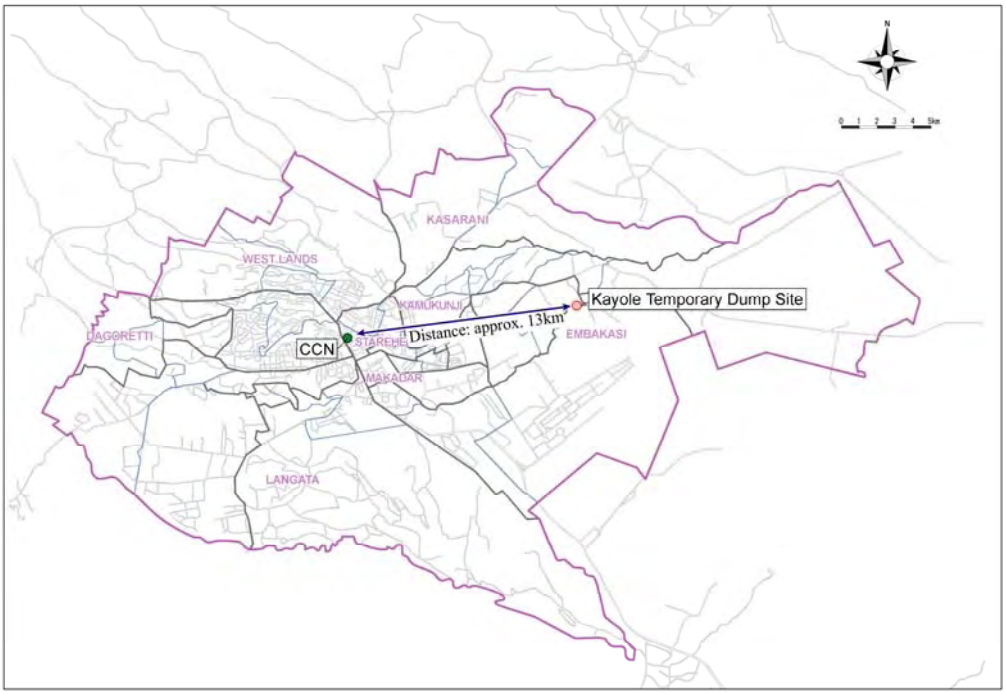


Figure E.4.4 Location MAP of Kayole Temporary Dumpsite

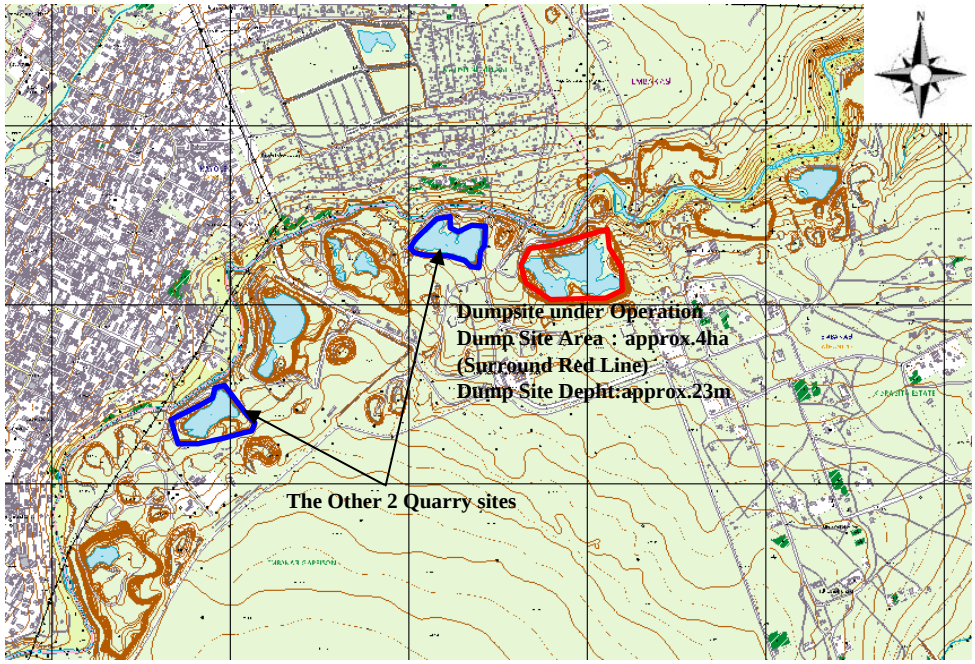


Figure E.4.5 Detailed Position of Kayole Temporary Dumpsites

2.3.2 Description of Current Condition

The quarry that is being used for landfill covers an area of 4 ha with a depth of 23m, and the volume for pocket is estimated to be around 920,000 m^3. On site it could be confirmed that the bedrock is exposed and there is no water filtration on the walls. The bedrock has a low permeability, based on the site observations. Water filtration through some fissures in the bedrock was not confirmed because only a partial part of the water pond was inspected. At the Kayole temporary dumpsite, after measurement by the temporary weighing bridge, the waste is carried and dumped into the bottom of the Quarry. The total amount of waste carried into the dumpsite in a day is approximately 400 tons, and waste is composed of river cleansing waste and municipal solid waste.

Within the landfill area, gas exhaust equipment and leachate drain facilities are not installed. There were 10 to 20 waste pickers and people doing stonecutting work in the dumpsite.

In addition, although the information gathered point to the existence of three quarries at the temporary dumpsite, landfill operation is actually performed in only one of them. The other two quarries are in a state where water has accumulated at the bottom, and in one of them, surplus soil from construction is being dumped.

2.3.3 Evaluation of Current Condition

The adverse impact on surrounding environment such as the generation of landfill gas has not been identified in the Kayole temporary dumpsite. However, its landfill is in the same situation as that of the Dandora dumpsite and it cannot be said that enough maintenance has been carried out. Therefore, the same measures such as soil covering and installation of gas exhaust equipment will be required as in Dandora. Also there is the possibility that there are fissures in the bottom of the quarry, allowing the flow of contaminants that might affect underground water deposits.

The current situation of the temporary dumpsite at Kayole is shown in the photos below.

Temporary Dumpsite at Quarry

The other 2 quarry sites

Photo E.4.2 The Kayole Temporary Dumpsites

3. REVIEW OF RELEVANT STUDIES

3.1 Review of UNEP Integrated Solid Waste Management Plan

The report was prepared on 17 February 2010, and its contents are composed of the vision and strategy for SWM, the Vaseline situation on SWM, success factor analysis, gap analysis, proposed plan of actions and specific actions for implementation.

(1) Goal

The goal of UNEP is related to final disposal to build environmentally sound infrastructure and systems for safe disposal of residual waste, replacing current disposal sites which must be rehabilitated.

(2) Target

The target of UNEP related to public awareness and education is as follows:

- For the establishment of a sanitary landfill for the city, an agreement has to be reached by mid-2010 between CCN, MoLG, MoENR and MoNMD (and other key actors) for MoNMD to take on the role of developing a safe disposal facility for residuals arising from the ISWM system. MoNMD shall undertake to bring such a facility on stream by 2015.

(3) Specific Actions for Implementation

The action proposed to reach the target is as follows:

- There is an urgent need to accelerate the movement of residual waste disposal to the proposed new engineered landfill at Ruai as per JICA's recommendations (1998) to reduce the environmental and public health effects of the City's generated waste.

(4) Evaluation

The UNEP report proposes that a sanitary landfill should be developed in Ruai as a new landfill site, replacing the existing Dandora dumpsite by the year 2015 and safely closing the existing dumpsite in accordance with the JICA MP-98's recommendation. The basic policy of this master plan is almost the same as the previous master plan and it planned to commence the operation of the new sanitary landfill and carry out the safe closure of Dandora dumpsite in 2007.

3.2 Review of the Previous JICA Master Plan

The previous Master Plan related to Final Disposal focused on the following plans:

(1) Short-Term (1998-2003)

(a) Strengthening of Operational Management of Dandora Dumpsite

The previous master plan proposed the additional supply of heavy equipment, enhancement of administrative staff, designation of disposal area, land-filling of hospital waste in separate lots and soil-covering it, weighing of incoming wastes at the dumpsite and its recording, implementation of environmental monitoring, and reporting in order to enhance the administrative structure. In DoE, however, only the recommended additional supply of heavy equipment (Contract-Out) and rough designation of disposal areas, measurement of incoming collection vehicles and its recording were implemented, while the other recommendations were not implemented. This seems to be due to the inability of DoE to secure the budget

required for the operation and maintenance and that DoE personnel were not aware of the detailed work contents.

In this master plan, the levelling of filled wastes, soil covering at areas where wastes may be scattered by wind or landfill gas will be generated, and development of access roads inside of the facility in parallel with the estimation of costs of soil covering are proposed to improve the current state of Dandora dumpsite.

(b) Design and Construction of New Landfill Site

In the previous master plan, the designing and construction of a new landfill site was proposed to be carried out in 1999, 2000 and 2001. However, the plans were not implemented. The financial support from the Kenyan Government or other donors seems to be a major factor and the fact that CCN considered the continuous use of Dandora is possible also could be one the reasons.

This master plan has the same policy as the proposals of the previous master plan such as the introduction of sanitary landfill in the new site. However, the new master plan proposes the implementation to be made during any period when other donors can support it. Besides, the new master plan shows that the existing Dandora dumpsite should be closed as much as possible at early stages through the re-evaluation of its current status.

(c) Land-filling and Well Maintenance and Operation of New Landfill Site

The previous master plan proposed appropriate operation and maintenance in the new final disposal site, but this was not implemented since the new landfill was not constructed. Some of the items of operation and maintenance are soil covering and environmental monitoring such as water quality and survey of leachate water.

(d) Closure Work on the Existing Dandora Dumpsite

The previous master plan proposed final soil covering, drainage ditch, leachate water drainpipes and vent pipes of exhaust gasses as the closure works in 2001 when the operation was scheduled to commence. However, these works were not implemented by the reason that there was no financial support from the Kenyan Government or foreign donors and the CCN's continuous use of the existing Dandora dumpsite.

The new master plan proposes the necessity of the safe closure of the Dandora dumpsite such as soil covering and installation of gas vent pipes, the same as in the previous master plan.

(2) Mid-Term (2004-2007)

(a) Proper Operation and Maintenance of New Landfill Site

The proposed operation and maintenance was not implemented since the construction of the new landfill was not implemented.

(3) Long-Term (2008)

(a) Preparation of the New Final Landfill Site

The previous master plan proposed to commence preparation of the next-phase landfill after 2009. However, this was not implemented because CCN is still using the existing Dandora dumpsite.

The comparison between the Old MP and the New MP is given in **Table E.3.1**.

Table E.4.6 Comparison between the Previous JICA MP and the New MP

Action Plans in Old Master Plan 1998	Actual Performance of Action Plans in Old Master Plan 1998		Proposed Action Plans in New Master Plan 2010	New Concepts to Remove Constraints in Old Master Plan 1998
	Results (Done: ●, Not done yet: × Partially done: ▲)	Cause or Constraints of "Not done yet" or "Partially done"		
Programme 3: Final Disposal Plan				
Short-Term Plan (Old Master Plan 1998-2003, New Master Plan 2011-2015)				
Strengthening of Operational Management of Dandora Dumpsite	▲	-A weighing bridge for the quantity of incoming waste has been installed at the dumpsite entrance since 2006. -The necessary costs for operation and maintenance couldn't be secured. -Ignorance of work necessary for operation and maintenance.	Implementation of Dandora Dumpsite Urgent Improvement Plan	It is clarified that the following work should be required: -Levelling of incoming waste -Covering soil -Onsite road construction
Basic Design and Detail Design of New Landfill Site	×	-CCN thought that Dandora Dumpsite was able to use continuance.	Formulation of New Landfill Site Construction Plan (First Phase)	The concept is similar to Old Plan: -Introduction of Sanitary landfill system (Installation of Leachate collection facility and Leachate treatment facility etc)
Construction of New Landfill Site, 1st Area	×	-CCN thought that Dandora Dumpsite was able to use continuance. -Financial arrangement with the central government or donor countries has not been done to implement the project.	Construction of New Landfill Site (First Phase) (I)	-In order to cope with fluctuations in the amount of incoming landfill waste, as the first phase, landfill sites will be constructed to serve for nine years between 2017~2025.
Construction of New Landfill Site, 2nd Area	×	-CCN thought that Dandora Dumpsite was able to use continuance. -Financial arrangement with the central government or donor countries has not been done to implement the project.	(Mid-term Plan)	
Landfilling at 1st Area	×	-New Landfill Site was not constructed.	(Mid-term Plan)	
Closure Work on Existing Dandora Dumpsite	×	-CCN thought that Dandora Dumpsite was able to use continuance. -Financial arrangement with the central government or donor countries has not been done to implement the project.	(Mid-term Plan)	
Well Maintenance and Operation of New Landfill Site	×	-New Landfill Site was not constructed.	(Mid-term Plan)	

