PART III : FEASIBILITY STUDY FOR THE PRIORITY PROJECTS

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CHAPTER III-1 FEASIBILITY STUDY FOR THE KABULIHAN SANITARY LANDFILL

1.1 Introduction

Following RA9003, the MOM closed the old dumping site on Boracay Island and started operation of MRFs in 2006. Since then, there has been no sanitary landfill site in the MOM where a large amount of solid waste could be disposed of. Under this situation, the candidate site in Barangay Kabulihan on the Mainland of Malay has been examined by the DENR, and the MOM has put the highest priority on developing a sanitary landfill there. However, the residual waste transported from Boracay Island has accumulated at the site without proper measures. Consequently, there are rising concerns about the environmental impacts from the accumulated residual waste such as water pollution and breaking out of disease vectors as suggested by the residents. At the MRFs on Boracay Island, they have been also having difficulty in coping with the daily accumulations of residual waste and a sizeable portion of the MRFs is being used for the temporary storage of the residual waste. Therefore, the development of a sanitary landfill is urgently needed to receive the residual waste properly. Accordingly, the development of a sanitary landfill site in Balangay Kabulihan has been proposed in the 10-year SWM Plan of the MOM and selected as one of the priority projects for which an F/S has been conducted. The proposed SLF, which extends to a total area of 6.25 ha, straddles the municipal boundary between the MOM and the Municipality of Buruanga (MOB).

1.2 Site Conditions

1.2.1 Topography and Hydrology

The site is accessed by an unpaved road, approximately 4 m wide and 560 m long, from the Provincial Road between Barangay Poblacion of the MOM and Barangay Buruanga Poblacion of the MOB. The road was acquired by the MOM in 2006 in order to ensure access to the site.

The site was identified by the DENR in February 2006 as a potential landfill site for the MOM. Following an assessment by the Mines and Geosciences Bureau (MGB), also in February 2006, it was considered, from a number of technical perspectives, to be a suitable site for the development of a sanitary landfill. The landfill site is not located within 10 km of any fault line known to be active. However, the site is subjected to occasional earthquakes with magnitudes approaching 7.0. The area which can be used for the site is shown in Figure 1.2-1.

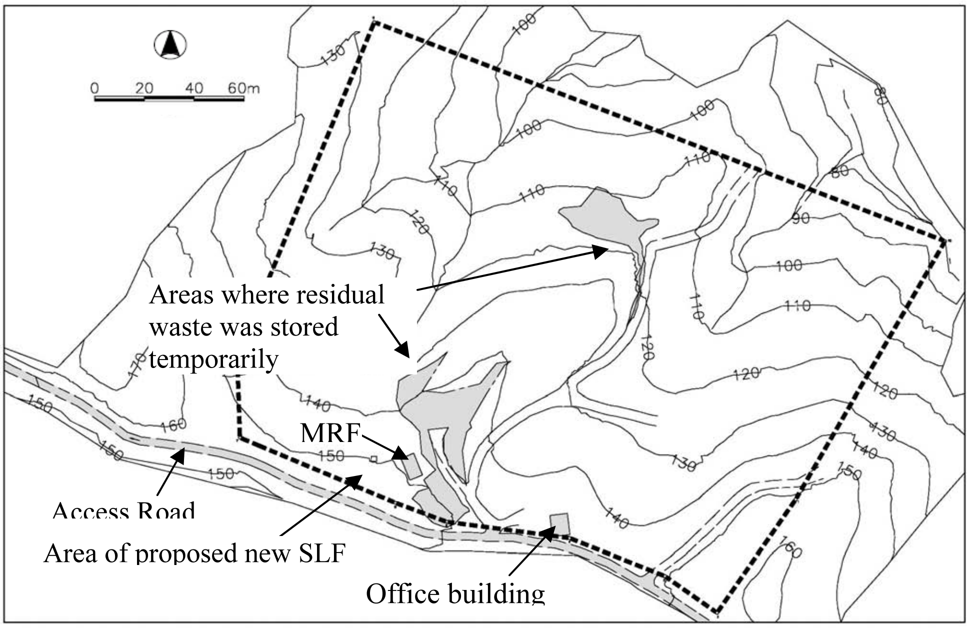


Figure 1.2-1 Topography of Proposed Sanitary Landfill

Source: JICA Study Team

The site is rectangular in shape, running approximately 300 m from west to east and approximately 200 m from south to north. The southern limit of the site lies adjacent to the access road, which, at this point, runs along a ridge line separating drainage systems to the north in the MOM (including the site) and to the south in the MOB.

The highest elevation at the site is recorded adjacent to the access road along the southern central site boundary at approximately 156 m above sea level (ASL). The lowest elevation, at approximately 80 m ASL is located at the extreme north-east corner of the site adjacent to a perennial creek.

The site encompasses two small drainage valleys with an intervening narrow ridge that runs approximately south to north in the central portion of the site. Elevations along the ridge line decline from 156 m ASL to approximately 115-120 m ASL in a northwards direction. The eastern valley, in which is located a small ephemeral creek which runs only during the rainy season, lies at an elevation that declines from approximately 135 m ASL in the south to approximately 84 m ASL at the northern margin of the site.

The western valley, which is somewhat larger in size, also has intermittent surface water flows confined to the wet season, and declines in elevation south to north from approximately 145 m ASL to approximately 91 m ASL. The average gradient in the valley floors is approximately 1:4 although the side slopes are considerably steeper, in many places steeper than 1:2.5 and occasionally as steep as 1:1 (45^{o}).

The MOM has constructed two structures at the site – an office building and a covered shed that is meant to serve as a MRF. The MOM also has a water supply to the site and single phase electricity to the office building. Since late 2006 the MOM has been transferring residual waste from Boracay Island and storing it temporarily at the site, pending the development of the engineered sanitary landfill. Waste is stored in two principal locations adjacent to the central ridge.

1.2.2 Geology

(1) Drilling and Core Sampling

Subsurface exploration by core drilling was undertaken to determine the engineering properties of the overburden materials. A total of eight boreholes (BHs) with an aggregate depth of 160.4m and four ground water observation wells, two Ground Water Deep wells (GWD) and two Ground Water Shallow wells (GWS), with a total depth of 80.0m were also drilled. Table 1.2-1 shows the boreholes drilled and their depths, while Figure 1.2-2 shows the location of boreholes.

Table 1.2-1 Summary of Boreholes Drilled

Borehole Number	Depth Drilled (m)
BH-1	20.10
BH-2	20.04
BH-3	20.08
BH-4	20.13
BH-5	20.09
BH-6	19.65
BH-7	20.62
BH-8	19.68
GWD-1	25.00
GWS-2	15.00
GWS-3	15.00
GWD-4	25.00

Source: JICA Study Team

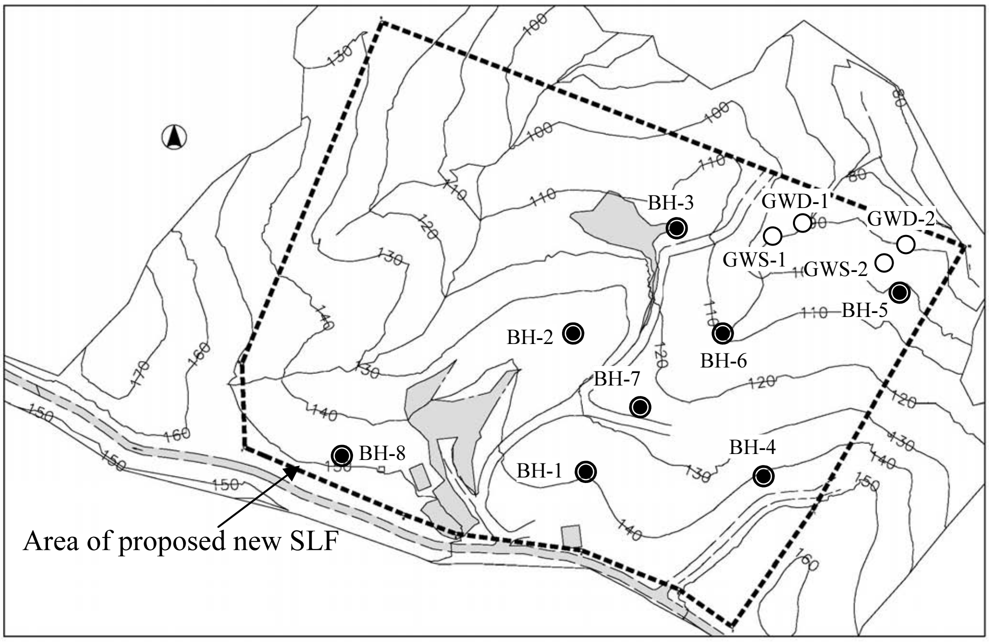


Figure 1.2-2 Location of Boreholes at the Proposed Sanitary Landfill

Source: JICA Study Team

The results of drilling are summarized as follows:

BH-1 (20.10m depth), which is located at the central upper slope of the landfill area, was drilled to the depth of 20.10 meters from the ground surface. The first eight m from the surface consists of alternating layers of silty sand, gravelly sandy silt and a mixture of unconsolidated gravel, pebbles, sand and silt. Core recovery of this borehole was low ranging from 7 to 28% indicating a very poor rock quality designation.

BH-2 (20.04m depth), drilled at the temporary dumpsite area showed that the soil is nine meter thick gravelly clay materials and is underlain by moderate to extremely weathered alternating layers of basalt flows, shale, mudstone, siltstone and conglomerate. Core recovery ranges from 4 to 28%.

BH-3 (20.08m depth) , which is located in the mid-eastern portion of the landfill area, penetrated through fifteen m thick overburden materials composed essentially of layers of dense to very dense reddish silty clay and silty sand.

BH-4 (20.13m depth) was drilled at the mid-eastern portion of the landfill and area encountered the same bedrock after seven meters of reddish layers of silty clay and gravelly silty clay.

BH-5 (20.09m depth) is located at the north-eastern portion of the new landfill area. The thickness of the layers of gravelly silty clay and fat clay is about 18.65m. Poor core recovery ranges from 9 to 33 %.

BH-6 (19.65m depth) is located at the midsection of the landfill area. The soil for the entire drill length is made of layers of silty/clay gravel, silty clay and totally weathered bedrock. Poor core recovery ranges from 8 to 28%.

BH-7 (20.62m depth) is located in the upper midsection of the landfill area. The thickness of overburden is 13m. It is made of medium dense to very dense layers of silty sand, gravelly sandy silt, and gravelly silty clay.

BH-8 (19.68m depth) is located at the southwestern upper most section of the landfill area. It is made of medium dense to very dense layers of gravelly silty clay, gravelly/ clayey silt and silty/clayey gravel.

GWD-1, GWS-2, GWS-3 and GWD-4 are located at the foot of the slope of the landfill site and is covered with silty clay soil and underlain by basalt flow (Fragante Formation). The bed rock is moderate to slightly weathered and closely fractured/jointed.

(2) Standard Penetration Test (SPT)

Standard Penetration Tests (SPT) were conducted in soft overburden materials, at every one meter interval in soil and weathered rock layers. They were performed using a standard split-spoon sampler. The number of blow counts for the seating drive was recorded. The total number of blows was counted for the last 12 inches of penetration which is known as the standard penetration resistance (N-value) of the soil. Correlation has been developed between the SPT (N-value) and soil parameters, which can be used for bearing capacity estimation. Tables 1.2-2 and -3 show the correlation between the cohesive soil and the penetration resistance (N-value) recorded.

Table 1.2-2 Correlation Between SPT and Soil Consistency (Granular Soil)

Description	Very Loose	Loose	Medium	Dense	Very Dense
Relative Density	0-0.15	0.15-0.35	0.35- 0.65	0.65-0.85	0.85-1.00
Standard Penetration Test #N-Value	0-4	5-10	11-30	31-50	51 Up
Approx. Internal Angle of Friction	25^0-28^0	28^0-30^0	30^0-35^0	35^0-40^0	40^0-43^0
Approx. Range of Moist Unit Weight, (KN/m^3)	11.0-15.7	14.1-18.1	17.3-20.4	18.3-22.0	20.4-23.6
Submerged Unit Weight (KN/m^3)	9.4	8.6-10.2	9.4-11.0	10.2-13.4	11.8

Source: JICA Study Team

Table 1.2-3 Correlation Between SPT and Soil Consistency (Cohesive Soil)

Description	Very soft	Soft	Medium	Stiff	Very Stiff	Hard
Unconfined Compressive Strength, Qu (KN/m^2)	0-23.9	23.9-47.9	47.9-95.8	95.8-191.6	191.6-383.1	383 -UP
Standard Penetration Test #N	0-2	3-4	5-8	9-16	17-32	33-UP
Approx. Range of Standard Unit Weight, Saturated (KN/m^3)	15.7-18.9	-	15.7-20.4	-	18.9-22.0	20.4 +

Source: JICA Study Team

After the SPT on each test interval, a string of rods and split-spoon samples were pulled out from the hole and the recovered disturbed samples were retrieved and placed in a moisture tight plastic bag for further visual examination and laboratory tests. The SPT results of all the boreholes revealed that there is an increase in bearing strength of the soil and deeply weathered rock in deeper portions. The overburden soils encountered across the site were generally made of reddish to yellowish gravelly silty and clayey silt of medium plasticity, and silty sand of very low to no plasticity. The bedrock encountered is slightly weathered and strong as noted in boreholes located near the lower most part of creek lines traversing the landfill area.

The SPT was conducted to determine the overburden bearing capacity/strength based on the resulting N-values. The SPT results indicated that the foundation materials of the site are covered with layers of medium dense residual and colluvial soils (22-26 N-value), and underlain with gradually grading to higher density overburden materials. The layers of moderately compacted overburden are dense with N-Value ranges from 31-50. The highly compacted overburden materials produced high N-values to refusal (>51 N-value), revealing an increase in compaction, consolidation and higher quantity of granular/or gravel fragments. The typical soil and mechanical properties of strata estimated from the N-values taken from cohesive, non-cohesive and extremely to totally weathered intercalating basalt flow, shale, mudstone, siltstone and conglomerate are enumerated in Table 1.2-4.

Table 1.2-4 Soil Mechanical Properties

Borehole No.	Depth (m)	SPT (N- value)	Relative density (%)	Typical Range of Unit Weight ,KN/m^3		Typical Ultimate Bearing Capacity (qu)=kg/cm^2
				Moist	Submerged	
BH-1	0.55-1.00	39	65-85	18.3-22.0	10.2-13.4	>4
	1.55 – 14.12	59 to refusal	85+	20.4-23.6	11.8	>4
BH-2	0.55 – 1.0	24	35-65	17.3-20.4	9.4-11	2 - 4
	1.55 – 3.0	42 -46	65-85	18.3-22.0	10.2-13.4	>4
	3.55-4.0	51	85+	20.4-23.6	11.8	>4
	4.55-7.0	47-48	65-85	18.3-22.0	10.2-13.4	>4
	8.0-9.10	refusal	85+	20.4-23.6	11.8	>4
BH-3	0.55-3.0	35-38	65-85	18.3-22.0	10.2-13.4	>4
	3.55-6.0	41-47	65-85	18.3-22.0	10.2-13.4	>4
	6.55-18.17	54 to refusal	85+	20.4-23.6	11.8	>4
BH-4	0.55-2.0	40-42	65-85	18.3-22.0	10.2-13.4	>4
	3.55-9.13	56 to refusal	85+	20.4-23.6	11.8	>4
BH-5	0.55-2.0	40-44	65-85	18.3-22.0	10.2-13.4	>4
	2.55 -17.70	51 to refusal	85+	20.4-23.6	11.8	>4
BH-6	0.55-5.0	31-39	65-85	18.3-22.0	10.2-13.4	>4
	5.55 -15.79	52 to refusal	85+	20.4-23.6	11.8	>4
BH-7	0.55-2.0	22-39	35-65	17.3-20.4	9.4-11	>4
	5.55-6.0	51	85+	20.4-23.6	11.8	>4
BH-7	6.55-9.0	48-49	65-85	18.3-22.0	10.2-13.4	>4
	9.55-15.78	54 to refusal	85+	20.4-23.6	11.8	>4
BH-8	0.55-2.0	21-26	35-65	17.3-20.4	9.4-11	2-4
	2.55-7.0	32-44	65-85	18.3-22.0	10.2-13.4	>4
	7.55-10.0	55-63	85+	20.4-23.6	11.8	>4

Source: JICA Study Team

(3) Permeability Test

Water pressure tests were conducted in the bedrock by a descending method or using a single packer assembly. The descending method was performed on boreholes drilled in broken ground or when there was danger of hole cave-in after drilling and washing. In addition, percolation tests were conducted on particular test sections of selected boreholes where water pressure can not be established.

Permeability tests by open-end falling head method were performed in overburden formations. Hole advance was made at any desired depth depending on the layer to be tested. Holes were properly cleaned to remove fine particles that could affect the permeability of the material. Before the start of the tests, the following data were recorded:

- Depth of casing
- Size of casing
- Groundwater level
- Length of the open hole

The test procedure was as follows:

- Fill the casing with water. Record time (To = 0) and drawdown (Ho = 0).
- Let the water in the casing drop, measuring the drawdown at regular time or depth intervals until the water level becomes constant.

A total of seven settings consisting of four percolation tests (PT) and three water pressure tests (WPT) were conducted on the drill holes. Table 1.2-5 is the summary of the field permeability test results obtained from the boreholes. The field permeability test results of the drill holes reveal that the overburden materials encountered ranged from pervious to semi-pervious.

Table 1.2-5 Result of Permeability Test

Borehole No.	Type of Field Test	Test Section (m)	Average K (cm/sec)	Remarks
BH-2	PT	6.3 - 7	7.74×10^{-4}	Pervious
BH-3	PT	3 - 4	5.70×10^{-5}	Semi-pervious
BH-4	PT	2 - 3	5.51×10^{-4}	Pervious
BH-5	PT	4.5 - 5	8.38×10^{-5}	Semi-pervious
GWD-1	WPT	7 - 12	1.28×10^{-4}	Pervious
GWD-1	WPT	13 - 18	4.39×10^{-5}	Semi-pervious
GWS-2	WPT	7.5 – 15	2.6×10^{-4}	Pervious

Source: JICA Study Team

(4) Infiltration Test

Field permeability tests using an infiltometer cylinder were conducted on soil covering the inside of the landfill area. Testing layers covered with organics were stripped and then the infiltometer was pressed about 20cm into the ground. The infiltometer cylinder was filled with clean water and then the drawdown of water inside the cylinder was noted with 2, 5, 8, 10 and 15 minutes intervals over two hours.

The results of the four infiltration tests are presented in Table 1.2-6. Average infiltration rates obtained in different soil textures varied from 5.35 to 17.65 cm/hr. In terms of basic infiltration, the rates varied from 3.21 to 10.24 cm/hr. These rapid intake rates suggest that the soil covering of the site is granular and very pervious.

Table 1.2-6 Results of Field Infiltration Test

Test Site No.	Surface Soil Type	Infiltration Rate (cm/hr)		Class
		Basic	Average	
1	Gravelly/sandy silt/silty sand	3.21	5.35	Moderate
2	Gravelly/sandy silt/silty sand	10.24	17.65	Rapid
3	Gravelly/sandy silt/silty sand	6.84	12.66	Rapid
4	Gravelly/sandy silt/silty sand	7.03	12.00	Rapid

Source: JICA Study Team

(5) Test Pit (TP)

The main source of construction materials for the clay liner may be quarried in and near the landfill area. A total of six test pits was dug at the site with a maximum depth of three meters after stripping of unfavorable soil covering. Bulk samples were taken for laboratory tests.

Laboratory test results indicate that the physical properties of the soil such as natural moisture content (NMC) has values ranging from 11.2% to 28.0% and the optimum moisture content (OMC) has values ranging from 15.5% to 20.3%. Such materials belong to the ML-SM group of soils characterized by low plasticity and compressibility. Tests for the mechanical properties of the soil were conducted using the California Bearing Ratio (CBR) test on the soil samples (TP-1 and TP-3). Values obtained for the Maximum Dry Density and Optimum Moisture Content are as follows:

- Maximum Dry Density: 1.74 to 1.85(g/cc)
- Optimum Moisture Content: 15.5 to 20.3 (%)

(6) Groundwater Monitoring Wells

Four groundwater monitoring wells were constructed at the foot of the slope of the landfill area. The area is covered with from one meter to 6.80m silty clay soil and underlain by closely fractured/jointed basalt. The rock is moderate to slightly weathered, hard and dense. The ground water level ranged from 10.75m to 11.70m at GWD-1 and GWS-2 and 1.46m to 1.95m for GWS-3 and GWD-4, respectively. The different depths of ground water elevation of the boreholes are controlled by the amount and distance of the recharge sources such as creek, gully and river.

(7) Summary of Geological Conditions

The proposed landfill site is underlain by rocks of the fragante formation, which is composed of massive, amygdaloidal, agglomeratic, and partly brecciated to basaltic lava flows intercalated with shale, conglomerate, and limestone. This formation is exposed in the base of the principal valleys draining the site, where it is seen to be slightly weathered to fresh, hard to very hard, massive and dense. Partings between beds and jointing in the outcrops of basalt were noted to be open and interconnected, rendering the rock unit relatively pervious and permeable.

Overlying the basalt formation is a thick sequence of residual soil derived from complete weathering of the basalt. The residual soil typically forms a silty clay soil that is also overlain by colluvial deposits of variable composition such as gravelly clay, sandy silt, silty sand and bouldery clay/sand/silt. The residual soil and colluvial soils are of variable thickness, typically 5 m or more but in places as much as 15 m in thickness. The residual soil appears to be discontinuous and is not recorded everywhere within the eastern part of the site investigated.

While the residual soil is typically fine grained in nature, it appears that weathering has produced a predominantly silty material that is of low permeability, of the order of 1×10^{-7} m/sec. *In situ* measurements confirm that the material has a low permeability, although not considered to be sufficiently low to meet the requirements to act as an in situ engineered barrier.

The surface water drainage pattern is generally dendritic and angular, influenced by rock type and the prevailing geological structures (attitude of volcanic flows, joints and folds). As noted above there are two principal valleys located within the site, both of which carry water seasonally during the rainy season. The surface water flows appear to be spring-fed and originate from groundwater seepages, both through the superficial soils and from fractured and jointed bedrock.

Groundwater monitoring wells installed at the site indicate the presence of groundwater close to the soil/rock interface and continuity in the groundwater regime in both superficial soils and in the bedrock. Water quality results have confirmed the similarity of water quality of both groundwater and surface water in and immediately downstream of the site.

1.2.3 Climate

The climate of the site belongs to a tropical monsoon so that the weather condition of the site is profoundly seasonal, with a single wet season and a single dry season. The rainy season is normally recognized as the southwest monsoon period, which lasts from June to December. Most annual rainfall occurs in these months with frequent squalls and strong westerly winds. The dry season, from January to May, falls under the period of the northeast monsoon period and is generally, although not always, comparatively drier.

There is rainfall intensity duration frequency (RIDF) data in Kalibo which was the nearest station from the site. The RIDF data can be used for the calculation of drainage design and leachate treatment pond as well. The calculated RIDF data is shown in Table 1.2-1.

Table 1.2-1 Rainfall Intensity Duration Frequency at Kalibo Station

(Unit:mm)

Return Period	Consecutive Duration														
	5 min	10 min	15 min	20 min	30 min	45 min	60 min	80 min	100 min	120 min	150 min	3 hr	6 hr	12 hr	24 hr
2 year	8.7	13.4	17.2	20.3	25.3	30.2	33.5	39.2	44.3	48.3	53.5	58.1	75.5	92.3	104.5
5 year	12.3	18.9	24.4	28.9	36.2	43.3	48.2	56.5	64.0	70.0	77.6	84.4	110.7	135.4	154.0
10 year	14.8	22.6	29.2	34.6	43.4	52.1	58.0	68.0	77.1	84.3	93.6	101.8	134.0	163.9	186.7
15 year	16.1	24.7	31.9	37.9	47.4	57.0	63.5	74.4	84.4	92.4	102.6	111.6	147.1	180.0	205.2
20 year	17.1	26.2	33.8	40.1	50.3	60.4	67.3	79.0	89.6	98.1	108.9	118.5	156.3	191.3	218.1
25 year	17.8	27.3	35.3	41.9	52.5	63.1	70.3	82.5	93.6	102.4	113.7	123.8	163.4	200.0	228.1
50 year	20.1	30.8	39.7	47.2	59.2	71.2	79.4	93.2	105.8	115.9	128.7	140.1	185.2	226.7	258.8
100 year	22.3	34.2	44.2	52.5	65.9	79.3	88.5	103.9	118.0	129.2	143.5	156.3	206.8	253.3	289.3

Note: Each data indicates the maximum rainfall amount during consecutive duration of each return period. For example, the consecutive 30 minutes rainfall which occurs with the probability once in 100 year will cause maximum rainfall amount of 65.9mm.

Source: PAGASA, (1980 to 2000)

1.2.4 Environment

(1) Physical Environment

A series of water quality survey was conducted by the JICA Study Team for surface waste and ground water in and around the proposed SLF as shown in Appendix III-1.2.1. The results of the survey are summarized below:

Surface water survey was conducted at three locations. One was taken from a spring near the site, and the others were taken at major creeks which drain from the site. The samples were collected in the dry season (June 2007) and rainy season (September 2007). The result did not show any significant differences between the dry and rainy seasons. The result revealed that there was no critical contamination in the water environment around the site except for coliform. The analysis of surface water detected magnesium and iron, but their concentrations were not at critical levels. In terms of lead, copper and cadmium, most samples had a concentration below their detection limits. However, total number of coliform was 2 to 9 times higher than the Philippine standard.

As for the groundwater surveys, the samples were taken from water quality monitoring wells in the site and the existing wells located along Malay River. The same as the surface water survey, neither the quality of the water in the monitoring wells nor of the existing wells showed critical contamination except for coliform. Though the analysis detected magnesium and iron, their concentrations were not at critical levels. Concentrations of lead, copper and cadmium of most samples were below their detection limits. All of the samples had much more coliform than the Philippine standard.

The landfill gas was measured by a G450 Portable Gas Detector as part of air quality survey. Four parameters, CH_4, CO_2, H_2S and NH_3, were measured at five sampling points in the site. Since the concentrations of all four parameters were below the detection limits of the Portable Gas Detector, the result of the survey did not indicate any landfill gas in the ambient air at the site. In terms of odor, no offensive odors were experienced during the survey on the site.

The noise levels were also recorded with a potable nose level meter. The recorded sound level ranged from 40 to 60 dB (A) which is the level under the normal conditions. The sound was generated by wind blowing, animal and bird singing, and working activities without operation of heavy equipment.

(2) Natural Environment

Based on the interview survey, Malay River and its tributaries provide habitat for shellfish, eels and shrimp. Residents in Barangay Kabulihan do not catch them to sell but rather for their daily consumption although fishing activities are not popular around the mouth of Malay River. Goat fish, snapper, butterfly fish and rabbitfish are commonly caught at a depth of over 15m of in offshore areas around the northern part of Malay Island.

Barangay Kabulihan, as well as the site, is home to a great number of plant species which are endemic in the area. During the survey, 60 kinds of plants were observed. Local residents utilize them as food, medicine, and materials for weaving and building houses.

Fruits bats are commonly observed by local residents around the site. Indiscriminate habitat destruction and hunting activities by the residents threaten the fruit bats. Monkeys commonly inhabit the areas around the site as well. In addition, several species of reptiles live around the site.

(3) Social Environment

Barangay Kabulihan, consisting of seven sitios (the smallest socio-political unit and a political subdivision of a barangay), had a total population of about 500 persons and 115 households at the survey time. Land use within a 1 km radius from the site is mainly composed of five usages: agricultural land, coconut plantation, grassland, secondary forest, and small areas of paddy fields. Though most of the local residents are engaging in agricultural and fishing activities, the harvest and catch are mainly for domestic consumption. Many of the residents interviewed earn their income through work, on Boracay Island.

In addition to water from Malay River, Agnaga River and seven creeks, local residents use water tanks located along Bajangan Creek to which ten communal faucets connect. There are ten deep wells and three dug wells around the site. Some of the more affluent families have installed motorized pumps.

Perception survey by the JICA Study Team was conducted targeting 99 residents around the site. About 15% were in favor of the project since it could contribute to improve the SWM system. However, 70% of the respondents showed their concerns about pollution of the environment and affects on their health. In terms of specific issues, 76 % of the respondents had a concern that the new SLF may cause negative effects to the groundwater quality especially during the operation phase. A total of 40% were anxious about the groundwater contamination which may continue even after its closure. Furthermore, 70% of the respondents said that the SLF may devalue their land.

While the respondents worried about the negative impacts caused by the proposed SLF, some benefits were also looked forward to. Positive impacts expected by respondents were better business opportunities and improved SWM.

1.3 Planning Concept

1.3.1 Overall Design Concept

There are a number of fundamental considerations in developing the overall design concept of the SLF. The key features of the overall development plan are as follows:

- the SLF should be developed progressively, with phased capital investments at discrete periods of time necessary to provide incremental void space. The timing of the required investments will be linked to the rate at which the available void capacity is utilize,
- within Phase 1, the site should be developed progressively in a series of sub-phases. Site engineering has been integrated to provide continuity between each sub-phase development and to avoid the need for duplication in site development works;

- in order to provide cost-effective disposal capacity it is necessary to excavate into the existing ground and to flatten some of the existing site slopes while, at the same time, enhancing disposal capacity through the provision of an embankment dam along the lower northern margin of the landfill footprint;
- excavation depths have been kept to a minimum in order to minimize initial investment costs. However, it is considered likely that additional cost-effective void capacity can be provided by excavating deeper within the landfill footprint, subject to local prevailing geological conditions, the stability of excavated slopes and the space constraints dictated by the requirement to store excess excavated materials;
- notwithstanding that the nature of the waste to be disposed will reduce the potential for pollution, environmental protection to surface water and groundwater is provided by the installation of basal containment layers (engineered barriers) to prevent the uncontrolled migration of contaminated waters (leachate) out of the base of the sanitary landfill, in conjunction with the provision of drainage systems to collect leachate and a treatment system to improve the quality of leachate to a level at which it can be discharged safely back into the environment. Only treated leachate effluent that conforms to national discharge standards will be discharged off-site;
- similarly, the engineered barriers will inhibit the uncontrolled migration of any landfill gas off-site. The landfill design incorporates passive gas vents given the small quantities of waste to be managed within the cell and the reduced potential for the generation of landfill gas;
- both permanent and temporary storm water drainage systems shall be installed progressively around and within the landfill footprint in order to minimize the ingress of surface water into the waste and to reduce the quantities of leachate generated;
- site operations will be undertaken in small discrete cells within each sub-phase in order to minimize the volume of leachate generated;
- the surface of the waste disposal area will be capped progressively upon reaching final height in order to minimize leachate generation. A layer of agricultural soil will be placed over the clay cap in order to promote vegetation growth;
- support infrastructure will be provided at the site entrance in order to facilitate appropriate management of the site. The operations compound will be fenced and include a temporary storage area for residual waste transferred to the site, and
- the operations compound will also include a special waste cell for the permanent secure storage of toxic and hazardous waste (THW) and health care waste (HCW).

It is envisaged that the landfill site will be developed progressively in two individual and separate Phases, with Phase 1 being developed in the eastern half of the site that is already partially cleared. Phase 1 will be developed partially under the 10-year SWM Plan, while Phase 2, would be developed in the final one to two years of filling of Phase 1. Figure 1.3-1 shows the overall development plan of Phase 1.

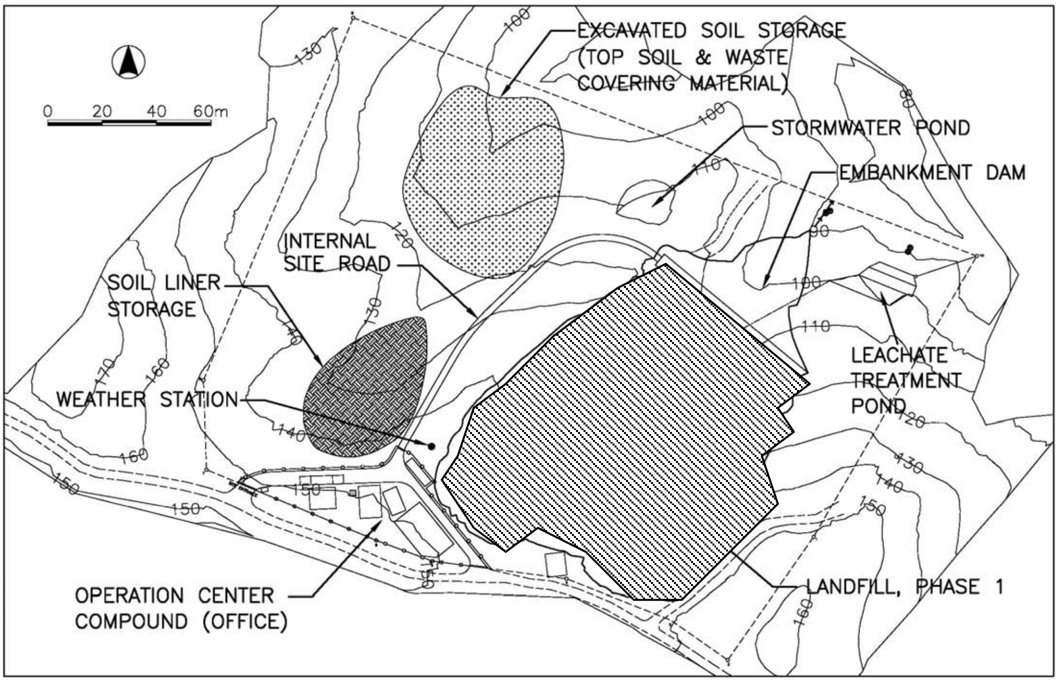


Figure 1.3-1 Overall Development Plan of Phase 1

Source: JICA Study Team

1.3.2 Design Condition

(1) Estimated Amount of Waste Disposal at the SLF

It is estimated that there is approximately 10 -13 tons of residual waste requiring disposal per day. This quantity is not expected to increase significantly within the planning period due to the proposed diversion activities although the total population, number tourists and the collection service area are expected to increase over time (Table 1.3-1).

It is deemed prudent to allow for some contingency for planning purposes. It is necessary to be conservative in forecasting waste disposal capacity needs in view of the development time required to bring additional capacity online in the event that the quantity of waste to be disposed has been underestimated and the available void space is being utilized at a faster rate than anticipated. If the waste disposal capacity is utilized at a slower rate than forecast then the lifespan of the disposal site will increase and delay the timing of any requirement for future investment.

Allowing for a 20% contingency, it is estimated that the SLF needs to accommodate approximately 55,000 tons of residual waste, including the residual waste currently stored on-site and the residual waste to be generated and requiring disposal by the end of 10-year SWM plan. By the end of 2008 these latter two components will be of the order of 9,000 tons.

Table 1.3-1 Incoming Residual Waste to Landfill

Year End	Incoming Waste (tons per day)	Planned Waste (tons per day)	Incoming Waste (tons per annum)	Cumulative Waste (tons)
2007	-	-	4,500	4,500
2008	10.70	12.84	4,699	9,199
2009	11.40	13.68	4,993	14,193
2010	12.40	14.88	5,431	19,624
2011	13.00	15.60	5,694	25,318
2012	12.00	14.40	5,270	30,588
2013	11.70	14.04	5,125	35,713
2014	11.10	13.32	4,862	40,575
2015	10.50	12.60	4,599	45,174
2016	10.50	12.60	4,612	49,785
2017	10.50	12.60	4,599	54,384

Note: The commencement of operation of the SLF is expected to be the middle of 2009.
Source: JICA Study Team

(2) Required Landfill Capacity

Based upon the above incoming waste streams, the required capacity of the SLF by the end of 2017 is calculated to be approximately 88,000 m^3 (Table 1.3-2) based on the following assumptions:

- compacted density of residual waste of 0.75 t/m^3, exclusive of cover materials and capping materials,
- an allowance of approximately 4,000 m^3 for the leachate collection gravel above the basal liner,
- an allowance of 5% of the waste volume as 'daily' cover material (approximately 3,625 m^3),
- an allowance of 5,345 m^3 of soil for intermediate cover, and
- an allowance of approximately 2,500 m^3 for final cover assuming 75 cm clay cap and 15 cm soil cover over a restored area of 2,780 m^2.

The overall density of the waste placed is calculated to be 0.62 t/m^3 on the basis of the total air space utilized (88,000m^3) and the quantity of residual waste disposed (approximately 55,000 tons). The compacted density of residual waste (assumed at 0.75 t/m^3) reflects the nature of the waste to be disposed, which is assumed to be low in biodegradable components and in recyclable components, such as plastic bottles, tin cans and cardboard, all of which have a relatively low bulk density.

