カリブ地域

カリブ地域海洋プラスチックごみ対策
アドバイザー業務

業務完了報告書

(Annex B)

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Pilot Project Technical Note

- B1 Guideline for the Formulation of a Regional Solid Waste Management Plan (Guyana).
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Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Pilot Project Technical Note No.1

Guideline for Preparation of a Regional Solid Waste Management Plan

JICA
Japan International Cooperation Agency

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Technical Project on Advisor for Marine Plastic Litter Management
in the Caribbean Region

- Guideline for Preparation of a Regional Solid Waste Management Plan -

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1 Background, Objective and Structure of Guideline

1.1 Background

In Guyana, a draft Solid Waste Management Bill has been being prepared to address the challenge of Solid Waste Management (SWM). This bill mandates the development of a National Solid Waste Management Strategy, which includes the establishment of National Solid Waste Management Authority under the Ministry of Local Government and Regional Development (MLGRD). The National Solid Waste Management Strategy from 2017 to 2030 has been drafted and is under the updating process under the MLGRD. After the approval of both the bill and strategy, each regional plan should be prepared by following the Solid Waste Management Bill and the National Solid Waste Management Strategy.

To consider the development of SWM system from collection to final disposal, it is necessary to prepare SWM plan. The operation of SWM is implemented in each region and the situation is slightly different in each region. Therefore, SWM plan is necessary for each region in Guyana. a guideline will be helpful to prepare the plan more efficiently and effectively.

This guideline includes the procedure and methodology for the preparation of the sections of the region profile, current SWM situation, the identification of issues, analysis of those issues, and the formulation of a vision and strategy considering future waste generation, planning of technical system, institutional system, implementation plan, financial aspects, etc.

1.2 Objectives

This guideline provides guidance on the creation of SWM plans for regions in Guyana to assist the planner of SWM plan such as MLGRD and/or each region in developing regional SWM plans and serves as a reference for the planning process. The main objective is to support the planner of SWM plan in each region in aspects of following points:

- To provide the procedures and methods to grasp the current status of SWM.
- To provide the procedure of issue identification, preparing vision and strategy and target setting
- To illustrate the method for prepare a future waste flow along with future waste generation projection.
- To provide a methodology for preparing the planning process and establishing institutional frameworks.

1.3 Structure of Regional SWM Plan

As described in the previous section, a regional SWM plan should be prepared for each region, taking into account the current status of SWM, as well as the surrounding natural environment and economic conditions unique to each area. The content of these plans encompasses the current state and identified issues of SWM, future vision, strategies and targets, technical systems, institutional arrangement, associated costs, cost recovery mechanisms, and conclusions with recommendations for the future. An example of the table of contents and planning flow are shown below.

Example of Table of Contents of SWM Plan

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10.1 Evaluation and Conclusion
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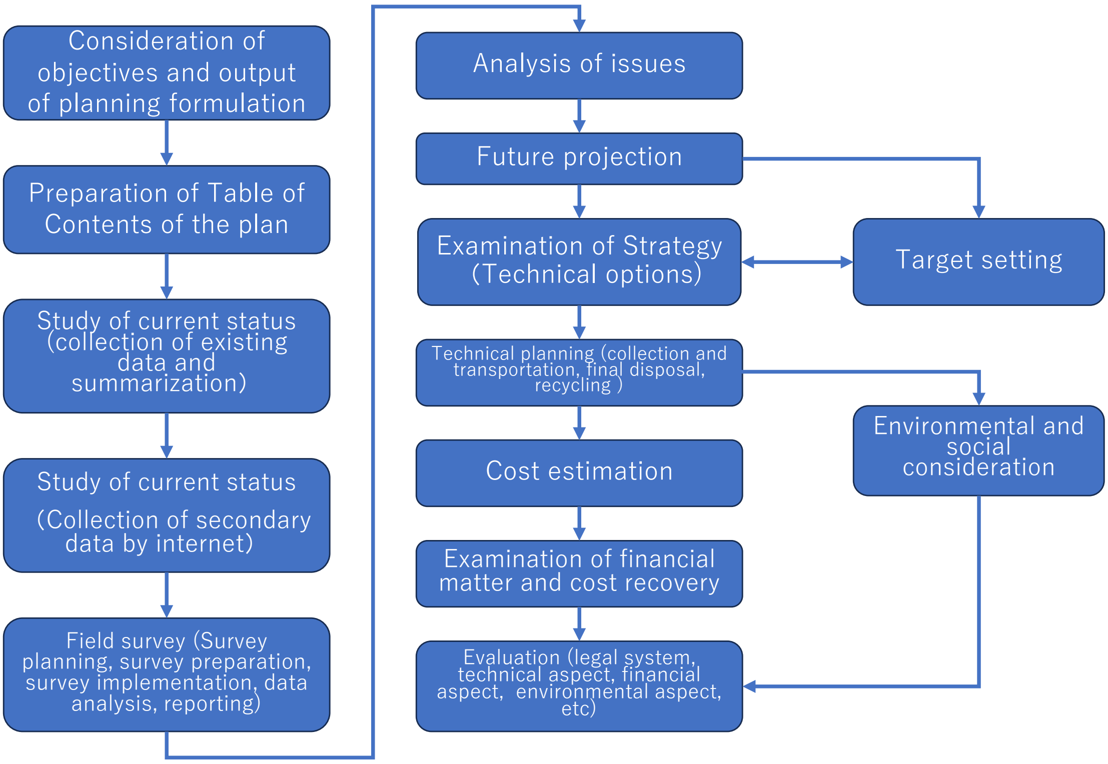
Source: JAT



Source: JAT

Figure 1: Flow of Planning Process of SWM Plan

2 Profile of Regions

In the context of regional profiling, social-economic information including population statistics, the number of businesses and public facilities (such as hotels, restaurants, stores, and schools), per capita GDP are necessary. As natural information, meteorological data, geological features, groundwater conditions, and flood-related information are also necessary. The following outlines the mainly required information and its purposes.

Table 1: Necessary Information for Economic Profile and Natural Profile

Item	Data Type	Purpose
Population	- Current and future projection	- To estimate total amount by daily waste amount per person, which is obtained from Waste Amount and Composition Survey (WACS)
Business establishment (hotel, restaurants, shops, public institutions, etc)	- Number of establishments, number of employees, number of tourists, amounts of sales, etc.	- To estimate waste amount from business establishment for each year
Economic profile and land use	- GDP per capita - Household income - Land use map	- To estimate waste amount in the future - To estimate affordability to pay for SWM cost - To estimate affordability to pay for SWM service charge - To grasp the current situation of economic development
Natural condition	- Temperature, precipitation, evaporation, wind direction - Geological data, such as underground water, rivers, historical data of flooding, etc.	- To estimate leachate amount from precipitation and evaporation - To consider leachate treatment method - To consider location of treatment facilities and landfills

Source: JAT

2.1 Population and business establishment

The population of each region will be projected at the regional level based on past trends for each municipality and/or NDC. During this process, fluctuations in population growth rates should be taken into consideration.

The population data for each region's NDC is available through census data provided by Guyana's statistical office. Currently, data from 2002 and 2012 have been publicly released. Although the latest national census was conducted in 2022, it has not yet been made public. However, estimated data is available online, and for the year 2021, these figures can be found on the site "Guyana - Subnational Population Statistics - guy_admpop_2021.xlsx - Humanitarian Data Exchange (humdata.org)." Population data based on census findings is also accessible on Guyana's statistical office website under "Census - Bureau of Statistics (statisticsguyana.gov.gy)."

2.2 Economic profile and land use

In this section, a summary of the economic profile and land use is provided. The regional economic situation is crucial as it influences the amount and composition of waste generation. In addition, land use related to economic profile affects suitable waste collection and transportation system and site selection of waste treatment and disposal facilities. The land use map is summarized on the website of "https://glsc.gov.gy/services/maps/#prettyPhoto".

2.3 Natural Condition

In this regional profile, it is essential to provide descriptions of the location and surrounding natural condition. In this section, the following information regarding the natural conditions in each region, including geographical features, geology, hydrology, soil, climate, etc.

Monthly precipitation data is available at the statistical office. The statistical office disseminates data including maximum and minimum temperatures, average precipitation, sunshine hours, humidity, etc. This information is collected from the meteorological station in the coastal regions of Guyana and compiled at the statistical office. It is accessible through Guyana's statistical office and can also be obtained on their website under "Hydrometeorological - Bureau of Statistics" (statisticsguyana.gov.gy).

The physical characteristics, including regional geology, hydrology and soil condition, also play a significant role in the development of waste treatment and disposal facilities. The information such as geological conditions and groundwater flow is useful for the planning and development of disposal and treatment facilities like landfills. A part of these data is accessible through Guyana's statistical office and can be obtained on their website under "Hydrometeorological - Bureau of Statistics (statisticsguyana.gov.gy)."

3 Current condition of SWM

3.1 Institutional Arrangements

3.1.1 Legislation

A SWM plan should be developed based on existing laws, bills, regulations, as well as national strategies and plans. The information on existing legal frameworks should be summarized to provide a clear and concise explanation of relevant laws, bills, and regulations.

In Guyana, there are legal frameworks related to SWM, including draft versions, which encompass the following laws and regulations as follows.

- Municipal and District Councils Act, Chapter 28:01, Laws of Guyana
- Environmental Protection Act, Chapter 20:05, Laws of Guyana
- Environmental Protection litter enforcement regulations, 2013
- Public Health Ordinance, Chapter 145, Laws of Guyana
- Draft Solid Waste Management Bill, 2022
- Regulations No. 8 of 2015 - The Environmental Protection (Expanded Polystyrene Ban) Regulations, 2015

Among these, the Draft Solid Waste Management Bill, 2022 is the basic legislation for SWM and, as of August 2023, has not yet received final approval. Currently the Ministry of Local Government and Regional Development (MLGRD) is undertaking a review and update process. The SWM plan should be prepared based on above existing laws and regulations, and updated based on the status of amendment.

3.1.2 Organization

(1) National Level

In this section, the role and responsibilities of national-level agencies related to SWM should be briefly described.

The Environmental Protection Agency (EPA) is an agency which has the responsibilities of regulating SWM for environmental protection. When developing solid waste treatment and disposal facilities, it requires environmental impact assessments and issues environmental permits for facilities and equipment. It also oversees and regulates hazardous waste, including industrial waste such as waste acids, alkalis, oils, electronic waste, medical waste, and waste generated during oilfield drilling. In the case of medical waste, collaborative efforts with the Ministry of Health are undertaken to formulate measures.

MLGRD is responsible for formulating the country's SWM policy and overseeing local government entities that implement SWM. Local government entities include Regional Democratic Councils (RDCs), Municipalities, and Neighbourhood Democratic Councils (NDCs). However, the actual implementation of SWM is carried out by Municipalities and NDCs. MLGRD supervises and guides SWM activities in these local authorities and is also involved in the operational and maintenance management of disposal sites along with facility design.

(2) Local Authority

Local authority has the responsibility of providing SWM including road cleaning, and drainage cleaning services to residents within their jurisdiction. Then, local authority such as municipality and NDC offers waste collection services, and in some regions, private companies also provide SWM services. In this section, the organizational structure of local authority such as municipality and NDC should be presented and the roles of those responsible for SWM should be described, along with specifying the number and roles of the personnels.

To identify the current organizational capacity where each staff member plays a role in SWM, information on the number of staff and their job responsibilities is essential. The table below shows an example.

Table 2: Information and staff related to SWM in each NDC/municipality

No.	Name of NDC/Municipality	Driver	Waste collector	Other staff (including the role)
Example	Xxx NDC	2	3	1 Revenue Collector 1 environmental education officer
1				
2				

Source: JAT

3.1.3 Finance (Revenue and Expenditure)

The current financial situation should be identified to prepare the plan which is realistic, practical and sustainable. Revenue and expenditure information should be collected not only from the Ministry of Finance, which handles the national budget, but also from local-level agencies such as municipalities and NDCs that manage the budgets of local authorities, in collaboration with the Ministry of Local Government and Regional Development (MLGRD). However, if the expenditures related to SWM are not explicitly described, it is necessary to distinguish and document expenses related to SWM separately from other expenditures. Within NDCs, it is necessary to obtain detailed information on each expenditure item and analysing it for identifying whether it is related to SWM or not.

Table 3: Financial Information in each NDC/municipality

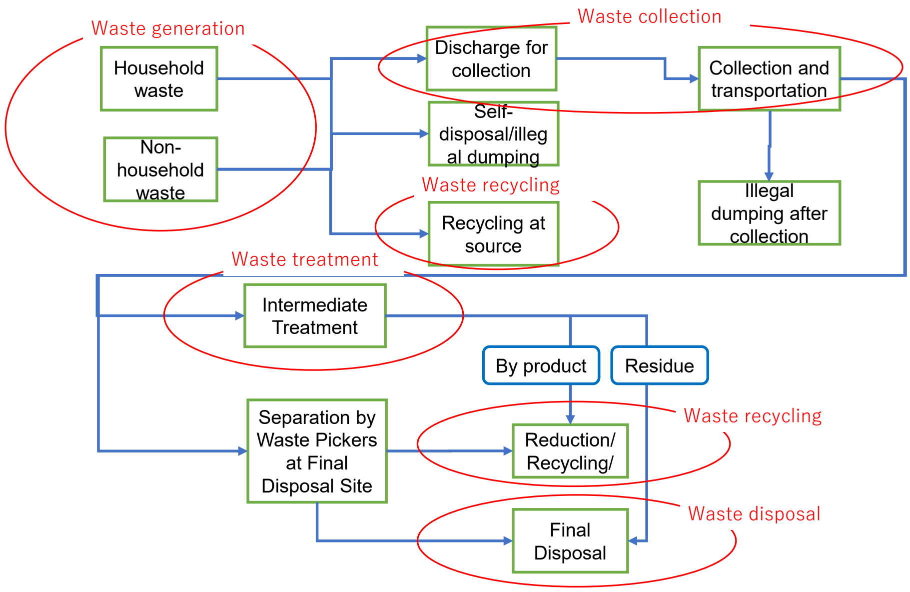
No.	Name of NDC/ Municipality	2019		2020		2021	
		Total budget	Expenditure for SWM	Total budget	Expenditure for SWM	Total budget	Expenditure for SWM
Example	xxx NDC						
1	xxx Municipality -						
2	xxx NDC						
3	xxx NDC						
4	…						
5	…						

Source: JAT

3.2 Technical Aspect

3.2.1 Identification of Current Waste Flow

In preparing SWM plan, it is significant to comprehend the current waste flow. The facilities and infrastructure required for SWM vary depending on the future flow of waste. The future waste flow is planned based on the current waste flow, including generation, collection, recycling, and disposal. In the case of developing countries, including Guyana, not all generated waste is collected. Some uncollected waste is sold to junk buyers for recycling, self-disposed, or dumped in open spaces. While accurately collecting quantitative data for such items is challenging, the information regarding waste amount at the generation source, collection point, and disposal site needs to be obtained for SWM planning. It is necessary to prepare a waste flow diagram as follows, detailing the waste flow from generation to final disposal, considering aspects such as recycling, collection, and disposal.



Source: JAT

Figure 2: Current waste flow

(1) Waste Generation Amount and Composition

To gasp the status of waste generation, it is important to conduct a Waste Amount and Composition Survey (WACS). The purpose of WACS is to identify the per capita daily waste generation amount [kg/person/day] and waste characterization such as physical composition, bulk density, moisture contents, etc. The amount of waste generation fluctuates with the daily activities of waste dischargers, exhibiting variances in activity levels during weekdays and weekends, as well as seasonal variations. Therefore, a survey of waste generation should be conducted, taking into account both seasonal fluctuations (e.g., twice a year during dry and rainy seasons) and daily ones (e.g., over an 8-day period, including holidays). Considering differences between NDCs and variations in waste amounts within each NDC, a sample size of 30-40 samples per NDC is necessary, with a focus on 3-5 NDCs. The necessary indicator to estimate waste generation amount is shown as following table and the detailed methodology for the WACS is provided in Attachment 1.

Table 4: Necessary Indicator to Estimate Waste Generation Amount

Waste generation source		Indicator for unit generation rate to estimate waste amount of the entire city
Household		Population data (including the number of persons in each household) (Desirably, waste generation rate is surveyed for each income level. However, in case of Guyana, there is no date of population data for each income level. In that case, sample will be selected to eliminate imbalance by such as the income level or the family structure, etc.)
Non-household waste (Business establishment such as Commercial, Institutional, others)	Restaurant	Number of seats, number of staffs, sales amount
	Hotel	Number of beds, number of staff, sales amount, number of rooms, etc.
	Shop	Number of staff, sales amount
	Offices/School	Number of staff, number of students, number of rooms

Source: JAT

(2) Waste Collection Amount

The amount of waste collection is estimated based on the number of trips made by each collection vehicle and the capacity of those vehicles. If existing records of receiving waste amount are unavailable, a survey is conducted to obtain the number of trips and the capacity of each collection vehicle to calculate the waste collection amount. The waste collection amount should be estimated these records.

(3) Waste Treatment and Disposal Amount

If the waste treatment facility or final disposal site is equipped with a weighbridge, it is possible to use the records from the weighbridge for measuring the amount of waste treatment and/or disposal. On the other hand, in the absence of a weighbridge, estimation can be based on the number of vehicles and their capacities upon arrival. In some areas, waste pickers may be separating valuable recyclables for resource utilization. The amount can be measured by the method described in the section of "(4) Waste Recycling". In such cases, it is necessary to subtract this amount from the recorded data on the weighbridge.

It is desirable to measure the composition of waste within the facility. Considering intermediate processing facilities and sorting facilities for reuse, a composition survey is necessary for waste processed and disposed of at the facility.

(4) Waste Recycling

To accurately understand the amount of recycled waste, it is necessary to gather information about junk shops and activities related to waste picking. Through on-site surveys at landfill sites and interviews conducted at some workshops, it is possible to roughly identify the amount of recycled waste. A sample format for information on waste recycling is provided in the table below.

Table 5: Information of Recycling Company and/or Junk Shop

No.	Name of company	Contact information (telephone number, e-mail)	Type of handled recyclable
Example			
1			
2			
3			

Source: JAT

Once the recycling companies and/or junk shop are identified, it is necessary to collect information from them regarding the amount of recyclable handled and their selling prices. A sample format for data collection is presented below.

Table 6: Information of Recyclable Handled in Each Company and/or Junk Shop

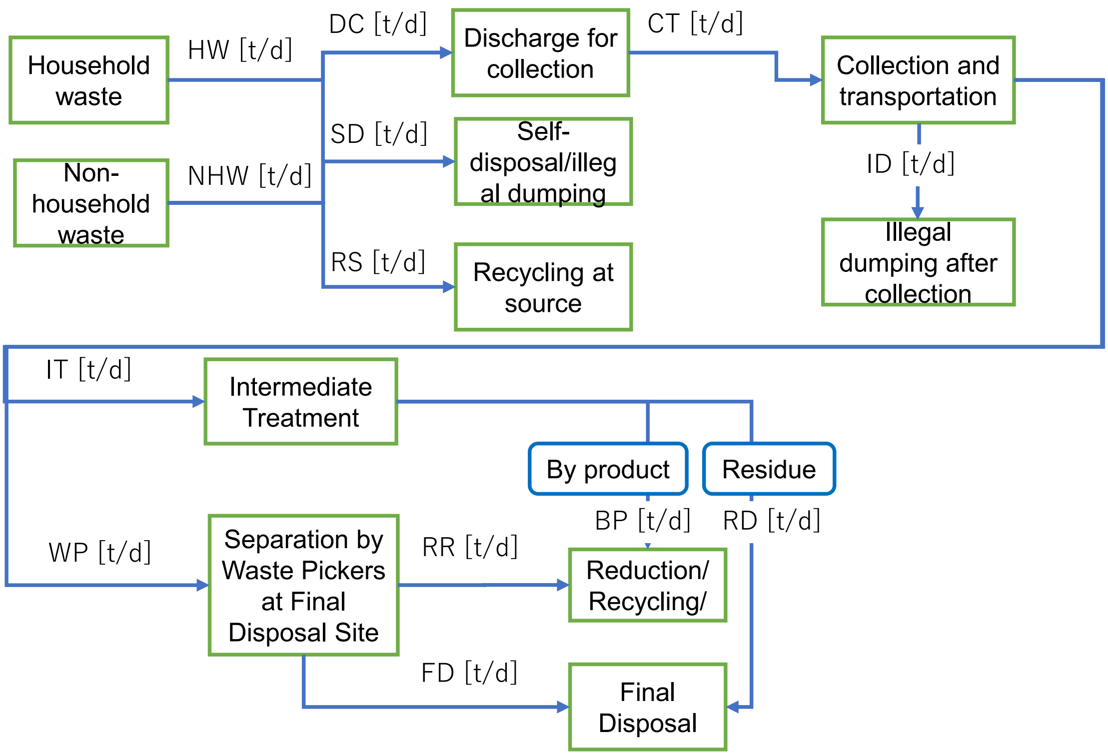
No.	Type of handled recyclable	Amount of handling [kg]	Selling price [GYD/kg]	Buyers
Example				
1				
2				
3				

Source: JAT

(5) Presentation of Current Waste Flow

After estimating the amount of waste generation, collection, uncollected waste, waste disposal, and waste reuse, it is essential to identify the waste flow. In the process of organizing the waste flow, discrepancies or abnormal data in the amount of waste can be relatively easily identified in waste flow. If there are discrepancies or abnormal data, a reconsideration of waste data is necessary to obtain accurate information. These precise data are crucial for inclusion in the regional SWM plan.

Based on the results of the waste amount and composition survey, the current estimated amounts of waste generation, collection, processing/disposal, and reduction/resource utilization should be represented as an example of the waste flow, as shown in the figure below.



Source: JAT

Figure 3: Current waste flow

Each value in the waste flow has the relationship described as the following formula.

HW[t/d] + NHW[t/d] = DC[t/d] + SD[t/d] +RS [t/d]

DC[t/d] = CT[t/d]

CT[t/d] = ID[t/d] + IT[t/d] +WP[t/d]

TFD[t/d] = FD[t/d] + RD[t/d]

HW : Household Waste Amount

NHW : Non Household Waste Amount

DC : Discharge Amount for Collection

SD : Self disposal/ Illegal Dumping Amount

RS : Recycling Amont at Source

CT : Collection and Transportation Amount

ID : Illegal Dumping Amount after Collection

IT : Intermediate Treatment Amount

WP : Waste Hauling Amount to Final Disposal Site

RD : Residue Amount from Intermediate Treatment

TFD : Total Final Disposal Amount

3.2.2 Source reduction and discharge

This section provides a description of the current status of waste generation source reduction and disposal methods. The objective is to understand the current situation and extract challenges by comprehending the current state of waste reduction at the source and discharge methods. Regarding the waste reduction, there are various methods such as home composting or selling recyclable to junkshop, etc. Regarding the discharge methods for waste, there are various methods such as disposal in bins, bagging, container discharge, etc. These situations are assessed through interviews with each municipality and on-site inspections, and the information is organized accordingly.

3.2.3 Collection and transportation

In this section, the current state of waste collection and transportation is outlined. The purpose of understanding the current state of waste collection and transportation is to grasp the situation in each municipality and extract challenges. The objective of time and motion studies is to evaluate the efficiency of waste collection and transportation by measuring the collection and transportation time and incorporate these findings into the planning process.

The required information includes the current collection rate, the condition of collection equipment (types, quantities, and trip counts), and the operational status of each collection vehicle (operating hours and movements: time and motion).

To gather information on the current collection rate and the condition of collection equipment, interviews with local authorities (NDCs) are conducted. The collected information is organized into a table, summarizing the collection rate, types and quantities of collection and transportation equipment, and trip counts.

Table 7: Information of Collection and Transportation

No.	Name of NDC/Municipality	Coverage area (%)	Type and Number of collection vehicle	Number of average trip per vehicle	Remarks
Example	xxx NDC				
1	xxx Municipality -				
2	xxx NDC				
3	xxx NDC				

Source: JAT

Table 8: Information of Collection and Transportation Vehicle

No.	Type of Vehicle	Capacity [ton and/or m3]	Average trip number [trip/day]	Average loading rate [%]	Remarks
Example	Compactor	5 [ton/day]	3	86	
1					
2					
3					

Source: JAT

On the other hand, the operational status of each collection vehicle is assessed through time and motion studies. Due to variations in loading time, unloading time, and transportation time depending on the vehicle type, such as compactor vehicles, dump trucks, skips, tractors, etc., time and motion studies are conducted through sampling for each vehicle type approximately 2 to 3 times. Since transportation time can be significantly influenced by factors like road conditions, in addition to the vehicle type, it is necessary to conduct 2 to 3 trips. The necessary information for time and motion survey is shown below.

Table 9: Necessary Information for Time and Motion Survey

Item	Contents
Time for preparation	Measure the time to prepare the departure
From the garage of collection vehicle to collection area	Measure the time and distance from the garage to collection area
Collection time and distance	Measure the waste collection time including loading time and moving time in the collection area and the moving distance during the collection
Transportation time and distance	Measure the waste transportation time and distance from the final points in the collection area to waste treatment and disposal facilities.
Waiting time in treatment and disposal facilities	Measure the waiting time at waste treatment and disposal facilities
Unloading time at waste treatment and disposal facility	Measure the unloading time at waste treatment and disposal facilities
Other time	Measure the time of daily maintenance and/or resting time of staff, etc.
Waste amount for collection and transportation	Measure the waste amount by weighbridge data or estimate the waste amount based on the capacity of each vehicle and the pictures

Source: JAT

Based on the measured time and distance data as described above, organize speed and time by vehicle type, and calculate data for time and speed for each vehicle type.

For detailed procedures of the time and motion study, refer to Attachment 2. In the case of Guyana, the introduction of a waste transfer transport system, including secondary transport to primary collection, transfer facilities, and final disposal sites, is a rare occurrence. However, if there are regions that have implemented a waste transfer transport system, it is necessary to investigate the primary collection, transfer facilities, and secondary transport to waste treatment and disposal facilities. When transfer facilities are used to transport waste to final disposal sites, provide information on the location, capacity, types of loading and unloading of waste, recovery of recyclables, facility/equipment details, operational status, and staff details.

3.2.4 Recycle and/or Recovery

In this section, the current status of recycling and reuse will be described. Currently, an investigation into recyclable waste and its market routes aims to understand whether sorting is being carried out at the source of emission or disposal sites. If sorting is not being conducted, the reasons for this need to be identified. This involves determining whether the reason is that there is no recycling market or that recyclable materials are not being sufficiently separated during the generation, collection, treatment/disposal processes though there is recycling market, etc.

On-site interviews should be conducted to investigate the recycling situation and current recycling and reuse activities. In Guyana, the only recyclable items are metal and glass beer bottles. These are collected at disposal sites by waste pickers, with metals exported through intermediary agents to countries like Trinidad and Tobago, and glass beer bottles reused within Guyana. Other recyclable materials were exported after shredding, but due to unstable distribution channels and markets, a consistent recycling route has not been established.

If considering the possibility of sustainable recycling, a brief market survey is necessary to gain a clearer understanding of the demand in the domestic recycling market and the recycling routes in neighboring countries.

3.2.5 Final Disposal

In this section, it is necessary to describe the current status of final disposal and extract challenges regarding how to improve it in the future. The goal is to understand the current situation of disposal sites, identify issues for improvement, grasp the current disposal amounts, and incorporate them into future planning.

In the case of Guyana, waste collected by local authorities such as municipalities and/or NDCs is typically disposed of in disposal sites. These disposal sites are open dumps without equipment like bulldozers for spreading and leveling the waste, heavy equipment (e.g., excavators) for moving incoming waste and/or for soil cover, or facilities for management (e.g., office buildings) and weighbridge. The example data format for collecting information on the final disposal site is shown below.

Table 10: Information of Existing Final Disposal Site

Item	Note for description
Area [m2]	Total area and landfill area should be described
Equipment	Type of equipment should be described such as bulldozer, wheel loader, excavator and landfill compactor or dump truck, etc
Facility	Gate, fence, landfill area, internal road, rainwater drainage, etc should be described with the specifications and pictures if there area.
Role and number of Staff	The role and the number of staff such as landfill manager, security staff, landfill equipment operator, etc should be described if there.
Operation condition	The situation of spreading and compaction of waste after unloading, implementation of soil cover should be described.
Waste picker activity	Number of waste pickers and type, amount and price of recyclable waste should be described

Source: JAT

3.2.6 Public awareness and environmental education

In this section, we study the current status of existing public awareness initiatives, specifically focusing on Information, Education, and Communication (IEC) activities. The aim is to identify challenges and undertake efforts to reflect them in future plans. We describe the implementation status of activities such as waste reduction, reuse, resource recovery, and composting promotion in each local authority. Additionally, information related to waste collection services, waste disposal, public hygiene and health, and environmental issues disseminated to the general public through awareness campaigns is included. During the investigation, interviews with local government stakeholders, as well as residents and businesses, are conducted to explore the awareness of waste generation sources and the beneficiaries of collection services among residents and businesses.

3.3 Identified Key Issues

Based on the current investigation, it is essential to grasp and identify the key issues and challenges in order to prepare a future implementation strategy. These issues encompass various aspects such as legal frameworks, organizational structures, waste generation, collection and transportation, processing and disposal, as well as discussions on the principles of 3R (Reduce, Reuse, Recycle). Issues related to waste collection and transportation, processing, disposal, and 3R can be discussed by utilizing waste flow diagrams, incorporating information from sources like WACS, along with photos and mapping data gathered through stakeholder interviews and on-site surveys to illustrate the situation.

4 Future Framework of Solid Waste Projection

4.1 Population Projection

In the development of a regional SWM plan, it is imperative to estimate population projections. Utilizing population forecasts from existing regional plans is advisable if applicable. However, in the case of Guyana, there are regions without such plans. In such instances, it becomes necessary to rely on data from the previous census for population estimation. Alternatively, in the absence of the latest census data, population projection websites such as "Guyana - Subnational Population Statistics - guy_admpop_2021.xlsx - Humanitarian Data Exchange (humdata.org)" for the year 2021 can be considered.

Furthermore, when anticipating future population influx or outflow from other regions, it is crucial to incorporate these factors into the forecasting process. For analyzing population growth scenarios, preparing three or more scenarios, such as high, medium, and low, is recommended. These scenarios should be compared and evaluated, leading to the selection of the most appropriate one. The following shows a scenario analysis for Region 5 as an illustrative example.

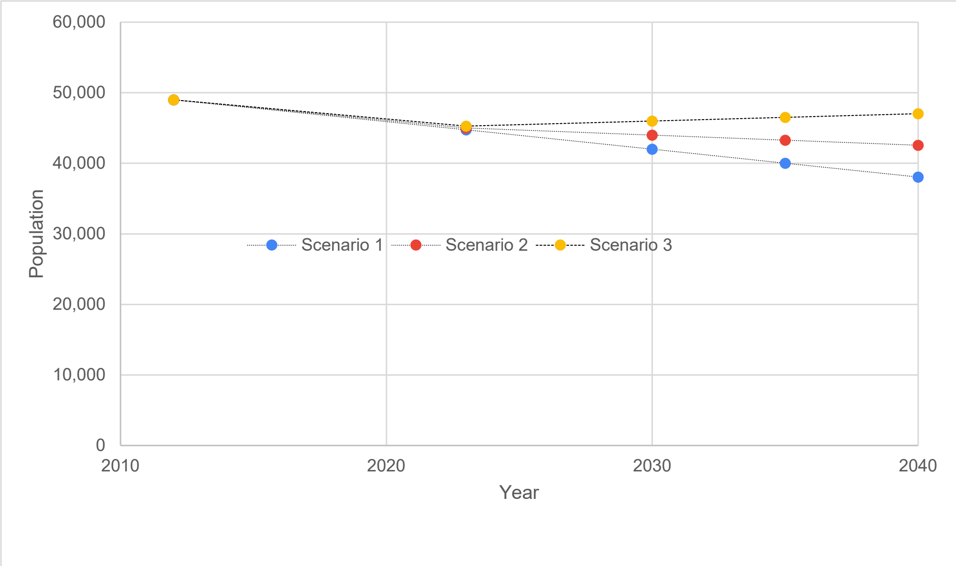
According to census data from 2002 and 2012 in Region 5, there has been a population outflow towards the urbanizing Region 4, leading to a gradual decline in the population growth rate in Region 5. Conversely, housing development plans are underway in Mahaïca and other regions adjacent to Region 4, suggesting a potential halt in the future trend of population outflow and a decrease in the population decline rate. Based on these considerations, three scenarios were examined, and population forecasts were conducted as shown in the following figure.

Scenario 1 is a scenario where housing development is promoted more than now, leading to population growth towards 2040.

Scenario 2 is a scenario that ongoing housing development near the western area in Region 5 will progress but the movement of the people from the eastern area in Region 5 to Region 4 will result in a slight population decline in Region 5.

Scenario 3 is a scenario where the current population decrease continuously.

As a realistic scenario, it is considered plausible that the population will decrease, but due to urban development in Region 4 and suburban housing development in the western part of Region 5, the population decline trend will slightly plateau. Therefore, Scenario 2 has been adopted in this plan.



	2012	2023	2030	2035	2040
Scenario 1	48,985	44,764	42,000	40,025	38,051
Scenario 2	48,985	45,014	44,000	43,275	42,551
Scenario 3	48,985	45,264	46,000	46,525	47,051

Source: JAT

Figure 4: Example of Population Projection

4.2 Projected Waste Generation

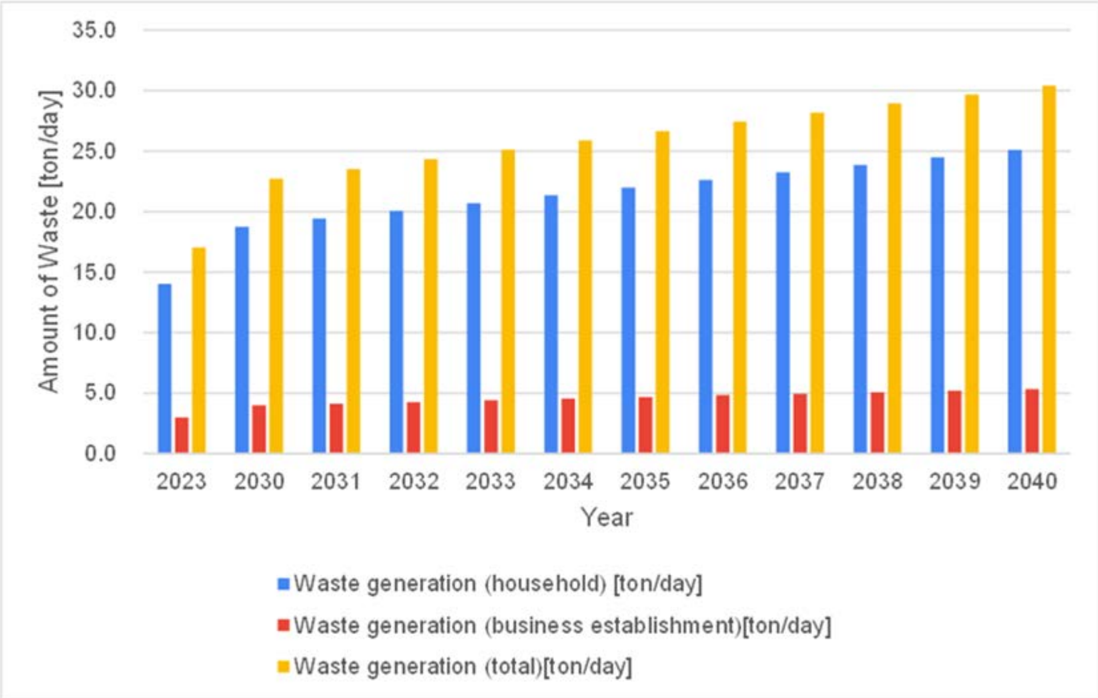
(1) Household Waste

As one approach to future projections, it is essential to estimate the future per capita daily waste generation based on the per capita daily waste generation amount [kg/person/day] obtained from waste amount and composition survey. In doing so, analyzing past trends and utilizing them for future estimates becomes feasible. These future estimates should be set, taking into account not only past trends but also factors such as neighboring areas, surrounding regions and levels of development. These projections can then be multiplied by the anticipated population to estimate future waste generation.

For instance, in the case of planning for Region 5, as Waste Amount and Composition Survey (WACS) were not conducted before 2023, an analysis of past trends was not possible. The baseline unit of current waste amounts is derived from the WACS conducted in 2023. Assuming urbanization in Georgetown aligns with the current situation until 2040, the Urban Growth Rate (UGR) of Georgetown is employed as the UGR for Region 5.

(2) Waste from Business Establishment

In cases where industrial development in a region is pronounced, it is anticipated that the rate of increase in waste generation from business establishments will significantly differ from that of household waste generation. However, assuming a similar urbanization process, it can be hypothesized that the rate of waste increase from workplaces can be assumed to be the same as that from households. For example, based on these assumptions, the future waste generation in Region 5 was estimated as follows.



Source: JAT

Figure 5: Projected Waste Generation in Region 5

5 Strategy for Planning

5.1 Vision and Goals

In alignment with Guyana's national waste strategy, it is imperative to formulate visions and goals that take into account the characteristics of each region. The current vision outlined in the national waste strategy is as follows.

"To participate in a nationwide integrated and financially self-sustainable SWM and resource recovery system that preserves public health and the environment, realizes the maximum value of resources, and minimizes long-term costs to households, industries, and the government."

Drawing from the National Waste Management Strategy, here are examples of key items:

1. Reduction of littering and illegal dumping.
2. Minimization of waste generation.
3. Enhancement of resource recovery.
4. Efficient and cost-effective waste collection.
5. Improvement of waste management facilities
6. Strengthening of human resources and institutional capacity.

As exemplified above, it is necessary to formulate goals and strategies for regional planning based on the National Waste Management Strategy.

5.2 Targets

Based on the current conditions in each region and in alignment with the National Waste Management Strategy, it is essential to establish achievable and realistic goals. These goals should be set considering the current situation, and points for future improvement should be progressively addressed. When developing this regional plan, it is advisable to set target years for the short term, medium term, and long term. In the National Waste Management Strategy in Guyana, the targe year is set as 2030 drafted in 2017. The target year will be after 15 to 20 years. In the period, each target for short, middle and long terms should be set. In this context, an example of timeframes for the short term, medium term, and long term are provided below.

Short term : Year 2023–- 2030

Middle term : Year 2030–- 2035

Long term : Year 2035–- 2040

As crucial indicators, the current collection rate (waste collected / waste generated), self-disposal rate (waste not collected / waste generated), recycle rate (recycled waste / waste collected), and final disposal rate (disposed waste / waste collected) should be established as future target values. Examples of set goals are provided below. These indicators will be continually adjusted based on the conditions. The following are examples of indicators for the SWM plan in Region 5.

Table 11: Future Target of Each Waste Management Rate

Item	2023	2030	2035	2040
Collection Rate (%)	70%	80%	85%	90%
Self-disposal Rate (%)	30%	20%	15%	10%
Recycle Rate (%)	2%	5%	7%	10%
Final disposal Rate (%)	98%	95%	93%	90%

Source: JAT

5.3 Future Waste Flow

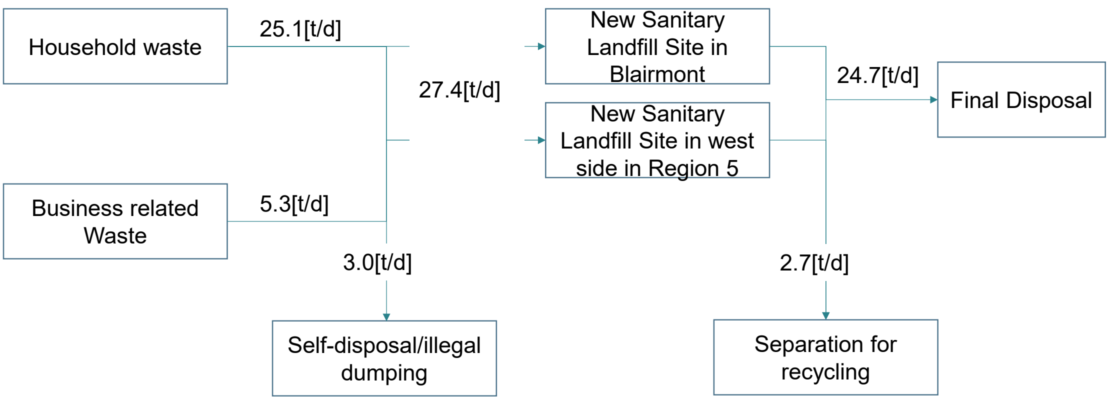
Based on the establishment of future goals, it is necessary to utilize an excel spreadsheet to calculate waste generation, collection and transportation, final disposal and recycling amounts, etc. Additionally, the future waste flow should be presented. The example of the case in 2030 in Region 5 is shown as follows.

Table 12: Example of Estimation of Waste Generation, Collection and Transportation, Recycling and Final Disposal Amounts

Item	2023	2030	2035	2040
Waste generation (household) [ton/day]	14.0	18.8	22.0	25.1
Waste generation (business establishment)[ton/day]	3.0	4.0	4.7	5.3
Waste generation (total)[ton/day]	17.0	22.7	26.7	30.4
Collection ant transporation amount [ton/day]	11.9	18.2	22.7	27.4
Self disposal amount [ton/day]	5.1	4.5	4.0	3.0
Recyling amount [ton/day]	0.2	0.9	1.6	2.7
Final disposal amount [ton/day]	11.7	17.3	21.1	24.7

Note: In the above case, "recycling at source", illegal dumping after collection, intermediate treatment is assumed.

Source: JAT



Source: JAT

Figure 6: Future Waste Flow in 2040

5.4 Strategy to Satisfy the Target

To address the current issues and challenges outlined in Section 3.4, strategies will be formulated along with the vision and goals set in Sections 5.1 and 5.2. For each aspect regarding legal frameworks, organizational structures, collection and transportation, intermediate treatment/3R, and final disposal, the gap analysis will be conducted by comparing the current status with the goals. This analysis will extract the gaps and guide the development of specific strategies. Below is an example of a gap analysis.

Table 13: Issues and Direction for the Future to Satisfy the Target

Item	Desirable situation to be targeted	Current problem/issue	Direction for the future to satisfy the target
Legal system	The Basic Act for SWM is established.	The Basic Act for SWM has yet to be established.	The Basic Act for SWM is established through support by foreign consultants.
	Necessary management regulations and technical guidelines for collection, transportation, recycling, and final disposal have been established	Management rules and guidelines for collection, transportation, recycling, and final disposal based on the Basic Law have yet to be established.	After the Basic Law is enacted, various guidelines will be established.
	National and regional SWM plans are established.	National and regional SWM plans have yet to be established.	A regional SWM will be established.
Organizational system	Suitable organizations of SWM have been established to implement SWM with sufficient organization and staff.	Suitable organizations of SWM have yet to be established.	The establishment of the National Solid Management Authority is described in the Basic Law on SWM, and the suitable organizational structure would be strengthened after the formulation of the Basic Law.
	National government agencies or local authorities are able to contract with private companies to implement SWM.	Monitoring of the private company conducting the collection has yet to be implemented.	In the future, when the NDC will gradually change from the direct collection by NDC to private contractors and collect waste collection service charges from residents, the National Solid Management Authority will contract with a private company to perform SWM.
Collection and transportation	Efficient collection is needed to satisfy the future targets of the collection rates.	Tractor-trailer-based collection systems could be more efficient when considering the expansion of collection areas and future transportation to new sanitary landfills.	The collection and transportation system will be improved by utilizing compactor trucks, which is partially implemented by private companies.
	The collection area is clear, fixed-point collection is implemented.	Although private collectors and transporters are collecting in some areas, the scope of the collection is not known by government agencies, and supervision and monitoring of SWM still need to be established.	Monitoring responsibilities in contracts between the government and private companies will be included and a mechanism for monitoring will be established at each NDC.

Item	Desirable situation to be targeted	Current problem/issue	Direction for the future to satisfy the target
Final disposal	Final disposal sites are not open dumping, but sanitary landfill site and the sites are properly operated.	The current disposal sites at each NDC are open dumping and there are no heavy equipment and the landfill area to be disposed of needs to be set up clearly.	The current disposal site is open dumping and needs more capacity for future landfilling is required. Therefore, a new landfill site will be developed, and the current disposal site will be closed with environmental remediation.
		A new sanitary landfill is currently planned, but the area is in low-level ground with adjacent drainage channels and potentially a higher groundwater table.	Due to lower level land, it is necessary to consider a liner system as well as the necessity of a groundwater collection system. It will be necessary to design based on necessary topographical surveying and geological investigation to secure the gradient of rainwater drainage and leachate collection and drainage in the future.
Reduce, Reuse, Recycle (3R)	With regard to the 3Rs, a state in which waste reduction is progressing and a collection system for reusable and recyclable (recyclable) waste has been established.	In Guyana, recyclable waste is currently limited. Only metals and glass bottles are accepted, while cardboard and plastic bottles may not be valuable.	The separation at the source and efficient collection of valuable materials will be promoted. A sorting area within the final disposal site will be prepared for the efficient collection of a recyclable waste considering the work environment for waste pickers. As for waste reduction, there is a collection system for returnable bottles, and in the future, programs to reduce waste at home and at schools will be promoted.
		Waste pickers collect valuable materials at the disposal site, but the work environment could be better and the system for efficient collection still needs to be put in place, and some recyclable waste is dumped without being collected.	

Source: JAT

In terms of strategies, initiatives such as waste reduction, promotion of recycling, improvement of collection and transportation, and final disposal are outlined. However, detailed technical options for these strategies are presented in Chapter 6.

Promotion of reduction and recycling

(1) Promotion of waste separation of recyclable at source

To promote recycling, it is essential to establish source separation of recyclable waste at waste generation sources such as residents and business establishment. This involves setting up a future source separation system, such as separate collection or collection at designated points in front of shops, etc., to encourage separation at the source. When source separation is conducted, it is conceivable to carry out periodic collection, perhaps on a monthly basis, for specific recyclable or reusable waste such as metal or glass bottles, starting on a small scale and gradually expanding the area and frequency. Additionally, considering business establishments and schools as potential collection points of recyclable.

(2) Promotion of waste reduction at source

To reduce the amount of waste generated, it is conceivable to restrict the distribution of free plastic bags. In Region 4, there has been a case where a pilot project for composting food waste was implemented. Based on the results of this project, the implementation of composting food waste by residents and schools is also under consideration.

Improvement of collection and transportation

(1) Establishment of fixed time and location of collection system

Even in locations where collection services are provided, there may be instances where the collection is not conducted regularly and on schedule. It is essential for each local government to monitor collection areas. Therefore, there is a need to establish a collection system by specifying collection times and points, enabling each NDC to monitor collection areas. This includes locations where private enterprises are involved in waste collection.

(2) Efficient collection and transportation

Currently, NDCs are conducting collection and transportation using small tractors, but this method seems to be inefficient due to low speed limit and small capacity of container of the tractor. Especially in the future, with the development of a waste disposal facility shared by all NDCs and the collection area in each NDC will be more far from the waste disposal facility. Therefore, large capacity of vehicle and higher speed for the transportation is necessary for efficient collection and transportation. Therefore, it is desirable to gradually make transition to more efficient collection and transportation methods such as compactor trucks or skips. In some cases where private enterprises are involved in collection, compactor trucks and skips are already utilized, and by observing these situations, it is believed that the efficiency of collection and transportation can be enhanced through system changes. Specific options for efficient collection and transportation are detailed in Chapter 6.

(3) Improvement of collection rate and frequency

In many NDCs, the collection frequency ranges from once a week to once every two weeks. As a result, even in areas where collection is being carried out, waste storage at individual households and businesses is challenging, leading to illegal dumping in open spaces and drainage channels. Therefore, there is a need for an improvement in the collection rate and an increase in collection frequency.

Improvement of Final Disposal

(1) Development of Sanitary Landfill Site for Final Disposal

In most of regions in Guyana, there is no sanitary landfill for final disposal, and there is a need to establish a new disposal site. The disposal site includes landfill sections, stormwater drainage facilities, gas venting pipes, facilities for the collection, drainage, and treatment of leachate, weighbridge, heavy machinery, among others.

(2) Closure of Open Dump Site and Environmental Remediation

After the development of the new landfill site, the existing open dump sites of each NDC should be closed. The closure plan includes the implementation of final cover to prevent rainwater infiltration for the environmental remediation.

6 Improvement of Technical System for SWM

6.1 Collection, Transportation and Sweeping

In this section, it is essential to outline a collection and transportation plan based on a strategic approach. The plans should be formulated to enable scheduled fixed point collections at regular intervals. There are mainly three types of collection system. The comparison of these systems is presented below.

Table 14: Comparison of Collection System

Item		Door to Door	Station	Container
Method		- Residents discharge waste in front of their houses on time and it is collected.	- Residents discharge waste into stations and it is collected.	- Residents discharge waste into the container and the container is transported.
Burden to residents	Discharge time	- Necessary to discharge at a fixed time.	- Necessary to discharge at a fixed time.	- There is no discharge time setting.
	Destination	- Discharge in front of the house	- Necessary to transport waste to the station	- Necessary to transport waste to the container
Management of the discharge point	Discharge site management	- No need to clean or manage collection sites.	- Station cleaning and maintenance required.	- Container cleaning and management required.
	Identification of not cooperated waste generators	- Easy for identification	- Hard for identification	- Not possible

Source: JAT

(1) Discharge Method

There are several options for waste disposal. To find the most suitable solution for each region, it is necessary to consider and compare the available alternatives for waste discharge methods. The comparison of waste discharge methods is shown below.

Table 15: Comparison of Discharge Method

Method of discharge	Feature	Image of equipment/situation	Proposed target area or target waste for this project
Garbage bin	Currently, private companies or NDCs rent waste bins for waste dischargers. Due to this system, the surrounding area will be kept clean.		Utilization for residential area Stations are prepared for 30 households
Plastic bag in an open space	It is a simple matter but there is some possibilities of the waste being scattered		Due to the possibility of waste scattering, it is not recommended. However, it is possible if monitoring system through environmental education in each NDC.
Metal container	Suitable for residential areas where waste dischargers bring the waste to the station and put the waste in the area.		Utilization for residential area Stations are prepared for around 20 to 40 households
Skip Container	Suitable for waste from the market areas where the container needs a certain area for installation.		Utilization for large-scale market area in the future

Source: JAT

(2) Type of collection equipment

The comparison of each type of collection equipment is shown as follows.

Table 16: Comparison of Collection Equipment

Method of collection and transportation	Image of collection and transportation system	Proposed target area or target waste for this project
Transport by compactor vehicle after the compaction of receiving waste in the vehicle		Compactor can transport waste efficiently by compaction. Loading is not so difficult due to the lower bucket. Large type compactor vehicle can be transport efficiently due to large capacity and smaller type compactor vehicle can collect the waste from generation source along narrow road.
Transport by dump truck after the receiving waste in some transfer stations by manual or equipment		Collect various types of waste such as bulky waste or glass bottles but the waste transportation is not as effective as compactor vehicle. Smaller type dump truck is suitable for narrow road.
Transport by skip container/container carrier		Collect various types of waste such as bulky waste or glass bottle. No need of loading waste manually but loading the skip or container carrier of each waste

Source: JAT

(3) Planning Condition

It is necessary to establish basic conditions in the planning of each region. The example of basic condition is shown as follows.

Table 17: Basic Condition for Collection Plan

Item	NDC Areas in the region
Target NDCs	Name of NDC
Collection frequency	Twice a week
Collection vehicle	Compactor vehicle (12m3, 8m3, 4m3)
Working hour	8 hours from Monday to Saturday

Source: JAT

The collection and transportation plan should be formulated based on information related to the targeted waste (including waste amount and characteristics), collection areas, and receiving facilities (such as intermediate processing facilities or final disposal sites).

(4) Basic plan of collection and transportation

The basic plan for collection and transportation should be developed based on collection areas and the locations of SWM facilities. The planning process of the collection and transportation to SWM facilities is described as follows.

1) Confirmation of Target Collection Areas

   Initially, it is necessary to establish and confirm all target collection areas. Estimation of the amount of waste generated and the characteristics of waste at each target area is essential.

2) Estimation of Waste Amount Generated in the Target Areas

   The approximate amount of each waste generated in the target areas is calculated. If a separate collection system is introduced, the recycle, treatment or disposal methods for each type of waste should be considered and separate collection for each type should be conducted. The amount for each separated type could be estimated and the collection schedule for separate collection should be considered.

3) Examination of Collection and Transportation System

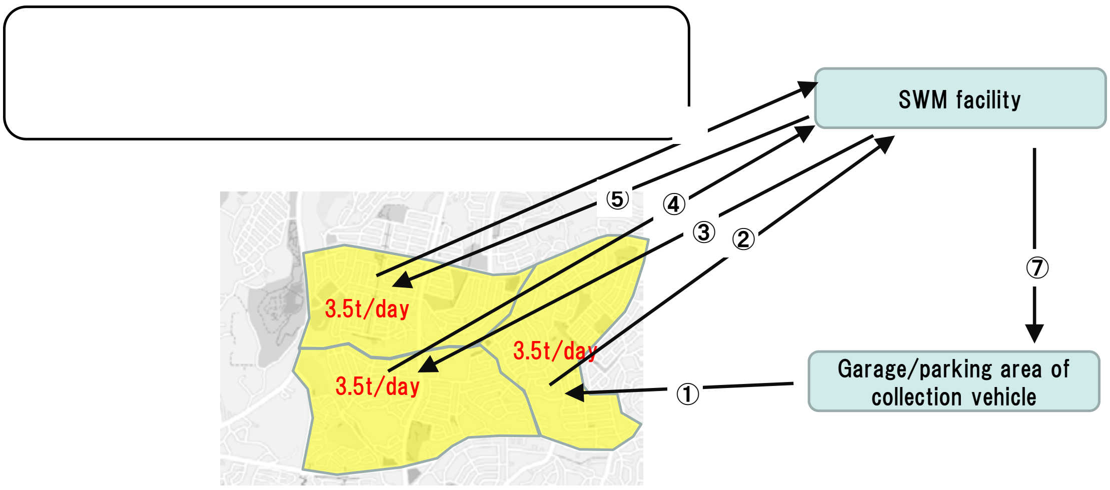
   The type of waste collection and transportation vehicle should be selected for each area with consideration of area characteristic such as road condition, width, population density the availability of the area for waste bin and or storage, possible distance in which waste can be brought by waste generators. For example, road width will affect the size of collection vehicles for transportation and possibilities of setting container. Population density will affect the necessity of primary collection.

4) Setting Collection Frequency and Operation Hours

   Collection frequency and operational hours for collection and transportation throughout the target region should be set.

5) Division of Target Collection Areas for Each Collection Vehicle Trip

   The target collection area should be divided into sections where each collection vehicle can collect waste in a single trip. For instance, if the loading capacity of a collection vehicle is 3.5 tons, divide the target collection area into regions where the waste collection amount does not exceed 3.5 tons. The number of divided collection areas corresponds to the number of trips.



Source: JAT

Figure 7: Typical trip between collection area and SWM facility

6) Calculate an approximate collection and transportation time per trip.

7) Determine the number of trips each vehicle can make in a day to collect the targeted waste.

8) Take into account the total operational time available for collection and transportation in a day, calculate the required number of collection vehicles based on the number of trips possible in a day.

(5) Main items for detail planning after vehicle procurement

1) Allocate each collection vehicle to the target collection areas, considering the estimated trip time from each trip area to the processing facility.

2) Adjust the collection and transportation time based on factors such as collection points and road conditions that may cause variations in time.

3) Adjust the amount of the target waste based on factors such as daily and seasonal variations. In cases where the planned amount of waste cannot be collected by the assigned collection vehicles, the nearest vehicle can provide assistance through communication devices such as mobile phones.

4) Ensure a clear understanding of the target areas for each collection vehicle, it is beneficial to prepare maps that include collection points and routes.

(6) Detail Plan (Routing and Scheduling)

For a detailed plan, it is essential to have the collection and transportation routes and schedules. In addition to the initial plan, monitoring is necessary during the implementation phase, and based on the results of the monitoring, the plan, including collection and transportation routes and schedules, the route and schedule should be updated. An image of a monitoring sheet for monitoring the planned collection is shown below.

Table 18: Image of Monitoring Sheet for Scheduled Collection

Area	Point No.	Number of households, business establishment	Estimated collected waste amount [kg/day]	Planned arrival time	Actual time	Remark
Area A	1	10	9	9:00	9:00	
Area A	2	7	6.3	9:02	9:03	
Area A	3	8	7.2	9:05	9:06	
Area A	4	7	6.3	9:07	9:08	
Area B	5	7	6.3	9:10	9:12	
・・・	・・・	・・・	・・・	・・・	・・・	・・・
・・・	・・・	・・・	・・・	・・・	・・・	・・・

Source: JAT

(7) Sweeping

In this situation, the sweeping and cleansing activities should be described. Currently, in Guyana, clean-up campaigns are sometimes conducted by various government ministries and private organizations under the directive of the president. These activities need to be carried out on a regular basis. On the other hand, it is crucial to educate local communities to prevent the waste dumping in surrounding areas and to keep the communities clean.

Furthermore, it is important to educate the general public about cleanliness, and conducting campaigns through schools, religious institutions, and businesses establishment. Particularly in areas where collection is irregular, scattered litter is observed. Outsourcing waste collection services, including waste cleaning, as a beautification service utilizing the specialized knowledge of private enterprises, could enhance the efficiency of service provision and contribute to the improvement of collection services.

6.2 3R (Source Reduction, Reuse, Recycle)

(1) Source Reduction

In this section, we will discuss waste reduction at the source. The following are examples of programs aimed at reducing food waste and other types of waste. Composting at the source is an effective means to reduce food waste. On the other hand, proposals include programs for returning glass bottles to retailers and reducing the use of plastic shopping bags to decrease non-biodegradable waste. The examples of source reduction program show as follows.

Table 19: Source Reduction Program

Objective	Item of the Activity	Contents
Reduction of organic waste	Promotion of home composting	Small scale compositing will be promoted for each household and small business establishment.
Reduction of inorganic waste	Promotion of collection of plastic containers for recycling by an economic incentive such as a deposit system	For producers, the collection of a used bottle is required. A deposit system on the product to collect used empty containers is introduced as a part of the procedure. This system is partially introduced for glass bottles but not plastic containers. The system will be promoted for plastic containers in the future.
	Promotion of reduction of usage of the plastic shopping bags	To reduce plastic shopping bags, my bag campaign will be implemented and plastic bags in the market will be charged.
	Introduction of group collection	Recyclable waste is collected at existing places where people gather, such as in front of the store, schools, and religious facilities (churches, temples, mosques, etc.). when a certain amount is accumulated, it is sold to a company that has recyclable waste.

Source: JAT

(2) Recycle

This section should describe the recycling plan. In Guyana, recycling is limited to the reuse of certain glass products such as locally produced beer bottles and the recycling of used metals. Metals are exported to other countries like Trinidad and Tobago, and the recycling market for valuable materials is very limited. To promote the recycling of valuable resources in the existing recycling market, the establishment of a system and technological development for resource recovery is essential.

Due to constraints in the recycling market and fluctuations in prices, sustainable recycling businesses cannot be realized without government subsidies or improvements in the appropriate institutional framework. Guyana is considering the introduction of Extended Producer Responsibility (EPR) and exploring the reduction of single-use plastic bags, as outlined in the draft Solid Waste Management Bill of 2022 and the National Waste Management Strategy from 2017 to 2030.

To promote recycling, it is crucial to establish an EPR system where consumers, collection companies, recyclers, manufacturers, and distributors, among other participants, actively engage in recycling. Roles and responsibilities for participation can be categorized into physical responsibilities for collection, transportation, sorting, and resource recovery; economic responsibilities such as financial burdens; and informational responsibilities such as providing information on product materials, sorting collection methods, and collection points. The following provides examples of the role and responsibility at each stage.

Table 20: Source Reduction Program

Each Item regarding responsibility	Each Stage		
	Pre consumer stage	Post consumer stage	
	Product design / retailing stage	Collection and transportation stage	Recycling Stage
Physical responsibilities (collection and transportation, recycling, final disposal of recyclable waste)	-	Local authority (ex. separate collection) Distributer (Establishment of collection depot)	Recycling facility operated by local authority Recycling company
Economic Responsibility (Financial burden)	-	Local authority (tax and subsidy from central government) Producers (collection transportation fee and/or recycling fee) Consumers (tax payment, deposit fee, etc)	
Informative Responsibilities (Material information of product, recyclable or not)	Producer (Display of Material, Display of recyclable classification, etc)	Local authority (Separation of recyclable by separate collection)	-

Source: JAT

The collection methods vary depending on the type of recyclable materials, such as container packaging waste, household appliances, and small electronics. It could involve separate collections by local authority, installation of collection bins by retailers, or take-back system by distribution companies, etc.

In the recycling stage after collection, there are currently no companies in Guyana capable of conducting recycling to produce final products from recyclable waste. Therefore, for recycling to occur, recyclable waste needs to be exported to neighboring countries such as Trinidad and Tobago, Brazil, and others.

The market value of recyclable materials fluctuates, and there are certain collection and transportation costs, as well as recycling costs associated with recycling. Depending on the market value, the value of recyclable materials may sometimes fall below the cost incurred during the stages of collection, transportation, and sorting. In such cases, based on the concept of Extended Producer Responsibility (EPR), financial support from the government, as well as financial contributions from manufacturers, importers, and container packaging companies, may be necessary.