Action Plans in Old Master Plan 1998	Actual Performance of Action Plans in Old Master Plan 1998		Proposed Action Plans in New Master Plan 2010	New Concepts to Remove Constraints in Old Master Plan 1998
	Results (Done: ●, Not done yet: × Partially done: ▲)	Cause or Constraints of "Not done yet" or "Partially done"		
			Formulation of Dandora Dumpsite Closure Plan	-To close Dandora Dumpsite properly, Survey and Design should be carried out. -Facilities will be designed with a view to minimising local environmental impacts. The target area will be 46 ha including private land.
			Clean Up of Illegal Dump Sites	-It is necessary to elaborate a plan to eliminate the illegal dumpsites. -Plans will be compiled with a view to eliminating local environmental impacts and ensuring that illegal dumpsites do not reappear.
Mid-Term Plan (Old Master Plan 2004-2007 , New Master Plan 2016-2020)				
Proper Operation and Maintenance of New Landfill Site	×	-New Landfill Site was not constructed.	Operation & Maintenance of New Landfill Site (I)	The concept is similar to Old Plan: -Carrying in management -Environmental management -Cover soil (dairy, intermediate, final)
			Operation & Maintenance of Dandora Dumpsite	It is clarified that the following work should be required: -Levelling of incoming waste -Covering soil -Onsite road construction
			Implementation of Closure Work of Dandora Dumpsite	-Conduct closure works over 46 ha including private land.
			Construction of New Landfill Site (First Phase) (II)	-In order to cope with fluctuations in the amount of incoming landfill waste, as the first phase, landfill sites will be constructed to serve for nine years between 2017~2025.
			Closure of Illegal Dump Site	-It is necessary to elaborate a plan to eliminate the illegal dumpsites. -Plans will be compiled with a view to eliminating local environmental impacts and ensuring that illegal dumpsites do not reappear.
Long-Term Plan (Old Master Plan 2008 , New Master Plan 2021-2030)				
Preparation of the Next Final Landfill Site	×	-CCN thought that Dandora Dumpsite was able to use continuance.		
			Formulation of New	-The second phase design will

Action Plans in Old Master Plan 1998	Actual Performance of Action Plans in Old Master Plan 1998		Proposed Action Plans in New Master Plan 2010	New Concepts to Remove Constraints in Old Master Plan 1998
	Results (Done: ●, Not done yet: × Partially done: ▲)	Cause or Constraints of "Not done yet" or "Partially done"		
			Landfill Site Construction Plan (Second Phase)	be conducted upon considering the first phase landfill conditions. The target landfill period will be five years from 2026 to 2030. Depending on the state of first phase landfilling, the landfilling period in the second phase may change.
			Construction of New Landfill Site (Second Phase)	-For the second phase, landfill site will be constructed to serve for five years.
			Operation & Maintenance of New Landfill Site (II)	The concept is similar to Old Plan: -Carrying in management -Environmental management -Cover soil (dairy, intermediate, final)

4. FUTURE PLANS FOR FINAL LANDFILL SITE

4.1 Introduction

The Dandora Dumpsite currently in operation for Nairobi City is an open dumping site that is not being properly managed adversely affecting the surroundings areas. For this reason, it is absolutely necessary to locate and create a new landfill site to replace the existing one as soon as possible. The new landfill site should be managed as a Sanitary Landfill to avoid the problems now being encountered at the existing site. The landfill activities could be during the period 2017-2030.

4.2 Introduction of Sanitary Landfill

4.2.1 Establishment of Landfill Concept

The aim of solid waste disposal is to remove solid waste from the urban community immediately and to reduce its volume, making it stable and hygienic. In choosing the process of proper treatment and disposal, not only technical opinions should be considered but also the financial situation and the level of technology within the organisation responsible for solid waste management. This management process can usually be divided into three processes: collection/transport, intermediate treatment and final disposal. Basically, the landfill disposal process finally restores solid wastes to nature.

The purpose of final landfill site is to stabilise the solid waste and to make it hygienic through proper dumping of waste and use of natural metabolic functions. Therefore, it is important to have a practical method of disposal which can be decided upon by regional condition and organisational situation. In making this decision, it is important to take into account the type, form, composition of waste, location of landfill site, regional, hydrological and climatic conditions.

In planning the final disposal system, it is necessary to determine the types and volumes of waste for landfill and to formulate an effective master plan for solid waste management based on actual needs of the region. The final disposal plan should also be formulated in such a manner as to be organic with the collection or hauling plan and the intermediate treatment plan.

4.2.2 Adoption of Sanitary Landfill

Though open dumping as currently practiced by CCN is the cheapest method of disposal, it causes environmental pollution and can potentially affect the health of local residents living near the Dandora dumpsite. Therefore, it is necessary for CCN to adopt the sanitary landfill method. Sanitary landfill of the high environmental standard is still much more economical than other intermediate treatments.

A complete landfill system requires a large amount of capital investment. Taking into consideration the size of the CCN's annual budget and its financial situation, various problems are expected with regard to the funding of a complete landfill system. It is thus unrealistic at the moment to adopt a complete landfill system.

It is also important at the same time to consider the need to achieve a balanced urban infrastructure improvement and aspects of urban environmental preservation. The basic landfill structure is to be planned through the decision on sanitary level in Nairobi City.

4.2.3 Suitable Sanitary Level of Landfill System

A complete landfill system requires a large amount of capital investment. Most of the funds are needed for the facilities' construction and their operation and management for the treatment of leachate. Also, for the operation of this facility, it is not only necessary to have a stable funding but also highly skilled staff with the required knowledge. If leachate treatment is not done with a good operation and

management system, this liquid may be released with little or no treatment. From the realistic approach, the Landfill System has to be introduced and its capacity slowly increased by levels.

The sanitary level of the landfill system can be classified into four (4), as tabulated below. The current capacity for operation and management for the existing Dandora Dumpsite has been established as Level 1, as shown in **Table E.4.1**. Considering the environmental effects that this dumpsite is causing to the surroundings, the required Sanitary Landfill Level including a Leachate Treatment System has to be of Level 3.

Table E.4.1 Classification of Sanitary Level of Landfill System

	Require level
Level 1	Controlled tipping
Level 2	With a bund and daily cover soil
Level 3	Effluent control of leachate
Level 4	Leachate treatment system

The sanitary level of landfill system, its target and so on, are as further summarised below.

(1) Level 1

(a) Target

- Introduction of controlled tipping

(b) Achievement Level

- Establishment of access to site
- Introduction of cover material in order to prevent fire, littering of wastes and odour
- Introduction of inspection, control and operational records of incoming wastes

(c) Further Improvement to Next Level

- Establishment of site boundary
- Introduction of environmental protection facilities
- Introduction of amenities for the staff such as sanitary facilities and locker room
- Introduction of a semi-aerobic landfill

(d) Environmental Issue

In this level, environmental protection measures are not established except the provision of cover material. Impact of landfill operations on the surroundings is great and may include the following:

- Surface and groundwater pollution by leachate
- Littering and dust
- Breeding of insects and rodents
- Unpleasant view of landfill
- Noise
- Odour

(2) Level 2

(a) Target

- With a bund and daily cover soil

(b) Achievement Level

- Establishment of site boundary to distinguish the disposal site and to eliminate scavenging
- Application of sufficient cover to disposed waste
- Establishment of disposal site by construction of enclosing bund
- Introduction of divider for unloading areas and working place
- Establishment of drainage system to divert storm water and seepage from surrounding areas and to reduce leachate
- Introduction of environmental protection facilities to lessen direct impact on surroundings, such as buffer zone, litter control and gas removal facilities
- Introduction of semi-aerobic landfill through the installation of gas removal facilities
- Introduction of amenities for staff

(c) Further Improvement to Next Level

- Improvement of semi-aerobic landfill
- Establishment of leachate control
- Establishment of leachate treatment

(d) Environmental Issue

In this level, since the disposal site and drainage system are already established, landfill operations can be controlled efficiently. Furthermore, with the application of sufficient cover and introduction of some environmental protection facilities, impacts from landfill operations are much reduced than Level 1. Besides, the installation of gas removal facilities introduces a semi-aerobic landfill system. However, leachate is still not controlled and a monitoring system has yet to be established.

(3) Level 3

(a) Target

- Effluent control of leachate

(b) Achievement Level

- Establishment of leachate control by the installation of effluent collection, storage and monitoring facilities

(c) Further Improvement to Next Level

- Introduction of leachate treatment system
- Establishment of semi-aerobic landfill

(d) Environmental Issue

Leachate accumulated at the bottom of landfill is discharged through drainpipes, i.e., leachate collection pipes. These pipes also permit the natural inflow of air to promote semi-aerobic condition for the decomposition of waste. To achieve favourable improvement, the monitoring and control of leachate levels and checking for malfunctioning of leachate collection pipes are essential.

(4) Level 4

(a) Target

- Leachate treatment

(b) Achieved Level

- Establishment of leachate treatment by the installation of oxidation pond, etc.
- Establishment of seepage control
- Establishment of semi-aerobic landfill

(c) Further Improvement to Next Stage

- Establishment of high-level treatment system
- Introduction of service system to the surrounding residents

(d) Environmental Issue

The installation of seepage control facilities and oxygenation pond with aerator for the leachate treatment would achieve the landfill sanitary level.

4.3 Selection and Evaluation of Candidate Final Sanitary Landfill Sites

The New Landfill Site will be selected from an area located near Nairobi City based on the geophysical and geographical analyses of the prospective sites. Also this Project will analyse the sites to be selected not only within the city but also from areas surrounding Nairobi, including the sites selected in The Study on Solid Waste Management in Nairobi City in the Republic of Kenya, 1998.

4.3.1 Selection Criteria for Final Sanitary Landfill Site

In selecting a sanitary landfill site, it is necessary to ensure that the site has a sufficient capacity to accept the planned landfill volume. In addition, the following aspects should also be jointly considered:

- Authenticity regarding reserve areas or national parks
- Jurisdiction of military authorities
- Land acquisition and relocation
- Volume of candidate site as final landfill
- Geological and hydrological situations
- Historical land use and future land use plan
- Accessibility to existing transportation and future transportation plan

In the construction of a landfill system it is necessary to plan with sufficient consideration each of the following factors. It is also important to carry out a preliminary assessment of the site.

(1) Authenticity regarding reserve areas or national parks

Since the Government of Kenya had established some areas as National Reserve Area and/or National Park, this Project will confirm that the site selected for waste disposal is not designated as such. Also the Project will confirm that the selected site is not located in a forest area or an area of reforestation even though the area is not designated as a protected area.

(2) Jurisdiction of military authorities

The Project will confirm that the site is not within or surrounding a military facility. In case that there is a site located in such areas, that site will be catalogued as Unsuitable.

(3) Land acquisition and relocation

The Project will confirm ownership of the site (Government, CCN or Private). In case that the land is owned by private parties, the site that will be selected as Landfill will require land acquisition negotiations. Furthermore, since negotiations for moving, etc., are needed in case residences exist in the candidate site, the existence and size of those residences should be confirmed.

(4) Volume of candidate site as final landfill

It is necessary to ensure that the area proposed for landfill could be utilised for a number of years. This is because the construction costs of facilities, which will include approach and access roads, leachate collection and treatment facilities, drainage system, guardhouse, etc., will be approximately the same as the expense for the area of landfill site. If the landfill has a short life because the area is small, this will mean that capital investment cost to build a new landfill will increase. As explained in 3.4, the total volume required for the New Landfill site is set between 4,200,000 and 12,700,000 m^3

(5) Geological and hydrological situation

It is preferable to choose a site with good geological conditions to reduce construction and maintenance costs. As much as possible the landfill system should be built on non-permeable ground, but not on soft ground or places where subsidence may occur. However, if such a situation is unavoidable it will be necessary to take countermeasures to prevent land subsidence.

In case that the proposed site is located upstream of headwaters such as dams and/or lakes, the site is not suitable for the creation of a Landfill.

(6) Historical land use and future land use plan

The Project will confirm the current usage given to the proposed site as well as future plans for such areas. If the site is currently being used or going to be developed for a housing project and/or agricultural use, such site is not suitable for a waste management project.

(7) Accessibility to existing transportation and future transportation plan

The Project will confirm the accessibility of the proposed sites as well as future road development in the surrounding areas. The proposed sites located nearby main roads are highly recommended.

4.3.2 Selection and Evaluation of Candidate Final Sanitary Landfill Site

The selection and evaluation of a landfill site was carried out from among the seventeen (17) candidate sites indicated in **Figure E.4.1**. As shown in **Figure E.4.1**, 11 of the proposed sites are located inside of the city and 6 sites in the suburbs. Also shown is the projection for road construction and improvement of existing ones. These roads are supposed to be available at the start of operation of the New Landfill.

In the selection of candidate final landfill site, the major constraints are as given in **Table E.4.2** below. The process of evaluation of the seventeen candidate sites in compliance with the selection criteria for landfill site is shown in **Tables E.4.3, E.4.4, and E.4.5**.

Table E.4.2 Major Constraints to the Selection of Candidate Final Landfill Site

Constraints of Disqualification	Name of Candidate Site
(1) Jurisdiction of military authorities	Kamukunji Eastleigh Embakasi Garrison
(2) Volume of candidate final disposal site	Ngong Road Forest Arboretum Karura Forest Kasarani Area J.K.I.A Industrial Area Njiru Area
(3) Historical land use and future land use plan	Mirema Farm Dagoretti Forest Ongata Rongai Ruiru Area Athi River Area
(4) Suitable Area for Landfill Site	Ruai Area Juja area Mavoko area

The results of evaluation indicate that three (3) sites have higher feasibility for development as a landfill site, namely; the Ruai A, Juja and Mavoko areas. The sites in Juja and Mavoko located outside of the city are owned by the Thika County Council and the Mavoko Municipal Council, respectively. Using these sites for the new CCN Landfill will require detailed negotiations. As for the Ruai site, this area is the only one located within Nairobi City and is owned by CCN. For these reasons, the Project considered the following three options for Landfill site, where the Ruai Area is the most preferred.