Table 1.3-2 Required Capacity for Landfill

Year End	Cumulative Waste	Compacted Volume of Waste	Cumulative Volume of Leachate Gravel	Cumulative Volume of Daily Cover	Cumulative Volume of Intermediate Cover	Cumulative Volume of Clay Cap	Cumulative Volume of Restoration Soil	Cumulative Volume Utilized	Development Phase
	(tons)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	
2008	9,199	12,266	0	0	0	0	0	12,266	Store
2009	14,193	18,924	1,060	946	2,530	0	0	23,460	1A-1
2010	19,624	26,165	2,085	1,308	2,530	0	0	32,088	1A-2
2011	25,318	33,757	2,085	1,688	2,530	814	163	41,036	1A-2
2012	30,588	40,784	2,085	2,039	2,530	814	163	48,415	1A-2
2013	35,713	47,617	3,998	2,381	5,345	814	163	60,317	1B
2014	40,575	54,100	3,998	2,705	5,345	814	163	67,124	1B
2015	45,174	60,232	3,998	3,012	5,345	2,086	417	75,089	1B
2016	49,785	66,380	3,998	3,319	5,345	2,086	417	81,545	1B
2017	54,384	72,512	3,998	3,626	5,345	2,086	417	87,984	1B

Source: JICA Study Team

(3) Minimum Design Requirements

Since the amount of receiving residual waste is estimated less than 15 t/day, the SLF is proposed to be designed as category 1 which is stipulated in DAO 10, Series of 2006. The design requirements for a category 1 landfill are as shown in Table 1.3-3.

Table 1.3-3 Design Requirements for Category 1 Landfill

Features	Minimum Requirement
Daily and Intermediate Soil Cover	√
Embankment/Cell Separation	√
Drainage Facility	√
Gas Venting	√
Leachate Collection	√
Leachate Treatment	Pond system
Leachate Re-circulation	At a later stage of operation
Clay liner	Clay liner is at least 60 cm thick and have a permeability of 1 x 10^{-5} cm/sec

Source: DAO 10, Series 2006

All waste disposal facilities, regardless of category, shall satisfy the Basic Siting Criteria of Section 40 of RA 9003 and its IRRs and meet all of the following operating requirements, except as otherwise provided:

- planned capacity with phased cell development,
- site preparation and containment engineering,
- compaction of waste to minimum specified target densities,
- specified operational procedures to protect amenities,
- fence, gate and other site infrastructure with surfaced primary access road,
- record of waste volumes, types and source,
- separate cells for municipal solid waste, treated THW or HCW. Handling and management of THW and HCW should be in accordance with the provisions of RA 6969 and Joint DENR-DOH Administrative Order No. 2 and, respectively,
- facility operation by a pool of fully-trained staff,
- prohibition of open burning,
- provision for aftercare following site restoration and closure, and
- prohibition of waste pickers at the immediate disposal area.

1.4 Conceptual Design of the SLF

1.4.1 Introduction

The conceptual design for the proposed SLF considers the following principal elements of site works and site infrastructure:

- overall landfill footprint including buffer zones,
- site phasing and sub-phase development to permit controlled disposal of residual waste,

- site preparation works including site clearance,
- embankment dams and peripheral bunds,
- containment landfill liner system,
- leachate control and management system,
- landfill gas control and management system,
- surface water control and management system,
- restoration and aftercare of completed areas of the waste disposal area,
- site roads, including site access road and internal on-site roads,
- waste reception and management area including the site office and ancillary buildings,
- site security works including fencing,
- utilities,
- special waste cell, and
- environmental monitoring system.

In preparing the conceptual design a variety of design options has been considered with respect to key aspects of the engineering design (eg. embankment dam, engineered barrier, leachate collection and treatment system) and the most technically-appropriate and economic solution adopted in the light of the design conditions highlighted above. It is proposed that the excavated materials from the SLF should be stored properly at the vicinity for future use such as construction of the embankment dam and daily cover materials.

1.4.2 Overall Landfill Footprint

Phase 1 of the SLF is proposed to be developed in the eastern valley. Phase 1 is rectangular in shape with approximate average dimensions of 130 m (NE-SW) by 120 m (NW-SE). The total landfill footprint of Phase 1 is approximately 15,635 m^2. The eastern, southern and western margins of Phase 1 abut higher ground. Along the northern margin, however, the stream valley provides a natural break in the continuity of the higher ground surrounding the landfill footprint. Accordingly in this latter location it is proposed to construct an embankment dam that serves to close off, and effectively raise in elevation, the lowest part of the landfill footprint. In delimiting the extent of the proposed landfill footprint and the location of site infrastructure outside of the landfill footprint, buffer zones have been incorporated.

At its closest approach, the landfill footprint lies approximately 10 m north of the southern margins of the project site, although the landfill footprint generally lies at a greater distance than this. Elsewhere the minimum buffer zone adopted is 20 m from the site boundary. Along the northern margin of Phase 1 residual waste will be disposed at a minimum distance of 60 m from the northern site boundary.

1.4.3 Phasing and Sub-Phase Development

The landfill footprint for Phase 1 has been subdivided into a series of Sub-Phases delimiting each major stage of phased progressive development. For planning purposes Phase 1 has been subdivided into three principal Sub-Phases (designated Sub-Phase 1A, Sub-Phase 1B and Sub-Phase 1C. Sub-Phase 1A is also developed in 1A-1 and 1A-2.).

The development of Phase 1 is proceed progressively, with the timing of the construction of each Sub-Phase driven by the rate of waste input and the rate at which void space is utilized. It is envisaged that the landfill will be developed first in the lowest part of the valley along the northern margins of Phase 1 and then progress southwards up gradient. Based upon the residual waste inputs, the following timing is anticipated for each Sub-Phase of the Phase 1 development (Table 1.4-1):

Table 1.4-1 Anticipated Sub-Phase Lifespan

Sub-Phase	Total volume (m^3) [1]	Cumulative Volume (m^3)	Net Volume (m^3) [2]	Estimated Closure Year	Sub-Phase Life (years)
1A-1	18,620	18,620	16,585	2009	0.57
1A-2	30,431	49,051	27,877	2013	3.48
Subtotal (1A)	49,051	67,671	44,462	-	-
1B	59,630	108,681	54,330	2020	6.96
1C	77,345	186,026	65,701	2030	10.00
Total	186,026	-	164,494	-	-

Notes: 1 Total volume is the available air space between the top of the basal lining system and the proposed restoration contours.
2 Net volume = total volume – volume of leachate collection gravel, capping layer and topsoil. Net volume is the available volume for waste disposal, inclusive of 5% allowance for 'daily' cover and provision for intermediate cover.

Source: JICA Study Team

Sub-Phase 1A provides sufficient soil materials for the immediate full construction of the embankment dam to be constructed at the northern limits of Phase 1. Within Sub-Phase 1A, the initial cut (Sub-Phase 1A-1) has been designed to provide sufficient disposal capacity at the initial stages of the project to accommodate the volumes of residual waste already stored at the site and the additional volume of waste anticipated to require disposal by the time the site is ready to commence operation. Accordingly, once Sub-Phase 1A-1 has been developed, all of the waste currently stored at the site can be transferred immediately to the waste disposal area. Thereafter, the balance of Sub-Phase 1 (Sub-Phase 1A-2) will provide additional disposal capacity for at least a further three (3) years or more.

In advance of Sub-Phase 1A being filled to capacity with waste, it is envisaged that Sub-Phase 1B can be developed to the south of the disposal area. The area to be developed for Sub-Phase 1B can act as the source of 'daily' and intermediate cover during operation.

Based on the anticipated timing outlined in Table 1.4-1, Sub-Phase 1C will be developed beyond the current planning period. The relevant development plans are shown in

Figures 1.4-2 and 1.4-3.

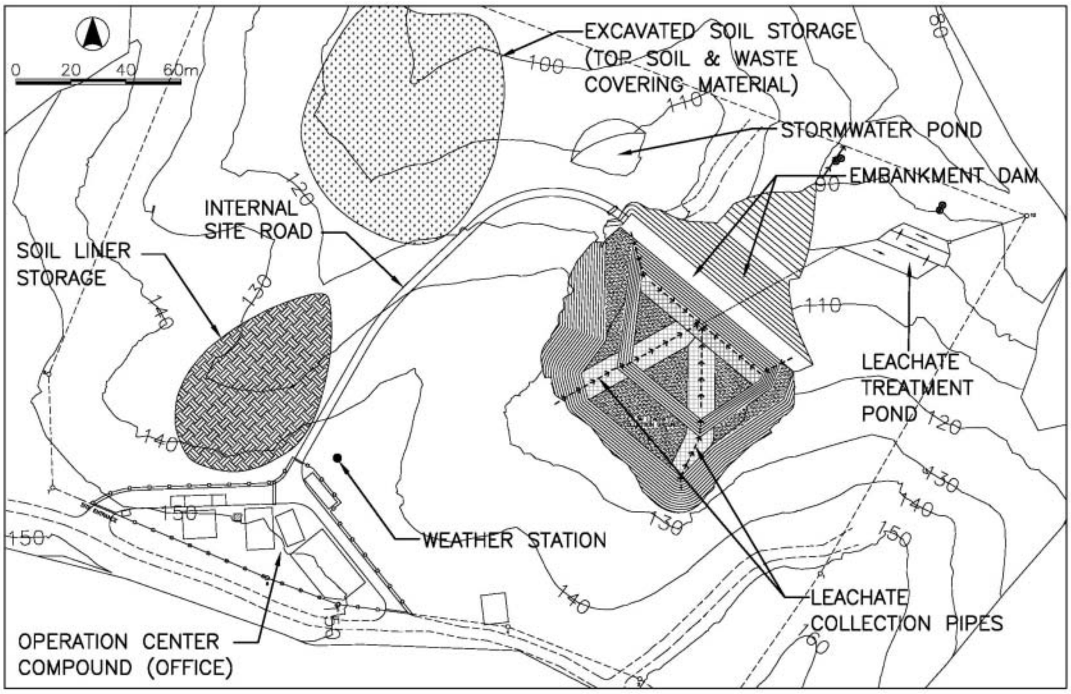


Figure 1.4-1 Development Plan of Sub-Phase 1A of Landfill Area
Source: JICA Study Team

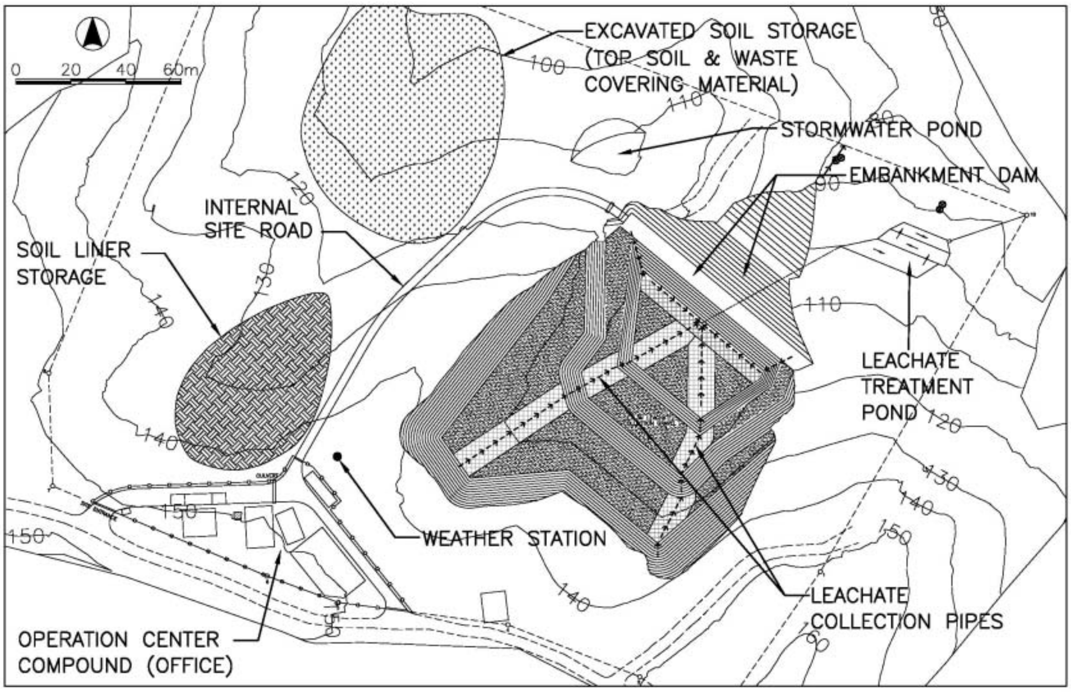


Figure 1.4-2 Development Plan of Sub-Phase 1B of Landfill Area
Source: JICA Study Team

1.4.4 Site Access

Access to the site is provided currently by an unsurfaced road, approximately 560 m in length, that runs from the existing Provincial Road between the MOM and MOB. The road is single lane, with a running course that is typically 4 m wide, which is generally passable even during the rainy season.

1.4.5 Site Preparation

The floor of the landfill within the landfill footprint will be prepared in advance of the deposition of waste in all Sub-Phases and adjacent areas of the site where support infrastructure is located. Site preparation works shall generally involve the following:

- clearance and grubbing of all vegetation from any area of the works,
- excavation, removal and disposal of unsuitable organic materials and organic soils,
- careful stripping and storing of existing soil-forming materials (topsoil, subsoil), although such materials are likely to be very thin or non-existent based upon site observations,
- clearance and stockpiling of unweathered rock boulders for subsequent use on-site (for example, for use in slope protection and drainage works),
- excavation and stock piling of superficial soils, either for general use (for example, structural fill, daily and intermediate cover) and for use as clay lining (completely weathered bedrock),
- compaction and grading of the sub-grade,
- excavation of soft spots and replacement with acceptable granular fill or structural fill, and
- potentially dozing and ripping of fractured and weathered rock.

1.4.6 Embankment Dam

(1) Embankment Dam

It is proposed that an embankment dam is constructed along the northern margin of Phase 1. The embankment dam will increase the average depth of waste that can be deposited substantially across the whole of the landfill footprint, since restoration of the completed landfill can commence from the top of the dam rather than at the prevailing elevation of the ground surface at the toe of the structure. In view of the requirement to maximize the capacity of the site within the smallest feasible landfill footprint it is considered that the embankment dam provides the most cost-effective means of enhancing and maximizing the available site capacity.

A variety of configurations has been assessed for the embankment in terms of the location on site and the overall geometry (embankment crest elevation and overall slope gradient). The location envisaged for the embankment dam is considered optimal since it maximizes the available height of the embankment and provides the most stable configuration since it abuts the valley-side slope immediately to the north-west of the outer slope of the dam. The overall geometry adopted for the dam is as follows:

- crest level – 117 m ASL
- crest width – 6.5 m
- inner slope – 1H:1V
- outer slope – a combination of 2H:1V in the lowest portion below the intermediate three m wide bench and 1.5H:1V above the intermediate bench

The embankment dam will be formed from site-won soils sourced from the excavations undertaken to develop Sub-Phase 1A-1. The estimated fill requirement to construct the embankment dam is approximately 13,300 m^3.

(2) Groundwater Drainage System

Given that the embankment dam will be formed across the valley which carries intermittent seasonal surface water flows and from primarily clayey materials. It is recommended that a granular drainage blanket, at least 0.6 m thick, is placed at dam foundation level in order to intercept and facilitate groundwater drainage and to relieve pore pressures during the construction of the dam. The drainage blanket shall be provided with a perforated reinforced concrete pipe of 610 mm nominal diameter embedded in the axis of the valley in order to provide a conduit for storm water flows arising from groundwater seepage. No further groundwater interception measures are deemed necessary beneath the waste disposal area at present.

1.4.7 Liner System (Engineered Barriers)

Low permeability strata, for example clays, are used to inhibit the inflow of water into a landfill and the outflow of leachate. The geotechnical survey of the site indicated that, whilst the permeability of the intact bedrock strata is very low, fractures and discontinuities render the bedrock *en masse* moderately permeable. Similarly the overlying colluvial soils and highly-completely weathered rock are also relatively permeable and water bearing, being in hydraulic continuity with the groundwater in bedrock fractures.

In situ and laboratory permeability measurements indicated typical permeabilities of the order of 5×10^{-5} cm/sec. As such, the site materials are considered marginal for use as natural clay liners unless considerable effort is undertaken in compacting the soils to the maximum dry density at the optimum moisture content. Given the prevailing climatic regime at the site the available construction time considered favorable for the installation of natural clay liners will be limited and likely to be restricted to the driest months of the year, in the period typically between January and May.

From environmental considerations, and given the nature and variability of the sub-grade within the landfill footprint, the conceptual design has adopted a dual approach, as follows:

- In the lowest parts of the site (Sub-Phase 1A-1), it is recommended to adopt a composite lining system comprising a geocomposite clay liner (GCL) above a secondary clay liner, 0.6 m thick, formed from suitable onsite clay. While this lining system exceeds the requirements of a category 1 landfill, the potential environmental sensitivity of the site dictates that high levels of containment are adopted where leachate accumulation will be greatest. Accordingly, since the lower bench will provide the focal point for all leachate drainage, it is recommended to adopt a composite lining system in this area. This also permits flexibility in landfill operations by providing the capability to store leachate in the lowerportion of the site at times of high leachate generation. In such circumstances added protection is afforded through the use of the GCL. Bentomat is a suitable GCL, suitably reinforced where deployed on steep slopes.
- In the remainder of the site (Sub-Phase 1A-2, Sub-Phase 1B and Sub-Phase 1C) the conceptual design is premised on the use of onsite materials recompacted to 95% of the maximum dry density at, or just wet of, the Optimum Moisture Content (range 0%-+4% of the OMC), in order to reduce the permeability to acceptable levels. For ease of construction, and for construction quality assurance purposes, it is recommended that the basal clay liner is 1.0 m thick, and formed from at least four layers of recompacted soil, with compaction undertaken using a sheep’s foot roller. High standards of construction quality assurance including frequent checks on material quality and properties are required to ensure successful installation of any clay liner.

1.4.8 Restoration Profile

For the conceptual design, the primary consideration has been to maximize the available void space. Accordingly, a steep restoration profile has been proposed. The exterior slopes of the completed landfill are envisaged to rise, as far as practicable, at a uniform gradient of 3H:1V, to a high point in the southern central portion of Phase 1, peaking at an elevation of approximately 152 m ASL , as shown in Figure 1.4-3 and Figure 1.4-4.

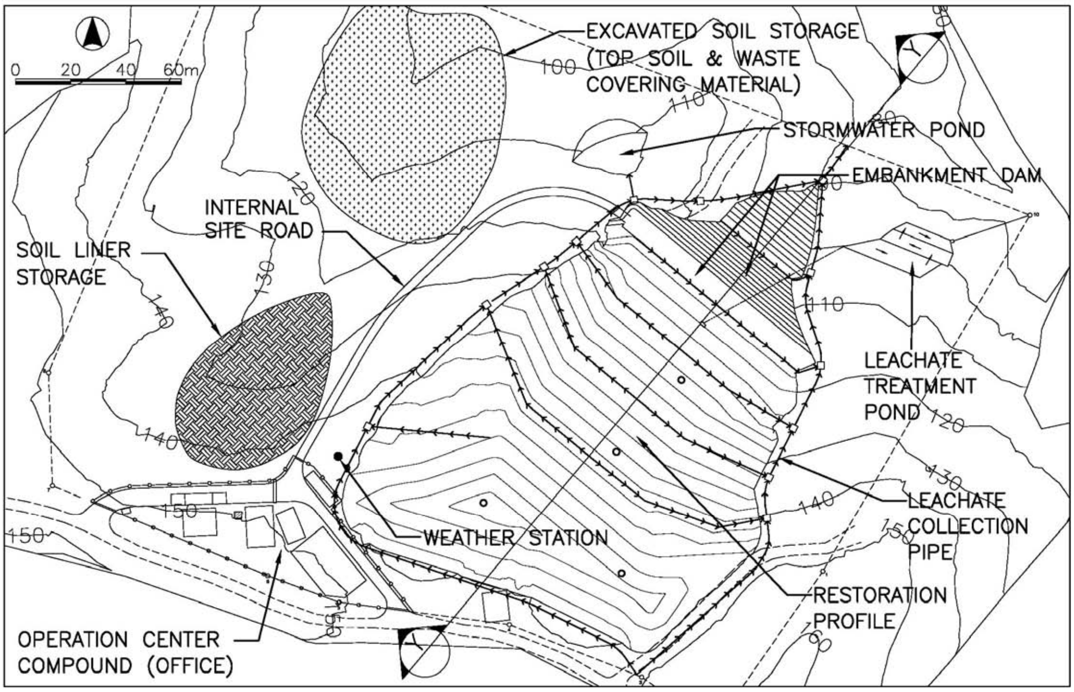


Figure 1.4-3 Final Restoration Profile of Phase 1 of Landfill Area
Source: JICA Study Team

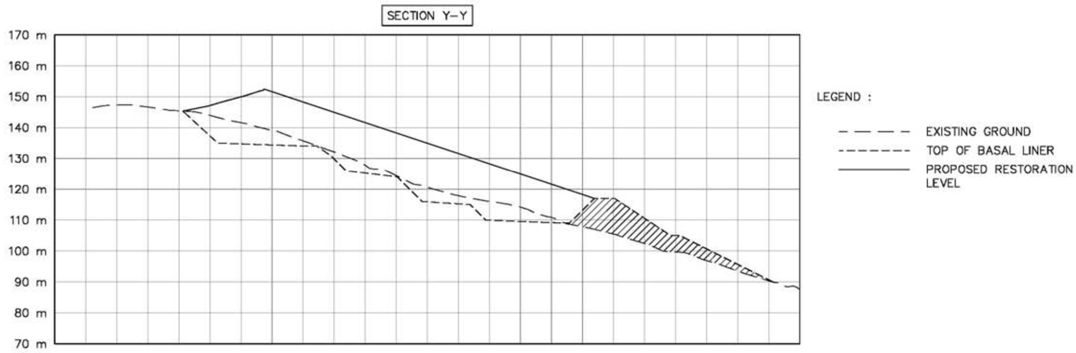


Figure 1.4-4 Cross Section of Restoration Profile of Phase 1 of Landfill Area
Source: JICA Study Team

The maximum depth of fill above the existing ground surface will be approximately 15 m, with a total maximum depth of fill of approximately 20 m above the top of the basal engineered barrier. The overall gross volumetric capacity of Phase 1 is estimated to be approximately 186,000 m^3 (Table 1.4-1).

Above the capping layer it is envisaged that a layer of suitable organic soil, at least 15 cm thick, and capable of supporting vegetation will be installed progressively across the site as waste deposition is completed in specific parts of the site.

As for the development of the base of the site it is envisaged that areas of the site will be filled progressively up to full height. After completion of filling, an intermediate cover soil, 300 mm thick, will be placed over inactive parts of the site. Following a period of time to allow initial settlement to take place, typically of the order of 2 to 3 years, the site will be capped off and the final topsoil placed.

1.4.9 Leachate Collection System

To prevent a build-up of leachate within the landfill footprint and to minimize the hydraulic head acting across the basal lining system, it is necessary to collect and remove leachate from the landfill for recirculation or treatment prior to the discharge of the treated effluent off-site. Leachate collection shall be achieved through the following principal measures:

- grading the floor of Sub-Phases to fall towards prescribed leachate drainage lines;
- the installation of a granular leachate drainage and collection layer above the primary lining system comprising 300 to 600 mm of uniform, non-calcareous, fine clean aggregate (typically 37.5-50 mm size), free draining with a permeability greater than 1×10^{-2} m/sec, and
- within the zones of thicker drainage gravel, the installation of 150 mm diameter perforated HDPE collection pipes, with a standard dimension ratio (SDR) of 17, graded to drain to a single collection sump located along the toe on the upstream face of the embankment dam in Sub-Phase 1A-1.

The leachate flow zone will be provided with a non-woven geotextile placed between the gravel and the waste in order to prevent clogging of the drainage layer. A similar geotextile will also be installed where the gravel directly overlies a basal clay liner.

Secondary leachate collection pipes will be laid in the leachate collection layer as required. Where feasible, the main leachate collection ditches are intended to be laid at gradients steeper than 3.3% (30H:1V), in order to develop sufficient velocity in the leachate collection piping to prevent solid deposition, thereby minimizing maintenance. Leachate drainage layers and leachate pipes are prone to silting and blockage by microbial and algal growth. Accordingly, the pipe work employed shall be sufficiently robust to permit jetting or rodding of the collection system, as necessary, to remove potential blockages.

1.4.10 Leachate Extraction and Transfer System

Leachate shall be removed from the active waste placement cell to a level as low as practical. It is proposed that the target control strategy shall be to limit the head on the lining system to a level with no more than 1.0 m of available leachate head on any point of the liner.

For the sake of simplicity it is envisaged that leachate will be drained from the collection sump through gravity, thus avoiding the necessity for continuous pumping of leachate from the site. It is anticipated that a 200 mm diameter HDPE pipe will transfer leachate from the leachate sump, through the embankment dam foundations, to the leachate treatment pond.

1.4.11 Leachate Management, Treatment and Discharge

The following principles are proposed for primary leachate management:

- balancing of leachate flows and volumes, as far as possible, within already deposited waste,
- redistribution and re-circulation of leachate, under appropriate climatic conditions, to dry absorptive waste in order to reduce the volume of leachate,
- redistribution and re-circulation of leachate to completed areas of deposited waste to enhance the rate of flushing of contaminants through the site, to enhance rates of stabilization and ultimately to reduce the strength of leachate, and
- periodic intermittent mist spraying of leachate onto the restored surface of the landfill, under appropriate meteorological conditions, to enhance evaporation of leachate.

It is proposed that leachate redistribution and re-circulation to deposited waste shall form one core element of the leachate treatment strategy. As a limited discharge option, all efforts shall be undertaken to optimize evaporation of leachate generated and to reduce the volumes of leachate to be treated through leachate re-circulation. Final processing of mature leachate shall be undertaken in order to reduce the polluting potential and to ensure its suitability for discharge back into the aquatic environment.

A preliminary assessment of potential leachate volumes has been undertaken on the basis of the following calculations:

L_o=[ER + IRA + WW] - [LTP + aW + DL]

Where:

L_o	=	free leachate retained
ER	=	effective rainfall
IRA	=	infiltration through restored and capped areas
WW	=	inherent free water content of waste
LTP	=	discharge of leachate off-site
a	=	unit absorptive capacity of waste
W	=	weight of absorptive waste
DL	=	designed seepage rate

A preliminary assessment of leachate generation at the site is reproduced in Table 1.4-2. Leachate generation is likely to be highest in the first few years of development as the operational area is comparatively large in the absence of having capped any parts of the site. Leachate generation rates are estimated to be of the order of 20 m^3/day initially, declining to less than 15 m^3/day towards the active operational life of the landfill and about 2 m^3/day once the site is fully capped and restored.

Table 1.4-2 Estimated Leachate Generation

Year	Waste Year	Active Phase	Active Area (m^2)	Active Infiltration (m^3)	Temporary Cap (m^2)	Temporary Cap Infiltration (m^3)	Restored Area (m^2)	Restored Infiltration (m^3)	Total Water (m^3)	Annual Waste Input (ton)	Absorptive Capacity Input (m^3)	Cumulative Absorptive Capacity (m^3)	Evaporative Loss (m^3)	Annual Leachate (m^3)
2009	1	1A	2,330	7,456	0	0	0	0	7,456	4,699	501	501	280	6,675
2010	2	1A	2,000	6,400	2,330	699	0	0	7,099	4,993	533	1,034	240	6,326
2011	3	1A	2,000	6,400	1,000	300	0	0	6,700	5,431	579	1,613	240	5,881
2012	4	1A	2,000	6,400	1,000	300	1,000	50	6,750	5,694	607	2,221	240	5,903
2013	5	1B	1,500	4,800	1,000	300	1,500	75	5,175	5,270	562	2,783	180	4,433
2014	6	1B	1,500	4,800	1,000	300	2,800	140	5,240	5,125	547	3,329	180	4,513
2015	7	1B	1,500	4,800	1,000	300	2,800	140	5,240	4,862	519	3,848	180	4,541
2016	8	1B	1,500	4,800	1,000	300	4,000	200	5,300	4,599	491	4,339	180	4,629
2017	9	1B	1,500	4,800	2,000	600	4,000	200	5,600	4,612	492	4,830	180	4,928
2018	10	1B	1,500	4,800	2,000	600	5,000	250	5,650	4,599	491	5,321	180	4,979
2019	11	1C	1,500	4,800	1,500	450	5,000	250	5,500	4,599	491	5,812	180	4,829
2020	12	1C	1,500	4,800	1,500	450	7,500	375	5,625	4,599	491	6,302	180	4,954

Source: JICA Study Team

It is assumed, based upon knowledge of leachate quality elsewhere in the Philippines, that simple treatment may be appropriate based upon the provision of aeration ponds. This is in accordance with design requirements for a category 1 landfill. Accordingly, three aeration ponds are proposed, with a combined capacity of approximately 1,000 m^3, providing a hydraulic retention time of approximately 60 days. It is envisaged that ponds will be developed in series, with gravity flow between ponds.

The rate of discharge from the ponds, once the ponds are full, will be determined by the rate at which leachate enters the pond system. A gate valve will be provided to control the entry of leachate into the ponds and to facilitate temporary storage of leachate within the cell in times of high leachate flows. It is envisaged that there will be little or no discharge of effluent from the ponds during the dry season since the likely evaporative losses from the pond surface may exceed the projected leachate inflow rates. However, during the rainy season it is inevitable that treated effluent will be discharged off-site, either directly through the outfall structure and drainage conduit or following re-circulation and spaying back onto restored parts of the site. During the rainy season it is anticipated that leachate strengths will be much lower on account of dilution by rainfall.

1.4.12 Landfill Gas Management

The general design of a typical vertical gas vent is illustrated at the site. The collection pipe is perforated over 10% to 20% of the surface area except for the upper two to three meters of the pipe over which length the pipe is solid (unperforated). The top of the gas vent is sealed by a layer of impermeable material, typically bentonite grout. Each gas vent will pass through the capping system in order to permit passive venting to the atmosphere.

Gas vents must accommodate vertical and lateral forces induced during waste degradation and settlement. Hence, it is anticipated that no gas vent will be installed until significant settlement of the waste has been accomplished and the relevant part of the site capped. It is recommended that no gas vent should be installed within the first 10 m of waste above the top of the lining system in order to prevent potential puncture of the basal lining system as a result of settlement and down drag. For the purposes of the conceptual design it has been assumed that each gas vent has a sphere of influence of 60 m radius, and, accordingly, four gas vents are required in Phase 1.

1.4.13 Surface Water Management

An overall permanent drainage system is proposed for Phase 1. There will be two principal permanent drainage lines, one to the east of the landfill footprint and the second one to the west. The drainage lines will drain the periphery of the landfill footprint as well as capture rainfall shed off the capped and restored surface. The maximum anticipated flow volumes at the outfall from the site are less than 1 m^3/sec even when the permanent drainage system is fully constructed.

The development of the drainage system is envisaged to be progressive in line with the overall phased site development. In the initial stages of construction the permanent drainage line for Sub-Phase 1 will be developed once the embankment dam is constructed. Thereafter, the permanent drainage lines will be extended southwards as filling proceeds and further areas of Phase 1 are developed for waste disposal.

The temporary drainage system will be developed at the back of each bench in order to capture surface water and groundwater seepages and to prevent such flows from entering the active landfill area. This drainage system will link into the permanent drainage system as it exits each bench.

It is proposed to provide a small storm water retention pond solely to service site needs. The pond will provide a source of water for use in irrigating restored parts of the site during periods of dry weather. It may also provide a supply of water for use in times of emergency, for dust suppression on site roads or for cleansing of operational plant and equipment.

The outfall structure is designed to return captured flows (surface and subsurface runoff) to the river or waterway without serious scouring or erosion. It is proposed to use a gabion mat for the outfall of the surface water flows along the northern margin of the project site.

1.4.14 Operation Compound

It is proposed that the landfill site will be provided with the following administration and operational facilities adjacent to the entrance to the site:

- entrance gates

- guard house
- new site office building
- parking lot and hardstanding
- temporary waste storage area which is to be used as a cluster MRF
- fencing and compound lighting
- site utilities - electricity, water supply, and communication links
- weather station
- special waste cell

1.4.15 Site Roads and Hardstanding

It is proposed that the whole of the operation compound is paved using 50 mm thick asphalt pavement in order to ensure all-weather working conditions. From the operation compound it is proposed to develop a permanent site road, also asphalt paved, which will serve as the primary access to the site throughout the whole of the operating life of Phase 1. Given site topographic conditions and the steep gradients on-site, it is not considered viable to construct and maintain unsurfaced roads for the primary access route. The profile along the primary access road indicates gradients as steep as 20%, necessitating that the drivable surface be paved.

1.4.16 Utilities

The site will be provided with a permanent power supply which will entail the extension of the existing power line from the provincial road to the operation compound, over a distance of approximately 600 m. While there is an existing water supply on-site, this is often dry. Accordingly, it is proposed to sink a new deep well in an attempt to provide a sustained permanent source of non-potable water for site use. A communication system will also be provided to the site.

1.4.17 Special Waste Cell

It is estimated that approximately 27 tons of HCW is expected to be delivered to the SLF between now and the end of 2017, based upon the quantities set out in Table 4.2-4 of Chapter II-4. It is proposed that a secure cell is provided for special wastes within the fenced operations compound. The cell, to be constructed adjacent to, but not within, the proposed landfill footprint for residual waste, will be developed separately and progressively as the volume of special wastes demands. The proposed design of the special cell is based upon securely encapsulating special wastes as follows:

- the cell will be excavated 4 m into existing ground and will be founded in suitable clay-rich soil of low permeability,
- the base and sidewalls of the cell will be lined with compacted clay liner a minimum of 0.6 m thick and with a permeability that should be no greater than 1 x 10^{-7} cm/sec,
- the inside of the cell will be lined with HDPE 1.5 mm thick,

- the base of the cell will contain a small sump designed to collect any liquids. Collected liquids will be treated as contaminated and directed to the leachate treatment pond for processing once the chemistry of the liquid has been checked and the liquid has proven to be non-toxic, non-hazardous and non-corrosive. Unsuitable liquids will be abstracted and treated separately to render them fit for treatment in the leachate treatment pond,
- within the excavated cell, a series of reinforced concrete bins will be cast in situ, of general dimensions 4 m long, 2 m wide and 2 m deep. The bins have the capacity to handle approximately one years estimated HCW delivered to the site,
- bins will be filled progressively and once at full capacity will be sealed at the top with reinforced concrete, thus encapsulating the waste within the bin,
- the excavated cell will be provided with a roof to prevent the ingress of rainwater, as well as a peripheral drainage system around the margins of the cell to minimize the generation of leachate within the base of the cell, and
- once part of the cell is completed it will be covered with a clay liner, at least 1.0 m thick designed to shed water away from the completed cell.

1.5 Facility and Equipment Plan

On the basis that the delivery of tonnage to the SLF will vary between 10-15 tons per day, the concept design assumes that the site will not be run as a fully functional sanitary landfill on a daily basis. Rather, as outlined above, the outline design of the facility incorporates provision for the storage of incoming waste temporarily prior to final disposal in the cell. Accordingly, routine daily operations will be restricted to the receipt and unloading of residual waste to the temporary store.

The majority of residual waste will be delivered in sacks and, accordingly, can be unloaded and stored manually. Waste from the mainland, however, will be delivered loose via garbage collection vehicles and/or dump trucks.

It is anticipated that transfer to the disposal cell take place only once or twice per week once sufficient quantities of waste have been accumulated at the temporary store. Transfer once per week will entail the most efficient and most economical use of equipment and personnel resources. Given that residual waste quantities will be in the range of 70 to 100 tons per week, it is feasible to dispose of the accumulated waste within one working day.

The anticipated mobile equipment requirements for waste loading from the temporary store, landfill disposal operations in the cell and covering of disposed waste by cover soils are set out in Table 1.5-1.

Table 1.5-1 Requirements for Mobile Equipment for Site Operation

Equipment	Specification	Unit	Estimated Workload (hrs/week)	Functions	Remarks
Backhoe loader	0.6-1.0 m^3	1 No.	6-8	- Loading waste from temporary store - Loading cover soils from store	To be procured
Bulldozer	15-20 tons	1 No.	2-3	- Spreading and compacting waste - Spreading cover soils	Available
Dump Truck	5-10 m^3	1 No.	6-8	- Transfer waste from temporary store - Transfer cover soils from store	Available
Service vehicle	4 x 4	1 No.	16	- General duties including supply of fuel	To be procured

Source: JICA Study Team

In addition to the above, it is necessary to procure at least one submersible pump unit and associated accessories to facilitate the management and re-circulation, as required, of leachate at the site and to provide the capability to water and irrigate capped and restored parts of the site during periods of dry weather.