6.3 Final Disposal

In formulating the final disposal plan, it is essential to calculate the required land area primarily based on the final disposal amount of waste. This involves the consideration of suitable site selection for the final disposal site, meeting the criteria for sanitary landfill facilities.

Additionally, with the development of a new final disposal site, existing open dumpsites require environmentally conscious improvement or closure.

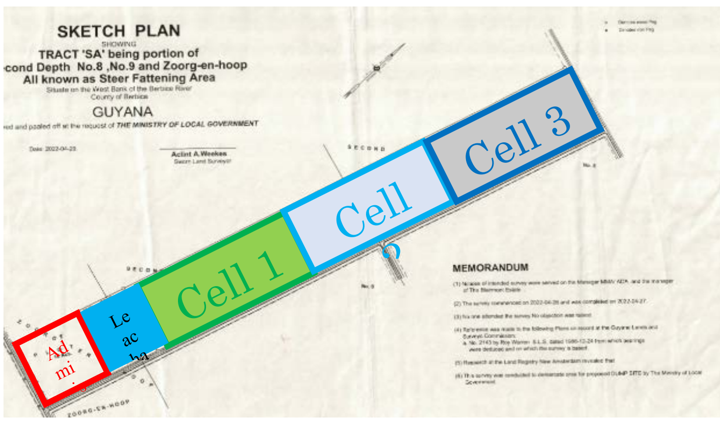
When evaluating the provision of disposal capacity, it is necessary to calculate the waste disposal amount for each year, taking into account the compacted waste density after decomposition of waste, cover soil amount, and other factors within the disposal site. The following provides an example of the basic conditions for capacity calculation in landfill sections.

Table 21: Basic Condition of Landfill Development

Density [ton/m3]	0.6
Soil cover rate (Soil cover[m3]/Waste amount[m3])	15%
Height [m]	2
Layer number	2

Source: JAT

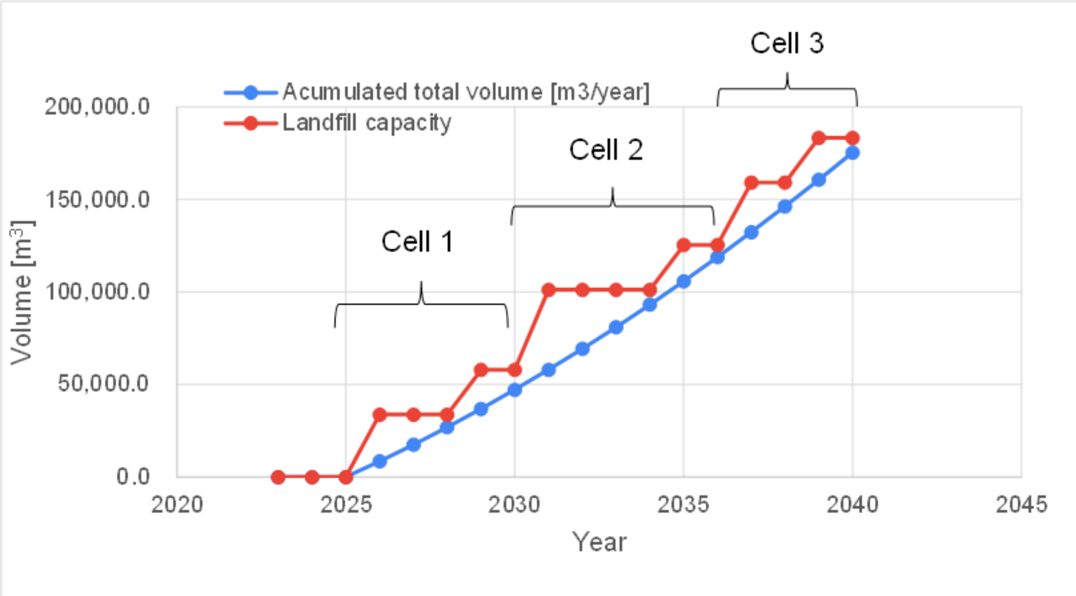
Furthermore, considering the budget for construction, the landfill should be developed in a phased manner with the possibility of change of the status during the construction phase. In facility development, for example, if the landfill site is divided into three cells, the management area (gate, weighbridge, administration building, etc.) should be located near the entrance, while the leachate treatment facility is ideally situated close to the drainage channels. The example is shown as follows.



Source: JAT

Figure 8: Example of Phased Development of a New Landfill Development

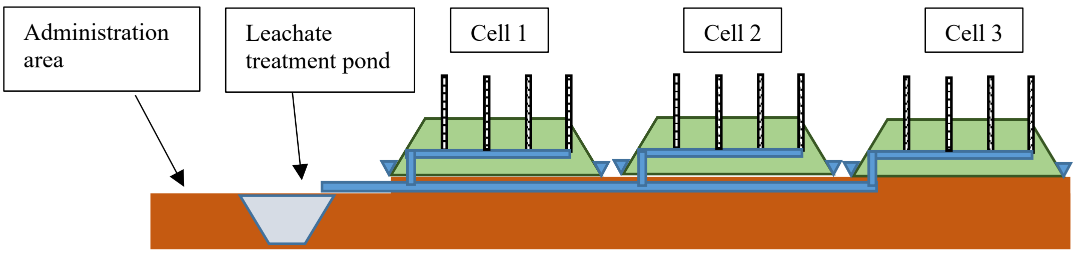
Each cell in the landfill section is developed in accordance with the required landfill capacity based on the disposal amount for each year. The relationship between the disposal amount of waste and the landfill capacity is showed as follows as an example.



Source: JAT

Figure 9: Example of Stepwise Development of New Landfill Development with consideration of landfill volume

In the case of Guyana, particularly in inland areas, it is noteworthy in the design phase that many regions have a local ground consisting of sandy layers. In such cases, there is a risk of slope collapse when implementing excavation, necessitating confirmation of the stability of the structures. Coastal areas, on the other hand, with low elevations and high groundwater levels, require elevation on the local ground for the construction of storage structures. Additionally, disposal site locations are often on flat terrain, and in regions close to the coast, where the groundwater level is high, the height of leachate collection and drainage pipes may be limited to almost the same level as the river's water level. In such cases, it is anticipated that the drainage by natural gravity for leachate may not be possible, requiring measures such as raising the landfill area or installing pumps for lifting leachate from the leachate collection pit. The image below illustrates a sectional view of the disposal site when developed in stages.



Source: JAT

Figure 10: Example of Stepwise Development of Current Acquired Area for a New Landfill Development

The main facilities required for a sanitary landfill and their respective roles are shown as follows.

Table 22: Main Facilities and Equipment for a New Landfill Development

Main Facility	Role and Function of Facility
The landfill area, is encompassed by an embankment	Embankments keep the waste in landfill areas to prevent scattering and breaking, and falling, as well as rainwater infiltration from the outside slope
Liner system	Liner sheets or compacted clay soil protect the leachate from each landfill layer.
Leachate collection and treatment facility	The facility collects the leachate to transport to the leachate treatment facility, which treats purifies the leachate to discharge outside watercourses. A part of the leachate will be recirculated to the landfill site.
Landfill gas exhaust facility	Vertical perforated pipe collects the landfill gas and exhausts it and promotes semi-aerobic condition in landfill layer.
Surface water drainage facility	Surface water drainage drain out the stormwater to prevent the inflow to landfill area, which causes leachate.
Weighbridge	Weighing both the collection vehicle loading waste and no-loading to identify the amount of loaded waste
Sorting and composting area	In the sorting area, only for separating solid waste and checking it. In the composting area, fermentation, and maturation are implemented.
Office building	Office building provides the working space for the staff working in the landfill site
Buffer zone and fence	Fence has the role of security and buffer zone has the role of protect the surrounding environment from negative impacts of odor, landscape, etc.
Landfill equipment	Landfill equipment is used for spreading and compacting solid waste and carrying and covering soil to waste mainly.

Source: JAT

In the selection of a final disposal site, it is crucial to base the decision on information about the surrounding natural and social environment, such as topography, geology, groundwater utilization, and land use in the vicinity. Consideration of risks such as landslides, slope collapse, floods, as well as groundwater usage conditions, irrigation areas, environmental conservation, cultural heritage protection, and other factors is necessary. Ideally, the selection process should be outlined if possible, and information such as on-site photographs may be required to illustrate the conditions of the surrounding areas. The checklist for the site selection process is provided below.

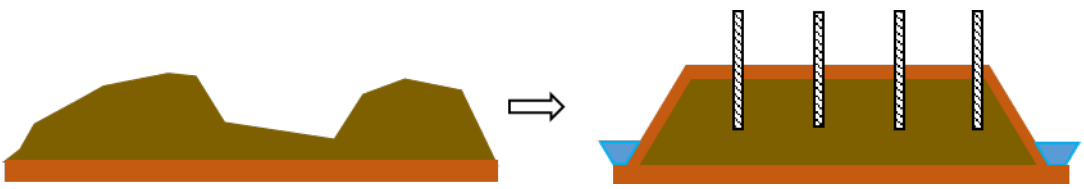
Table 23: Check List for Site Selection of Landfill Development

Item	Point to be checked
Topography, Geology	● To check whether the area is at risk of landslide or slope failure or not. ● To check whether the area is free from high tides and flooding hazards such as sea, rivers, lowlands, etc. or not. ● To check to see whether the topography is such that the repository capacity can be easily secured or not (i.e., a depression or flat terrain that is not steeply inclined), and to select an area with topography that can be easily secured as much as possible. ● To check the soil conditions, such as clay and sand layers, and consider the need for impervious construction. ● To check the water level of groundwater whether the groundwater collection and drainage system is necessary. ● To Check the accessibility to the disposal site and select a topographically accessible area.
Living Environment	● To check whether groundwater usage or not and to avoid areas where there are residences nearby and groundwater is used. ● To check whether the surrounding land use or not and to avoid residential, agricultural, commercial, and tourist areas. ● To check whether the water withdrawal conditions, especially for agricultural irrigation or not and drinking water, and to avoid those areas.
Environmental Protection	● To check whether endangered species and environmental protection area surrounding the in the target area or not, and to avoid those areas. ● To check the conservation area of heritage or cultural asset and avoid the area, and to avoid those areas.

Source: JAT

(1) Closure of Existing Open dumping Site

In existing open dumping sites, litter is not only scattered within the landfill area but also in locations such as access roads and near the site entrance. Therefore, such scattered waste needs to be gathered within the landfill area, covered with soil from above to prevent rainwater infiltration, and drainage channels should be installed to prevent rainwater from entering the area from the surroundings. Additionally, if gas vent pipes are not installed, it is desirable, for the expedited decomposition of waste, to install gas vent pipes as much as possible after partial excavation. The image below shows the situation after the closure of the open dumpsite.



Source: JAT

Figure 11: Image of Closure of Open Dumping Site in each NDC

7 Institutional Arrangements for SWM

7.1 Legislation

In 2014, the Waste Management Act was drafted, stipulating that the National Waste Management Agency would implement SWM in accordance with this law. However, following the drafting of this law, there have been changes in the government, and the law has not yet been formally promulgated.

Subsequent to the enactment of this law, there is a need for related laws, standards, guidelines, etc., concerning SWM. Initially, a bill needs to be formulated, and then the National Waste Management Agency, established based on this law, must establish a legal framework for waste-related matters.

The potential main regulations to be considered are outlined below.

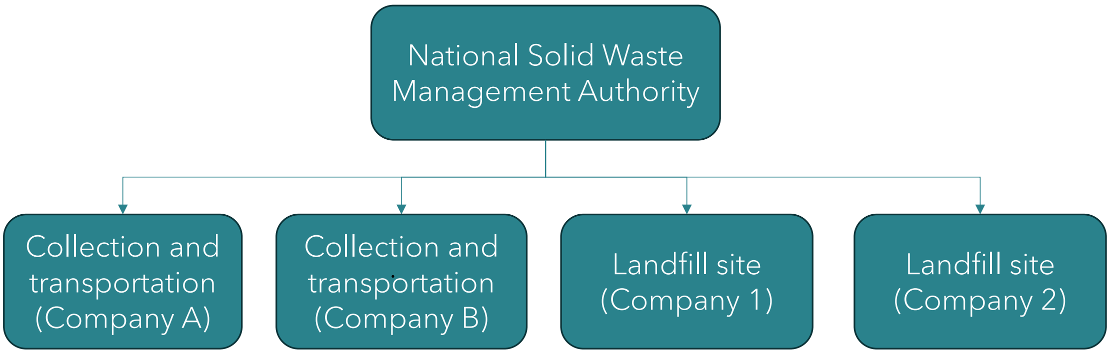
- Legislation or regulations regarding Extended Producer Responsibility (EPR)
- Legislation or regulations promoting the 3Rs (Reduce, Reuse, Recycle)
- Legislation or regulations concerning disposable plastics
- Legislation or regulations promoting Green Products
- Regulations pertaining to SWM in various regions

7.2 Organization

It is necessary to establish organizations for the SWM including operation and maintenance in each region. Currently, waste collection and transportation are carried out directly by each NDC, except for Region 4 and some collection areas. Regarding final disposal, apart from the privately contracted disposal site in Region 4, MLGRD staff handles it directly.

When implemented directly, conducting waste collection at each NDC is challenging due to the smaller scale and lower population of each NDC, leading to a lack of organizational functionality. Providing efficient and adequate waste collection services and ensuring proper final disposal are difficult in such circumstances. On the other hand, if implemented on a regional basis, establishing SWM organizations in each RDC is challenging given the current organizational structure.

In the case of private outsourcing, some regions, including Region 4, Region 3, and parts of Region 5, already have private entities handling waste collection, transportation, and final disposal. These private entities have experience in providing waste management services. In Region 4, contractual arrangements exist between MLGRD, local authorities, and private contractors, making monitoring by local authorities feasible. Therefore, it is desirable to implement contract management at the national level for SWM in each region. The following illustrates the relationship between the SWM organization at national level and various stakeholders.



Note: The allow show the contract relationship

Source: JAT

Figure 12: Organization Structure of SWM in case of Public Private Partnership in Guyana

In both cases of private outsourcing or direct management, personnel involved in waste collection, transportation, processing, and disposal facilities should be worked as the base of administrative offices. The following provides an example of the number of staff and their respective roles.

Table 24: Necessary Staff for SWM in a region

Position	Necessary Number	Role and responsibility
Supervisor	1	Overall manage the SWM
Driver	Equivalent to the number of collection vehicles	Drive the collection vehicle for waste collection
Collector	2 to 3 persons / one truck is necessary	Collect solid waste and transport to the waste treatment and disposal facilities
Environmental monitor	A few persons at least	Environmental monitoring of waste treatment and disposal facilities such as landfill sites and collection areas (assisted by senior staff)
Supervisor at landfill site	1	Supervising at existing landfill sites such as Haags Bosch landfill site and Lusingan landfill site
Landfill operator	2	Operate each facility in the landfill site and maintain the equipment and facility
Heavy equipment operator	Equivalent to the number of heavy equipment	Operate the heavy equipment for waste spreading, compaction and soil cover, etc.
Weighbridge operator	1 to 2 persons	Weighbridge data management and monitoring
Security guard	1 to 2 persons	Check the visitors and prevent the entering without the permission

Source: JAT

7.3 Finance (Revenue and Expenditure)

The budget for SWM in the sanitation sector of Guyana is administered by the Ministry of Finance, and the information can be obtained from its website in Ministry of Finance. According to the data from the Ministry of Finance, the national budget for SWM in Guyana is as follows.

Table 25: Budget for SWM in MLGRD

Unit: GYD

Item	2021	2022	2023
Budget for SWM in MLGRD	$1.1 billion	1.4 billion	1.9 billion

Note: GYD is Gyana Dollar

Source: Ministry of Finance

However, currently, detailed financial information regarding various aspects of SWM in Guyana, such as collection and transportation, final disposal, etc., could not be verified. Clarifying this information is important for assessing the cost recovery of this plan and comparing it with the results of cost estimates.

7.4 Public awareness and environmental education

To ensure the smooth implementation of SWM and to obtain public cooperation, it is important to enhance public awareness and provide environmental education using Information, Education, and Communication (IEC) tools. Various methods of environmental education, utilizing mass media and interpersonal communication, can be employed to raise public awareness. The following are examples of tools for enhancing public awareness and environmental education.

Table 26: Various Tools of Environmental Education

No.	Media	Descriptions	Contents
Mass Communication and Education			
(1) SNS Media			
1.	Facebook	Facebook is one of the effective tools of social media with low-cost media to raise people's awareness on a large scale.	The progress of the regional SWM plan and the activities of SWM, could be disseminated with this tool widely and could obtain some feed backs from readers.
2.	Websites	Websites could provide people with details of the SWM activities	The components, progress, and outcomes of the regional SWM plan as well as SWM information, are often updated.
(2) Traditional Media			
3.	Posters, leaflets, stickers	These printed media are effective with literate people, tourists, and school children, and can be used often. Stickers can be attached to various places for publicity including transport vehicles like ships, buses, vans, cabs, tricycles, and pump boats.	The printed media are distributed to the residents, business establishments, etc. Various catchy and short messages on SWM are printed and distributed.
4.	Billboards, banners	Billboards and banners can be seen by people on a large scale with high visibility and can be changed from one place to another (mobile).	Billboards and Banners regarding the advantages of proper SWM are set up at strategic points such as markets and religious facilities such as temples, mosque and church.
Interpersonal Communication and Education			
5.	Public and educational events	Public and educational events can be held by inviting many people with various displays, exhibitions, trade fairs, and events.	Not only activities of the regional SWM Plan but also related activities of the NGOs and private sectors are displayed at the events.

No.	Media	Descriptions	Contents
6.	Environmental education at school	Children are considered powerful and effective media for the transmission of hygiene, sanitation, and environmental messages from school to family members, neighbours and communities.	Education on proper SWM is conducted at schools. During that time, school flag ceremonies, talks, essays, and painting competitions on SWM among school children are also conducted.
7.	Creation or encouragement of community groups	In rural areas, community groups could be created or encouraged to convince people of SWM. They are expected to play a key role in group recycling activities.	Formation of community groups and training and strengthening of them, including exposure visits to other groups with good practices, are conducted.

Source: JAT

8 Implementation plan

8.1 Implementation Schedule

In this section, we will outline the implementation process, providing a concise description of the activities for each year along with a corresponding bar chart. An example is presented as follows.

Table 27: Implementation Schedule of SWM in Region 5

Activity		2023	2024	2025	2026	2027	2028	2029	2030	2031-2035	2035-2040
Collection and transportation	Introduction of effective collection by compactor vehicle										
	Improvement of Collection Rate and Frequency										
	Examination of separate collection										
Final disposal	Construction of new landfill site in Blairmont										
	Closure of existing open dumping sites in each NDC										
	Examination of new landfill site in east side in Region 5										
Promotion of recyling activity	Source Reduction Program										
	Promotion of Recycling										

Source: JAT

9 Cost Estimation and Financial Aspect

The purpose of estimating approximate costs and conducting financial considerations is to calculate the estimated costs at the master plan level, perform financial evaluations, and confirm the feasibility of the plan. Therefore, from this perspective, an assessment will be made to verify whether revenue exceeds expenditure and to confirm the cost-effectiveness in comparison with other regions.

9.1 Initial cost (Capital Expenditure (CAPEX))

Firstly, for the initial investment related to SWM, list the equipment for SWM, equipment, facilities, and construction costs for waste treatment and disposal facilities. The costs will be estimated based on the Bill of Quantities (BOQ) for each item and the respective unit prices.

Additionally, it is advisable to obtain cost estimates in advance for equipment used in collection and transportation, such as machinery used in the final disposal site. If obtaining estimates is challenging, it is possible to utilize existing data or other sources and use approximate values. Moreover, for the construction costs of waste treatment and disposal facilities, in the planning phase, topographic survey and geological investigation will not be implemented and drawings may not have been created. In such cases, it could be possible to use existing data from similar facilities to estimate approximate costs. An example of estimating approximate costs is shown as follows.

Table 28: CAPEX for Collection, Transportation, and Final Disposal

Item		Contents / Detail	Number (Year 2030)	Cost [US$]
Collection and transportation	Compactor vehicle (12m3)		5	1,170,000
Landfill development	Landfill Facility (6ha, 25 year)	Landfill Area, Gas ventilation pipe, Rainwater drainage, Leachate collection pipe, Leachate treatment system, Sorting area, Weighbridge and monitoring room, Washing and parking area, Gatehouse, Fence	1	4,369,000
	Landfill equipment	Bulldozer (Swamp type around 260HP)	1	299,000
		Excavator (around 150 HP)	1	184,000
		Wheel Dozer (around 300 HP)	1	266,000

Source: JAT

9.2 Operation and maintenance costs (Operation and Maintenance Expenditure (OPEX))

In accordance with the collection and transportation plan, final disposal plan, and recycling plan, it is necessary to estimate the operational and maintenance costs, and the results will be detailed in this section. These costs are categorized into personnel expenses, operating expenses, and maintenance expenses. For personnel expenses, calculations are based on the operating days or months and the unit price. Operating expenses are derived from fuel unit prices and consumption rates, while maintenance expenses are calculated based on equipment costs or a percentage of the operating expenses. An example of OPEX (Operational and Maintenance Expenditure) is shown as follows.

Table 29: OPEX for Collection, Transportation, and Final Disposal in Region 5

Item		OPEX (2030) [US$]	OPEX (2040) [US$]
Personnel cost	Collection and transportation	142,800	261,000
	Landfill	72,600	72,600
Operation	Collection and transportation	53,800	65,100
	Landfill	26,500	46,400
Maintenance		7,899	8,070

Note: Maintenance cost is 15% of O&M cost

Source: JAT

Table 30: Monthly Personnel Cost in Region 5

Position	Number of Personnel (2030)	Number of Personnel (2040)	Unit cost (US$/month)	Subtotal of Personal cost (2030)	Subtotal of Personal cost (2040)
Supervisor	1	1	1000	1000	1000
Driver	5	7	700	3500	4900
Collector	10	14	600	6000	8400
Environmental monitor	2	2	700	1400	1400
Supervisor in landfill site	1	1	900	900	900
Landfill operator	2	2	800	1600	1600
Heavy equipment operator	3	3	750	2250	2250
Weighbridge operator	1	1	750	750	750
Security guard	1	1	550	550	550

Source: JAT

Table 31: Detail of Operation Cost in Region 5

Collection vehicle	Operation distance (2030) [km/week]	Operation distance (2040) [km/week]	Fuel consumption rate [km/L] (for collection vehicle)	Fuel cost [US$/L]	Operation cost (2030)	Operation cost (2040)
	8,600	10,400	10	1.2	53,800	65,100
Heavy equipment	Operation hour (2030) [hr./week]	Operation hour (2040) [hr./week]	Fuel consumption rate [L/h] (for heavy equipment)	Fuel cost [US$/L]	Operation cost (2030)	Operation cost (2040)
	40	70	5	1.2	26,500	46,400

9.3 Annual Budget and Cost Recovery

Analyzing the trends in the budget over the past few years allows for estimating the anticipated future annual budget. However, if there are revisions to the future policies or strategies related to SWM, the amendment should be made for more accurate estimates.

Furthermore, it is important to compare the expenditure status of initial investments and operational and maintenance costs with the estimated future budgets. Analyzing whether cost recovery is feasible is significant for preparing a feasible plan.

Typically, SWM projects may not be financially profitable, and financial analysis may not be conducted. In terms of economic analysis, the benefits is estimated based on the Affordable to Pay of waste dischargers. According to JICA's guideline[1], in the SWM sector, the payable amount is set at 2% of the beneficiary's disposable income.

As another method, the comparison is based on the cost per ton and the ratio of revenue to expenditure. The cost effectiveness is calculated by the following formula and is compared across different regions.

（Indicator of cost benefit [GS$/ton]）=Cost [GS$] ／Disposal Amount [ton]

[1] Research Methodology for Economic Evaluation (Solid Waste), 2002, JICA

10 Evaluation, Conclusion, and Recommendation

10.1 Evaluation and Conclusion

(1) Institutional Aspect

The plan should be appropriate in term of legal aspect. In terms of the legal framework in Guyana, the Solid Waste Management Bill, which serves as the fundamental law for SWM, is currently in the draft stage. The establishment of national institutions such as the National Solid Management Authority is not yet realized. Additionally, while a draft for the National Waste Management Strategy (2017-2030) has been created, it is not approved, and the existing situation may lead to potential changes in the system.

This guideline was formulated with reference to the draft versions of these laws and strategies. However, it is important to note that revisions may be necessary if there are changes in their content in the future. While the foundational aspects for SWM in each region are covered as part of the basic laws and strategies for implementation, certain areas need improvement for building a circular economy. This includes the need for systems like Extended Producer Responsibility (EPR), measures to curb disposable plastic usage, and guidelines for Public-Private Partnerships (PPP) and private outsourcing, considering collaborations with private companies. Enhancements in these areas will be necessary for effective implementation in the future.

(2) Technical Aspect

From a technical standpoint, the evaluation will be based on the plan to determine the feasibility of facility development and equipment procurement in each region. It is necessary to confirm that the capacity of operation and maintenance is suitable for the proposed facilities and equipment.

The key points to particularly consider during this evaluation are outlined as follows.

- Within the plan, is it possible to domestically procure facilities and equipment?
- If domestic procurement is not possible, can they be easily obtained from neighboring countries?
- Does the proposed operation of the facilities and equipment in the plan have prior experience? If not, is it easy to receive technical guidance for operation?
- Is it easy to maintain and manage the proposed facilities and equipment in the plan? Are workshops available for maintenance, including outsourced options, and is obtaining spare parts not difficult?

(3) Financial and Economic Aspect

Waste projects are typically not revenue-generating, so financial analysis is usually not conducted. However, for financial feasibility, it is considered achievable if the payment capacity per citizen is within 2% of disposable income. In economic analysis, quantitative benefits such as 1) improvement in sanitation, 2) reduction in greenhouse gas emissions, and 3) revenue from the sale of recyclable materials are assessed as benefits, and the Economic Internal Rate of Return (EIRR) is calculated.

(4) Environmental Aspect

In terms of the environment, the Environmental Impact Assessment (EIA) will be conducted following Guyana's EIA system. While there are no specific guidelines for the waste sector, the assessment will adhere to the Rules and Procedures for Conducting and Reviewing EIAs in 2004, which are common across sectors. For donor-funded projects, it is necessary to implement environmental and social considerations in accordance with the environmental and social safeguard guidelines of each donor. An evaluation will be conducted to ensure the appropriateness of environmental and social considerations for each project. Donor-funded projects often require consideration of alternative options, including the zero option, and the implementation of public consultations during the scoping and draft stages. The necessary details for each donor-funded project are compiled in the websites listed in the table below.

Table 32: Useful Site for Guidelines Environmental and Social Consideration of each Donor

Item	Web site to obtain the guidelines of each donor
JICA Project	guideline_202201_e.pdf (jica.go.jp)
IDB Project	IDB | Environmental and Social Performance Standards (iadb.org)
WB Project	Environmental and Social Framework (ESF) (worldbank.org)

Source: JAT

10.2 Recommendation

In the context of regional SWM plan and the formulation process of this guideline, the following considerations should be conducted as future recommendations:

(1) Monitoring of Private Sector Operations

The government's monitoring the operations and maintenance conducted by the private sector is important. The MLGRD and local authorities such as NDCs or municipalities should actively monitor the activities of private sector operations. Currently, the MLGRD does not have sufficient information on the activities and operations of the private sector. While information about the Haags Bosch landfill and waste collection in Georgetown, where contracts are in place, is obtainable, data for other regions, especially concerning waste collection, is not readily available. Even in the absence of contracts, obtaining data on operational aspects such as collection routes and fee collection status is essential for effective monitoring.

(2) Information Sharing Within MLGRD

MLGRD currently employs around ten staff members, each with distinct responsibilities related to the implementation of SWM. Information on various activities should be shared among staff members, particularly for training purposes, especially among younger staff.

(3) Data Updates (Socio-economic conditions, CAPEX, and OPEX Unit Costs)

While national censuses are conducted every ten years, with the latest one taking place in 2022, the analysis and report compilation of the data are ongoing. Consequently, the planning process currently relies on data from 2002 and 2012. Therefore, for plans developed using older data, there is a need to update population data and other relevant information once the latest census results are published. Additionally, given the fluctuations in economic and market conditions, periodic acquisition and updating of unit cost information for equipment and materials are necessary.

(4) Cost Recovery Analysis

Detailed financial data is essential for conducting a cost recovery analysis. During the planning and guideline creation process, obtaining detailed data for each expense category proved challenging. Therefore, it is necessary to organize the data and conduct a cost recovery analysis after obtaining detailed expense data. This will enhance the feasibility of the plan.

(5) Continuous improvement of SWM plan

Once the regional SWM plan is formulated, it is crucial to assess its feasibility. To evaluate the SWM plans for each region effectively, employing the Plan-Do-Check-Act (PDCA) cycle methodology is recommended.

These regional SWM plans should undergo periodic reviews, incorporating the PDCA cycle. Revisions to the plans will be based on the acquisition of new data and updates, ensuring a continuous improvement process aligned with the PDCA methodology.

1) Plan

First, as explained in this document, it is necessary to develop regional SWM plans for each area. Referring to this guide and existing SWM plans in other regions, a specific SWM plan for the region will be formulated. Based on this plan, an annual activity plan will be developed to outline activities in near future. Additionally, the regional SWM plan and the annual activity plan should be widely disseminated among stakeholders and the entire organization, encouraging active participation for a thorough understanding and improvement of SWM.

2) Do

The regional SWM should be implemented according to the above plan. In doing so, create annual action plans to guide and facilitate the implementation.

3) Check

The MLGRD should utilize monitoring indicators established in the regional SWM plan to monitor the progress of proposed programs and projects outlined in the regional SWM plan.

4) Act

It is advisable to review and revise the regional SWM plan approximately every five years through the "3) Check" process. Furthermore, if there are significant changes in the conditions or criteria for establishing the regional SWM plan, it is recommended to reconsider the plan.

Ideally, it is better to sample for each income level in WACS. However, because there is no population data for each income level in case of Guyana, even if the sampling survey is implemented for each income level in household, the analysis of total amount of waste in the region. Therefore, selection of sampling should be representative generation sources as sampling with consultation with each NDC.

The example of sampling method is shown in the following table.

Table Method of Waste Amount Survey

Item	Description
Duration of the survey	Continuous eight (8) days including two (2) weekends
Survey area	Selected a few NDCs [1]
Number of Samples	Thirty (30) households to be selected for each NDC
	Three (3) restaurants for each NDC
	Three (3) hotels for each NDC
	Three (3) shops or markets for each NDC
	Three (3)institutions (offices and/or schools) for each NDC
Methods	- Solid waste shall be collected from households, restaurants, and hotels who are asked in advance to store all waste generated in their respective locations (generation sources) - Solid waste stored in each generation source for each day shall be collected every day. The staff will measure the weight of the waste by scale. - However, the solid waste stored on the first day shall not be included in the analysis. This is because the waste bins at each generation source are needed to be emptied. - At the same time, basic information about selected households such as the number of family members, and type of residence, shall be recorded through a hearing with the residents. Basic information about business sectors shall also be collected, especially the number of staff and guests each day of the survey at hotels, restaurants, shops, and institutions.

2.2 Solid Waste Composition Survey

In solid waste composition survey, each type of waste in the sampled waste is measured to identify the physical composition. Also, the volume and weight are measured to identify the bulk density. After drying the waste, dried waste is also measured to identify the moisture contents. The physical composition and moisture contents is used for the combustible contents and ash contents in the sample.

The solid waste composition survey should be implemented in accordance with the method given in the following table.

Table Method of Composition Survey

Item	Description
Duration of the survey	Two (2) weekdays and one (1) weekday among three (3) days of the waste amount survey described above for January or February
Number of Samples	Household waste: Waste composition, bulk density, moisture, three components 3 days (number of survey days) x number of NDCs
	Waste from Hotel: Waste composition, bulk density, moisture, three components 3 days (number of survey days) x number of NDCs
	Waste from Restaurant: Waste composition, bulk density, moisture, three components 3 days (number of survey days) x number of NDCs
	Waste from Shop: Waste composition, bulk density, moisture, three components 3 days (number of survey days) x number of NDCs
	Waste from Institution: Waste composition, bulk density, moisture, three components 3 days (number of survey days) x number of NDCs
Methods	(1) Preparation of Sample The solid waste material shall be put on a dried plastic seat and mixed well at first. After mixing, the mass of waste shall be piled up conically and cut to divide four smaller groups. Two groups of opposite angles shall be picked up and left for another sample adjustment from four groups and the other two groups shall be discarded. Remained two groups shall be mixed and divided into other four groups in the same way. This subdividing process shall be continued a few times until the amount of the sample become around 40 L. (2) Volume and Bulk density 1) Weight and Volume The weight of waste is measured by a plastic bucket (40L) of which volume has been known and the measurement of the height of the waste in the vessel by scale, 2) Bulk density Bulk density is calculated by weight and volume. (3) Physical Composition - After measurement of volume and weight, the sample shall be separated manually into 15 items as described in the “Physical Composition”. The items are as follows; 1) kitchen waste, 2) wood/grass, 3) recyclable paper (cardboard, office paper, books, magazines, notes, etc), 4) -non-recyclable paper (film paper, etc), 5) recyclable plastic (PET bottle, other plastic bottles, styrene foam, drinking straw/plastic cup, etc), 6)-non-recyclable plastic, 7) recyclable glass (transparent glass bottle, color glass bottle, etc), 8) nonrecyclable glass, 9) metal (aluminum can, steel can, etc),

Item	Description
	10) textile, 11) leathers, 12) bulky waste, 13) ceramics/stone, 14) Hazardous and infectious (paper diaper, battery, etc), 15) others The weight and volume of each separated material shall be also measured for Physical Composition. The pictures shall be taken for classified samples, especially for the samples classified as others for recording. (4) Analysis of Three components, (combustible, moisture, ash) (See attached Photos) - The waste samples were sorted and weighed before drying. - After natural drying for one week, the weight was measured. After drying by drying equipment, the weight is almost similar. The drying waste weight has been determined. - Drying and dried will be used for samples in determining the ash content of each category after weighing Dried Waste. - Ash contents will be calculated based on the experienced data Based on the following calculation, combustible is calculated. - Combustible = Original Waste (Wet waste) - Moisture (= Wet waste - Dried waste) - Ash

(Note)

- Possible recyclable and nonrecyclable waste information should be considered based on the information of possible recyclable waste and nonrecyclable waste according to the information of existing market flow of recyclable.

2.3 Public Awareness Survey

Public awareness survey should be implemented before the sampling of Waste Composition Survey. The survey should be implemented in the workshop or by interview for each generation source. The sample questionnaire sheet is attached in the attachment 2-5.

3. Data Analysis Method

3.1 Waste amount

(1) Waste from household

After the measurement of the weight of waste, the waste generation rate is calculated as follows.

Total amount of waste from one household: W [g/week] = W1+ W2+ W3+ W4+ W5+W6+W7

The number of family: F [person]

Waste generation rate for a household: WGR [g/person/day] = W / 7 x F

The maximum and minimum and average value of waste generation rate should be calculated.

The example of calculated result is shown as follows.

Unit [kg/ day]

	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7			waste generation per capita
HH-MA-1	1.554	1.716					1.754				1.116	3.252	0.856	0.812	4	0.40
HH-MA-2	1.62		3.694		3.312		3.07		3.74		2.078		2.466	0.686	3	0.98
HH-MA-3	2.142		0.836		0.476		0.72		0.594		0.432		0.99		3	0.29
HH-MA-4	1.032		1.02		0.804		1.21		2.14		0.954		1.082		4	0.29
HH-MA-5	0.554		0.568		0.932		0.54		0.598		0.58		0.888		3	0.22
HH-MA-6	1.264	0.344	0.858	0.954	0.35	0.634	1.48	0.806	0.76	0.714	0.528	1.014	1.966		4	0.42
HH-MA-7	0.396		1.052		3.512				3.352				3.12		2	0.82
HH-MA-8	2.002		1.632		3.164		2.794		2.366		2.56		1.886		4	0.59
HH-MA-9	0.374				0.794		0.618		0.53		0.15		0.198		2	0.19
HH-MA-10	0.198		1.122		0.562		0.29		0.412		0.222		0.434		5	0.09
HH-MA-11	1.36		0.922		1.918		0.176		1.32		1.314				2	0.50
HH-MA-12	0.626		1.372	0.858	0.468	0.562	1.648	0.54	0.534		1.12	0.822	0.326	0.598	3	0.45
HH-MA-13	0.408				0.444		0.496		0.716		0.6		0.012		3	0.13
HH-MA-14	6.758	1.66	1.968	4.422	1.696		0.14		3.634		1.296		1.308		7	0.47
HH-MA-15							0.586	1.301					0.942		4	0.10
HH-MA-16	1.574		2.27		0.334		2.562		1.7		2.594				4	0.39
HH-MA-17	0.582		0.302		0.368		0.392		0.462		1.648				2	0.21
HH-MA-18	2.31		0.468		1.578						0.384				3	0.23
Average																0.38

After the analysis should be summarized. The example of summarization is shown as follows.

Item	Total of 3 NDCs
Planned sample number	90
Actual and effective sample number	65
Average [kg/person/day]	0.31
Upper limit [kg/person/day]	0.98
Lower limit [kg/person/day]	0.04

(1) Waste from the Others (Restaurant, Shop, Institution (School))

After the measurement of the weight of waste, the waste generation rate is calculated as follows.

> *Total amount of waste from one household: W [g/week] = W1+ W2+ W3+ W4+ W5+W6+W7*
>
> *The number of staff: F [person]*
>
> *Waste generation rate for a household: WGR [g/person/day] = W / 7 x F*

The maximum and minimum and average value of waste generation rate should be calculated.

The example of calculated result is shown as follows.

Unit [kg/ day]

	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7		Total	Number of staff	per capita generation
SH-MA-1																	
SH-MA-2																	
SH-MA-3																	
SH-BW-1	19.225						5.95	21.784			13.93	14.126	13.844		88.859	9	1.41
SH-BW-2	22.7		0.88		6.154	4.51			9.168	5.112	1.704	3.504	20.46		74.192	8	1.32
SH-BW-3	1.784				4.22		2.524		2.85		4.56				15.938	4	0.57
SH-BG-1			1.966				1.677		2.004		7.968	1.96	4.018	3.11	22.703	3	1.08
SH-BG-2			3.758		1.02		1.89				3.512		1.462		11.642	1	1.66
SH-BG-3			2.078		2.914				1.462				4.214		10.668	2	0.76
																Average	1.14

Item	Restaurant	Shop	Institution (School)
Planned sample number	9	9	9
Actual and effective sample number	1	6	8
Average [kg/ day/staff]	0.61 -	1.14	0.37
Upper limit [kg/ day/ staff]		1.66	1.08
Lower limit [kg/ day/ staff]		0.57	0.08

3.2 Waste composition

3.2.1 Physical composition

（1）Waste from household and non-household

Total amount of a week is summated and the ratio of each type of waste is calculated. The sample of calculation is shown as follows.

$[P_i (\%)] = [W_i (kg)] / [W_T (kg)]$

$[P_i (\%)]$: Physical composition of each item

$[W_i (kg)]$: Weight of each item

$[W_T (kg)]$: Total weight

Attachment 1

Composition (wet-base)	Mahaicony			Park Woodley Land			Blairmont		
	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4
Kitchen waste	1120	4148	1636	1713	2049	4437	3340	2966	2303
Wood/grass	110	55	159			123	243	71	43
Recyclable paper				46				60	
Non recyclable paper	546	641	622	230	548	2308	563	611	793
Recyclable plastic	204	203	266	558	213	272	581	157	276
Non recyclable plastic	554	721	704	940	730	3900	581	855	1016
Recyclable glass	203				326	766		463	
Non recyclable glass		215					1193	98	
Metal	272	116	149	110	240	173	217	269	11
Textile			88	186	56	315	643		107
Leathers									
Bulky waste									
Ceramics/stone			307				223		
Hazardous and infectious	866	1075	2033		306	337	99	1756	103
Others									
Total	3875	7174	5964	3783	4468	12631	7683	7306	4652

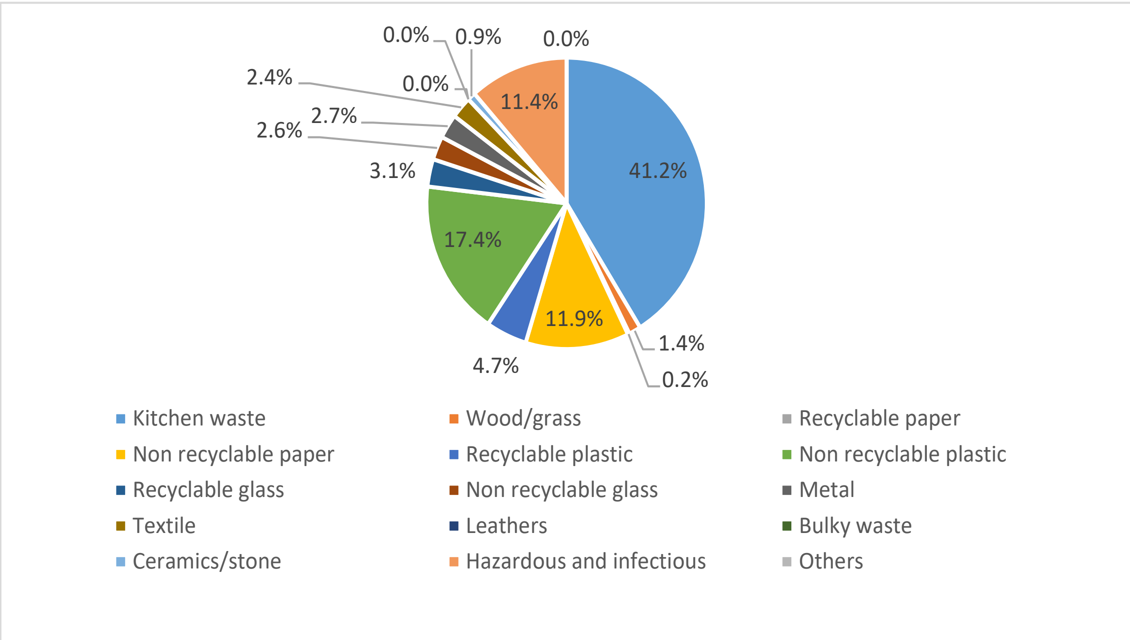


Figure Physical Composition of the Waste Sampled from Household

Attachment 1

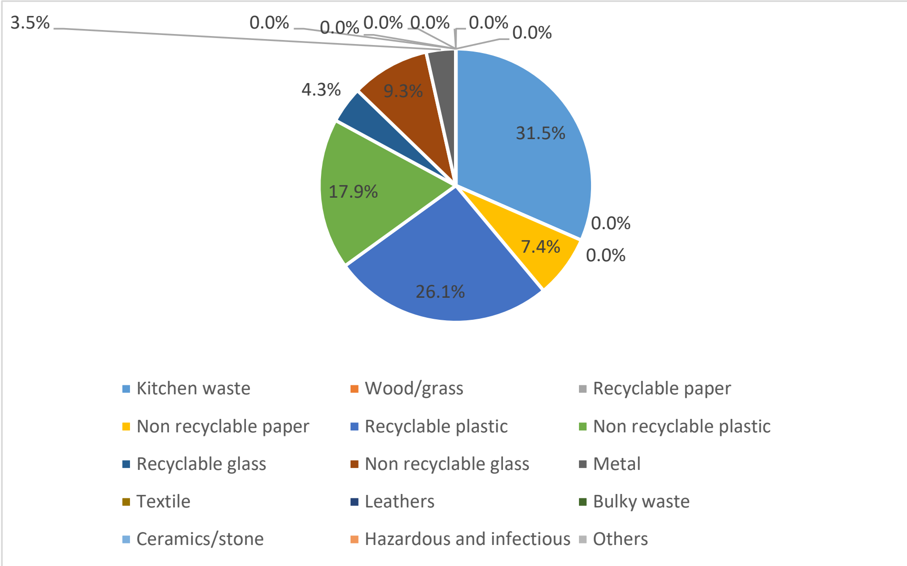


Figure Physical Composition of the Waste Sampled from Restaurant

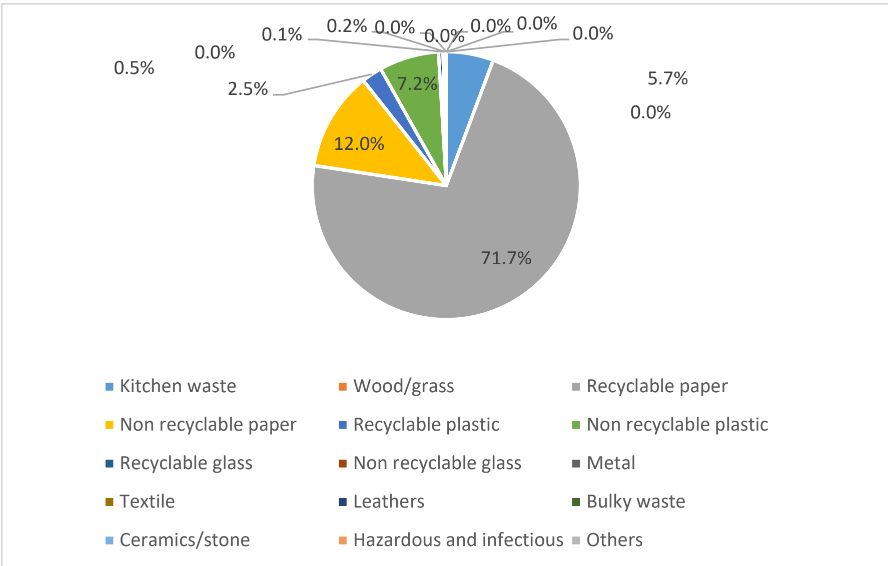


Figure Physical Composition of the Waste Sampled from Shop

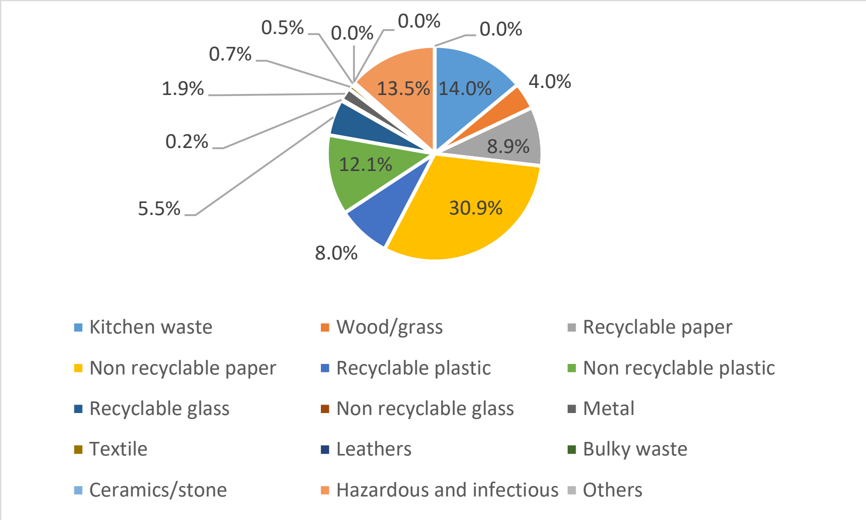


Figure Physical Composition of the Waste Sampled from School

3.2.2 Bulk Density

The bulk density is calculated as follows.

[BD (kg/L)] = [W (kg)] / [V (L)]

B: Bulk density

W: Weight

V: Volume

The example of the results of bulk density measurements of household waste are shown below.

Composition	Mahaicony/Abary NDC			Bath/WoodleyPark NDC			Blairmont/Gelderland NDC		
	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4
Volume (L)	40	40	40	40	40	40	40	40	40
Weight (kg)	8.85	9.06	7.20	8.69	5.77	6.12	9.84	9.45	6.85
Bulk density (kg/L)	0.22	0.23	0.18	0.22	0.14	0.15	0.25	0.24	0.17

Composition	Restaurant			Shop			Institute		
	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4
Volume (L)	—	40	40	40	40	40	40	40	40
Weight (kg)	—	9.06	7.20	8.69	5.77	6.12	9.84	9.45	6.85
Bulk density (kg/L)	—	0.23	0.18	0.22	0.14	0.15	0.25	0.24	0.17

3.3.3 Three components

(1) Moisture Content

After the measurement of bulk density, the sample should be dried naturally and/or heating equipment like oven or drier around 100℃ for a certain day. To check the completion of dry of the samples, the samples should be weighed, whose weight become saturated.

[M (%)] = [W_0 (kg)] - [W_i (kg]) / [W_0 (kg)]

(2) Combustible

Due to no electric oven in Guyana, it is difficult to measure only combustible contents. As an alternative, it could be estimated based on combustible contents of each physical composition because combustible in the sample is correlated with the physical composition.

Based on the survey of three components in Japan, three components in each physical component are shown as follows.

Item	Moisture	Combustible	Ash
Kitchen waste	63.6	27.8	8.7
Wood/grass	30.1	65.9	4.0
Recyclable paper	39.1	46.2	14.8
Non recyclable paper	39.1	46.2	14.8
Recyclable plastic	16.8	74.3	8.9
Non recyclable plastic	16.8	74.3	8.9
Recyclable glass	1.2	0.0	98.8
Non recyclable glass	1.2	0.0	98.8
Metal	7.8	0.0	92.2
Textile	28.3	66.9	4.8
Leathers	6.4	76.6	17.0
Ceramics/stone	3.0	0.0	97.0
Hazardous and infectious	14.2	66.9	19.0

[C (%)] = Σ [C_i (%)] x [P_i (%)]

(3) Ash Content

Ash contents are calculated from the following calculation.

[A (%)] = 100 (%) - [M (%)] - [C (%)]

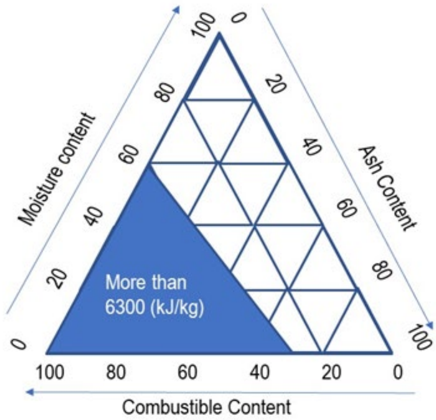
The evaporation was calculated from the weight before and after drying obtained by the following measurements, and the results for moisture content are shown below.

3.3.3 Lower Calorific Value

The lower calorific value could be estimated by utilizing the following calculation formula.

LCV (Lower Calorific Value) [kJ/kg] =190 x C [%] -25 x W [%]

Basically, 6,300 kJ/kg as Lower Calorific Value is necessary for the suitable operation of the WtE facility as shown in the following diagram. The value of Lower Calorific Value and the three components could be referred for consideration of WtE.



Source: National Institute for Environmental Study

Attachments

Attachment 1-1

Waste Amount and Composition Survey (WACS)

Work procedure of WACS for Region xxx

JICA Advisory Team

Objective of WACS

- The objective of WACS is to obtain basic data about the waste, such as waste generation rate (kg/person/day), bulk density (kg/litre), physical composition and calorific value (kJ/kg) to prepare Regional Solid Waste Management Plan in Region 5.

- Such basic data are essential for proper solid waste management.

Contents of Work

1. Site selection
2. Selection of households
3. Interview Survey
4. WACS
    1. Data to be obtained
    2. Number of samples
    3. Work flow
5. Reporting

1. Site selection

- Three NDCs are to be selected with different economic status, population density, etc

- The following data shall be collected
  - Name of the NDC
  - Name of the village
  - Number of households in the village
  - Number of people in the village
  - Number of restaurants, hotels, shops, institutions to be considered as the main waste generation source.

2. Selection of households

This work shall be conducted by the surveyors with support of JAT.

- 30 households, 3 hotels, 3 restaurants, 3 shops and 3 institutions (including school) shall be selected from each NDC, i.e. 90 households and 36 establishments (hotels, restaurants, shops, institutions in total for the three NDCs.
- Households, hotels, restaurants, shops and institutions shall be informed about the following:
  - Objective of the survey
  - Schedule of the survey
  - How to prepare waste samples
    - Only waste generated in each day has to be submitted as sample.
    - If there are sanitary items such as diapers, such waste has to be sorted separately from the general waste.
    - Necessary number of bags for sampling with stacker to identify the sample has to be delivered to the households.

3. Interview Survey

This work shall be conducted by the Surveyors. However, it may be carried out at the same time when the samples are collected.

The following page shows a main contents of questionnaire for this work.

Questionnaire (draft)

1) Number of family members:

- How many family members are living in this household?
- How many persons are usually living or working in your house, such as maid and driver?

2) Waste collection service:

- Do you obtain collection service?
- How often do you have this service?
- Who collects your discharging waste?

3) Self disposal

- Do you burn your waste in your backyard?
- Do you bury your waste in your backyard?
- Do you dump your waste to vacant area, rivers, etc.?

4) Recycle

- Do you separate recyclable materials?
- Do you use organic waste for making compost?

4. Waste Amount and Composition Survey
4.1 Data to be obtained

■ The following data shall be obtained:

a. Waste generation rate (kg/person or staff number/day)
b. Bulk density (kg/litre)
c. Physical composition (wet-base)
d. Three components: combustible, moisture and ash contents (measurement of ash and calculation of the others)
a. Lower calorific value (kJ/kg) (by calculation)

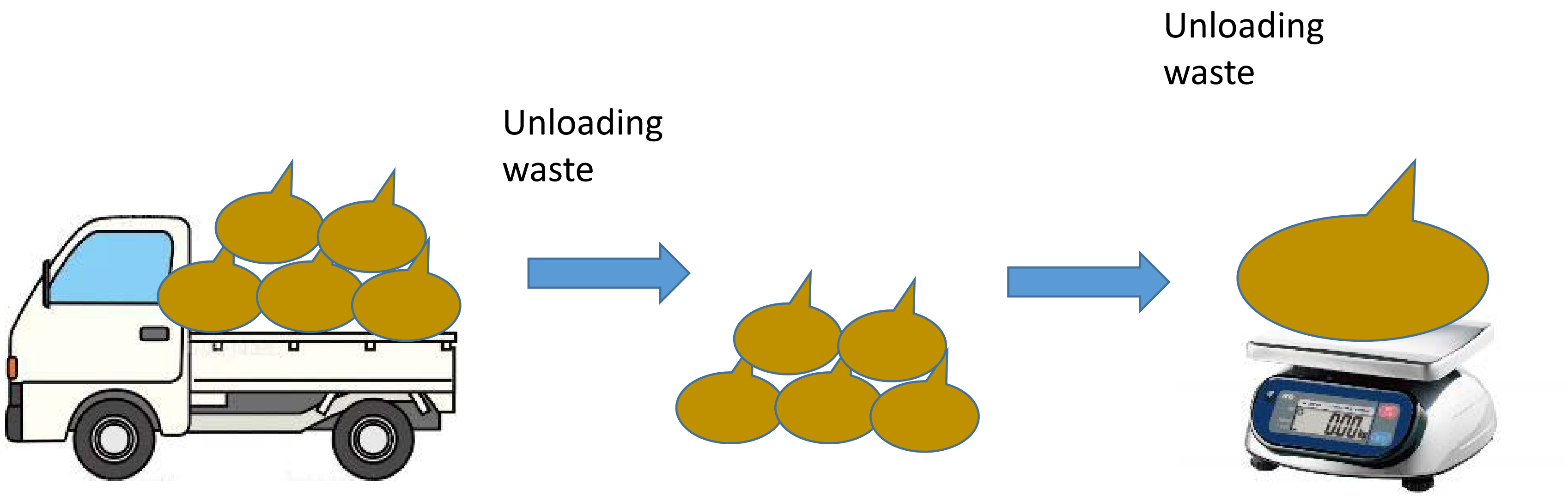
4.2 Number of samples

- In total, 882 samples will be taken for the Waste Amount Survey, and 21 samples for the Waste Composition Survey.
- The waste amount survey shall be conducted for seven (7) consecutive days after the complete collection of waste at first day . The waste composition survey shall be carried out by the samples collected in 1st day, 3th day and 4th day.

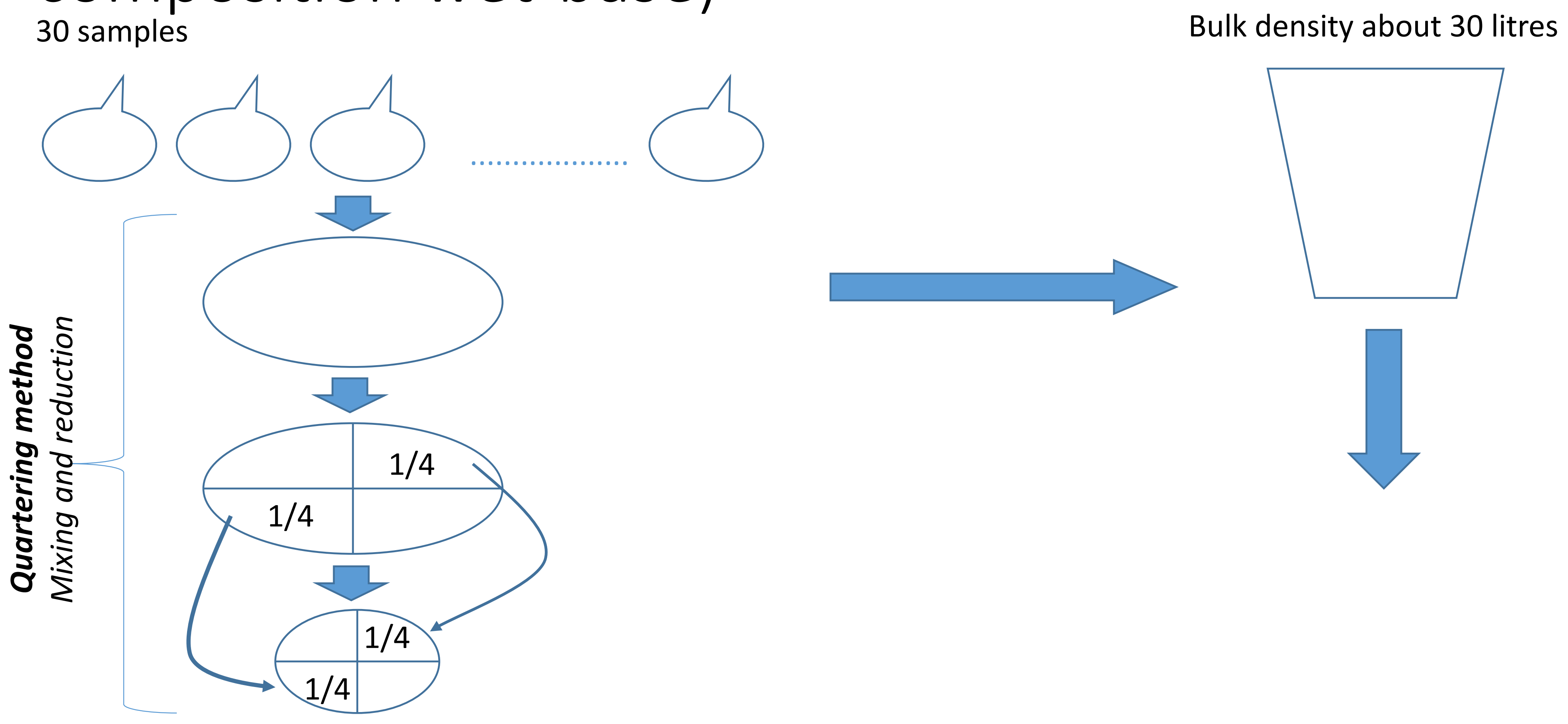
Number of Samples

Generation Source	Nos. of Households per NDC	Nos. of Hotel, Restaurant, Shop, Institution per NDC	Waste Amount Survey			Waste Composition Survey			
			Samples/ Day	Days of Sampling	Samples Total	Household sampling. No./day	Other sampling. No./day	Days of Sampling	Samples Total
			AxB	-	CxD	-		-	FxG
	B		C	D	E	F		G	H
High Income NDC	30	12	42	7	294	1	4	3	21
Medium Income NDC	30	12	42	7	294	1		3	
Low Income NDC	30	12	42	7	294	1		3	
Total	90	36	126	-	**882**	-		-	**21**

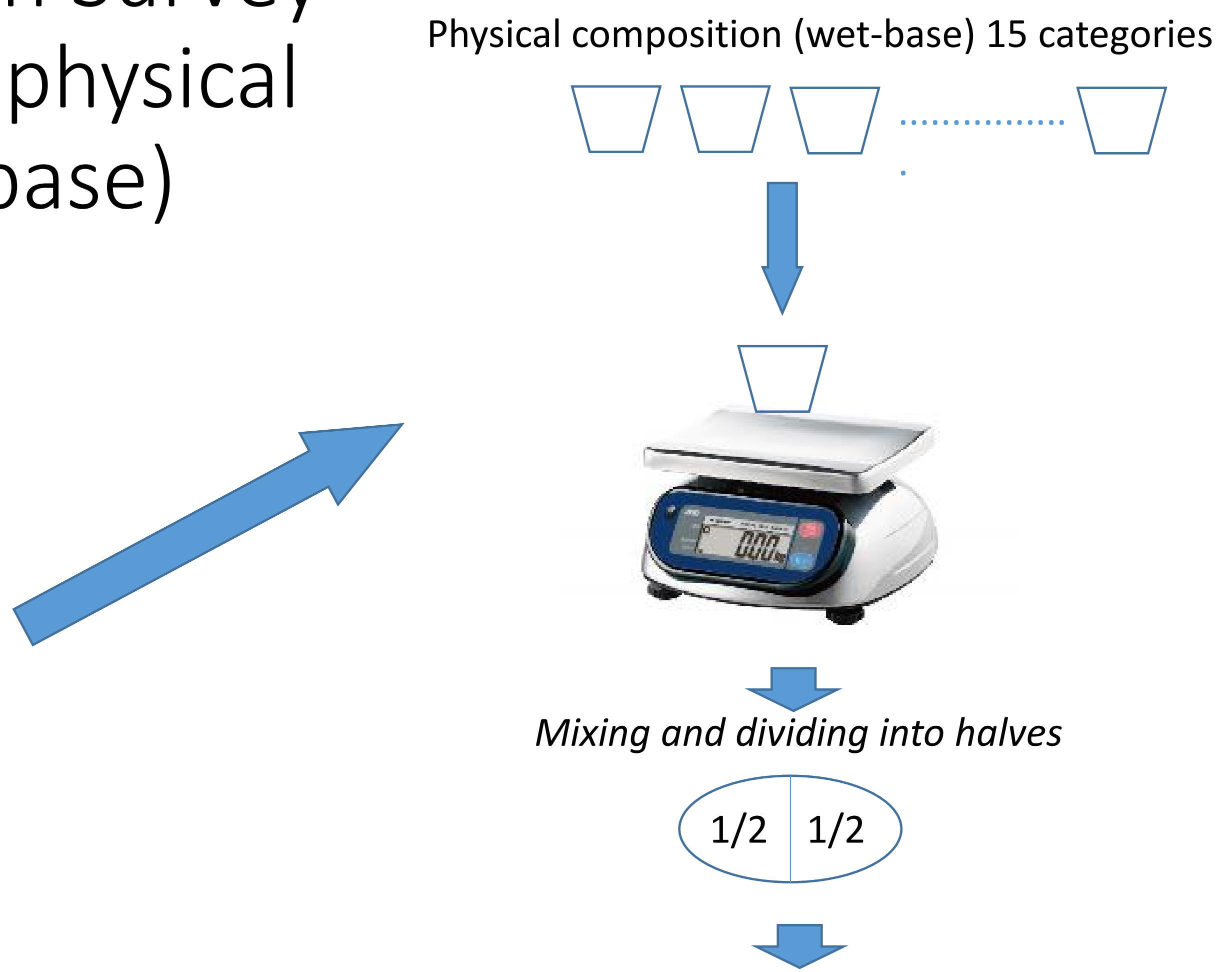
Waste Amount Survey (Measurement)



Waste Composition Survey (Physical composition wet-base)



Waste Composition Survey (Bulk density and physical composition wet-base)



Waste Composition Survey (Moisture contents)

Before Drying

Drying waste

After Drying

Calculation method

[Bulk Density] = [Waste (wet base)] / [Volume]

[Physical Composition (wet-base)] = [Each categorized waste (wet base)] / [Waste (wet-base)]

[Moisture contents] = [Waste (wet-base)] – [Waste (dry–base)]

[Combustible] = [Waste (wet-base)] – [Moisture contents] – [Ash contents]

[Lower Calorific Value] = 190 x [Combustible] – 25 x [Moisture Contents]

Attachment 1-2
Ministry of Local Government
and Regional Development *JICA Advisory Team*

Instruction for Solid Waste Amount and Composition Survey to Residents/Business Establishment

1. Purpose of this survey

This Technical Cooperation Project on Advisor for Marine Plastic Litter Management in the Caribbean Region is implemented through the cooperation of Japan International Cooperation Agency (JICA) and Ministry of Local Government and Regional Development in Guyana to improve Solid Waste Management in Guyana. In this advisory work, we try to prepare the regional SWM plan in Region 5. In this context, it is necessary to grasp the amount and composition of waste generated in Region 5. Then, we would like to implement the survey.