- Option 1: Ruai Area
- Option 2: Ruai Area + Juja Area
- Option 3: Ruai Area + Mavoko Area

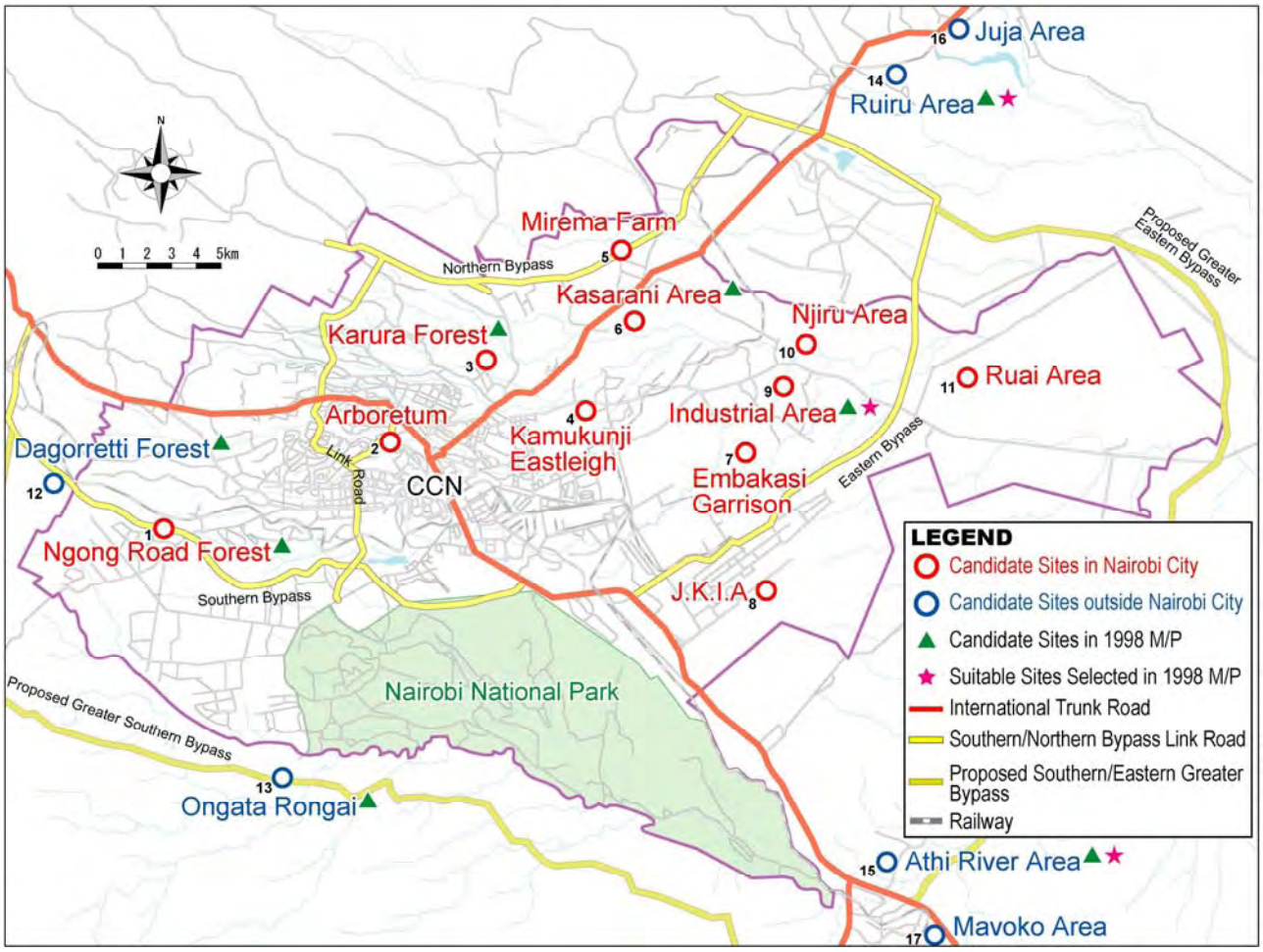


Figure E.4.1 Location Map of Candidate Final Sanitary Landfill Sites

Table E.4.3 Evaluation of Candidate Final Landfill Sites (Western & Central Zones in Nairobi City)

Site Conditions	1. Ngong Road Forest	2. Arboretum	3. Karura Forest	4. Kamukunji Eastleigh	5. Mirema Farm	6. Kasarani Area
(1) Authenticity regarding reserve areas or national parks	- No Include a forest **Unsatisfactory**	- No Include a forest **Unsatisfactory**	- No Include a forest **Unsatisfactory**	- No **Good**	- No **Good**	- No **Good**
(2) Jurisdiction of military authorities	- No **Good**	- No **Good**	- No **Good**	- Military protect area **Unsuitable**	- No **Good**	- No **Good**
(3) Land Acquisition and Relocation	- Government of Kenya **Good** - No residences **Good**	- Government of Kenya **Good** - No residences **Good**	- Government of Kenya **Good** - No residences **Good**	- Government of Kenya **Good** - No residences **Good**	- Private **Unsatisfactory** - No residences **Good**	- City Council of Nairobi **Excellent** - No residences **Good**
(4) Volume of candidate site as Final Landfill (sufficient area)	- 20 ha **Unsuitable**	- 20 ha **Unsuitable**	- 20 ha **Unsuitable**	- 25 ha **Unsuitable**	- 35 ha **Good**	- 16 ha **Unsuitable**
(5) Geological and hydrological(water source) situation	- G: Topsoil (sandy/loam) distributes 50 cm. Base rock is Kerichwa Valley Tuffs. - H: No water source **Good**	- G: Topsoil distributes less than 1 m. Base rock is Nairobi Trachytes. - H: No water source **Good**	- G: Topsoil (loam) distributes more than 1 m. Base rock is Kerichwa Valley Tuffs. - H: No water source **Good**	- G: Topsoil (loam) distributes more than 1 m Base rock is Nairobi Phonolites - H: No water source **Good**	- G: Topsoil (loam) distributes more than 3 m. Base rock is Kerichwa Valley Tuffs. - H: No water source **Good**	- G: Topsoil distributes less than 1 m. Base rock is Nairobi Trachytes. - H: No water source **Good**
(6) Historical land use and future land use plan	- Forest Include a part of Bypass plan area **Unsuitable**	- Park, Forest Close to State house **Unsuitable**	- Forest **Unsatisfactory**	- Grassland Close to Embakasi Airport **Unsuitable**	- Grassland Include a part of Bypass plan area **Unsuitable**	- Park, grassland Close to sports facilities, Electric power line is located in the site centre **Unsuitable**
(7) Accessibility to existing transportation and future transportation plan	- Close to primary road - Close to new bypass **Excellent** - Distance to central city : 10km **Excellent**	- Close to primary road - Close to new bypass **Excellent** - Distance to central city : 3km **Excellent**	- Close to primary road - 300 m access road should be constructed in forest **Good** - Distance to central city : 12km **Excellent**	- Close to primary road **Excellent** - Distance to central city : 8km **Excellent**	- Close to primary road - Close to new bypass **Excellent** - Distance to central city : 12km **Excellent**	- Close to secondary road **Good** - Distance to central city : 12km **Excellent**
Evaluation (Reason for unsuitable)	**Unsuitable** 1. Include a forest 2. Capacity is not enough 3. Include a part of bypass plan area	**Unsuitable** 1. Include a forest 2. Capacity is not enough 3. Close to State house	**Unsuitable** 1. Include a forest 2. Capacity is not enough	**Unsuitable** 1. Military protect area 2. Capacity is not enough 3. Close to Embakasi Airport	**Unsuitable** 1. Include a part of bypass plan area	**Unsuitable** 1. Capacity is not enough 2. Close to sports facilities, electric power line, Electric power line is located in the site centre

Note: G: geological situation; H: hydrological (water source) situation

Table E.4.4 Evaluation of Candidate Final Landfill Sites (Eastern Zone in Nairobi City)

Site Condition	7. Embakasi Garrison	8. J.K.I.A	9. Industrial Area	10. Njiru Area	11. Ruai Area	
(1) Authenticity regarding reserve areas or national parks	- No **Good**	- No **Good**	- No **Good**	- No **Good**	- No **Good**	
(2) Jurisdiction of military authorities	Military protect area **Unsuitable**	No **Good**	No **Good**	No **Good**	No **Good**	
(3) Land Acquisition and Relocation	- Government of Kenya **Good** - No residences **Good**	- Government of Kenya **Good** - No residences **Good**	- Private **Unsatisfactory** - No residences **Good**	- Private **Unsatisfactory** - No residences **Good**	- City Council of Nairobi **Excellent** - No residences **Good**	
(4) Volume of candidate final landfill site (sufficient area)	- 50 ha **Excellent**	- 20 ha (Quarry) **Unsuitable**	- 16 ha (grassland) **Unsuitable**	- 16 ha (Quarry depth10m) **Unsuitable**	- 80 ha (grassland) **Excellent**	
(5) Geological and hydrological(water source) situation	- G: Base rock(Nairobi Phonolites) is outcrop - H: No water source **Good**	- G: Base rock(Nairobi Phonolites) is outcrop - H: No water source **Good**	-- G: Topsoil distributes less than 0.5 m. Base rock is Nairobi Phonolites - H: No water source **Good**	- G: Base rock(Kerichwa Valley Tuffs) is outcrop - H: No water source **Good**	- G: Alluvium deposit Base rock is Athi Tuffs - H: No water source **Good**	
(6) Historical land use and future land use plan	- Military land **Unsuitable**	- Not use Close to airport **Unsuitable**	- Grassland Electric power line is located in the site **Unsuitable**	- Quarry **Good**	- Grassland **Good**	
(7) Accessibility to existing transportation and future transportation plan	- 2.5km new access road should be constructed **Unsatisfactory** - Distance to central city : 16.5km **Good**	- 6.5km access road should be constructed **Unsatisfactory** - Distance to central city : 18.5km **Good**	- Close to primary road **Excellent** - Distance to central city : 19.5km **Good**	- 1.8km access road should be constructed **Unsatisfactory** - Distance to central city : 16.5km **Good**	- 6.0km access road should be constructed **Unsatisfactory** - Distance to central city : 28km **Unsatisfactory**	
Evaluation (Reason for unsuitable)	**Unsuitable** 1. Military protect area 2. Access road is not paved	**Unsuitable** 1. Capacity is not enough 2. Close to airport 3. Access road is not paved	**Unsuitable** 1. Capacity is not enough 2. Electric power line is located in the site	**Unsuitable** 1. Capacity is not enough 2. Access road is not paved	**Suitable** 1. Access road is not paved 2.Transportation	

Note: G: geological situation; H: hydrological (water source) situation

Table E.4.5 Evaluation of Candidate Final Landfill Sites (Out of Nairobi City)

Site Condition	12. Dagorretti Forest	13. Ongata Rongai	14. Ruiru Area	15. Athi River Area	16. Juja Area	17. Mavoko Area
(1) Authenticity regarding reserve areas or national parks	- No Include a forest **Unsatisfactory**	- No **Good**	- No **Good**	- No **Good**	- No **Good**	- No **Good**
(2) Jurisdiction of military authorities	- No **Good**	- No **Good**	- No **Good**	- No **Good**	- No **Good**	- No **Good**
(3) Land Acquisition and Relocation	- Government of Kenya **Good** - No residences **Good**	- Private **Unsatisfactory** - No residences **Good**	- Private **Unsatisfactory** - There are many residences **Unsuitable**	- Private **Unsatisfactory** - No residences **Good**	- Private **Unsatisfactory** - No residences **Good**	- Private **Unsatisfactory** - No residences **Good**
(4) Volume of candidate site as final Landfill (sufficient area)	- 20 ha **Good**	- 40 ha (Quarry) **Good**	- 16 ha **Good**	- 20 ha **Good**	- 47 ha (Quarry) **Excellent**	- 70 ha **Excellent**
(5) Geological and hydrological(water source) situation	- G: Topsoil (loam) distributes more than 1m. Base rock is Limuru Trachytes. - H: No water source **Good**	- G: Base rock (Kerichwa Valley Tuffs) is outcrop. - H: No water source **Good**	- G: Topsoil distributes more than 1 m. Base rock is Kerichwa Valley Tuffs. - H: No water source **Good**	- G: Topsoil distributes more than 1 m Base rock is Athi Tuffs - H: No water source **Good**	- G: Base rock (Kerichwa Valley Tuffs) is outcrop. - H: No water source **Good**	- G: Topsoil (black cotton soil) distributes more than 1 m. Base rock is Athi Tuffs. - H: No water source **Good**
(6) Historical land use and future land use plan	- Forest **Unsatisfactory**	- Quarry Close to school and residential area **Unsuitable**	- Residential area **Unsuitable**	- Plantation area **Unsuitable**	- Quarry	- Grassland
(7) Accessibility to existing transportation and future transportation plan	- Close to new bypass **Excellent** - Distance to central city : 15km **Excellent**	- Close to new bypass **Excellent** - Distance to central city : 23km **Good**	- 1.5km new access road should be constructed **Unsatisfactory** - Distance to central city : 24km **Good**	- Close to main road **Excellent** - Distance to central city : 27km **Unsatisfactory**	- Close to main road and railway **Excellent** - Distance to central city : 32km **Unsatisfactory**	- Close to railway **Excellent** - Distance to central city : 30km **Unsatisfactory**
Evaluation (Reason for unsuitable)	**Unsuitable** 1. Out of Nairobi city 2. Include a forest	**Unsuitable** 1. Out of Nairobi city 2. Close to school and residential area	**Unsuitable** 1.Out of Nairobi city 2.Residential area 3. Access road is not paved	**Unsuitable** 1. Out of Nairobi city 2. Plantation area 3. Transportation	**Suitable** 1. Out of Nairobi city 2. Transportation	**Suitable** 1. Out of Nairobi city 2. Transportation

Note: G: geological situation H: hydrological(water source) situation

4.3.3 Aviation Act (Ruai Area)

As shown in **Figure E.4.2**, the Ruai Area is located on extension line of runway for the Jomo Kenyatta International Airport (J.K.I.A). Although Section 9.4.4, Bird Hazard Reduction, Annex 14 of the Convention on International Civil Aviation[1] enacted by the International Civil Aviation Organisation (ICAO) has the following provision relating to the landfill site, it does not mention about "isolation" from the runway: (Note: *Figure affixed at the end of a word or a sentence refers to the source listed at the end of this supporting report.*)

> "9.4.4 The appropriate authority shall take action to eliminate or to prevent the establishment of garbage disposal dumps or any such other source attracting bird activity on, or in the vicinity of, an aerodrome unless an appropriate aeronautical study indicates that they are unlikely to create conditions conducive to a bird hazard problem."