1.6 Operation and Management Plan

1.6.1 Receipt and Temporary Storage of Residual Waste

It is proposed that residual waste delivered to site will be stored initially, and on a temporary basis, in a storage area located within the operation compound. After recording the waste delivery, waste will be unloaded, either manually if delivered in sacks, or by discharging directly from the dump truck if delivered loose.

Un-sacked waste will be consolidated into a small heaped pile following any further sorting that may be required, subsequently covered before the end of the day by tarpaulin in order to ensure that the waste remains relatively dry. Similarly waste will be stacked securely and covered to ensure that the waste remains relatively dry.

The area allocated for this operation is up to 350 m^2, providing sufficient space for the storage of waste and the waste transfer operation by a dump truck. It is proposed that waste is stored for up to one week in the temporary store.

1.6.2 Disposal of Residual Waste in the Landfill Cell

Once sufficient residual waste has been accumulated at the temporary store to warrant final disposal, the stored waste will be loaded onto the site-based dump truck for delivery to the active waste disposal area. The primary equipment used for this purpose will be a backhoe loader.

Residual waste shall be deposited in its final place of burial, adopting the area method of landfilling, in accordance with the contractor's specified operating practices and procedures, which shall be formulated in order to:

- achieve the design objectives of the site,
- be inherently safe and to provide the minimum of risk to the environment surrounding the site, and
- minimize the nuisance to local residents and amenity in the vicinity of the site.

1.6.3 Staffing Requirements

Consistent with the proposed *modus operandi* for site operations, it is recommended that the requirements for site staff are kept to a minimum level in order to minimize operational costs. Table 1.6-1 set out the proposed site operational staff.

Table 1.6-1 Estimated Minimum Staff Requirement for Site Operation

Staff	Full-time	Part-time	Total Workload (hrs/month)
Landfill Manager (Engineer)	-	1	20
Supervisor	1	-	168
Clerk	2	1	240
Operators (heavy equipment, dump truck)	2	-	84
Labor	3	2	600
Security guard	3	-	720

Source: JICA Study Team

1.7 Implementation Plan

Operation of landfill site needs a sense of technique such as soil cover, leachate treatment and planned land filling. If the operation and maintenance is not handled well, the costs would increase and the lifetime of the landfill would shorten. Decrease in the lifetime of landfill means also increase in the costs. In deed, the MOM has not enough experience on landfill management. Current human resources on SWM of the MOM are limited and increase in the human resources is hardly expected in the MOM. Therefore, utilization of the private sector would be more effective rather than operation by the MOM.

In this case, it is preferable to contract with a private sector party by Design-Build-Operate (DBO) based on the following comparison between the existing method (Separate Order) and DBO as shown in Table 1.7-1.

Table 1.7-1 Comparison between the Existing Method and DBO

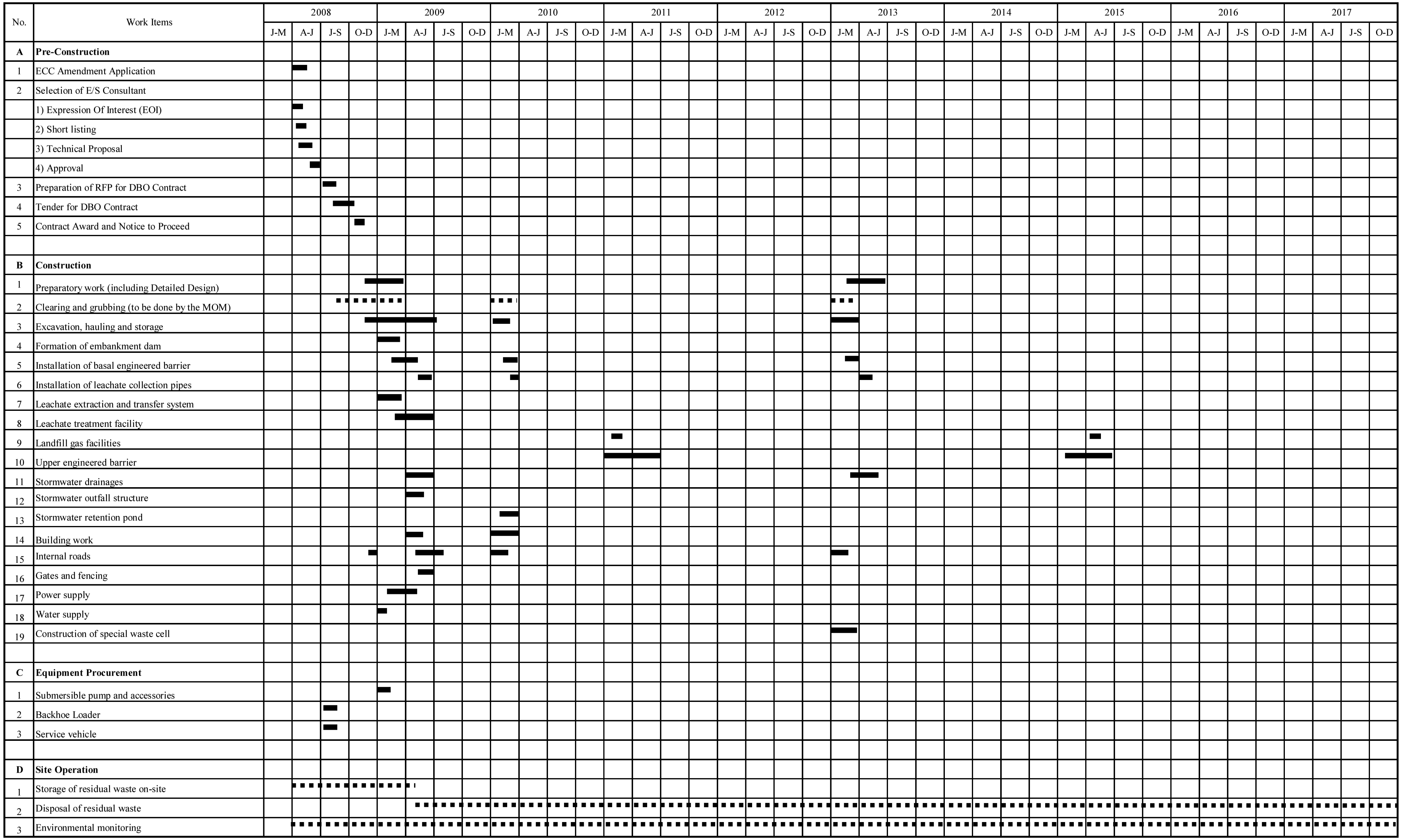
No.	Item	Existing Method (Separate Order)	DBO
1	Financing	Annual budget is necessary.	Cost could be equalized based on long-term agreement.
2	Cost	Possibility higher costs than DBO.	Reduction in total construction and operation costs could be expected.
3	Procedure of contract	Procedures are necessary in each process (design, build and operation).	Procedures could be done promptly thanks to package deal contract.

Note: DBO is one a type of contract, which combines design, construction and long term operation and maintenance of a facility into one single contract awarded to a single contractor. The type of contract is expected to equalize cost based on long-term agreement and design building to be effectively operated by the single contractor.
Source: JICA Study Team

In addition, it should be decided whether the MOM contract transportation of residual waste from the MRFs to landfill site with a contractor of DBO. It is preferable to do this because they can effectively carry out the transportation. However, the following things should be considered to implement DBO.

- Utilization of the existing equipments owned by the MOM: This condition should be added in the contract because it leads to cost reduction.
- Response to trouble: Expert knowledge is necessary if any troubles happen.
- How to select a contractor: Examination of qualification, technical review and evaluation of cost is necessary.
- The anticipated schedule for the development of the SLF, for the whole 10 year period covered by the plan, is formulated considering DBO contractual arrangement.

The overall schedule for the development of the SLF is formulated as shown in Figure 1.7-1 including the periods of procurement of consultant and contractor, preparatory works which consist of detailed design and mobilization for main construction works, and clearing and grubbing the site by the MOM, prior to the main construction works.



Source: JICA Study Team

Figure 1.7-1 Implementation Schedule for Development of the Kabulihan SLF

1.8 Cost Estimate

1.8.1 Investment Cost

The investment cost is estimated as shown in Table 1.8-1.

Table 1.8-1 Investment Cost of the Kabulihan SLF

(Unit: x10^3 PhP)

Item	Description	Total Cost
1. Engineering Services (E/S)		2,250
2. Construction Cost		44,993
	(1) Preliminaries	5,922
	(2) Site Preparation	7,431
	(3) Formation of Embankment Dam	4,427
	(4) Basal Engineered Barrier	8,283
	(5) Leachate Collection System	6,298
	(6) Leachate Extraction and Transfer System	404
	(7) Leachate Treatment Facility	2,518
	(8) Landfill Gas Facilities	112
	(9) Upper Engineered Barrier	2,152
	(10) Stormwater Drainage System	2,011
	(11) Building Works	1,890
	(12) Road Works and Hard Standing	1,389
	(13) Miscellaneous Works	2,156
3. Administration Cost		2,362
4. Procurement of Equipment		1,450
5. Physical Contingency		5,033
Total Investment		56,088

Source: JICA Study Team

1.8.2 Annual Cost

The disbursement schedule during the 10 years from 2008 to 2017 was prepared on the basis of the implementation schedule for the development of the SLF. The annual cost including one for transport of the residual waste from the MRFs to the SLF is estimated as shown in Table 1.8-2 (see Appendix III-1.8.1).

Table 1.8-2 Annual Investment and O&M Costs of the Kabulihan SLF

(Unit: x10^3 PhP)

No.	Work Items	Total	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A	Engineering Service(1)[(2)*0.05]	2,250	169	1,074	254	45	0	639	0	68	0	0
B	Construction (2)	44,992	3,388	21,477	5,075	896	0	12,788	0	1,368	0	0
1	Preparatory work (including Detailed Design)	5,922	2,523	1,505	104	0	0	1,790	0	0	0	0
2	Excavation, hauling and storage	7,431	803	2,430	162	0	0	4,037	0	0	0	0
3	Formation of embankment dam	4,427	0	4,427	0	0	0	0	0	0	0	0
4	Installation of basal engineered barrier	8,283	0	3,558	1,547	0	0	3,178	0	0	0	0
5	Installation of leachate collection pipes	6,298	0	1,929	1,468	0	0	2,901	0	0	0	0
6	Leachate extraction and transfer system	404	0	404	0	0	0	0	0	0	0	0
7	Leachate treatment facility	2,518	0	2,518	0	0	0	0	0	0	0	0
8	Landfill gas facilities	112	0	0	0	56	0	0	0	56	0	0
9	Upper engineered barrier	2,152	0	0	0	840	0	0	0	1,312	0	0
10	Stormwater drainages	1,099	0	880	0	0	0	219	0	0	0	0
11	Stormwater outfall structure	124	0	124	0	0	0	0	0	0	0	0
12	Stormwater retention pond	788	0	0	788	0	0	0	0	0	0	0
13	Building work	1,890	0	945	945	0	0	0	0	0	0	0
14	Internal roads	1,389	62	1,202	62	0	0	62	0	0	0	0
15	Gates and fencing	656	0	656	0	0	0	0	0	0	0	0
16	Power supply	600	0	600	0	0	0	0	0	0	0	0
17	Water supply	300	0	300	0	0	0	0	0	0	0	0
18	Construction of special waste cell	600	0	0	0	0	0	600	0	0	0	0
C	Administration Cost (3)[((1)+(2))*0.05]	2,362	178	1,128	266	47	0	671	0	72	0	0
D	Equipment Procurement (4)	1,450	1,400	50	0	0	0	0	0	0	0	0
1	Submersible pump and accessories	50	0	50	0	0	0	0	0	0	0	0
2	Multi-cab	200	200	0	0	0	0	0	0	0	0	0
3	Backhoe Loader	1,200	1,200	0	0	0	0	0	0	0	0	0
E	Physical Contingency(5)[((1)+(2)+(3))*0.1+(4)*0.05]	5,033	444	2,370	560	99	0	1,410	0	151	0	0
	Subtotal of Investment (6) [(1)+(2)+(3)+(4)+(5)]	56,086	5,579	26,099	6,155	1,086	0	15,508	0	1,659	0	0
F	Operation and Maintenance Cost (7)											
1	Transport of Residual Waste	38,609	4,925	5,199	5,647	5,531	3,337	3,077	2,808	2,740	2,673	2,673
2	O&M of SLF	22,768	2,145	2,275	2,478	2,601	2,406	2,341	2,224	2,097	2,100	2,102
	Subtotal of O&M (7)	61,377	7,070	7,473	8,125	8,132	5,743	5,418	5,032	4,837	4,773	4,776
	Price Escalation (8)		632	3,441	2,251	1,986	1,587	7,117	2,048	3,102	2,631	3,003
	Total Cost (9)[(6)+(7)+(8)]	145,262	13,282	37,013	16,530	11,204	7,329	28,042	7,080	9,598	7,404	7,779

Note: Because the number after decimal point is rounded, accidental error occurs in first digit.
Source: JICA Study Team

1.9 Financial Analysis

The development of the Kabulihan SLF is proposed to be implemented in three sub-phases during the term of the 10-year SWM Plan. Since the amount of investments would be relatively high in 2009 and 2010 at Sub-Phase 1A-1, it is necessary to cover the cost by arrangement of a loan for both years. The loan would contribute to the reduction in the amount of cash that the MOM should pay at one time. Main sources are General Fund of the MOM and the GCF. A part of income of the EAF also could be appropriated.

In the 10-year SWM Plan, it is proposed to establish a Local Common Fund (LCF). The proposed LCF would manage not only the SLF but also the total cost of SWM. The financial analysis covers the following components:

- Investment cost for development of the SLF
- O&M costs of the SLF excluding the cost for transport of residual from Boracay Island to the SLF

As for the basic concept of cost recovery system, the cash flow of the development of the SLF was prepared based on the following conditions:

- As the result of the calculation of waste quantity by waste generation sources, cost sharing and demarcation between the residents and business establishments is considered to be approximately 30 % for the residents and 70% for business establishments based on the principle of PPP. However, general taxes or IRA of the General Fund could recover the remaining costs that the GCF could not recover.

- 13% of GCF from households and business establishments would be appropriated for disposal at the SLF based on the ratio of costs for disposal during period of the 10-year SWM Plan.
- A loan[1] would be applied to the investment for development of the SLF in 2009 and 2010 at Sub-Phase 1A-1. Investments in the other years at Sub-Phase 1A-2 and 1B would be sourced from the self-sustaining funds.
- A portion of repayment and interests of the loan would be sourced from IRA of the MOM/barangays. However, they are also sourced from the EAF so that IRA could be applied to other projects.

The cash flow was calculated as shown in Table 1.9-1.

Table 1.9-1 Cash Flow for Development of the Kabulihan SLF

(x10³PhP)

Year			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cash Inflows		A	2,838	34,130	13,547	6,847	11,609	33,122	11,621	13,331	10,327	4,800
	GCF from HH		-	88	92	104	172	188	202	220	237	248
	General Taxes/IRA from MOM and Barangays and EAF		2,838	7,397	6,262	5,752	10,400	31,862	10,326	11,988	8,640	3,070
	GCF from BE		-	749	780	992	1,036	1,072	1,093	1,122	1,451	1,482
	Income from Loan Payable		0	25,897	6,412	0	0	0	0	0	0	0
Cash Outflows		B	2,838	34,130	13,547	6,847	11,609	33,122	11,621	13,331	10,327	4,800
	Investment for Development of Kabulihan Sanitary Landfill Sourced from Self-Sustaining Fund		586	2,877	712	132	0	20,782	0	2,451	0	0
	OM related to Landfill		2,252	2,508	2,868	3,161	3,070	3,137	3,129	3,099	3,257	3,425
	Payment of Principal on Loan Payable		0	0	0	0	5,179	6,462	6,462	6,462	6,462	1,282
	Interest		0	2,849	3,554	3,554	3,359	2,741	2,030	1,319	608	93
	Investment for Development of Kabulihan Sanitary Landfill sourced from a Loan		0	25,897	6,412	0	0	0	0	0	0	0
Net Increase in Cash		C=A-B	0	0	0	0	0	0	0	0	0	0

Note: The cash outflows include inflation rate and physical contingency.
Source: JICA Study Team

1.10 Social and Environmental Considerations

The MOM has finished an IEE study for the new SLF and submitted an IEE report to the DENR-EMB Regional Office on February 10, 2007. The office has approved it and issued an ECC for the new SLF on June 5, 2007. However, the 10-year SWM Plan and F/S has modified several components of the new SLF for which the ECC was issued. Thus, the MOM needs to amend the existing IEE report to obtain an amended ECC. This investigation of the environmental and social considerations is aimed at supplementing the IEE study previously done by the MOM.

1.10.1 Philippine Environmental Impact Statement (EIS) System

(1) Procedural Requirement for Development of the SLF

DAO 2006-10, Series 2006, promulgates the guidelines on the categorization of final disposal facilities or SLFs, in support of RA 9003. There are four categories based on the potential net residual waste disposal:

[1] The loan condition is set as term repayment of five years, a grace period of three year and the interest rate of 11%.

- Category 1: final disposal facility or SLF for an LGU or cluster of LGUs with net residual waste of ≤ 15 tones per day (TPD),
- Category 2: final disposal facility or SLF for an LGU or cluster of LGUs with net residual waste of > 15 TPD, but ≤ 75 TPD,
- Category 3: final disposal facility or SLF for an LGU or cluster of LGUs with net residual waste of > 75 TPD, but ≤ 200 TPD,
- Category 4: final disposal facility or SLF for an LGU or cluster of LGUs with net residual waste of > 200 TPD.

The guidelines also clarify the ECC requirements for each category. Categories 1 and 2 need an IEE checklist, while Categories 3 and 4 need an IEE report in order to obtain an ECC. A SLF with a capacity of 1,000 TPD and above must prepare an environmental impact statement (EIS) for an ECC. Since the proposed Kabulihan SLF is classified as Category 1, the MOM only needs to submit an IEE checklist to obtain an ECC.

(2) ECC Amendment

The current ECC for the new SLF on the Mainland of Malay was issued on June 5, 2007 with several conditions for environmental management. The conditions of the ECC have been taken into consideration in the design of the newly proposed SLF as environmental mitigation measures as well as the proposed Environmental Management and Monitoring Plan (EMMP) (See Appendix III-10.1.1).

On the other hand, it is necessary to amend the current ECC mainly because the area of the SLF will be expanded from 5 ha proposed in the first IEE report to 6.25 ha proposed in the F/S. There are two levels of ECC amendment, i.e. major and minor. If a modified project includes components such as expansion of land or project area; increase of production capacity; major changes in process flow or technology to be used, the ECC amendment is categorized as major. Meanwhile, modifications of components such as typographical error, extension of deadlines for submission of post-ECC requirements, extension of ECC validity; change in company name or ownership; decrease of land or project area or production capacity, are regarded as minor requests. Therefore, the ECC amendment for the proposed SLF is regarded as major and the legislative procedures for amending the ECC are as follows:

- The MOM should request an ECC amendment by letter with necessary data to the DENR-EMB Regional Office.
- After receiving the letter, the DENR-EMB Regional Office immediately starts to evaluate the request.
- An ECC amendment should be approved by the DENR-EMB Regional Office. For an ECC issued based on an IEE study, the period of reviewing the amendment request shall not exceed 30 working days.

1.10.2 Public Consultation Meetings

Before the study began, the MOM organized public consultation meetings regarding the new SLF twice. On the other hand, during the study, the MOM, with support from the JICA Study Team, held a third public consultation meeting. Table 1.10-1 presents their summarized outlines.

Table 1.10-1 Summary of Public Consultation Meetings

No.	Study Phase	Main Subject	Date	Number of Participants
1	Preliminary survey on the new SLF site	– Introduction of the plan of the new SLF – Explanation of geological and physical environmental assessments of the new SLF site	4th of April, 2006	8
2	Preliminary survey of the new SLF site	– Explanation of geological and physical environmental assessment of the new SLF site and its approval	30th of November, 2006	8
3	F/S (Drafting IEE report)	– Background of the proposed SLF project – Project description – Environmental and social issues	10th of December, 2007	38

Source: MOM and JICA Study Team

(1) First Public Consultation Meeting

The MOM organized the first public consultation meeting at the Malay Session Hall on the Mainland of Malay on April 4, 2006. The Mayors of MOM and MOB, all of barangay chairpersons of the MOM, DENR Aklan and DENR-EMB Region 6 personnel attended the meeting.

In the meeting, the MOM introduced their ideas for development of the new SLF and explained the results of the geological and environmental assessments. The DENR and MOM conducted the geological and environmental assessments on the proposed new SLF site in order to identify its area, land classification and ecological conditions. The survey revealed that about one fifth of the area is Timber Land, i.e. public land, and rest of it is classified as Alienable and Disposable Land, i.e. land which can be owned privately.

(2) Second Public Consultation Meeting

The MOM held the second public consultation meeting at the Barangay Hall in Barangay Kablihan on November 30, 2006. The MOM explained that the DENR had determined that the proposed site was suitable for the new SLF based on the geological and environmental assessments. The Council of Barangay Kablihan endorsed the development of the new SLF on the condition that the several conditions presented in the minutes are complied with.

(3) Third Pubic Consultation Meeting

The MOM, with support from the JICA Study Team, held the third public consultation meeting on December 10, 2007. The objective was to explain the project outline, such as the background, necessity, location and key components of the design, development plan, and a brief presentation on the results of the environmental and social survey to relevant stakeholders. The meeting also aimed at collecting participants' opinions and concerns. The participants expressed their opinions and concerns, and the MOM answered them. The local language, Tagalog, as well as English were used in the meeting.

Thirty eight (38) participants attended the meeting. They were composed of the barangay chairperson, members of Kagawad (council at barangay level), officials from the SB, staff from the MOM, official of DENR-EMB, Kabulihan Farmers and Forest Developers Association (KFFDA), and the JICA Study Team.

1) Main Discussion

Throughout the meeting, the atmosphere was supportive for the new SLF project and the attendees actively exchanged their opinions. Firstly, in terms of environmental aspects, the impact on the groundwater and surface water quality was one of the things that most concerned the participants. The JICA Study Team explained that several measures, such as a leachate treatment facility, were incorporated into the design of the SLF to prevent deterioration of the water quality. The MOM also explained the results of present water quality tests and a plan to monitor the quality. On the other hand, one participant raised a concern about breeding of flies and offensive odors due to disposed waste in the SLF. The participants discussed that it is biodegradable waste that causes breeding of flies and offensive odors, and strict segregation is crucial before the waste is transferred into the SLF. The participants and MOM confirmed that the new SLF would accept residual waste and the importance of the IEC for enhancing segregation activities.

Secondly, the participants and the MOM discussed the importance of waste diversion. The major components of SWM are reduction, recycling, composting and final disposal of residual waste. To reduce the amount of residual waste, the business sector should tackle reducing the amount of waste discharged. Recycling and composting activities should be enhanced as well. These activities would contribute to extend the life span of the SLF. The participants and the MOM agreed that solidarity is crucial to promote better SWM.

Finally, the participants requested the MOM to continue disclosure of information and implement all of the necessary actions in management of the new SLF.

2) Findings and Recommendations

Most of the participants were in favor of the new SLF project. However, the meeting revealed the following concerns among the attendees:

- Impacts on groundwater and surface water quality
- Breeding of flies and offensive odors
- Methods to deal with the residual waste currently stockpiled in Yapak, Barabag and

Maonc-Manoc MRFs on Boracay Island

- Proper waste transportation by vehicles for prevention of waste scattering along roads
- Appropriate implementation of necessary actions in management of the new SLF by the MOM

The above findings and recommendations have been reflected on the SLF design as mitigation measures and the proposed EMMP. It was still strongly recommended that the MOM should address these concerns and take necessary actions in suitable manners and times. The MOM should continue to disclose information not only to governmental officials but also to the local residents.

1.10.3 Impact Assessment and Mitigation Measures

The environmental and social impacts during the pre-construction, construction and operation phase were evaluated in terms of their nature, their duration, extent, and reversibility or permanency.

(1) Analysis of Alternatives

Abandoning the new SLF project is regarded as a 'Do-Nothing' option. This option is not acceptable for the MOM because if the new SLF will not be constructed, the waste generated from Boracay Island has no final disposal area and could cause severe environmental impacts.

Since the closure of the old dump site on Boracay Island in 2006, the MOM has not conducted any practical measures on disposal of the residual waste generated from Boracay Island. So far, the MOM has transferred the waste to the proposed new SLF site, and just stockpiled it there without any appropriate measures. The estimated generation of residual waste is 10-13 ton/day, and the volume of piled waste is increasing daily. Besides, due to the surge of the tourist industry, it is predicted that the amount of waste will increase rapidly in the future. Therefore, to establish the new SLF is an urgent issue for the MOM. Without a proper final disposal facility, the residual waste might cause environmental impacts such as groundwater, surface water and soil contamination and bad odors. The MOM cannot select the 'Do-Nothing' option at all.

(2) Environmental Scoping

For the results of environmental scoping referring to the IEE (see Part II). One of the most critical environmental issues would be contamination of surface water and groundwater around the proposed SLF. Local residents use water from Malay River and its tributaries for their daily lives, and catch fishes and shellfish in the River. Thus, the impacts on the water environment need to be assessed appropriately for establishing suitable mitigation measures.

(3) Impacts and Mitigation Measures during the Construction Phase

Major environmental impacts predicted during the construction phase were evaluated as moderately significant and temporary. They can be minimized or mitigated well by an appropriate design based on a detailed site survey and construction management.

Geological mapping indicates that the proposed SLF site is not in any geo-hazard zone of the Municipality or province. Land clearing and earthmoving activities may change the vegetation cover and terrain around the site. Hence, it is a concern that soil erosion and siltation in Malay River and its tributaries would occur, especially during the rainy season. It is also a concern that these changes could damage the terrestrial and aquatic ecosystem. In order to mitigate these impacts, it is recommended that excessive land clearing be avoided, and construction activities would be executed mainly during the dry season. Additionally, proper management of excavated soil and close monitoring of unstable slope and water quality in Malay River are necessary. Though the construction activities would cause some extent of noise and vibration, it is predicted that the impacts would be of little significance because the proposed site is surrounded by forests and farm land, and there are few households adjacent to the site.

In terms of positive effects, the construction could provide local residents and enterprises with jobs and income generation opportunities. Procurement of construction materials and other supply requirements within local areas, if available, should be one of the requirements for a contractor.

(4) Impacts and Mitigation Measures during the Operation Phase

One of the major concerns is surface water, i.e. Malay River and its tributaries, and groundwater contamination due to leachate from the SLF. Local residents catch fishes and shellfish in Malay River and use the river water in their households and drink the groundwater. Hence, the deterioration of water quality would be a significant impact on local residents' life.

In order to mitigate the impact on the water environment, a leachate control system will be installed. The system has a pumping system to re-circulate excess leachate back to the SLF. However, especially during the rainy season, it is predicted that the volume of leachate would increase, therefore, some extent of treated leachate effluent which meets national discharge standards would be discharged off-site. In addition, storm water drainage system around the SLF cells would be established to intercept surface run-off and minimize the production of leachate. The natural clay soil at the site can be used as a liner to minimize percolation of leachate out of the site. Based on the soil test conducted on in situ soil materials, there is enough quantity for soil liners that meet the requirement of permeability of 10^{-5} cm/sec for category 1 landfills which is stipulated in DAO No.10. However, the MOM is requested to monitor the quality of leachate, effluent, surface water and groundwater regularly.

Landfill gas generated during waste decomposition would be a concern as well. In order to minimize the impact, landfill gas wells for passive relief and buffer zones would be installed. The MOM will also monitor the composition of landfill gas at an appropriate frequency.

Offensive odors and propagation of disease vectors could occur during the operation phase. They would annoy local residents and workers at the SLF. Periodical soil cover, securing buffer zones and cleaning the site would be applied to mitigate the impacts. The extent of offensive odors and propagation of disease vectors will be monitored regularly by the MOM and mitigation measures will be taken if necessary.

The SLF is expected to accept estimated 26.7 tons of HCW up to the end of 2017. Before transfer to the SLF, the HCW should be treated properly. Only treated HCW is destined for disposal in the special separated cells which are to be constructed within the SLF. It is necessary that any liquids be collected at a base of the cell and processed in the leachate treatment pond. In the cell, reinforced concrete bins, in which the HCW is disposed of, will be installed. Once the bins become full, they will be sealed for encapsulation of the HCW.

1.10.4 Environmental Management and Monitoring Plan (EMMP)

An important objective of the EMMP is to clarify targets and conditions to be met during project implementation. Additionally, the EMMP shows procedures and plans to guarantee that the mitigation measures are actually implemented in subsequent phases of the project.

(1) Environmental Management and Monitoring Plan (EMMP)

The EMMP has been proposed for the development of SLF consisting of two components, i.e. i) Environmental and Social Impacts and its Mitigation Measures, and ii) Environmental Monitoring Plan (The proposed EMMP is shown in Appendix III-1.10.2).

The MOM should implement environmental monitoring activities stipulated in the EMMP. Given the capacity and funding limitations of the MOM, it is recommended that the EMMP would focus on the prioritized parameters such as water quality, offensive odor and landfill gas. The four groundwater monitoring wells have been installed already on-site during the study. They are located immediately north of the embankment dam and the leachate treatment pond and can be used for the EMMP. In addition, a set of standard operating procedures is stipulated in the EMMP in order to provide enhanced protection to the environment, including compaction and daily covering of waste. It is MOM’s responsibility to follow the requirements presented in the ECC and EMMP. The MOM should clarify their commitments by preparation of the Self-monitoring Reports (SMRs) and submit them to the DENR-EMR Regional Office on a semi-annual basis.

(2) Institutional Framework of the EMMP

1) Establishment of Sanitary Landfill Management Unit

In the 10-year SWM Plan, it is proposed that the MOM would organize a Sanitary Landfill Management Unit (SLFMU) whose main tasks will be to manage the SLF. The SLFMU has several responsibilities including the EMMP during all the project cycles as follows:

- Monitor the environmental requirements proposed in the EMMP, monitor actual impacts caused by the project, and establish necessary management measures, and if necessary, recommend the revision of the EMMP.
- Ensure all conditions and restrictions of the approved ECC are being met and fulfill monitoring and reporting requirements.
- Submit SMRs semi-annually using the ECC compliance monitoring report (Self-monitoring Report EMB-EIA form No. 03).
- Ensure that the commissioned contractors comply with the all conditions of the ECC and EMMP, and Terms of Reference (TOR) for the contractors included in the requirements.

2) Establishment of Multi-partite Monitoring Team

It is recommended that the MOM should organize a Multi-partite Monitoring Team (MMT) which will monitor the MOM's compliance with conditions stipulated in the ECC. The MMT should be composed of various stakeholders such as representatives of the DENR-EMB, PENRO, CENRO, MOM, Barangays, NSWMC and local residents. The MMT should report the findings to the DENR-EMB Regional Office by submitting Compliance Monitoring and Validation Report (CMVR). Major responsibilities of the MMT are as follows:

- Monitor MOM's compliance with the conditions stipulated in the ECC and EMMP,
- Validate self monitoring activities conducted by the MOM,
- Receive complaints, and transmit recommended measures in a timely manner to address the complaints to the MOM and DENR-EMB,
- Prepare and disseminate simplified monitoring reports to stakeholders, and
- Make regular and timely submission of reports to the DENR-EMB Regional Office.

1.11 Evaluation and Conclusion

1.11.1 Technical Aspect

The technical system proposed in the F/S for Development of the Kabulihan SLF basically follows the DAO 10 Series 2006 Guideline for Development of Sanitary Landfill Sites by NSWMC. Basically, the technological methodologies adapted for the development of the SLF are not complicated and can be conducted in the Philippines. Therefore, the development of the SLF is evaluated as technically viable.

1.11.2 Social and Environmental Aspects

The proposed development of the SLF is expected to contribute to mitigate the negative environmental impacts which may be caused by the waste being dumped at sites other than the SLF. In order to mitigate the negative environmental impacts which could be caused by the development of SLF itself, careful environmental considerations have been given to the development plan such as a leachate collection and treatment system and liner system at the bottom of the landfill area. Although no serious environmental or social impacts are expected, environmental monitoring, especially on both surface and ground water, is planned to be conducted. As a result, the Development of Kabulihan SLF is evaluated as environmentally sound.

1.11.3 Financial and Economic Aspects

The result of a cost estimate for the Development of Kabulihan SLF shows that the necessary investment costs may be beyond the annual budget of the MOM and may require an increase in revenue. However, the arrangement of a loan is planned and the necessary costs could thereby be covered by the MOM. On the other hand, the development works are designed with minimum facilities and equipment and the development of the SLF itself would contribute to protect the environment. The protected environment would contribute to attract more tourists. Therefore, the plan is evaluated as financially and economically feasible.

1.11.4 Overall Evaluation

The proposed SLF is planned following the DAO 10 Series 2006 which should be adapted to the SLF development in the Philippines. Careful social and environmental considerations have also been given to the development plan based on DAO 10. The SLF aims to dispose of the residual waste in a sanitary way so that the environmental degradation which has been brought about by the waste dumped at sites other than the SLF can be minimized. It is also expected that the development of the SLF would contribute to make the whole area of the MOM clean and attractive. As for the financial aspects, investment and O&M costs for the development of the SLF can be recovered by the MOM. Considering the above series of evaluations from the technical, social & environmental, financial & economical aspects, the Development of the SLF is evaluated as viable as a whole.

CHAPTER III-2 FEASIBILITY STUDY FOR THE OLD DUMP SITE

2.1 Introduction

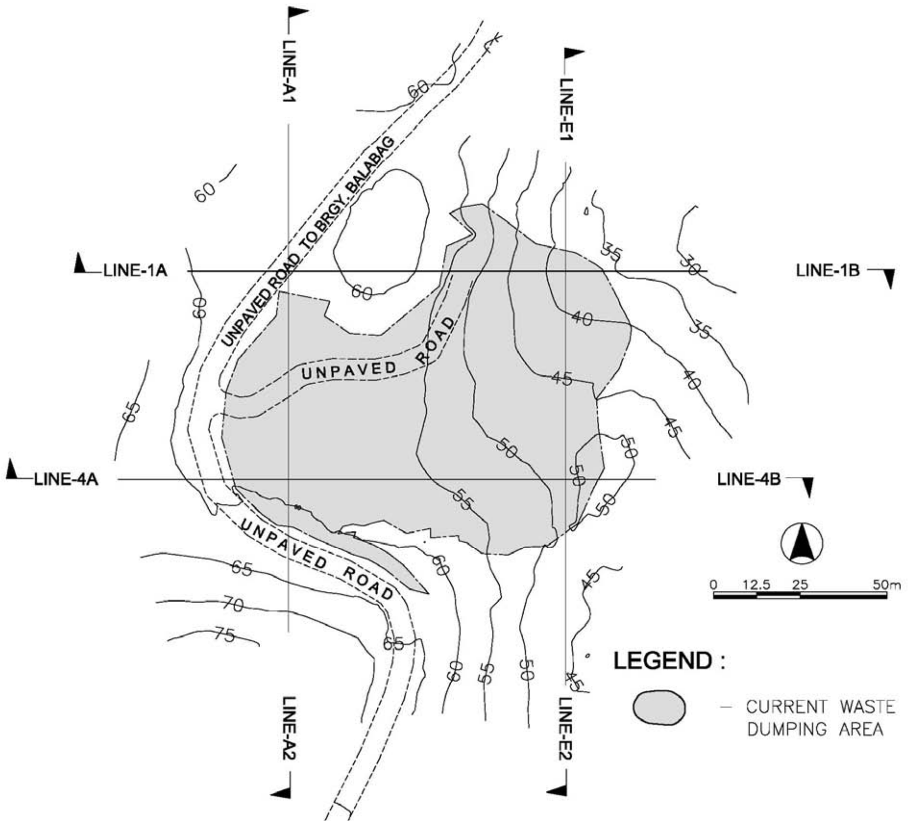
The old dump site is located in Barangay Balabag, which is situated on the northeastern side of Boracay Island. The MOM started dumping of waste at the dump site in 1996. The site is a privately-owned property leased to the MOM since 1997. In the area, hauled waste was burned to reduce the volume of solid waste but later stopped due to problems due to the effects of smoke coming from the site. Only residual waste has been allowed to be dumped in the site since 2002. As RA 9003 forced LGUs to close and rehabilitate all open dump sites in the Philippines, the MOM terminated dumping activities in January 2006. However, it has not taken adequate measures for rehabilitation of the dump site so far. Based on environmental and social perspectives and legislative requirements, it is an obligation for the MOM to implement proper closure measures immediately. In this context, the rehabilitation of the old dumping site has been proposed in the 10-year SWM Plan of the MOM and selected as one of the priority projects for which a F/S has been conducted.