2. Procedure

Solid waste sampling for the survey will be continued. This will include 1 day for preliminary survey (collection of all the waste) and 7 consecutive days for actual survey. The procedure is as follows;

(1) Waste Packing

You shall be provided with bags for waste collection as following picture. After all waste is put into the plastic bags, you should tie with strings.

(2) Storage of Packed Waste

All the waste that you have generated for one target day must be kept in your house or yard for pick-up by survey collectors only. Please do not discharge the waste along the road or other waste collection points where solid waste is collected by government truck.

(3) Waste Collection

We will collect the plastic bags from xxx to xxx a.m.


(4) Sampling Number

Item	Description
Duration of the survey	Continuous seven (7) days including two (2) weekends in January or February
Survey area	3 NDCs in Region 5
Number of Sample	Ninety (90) households to be selected in 3 NDCs
	Nine (9) restaurants in 3 NDCs
	Nine (9) hotels in 3 NDCs
	Nine (9) shops or markets in 3 NDCs
	Nine (9) institutions (offices and/or schools) in 3 NDCs

For any inquiries or clarifications, please contact or text to xxx.

Thank you very much for your cooperation.

Explanation to Driver (as an Example)

- Please Start Georgetown at 7 am to the target NDC to collect the waste
- Please meet with one collector (see below information) in Blairmont/Gelderland NDC before 10 am.
- Please go to each household with collectors from 10 am to 12 pm to collect the waste
- Collector will pick up the waste from each household, hotel, restaurant, shop and school.
- Please drive the vehicle and the collector will collect all the target household, hotel, restaurant, shop and school.
- After finishing the collection around 12 pm, please transport the waste to the workshop area in Hachs Baag Landfill Site

Name of Collector : xxxx xxxx
Mobile number of collector : xxx xxxx

Name of collector of waste and the mobile number should be described.

NDC Blairmont / Gelderland
Name of Contact Person : xxxx xxxx
Mobile number of collector : xxx xxxx

Name of contact person of each target NDC and the mobile number should be described.

Name, address and telephone number of target residents, schools and shops for the survey should be described.

List of target residents, shops and schools for waste collection

(1) Residents

No.	Name	Address	Telephone number
1	xxxx xxxx	xxxxx	xxxxx
2	xxxx xxxx	xxxxx	xxxxx
3	xxxx xxxx	xxxxx	xxxxx

(2) Shop

No.	Name of Shop	Address	Telephone number
1	xxxx xxxx	xxxxx	xxxxx
2	xxxx xxxx	xxxxx	xxxxx
3	xxxx xxxx	xxxxx	xxxxx

(3) School

No.	Name of School	Address	Telephone number
1	xxxx xxxx	xxxxx	xxxxx
2	xxxx xxxx	xxxxx	xxxxx
3	xxxx xxxx	xxxxx	xxxxx

Necessary Equipment and Material

Name	Number	Remark / Picture
Truck for waste collection (around 2 ton) with drivers (Rental 8 days)	3	
Scale (0 to 2 kg, accuracy 1 g)	1	
Scale (0 to 30 kg, accuracy 100 g)	1	
Large Container	Around 40 L	
Bucket for separation of waste during waste composition survey (As same as separation item number) (Φ 20cm x 20	10 (for each physical composition)	

cm)		
Bucket for separation of waste during waste composition survey (As same as separation item number) (Φ 20cm x 10 cm)	10 (for each physical composition)	
Bucket for storage in drying process (Φ 20cm x 10 cm)	5 (generation source) x 3 (NDC) x 3 (days) = 45	
Metal container (for combustion)	5	
Gas burner (for combustion)	1	
Plastic sheet	4 sheets (5 m x 5 m)	

Attachment 1-4

Shovel (Big)	2	
Shovel (middle)	2	
Broom	4	
Hoe	2	
Dust tray for waste collected by broom	4	

Attachment 1-4

Glove	10	
Mask	10	
Drier (for drying process)	3	
Extension cord for drier	1	
Scissors/ cutting tools for waste	3	
Scissor for sealing tape	1	

Attachment 1-4

Transparent plastic bag (for sampling collection)	Around 1500 pieces	
Transparent sealing tape (for sealing paper with sign)	1 set	

Attachment 1-5

Survey Questionnaire for Residents

1. Introduction:

This waste amount and composition survey is implemented to prepare a regional solid waste management plan in region 5. To create the plan, information of target household is needed to grasp the current situation of solid waste management in the region. Your responses will be used for this purpose only. Please respond to the questions as accurately as you can. Thank you very much for your cooperation.

2. Household Details

1. Name of the head of the household:………………………………………….
2. Address:…………………………………………………………
3. Telephone number:……………………………………………………………………………….
4. Educational qualifications of the head of the household:……………………………………………….
   (a) Illiterate (b) Primary Schooling (c) Secondary Schooling (d) College or higher
5. Number of people in your family:…………………………………………………
6. Please describe names and types (new or secondhand) of all of your vehicles you own:………………………………………………………………………………………………

3. Waste Management

7. Do you agree on the fact that if waste is not properly disposed of, it can pollute the environment?
   (a) Yes (b) No

   If your answer is yes to the question above, kindly identify the cause/reasons for some of these problems. (Select All That Apply)

   (a) There is no bin available to dispose of garbage
   (b) There is no proper collection of garbage by collection service providers
   (c) Waste is disposed of anywhere such as drains and roadways which creates a nuisance within the community
   (d) Collection fees are too expense
8. Do you dispose of your waste by yourself or discharged for collection service?
   (a) Disposed of my waste by myself (b) discharged for collection service
9. If you select (a) in Question No. 9, how do you dispose of your waste?
   (a) dumping in my backyard (d) burning in my backyard, (c) composting in my backyard, (d) others (please specify:)
10. If you select (b) in Question No. 9, how do you discharge your waste?

(a) Discharge in the collection point by plastic Bag (b) Discharge in the collection point by metal or plastic drum, (c) others (please specify:)

11. How often do you discharge/dispose of your household waste?
    (a) Every day (b) Once every two days (c) once every three days (d) Once a week (e) Once every two weeks
12. Is the current frequency of collection service enough?
    (a) Yes (b) No
13. How much are you currently paying on garbage collection per month? ………GYD
14. How much can you pay on garbage collection per month, if waste collection system is improved? ………GYD
15. Do you currently separate different types of waste at your home, such as metal cans, glass bottles, etc.?
    (b) Yes (b) No
16. If you are told by your collection service provider to separate your waste in the future, would you comply?
    (a) Yes (b) No

5. Awareness for Solid Waste Management within the Community:

17. Do you think that the media has raised your awareness of water, sanitation, and solid waste management?
    (a) Yes (b) No
18. If YES, which media do you think has raised your awareness of water, sanitation, and solid waste management?
    (a) Radio (b) Television (c) Newspaper (d) Social media

End of Questionnaire

Guide for Time and Motion Survey

1. Objective

To prepare the regional solid waste management plan, it is necessary to grasp the current situation of waste collection and transport. In addition, it is also necessary to simulate the collection and transportation efficiency for the future plan. Therefore, time and motion survey of collection and transportation should be implemented. The main objectives of the survey are follows.

- To grasp current collection and transportation situation in the target region
- To identify the issues of collection and transportation based on the data
- To obtain the time and motion data for the future collection and transportation plan

2. Selection of target Vehicle

Type of vehicle	Sampling number	Remark
Compactor	2 to 3 trips	
Skip loader	2 to 3 trips	
Trailer tractor	2 to 3 trips	
Truck without dump	2 to 3 trips	

3. Survey Method

- Turn on the GPS device and/or timer and start the from vehicle compound/Arm roll container/FDS.
- Follow vehicle and record activities (collection/moving/stop) of collection vehicle and take photos of activities
- Check arrival time and starting time in each collection point
- Measure loading in the collection area and unloading time
- Arrive at the destination and turn the GPS devise and/or timer off.

The image of the record of time and motion survey are shown in the following figure.

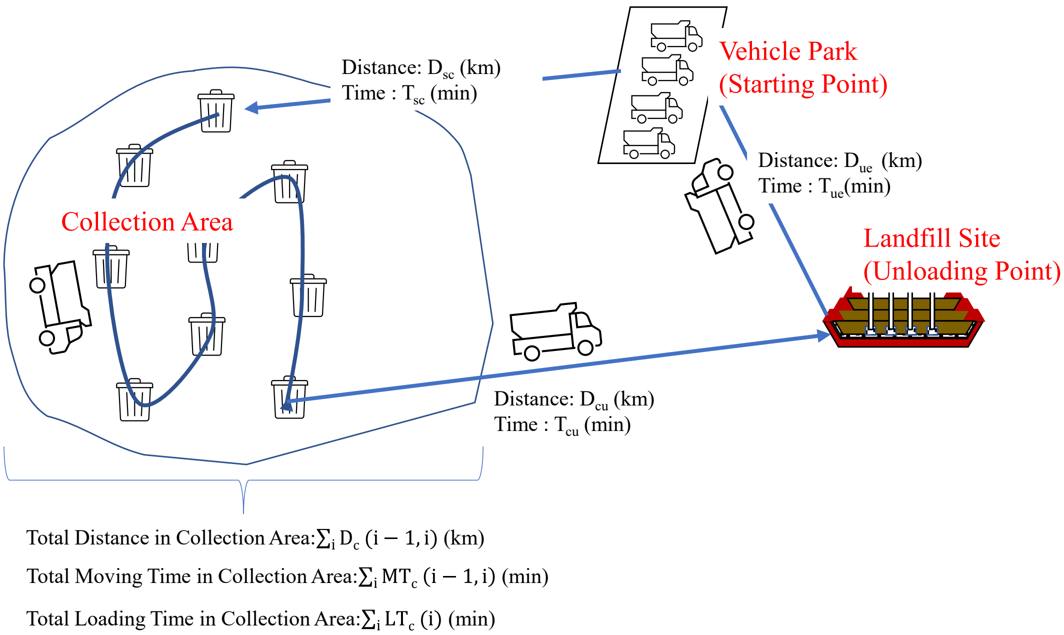


Figure Image of Recording of Time and Motion Survey of Collection and Transportation

(1) Collection

During time and motion survey, the loading time in collection area, transportation time, and unloading time in landfill site was collected. Continuously recording the time and motion of loading, moving, and unloading at each point is sometimes difficult. To improve the efficiency and the accuracy of the survey, and a GPS logger or video recording should be utilized.

Table Necessary Data

Item	Data	Remark
Distance between collection areas and starting point (km)	D_{sc}	GPS, GPS data logger
Distance between collection point i-1 and i (km)	D_c (i-1, i)	
Total distance between collection areas (km)	$\sum_i \mathrm{Dc}\,(\mathrm{i}-1,\mathrm{i})$	
Distance between collection areas and unloading point (km)	D_{cu}	
The Distance between the unloading point and the ending point (km)	D_{ue}	
Time from starting point to collection areas (min)	MT_{sc}	GPS, stopwatch, etc
Time for moving between collection points i-1 and I (min)	MT_c (i-1, i)	
Total time for moving into collection area (min)	$\sum_i \mathrm{MTc}\,(\mathrm{i}-1,\mathrm{i})$	
Time for loading waste at collection point i (min)	LT_c (i)	
Total time for loading waste in collection area (min)	$\sum_i \mathrm{LTc}\,(\mathrm{i})$	
Time from a collection area to the unloading point at the waste treatment facility or final disposal site (min)	MT_{cu}	
Time for unloading of waste at the waste treatment facility or final disposal site (min)	UT_u	
Time from unloading point to ending point (min)	MT_{ue}	
Other time (rest time, etc) (min)	OT	
Quantity of collected waste (ton)	CWQ	Measured in weighing bridge or estimation by visual inspection by eye, picture or video of collection vehicle
Number of loaded dust bins	N_{db} (i)	Visual inspection by eye, picture or video
Number of loaded plastic bags	N_{Pb} (i)	Visual inspection by eye, picture or video

Total time $T = MT_{sc} + \sum_i \mathrm{LTc}\,(\mathrm{i}) + \sum_i \mathrm{MTc}\,(\mathrm{i}-1,\mathrm{i}) + MT_{cu} + UT_u + MT_{ue} + OT$

Total distance $D = D_{sc} + \sum_i \mathrm{Dc}\,(\mathrm{i}-1,\mathrm{i})$

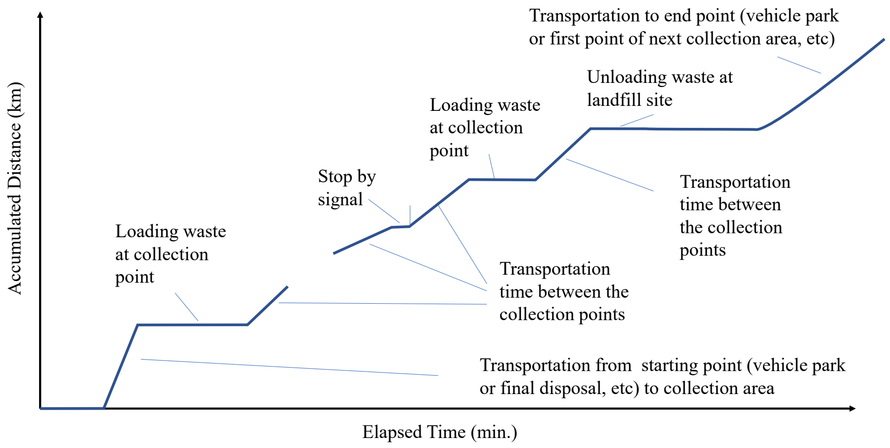


Figure Image of Time and Total Distance for Collection and Transportation

(2) Data Analysis

After the data collection, data should be analysed to identify the current condition of collection and transportation and to utilize the plan of collection and transportation. Basically, the following analysis should be implemented. The required data for analysis and considered utilization methods are summarized as follows.

Table Data Analysis

Item to be analyzed	Data	Remark (purpose of analysis, etc)
Travel speed from a collection area to the landfill site	MT_{cu}	To identify the overall spending time on collection and transportation
Time for loading waste at collection point i (min)	LT_c (i)	Identifying the loading efficiency depend on the type of vehicle
Time for unloading of waste the at waste treatment facility or final disposal site (min)	UT_u	Identifying the unloading efficiency depend on the type of car

1) Relationship between travel and type of collection vehicle
2) Relationship between loading time and type of vehicle
3) Relationship between unloading time and type of vehicle
4) The above information is one of examples of how the analysis should be implemented.

4. Necessary Survey Team

It is necessary to organize the survey team. The required members and their positions and responsibilities are shown in the following table.

Table Team Members

No.	Position	Number	Responsibilities
1	Supervisors	1	- Preparer the survey plan - Explain the survey plan for each member - Arrange preparatory survey and monitor and supervise the survey and advise for each member - Supervise the activities of each member

No.	Position	Number	Responsibilities
			during the implementation of the survey
2	Recorder	1 for each trip	- Prepare the draft survey data sheet - Record the time and distance during the survey
3	Time keeper	1 for each trip	- Check and read out loud the departure time and arrival one, and loading and unloading time for recorder
4	Photographer	1 for each trip	- Taking the photo during the survey - The photo should include the time and GPS information for checking
5	Driver	1 for each trip	- Drive the car

5. Necessary Equipment

It is necessary to prepare the equipment for the survey. The necessary equipment and the purpose are shown as follows.

No.	Position	Number	Remark
1	Car	1	- Following the collection and transportation vehicle
2	Camera	1	- Taking the photos and record the location of the photos
3	Stopwatch	1	- Recording the time of each activity such as loading, transportation, unloading, etc
4	GPS recorder (or smartphone)	1	- Recording the locations and routes of the collection and transportation
5	Data sheet	1 set	- Recording the time at each collection points, loading time transportation time and unloading time

6. Data Sheet

Collection Point No.	Arrival time	Loading/unloading time (min)	Departure time	Location (km)	Remark
Example	8:23	5:35	8:30		-
1 (Starting point)	-	-			
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
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Landfill site			-		

Check the watch and arrival time and taking the photo.

Check the watch and departure time and taking the photo.

Measure the stopwatch and record the loading time and unloading time. Video camera also support the time measurement of unloading and loading.

Check the distance meter and record it. If there are GPS recorder is useful for check the location.

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Pilot Project Technical Note No.2

Solid Waste Management Plan in Region 5, Guyana

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management
in the Caribbean Region

- Solid Waste Management Plan in Region 5, Guyana -

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October 2023

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1 Background and Objective

1.1 Background

In Guyana, there has not yet to be a future plan for Solid Waste Management (SWM) at the regional level as well as national level. Therefore, the facility development and equipment procurement for SWM is implemented on an ad-hoc basis. However, there is a draft national solid waste management strategy in Guyana, and they have prepared the draft Solid Waste Management Bill which is currently under the review and endorsement process. In this situation, a SWM plan is necessary at the regional level to implement comprehensive and effective SWM. The regional plan includes grasping current conditions, and identification of issues. After the analysis of issues, a vision, and strategy will be prepared considering waste generation in the future.

1.2 Objectives

The overall goal of the planning is to implement SWM along with the Solid Waste Management Bill though the bill still needs to be stipulated. Therefore, MLGRD is preparing the regional SWM plan. The proposed plan is expected to be utilized as a reference guide for formulating the regional SWM plan of each region with similar local conditions in Guyana. Under the above overall goal, the planning was conducted. The main objectives of the regional SWM plan are shown as follows.

1) To identify the issues of the current situation of SWM in region 5
2) To identify the future waste generation and waste flow
3) To consider the strategy to solve the issues and prepare the plan based on the future waste flow
4) To grasp the overall necessary budget for the plan

2 Profile of Region 5

2.1 Location and natural condition

Region 5 is a part of Guyana's ten administrative regions which borders region 6 to the east, region 4 to the west, region 10 to the south and west and the Atlantic Ocean to the North.

It contains 10 NDCs and no municipality. The Mahaica River runs along the region's western border. The Berbice River is the eastern border. The Mahaicony and Abary Rivers run south to north.

In Guyana, the coastal zone accounts for approximately seven (7) percent of the total land area, and ninety (90) percent of the population inhabits this area. In region 5, most of the population is in the northern parts of NDCs and most of the economic and administrative activities are concentrated here.

2.2 Population

The current population in Neighbourhood Democratic Councils in Region 5 estimated in 2021 are summarized as follows.

Table 1: Estimated population in Region 5 in 2021

Name of NDC/Municipality	Population
Blairmont - Gelderland	3,338
Zeelust - Rosignol	8,238
Woodlands - Belair Park	1,428
Bath - Woodley Park	6,610
Union - Naarstigheid	7,023
Seafield - Tempe	2,831
Profit - Rising Sun	3,491
Mahaicony - Abary	4,649
Hamlet – Chance	2,035
Woodlands - Farm	4,277
St. Francis Mission	681
Rest of Region 5	896

Source: Guyana - Subnational Population Statistics - guy_admpop_2021.xlsx - Humanitarian Data Exchange (humdata.org)

2.3 Economic profile and land use

Regarding economic growth, the IMF estimates that Guyana's economy will grow by 47.2% by the end of the year and that it has remained resilient in the face of global economic tensions. This is slightly lower than the World Bank's forecast of 47.9%, which predicts 34.3% growth for Guyana in 2023. Though the economic situation in urban area in Guyana will be developed due to the oil industry, the economic situation in Region 5 will not develop like that because rice farming is the main economic activity of this region, which is followed by sugar and coconut farming, and cattle ranching. In addition, the Region has the demand of arrangement of irrigation and drainage for such agricultural activities. However, development and urbanization in the adjacent region like Region 4 will affect the economic profile in Region 5.

3 Current condition of SWM

3.1 Institutional Arrangements

3.1.1 Legislation

The acts, bills and regulations related to SWM are summarized as follows.

Table 2: List of Acts, Bills and Regulations regarding SWM

Name of Act, bill and Regulations	Contents
Municipal and District Councils Act, Chapter 28:01, Laws of Guyana	The act describes the liability of waste storage and cleaning of each household and of businesses such as restaurants and stores in municipalities and districts.
Environmental Protection Act, Chapter 20:05, Laws of Guyana	This law includes a description of hazardous waste management, which includes definitions, responsibilities, and regulations for hazardous waste.
Environmental Protection litter enforcement regulations, 2013	This regulation prepared by the Minister of Natural Resources and Environment in accordance with Section 68 of the Environmental Protection Act of 1996, prohibits littering in public places and dumping waste on private property by appointing a litter prevention monitor (appointed by a public authority or the Minister of Natural Resources and Environment), and provides for enforcement of litter removal.
Public Health Ordinance, Chapter 145, Laws of Guyana	It defines the establishment of a Board of Health, chaired by the Director of Medical Services, and provides for the responsibility for the disposal of medical waste.
Draft Solid Waste Management Bill, 2014	The fundamental law on SWM was Drafted in 2014 and the law stipulates that the National Solid Waste Management Authority will implement SWM. However, after its drafting, there was a change of administration, and the law has not yet been officially promulgated.
Regulations No. 8 of 2015 - The Environmental Protection (Expanded Polystyrene Ban) Regulations, 2015	Laws and Regulations Prohibiting the Use of Polystyrene

Source: JAT

3.1.2 Organization

(1) National Level

The management organization of solid waste at the national level is the Ministry of Local Government and Regional Development (MLGRD), which covers local governance sectors. Sanitation Department provides technical and financial supports in SWM to Local Government.

Table 3: Current Staff in Sanitation Department in MLGRD

Positions	Number of persons	Main responsibility
Director	1	Overall management of the Sanitation Department
Advisor for SWM	1	Advisory services for overall SWM
Senior Environmental Officer	1	Environmental monitoring of waste treatment and disposal facilities such as landfill sites and collection areas
Environmental Officer	1	Environmental monitoring of waste treatment and disposal facilities such as landfill sites and collection areas (assisted by senior staff)
Civil and Environmental Engineers	2	Planning and design of waste treatment and disposal facilities
Overseers of landfill sites	2	Supervising at existing landfill sites such as Haags Bosch landfill site and Lusingan landfill site
Ranger	1	Implementation of security
Scale House Operator	1	Truck scale data management and monitoring

Source: MLGRD

(1) Local Authority

As local authorities in case of Region 5, Each Neighbourhood Democratic Council (NDCs) provides a waste collection service. For example, in Region 5, there are ten NDCs and each NDC uses small tractor-trailers with a driver and a few collectors. Though the collected waste is disposed of in the dumping site or open space in each NDC, there needs to be more staff in the disposal site. The current main staff in each NDC are shown as follows.

Table 4: Staff in SWM in each NDC

Name of NDC/Municipality	Driver	Waste collector (including other labour)
Blairmont - Gelderland	2	3 (1 Revenue Collector)
Zeelust - Rosignol	2	3 (2 permanent and 1 temporary)
Woodlands - Belair Park	1	2
Bath - Woodley Park	1	2
Union - Naarstigheid	1	0
Seafield - Tempe	1	2
Profit - Rising Sun	1	1 and the other part time staffs
Mahaicony - Abary	1	2
Hamlet – Chance	1	2
Woodlands - Farm	1	2

Source: Each NDC

3.1.3 Finance

(1) Budget for SWM in MLGRD

In case of MLGRD, the expenditure is divided into the capital expenditure and operation one. Current situation, there is available data in 2022. The each component of the budget is shown as following table.

Table 5: Budget regarding SWM by MLGRD

Unit (GYD)

Item	2020	2021	2022
Total budget	-	-	-
Budget of SWM (budget for capital expenditure)	-	-	1,362,000,000
Budget of SWM (budget for operation expenditure) for all the regions	-	-	1,063,000,000
Budget of SWM (budget for operation expenditure) for Region 5	-	-	60,500,000

Note: GYD is Guyana Dollar

Source: MLGRD

(1) Total budget and the expenditure for SWM in each NDC

According to the NDC office in MLGRD, the total budget for each NDC and the expenditure for SWM are show as follows. The expenditure for SWM is different from each NDC.

Table 6: Financial situation in each NDC in Region 5

Unit (GYD)

Name of NDC/Municipality	2019		2020		2021	
	Total budget	Expenditure for SWM	Total budget	Expenditure for SWM	Total budget	Expenditure for SWM
Blairmont - Gelderland	19,784,893	501,981	21,418,022	384,040	25,328,893	1,041,326
Zeelust - Rosignol	22,417,077	14,082,542	16,148,776	13,545,945	24,403,269	15,254,940
Woodlands - Belair	13,235,879	714,548	15,718,587	664,400	19,097,999	602,486
Bath - Woodley Park	1,430,005	1,320,000	3,245,000	1,350,000	3,565,000	1,376,500
Union - Naarstigheid	75,738,283	3,000	100,620,329	500,050	113,030,784	22,000
Seafield - Tempe	23,241,530	100,000	26,186,124	100,000	26,878,738	100,000
Profit - Rising Sun	21,417,488	14,601,527	31,402, 253	15,744,771	32,328,707	18,576,003
Mahaicony - Abary	1,200,000	702,500	1,500,000	725,500	1,500,000	913,500
Hamlet – Chance	19,466,601	195,500	24,424,599	0	23,140,201	0
Woodlands - Farm	35,209,959	800,225	38,947,683	1,357,877	41,616,524	1,425,377

Note: GYD is Guyana Dollar

Source: Each NDC

The ratio of the expenditure of SWM in total budget for each NDC are shown as follows. The ratio depends on each NDC. The ratio of NDCs of Blairmont - Gelderland, Zeelust - Rosignol, Union - Naarstigheid, Seafield - Tempe, Hamlet – Chance is very low such as less than 10%, on the other hand, the rations in the other NDCs are very high. It is difficult to analyse the reason of variable of the ratio. Therefore, it will be necessary to collect the itemized data in the future.

Table 7: Ratio of the expenditure of SWM in total budget in each NDC in Region 5

Unit (%)

Name of NDC	2019	2020	2021
Blairmont - Gelderland	2.5	1.8	4.1
Zeelust - Rosignol	62.8	83.9	62.5
Woodlands - Belair	5.4	4.2	3.2
Bath - Woodley Park	92.3	41.6	38.6
Union - Naarstigheid	0	0.5	0
Seafield - Tempe	0.4	0.4	0.4
Profit - Rising Sun	68.2	50.1	57.5
Mahaicony - Abary	58.5	48.4	60.9
Hamlet – Chance	1.0	0	0
Woodlands - Farm	2.3	3.5	3.4

Source: Each NDC

3.1.4 Public awareness and environmental education

Policy or law for supporting the informal sector: None, however, the EPA is working along with all stakeholders to ban single-use plastics such as drinking straws, bags, eating utensils, cups, etc.

Public awareness-raising activities: Green Generation Guyana and 3Rs Programs focus on promoting SWM & WASH in primary schools and at social events, SWM sensitization program by the municipality, and private groups also focus on beach and park cleaning activities, etc.

3.2 Solid Waste Amount, Characterization and Waste Flow

3.2.1 Waste generation and characterization

In order to grasp the amount and characterization of waste generated, a survey of waste amount and composition was conducted. Usually, it is desirable to conduct the survey twice a year, once in the dry season and once in the rainy season, over a period of eight days including holidays. A summary of the results follows.

(1) Waste Generation Amount

1) Waste from Household

For the amount and composition of household waste, it was assumed that 90 samples would be collected from each household, but only 65 samples were collected. The amount of waste generated per capita by each household differed, but this may be due to differences in lifestyle. No significant differences were found among the targeted NDCs. The results of the waste amount survey are shown below. For further details, please refer to Appendix 1 for the results of the waste amount and composition surveys.

Table 8: Per capita waste generation from Household in Region 5

Item	Household Waste
Planned sample number	90
Actual and effective sample number	65
Average [kg/person/day]	0.31
Upper limit [kg/person/day]	0.98
Lower limit [kg/person/day]	0.04

Source: JAT

2) Waste from the Others (Restaurant, Shop, Institution (School))

For the amount and composition of waste generated by businesses, it was assumed that, for a total of 27 samples, every 9 samples from restaurants, shops and schools would be taken from each source to be surveyed, but only 15 samples were taken in total. The survey results on the amount of waste generated from restaurants, stores, and schools are shown below. For further details, please refer to Appendix 1 for the results of the waste volume and waste quality surveys.

Table 9: Per capita waste generation from the others in Region 5

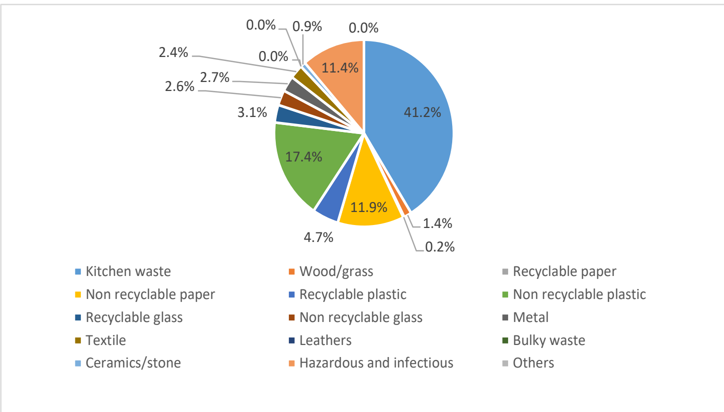
Item	Restaurant	Shop	Institution (School)
Planned sample number	9	9	9
Actual and effective sample number	1	6	8
Average [kg/ day/staff]	0.61	1.14	0.37
Upper limit [kg/ day/ staff]		1.66	1.08
Lower limit [kg/ day/ staff]		0.57	0.08

Source: JAT

(2) Waste Composition

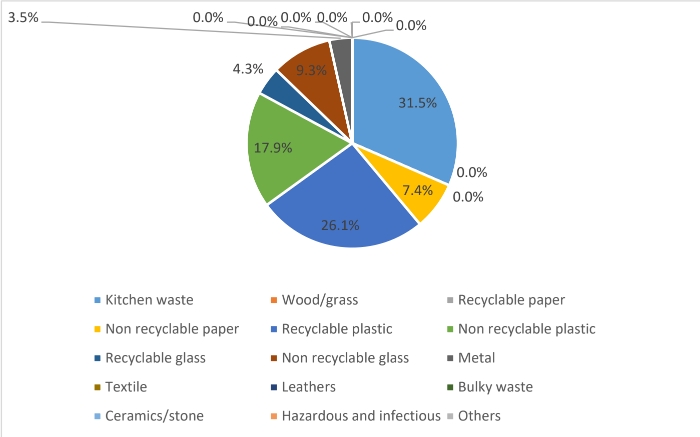
The results of the wet-based physical composition of household waste are shown as follows. Kitchen waste and wood/ grass has the large portion of household waste as total 52. 6% and non recyclable waste or hazardous and infectious waste also have a large portion.

In restaurants, kitchen waste accounted for 32%, and a relatively large share compared to schools (14%) and stores (6%). On the other hand, in stores, paper and plastic used as containers and packaging accounted for a large share (94% total).



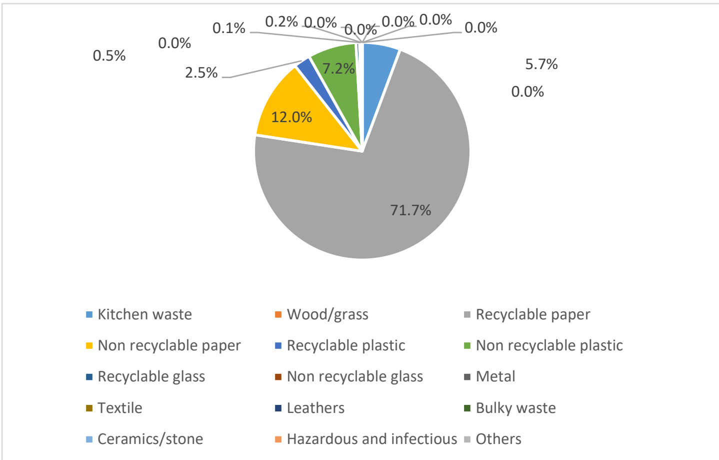
Source: JAT

Figure 1: Physical Composition of Household Waste



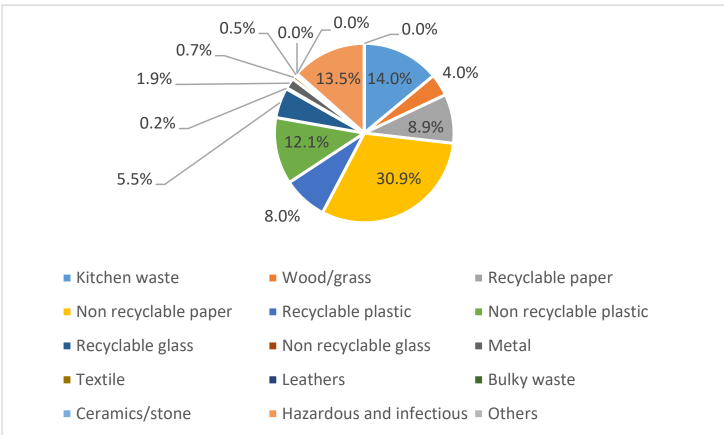
Source: JAT

Figure 2: Physical Composition of Waste from Restaurant



Source: JAT

Figure 3: Physical Composition of Waste from Shop

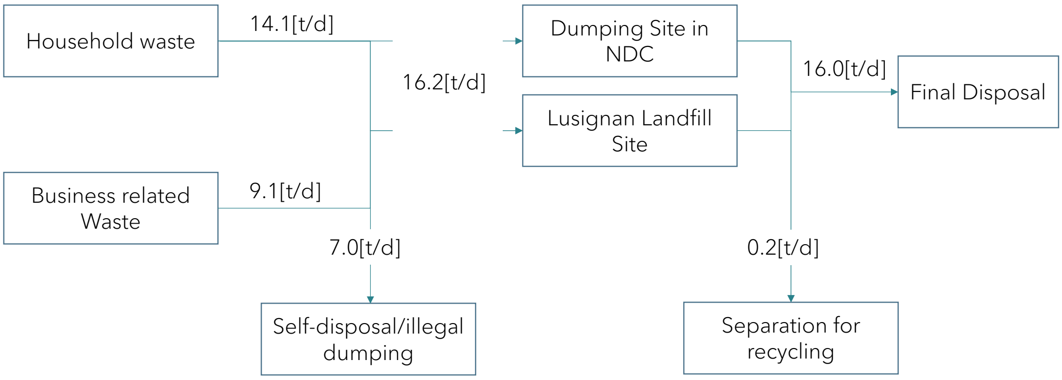


Source: JAT

Figure 4: Physical Composition of Waste from School

3.2.2 Current Waste Flow

Based on the results of the waste amount and composition survey, the current estimated amount of waste generation, collection, on-site treatment, disposal, and recycling are shown in the following figure as a waste flow.



Source: JAT

Figure 5: Current waste flow

3.3 Technical Aspects

3.3.1 Source reduction and discharge

In each of the Region 5 NDCs, waste reduction at the source is not implemented. In areas where the collection is infrequent or uncollected, solid waste is dumped in backyards. Some households may be composting, but no activities such as campaigns by NDCs or other organizations were identified during the survey. On the other hand, it was also observed that residents are dumping solid waste in open spaces and/or drainage, and other public spaces, which is causing environmental degradation in the surrounding areas.

3.3.2 Collection and transportation

The collection and transportation of waste generated in residential areas is conducted by each NDC. Private companies collect commercial waste, primarily from restaurants, stores, and hotels, and solid waste from some households which pay a collection fee. According to the Waste Management Strategy, the collection fee for private companies such as Cevon Solid Waste Management Company and Puran Brothers is GYD 300 per barrel according to the National Solid Waste Management Strategy.

The coverage area for waste collection is about 60-80%. Utilized collection vehicles are one or two tractors owned by each NDC. As for the private sector, compactor vehicles are used for collection and transportation. Photos of the collection situation are shown as follows.

	
Collection by compactor vehicle of a private company	Collection by small tractor-trailer of NDC

The number of collection and transportation equipment and heavy equipment are shown in the following table.

Table 10: Equipment for SWM in each NDC

No.	Name of NDC/Municipality	Collection and transportation equipment		Heavy equipment for final disposal	
		Type of equipment	Number	Type of equipment	Number
Example :		Compactor	1	Bulldozer	1
		Truck	2	Excavator	1
1	Blairmont - Gelderland	Tractor & Trailor	2	Excavator (Backhoe)	1
2	Zeelust - Rosignol	Tractor & Trailor	2	Bulldozer	1
3	Woodlands - Belair Park	Tractor & Trailor	2	No equipment	
4	Bath - Woodley Park	Tractor & Trailor	2	Bulldozer	1
5	Union - Naarstigheid	Tractor & Trailor	2	No equipment	
6	Seafield - Tempe	No information			
7	Profit - Rising Sun	Compactor	1	Excavator	1
8	Mahaicony - Abary	Truck	2	Bulldozer	1
9	Hamlet – Chance	Tractor & Trailor	1	No information	
10	Woodlands - Farm	No information			

Source: Each NDC

A time and motion survey was conducted to determine the current collection status and collection efficiency. A summary of the survey results follows. According to the survey, compactor vehicle and truck is faster than the other vehicles. The loading time per loading waste amount of skip vehicle is faster than the other vehicles. The reason that the loading time of the truck is shorter than the small tractor trailer will be that loading platform is wider than smaller tractor trailer. The reason that the loading time of the compactor vehicle is longer than the truck will be the necessity of compaction time. The unloading time of truck without dump function is much longer than the other vehicles due to the necessity of unloading manually. According to the survey, the average speed of compactor vehicle during transportation is faster than the other vehicles. Therefore, the transportation distance become longer, it will be better to utilize compactor vehicle. However, in the case of that there are many collection points and the transportation distance is short, truck will implement collection and transportation more efficiently. The detail is described in Appendix 2: Time and Motion Survey Report.

Table 11: Result of Time and Motion Survey

Type of vehicle	Average loading time [Second]	Loading points	Average speed during transportation [km/h]	Unloading time at final disposal site [Second]
Compactor vehicle	30	46	54	130
Skip vehicle	35	1	24	84
Small tractor-trailer	35	18	14.4	37
Truck without dump function	17	15	50.5	590

Source: JAT

3.3.3 Recycle and/or Recovery

In Guyana, the only recyclables for which there are reuse or recycling routes are currently metals and glass bottles. These are collected by waste pickers at disposal sites and the glass bottle are sold to the local beverage company such as Banks DIH and the metal is exported through intermediaries to the Republic of Trinidad and Tobago, elsewhere. Other recyclable materials are exported in fragments, but the distribution channels and markets are unstable, and recycling routes still needs to be established.

3.3.4 Final Disposal

Solid waste collected by the NDC is currently dumped at the NDC's disposal site and open space.

The disposal sites are open dumps such as final disposal site in Blairmont NDC and final disposal site in de Edward village in Zeelust - Rosignol NDC), with no bulldozers to spread and compact the waste, no heavy equipment such as excavators to move the solid waste or supply cover material, and no facilities to manage the site such as administration buildings or weighbridge (see the picture of the final disposal site in Blairmont). The solid waste dumped by collectors and haulers is left in the same condition as it was. On the other hand, a private hauler (Puran Brothers Ltd.) transports the waste to the Lusignan landfill site in Region 4 and dumps it there. The landfill site has an administration building, and waste is spread and compacted, but there are no storm drainage facilities, vent pipes, fences, truck scales, or other facilities necessary for a sanitary landfill, and no soil covering has been implemented. In addition, the situation is such that several waste pickers crowd around the dumping of waste from collection trucks to collect recyclables. Photographs of the Region 5 and Region 4 landfills are shown below.

	
Final disposal site in Blairmont in Region 5	Lusignan landfill site in Region 4

3.4 Identified Key Issues

3.4.1 Requirements Based on Existing Laws and Regulations

Based on the existing laws such as the Environmental Protection Law and draft Solid Waste Management Bill, the following SWM is required.

- The Solid Waste Management Bill, the basic law on waste, states establishing the National Solid Waste Management Authority, which is responsible for waste management.

- The bill also stipulates that the Authority shall implement waste management - collection, transportation, treatment, and disposal shall be carried out by the local government but may also be carried out by private companies under a licensing system or as contracted services.

3.4.2 Identified Key Issues

(1) Legal system, strategy, and planning

- The Basic Law on Waste has yet to be approved, although it has been drafted. The Basic Law defines the establishment of a National Solid Management Authority, which will have jurisdiction over treatment and disposal. In addition, there are no administrative rules or guidelines for collection, transportation, recycling, and final disposal based on the Basic Law. The need for a set of national policy has affected the development of proper waste management plans for each region.

- There is a National Solid Waste Management Strategy (2017-2030), but no SWM plan exists in the country or region based on waste generation and future projections. As a result, budgetary measures related to SWM are not available.

(2) Organizational System

- At the national level, the MLGRD implements SWM. Still, the planning and implementing agencies are integrated, and the number of staff needs to be increased compared to the nature of the work.

- Both the NDC and private companies are collecting. Still, the private companies are collecting from sources that are paying fees, and the NDC needs to know which households are relying on the private companies for collection. As a result, even within the collection area, the waste generated at certain generation sources are being collected and others are not.

(3) Waste discharge, collection, and transportation

- The collection system using tractor trailers could be more efficient when considering the expansion of collection areas and future transportation to new sanitary landfill sites.

- Private collection companies are collecting in some areas, but government agencies are not aware of the scope of the collection, and there is no supervision or monitoring of SWM.

(4) Treatment and disposal

- The current landfills at each NDC are open dumping, have no heavy equipment, and have no landfill area set aside, so the waste is unloaded and dumped on site.
- A new sanitary landfill is currently planned for Blairmont, but it is at a lower elevation, on level ground with adjacent drainage channels and potentially a higher groundwater table.

(5) Reduce, Reuse, and Recycle (3R)

- In Guyana, recyclable waste is currently limited. According to interviews with waste pickers and private companies operating at the landfill, only metals and glass bottles are recyclable, and although there was a time when some cardboard and PET bottles were collected for value, due to fluctuations in market prices, they are not currently collected as valuable resources.
- Waste pickers are collecting valuable resources at the disposal sites, but the working environment is not conducive to efficient collection systems, and some of the resources are dumped without being collected.

3.4.3 Gap analysis

The following comparison of the desirable situation considering SWM strategy and draft Solid Waste Management Bill existing legal system and future ideals with the current challenges is outlined in the table.

Table 12: Issues and Direction for the Future to Satisfy the Target

Item	Desirable situation to be targeted	Current problem/issue	Direction for the future to satisfy the target
Legal system	The Basic Act for SWM is established.	The Basic Act for SWM has yet to be established.	The Basic Act for SWM is established through support by foreign consultants.
	Necessary management regulations and technical guidelines for collection, transportation, recycling, and final disposal have been established	Management rules and guidelines for collection, transportation, recycling, and final disposal based on the Basic Law have yet to be established.	After the Basic Law is enacted, various guidelines will be established.
	National and regional SWM plans are established.	National and regional SWM have yet to be established.	A regional SWM plan will be established.
Organizational system	Suitable organizations of SWM have been established to implement waste management with sufficient organization and staff.	Suitable organizations of SWM have yet to be established.	The establishment of the National Solid Management Authority is described in the basic law on SWM, and the suitable organizational structure would be strengthened after the formulation of the Basic Law.
	National government agencies or local	Monitoring of the private company conducting the	In the future, when the NDC will gradually

Item	Desirable situation to be targeted	Current problem/issue	Direction for the future to satisfy the target
	authorities are able to contract with private companies to implement SWM.	collection has yet to be implemented.	change from the direct collection by NDC to private contractors and collect waste collection service charges from residents, the National Solid Management Authority will contract with a private company to perform SWM.
Collection and transportation	Efficient collection is needed.	Tractor-trailer-based collection systems could be more efficient when considering the expansion of collection areas and future transportation to new sanitary landfills.	The collection and transportation system will be improved by utilizing compactor trucks, which is partially implemented by private companies.
	The collection area is clear, fixed-point collection is implemented.	Although private collectors and transporters are collecting in some areas, the scope of the collection is not known by government agencies, and supervision and monitoring of SWM still need to be established.	Monitoring responsibilities in contracts between the government and private companies will be included and a mechanism for monitoring will be established at each NDC.
Final disposal	Final disposal sites are not open dumping, but sanitary landfill site and the sites are properly operated.	The current disposal sites at each NDC are open dumping and there are no heavy equipment and the landfill area to be disposed of needs to be set up clearly.	The current disposal site is open dumping and needs more capacity for future landfilling is required. Therefore, a new landfill site will be developed, and the current disposal site will be closed with environmental remediation.
		A new sanitary landfill is currently planned at Blairmont, but the area is in low-level ground with adjacent drainage channels and potentially a higher groundwater table.	Due to lower level land, it is necessary to consider a liner system as well as the necessity of a groundwater collection system. It will be necessary to design based on necessary topographical surveying and geological investigation to secure the gradient of rainwater drainage and leachate collection and drainage in the future.
	With regard to the 3Rs, a state in which waste	In Guyana, recyclable waste is currently limited.	The separation at the source and efficient

Item	Desirable situation to be targeted	Current problem/issue	Direction for the future to satisfy the target
Reduce, Reuse, Recycle (3R)	reduction is progressing and a collection system for reusable and recyclable (recyclable) waste has been established.	Only metals and glass bottles are accepted, while cardboard and plastic bottles may not be recyclable. Waste pickers collect recyclables at the disposal site, but the work environment could be better and the system for efficient collection still needs to be put in place, and some recyclable waste is dumped without being collected.	collection of recyclables will be promoted. A sorting area within the final disposal site will be prepared for the efficient collection of a recyclable waste considering the work environment for waste pickers. As for waste reduction, there is a collection system for returnable bottles, and in the future, programs to reduce waste at home and at schools will be promoted.

Source: JAT

4 Future Framework

4.1 Socio-Economic Framework Population

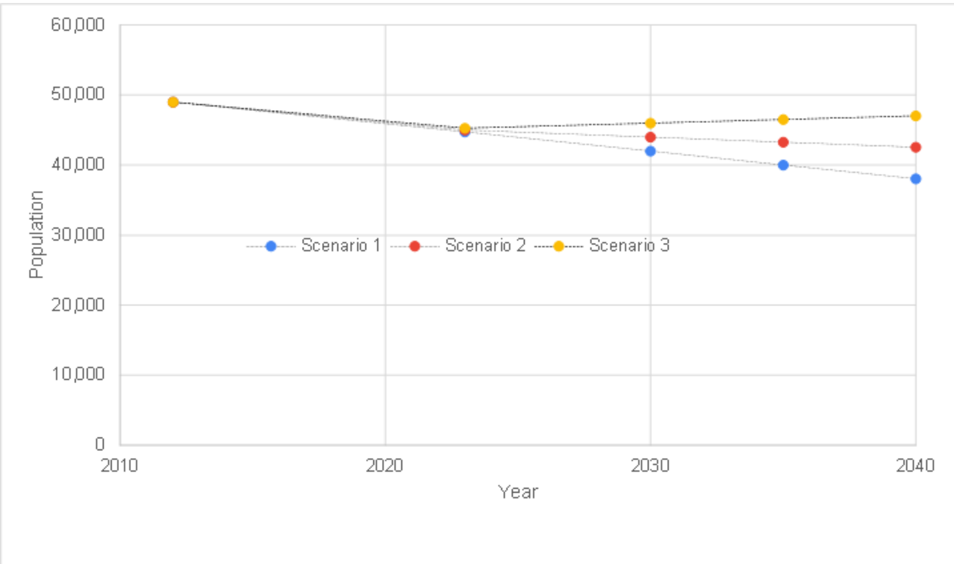
In Region 5, population outflow to Region 4 where urbanization is progressing is occurring, and the rate of population growth in Region 5 is gradually decreasing, according to the census data in 2002 and 2012. On the other hand, there are plans for residential development in Mahaica and other areas adjacent to Region 4, which will halt the tendency of population outflow and reduce the rate of decline in the future. Based on the above considerations, three scenarios were considered, and population projections were conducted.

Scenario 1 is a scenario in which housing development is promoted and population growth proceeds toward 2040.

Scenario 2 is a scenario in which housing development is promoted and the population decrease is curbed slightly.

Scenario 3 is a scenario in which population decrease continues as it does now.

As a realistic scenario, although the population will decrease, it is considered more realistic to assume that the population will decrease slightly as the urban development in Region 4 progresses and residential development in the suburbs proceeds, which in turn leads to residential development in the western part of Region 5, which in turn leads to a slight halt in the population decrease trend. Therefore, Scenario 2 is adopted in this plan.



Source: JAT

Figure 6: Population Projection in Region 5

4.2 Other Socio-economic Situations

The primary industry in Region 5 is agriculture, and land is used for agriculture including rice fields and sugarcane fields for agro-processing sugar factories. In the future, Region 5 will be developed in the same way as the urbanization of the adjacent Region 4, but there are no plans for large-scale development, and major socioeconomic changes are not expected to occur.

4.3 Projected Waste Generation

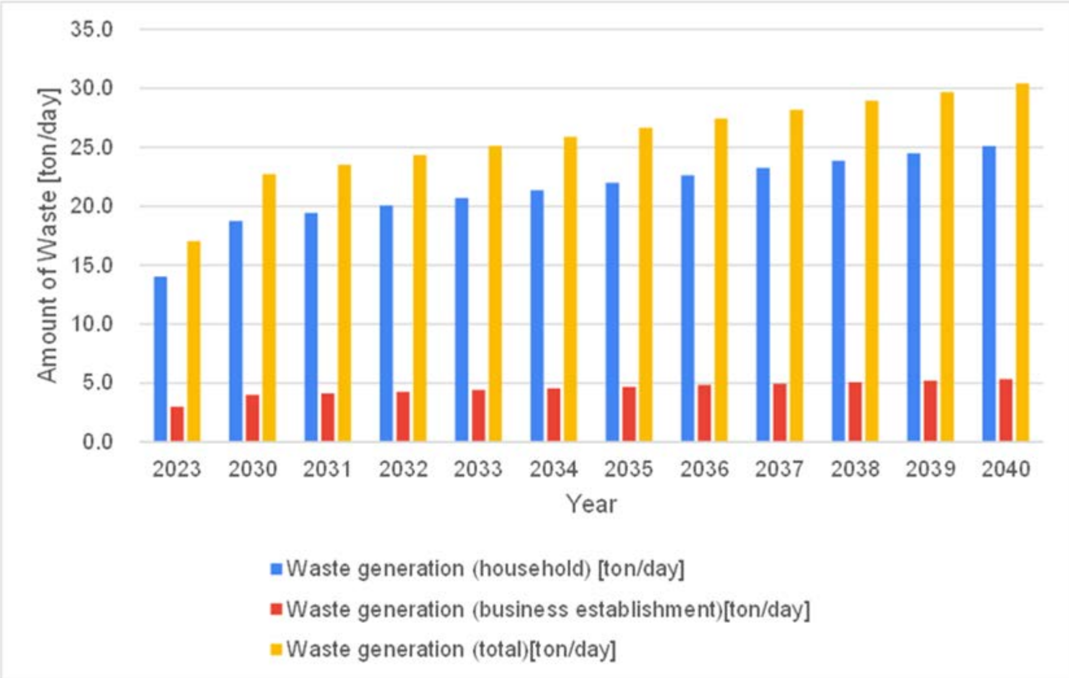
(1) Household Waste

Based on existing data from previous studies and the results of the Waste Amount and Composition Survey (WACS) conducted in 2023, the Waste Generation Rate (WGR) in 2023 in Region 5 was grasped. Based on previous experience in other countries, WGR typically increases with economic growth and lifestyle changes.

A hypothetical assumption was made that urbanization would progress to the current situation in Georgetown around 2040, and the current WGR in Georgetown is used for the WGR in Region 5.

(2) Non Household Waste (Commercial and Institutional Waste)

Assuming the same urbanization process for commercial and institutional waste as for residential waste, the rate of increase was assumed to be the same as for household waste.



Source: JAT

Figure 7: Projected Waste Generation in Region 5

5 Planning Strategy

5.1 Vision and Goals

According to National Waste Strategy, the private sector and communities' partner with the central government in participating in nationwide, integrated, and financially self-sustaining SWM and resource recovery system that preserves public health and the environment, realizes maximum value from resources and minimizes long-term costs to households, industry, and government.

According to National Waste Strategy, the main target as follows.

1. Less litter and illegal dumping
2. Less waste generated
3. Better resource recovery
4. Efficient and cost-effective waste collection
5. Better waste infrastructure
6. Strengthened human and institutional capacity

Based on the strategy at national level, targets and strategy for this regional plan will be set.

5.2 Targets

Based on the current situation, future improvements should be phased in. In developing this regional plan, the following target years were established for the short, medium, and long term.

Short term : Year 2023–- 2030

Middle term : Year 2030–- 2035

Long term : Year 2035–- 2040

Based on the current collection rate (waste collection amount/waste generation amount) / , self-disposal rate (non-waste collection amount / waste generation amount), recycle rate (waste recycling amount/waste collection amount), and final disposal rate (final disposal amount/waste collection amount), the future target values are shown below.

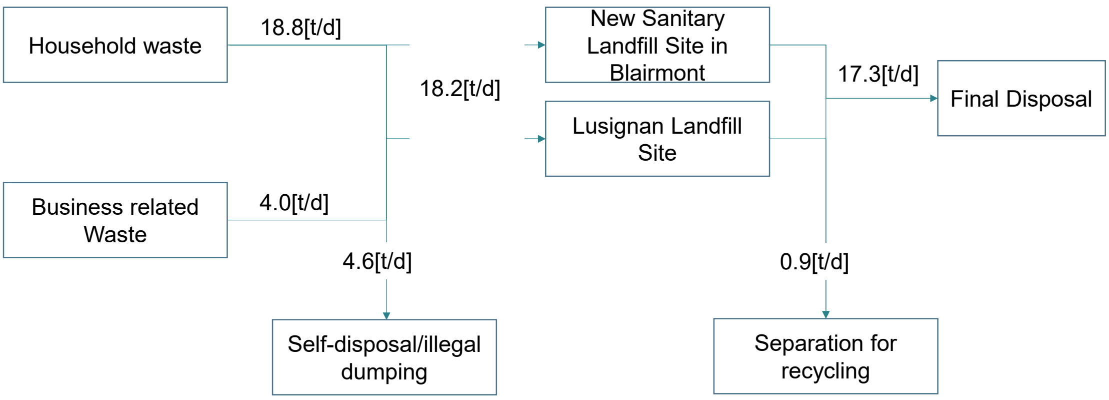
Table 13: Future Target of Each Waste Management Rate

Item	2023	2030	2035	2040
Collection Rate (%)	70%	80%	85%	90%
Self-disposal Rate (%)	30%	20%	15%	10%
Recycle Rate (%)	1.7%	5%	7%	10%
Final disposal Rate (%)	98%	95%	93%	90%

Source: JAT

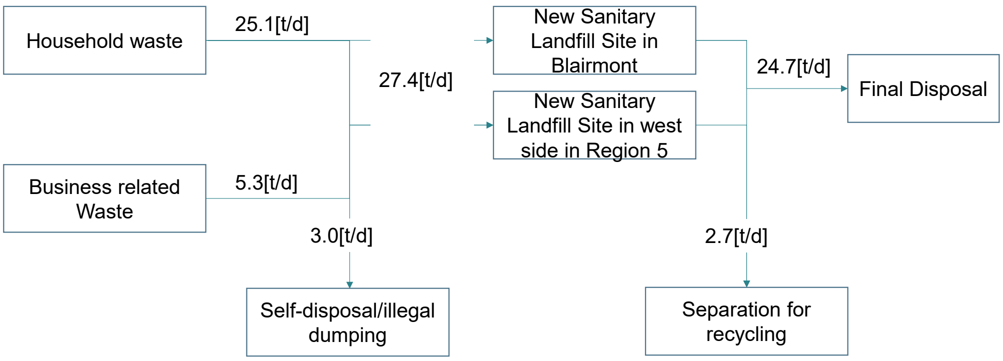
5.3 Future Waste Flow

The future waste flows in 2030 and 2040 based on the above targets are shown below.



Source: JAT

Figure 8: Future waste flow in 2030



Source: JAT

Figure 9: Future waste flow in 2040

5.4 Strategy to Satisfy the Target

Based on the current issues described in 3.4, the following are the strategies that should be taken in the future SWM in Region 5 in order to achieve the targets in 5.2.

Improvement of collection and transportation

(1) Establishment of Fixed Time and Point Collection System

Even though in the area where collection services are provided, collection is not being carried out on a regular basis, and collection areas need to be monitored by each municipality. Therefore, collection time and collection points should be fixed and the collection system should be established to enable each NDC to monitor the collection area, including where private companies are collecting waste.

(2) Effective Collection and Transportation

Currently, NDC provides the collection and transportation service with small tractors, which could be more efficient for collection. In particular, if a sanitary landfill site is developed in the future and shared by all NDCs, collection and, transportation will take more time, significantly since the transportation distance from the collection area to the final disposal site will increase in the west side of Region 5. Therefore, it is better that the collection and transportation vehicles will be gradually changed to compactor vehicles or skips. Since private companies are already using compactor vehicles and skips for collection, the private company will be able to improve collection and transportation efficiency.

(3) Improvement of Collection Rate and Frequency

The collection frequency is once a week or once in two weeks at each NDC. As a result, even in areas where the collection is being implemented, dumping into vacant places and drainages occurs due to the difficulty of storing the waste at the source of each household or business. Therefore, it is necessary to improve the collection rate and increase the collection frequency.

Improvement of Final Disposal

(1) Development of Sanitary Landfill Site

In Region 5, there is no sanitary landfill site for final disposal, and it is necessary to develop a new sanitary landfill. Sanitary landfill site includes landfill area, rainwater drainage, gas ventilation pipe, leachate collection and treatment facility weighbridge, heavy equipment for landfill activities, etc. MLGRD is progressing with the development of a landfill by land acquisition in Blairmont, by preparing an access road.