Based on 9.4.4 Bird Hazard Reduction, according to the Bird Strike Committee USA, Federal Aviation Administration (FAA) prescribes that the isolation between airport and landfill site would be kept than 5 miles[2]. Since the location of the Ruai Area is about 7.5 miles from the runway of J.K.I.A., it is considered that the site is not covered by the regulation in the civil aeronautics law.

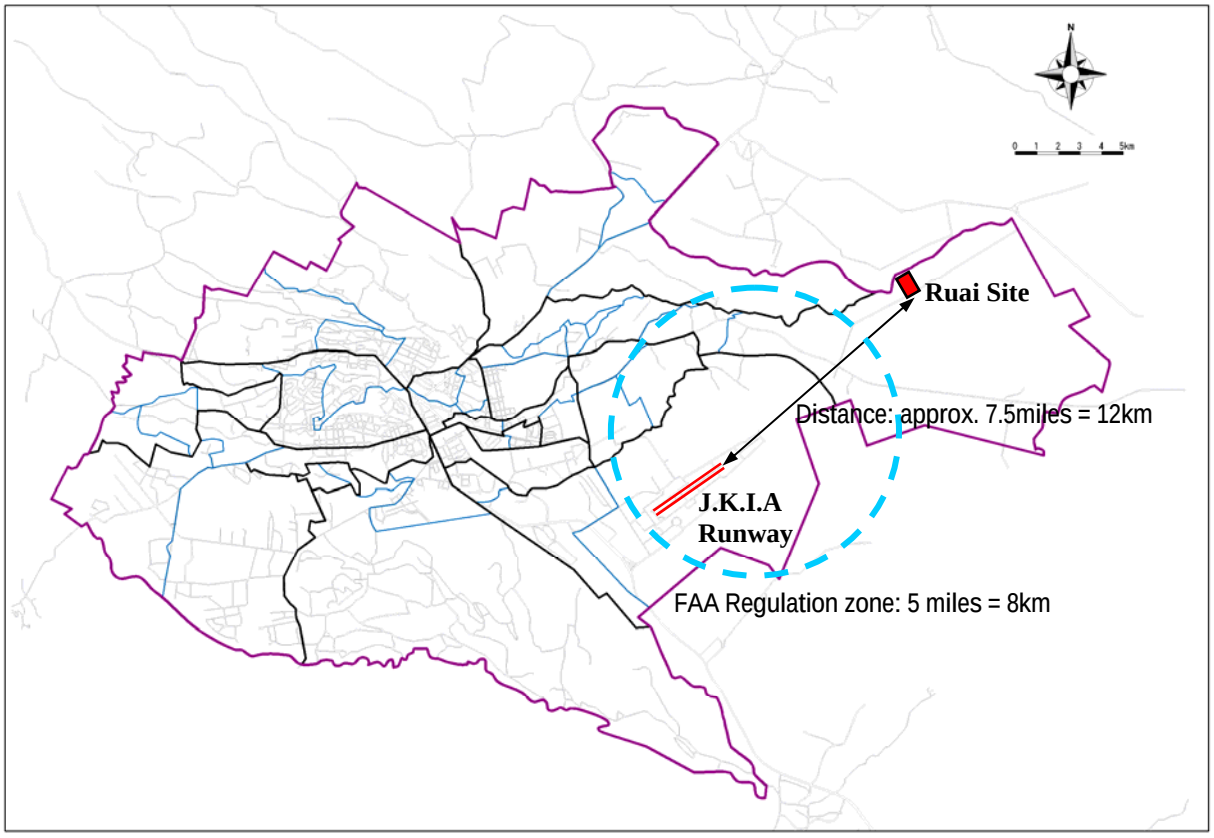


Figure E.4.2 Location Map of Ruai and J.K.I.A.

4.4 Final Disposal and Facility Plan

4.4.1 Landfill Site Capacity Requirement

To determine the scale of facilities on the new landfill site, the necessary capacity will be calculated. The new landfill site is scheduled to go into operation from 2017, and since it is scheduled to operate until 2030, it will be necessary to secure enough capacity to hold waste for 14 years (2017~2030). Bulk density (unit weight) of land-filled waste could be determined based on the literatures discussed below.

- Construction, Operation and Maintenance of Environmentally Conscious MSW Solid Waste Disposal Sites, Nobutoshi Tanaka, Gihoudou Publishing Company Corp., 2001.2.1. [3]
- Integrated Solid Waste Management: Engineering Principles and Management Issues, George Tschobanoglous, Hilart Theisen, Samuel Vigil, McGrawiHill, Inc, 1993. [4]

(1) Construction, Operation and Maintenance for Environmentally Conscious MSW Landfill Sites

Table 1 in this Reference Paper No. 1 [5] shows the characteristics of each sort of waste. These characteristics are as quoted in **Table E4.6**. By substituting the data from this table, the landfill amount of each type of waste, in cubic metres, is supposed to reflect the amount of a particular sort of waste in grams / ($\rho \times C$), as illustrated below.

In **Table E.4.6,** the unit specific volumetric weight of food waste is shown as 0.75 ton/m^3 and the compaction efficient C_N is 1.5. Based on these data, the unit volume per ton of food waste can be calculated as follows:

Unit weight per ton (m^3/ton) = 1 to / (0.75 t/m^3 × 1.5)

= 0.89 m^3/ton (1.12 ton/m^3)

Table E.4.6 Characteristic Values of Each Sort of Waste

	ρ (t/m^3)	C_N		σ_W (m^3/m^3)	C (kg/kg)	A (kg/kg)	W (kg/kg)
		Bull	Compactor				
1. Food waste	0.75	1.5	1.5	0.40	0.43	0.150	0.85
2. Papers	0.35	2.0	2.5	0.40	0.43	0.075	0.40
3. Fabrics	0.20	2.0	2.0	0.40	0.49	0.030	0.20
4. Plastics	0.20	4.5	5.0	0.20	0.72	0.060	0.25
5. Metal	0.20	5.0	8.5	0.10	0.00	1.000	0.03
6. Glass bottles, ceramics	0.35	4.5	5.5	0.10	0.00	1.000	0.03
7. Glasses, Woods	0.25	2.0	2.0	0.35	0.48	0.030	0.40
8. Bulky fabric waste	0.20	2.0	2.0	0.40	0.60	0.050	0.05
9. Wooden furniture	0.10	2.0	2.5	0.30	0.48	0.030	0.05
10. Home electronics	0.30	2.0	2.5	0.10	0.22	0.700	0.05
11. Bulky Metallic waste	0.30	2.0	3.0	0.10	0.00	1.000	0.05
12. Incinerated residue (ash)	0.85	2.0	2.0	0.30	0.05	0.950	0.20
13. Chelated fly ash (stabilised cement)	1.50	1.1	1.1	0.10	0.00	1.000	0.10
14. Melted slag	1.80	1.1	1.1	0.10	0.00	1.000	0.10
15. Cover soil	1.60	1.1	1.1	0.30	0.00	1.000	0.10

Note: ρ= specific density of received waste; σ_ω= critical water-holding capacity [m^3-w/m^3]; C = carbon content in dried waste; A = ash content in dried waste; W = water content [kg-w/kg-waste], in case of shredded bulky waste, W = 0; Bull = land-filling by a bulldozer, Con = land-filling by a compactor

As for the new landfill, food waste, paper, plastics, grass, wood, glass bottles, soil, etc., are planned to be received. The results of calculation for volumetric conversion efficient using the typical value from the survey on waste ratio in **Table 2.2.5** of **Volume 2, Main Report** is shown in **Table E.4.7**. As shown in **Table E.4.7**, the volumetric conversion efficient is 1.02 m^3/ton.

Table E.4.7 Results of Volumetric Conversion Efficient Calculation

Item	Weight Ratio (%)	Coefficient ($\rho \times C_N$)	Volume (m^3 weight/efficient)
Food Waste	63.8	1.125	56.71
Paper	13.8	0.700	19.71
Fabrics	1.4	0.400	3.50
Plastics	11.2	0.900	12.44
Metal	0.9	1.000	0.90
Glass Bottle	1.5	1.575	0.95
Grass and Wood	2.4	0.500	4.80
Cover Soil	5.0	1.760	2.84
Total	100.0		101.85

(2) Integrated Solid Waste Management: Engineering Principles and Management Issues

Table E.4.8 as well as **Table E.4.6** shows the characteristics of each type of waste as given in this Reference Paper No. 2. [6] According to these figures in **Table E.4.8**, the volumetric conversion coefficient of food waste is estimated to be 1.2 m^3/ton or 0.83 ton/m^3.

As in the calculation in the first reference paper, the volumetric conversion coefficient of the whole contents of waste is assumed at 1.57 m^3/ton (equivalent to 0.64 ton/m^3 as shown in **Table E.4.9**).

Table E.4.8 Characteristics of Each Sort of Waste

Component	Weight of solid waste,[a] lb	Volume as discarded,[b] ft³	Compaction factor[c]	Volume in landfill, ft³
Organic				
Food wastes	90	4.96	0.33	1.64
Paper	340	61.2	0.15	9.18
Cardboard	60	19.06	0.18	3.53
Plastics	70	17.18	0.10	1.72
Textiles	20	4.91	0.15	0.74
Rubber	5	0.61	0.3	0.18
Leather	5	0.50	0.3	0.15
Yard wastes	185	29.38	0.2	5.88
Wood	20	1.35	0.3	0.41
Inorganic				
Glass	80	6.55	0.4	2.62
Tin cans	60	10.80	0.15	1.62
Aluminum	5	0.50	0.15	0.08
Other metal	30	1.50	0.3	0.45
Dirt, ashes, brick, etc.	30	1.00	0.75	0.75
Total	1000			28.95

	Compaction factors for components in landfills[a]		
Component	Range	Normal compaction	Well compacted
Organic			
Food wastes	0.2–0.5	0.35	0.33
Paper	0.1–0.4	0.2	0.15
Cardboard	0.1–0.4	0.25	0.18
Plastics	0.1–0.2	0.15	0.10
Textiles	0.1–0.4	0.18	0.15
Rubber	0.2–0.4	0.3	0.3
Leather	0.2–0.4	0.3	0.3
Garden trimmings	0.1–0.5	0.25	0.2
Wood	0.2–0.4	0.3	0.3
Inorganic			
Glass	0.3–0.9	0.6	0.4
Tin cans	0.1–0.3	0.18	0.15
Nonferrous metals	0.1–0.3	0.18	0.15
Ferrous metals	0.2–0.6	0.35	0.3
Dirt, ashes, brick, etc.	0.6–1.0	0.85	0.75

[a] Compaction factor = V_f / V_i where V_f = final volume of solid waste after compaction and V_i = initial volume of solid waste before compaction.

Table E.4.9 Results of Volumetric Conversion Coefficient Calculation

	Weight Ratio (%)	Coefficient (m^3/ton)*	Volume (m^3)
Food waste	63.8	1.20	76.56
Paper	13.8	2.24	30.91
Plastics	10.6	2.29	24.27
Rubber Leather	0.6	2.28	1.37
Textiles	1.4	2.75	3.85
Yard waste	2.4	2.47	5.93
Glass	1.5	3.06	4.59
Metal	0.9	0.56	0.50
Ash, etc.	5.0	1.77	8.85
Total	100.0		156.83

Note *: Coefficient(m^3/ton)=(b × Normal Compaction Factor)／(a/1,000) 1lb=0.454kg 1ft^3=0.0283m^3

Relevant coefficient figures in Reference Paper No. 1 and No. 2 are as rearranged in **Table E.4.10**. In **Table E.4.10**, the unit volumetric weight is added and included.

Table E.4.10 Rearranged Relevant Coefficient Figures

	Reference No. 1*	Reference No. 2**	Previous Master Plan
Volumetric Conversion Coefficient (m^3/ton)	1.02 (0.89)	1.57 (1.2)	0.68 – 1.43
Unit Volumetric Weight (ton/m^3)	0.98 (1.12)	0.64 (0.83)	0.7 – 1.48

Note: Figures in parentheses show the value for only food waste.
Source: *Reference Paper No. 1, Construction, Operation and Maintenance of Environmentally Conscious MSW Solid Waste Disposal Sites, Nobutoshi Tanaka, Gihoudou Publishing Company Corp., 2001.2.1.
**Reference Paper No. 2, Integrated Solid Waste Management: Engineering Principles and Management Issues, George Tschobanoglous, Hilart Theisen, Samuel Vigil, McGrawiHill, Inc, 1993.

As shown in **Table E.4.10**, the volumetric conversion coefficients ranging from 1.02 to 1.57 m^3/ton vary more than the coefficients shown in the previous master plan, which are 0.68 to 1.43 m^3/ton.

(3) Confirmation of Bulk Density

The main waste to be land-filled in the new waste landfill is food waste, which is assumed to have been compacted and its volume reduced by biodegradation. Therefore, the compaction rate from early stages is to be considered under Reference Paper No. 3, i.e., "Management of Solid Waste in Developing Countries," a WHO textbook written originally by Frank Flintoff and translated by the Tokyo Metropolitan Government. [7]

In this Reference Paper No. 3, there are measured values of unit volumetric weights in the part entitled "Waste Management in Kolkata" (the National Institute of Environmental Survey, India, 1970). In this part, the unit volumetric weights of received waste are from 518 to 760 kg/m^3 (0.52 ~ 0.76 ton/m^3), and the unit volumetric weights have changed to 1.128 kg/m^3 (1.13 ton/m^3) on average for 6 months since the start of land-filling. To rearrange the relevant figures, the compaction rate is supposed to be 0.46 to 0.67 (0.57 in average), or is at least 0.60 and over on average in this study.