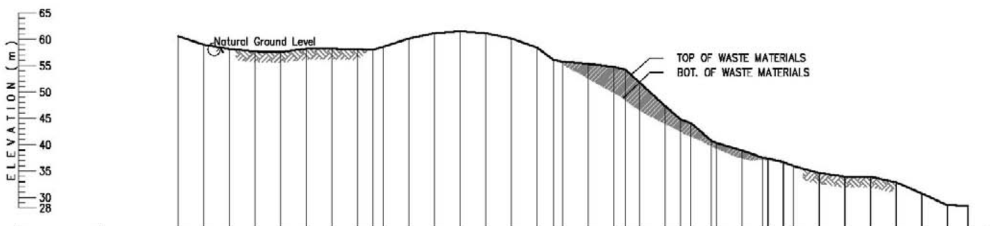
2.2 Site Condition

2.2.1 Topography, Geology and Soil Conditions

The topographic map and the areas to which solid waste has been dumped are shown in Figure 2.2-1. The site occupies a small valley between two low hills, one to the north which reaches an elevation of approximately 63 m ASL. Approximately 100-200 m to the east of the site is the coastline, which comprises a vertical cliff approximately 20 m high in this location. The steep slope of the dump site is unstable and is prone to slope failures, particularly in the central and northern sections where failure of the slopes is continuing and has accelerated with the onset of the rainy season. During a failure, the waste flows down and out as a series of lenses up to and beyond the recorded margin of the dump site.

According to the topographic and boring survey, solid waste was dumped along the northern edge of a steep northeast-southwest ridge and the dumping area is approximately 0.7 ha and the depth of deposited waste is 0.5 to 7.0 m as shown in Figure 2.2-2. According to the information, dumped solid waste is estimated at about 15,000m^3.

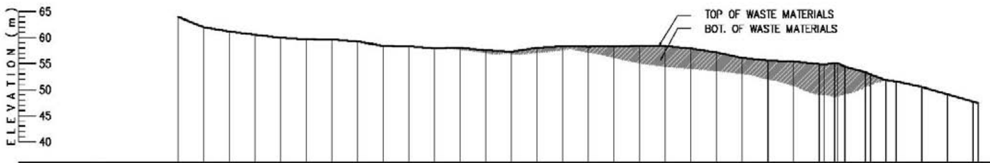




ORIGINAL GROUND LINE

DISTANCE	ELEVATION
0+000	60.620
0+005	59.005
0+010	58.190
0+015	57.735
0+020	57.620
0+025	58.227
0+030	58.250
0+035	58.125
0+038	58.030
0+040	58.600
0+045	60.185
0+050	61.190
0+055	61.555
0+060	61.200
0+065	60.185
0+070	58.460
0+073	56.096
0+075	55.765
0+080	55.370
0+085	54.815
0+087	54.267
0+090	51.800
0+095	47.320
0+098	44.800
0+100	44.130
0+104	40.740
0+105	40.340
0+110	38.900
0+114	37.560
0+115	37.450
0+118	36.750
0+120	35.950
0+125	34.640
0+130	33.940
0+135	33.955
0+140	32.870
0+145	30.755
0+150	28.520
0+154	28.430

CROSS SECTION @ LINE 1A – 1B



ORIGINAL GROUND LINE

DISTANCE	ELEVATION
0+000	63.970
0+005	62.000
0+010	61.170
0+015	60.550
0+020	59.950
0+025	59.643
0+030	59.600
0+035	59.240
0+040	58.420
0+045	58.330
0+050	57.970
0+055	58.065
0+060	57.580
0+065	57.307
0+070	58.060
0+075	58.343
0+080	58.250
0+085	58.345
0+090	58.400
0+095	58.390
0+100	57.930
0+105	57.145
0+110	56.100
0+115	55.590
0+120	55.390
0+125	54.880
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
0+130	54.430
0+134	53.380
0+135	52.935
0+138	51.800
0+140	51.580
0+145	50.505
0+150	49.130
0+155	47.705
0+156	47.421

CROSS SECTION @ LINE 4A–4B

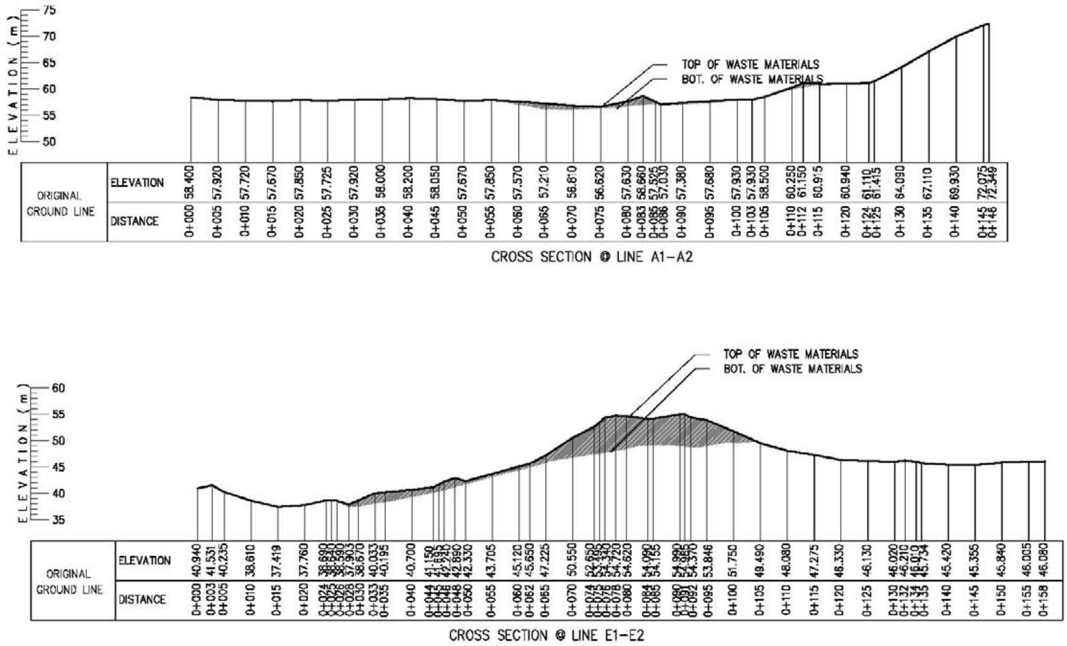


Figure 2.2-1 Area Where Solid Waste was Dumped at the Old Dump Site

Note: Shaded area shows the area where solid waste was dumped.
Source: JICA Study Team

2.2.2 Climate

The climate of the Philippines belongs to a tropical monsoon so that the weather condition of the site is profoundly seasonal, with a single wet season and a single dry season. The rainy season is normally recognized as the southwest monsoon period, which lasts from June to December. Most annual rainfall occurs in these months with frequent squalls and strong westerly winds. The dry season, from January to May, falls under the period of the northeast monsoon period and is generally, although not always, comparatively drier. The Rainfall Intensity Duration Frequency (RIDF) data are available at Kalibo station which is the nearest station from the site. The RIDF data can be used for the calculation of drainage design. The calculated rainfall intensity duration frequency data is shown in Table 2.2-1.

Table 2.2-1 Rainfall Intensity Duration Frequency Data at Kalibo Station

(Unit:mm)

Return Period	Consecutive Duration														
	5 min	10 min	15. min	20 min	30 min	45 min	60 min	80 min	100 min	120 min	150 min	3 hr	6 hr	12 hr	24 hr
2 year	8.7	13.4	17.2	20.3	25.3	30.2	33.5	39.2	44.3	48.3	53.5	58.1	75.5	92.3	104.5
5 year	12.3	18.9	24.4	28.9	36.2	43.3	48.2	56.5	64.0	70.0	77.6	84.4	110.7	135.4	154.0
10 year	14.8	22.6	29.2	34.6	43.4	52.1	58.0	68.0	77.1	84.3	93.6	101.8	134.0	163.9	186.7
15 year	16.1	24.7	31.9	37.9	47.4	57.0	63.5	74.4	84.4	92.4	102.6	111.6	147.1	180.0	205.2
20 year	17.1	26.2	33.8	40.1	50.3	60.4	67.3	79.0	89.6	98.1	108.9	118.5	156.3	191.3	218.1
25 year	17.8	27.3	35.3	41.9	52.5	63.1	70.3	82.5	93.6	102.4	113.7	123.8	163.4	200.0	228.1
50 year	20.1	30.8	39.7	47.2	59.2	71.2	79.4	93.2	105.8	115.9	128.7	140.1	185.2	226.7	258.8
100 year	22.3	34.2	44.2	52.5	65.9	79.3	88.5	103.9	118.0	129.2	143.5	156.3	206.8	253.3	289.3

Note: Each data indicates the maximum rainfall value for consecutive rainfall of each consecutive duration period with each return period. For example, the consecutive 30 minutes rainfall which occurs with the probability once in a 100 year will cause rainfall amount of less than 65.9mm.
Source: PAGASA, 1980 to 2000

2.2.3 Environment

In order to consider a rehabilitation plan of the site, the current environmental conditions in and around the site were surveyed by the JICA Study Team focusing on the possible environmental impacts which may be caused by the dumped waste. This field-based survey included a series of water quality tests of sea, surface and ground waters and monitoring of landfill gas using a portable gas detector and field reconnaissance, site investigations of the ecological environment such as flora and fauna, social conditions such as distribution of the surrounding residents, facilities, land use and water uses. The results of the environmental survey are summarized below:

(1) Physical Environment

Samples of sea water were taken during the dry season (June, 2007) and rainy season (September, 2007) in order to test for quality. The result did not indicate any critical contamination. Neither did it present any significant differences between the rainy and dry seasons or the high and low tides. Concerning surface water that runs on the old dump site only after torrential rain, there was no significant pollution identified except for a few parameters such as iron, lead and total coliform.

Groundwater quality was analyzed during the rainy season (August and September, 2007). In September, samples were taken at both high tide and low tide. The results indicated several contaminants, though their extent was not significant. The same as in the surface water survey, the groundwater contained high concentrations of iron, and the concentration of lead was also higher than the Philippine standards. COD of every sample was relatively high ranging from 286.0 – 1,858.0 mg/l. In terms of total coliform, although the Philippine standard requires that coliform should not be detectable in a 100 ml sample, the survey showed higher results ranging from 7,000 – 240,000 MPN/100ml.

The gas survey did not detect any serious landfill gas around the old dump site. Four parameters, CH_4, CO_2, H_2S and NH_3 were below detection limits of the G450 Portable Gas Detector. On the other hand, light odor was experienced at the site. During the survey, the odor was identified by four levels: light; medium; heavy; and very heavy. At two out of four points, adjacent to and within the site, the odor was described as light and medium respectively. The local residents claimed that they still smell odors from the site though the condition became better after the closure of site.

(2) Natural Environment

Boracay Island has relatively low biodiversity, but fruits bats, an endangered species, are commonly observed. The area around the old dump site is composed of limestone forest, secondary forest, grass land and residential areas. Local people plant cultivated crops such as coconut and banana in the residential areas. No endangered plants were identified in the area. Based on the interview, several kinds of fishes, such as goat fish, snapper, and butterfly fish are caught in a fishing ground along the northern part of Boracay Island. As the result of the survey, no serious negative impact was identified on the ecological environment around the site.

(3) Social Environment

The population of Barangay Balabag, at which the old dump site is located, was 3,461 in 2006. Its land area is 3.2 km^2 and the population density was 1,095 person/ km^2 in 2006. All households on Boracay Island have been served with tap water since 2000, but some households still use groundwater from deep wells and communal pump wells for washing and bathing.

There are three sitios (the smallest socio-political unit and a political subdivision of a barangay) around the site. A perception survey was conducted targeting 48 residents in the three sitios: Pinaungon; Bulabog; and Lapos-lapos. Around 66 % of x respondents positively accepted the closure of old dump site, and 8 % showed a negative response. The major reasons for acceptance were expectation of improvement of the air environment and alleviation of the propagation of flies. It can be presumed that respondents who presented a negative response are involved in scavenging activities at the old dump site. During the operation of the old dump site, dust and occurrence of trucks were major annoyances among the local residents. On the other hand, 11 respondents claimed that groundwater quality after the operation was worse than before the operation.

2.3 Planning Concept

2.3.1 Development of Technical Options

The planning concept for the rehabilitation of the old dump site was considered based on the results of the site condition surveys as well as DAO 09 Series 2006 and the Guidebook for Safe Closure System Applied for Disposal Site by the NSWMC. One of the most critical environmental issues which should be taken into consideration is contamination of groundwater in and around the old dump site. Since there is a coastline east of the site, the contaminated groundwater could possibly flow out to the ocean especially when it is low tide. The other issue which was considered is to minimize the rehabilitation cost. DAO 09 requests to apply and maintain soil cover at least 60 cm thick for the final soil cover which includes a 15 cm topsoil and 45 cm compacted soil together with a drainage control system. If the area to be covered by the soil is reduced it will minimize the necessary soil materials and therefore, also the rehabilitation cost. Taking into account the above discussions, the following four technical options were proposed mainly focusing on the mitigation of groundwater contamination.

(1) Option 1

Option 1 was developed to reduce the area in order to reduce the requirements for cover soil. This involves excavation of waste from the eastern part of the dump site and its relocation into the western half of the site. The side slopes are to be re-graded to conform to DAO 09 specifying a 3H: 1V as the maximum slope. The dumped waste is graded and compacted and then soil cover is employed after re-grading. This option is illustrated schematically in Figure 2.3-1.

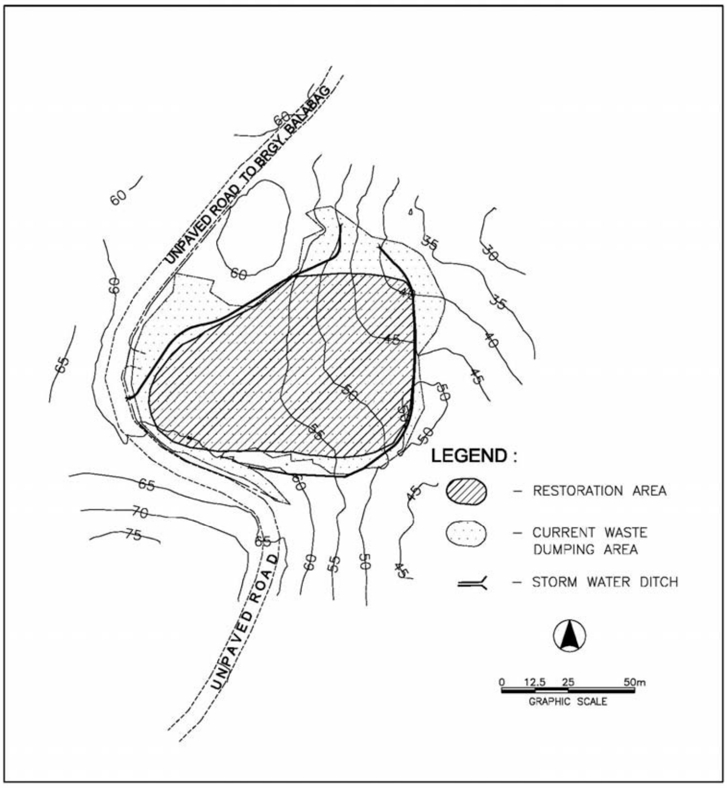


Figure 2.3-1 Rehabilitation Option for the Old Dump Site (Option 1)

Source: JICA Study Team

(2) Option 2

Option 2 was also developed to reduce the area as small as practical in order to reduce the requirements for cover soil by employing the capping and reshaping of the wastes and providing an earth embankment along the bottom slope of the disposal site. At the area where solid waste was dumped, activities shall be concentrated on the stabilization of the eastern margin of the dump site by flattening the slopes. Excess material excavated during this exercise is to be placed and shaped along the embankment. This option is illustrated schematically in Figure 2.3-2.

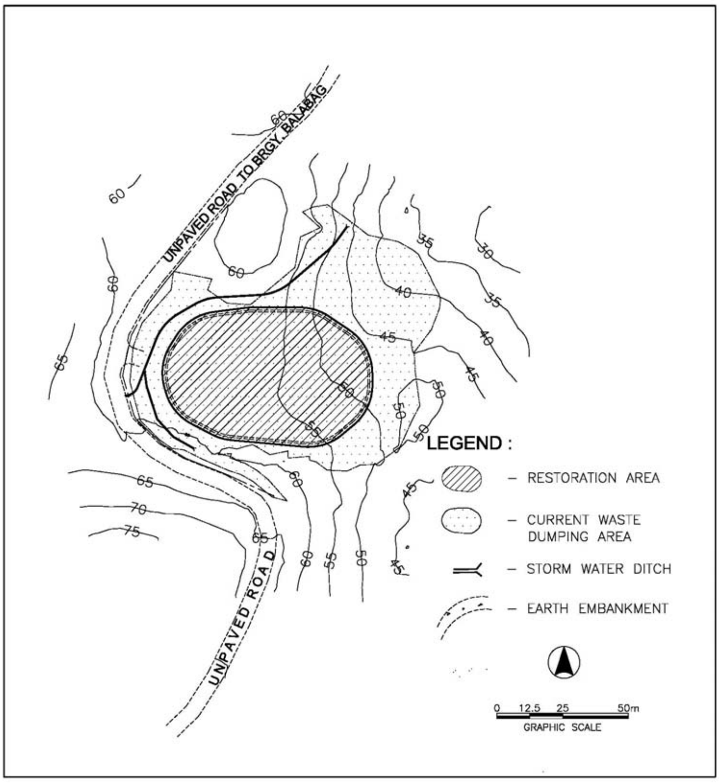


Figure 2.3-2 Rehabilitation Option for the Old Dump Site (Option 2)

Source: JICA Study Team

(3) Option 3

Option 3 is similar to Option 1 but relies on an alternative slope stabilization strategy involving the use an inverted-T retaining wall at the waste boundaries with critical slopes and to re-grade the waste. There would be limited transfer of waste to the western half of the site and the existing topography would be retained more or less as it is. This option is illustrated schematically in Figure 2.3-3.

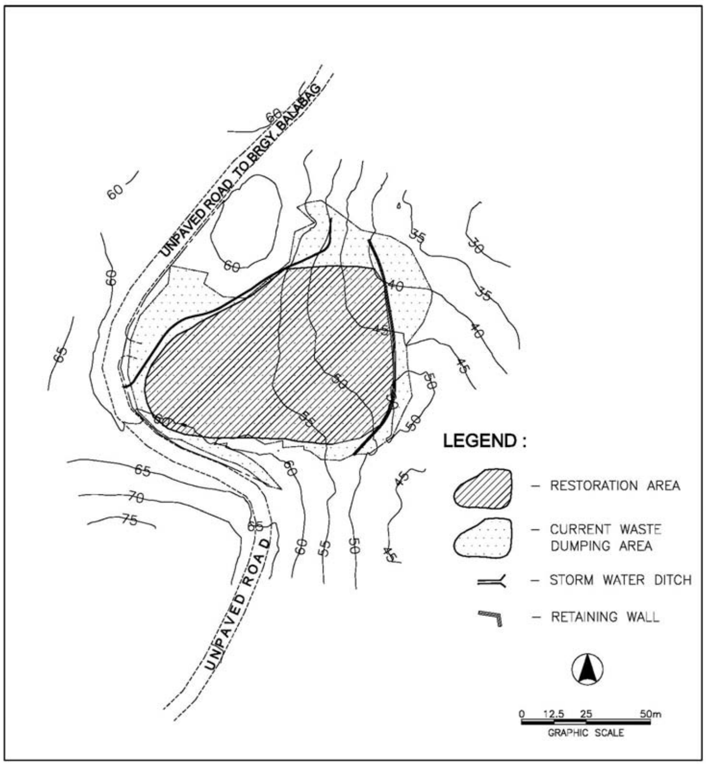


Figure 2.3-3 Rehabilitation Option for the Old Dump Site (Option 3)

Source: JICA Study Team

(4) Option 4

Option 4 is a variation on Option 3 but the dumped waste is pushed down the slope and an inverted-T retaining wall is constructed at the lower end so the waste area can be minimized as much as possible. The standard Inverted-T retaining wall is to be constructed at the boundary of the wastes having critical slopes. Side slopes are set at 7H: 1V. The wastes are re-shaped and re-graded to minimize the area that needs soil cover. This option is illustrated schematically in Figure 2.3-4.

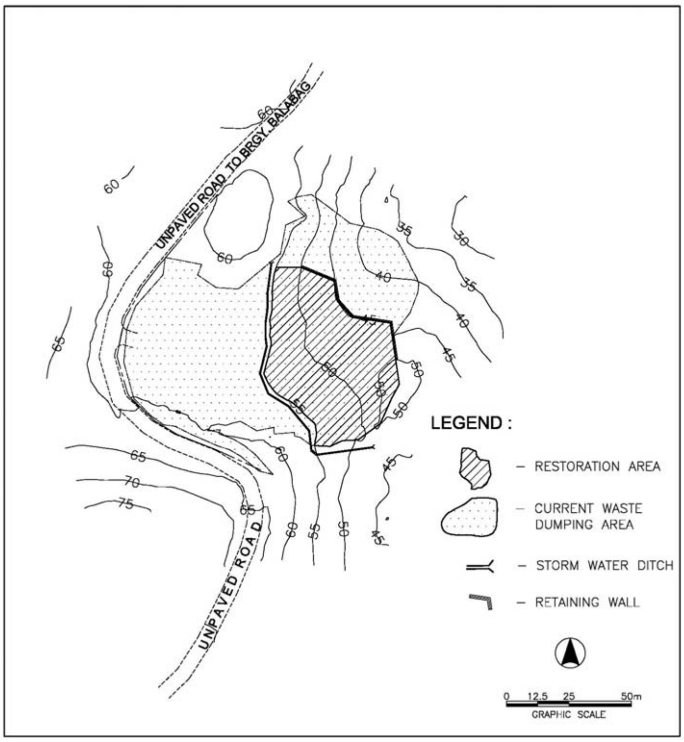


Figure 2.3-4 Rehabilitation Option for the Old Dump Site (Option 4)

Source: JICA Study Team

2.3.2 Selection of Technical Option

The four proposed technical options are compared as summarized in Table 2.3-1.

Table 2.3-1 Comparison of Options for Rehabilitation of the Old Dump Site

Items	Option 1	Option 2	Option 3	Option 4
Surface Area to be Covered by Soil (Restoration Area)	The surface area to be covered restoration area are computed using the re-contoured topographic map as follows:			
	5,149 m^2	3,472 m^2	5,417 m^2	2,537 m^2
Length of T-Retaining Wall	Concrete volume was computed based on the design section of the T-Retaining Wall. The estimated total lengths of the T-retaining wall are as follows:			
	None	None	64 m	62 m
Length of Drainage Facility	Drainage facilities are to be provided in accordance with DAO 09 and the Guidebook for Safe Closure System Applied for Disposal Site. The estimated total lengths of the drainage are as follows:			
	205 m	150 m	200 m	92 m

Source: JICA Study Team

Base on the above quantities of the facilities, the tentative rehabilitation costs were estimated for each option. Option 4 showed the lowest cost for the rehabilitation works since the area to be covered by soil is less than other options which produces the minimum cost for soil capping. However, because the Inverted-T retaining wall which is developed could be seen from the sea side it would not be good for the landscape of Boracay Island. In addition, there is a possibility to produce negative impacts on the environment by moving a relatively large amount of the dumped waste. Therefore, Option 2 is selected as the rehabilitation method for the old dump site.

Under Option 2, the waste is re-shaped and a cover soil on top of the final waste layer is put in place to provide improvement of the sanitary condition, landscape, etc. and to reduce infiltration of water into the garbage heaps. This also prevents burrowing animals from damaging the cover, prevents the emergence of insects and rodents from the compacted waste and minimizes the escape of odors. The soil cover should also be graded so as to prevent water ponding in the site. The final cover is to be 60 cm thick which includes 15 cm top soil and 45 cm compacted soil according to DAO No.09.

A vegetation cover layer is applied after the final cover to improve the stability of the slopes, reduce soil erosion and landscape the area. To enhance the growth of grasses, hydro seeding is also to be employed. The finished surface of the soil cover is to be re-graded to conform to the DENR guidelines specifying a 2 to 4% grade. Top soil suitable for turfing and planting to protect from erosion is to be provided.

2.4 Concept Design

2.4.1 Physical Closure (PC)

DAO 09 stipulates that the following shall be considered in physical closure of the open dump sites:

- Site clearing (removal of existing structures)
- Site grading and stabilization of critical slopes
- Application and maintenance of soil cover
- Provision of drainage control system
- Leachate management
- Gas management
- Fencing and security
- Erection of appropriate signage

However, it is not being considered nor would it be cost effective to install a system for leachate collection or treatment because the application and maintenance of soil cover and provision of the drainage control system would significantly mitigate the potential for leachate generation. In addition, the waste which is currently dumped is mainly garden waste or beach debris which have so much potential landfill gas generation and the waste which has been dumped already decomposed or burned previously. Therefore considering the type, volume, and thickness of the waste after re-grading, gas management is not considered necessary. In addition, considering the type, volume, and thickness of the waste after re-grading, gas management is not considered necessary. Under the selected Option 2, it is envisaged that the following will be considered for designing.

- Excavation of existing waste in order to stabilize any unstable slopes by reducing slope gradients to a maximum of 1:3 or 1:4
- Excavation of existing waste to reduce the area to reduce the amount of capping as well as leachate which may infiltrate
- Deposition of waste in the western half of the site in order to re-shape the existing topography into a shape compatible with any proposed future use
- Provision of embankment to protect against the collapse of the waste layer as well as preventing intrusion of surface waste into the waste dumping area
- Compaction of all existing waste in order to reduce the volume of the waste mound
- Application of a suitable soil cover over the waste and also over the areas that were cleared of waste during the re-grading in order to promote vegetative growth
- Re-vegetation of the dumping and cleared areas
- Provision of storm water drainage systems around the areas that received soil cover to collect surface run-off and thus to prevent surface erosion of the covered areas,
- Fencing of the site to prevent unauthorized access

The cross section drawings are provided in Figures 2.4-1 and Figures 2.4-2.

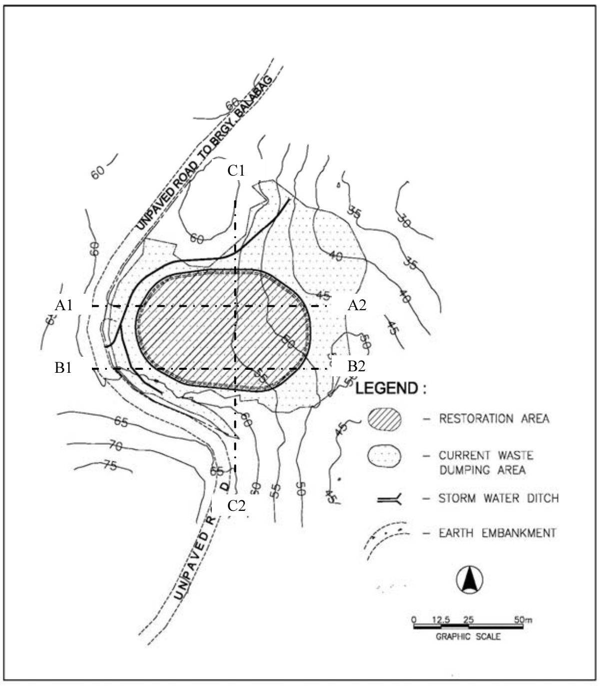


Figure 2.4-1 Physical Closure of the Old Dump Site

Source: JICA Study Team

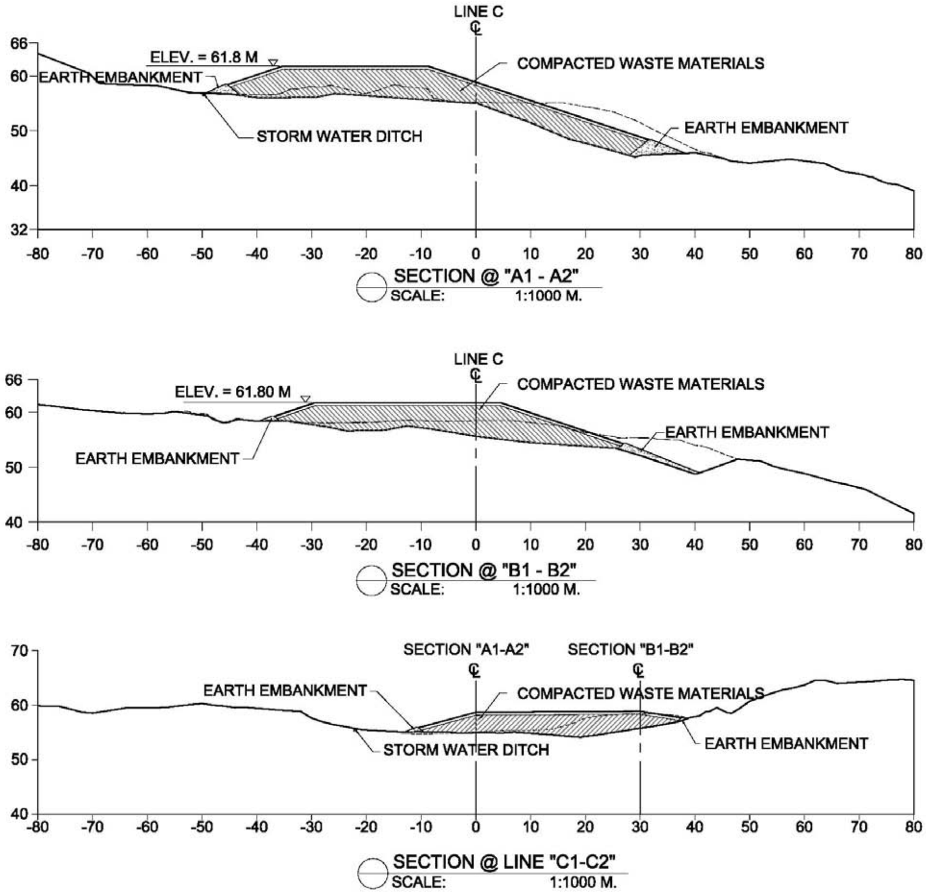


Figure 2.4-2 Cross Sections of Physical Closure of the Old Dump Site

Source: JICA Study Team

2.4.2 Drainage Plan

The storm drainage system for the old dump site aims to drain the storm run-off collected from the catchment area of old dump site to prevent from interflowing to waste dumping area to minimize the contact between the waste and surface flow.

In the process of drainage design, the following matters were considered.

- Conveyance of storm run-off will be by gravity flow as permitted by the site grading elevation.
- All drainages are designed with trial rectangular ditch.

The design storm frequencies were considered based on the 10 years return period for pipe culverts and the rectangular canal. The RIDF data in Kalibo, Aklan has been adopted. These data were obtained from the publication of the Flood Forecasting Branch of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). I_{10}= 135.60 mm/hr of 10 years return period and minimum time of concentration was set at 10 minutes, which are utilized for the calculation.

The run-off volume calculation was done using the rational formula for the catchment area and the velocity of water in drainage facilities both in open canals were determined using

Manning's Formula. Trial rectangular ditch is considered for the drainage and the cross section is assumed as 0.3m w and 0.3m d.

Table 2.4-1 Parameter for Drainage Calculation

Item	Parameter
Rainfall Intensity	135.6[mm/hr]
Coefficient of flow	0.7
Cross-section Area, a = 0.3 x 0.3	0.09[m^2]
Wetted Perimeter, p = 0.3+0.3+0.3	0.9[m]
Maximum Gradient of Ditch (Based on actual topography)	0.12
Manning's Coefficient of Roughness, n	0.015

Source: JICA Study Team

In the result of calculation, the cross section of trial rectangular ditch of 0.3m (width) and 0.3m (depth) is applicable for the drainage in old dump site.

2.5 Facility Plan

The facilities to be installed at the site for the rehabilitation are described in Table 2.5-1.

Table 2.5-1 Facility Plan

Facility	Explanation	Specification
Earth Embankment	Will be prepared to protect against the collapse of the waste layer as well as protect against the intrusion of surface water into the waste dumping area.	Length of the earth embankment: 216m
Drainage Facility	To be constructed along the periphery of the closed disposal site to divert surface run-off away from the area.	Length of the drainage facility: 150m
Fencing, Gate, and Sign Board	The site is to be fenced to control access and to prevent stray animals from getting into the site. Sign boards which inform the public that the site is a former disposal area and a gate are to be installed.	Length of the fence: 160m
Water quality monitoring wells	During the study, ground water monitoring wells have been installed upstream and downstream of the site.	Two wells upstream and down stream

Source: JICA Study Team

2.6 Post Closure Management Plan

2.6.1 Operation and Maintenance of the Site

Since the site will be retuned to the landowner after the rehabilitation works, it will not be necessary to continue operation of the waste disposal site after the rehabilitation. However, periodic inspection and maintenance of the capped areas to ensure their integrity as post closure management (PCM) including environmental monitoring especially on ground and sea water quality will be required. In addition, currently some people are still dumping their waste there even after the termination of the operation of the old dumping site. Considering the situation, some form of guard will be needed during and after the rehabilitation process. Therefore, guards should inspect the site randomly checking for illegal dumping and the functionality of the drainage systems.

Other than development or utilization of the land by the owner, it is reasonable to consider that the MOM should have the responsibility to conduct the follow up and environmental monitoring activities for a while even after returning the site to the landowner. Once effects of the rehabilitation will be confirmed and stabilized, all responsibilities could be transferred to the landowner.

2.6.2 Environmental Monitoring

The MOM has responsibility to monitor the environmental conditions in and around the old dump site even after the rehabilitation. Monitoring activities during the post closure period are crucial for early detection of any developing negative environmental impacts as well as for confirmation of the stabilization process. Given the capacity of the MOM and current extent of pollution around the old dump site, it is suggested that the MOM could monitor focusing on the most crucial items, i.e. groundwater and sea water quality, while the MOM will not necessarily need to monitor other items because the survey did not detect any significant impacts. Light odors were experienced during the survey, but this could be mitigated by appropriate application and maintenance of soil cover.

(1) Environmental Monitoring Activities

The proposed groundwater and sea water quality monitoring plan (EMP) is as shown in Table 2.6-1 because the environmental survey revealed some extent of contamination whose probable source is the dumped waste. Though the EMP is planned for the 10 years after the closure of the site, it can be terminated once the impacts are considered to be well mitigated.

Table 2.6-1 Monitoring and Frequency Parameters for the Old Dump Site

Items	Parameters	Frequency	Location	Responsibility	Reference Standards
Groundwater	Temperature, pH, Color, Turbidity, DO, TSS, TDS, Conductivity, BOD, COD, Coliform	Twice/year (10 years)	Two installed monitoring wells	MOM/DENR	Philippine Standard for Drinking Water (PSDW)
Sea water	Obtain results of regular monitoring by DENR	Twice/year (10 years)	2 points (Stations 13 and 14)	DENR	DAO No. 34 (Class SB)

Source: JICA Study Team

1) Groundwater Quality Monitoring

The MOM should monitor the basic parameters of groundwater quality at the two monitoring wells installed in the old dump site twice a year. There are two micro-laboratories in the

MOM, one is located in Caticlan on the Mainland of Malay, and the other is on Boracay Island. However, due to a lack of equipment and personnel, the laboratories have not obtained an accreditation for analysis from the Department of Health (DOH). Therefore, it is proposed that the water samples would be analyzed at the DENR-EMB Laboratory in Iloilo City, Panay Island, with support from the DENR Regional Office.

2) Sea Water Quality Monitoring

The DENR takes monthly samples of the seawater at 15 stations around Boracay Island as shown Figure 2.6-1. The DENR-EMB Laboratory at Iloilo City analyzes their quality. The monitored parameters are BOD, COD, TSS, Oil and Grease, NO_2-N, PO_4-P, Total Coliform, Fecal Coliform and Color. It is proposed that, instead of taking samples and analyzing them by the MOM itself, the MOM would refer to the DENR's monitoring results at Stations 13 and 14, which are the locations nearest to the old dump site as its monitoring activity.