(2) Closure of Existing Open Dumping Site and Environmental Remediation

After the development of a new landfill site in Blairmont, existing open dumping sites in each NDC will be closed. The closure plan should include rainwater drainage and final soil cover to prevent rainwater infiltration.

Promotion of reduction and recycling

(1) Promotion of separation discharge of recyclables at source

Residents and businesses will promote the separation of recyclable waste at the generation source, and separate discharge of recyclable waste at source will be promoted to establish a separate collection system in the future.

(2) Promotion of waste reduction at the source

- Curbing the distribution of free plastic bags to reduce waste generation will be considered.

- A pilot project for composting food waste has been implemented in Region 4. Based on the results of this project, the implementation of composting food waste by residents and schools will be considered.

The development direction of collection and transportation system and final disposal is that the waste generated in east side in Region 5 is transported to the new landfill site in Blairmont and the waste in west side is transported to Lusigan landfill site until near future. However, new landfill site should be developed in the area of west side in Region 5 in the future.

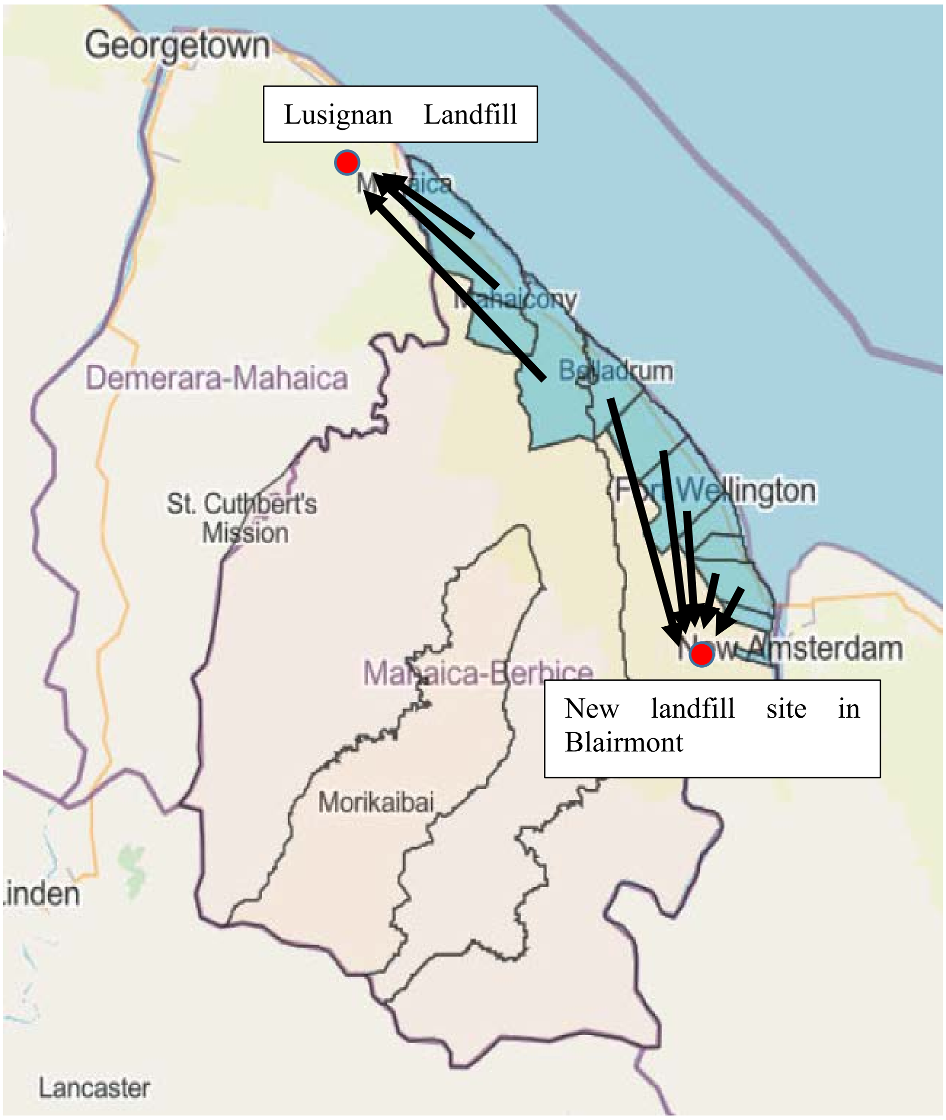


Figure 10: Development Direction of Collection and Transportation and Final Disposal

6 Technical System for SWM

6.1 Collection and Transportation and Sweeping

Considering the situation of the current collection and transportation, the improvement of collection and transportation system is needed for the future. As indicated in the strategy, the current collection rate should be increased. To do so, it is necessary to increase the efficiency of collection and transportation. A plan should be developed to enable the implementation of fixed-point collection at regular intervals.

(1) Discharge Method

There are some options for the discharge methods. Currently, private companies provide their services to residents by providing a bin and charging a fee from residents on the day of collection. However, the NDCs do not offer a disposal container for the residents but would collect their garbage by the residents throwing it into the tractors or salt bags and would also collect a fee. Both private companies and the NDC have a door-to-door system. The discharge methods are compared as follows.

Table 14: Comparison of Discharge Method

Method of discharge	Feature	Image of equipment/situation	Proposed target area or target waste for this project
Garbage bin	Currently, private companies rent garbage bins for waste dischargers. Due to this system, the surrounding area will be kept clean.		Utilization for residential area Stations[1] are prepared for 30 households
Plastic bag in an open space	It is a simple method but there is some possibilities of the waste being scattered		Due to the possibility of waste scattering, it is not recommended for this plan.
Metal container	Suitable for residential areas where waste dischargers bring the waste to the station and put the waste in the area.		Utilization for residential area Stations are prepared for 30 households
Skip Container	Suitable for waste from the market areas where the container needs a certain area for installation.		Utilization for large-scale market area in the future though there is currently no large-scale market in Region 5

Source: JAT

[1] Station means a collection point of waste where a few waste dischargers bring the waste from each generation source and some garbage bins or containers for waste storage for short term are provided in the collection point.

(2) Collection Method

Currently, MLGRD is planning a new sanitary landfill in Blairmont in east side of Region 5. At each NDC, there are both collection by NDCs with small tractors and by private companies with compactor vehicle. Based on the results of the time and motion study, the collection system of compactor vehicle is proposed to improve the efficiency of collection and transportation. The comparison of each type of collection system is shown as follows.

Table 15: Comparison of Collection Method

Method of collection and transportation	Image of collection and transportation system	Proposed target area or target waste for this project
Transport by compactor vehicle after the compaction of receiving waste in the vehicle		Compactor can transport waste efficiently by waste compaction. Loading is not so difficult due to the lower bucket
Transport by dump truck after the receiving waste in some transfer stations by manual or equipment		Collect various types of waste such as bulky waste or glass bottles but the waste transportation is not effectively like compactor vehicle.
Transport by skip container/container carrier		Collect various types of waste such as bulky waste or glass bottle No need of loading waste manually but loading the skip or container carrier of each waste

Source: JAT

(3) Planning

The basic condition for planning is shown as follows.

Table 16: Basic Condition for Collection Plan

Item	10 NDC Areas in Region 5
Target NDCs in Region 5	Blairmont - Gelderland, Zeelust–Rosignal, Woodlands- Belair Park, Bath-Woodley Park, Union-Naarstigheid, Seafield-Tempe, Profit-Rising Sun, Mahaicony-Abary, Hamlet-Chance, Woodlands- Farm
Collection frequency	Twice a week
Collection vehicle	Compactor vehicle (12m3, 8m3, 4m3)
Working hour	8 hours from Monday to Saturday

Source: JAT

Based on the future estimation data, the waste amount to be collected is as follows.

Table 17: Waste Collection Amount

Unit [ton/day]

Name of NDC	Year 2023	Year 2030	Year 2040
Blairmont - Gelderland	1.2	1.6	2.1
Zeelust–Rosignal	3.1	4.0	5.2
Woodlands- Belair Park	0.5	0.7	0.9
Bath-Woodley Park	2.5	3.2	4.2
Union-Naarstigheid	2.6	3.4	4.4
Seafield-Tempe	1.1	1.4	1.8
Profit-Rising Sun	1.3	1.7	2.2
Mahaicony-Abary	1.7	2.3	2.9
Hamlet-Chance	0.8	1.0	1.3
Woodlands-Farm	1.6	2.1	2.7

Source: JAT

To consider the trip number with considering collection time in the collection area and transportation time, the following information is used.

Table 18: Transportation Distance for Collection and Transportation

Name of NDC	Distance in collection area [km]	Distance between new landfill site in Blairmont [km]	Distance from Lusignan landfill site [km]
Blairmont - Gelderland	30.8	5.4	120
Zeelust–Rosignal	51.75	10.2	115.2
Woodlands- Belair Park	27.4	15.7	109.7
Bath-Woodley Park	34.2	17.2	108.2
Union-Naarstigheid	95.4	24	101.4
Seafield-Tempe	69.3	37.2	88.2
Profit-Rising Sun	57.15	42	83.4
Mahaicony-Abary	105.7	52.1	73.3
Hamlet-Chance	72.2	60.4	65
Woodlands-Farm	99.5	65.4	60

Source: JAT

According to the above table, the waste from Woodlands-farm NDC will be transported to the Lusignan landfill site until near future before development of new landfill site in west side of region 5, and the waste from the other NDCs will be transported to the new landfill site in Blairmont.

Table 19: Time Used for Collection and Transportation

Name of NDC	Time for transportation in collection area [hr]	Time for transportation from collection area to landfill site [hr]
Blairmont - Gelderland	5.1	0.1
Zeelust–Rosignal	8.6	0.2
Woodlands- Belair Park	4.6	0.3
Bath-Woodley Park	5.7	0.3
Union-Naarstigheid	15.9	0.4
Seafield-Tempe	11.6	0.7
Profit-Rising Sun	9.5	0.8
Mahaicony-Abary	17.6	1.0
Hamlet-Chance	12.0	1.1
Woodlands-Farm	16.6	1.2

Source: JAT

The possible trip number should be calculated from the aspect of time for collection and transportation and the capacity of vehicle for respective cases (12m^3, 8 m^3, 4 m^3). The necessary trip number in 2030 and 2040 are shown in the following tables.

Table 20: Possible Trip Number in Aspect of Collection and Transportation Time and Necessary Trip Number in Respective Cases (12 m^3, 8m^3, 4m^3) for Collection and Transportation in 2030

Name of NDC	Possible trip for all the area [trips/day]	Necessary Trip number (trips /week) (12 m3)	Necessary Trip number (trips /week) (8 m3)	Necessary Trip number (trips /week) (4 m3)
Blairmont - Gelderland	2	2	4	6
Zeelust–Rosignal	4	6	8	14
Woodlands- Belair Park	2	2	2	4
Bath-Woodley Park	2	4	6	12
Union-Naarstigheid	6	4	6	12
Seafield-Tempe	4	2	4	6
Profit-Rising Sun	4	2	4	6
Mahaicony-Abary	6	4	4	8
Hamlet-Chance	4	2	2	4
Woodlands-Farm	6	4	4	8

Source: JAT

Table 21: Possible Trip Number in Aspect of Collection and Transportation Time and Necessary Trip Number in Respective Cases (12 m^3, 8m^3, 4m^3) for Collection and Transportation in 2040

Name of NDC	Possible trip for all the area [trips/day]	Necessary Trip number (trips /week) (12 m3)	Necessary Trip number (trips /week) (8 m3)	Necessary Trip number (trips /week) (4 m3)
Blairmont - Gelderland	2	2	4	6
Zeelust–Rosignal	4	6	8	14
Woodlands- Belair Park	2	2	2	4
Bath-Woodley Park	2	4	6	12
Union-Naarstigheid	6	4	6	12
Seafield-Tempe	4	2	4	6
Profit-Rising Sun	4	2	4	6
Mahaicony-Abary	6	4	4	8
Hamlet-Chance	4	2	2	4
Woodlands-Farm	6	4	4	8

Source: JAT

The compactor vehicle of 12 m^3 is more efficient than of 8m^3 and 4m^3. However, there are some areas where have narrow roads. But compactor vehicles pass the narrow roads easier than the current small tractor trailer. Therefore, a compactor vehicle of 12m^3 is selected as the vehicle to collect the waste in Region 5. The necessary trip numbers in 2030 and in 2040 in case of 12m^3 are shown as the following table.

Table 22: Necessary Trip Number for Collection and Transportation in 2030 and 2040

Name of NDC	Necessary trip in 2030 (trips /week)	Necessary trip in 2040 (trips /week)
Blairmont - Gelderland	2	4
Zeelust–Rosignal	8	10
Woodlands- Belair Park	2	2
Bath-Woodley Park	4	6
Union-Naarstigheid	9	13
Seafield-Tempe	4	7
Profit-Rising Sun	3	6
Mahaicony-Abary	10	10
Hamlet-Chance	4	4
Woodlands-Farm	10	10

Source: JAT

(4) Considering separate collections for the future

The amount of recyclable waste which is generated in region 5 is very small. According to the WACS, the amount of recyclable waste is only around 200 to 300 [kg/day] (1.7 % of total waste generation amount) in Region 5. In that case, separate collection is very difficult to collect the suitable recyclable waste daily or weekly. However, it is important to improve the working condition of waste pickers and to increase the efficiency of sorting recyclable waste. Recyclable waste will be collected only once a month by renting a truck with a separation container and transported to the sorting area in the new landfill site in Blairmont.

(5) Necessary Equipment

If collection vehicles can be shared in NDCs, the collection and transportation can be implemented over adjacent NDCs which will collect and transport the waste more effectively. However, according to MLGRD, some of NDCs would like to provide waste collection services by themselves by using their own equipment. Therefore, the necessary equipment is estimated as two cases.

1) Case 1 (Common usage of collection and transportation vehicle)

In case collection vehicles can be used in all the region, the equipment used in an NDC can be utilized in the other NDCs. The number of pieces of equipment is shown as follows.

Table 23: Necessary Compactors in Case of Vehicles Owned in Region Level in 2030 and 2040

Name of NDC	Necessary trip in 2030	Necessary trip in 2040
Blairmont - Gelderland [trips / week]	2	4
Zeelust–Rosignal [trips / week]	8	10
Woodlands- Belair Park [trips / week]	2	2
Bath-Woodley Park [trips / week]	4	6
Union-Naarstigheid [trips / week]	9	13
Seafield-Tempe [trips / week]	4	7
Profit-Rising Sun [trips / week]	3	6
Mahaicony-Abary [trips / week]	10	10
Hamlet-Chance [trips / week]	4	4
Woodlands-Farm [trip / week]	10	10
Total number of trips [trips / week]	56	72
Total number of vehicles	5	7

Source: JAT

2) Case 2 （Usage of collection and transportation vehicle in each NDC）

In case of that collection vehicles are owned by each NDC, the equipment is used in the NDC. The number of pieces of equipment is shown as follows.

Table 24: Necessary Compactors in Case of Vehicles Owned in Each NDC in 2030 and 2040

Name of NDC	Necessary trip in 2030 [trip / week]	Number of necessary vehicle in 2030	Necessary trip in 2040 [trip / week]	Number of necessary vehicle in 2040
Blairmont - Gelderland	2	1	4	1
Zeelust–Rosignal	8	1	10	2
Woodlands- Belair Park	2	1	2	1
Bath-Woodley Park	4	1	6	1
Union-Naarstigheid	9	1	13	1
Seafield-Tempe	4	1	7	1
Profit-Rising Sun	3	1	6	1
Mahaicony-Abary	10	1	10	1
Hamlet-Chance	4	1	4	1
Woodlands-Farm	10	1	10	1
Total number of vehicles	-	10	-	11

Source: JAT

(6) Sweeping

Currently, clean-up campaigns are being conducted in Guyana on an irregular basis, with the participation of various Ministries and private organizations, at the direction of the President and others. It would be desirable if these activities were carried out regular basis. On the other hand, it is important to educate the local communities to prevent the discharge of waste in the surrounding areas and clean up around own households

In addition, it is important to educate the public about clean-up, and campaigns should be conducted through schools, religious institutions, companies, etc.

In particular, areas, where the collection is only conducted irregularly, are seen to be littered with garbage. Outsourcing waste collection to the private sector as a beautification service that also includes waste cleaning services would help to improve the provision and efficiency of waste collection services by utilizing the expertise of private companies.

6.2 3R (Source Reduction, Reuse, Recycle)

(1) Source Reduction

Based on the idea of reducing the amount of waste at the source, the following is a proposed program for reducing food waste and other types of waste. Composting at the source is an effective means to reduce food waste. To reduce non-biodegradable waste, programs are already in place to return bottles to vendors and reduce the use of plastic shopping bags are proposed. In addition, programs to reduce the use of disposable plastic containers and packaging that are being implemented, and collective collection programs are proposed.

Table 25: Source Reduction Program

Objective	Item of the Activity	Contents
Reduction of organic waste	Promotion of home composting	Small scale compositing will be promoted for each household and small business establishment.
Reduction of inorganic waste	Promotion of collection of plastic containers for recycling by an economic incentive such as a deposit system	For producers, the collection of a used bottle is required. A deposit system on the product to collect used empty containers is introduced as a part of the procedure. This system is partially introduced for glass bottles but not plastic containers. The system will be promoted for plastic containers in the future.
	Promotion of reduction of usage of the plastic shopping bags	To reduce plastic shopping bags, my bag campaign will be implemented and plastic bags in the market will be charged.
	Introduction of group collection	Recyclable waste is collected at existing places where people gather, such as in front of the store, schools, and religious facilities (churches, temples, mosques, etc.). when a certain amount is accumulated, it is sold to a company that handles recyclable waste.

Source: JAT

(2) Recycle

In Guyana, there are currently no market routes for recycling except for some glass bottles and valuable recyclable materials such as metals. As stated in the Solid Waste Management Bill, Guyana is considering EPR (Extended Producers Responsibility), Guyana is considering EPR, and the private sector needs to establish a mechanism to burden the cost based on the principle of EPR.

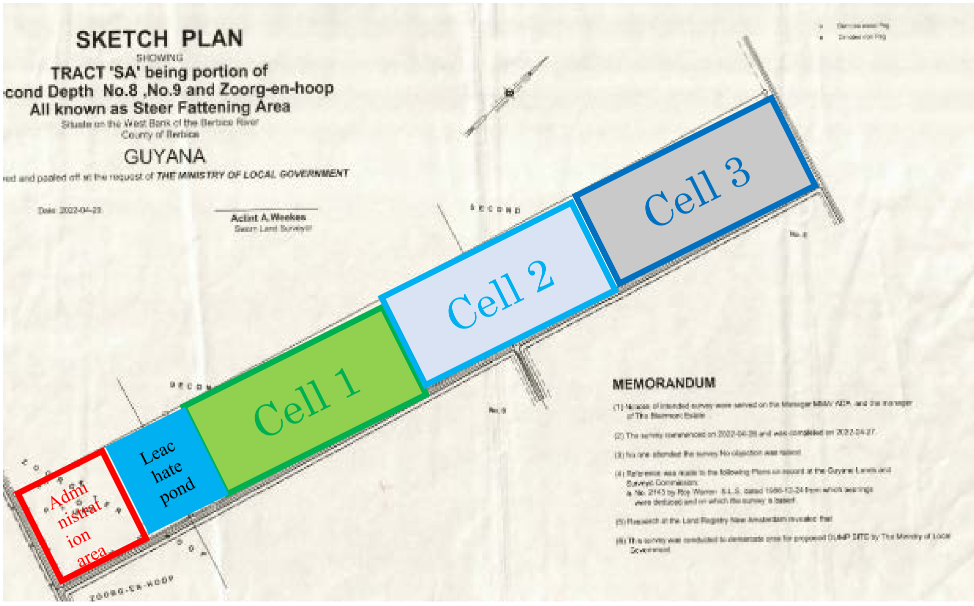
As for recyclable waste, it is difficult to efficiently implement separate collection due to its small amount of recyclable waste.

but it is necessary to create a system that facilitates sorting commingled waste by waste pickers. To do so, a separate collection service could be introduced such that recyclable waste could be collected separately only once a month. These collected recyclables will be brought to the landfill, where a sorting area will be set up and sorting could be more easily carried out by the waste pickers.

6.3 Final Disposal

(1) Development of a New Landfill Site in Blairmont

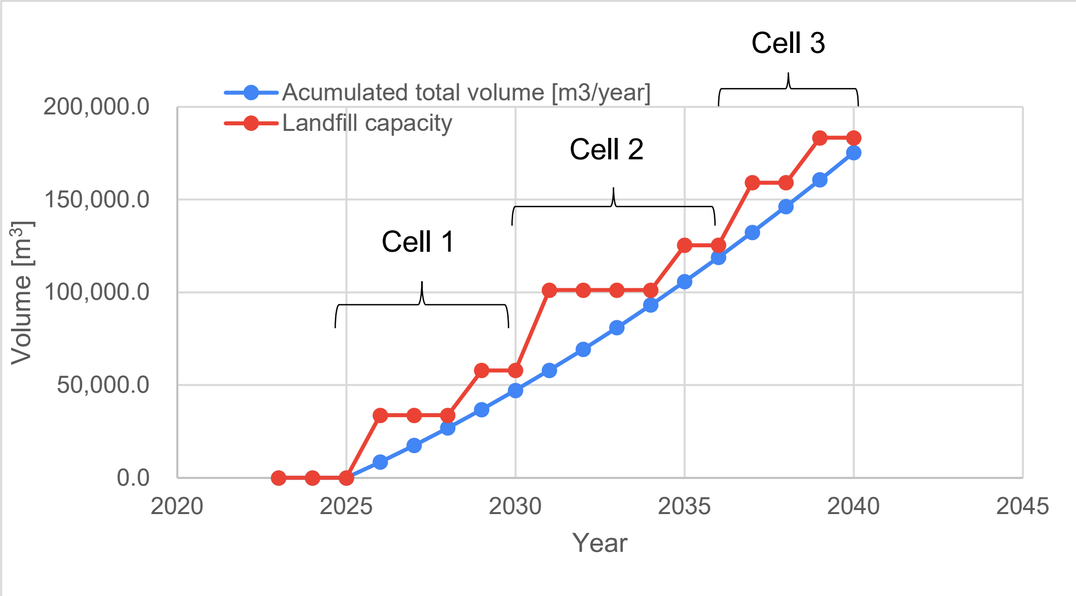
The new site for final disposal has been acquired in Blairmont in Region 5. The site is located along the boundary of a sugar cane field and is bordered by an irrigation canal and drainage channel. The access road from the existing road is currently under construction, and the access road will be built on the other side of the drainage canal so that loading and unloading to and from the site will be done through a road bridge over the drainage canal. The site is a flat area with low elevation and close to the Berbice River, an area that will be floodproofed by closing the sluice gates when the water level rises. The site area is approximately 40 Acres, which is 16 ha, and its shape is a slender rectangle. Considering the construction cost and waste amount to be landfilled in Region 5, the stepwise approach of the plan will be better. Therefore, the landfill area will be divided into three phases: an administrative area (gate, truck scale, administration building, etc.) will be located near the entrance near the access road, and a leachate treatment area will be near the drainage channel.



Source: JAT

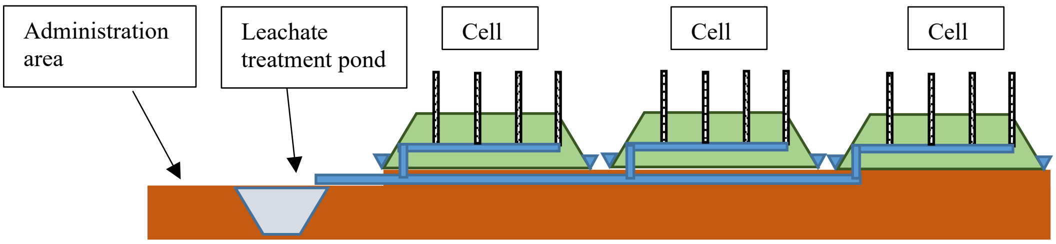
Figure 11: Stepwise Development of Current Acquired Area for a New Landfill Development in Blairmont

Each cell of landfill will be stepwise developed based on the requirement of landfill capacity. The relationship between amount of waste to be disposed and landfill capacity are shown in the following figure.



Source: JAT

Figure 12: Stepwise Development of Current Acquired Area for a New Landfill Development in Blairmont



Source: JAT

Figure 13: Stepwise Development of Current Acquired Area for a New Landfill Development in Blairmont

The basic condition of the development of the new landfill site and main facilities are shown in the following figures.

Table 26: Basic Condition of Landfill Development

Density [ton/m3]	0.6
Soil cover rate (Soil cover[m3]/Waste amount[m3])	15%
Height [m]	2
Layer number	2

Source: JAT

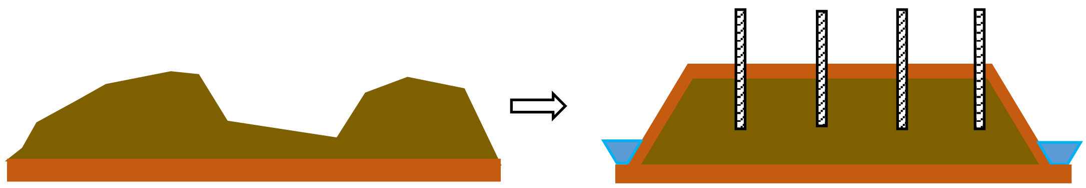
Table 27: Main Facilities and Equipment for a New Landfill Development in Region 5

Main Facility	Function of Facility
The landfill area, is encompassed by an embankment	Embankments keep the waste in landfill areas to prevent scattering and falling waste, as well as rainwater infiltration from the outside slope
Liner system	Liner sheets or compacted clay soil to mitigate leachate seepage from each landfill layer.
Leachate collection and treatment facility	The facility collects the leachate to transport to the leachate treatment facility, which treats the leachate to discharge outside watercourses. A part of the leachate will be recirculated to the landfill site.
Landfill gas exhaust facility	Vertical perforated pipe collects the landfill gas and exhausts it and promotes semi-aerobic condition in landfill layer.
Surface water drainage facility	Drain out the stormwater to prevent the inflow to landfill area, which causes leachate.
Weighbridge	Weighing both the collection vehicle loading waste and no-loading to identify the amount of loaded waste
Sorting and composting area	In the sorting area, only for separating solid waste and checking it. In the composting area, fermentation, and maturation are implemented.
Office building	Office for staff worked in a landfill site
Buffer zone and fence	Protect the surrounding environment from negative impacts of odour, landscape, etc
Landfill equipment	Landfill equipment is used for spreading and compacting solid waste and carrying and covering soil to waste mainly.
Internal service roads	Provide access to all the facilities on site

Source: JAT

(2) Closure of Existing Open dumping Site

In existing open dumping sites, waste is scattered in the area. Therefore, such scattered waste should be accumulated and prevent infiltration of rainwater in the accumulated waste by soil cover on the top of waste and rainwater drainage in the surrounding area. The image of after closure of the open dumping site is as follows.



Source: JAT

Figure 14: Image of Closure of Open Dumping Site in each NDC

7 Institutional Arrangements for SWM

7.1 Legislation

The basic law on SWM was drafted in 2014 as Solid Waste Management Bill, and the law stipulates that the National Solid Waste Management Authority will implement waste management. After its drafting, there was a change of administration, and the law has yet to be officially promulgated.

In addition, by laws, standards, guidelines, etc., will be needed after this law is enacted. First of all, this law must be enacted, and it is necessary for the National Solid Waste Management Authority, which will be established based on this law, and for local government to establish the relevant legal systems.

The main necessary by-laws are shown as follows.

- By-law regarding Extended Producers Responsibly
- By-law regarding the promotion of Product Stewardship
- By laws of SWM in Region 5.

7.2 Organizations

The organization will be setting up a new landfill site in Region 5. All the staff regarding collection and transportation in the office of the administrative building and fields.

Table 28: Necessary Staff for SWM in Region 5

Position	2030	2040
Supervisor	1	1
Driver	5	7
Collector	10	14
Environmental monitor	2	2
Supervisor in landfill site	1	1
Landfill operator	2	2
Heavy equipment operator	3	3
Truck scale operator	1	1
Security guard	1	1

Source: JAT

7.3 Finance (Revenue and Expenditure)

There is some information on the budget of some projects in Guyana. According to the ministry of finance, the budget regarding SWM in the sanitation department in Guyana is shown as follows.

Table 29: Budget for the development cost for SWM in MLGRD

Unit (GYD)

Item	2021	2022	2023
Budget for SWM in MLGRD	1.1 billion	1.4 billion	1.9 billion

Source: Ministry of Finance

However, there is currently no detailed revenue and expenditure information for each purpose, such as collection, transportation, and final disposal, related to SWM in Guyana. If it is clarified it is essential to compare the result of cost estimation to consider the cost recovery of this plan.

7.4 Public awareness and environmental education

Public awareness raising and environmental education of SWM by utilizing IEC tools is important for the smooth implementation of SWM with public cooperation. There are various methods of environmental education using mass communication and interpersonal communication.

Various public awareness raising and environmental education could be adopted, taking advantage of the different methods available as follows.

Table 30: Various Tools of Environmental Education

No.	Media	Descriptions	Contents
Mass Communication and Education			
(1) SNS Media			
1.	Facebook	Facebook is one of the effective tools of social media with low-cost media to raise people's awareness on a large scale.	The progress of the regional SWM plan and the activities of SWM, could be disseminated with this tool widely and could obtain some feedback from readers.
2.	Websites	Websites could provide people with details of the SWM activities	The components, progress, and outcomes of the regional SWM plan as well as SWM information, are often updated.
(2) Traditional Media			
3.	Posters, leaflets, stickers	These printed media are effective with literate people, tourists, and school children, and can be used often. Stickers can be attached to various places for publicity including transport vehicles like ships, buses, vans, cabs, tricycles, and pump boats.	The printed media are distributed to the residents, business establishments, etc. Various catchy and short messages on SWM are printed and distributed.
4.	Billboards, banners	Billboards and banners can be seen by people on a large scale with high visibility and can be changed from one place to another (mobile).	Billboards and Banners regarding the advantages of proper SWM are set up at strategic points such as markets and religious facilities such as temples, mosque and church.
	Public Service Announcements	Radio, television	Short messages (30 seconds, 60 seconds etc.
Interpersonal Communication and Education			

No.	Media	Descriptions	Contents
5.	Public and educational events	Public and educational events can be held by inviting many people with various displays, exhibitions, trade fairs, and events.	Not only activities of the regional SWM Plan but also related activities of the NGOs and private sectors are displayed at the events.
6.	School environmental education	Children are considered powerful and effective media for the transmission of hygiene, sanitation, and environmental messages from school to family members, neighbours and communities.	Education on proper SWM is conducted at schools. During that time, school flag ceremonies, talks, essays, and painting competitions on SWM among school children are also conducted.
7.	Creation or encouragement of community groups	In rural areas, community groups could be created or encouraged to convince people of SWM. They are expected to play a key role in group recycling activities.	Formation of community groups and training and strengthening of them, including exposure visits to other groups with good practices, are conducted.

Source: JAT

8 Implementation plan

8.1 Implementation Schedule

The proposed activities in the regional SWM Plan in region 5 will commence in 2024 as the base year, and its implementation schedule is shown in the following table.

Table 31: Implementation Schedule of SWM in Region 5

Activity		2023	2024	2025	2026	2027	2028	2029	2030	2031-2035	2035-2040
Collection and transportation	Introduction of effective collection by compactor vehicle										
	Improvement of Collection Rate and Frequency										
	Examination of separate collection										
Final disposal	Construction of new landfill site in Blairmont										
	Closure of existing open dumping sites in each NDC										
	Examination of new landfill site in east side in Region 5										
Promotion of recyling activity	Source Reduction Program										
	Promotion of Recycling										

Source: JAT

9 Cost Estimation and Financial Aspect

9.1 Initial cost (Capital Expenditure (CAPEX))

The cost of collection vehicle and construction of the landfill site, including necessary equipment, are preliminarily estimated. Due to the difficulty of obtaining the information of the private companies and local authorities, the cost is assumedly estimated by the data used in similar projects temporarily. The costs are shown as the following table.

Table 32: CAPEX for Collection, Transportation, and Final Disposal in Region 5

Item		Contents / Detail	Number (Year 2030)	Cost [US$]
Collection and transportation	Compactor vehicle (12m3)		5	1,170,000
Landfill development	Landfill Facility (6ha, 25 year)	Landfill Area, Gas ventilation pipe, Rainwater drainage, Leachate collection pipe, Leachate treatment system, Sorting area, Weighbridge and monitoring room, Washing and parking area, Gatehouse, Fence	1	4,369,000
	Landfill equipment	Bulldozer (Swamp type around 260HP)	1	299,000
		Excavator (around 150 HP)	1	184,000
		Wheel Dozer (around 300 HP)	1	266,000

Source: JAT

9.2 Operation and maintenance costs (Operation and Maintenance Expenditure (OPEX))

Based on the collection and transportation plan and final disposal plan, operation and maintenance costs are and preliminarily estimated as follows. There needs to be an accurate unit cost information at this moment. Therefore, the data is assumedly estimated by using the assumed unit price. After obtaining a more accurate price, the cost should be revised.

Table 33: OPEX for Collection, Transportation, and Final Disposal in Region 5

Item		OPEX (2030) [US$]	OPEX (2040) [US$]
Personnel cost	Collection and transportation	142,800	261,000
	Landfill	72,600	72,600
Operation	Collection and transportation	53,800	65,100
	Landfill	26,500	46,400
Maintenance		7,899	8,070

Note: Maintenance cost is 15% of O&M cost
Source: JAT

Table 34: Monthly Personnel Cost in Region 5

Unit: US$

Position	2030	2040	Unit cost (US$/month)	Subtotal of Personal cost (2030)	Personal cost (2040)
Supervisor	1	1	1,000	1,000	1,000
Driver	5	7	700	3,500	4,900
Collector	10	14	600	6,000	8,400
Environmental monitor	2	2	700	1,400	1,400
Supervisor in landfill site	1	1	900	900	900
Landfill operator	2	2	800	1,600	1,600
Heavy equipment operator	3	3	750	2,250	2,250
Truck scale operator	1	1	750	750	750
Security guard	1	1	550	550	550

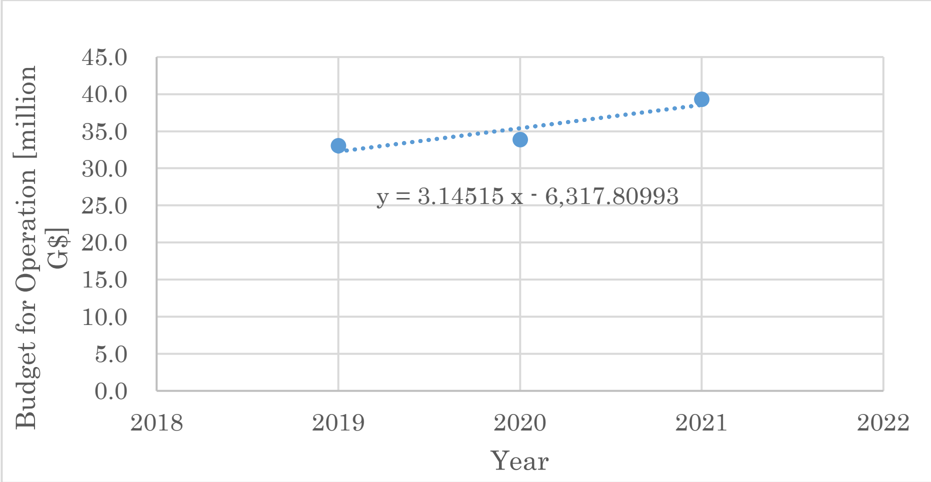
Source: JAT

Table 35: Detail of Operation Cost in Region 5

Collection vehicle	Operation distance (2030) [km/week]	Operation distance (2040) [km/week]	Fuel consumption rate [km/L] (for collection vehicle), [L/h] (for heavy equipment)	Fuel cost [US$/L]	Operation cost (2030)	Operation cost (2040)
	8,600	10,400	10	1.2	53,800	65,100
Heavy equipment	Operation hour (2030) [hr/week]	Operation hour (2030) [hr/week]	Fuel consumption rate [L/h] (for heavy equipment)	Fuel cost [US$/L]		
	40	70	5	1.2	26,500	46,400

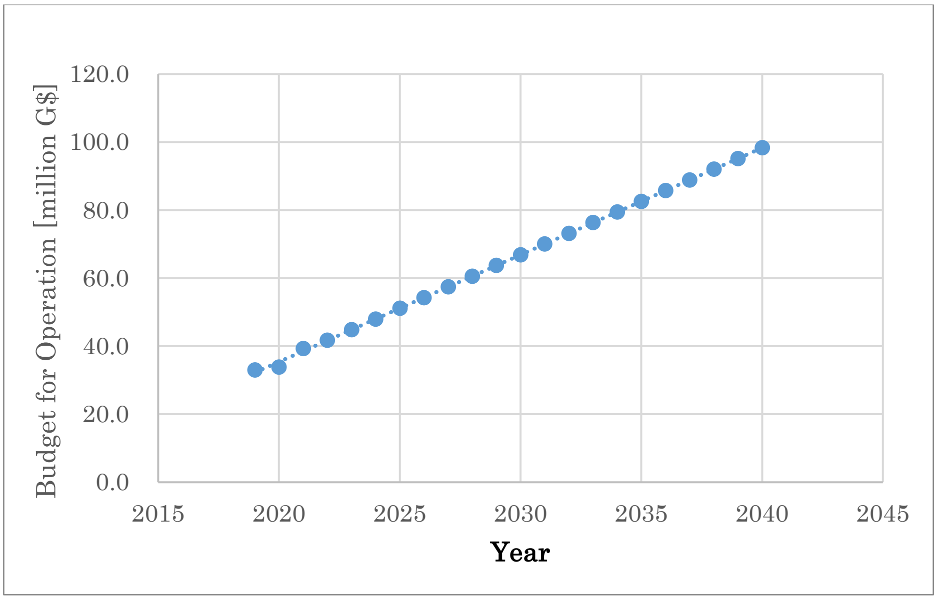
9.3 Annual Budget

It is difficult to estimate annual budget accurately. However, there are the information of the budget of last three years. Based on the information of annual budget in 2019, 2020 and 2021, the future amount of budget is preliminarily estimated as the below figures.



Source: JAT

Figure 15: Budget for SWM in Previous Three Years in Region 5



Source: JAT

Figure 16: Assumed Budget for SWM in Years in Region 5

9.4 Cost Recovery

As explained the section 9.2, the estimated expenditure of operation and maintenance cost is 57.1 million G$ in 2030 and 91.0 million G$ in 2040. This budget will be necessary in the year. Based on the assumption of budget in 2030 and 2040, 66.8 [million GYD] and 98.3 [million GYD]. It will be different depend on the price escalation, etc. In case of no consideration of price escalation, the assumed budget could cover 90 to 100 % of the necessary operation and maintenance cost.

Table 36: Comparison between Assumed Budget and Operation and Maintenance Cost in the Future in Region 5

Item	OPEX (2030) [million GYD]	OPEX (2040) [million GYD]
Assumed budget	66.8	98.3
Operation and maintenance cost	57.1	91.0

Source: JAT

10 Evaluation, Conclusion, and Recommendation

10.1 Evaluation

(1) Legal Aspect

As legal aspect, Solid Waste Management Bill, which is the basic law for SWM, is still in the draft stage in Guyana, and national institutions such as the National Solid Management Authority have not yet been established. In addition, a draft of the National Waste Management Strategy (2017 -2030) has been prepared, but it has not been approved. After the approval of the bill and strategy, it is necessary to revise this plan accordingly.

(2) Technical Aspect

As technical aspect, the possibility of this plan is considered during the planning process. Main improvement parts are collection and transportation and final disposal. In aspect of collection and transportation, compactor vehicle from tractor trailer has been proposed. In Georgetown, capital in Guyana, compactor vehicles are used for collection and transportation, Therefore, the introduction of compactor vehicles in Region 5 could be conducted. There is no issues of procurement, operation and maintenance of the compactor vehicles. In aspect of final disposal, sanitary landfill by utilizing semi aerobic method has been proposed. In Haags Bosch landfill site, semi aerobic landfill method is implemented and there are available of material for gas ventilation pipe and/or leachate collection pipe to develop semi aerobic landfill site. In addition, the operation and maintenance of sanitary landfill site with semi aerobic method is conducted though there are various issues. Considering the case of Haags Bosch landfill site, it is possible to develop sanitary landfill site by utilizing semi aerobic landfill system in Region 5.

(3) Financial and economic aspects

SWM projects are not usually profitable. What is important is whether the income generated, including from public budgets, can cover the operation and maintenance costs. Therefore, the future budget has been compared with the O&M costs to determine whether the project proposed here is financially viable or not. The result shows that the budget will exceed the O&M costs. Then it can be said that the proposed project will be financially viable. As for the economic aspect, SWM projects usually bring various benefits such as improvement of environmental and sanitary conditions, reduction of virgin materials through recycling, etc., and these bring better economic condition to the target area. The proposed project will also bring these economic benefits.

(4) Environmental and social aspects

This regional SWM plan contributes the improvement of public health and environmental condition by improvement of collection service and suitable waste disposal. To do so, the development of sanitary landfill site, the procurement of collection and transportation equipment has been proposed. In this planning stage, because the detail planning including design of landfill site has not been prepared, it is not possible to predict the environmental impacts in this stage. In the future, the EIA should be implemented based on the Rules and Procedures for Conducting and Reviewing EIAs in 2004.

10.2 Conclusion

- Regional Master Plan in Region 5 is drafted based on the existing information and the surveys such as WACS and time and motion survey.
- Due to no availability of existing data, population projection or cost estimation is preliminarily implemented.

10.3 Recommendation

In the process of this plan, it is difficult to obtain the latest data. Therefore, this plan should be updated periodically by MLGRD.

- This plan could not utilize the census data implemented in 2022 data. After the availability of the data, the population projection should be updated.
- After obtaining updated unit cost data, the CAPEX and OPEX should be revised.
- The plan should be periodically review. In the process of review, PDCA (Plan-Do-Check-Act) cycle method is useful. This SWM plan in region 5 should be reviewed regularly and updated based on the obtained and updated new data and by referring PDCA cycle as shown in the guideline.

Appendices

Appendix 1:
Waste Amount and Composition Survey Report

Appendix 2:
Time and Motion Survey Report

Appendix 1

Waste Amount and Composition Survey Report

Waste Amount and Composition Survey for the Preparation of Regional Plan in Region 5

1. Introduction

To prepare the regional solid waste management plan, it is necessary to grasp the current waste generation amount and composition.

The JICA Advisory Team (JAT) to supported the survey for the Solid Waste Amount and Composition Survey in Region 5.

2. Survey Methodology

The Works will comprise:

1） Waste Amount Survey
2） Waste Composition Survey
3） Analysis of the results

The details of the Survey methods are as follows:

2.1 Waste Amount Survey

The waste Amount Survey has been implemented from the 4th to the 11th of February in accordance with the method given in the following table.

Table Method of Waste Amount Survey

Item	Description
Duration of the survey	Continuous eight (8) days including two (2) weekends
Survey area	3 NDCs [1] (Mahaicony/Abary NDC, Bath/WoodleyPark NDC, Blairmont/Gelderland NDC) in Region 5
Number of Samples	Ninety (90) households to be selected in 3 NDCs
	Nine (9) restaurants in 3 NDCs
	Nine (9) hotels in 3 NDCs
	Nine (9) shops or markets in 3 NDCs
	Nine (9) institutions (offices and/or schools) in 3 NDCs
Methods	- Solid waste shall be collected from households, restaurants, and hotels who are asked in advance to store all waste generated in their respective locations (generation sources) - Solid waste stored in each generation source for each day shall be collected every day. The staff will measure the weight of the waste by scale.

[1] Due to similar living condition in each NDC in Region 5, 3 NDC (west, center and east coastal area in Region 5) has been selected through the discussion with MLGRD.

Item	Description
	- However, the solid waste stored on the first day shall not be included in the analysis. This is because the waste bins at each generation source are needed to be emptied. - At the same time, basic information about selected households such as the number of family members, and type of residence, shall be recorded through a hearing with the residents. Basic information about business sectors shall also be collected, especially the number of staff and guests each day of the survey at hotels, restaurants, shops, and institutions.

Source: JAT

2.2 Solid Waste Composition Survey

A solid waste composition survey has been implemented in accordance with the method given in the following table.

Table Method of Composition Survey

Item	Description
Duration of the survey	Two (2) weekdays and one (1) weekday among three (3) days of the waste amount rate survey described above for January or February
Number of Samples	Household waste: Waste composition, bulk density, moisture, three components 9 samples = 3 days (number of survey days) x 3 NDCs
	Waste from Hotel: Waste composition, bulk density, moisture, three components 3 samples = 3 days (number of survey days)
	Waste from Restaurant: Waste composition, bulk density, moisture, three components 3 samples = 3 days (number of survey days)
	Waste from Shop: Waste composition, bulk density, moisture, three components 3 samples = 3 days (number of survey days)
	Waste from Institution: Waste composition, bulk density, moisture, three components 3 samples = 3 days (number of survey days)
Methods	(1) Preparation of Sample The solid waste material shall be put on a dried plastic seat and mixed well at first. After mixing, the mass of waste shall be piled up conically and cut to divide four smaller groups. Two groups of opposite angles shall be picked up and left for another sample adjustment from four groups and the other two groups shall be discarded. Remained two groups shall be mixed and divided into other four groups in the same way. This subdividing process shall be continued a few times until the amount of the sample become around 40 L.

Item	Description
	(2) Volume and Bulk density 1) Weight and Volume The weight of waste is measured by a plastic bucket (40L) of which volume has been known and the measurement of the height of the waste in the vessel by scale, 2) Bulk density Bulk density is calculated by weight and volume. (3) Physical Composition - After measurement of volume and weight, the sample shall be separated manually into 15 items as described in the "Physical Composition". The items are as follows; 1) kitchen waste, 2) wood/grass, 3) recyclable paper (cardboard, office paper, books, magazines, notes, etc), 4) -non-recyclable paper (film paper, etc), 5) recyclable plastic (PET bottle, other plastic bottles, styrene foam, drinking straw/plastic cup, etc), 6)-non-recyclable plastic, 7) recyclable glass (transparent glass bottle, color glass bottle, etc), 8) nonrecyclable glass, 9) metal (aluminum can, steel can, etc), 10) textile, 11) leathers, 12) bulky waste, 13) ceramics/stone, 14) Hazardous and infectious (paper diaper, battery, etc), 15) others The weight and volume of each separated material shall be also measured for Physical Composition. The pictures shall be taken for classified samples, especially for the samples classified as others for recording. (4) Analysis of Three components, (combustible, moisture, ash) (See attached Photos) - The waste samples were sorted and weighed before drying. - After natural drying for one week, the weight was measured. After drying by drying equipment, the weight is almost similar. The drying waste weight has been determined. - Drying and dried will be used for samples in determining the ash content of each category after weighing Dried Waste. - Ash contents will be calculated based on the experienced data Based on the following calculation, combustible is calculated. - Combustible = Original Waste (Wet waste) - Moisture (= Wet waste - Dried waste) - Ash

Source: JAT

- Items of physical composition are based on the information of possible recyclable waste and nonrecyclable waste based on the information of recycling flow.
- There is no significant difference in income level in each NDC in Region 5. Therefore, the NDC of 3 locations (west, center, east side) through the discussion with MLGRD is selected as different locations

3. Survey Result

3.1 Waste amount

(1) Waste from household

The result of the waste amount survey from households is shown as follows.

Table Result of Waste Amount Survey for Household Waste

Item	Total of 3 NDCs
Planned sample number	90
Actual and effective sample number	65
Average [kg/person/day]	0.31
Upper limit [kg/person/day]	0.98
Lower limit [kg/person/day]	0.04

Source: JAT

(1) Waste from the Others (Restaurant, Shop, Institution (School))

The result of the waste amount survey from restaurants, shops and schools is shown as follows.

Table Result of Waste Amount Survey for Non Household Waste

Item	Restaurant	Shop	Institution (School)
Planned sample number	9	9	9
Actual and effective sample number	1	6	8
Average [kg/ day/staff]	0.61 -	1.14	0.37
Upper limit [kg/ day/ staff]		1.66	1.08
Lower limit [kg/ day/ staff]		0.57	0.08

Source: JAT

3.2 Waste composition

3.2.1 Physical composition

（1）Waste from household

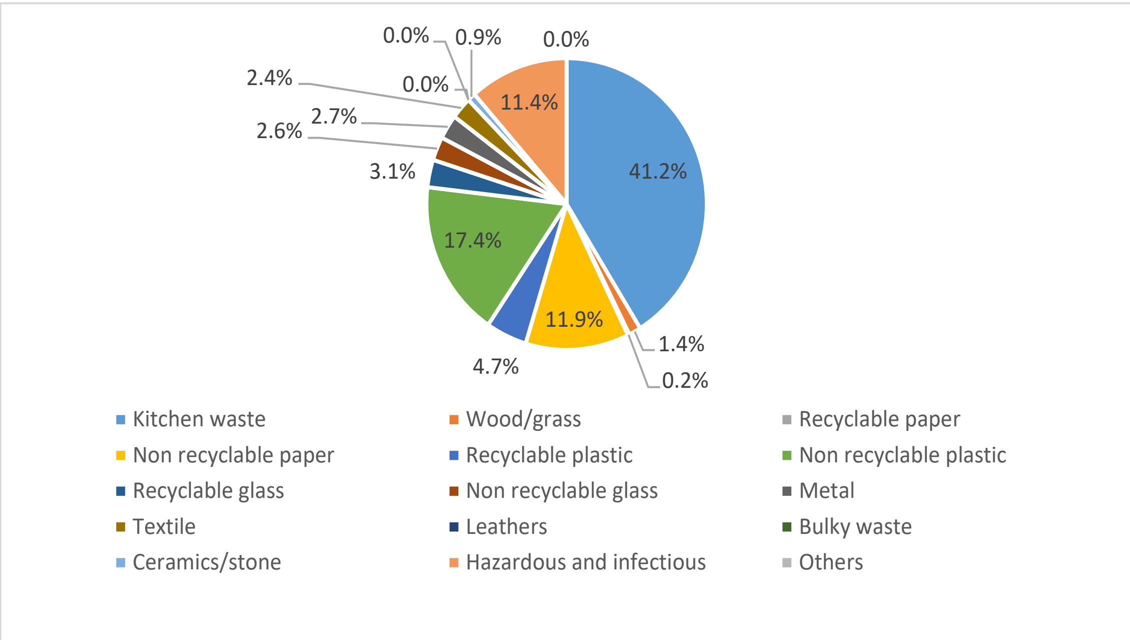
The results of the wet-based physical composition of household waste are shown as follows.

For all NDCs, kitchen waste was about 40%, with paper and plastics at 10-15% and 16-33%, respectively. On the other hand, Mahaicony/Abary had a higher percentage of hazardous and infectious waste than the other NDCs, which was mostly diapers.

Table Physical Composition of the Waste Sampled from Household

Item	Mahaicony/Abary NDC	Bath/WoodleyPark NDC	Blairmont/Gelderland NDC	Household (average)
Kitchen waste	41%	39%	44%	41.2%
Wood/grass	2%	1%	2%	1.4%
Recyclable paper	0%	0%	0%	0.2%
Nonrecyclable paper	11%	15%	10%	11.9%
Recyclable plastic	4%	5%	5%	4.7%
Nonrecyclable plastic	12%	27%	12%	17.4%
Recyclable glass	1%	5%	2%	3.1%
Nonrecyclable glass	1%	0%	7%	2.6%
Metal	3%	3%	3%	2.7%
Textile	1%	3%	4%	2.4%
Leathers	0%	0%	0%	0.0%
Bulky waste	0%	0%	0%	0.0%
Ceramics/stone	2%	0%	1%	0.9%
Hazardous and infectious	23%	3%	10%	11.4%
Others	0%	0%	0%	0.0%

Source: JAT



Source: JAT

Figure Physical Composition of the Waste Sampled from Household

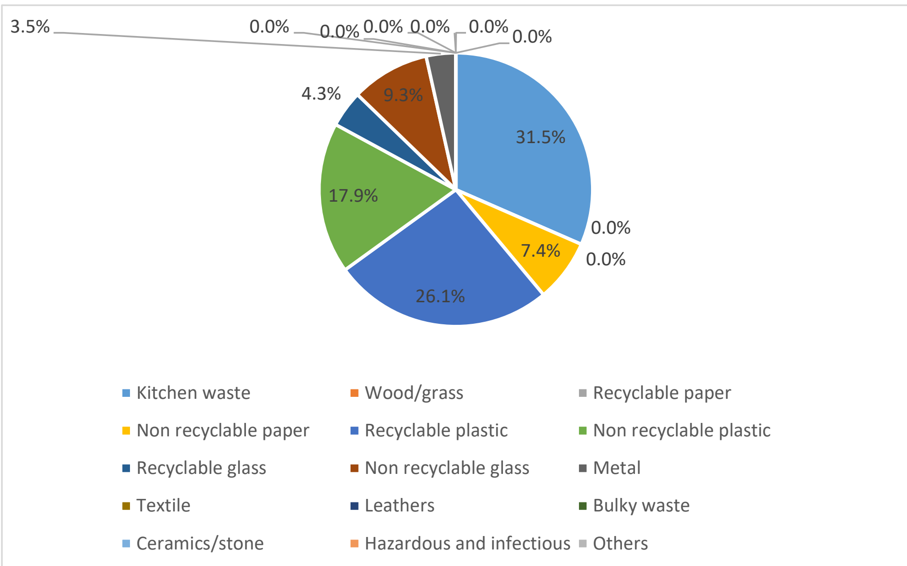
（2） Waste from the Others (Restaurants, Shops, Institutions (Schools))

In restaurants, kitchen waste accounted for 32%, a relatively large share compared to schools (14%) and stores (6%). On the other hand, in stores, paper and plastic used as containers and packaging accounted for a large share (94% total).

Table Physical Composition of the Waste Sampled from Non Household

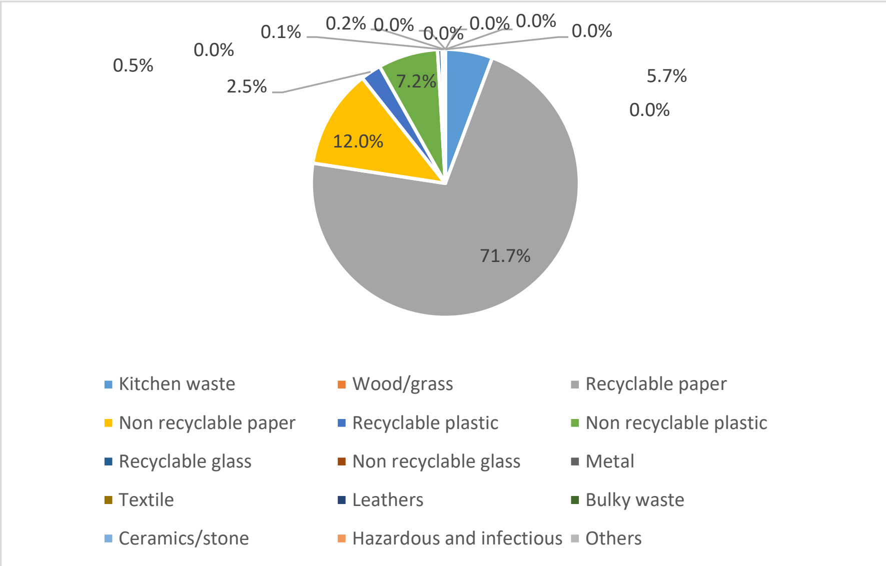
Item	Restaurant	Shop	Institute
Kitchen waste	32%	6%	14%
Wood/grass	0%	0%	4%
Recyclable paper	0%	72%	9%
Nonrecyclable paper	7%	12%	31%
Recyclable plastic	26%	2%	8%
Nonrecyclable plastic	18%	7%	12%
Recyclable glass	4%	1%	5%
Nonrecyclable glass	9%	0%	0%
Metal	3%	0%	2%
Textile	0%	0%	1%
Leathers	0%	0%	1%
Bulky waste	0%	0%	0%
Ceramics/stone	0%	0%	0%
Hazardous and infectious	0%	0%	13%
Others	0%	0%	0%

Source: JAT



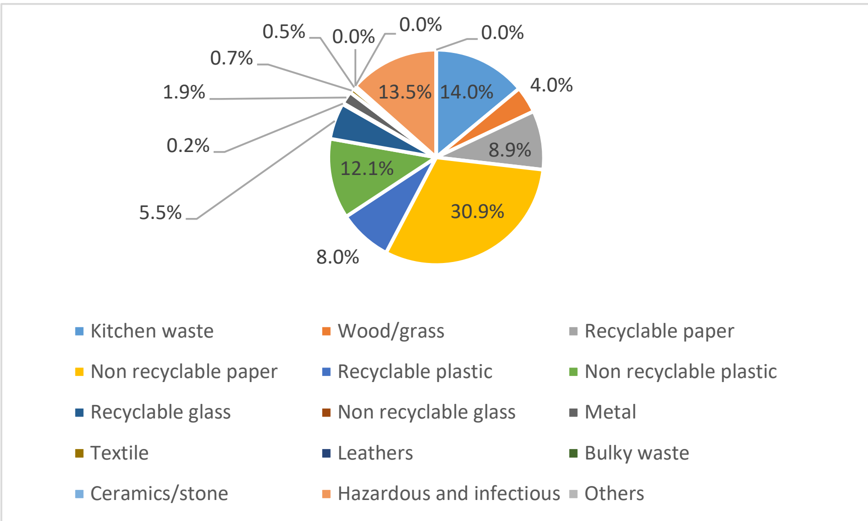
Source: JAT

Figure Physical Composition of the Waste Sampled from Restaurant



Source: JAT

Figure Physical Composition of the Waste Sampled from Shop



Source: JAT

Figure Physical Composition of the Waste Sampled from School

3.2.2 Bulk Density

(1) Waste from household

The results of bulk density measurements of household waste are shown below, ranging from 0.14 to 0.25 [kg/L].

Table Bulk Density of the Waste Sampled from Household

Composition	Mahaicony/Abary NDC			Bath/WoodleyPark NDC			Blairmont/Gelderland NDC		
	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4
Volume (L)	40	40	40	40	40	40	40	40	40
Weight (kg)	8.85	9.06	7.20	8.69	5.77	6.12	9.84	9.45	6.85
Bulk density (kg/L)	0.22	0.23	0.18	0.22	0.14	0.15	0.25	0.24	0.17

Source: JAT

(2) Waste from the others (Restaurants, Shops, Institutions (Schools))

The following table shows the results of bulk density measurements of waste from the others. The range was 0.18-0.23 [kg/L] for restaurants, 0.14-0.22 [kg/L] for stores, and 0.17-0.25 [kg/L] for public facilities (schools). No significant differences were observed for each generation source.

Table Bulk Density of the Waste Sampled from Non Household

Composition	Restaurant			Shop			Institute		
	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4
Volume (L)	—	40	40	40	40	40	40	40	40
Weight (kg)	—	9.06	7.20	8.69	5.77	6.12	9.84	9.45	6.85
Bulk density (kg/L)	—	0.23	0.18	0.22	0.14	0.15	0.25	0.24	0.17

Source: JAT

Note: No collection from the restaurant on the first day

3.3.3 Three components

The evaporation was calculated from the weight before and after drying obtained by the following measurements, and the results for moisture content are shown below.

(1) Waste from household

Moisture content is not significantly different in each NDC, ranging from 25.5% to 36.5%.

Table Moisture Content of the Waste Sampled from Household

Item	Mahaicony/Abary NDC			Bath/WoodleyPark NDC			Blairmont/Gelderland NDC		
	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4
Wet base sample before drying [g]	1210	1526	1570	1182	603	1100	1508	1732	757
Dried base sample after drying [g]	818	1091	1061	751	432	820	1042	1251	561
Moisture content [g] (%)	392	435	509	431	171	280	466	481	196
Moisture content [%] (%)	32.4	28.5	32.4	36.5	28.4	25.5	30.9	27.8	25.9

Source: JAT

(2) Waste from the Others (Restaurants, Shops, Institutions (Schools))

Moisture content did not differ significantly among the sources and ranged from 23.0% to 46.2%.

Table Moisture Content of the Waste Sampled from Non Household

Item	Restaurant			Shop			Institute		
	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4	Day 1	Day 3	Day 4
Wet base sample before drying [g]	—	1016	530	540	732	670	832	1026	1070
Dried base sample after drying [g]	—	691	312	330	423	440	641	552	681
Moisture content [g] (%)	—	325	218	210	309	230	191	474	389
Moisture content [%] (%)	—	32.0	41.1	38.9	42.2	34.3	23.0	46.2	36.4

Note: No collection from the restaurant on the first day

Source: JAT

A comparison of household and other wastes shows that the moisture content of the other waste is relatively higher than that of household waste.

Using the following proportions of three components of each physical composition in Japan, calculations were also made for combustible content and ash content.