Using the compaction rate, the calculation results using the figures in **Table E.4.10** are as follows:

1.00 m^3/ton × 0.60 = 0.60 m^3/ton (1.67 ton/m^3)

1.57 m^3/ton × 0.60 = 0.94 m^3/ton (1.06 ton/m^3)

Here, the volumetric conversion coefficients are 0.60 to 0.94 m^3/ton (1.06 to 1.67 ton/m^3)

To sum up, various volumetric conversion coefficients (m^3/ton) for the new waste landfill design are assumed. However, considering the characteristics of waste in Nairobi City, 60 to 70% of the waste to be land-filled is expected to be food waste, which is supposed to undergo compaction and reduction in volume by biodegradation, so that there could be some volume reduction in the new waste landfill. The volumetric conversion coefficient of 1.0 m^3/ton (1.0 ton/m^3) has been applied in this Survey.

Concerning the landfill site capacity requirement, the three options shown in **Subsection 4.3.2** have been calculated. **Table E.4.11** shows Option 1, while **Table E.4.12** shows Options 2 and 3. In Option 1, i.e., in the case where the new landfill site will be constructed in only one place (Ruai), the capacity of 12,670,000 m^3 is required. As for Option 2 or 3, i.e., the cases where a new landfill sites is going to be setup in two places (Ruai and Juja or Mavoko), the necessary capacity will have to be 8,490,000 m^3 for Ruai and 4,180,000 m^3 for Juja or Mavoko.

Table E.4.11 Landfill Site Capacity Requirement (Option 1)

	Waste Amount (t/d) (1)	Waste Amount (m^3/d) (Bulk Density) (2) = (1)* 1.0	Waste Amount (m^3/year) (3) = (2)*365	Cover Soil (m^3/year) (4) = (3) / 3	Total Waste Amount (m^3) (5) = (3)+(4)
2017	1,067	1,067.0	389,455	129,818	519,273
2018	1,159	1,159.0	423,035	141,012	1,083,320
2019	1,256	1,256.0	458,440	152,813	1,694,573
2020	1,353	1,353.0	493,845	164,615	2,353,033
2021	1,477	1,477.0	539,105	179,702	3,071,840
2022	1,610	1,610.0	587,650	195,883	3,855,373
2023	1,744	1,744.0	636,560	212,187	4,704,120
2024	1,887	1,887.0	688,755	229,585	5,622,460
2025	2,035	2,035.0	742,775	247,592	6,612,827
2026	2,177	2,177.0	794,605	264,868	7,672,300
2027	2,329	2,329.0	850,085	283,362	8,805,747
2028	2,481	2,481.0	905,565	301,855	10,013,167
2029	2,643	2,643.0	964,695	321,565	11,299,427
2030	2,815	2,815.0	1,027,475	342,492	**12,669,394**
Total			**9,502,045**	**3,167,349**	

Note: Option 1 is Ruai.

Table E.4.12 Landfill Site Capacity Requirement (Options 2 and 3)

	Waste Amount (t/d) (1)		Waste Amount (m^3/d) (Bulk Density) (2) = (1)*1.0		Waste Amount (m^3/year) (3) = (2)*365		Cover Soil (m^3/year) (4) = (3)/3		Total Waste Amount (m^3) (5) = (3)+(4)	
	Ruai	Juja Mavoko	Ruai	Juja Mavoko	Ruai	Juja Mavoko	Ruai	Juja Mavoko	Ruai	Juja Mavoko
2017	715	352	715.0	352.0	260,975	128,480	86,992	42,827	347,967	171,307
2018	776	383	776.0	383.0	283,240	139,795	94,413	46,598	725,620	357,700
2019	841	415	841.0	415.0	306,965	151,475	102,322	50,492	1,134,907	559,667
2020	905	448	905.0	448.0	330,325	163,520	110,108	54,507	1,575,340	777,694
2021	989	489	989.0	489.0	360,985	178,485	120,328	59,495	2,056,653	1,015,674
2022	1,077	532	1,077.0	532.0	393,105	194,180	131,035	64,727	2,580,793	1,274,581
2023	1,167	577	1,167.0	577.0	425,955	210,605	141,985	70,202	3,148,733	1,555,388
2024	1,263	624	1,263.0	624.0	460,995	227,760	153,665	75,920	3,763,393	1,859,068
2025	1,362	673	1,362.0	673.0	497,130	245,645	165,710	81,882	4,426,233	2,186,595
2026	1,458	719	1,458.0	719.0	532,170	262,435	177,390	87,478	5,135,793	2,536,508
2027	1,561	768	1,561.0	768.0	569,765	280,320	189,922	93,440	5,895,480	2,910,268
2028	1,664	817	1,664.0	817.0	607,360	298,205	202,453	99,402	6,705,293	3,307,875
2029	1,774	869	1,774.0	869.0	647,510	317,185	215,837	105,728	7,568,640	3,730,788
2030	1,890	924	1,890.0	924.0	689,850	337,260	229,950	112,420	**8,488,440**	**4,180,468**
Total					6,366,330	3,135,350	2,122,110	1,045,118		12,668,908

Note: Option 2 is Ruai+Juja; Option 3 is Ruai+Mavoko.

4.4.2 Facility Plan of New Landfill Site

(1) Landfill Method

Landfill methods are classified into **the anaerobic landfill method** and **the semi-aerobic landfill method**; depending on the microorganism environment inside the landfill.

The anaerobic landfill method adopts a structure in an anaerobic state in which water (for example) is accumulated in the landfill and waste does not come into contact with air. In this state, methane gas is easily generated, and there are numerous cases in Europe and America where electricity is generated from landfill gas following completion of landfill. However, this method requires more time for waste and leachate quality to stabilise, and high-level operation and maintenance are required in order to prevent impacts on the local environment.

In contrast, in the semi-aerobic landfill method, keeping the structure free of water and securing a good air circulation on the site will create an aerobic state. In such environment, the waste and quality of leachate will become stabilised faster.

Taking into consideration the current state of Operation and Management situation, costs, and local environmental impact on the Dandora Dumpsite, The semi-aerobic landfill method shall be adopted. **Figure E.4.3** gives a sketch of the new landfill site.

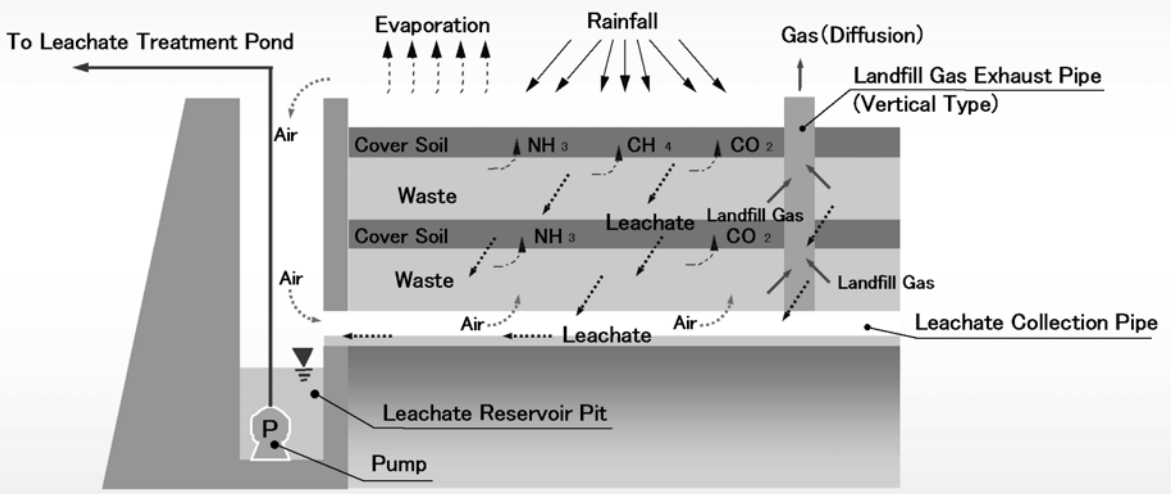


Figure E.4.3 Typical Structure of Sanitary Landfill Site

(2) Topography and Geological Condition

Topographical and geological conditions of the candidates for the new landfill site at Ruai, Juja and Mavoko are presented below. Before conducting the detailed design for the three sites, it will be necessary to implement topographical and geological surveys to gauge the current conditions in detail.

(a) Ruai

Topography

The Ruai Site, which covers an area of 80 ha, is rectangular-shaped measuring 1,000m by 800m. Nairobi River is located to the north of the site, and the site is composed of almost flat grassland sloping gently down towards the river.

Geology

Detailed survey of geological condition of the Ruai Site was conducted in the "GEOLOGICAL SURVEY OF THE PROPOSED WASTE DUMPING SITES IN NAIROBI, KENYA (JANUARY, 1998)".[8] According to the findings, overburden generally comprises dark gray clays which vary in thickness of between 0.8 m and 2.0 m. Moreover, the basement rock is composed of an impermeable layer of tuff possessing permeability of 1 x $10^{-4\sim5}$cm/sec. The groundwater level is distributed over the range of GL-1.5m~6.0 m. The present situation of the Ruai Site is as shown in **Photo E.4.1**.

Photo E.4.1 The Present Situations of Ruai Site

(b) Juja

Topography

The Juja Site covers an area of approximately 47 ha. It is an elongated site stretching along Kamiti River which flows along the northwest side of the site. **Figure E.4.4** shows the rough cross-section. The site bottom, which was excavated as a quarry, is bumpy and, lengthwise, the site slopes gradually in line with Kamiti River.

Geology

The basement rock of Kerichwa Valley Tuff is exposed in parts, however, no spring water, etc. was observed flowing from the walls. The present situations of the Juja Site are as shown in **Photo E.4.2**.

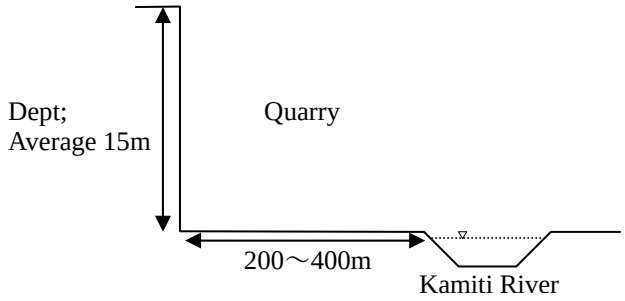


Figure E.4.4 Outline Sectional View

Photo E.4.2 The Present Situations of Juja Site

(c) Mavoko

Topography

The Mavoko Site comprises very expansive, flat grassland. The exact site area has not been confirmed, however, an area of around 70 ha can be secured. A railway line running from north to south is installed on the west side of the site.

Geology

It is guessed that black cotton soil exists for around 1 m from the surface. The basement rock comprises Athi tuffs.

The present situations of the Mavoko Site are as shown in **Photo E.4.3**.


Photo E.4.3 The Present Situations of Mavoko Site

(3) Facility Plan and Design

Regarding the design concept for the new landfill site, a structure that enables the simplest possible maintenance and minimum impacts on the local environment shall be adopted so as to stabilise the land-filled waste (render it harmless) as quickly as possible.

(a) Site Reclamation

(i) Ruai

It will be necessary to secure the capacity of 8,490,000 m^3 or 12,670,000 m^3 on the Ruai Site. In the case where the entire capacity is installed over one section, since the waste will be dumped indiscriminately over an extended area, the site management will become complicated. Moreover, since the leachate treatment facility becomes larger as the site area increases, the construction cost will be expensive. Accordingly, the site shall be constructed as two distinct zones. Furthermore, considering the possibility that the amount of waste will vary, the capacity of Phase 1 shall be designed on the large side to cope with the situation where the amount of waste in the initial stages is larger than originally expected.

Concerning geological conditions of the Ruai Site, according to the GEOLOGICAL SURVEY OF THE PROPOSED WASTE DUMPING SITES IN NAIROBI, KENYA (JANUARY, 1998)[9], the impermeable basement rock layer is distributed over depths of GL -0.8m to -2.0m and deeper. Therefore, to prevent leachate from filtering underground, the bottom of the final landfill site shall be excavated at least 2.0m deeper than the existing ground height. In this case, it will not be necessary to install a liner to prevent groundwater pollution. Furthermore, groundwater exists over the range of 1.5m ~ 6.0m. When waste comes into contact with groundwater, it becomes contaminated and negative impacts are imparted to the local environment. Thus the bottom of the landfill should be set higher than the groundwater level. Also, to efficiently collect leachate, a gradient should be applied from the upstream to the downstream direction. Accordingly, the Ruai site creation plan will comprise the following contents.

- Batholith gradient: i = 0.5%
- Excavation depth: 2~6 m

In areas where the excavation is shallow, it will be necessary to build enclosure dikes to prevent fly-off of waste. The height of enclosure dikes should be no more than 5m and they should be constructed as the landfill grows. Moreover, Hazardous Waste (in an ash state) such as medical waste will be disposed on the new landfill site, although this kind of

waste should be kept apart from food waste that contains water content, and should be buried in areas not prone to water accumulation. Accordingly, a divider dike shall be installed on the upstream side of the landfill site in order to zone the site and keep household waste separated from the hazardous waste.

(ii) Juja

Since Juja will only have landfill capacity of 4,180,000 m^3, which is less than half that of Ruai, it will only have one section.

In terms of geology, since impermeable bedrock is already exposed, there is no need to perform excavations. However, because the batholithic is uneven and is not suited to efficiently collect leachate, the batholithic shall be excavated by 1 m on average to secure a gradient. It will also be necessary to install an enclosure dike alongside Kamiti River in line with the progress of landfill. Other contents will be the same as on Ruai site.

(iii) Mavoko

Like Juja, Mavoko has less than half the capacity of Ruai, it will also comprise just one section. The detailed geological conditions are unknown; however, since they are considered to be similar to Ruai, the same concept as Ruai shall be applied. However, when conducting the detailed design, it will be necessary to conduct geological survey and modify the plan according to the findings.