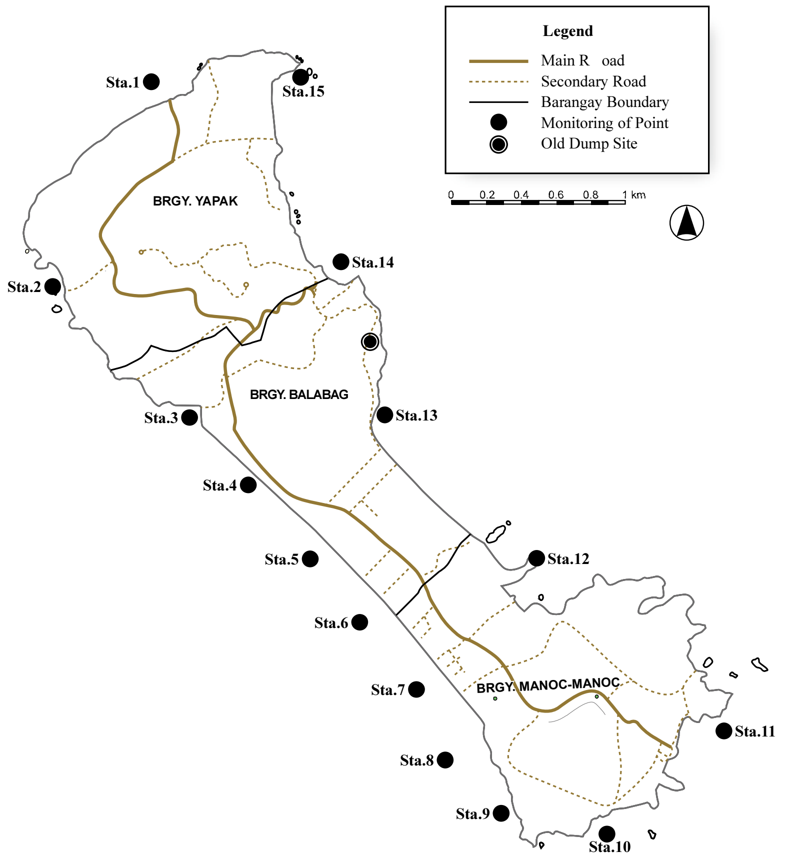


Figure 2.6-1 Monitoring Points of Sea water Quality around Boracay Island

Source: DENR-Region VI

(2) Reporting of Management and Monitoring Activities

The MOM should prepare a report about the monitoring activities including data, and submit it to the EMB Regional Office immediately after conducting the activities. In addition, the

DENR-EMB Regional Office requires the MOM to submit a Closure and Rehabilitation Checklist. By the checklist, the MOM would clarify their activities to improve the conditions of the old dump site.

2.6.3 Other Follow up Activities

Periodic inspection and maintenance of the capped areas and operational condition of the drainage systems should be carried out. Currently some people are still dumping waste from outside the area even after the termination of the operation of the old dumping site. The site should be inspected periodically for illegal dumping activities.

2.6.4 Organization

The rehabilitation works should be conducted by the MOM because the MOM has been using the site for open dumping. On the other hand, even though the site is to be retuned to the landowner after the rehabilitation and the site will be used by the landowner the environmental monitoring and follow up activities are remain the responsibility of the MOM. Environmental monitoring as well as the follow-up should be carried out by the staff of the Environmental Service of the MOM.

2.7 Implementation Plan

The implementation schedule for the rehabilitation of the old dump site is as shown in Figure 2.7-1. Basically, the rehabilitation works should be commenced as soon as possible in order to avoid further environmental degradation in and around the site.

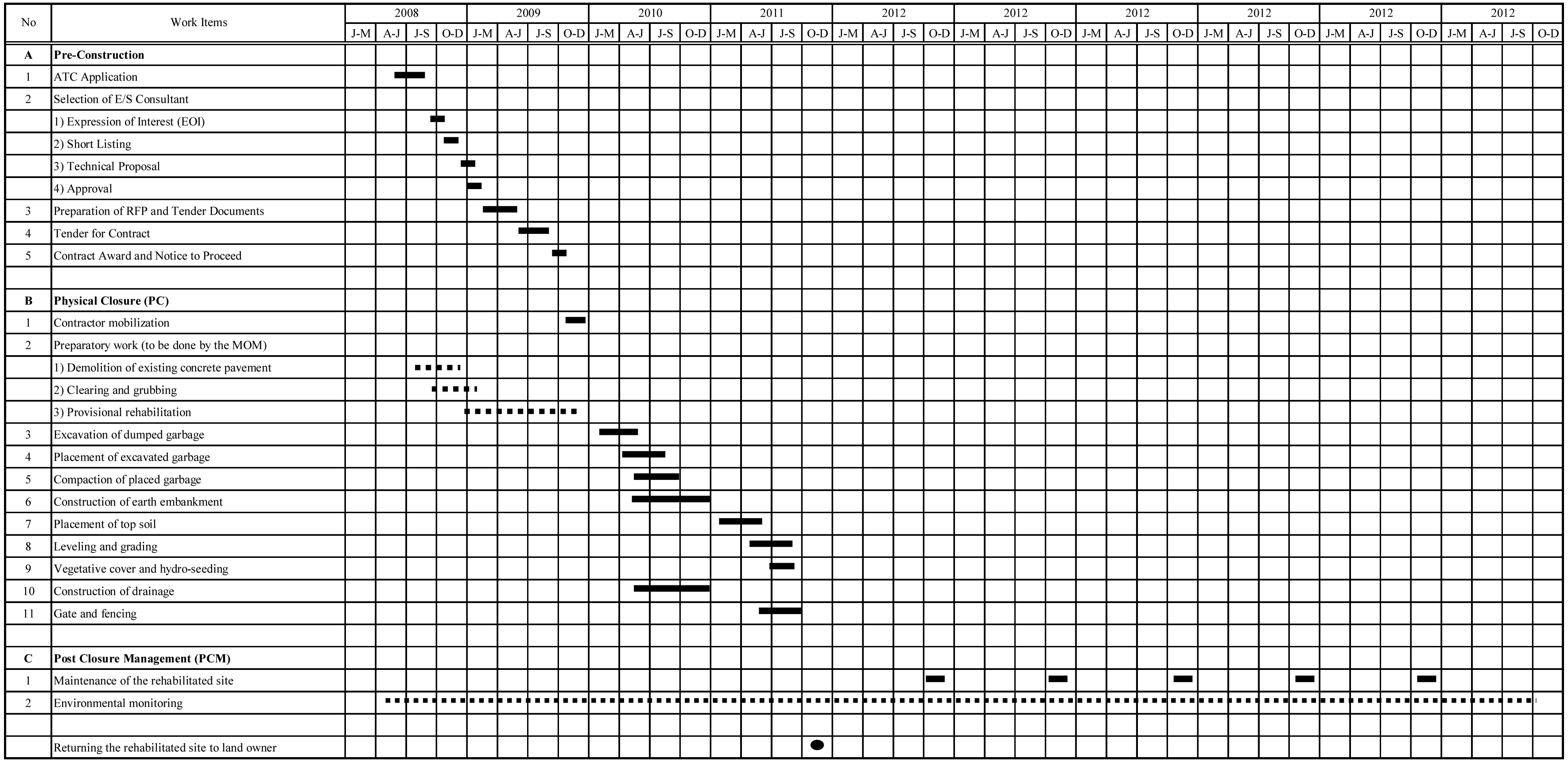


Figure 2.7-1 Implementation Schedule for Rehabilitation of the Old Dump Site

Source: JICA Study Team

2.8 Cost Estimate

2.8.1 Investment Cost

Based on the quantities of the rehabilitation works, investment, engineering service including bidding support and administration costs are estimated as shown in Table 2.8-1.

Table 2.8-1 Investment Cost of the Rehabilitation of Old Dump Site

(Unit: x10^3 PhP)

Category	Total
Engineering Service (E/S) Cost including Bidding Support	335
Physical Closure (PC)	6,708
Administration Cost	352
Sub-total	7,395
Physical Contingency	740
Total	8,135

Note : 1) Engineering service (E/S) cost is 5% of PC cost.
2) Administration cost is 5% of total costs of PC and E/S.
3) Physical contingency is 10% of total costs of PC, E/S and administration.
Source: JICA Study Team

2.8.2 Annual Costs

The disbursement schedule during the 10 years from 2008 to 2017 was prepared on the basis of the implementation schedule for the rehabilitation of old dump site. The O&M costs are required for the post-closure management, i.e. the environmental monitoring. The annual cost is estimated as shown in Table 2.8-2.

Table 2.8-2 Annual Investment and O&M Costs of the Rehabilitation of Old Dump Site

(Unit: x10^3 PhP)

No	Work Items	Total	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A	Engineering Service(1)[(2)*0.05]	335	9	21	218	87	0	0	0	0	0	0
B	Physical Closure (2)	6,709	183	427	4,361	1,738	0	0	0	0	0	0
1	Preparatory work	610	183	427	0	0	0	0	0	0	0	0
2	Excavation of dumped garbage	1,065	0	0	1,065	0	0	0	0	0	0	0
3	Placement of excavated garbage	985	0	0	985	0	0	0	0	0	0	0
4	Compaction of placed garbage	82	0	0	82	0	0	0	0	0	0	0
5	Construction of earth embankment	1,538	0	0	1,538	0	0	0	0	0	0	0
6	Placement of top soil	468	0	0	0	468	0	0	0	0	0	0
7	Leveling and grading	406	0	0	0	406	0	0	0	0	0	0
8	Vegetative cover and hydro-seeding	514	0	0	0	514	0	0	0	0	0	0
9	Construction of drainage	691	0	0	691	0	0	0	0	0	0	0
10	Gate and fencing	350	0	0	0	350	0	0	0	0	0	0
C	Administration Cost (3)[((1)+(2))*0.05]	352	10	22	229	91	0	0	0	0	0	0
D	Post Closure Management Cost (4)	900	0	100	100	100	100	100	100	100	100	100
E	Physical Contingency(5)[((1)+(2)+(3))*0.1]	740	20	47	481	192	0	0	0	0	0	0
	Subtotal of Investment (6) [(1)+(2)+(3)+(4)+(5)]	9,036	222	617	5,389	2,208	100	100	100	100	100	100
	Price Escalation (7)[(5%/year) of (6)]	1,668	11	63	849	476	28	34	41	48	55	63
	Total Cost (8)[(6)+(7)]	10,704	233	680	6,238	2,684	128	134	141	148	155	163

Note: Because the number after decimal point is rounded, accidental error occurs in first digit.
Source: JICA Study Team

2.9 Financial Analysis

All investments of the rehabilitation of old dump site would be sourced from self-sustaining fund of the General Fund/IRA and the EAF, and the cost for O&M would be also sourced from them. These resources would be managed as the LCF which is expected to manage all budgets and expenditures related to rehabilitation of the old dump site. The cash flow of rehabilitation of old dump site was calculated as shown in Table 2.9-1.

Table 2.9-1 Cash Flow of the Rehabilitation of Old Dump Site

(x10[3]PhP)

			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cash Inflows		A	233	681	6,237	2,684	128	134	141	148	155	163
	General Taxes/IRA from MOM and Barangays and EAF		233	681	6,237	2,684	128	134	141	148	155	163
Cash Outflows		B	233	681	6,237	2,684	128	134	141	148	155	163
	Investment for Rehabilitation of Old Dump Site		233	571	6,121	2,562	0	0	0	0	0	0
	OM related to Rehabilitation of Old Dump Site		0	110	116	122	128	134	141	148	155	163
Net Increase in Cash		C=A-B	0	0	0	0	0	0	0	0	0	0

Note: The case outflows include inflation rate and physical contingency.
Source: JICA Study Team

2.10 Environmental and Social Considerations

2.10.1 Legislative Requirements for Procedures for Rehabilitation of Disposal Sites

DAO 2006-09 requires a LGU to follow appropriate closure procedures. The first step is a pre-closure assessment which includes activities such as reviewing information with regard to the dump; evaluating potential or existing impacts on the ecological and human environment; and formulating proper mitigating and remedial measures. During the pre-closure assessment, the LGU shall assess several parameters, e.g. geology of the dump site; depth of groundwater; total volume/capacity, types of disposed waste; land use around the area; inventory of existing settlements, structures, surface water bodies, springs and wells; points of leachate; gas leakage; and, if practical, conduct leachate and gas sampling.

After conducting the pre-closure assessment, the LGU shall prepare a Closure and Rehabilitation Plan composed of such components as application and maintenance of soil cover; drainage control system; leachate and gas management; fencing and security. The LGU submits the Plan to the EMB Regional Office that reviews and evaluates it. Within 15 days after submission, the EMB Regional Office shall issue an Authority to Close (ATC) to the LGU if the Plan is sufficient or if not inform the LGU of the other requirements.

In addition to DAO 09, 2006, ‘Guidebook for Safe Closure of Disposal Sites’ issued by the NSWMC provides technical requirements for closure of disposal sites. The guidebook emphasizes that an LGU should monitor environmental pollution and stabilization of waste continuously during the post-closure stage.

2.10.2 Impact Assessment and Mitigation Measures

The result of the surface water and groundwater survey revealed several contaminations such as lead, iron, COD and Coliform, though none were severe. It is supposed that they were derived from the waste in the old dump site. Thus, the do-nothing option is not acceptable for the MOM. In order to mitigate the water pollution, minimizing contact of rainwater with the dumped waste and lessening the generation of leachate should be emphasized. Applying soil cover would be a suitable measure for the old dump site.

To mitigate the water pollution, soil cover should be applied. Firstly, the existing waste would be excavated and compacted to reduce the area occupied by the waste. Then, it would be capped with suitable soil to minimize the generation of leachate. There would be no plan to install a leachate treatment system, because it is not cost effective and the current contamination is not significant. Proper application and maintenance of the soil cover should minimize generation of leachate. Additionally, drainage systems will be installed along the periphery of the site to prevent storm water from running on to and off of the site. In terms of odor impact, it is not necessary to install landfill gas wells, because the soil cap should also mitigate odor significantly as well.

The eastern edge of the old dump site is a steep slope whose bottom faces the coast line and some of the waste in the old dump site scatters on to the beach. Especially during the rainy season, it is prone to failure and excavation of the existing dumped waste would be necessary so as to stabilize the slopes. However, no serious environmental impacts are expected during the rehabilitation works. As for the social issues, currently no waste pickers are working at the site. Therefore, no serious social impacts are expected due to the rehabilitation works.

2.11 Evaluation and Conclusion

2.11.1 Technical Aspect

The technical system proposed in the F/S for Rehabilitation of the Old Dump Site is basically followed by DAO 09 and the Guideline of Closure and Rehabilitation of Old Dump Sites. Basically, the technological methodologies adapted for the rehabilitation are not complicated and can be conducted in the Philippines. Therefore, the Rehabilitation is evaluated as technically viable.

2.11.2 Social and Environmental Aspects

The proposed rehabilitation plan would contribute to mitigate the negative environmental impacts which may be caused by the dumped waste at the site. In order to mitigate the negative environmental impacts which could be caused by the rehabilitation itself, careful environmental considerations have been given to the rehabilitation plan. No serious environmental or social impacts are expected, and monitoring of water quality will be conducted. As a result, the Rehabilitation of the Old Dump Site is evaluated as environmentally sound.

2.11.3 Financial and Economic Aspects

The result of a cost estimate for the Rehabilitation of the Old Dump Site shows that the necessary investment costs may be beyond the annual budget of the MOM and will require an increase in the revenue. For this, institutional arrangements such as the revisions of the EAF and GCF are planned and the necessary costs can thereby be covered by the MOM. On the other hand, the rehabilitation works are designed with minimum facilities and the rehabilitation would contribute to protect the environment. The protected environment would contribute to attract more tourists. Therefore, the plan is evaluated as financially and economically feasible.

2.11.4 Overall Evaluation

The Rehabilitation of the Old Dump Site aims to mitigate the environmental degradation which has been brought about by the waste that has been dumped. Based on the 10-year SWM Plan, it is expected that the implementation of the rehabilitation would contribute to make the whole area of the MOM clean and attractive especially on Boracay Island. Considering the above series of evaluations from the technical, social and environmental, financial and economical aspects, the Rehabilitation of the Old Dump Site is evaluated as viable as a whole.

CHAPTER III-3 FEASIBILITY STUDY FOR CENTRALIZED MATERIAL RECOVERY FACILITY

3.1 Introduction

According to RA9003, "There shall be established a Materials Recovery Facility (MRF) in every barangay or cluster of barangays." As well as establishment of the waste flow from the generation sources to proper treatment and disposal, it is important to divert the solid waste from the final disposal facility by the establishment of recycling flow through segregation and recycling at facilities such as MRFs as well as reduction and reuse at the sources. The MRFs have to have the function of effective segregation and proper handling and treatment of recyclable and biodegradable wastes such as composting, small scale recycling or market flow to junkshops. On Boracay Island, there are three MRFs, one for each barangay. The operational condition is different from barangay to barangay and it is necessary to improve the condition of each MRF to segregate recyclable and biodegradable wastes properly and effectively.

With the object of collection and transport to the MRFs, it has been identified through the Study that as the collection coverage area of each current MRF is too small and the current boundary of the collection coverage area of each MRF is not suitable for establishing appropriate collection routes, working staff and collection vehicles are not utilized effectively. The collection boundary should be changed or removed and more effective collection will be expected in accordance with development of a centralized MRF. In addition, large scale diversion activities such as composting, sorting of recyclable waste and diversion of residual waste will be possible in combination with each MRF, which will contribute to improve the efficiency of the MRF operation.

The proposed centralized MRF is to be located in Barangay Manoc-Manoc based on the aspect of transport efficiency of residual waste and land availability including the possibility of extension of the existing area. The candidate sites were compared as follows.

- In consideration of new transport routes from the MRF to the proposed SLF, the centralized MRF should be located close to the port which will be used for marine transportation of residual waste from the MRF.
- The Centralized MRF should be established with consideration of target collection areas.
- The MRF should be located in a place which does not cause environmental problems for the neighboring areas.

After the alternative analysis, the location of the Centralized MRF was determined to be in the general area of the current Manoc-Manoc MRF.

3.2 Site Condition

3.2.1 Topography

The proposed site of centralized Manoc-Manoc MRF is gently slopes south to north and there is a small hill at the east side. The land has a gradual gradient from south to north, i.e. the elevation of northern part of the site is lower than the southern part. The northern area is prone to be inundated and muddy during the rainy season. The soil is the typical sandy clay found on Boracay Island. The area includes the previous dumping area (a part of the current Manoc-Manoc MRF) and no structural building should be planned in that area.

3.2.2 Climate

The climate of the Philippines belongs to a tropical monsoon so that the weather condition of the site is profoundly seasonal, with a single wet season and a single dry season. The rainy season is normally recognized as the southwest monsoon period, which lasts from June to December. Most annual rainfall occurs in these months with frequent squalls and strong westerly winds. The dry season, from January to May, falls under the period of the northeast monsoon period and is generally, although not always, comparatively drier.

There is rainfall intensity duration frequency (RIDF) data in Kalibo which was the nearest station from the proposed site of Manoc-Manoc MRF. The RIDF data can be used for the calculation of drainage design and leachate treatment pond. The calculated rainfall RIDF data is shown in Table 3.2-1.

Table 3.2-1 Rainfall Intensity Duration Frequency Data at Kalibo Station

(Unit:mm)

Return Period	Consecutive Duration														
	5 min	10 min	15 min	20 min	30 min	45 min	60 min	80 min	100 min	120 min	150 min	3 hr	6 hr	12 hr	24 hr
2 year	8.7	13.4	17.2	20.3	25.3	30.2	33.5	39.2	44.3	48.3	53.5	58.1	75.5	92.3	104.5
5 year	12.3	18.9	24.4	28.9	36.2	43.3	48.2	56.5	64.0	70.0	77.6	84.4	110.7	135.4	154.0
10 year	14.8	22.6	29.2	34.6	43.4	52.1	58.0	68.0	77.1	84.3	93.6	101.8	134.0	163.9	186.7
15 year	16.1	24.7	31.9	37.9	47.4	57.0	63.5	74.4	84.4	92.4	102.6	111.6	147.1	180.0	205.2
20 year	17.1	26.2	33.8	40.1	50.3	60.4	67.3	79.0	89.6	98.1	108.9	118.5	156.3	191.3	218.1
25 year	17.8	27.3	35.3	41.9	52.5	63.1	70.3	82.5	93.6	102.4	113.7	123.8	163.4	200.0	228.1
50 year	20.1	30.8	39.7	47.2	59.2	71.2	79.4	93.2	105.8	115.9	128.7	140.1	185.2	226.7	258.8
100 year	22.3	34.2	44.2	52.5	65.9	79.3	88.5	103.9	118.0	129.2	143.5	156.3	206.8	253.3	289.3

Note: Each data indicates the maximum rainfall amount during consecutive duration of each return period. For example, the consecutive 30 minutes rainfall which occurs with the probability of once in a 100 year will cause maximum rainfall amount of 65.9mm.
Source: PAGASA, (1980 to 2000)

3.2.3 Environment

There are no water bodies such as creeks or ponds in or around the proposed site. There are several facilities such as a fire station, spa, and fighting cock arena adjacent to the site. Inside of the boundary of the proposed centralized MRF, there are only a few households. However, several houses are located along the northern boundary. Single phase electricity and tap water service are provided in the area. On the other hand, since there is no sewage system in the site, septic tanks are used. Figure 3.2-1 shows environmental and social conditions including topographic information of the proposed site for the centralized MRF.

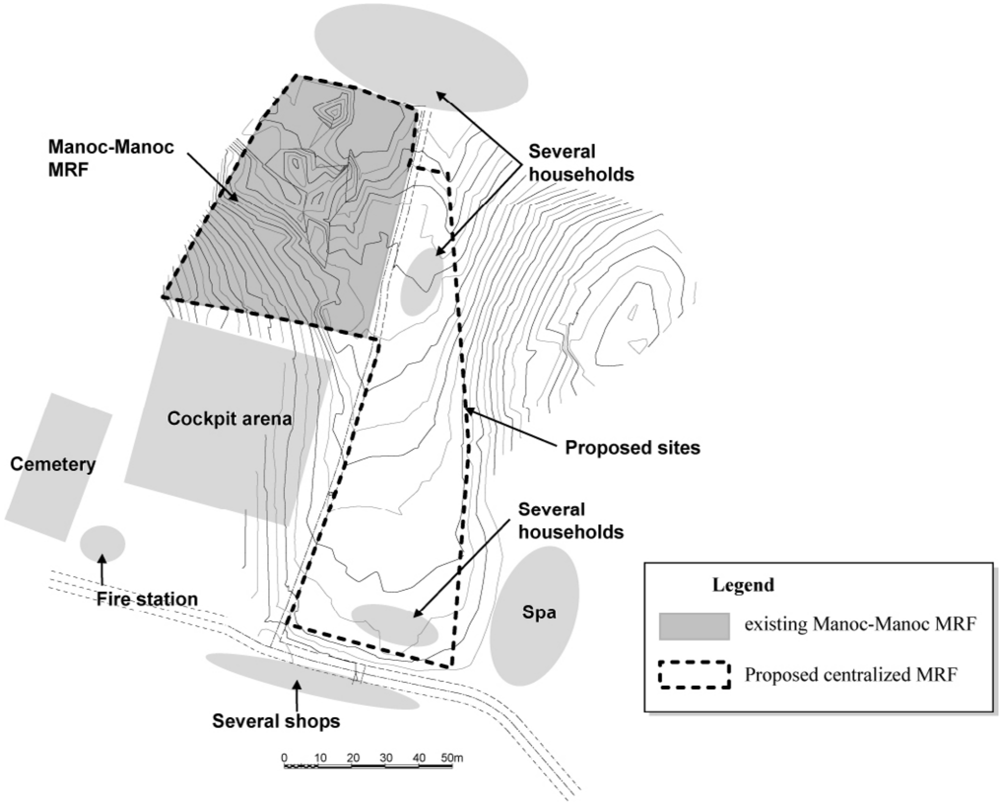


Figure 3.2-1 Environmental and Social Conditions of Proposed Site for the Centralized MRF

Source: JICA Study Team

3.3 Planning Concept

3.3.1 Basic Concept

(1) Development Concept

In order to minimize the transport cost as well as utilize the SLF for a longer time, the discharged waste is to be diverted from the waste flow as much as possible. Small scale recycling technologies, which are applicable for MRFs to prepare the products, are also proposed. For this, the material flow and markets for recyclable materials and compost should be developed. It is also proposed to secure enough storage for residual waste as well segregated recyclable waste and compost products in context of the instability or development process of the recycling market.

Considering the financial constraints of the MOM, the land availability and social acceptance from the surrounding residents, phase by phase development is proposed. The implementation will be divided into three phases.

Since various kinds of equipment have been installed in the existing MRFs, they are to be moved to and utilized in the Centralized MRF as well.

(2) Suitable Operation and Maintenance System

It is proposed to implement periodic training of the MRF workers for enforcement of the segregation, composting and small scale recycling and to promote daily maintenance for the equipment and facilities to extend their lifespans and this will be carried out in compliance with the manuals and guidelines which are to be prepared for the centralized MRF.

(3) Sufficient Environmental and Social Consideration

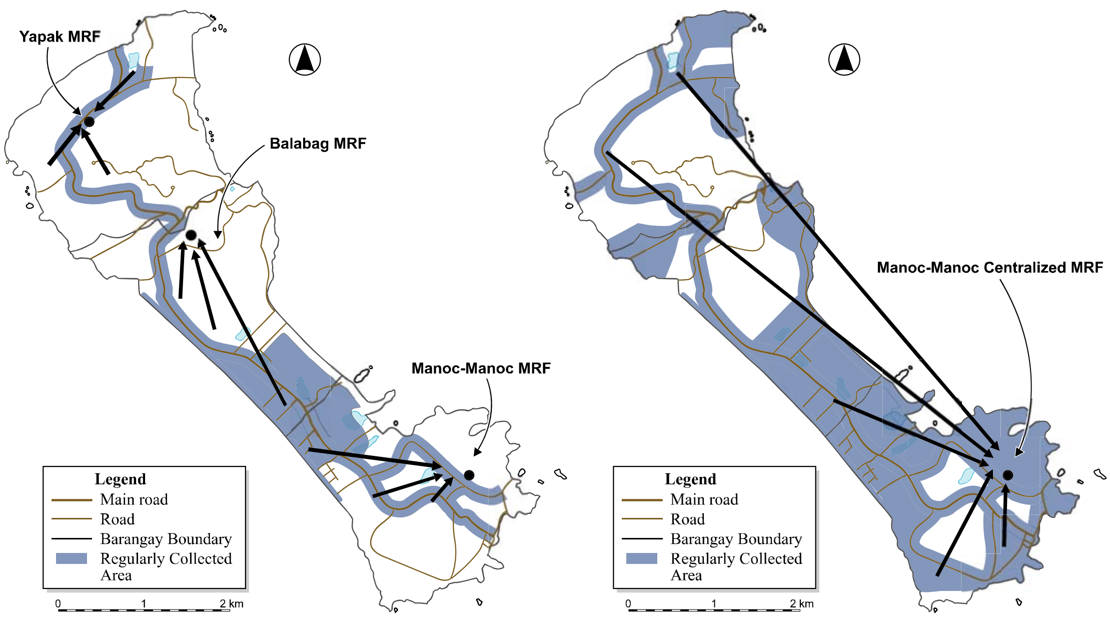
The centralized MRF is proposed to avoid the relocation of the residents as much as possible. In addition, the facilities and equipment which might generate odors or noise are proposed to be located far from the residential area and to apply practical mitigation measures during the operation, considering the environmental condition of the surrounding areas.

3.3.2 Optimization of Basic Conditions

(1) Revision of Collection System Corresponding to the Centralized MRF

Based on the concept of phase by phase development, the collection coverage area of the proposed centralized MRF is also to be expanded from Phase I to Phase II. In Phase I, the systems of organization and technology will be revised but the coverage area of the MRF will only be Barangay Manoc-Manoc, the same as the current coverage area.

In Phase II, segregated discharge and collection in almost the entire coverage area of the centralized MRF is to be applied with expansion to Barangays Yapak and Balabag. Figure 3.3-1 shows the collection coverage area for each of the development phases.



2008-2011 (Phase I) 2012-2017 (Phases II and III)

Figure 3.3-1 Collection Coverage Area of the Manoc - Manoc Centralized MRF

Source: JICA Study Team

(2) Introduction of Segregation Collection System

To implement effective sorting activity in the proposed centralized MRF, a segregated collection system is to be introduced in the other barangays in accordance with the expansion of the collection areas of the centralized MRF. Currently, segregated collection systems for biodegradable, recyclable and residual wastes are applied in the area of Barangay Balabag by utilizing three types of collection vehicles. In the case of this segregated collection, collection vehicles must collect the solid waste from the same location at least three times (for biodegradable, recyclable and residual wastes) everyday without any relation to the amount of waste discharged. If a system is introduced in which the type of waste collected is determined by the date and the waste is collected only three days a week after source segregation (date difference segregated collection system[1]), the segregated collection system will be more efficient. The system will also have the effect of minimizing the time that the collection vehicle waits for other vehicles which collect other types of waste and the time required for the segregation activities by the collection helpers in the collection points. According to a public awareness survey, residents or business establishments can store recyclable and residual waste for a few days but not biodegradable waste. In this context, the system of segregated collection by date is to be introduced in all barangays on Boracay Island. Additionally, monitoring the segregated discharge and collection condition is important for promoting segregation at sources.

[1] The type of collected waste is determined by each date.

3.3.3 Optimization of Waste Handling System in the MRF

Based on the comparisons discussed in Part II, the optimized system was selected. Considering the introduction of new technology or the development schedule of the centralized MRF, the overall development of the system by Phase is summarized in Table 3.3-1.

Table 3.3-1 Selection of Waste Handling Procedures

Type of Waste	Handling Technique	Phase I	Phase II	Phase III
Biodegradable waste	Bioreactor	○	○	○
Recyclable waste	Sorting on a belt conveyor system		○	○
	Preparation of products from poly styrene foam utilizing a melting oven	○	○	○
	Glass crushing after sorting	○	○	○
Residual waste	Bailing system	△*	○	○
	Hollow block making system from residual waste	△*	○	○

Note: △* means that the bailing system and hollow block making system from residual waste will be introduced in only Balabag MRF before Phase I and the equipment and facilities of the systems will be moved to the Centralized MRF in Phase II.

Source: JICA Study Team

3.4 Concept Design

3.4.1 Overall Concept

(1) Phase I

1) Development Concept of Phase I

- To utilize the equipment of the existing Manoc-Manoc MRF
- To develop areas and facilities and procure equipment in consideration of the future development plan for Phase II
- To utilize current available land for effective operation of the centralized MRF
- To allocate the facilities and equipment in consideration of minimum transfer during the transition period from Phase I to Phase II

2) Design Condition

- Location : Manoc-Manoc MRF, Barangay Manoc-Manoc
- Area : 0.37 ha
- Collection Service Coverage Area : Barangay Manoc-Manoc
- Estimated waste quantity and characteristics: As shown in Tables 3.4-1 and Table 3.4-2.

Table 3.4-1 Estimated Waste Quantity in Phase I

[ton/day]

Type of Waste	2010	2011
Biodegradable waste	1.8	1.9
Recyclable waste	1.6	1.8
Residual waste	1.3	1.4
Total	4.7	5.2

Source: JICA Study Team

Table 3.4-2 Estimated Waste Characteristics in Phase I

[wt%, wet basis]

Physical Composition	Biodegradable waste	Recyclable waste	Residual waste
Kitchen	49%	1%	3%
Grass, wood	32%	0%	0%
Paper	15%	30%	23%
Plastic	1%	20%	61%
Textiles and Leathers	1%	2%	3%
Glass	0%	39%	8%
Metal	0%	7%	1%
Others	2%	1%	1%
Total	100%	100%	100%

Source: JICA Study Team

3) System Flow

The waste collected from Barangay Manoc-Manoc is transported into the Manoc-Manoc MRF and handled in each waste handling area there as shown in Figure 3.4-1.

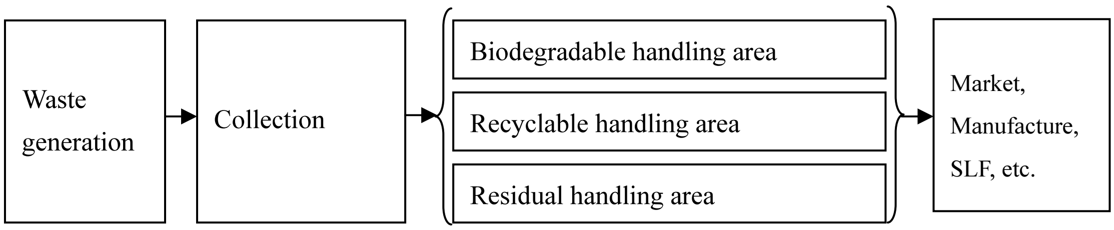


Figure 3.4-1 Overall System Flow of the MRF (Phase I)

Source: JICA Study Team

(i) Biodegradable Waste Handling

A biodegradable handling area is to be prepared for unloading, sorting out impurities or unsuitable material, composting by bioreactor, curing, maturing, packing and storage for sale as compost. To combat fluctuations in the market, adequate storage area is to be secured along with fields or gardens for compost utilization to make the facilities self-sustaining in this regard and also for demonstration purposes.

The biodegradable waste is to be unloaded in an unloading area and carried into a sorting area. The plastic, cord, metals and broken glass are sorted out in the sorting area before shredding. After shredding of the biodegradable waste, the biodegradable waste is composted in a bioreactor. After fermentation of 8 hours in the bioreactor at less than 65 degrees C, biodegradable waste is cured in the curing area for 20 to 30 days at around 40 degrees C.

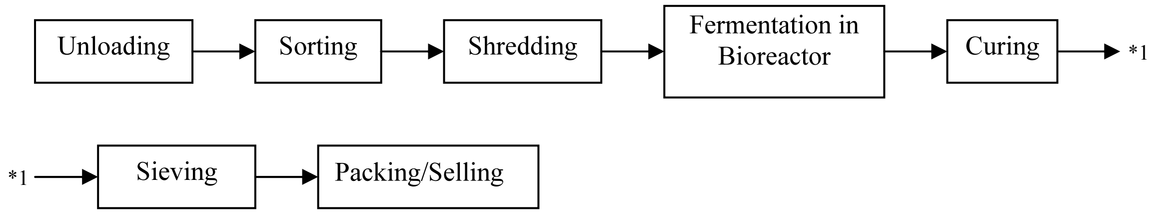


Figure 3.4-2 System Flow for Biodegradable Waste Handling

Source: JICA Study Team

(ii) Recyclable Waste Handling

A recyclable handling area is prepared for sorting the recyclable waste for selling to junkshops and to sort out the residual waste included in the waste collected as recyclable waste. The sorting activities are carried out manually in Phase I with a more systematic manner in a larger sorting area than the current sorting activities.

A table is provided in the handling area upon which to place the unsorted recyclable waste in order to facilitate the sorting process. Each sorter sorts the recyclable waste and divide it into the three separate categories. The sorted recyclable waste is to be transported by hand cart to a storage area and stored temporarily. Glass cullet products and molded products are to be produced on a small scale or at the pilot level. The system flow is shown in Figure 3.4-3.

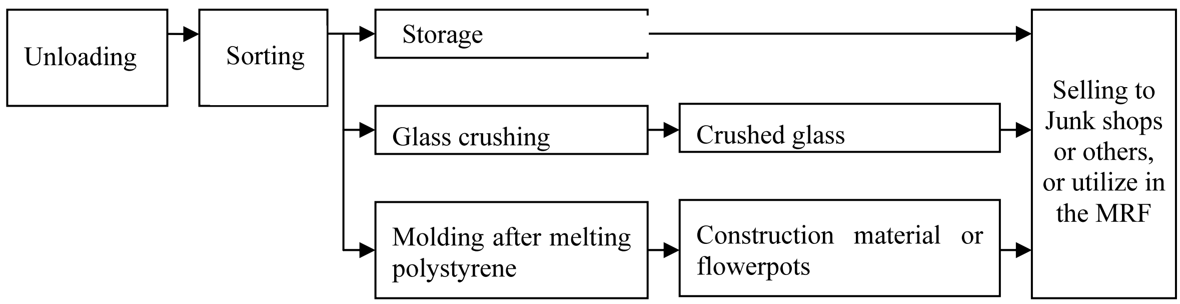


Figure 3.4-3 System Flow for Recyclable Waste Handling

Source: JICA Study Team

(iii) Residual Waste Handling

Residual waste is handled by utilizing the existing sorting area. The unloaded residual waste and the residual waste sorted out from the waste collected as recyclable or biodegradable waste is packed into sacks for transporting to the new SLF. The system flow of the residual waste is shown in Figure 3.4-2.