Table Three Components of Each Physical Composition in Representative Case in Japan

Item	Moisture [%]	Combustible[%]	Ash[%]
Kitchen waste	63.6	27.8	8.6
Wood/grass	30.1	65.9	4.0
Recyclable paper	35.5	58.4	6.1
Nonrecyclable paper	35.5	58.4	6.1
Recyclable plastic	16.8	74.3	8.9
Nonrecyclable plastic	16.8	74.3	8.9
Recyclable glass	1.2	0.0	98.8
Nonrecyclable glass	1.2	0.0	98.8
Metal	7.8	0.0	92.2
Textile	28.3	66.9	4.8
Leathers	6.4	76.6	17.0
Bulky waste	-	-	-
Ceramics/stone	3.0	0.0	97.0
Hazardous and infectious	14.2	66.9	19.0
Others	-	-	-

Source: Waste treatment facility planning and design guidelines in Japan

The three components in this survey are calculated based on the result of physical composition and the above representative three component ratio for each physical composition in Japan. The result of three components for household and for non household waste is shown in the below table.

Table Three Components of the Sampled Waste

Item	Household	Restaurant	Shop	Institute
Moisture: W[%]	38	32	39%	47%
Combustible: B[%]	45	45	54%	41%
Ash: A [%]	17	23%	7%	12%

Source: JAT

3.3.3 Lower Calorific Value

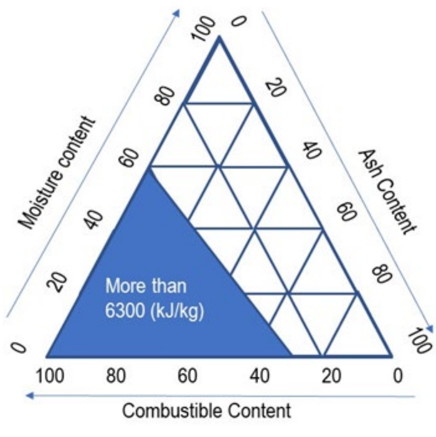
The lower calorific value was estimated from the data of the physical composition of each type of waste by utilizing the following calculation formula.

LCV(Lower Calorific Value) [kJ/kg] =190 x B [%] -25 x W [%]

Item	Household	Restaurant	Shop	Institute
Lower Calorific Value [kJ/kg]	7,587	7,682	9,305	6,688

Source: JAT

Basically, 6,300 kJ/kg is necessary for the suitable operation of the WtE facility as shown in the following diagram. Therefore, in the aspect of calorific value, waste generated in Region 5 in Guyana will be suitable for WtE according to the calculation.



Source: National Institute for Environmental Study

Attachments

Attachment 1	: Overview Explanatory Material
Attachment 2	: Instruction for Solid Waste Amount and Composition Survey to Residents/Business Establishment
Attachment 3	: Explanation to Driver (as an Example)
Attachment 4	: Necessary Equipment and Material
Attachment 5	: Survey questionnaire for residents.

Attachment 1

Waste Amount and Composition Survey (WACS)

Work procedure of WACS for Region 5

JICA Advisory Team

Objective of WACS

- The objective of WACS is to obtain basic data about the waste, such as waste generation rate (kg/person/day), bulk density (kg/litre), physical composition and calorific value (kJ/kg) to prepare Regional Solid Waste Management Plan in Region 5.

- Such basic data are essential for proper solid waste management.

Contents of Work

1. Site selection
2. Selection of households
3. Interview Survey
4. WACS
    1. Data to be obtained
    2. Number of samples
    3. Work flow
5. Reporting

1. Site selection

- Three NDCs are to be selected with different economic status, population density, etc

- The following data shall be collected
  - Name of the NDC
  - Name of the village
  - Number of households in the village
  - Number of people in the village
  - Number of restaurants, hotels, shops, institutions to be considered as the main waste generation source.

2. Selection of households

This work shall be conducted by the surveyors with support of JAT.

- 30 households, 3 hotels, 3 restaurants, 3 shops and 3 institutions (including school) shall be selected from each NDC, i.e. 90 households and 36 establishments (hotels, restaurants, shops, institutions in total for the three NDCs.
- Households, hotels, restaurants, shops and institutions shall be informed about the following:
  - Objective of the survey
  - Schedule of the survey
  - How to prepare waste samples
    - Only waste generated in each day has to be submitted as sample.
    - If there are sanitary items such as diapers, such waste has to be sorted separately from the general waste.
    - Necessary number of bags for sampling with stacker to identify the sample has to be delivered to the households.

3. Interview Survey

This work shall be conducted by the Surveyors. However, it may be carried out at the same time when the samples are collected.

The following page shows a main contents of questionnaire for this work.

Questionnaire (draft)

1) Number of family members:

- How many family members are living in this household?
- How many persons are usually living or working in your house, such as maid and driver?

2) Waste collection service:

- Do you obtain collection service?
- How often do you have this service?
- Who collects your discharging waste?

3) Self disposal

- Do you burn your waste in your backyard?
- Do you bury your waste in your backyard?
- Do you dump your waste to vacant area, rivers, etc.?

4) Recycle

- Do you separate recyclable materials?
- Do you use organic waste for making compost?

4. Waste Amount and Composition Survey
4.1 Data to be obtained

■ The following data shall be obtained:

a. Waste generation rate (kg/person or staff number/day)
b. Bulk density (kg/litre)
c. Physical composition (wet-base)
d. Three components: combustible, moisture and ash contents
   (measurement of ash and calculation of the others)
a. Lower calorific value (kJ/kg) (by calculation)

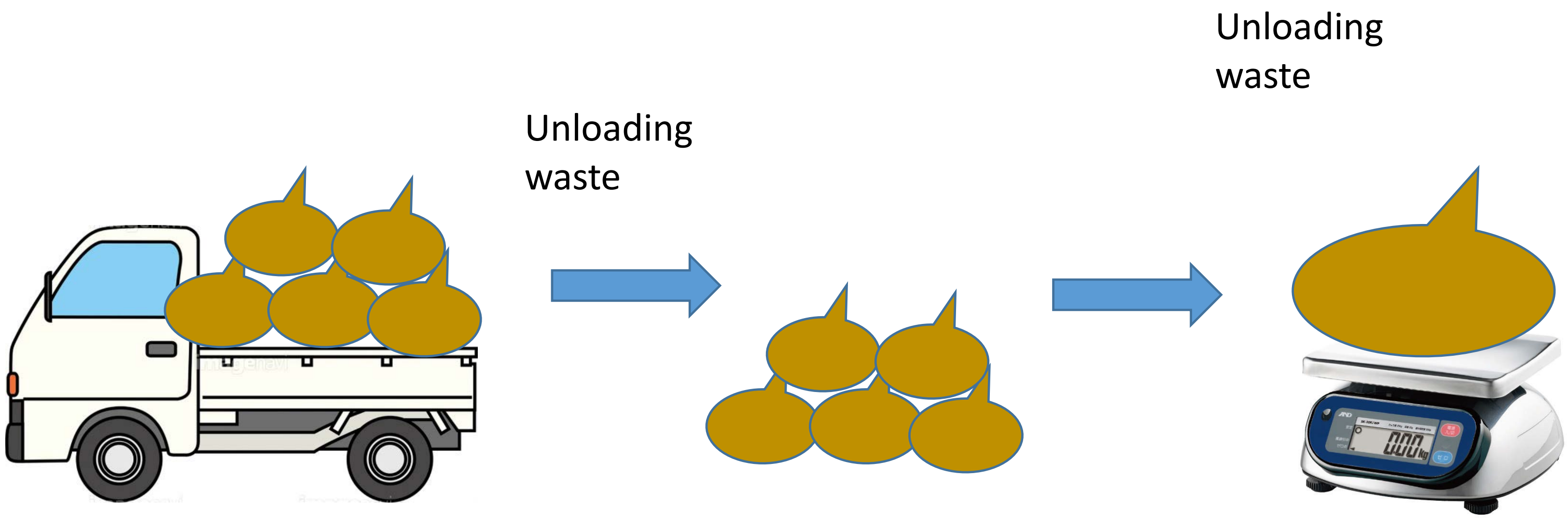
4.2 Number of samples

- In total, 882 samples will be taken for the Waste Amount Survey, and 21 samples for the Waste Composition Survey.
- The waste amount survey shall be conducted for seven (7) consecutive days after the complete collection of waste at first day . The waste composition survey shall be carried out by the samples collected in 1st day, 3th day and 4th day.

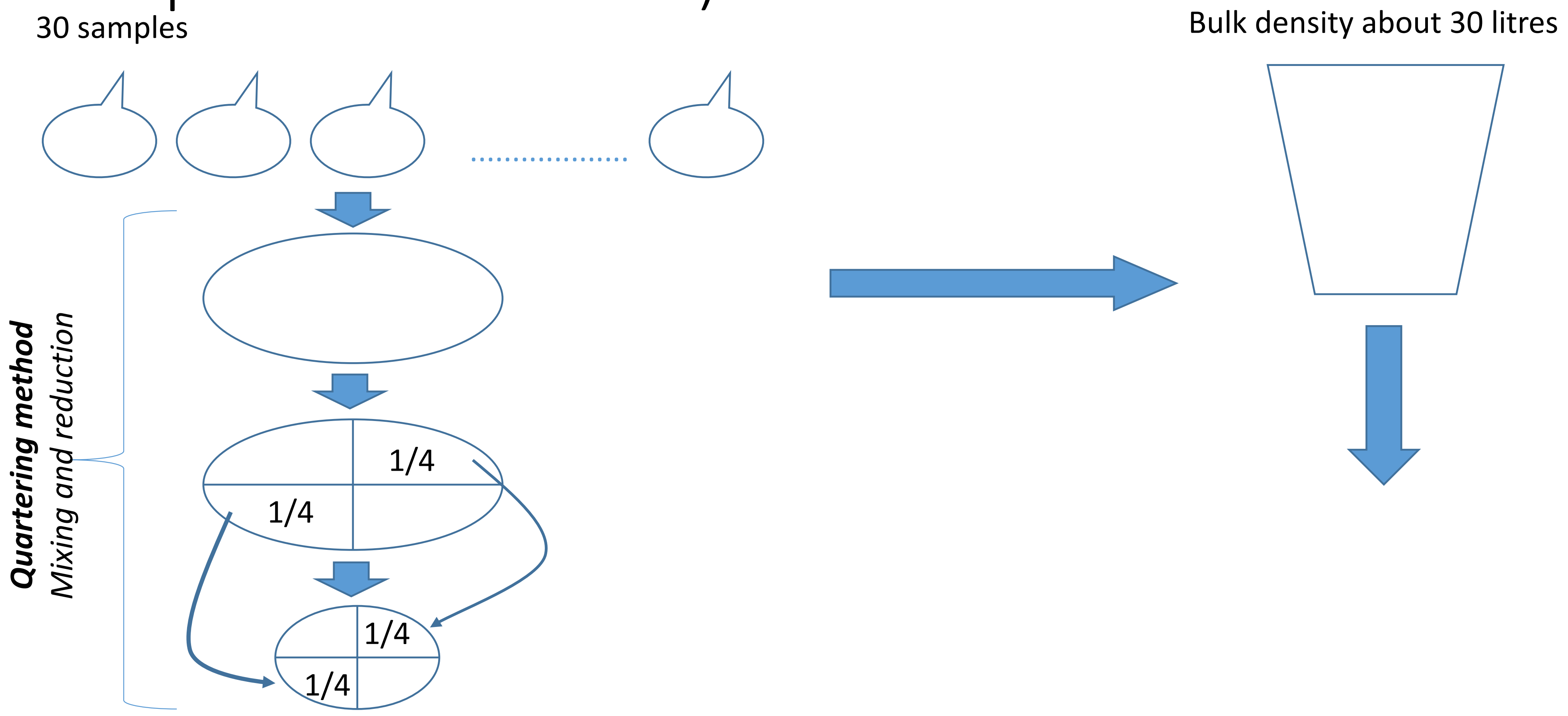
Number of Samples

Generation Source	Nos. of Households per NDC	Nos. of Hotel, Restaurant, Shop, Institution per NDC	Waste Amount Survey			Waste Composition Survey			
			Samples/ Day	Days of Sampling	Samples Total	Household sampling. No./day	Other sampling. No./day	Days of Sampling	Samples Total
			AxB	-	CxD	-		-	FxG
	B		C	D	E	F		G	H
High Income NDC	30	12	42	7	294	1	4	3	21
Medium Income NDC	30	12	42	7	294	1		3	
Low Income NDC	30	12	42	7	294	1		3	
Total	90	36	126	-	**882**	-		-	**21**

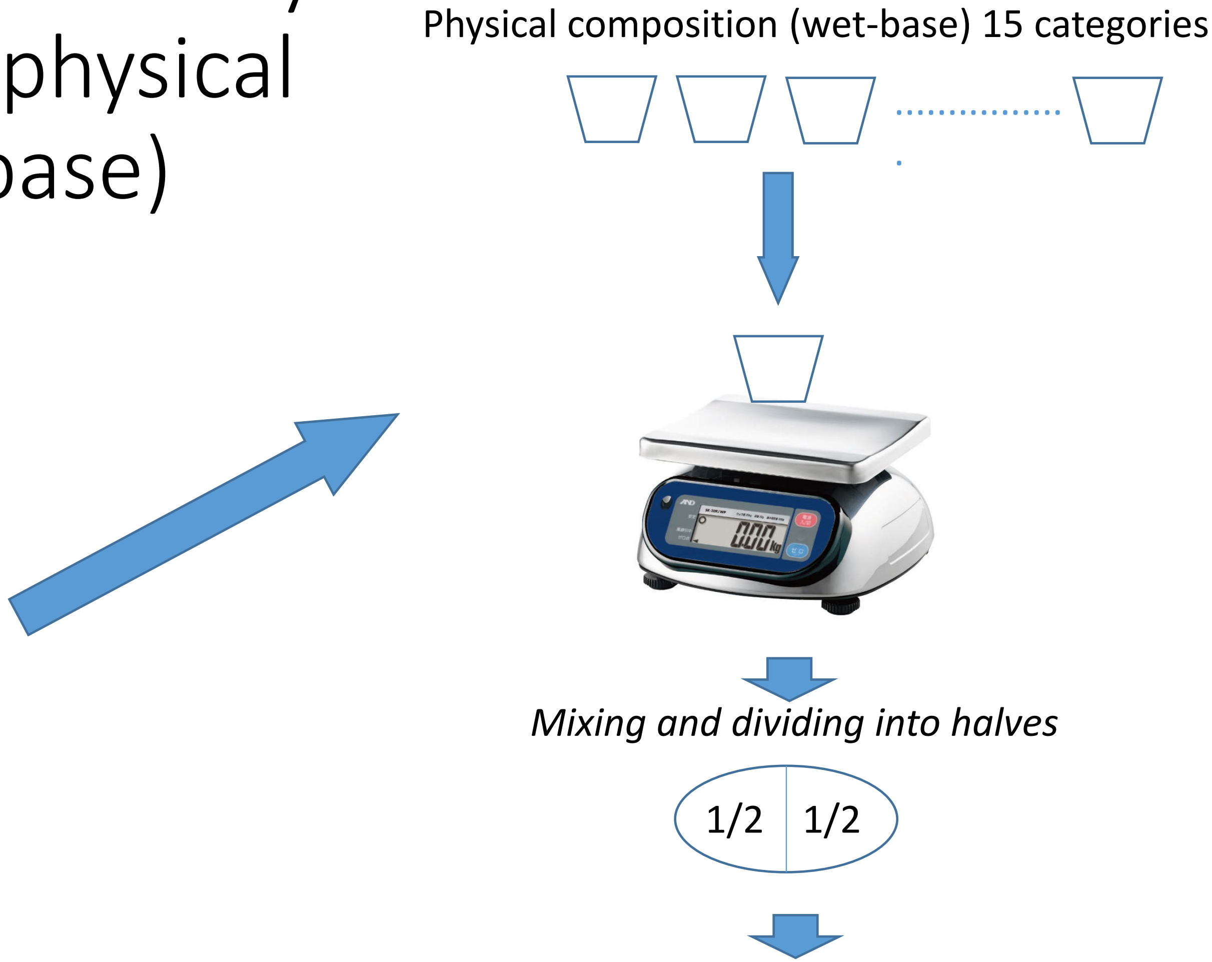
Waste Amount Survey (Measurement)



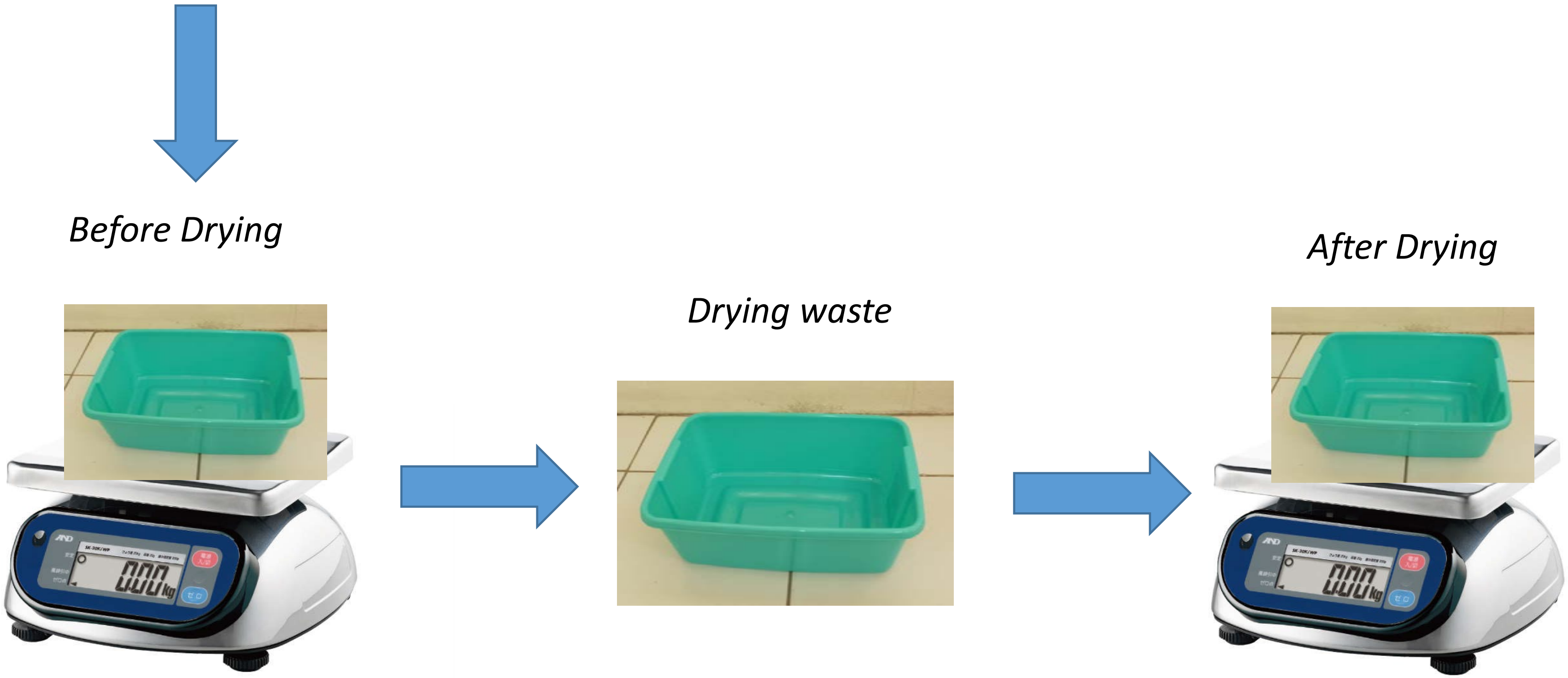
Waste Composition Survey (Physical composition wet-base)



Waste Composition Survey (Bulk density and physical composition wet-base)



Waste Composition Survey (Moisture contents)



Calculation method

[Bulk Density] = [Waste (wet base)] / [Volume]

[Physical Composition (wet-base)] = [Each categorized waste (wet base)] / [Waste (wet-base)]

[Moisture contents] = [Waste (wet-base)] – [Waste (dry–base)]

[Combustible] = [Waste (wet-base)] – [Moisture contents] – [Ash contents]

[Lower Calorific Value] = 190 x [Combustible] – 25 x [Moisture Contents]

Instruction for Solid Waste Amount and Composition Survey to Residents/Business Establishment

1. Purpose of this survey

This Technical Cooperation Project on Advisor for Marine Plastic Litter Management in the Caribbean Region is implemented through the cooperation of Japan International Cooperation Agency (JICA) and Ministry of Local Government and Regional Development in Guyana to improve Solid Waste Management in Guyana. In this advisory work, we try to prepare the regional SWM plan in Region 5. In this context, it is necessary to grasp the amount and composition of waste generated in Region 5. Then, we would like to implement the survey.

2. Procedure

Solid waste sampling for the survey will be continued. This will include 1 day for preliminary survey (collection of all the waste) and 7 consecutive days for actual survey. The procedure is as follows;

(1) Waste Packing

You shall be provided with bags for waste collection as following picture. After all waste is put into the plastic bags, you should tie with strings.

(2) Storage of Packed Waste

All the waste that you have generated for one target day must be kept in your house or yard for pick-up by survey collectors only. Please do not discharge the waste along the road or other waste collection points where solid waste is collected by government truck.

(3) Waste Collection

We will collect the plastic bags from xxx to xxx a.m.


(4) Sampling Number

Item	Description
Duration of the survey	Continuous seven (7) days including two (2) weekends in January or February
Survey area	3 NDCs in Region 5
Number of Sample	Ninety (90) households to be selected in 3 NDCs
	Nine (9) restaurants in 3 NDCs
	Nine (9) hotels in 3 NDCs
	Nine (9) shops or markets in 3 NDCs
	Nine (9) institutions (offices and/or schools) in 3 NDCs

For any inquiries or clarifications, please contact or text to xxx.

Thank you very much for your cooperation.

Attachment 3

Explanation to Driver (as an Example)

- Please Start Georgetown at 7 am to the target NDC to collect the waste
- Please meet with one collector (see below information) in xxx NDC before 10 am.
- Please go to each household with collectors from 10 am to 12 pm to collect the waste
- Collector will pick up the waste from each household, hotel, restaurant, shop and school.
- Please drive the vehicle and the collector will collect all the target household, hotel, restaurant, shop and school.
- After finishing the collection around 12 pm, please transport the waste to the workshop area in Hachs Baag Landfill Site

Name of Collector : xxxx xxxx
Mobile number of collector : xxx xxxx

Name of collector of waste and the mobile number should be described.

NDC : xxx
Name of Contact Person : xxxx xxxx
Mobile number of collector : xxx xxxx

Name of contact person of each target NDC and the mobile number should be described.

Name, address and telephone number of target residents, schools and shops for the survey should be described.

List of target residents, shops and schools for waste collection

(1) Residents

No.	Name	Address	Telephone number
1	xxxx xxxx	xxxxx	xxxxx
2	xxxx xxxx	xxxxx	xxxxx
3	xxxx xxxx	xxxxx	xxxxx

(2) Shop

No.	Name of Shop	Address	Telephone number
1	xxxx xxxx	xxxxx	xxxxx
2	xxxx xxxx	xxxxx	xxxxx
3	xxxx xxxx	xxxxx	xxxxx

(3) School

No.	Name of School	Address	Telephone number
1	xxxx xxxx	xxxxx	xxxxx
2	xxxx xxxx	xxxxx	xxxxx
3	xxxx xxxx	xxxxx	xxxxx

Attachment 4

Necessary Equipment and Material

Name	Number	Remark / Picture
Truck for waste collection (around 2 ton) with drivers (Rental 8 days)	3	
Scale (0 to 2 kg, accuracy 1 g)	1	
Scale (0 to 30 kg, accuracy 100 g)	1	
Large Container	Around 40 L	
Bucket for separation of waste during waste composition survey (As same as separation item number) (Φ 20cm x 20	10 (for each physical composition)	

cm)		
Bucket for separation of waste during waste composition survey (As same as separation item number) (Φ 20cm x 10 cm)	10 (for each physical composition)	
Bucket for storage in drying process (Φ 20cm x 10 cm)	5 (generation source) x 3 (NDC) x 3 (days) = 45	
Metal container (for combustion)	5	
Gas burner (for combustion)	1	
Plastic sheet	4 sheets (5 m x 5 m)	

Attachment 4

Shovel (Big)	2	
Shovel (middle)	2	
Broom	4	
Hoe	2	
Dust tray for waste collected by broom	4	

Attachment 4

Glove	10	
Mask	10	
Drier (for drying process)	3	
Extension cord for drier	1	
Scissors/ cutting tools for waste	3	
Scissor for sealing tape	1	

Attachment 4

Transparent plastic bag (for sampling collection)	Around 1500 pieces	
Transparent sealing tape (for sealing paper with sign)	1 set	

Attachment 5

Survey Questionnaire for Residents

1. Introduction:

This waste amount and composition survey is implemented to prepare a regional solid waste management plan in region 5. To create the plan, information of target household is needed to grasp the current situation of solid waste management in the region. Your responses will be used for this purpose only. Please respond to the questions as accurately as you can. Thank you very much for your cooperation.

2. Household Details

1. Name of the head of the household:………………………………………….
2. Address:…………………………………………………………
3. Telephone number:……………………………………………………………………………….
4. Educational qualifications of the head of the household:……………………………………………….
   (a) Illiterate (b) Primary Schooling (c) Secondary Schooling (d) College or higher
5. Number of people in your family:…………………………………………………
6. Please describe names and types (new or secondhand) of all of your vehicles you own:…………………………………………………………………………………………………

3. Waste Management

7. Do you agree on the fact that if waste is not properly disposed of, it can pollute the environment?
   (a) Yes (b) No

   If your answer is yes to the question above, kindly identify the cause/reasons for some of these problems. (Select All That Apply)

   (a) There is no bin available to dispose of garbage
   (b) There is no proper collection of garbage by collection service providers
   (c) Waste is disposed of anywhere such as drains and roadways which creates a nuisance within the community
   (d) Collection fees are too expense
8. Do you dispose of your waste by yourself or discharged for collection service?
   (a) Disposed of my waste by myself (b) discharged for collection service
9. If you select (a) in Question No. 9, how do you dispose of your waste?
   (a) dumping in my backyard (d) burning in my backyard, (c) composting in my backyard, (d) others (please specify:)
10. If you select (b) in Question No. 9, how do you discharge your waste?

(a) Discharge in the collection point by plastic Bag (b) Discharge in the collection point by metal or plastic drum, (c) others (please specify:)

11. How often do you discharge/dispose of your household waste?
    (a) Every day (b) Once every two days (c) once every three days (d) Once a week (e) Once every two weeks
12. Is the current frequency of collection service enough?
    (a) Yes (b) No
13. How much are you currently paying on garbage collection per month? ………GYD
14. How much can you pay on garbage collection per month, if waste collection system is improved? ………GYD
15. Do you currently separate different types of waste at your home, such as metal cans, glass bottles, etc.?
    (b) Yes (b) No
16. If you are told by your collection service provider to separate your waste in the future, would you comply?
    (a) Yes (b) No

5. Awareness for Solid Waste Management within the Community:

17. Do you think that the media has raised your awareness of water, sanitation, and solid waste management?
    (a) Yes (b) No
18. If YES, which media do you think has raised your awareness of water, sanitation, and solid waste management?
    (a) Radio (b) Television (c) Newspaper (d) Social media

End of Questionnaire

Appendix 2

Time and Motion Survey Report

Time and Motion Survey Report

1. Objective

The main objective of this survey is to have a better understanding of the current situation of waste collection and transport in a few NDCs in Region 5 to formulate a regional Solid Waste Management Plan in Region 5 through the use of data obtained during this survey.

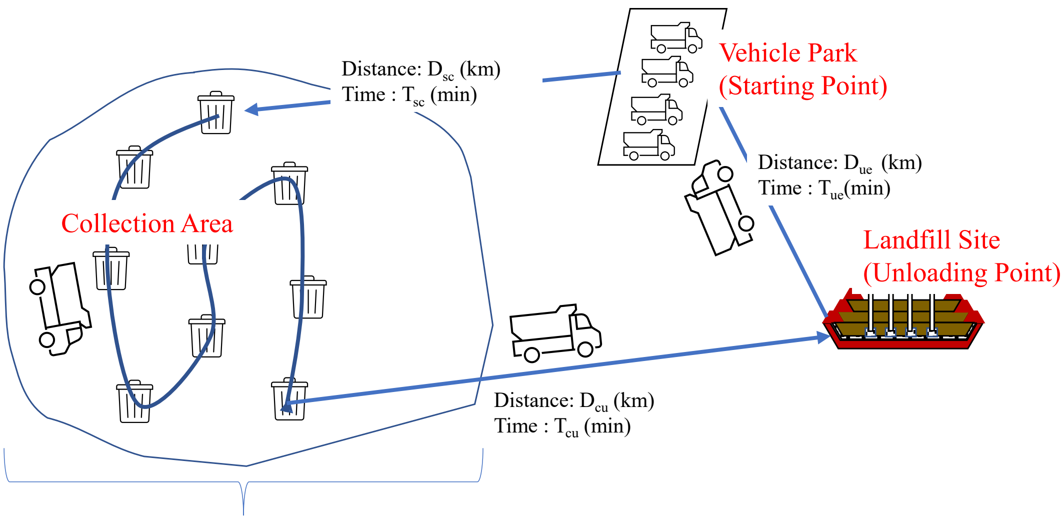
2. Selection of target Vehicle

Type of vehicle	Sampling number	Remark
Compactor	1 trip	
Skip loader	1 trip	
trailer tractor	1 trip	
Truck without dump	1 trip	

3. Survey Method

- Turn on the GPS device and/or timer and start the from vehicle compound/Arm roll container/FDS.
- Follow vehicle and record activities (collection/moving/stop) of collection vehicle and take photos of activities
- Check arrival time and starting time in each collection point
- Measure loading in the collection area and unloading time
- Arrive at the destination and turn the GPS devise and/or timer off.

The image of the record of time and motion survey are shown in the ollowing figure.



Total Distance in Collection Area: $\sum_i D_c\,(i-1,i)$ (km)

Total Moving Time in Collection Area: $\sum_i MT_c\,(i-1,i)$ (min)

Total Loading Time in Collection Area: $\sum_i LT_c\,(i)$ (min)

Figure Image of Recording of Time and Motion Survey of Collection and Transportation

(1) Collection

During time and motion survey, the loading time in collection area, transportation time, and unloading time in landfill site was collected. Continuously recording the time and motion of loading, moving, and unloading at each point is sometimes difficult. To improve the efficiency and the accuracy of the survey, and a GPS logger or video recording should be utilized.

Table Necessary Data

Item	Data	Remark
Distance between collection areas and starting point (km)	D_{sc}	GPS, GPS data logger
Distance between collection point i-1 and i (km)	D_c (i-1, i)	
Total distance between collection areas (km)	$\sum_i \mathrm{Dc}\,(i-1, i)$	
Distance between collection areas and unloading point (km)	D_{cu}	
The Distance between the unloading point and the ending point (km)	D_{ue}	
Time from starting point to collection areas (min)	MT_{sc}	GPS, stopwatch, etc
Time for moving between collection points i-1 and I (min)	MT_c (i-1, i)	
Total time for moving into collection area (min)	$\sum_i \mathrm{MTc}\,(i-1, i)$	
Time for loading waste at collection point i (min)	LT_c (i)	
Total time for loading waste in collection area (min)	$\sum_i \mathrm{LTc}\,(i)$	
Time from a collection area to the unloading point at the waste treatment facility or final disposal site (min)	MT_{cu}	
Time for unloading of waste at the waste treatment facility or final disposal site (min)	UT_u	
Time from unloading point to ending point (min)	MT_{ue}	
Other time (rest time, etc) (min)	OT	
Quantity of collected waste (ton)	CWQ	Measured in weighing bridge or estimation by visual inspection by eye, picture or video of collection vehicle
Number of loaded dust bins	N_{db} (i)	Visual inspection by eye, picture or video
Number of loaded plastic bags	N_{Pb} (i)	Visual inspection by eye, picture or video

Total time $T = MT_{sc} + \sum_i \mathrm{LTc}\,(i) + \sum_i \mathrm{MTc}\,(i-1, i) + MT_{cu} + UT_u + MT_{ue} + OT$

Total distance $D = D_{sc} + \sum_i \mathrm{Dc}\,(i-1, i)$

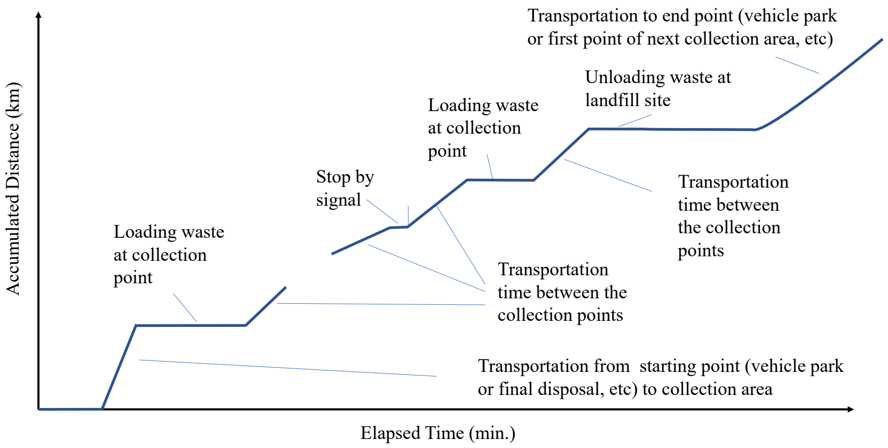


Figure Image of Time and Total Distance for Collection and Transportation

(2) Data Analysis

After the data collection, data should be analysed to identify the current condition of collection and transportation and to utilize the plan of collection and transportation. Basically, the following analysis should be implemented. The required data for analysis and considered utilization methods are summarized as follows.

Table Data Analysis

Item to be analyzed	Data	Remark (purpose of analysis, etc)
Travel speed from a collection area to the landfill site	MT_{cu}	To identify the overall spending time on collection and transportation
Time for loading waste at collection point i (min)		Identifying the loading efficiency depend on the type of vehicle
Time for unloading of waste the at waste treatment facility or final disposal site (min)	UT_u	Identifying the unloading efficiency depend on the type of car

1) Relationship between travel and type of collection vehicle
2) Relationship between loading time and type of vehicle
3) Relationship between unloading time and type of vehicThe above information is one the of examples of how the analysis should be implemented.

4. Schedule

This time and motion survey has been implemented as follows:

Table Schedule of Survey

Type of vehicle	Date
Compactor	11th, February
Skip loader	15th, February
Tractor trailer	16th, February
Truck without dump	17th, February

5. Result of Survey

(1) Compactor Vehicle

The Compactor Vehicle is a collection vehicle that compresses waste after it is loaded and transported with increased loading efficiency. Below is a photo of the Compactor Vehicle and a history of this trip.

1) Collection

At the time of collection, the plastic waste bins are loaded manually or by machine, depending on their capacity. Within the collection area, most households along the main road place the their plastic waste bins in front of their houses at the time of collection. During the walking time for collection he waste collectors were required to pick up plastic waste bins in areas not facing a major road. The loading times are summarized below.

Table Loading Time of Waste to Compactor Vehicle

Activity	Item	Time (second)
Loading of plastic bin	Minimum loading time	4.9
	Maximum loading time	106.0
	Average loading time	29.7

2) Transportation

As shown below, the maximum speed was 80.5 [km/h] and the average speed was 54 [km/h]. Although slightly slower than a standard vehicle, it can travel at higher speeds because loaded is inside the vehicle and not exposed to the air after being compacted.

Table Speed of Compactor Vehicle during Waste Transportation

Item	Speed [km/h]
Maximum Speed	80.5
Average Speed	54

3) Unloading

The compacted and transported waste is unloaded at the final disposal site. Unloading times are shown below. Since there is no weighing bridge at the final disposal site, the weight of the loaded waste is unknown, but it is estimated to be about 70% of the load.

Table Unloading Time of Waste from Compactor Vehicle

Activity	Location	Time (second)
Unloading of compacted waste	Waste unloading point (landfill site)	130

(2) Skip Loader
The Skip Loader is a vehicle that loads and transports containers that are placed at the collection point. During collection, it takes time to load and unload empty containers, time to place and load containers with waste, and time to load and unload containers at the disposal site. Below are photos of the Skip Loader and a history of this trip.

1) Collection
In some cases, two containers may be loaded, at which time the two containers must be unloaded once and only one container stacked for placement at the collection point and unloading of waste at the disposal site. The following table shows the loading time of containers with waste at collection and the unloading time of empty containers.

Table Loading Time of Waste to Skip Loader

Activity	Location	Time (second)	Skip number
Loading time of container	Waste collection point	33～37	1
Unloading of container	Waste collection Point	40～42	1
Loading time of container	Waste collection Point	130~135	2
Unloading time of container	Waste collection Point	140～145	2

2) Transportation
As shown below, the maximum speed during transport was 62.5 [km/h] and the average speed was 24.0 [km/h]. Although slower than the packer trucks, this is thought to be due to the fact that the maximum speed is set at about 60-70 km/h to prevent waste scattering from the top of the container. Therefore, transportation efficiency is not very good.

Table Speed of Skip Loader during Waste Transportation

Item	Speed [km/h]
Maximum Speed	62.5
Average Speed	24.0

3) Unloading
The hauled waste is unloaded at the final disposal site. The unloading time is shown below.
In case of loading containers in skip vehicle, it takes longer because another container below should be unloaded at another location after a upper container unloading and moving to different location.

Table Unloading Time of Waste from Skip Loader

Activity	Location	Time (second)	Skip number
Unloading full container and loading empty container at dumping site	Waste unloading point (landfill site)	84	1
Unloading full container and loading empty container at dumping site	Waste unloading point (landfill site)	845	2

(3) Small Tractor Trailor

The used small tractor trailer is an agricultural tractor towing a trailer to perform collection and transportation. Compared to large compactor vehicle and skip loaders, they can pass on slightly narrower roads, but it is easier for compactor vehicles and skip loaders to turn left and/or right in a cross section and backward. Below are photos of the small tractor trailer and a history of this trip.

1) Collection

At the time of collection, plastic bags are manually loaded with garbage. Within the collection area, most households along the main road place plastic waste bins in front of their houses at the collection time. However, it will take time to collect the waste in plastic waste bins in areas not facing a major road. The loading times are summarized below.

Table Loading Time of Waste to Small Tractor Trailor

Activity	Item	Time (second)
Loading of plastic bin	Minimum loading time	5.8
	Maximum loading time	127.2
	Average loading time	35.2

2) Transportation

As shown below, the maximum speed during transport was 20.1 [km/h] and the average speed was 14.4 [km/h]. The transport speeds were considerably slower than those of compactor vehicles and Skip loaders.

Table Speed of Small Tractor Trailor during Waste Transportation

Item	Speed [km/h]
Maximum Speed	20.1
Average Speed	14.4

3) Unloading

The transported waste is unloaded at the final disposal site. Unloading times are shown below. Since there is no truck scale at the final disposal site, the weight of the load is unknown, but it was estimated to be about 3-4 tons.

Table Unloading Time of Waste from Small Tractor Trailor

Activity	Location	Time (second)
Unloading of compacted waste	Waste unloading point (landfill site)	37

(4) Truck without dump
At the time of collection, the plastic bags entering waste are manually loaded. Below is a photo of the flatbed truck and a history of this trip.

1) Collection
At the time of collection, the waste was placed in plastic bags and loaded manually. The target households and the other establishment were basically located on major roads during the survey. The loading times are summarized below.

Table Loading Time of Waste to Truck

Activity	Item	Time (second)
Loading of plastic bag	Minimum loading time	1.7
	Maximum loading time	74.8
	Average loading time	16.8

2) Transportation
As shown below, the maximum speed was 70 [km/h] and the average speed was 50.5 [km/h]. Although slower than compactor vehicles, the reason for this is thought to be that the trucks were operating at a lower speed to prevent waste from scattering from the top of the load-carrying tray. Therefore, transportation efficiency is not very good.

Table Speed of Truck during Waste Transportation

Item	Speed [km/h]
Maximum Speed	70
Average Speed	50.5

3) Unloading
The transported waste is unloaded at the final disposal site. Unloading times are shown below. The weight of the load was about 0.02 tons. The lack of a dump function resulted in a slow unloading process.

Table Unloading Time of Waste from Truck

Activity	Location	Time (second)
Unloading of compacted waste	Waste unloading point (landfill site)	590

6. Issues regarding this survey and utilization of data

Since Region 5 is far from Georgetown and there were restrictions on early morning and late-night travel, it was not possible to survey the entire sequence of collection, transport, unloading at the disposal site, collection and transport again, and finally return to the parking lot. On the other hand, since time and motion data were obtained for each vehicle's collection and transportation, they could be analysed, and utilized for collection and transportation planning.

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Pilot Project Technical Note No.3

Plastic Policy Development in Jamaica

Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management
in the Caribbean Region

Pilot Project Technical Note No. 3
- Plastic Policy Development in Jamaica -

Prepared by Taisuke WATANABE, JICA Advisory Team
October 2023

Table of Contents

Tables

1 Objective

Objective of the plastic policy development in Jamaica is to strengthen plastic regulations through plastic material flow estimation and case studies of other countries.

As for the plastic regulation, since the strengthening of the regulation is under consideration, it is important as capacity building to organize considerations for the regulation and for promoting recycling, while understanding the situation of plastics. The plastic material flow estimation will lead to an understanding of the plastics situation (including what data is or is not known), knowledge transfer through case studies from other countries will lead to an organization of issues that need to be considered for strengthening regulations, and regulatory review work by NEPA consultants will lead to an organization of what specific issues need to be considered when studying specific regulatory proposals, thereby strengthening capacity.

2 Plastic Material Flow

The status of plastics and plastic products is understood by following the stages of importation, manufacturing, waste generation, recycling, exportation, and environmental runoff, and by quantifying plastics at each stage. Since activities are to find data that could be utilized, the form of the flow that could be done was not what was envisioned. As for the data obtained, only the volume of pure plastic products (including resin) was available for the import stage, and for the manufacturing stage, no data was provided by the manufacturing companies, so only plastic bottles were available as quantitative data. From the waste stage onward, the amount of environmental leakage could be estimated based on waste generation and collection rates. This allowed C/P to understand what data was or was not captured. The materials prepared are shown in the table below. These are attached as annexes.

Table 1: List of Plastic Material Flow Materials

Title	Abstract
Plastic Material Flow (Ver.2)	Objective: ● To understand the situation of plastics in Jamaica, data is collected and estimated by stage: plastics import/export, manufacturing, waste generation, waste collection, recycling and leakage. A summary of material flows is presented in PPT. Overview: ● Key findings include that the main plastic pollution problem in Jamaica is marine and coastal plastics, leading to an estimated potential environmental leakage of plastics of approximately 71,400 tonnes per year for the country as a whole and approximately 21,800 tonnes for the Kingston Metropolitan Area (KMA). ● Data on the import and export of plastic products, manufacturing data, waste generation data, recycling data and leakage data have been collected and provide insight into the marine leakage of plastics, although the data are general overview data, such as manufacturing data, which is limited. ● The application of the material flow is shown to focus on specific plastic products.
Plastic Material Flow (Detail) (Ver.2)	Objective: ● To understand in detail the material flow of plastics in Jamaica. Overview: ● To provide details of the data presented in the PPT above, how it was obtained and how it was calculated.

Title	Abstract
Data Resource Guidance for Plastic Material Flow	Objective: ● To indicate sources of data and information for the use and updating of plastic material flows. Overview: ● Data sources for imports and exports: description of UN COMTRADE. ● Data on plastic manufacturing: no statistics are available, so interviews with manufacturers and bottlers are required, but manufacturers tend to decline to provide data. ● Waste generation and recovery data: based on Jamaica Waste Characterization Survey Report and NSWMA Annual Report. ● Plastic recycling data: based on interviews with RPJ and Jamaica Recycles, which provided data mainly on plastic bottles. ● Data for the Kingston metropolitan area: due to the lack of data for the Kingston metropolitan area, data has been transformed based on population ratios.
Plastic Material Flow- Follow-up	Objective: ● To provide supplementary information on the use of plastic material flows. Overview: ● An important finding on plastics material flows is that environmental leakage is an issue when considering environmental pollution from plastics, and environmental leakage is estimated from non-collected plastic waste. ● The application of material flows to specific plastic products and reliable data collection methods are described. As an example, it explains that in the case of data collection for PET bottles, manufacturing data is likely to be available due to the limited number of major manufacturers, recycled quantities can be obtained from recyclers and environmental leakage and recycling rates can be estimated.

3 Plastic Policy Development

The MEGJC presented the direction of plastics policy as strengthening the regulation of single-use plastics and the Deposit Refund Scheme for plastics recovery, as well as the preparation of intergovernmental negotiations (starting in November 2022) for the creation of an international framework (a treaty is envisioned) for plastic pollution as a matter of concern. Knowledge transfer in response to these issues was provided in the form of workshops and materials; topics for each session were selected based on C/P interests, pilot project activities, and related information. For example, in the third session, as the expansion of the regulation (prohibition) of single-use plastics is under consideration, examples of how the legal text of the target products and those treated as exceptions are prescribed were introduced from the legal texts of Caribbean islands countries. Also, since there are activities in Jamaica by industry associations, NGOs and others to combat plastics, interviews with these organizations were conducted and presented in the 11th session. The list of knowledge transfer activities is as follows. These are attached as annexes.

Table 2: List of Knowledge Transfer Sessions

No	Date & Title	Outline of Contents
1	Date: Aug. 5, 2022 Title: Outline of JICA Activity in Jamaica	Objective: ● Creation of a policy tool for integrated marine litter prevention to contribute to the policy proposal for marine plastic litter prevention measures

No	Date & Title	Outline of Contents
		Contents: ● Survey on gully and maps ● Plastic Material Flow ● Support for Policy Proposal
2	Date: Aug. 22, 2022 Title: Regulation on Single-Use Plastics and Plastic Bottle Refund	Objective: ● Provide knowledge and implications on regulation on single-use plastics, and plastic bottle refund Contents: ● Regulation on Single-Use Plastics- Issues, Context and Examples of Caribbean Islands ● Plastic Bottle Refund- For expansion of DRS and Examples of Caribbean Islands
3	Date: Oct. 10, 2022 Title: Legislation of the Deposit Refund Scheme	Objective: ● Provide knowledge and implications on legislation of the deposit refund scheme Contents: ● Approach to the legislation ● What is to be legislated (Mandatory case) ● What is to be legislated (Voluntary case) ● Reference
4	Date: Oct. 20, 2022 Title: Regulation on Single-Use Plastics	Objective: ● Explain on the issues for regulation of single-use plastics Contents: ● Introduction (existing practice, justification and lessons from Antigua and Barbuda) ● How to prescribe the product ● How to prescribe the exemption ● Biodegradable plastic
5	Date: Nov. 22, 2022 Title: Preparation for the 1st INC on Plastic Pollution Convention	Objective: ● Make preparations for the 1st INC on Plastic Pollution Convention Contents: ● What to be discussed? ● What is prepared for discussion by Secretariat? ● Discussion points ● What Jamaica wants in the treaty? ● How Jamaica enlarge its voice
6	Date: Jan. 16, 2023 Title: Plastic Material Flow and etc.	Objective: ● Understand the rough plastic volume in Jamaica, and provide information to stakeholders Contents: ● Plastic Material Flow in Jamaica including volume in stages ● Other output from Pilot Project ● Progress on preparation of regulation
7	Date: Feb.14, 2023 Title: Supporting Plastic Policy Development in Jamaica	Objective: Introduce JICA project activities including plastic material flow and plastic policy support Contents: ● JICA Project Activities ● Plastic Material Flow: Reason, Problem and Figures in Stages

No	Date & Title	Outline of Contents
		● Other Plastic Policy Support ● The Way Forward
8	Date: May 15, 2023 Title: Enactment of Japan's Containers and packaging Recycling Law - process and stakeholders' comments	Objective: ● Introduce the process of Japan's enactment of the Containers and Packaging Recycling Law, and introduce consultations with stakeholders. Contents: ● Major Gov. Agencies ● What is the Containers and Packaging Recycling Law? ● What Process was Used to Develop the Law? ● Comments from Industry ● Comments from Consumers (Community Groups) ● Comments from Local Governments ● Comments from Ministries (MHW & MITI vs. MAFF)
9	Date: July 30, 2023 Title: Deposit Refund Scheme in Palau and Pacific Islands	Objective: ● Introduce deposit refund scheme in Palau and Pacific islands Contents: ● CDS (Container Deposit Scheme) in Palau ● Designing CDS in Pacific Islands ● Introduction of CDS in Marshall Islands
10	Date: Aug. 25, 2023 Title: Information on plastic alternatives	Objective: ● To provide study information on plastic alternatives Contents: ● Study report in Trinidad & Tobago ● Examples of descriptions related to the proposed regulations or impact assessments on single-use plastics
11	Date: Aug. 31, 2023 Title: NGO/Private sector activities related to plastic pollution in Jamaica	Objective: ● Overview the activities of NGOs and private actors on plastic pollution for understanding the status of plastic management in Jamaica Contents: ● Recycling and Deposit Refund Scheme ● Campaign by bottling company ● Hotel and Tourism Association ● Kingston Harbour Cleanup Project ● Annual International Coastal Cleanup Day ● Nuh Dutty Up Jamaica Campaign ● (Reference) NSWMA activity
12	Date: Sep. 15, 2023 Title: Plastic Material Flow in Jamaica (Supplement)	Objective: ● Provide supplemental information to the material flow Contents: ● Plastic Material Flow (Ver.2) ● Plastic Material Flow Detail (Ver.2) (Detailed explanation) ● Plastic Material Flow Data Resource Guidance (Reference guide for the data source) ● Plastic Material Flow Follow-up (supplementary development and use of material flow)
13	Date: Oct. 10, 2023 Title: Advanced Comments on the report from the	Objective: ● JAT provides the comments to clarify the reviewing points of the report from the consultant on SUP

No	Date & Title	Outline of Contents
	consultant on National policy on Single Use Plastics (SUP)	Contents: ● Background & Objective ● Review of related national planning, development policies and etc. relevant to SUP ● Review of international, regional and selected country commitments, obligations strategies, action plans and associated legislation and regulation ● Facilitating consultations ● Review of the current legislative framework, and recommendations for the most appropriate legislative and regulatory framework ● Review related capacity of primary stakeholders ● Preparing a draft National Policy ● Other Suggestions which can be included in the draft National Policy

4 Other Support for NEPA's Regulatory Development

During the field survey period, meetings were held with NEPA once every 1-2 weeks to explain the progress of the pilot project, hear about issues of interest, and exchange information, including knowledge transfer on plastic material flow, case studies from other countries, etc.

NEPA has secured a budget to use outside consultants ("Policy Consultant to prepare a National Policy on Single Use Plastic Management" and "Consultant to prepare a Legislative Framework for a Deposit Refund Scheme for PET Bottles") to study specific plastics legislation and policies. Legislative Framework for a Deposit Refund Scheme for PET Bottles") to study the specifics of plastics legislation and policy. In response, the following activities were undertaken. "Policy Consultant to Prepare a National Policy on Single Use Plastic Management" was selected during the field study period to examine single-use plastic regulations. Consultation with stakeholders is included in the consultant's TOR, and this report is awaited, as the consideration of products subject to regulatory expansion is heavily influenced by stakeholder views on the supply of alternatives, etc.

- Provided comments on two draft TORs of the consultant.
- Provided comments on the inception report as the consultant for "Policy Consultant to Prepare a National Policy on Single Use Plastic Management" was selected.
- Provided comments explaining the review points when the report comes out (#13 on the list in the previous section), as the report of "Policy Consultant to Prepare a National Policy on Single Use Plastic Management" is not submitted yet.

5 Lessons from the Pilot Project

a. Capacity development

(Response by NEPA)

There were numerous opportunities for organizational and individual capacity development from the support of the JICA Advisory Team including the development of Plastic Material Flow. These included the sessions where information was shared on:

- Jurisdictional research conducted on plastic waste management including Deposit Refund Schemes, Bans on Plastics and Economic Incentives implemented in other Caribbean Islands.
- Plastic Policies, Plastic Material Flow and waste separation practices in Japan.
- Workshops for direct information exchange on current practices of waste management amongst the Caribbean Islands.

b. Continued development of pilot project

In ascertaining information on plastics, it was recognized that obtaining information on plastic waste was important for estimating leakage into the environment. On the other hand, it was difficult to obtain information from manufacturers of plastic products, including not only the amount (number) of plastic products manufactured but also the type of plastic used. It is important to learn from this experience and to promote information collection by targeting specific plastic products (e.g., PET bottles, for which the number of manufacturers is limited).

Regarding the strengthening of plastics regulations, work is underway by NEPA consultants to study strengthening the single-use plastics regulation (ban). A report that can adequately justify the proposed regulation is awaited. Once this report is completed and discussions with sector groups proceed, the conditions for strengthening the regulations will be in place, although the final decision will depend on the political situation. Given NEPA's limited staffing, it is appropriate to use consultants, but it is also important to create an environment in which consultants can work effectively (e.g., provide a list of key stakeholders).

ANNEX

Lecture materials for the plastic material flow

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Plastic Material Flow in Jamaica (Ver.2) –

Sep. 1, 2023
NEPA
With support of JICA Advisory Team

1

Contents

2

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1. Background and Objective

- JICA Technical Cooperation Project supports the development of plastic policy in Jamaica.
- To understand the plastic situation in Jamaica, how plastic becomes product, waste and go to the marine and figures in such flow is the provides the basis to identify the points of action. Material flow is import, manufacture, waste generation, waste collection and recycling and leakage. JAT support the development of plastic material flow.
- Following is the plastic material flow with a rough estimate on a national level and the Kingston Metropolitan Area (KMA) level. As this is a rough estimate, please read the Note below carefully to understand the characteristics of the figures.

Note:

- Not all quantities of plastics are addressed and depending on the item, covered plastics are limited. For example,, plastic in bulky waste is not covered overall.
- Figures are estimates with assumption, as availability of data is very limited except for UN statistical data on Imports and Exports.
- Because the ground and covered plastic are different in each stage. comparing figures in stage by stage is not appropriate.

3

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1. Major Findings

- Considering that the biggest plastic pollution issue is plastics in the marine, especially at the coastal area, it is important to understand the possible plastic leakage to marine in Jamaica.
- Potential plastic leakage is around 71,400 ton/year in nationwide.
- Potential plastic leakage is around 21,800 ton/year in KMA.
- If assuming that plastics on land are finally discharged to marine, as Jamaica is mostly hilly/mountainous and have small plain land area, amount of potential leakage can be understood nearly as the amount discharged to the marine.

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1. Major Findings (Application)

- ➢It is effective way to apply the material flow method to the target plastic product situation.
- ➢If you are to collect data on PET bottle, you can collect more reliable data, because PET resin is imported (not produced in Jamaica), amount of PET bottle manufactured can be obtained, as number of major manufacturer is limited. Manufactured PET bottle will become waste bottle (not retained in houses). Waste collection rate is applied and recycled amount can be obtained from recycler.
- ✓As a result, amount of manufactured (=import), waste, uncollected waste, recycled and potential leakage of PET bottle can be obtained.

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2. Plastic Material Flow (National Level)

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Figures in stages

To cover the flow, import, manufacture, waste generation, waste collection and recycling and leakage. Following is the covered/calculated plastic in each stage.

- Import and export: Plastic products categorized under HS codes of Chapter 39 (Plastics and articles thereof) . Plastics included in some products (ex. electric product) are not covered.
- Manufacture: Only available data is number of plastic bottles sold in Jamaica. The weight is calculated from number of bottles x typical weight per bottle.
- Plastic waste generation: Calculated from total waste generation amount x plastic portion in waste. Per capita waste generation amount is used for estimation of total waste generation .
- Uncollected waste: Calculated from plastic waste generation amount X plastic uncollection rate, while used uncollection rate is one of the reported figure.
- Plastic recycled : Only amount of plastic bottle collected.
- Potential plastic leakage: Assuming that (uncollected waste - plastic recycled) can lead to the leakage.

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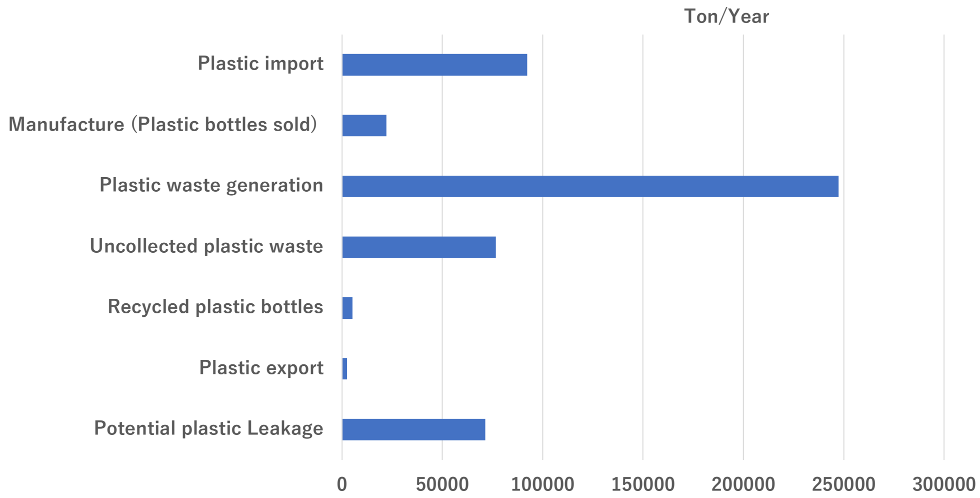
- Figures at glance



Reminder: The covered plastic are different in each stages and much assumption is used to get figures.

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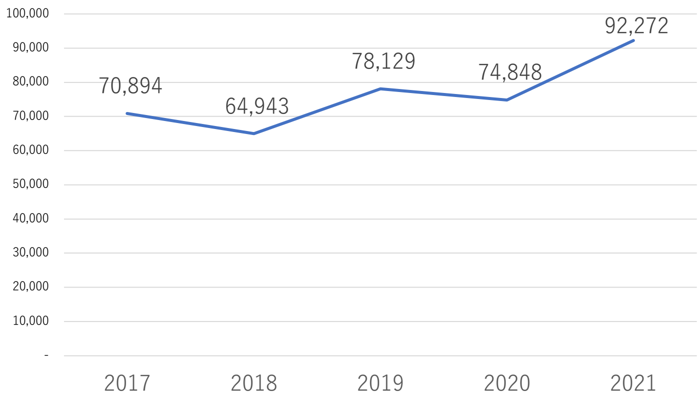
- Plastic Import

- Plastic products categorized under HS codes of Chapter 39 (Plastics and articles thereof) are covered.
- Plastics included in some product (ex. electric product) is not covered.

Total Import of Plastics in Jamaica (ton/year)



Source: UN Comtrade Database, 2022

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- Plastic Import (Major Import)

Categories representing major plastic imports

H.S Code	Description	2021
3902	Polymers of propylene or of other olefins, in primary forms	9.5%
3915	Waste, parings and scrap, of plastics	50.5%
3919	Self-adhesive plates, sheets, film, foil, tape, strip and other flat shapes, of plastics, whether or not in rolls	9.9%
3925	Plastics; builders' wares n.e.c. or included	16.1%

Source: UN Comtrade Database, 2022

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- Plastic Product Manufacturing (bottles)

Plastic bottles sold in Jamaica in 2018

- PET (Clear): 807,369,069 bottles
- HDPE: 39,051,547 bottles
- Other types of plastics (PET Blue, PET Amber, PET Green and PET Black bottles): 65,545,081 bottles.

Source: National Environment and Planning Agency , Final Regulatory Impact Assessment Report, Plastic Waste Minimization Project, 2020

To convert the number of bottles to weight of bottles, assume that weight of PET bottle is 23 g and weight of HDPE bottle is 55 g, whatever the bottle size is.

Estimate of the weight of plastic bottles sold in Jamaica in 2018≒ 22,200 tons

- Plastic Waste Generation

- The plastic waste generation amount is from Jamaica Waste Characterization Final Report 2022 by DBJ (Development Bank of Jamaica)
- It is assumed that plastic waste generation amount is from overall waste generation x plastic portion in the overall waste (16.8 %)

Plastic waste generation (tons/year) = 247,545 ≒ 247,500

Estimated annual waste generation in Jamaica

Population (2019)	Household solid waste generation (tons/year)	ICI waste generation (tons/year)	Overall waste generation (tons year)
2,734,094	1,090,923	384,549	1,475,473

Source: Jamaica Waste Characterization Final Report 2022

- Uncollected Plastic Waste

- Uncollected plastic waste is estimated from plastic waste generation x uncollection rate.
- While there is not fixed collection rate, 69% (from DBJ) is used.

$$Uncollection\ rate = 100 - collection\ rate\ 69\% = 31\ \%$$

Uncollected plastics (tons/year) ≒76,700

Uncollected plastic amount in Jamaica

Plastic solid waste generation (tons/year)	Uncollection rate (%)	Uncollected plastic amount (tons/year)
247,545	31	76,739

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- Plastic Recycled (plastic bottles)

Available data on plastic recycling is plastic bottle collection by the Recycling Partners of Jamaica (RPJ) and one recycling company:

- 5,368 (≒5,400) tons in 2022

- Collected plastic bottles are compressed/baled and exported.