(b) Leachate Collection and Drainage Facility

As extremely important facilities for achieving the semi-aerobic landfill method, the leachate collection and drainage facilities need to have the following functions:

- Function for quickly collecting leachate and removing it from the landfill site
- Function as air ventilation pipes
- Function for removing landfill gas

In terms of layout, the leachate drain mains will be installed in the longitudinal direction, while the leachate drain branches will be installed horizontally across the mains. The leachate drain mains will be installed at intervals of 100 m while the leachate drain branches will be installed at intervals of 50 m.

The leachate collection facilities are composed of porous materials such as crushed stone and porous PVC pipes. The PVC pipes should possess not only drainage capability but also air ventilation capacity. In Japan, the minimum diameter of PVC pipes is prescribed at 200 mm irrespective of drainage capacity. Accordingly, the diameter of leachate drain branches shall be set at 200 mm and leachate drain mains shall be double at 400 mm.

Leachate will enter the leachate reservoir pit downstream of the dumpsite, and from there it will be pumped to the leachate treatment facility. It will be necessary to control the pumps so that the water level inside the pit is lower than the bottom of the drainpipe and air can always circulate around the landfill layer via the drainpipes. **Figure E.4.5** shows the structural drawing of the leachate drainpipe.

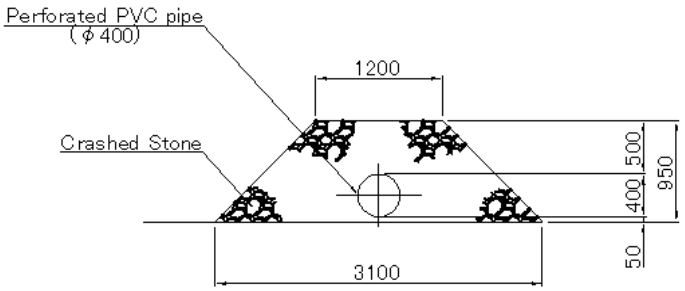


Figure E.4.5 Leachate Drain Equipment

(c) Leachate Treatment Facility

The purpose and function of the leachate treatment facility is to treat the collected leachate and drainage facilities inside the landfill site without causing pollution to the water bodies.

(i) Design Treatment Flow

The design treatment flow should be determined according to past rainfall in the area around the new landfill site. Since it is planned to utilise the new landfill site for 14 years, rainfall data for the past 14 years (1986~2009) should be made as the reference. Since the leachate treatment facility needs to have enough capacity to cope with heavy rainfall, the treatment flow should be decided based on the heaviest monthly rainfall in the past 14 years, i.e., 323 mm/month in May 1998 [READINGS OF VARIOUS METEOROLOGICAL PARAMETERS (J.K.I.A) by KENYA METEOROLOGICAL DEPARTMENT][10]. Moreover, in the case of Ruai, it is necessary to divide the site into zone sections. When landfill starts on the second section, landfill on the first section will have been finished and final earth covering will have been conducted on the first. If the final earth covering is carried out, only a part of rainfall will percolate into the landfill while the rest will drain on the surface as storm water. Moreover, since it is expected that the amount of leachate from the finished section will be smaller than the amount generated during landfill, the leachate flow on the finished section is assumed to be 0.6 times the amount coming out of the section still undergoing landfill.

$Q = (I / 30 - E / 365) / 1000 \times A \text{ (or } A_2) \times ((I / 30 - E / 365) / 1000 \times A_1 \times 0.6)$

Where,

Q : Quantity of leachate confined in ponds (m^3/day)

I : Precipitation intensity (323mm/month)

E : Evaporation intensity (800mm/year)

A : Land-filling duration area (Ruai: *Option 1:* A_1(First Phase) 31.8ha, A_2(Second Phase) 31.8ha; *Option 2*: A_1(First Phase) 21.3ha, A_2(Second Phase) 21.3ha; Juja: 30.1ha; Mavoko: 19.0ha)

The design treatment flow of each candidate site is as given below:

Ruai : Option 1 = 4,500m^3/day; Option 2 = 3,010m^3/day

Juja : 2,660m^3/day

Mavoko : 1,680m^3/day

(ii) Quality of Leachate and Discharge

Quality of Leachate

The waste carried into the new landfill site will be burned items mainly comprising food waste. When waste mainly consists of organic materials such as food waste, the resulting leachate will have relatively high concentrations of BOD, COD and T-N, etc. Accordingly, the primary target of leachate treatment in this project shall be BOD. In Japan, leachate from landfill sites handling mainly combustible wastes is said to have the BOD content of 1,000 mg/L. Accordingly, leachate BOD content in the project shall be set at 1,000 mg/L. Moreover, since the survey on the Dandora Dumpsite found leachate on that site to be 240 mg/L, it is possible that the actual leachate quality will be less than 1,000 mg/L.

Quality of Discharge

Treated effluent quality standards are stipulated in the NEMA Third Schedule: Standards for Effluent Discharge into the Environment, although these standards do not include final disposal sites among the targets. Apart from the Third Schedule, the Water Quality Regulation prescribes the Sixth Schedule as a monitoring item for treated effluent discharged into rivers, etc. The Sixth Schedule contains general items selected from the Third Schedule and includes BOD and COD that are expected to exist in high concentrations in the leachate. The quality of treated effluent will be based on the Water Quality Regulation, Sixth Schedule. **Table E.4.13** shows standard values.

Table E.4.13 Monitoring for Discharge of Treated Effluent into the Environment

Parameter	unit	Guide value
pH		6.5 ~ 8.5
Biochemical Oxygen Demand (BOD 5days at 20 C)	mg/l	30
Chemical Oxygen Demand	mg/l	50
Suspended Solids	mg/l	30
Ammonia-HN_4^+ Nitrate-NO_3^+ Nitrite-NO_2	mg/l	100
Total Dissolved solids	mg/l	1200
E. Coli	/100ml	0
Total Coliforms	/100ml	1000

Source: Water Quality Regulation; Sixth Schedule (NEMA) [11]

(iii) Leachate Discharge Method

Numerous technologies are currently available for treating leachate: these ranges from simple methods such as the lagoon system combined with sedimentation tanks to sophisticated methods that utilise chemicals and instruments. The sophisticated methods produce higher quality effluent than the simple methods; however, the construction cost and maintenance costs for power and chemicals are expensive. Moreover, high-level management technology is required to control dosages of chemicals according to leachate quality fluctuations and to determine chemical replacement intervals, as well as to conduct equipment maintenance to ensure that facility functions are maintained. If management is inadequate, the quality of treated effluent will remain the same or become even worse than the original leachate.

On the other hand, the lagoon method, despite having lower treatment capacity than more sophisticated methods, entails cheaper costs and easier maintenance, and it is also able to respond to leachate quality fluctuations. Accordingly, the lagoon system combined with anaerobic pond, facultative pond and maturation pond shall be adopted as the treatment system at the new landfill site. Moreover, a settling basin shall be installed before the anaerobic pond with a view to enhancing treatment capacity and making maintenance work easier. One treatment system will comprise four treatment ponds, and two lines shall be installed in order to enable ponds to be cleaned without halting operations.

Treated effluent will be discharged into Nairobi River via a sand sedimentation pond installed at the end of the rainwater drainage route from the maturation pond. **Table E.4.14** shows the retention time (days) and capacity of each pond.

Table E.4.14 Volume of Treatment Ponds

	Retention Time (day)	Volume (m^3)			
		Option 1 Ruai	Option 2		
			Ruai	Juja	Mavoko
Settling Basins Pond	0.13	590	400	350	220
Anaerobic Pond	5	22,820	15,270	13,500	8,530
Facultative Pond	10	45,630	30,530	27,000	17,050
Maturation Pond	3	13,690	9,160	8,100	5,120

(iv) Response to Emergency Situations

Leachate quality fluctuates greatly depending on the quality of waste materials. Accordingly, there may be situations where the quality of treated effluent doesn't meet standards in cases where unexpected wastes are carried in and cases where leachate builds up inside the landfill site following localised torrential rain and so on. Therefore, pumps will be installed in the maturation pond at the end of the final treatment process to create a system for returning leachate to the final disposal site when the quality of treated effluent deteriorates.

(d) Landfill Gas Exhaust Equipment

Landfill gas exhaust equipment will be installed to rapidly remove landfill gas from and supply air to the landfill site. The equipment will need to have the following three functions:

- Function for collecting and treating landfill gas
- Air supply function for promoting stabilisation of the landfill
- Function as leachate collection and drainage pipes
-

Landfill gas exhaust equipment comprises two types, i.e., vertical pipes installed from the leachate collection pipes in line with the progress of landfill work, and slope equipment installed on landfill slope sections.

Landfill gas exhaust equipment can function effectively through connecting to leachate collection pipes. Therefore, as in the case of the leachate collection pipes, PVC pipes wrapped in crushed stones shall be adopted as the structure of the equipment. The diameter of PVC pipes shall be 200 mm. **Figure E.4.6** shows a structural drawing of the landfill gas exhaust equipment (vertical type).

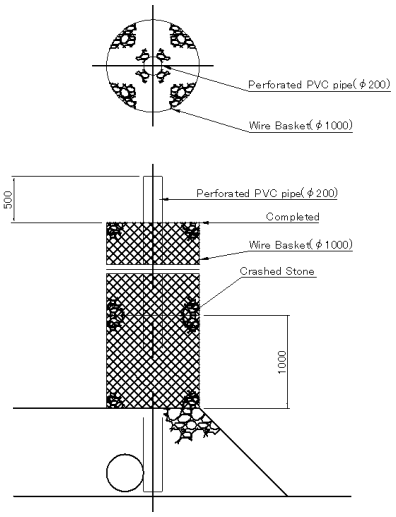


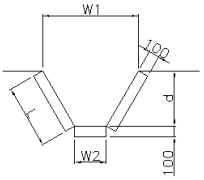
Figure E.4.6 Landfill Gas Exhaust Equipment (Vertical Type)

(e) Rainwater Drainage

The purpose of rainwater drainage installed on landfill sites is to rapidly remove rainwater before it comes into contact with waste. By doing this, it is possible to greatly reduce the amount of leachate and downsize the leachate treatment pond. Here, the rainwater drainage shall be installed around the perimeter of the landfill site.

Since life of the new landfill site is planned to be 14 years, the scale of rainwater drainage shall be decided based on the heaviest daily rainfall in the past 14 years, i.e., 83.3 mm on January 16, 1998 [READINGS OF VARIOUS METEOROLOGICAL PARAMETERS (J.K.I.A) by KENYA METEOROLOGICAL DEPARTMENT] [12]. Moreover, the scale of rainwater drainage should be decided upon considering the shape of the landfill site following the end of landfill.

In Ruai and in Mavoko, since it is anticipated that the collected rainwater will contain sediment, a sand sedimentation pond shall be installed at the end of the rainwater drainage to remove the sediment and to protect the environment of the discharge river. **Figure E.4.7** shows the structural drawing of the rainwater drainage.



Type	W1 (mm)	W2 (mm)	d (mm)	L (mm)
600-300×260	600	300	260	300
900-600×260	900	600	260	300
900-300×520	900	300	520	600
1200-600×520	1200	600	520	600

Figure E.4.7 Rainwater Drain Equipment

(f) Access Road and Onsite Road

Two types of road will be installed on the landfill site: access road for getting to the landfill site from the existing general highway, and onsite roads for entering the site from the access road. The access road will be constructed for the trucks carrying waste onto the site and the employees working on the site. The access road shall have width of 8 m to enable the passage of trucks travelling in opposite directions. As for Juja and Mavoko, since waste will be carried by railway, the access road will only need to be 6 m to allow passage by employees' vehicles. Roads shall be paved.

The onsite roads will be constructed to allow waste trucks to reach the dump sites from the access roads. They will have the same width (8 m) as the access roads. Since these roads will eventually become buried in waste as the landfill progresses, it will be necessary to keep adding the roads. Consequently, in view of the short period of use of the roads, they will comprise basic crushed stone paving.

(g) Groundwater Monitoring Facility

The groundwater monitoring facility will be installed to confirm the quality of groundwater. This is an important item for ascertaining impacts of the landfill site on the local environment. On the new landfill site, monitoring wells shall be installed upstream and downstream (one each) of the landfill. The depth of monitoring wells should be determined based on the results of groundwater level survey.

(h) Incidental Facilities

The following incidental facilities shall be installed:

- Truck scale: Two (2) truck scales shall be installed at the entrance to the landfill site to measure the weight of waste carried onto the site.
- Net fence: Net fences shall be installed around the perimeter of the landfill site with the objective of preventing waste fly-off and preventing trespassers from entering the site. The fences shall be 2.5 m in height and a gate shall be installed at the site entrance.
- Administration office: An administration office comprising an office equipped with the truck scale, PC and other supplies, and a rest room for site workers shall be constructed at the site entrance.
- Other facilities: A warehouse for storing the landfill heavy machinery and domestic hazardous waste, and equipment for washing the incoming trucks shall be installed. The position of the vehicle washing equipment should be decided upon considering the traffic lines of waste carrying vehicles.

Figures E.4.8 and E.4.9 show the layout plan and vertical sectional view of Ruai.