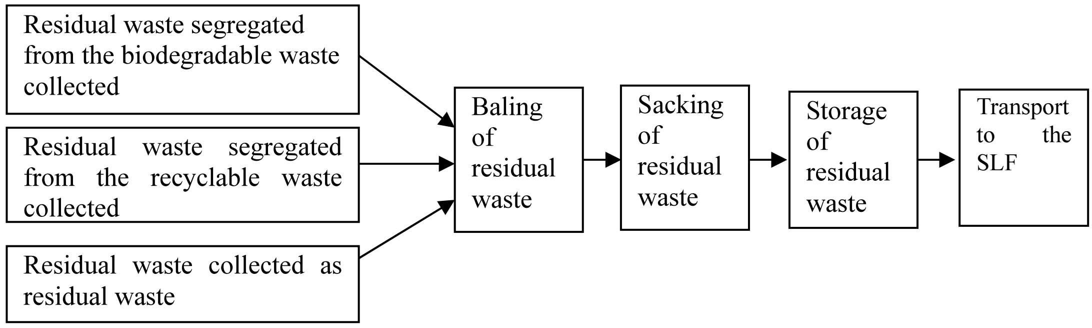


Figure 3.4-4 System Flow for Residual Waste Handling

Source: JICA Study Team

(2) Phase II

1) Development Concept of Phase II

- To utilize the equipment used in Phase I and also the existing MRFs for the new Centralized MRF
- To develop and improve the existing Manoc-Manoc MRF into a new Centralized MRF
- To utilize current available land for effective operation of the Centralized MRF
- To allocate the facilities and equipment with consideration of minimum transfer during the transition period of Phase I to Phase II

2) Design Condition

- Location : Manoc-Manoc MRF
- Area : 0.7 ha
- Service Area : Barangay Manoc-Manoc, Barangay Balabag, Barangay Yapak

Estimated waste quantity and characteristics to be handled in Phase II are described in Table 3.4-3 and Table 3.4-4.

Table 3.4-3 Estimated Waste Quantity in Phase II

[ton/day]

Type of Waste	2012	2013	2014
Biodegradable waste	6.5	6.9	7.1
Recyclable waste	6.1	6.5	6.7
Residual waste	4.9	5.2	5.4
Total	17.5	18.6	19.2

Source: JICA Study Team

Table 3.4-4 Estimated Waste Characteristics in Phase II

[wt%, wet basis]

Physical Composition	Biodegradable waste	Recyclable waste	Residual waste
Kitchen	51%	1%	2%
Grass, wood	33%	0%	0%
Paper	13%	31%	23%
Plastic	1%	19%	62%
Textiles and Leathers	0%	1%	3%
Glass	0%	40%	8%
Metal	0%	7%	1%
Others	2%	1%	1%
Total	100%	100%	100%

Source: JICA Study Team

3) Overall System Flow

Though overall system flow is similar to Phase I, a segregated collection system is to be introduced in Phase II and a belt conveyor system for sorting of recyclable waste is also to be introduced. The sorting activity is expected to be remarkably improved. The schematic flow is described as shown in Figure 3.4-5:

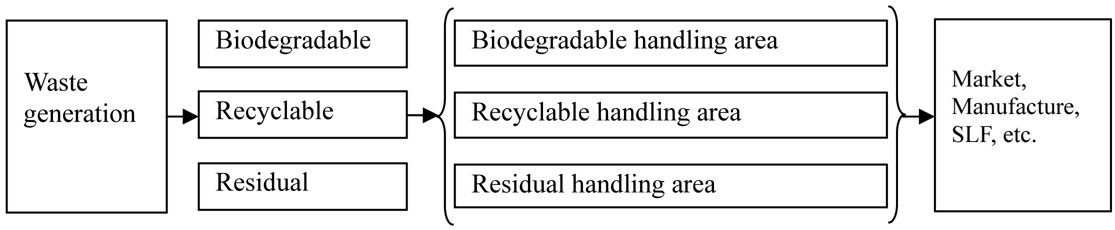


Figure 3.4-5 Overall System Flow of the MRF (Phase II)

Source: JICA Study Team

(i) Biodegradable Waste Handling

The Biodegradable handling area is for unloading, sorting impurities or unsuitable material, composting in a bioreactor, curing, maturing, packing and storage for sale as compost. To combat fluctuations in the market, adequate storage area is to be secured along with fields or gardens for compost utilization to make the facilities self-sustaining in this regard and also for demonstration purposes.

The biodegradable waste is to be unloaded in the unloading area and carried into the sorting area. The plastic, cord metal and broken glass are to be sorted out in the sorting area before shredding. After shredding of the biodegradable waste, the biodegradable waste is composted in a bioreactor or recycled in the form of charcoal by the charcoal system. Regarding kitchen waste and animal waste, composting is adopted, after fermentation of 8 hours in a bioreactor at less than 65 degrees C, the biodegradable waste is cured in the curing area for 20 to 30 days. The carbonization system as well as composting is shown in Figure 3.4-6.

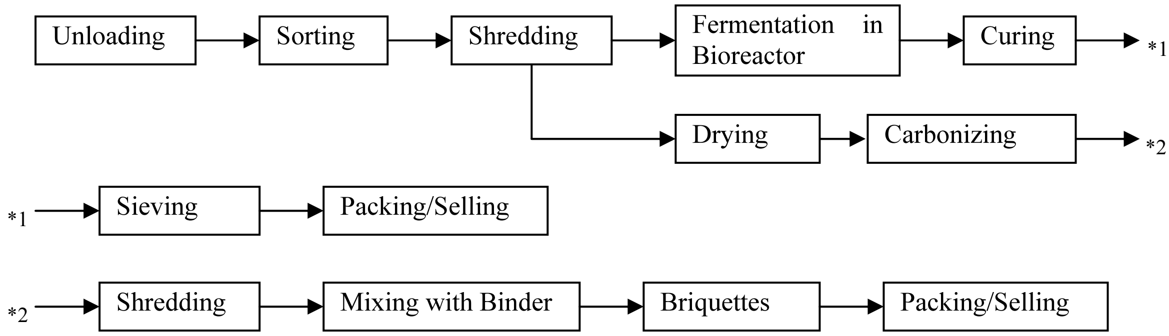


Figure 3.4-6 System Flow of Biodegradable Waste Handling

Source: JICA Study Team

(ii) Recyclable Waste Handling

In Phase II, a belt conveyor for sorting of recyclable waste is to be introduced. In addition, the area of glass crushing and molded product system for polystyrene foam is to be introduced. The system flow is shown in Figure 3.4-7.

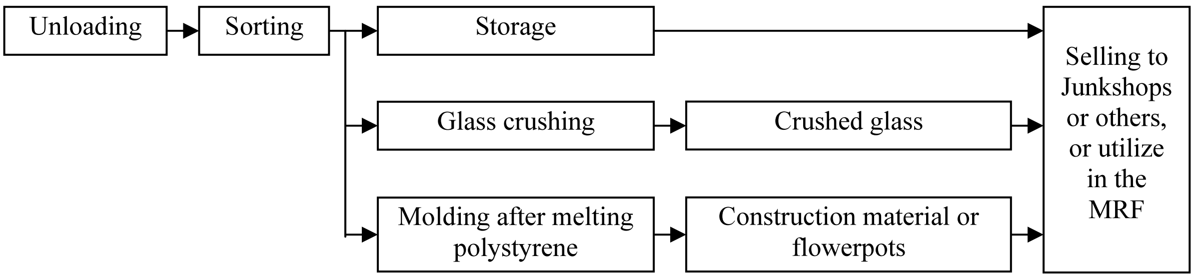


Figure 3.4-7 System Flow of Recyclable Waste Handling

Source: JICA Study Team

(iii) Residual Waste Handling

In the residual handling area, a bailing machine is to be introduced for bailing the residuals to minimize the volume during transportation as well as in landfilling. The main handling procedure is to pack residual waste into sacks after bailing. In addition to the bailing machine, a hollow block making system will be introduced to divert the residual. The system flow of the residual handling is described in Figure 3.4-7.

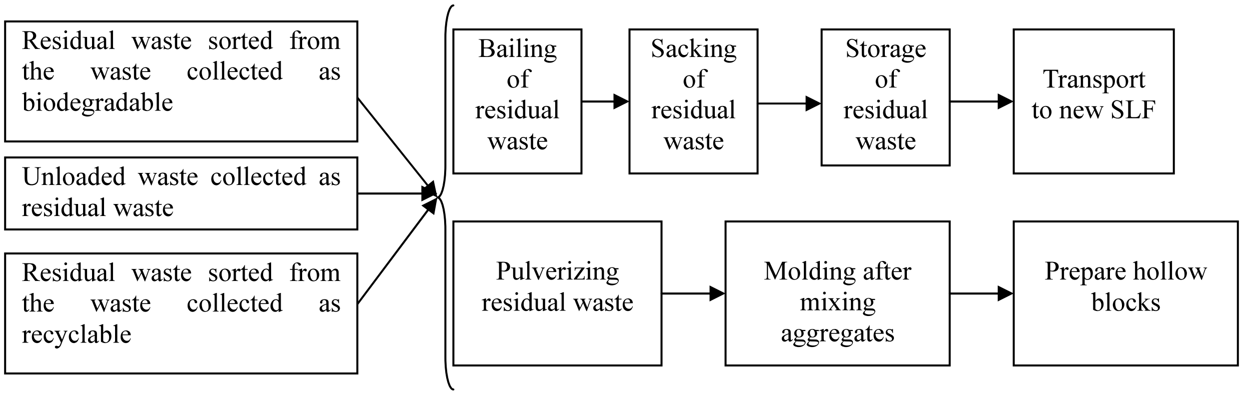


Figure 3.4-8 System Flow of Residual Waste Handling

Source: JICA Study Team

(3) Phase III

1) Design Condition

- Location: MRF Manoc-Manoc, Barangay Manoc-Manoc
- Area: Around 0.7 ha
- Service Area : Barangay Manoc-Manoc, Barangay Balabag, Barangay Yapak

Estimated waste quantity and characteristics to be handled in Phase III are described in Tables 3.4-5 and 3.4-6.

Table 3.4-5 Estimated Waste Quantity in Phase III

Type of Waste	2015	2016	2017
Biodegradable waste	7.4	7.6	7.9
Recyclable waste	7.0	7.2	7.4
Residual waste	5.6	5.8	6.0
Total	20.0	20.6	21.3

Source: JICA Study Team

Table 3.4-6 Estimated Waste Characteristics in Phase III

Physical Composition	Biodegradable waste	Recyclable waste	Residual waste
Kitchen	54%	0%	1%
Grass, wood	37%	0%	0%
Paper	8%	32%	23%
Plastic	1%	19%	62%
Textiles and Leathers	0%	0%	4%
Glass	0%	41%	8%
Metal	0%	7%	1%
Others	0%	1%	1%
Total	100%	100%	100%

Source: JICA Study Team

2) Overall System Flow

Overall system flow is the same as Phase II. In addition to Phase II, a recycling promotion center which exhibit some recycled products or panel describing recycling process and where some meetings or seminar for environmental education regarding 3R activities be held, is developed for promotion of sales of recyclables and for development of new technology regarding recycling activities. The gardens or flowerbeds will be also developed.

3.4.2 Layout Plan

According to the design concept, each facility is developed phase by phase. In Phase I, the area of the current Manoc-Manoc MRF is utilized for all types of waste handling.
The layout of facilities in Phase I is described in Figure 3.4-9.

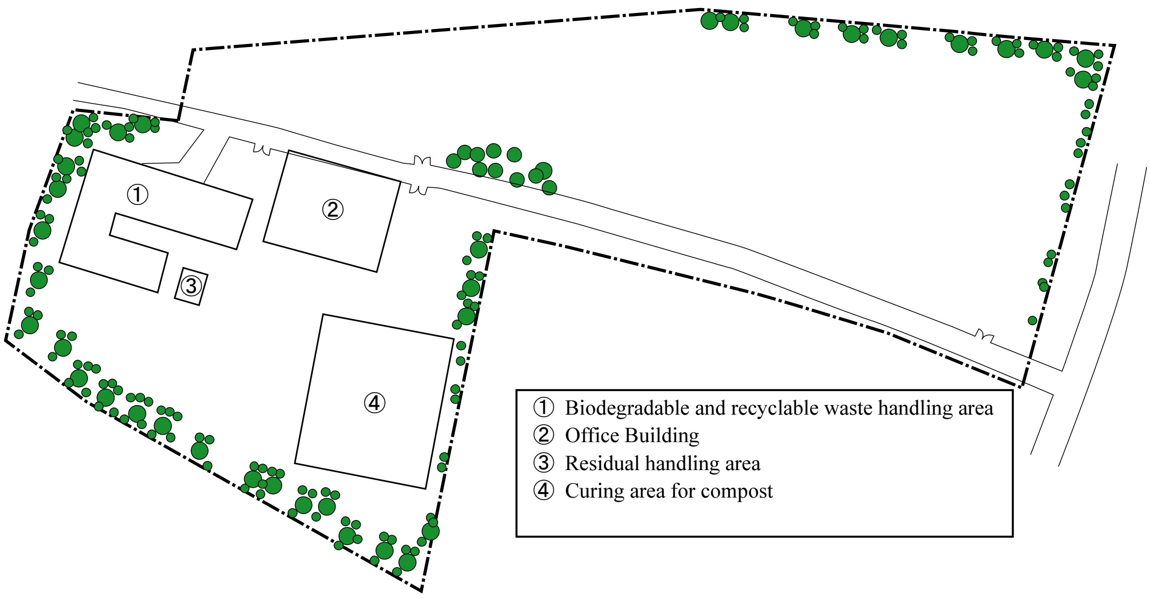


Figure 3.4-9 Layout Plan of Phase I

In Phase II, the area will be expanded into the current garden areas on opposite sides of the current Manoc-Manoc MRF and will be utilized for biodegradable and recyclable handling areas except for curing compost. The layout of facilities in Phase II is described in Figure 3.4-10.

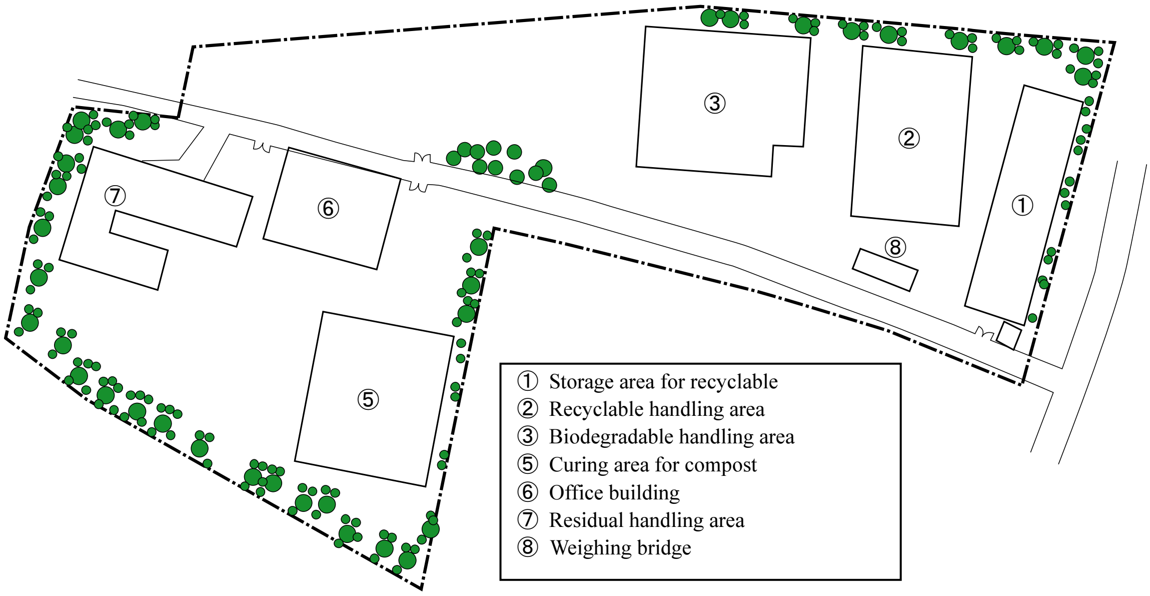


Figure 3.4-10 Layout Plan of Phase II

In Phase III, the recycling promotion center will be developed in the area. The layout of facilities in Phase III is described in Figure 3.4-11.

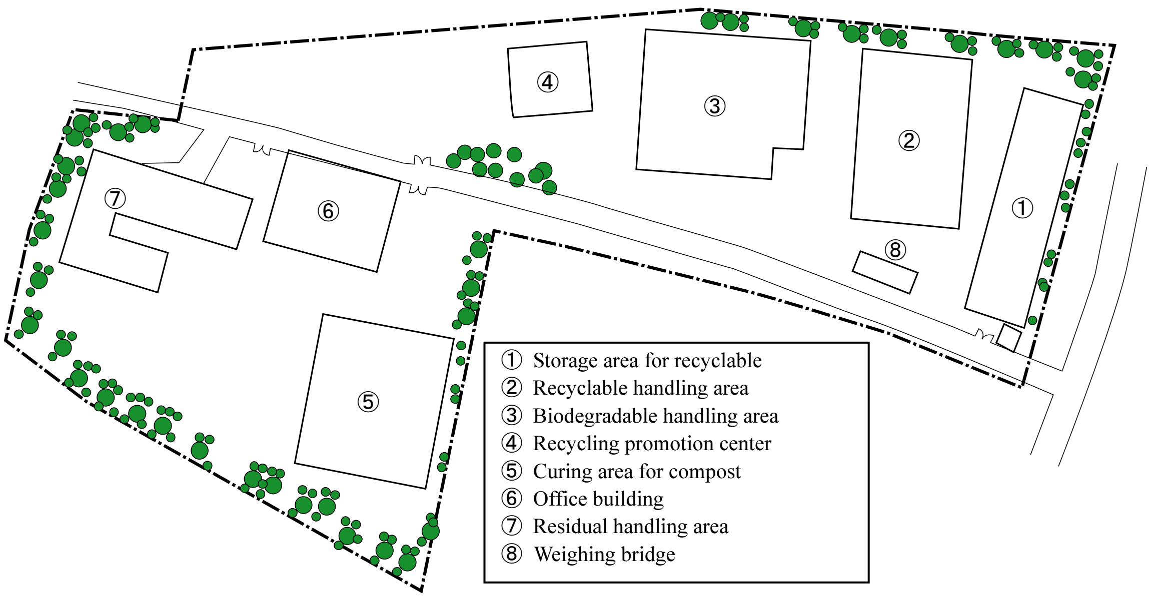


Figure 3.4-11 Layout Plan of Phase III

3.4.3 Civil Design

Considering the slope condition and financial capability of the MOM, pavement is not necessary but sufficient site arrangement such as compaction is required for the operation of vehicles. Drainage facilities are needed for prevention of flooding in the rainy season.

The storm water drainage system for the proposed MRF aims to drain the storm water collected from the structures within the vicinity bounded by the perimeter of the MRF site and the adjacent lots that contribute to the drainage catchment area. The scheme makes use of interconnected circular concrete pipes from the building structures and discharges to the open canal which serves as the main drainage line. Storm water is finally conveyed towards a collector pond before it reaches its final outfall or to the lower ground.

(1) Design Consideration

In the process of drainage design, the following matters were considered.

- Conveyance of storm run-off will be by gravity flow as permitted by the site grading elevation.
- Optimum use of available surface slope is attempted in pipe and open canal grade design within the design velocity ranging from 0.60 to 3.00 m/sec.
- A minimum diameter of 150 mm for storm water pipe around the facilities is adopted. However 200 mm diameter pipes will also be used for maximum design capacity.
- Catch basins or manholes are to be incorporated for drops in pipe orifice of two abutting pipes. These were sized to accommodate the pipes.
- An open canal was provided to collect the accumulated water from the facilities and transport it to a common pond before it discharges to its outfall.

(2) Design Criteria

The design storm frequencies were considered based on the 10 years return period for pipe culverts and the rectangular canal. The RIDF data in Kalibo, Aklan has been adopted. These data were obtained from the publication of the Flood Forecasting Branch of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). I_{10}= 135.60 mm/hr of 10 years return period and minimum time of concentration was set at 10 minutes, which are utilized for the calculation.

The run-off volume calculation was done using the Rational Formula for the catchment area and the mean velocity of water in drainage facilities both in open canals and pipes were determined using Manning's Formula. Computed design flow capacities of reinforced concrete pipes and the open canal used are as shown in Table 3.4-7.

Table 3.4-7 Designed Drainage Size and Design Flow Capacity

Type of Drainage	Size of Drainage Structures at minimum slope = 0.5%	Capacity (m^3/sec)
Pipe around facilities	150mm diameter concrete pipe	0.01
Pipe around facilities	200mm diameter concrete pipe	0.02
Rectangular canal	400mm x 600mm	0.32 to 0.71 (at max S [gradient of the drainage in Manning Formula] =0.03)

Source: JICA Study Team

3.5 Facility and Equipment Plan

The proposed facilities and equipment of the Manoc-Manoc Centralized MRF in Phases I, II and III are described in Table 3.5-1

Table 3.5-1 Facility and Equipment Proposed for the Manoc-Manoc Centralized MRF

No.	Facility/ Equipment	Function	Total Number and Specification of Equipment and Facilities	Utilize existing equipment	Newly purchased equipment or constructed facility
Facility					
1	Office building	An office for the site staff including space for visitors.	RC structure with an area of approx. $200m^2$	-	1 unit in Phase I
2	Biodegradable and Recyclable Handling Area (Phase I)	Including sorting area, bioreactor area, sieving and packing area.	RC structure with an area of approx.280 m^2	-	1 unit in Phase I
3	Biodegradable Handling Area(Phase II)	Including sorting area, bioreactor area, sieving and packing area, charcoal briquette making area.	RC structure with an area of approx.500 m^2	-	1 unit in Phase II
4	Recyclable Handling Area(Phase II)	Including sorting area, packing area, area for making block from polystyrene foam.	RC structure with an area of approx.300 m^2	-	1 unit in Phase II
5	Storage Area for Recyclable	The purpose of these areas is to storage sorted recyclable waste and treated HCW.	RC structure with an area of approx. 310 m^2	-	1 unit in Phase II
6	Curing Area for Compost	An area is needed for curing after removal of compost from the bioreactor. The curing time is assumed to be around 30 days.	RC structure with an area of approx. 450 m^2	-	1 unit in Phase II
7	Rainwater drainage facility	To drain the rainwater running off the slope of the site and prevent the rainwater from getting into the waste areas.	Open canal of bottom width 400mm x depth 600mm in a trench along with concrete pipes of 150mm diameter and 200mm diameter	-	Phase I and Phase II
8	Weighbridge	The gross weight of trucks which load solid waste or recyclable is to be measured to identify the waste and material flow.	Mobile weighbridge (1set) with a maximum capacity of 20 ton	-	Phase I
9	Gate/gate house/ fence	The entire MRF area is to be encompassed by a fence and all the people and vehicles which enter into the site are to be checked at the gate.	Approximately 200m of fence and the gate house is 6 m^2	-	Phase I and Phase II
10	Vehicle Washing Area (Collector pond)	A vehicle washing area is to be prepared for washing waste from the tires of the collection vehicles before they exit the site.	Approximately $10m^2$ with a wash pool and water supply system	-	1 unit (Phase I and Phase II)
11	Recycling Promotion Center	The recycling promotion center is for small scale and new technology development for preparing recycled products and for exhibition of recycled products as well as environmental education through MRF activities.	$86m^2$ including the area for the technology development and exhibition area for recycled products	-	1 unit (Phase III)
Equipment					

No.	Facility/ Equipment	Function	Total Number and Specification of Equipment and Facilities	Utilize existing equipment	Newly purchased equipment or constructed facility
1	Bioreactor***	Bioreactors quickly decompose biodegradable waste through primary fermentation process.	0.5 [ton/day]	3 unit	-
			1 [ton/day]	-	2 unit (Phase I :1 unit Phase II :1 unit)
			2[ton/day]	-	1 unit in Phase II
2	Charcoal Briquette Making System**	The charcoal briquette making facility aims to prepare charcoal from cellulose material. After shredding and drying the wood or grass, carbonization is accomplished through heating, binding, and pressing process.	The handling area is to be approximately 15m^2. The charcoal briquette system includes a carbonizer, shredder, mixer and briquettes. The capacity is approximately 0.5 ton/day	1 unit	-
3	Belt Conveyor	Transport the waste collected as recyclable for sorting activity in the recyclable handling area.	The total length of belt conveyor is 20m	-	1 unit (Phase II)
4	Glass Crusher*	The glass crusher crush the broken glass or unsold glass bottles to prepare cullet.	Two glass crushers with capacity of 500kg/hr	1 unit	1 unit (Phase II)
5	Shredder**	The shredder shred the garden waste for putting into bioreactor or charcoal briquette making system.	Two shredder	2 unit	1 unit (Phase I)
6	Plastic Densification System***	The plastic densification system aims to melt polystyrene foam with used oil and prepare tiles or blocks from molds.	The capacity is to be approximately 5kg/hr	1 unit	-
7	Hollow block preparation system**	After it is pulverized, the residual waste will be mixed with aggregates and binding agents. After mixing, it is molded and cured for a certain period.	The pulverizer with capacity of 2 ton/day	1 unit	-
8	Bailing Machine*	Pressing waste to reduce the volume of waste for effective transportation and extension of the lifetime of the SLF	The capacity of bailing machine is approximately 500kg/hr	-	1 unit (Phase I)

Note: * Bailing machine is planned to purchase for the Balabag MRF in 2008. In the F/S, the cost is tentatively included in Phase I.
** Charcoal Briquette Making System and Hollow Block Preparation System are assumedly donated by DOT.
*** Three bioreactors (0.5ton/day) and Plastic Densification System will be transported from each MRF on Boracay Island to the Manoc-Manoc centralized MRF in Phase II.
Source: JICA Study Team

3.6 Operation and Management Plan

3.6.1 Operation and Maintenance System

(1) Operation

1) Operation Plan

For O&M of the Manoc-Manoc Centralized MRF, the following activities are necessary:

- Collection vehicle operation: Control waste collection vehicles coming to and leaving from the MRF, weighing waste collection vehicles in a weigh bridge and daily maintenance of the vehicles, etc.
- Biodegradable Handling Area Operation (Phases II and III)[2]: Unloading and treatment of biodegradable waste, and O&M of facilities such as bioreactors and shredders.
- Recyclable Handling Area Operation (Phases II and III): Unloading of recyclable waste, sorting of both recyclable and residual wastes to be transported to the SLF, and handling of the polystyrenes or broken glass for recycling and storage of other recycled waste.
- Residual Handling Area Operation (Phases I, II and III): Daily operation activities include unloading of residual waste, sorting of other types of waste, bailing and sacking of the residual waste to be transported to the SLF.
- Daily operating hours: 5:30 to 18:00, in principle, to be applied to all seasons

2) Collection Vehicle Operation

Though segregated discharge is promoted, mixed collection by one collection vehicle with some partition for segregation is to be adopted in Phase I. The collected waste is to be unloaded in the biodegradable, recyclable and residual waste unloading areas in Phase I. The operation of collection vehicles is presented in Figure 3.6-1.

[2] In phase I, biodegradable and recyclable handling area is to be located in a similar facility in the area of the current Manoc Manoc MRF.

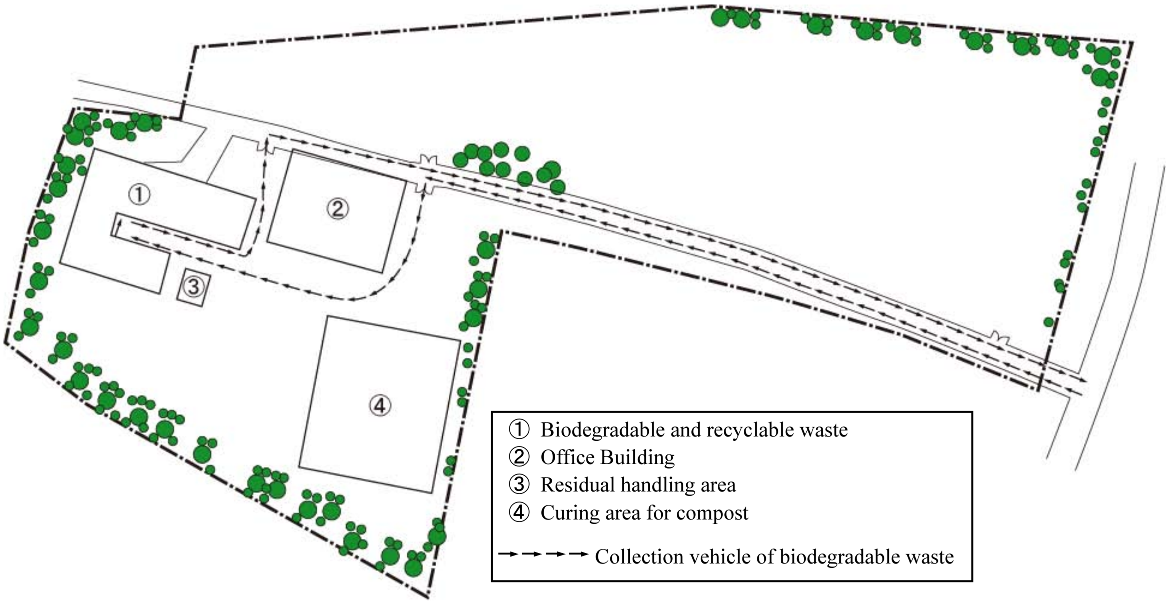


Figure 3.6-1 Operation Plan for Collection Vehicle (Phase I)

Source: JICA Study Team

Segregated collection is to be applied in Phases II and III. In Phase II, all the collection vehicles should pass through the weighbridge to measure the weight of the collection vehicle that will be loading waste. Though the residual waste handling area is outside of the area where the weighbridge is to be located, the collection vehicles for residual waste have to pass over the weighbridge before unloading. The operation plan for each type of collection vehicle is described in Figures 3.6-2 to 3.6-4.

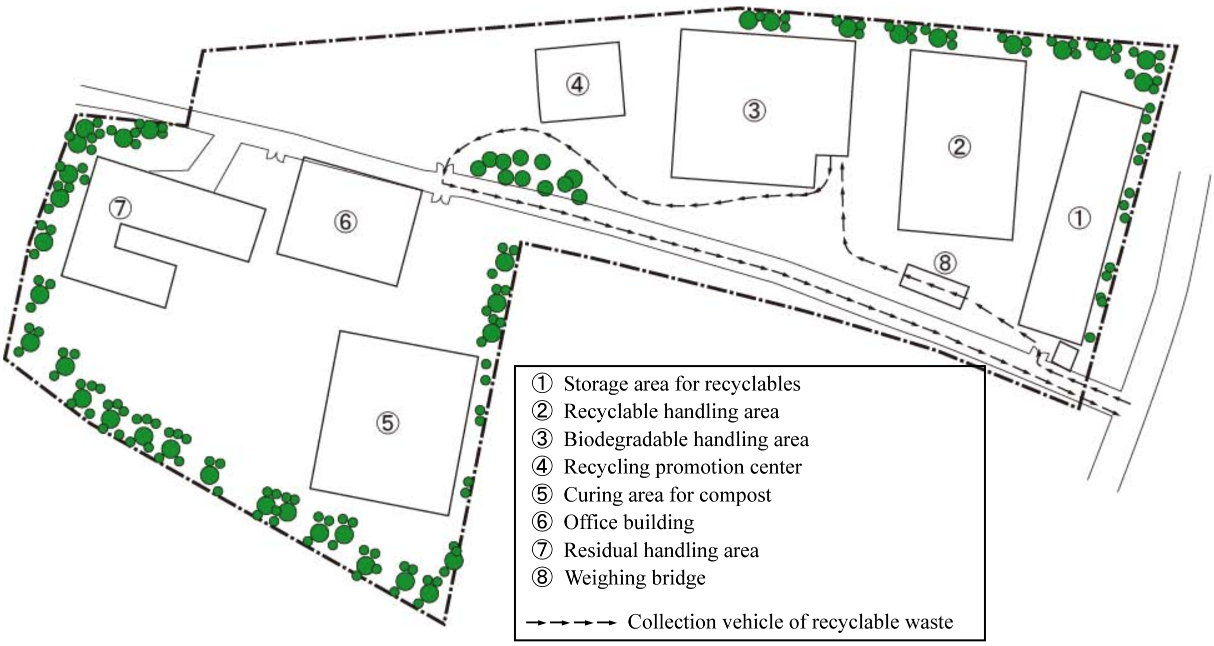


Figure 3.6-2 Operation Plan for Biodegradable Waste Collection Vehicle (Phases II and III)

Source: JICA Study Team

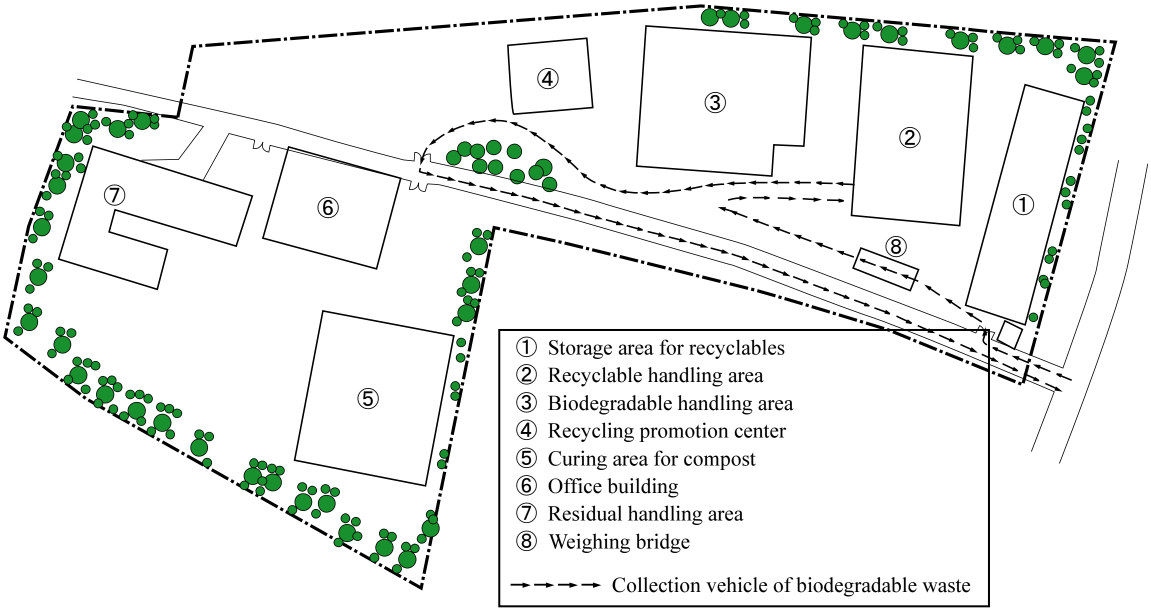


Figure 3.6-3 Operation Plan for Recyclable Waste Collection Vehicle (Phases II and III)

Source: JICA Study Team

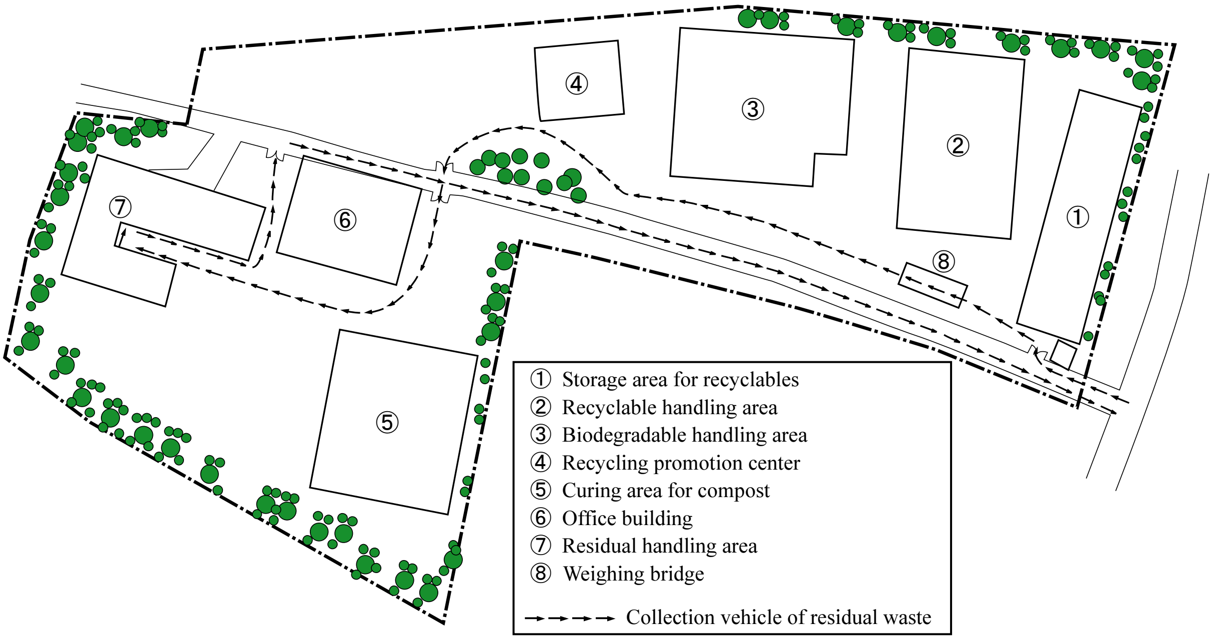


Figure 3.6-4 Operation Plan for Residual Waste Collection Vehicle (Phases II and III)

Source: JICA Study Team

3) Operation in the Biodegradable Handling Area

Biodegradable waste is to be unloaded in the biodegradable handling area and shredded after removing impurities such as recyclable or residual wastes. Some of the garden waste is to be treated at the carbonization area to make charcoal briquettes in Phase II. On the other hand, kitchen waste is to be put into the bioreactor for eight hours primary fermentation. After the primary fermentation and sieving, the compost is to be cured for 30 days before packing as a product. The flow of the biodegradable waste is shown in Figure 3.6-5.