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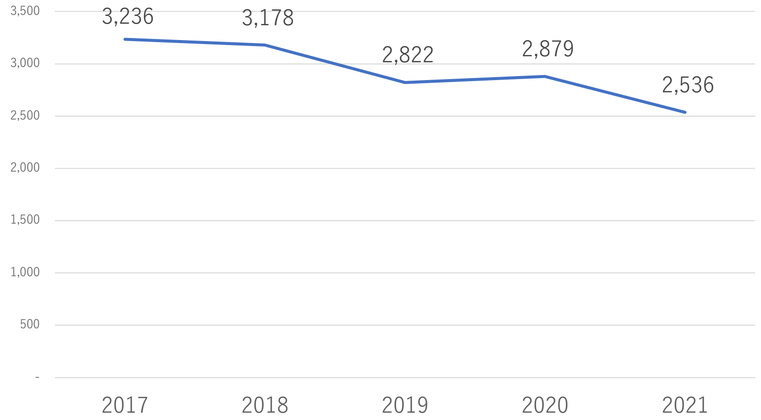
- Plastic Export

➢ Plastic products categorized under HS codes of Chapter 39 are covered



Source: UN Comtrade Database, 2022

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1. Plastic export data (major export)

Among the export of plastics, "Waste, parings and scrap, of plastics" is the biggest category.

Categories representing major plastic exports

H.S Code	Description	2021
3902	Polymers of propylene or of other olefins, in primary forms	7.6%
3915	Waste, parings and scrap, of plastics	40.6%
(3915.90)	(Plastics not elsewhere classified in heading no. 3915; waste, parings and scrap)	(26.1%) (included in 3915)
3925	Plastics; builders' wares n.e.c. or included	13.0%

Source: UN Comtrade Database, 2022

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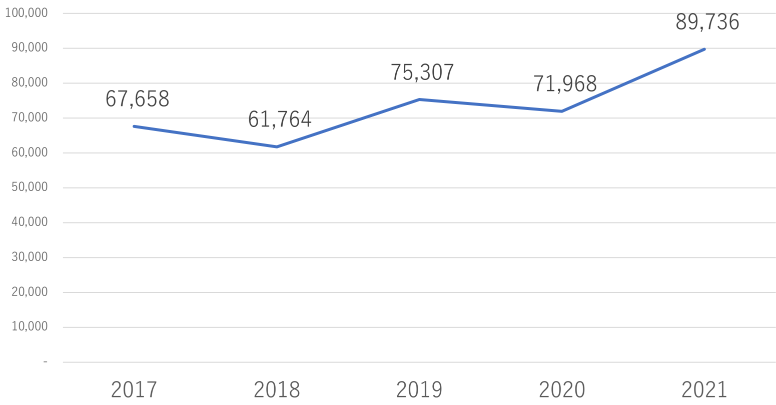
- Plastic Import - Export

- (Import – Export) is over 95% of total Import from 2018 to 2021
- Plastic products categorized under HS codes of Chapter 39 are covered



Source: UN Comtrade Database, 2022

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- Potential Plastic Leakage

- (Uncollected Plastic Waste – recycled plastic) is assumed to be potential plastic leakage in rough way.

  76,739 – 5,368 = 71,371≒71,400 ton/year

(Note)

This is by assuming that (uncollected plastic waste – recycled plastic) could be left and finally lead to leakage, while the figure is with much uncertainty.

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3. Plastic Material Flow (Kingston Metropolitan Area (KMA))

Note: Export/Import and Manufacturing is not included, as these figures are for national level.

- Plastic Waste Generation in KMA

- The plastic waste amount of MPM area is from Jamaica Waste Characterization Final Report 2022
- MPM figure is converted to KMA figure by the population ratio.

The population in MPM (1,277,686): The population in KMA (662,426*)
= The amount of waste generation in MPM: The amount of waste generation in KMA
= The amount of plastic waste in MPM: The amount of plastic waste in KMA
(Plastic waste generation in MPM is 143,789 ton/year)

Plastic waste generation (tons/year) = 74,548 ≒ 74,500

* By Calculation from Parish Profiles by Jamaica Information Service

- Uncollected Plastic Waste in the KMA

- Uncollected plastic waste is estimated from plastic waste generation x uncollection rate.
- Uncollection rate is from the national level.

$$Uncollection\ rate = 100 - collection\ rate\ 69\ \% = 31\ \%$$

Uncollected plastics (tons/year) ≒ 23,100

Uncollected plastic amount in Jamaica

Plastic solid waste generation in KMA(tons/year)	Uncollection rate (%)	Uncollected plastic amount (tons/year)
74,548	31	23,110

- NSWMA Annual Report 2019/2020

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- Potential Plastic Leakage in the KMA

- (Uncollected Plastic Waste – recycled plastic) is assumed to be potential plastic leakage in rough way.
- Recycled plastic amount (national) and population ratio (662,426 / 2,734,094) provides recycled plastic amount in the KMA (=1,301 ton).

23,110 -1,301 ≒ 21,800 ton/year

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4. For the Improvement of Data

- It is found that available data/information is very limited in plastic input (import and manufacturing).
- It is important to accumulate data step by step including spot survey data. For example, there is no data on manufacturing/sales/waste on the bulky products containing plastics.
- When looking at the leakage to the ocean, we need to look at the social aspects, especially people's behavior on dumping waste.
- It is noted that the solid waste operation, especially waste collection, may change because of the realization of SWM PPP project.

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3. Suggestion on further data collection

- It is found that available data/information on plastic is very limited.
- If you limit the target plastic product, it is more possible to collect data.
- If you are to collect data on PET bottle, you can collect more reliable data, because PET resin is imported (not produced in Jamaica), manufactured amount can be obtained (number of major manufacturer is limited), manufactured PET bottle will become waste bottle (not retained in houses), recycled amount can be obtained from recycler. As a result, amount of manufactured (=import), waste, uncollected waste, recycled and potential leakage of PET bottle can be obtained.

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Restricted

Plastic Material Flow in Jamaica (Ver.2)

September 1, 2023
NEPA
With support of JICA Advisory Team

Contents

1 Background & Objective

- JICA Technical Cooperation Project supports the development of plastic policy in Jamaica.
- It is agreed to develop plastic material flow to understand the plastic situation in Jamaica, while the data/information is limited.
- This is the plastic material flow with rough estimate on national level and the Kingston Metropolitan Area (KMA) level. As this is the rough estimate, please read the Note below carefully to understand the characteristics of figures.

Note:

- Not all quantities of plastics are addressed and depending on the item, covered plastics are limited.
- Figures are estimates as there are no statistical data available except for data on Imports and Exports.
- Cannot compare figures in each stage. Because the ground and covered plastic are different in each stage. Also, base year in each stage is different.

  Covered/calculated plastic in each stage:

  - ✓ Import and export: Plastic products categorized under HS codes of Chapter 39 (Plastics and articles thereof) . Plastics included in some products (ex. electric product) are not covered.
  - ✓ Manufacture: Only available data is number of plastic bottles sold in Jamaica. The weight is calculated from number of bottles x typical weight per bottle.
  - ✓ Plastic waste generation: Calculated from total waste generation amount x plastic portion in waste. Per capita waste generation amount is used for estimation of total waste generation.
  - ✓ Uncollected waste: Calculated from plastic waste generation amount x plastic uncollection rate, while used uncollection rate is one of the reported figure.
  - ✓ Plastic recycled : Only amount of plastic bottle collected.
  - ✓ Potential plastic leakage: Assuming that (uncollected waste - plastic recycled) can lead to the leakage.

2 Major findings

2.1 Major findings

- Considering that the biggest plastic pollution issue is plastics in the marine, especially at the coastal area, it is important to understand the possible plastic leakage to marine in Jamaica. Potential plastic leakage can be estimated as follows (detail is in Chapter 8), while it is difficult to track all of plastic flow.
- Potential plastic leakage is around 71,400 ton/year in nationwide.
- Potential plastic leakage is around 21,800 ton/year in KMA.

- If assuming that plastics on land are finally discharged to marine, as Jamaica is mostly hilly/mountainous and have small plain land area, amount of potential leakage can be understood nearly as the amount discharged to the marine.

2.2 Application

- It is effective way to apply the material flow method to the target plastic product situation.
- If you are to collect data on PET bottle, you can collect more reliable data, because PET resin is imported (not produced in Jamaica), and PET bottle manufactured amount can be obtained from manufacturers, as number of major manufacturer is limited. Manufactured PET bottle will become waste bottle (not retained in houses). Waste collection rate is applied and recycled amount can be obtained from recycler.
- As a result, potential leakage of PET bottle can be obtained as follows.
- [amount of manufactured (=import) (same as amount of waste) - uncollected waste – recycled] = potential leakage of PET bottle

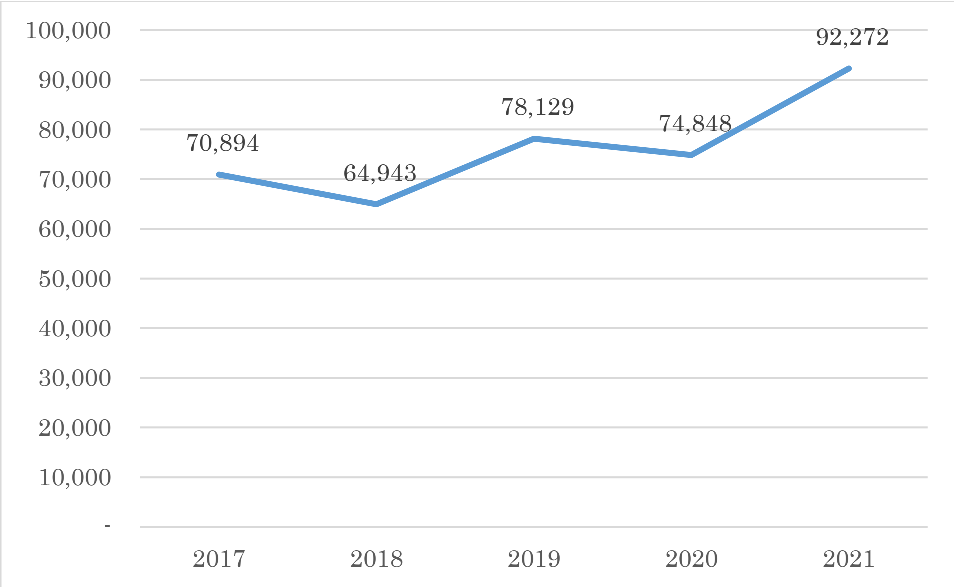
3 Plastic Import

3.1 Method

The data on the Import of plastics in Jamaica is extracted from UN Comtrade Database[1]. Plastic products are categorized under HS codes of Chapter 39[2] (Plastics and articles thereof) where there are 26 categories from H.S. 3901-3026 (Please see Attachment for description). This category covers plastic polymers and resins, waste plastics, plastic only products such as tubes, film and plastic packaging. 5-year data from 2017-2021 reported by all nations are used to estimate the volume of plastic imports. It should be noted that the amount of re-imported waste is excluded. Moreover, products containing plastic, such as electric appliances are not covered.

1 https://comtrade.un.org/data/
2 https://www.tariffnumber.com/2022/39

3.2 Volume



Source: UN Comtrade Database, 2022

Figure 1 Total Import of HS 39 in Jamaica (ton)

3.3 Major import

To understand the contents of import, import volume by category is shown. Categories are representing major plastic import items which include H.S 3915 (Waste, parings and scrap of plastics), H.S.3907 representing Polyacetals and related plastics, H.S.3923 (Plastic articles for the conveyance or packing of goods; stoppers, lids, caps and other closures of plastics) and H.S. 3925 representing plastics for builders' wares.

Table 1 Primary Imported products

H.S Code	Description	2017	2018	2019	2020	2021
3901	Polymers of ethylene, in primary forms	10,364 (0.3%)	34,172 (1.2%)	167,850 (6.5%)	22,060 (0.9%)	24,750 (1.1%)
3902	Polymers of propylene or of other olefins, in primary forms	102,512 (3.3%)	217,063 (7.7%)	0 (0%)	0 (0%)	221,850 (9.5%)
3907	Polyacetals, other polyethers and epoxide resins, in primary forms; polycarbonates, alkyd resins, polyallyl esters and other polyesters, in primary forms	457,353 (14.7%)	914,679 (32.2%)	524,511 (20.3%)	646,661 (24.9%)	94,080 (4.0%)
3915	Waste, parings and scrap, of plastics	1,250,701 (40.2%)	402,794 (14.2%)	883,857 (34.2%)	1,143,044 (44.1%)	1,183,777 (50.5%)
3919	Self-adhesive plates, sheets, film, foil, tape, strip and other flat shapes, of plastics, whether or not in rolls	11,437 (0.4%)	7,491 (0.3%)	961 (0.04%)	786 (0.03%)	233,250 (9.9%)
3920	Plastics; plates, sheets, film, foil and strip (not self-adhesive); non-cellular and not reinforced, laminated, supported or similarly combined with other materials, n.e.c. in chapter 39	208,687 (6.7%)	45,140 (1.6%)	4,008 (0.2%)	143,765 (5.5%)	28,022 (1.2%)

3923	Plastic articles for the conveyance or packing of goods; stoppers, lids, caps and other closures of plastics	536,045 (17.2%)	758,640 (26.7%)	654,526 (25.3%)	310,747 (12.0%)	148,456 (6.3%)
3924	Tableware, kitchenware, other household articles and hygienic or toilet articles, of plastics	273,872 (8.8%)	190,916 (6.7%)	27,346 (1.1%)	74,061 (2.9%)	33,303 (1.4%)
3925	Plastics; builders' wares n.e.c. or included	263,350 (8.5%)	266,290 (9.4%)	319,661 (12.4%)	252,932 (9.8%)	378,922 (16.1%)
TOTAL		3,114,321 (100%)	2,837,185 (100%)	2,582,720 (100%)	2,594,056 (100%)	2,346,410 (100%)

Note: Materials included in Chapter 39 are shown here: https://www.tariffnumber.com/2022/39

Source: UN Comtrade Database, 2022

4 Plastic product manufacturing (plastic bottles)

4.1 Availability of data

There is no statistics on plastic product manufacturing not retail in Jamaica. We approached to the plastic product manufacturers but the no manufacturer provided the amount of production or sales. Because of this, only available data which is number of plastic bottles sold in Jamaica is used.

4.2 Plastic bottles

The main manufacturers of plastic bottles in Jamaica include Bay Packaging & Containers Ltd., Poly Pet Co. Ltd., Sweet Craft Ltd., United Plastics Ltd., Greif Jamaica Ltd., and Versachem International Ltd. Information from the Jamaica Manufacturers and Exporters Association estimated that the amount of PET (Clear) and HDPE plastic bottles sold in Jamaica for 2018 was 807,369,069 and 39,051,547 respectively. Other types of plastics sold in Jamaica in 2018 such PET Blue, PET Amber, PET Green and PET Black bottles amounted to 65,545,081 bottles.[3]

To convert the number of bottles to the weight of bottles, assume that the average weight of PET bottle is 23 g and the average weight of the HDPE bottle is 55 g, whatever the bottle size is. The estimate of the weight of plastic bottles sold in Jamaica in 2018 is 20,077 + 2,148 = 22,225 tons.

Table 2 PET bottle weight[4]

The type of bottle (500ml)	gram (average)
bottle against heat	25.52
bottle for carbonated drinks	24.56
bottle against germ	18.8748
average (1:1:1)	22.98

Table 3 HDPE bottle weight[5]

The type off bottle (1000ml)	gram (average)
HDPE	54.75

3 National Environment and Planning Agency, Final Regulatory Impact Assessment Report, Plastic Waste Minimization Project, 2020

4 PET Bottle Recycling Promotion Council (Japan) webpage (viewed in 2022)

5 Krueger, M., Kauertz, B. and Mayer, C., Life Cycle Assessment of Packaging Systems for Enteral Nutrition Products: Multilayer Pouch and High-Density Polyethylene Bottle, 2021

(Reference)
RPJ collects plastic bottle production information from bottlers to estimate the recycling rate. From the data in 2021 (collected plastic bottle is 1,633 ton and recycling rate is 15%, plastic bottle production could be 10,900 tons.

5 Plastic waste generation

5.1 Volume of plastic waste generation

The plastic waste generation amount is from Jamaica Waste Characterization Final Report 2022 by DBJ (Development Bank of Jamaica). The estimate is based on the waste sample collection carried out from July 2021 to March 2022. It is is assumed that plastic waste generation amount is from overall waste generation x plastic portion in the overall waste (16.8 %) (by waste composition survey).

Plastic waste generation (tons/year) = overall waste generation * plastic percentage in the overall waste = 247,545 ≒ 247,500

Table 4 Estimated annual waste generation in Jamaica (ton/year)

Population (2019)	Household solid waste generation (tons/year)	ICI waste generation (tons/year)	Overall waste generation (tons/year)
2,734,094	1,090,923	384,549	1,475,473

Source: Jamaica Waste Characterization Final Report 2022[6]

5.2 Uncollected plastic waste

Uncollected plastic waste is estimated from plastic waste generation x uncollection rate. While there is not fixed collection rate, 69% collection rate is used. This waste collection rate is used in the business case for the solid waste PPP project by DBJ while where wide range data is reported.

$$Uncollection\ rate = 100 - collection\ rate\ (69\ \%) = 31\ \%$$

Uncollected plastics (tons/year) ≒76,700

Table 5 Uncollected plastic amount in Jamaica

Plastic solid waste generation (tons/year)	Uncollection rate (%)	Uncollected plastic amount (tons/year)
247,545	31	76,739

[6] P.35 Table 16: Estimated yearly MSW and ICI waste generation per wasteshed in 2021/2022; P.20 Table 1 Estimated quantity of waste produced yearly at a national scale and per wasteshed (tons)

(Reference)
Collection rate (waste_collection_coverage_total_percent_of_households) in Jamaica by the Wold Bank is 64.0 %[7].

6 Plastic Recycled

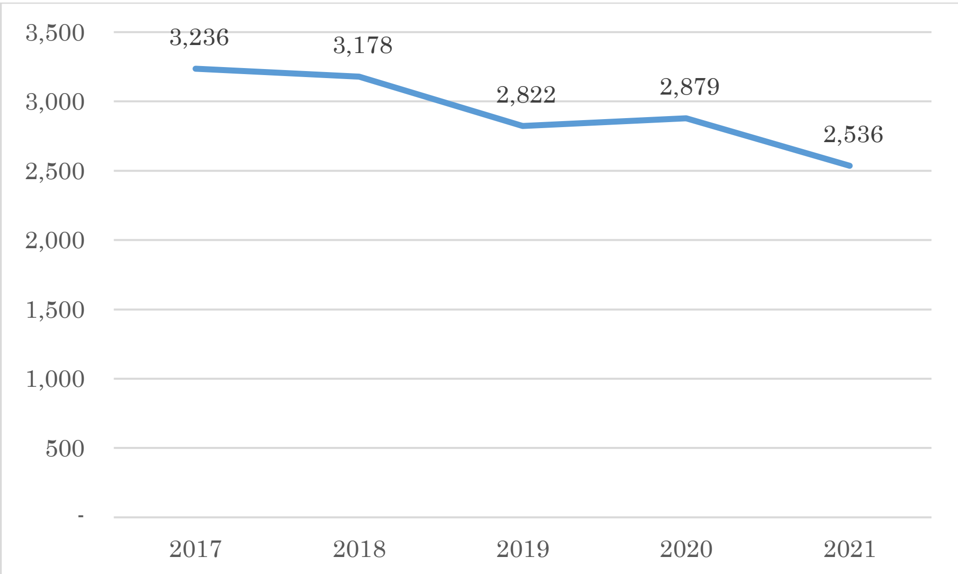
Some plastics are recovered by recycling entities. Available data on plastic recycling is plastic bottle collection by the Recycling Partners of Jamaica (RPJ) and Jamaica Recycles. 5,368 tons of plastic bottles were collected in 2022 by the RPJ and Jamaica Recycles. Bottles are compressed/baled and exported (to Nicaragua in RPJ case).

7 Export

7.1 Method

The data on the Export of plastics in Jamaica is extracted from UN Comtrade Database[8]. Plastic products are categorized under HS codes of Chapter 39[9] where there are 26 categories from H.S. 3901-3026. 5-year data from 2017-2021 reported by all nations are used to estimate the volume of plastic exports. It should be noted that the amount of re-exported waste is excluded. Moreover, products containing plastic, such as electric appliances are not covered (same as import).

7.2 Amount of Export



Source: UN Comtrade Database, 2022

[7] World bank, What a waste global database – Country level dataset, 2019
[8] https://comtrade.un.org/data/
[9] https://www.tariffnumber.com/2022/39

Figure 2 Total Export of HS 39 in Jamaica (ton)

7.3 Major export

To understand the contents of export, export volume by category is shown. Categories representing major plastic export items include H.S 3902 (Polymers of propylene or of other olefins, in primary forms), H.S 3915 (Waste, parings and scrap of plastics), H.S.3915.90 representing plastic waste, parings and scrap and H.S.3925 (Plastics; builders' wares n.e.c. or included).

Table 6 Primary Exported products in kg (% proportion to total primary exported products)

H.S Code	Description	2017	2018	2019	2020	2021
3902	Polymers of propylene or of other olefins, in primary forms	102,512 (2.7%)	217,063 (7.3%)	- (0%)	- (0%)	221,850 (7.6%)
3907	Polyacetals, other polyethers and epoxide resins, in primary forms; polycarbonates, alkyd resins, polyallyl esters and other polyesters, in primary forms	457,353 (12.2%)	914,679 (30.7%)	524,511 (16.1%)	646,661 (18.6%)	94,080 (3.2%)
3915	Waste, parings and scrap, of plastics	1,250,701 (33.3%)	402,794 (13.5%)	883,857 (27.1%)	1,143,044 (32.8%)	1,183,777 (40.6%)
(391590)	Plastics n.e.c. in heading no. 3915; waste, parings and scrap	637,028 (17.0%)	150,656 (5.1%)	803,619 (24.7%)	900,273 (25.9%)	761,041 (26.1%)
3917	Tubes, pipes and hoses, and fittings therefor (for example, joints, elbows, flanges), of plastics.	22,391 (0.6%)	34,110 (1.1%)	40,899 (1.3%)	10,430 (0.3%)	66,322 (2.3%)
3920	Plastics; plates, sheets, film, foil and strip (not self-adhesive); non-cellular and not reinforced, laminated, supported or similarly combined with other materials, n.e.c. in chapter 39	208,687 (5.6%)	45,140 (1.5%)	4,008 (0.1%)	143,765 (4.1%)	28,022 (1.0%)
3923	Plastic articles for the conveyance or packing of goods; stoppers, lids, caps and other closures of plastics	536,045 (14.3%)	758,640 (25.5%)	654,526 (20.1%)	310,747 (8.9%)	148,456 (5.1%)

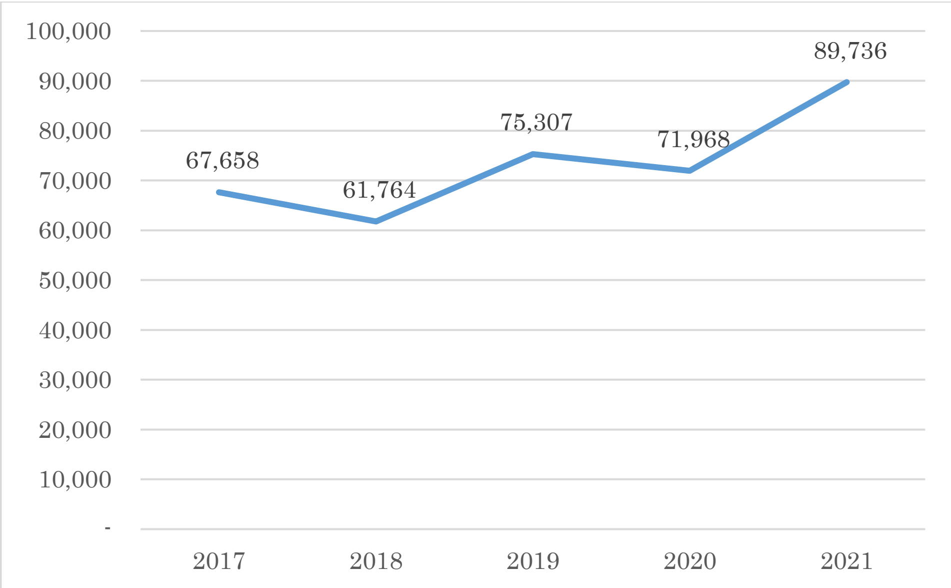
3924	Tableware, kitchenware, other household articles and hygienic or toilet articles, of plastics	273,872 (7.3%)	190,916 (6.4%)	27,346 (0.8%)	74,061 (2.1%)	33,303 (1.1%)
3925	Plastics; builders' wares n.e.c. or included	263,350 (7.0%)	266,290 (8.9%)	319,661 (9.8%)	252,932 (7.3%)	378,922 (13.0%)
TOTAL		3,751,939 (100%)	2,993,988 (100%)	3,271,202 (100%)	3,632,923 (100%)	2,915,773 (100%)

Note: Materials included in Chapter 39 are shown here: https://www.tariffnumber.com/2022/39

Source: UN Comtrade Database, 2022

7.4 Import-Export

Compared to the total Import, the percentage of the amount of Import deducted by the amount of Export is over 95% throughout the years from 2018 to 2021. Again, plastic products categorized under HS codes of Chapter 39 are covered.



Source: UN Comtrade Database, 2022[10]

Figure 3 Import - Export of HS 39 in Jamaica (ton)

8 Potential plastic leakage to Ocean

(Uncollected Plastic Waste – recycled plastic) is assumed to be potential plastic leakage. This is by assuming that (uncollected plastic waste – recycled plastic) could be left and finally lead to leakage, while the figure is with much uncertainty.

$$\text{Potential plastic leakage} = 76{,}739 - 5{,}368 = 71{,}371 \fallingdotseq 71{,}400 \text{ ton/year}$$

[10] https://comtrade.un.org/data/

9 Figures in the Kingston Metropolitan Area (KMA) [11]

9.1 Volume of plastic waste in KMA

The plastic waste generation amount in MPM[12] is from Jamaica Waste Characterization Final Report 2022 by DBJ. The estimate is based on the waste sample collection carried out from July 2021 to March 2022. It is is assumed that plastic waste generation amount is from overall waste generation x Plastic portion in the overall waste (16.8 %).
From that plastic waste generation in MPM is 143,789 ton/year;

The Population of MPM (1,277,686): The population of KMA(662,426[13])

= The amount of plastic waste in MPM: The amount of plastic waste in KMA

Plastic waste generation (tons/year) = 74,548 ≒ 74,500

9.2 Uncollected plastic waste in KMA

Uncollected plastic waste is estimated from plastic waste generation X uncollection rate.
Uncollection rate is from the national level.

$Uncollection\ rate = 100 - collection\ rate\ \ 69\ \% = 31\ \%$

Uncollected plastics (tons/year) ≒ 23,100

Table 7 Uncollected plastic amount in KMA

Plastic solid waste generation (tons/year)	Uncollection rate (%)	Uncollected plastic amount (tons/year)
74,548	31	23,110

9.3 Plastic recycled in KMA

Recycled plastic amount in the KMA is from recycled plastic amount (national) and population ratio of KMA (662,426 / 2,734,094) and recycled plastic amount in the KMA comes 1,301 ton.

[11] Export/Import and Manufacturing is not included, as these figures are for national level.
[12] MPM is MPM Waste Management Limited which covers solid waste management in Kingston, St. Andrew, St. Catherine and St. Thomas.
[13] By calculation from Parish Profiles by Jamaica Information Service

9.4 Potential plastic leakage to Ocean in KMA

(Uncollected Plastic Waste – recycled plastic) is assumed to be potential plastic leakage in rough way.

23,110 -1,301 ≒ 21,800 tons/year

Attachment

Chapter 39 Plastics and articles thereof

HS Code	Description
3901	Polymers of ethylene, in primary forms
3902	Polymers of propylene or of other olefins, in primary forms
3903	Polymers of styrene, in primary forms
3904	Polymers of vinyl chloride or of other halogenated olefins, in primary forms
3905	Polymers of vinyl acetate or of other vinyl esters, in primary forms; other vinyl polymers in primary forms
3906	Acrylic polymers in primary forms
3907	Polyacetals, other polyethers and epoxide resins, in primary forms; polycarbonates, alkyd resins, polyallyl esters and other polyesters, in primary forms
3908	Polyamides in primary forms
3909	Amino-resins, phenolic resins and polyurethanes, in primary forms
3910	Silicones in primary forms
3911	Petroleum resins, coumarone-indene resins, polyterpenes, polysulphides, polysulphones and other products specified in Note 3 to this Chapter, not elsewhere specified or included, in primary forms
3912	Cellulose and its chemical derivatives, not elsewhere specified or included, in primary forms
3913	Natural polymers (for example, alginic acid) and modified natural polymers (for example, hardened proteins, chemical derivatives of natural rubber), not elsewhere specified or included, in primary forms
3914	Ion-exchangers based on polymers of headings 3901 to 3913, in primary forms
3915	Waste, parings and scrap, of plastics
3916	Monofilament of which any cross-sectional dimension exceeds 1 mm, rods, sticks and profile shapes, whether or not surface worked but not otherwise worked, of plastics
3917	Tubes, pipes and hoses, and fittings therefor (for example, joints, elbows, flanges), of plastics

3918	Floor coverings of plastics, whether or not self-adhesive, in rolls or in the form of tiles; wall or ceiling coverings of plastics, as defined in Note 9 to this Chapter
3919	Self-adhesive plates, sheets, film, foil, tape, strip and other flat shapes, of plastics, whether or not in rolls
3920	Other plates, sheets, film, foil and strip, of plastics, noncellular and not reinforced, laminated, supported or similarly combined with other materials
3921	Other plates, sheets, film, foil and strip, of plastics
3922	Baths, shower-baths, sinks, wash-basins, bidets, lavatory pans, seats and covers, flushing cisterns and similar sanitary ware, of plastics
3923	Articles for the conveyance or packing of goods, of plastics; stoppers, lids, caps and other closures, of plastics
3924	Tableware, kitchenware, other household articles and toilet articles, of plastics
3925	Builders' ware of plastics, not elsewhere specified or included
3926	Other articles of plastics and articles of other materials of headings 3901 to 3914

Notes can be found here: https://www.wcoomd.org/-/media/wco/public/global/pdf/topics/nomenclature/instruments-and-tools/hs-nomenclature-older-edition/2002/hs-2002/0739e.pdf?la=en

Data Resource Guidance for Plastic Material Flow in Jamaica

1 Objective

This document provides the guidance on data and information source to update the data for the plastic material flow in Jamaica. The guidance shows the method and source to obtain data and information on each stage in the material flow.

2 Data source for the Imports and Exports

The data on the Import and Exports of plastics in Jamaica can be extracted from UN Comtrade Database[1]by imput of HS code. Plastic products are categorized under HS codes of Chapter 39[2] where there are 26 sub-categories from H.S. 3901-3026 (See Attachment for description) . It should be noted that the amount of re-imported waste and re-exported waste can be selected at the data search and can be used for analysis (See the images below). Moreover, products containing plastic, such as electric appliances are not covered in HS 39 category.

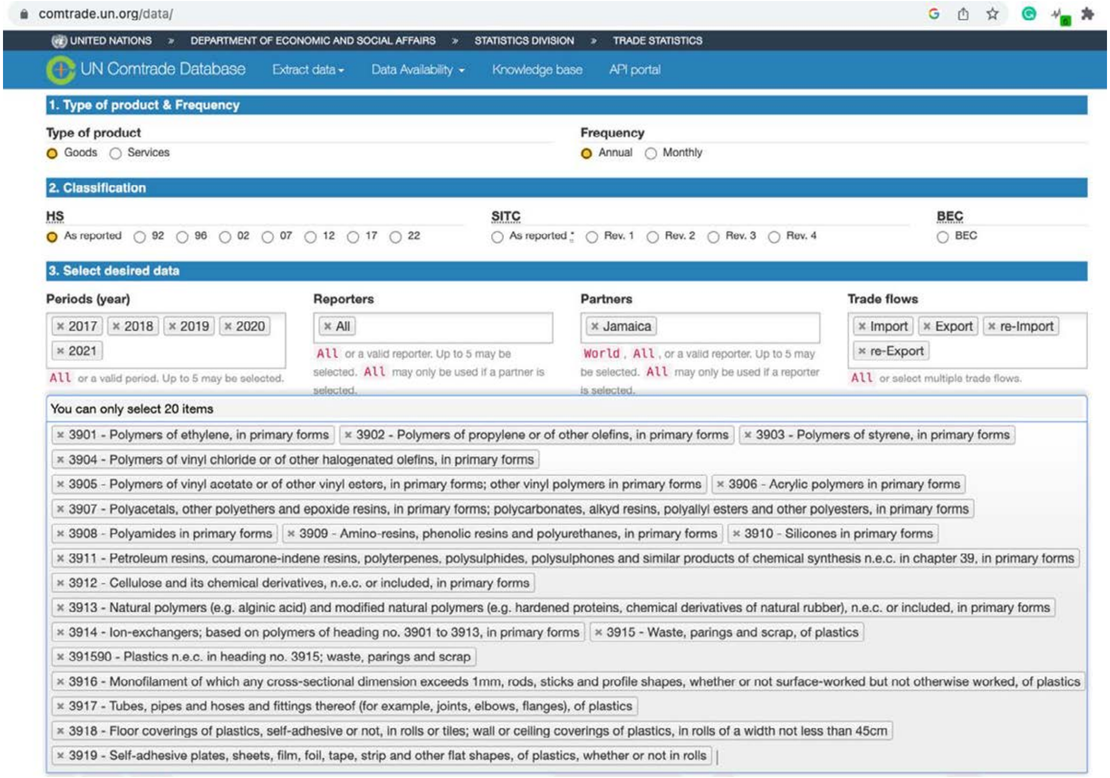
Data extraction and collation method:

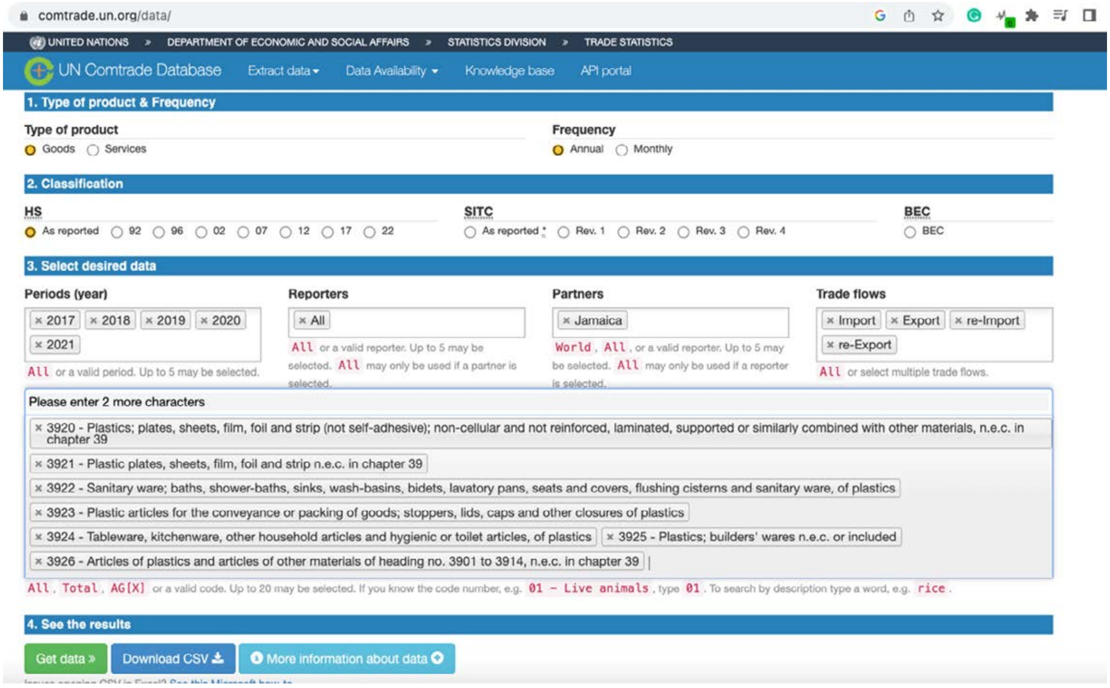
5-year data from 2017 to 2021 and items in Chapter 39 from 3901 to 3926 were obtained from the database. Data from 1962 is available and periods of years can be selected depending on the need. “Partner” is selected as Jamaica, and “Reporters” are selected as All Nations for the accuracy of data. Thus, it should be noted that for the collation of data, data shown as Import is Export by Jamaica, and data shown as Export is Import by Jamaica. (For example, an imported product reported by the United States is exported from Jamaica).

Data were extracted as CSV and the sum of Imports and Exports as well as re-import and re-exports for each category were calculated in excel. The amount of re-imported items and re-exported items were deducted from total Imports and Exports respectively.

Please see the following screenshots for the selection of data on UN Comtrade Database:

[1] https://comtrade.un.org/data/
[2] https://www.tariffnumber.com/2022/39





3 Data source for Plastic Manufacturing

Since there are no official statistics available, interviews with manufacturers and bottlers (who produce beverage containers from resin) were carried out to collect data. It is noted that manufacturers are declined to provide amount data.

Only available data is number of plastic bottles sold in Jamaica for 2018 in the Final Regulatory Impact Assessment Report, Plastic Waste Minimization Project, 2020 by NEPA.

To convert the number of bottles to the weight of bottles, the data on the weight of PET bottle and HDPE bottle from the article/web site data is used, while the number of bottle sold by size is not known.

When interview with manufacturers is tried, it is suggested direct push from the government is needed to collect data and collected individual data is not disclosed (keep confidentiality).

4 Data source for the estimation of the Volume of Plastic Waste Generation and Collection

The estimate is based on Jamaica Waste Characterization Final Report 2022 and NSWMA Annual Report 2019/2020. It should be noted that the Jamaica Waste Characterization Final Report is based on sample collection from July 2021 to March 2022 and the waste characterization study was conducted on a spot basis.
NSWMA Annual Report 2019/2020 provides the activities for 2019/2020. At the moment, DBJ prepares the SWM PPP project which covers the whole SWM operation from collection, treatment and final disposal.

4.1 Data on the amount of MSW, ICI and Overall waste generation

"Overall waste generation" used in the estimation is the sum of household solid waste generation and ICI (Institutional, Commercial and Industrial) waste generation. It should be noted that while daily per capita waste generation for households is estimated by spot study and the estimation of ICI waste generation is not easy.

4.2 Data on the amount of plastic waste generation

The amount of plastic waste generation for Jamaica and MPM is based on the data which the composition of the waste (including plastics) is investigated, and from this data, the waste generation amount is multiplied by the percentage of plastics in the waste (16.8% for national level) to estimate the amount of plastic waste generation.

4.3 Data on waste collection

The waste collection rate (69%) is from the DBJ which set the collection rare for preparation of business case of the PPP project.
The collected amount of household waste by NSWMA can be obtained, while the collected amount of ICI waste is not known. NSWMA shows the collection amount in its annual report and it is by calculating from number of the collection vehicle, as there is no weigh bridge at the disposal site. Obtaining non-collection rate is important for the estimation of potential plastic leakage.

5 Data Source for Plastic Recycling

The data is based on interviews with recyclers (Recycling Partners of Jamaica (RPJ) and Jamaica Recycles). This data is mainly for plastic bottles. Other recycling amount is not known while there are waste pickers collecting plastic bags.

6 Data Source for the Kingston Metropolitan Area

As there is no specific data for the Kingston Metropolitan Area (KMA), data for national or MPM is used from the Jamaica Waste Characterization Final Report 2022.

Converting the national or MPM data to KMA is based on the proportion on population. The population estimate of KMA is based on Parish profiles by Jamaica Information Service[3]. The population of KMA is calculated as a sum of the population of St.Andrew and Kingston. As the population census for Jamaica was carried out in 2022, for the latest population, the result by the Statistics Institute of Jamaica is awaited.

[3] https://jis.gov.jm/information/parish-profiles/parish-profile-st-andrew/, https://jis.gov.jm/information/parish-profiles/parish-profile-kingston/

Attachment

Chapter 39 Plastics and articles thereof

HS Code	Description
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3924	Tableware, kitchenware, other household articles and toilet articles, of plastics
3925	Builders' ware of plastics, not elsewhere specified or included
3926	Other articles of plastics and articles of other materials of headings 3901 to 3914

Notes can be found here: https://www.wcoomd.org/-/media/wco/public/global/pdf/topics/nomenclature/instruments-and-tools/hs-nomenclature-older-edition/2002/hs-2002/0739e.pdf?la=en

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Plastic Material Flow in Jamaica (Supplement) –

Sep. 1, 2023
Taisuke Watanabe
With support of JICA Advisory Team

EX Research Institute Ltd.
Environmental and Regional Planning, Research and Consulting

NIPPON KOEI

1

Contents

This file provides supplemental information to the material flow file in February.

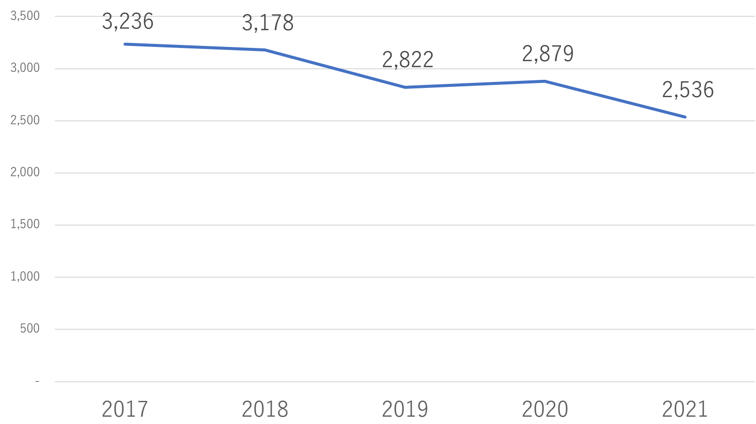
2

2

1. Plastic export data

- Plastic products categorized under HS codes of Chapter 39 are covered

Total Import of Plastics in Jamaica (ton/year)



Source: UN Comtrade Database, 2022

3

3

1. Plastic export data (major export)

Among the export of plastics, “Waste, parings and scrap, of plastics” is the biggest category.

Categories representing major plastic exports

H.S Code	Description	2021
3902	Polymers of propylene or of other olefins, in primary forms	7.6%
3915	Waste, parings and scrap, of plastics	40.6%
(3915.90)	(Plastics not elsewhere classified in heading no. 3915; waste, parings and scrap)	(26.1%) (included in 3915)
3925	Plastics; builders' wares n.e.c. or included	13.0%

Source: UN Comtrade Database, 2022

4

4

2. Important findings from plastic material flow

- Considering that the biggest plastic pollution issue is plastics in the marine, especially at the coastal area, it is important to understand the possible plastic leakage to marine in Jamaica. The leakage is estimated from the uncollected waste amount.
- ✓Potential plastic leakage is around 71,400 ton/year in nationwide.
- ✓Potential plastic leakage is around 21,800 ton/year in KMA.
- If assuming that plastics on land are finally discharged to marine, as Jamaica is mostly hilly/mountainous and have small plain land area, amount of potential leakage can be understood nearly as the amount discharged to the marine.

5

5

3. Suggestion on further data collection

- It is effective way to apply the material flow method to the target plastic product situation.
- If you limit the target plastic product, it is more possible to collect data.
- If you are to collect data on PET bottle, you can collect more reliable data, because PET resin is imported (not produced in Jamaica), amount of PET bottle manufactured can be obtained, as the number of major manufacturer is limited such as Wisynco (this means easier to approach the company to obtain data). Manufactured PET bottle will become waste bottle (not retained in houses), recycled amount can be obtained from recycler.
- As a result, amount of manufactured, waste(need composition study to know the PET bottle rate), uncollected waste (from collection rate), recycled (from RPJ and Jamaica Recyclers), potential leakage and recycling rate of PET bottle can be obtained.

6

6

ANNEX

Lecture materials for the plastic policy development

No.1 Outline Activity in Jamaica

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Outline Activity in Jamaica -

Aug. 5, 2022

Taisuke Watanabe
JICA Advisory Team

EX Research Institute Ltd.

NIPPON KOEI

Contents

1. Objective

【Background】

- In recent years, the seriousness of the marine plastic waste problem has been recognized by the international community, and each country and organization are working on this problem..
- This project supports five target countries (Jamaica, Antigua and Barbuda, Grenada, Saint Lucia, Guyana) with a view to building a cooperation framework in the Caribbean region in the future.

【Objective】

- In Jamaica, to contribute to the policy proposal for marine plastic litter prevention measures with focus on the Kingston Bay through the creation of a policy tool for integrated marine litter prevention (causal linkages between solid waste management on land and leakage of plastic waste into the Kingston Bay)

2. Activities on Plastic and Solid Waste Linkage

2-1 Survey on gully and maps

- Estimation of linkage between solid waste management (SWM) at land and leakage of plastic waste into the Kingston Bay

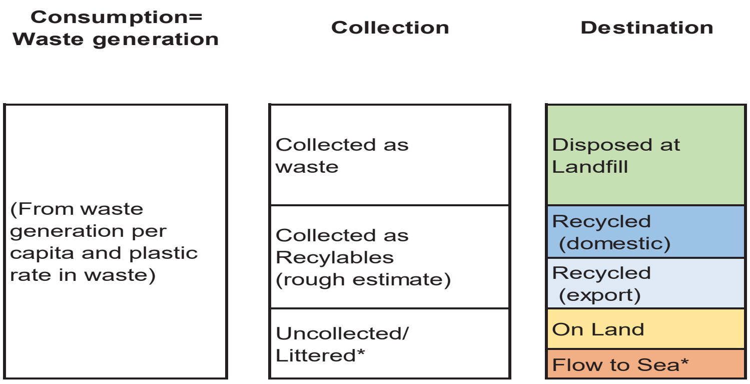
  Measure the amount of waste litter in some gullies within the budget and estimate the annual per capita plastic discharge amount to be used for the plastic material flow. This activity is combined with the Public opinion survey on littering in the area where the measurement is conducted.
- Showing littering background info by GIS maps

  GIS maps with community border show information such as waste amount and waste collection service intensity

2. Activities on Plastic and Solid Waste Linkage

2-2 Plastic Material Flow

➢ Plastic Material Flow in the Kingston Metropolitan Area



* From measurement

(Note) Focus on single-use plastic (excluding bulky waste)

2. Activities on Plastic and Solid Waste Linkage

【Note】

Although we do our best, as existing and reliable data is limited, result of these activities are trial base information.

→

Quantification is estimation basis and subject to change by updated data/information.

3. Knowledge Transfer for Plastic Policy Development

2-3 Support for Policy Proposal

Provide support for the development of a policy proposal by MEGJC and NEPA through transfer of knowledge and experience of JICA Advisory Team.

【Background Situation】

- Existing plastic regulation is enforced by 2 Orders on ban of plastic bag, packaging and drinking straws.
- Intergovernmental negotiating committee (INC) developing an international instrument on plastic pollution is scheduled from November 2022 till December 2024 (From OEWG in June, 2022)

3. Knowledge Transfer for Plastic Policy Development

【Background Movement】

- Legal regulation is enforced by 2 Orders on plastic bag, packaging and drinking straws
- Intergovernmental negotiating committee (INC) developing an international instrument on plastic pollution, including in the marine environment, is scheduled from November 2022 till December 2024 (From OEWG in June, 2022).

3. Knowledge Transfer for Plastic Policy Development

【Present topic】
- Regulation on single-use plastic product
  - ✓ Regulation in Caribbean Island countries
  - ✓ Regulation on microbeads (ban in developed countries)
- Deposit-Refund Scheme
  - ✓Plastic bottle refund in Caribbean Island countries
  - ✓Example of legislation on Deposit-Refund Scheme

Thank you!

Will keep in touch!

Contact:

Taisuke Watanabe (Mr.)

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No.2 Knowledge Brief for Jamaica

Technical Cooperation Project on

Advisor for Marine Plastic Litter Management in the Caribbean Region

- Knowledge Brief for Jamaica –

Regulation on Single-Use Plastics and Plastic Bottle Refund

Aug. 22, 2022

Taisuke Watanabe

JICA Advisory Team

EX Research Institute Ltd.

NIPPON KOEI

Contents

Knowledge and Implications on:

1. Regulation on Single-Use Plastics
2. Plastic Bottle Refund

1. Regulation on Single-Use Plastics

【Background】

- There are data on plastic composition in the recovered waste at the beach clean-up, while no statistics on manufacturing nor retail of plastic product
- There are 2 existing regulations, targeting on plastic bags (with specific dimension), polystyrene foam and plastic drinking straws.

【Type pf single-use plastic】

- Bottles, caps & lids
- Containers
- Packaging materials
- Bags
- Straws and cutlery
- Others such as sanitary items

1. Regulation on Single-Use Plastics

【Issues to be considered】

- Easier enforcement/compliance
  - ✓ Consultation with importer/manufacturer/retailer
  - ✓ Lessons from introduction of present regulation
- Alternatives
  - ✓ Cost of alternatives
  - ✓ Support by tax benefits
- Exemptions
  - ✓ Bio-degradable not easy to handle
- Awareness raising
  - ✓ Education/training and promotional activities with private sector
  - ✓ Can be combined with Deposit-Refund Scheme

1. Regulation on Single-Use Plastics

【Context in Jamaica】

- Enforcement by limited manpower
  - ✓ Good compliance by private sector
  - ✓ Good consultations (formal and informal) - consensus making
  - ✓ Involving government agencies ex. custom on import
- Simple method
  - ✓ Avoid complexity
- Schedule
  - ✓ Phased enforcement

1. Regulation on Single-Use Plastics

【Reference: Examples of regulation in Caribbean Islands】

Country	Target Single-Use Plastic (Ban)
Antigua and Barbuda	- shopping plastic bags and styrofoam
Bahamas	- plastic bags, plastic straws, plastic utensils, styrofoam cups and food containers - Permit on release any number of balloons
Barbados	- plastic containers and single-use plastic cutlery
Grenada	- styrofoam food service containers, plastic bags, plastic food service products and utensils
Haiti	- black plastic polyethylene bags and polystyrene foam containers
St. Lucia	- styrofoam and plastic food service containers

1. Regulation on Single-Use Plastics

【Reference: Example of regulation on microbeads】
- ➢ Major cosmetics company replaced plastic with alternatives
  - ✓ Ex. Plastic from bio-organics or minerals
- ➢ Many industrialized countries ban
  - ✓ Ex. UK, USA, Canada and European countries
- ➢ Target product in regulation
  - ✓ Ex. Cosmetics, rinse-off product or toiletries

2. Plastic Bottle Refund

【Background】
- ➢ Recycling Partners of Jamaica (RPJ)
  - ✓ RPJ, non-profit organization collect PET and HDPE bottles from drop-off point, then compress & bale and export it. Also build and support national awareness of the need to recycle.
- ➢ Deposit Refund Scheme (DRS)
  - ✓ RPJ with partners and government support, launched the DRS, which is voluntary plastic bottle collection and consumers (at present big consumer) get refund by bringing plastic bottles.

2. Plastic Bottle Refund

【For expansion of DRS (Short term)】

- Finance
  - ✓ Financing to the scheme rely on the contribution from private sector and revenue by export. Need a plan for financing the program expansion.
- Constraint by processing capacity
  - ✓ RPJ plans to set up new baling and depo facility. That needs land and investment.
- Quantification
  - ✓ Quantification such as getting production data from manufacturer/bottler is important to clarify the achievement.

2. Plastic Bottle Refund

【For expansion of DRS (Short term)】

- Awareness raising
  - ✓ More activities including schools will be needed, as consumers brings plastic bottles to drop-off point by themselves.
  - ✓ If a retail company offers promotional tools (ex. vouchers) to the consumer who bring bottles, it can work well.
- Expansion of the partnership
  - ✓ More partnership companies.
- Expansion of the plastic collection by NSWMA
  - ✓ NSWMA have plastic bottle collection program in limited number of community.

2. Plastic Bottle Refund

【For expansion of DRS (long term)】

- ➢ Finance
  - ✓ Expansion of contribution is necessary.
  - ✓ Example: specific allocation to related companies, finance from the government
- ➢ Deposit
  - ✓ Institutionalizing the deposit system.

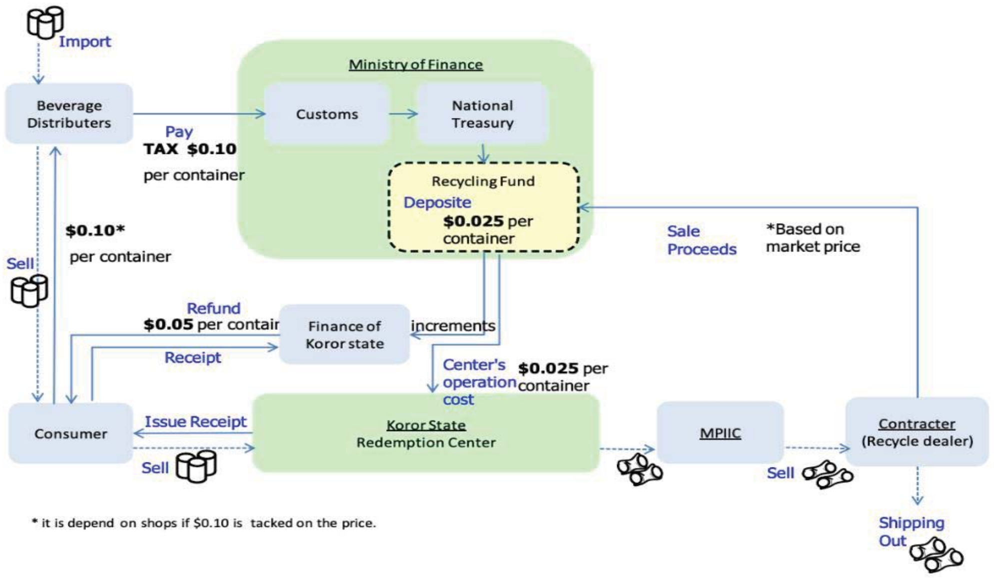
2. Plastic Bottle Refund

【Reference: Examples of plastic bottle refund in Caribbean Islands】

Country	Refund value per PET bottle (USD)
Antigua and Barbuda	【project base】 - 0.74 cent
Barbados	【legislation】The Returnable Containers Act (RCA) of 1986 - 5 cent
Trinidad and Tobago	【project base】 - 0.75 cent

2. Plastic Bottle Refund

【Reference: Examples of mandatory Deposit-Refund in Palau】



I will provide detailed reference later.

Please inform me if any interested point.

Thank you!

Contact: Taisuke Watanabe (Mr.)

t-watanabe@exri.co.jp

No. 3 Knowledge Workshop for Jamaica

Technical Cooperation Project on

Advisor for Marine Plastic Litter Management in the Caribbean Region

- Knowledge Workshop for Jamaica –

Discussion on Legislation of the Deposit Refund Scheme (DRS)

Oct. 10, 2022

Taisuke Watanabe

JICA Advisory Team

Contents

Setting the Scene

Assuming:

1. Need draft DRS legislation
2. Target: plastic bottle

Today:

Presenting basic points and options for legislation

1. Approach to the Legislation

【Strategy】

- ➢ Mandatory Scheme
  - ✓ Normally legislation is needed to make action with compelling force.
  - ✓ Strong approach to show requirements.
- ➢ Voluntary Scheme
  - ✓ Promoting action by legislation.
  - ✓ Easier for building consensus.
  - ✓ Can be positioned as the temporary step towards the mandatory.

1. Approach to the Legislation

【Preparation】

- Mandatory Scheme
  - ✓ Needs feasibility study to design goods/monetary flow and financial balance. Then design institutional mechanism.
  - ✓ Market sounding is important to design and clarify who shall do what and how.
  - ✓ Especially financing estimation is critical for sustainability of the system.
  - ✓ Normally DRS specific fund/organization is needed to manage the system.

1. Approach to the Legislation

【Preparation】

- Voluntary Scheme
  - ✓ Get more contributor/conrtibution to expand the scheme.
  - ✓ Clarify effective promotional/awareness raising measures
  - ✓ Discuss government support (ex. financing, property).

1. Approach to the Legislation

【Preparation】

- Both
  - ✓ As the scheme is already started, it is important to clarify what can be done through the dialogue with individual stakeholder.
  - ✓ Dialogue is important also for building justification and consensus.
  - ✓ Designing the requirements/request/call not to cause strong objection.

1. Approach to the Legislation

【Support for decision-making】

- Consensus
  - ✓ Discussion with major stakeholders including media.
  - ✓ Discussion among concerned politicians.
  - ✓ What to be presented to stakeholders.

2. What to be legislated (Mandatory case)

【Basic options-1】
- ➢ Both deposit and refund mandatory
  - ✓ Needs much work towards consensus
- ➢ Only Refund mandatory
  - ✓ Needs contributor (sponsor) to finance.

【Basic options-2】
- ➢ Principles only, details by Government order/regulation
  - ✓ Tough to manage.
- ➢ Including who should do what
  - ✓ Need consensus

2. What to be legislated (Mandatory case)

【General】
- ➢ From Key points in “Container Deposit Schemes in the Pacific Islands”

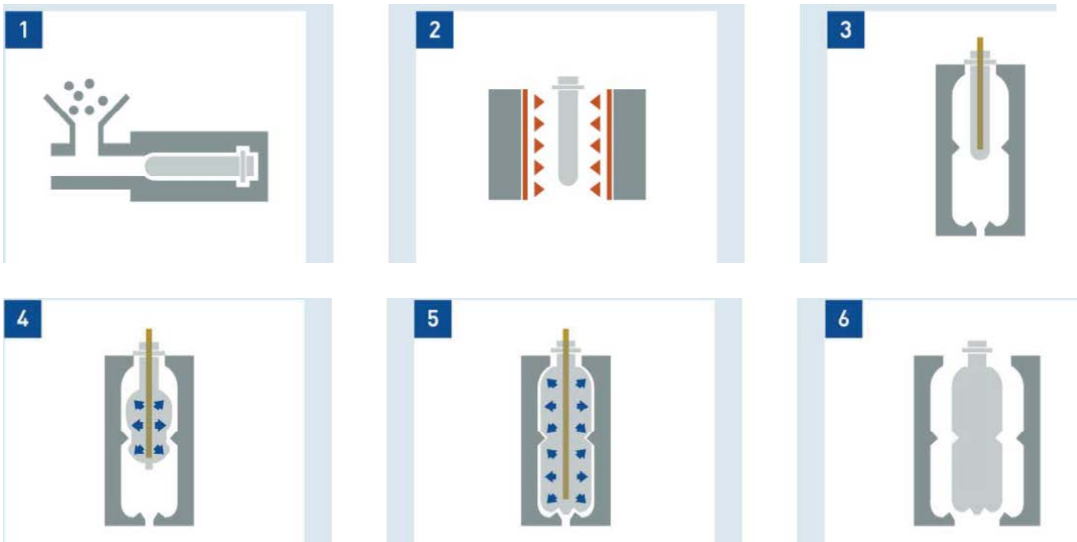
1. Deciding the target products and estimating waste generation
2. End of use products management and material recycle facilities
3. Mapping the collection/redemption points
4. Assessing who can operate the system
5. Estimating the running costs
6. Determining the refunds and deposits
7. Setting up the Fund management system

2. What to be legislated (Mandatory case)

【Control of finance】

- Deposit
  - ✓ Study how the bottles are produced/imported (ex. locally produced from the imported resin by bottling company) and retailed, which leads to the identification of importer/producer/retailer and volume by bottle type.
  - ✓ When charge: Import, Manufacture and/or Retail

2. What to be legislated (Mandatory case)



https://www.t-petco.co.jp/column/post-125/

2. What to be legislated (Mandatory case)

【Control of finance】

- Refund
  - ✓ Much depends on the plan of collection points and redemption centres.
  - ✓ Involving retailers for collection?
- Costs other that refund
  - ✓ Cost estimation is important.
- Fund management
  - ✓ Transparency (ex. reporting) is important.

3. What to be legislated (Voluntary case)

【Policy tools】

- Government to set:
  - ✓ Policy/key principle
  - ✓ Support/facilitation program

【Role of stakeholder】

- Define role (not responsibility):
  - ✓ Importer/manufacturer
  - ✓ Retailer
  - ✓ Consumer
  - ✓ Waste handler/recycler

3. What to be legislated (Voluntary case)

【Requesting action】

- promote, encourage, expect
  - ✓ Ex. Manufactures shall endeavour to do A .
  - ✓ Ex. Manufactures are encouraged to do B.
  - ✓ Ex. It is expected that manufactures make effort to do C

3. Reference

Case	Reference
Key points for legislation of mandatory case	- Container Deposit Schemes in the Pacific Islands, SPREP*1 - Legislative Guide for the Regulation of Single-Use Plastic Products, UNEP
Country legislation cases	- "Major provisions for legislation cases"
Legislation	- 【Barbados】The Returnable Containers Act (RCA) of 1986 - 【Palau】RPPL 7-24 2006 on Recycling Program

*1https://www.sprep.org/sites/default/files/documents/publications/%E5%88%A5%E6%B7%BB%EF%BC%91%E3%80%80Final%20Copy%20CDS%20Guide.pdf

*2https://www.unep.org/resources/toolkits-manuals-and-guides/tackling-plastic-pollution-legislative-guide-regulation

Reference (legislation document) files are sent by e-mail later

I will e-mail document files on legislation cases and reference material .

Please inform me if any interested point.

Thank you!

Contact: Taisuke Watanabe (Mr.)

t-watanabe@exri.co.jp

Questions.

What is the Minister's concern?