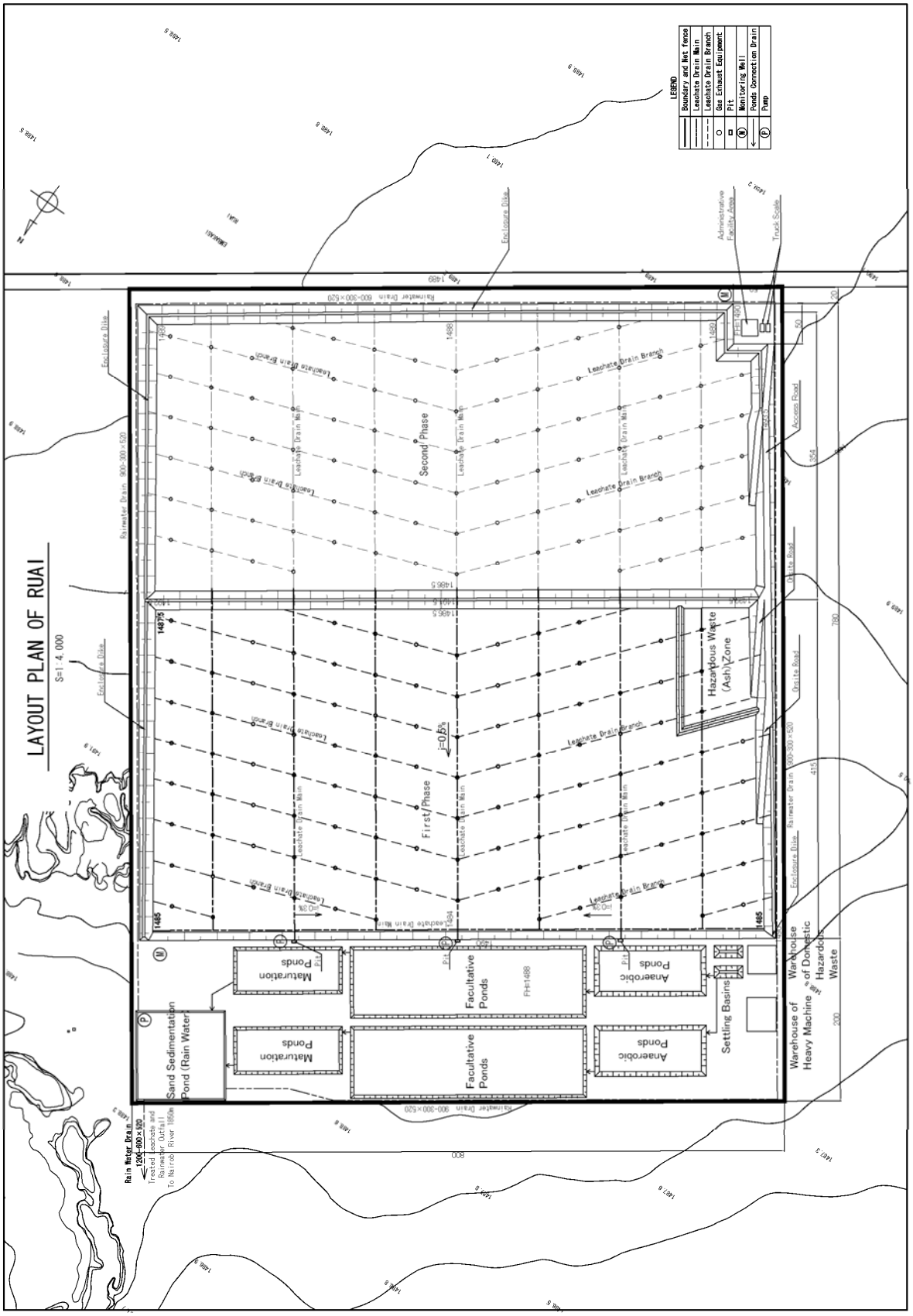


Figure E.4.8 Layout Plan of Ruai

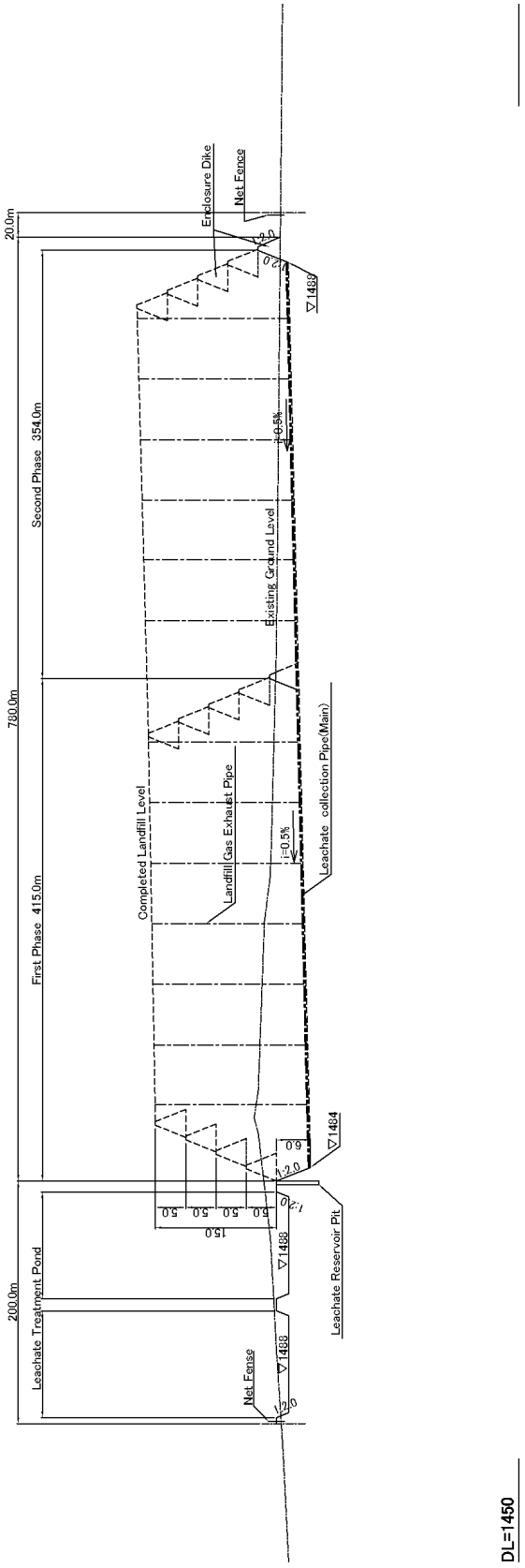


Figure E.4.9 Vertical Section View of Ruai

(4) Management of Landfill System

To appropriately manage and safely use the landfill site, it is important to establish a management setup and implement control of the incoming waste and environmental management of groundwater and treated leachate quality, etc.

(a) Operation Organisation

The arrangement of proper organisation for the site is a very important point to sustain the sanitary landfill system. The proposed organisation is as shown in **Table E.4.15**. The number of operators will depend on the transported waste amount.

Table E.4.15 Operational Organisation

Staffing	Responsibility
Site Manager	All responsibilities for handling the site, and contact and reporting to NCC
Secretary	Controls and regulates the schedule of the Site Manager, register income and outlay daily management
Chief of Engineering Section	Responsible for all engineering matters, planning and conduct suitable landfill operation method
Truck Scale Engineer	Responsible for operating truck scale to measure the waste quantity and quality, and for directing the trucks to the designated landfill area
Site Inspector	Responsible for inspection of safety against disasters at the site and illegal dumping
Chief Operator	Responsible for controling daily operator's work and for directing trucks to the designated landfill area in the site
Operator	Responsible for landfilling the waste
Security Guard	Responsible for preventing theft of equipment and entry of trespassers.

(b) Carrying-in Management

This involves recording and storing of data on the volume of solid waste dumped, volume of cover material used and the condition of the landfill site to correctly control the volume of solid waste dumped into the site and for the planning of efficient operations.

(c) Environmental Management

To confirm the impacts of the landfill site on the local environment, the following items will be measured and controlled:

- Treated leachate quality
- Groundwater quality
- Leachate quality
- Landfill gas composition

(i) Quality Control of Treated Leachate

The treated leachate will be discharged into Nairobi River after passing through the sand sedimentation pond. NEMA prescribes water quality standards concerning effluent discharge into Nairobi River.[13] It will be necessary to analyse water quality in the sand sedimentation pond in order to confirm that the water quality standards are satisfied. The analysis items are as shown in **Table E.4.13** and analysis shall be implemented once a

month. In the event where effluent is found not to satisfy the standards, it will be necessary to immediately suspend discharge to Nairobi River, then pump effluent back to the landfill site, and check conditions in the leachate treatment ponds. If sludge and other sediments are found in the water, they should be immediately removed and the effluent should be analysed again to confirm that it satisfies the standard values before resuming discharge to Nairobi River.

(ii) Groundwater Quality Control

To confirm that the waste is having no impact on the quality of groundwater, it will be necessary to conduct water quality analysis at monitoring wells installed upstream and downstream of the site. Since the objective of analysis will be to confirm the impacts of waste on groundwater, the analysis items will be the same as in analysis of treated leachate. Analysis shall be conducted once every six (6) months. If some kind of deviation is confirmed in the quality of groundwater, it will be necessary to confirm the impact on Nairobi River, check water level and conditions in the leachate treatment ponds inside the landfill site and implement the necessary countermeasures. Moreover, it will be necessary to analyse groundwater quality once a month with a view to closely observing progress. If there are any households, etc. that use groundwater in the local area, it will be necessary to investigate the quality of the used groundwater and check for any impact. In case some kind of deterioration of water quality is confirmed, it will be necessary to ask the households concerned to stop using the groundwater and to arrange for the CCN to provide water for living purposes.

(iii) Leachate Quality Control

Through analysing the quality of leachate, it is possible to confirm the conditions of waste stabilisation. Moreover, through comparing the quality of leachate with that of treated effluent, it is possible to confirm treatment conditions. For this purpose, it is necessary to conduct quality analysis on leachate flowing into the leachate reservoir pit. The analysis items shall be the same as the treated effluent analysis items, and the analysis shall be conducted once every three months.

(iv) Landfill Gas Composition Control

Landfill gas, like leachate, is an indicator of how far the stabilisation of waste is progressing. Accordingly, it will be necessary to analyse the composition of landfill gas generated from the landfill gas exhaust pipes (vertical type). In cost terms it is desirable to conduct analysis using basic portable instruments. The analysis items shall be CH_4, CO_2, O_2, CO, H_2S and temperature, and analysis shall be conducted around once every three months. It is desirable to have around five measurement points. **Photo E.4.4** shows an example of the type of analysis instrument used.

Photo E.4.4 Portable Landfill Gas Analyser (Geotechnical Instruments Inc)

Table E.4.16 shows the survey items.

Table E.4.16 Monitoring Items

Monitoring Items	Monitoring Facilities	Frequency	Inspection Items
Treated Leachate	Sand Sedimentation Pond	1/month	pH, BOD, COD, SS, NH_4^+, TDS, E. coli, Total Coliforms
Groundwater	Monitoring well (x2)	2/year	pH, BOD, COD, SS, NH_4^+, TDS, E. coli, Total Coliforms
Leachate	Leachate Reservoir Pit	4/year	pH, BOD, COD, SS, NH_4^+, TDS, E. coli, Total Coliforms
Landfill Gas	Landfill Gas Exhaust Pipe (Vertical Type)	4/year	CH_4, CO_2, O_2, CO, H_2S, Temperature

(5) Landfill Operation and Maintenance

To maintain the landfill site functions, it is essential to carry out appropriate operation and maintenance. If this is not done, there is a possibility that facilities will cease to function effectively, thereby leading to the fly-off of waste and impacts on the local environment caused by leachate, etc.

(a) Cell Construction

There are two approaches to cell construction on landfill sites, namely; the sandwich method and the cell method of construction.

(i) Sandwich Method

The sandwich method entails levelling wastes and creating alternate layers of waste and covering earth. In Japan, this method is usually adopted on landfill sites with restricted space. **Figure E.4.10** shows a schematic view of the sandwich method.

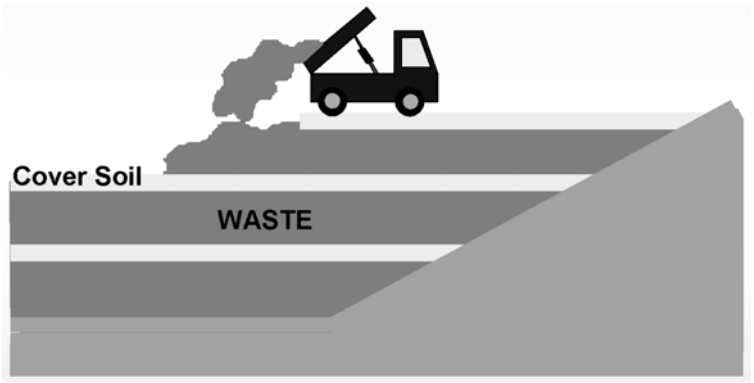


Figure E.4.10 Sandwich Method

(ii) Cell Method

This method, shown in **Figure E.4.11** has a cell of solid waste topped with a layer of cover soil and is the most popular method today. The size of each cell is determined by the amount of solid waste used per day. Since each cell is an independent landfill area, each cell acts as a fire-breaker. It also prevents the solid waste from being scattered, emission of bad odours and harmful vectors from breeding.

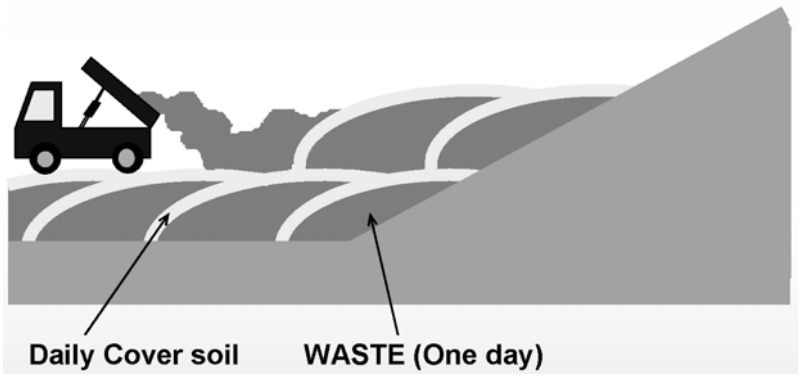


Figure E.4.11 Cell Method

On the new landfill site, the sandwich cell method that combines the sandwich method and the cell method shall be adopted. In this approach, covering earth will be placed over waste at the end of landfill each day for a number of days, and an intermediate earth covering of around 50 cm will be made for every waste layer of 2~3 m. **Figure E.4.12** shows a schematic view of the sandwich cell method.