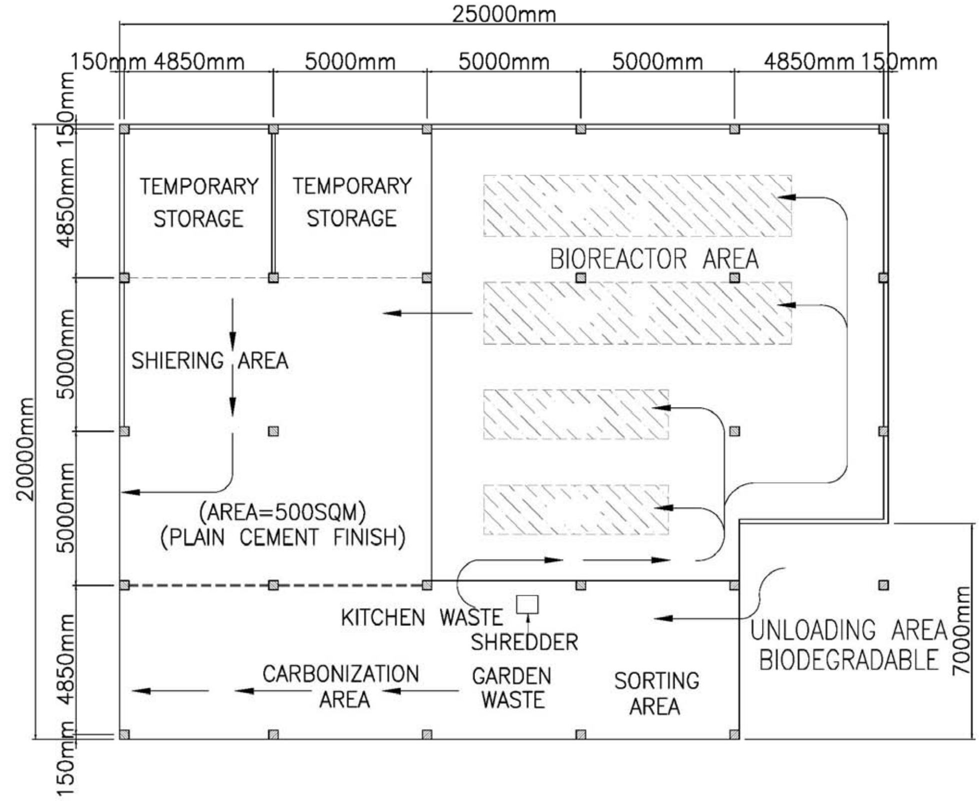


Figure 3.6-5 Operation Plan of the Biodegradable Handling Area (Phases II and III)

Source: JICA Study Team

4) Operation in the Recyclable Handling Area

Recyclable waste is to be unloaded in the recyclable handling area and loaded onto a belt conveyer. Sorting staff will implement sorting of target recyclables and then the residual waste is to be conveyed to the residual waste stock yard and then transported into the residual handling area for packing. Each package of recyclable waste sorted is to be carried to the recyclable waste storage area. Glass and styrene foam is to be treated in each of the handling areas and utilized as recycled products or the source of recycled products. The flow of the recyclable waste is shown in Figure 3.6-6.

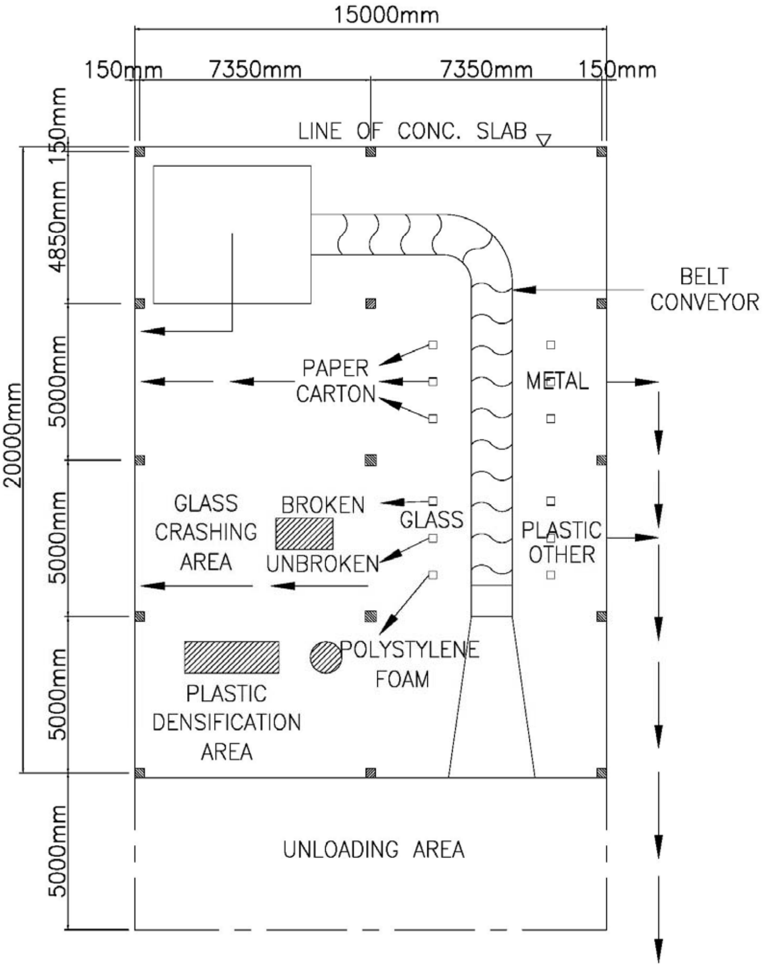


Figure 3.6-6 Operation Plan of the Recyclable Handling Area

Source: JICA Study Team

5) Other Operations including Residual Handling

Residual waste is to be unloaded at the residual waste handling area, and then bailed and packed into sacks for transport to the SLF. Some of the residual waste is to be pulverized and molded with a mixture of cement or aggregates to make hollow blocks.

A recycling promotion center together with garden and flowerbeds are planned to be developed to demonstrate the quality of the recycled products and compost which is also to be utilized for flower planting.

(2) Maintenance

Maintenance is to be conducted to ensure long lifespans for the facilities and equipment as well as to ensure that they operate smoothly. Each facility and piece of equipment is to be checked periodically as stipulated in the fabricator's manual or their recommendation. A set of maintenance manuals including daily, weekly and monthly maintenance items and necessary countermeasures for emergencies shall be prepared.

(3) Quality Control

1) Promotion of Proper Segregation at Sources

Although source segregation is currently promoted in the collection area on Boracay Island, the segregation ratio is 70 to 80% according to the WACS by the JICA Study Team. It is important to promote proper source segregation in order to implement sorting in the MRF effectively. Especially, manual sorting of commingling of impurities in the biodegradable waste, and breakage of the blades of the shredder due to the presence of impurities should be prevented. It is desirable to implement comprehensive source separation. Regarding recyclable and residual wastes, promotion of source segregation is important to sort the recyclable waste and for packing residual waste to be sacked effectively. Therefore, random sampling inspections of the waste hauled to the Centralized MRF should be implemented for all types of waste to prevent the mixture of impurities. In the IEC program, promotion of proper segregation at the sources will be conducted to publicize the procedure with posters, leaflets, radio programs or short messages.

2) Quality Control and Securing the Market for Products and Output Materials

Although paper and cartons can be sold to junkshops, some of the paper and cartons are not currently being sold to them but rather are being stored in the MRFs. This is mainly because the stored papers and cartons often got wet and tainted. A storage place to prevent rainfall or dirty additives from the stored paper or cartons should be arranged.

Thermo plastics such as PET, but excluding plastic film, can be sold to recycling companies as San Miguel’s Brewery Co., Ltd. is doing. If there is no possibility of selling some plastic, a take-back system by junkshops or distributors without any charge with other sellable recyclable wastes could be applied. Some of the aluminum, which has a high value, is already being sorted by the waste generators to sell to junkshops.

Compost has been sold to hotels and resorts as a fertilizer for ornamental plants at 5 PhP/kg. Considering the current quality of the compost, the application is limited. However, extension of the market should be possible by improvement of the quality. To extend or develop the market, a garden, flowerbeds or a farm should be prepared in the MRF for the demonstration of the quality of compost as well as to act as a countermeasure against seasonal or other fluctuations in the market for compost.

3.6.2 Organization

The operational organization of the Manoc-Manoc Centralized MRF is proposed to be set up as part of the re-organized Boracay Solid Waste Management Action Team (BSWMAT). The organization for the operation of the MRF is as shown in Figure 3.6-7. The overall management of the MRF together with sweeping and collection on the whole of Boracay Island will be conducted by the management supervisor while technical issues are to be managed by the Manager of MRF.

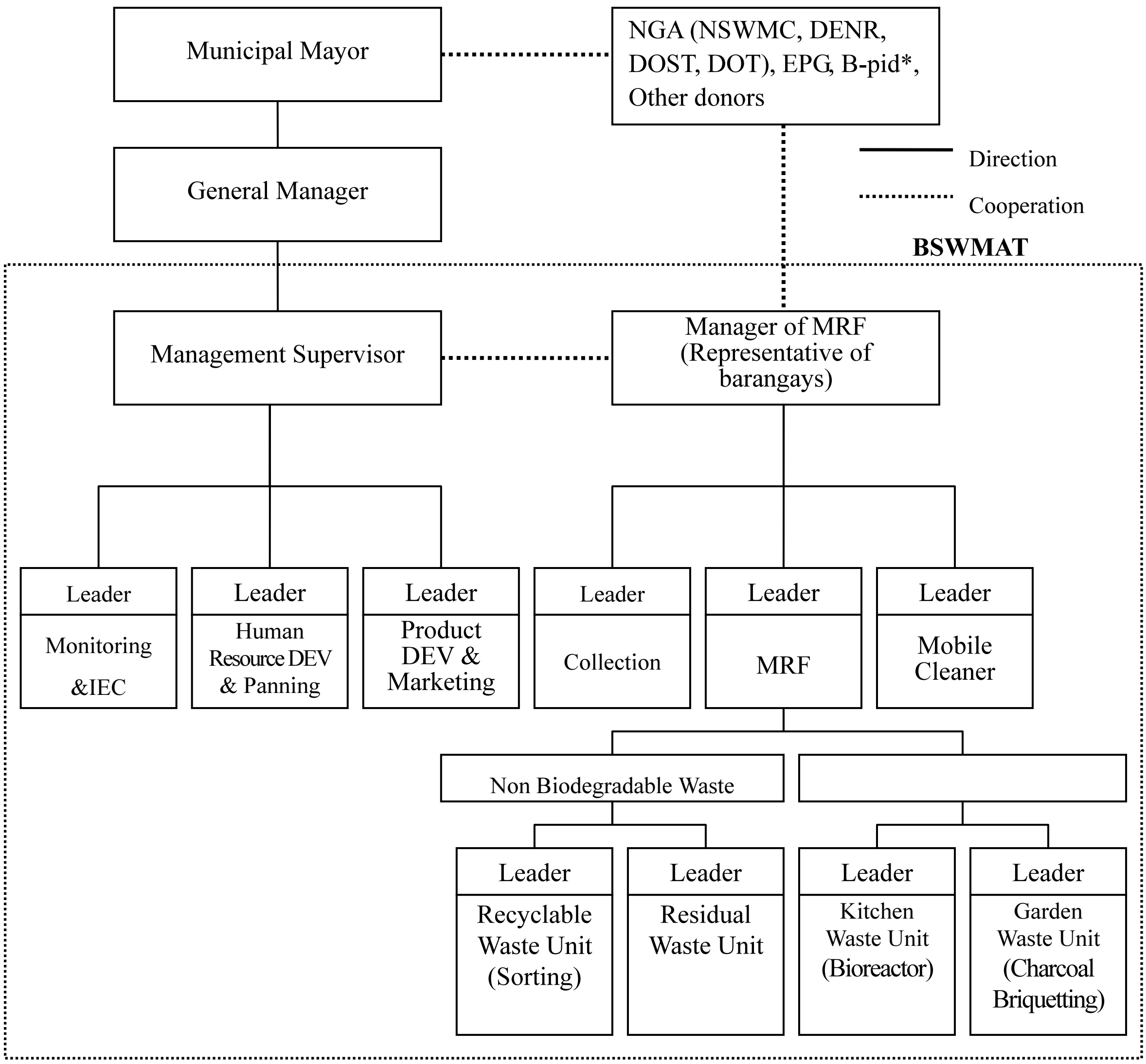


Figure 3.6-7 Operational Organization of the Manoc-Manoc Centralized MRF

Source: JICA Study Team

The staff required in each section and their roles are described in Table 3.6-1.

Table 3.6-1 Required Staff for each Role

Position	Number of Staff			Roles
	Phase I	Phase II	Phase III	
Manager of MRF	1	1	1	In-charge of over-all MRF operations
Management supervisor	1	1	1	Inspects the operation of MRF along with Manager of MRF
Leader	0	4	4	Manages each section of the MRF, collection and transportation and environmental monitoring
Secretary	1	1	1	Assist supervisor by handling accounting and administrative matters
Drivers of collection trucks	3	6	6	Driving and maintenance of collection trucks
Truck helpers	6	12	12	Checks, loads and unloads garbage
Eco-aide	0	8	9	Collects from inaccessible areas with pushcart then also helps in sorting
Beach Cleaners	-*	20	25	Clean the beaches and collect and bring the beach debris to collection points
Street Sweepers	-*	20	25	Clean road and collect and bring the garbage from streets to collection points
Sorting staff	8	6	8	Segregating recyclable waste and packing residuals
Technical staff (Biodegradable handling area)	2	2	2	Operation and maintenance of equipment in the area and handle the biodegradables for composting and making charcoal
Technical staffs (Recyclable Handling Area)	1	2	2	Operation and maintenance of equipment in the area and handle the recyclables
Technical Staff (Other areas)	1	1	2	Operation and maintenance of equipment in the area and handle residuals
Weigh bridge operator	0	1	1	Operate weigh bridge and manage the records of each vehicle and waste handled.
Environmental monitor	4	20	25	Monitoring and enforcement of source segregation activities as well as other public awareness raising activities and collection of GCF

Note: * Beach cleaners and street sweepers are employed by the MOM directly until 2011, while they are planned to be employed by the re-organized BSWMAT from 2012.
Source: JICA Study Team

3.6.3 Human Resources Development

It is essential to develop and manage human resources to establish and operate the Manoc-Manoc Centralized MRF. As the starting point of the new system, field supervisors and some technical staff and workers as well as supervisors should be involved in the process beginning with the planning and design stages. In the process, the technical staff and workers could have the capability of flexible operation through the experiences of early stage.

A set of operation manuals shall be prepared for the operators. Based on the manuals, the operators shall be trained for suitable operation. The operation manuals should include the following contents.

- Operation hours of the MRF, equipment and facilities
- Handling procedures for the waste for each section
- Operation procedures for the equipment

The purpose and system of the MRF including the SWM system on Boracay Island should be taught to all the staff. The knowledge will assist their clear understanding of their roles and responsibilities and of the relationship of each role of the staff, equipment, and facilities to operate the MRF smoothly. In addition, because some staff may change in the future, the manuals and daily records shall be kept to utilize as information gained through experience. The training program should include the following components for each staff member.

Table 3.6-2 Training Program for Each Staff Member of the Centralized MRF

Position	Training Program
Technical Supervisor	- Training regarding technical issues of MRF operation - Site visit to examples of good MRFs
Leader	- Training regarding management and supervising - Site visit to examples of good MRFs
Chief	- Training regarding management and supervising - Site visit to examples of good MRFs
Secretary	- Handling the financial system and recording all the management activities in the MRF.
Drivers of collection trucks	- Driving the trucks, understanding the routes and schedules - Training regarding daily inspection and periodical maintenance
Truck helpers	- Understanding the routes and schedules - Training regarding the segregation methods in MOM in the field - Training in effective collection methods
Eco-aides	- Understanding the routes and schedules - Training in the segregation methods on Boracay island - Training in effective collection methods
Sorting staff	- Understanding the categories of recyclable waste and operation procedures of the sorting equipment such as the belt conveyor
Technical staff (Biodegradable handling area)	- Biodegradable handling measures including operation methods of the bioreactor, and other handling measure of biodegradable waste in the composting process
Technical staff (Recyclable Handling Area)	- Recyclable handling measures and other handling measure of recyclable waste in the plastic densification or glass crushing process
Technical Staff (Other area)	- Residual handling measure including operation methods of pulverizer or molding equipment to prepare hollow blocks
Weigh bridge operator	- Operation of the weighbridge - Methods of recording the information gathered at the weighbridge
Environmental monitor	- Categories of segregated collection, route and time schedule of the collection vehicles, collection coverage area, and coverage area of the environmental monitoring activities

Source: JICA Study Team

3.7 Implementation Plan

The implementation schedule of the MRF is generally divided into Phases I to III as shown in Figure 3.7-1.

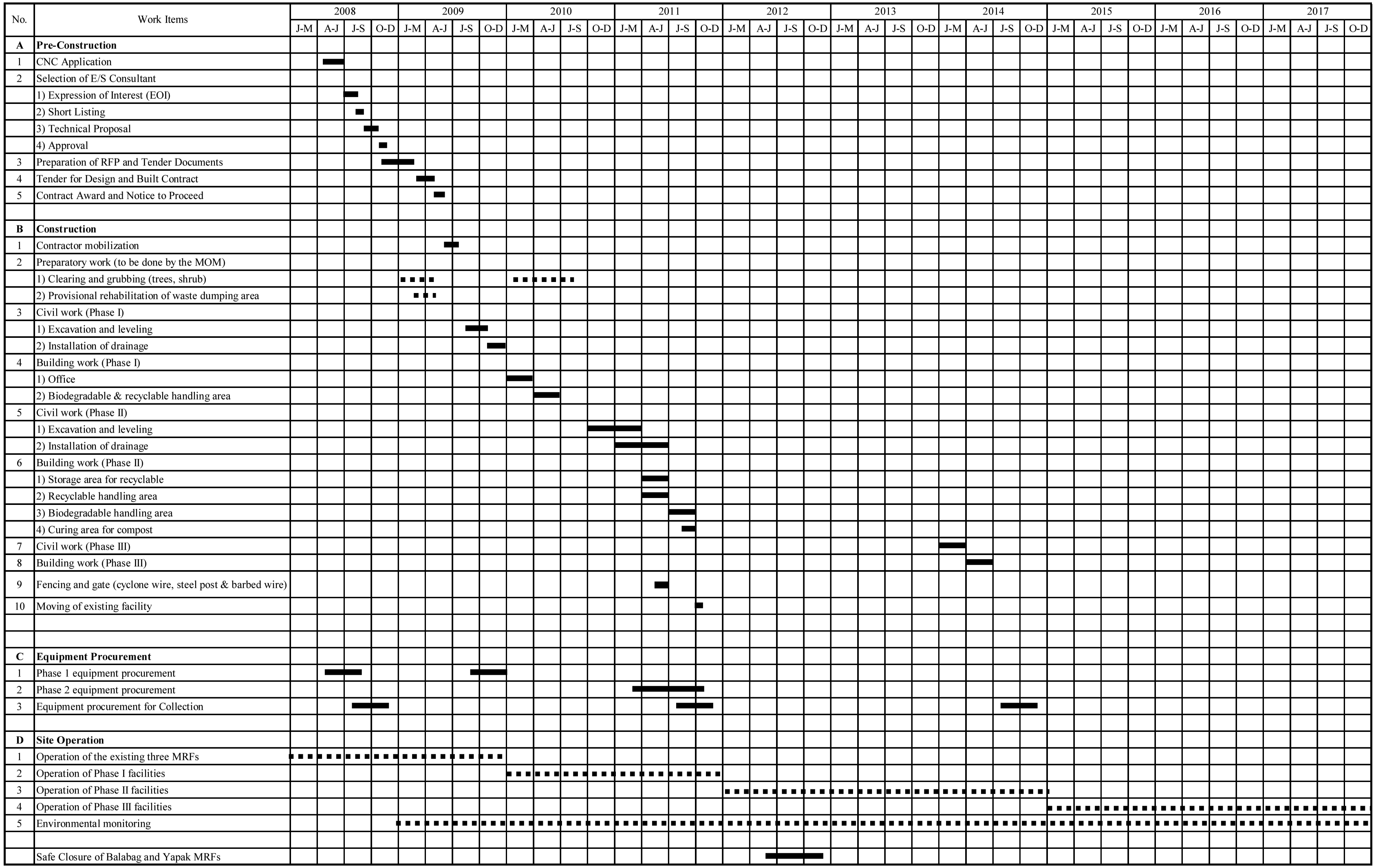


Figure 3.7-1 Implementation Schedule for the Development of the Manoc-Manoc Centralized MRF

Source: JICA Study Team

3.8 Cost Estimate

3.8.1 Investment Cost

Based on the quantities and the unit costs of each facility and piece of equipment, the construction cost, procurement cost of the equipment, engineering service cost including bidding support and administration cost are estimated as shown in Table 3.8-1.

Table 3.8-1 Investment Cost of the Manoc-Manoc Centralized MRF

(Unit: x10^3 PhP)

Category	Phase I	Phase II	Phase III	Total
Engineering Service (E/S) Cost including Bidding Support	514	851	108	1,473
Construction of MRF	10,287	17,025	2,164	29,476
Administration Cost	540	894	114	1,548
Procurement of Equipment	2,050	2,750	0	4,800
Sub-Total	13,391	21,520	2,386	37,297
Physical Contingency	1,237	2,014	239	3,490
Total	14,628	23,534	2,625	40,787

Note : 1) Engineering service (E/S) cost is 5% of construction cost.
2) Administration cost is 5% of summation of construction and E/S costs.
3) Physical contingency is 10% of total costs of construction, E/S and administration, and 5% of equipment procurement.
Source: JICA Study Team

3.8.2 Annual Cost

The disbursement schedule during the 10 years from 2008 to 2017 was prepared on the basis of the implementation schedule for the development of the Manoc-Manoc Centralized MRF. The annual cost is estimated as shown in Table 3.8-2 (see Appendix III-3.8.1).

Table 3.8-2 Annual Investment and O&M Costs of the Manoc-Manoc Centralized MRF

(Unit: x10^3 PhP)

No.	Work Items	Total	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A	**Engineering Service (1)[(2)*0.05]**	1,474	0	87	427	851	0	0	108	0	0	0
B	**Construction (2)**	29,476	0	1,740	8,547	17,025	0	0	2,164	0	0	0
1	Preparatory work	956	0	519	437	0	0	0	0	0	0	0
2	Civil work (Phase I)											
1)	Excavation and leveling	910	0	910	0	0	0	0	0	0	0	0
2)	Installation of drainage	97	0	97	0	0	0	0	0	0	0	0
3	Building work (Phase I)											
1)	Office	4,050	0	0	4,050	0	0	0	0	0	0	0
2)	Biodegradable & recyclable handling area	2,750	0	0	2,750	0	0	0	0	0	0	0
4	Civil work (Phase II)											
1)	Excavation and leveling	1,144	0	0	572	572	0	0	0	0	0	0
2)	Installation of drainage	965	0	0	0	965	0	0	0	0	0	0
5	Building work (Phase II)											
1)	Storage area for recyclable	2,800	0	0	0	2,800	0	0	0	0	0	0
2)	Recyclable handling area	2,500	0	0	0	2,500	0	0	0	0	0	0
3)	Biodegradable handling area	4,000	0	0	0	4,000	0	0	0	0	0	0
4)	Curing area for compost	4,500	0	0	0	4,500	0	0	0	0	0	0
6	Civil work (Phase III)	599	0	0	0	0	0	0	599	0	0	0
7	Building work (Phase III)	1,200	0	0	0	0	0	0	1,200	0	0	0
8	Fencing and gate (cyclone wire, steel post & barbed wire)	1,574	0	0	262	1,049	0	0	262	0	0	0
9	Moving of existing facilities	29	0	0	0	29	0	0	0	0	0	0
10	Miscellanous works (water supply, power supply)	1,404	0	215	476	610	0	0	103	0	0	0
C	**Administration Cost (3)[((1)+(2))*0.05]**	1,548	0	91	449	894	0	0	114	0	0	0
D	**Equipment Procurement (4)**	6,480	0	2,290	500	2,950	0	240	500	0	0	0
1	Phase 1 equipment procurement for MRF	2,050	0	2,050	0	0	0	0	0	0	0	0
2	Phase 2 equipment procurement for MRF	2,750	0	0	0	2,750	0	0	0	0	0	0
3	Collection equipment procurement	1,680	0	240	500	200	0	240	500	0	0	0
E	**Physical Contingency (5)[((1)+(2)+(3))*0.1+(4)*0.05]**	3,574	0	306	967	2,024	0	12	264	0	0	0
	Subtotal of Investment (6) [(1)+(2)+(3)+(4)+(5)]	42,551	0	4,515	10,890	23,744	0	252	3,150	0	0	0
F	**Operation and Maintenance Cost (7)**											
1	O &M of MRF	48,839	4,167	4,707	5,521	5,588	4,516	4,577	4,612	4,980	5,046	5,123
2	O& M of Collection on Boracay Island	59,698	4,861	4,982	5,835	5,906	5,848	5,890	5,933	6,785	6,825	6,832
	Subtotal of O&M (7)		9,028	9,689	11,357	11,494	10,365	10,467	10,546	11,765	11,872	11,955
	Price Escalation (8)	44,774	451	1,456	3,507	7,594	2,864	3,646	5,575	5,617	6,545	7,519
	Total Cost (9)[(6)+(7)+(8)]	195,862	9,479	15,659	25,754	42,832	13,228	14,365	19,271	17,383	18,417	19,474

Note: 1) Detail O&M cost is described in Appendix III-3.8.2
2) Because the number after decimal point is rounded, accidental error occurs in first digit.

Source: JICA Study Team

3.9 Financial Analysis

The costs of the collection and transport of waste, including transport of the residual waste from MRF(s) to the proposed SLF which accounts for a relatively large portion of the total SWM cost, are expected to increase by the increase in the amount of waste to be collected and transported. In the 10-year SMW Plan, however, the improvement of the collection system on Boracay Island is planned aiming at improving collection efficiency in accordance with centralization of the three MRFs. This includes changing collection areas and methods such as collection frequencies of the segregated wastes. The development of Manoc-Manoc Centralized MRF could contribute to a decrease in the cost for the transport of residual waste because the MRF is proposed to be near the port which is used for shipping of the residual to the SLF on the Mainland of Malay. In addition, the proposed bailing system for the residual waste would decrease the volume of the residual waste to be transported. Under this condition, the annual costs regarding O&M of the MRF(s) on Boracay Island and Collection and Transport as shown in Table 3.9-1.

Table 3.9-1 Costs of O&M of the MRF(s) and Collection and Transport on Boracay Island

(Unit: x10^3 PhP)

Category	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Collection and Transport to the MRF on Boracay Island	4,861	4,982	5,835	5,906	5,848	5,890	5,933	6,785	6,825	6,832
Transport from the MRF to the SLF	4,925	5,199	5,647	5,531	3,337	3,077	2,808	2,740	2,673	2,673
Subtotal (Collection and Transport)	9,786	10,181	11,482	11,437	9,185	8,967	8,741	9,525	9,498	9,505
O&M of Yapak MRF	1,013	1,032	1,025	1,020	0	0	0	0	0	0
O&M of Balabag MRF	1,908	2,730	3,040	3,144	0	0	0	0	0	0
O&M of Manoc-Manoc	1,245	1,276	2,016	2,059	4,516	4,577	4,612	4,980	5,046	5,123
Subtotal (O&M of MRFs)	4,166	5,038	6,081	6,223	4,516	4,577	4,612	4,980	5,046	5,123
Total	13,952	15,219	17,563	17,660	13,701	13,544	13,353	14,505	14,544	14,628

Source: JICA Study Team

In the 10-year SWM Plan, it is proposed to establish a Local Common Fund (Lo-Co-Fund) to manage not only the proposed centralized MRF but also collection and transport, including sweeping and monitoring, on Boracay Island. The financial analysis covers the following components:

- Investment cost for development of the Centralized MRF
- Investment cost for closure of existing MRFs
- O&M costs regarding the collection and transport of biodegradable, recyclable and residual waste from collection areas to the Centralized MRF including monitoring and sweeping activities
- Cost regarding the transport of residual waste from the Centralized MRF to the SLF

As for the basic concept of cost recovery system, the cash flow of development of the Manoc-Manoc Centralized MRF was prepared based on the following conditions:

- At the result of the calculation of waste quantity by waste generation sources, cost sharing and demarcation between the residents and business establishments is considered to be approximately 30 % for the residents and 70% for business establishments based on the principal of PPP.
- 87% of the GCF from residents and business establishments would be appropriated to the MRF development and collection and transport based on the ratio of costs for processing, collection and transport during period of the 10-year SWM Plan.
- All costs for development of the centralized MRF would be sourced from the IRAs of the barangays and MOM. However, they are also sourced from the EAF so that IRA could be applied to other projects.

- The equipment for the collection and O&M of the MRF(s) could be sourced from grant or donation. However, they were not taken into consideration because it is not sure whether grant or donation is obtained or not.

The revenue and expenditure were calculated as shown in Table 3.9-2. The expected amount of revenues to the LCF could cover the total costs required to manage collection and transport and O&M of the MRF(s) as the SWM system on Boracay Island including the Development of Centralized MRF.

Table 3.9-2 Cash Flow of SWM including Development of the Centralized MRF and Collection and Transport on Boracay Island

(x10^3PhP)

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cash Inflows	A	14,650	21,783	33,002	50,354	20,070	18,523	23,300	21,431	22,564	23,828
GCF from HH		-	589	616	695	727	815	854	953	998	1,045
General Taxes/IRA from MOM and Barangays and EAF		14,650	14,655	25,422	40,581	9,181	6,581	10,496	8,603	6,914	7,239
Profit from Compost/ Recyclables at MRFs, etc.		-	1,526	1,742	2,443	3,345	4,079	4,774	4,508	5,138	5,827
GCF from BE		-	5,014	5,222	6,636	6,816	7,048	7,176	7,367	9,514	9,718
Cash Outflows	B	14,650	21,783	33,002	50,354	20,070	18,523	23,300	21,431	22,564	23,828
Investment for Development of the Centlized MRF		0	4,700	11,999	28,606	0	0	3,694	0	0	0
Investment for Closure of Existing MRF		0	0	0	0	2,583	0	0	0	0	0
MOOE related to MRF		4,375	5,553	7,040	7,565	5,764	6,134	6,490	7,358	7,829	8,345
Investment for Collection and Transport		0	307	671	282	0	373	816	0	0	0
MOOE related to Collection and Transport		10,275	11,224	13,292	13,902	11,723	12,016	12,300	14,073	14,735	15,484
Net Increase in Cash	C=A-B	0	0	0	0	0	0	0	0	0	0

Note: The case outflows include inflation rate and physical contingency.
Source: JICA Study Team

3.10 Social and Environmental Considerations

Due to the establishment of the Centralized MRF on Boracay Island, some extent of environmental and social impacts, such as offensive odors and impacts on job opportunities, are predicted. Besides, environmental monitoring should be emphasized during the operation phase for early detection of adverse impacts and appropriate management of the Centralized MRF. Although the Philippine Environmental Impact Statement (EIS) system does not require the project proponent, the MOM, to assess environmental or social impacts that could be caused by the Centralized MRF, environmental and social considerations at an IEE level were discussed during the F/S.

3.10.1 Compliance of the Environmental System

Based on the Philippine EIS system, it is the capacity of the composting facility that defines whether an MRF with a composting facility needs an ECC or a Certificate of Non-Coverage (CNC). The criteria regarding EIS requirements for an MRF is whether the capacity of the composting facility is ≥15MT daily or 5,475MT annually. Since the capacity of the proposed composting facilities in the proposed Centralized MRF will be around 7.3 ton daily in 2017, the MOM does not have to prepare an EIS or IEE report to secure an ECC, but it does need to obtain a CNC.

3.10.2 Environmental Impacts and Mitigation Measures

(1) Resettlement of Squatters

Several squatters live inside of the boundary of the proposed Centralized MRF. Appropriate procedures and resettlement are necessary for dealing with those squatters. RA No.7279, known as the 'Urban Development and Housing Act of 1992' and its IRR stipulate the grounds, procedures and requirements for eviction of squatters from land required for a government infrastructure project with available funding. RA No.7279 allows for eviction of individual squatters or groups who occupy lands without the consent of the landowner and who have sufficient income to pay for legitimate housing, without any compensation. It will be necessary to resettle several squatters for the construction of the Centralized MRF. Although it may not be necessary to provide any compensation on a legal basis, some assistance, such as providing job opportunities in the Centralized MRF, for the resettled households is recommended.

(2) Guarantee of Stable Land Use for the Centralized MRF

Guarantee of land use for the Centralized MRF is critical for stable operation for a long term. The MOM and Barangay Manoc-Manoc prefer a lease from the land owner rather than acquisition of the land to decrease capital costs. Finally, the Barangay Manoc-Manoc and the land owner have concluded the contract for a ten-year lease with a rental fee, one peso per annum.

(3) Water Pollution

The proposed site is surrounded by low hills and has a gradual gradient from south to north. So, the lowest area, i.e. the northern part of the site is prone to inundation and becomes muddy especially during the rainy season. Further, no municipal drainage system serves the site. As a result, rain water that contacts stored waste and water discharged from activities in the Centralized MRF might run off to the surrounding areas. Therefore, the following mitigation measures are recommended:

- Water collection system for rain water and discharged water
- Ditches for prevention of inflow of rain water from surrounding areas
- In order to prevent inundation, flatten the gradient of the site

(4) Offensive Odor

According to the residents living behind the bioreactor in the existing Manoc-Manoc MRF, they have not had any trouble with bad odors during the first year after the MRF started its operation in January 2006. However, from around the second year of the operation, bad odors have been annoying them. One of the sources of bad odors is biodegradable waste transferred to the Manoc-Manoc MRF. Due to inadequate training, current workers do not compost biodegradable waste immediately after it is transferred to the Manoc-Manoc MRF. As a result, it is stored without composting for a while and causes bad odors. The Manoc-Manoc MRF used to spray a solution to prevent bad odors. However, it has often stopped spraying and does not now take any action for preventing bad odors.

The Centralized MRF could accommodate more biodegradable waste than the Manoc-Manoc MRF does. The capacity of the composting facility would be 5 ton daily in the proposed Centralized MRF. Bad odors could become worse unless the Centralized MRF manages biodegradable waste properly and promptly. Recommendable mitigation measures for bad odors are as follows:

- Keep an adequate distance between the location of the bioreactor and establishments around the site
- Establish a buffer zone with plants along the boundary
- Periodically spray the stored waste
- Use/sell compost at an appropriate frequency
- Proper training for workers

(5) Accidents

Due to the limited capacity of the bioreactor, the existing Manoc-Manoc MRF dumps a certain amount of biodegradable waste within its area and covers it with garden waste. This unplanned dumping has caused several accidental fires so far. For instance, in August 2006, the dumped biodegradable waste caught fire and the Manoc-Manoc MRF called the fire station. The dumping areas also produce heat and smoke sometimes after rain. Therefore, the following mitigation measures for preventing accidents are recommended:

- Dumping of biodegradable waste should be prohibited in the Centralized MRF;
- Install a bioreactor with an appropriate capacity;
- Proper rehabilitation measures, such as soil cover, should be applied for the current dumping areas.

(6) Propagation of Disease Vectors

In the existing Manoc-Manoc MRF, a number of flies are seen especially around stockpiled residual waste and in the composting area. Residents who live behind the bioreactor complain that many flies annoy them. Propagation of disease vectors annoys workers as well. The Manoc-Manoc MRF used to spray a solution to prevent propagation of disease vectors. However, it has stopped spraying and does not take any specific actions now.

The Centralized MRF will receive more residual and biodegradable wastes than the current Manoc-Manoc MRF does. Appropriate measures are necessary for prevention of breeding disease vectors. Recommendable mitigation measures are as follows:

- Keep an adequate distance between the location of the bioreactor, curing space, and stock pile area and the establishments around the site;
- Establish a buffer zone with plants along the boundary;

- Periodically spray the stored waste;
- Use/sell compost at an appropriate frequency;
- Transfer of residual waste to the new SLF at an appropriate frequency;
- Proper training for workers.