What preparation works are already done?

No.4 Regulation on Single-Use Plastics (Knowledge Workshop for Jamaica)

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Knowledge Workshop for Jamaica –

Regulation on Single-Use Plastics

Oct. 20, 2022

Taisuke Watanabe

JICA Advisory Team

EX Research Institute Ltd.

Environmental and Regional Planning, Research and Consulting

NIPPON KOEI

Premise

1. Today, legal provisions on ban of single-use plastics in Caribbean island countries are introduced, and targets and exemptions are focused.

2. Regarding products subject to the ban, examples of the product terminology are shown but what to the target is not discussed.

3. For bio-degradable, matters to be considered will be indicated.

Contents

How interpret regulation

- ➢It is important to prepare the interpretation on the provisions of the new/revised regulation.
- ✓Organizing the interpretation on the provisions of the present regulation, such as the amount of commercial quantity.
- ✓Organizing the detail and reason of exemption cases on the present regulation, such as “public health” purpose or Minister approval case.
- ✓Organizing the detail and reason of the illegal cases.

Utilizing existing practice

- ➢You can compare the candidate product and existing regulated product.
- ➢You may solve the issues in the existing regulation.

Getting information for justification

- ➢You can collect information from the stakeholders.
- ✓Alternative (availability and cost) information from manufacturers
- ✓Plastic bag size/thickness demand (who need why) from retailers
- ✓You can question on the needs on the exemption, which specific stakeholder has this needs

Lessons from Antigua and Barbuda

- Four lessons:
  1. The Phased Implementation of the Ban
  2. The Clarity of the Message
  3. Active and Continued dialogue
  4. The Support of Government
- List of approved alternatives: Bagasse (sugarcane), PLA Cornstarch (Non–GMO) , Bamboo, Wheat Straw, Cardboard/Paper, Areca Palm, Potato Starch

Source: UNEP (2019) Report on the status of styrofoam & plastic bags in the wider Caribbean region

Target Item in Antigua and Barbuda

- shopping plastic bags
- styrofoam food service containers: clamshell & hinge containers, hotdog containers, bowls, plates, hot & cold beverages cups, lids and caps
- utensils: plastic spoons, forks, knives, and straws
- fruit trays, meat trays & vegetable trays
- egg cartons
- naked styrofoam coolers

How to prescribe the product - Countries covered

- Antigua & Barbuda
- Grenada
- Saint Lucia
- The Bahamas
- Barbados
- Jamaica
- Trinidad & Tobago
- St Vincent & the Grenadines

Targeted Plastic Products

Countries	Products
Antigua & Barbuda	shopping plastic bags, styrofoam food service containers, utensils, trays, egg cartons, naked styrofoam coolers
Grenada	non-biodegradable/single use plastic bags, food containers, food product
Saint Lucia	disposable styrofoam or plastic food service containers
The Bahamas	single use plastic food ware; non-biodegradable, oxo-biodegradable, or biodegradable single use plastic bags
Barbados	single-use plastic containers & cutlery; petro-based plastic bags
Jamaica	single use plastic
Trinidad & Tobago	polystyrene foam products
St Vincent & the Grenadines	disposable plastic shopping bags, plastic food containers

Targeted Plastic Products
Plastic bags

Application	Material	Type
・ Shopping (AG)(VC)	・non-biodegradable (GD) ・non-biodegradable, oxo-biodegradable, or biodegradable (BS) ・ petro-based (BB) ・ made wholly or in part of polyethylene or polypropylen (JM)	・disposable (VC) ・single-use (GD)(BS)(JM)

Note: JM sets out applicable dimensions.

Each country code is described as below:
Antigua and Barbuda, AG; Grenada, GD; Saint Lucia, LC;
The Bahamas, BS; Barbados, BB; Jamaica, JM; Trinidad and Tobago, TT;
St Vincent and the Grenadines, VC
(Source: ISO 3166 - Codes for the representation of names of countries)

Targeted Plastic Products
Plastic containers/Packaging

Application	Material	Type
・ product (GD)(TT) ・ food product (GD) ・ food service products ・ food containers (GD)(VC) ・ food service containers (AG)(LC) ・ food ware (BS) ・ containers(BB) ・ packaging (JM)	・styrofoam(AG)(LC) ・non-biodegradable (GD) ・expanded polystyrene (GD) ・ polystyrene (BS) ・ polystyrene & other similar polystyrene (BS) ・ made wholly or in part of expanded polystyrene foam (JM) ・polystyrene foam (TT)	・single-use (GD)(BS)(BB)(JM) ・disposable (LC)(VC)

Note: One country uses multiple words for one subject.

Targeted Plastic Products Utensils

Application	Material	Type
・utensils (see below) (AG) ・product (GD) ・cutlery (GD)(BB) ・ individual item (see below) (LC) (BS) ・ drinking straws (JM)	・non-biodegradable (GD) ・made wholly or in part of polyethylene or polypropylene (JM)	・disposable (LC) (VC) ・single-use (GD) (BS)(BB) (JM)

Note: GD: fork, spoon, spork or knife
LC : fork, spoon, knife, straw & stirrer
AG & BS : fork, spoon, knife & straw

Provisions on the Exemption Plastic bags

- Common subjects/categories:

✓Food: solely to contain/wrap fresh fish.. (AG), used for perishables/preservation of food (LC)(BB); solely to contain wholly/partly unwrapped food… (BS); solely to contain uncooked fish..(BS); used for certain purpose.. incl. fresh fish..(VC)

✓Waste : use in waste storage and disposal (AG); designed for, packaged & retailed specifically for the disposal of waste (LC)(BB); used solely for the disposal of waste (BS); used for certain purposes incl. …garbage bags (VC)

✓Materials: biodegradable (LC); biodegradable materials & others (VC); compostable (BS); composed primarily of thermoplastic synthetic polymeric materials, which is provided by a food business to a customer at the point of sale and incidental to the purchase of other goods (LC)

Provisions on the Exemption Plastic containers/Packaging (1/2)

- Common subjects/categories :

✓Food/beverage: meat trays & vegetable trays (GD); beverage container referred to in a law relating to the management of containers (LC); a tray made of PS used for the packaging of fresh meat (BB); packaging used by wholesalers and retailers to distribute raw meat… (JM)

✓Medicals : container or item for pharmaceutical dispensing or other medical use(LC)(BB); imported/distributed by the Ministry responsible …for use in the practice of medicine or dentistry, in veterinary practice, or in any other medical field (JM)

Provisions on the Exemption Plastic containers/Packaging (2/2)

- Common subjects/categories :
  - ✓Sealed condition:
    - ➢ food that was packaged and sealed in or with… food service container prior to receipt by a person. (LC)
    - ➢ ware that is an integral part of the packaging in which food or drink is sealed prior to its delivery to a point of sale. (BS)

Provisions on the Exemption Utensil

- Straw's criteria:
  - ✓a plastic straw attached to a small tetra pack box. (LC) (BB)
  - ✓drinking straws for use by persons with disabilities by the recognized body… (JM)

Provisions on the Exemption for All or only bags

- Expressing the Minister
  - ✓ The Minister may designate as exempted any other shopping plastic bag from the prohibition. (AG)
  - ✓ The Minister may by Order authorize ….product if he or she satisfied that sale of the product is in the public interest. (GD)
  - ✓Any other bag that the Minister may by Order exempt. (BS)
  - ✓The Oder does not apply to single use plastics manufactured or used with the approval of the Minister. (JM)

How to treat biodegradable plastics

Points to consider

- There is no common clear definition of biodegradability, while there are many expressions such as bio-based, oxo- and compostable. "Biodegradable" need clear definition if it is used for exemption.
- Can customs determine whether the plastic is biodegradable or not (ex. would labels/logos alone be sufficient to make an appropriate decision)?

How to treat biodegradable plastics

Points to consider

- Draft Jamaican Standard "Specification for Oxo-biodegradable plastic" (DJS 355: 202X) provides the standard on the criteria and the testing method on , while there are variety conditions in the environment. Therefore, there may be concerns about biodegradability in actual environment.

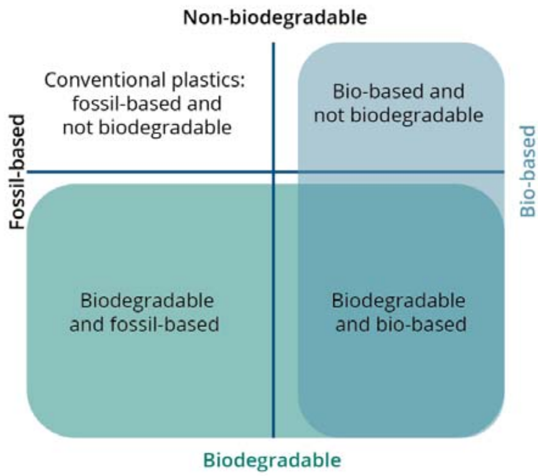
Overview of types of plastics (1/2)

Biodegradable plastics

- Designed to biodegrade in a specific medium (water, soil, compost) under certain conditions and in varying periods of time. Plastic may be degradable, but not biodegradable – for example, if it is degraded by light.

Bio-based plastics

- Fully or partly made from biological raw materials as opposed to the fossil raw material (oil) used in conventional plastics.
- They are often, but not always fully biodegradable depending on additives and composition.



Source: ETC/WMGE and EEA. (EEA, 2020)

Overview of types of plastics (2/2)

Compostable plastics

- **Industrially compostable plastics:** designed to biodegrade in the conditions of an industrial composting plant or an industrial anaerobic digestion plant with a subsequent composting step.
- **Home compostable plastics:** designed to biodegrade in the conditions of a well-managed home composter at lower temperatures than in industrial composting plants. Most of them also biodegrade in industrial composting plants.

Oxo-degradable plastics

- Include additives that, through oxidation, lead to their fragmentation into microplastics or chemical decomposition.

Non-biodegradable plastics

- Last for long periods of time. They can disintegrate into smaller pieces, forming microplastics, and accumulate in the environment.

(EEA, 2020)

Testing method provided in DJS 355

Scope

Tier 1

- Abiotic degradation

Tier 2

- Biotic degradation

Tier 3

- Plant eco-toxicity test
  (Plant germination and growth)

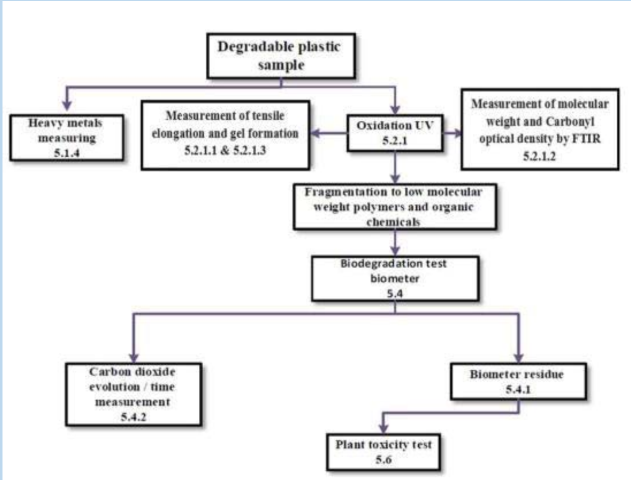


Figure Guide for Tests

Reference: Size & thickness of plastic bag

- Several countries have regulation by size/thickness in the ban of plastic bag. (See reference document file)
- There is no common/typical size or thickness.
- It seems important to discuss the needs of plastic bag with stakeholders.

Reference docs sent

- Plastic regulation (ban) in Caribbean island countries
- Reference documents on biodegradable plastic
- Examples on Size & thickness of plastic bag ban

What is your interest for the next briefing session?

Ex. Preparation towards the coming INC?, Enforcement of ban?

Thank you!

Contact: Taisuke Watanabe (Mr.)

t-watanabe@exri.co.jp

No.5 Preparation for the 1st INC on Plastic Pollution Convention

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Preparation for the 1st INC on Plastic Pollution Convention –

Nov. 20, 2022

Taisuke Watanabe
JICA Advisory Team

Today's outline

- What to be discussed?
- What is prepared for discussion by Secretariat?
- Discussion points
- What Jamaica wants in the treaty?
- How Jamaica enlarge its voice

What to be discussed?

AGENDA

- Opening of the meeting
- Election of officers: It is expected that the INC will elect its officers (1 chair, 9 vice-chairs, 1 rapporteur, etc.) at the beginning of the session. ...the committee may wish to consider the election of 2 officers from each of the 5 UN regions and a representative from the small island developing States, who will collectively constitute the bureau
- Organizational matters
- Preparation of an international legally binding instrument on plastic pollution, including in the marine environment
- Other matters

What is prepared for discussion by Secretariat? (1/5)

DOCUMENTS (See "Reference Outline of meeting documents")

- Provisional agenda/Annotated provisional agenda
- Scenario note for the 1st session of the INC to develop an international legally binding instrument on plastic pollution, including in the marine environment (the underline is hereafter called the instrument)
- Draft rules of procedure for the work of the INC to develop the instrument
- Broad options for the structure of the instrument
  - ✓ Specific convention model (treaty with specific annexes)
    - ➢ Establishing a comprehensive instrument with control measures either in the main body or in annexes of varying detail
    - ➢ Annexes can have different scopes and varying levels of detail.
    - ➢ The most frequently used form of multilateral environmental agreement

What is prepared for discussion by Secretariat? (2/5)

- Broad options for the structure of the instrument
  - ✓ Framework convention model
    - ➢ Allowing key details to be placed in legally distinct protocols
    - ➢ Allowing and problems to be addressed in an incremental manner
    - ➢ The success of framework conventions depends on the continued willingness of parties to the main convention to also adopt subsequent protocols.
    - ➢ Protocols are generally only open for adoption by parties to the main convention and usually contain provisions indicating that the protocol may not contradict the control measures or other provisions set out in the main convention.
    - ➢ Parties to specific conventions may also adopt protocols.
    - ➢ There are several examples of multilateral environmental agreements using the framework convention model.

What is prepared for discussion by Secretariat? (3/5)

- Potential elements including key concept, procedures and mechanisms of legally binding multilateral agreements that may be relevant to furthering implementation and compliance under the future instrument
  - ✓ Preliminary Questions
    - ➢ What key terms and concepts need to be defined in the instrument?
    - ➢ What objective will be set out in the instrument?
    - ➢ Which types of substances, materials, products and behaviours will be covered by the instrument?
    - ➢ What core obligations will parties have under the instrument?
    - ➢ What forms of technical and scientific cooperation and coordination are envisaged under the instrument? What other forms of cooperation and coordination may be considered?
    - ➢ Will the instrument establish or designate a financial mechanism?

What is prepared for discussion by Secretariat? (4/5)

- Glossary of key terms
- Plastics science
- Description of standard articles on final provisions that are typically included in multilateral environmental agreements
- Overview of existing funding currently available for addressing plastic pollution through international funding arrangements

What is prepared for discussion by Secretariat? (5/5)

- Overview of information to promote cooperation and coordination with relevant regional and international conventions, instruments, and organizations
- Priorities, needs, challenges and barriers relating to ending plastic pollution at the national level
- Overview of stakeholder engagement frameworks under other instruments and of potential approaches for the instrument
- Existing information that might assist policymaker

(Meeting documents are uploaded:

https://www.unep.org/events/conference/inter-governmental-negotiating-committee-meeting-inc-1)

Discussion points
Example of Minamata Convention (1/2)

- Common but Differentiated Responsibilities

  "Differentiated between developed and developing countries"

  vs. "Differentiation based on the specific circumstances of countries and reflect today's socio-economic realities"
- Differentiation and Flexibility

  ✓Time-limited exemptions

  ✓Different measures for different existing source categories

  ✓Taking measures to control releases by only parties that identified relevant point sources

Discussion points
Example of Minamata Convention (2/2)

- Supply and Trade

  ✓Whether some sources of mercury supply should be prohibited.

  ✓How trade should be limited.
- Products

  Positive list (a list of those product that were banned) vs.

  Negative list (a general ban with exemption) vs. Hybrid approach (some sort of compromised between the two)
- Finance

  The model of Montreal Protocol's multilateral fund vs. GEF

What Jamaica wants in the treaty (example of country request)

Example of Country Requests (See "Reference_Country requests")

- Costa Rica
  - ✓Comprehensive approach: full lifecycle of plastic, circular economy
  - ✓Financial mechanism：the creation of a specific fund for technical assistance
  - ✓National action plans: the objectives of the instruments, international cooperation and financial support for its implementation
  - ✓Others: broad stakeholder involvement, plastic substitution, labeling for correct disposal, EPR, regional/subregional approach
- Indonesia
  - ✓Definition: development definitions about "legally binding instrument", "plastic pollution", "full life-cycle plastic"
  - ✓Standardized tools/instruments: development of parameters, pollution standard index, sampling procedure, laboratory test, etc.

What Jamaica wants in the treaty (example of country request)

  - ✓Others: Identifying the needs of member states for capacity/technology/finance
- Sri Lanka
  - ✓Global, regional and national action plans with feasible time targets including
    - ■ Development: <u>technical/financial mechanism</u> for cleaning/rehabilitation of plastic contaminates sites; <u>green jobs/economy</u> in the field of plastic management; <u>a mechanism to trace/control illegal plastic waste</u> exportation, dumping and transportation/floating through sea water currents
    - ■ Production/usage control of highly hazardous plastics
    - ■ Mandatory data on material flow analysis and life cycle assessments of plastics
    - ■ Promotion: plastics <u>alternatives</u>; <u>collaborative research</u> related to plastic pollution/management

What Jamaica wants in the treaty (example)

◆What kind of article Jamaica wants to put in the draft convention?

For example;

- Assert the clarification of responsibility of stakeholders, ex. upstream stakeholders?
- Request finance, investment and technical support by international, bilateral and private sector communities by requesting to estimate cost to establish plastic circular system?
- In Climate Change COP 27, new 'Loss and Damage" funding for vulnerable countries agreed.

How Jamaica enlarge its voice? (example)

Through Bureau of the INC

- It is expected that the intergovernmental negotiating committee will elect its officers, including a chair, nine vice-chairs and a rapporteur, at the beginning of the session. To ensure adequate regional representation, and consistent with the proposed draft rules of procedure, the committee may wish to consider the election of two officers from each of the five United Nations regions and a representative from the small island developing States, who will collectively constitute the bureau.
- At the Open Ended Working Group meet to prepare for the INC in May, Ms. Asha Challenger (Antigua and Barbuda) was one of the Vice Chair.

How Jamaica enlarge its voice? (example)

Through Alliance

(Example of group of countries on plastic) (See "Reference_Example of Alliance")

- High Ambition Coalition To End Plastic Pollution
  - ✓Launched in Aug. 2022
  - ✓Members: 20 countries including Costa Rica, Dominican Republic
  - ✓Arguments: developing a legally binding instrument based on a comprehensive and circular approach; advocating for a treaty which includes global standards, bans, and restrictions on plastic
- Ocean Day Plastic Pollution Declaration (Alliance of Small Island States (AOSIS))
  - ✓Launched in Jun. 2021 to adopt a mandate for an INC at UNEA 5.2
  - ✓Members: 39 countries (16 for Caribbean; 15 for Pacific; 8 for African, Indian Ocean and South China Sea (AIS)) including Jamaica, Dominican Republic
  - ✓Argument: developing a legally binding global agreement on plastic pollution

How Jamaica enlarge its voice? (example)

- Does Jamaica work to form Alliance?
- Do you know the country contacts of Caribbean countries?
- Do Caribbean countries hold a meeting on plastic convention?

Next briefing

What is the topic for the next session?

Ex.

- Review of First INC (depends on when the meeting report is uploaded)?
- Review of the 2 consultants work on plastics (depends on the schedule of the work of the selected consultant)?

Timing

After the INC (till December 2), will people take a leave?

Mid of January?

Thank you!

Contact: Taisuke Watanabe (Mr.)

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No.6 Plastic Material Flow and etc.

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Plastic Material Flow and etc. –

Jan. 16, 2023

Taisuke Watanabe

JICA Advisory Team

EX Research Institute Ltd.
Environmental and Regional Planning, Research and Consulting

NIPPON KOEI

1. Plastic Material Flow in Jamaica

Objective and usage (to be discussed)

- To understand the rough plastic volume in Jamaica
- To provide information to stakeholders

Output

Kingston Metropolitan Area Level (not including import/export and manufacturing) and National level

- PPT
- Report (in more detail)

1. Plastic Material Flow in Jamaica

Stages and covered plastics

- Import: Plastic only product, not include the items which contains plastic partly (from UN database)
- Manufacturing: Mainly plastic bottles and some single-use plastics (from interview)
- Plastic waste: Household plastic waste, not include institutional, commercial and industrial) (Uncollected plastic waste is calculated by Plastic portion in Generated household waste – collected plastic waste
- Recycled plastic: Mainly plastic bottles (from interview)
- Export : same category as import (from UN database)
- Potential plastic leakage: (uncollected plastic waste – recycled plastic is assumed to be leaked to ocean finally)

1. Plastic Material Flow in Jamaica

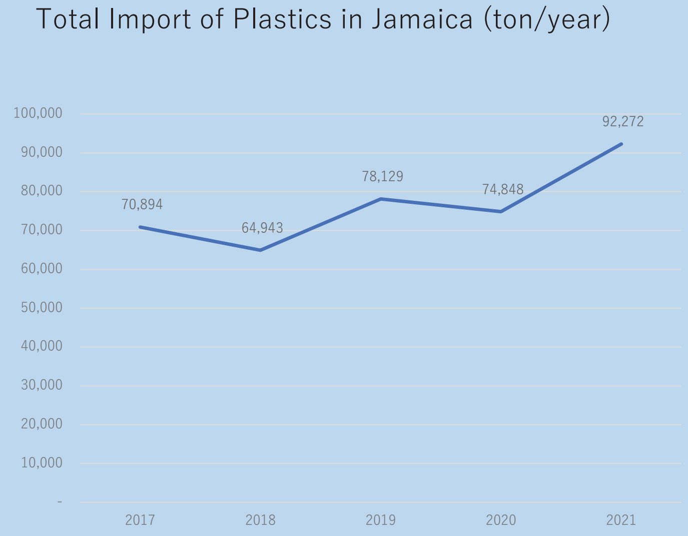
Note

- Not all quantities of plastics are addressed and covered plastics are different depending on the stage.
- So cannot compare each stage figure, because the ground and covered plastic are different in each stage.
- Figures are rough estimates as there are no statistical data available except for data on Imports and Exports.

1-1Plastic Material Flow - Import

Import figure

- Plastic products categorized under HS codes of Chapter 39 are covered.



1-1Plastic Material Flow - Import

Major Plastic Import Category (percentage is in 2021)

HS Code	Descrition	%
3915	Waste, parings and scrap of plastics	51
3925	Plastics for builders' wares	16
3919	Self-adhesive plates, sheets, film, foil ---	10
3902	Polymers of propylene or of other olefins, in primary forms	10

1-2 Plastic Material Flow - Manufacturing

- It is under survey.
- Interviews with 6-7 manufacturers (plastic product manufacturers and beverage company)
- Try to obtain Manufacturing volume per year by type of product

1-3 Plastic Material Flow - Waste

- Waste generation data and waste characterization study by DBJ
- Waste collection amount from NSWMA Annual Report
- Plastic waste generation: Household plastic waste, not include institutional, commercial and industrial. Per capita generation x population x Plastic portion (%) = Plastic waste generation
- Uncollected plastic waste: It is calculated by Plastic waste generation – collected plastic waste

1-3 Plastic Material Flow - Waste

Note

- Solid waste collection rate (collected amount / generation amount) is not high (59%).
- This leads to large amount of uncollected solid waste and uncollected plastic waste (75,000 ton/year).

1-4 Plastic Material Flow - Recycling

- It is under survey.
- Interviews with 5 recyclers (including Recycling Partners of Jamaica)
- Try to obtain Recycled plastic volume per year

1-5 Plastic Material Flow - Export

Method is same as import.

- The percentage of the amount of Import deducted by the amount of Export is over 95% in the year.
- Most of the imported plastics remain in Jamaica.

1-6 Plastic Material Flow - Leakage

- Uncollected plastic waste – recycled plastic = Potential plastic leakage
- (If it is assumed that littered plastic finally reach to ocean as there is not big flat area.) Potential plastic leakage = Potentia plastic leakage to the Ocean

1-7 Plastic Material Flow - KMA

Result in KMA will be also presented.

- Plastic waste
- Potential leakage (recycled amount is prorated by population)

1-8 Plastic Material Flow - Discussion

- How to explain findings on Plastic Material Flow.

Q1: What objective do you want in making plastic material flow?

Q2: Do we show figures in one table/figures, while meanings of figure in stage are different?

Q3: Do we show the plastic leakage amount, while the figure is with much uncertainty.

Q4: Do we explain the result to the Ministry of Local Government and Rural Development? Do we explain the result to other stakeholders such as Grace&Kennedy Foundation?

Q5: Does MEGJC or NEPA makes the result to open to public?

2 Other output from Pilot Project

GIS maps in KMA, for example:

- Waste generation by Enumeration district
- Location of waste stockpiles

Utilization of GIS maps will be discussed with NSWMA.

3 Arrangement request

I'll appreciate your meeting arrangements during my stay in Jamaica, that is Jan. 27 to Feb. 14.

- Honourable Minister Samuda
- Cement company
- (Ministry of Local Government and Rural Development)

We directly contact with other institutions such as Grace&Kennedy Foundation.

4 Progress on preparation of regulation

- 2 NEPA procurement of consultancy services
- Discussion on target single-use plastics
- Present time frame for single-use plastic regulation and deposit-refund scheme legislation

5 Next discussion

What is the topic for the next session?

Ex.

- (Depends on progress) Discussion on Work Plan of selected consultant?
- What will be stated when preparing the Statement of Jamaica for the coming INC?
- Example of policy discussion : Discussion on the New Plastic legislation in Japan

Thank you!

Contact: Taisuke Watanabe (Mr.)

t-watanabe@exri.co.jp

No.7
ENACTMENT OF JAPAN'S CONTAINERS AND PACKAGING RECYCLING LAW - PROCESS AND STAKEHOLDERS' COMMENTS

XX 2023

Mr. Taisuke Watanabe

Purpose

- Japan introduced a system which manufacturers share some responsibility for promoting recycling. For introducing the system, it is important to hear comments from stakeholders.
- Understanding a process how Japan's Containers and Packaging Recycling Law was enacted.
  - ✓What is Japan' Containers and Packaging Recycling Law?
  - ✓What process was used to develop the law?
  - ✓What comments did stakeholders express during the process?

Major Gov. Agencies

Ministries/agencies in charge at the time:

- Ministry of Health and Welfare(MHW): in charge of waste management (municipalities actually carried out municipal solid waste management).
- Ministry of International Trade and Industry (MITI): in charge of industries and distributions (excluding food & beverage industries and distributions).
- Environmental Agency (EA): in charge of environmental regulations.
- Ministry of Agriculture, Forestry and Fisheries (MAFF): in charge of food & beverage industries/distributions.

What is the Containers and Packaging Recycling Law?

- The law was developed to recycle product containers and packaging (glass bottles, PET bottles, paper boxes/film bags for snacks, shopping plastic bags, etc.) disposed as waste by ordinary households.
- The law is characterized by shared responsibilities: consumers sort and dispose of waste; municipalities collect the sorted waste; business operators recycle.

What Process was Used to Develop the Law? (1/2)

- Sep. 1993 - Apr. 1994: Organized a committee of academic experts to compare policy options by ministries/agencies. (MHW and EA)
- Sep. 1993 - Oct. 1994: Established an expert committee consisting of academic experts/stakeholders in a council, an organization that makes recommendations to the ministry/agency, and gathered opinions for legislation. (MHW and MITI)
- Mar. 1995 – Apr. 1995: Coordination for the law among ministries/agencies. (MHW, MITI and MAFF)

What Process was Used to Develop the Law? (2/2)

- Apr. 1995 – Jun. 1995: Diet Proceedings
- Dec. 1995- Apr. 2000: Enforcement of the Law with several phases.
  - ✓1st Phase - Basic policy
  - ✓2nd Phase - Municipal Sorted Collection Plan
  - ✓3rd Phase – Targeted items for glass & PET bottles; recycling requirement for large companies
  - ✓4th Phase – Fully enforced with Paper & Plastic containers/wrappings for items; small & medium companies for recycling requirement

Comments from Industry (1/2)

- Japan business federation/Japan association of corporate executives: business operators share recycling responsibilities; municipalities pay for sorted collection services; consumers accept the waste charge.
- Food & beverage manufacturers: no objections to the municipal sorted collection, but to the cost burden on a designated juridical person under the new law.

※ A designated juridical person: who recycles waste containers and packaging that conform to the sorting standards upon entrustment by manufacturers/users. (the article 22 of the law)

Comments from Industry (2/2)

- Packaging and containers manufacturers: supported the new law.
- Plastic industries: proposed that recycling methods should prioritize material and chemical (conversion of plastic waste into oil) over thermal (energy recovery) .
- Can manufacturing industries: did not need the designated juridical person, since steel/aluminum cans were recycled for profit or free of charge.
- Glass bottle industries: no consensus due to conflicting interests (returnable vs. one-way bottles).

Comments from Consumers (Community Groups)

- Dominant opinions were:
  - ✓Ensure transparency in the development process of the new law.
  - ✓Create a system to provide economic incentives.
  - ✓Discuss actively/constructively across ministries to eliminate the vertically divided administrative problems.
  - ✓First, specify the vision of this country for what kind of a material-recycling-based society is expected, and then discuss the enactment of relevant individual laws based on the vision.

Comments from Local Governments (1/2)

- Tokyo Metropolitan Government concerned as below:
  - ✓Sufficiency requiring business operators to recover the waste containers/packaging in the new law content.
  - ✓Extent to increase the burden of the sorted-collection costs paid by municipalities.
  - ✓How well the existing municipal waste sorting capacity fits to the new requirement for the sorted-collection.
  - ✓Quality required for the sorted-collection by municipalities.

Comments from Local Governments (2/2)

  - ✓Volume level which business operators must accept separately collected waste containers/packaging from municipalities.
  - ✓TMG believes that returnable bottles are still the benchmark, despite the increase in disposable bottles.
- Funabashi City expected as below:
  - ✓Enactment of the new law as soon as possible.
  - ✓Resolution of "reverse charge", which recyclables became chargeable.

Comments from Ministries (MHW & MITI vs. MAFF) (1/3)

- Targeted Items

MHW & MITI : Assign to only manufacturers/sellers (including importers) of contents of the containers/packaging.

MAFF: Assign to manufacturers/sellers (including importers) of the contents as well as outer packaging (materials and containers).

Comments from Ministries (MHW & MITI vs. MAFF) (2/3)

- Responsibilities

MHW & MITI : Municipalities collect while business operators recycle.

MAFF: Municipalities are responsible for sorted collection and recycle (sale to end users), while business operators pay some or all of the costs. It proposed to introduce a product surcharge (establishing a new tax on waste containers/packaging and using the revenue for the recycling).

Comments from Ministries (MHW & MITI vs. MAFF) (3/3)

- The designated juridical person (the person)

  MHW & MITI : The person carries out the takeover/recycling tasks on behalf of business operators, and the operators pay the expenses.

  MAFF: Since the takeover/recycling is carried out by municipal contractors, the main functions of the person are to collect the burden charge from business operators and to distribute subsidies to recycling companies.

No.8 Supporting Plastic Policy Development in Jamaica

Technical Cooperation Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

- Supporting Plastic Policy Development in Jamaica –

Feb.14, 2023
Taisuke Watanabe
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JICA Advisory Team

EX Research Institute Ltd.
Environmental and Regional Planning, Research and Consulting

NIPPON KOEI

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Contents

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1. Introduction

➢JICA Technical Cooperation Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Objective	To support to develop capacity of target coutries to response issues toward reducing marine plastic waste
Countries	Jamaica, Antigua & barbuda, Grenada, Guyana, and St. Lucia
Period	From Jan. 2022 to Dec. 2023
Consultant	EX Research Institute and Nippon Koei

➢ In Jamaica, major activities are:
- ✓ Making plastic material flow
- ✓ Discussing knowledge on plastic policy formulation
- ✓ Providing waste background information in Kingston in map

2. Plastic Material Flow

◆Why Plastic Material Flow?

➢ To understand the plastic situation by volume in Jamaica in simple manner (could provide a justification for strengthening plastic policy).

➢Can show the situation from incoming (import) to outflow (recycling and export), then potential leakage.

➢Also it shows the situation of data/information.

◆Problem in Plastic Material Flow in Jamaica!

➢Not all quantities of plastics are addressed and depending on the item, covered plastics are limited.　Also, availability of data is very limited.

➢That resulted in the cannot compare figures in each stage. Because the ground and covered plastic are different in each stage. Also, base year in each stage is different.

2. Plastic Material Flow

Covered/calculated plastic in each stage.

- Import and export: Plastic products categorized under HS codes of Chapter 39 (Plastics and articles thereof) . Plastics included in some products (ex. electric product) are not covered.
- Manufacture: Only available data is number of plastic bottles sold in Jamaica. The weight is calculated from number of bottles x typical weight per bottle.
- Plastic waste generation: Calculated from total waste generation amount x plastic portion in waste. Per capita waste generation amount is used for estimation of total waste generation .
- Uncollected waste: Calculated from plastic waste generation amount X plastic uncollection rate, while used uncollection rate is one of the reported figure.
- Plastic recycled : Only amount of plastic bottle collected.
- Potential plastic leakage: Assuming that (uncollected waste - plastic recycled) can lead to the leakage.

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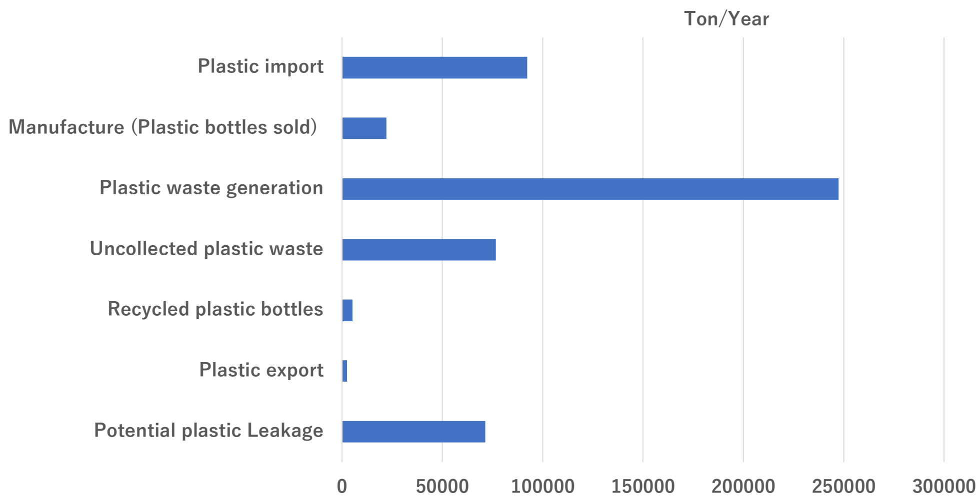
2. Plastic Material Flow - - Figures at glance



Reminder: The covered plastic are different in each stages and much assumption is used to get figures.

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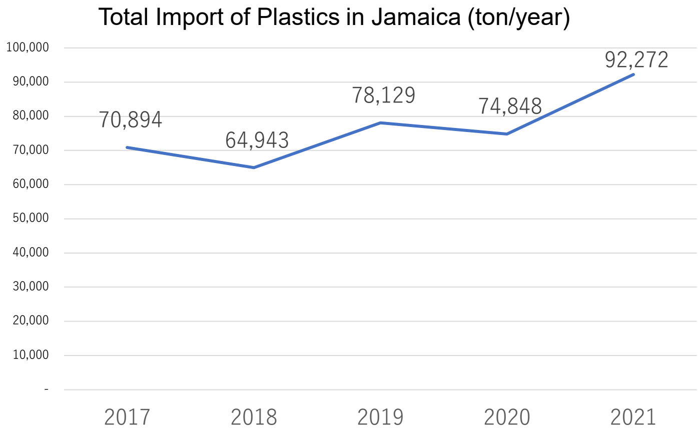
2. Plastic Material Flow - Plastic Import

- Plastic products categorized under HS codes of Chapter 39 (Plastics and articles thereof) are covered.
- Plastics included in some product (ex. electric product) is not covered.



Source: UN Comtrade Database, 2022

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2. Plastic Material Flow
- Plastic Product Manufacturing (plastic bottles)

Plastic bottles sold in Jamaica in 2018

- PET (Clear): 807,369,069 bottles
- HDPE: 39,051,547 bottles
- Other types of plastics (PET Blue, PET Amber, PET Green and PET Black bottles): 65,545,081 bottles.

Source: National Environment and Planning Agency , Final Regulatory Impact Assessment Report, Plastic Waste Minimization Project, 2020

To convert the number of bottles to weight of bottles, assume that weight of PET bottle is 23 g and weight of HDPE bottle is 55 g, whatever the bottle size is.

Estimate of the weight of plastic bottles sold in Jamaica in 2018≒ 22,200 tons

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2. Plastic Material Flow - Plastic Waste Generation

- The plastic waste generation amount is from Jamaica Waste Characterization Final Report 2022 by DBJ
- It is assumed that plastic waste generation amount is from overall waste generation x Plastic portion in the overall waste (16.8 %)

Plastic waste generation (tons/year) = 247,545 ≒ 247,500

Estimated annual waste generation in Jamaica

Population (2019)	Household solid waste generation (tons/year)	ICI waste generation (tons/year)	Overall waste generation (tons year)
2,734,094	1,090,923	384,549	1,475,473

Source: Jamaica Waste Characterization Final Report 2022

2. Plastic Material Flow - Uncollected Plastic Waste

- Uncollected plastic waste is estimated from plastic waste generation x uncollection rate.
- While there is not fixed (clear) collection rate, 69% (from DBJ) is used.

$$Uncollection\ rate = 100 - collection\ rate$$ 69%= 31 %

Uncollected plastics (tons/year) ≒76,700

Uncollected plastic amount in Jamaica

Plastic solid waste generation (tons/year)	Uncollection rate (%)	Uncollected plastic amount (tons/year)
247,545	31	76,739

2. Plastic Material Flow - Plastic Recycled

Available data on plastic recycling is plastic bottle collection by the Recycling Partners of Jamaica (RPJ) and one recycling company:

- 5,368 (≒5,400) tons in 2022

- Collected plastic bottles are compressed/baled and exported.

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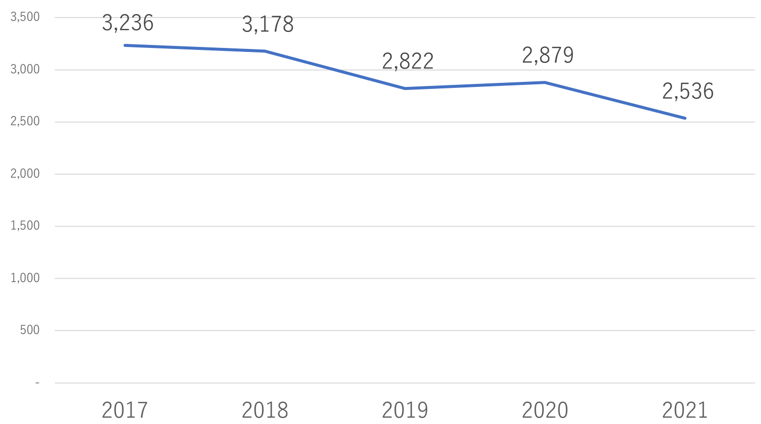
2. Plastic Material Flow - Plastic Export

- Plastic products categorized under HS codes of Chapter 39 are covered

Total Import of Plastics in Jamaica (ton/year)



Source: UN Comtrade Database, 2022

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2. Plastic Material Flow - Potential Plastic Leakage

- (Uncollected Plastic Waste – recycled plastic) is assumed to be potential plastic leakage in rough way.

  76,739 – 5,368 = 71,371≒71,400 ton/year

(Note)

This is by assuming that (uncollected plastic waste – recycled plastic) could be left and finally lead to leakage, while the figure is with much uncertainty.

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2. Plastic Material Flow - Deliverables

- Following files are provided to NEPA for their comment
  - ✓ PPT
  - ✓ Detailed report with methodologies and data
  - ✓ Guidance for future update with data source

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3. Other Plastic Policy Support

1) Discussing knowledge for plastic policy formulation

✓ Providing knowledge/information on

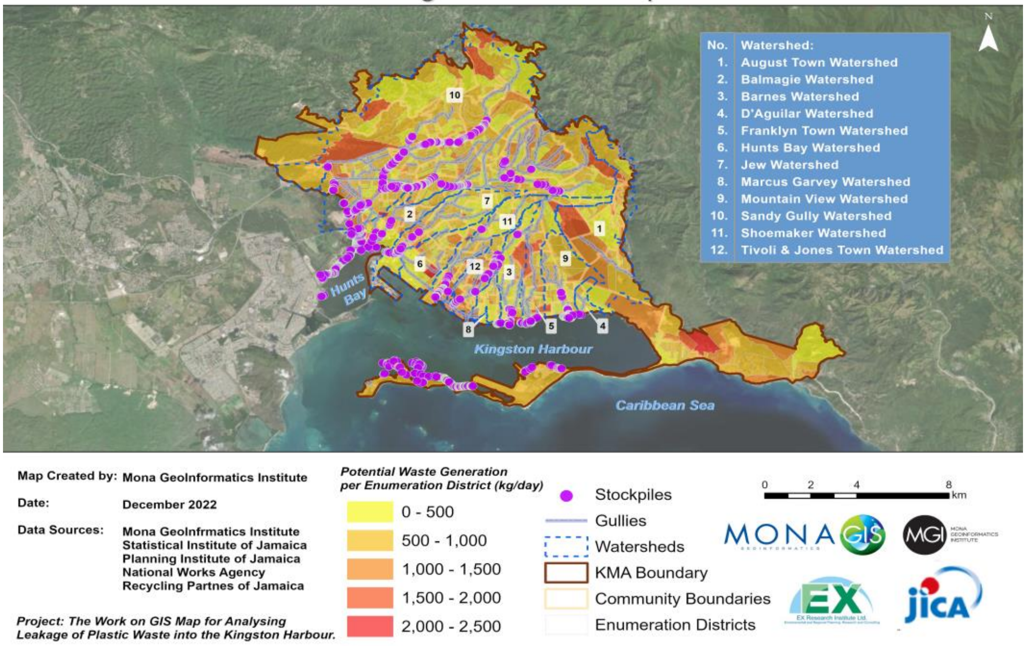
- Regulation on SUPs and DRS (general)
- Legislative basics for DRS
- Regulation on SUPs in Caribbean countries
- 1st INC on plastic pollution convention
- Available data on plastics in Jamaica

3. Other Plastic Policy Support

2) Providing waste background information in Kingston in map

✓ GIS map is delivered to NEPA and NSWMA for their utilization.

Potential Waste Generation by Enumeration District within the Kingston Metropolitan Area



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The Way Forward

- Providing comments on the work plan and reports by the NEPA procured consultant (single-use plastics and later DRS)
- Providing summary info on the plastic related activities by stakeholders in Jamaica
- Providing knowledge and sample cases on requested topic (Topic depends on the concern and policy development)
- JAT will have a discussion on regional information sharing on SWM or plastic waste at the final seminar (Sep or Oct)

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No.9 Knowledge Brief for Jamaica – Deposit Refund Scheme in Palau and Pacific Islands

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Knowledge Brief for Jamaica –

Deposit Refund Scheme in Palau and Pacific Islands

July 24, 2023

Taisuke Watanabe

JICA Advisory Team

EX Research Institute Ltd.

NIPPON KOEI

Contents

1. CDS in Palau
2. Designing CDS in Pacific Islands
3. Introduction of CDS in Marshall Islands

(note)

Deposit Refund Scheme is called as Container Deposit Scheme (CDS) in Pacific Islands.

1. CDS in Palau

【Why Palau】

- CDS in Palau is working well for long years and the system is a simple system (fee collection is at custom only and number of refund point is limited).

【Introduction: About Palau】

- Area: 488 km2, Population: 18,000 (2000) (the system is implemented in Koror State)

【Legislation on CDL】

- The Republic of Palau Public Law: RPPL No. 7-24 (2005)
- Beverage Container Recycling Regulations
- (on solid waste management) Solid Waste Management Regulation (2013)

1. CDL in Palau

【Target product】

- Deposit beverage container which includes plastic pellets, not including a liquid ingested for medical purpose only, syrup, or instant drink powder

【Fee (Deposit) and Refund】

- Custom fee at the import of deposit beverage container : 0.10 USD per container
- Refund: 0.05 USD per container which is brought to the refund center
- Administrative cost: 0.025 USD per container for the recycling fund

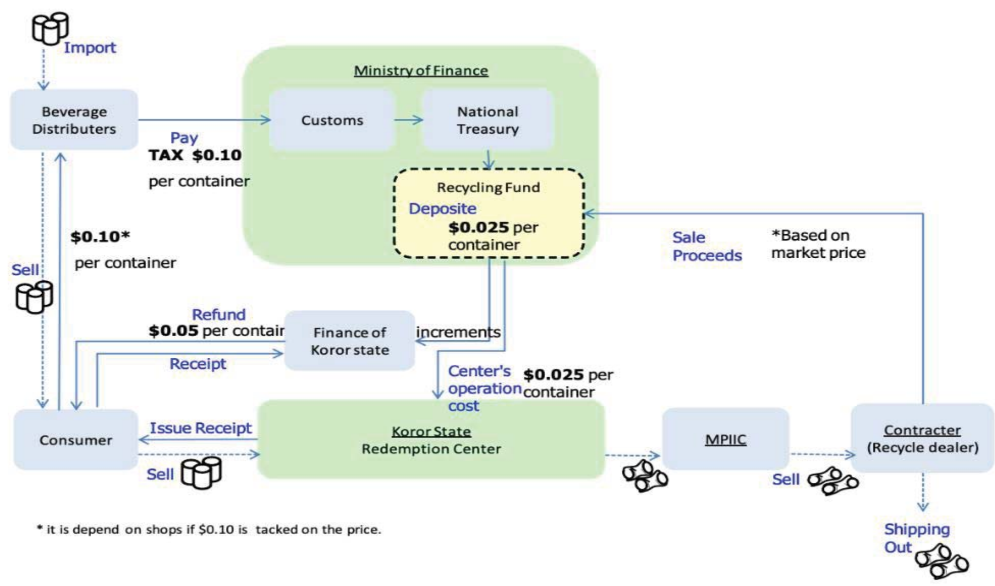
1. CDL in Palau

【Responsibility of Concerned Organizations】

- Ministry of Public infrastructure, Industry and Commerce:
  - ✓ Implementation of the recycling program
  - ✓ Approve and monitor the redemption center(s)
  - ✓ Export or find ways to export redeemed containers
- Ministry of Finance (MOF):
  - ✓ Management and maintenance of fund
  - ✓ Monitoring of Fund
  - ✓ Collection of deposit fee by the Customs Office under MOF
- Koror State Government
  - ✓ Operation of redemption center

1. CDL in Palau

【Flow diagram on CDL in Palau】



1. CDL in Palau

【Raising awareness activities】
- ✓ Presentation at schools by quizzes and games
- ✓ Campaign at the events
- ✓ Setting recycle box at the airport
- ✓ Site tour to the redemption center and landfill
- ✓ Educational programs by NGOs

1. CDL in Palau

【Achievement】
- ➢ Recovery
  - ✓ Recovery rate of containers in 2021: 87% (total import is 16,995,000 and redeemed (recovered) is 14,728,000)
  - ✓ Recovered amount in 2021: PET 103 t, Aluminum 104 t, Steel 1 t
- ➢ Finance (FY2021)
  - ✓ Fee collection: 1.7 million USD
  - ✓ Refunded: 0.74 million USD
  - ✓ Operation cost: 0.37 million USD
  - ✓ The rest (0.42 million USD) is accumulated in the Recycling Fund

1. CDL in Palau

【Export of recovered containers】

- Recovery
  - ✓ Recovery rate of containers in 2021: 87% (total import is 16,995,000 and redeemed (recovered) is 14,728,000)
  - ✓ Recovered amount in 2021: PET 103 t, Aluminum 104 t, Seel 1 t
- Finance (FY2021)
  - ✓ Fee collection: 1.7 million USD
  - ✓ Refunded: 0.74 million USD
  - ✓ Operation cost: 0.37 million USD
  - ✓ The rest (0.42 million USD) is accumulated in the Recycling Fund

1. CDL in Palau

【Distinctive point】

- Simplified monetary flow
  - ✓ Deposit (fee charging) point is Custom only and refund (payment to consumer) point is redemption center only. Collected container is sold to the recyclers. Thus fund control is simple and easy.
- Simple operation
  - ✓ The containers which brought to the redemption center is sold to the private sector (2 companies are selected). The private sector look for the buyer.
  - ✓ Sustainable finance
  - ✓ The balance (collected fee amount – refunded amount) is more than operation cost.

1. CDL in Palau

【Issues on CDL】

- Separation
  - ✓ Although there are waste collection point with separated box for containers, cartons and others), separation do not work well.
- Quality of recovered containers (PET case)
  - ✓ PET bottles are compressed with label films and caps (not high quality for sale), while without left drinks and straws.
- Sales (export)
  - ✓ Sales of recovered containers is not easy. When bidding, no one bids for PET only and combination of PET and aluminum can find bidders (to be exported).
- Containers other than beverage container
  - ✓ Present CDL system do not cover (some are under consideration).
- Balance of finance
  - ✓ What use (to where the balance is used) is effective to reduce the waste.

1. CDL in Palau

【Reference】

- Detailed explanation of the scheme- Manual for Beverage Container Deposit Fee Program
  https://www.sprep.org/attachments/j-prism/events/2013/Nov/1._Manual_for_Beverage_Container_Deposit_Fee_Program.pdf

2. Designing CDS in Pacific Island

【Points of Reference】
- ✓ Reference documents provides the important point and steps to design the CDS.

【Major points from the Reference document (to be explained)】
- ✓ Chapter 1: Operational Models and Legal Arrangements
- ✓ Chapter 2: Designing a viable CDS

【Reference document】
- ➢ "Container Deposit Schemes in the Pacific Islands – a Guide for Policy Makers"
  https://library.sprep.org/content/container-deposit-schemes-pacific-islands-guide-policy-makers

2. Designing CDS in Pacific Island

【Operational Models】
The report shows 2 models.
- ➢ 1) Special Fund Model
- ✓ Features: Government collects deposits and pays out refunds from a designated 'Special Fund'. Government contracts out material handling operation e.g. collection, redemption, processing, recycling/exporting.
- ✓ Note from Watanabe: It is not easy to make the deposit-refund specific fund. When the finance ministry controls the fund, the finance ministry want to respond to many issues (typically environmental levy at the import in many countries go to the general budget).

2. Designing CDS in Pacific Island

【Operational Models】

The report shows 2 models.

➢ 2) Managing Agency Model

✓ Features: Non-government Managing Agency collects deposits, pays refunds, and contracts out material handling operation.

✓ Note from Watanabe: It is workable when there is a existing organization which does recycling work with financing window. Involving the private sector and keeping transparency is critical point to design the Agency.

2. Designing CDS in Pacific Island

【Designing a viable CDS 】

The report shows 9 elements.

i. *Deciding the Target Products and Estimating Waste Generation*
ii. *End of Use Product Management and Material Recovery Facilities*
iii. *Mapping the Collection/ Redemption Points*
iv. *Assessing Who Can Operate the System (System Operator)*
v. *Estimating the Running Cost (Handling Fee)*
vi. *Determining Refunds and Deposits*
vii. *Establishing the Fund Management System*
viii. *Absorbing Legacy Waste*
ix. *Data Reporting and Implementation Monitoring*

2. Designing CDS in Pacific Island

【Designing a viable CDS 】
Another and most important point to establish the system is the acceptance of related stakeholders, considering the burden of the stakeholders by the design of the system. There are some tendency.

- Drink bottlers: Be prepared to accept some burden (ex. voluntary system) but object to the full cost responsibility.
- Retailers: Object to the system which require retailers to collect deposit at the sales of container products.
- Consumers: Want enough incentives to bring containers to the collection points.
- Waste management department: Object to have additional collection system for containers without additional budget.

3. Introduction of CDS in Marshall Islands

【Why Marshall Islands】
The CDS is introduced to Majuro island in the Republic of Marshall Islands (RMI) in 2019. This recent case provides the discussion in designing the system.

【Reference document】
Introduction of Container Deposit Recycling System in RMI
https://www.sprep.org/sites/default/files/documents/publications/%E3%80%90FIN%E3%80%91_JPRISM_Good_Practice_RMI%20CDS_web.pdf

3. Introduction of CDS in Marshall Islands

【Legislation】

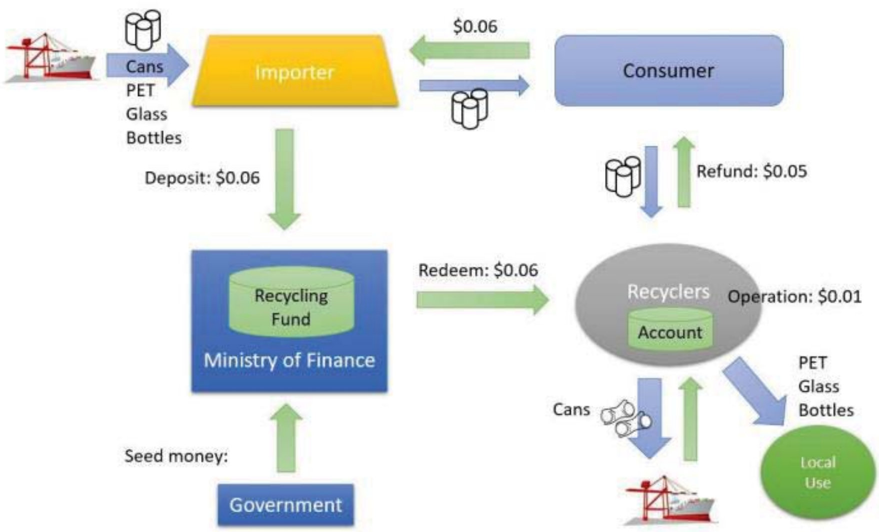
Styrofoam Cups and Plates and Plastic Products Prohibition and Container Deposit Act 2016 (amended in 2018).

【Agencies】

- ✓ The Marshall Islands Environmental Protection Authority (EPA) is the lead agency for the Container Deposit Recycling System, as the designated Recycling Agent under the legislation.
- ✓ The Majuro Atoll Waste Company (MAWC) is contracted by EPA to operate the recycling process, and pay out refunds, as the 'System Operator'.
- ✓ The Ministry of Finance manages the Recycling Special Revenue Fund, collecting deposits at import through RMI Customs and the local manufacturer's deposits for locally produced bottled water.

3. Introduction of CDS in Marshall Islands

【System diagram】



3. Introduction of CDS in Marshall Islands

【Export】

- ✓ PET bottles (transparent color) was exported to Australia in 2019 with the support by Moana Taka Partnership.
- ✓ The Moana Taka Partnership is the program by Swire Shipping and SPREP (Secretariat of the Pacific Regional Environmental Program), supported by EU.
- ✓ The Moana Taka Partnership helps alleviate the burden of waste on islands in the Pacific by utilising Swire Shipping vessels to fill empty shipping containers to transport non-commercial recyclable waste from islands.

3. Introduction of CDS in Marshall Islands

【Success factors】

The document points out the following.

- ✓ Existing recycling shed which is used as recycling facility.
- ✓ Strong political support: The Minister responsible for Environment initiated the legislation process, got the Cabinet support and involved the key personnels to design the system.
- ✓ The local business community: Largely importers actively supported and cooperated with the implementation.
- ✓ Good communication with all stakeholders: The Environmental Protection Authority (EPA) acted as the central communicator and keep stakeholders informed.

Please inform me if any interested point.

Thank you!

Contact: Taisuke Watanabe (Mr.)

t-watanabe@exri.co.jp

Information on plastic alternatives

Examples on alternatives of single-use plastics are as follows.

1. Study on Trinidad & Tobago

It includes alternative costs.

https://repositorio.cepal.org/bitstream/handle/11362/46280/4/S2000658_en.pdf

2. Proposed Single-Use Plastics Prohibition Regulations in Canada

It does not evaluate the alternatives but provides wide range of information.

Draft Regulations

https://www.gazette.gc.ca/rp-pr/p1/2021/2021-12-25/html/reg2-eng.html

Alternatives

https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/consultations/proposed-single-use-plastics-prohibition-regulations-consultation-document.html#toc13

3. Impact assessment on the bam on single-use plastics in UK.

It includes some information on alternatives (not detail).

https://consult.defra.gov.uk/environmental-quality/consultation-on-proposals-to-ban-commonly-littered/supporting_documents/Plates%20and%20Cutlery%20Impact%20Assessment.pdf

https://www.resourcefutures.co.uk/project/impacts-of-a-potential-uk-ban-of-plastic-straws-plastic-cotton-bud-sticks-and-plastic-drinks-stirrers/

4. Impact assessment in NZ

It includes the description on alternatives.

https://environment.govt.nz/assets/publications/plastic-phase-outs-regulatory-impact-statement.pdf

No.10 Knowledge Brief for Jamaica –
NGO/Private sector activities related to plastic pollution in Jamaica
Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Knowledge Brief for Jamaica –

NGO/Private sector activities related to plastic pollution in Jamaica

Aug. 30, 2023

Taisuke Watanabe

JICA Advisory Team

Objective

To overview the activities of NGOs and private actors on plastic pollution for understanding the status of plastic management in Jamaica.

Contents

1. Land-based Measures
    - Recycling with Deposit Refund Scheme (DRS)
    - Campaign by bottling company
    - Hotel and Tourism Association
2. Ocean-based Activities
    - Kingston Harbour Cleanup Project
    - Annual International Coastal Cleanup Day
    - The Nuh Dutty Up Jamaica Campaign
    - KHEAM project

Reference: NSWMA

(Note) Mass Media activities are not covered.

Activities

Plastic Recovery

・DRS

・Kingston Harbour Cleanup Project
・Annual International Coastal Cleanup Day

Land based

Ocean based

・Campaign by bottling company
・Hotel and Tourism Association

・Annual International Coastal Cleanup Day
・The Nuh Dutty Up Jamaica Campaign
・KHEAM project
・MGIBlue

Advocacy & Research

1. Recycling and Deposit Refund Scheme (DRS) 1/3

【Description of DRS】

- Collecting funds from funding partners, the bottlers, and distributors of food products manufactured in PET plastics (without government finance).
- Payment to consumers who bring large amount of plastic bottles to drop off points.
- Reimbursement collection partners.

【Players】

- **Recycling Partners of Jamaica (RPJ)** acts as the administrator of the DRS.
- **RPJ & Jamaica Recycles** collect and process (sorting and bailing) the plastics, and export the processed plastics to overseas.

1. Recycling and Deposit Refund Scheme (DRS) 2/3

【Target】

- PET : water & drink bottles, etc.
- HDPE : detergent and lubricant bottles

【Achievement】

- **RPJ**: In 2020 and 2021, collected 1,150 tonnes and 1,800 tonnes respectively.
- **Jamaica Recycles**: collected about 220 tonnes.

【Partners & Collaboration】

- **RPJ**'s partners are Wisynco Group Ltd., Pepsi Cola Jamaica Bottling Ltd., Grace Foods & Services Ltd., Jamaica Beverages Ltd., Lasco Manufacturing Ltd., Trade Winds Citrus Ltd. and Seprod Ltd.

1. Recycling and Deposit Refund Scheme (DRS) 3/3

【Communication & Public Awareness】

- **RPJ** carries out public education by collaborating with multiple institutions including Schools, NSWMA, GKF, TPDCO, Churches and Housing Schemes.
- **Jamaica Recycles** collaborate with schools, residential associations, churches and informal sectors.

2. Campaign by bottling company

- **Wisynco** carries out awareness campaigns (Eco Club, Recycle Challenge) and activities (Eco Troopers).
  - ✓ Eco Club: makes recycling a lifestyle and habit within the school community.
  - ✓ Recycle Challenge: aims to assist persons within the organization in becoming more environmentally conscious and making recycling a habit in their daily lives.
  - ✓ Eco Troopers: Wisynco staffs voluntarily lead the enhancement of environmental awareness of staff members and encourage recycling at work and home.

3. Hotel and Tourism Association

【Description】
- Waste separation at a hotel, educational activities and the reduction of energy use by utilizing energy efficient equipment etc.

【Players】
- **Jamaica Hotel & Tourist Association (JHTA)**

【Target】
- Waste and energy

【Partners & Collaboration】
- Collaborating the Ministry of Tourism and its agencies, including Jamaica Tourist Board (JTB), the Tourism Product Development Company (TPDCo) and the Tourism Enhancement Fund (TEF).

【Communication & Public Awareness】
- Provide guidance to the member in dealing with the stakeholders and liaise with the gov. about possible solution to a problem.

4. Kingston Harbour Cleanup Project 1/2

【Description】
- Installing an interceptor barrier to collect debris that flows from Kingston's gullies into the harbour.

【Main Player】
- **GraceKennedy Foundation**

【Target】
- Plastics flows through gullies

【Achievement】
- As of Nov. 2022, 10,000 kg of plastic was collected at the mouth of 3 gullies.

4. Kingston Harbour Cleanup Project 2/2

【Partners & Collaboration】

- Collaborating with **the Ocean Cleanup** and **Clean Harbours Jamaica (CHJ)**.
- **Mona Geoinformatics Institute (MGI)** provides environmental profiling, data and field monitoring support.
- **RPJ** will be collecting plastic from interceptor's offloading site and has provided financial contributions.