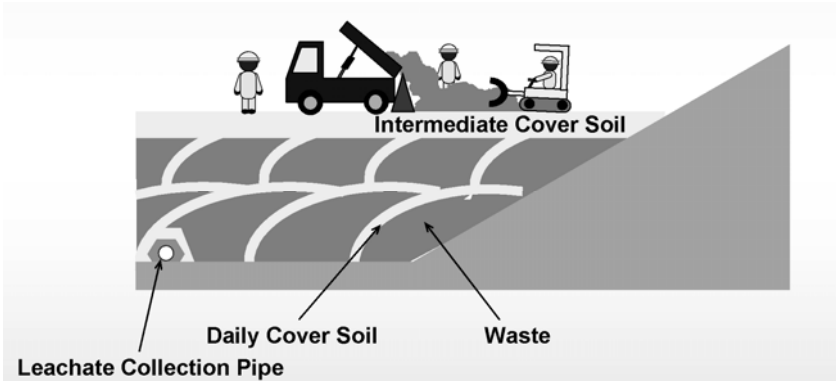


Figure E.4.12 Sandwich Cell Method

(b) Cover Soil

The cover soil prevents bad odour from dispersing, the littering and flowing out of waters, breeding of vectors and other animals. It also prevents fire from spreading and for that matter, acts as a firebreak. It will provide good appearance as it acts as a means of protecting the environment. Further, it also allows easy solid waste spreading and compaction works, prevent rainwater from seeping into the inner layers of the landfill site (thus reducing leachate volume). Cover soil is composed of three components, i.e., daily cover soil, intermediate cover soil and final cover soil. Providing that the cover soil is not too clayey and moist for compacting by heavy machinery, it is possible to use residual earth from construction works. If such earth cannot be obtained, it will need to be purchased.

(i) Daily Cover Soil

Daily cover soil will be applied with the objective of preventing waste fly-off and odour. Concerning the thickness of daily cover soil, around 10~20 cm is desirable in the case of food waste and other combustible wastes, and around 20~30 cm is desirable in the case of relatively bulky waste. Daily cover soil is usually placed at the end of landfill work each day, however, if waste that is prone to fly-off is being dumped, it is necessary to apply the covering as soon as the waste is placed.

(ii) Intermediate Cover Soil

Intermediate cover soil of around 50 cm thickness will be placed for every 2~3 m of waste to promote evaporation of rainwater from the waste transportation vehicle roads and site areas where the waste is discarded for a relatively long time.

(iii) Final Cover Soil

When all landfill works are finished, this topmost final cover soil is laid, bearing in mind the post-closure land-use of the completed landfill site, and leachate volume reduction purposes.

(c) Operation and Maintenance of Facilities

(i) Enclosure Dike

It will be necessary to build enclosure dikes in line with the progress of landfill. Since the enclosure dike is intended to prevent fly-off of waste, it needs to be built before the height of waste exceeds the dike. Since collapse of the enclosure dike could lead to waste being discharged outside the site, construction of the dike should be contracted to a specialist civil engineering firm.

(ii) Leachate Collection Facility

Since the leachate collection facility is an extremely important facility in the semi-aerobic landfill method, the work around pipes should be implemented with extreme care to ensure that pipes are not broken. Furthermore, water level inside leachate reservoir pits should be controlled so that it does not go higher than the bottom of the leachate drain mains.

(iii) Leachate Treatment Facility

To sustain the purification functions of the leachate treatment system, it is necessary to conduct daily monitoring of conditions in the settling basin and quickly remove sludge that builds up in the bottom. Removed sludge should be dumped in an area in the landfill site where water does not tend to accumulate. Concerning other ponds, sludge accumulation should be confirmed around once a month and sludge should be removed as required.

(iv) Landfill Gas Exhaust Equipment

As with the leachate collection facility, since the landfill gas exhaust equipment plays a very important role in the semi-aerobic landfill method, landfill work around pipes should be implemented with extreme care to ensure that pipes are not broken. Moreover, it is necessary to keep extending the length of vertical pipes in line with the progress of landfill work.

(v) Rainwater Drainage

Is necessary to check for the build-up of sediment and grass, etc. in drains and remove them according to necessity. Moreover, it is necessary to confirm sediment accumulation conditions in the sand sedimentation pond at the end of the drainage system around once a month, and to remove sediments from the pond if they have accumulated.

(vi) Access Road and Onsite Road

The access roads should be immediately repaired if they become very bumpy, while the onsite roads will need to be re-laid in line with the progress of landfill. This relaying work should be planned and conducted in consideration of the landfill conditions.

(vii) Net Fence

Net fences will need to be checked every day and immediately repaired if any breakage, etc. is found.

(viii) Truck Scale

Truck scales will need to undergo regular operation checks by a specialist operator.

(6) Cost Estimation

Cost estimation for the new landfill site will be conducted for Option 1 (Ruai) and Option 2 (Ruai + Juja) and Option 3 (Ruai + Mavoko). **Table E.4.17** shows the summarised landfill site estimation results. The detailed results will be shown in **Section E of Volume 4, Data Book**. According to these, the total cost including construction cost, land purchase cost and operation and maintenance costs up to 2030 will be cheapest in Option 1. The detailed information of cost estimate is shown in **Section E of Volume 4, Date Book**.

Table E.4.17 Summarised Landfill Site Estimation Results (1000KSh)

		Option 1	Option 2	Option 3
		Ruai	Ruai + Juja	Ruai + Mavoko
Waste Amount (m^3)	Ruai	12,670,000	8,490,000	8,490,000
	Juja or Mavoko	0	4,180,000	4,180,000
Land Acquisition		0	108,000	79,000
Construction	Main	4,961,000	5,180,000	5,585,000
	Enclosure Dike	2,916,660	2,506,950	3,064,230
Engineering Fee (Construction Main×10%)		496,100	518,000	558,500
O&M (2017-2030)		2,674,080	3,228,880	2,825,860
Procurement of Heavy Machinery		268,300	280,600	280,600
Sub-Total		11,316,140	11,822,430	12,393,190
Physical Contingency (10%)		837,376	820,495	920,773
Total		**12,153,516**	**12,642,925**	**13,313,963**

Note: Physical Contingency is calculated as 10% of construction cost and engineering fee.

Table E.4.18 shows the annual landfill expenditure in the case of Option 1.

Table E.4.18 Annual Landfill Expenditure (1000KSh)

	Waste Amount (m^3/year)	Construction		Engineering Fee		O&M	Procurement of Heavy Machine Equipment	Total
		Main	Enclosure Dike	Design	Construction Supervision			
2013				180,800				180,800
2014								
2015		1,265,600			63,280			1,328,880
2016		2,350,400			117,520		140,300	2,608,220
2017	519,273					66,850		66,850
2018	564,047					69,830		69,830
2019	611,253		477,690			73,560		551,250
2020	658,460					77,280		77,280
2021	718,807		456,650			83,580	57,500	597,730
2022	783,533			67,250		88,030		155,280
2023	848,747		439,810			92,480		532,290
2024	918,340	470,750	404,040		23,538	96,920		995,248
2025	990,367	874,250			43,712	101,370		1,019,332
2026	1,059,473					109,810	70,500	180,310
2027	1,133,447		296,720			414,820		711,540
2028	1,207,420		292,510			439,810		732,320
2029	1,286,260		288,300			466,090		754,390
2030	1,369,967		260,940			493,650		754,590
Sub-Total	12,669,394	4,961,000	2,916,660	248,050	248,050	2,674,080	268,300	11,316,140
P/C	-	496,100	291,666	24,805	24,805	-	-	837,376
Total	-	5,457,100	3,208,326	272,855	272,855	2,674,080	268,300	12,153,516

Note: P/C stands for "Physical Contingency" which is calculated as 10% of construction cost and engineering services cost.

4.4.3 Temporary Dumpsite

(1) Temporary Dumpsite Capacity Requirement

The new landfill site is scheduled to start operation in 2017. Accordingly, it is necessary to have a temporary landfill site for dealing with waste up to 2016. Although soil covering is not currently conducted on Dandora Dumpsite, cover soil should be applied on the temporary landfill site to prevent waste fly-off and minimise local environmental impacts. Accordingly, when calculating the required landfill capacity, cover soil equivalent to 10 percent of the waste volume (m^3) will be assumed. **Table E.4.19** shows the landfill capacity between 2010~2016. Necessary capacity of the temporary landfill will be 2,251,000 m^3.

Table E.4.19 Landfill Site Capacity Requirement (2011 to 2016)

	Waste Amount (t/d) (1)	Waste Amount (m^3/d) (Bulk Density) (2) = (1) * 1.0	Waste Amount (m^3/year) (3) = (2)*365	Cover Soil (m^3/year) (4) = (3) / 10	Total Waste Amount (m^3) (5) = (3)+(4)
2010	634	634	231,300	23,100	254,400
2011	690	690	251,800	25,200	531,400
2012	743	743	271,300	27,100	829,800
2013	798	798	291,200	29,100	1,150,100
2014	853	853	311,300	31,100	1,492,500
2015	911	911	332,600	33,300	1,858,400
2016	979	979	357,300	35,700	**2,251,400**
Total			2,046,800	204,600	

(2) Temporary Dumpsite

Either the current Dandora Dumpsite or the Kayole Temporary Dumpsite can be used as the temporary dumpsites. Dandora shall continue to be used for the reasons cited below. However, to mitigate impacts on the surrounding environment, it will be essential to apply cover soil. Furthermore, since almost all of Dandora Dumpsite is privately-owned land, it will be necessary to secure consent from the landowners to continue landfill.

- Dandora Dumpsite covers an area of 46 ha. In the case where it receives 2,251,000 m^3, since the waste layer will increase by around 5 m over the present level, this should be an acceptable level.
- Dandora Dumpsite is closer to the city centre than Kayole Temporary Dump Site. Moreover, since Dandora is situated on a major road while Kayole is separated from main roads, the first is a better option in terms of transportation efficiency.
- In the case where Kayole is adopted as the temporary dumpsite, this will have a major impact on the waste pickers who inhabit Dandora Dumpsite. Accordingly, this would not be desirable in terms of social and environmental considerations.
- At Kayole Temporary Dumpsite, the quarry currently undergoing landfill only has the capacity of around 920,000 m^3, while the other two quarries have a lot of accumulated water and cannot be used as dumpsites. Accordingly, Kayole does not possess the necessary capacity to function as the temporary landfill site in this case.

4.4.4 Example of Development Plan of Landfill Outside Nairobi City

The situation of final disposal sites in the major cities other than Nairobi is given in **Table E.4.20**. **Table E.4.20**, was taken from the results of the Situation Analysis on Solid Waste Management (2007 NGO Practical Action). [14]

From the table, it could be understood that each city requires a new final disposal site. However, there are only two cities, Mombasa and Nakuru that are considering a concrete plan. In Mombasa, the F/S was conducted in 2004 and the building lot, planning policy, etc. were examined. After that, however, a detailed design was not performed and the plan is still pending. In Nakuru, a private land in the suburbs has been leased and the detailed design was started in January 2010. The operation of the new disposal site is due to be started after 19 months.

Table E.4.20 Situation Analysis of Solid Waste Management in Major Cities other than Nairobi

No.	Town	Future Plan	Planned Landfill Site
1	MOMBASA	1) Development of new sanitary landfill within the south coast with the assistance of AFD. 2) Development of the Mwakirunge dumpsite and improvement of access roads through AFD funding.	◎
2	MERU	1) Plans to formalise dumpsite to be reflected in the council development plans.	○
3	ISIOLO	1) The council will relocate from the current dumpsite to a new one.	○
4	THIKA	1) Finalising land tenure at the current dumpsite to avoid conflict with NEMA. 2) Acquire machinery to help bury waste into the dumpsite.	×
5	EMBU	1) Construction of more refuse chambers in selected areas for storage. 2) Council will try to pilot waste separation from the source. 3) Fence-off dumpsite.	○
6	NYERI	1) Purchase extra bulk compactor vehicle to increase solid waste collection. 2) To acquire a new appropriate dumpsite since the current one is almost full and is not a designated dumping site.	○
7	MACHAKOS	1) Sanitary land filling at dumpsite to be developed slowly. 2) Fence-off dumpsite.	○
8	KITUI	1) Shifting from current dumpsite to a new purchased site though not designated as dumpsite.	○
9	GARISSA	1) Plans to increase vehicles for SWM by buying one tipper lorry and tractor shovel.	×
10	KISUMU	1) Acquire a grader machinery to manage the dumpsite safely and efficiently. 2) Acquire and relocate to a new appropriate dumpsite. 3) Venture into practicing sanitary land filling. 4) Under LASDAP (Local Authorities Sustainable Development Action Plan), one ward proposed construction of refuse chambers at KSh 600,000 in next financial year. 5) Partnerships with Bluestar Company, if the council will manage to prove that the company can access a minimum waste amount of 200 tons/day. The company wants to invest in waste processing.	○
11	KAKAMEGA	1) Plans to partner with private sector for SWM in the municipality. 2) Council plans to acquire its own appropriate disposal site. 3) Buy a garbage collection lorry using LATF (Local Authority Transfer Fund) in the next budget 2007/08	○
12	KERICHO	1) Relocate disposal of refuse to new appropriate dumpsite.	○
13	NAKURU	1) Improved dumpsite interventions through Gioto stakeholders' forum spearheaded by Practical Action and other stakeholders working closely with MCN. 2) The council aims to relocate the current dumpsite to some 18km away towards Naivasha where sanitary land filling will be practiced. When this comes to effect, there will also be a transfer station created with the municipality.	◎
14	ELDORET	1) Council plans to relocate to new appropriate dumpsite. 2) Council plans to construct her own incinerator in one of council institution to deal with hazardous waste which council does not collect.	○

Source: Situation Analysis on Solid Waste Management (NGO Practical Action)
Note: ◎ =Planned landfill site with location indicated
○ =Planned landfill site but no location indicated
× =No plan