(7) Local Economy

For the establishment of the Centralized MRF, the MRFs in Yapak and Balabag are planned to be closed. As a result, current workers in the two MRFs, 15 in the Barabag MRF and 12 in the Yapak MRF, may lose their jobs. On the other hand, the construction and operation of the Centralized MRF can provide local residents with job opportunities. To mitigate the impacts on local economy, it is recommended that the MOM provide workers who may lose their jobs with alternative job opportunities or support in finding new jobs. From the long term viewpoint, a proper management system for the centralized MRF and strategic employment plans are necessary.

3.10.3 Environmental Monitoring

The MOM and Barangay Manoc-Manoc should undertake monitoring activities during the operation phase to survey the environmental conditions of the Centralized MRF and to develop countermeasures against any negative environmental impacts until the sources of the environmental problems are controlled. The following items are recommended as monitoring obligations;

- Extent of odors
- Propagation of disease vectors
- Listen to complaints from surrounding households

One of the biggest concerns which surrounding households have is offensive odors and propagation of disease vectors. The MOM and Barangay Manoc-Manoc should check the extent of odors and propagation of disease vectors on a steady basis during the operation. They should also hear and accept claims from the surrounding households periodically to improve the environmental conditions around the Centralized MRF.

3.11 Evaluation and Conclusion

3.11.1 Technical Aspect

As the technical system proposed for the Centralized MRF for the handling of biodegradable waste, bioreactors which have been used at the existing MRFs are planned to be used continuously and a new carbonization system to prepare charcoal is planned to be adapted on a pilot scale as new technology. For handling of recyclable waste at the MRFs, a more effective sorting system with considerations of the recycling market should be instituted. For residual waste, the hollow block preparation system will be adapted for a part of the non-recyclable plastic and paper wastes and the other residual waste will be transported to the proposed SLF with proper sacking. Basically, the technological system adopted has previously been used in the Philippines or is a new system being developed with support from the DOST. From the above discussions, the development of the Manoc-Manoc Centralized MRF is evaluated as technically viable.

3.11.2 Environmental and Social Aspects

As for the facilities development, especially, the development of Manoc-Manoc Centralized MRF, consensus among stakeholders including workers at the existing MRFs, junkshops, farmers, and residents near the proposed site are essential. The cooperation of the landowner of the site is also prerequisite. The proposed MRFs would contribute to mitigate any negative impacts and accomplish proper handling of the collected waste, especially the biodegradable waste. On the other hand, some environmental impacts would be expected due to the Manoc-Manoc Centralized MRF. In order to mitigate the negative environmental impacts, careful environmental considerations and suitable mitigation measures regarding O&M as well as for the facility development plan will be implemented. As a result, the development of the Manoc-Manoc Centralized MRF is evaluated as environmentally sound since no serious adverse impacts are expected.

3.11.3 Financial and Economic Aspects

An investigation of the necessary costs for the development of the Centralized MRF showed that the investment cost may be beyond the current financial capability (budget) of the MOM. For this, institutional arrangements such as the revision of the EAF and GCF together with the arrangement of the LCF are planned. Since through such financial arrangements, the necessary costs can be covered, the project is evaluated as financially feasible.

As for the economic aspects, the O&M of the MRF is expected to increase in accordance with the increase in the amount of waste to be handled. However, one of the objectives of the centralized MRFs is to improve operational efficiency in terms of cost and time for handling waste. After the centralization of the MRFs, the operation efficiency of the MRF is expected be improved as shown in Table 3.11-1. The centralization of existing MRFs would contribute to effective sorting as well as composting and recycling activities at the MRF and to reduce the O&M cost.

Table 3.11-1 Comparison of O&M Costs of the MRFs

(Unit: PhP/ton)

Year	Yapak MRF	Balabag MRF	Manoc-Manoc MRF	Manoc-Manoc Centralized MRF
2008	3,083	637	922	-
2012	-	-	-	707
2017	-	-	-	659

Source: JICA Study Team

Figure 3.11-1 shows the O&M costs, which include the ones for collection and transport, simulated for the cases with the development of Centralized MRF (with-case) and with the current individual MRFs (without-case). The O&M costs of the without-case were estimated to be almost twice as much as the with-case.

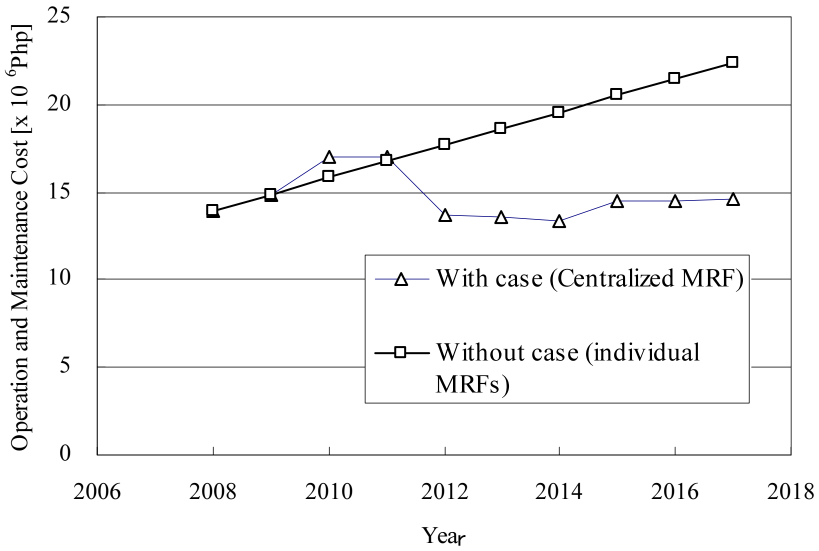


Figure 3.11-1 Comparison of Total O&M Costs of the Centralized MRF Including Improvement of the Collection and Transportation System

Source: JICA Study Team
Note: The discount rate is not considered in the O&M cost due to the purpose of the comparison between "with case" and "without case" in each year

Therefore, since the development of the centralized MRF together with the improvement of the collection and transportation system could contribute to establish effective SMW on Boracay Island, the development of the centralized MRF is evaluated as economically feasible.

3.11.4 Overall Evaluation

The development of the Manoc-Manoc Centralized MRF aims at producing sufficient diversion of the solid waste to be transported to the new SLF based on the vision of the 10-year SWM Plan. The proposed plan covers seven major fields to archive the vision. Corresponding projects have been proposed to attain the specific targets of diversion, collection and disposal. It is expected that the implementation of the proposed projects will contribute to make the whole area of the MOM clean and attractive especially on Boracay Island. Considering the above series of evaluations from the technical, social & environmental, financial & economic aspects, the development plan of the Centralized MRF is evaluated as viable as a whole.

PART IV : RECOMMENDATIONS

PART: IV RECOMMENDATIONS

1. Recommendations for Municipality of Malay

1.1 Practical Implementation of the 10-year Solid Waste Management Plan

1.1.1 Necessary Actions to be Taken in 2008 as the First Step of the 10-year SWM Plan

(1) Official Approval of the proposed 10-year Solid Waste Management Plan

In accordance with Section 16 of RA9003, the province, city or municipality, through its local solid waste management boards, shall prepare its respective 10-year SWM Plan consistent with the National Solid Waste Management Framework. It is therefore recommended to obtain an official approval of the 10-year SWM Plan by NSWMC to increase plan's effectiveness. For this, the MOM should obtain the official approval of the plan from the MSWMB and the SB at first. Besides, although many LGUs have developed respective 10-year SWM Plan, no plan has been approved by the NSWMC. In order to enhance the implementation of RA9003, the best practice model, officially approved 10-year SWM Plan, should be generated as soon as possible.

(2) Proceeding of the Priority Projects

Necessary actions to be conduced in 2008 as part of the proposed 10-year SWM Plan were clarified. It is suggested that the following actions are necessary to proceed the priority projects at first.

- Development of Kabulihan SLF: Amendment of the IEE to obtain the amended ECC
- Rehabilitation of Old Dump Site: Submission of a rehabilitation plan to obtain ATC
- Development of Manoc-Manoc Centralized MRF: Application of CNC

As for the fund arrangement, the MOM should arrange the loan to implement the above priority projects. Especially for the SLF development, the MOM is advised to take urgent actions in order to secure the commencement of official operation of the landfill site from the middle of 2009.

(3) Other Activities to be Commenced in 2008

As it has been proposed in the 10-year SWM Plan, it is recommended to implement the following major activities in 2008 in addition to the above discussed priority projects.

1) Introduction of Source Reduction Program
   - BALIK BAYONG Program
   - BALIK BOTE Program

2) Improvement of Collection System on Boracay Island
   - Revision of collection area
   - Improvement of collection method
   - Equipment procurement
   - Human resource development

3) Implementation of Public Education and Information:
   - Training of trainers
   - General advocacy of the 10-year Solid Waste Management

4) Arrangement of Legal System
   - Amendment of MO

5) Organization Set Up

6) Introduction of Cost Recovery System
   - Setting up a LCF
   - Revision of GCF system (setting up basic rules)
   - Revision of EAF system (setting up basic rules)

7) Capacity Development
   - Training program
   - Development of solid waste administrative tools (manuals, guidelines)

1.1.2 Revision and Updating of the 10-year SWM Plan

The 10-year SWM Plan should be viewed as a dynamic document which requires periodic updates due to changes in laws, ordinances and regulations, technologies associated with SWM practices and the social and economic conditions. This is also stipulated in RA 9003 as one function of the MSWMB to review the plan every two years. Considering that many of the regulations and subsequent guidelines that will bring this 10-year SWM Plan into full operational mode are still to be finalized, updating every two years should be highly recommended.

1.1.3 Introduction of Progress Assessment System

In order to secure progress of the 10-year SWM Plan, it is recommended to introduce a progress assessment system. Under the system, the MOM should have annually meetings for progress assessment of the 10-year SWM Plan. The MOM also should accept appraisals by outsiders such as NGOs who evaluate the progress and activities based on the documents that report activities implemented, indicators to be monitored and expenditures related to SWM. The results of the outside evaluation and meetings should be open as well. The progress assessment with outside evaluation is expected to encourage the MOM and barangays to improve their activities and systems for the achievement of the 10-year SWM Plan.

1.1.4 Introduction of Human Resource Management Program

In order to manage human resources for SWM (but not limited to this) of the MOM and barangays, a human resource management (HRM) program should be initiated. The HRM program consists of database of human resources and a series of trainings. The following HRM program should be introduced in the MOM.

- Development of database of human resources for SWM of the MOM and barangays
- Development of a HRM program regarding SWM
- Introduction of management by objective with annual appraisal of performance of each staff member against the agreed tasks
- Improvement of morale and motivation through encouragement and motivation of the staff, and rewarding good performance for improving their works for SWM, for example, bonuses and/or linking promotions

1.1.5 Establishment of Financial Management System

Even though the LCF is established, any system are prepared, it is difficult to adequately manage the fund without transparent sharing of relating information among person and bodies concerned. In particular, daily information on amount of income and expenses should be regularly checked by several practitioners from each related section. After that, these data should be reported to private sectors and general public on the necessary procedure. It is recommended to develop a process to share the information on the following items. Development process should be also described in the operational guideline of LCF.

- Which information should be checked?
- When should the information be checked?
- Who should check the information?
- How should the related persons/bodies check the information?

Cost sharing can be realized among barangays when the LCF is established, however, it is an issue how they share the costs in practice. A criterion is necessary to share the costs with their consensus. To establish the consensus, the way of securing equity among barangays should be taken into consideration. Recycling rate, quality of separated waste, reduction rate and amount of residual waste could be indexes to decide amount of costs shared among barangays with equity. Consequently, to decide the amount of costs based on such kind of indexes is an incentive for barangays to address reduction of waste actively. It is recommended for MOM and barangays to establish the rule on this.

1.1.6 Promotion of Coordination between LGU and Barangays

The MOM has organized the MSWMB with various sectoral representatives designated as members including the Association of Barangay Chairperson. The board meetings are held every month in principle to discuss various issues on SWM and they are also expected to play a coordination role among stakeholders. However, as not all barangay chairpersons are involved in the meetings and also, at the barangay level, the Barangay SWM Committee has not been functioning well, a coordination mechanism between LGU and barangays should be established in order to improve information and to exchange opinion among stakeholders. For the coordination between the LGU and barangays, the existing BSWMAT and proposed MSWMAT are expected to play important roles.

There is the Association of Barangay Chairperson to coordinate various issues including those regarding SWM. Since it is difficult for the all barangay chairpersons to gather together many times, it is recommended that sub-associations of barangay chairpersons be established for Boracay Island and the Mainland of Mainland respectively so that they can gather together more often. The other stakeholders such as business establishments and NGOs are also to be invited to the meetings.

1.1.7 Promotion of Collaboration among Stakeholders

In order to minimize the necessary costs for the implementation of the 10-year Solid Waste Management Plan by the MOM and barangays, as well as to make its implementation practical and effective, support from national governmental agencies (NGAs) such as NSWMC, DENR Region VI, DOST and DOT, business sectors and NGOs instead of utilization of consultants are essential. Especially DENR Region VI together with NSWMC has committed to provide the MOM and barangays with full technical support such as waste reduction at the sources and the IEC program. Support from DOT and DOST are also expected to the MRF development and O&M. It is recommended to promote further collaboration between them.

Currently, the biodegradable/ compostable wastes and reusable/recyclable wastes are collected by barangays while the residual waste (non-recyclable/non recoverable material) is collected by the MOM in accordance with RA9003. In order to conduct collection activities efficiently, the revision of the collection system was proposed in the 10-year SWM Plan and it would request to establish collaboration among concerned organizations. Especially, close collaboration is prerequisite for the proposed centralized MRF and establishment of local common fund.

1.1.8 Encouragement of Collaboration with Neighboring Countries

From November 23 to 28, 2007, three individuals from Palau who are working in SWM at the National Government of Palau and Koror State Government visited the Philippines to exchange experiences in SWM (see Appendix IV-1.1.1). They are also working as counterparts of a technical cooperation project between Japan and Palau on SWM. They visited MRFs on Boracay Island and the proposed SLF, and also saw the source segregation collection activities. The experience exchange meetings were held between the persons concerned with SWM of the MOM, those from Palau, and the NSWMC. As a result of this study tour, an atmosphere to promote further collaboration among the participants has been created and information exchange has started through e-mails. Since Palau is an island country which is famous as a tourist destination, the problems which Palau are facing are similar to those in Boracay. Therefore, it is recommended to collaborate with them closely and continuously to promote better SWM. In addition, not only Palau but also other neighboring island countries may be facing SWM problems similar to Boracay Island. It is therefore also recommended to collaborate with them to create synergy effects in SWM.

1.1.9 Grasping Material Balance Inflow and Outflow to/from Boracay Island

In order to promote diversion especially on Boracay Island, reduction of waste generation at the sources is to be tackled first. The reduction of the waste at the sources also contributes to reduce burdens on SWM to each barangay as well as to the environment. For effective source reduction including avoidance of use of materials which may become waste, especially residual waste, grasping of material balance inflow and outflow to/from Boracay Island is important to establish and implement measures and its monitoring. However, such material balance has not been recorded even at the ports. Therefore, the material balance including recyclable materials should be recorded.

1.1.10 Receiving of Waste from the Municipality of Buruanga

The MOB is located in the southern side of MOM and has 15 barangays with total population of around 15,000 in 2,000. The amount of waste collected is currently not so much compared with the MOM because the collection coverage area is small. There is no MRF in the MOB at this moment.

In the 10-year SWM Plan, new Kabulihan SLF will receive only residual waste. If the MOB tries to haul the waste there, the MOB is requested to develop a suitable MRF for handling biodegradable and recyclable to segregate them from residual waste to be transported the new SLF. It is desirable that the hauled residual waste from the MOB as well as one from Boracay Island would be packed in sacks not to spill out as well as to count the number of sacks to identify the amount of hauled waste to estimate the remaining landfill capacity. The hauled waste from both municipalities should be inspected in temporary garbage storage area. In addition, if the tipping fee system is introduced, the required tipping fee should be collected from the MOB and the amount of tipping fee should be determined based on the operation and maintenance fee of the SLF according to the concept of cost sharing.

1.2 Tourism Management for Environmental Conservation

1.2.1 Counting the Number of Tourists

The number of tourist arrivals at Boracay Island has been counted and recorded by the Tourism Office of the MOM. Although the tourists are being checked at the Caticlan Airport and jetty port, there are some uncounted tourists. This figure is essential data for not only SWM but also other environmental management efforts as well as for development.

This also closely relates to the proposed cost recovery system for the 10-year SWM Plan implementation. Therefore, the tourist counting and recording system should be improved through measures such as introduction of tourist counting at hotels and resorts.

1.2.2 Consideration of the Boracay Integrated Tourism Master Plan

The Boracay Integrated Tourism Master Plan is being developed by the PTA. The development plan covers not only Boracay Island but also Carabao Island where the new international airport is planned to be developed. This Tourism Master Plan is aiming at inviting more tourists to the region including Boracay Island. Since this master plan has not been prepared yet, it is necessary to integrate its ideas and future framework once the plan is available.

1.2.3 Consideration of Carrying Capacity of Boracay Island

Carrying capacity is an important concept for balancing development and environmental conservation and it is used for various parks and tourists sports where the natural environment is essential for the attraction. According to the official of the Boracay Water Supply and Sewerage Service (BWSS), the amount of sewerage flowing into the sewerage treatment plant during the peak season has been reaching almost treatment capacity (14,198m^3/day). From the pollution control viewpoint it could be said that the current number of tourists is almost reaching the carrying capacity. If the development works continue without additional measures, the environment of Boracay Island may become worse and it may cause negative impressions to the tourists, and finally it may lead to decreasing of the number of tourists. Therefore, in addition to SWM, a comprehensive carrying capacity study should be conducted so that the appropriate roadmap for the development works can be produced with balance between environmental conservation and tourism development.

2. Recommendations regarding Sludge Treatment

2.1 Current Situation and Issue of Sludge Treatment

2.1.1 Current Situation

Under the Boracay Environmental Conservation Project by the PTA, a sewerage treatment plant has been constructed at Barangay Balabag on Boracay Island. The sludge drying facility has also been constructed within a 1.2 ha parcel of land (the area of the sludge drying facility itself is 0.2ha) in the outskirts of Mt. Luho. All sludge produced at the plant is transported daily to the sludge drying facility by vacuum cars of 2m^3 capacity with approximately 18 trips per day. The sludge drying facility has six compartments (beds), each with dimensions of 18m length x 10m width x 1.2 m depth with perforated pipe at the bottom leading to an access manhole for liquid removal which then goes to the lagoon for wastewater treatment. The duration of drying sludge is approximately 45 to60 days in the rainy season and 30 days in the dry season.

In order to utilize the sludge as fertilizer or soil conditioner to dispose of it continuously, it is necessary to obtain information regarding the quality of the sludge. The current analysis of dried sludge in 2007 is summarized in Table 2.1-1.

Table 2.1-1 Quality of Dried Sludge

Total Nitrogen (% N)	Total Phosphorus (% P_2O_5)	Total Potassium (% K_2O)	Total Ca Oxide (% CaO)	pH
2.29	1.92	0.04	-	7.0

Source : PTA

2.1.2 Identified Issues

There are some issues including presence of odors in the areas surrounding the sludge drying facility, difficulty in drying the sludge, especially during the continuous rain in the rainy season and insufficient capacity for storage for dried sludge as discussed in Table 2.1-2.

Table 2.1-2 Analysis of Dried Sludge

Identified Issues	Contents of Issues	Sludge Drying Procedure	Handling of Dried Sludge
Presence of odors	When the sludge drying facility was constructed, there were no buildings in the surrounding area. Currently, some estates have been developed in the surrounding areas and the occupants have some complaints about the odors from the sludge drying facility.	○	△
Difficulty of drying sludge	Of the six beds, only three have roofs and the others are not protected from rainfall. In those unprotected beds, the sludge is not dried while it rains and sometimes rainwater overflows from the sludge drying beds as well as the overflow from the waste water retention pond polluting the surrounding area.	○	-
Insufficient capacity for storage areas	Based on the expected future extension of the coverage area of the sewerage system, the increase of population and tourists may cause an increase of sludge generation. Currently, some dried sludge is sacked and dumped in the area. Though the dried sludge is sacked, it may cause impacts on the surrounding environment. In addition, the area for dumping the sacked sludge is limited.	-	○
Effluent of wastewater	The effluent from the sludge drying beds is sometimes discharged into the lagoon even though it has had insufficient retention time, especially in the rainy season. In that case, the water quality of the effluent does not meet the effluent standards in the Philippines.	○	-

Note: ○ Recommended, △ Rather recommended
Source : JICA Study Team

2.2 Possible Technical Options

Discussions have been raised whether the sludge could be handled together with biodegradable waste for making compost at the MRFs. From the technical point of view, the sludge could be treated by the bioreactor together with biodegradable waste. However, since the water content of the sludge is much higher than the biodegradable waste and the bacteria that exist in the sludge and those that exist in the biodegradable waste may be different, relatively difficult operations are required such as timing and volume of input of inoculants. In principle, the sludge produced from the sewerage treatment plant shall be treated based on the Toxic Substances, Hazardous and Nuclear Waste Control Act of 1990

(RA6969), not as solid waste as defined in RA9003. It is therefore recommended that the sludge and biodegradable waste should be handled individually. In this connection, possible technical options have been proposed.

2.2.1 Improvement of Sludge Drying Procedures

Main options of sludge drying procedures for dewatering are vacuum filtration, pressure filtration, centrifugation, and drying beds. The recommended options were selected in aspect of the financial and technical conditions of the PTA. Each option was compared as described in Table 2.2-1.

Table 2.2-1 Comparison of Sludge Drying Procedures

Sludge Drying Procedures	Explanation	Advantage	Disadvantage	Evaluation
Drying Bed (Current system)	Drying beds consisting of perforated drainage pipes laid within a gravel base are used for dewatering. The gravel is covered with a layer of sand. The sludge on sand beds is dried by allowing water to drain and natural evaporation to the air. As the sludge dries, cracks develop in the surface allowing evaporation to occur from the lower layers	- Small initial investment and O& M costs	- Odor problems - Rain prevents the drying process	△
Drying Bed (Covered system)	Though the total system is the same as above, a fence is prepared and an odor control chemical such as hydrate or chlorinated lime is used. A fence or cover to protect and mitigate odors is provided.	- Small initial investment and O& M costs	- Slight odor problems	○
Vacuum Filtration	The vacuum filter for dewatering sludge is a drum over which is laid the filtering medium consisting of a cloth of cotton, wool, nylon, fiber glass, etc. The application of the vacuum is continued as the drum rotates out of the sludge and into the atmosphere. This pulls water away from the sludge, leaving a moist mat or cake on the outer surface.	- Less required land area - Not affected by season - Sufficient dewatering	- High O&M costs - Need of chemical adjustment - Slightly difficult operation and daily maintenance	×
Pressure Filtration	Pressure filtration is a process similar to vacuum filtration where solids are separated from the liquid. Leaf filters probably are the most common type of unit. Like vacuum filtration, a porous media is used in leaf filters to separate solids from the liquid, which build up on the media surface and they reinforce the media in its solid-liquid separation action.	-Minimal chemical cost in comparison with vacuum filtration	- High O& M cost - Need for batch operation	×
Centrifu-gation	Centrifuges separate solids from the liquid through sedimentation and centrifugal force. Sludge is fed through a stationary feed tube along the centerline of the bowl through the hub in a screw conveyor. Solids settled through the liquid pool are compacted by centrifugal force against the walls of the bowl, and are conveyed by the screw conveyor to the drying or beach area of the bowl. The beach area is an inclined section of the bowl where further dewatering occurs before the solids are discharged.	- Small initial cost but relatively high O&M cost - Minimization of odor by enclosed facility and equipment - Simple unit and less space	- Poor solids capture without use of chemicals - Substantial chemical costs - Often lower dewatering than others	×

Note: ○ Recommended, △ Rather recommended, × Not recommended
Source http://water.me.vccs.edu/courses/ENV149/dewatering.htm (Arranged by JICA Study Team)

2.2.2 Improvement of Handling Methods for Dried Sludge

Main options for handling method for dried sludge are biogas preparation, composting by utilizing bioreactors and landfill. The recommended options should be selected in view of the financial and technical conditions of the PTA. Each option is compared as shown in Table 2.2-2.

Table 2.2-2 Comparison of Handling Methods for Dried Sludge

Handling Methods	Explanation	Advantage	Disadvantage	Evaluation
Providing to farmers	Dried sludge is to be provided to the farmers as fertilizer.	- Effective utilization of the sludge and easy disposal	- Need of identification of the farmers (end users) and transportation of sludge to the Mainland of Malay	○
Re-treatment by bioreactor	Dried sludge is treated in combination with carbonaceous materials such as sawdust, rice hulls and/or yard wastes for better quality fertilizer (compost product).	- Utilization of experience composting biodegradable waste (sludge can be adjusted by the addition of wood chips, sawdust or garden waste)	- Relatively high initial and O&M costs. - Need of identification of the farmers (end users) and transportation of sludge to the Mainland of Malay	△
Landfill at the SLF	Dried sludge is packed and transported to the SLF.	- Easy disposal at the SLF	- Need of transportation of sludge to the Mainland of Malay - Reduction of the lifetime of the SLF. - Difficult to get acceptance of the SLF from the local people.	×
Utilize in biogas system	Dried sludge is allowed to digest in the absence of oxygen which generates methane and the digested remains are used for fertilizer.	- Not only for reduction and stabilization of sludge but also for effective utilization of energy	- High initial and O&M costs. - Difficult O&M and control of biogas system in the aspects of technical and financial capabilities	△

Note: ○ Recommended, △ Rather recommended, × Not recommended
Source : JICA Study Team

3. Recommendations for other LGUs and NSWMC

3.1 Structure of the 10-year Solid Waste Management Plan

The proposed 10-year SWM Plan has been prepared based on the annotated outline of the plan which was prepared by NSMWC. During the preparation of the plan in this study, the JICA Study Team prepared the 10-year SWM Plan strictly applying the structure of the annotated outline at first. However, the current structure of the plan discussed in the annotated outline is a relatively redundant one which guides the LGUs to repeat the same issues and the structure itself is not complicated. This may be come from the fact that the annotated outline has tried to include “every thing” relating to SWM.

In this connection, the JICA Study Team has discussed the structure of the 10-year SWM Plan with the related people and settled upon the structure of the 10-year SWM Plan as described in Part II of this report. It addresses the following subjects:

- Introduction
- Profile of Municipality of Malay
- Current Conditions of Solid Waste Management
- Future Framework
- Plan Strategy
- Technical System of SWM
- Institutional, Organizational System of SWM
- Implementation Plan
- Cost Estimates and Financial Aspects
- Social and Environmental Aspects
- Evaluation

Therefore, it is recommended that those LGUs which will prepare their own respective 10-year SWM Plans should refer to the contents of the proposed 10-year SWM Plan in Part II of this report. The comparison between the contents of the proposed 10-year SWM Plan and the annotated outlines is as attached in (see Appendix IV-3.1.1).

3.2 Calculation Methods for Diversion

3.2.1 Calculation Methods for Diversion Suggested by the NSWMC

Diversion rate is an important parameter of the 10-year SWM Plan as RA9003 mentions that "waste diversion shall refer to activities which reduce or eliminate the amount of solid waste from waste disposal facilities". However, the definition of the calculation method of diversion rate was not defined in RA9003. In this connection, as shown in Table 3.2-1, the NSWMC suggests four calculation methods for diversion rate which are utilized case by case.

Table 3.2-1 Calculation Methods for Diversion Suggested by NSWMC

Methods	Formula	Advantage/Disadvantage
Method 1	The quantity of waste collected for each type of waste is measured at the MRF. The quantity of solid waste to be landfilled is measured at the landfill site. The quantity of waste diverted is calculated by utilizing the following formula. <Diversion Rate>=<Total collected at MRF> - <Total Solid Waste at End of Pipe>/ <Total Solid Waste at Source>	If there is a weighbridge in the MRF and landfill site, it is relatively easy to monitor and calculate the diversion rate. However the increase of source reduction does not affect the increase of diversion rate. In that case, the effect of source reduction programs to reduce the waste to be disposed of is not reflected in the diversion rate based on this definition.
Method 2	The quantity of solid waste at the generation source is estimated and the quantity of solid waste landfilled is measured or estimated. The quantity of diverted waste is calculated by utilizing the following formula. <Diversion Rate> = <Quantity of Total Waste Generated>-<Quantity of All Waste Landfilled>/<Quantity of Total Waste Generated>	The quantity of waste landfilled is easy to monitor and total waste generation can be estimated based using this formula. However, according to this formula, some of the waste which is uncollected or self-disposed like burning or illegal dumping in inappropriate manners may be included the quantity of diverted waste. Therefore, the diversion ratio does not reflect the quantity of actual source reduction by reduce, reuse, recycle or composting and recovery.

Methods	Formula	Advantage/Disadvantage
Method 3	The total recyclable materials (including compostable and other recoverables) which are recovered is measured through junkshops or the MRF or interviews at waste generation sources such as households or business establishments <Diversion Rate> = <Total Recyclable Material which was Recovered>/<Quantity of Total Waste Generated>	The quantity of recyclable materials recovered including recycled products or compost is different from the quantity of reusable, recyclable or biodegradable waste and the segregated recyclables or compost depend on the recycling procedure. Namely, the recycled product including compost is not the same quantity as the recyclable or compostable source material in consideration of the mass flow of the process
Method 4	The quantity of waste landfilled at the base year is measured or estimated for comparison with the target year. <Diversion Rate> = (<Total Waste Landfilled of Base Year>-<Total Waste Landfilled of Target Year>/ <Total Waste Landfilled of Base Year>	The measurement and calculation is relatively easy. The method is based on the assumption of the same annual growth rate of waste generation quantity. This diversion ratio defined in the formula on the left increases without the increase of actual diversion if the quantity of waste generation decreases.

Source: NSWMC modified by the JICA Study Team

3.2.2 Recommended Calculation Method for Diversion

Theoretically, diversion should include the affect of all proper waste reduction from the waste flow to the SLF as defined in RA9003. The waste reduction includes source reduction such as home composting, collection of returnable containers or selling to junkshops at generation sources, and intermediate reduction such as selling to junkshops and recycling at the MRF. Some households or business establishments are implementing dumping or burning to dispose of the waste at the source and this kind of activity should not be counted in diversion because burning is illegal and dumping may have an adverse impact on the surrounding environment. In this context, the following calculation method (formula) of diversion rate is applied in the Study and it is recommended that this formula should be used commonly in the Philippines so that diversion can be measured appropriately and compared among the LGUs.

[WDR] = {[QWRS] + [QWRM]} / [QWG]

where:

WDR : Waste Diversion Ratio

QWRS : Quantity of Waste Reduced at Source (sold to junkshops, home composting and livestock feeding)

QWRM : Quantity of Waste Reduced at MRF (recycled, composted and other waste reduction activities)

QWG : Quantity of Waste Generated

To calculate the waste diversion ratio (WDR), the procedure of measurement of the relevant value and the calculation based on the measured relevant vale should be conducted as shown in Figure 3.2-1.

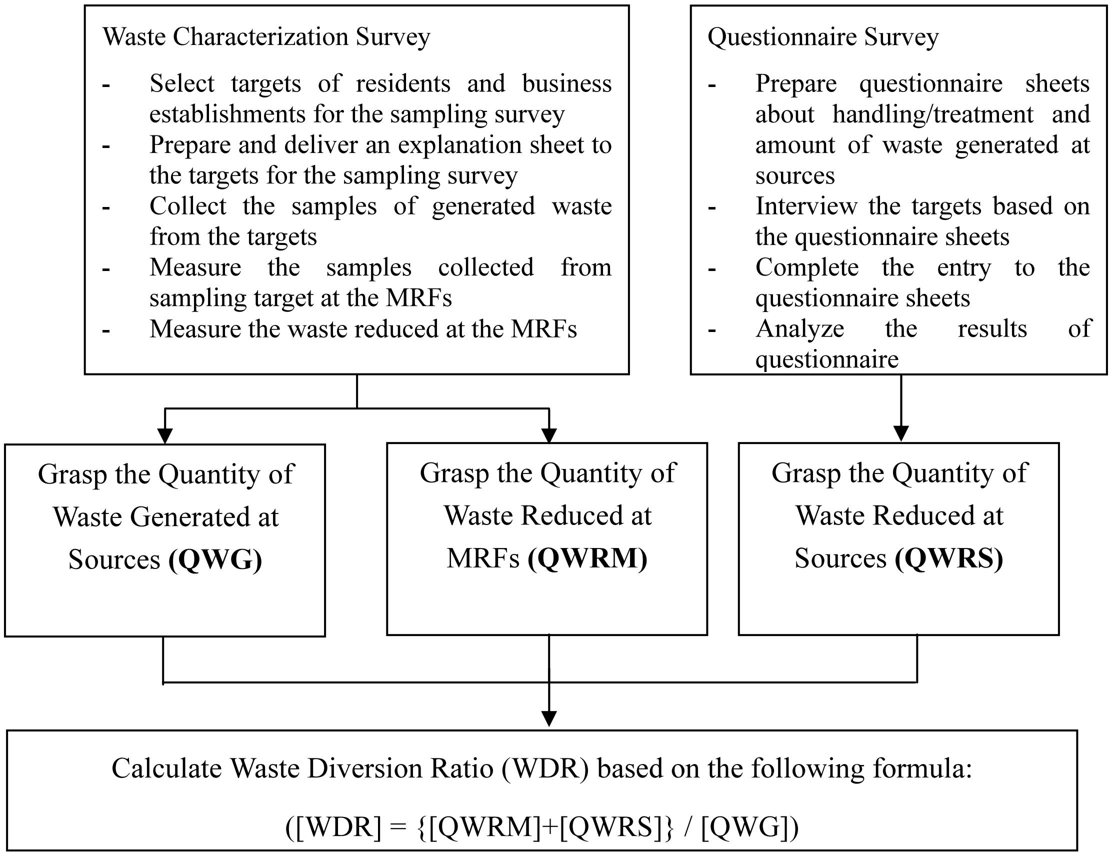


Figure 3.2-1 Procedure of Diversion Calculation Based on the Sampling Data
Source: JICA Study Team

3.3 Development of Sanitary Landfill in the Philippines

3.3.1 Careful Arrangement of Land

At the commencement of the Study, the JICA Study Team was advised that the whole of the site offered by DENR for the SLF was available. However, it soon became apparent that a portion of the identified site was classified as Alienable and Disposable (A & D) land that was the subject of a claim by the heirs of Mr. Conrado Acosta. The claimed land extends to just over 1.038 Ha. as per the survey plan by Mr. Acosta and approved by DENR in April 2007. Subsequently, the Provincial Assessor's Office issued a Tax Declaration on the claimed land in favor of the heirs of Mr. Acosta on June 12, 2007. The issue of the Tax Declaration confirms that the relevant authorities are satisfied that the heirs of Mr. Acosta have a legal claim to the land, although it is noted that title to the land has not yet been issued. It was explained by the MOM that the process of resolution of the land issue by the government was finished when a certificate for the "Order for the Immediate Cancellation of Survey Plan was issued to heirs of Mr. Conrado Acosta" by the Regional Executive Director, DENR-VI for Regional Technical Director - Land Management Services, DENR-VI dated on October 4, 2007. The MOM has yet to acquire all the area needed for the SLF development (see Appendix IV-3.3.1).

From the above lesson, it is strongly recommended that the lands should be arranged carefully for facilities' development. If it is difficult to obtain the lands especially for landfill development, re-using the existing landfill site through its rehabilitation should be considered as an option.

3.3.2 Requirements for Sanitary Landfill Development

According to DAO 10, there are four categories for SLF development which depend on the amount of residual waste to be received at the site. In the proposed 10-year SWM Plan as well as associated F/S on the SLF are classified Category 1, namely the lowest level of the SLF development, because the proposed SLF plans to receive less than 15 ton/day of the residual waste. In addition, minimal facilities and equipment are also proposed for the SLF. However, the estimated investment cost for the development of the SLF, was beyond the annual budget of the MOM which can be allocated to SWM. Consequently, the MOM should be planning to arrange a budget by arranging a loan. Even a Category 1 SLF should have a clay liner at least 60cm thick with a permeability no greater than 10-5 cm/sec, leachate collection and treatment facilities, etc. Although the MOM could cover the development cost by using various financial sources including the EAF, it may be difficult to develop the SLF, even though it is Category 1, considering their ability to cover the development cost in the cases for smaller scale LGUs. It is therefore recommended to create additional categories with less stringent requirements for smaller scale SLF development so that the LGUs can afford the development of their own SLFs, subject of course to obtaining proper environmental permits.