【Communication & Public Awareness】

- Public education programs have been held to divert waste disposal in gullies, targeting communities, schools and individuals making a livelihood through the activities (Environmental Wardens, etc.).

5. Annual International Coastal Cleanup Day

【Description】

- Beach cleanups are facilitated as an educational opportunity.(International cleanup day is among the beach cleanup acirvities.)

【Players】

- **Jamaica Environment Trust (JET) with other collaborators**

【Target】

- Single-use plastics

【Achievement】

- On International Coastal Cleanup Day in 2021, 1,7124-18,558 kg of waste was collected.
- The breakdown are plastic bottles (55%), plastic caps (12%), Plastic cups & plate (5%).

【Partners & Collaboration】Many groups joins the event

【Communication & Public Awareness】JET and partners campaign the event.

6. Nuh Dutty Up Jamaica Campaign

【Description】
- Public education campaign that aims to improve citizens knowledge about the impact of improper disposal of waste on public health and the environment and encourage personal responsibility for the generation and disposal of waste.

【Players】
- **Jamaica Environment Trust (JET)**

【Target】
- Single-use plastics

【Partners & Collaboration】
- Tourism Enhancement Fund (TEF) , the Cleanup Network (25 community-based group)

7 . KHEAM Project

【Description】
- Identifying waste hotspots at major gullies & mangroves through geospatial analyses of drone imagery, documentation of changes in flow discharge throughout the major gullies and identification of oceanographic parameters within the Kingston Harbour. (as research work)

【Players】
- **Mona Geoinformatics Institute (MGI)**

【Target】
- Solid Waste

【Partners & Collaboration】
- **GraceKennedy Foundation**
- Funded by German Ministry for the Environment (BMUV), KfW (German development bank), Caribbean Biodiversity Fund

(Reference) NSWMA 1/3

1. Rae Town Recycling Pilot Project

【Description】
- Aims to Reduce the marine litter along the Rae Town Fishing Village Coastline by reducing the volume of garbage within the gully.
- Hosted clean-ups, carried out garbage collection, facilitated the separation of plastics at source and designated environmental wardens in order to create a culture of separation at source.

【Achievement】
- Collected 15231kg of PET bottles between July 2020 and April 2021.

(Reference) NSWMA 2/3

2. Northern Belt Plastic Recycling Initiative

【Description】
- Aims to enhance sensitization towards plastic recycling and to encourage plastic separation at source.

【Achievement】
- Over 108637 kg of PET was collected since January 2020.

(Reference) NSWMA 3/3

3. Mobile App

【Description】

- Developed a mobile application (app) to report littering in public spaces and illegal dumping in a bid to promote clean public spaces.
- Conducted extensive investigation on identifying illegal dumpsites across the island.

【Achievement】

- The mobile app allowed the NSWMA to establish an aggressive 24- to 48-hour response time to notifications received about delayed garbage collection and littering.

Please inform me if any interested point.

Thank you!

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No.11 Plastic Material Flow in Jamaica (Supplement) & (Ver.2)

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Plastic Material Flow in Jamaica (Supplement) –

Sep. 1, 2023

Taisuke Watanabe
With support of JICA Advisory Team

Contents

This file provides supplemental information to the material flow file in February.

1 Export data

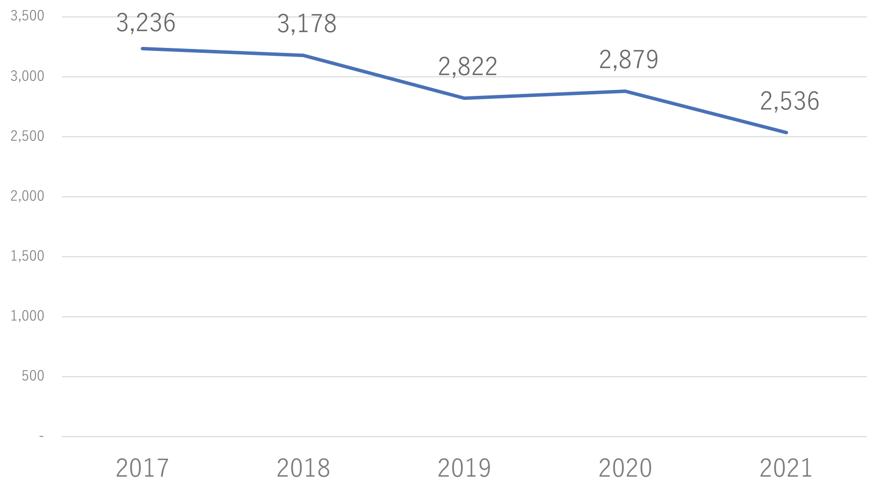
2 Important findings from plastic material flow

3 Suggestion on further data collection

1. Plastic export data

- Plastic products categorized under HS codes of Chapter 39 are covered

Total Import of Plastics in Jamaica (ton/year)



Source: UN Comtrade Database, 2022

1. Plastic export data (major export)

Among the export of plastics, “Waste, parings and scrap, of plastics” is the biggest category.

Categories representing major plastic exports

H.S Code	Description	2021
3902	Polymers of propylene or of other olefins, in primary forms	7.6%
3915	Waste, parings and scrap, of plastics	40.6%
(3915.90)	(Plastics not elsewhere classified in heading no. 3915; waste, parings and scrap)	(26.1%) (included in 3915)
3925	Plastics; builders' wares n.e.c. or included	13.0%

Source: UN Comtrade Database, 2022

3. Suggestion on further data collection

- It is effective way to apply the material flow method to the target plastic product situation.
- If you limit the target plastic product, it is more possible to collect data.
- If you are to collect data on PET bottle, you can collect more reliable data, because PET resin is imported (not produced in Jamaica), amount of PET bottle manufactured can be obtained, as the number of major manufacturer is limited such as Wisynco (this means easier to approach the company to obtain data). Manufactured PET bottle will become waste bottle (not retained in houses), recycled amount can be obtained from recycler.
- As a result, amount of manufactured, waste(need composition study to know the PET bottle rate), uncollected waste (from collection rate), recycled (from RPJ and Jamaica Recyclers) and potential leakage of PET bottle can be obtained.

No.11 Plastic Material Flow in Jamaica (Supplement) & (Ver.2)

Technical Cooperation Project on
Advisor for Marine Plastic Litter Management in the Caribbean Region

- Plastic Material Flow in Jamaica (Ver.2) –

Sep. 1, 2023

NEPA

With support of JICA Advisory Team

EX Research Institute Ltd.
Environmental and Regional Planning, Research and Consulting

NIPPON KOEI

Contents

1. Background and Objective

- JICA Technical Cooperation Project supports the development of plastic policy in Jamaica.
- To understand the plastic situation in Jamaica, how plastic becomes product, waste and go to the marine and figures in such flow is the provides the basis to identify the points of action. Material flow is import, manufacture, waste generation, waste collection and recycling and leakage. JAT support the development of plastic material flow.
- Following is the plastic material flow with a rough estimate on a national level and the Kingston Metropolitan Area (KMA) level. As this is a rough estimate, please read the Note below carefully to understand the characteristics of the figures.

Note:

- Not all quantities of plastics are addressed and depending on the item, covered plastics are limited. For example,, plastic in bulky waste is not covered overall.
- Figures are estimates with assumption, as availability of data is very limited except for UN statistical data on Imports and Exports.
- Because the ground and covered plastic are different in each stage. comparing figures in stage by stage is not appropriate.

1. Major Findings

- Considering that the biggest plastic pollution issue is plastics in the marine, especially at the coastal area, it is important to understand the possible plastic leakage to marine in Jamaica.
- Potential plastic leakage is around 71,400 ton/year in nationwide.
- Potential plastic leakage is around 21,800 ton/year in KMA.
- If assuming that plastics on land are finally discharged to marine, as Jamaica is mostly hilly/mountainous and have small plain land area, amount of potential leakage can be understood nearly as the amount discharged to the marine.

1. Major Findings (Application)

- It is effective way to apply the material flow method to the target plastic product situation.
- If you are to collect data on PET bottle, you can collect more reliable data, because PET resin is imported (not produced in Jamaica), amount of PET bottle manufactured can be obtained, as number of major manufacturer is limited. Manufactured PET bottle will become waste bottle (not retained in houses). Waste collection rate is applied and recycled amount can be obtained from recycler.

✓As a result, amount of manufactured (=import), waste, uncollected waste, recycled and potential leakage of PET bottle can be obtained.

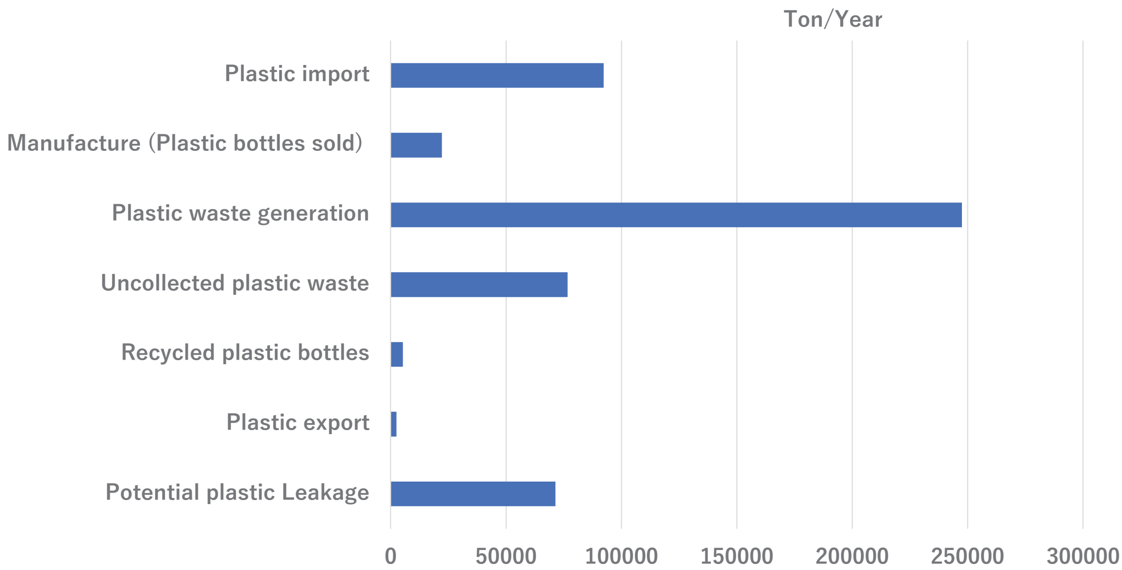
2. Plastic Material Flow (National Level)

Figures in stages

To cover the flow, import, manufacture, waste generation, waste collection and recycling and leakage. Following is the covered/calculated plastic in each stage.

- Import and export: Plastic products categorized under HS codes of Chapter 39 (Plastics and articles thereof) . Plastics included in some products (ex. electric product) are not covered.
- Manufacture: Only available data is number of plastic bottles sold in Jamaica. The weight is calculated from number of bottles x typical weight per bottle.
- Plastic waste generation: Calculated from total waste generation amount x plastic portion in waste. Per capita waste generation amount is used for estimation of total waste generation .
- Uncollected waste: Calculated from plastic waste generation amount X plastic uncollection rate, while used uncollection rate is one of the reported figure.
- Plastic recycled : Only amount of plastic bottle collected.
- Potential plastic leakage: Assuming that (uncollected waste - plastic recycled) can lead to the leakage.

- Figures at glance

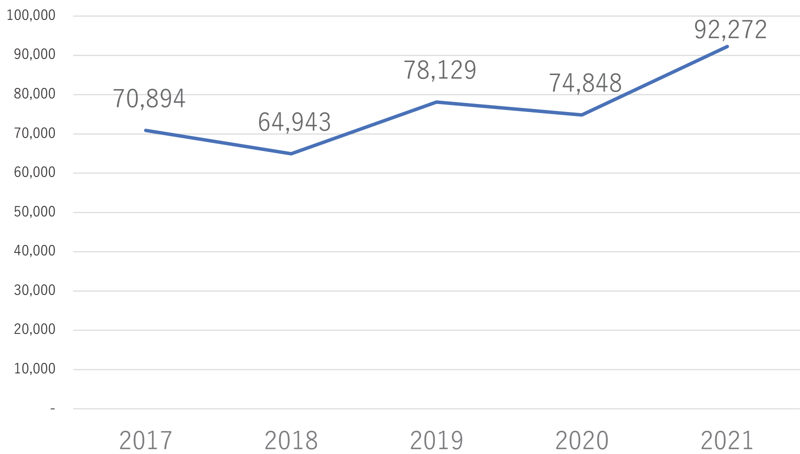


Reminder: The covered plastic are different in each stages and much assumption is used to get figures.

- Plastic Import

- Plastic products categorized under HS codes of Chapter 39 (Plastics and articles thereof) are covered.
- Plastics included in some product (ex. electric product) is not covered.

Total Import of Plastics in Jamaica (ton/year)



Source: UN Comtrade Database, 2022

- Plastic Import (Major Import)

Categories representing major plastic imports

H.S Code	Description	2021
3902	Polymers of propylene or of other olefins, in primary forms	9.5%
3915	Waste, parings and scrap, of plastics	50.5%
3919	Self-adhesive plates, sheets, film, foil, tape, strip and other flat shapes, of plastics, whether or not in rolls	9.9%
3925	Plastics; builders' wares n.e.c. or included	16.1%

Source: UN Comtrade Database, 2022

- Plastic Product Manufacturing (bottles)

Plastic bottles sold in Jamaica in 2018

- PET (Clear): 807,369,069 bottles
- HDPE: 39,051,547 bottles
- Other types of plastics (PET Blue, PET Amber, PET Green and PET Black bottles): 65,545,081 bottles.

Source: National Environment and Planning Agency , Final Regulatory Impact Assessment Report, Plastic Waste Minimization Project, 2020

To convert the number of bottles to weight of bottles, assume that weight of PET bottle is 23 g and weight of HDPE bottle is 55 g, whatever the bottle size is.

Estimate of the weight of plastic bottles sold in Jamaica in 2018≒ 22,200 tons

- Plastic Waste Generation

- The plastic waste generation amount is from Jamaica Waste Characterization Final Report 2022 by DBJ (Development Bank of Jamaica)
- It is assumed that plastic waste generation amount is from overall waste generation x plastic portion in the overall waste (16.8 %)

Plastic waste generation (tons/year) = 247,545 ≒ 247,500

Estimated annual waste generation in Jamaica

Population (2019)	Household solid waste generation (tons/year)	ICI waste generation (tons/year)	Overall waste generation (tons year)
2,734,094	1,090,923	384,549	1,475,473

Source: Jamaica Waste Characterization Final Report 2022

- Uncollected Plastic Waste

- Uncollected plastic waste is estimated from plastic waste generation x uncollection rate.
- While there is not fixed collection rate, 69% (from DBJ) is used.

$$Uncollection\ rate = 100 - collection\ rate\ 69\% = 31\ \%$$

Uncollected plastics (tons/year) ≒76,700

Uncollected plastic amount in Jamaica

Plastic solid waste generation (tons/year)	Uncollection rate (%)	Uncollected plastic amount (tons/year)
247,545	31	76,739

- Plastic Recycled (plastic bottles)

Available data on plastic recycling is plastic bottle collection by the Recycling Partners of Jamaica (RPJ) and one recycling company:

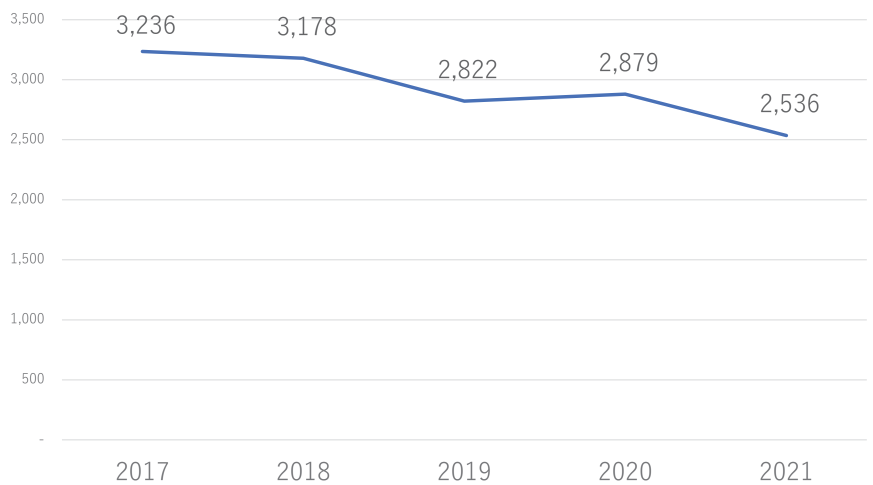
➢5,368 (≒5,400) tons in 2022

➢Collected plastic bottles are compressed/baled and exported.

- Plastic Export

➢ Plastic products categorized under HS codes of Chapter 39 are covered

Total Import of Plastics in Jamaica (ton/year)



Source: UN Comtrade Database, 2022

1. Plastic export data (major export)

Among the export of plastics, “Waste, parings and scrap, of plastics” is the biggest category.

Categories representing major plastic exports

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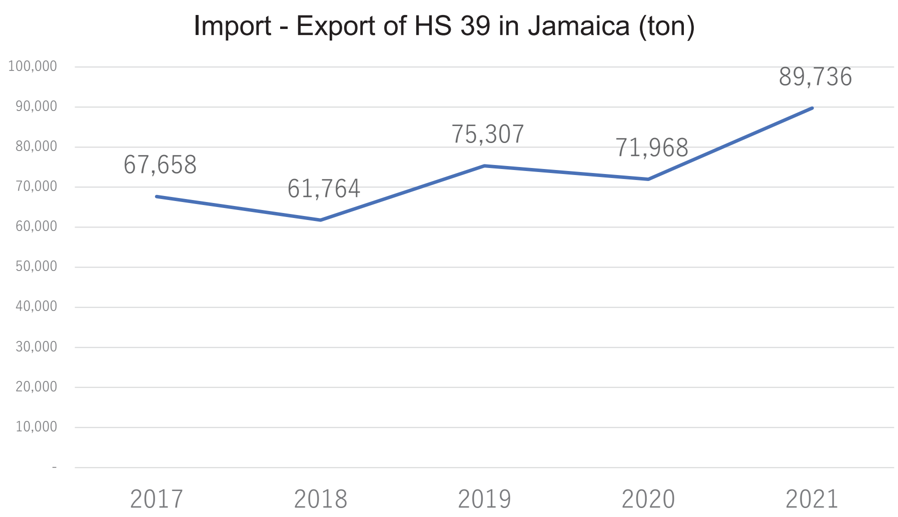
3902	Polymers of propylene or of other olefins, in primary forms	7.6%
3915	Waste, parings and scrap, of plastics	40.6%
(3915.90)	(Plastics not elsewhere classified in heading no. 3915; waste, parings and scrap)	(26.1%) (included in 3915)
3925	Plastics; builders' wares n.e.c. or included	13.0%

Source: UN Comtrade Database, 2022

- Plastic Import - Export

- (Import – Export) is over 95% of total Import from 2018 to 2021
- Plastic products categorized under HS codes of Chapter 39 are covered



Source: UN Comtrade Database, 2022

- Potential Plastic Leakage

- (Uncollected Plastic Waste – recycled plastic) is assumed to be potential plastic leakage in rough way.

  76,739 – 5,368 = 71,371≒71,400 ton/year

(Note)

This is by assuming that (uncollected plastic waste – recycled plastic) could be left and finally lead to leakage, while the figure is with much uncertainty.

3. Plastic Material Flow (Kingston Metropolitan Area (KMA))

Note: Export/Import and Manufacturing is not included, as these figures are for national level.

- Plastic Waste Generation in KMA

- The plastic waste amount of MPM area is from Jamaica Waste Characterization Final Report 2022
- MPM figure is converted to KMA figure by the population ratio.

The population in MPM (1,277,686): The population in KMA (662,426*)
= The amount of waste generation in MPM: The amount of waste generation in KMA
= The amount of plastic waste in MPM: The amount of plastic waste in KMA
(Plastic waste generation in MPM is 143,789 ton/year)

Plastic waste generation (tons/year) = 74,548 ≒ 74,500

* By Calculation from Parish Profiles by Jamaica Information Service

- Uncollected Plastic Waste in the KMA

- Uncollected plastic waste is estimated from plastic waste generation x uncollection rate.
- Uncollection rate is from the national level.

$$Uncollection\ rate = 100 - collection\ rate\ 69\ \% = 31\ \%$$

Uncollected plastics (tons/year) ≒ 23,100

Uncollected plastic amount in Jamaica

Plastic solid waste generation in KMA(tons/year)	Uncollection rate (%)	Uncollected plastic amount (tons/year)
74,548	31	23,110

- NSWMA Annual Report 2019/2020

- Potential Plastic Leakage in the KMA

- (Uncollected Plastic Waste – recycled plastic) is assumed to be potential plastic leakage in rough way.
- Recycled plastic amount (national) and population ratio (662,426 / 2,734,094) provides recycled plastic amount in the KMA (=1,301 ton).

23,110 -1,301 ≒ 21,800 ton/year

4. For the Improvement of Data

- It is found that available data/information is very limited in plastic input (import and manufacturing).
- It is important to accumulate data step by step including spot survey data. For example, there is no data on manufacturing/sales/waste on the bulky products containing plastics.
- When looking at the leakage to the ocean, we need to look at the social aspects, especially people's behavior on dumping waste.
- It is noted that the solid waste operation, especially waste collection, may change because of the realization of SWM PPP project.

3. Suggestion on further data collection

- It is found that available data/information on plastic is very limited.
- If you limit the target plastic product, it is more possible to collect data.
- If you are to collect data on PET bottle, you can collect more reliable data, because PET resin is imported (not produced in Jamaica), manufactured amount can be obtained (number of major manufacturer is limited), manufactured PET bottle will become waste bottle (not retained in houses), recycled amount can be obtained from recycler. As a result, amount of manufactured (=import), waste, uncollected waste, recycled and potential leakage of PET bottle can be obtained.

No.12 Advanced Comments on the report from the consultant on National policy on Single Use Plastics (SUP)

Advanced Comments on the report from the consultant on National policy on Single Use Plastics (SUP)

1. Background & Objective

As the report from the consultant on SUP will play an important role in preparing the draft regulation on SUP, JAT provides the comments to clarify the reviewing points when the report is submitted. It is important to have an accountable report for policy development. The comments is along with the points of the Scope of Work.

2. Review of related national planning, development policies and etc. relevant to SUP
1) Clarify the reason on the selection on the policy is most relevant and valuable in reviewing.
2) Clarify the review and evaluation on the Trade (Plastic Packaging Materials Prohibition) Order, 2018 and the NRCA (Plastic Packaging Materials Prohibition) Order, 2019.
3) Clarify the review on the present exemption (NEPA approval) situation based on the Paragraph 5 in the NRCA (Plastic Packaging Materials Prohibition) Order, 2019.

3. Review of international, regional and selected country commitments, obligations strategies, action plans and associated legislation and regulation
1) Clarify the reason on the selection of the document most relevant and valuable for alignment in reviewing.
2) Clarify the implications from the review of documents.

4. Facilitating consultations
1) Show the list of participants for consultation for both participated and not participated.
2) Clarify the method of consultation. For example, if the questionnaire is prepared, clarify the intention on questions.
3) Clarify the response/opinions of the participants by the type of participants. For example, clarify he opinion from the manufacturer on the dimension and thickness of plastic bag, availability of alternative, user demand on the size.

5. Review of the current legislative framework, and recommendations for the most appropriate legislative and regulatory framework.
1) Clarify the method of review on the Trade (Plastic Packaging Materials Prohibition) Order, 2018 and the NRCA (Plastic Packaging Materials Prohibition) Order, 2019? For example, how the effectiveness and/or impact of these orders are evaluated?
2) Clarify the reasons/justification on the issues/lacking point. For example, if the size of plastic bag is raised as an issue, the reason (ex. availability of alternative) shall be explained.

5. Review related capacity of primary stakeholders

1) Clarify the viewpoints to review/examine the capacity of stakeholders.
2) Clarify the capacity by type of stakeholders.

6. Preparing a draft National Policy

1) Clarify the options in each policy area/category and describe the reason for the selection of the proposed policy with the comparison of options.
2) On the selection of the targeted single-use plastic product for ban, it is recommended that the consultant is to prepare the reason/justification. For example, the availability of alternative which information on the cost by material from manufacturer is used, can be the criteria. Also, if exempted item is proposed, it is recommended to clarify the detail of the exempted item and reason for exemption.

8. Other Suggestions which can be included in the draft National Policy

1) Strategic planning and inter-sectoral collaboration

- For strategic planning, it is suggested to include data collection to examine the present condition and effect of setting National policy, covering import, manufacturing, consumption and waste generation, waste collection & disposal, recycling, export and discharge.
- For inter-sectoral collaboration, an example of effective way is setting up a inter-ministerial council on plastic to disseminate, share and collect information.

2) Plastic flow and product life cycle management

- It is suggested to state the importance to grasp the plastic flow and plastic data collection (can be on specific product). It is noted that the life cycle is different by type of product, especially by the potential of reuse or recycle.

3) Extended Producer Responsibility

- It is suggested to cover which producer can bear what responsibility. For example, when designing the plastic bottle refund system, plastic bottle manufacturer can bear the cost for refund and processing (baling) cost and plastic bottle retailer can bear the cost for collection cost.

4) Regulatory Framework

- It is suggested that the framework include the implementation mechanism. For example, reporting from important stakeholders is an idea.

5) Promotion of waste reduction and recycling by waste generators

- It is suggested to include the improvement of waste collection by waste management entity, as waste littering is the important source of plastic pollution.

6) Implementation arrangements

- It is recommended to include necessary resources (manpower and budget) for the enforcement/implementation of proposed National Policy.




Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Pilot Project Technical Note No.4

Use of Geographic Information in Preventing Plastic Litter from Leaking into the Ocean

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management
in the Caribbean Region

Pilot Project Technical Note No. 4

- Use of Geographic Information in Preventing Plastic Litter from Leaking into the Ocean -

Prepared by Ikuo MORI, JICA Advisory Team
October 2023

Table of Contents

1 Objectives of this technical note

This technical note aims to share readers with information regarding a pilot project which tried to utilise geographical information in preventing plastic litter from leaking into the Kingston Harbour, Jamaica.

2 Background

Kingston Metropolitan Area (hereinafter referred as "KMA") has the Blue Mountains behind it and the city is lined with many waterways, known as gullies. A large amount of waste is dumped into these gullies, polluting the water quality of Kingston Harbour, where the gullies end, and the mangrove forests along the water's edge, which has become a social problem.

Although it is recognised by the relevant authorities that the causes of dumping are a combination of factors such as lack of public awareness of environmental protection, insufficient waste collection services and the characteristics of communities (e.g., where there are only narrow roads that cannot be accessed by waste collection vehicles), there has been a lack of logical problem-solving initiatives based on analysis with quantitative data.

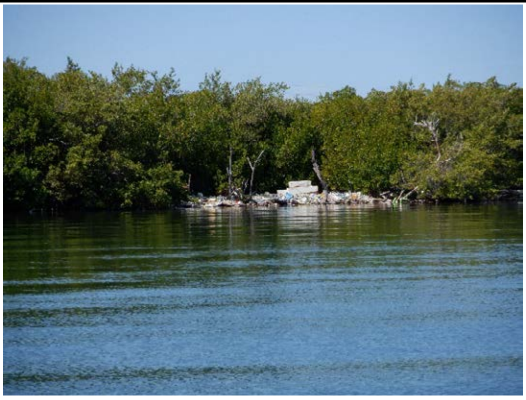
In the pilot project in the KMA, quantitative data on waste dumping was obtained as a starting point for developing a strategy to reduce waste entering the Kingston Harbour, and an attempt was made to visualise the problem using geographical information technology.

A stockpile at midstream

A stockpile at midstream

Stockpiles at the mouth of a gully

Stockpiles at the mouth of a gully

	
Spillage prevention activities and garbage collection boats at the mouth of the gully by the GraceKennedy Foundation.	Waste accumulated in the mangroves in the Harbour.

3 Geographical Information

3.1 Data acquired

KMA comprises the parishes of Kingston and St. Andrew. Below the parishes there are communities, and below those there are enumeration districts. Data acquired were the following and attribute to each enumeration district.

0. Name of community and enumeration district

   i. Name of community
   ii. Name of enumeration district

A. Base Socio-Economic Data

   i. Population (enumeration district)
   ii. Population density, person / km2
   iii. Squatter settlements
   iv. Roads (largest road class in the enumeration district)
   v. Income proxy, by level (Low-income, Lower-middle income, Middle income, Upper-middle income, and High income)
   vi. Poverty
   vii. Name of gully (watershed)
   viii. Area of enumeration (km2)

B. Primary Data

   i. Number of waste stockpiles (from satellite image analysis)
   ii. Number of plastic bottle drop/deposit points by Recycling Partners of Jamaica (RPJ)

C. Waste collection service data

   i. Number of waste collection days, day(s) per week
   ii. Waste collection routes

3.2 Data Entry

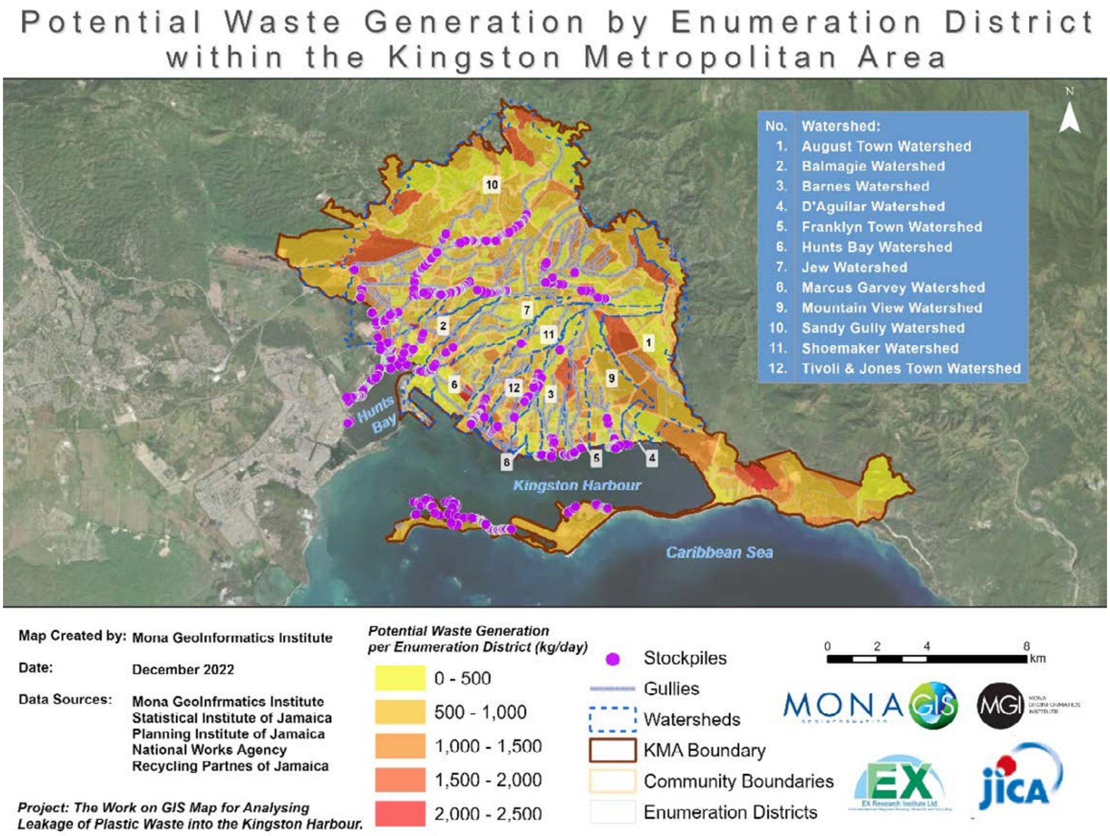
Data were organised in the format shown in the table below.

Table 3-1: Data Entry Sheet

Data code	0-i	0-ii	A-i	A-ii	A-iii	A-iv	A-v	A-vi	A-vii	A-viii	B-i	B-ii	C-i	C-ii
No.	Name of Enumeration District	Name of community	Nos. of Population	Population density (person/km2)	Existence of squatter settlement (Y/N)	Roads (largest road class in the enumeration district) (highest road class only)	Income proxy by Level	Poverty	Name of gully	Area of Enumeration (km2)	Nos. of waste stockpiles	Nos. of RPJ points	Nos. of waste collection days per week	Nos. of waste collection route
1														
2														
3														

4 Results

Below is a map prepared from the data acquired.



The map entitled "Potential Waste Generation by Enumeration District within the Kingston Metropolitan Area" primarily highlights the potential waste generation amount per enumeration district (hereinafter referred as "ED") within the KMA based on the per capita waste production derived from a waste characterization study conducted by the Inter-American Development Bank in 2022. The household waste production ratio of 1.18 kg/capita/day was multiplied by the total population of each ED and a graduated colour symbology used to show the quantitative differences. The colours ranged from a bright yellow (ED's with the lowest potential waste generation amount) to a bright red (ED's with the highest potential waste generation amount).

The map shows that waste accumulates mostly at the mouth of each gully and on the opposite side of the harbour where mangrove forests extend. However, it is also obvious that there are many stockpiles at midstream and upper stream, especially in the Sandy Gully Watershed.

5 Discussion and Conclusion

The map prepared clearly shows where waste stockpiles form in the upper and middle streams of gullies and accumulate especially near the mouths, and how they pollute the mangrove forests on the other side of the harbour, and could be used to raise public awareness as an environmental learning tool for students.

No clear causal relationship between potential waste generation and stockpiles was found. Detailed data on the frequency of waste collection services, which is considered to be one of main causes of stockpiling, was not available, so a causal relationship with stockpiling was unclear. It is recommended that the monitoring system for collection services be improved in the future and that data should be updated on an ongoing basis.

Public awareness is believed to be another important factor in littering, so instead of conducting public awareness surveys across the KMA, it is recommended to actually conduct public awareness activities and collect such data as to how much the number of waste stockpiles in the target area has been reduced as a result of these activities, in order to continuously improve the public awareness activities.

The stockpile information was obtained using a special technique called satellite remote sensing, which is probably an inexpensive tool to obtain data for a large area, the whole of KMA. Stockpiles will continue to change in number and location, so regular updates are recommended.

It is clear from the stockpile situation in the gullies that preventing litter dumping into the gullies is of paramount importance in reducing waste in the Kingston Harbour. The key measures are the provision of adequate collection services and raising public awareness. Both of these are costly measures, then, efficient implementation and a quantitative explanation of their effectiveness will support the continued implementation of the measures. The acquisition of various types of information and visualisation as maps introduced in this paper can be an effective tool for efficient implementation and explanation of the effects of littering control measures.

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Pilot Project Technical Note No.5

Landfill Operation and Maintenance Manual for the Caribbean Region

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

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- Landfill Operation and Maintenance Manual for the Caribbean Region -

Prepared by Saint Lucia Solid Waste Management Authority and
Yukihisa SAKATA, JICA Advisory Team

October 2023

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1 Introduction

This manual is based on observations and lessons learned from the pilot project in Saint Lucia. The main purpose is in particular to contribute to solving issues considered relevant to the operation and maintenance of landfills.

2 Landfill operation and maintenance

2.1 Landfill operation

2.1.1 General

A landfill operation and maintenance plan must be in place for the effective management. The plan will consist of:

1. The landfill area

2. Landfill methods, which include unloading, compaction and covering of waste

3. Monitoring of the operations

The monitoring plan should include how daily operations will be conducted, measurement of remaining capacity, environmental monitoring, etc.

2.1.2 Landfilling

The landfill method presented here (see figure below) is the sandwich method, where the waste layer (H = 2.0 m) and the intermediate cover layer (H = 0.5 m) are repeatedly filled. The waste layers are formed with waste cells. Each cell is filled with waste delivered on the same day. The surface of the cell is then covered with soil every day. During this process, the waste is well mixed and compacted.

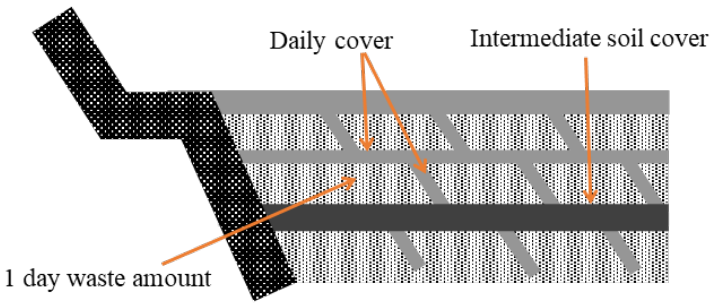


Figure 1: Landfilling method

Issues to consider:

1) Poorly permeable waste should not be placed around leachate collection and drainage pipes. (Avoid impermeable layers around the pipes).

2) For protection against heavy machinery, a protective layer (t = 0.5 m) of tyres, mountain sand, etc. should be placed inside slopes and small embankments before the area is reclaimed and compacted.

3) Small compaction equipment should be used to carefully backfill areas near vertical drainage pipes and vertical gas ventilation pipes.

4) Once the day's landfilling is completed, the ground is covered the same day. During covering, bulldozers and other equipment should be driven repeatedly to ensure adequate compaction. Covering should normally be carried out at the end of the day, but in the event of strong winds, covering should be carried out to prevent dust from the waste from being dispersed.

5) For the first layer of waste, the spreading thickness should be 0.5 m or more so as not to interfere with leachate collection and drainage pipes, and compaction should be carried out with a bulldozer.

6) To prevent accidents when reversing heavy machinery, a visual check of the rear and surrounding structures should be carried out before getting on the machine. A board with the reversing rules should be placed inside the heavy machinery and efforts should be made to ensure that the rules are thoroughly enforced.

2.1.3 Soil cover

There are three types of soil cover: daily cover, intermediate cover and final cover.

a. Daily soil cover

Waste shall be covered with soil at the end of each day of landfilling to prevent dispersal and odour. Landfills where there is a normal tendency for the waste to disperse or spill, to emit offensive odours or to be a source of rodents, birds, flies or other pests shall be covered with soil. Soil cover shall be applied immediately after the waste has been compacted at the discretion of the operator. The cover material should be temporarily placed in the vicinity of the landfill on a case-by-case basis.

[How to check the daily soil cover]

- The operator confirms the completion of the daily soil cover and reports to the landfill manager.
- The landfill manager confirms the completion of the daily soil cover on site.
- If rework is required, it shall be re-covered as soon as possible.

b. Intermediate soil cover

An intermediate soil cover is recommended when the thickness of the waste layer (including the daily soil cover) reaches $H = 2.0$ m, with a soil layer of $t = 0.3$ - 0.5 m.

The intermediate cover shall be voluntarily inspected after implementation.

[How to check the intermediate soil cover]

- Inspections of the intermediate soil cover should be carried out at a rate of one site per 500 m^2.

c. Final soil cover

The top layer of the landfill shall be covered with at least 1 m of soil. The soil type, thickness and surface finish of the final soil cover should be determined on the basis of the landfill use plan.

The surface of the soil cover should be compacted and carefully constructed, as it will be exposed to the elements for a long period of time as the surface of the landfill.

d. General observation

A fixed-point observation of the waste disposal from an elevated point overlooking the landfill site shall be carried out weekly.

2.1.4 Precautions for soil cover operations

There are many important structures at the bottom of the landfill, on the slope and on the surface of the embankment. Precautions should be taken to avoid damage to them. For example, areas around leachate collection pipes and vertical gas ventilation pipes should be carefully and evenly filled with waste using a small machine to avoid uneven loading that could damage the pipes.

2.1.5 Landfilling plan

Common challenges in the Caribbean region are the disposal of mixed waste in landfills without segregation, the lack of recycling and final disposal without intermediate treatment, and the disposal of hazardous and industrial waste in the same landfill.

To ensure proper landfilling in these circumstances, the following should be practised:

- Keep the landfill hygienic: Due to kitchen waste, which makes up a large proportion of mixed waste, landfills are often infested with unhygienic flies and kitchen waste is the main source of odours. To control this, regular soil cover is required, and the daily working area of the landfill needs to be clearly defined. Specifically, plans should be prepared and implemented to (i) determine the area of the required working area and (ii) make the landfill working area continuous on a weekly and monthly basis.
- An example of a planned area allocation is shown in the figure below. Provided that the access road to each landfill area is secured, the waste unloading and landfilling process should be carried out in an orderly manner.

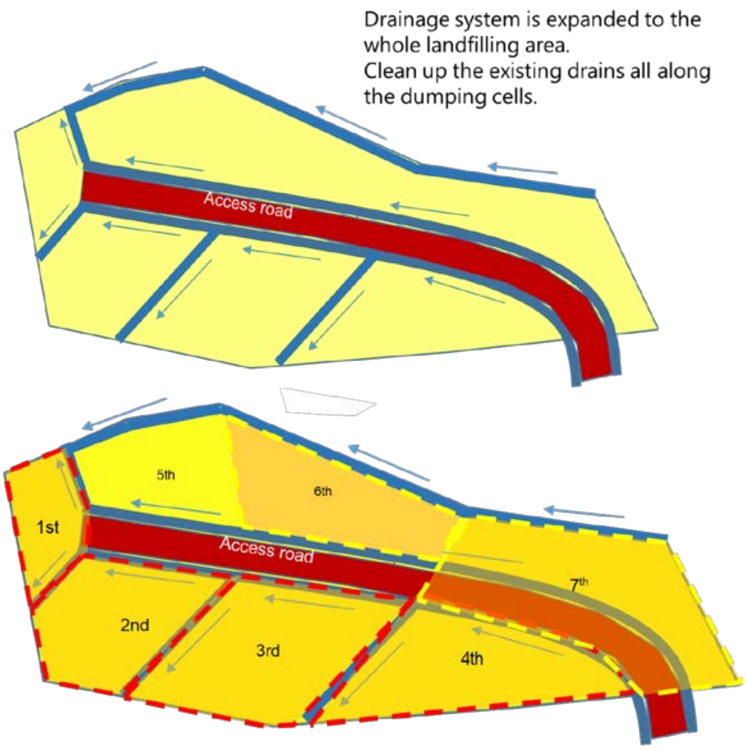


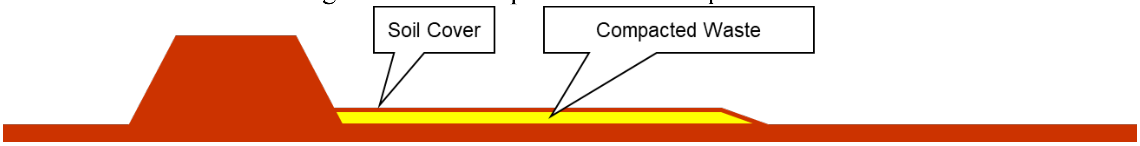
Figure 2: Landfill area distribution in order

2.1.6 Daily landfilling

This section explains how to conduct the daily landfilling.

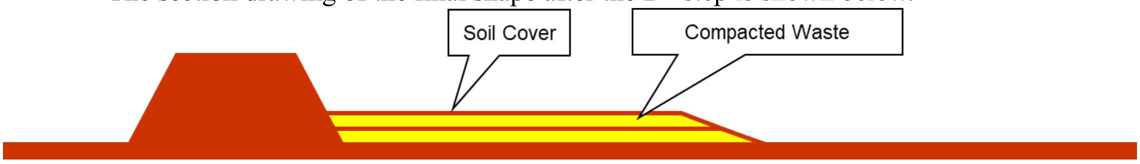
1st step

- A waste vehicle comes to the site and unloads the waste.
- Spread the waste with a dozer parallel to the embankment.
- Compact the waste with a dozer moving back and forth 10-15 times.
- Fill the target landfilling area with the waste.
- Repeat until the waste is piled up to 50 cm.
- Bring soil cover and spread it out on the compacted waste layer.
- Thickness of the soil cover is 15 cm.
- The section drawing of the final shape after the 1st step is shown below.



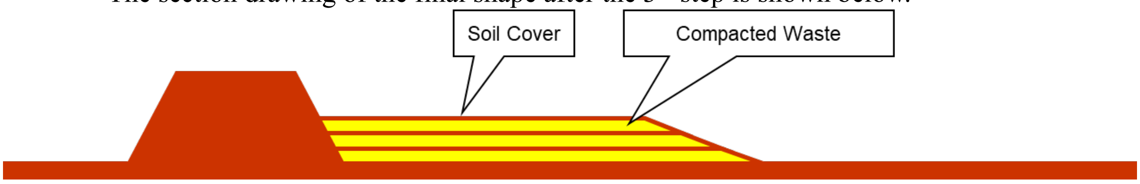
2nd step

- A waste vehicle comes to the site and unloads waste on the first compacted waste layer.
- Spread the waste with a dozer parallel to the embankment.
- Compact the waste with a dozer moving back and forth 10-15 times.
- Fill the target landfilling area with the waste.
- Repeat until the waste is piled up to 100 cm + 30 cm soil cover from the original ground level.
- Bring soil cover and spread it out on the compacted waste layer.
- Thickness of the soil cover is 15 cm.
- The section drawing of the final shape after the 2nd step is shown below.



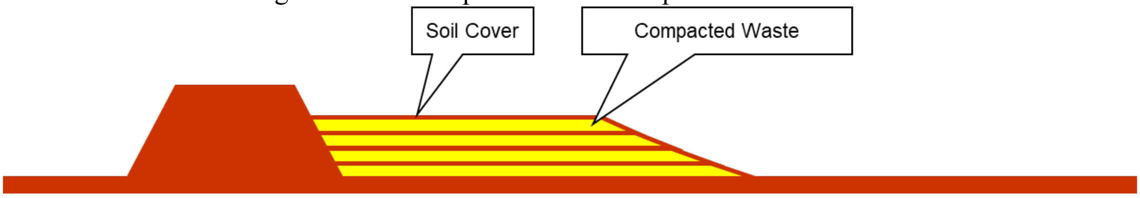
3rd step

- A waste vehicle comes to the site and unloads waste on the second compacted waste layer.
- Spread the waste with a dozer parallel to the embankment.
- Compact the waste with a dozer moving back and forth 10-15 times.
- Fill the target landfilling area with the waste.
- Repeat until the waste is piled up to 150 cm + 45 cm soil cover from the original ground level.
- The section drawing of the final shape after the 3rd step is shown below.



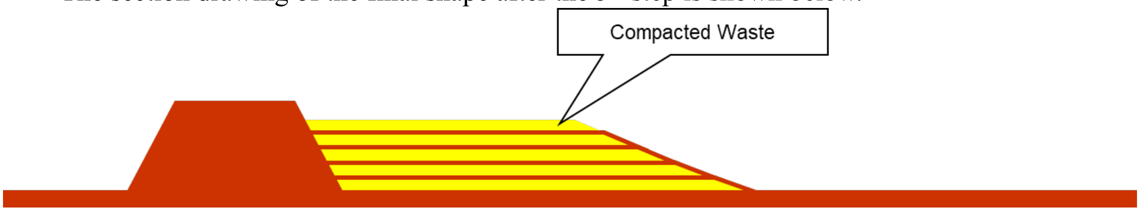
4^{th} step

- A waste vehicle comes to the site and unloads waste on the third compacted waste layer.
- Spread the waste with a dozer parallel to the embankment.
- Compact the waste with a dozer moving back and forth 10-15 times.
- Fill the target landfilling area with the waste.
- Repeat until the waste is piled up to 200 cm + 60 cm soil cover from the original ground level.
- The section drawing of the final shape after the 4^{th} step is shown below.



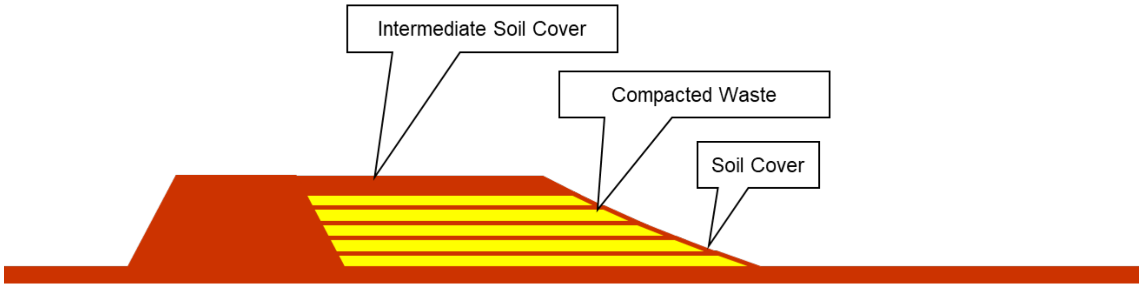
5^{th} step

- A waste vehicle comes to the site and unloads waste on the second compacted waste layer.
- Spread the waste with a dozer parallel to the embankment.
- Compact the waste with a dozer moving back and forth 10-15 times.
- Fill the target landfilling area with the waste.
- Repeat until the waste is piled up to 240 cm + 60 cm soil cover (without additional cover in this step) from the original ground level.
- The section drawing of the final shape after the 5^{th} step is shown below.



6^{th} step

- Bring intermediate soil cover and spread it out on the compacted waste layer.
- Thickness of the soil cover is 50 cm as intermediate soil cover.



In the guideline for final disposal of solid waste in Japan, an intermediate soil cover shall be laid for every 3m of waste layer. To summarize this procedure, the final section drawing of the landfill layer is shown on the next page.

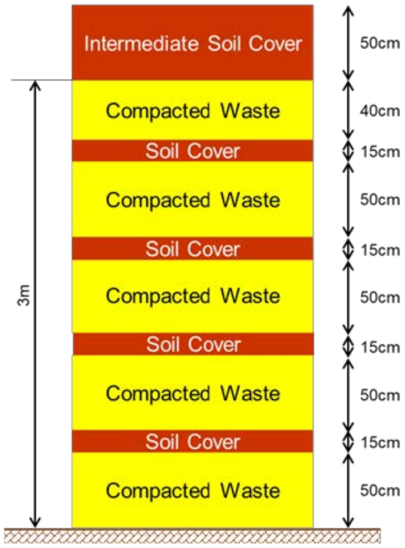


Figure 3: Landfill layer to intermediate soil cover

2.1.7 Temporary shelter installation for effective operation

In the Caribbean region, it rains a lot and sometimes strong winds blow around the landfills. However, waste continues to arrive during operating hours, so spotters and supervisors must continue to work even during inclement weather. To temporarily avoid bad weather, it is recommended to build a covered shelter near the landfill instead of using umbrellas. As it is windy, it is better not to have any side walls and the posts should be fixed to the ground (example of shelter below).

Source: https://canopia.com/product/martinique-12-ft-x-16-ft-gazebo-kit/?attribute_structure-color=grey&attribute_product-series-name=martinique

Figure 4: Example of a shelter (12 ft × 16 ft)

2.2 Landfill maintenance

The main facilities covered in this section are as follows:

- Leachate drainage facilities: Leachate sedimentation tank, channels
- Leachate treatment facilities: Treatment ponds, stabilization pond
- Storm water drainage facilities: Stormwater drainage channels, balancing pond
- Gas ventilation pipes: Gas ventilation pipes, slope gas ventilation pipes.
- Storage structures: embankments
- Monitoring facilities: Groundwater monitoring wells
- Ancillary facilities: Access roads, internal roads

2.2.1 Composition of water-related facilities

First of all, water-related facilities to be maintained are shown below. It consists of stormwater drainage system and leachate treatment system.

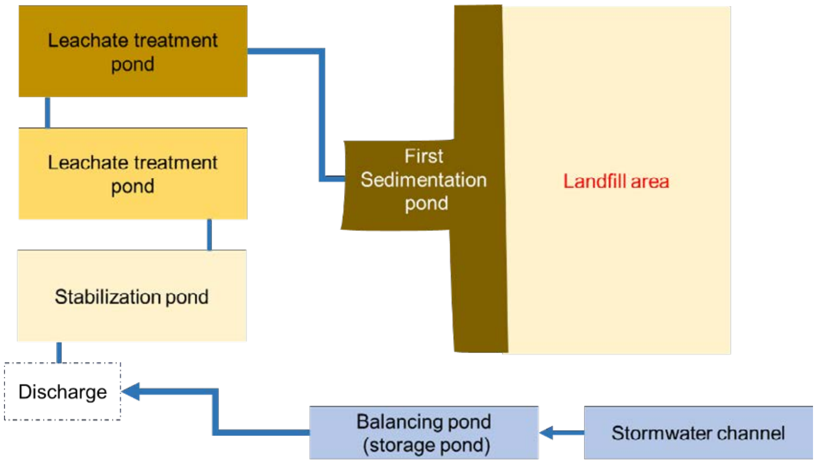


Figure 5: Water-related facilities in the landfill

2.2.2 First sedimentation pond

a. Function

The first sedimentation pond is also known as leachate collection pit (sump), which receives leachate from the leachate collection pipes under gravity flow conditions. The leachate is retained for a period of time and a certain amount of sediment is separated before the water is sent to the leachate treatment pond.

b. Inspection

Visual inspections should be carried out once a year to check for cracks and leaks in the structure. The use of an internal camera is also effective. Sediment should also be removed during the inspection.

c. Sediment removal

Sediment accumulated should be checked and removed if present. The amount sucked by the vacuum truck shall be measured.

2.2.3 Leachate treatment facility

a. Daily inspections

A daily inspection shall be carried out and a daily leachate treatment plant management report shall be prepared. Operating conditions shall be set according to various tests and treatment conditions. Simple water quality measurements shall be carried out. Monitoring equipment shall be inspected and maintained. These should be calibrated and cleaned.

b. Annual maintenance and inspection

Equipment and instrumentation shall be inspected and maintained. These shall be repaired and renewed if necessary.

c. Periodic water quality analysis

The analysis is carried out by a company specialising in the analysis of water quality. Samples are taken from:

- Groundwater monitoring wells,
- Leachate sedimentation pond, and
- Discharge point.

The table below gives an example of criteria for discharged leachate. In the Caribbean region, most leachate treatment facilities do not have advanced treatment systems or chemical treatment processes. Therefore, the parameters to be monitored should be biodegradable substances as shown in the table.

Table 1: Design criteria for treated leachate

Parameter	Limit*	Lab's recommendation
COD[1]	90 mg/l	30 mg/l
BOD[2]	60 mg/l	30 mg/l
Oil and Grease	30 mg/l	15 mg/l
TSS[3]	60 mg/l	30 mg/l
TN[4]	60 mg/l as daily average	80 mg/l
Nitrate	Not stipulated**	5 mg/l
Ammonia Nitrogen		10 mg/l
Coliform	200 CFU/100 ml	200 CFU/100 ml

d. Water quality self-checks

e. Water quality shall be checked once a week using a portable analyser for the following locations and water quality items.

e.1 Water sampling locations

- Leachate sedimentation pond
- Discharge point

e.2 Water quality items

- pH
- EC[5]
- Water temperature

[1] COD: Chemical Oxygen Demand
[2] BOD: Biochemical Oxygen Demand
[3] TSS: Total Suspended Solids
[4] TN: Total Nitrogen
[5] EC: Electrical Conductivity

Figure 6: Portable water quality analyser

f. Maintenance of monitoring equipment

f.1 Frequency of inspection

Once a year, manufacturer's inspection and calibration.

f.2 Inspection details

Loop test, pseudo-flow test with calibrator, scaling on detectors.

f.3 Description of work

Open detector, manufacturer's inspection, scale removal and cleaning.

2.2.4 Stormwater drainage system

The items listed in the table below and the channels around the perimeter of the facility shall be inspected.

If the inspection reveals sediment accumulation or damage, the sediment accumulation shall be removed, and the damage shall be repaired.

Table 2: Inspection list

Location	Item	Frequency
Stormwater channel	Visual inspection (sediment deposition/damage)	Daily
	Visual inspection (overflow)	Rainfall
Road to disposal site	Visual inspection (sediment run-off)	Weekly / Rainfall

2.2.5 Landfill gas removal facilities

a. Vertical gas vents

The items to be managed are listed in the following table.

Table 3: Inspection list of vertical gas vents

Location	Item	Frequency	Report
Vertical gas vents	Blockage	Monthly	Daily operation report
	Not overturned or damaged		Daily operation report
	Record of height at time of raising	When raised	Construction record*
	Measurement of concentration of gases generated	Weekly	Weekly operation report
	Visual inspection (appearance, water stagnation around the perimeter, smoke)	Weekly	Weekly operation report
	Gas analysis	Twice a year	Analysis report

*: Construction records include construction photos, construction drawings, material documents and other documents.

Note:

- The depth of the vertical vent pipe is measured with a weight to check the integrity of the vertical vent pipe.
- Raise the vertical vent pipe as the landfill progresses.
- If blockages, overturned or damaged pipes are found during the inspection, a report should be submitted with photographs and other information. If repairs are made, the details of the repairs and photographs shall be attached and kept as a record.

b. Slope gas vents

The items to be managed are listed in the following table.

Table 4: Inspection list of slope gas vents

Location	Item	Report
Slope gas vents	No damage, no overflows	Weekly operation report
	Gas analysis (twice a year)	Analysis report

[Precautions for work]

- Blockages are checked by checking the gas concentration from the release section and the integrity of the gas vent pipe is confirmed.
- The slope gas vent pipe is already in place (bent joint stop) at the start of landfilling along the slope. The vertical pipe is raised during the construction of the small embankment.
- During the inspection, any damage or overflows shall be reported. If repairs are made, the details of the repairs and photographs should be attached and kept as a record.
- Fire is strictly prohibited in the surrounding area, as flammable gases may be trapped in the landfill.
- The pipe connection at the road crossing (unconnected section) should be made according to the status of the landfill.

2.2.6 Monitoring of groundwater

Monitoring wells are installed in and around the landfill site to monitor the water level and quality as described in the table below.

Table 5: Monitoring of groundwater

Type of monitoring well	Location	Objective	Main device	Frequency of inspection
Groundwater monitoring wells	Two locations outside the landfill site (upstream and downstream)	Management of groundwater quality	Wells, water level meters	Weekly

2.2.7 Roads

The speed of traffic must be limited in the landfill. The following are examples:

- On the access road, traffic must be limited to a speed of less than 10 km/h.
- On the management road, traffic must be limited to a speed of less than 10 km/h.
- On the temporary on-site road, traffic must be limited to a speed of less than 10 km/h.

The following table shows inspection items and frequency of the roads.

Table 6: Inspection list of roads

Location	Item	Frequency
Access road	Cleaning of road surface (removal of soil, sand, and dust)	Weekly
	Cleaning of channels and catch basins	Weekly
	Cleaning of rubbish (removal of scattered rubbish)	Weekly
	Weeding of surrounding areas	Twice a year
Management road	Cleaning of road surfaces	Weekly
	Cleaning of channels and catch basins	Weekly
	Weeding of surrounding areas	Twice a year
	Visual check for cracks and fissures on slopes	Weekly
On-site road	Inspection of pavement for cracks, sinking and swell	Every inspection day
	Collapsed shoulders, soil spills	Daily
	Presence of standing water (if present, drainage should be carried out)	Daily

2.2.8 Stormwater balancing pond

The management points of the stormwater balancing pond are as follows. However, they should always be inspected in conjunction with inspections of other facilities immediately after heavy rainfall, earthquakes, etc.

If a large amount of sediment is deposited, the effective water depth cannot be guaranteed. If sediment and other materials are deposited on the pond bottom and discharge pipes and this is affecting the operation of the system, removal work should be carried out as soon as possible.

The storage structures of the stormwater balancing pond shall be visually inspected for cracks and other deformations in the concrete. The storage capacity shall be visually checked at the reference observation points and inspected once a week to ensure that there are no obstructions to the storage function. If any damage to the concrete is found during the inspection, it should be repaired immediately. In addition, a record and photographs of the repairs shall be reported as a repair record, and the location, date, time and outline of the repairs shall be recorded in the facility management daily report and kept with the repair record.

3 Maintenance of Refuse Collection Vehicles

Most refuse collection vehicles (RCVs) used in the Caribbean region are second- or third-hand, imported vehicles. As a result, original operating and maintenance manuals are often not available. This section provides information on the maintenance of such RCVs.

3.1 General inspection points

- Always carry out a pre-operational inspection before each working day (especially to check the safety devices).
- Carry out monthly and yearly periodic inspections. The inspection record must be kept for the entire period of use.
- Fluid and filters are consumables and should be replaced periodically (according to the manufacturer's instructions).
- The hydraulic pressure should be checked annually. (The hydraulic adjustment should be carried out by the manufacturer's service centre.)
- Be sure to wash the vehicle at the end of each working day. (Electronic parts must not be washed: see the manufacturer's manual.)
- If there is a problem with the vehicle, contact the nearest workshop designated by the manufacturer immediately.

3.2 Hydraulic equipment and driveline

- Each cylinder, drive unit (drive shaft, chain, etc.), and loading device is subjected to high loads in daily collection operations.
- Hydraulic pumps (plunger type, gear type, etc.), cylinders, electromagnetic valves, etc., which are precision parts, are used in hydraulic equipment, and hydraulic oil (oil) flows with high hydraulic force.
- Hydraulic oil, hydraulic hoses, sewage packing, etc. deteriorate day by day.
- Failure to regularly replace parts and lubricate the oil may not only cause breakdowns, but also accidents and disasters.

The following diagrams are examples of maintenance of the hydraulic equipment and driveline.

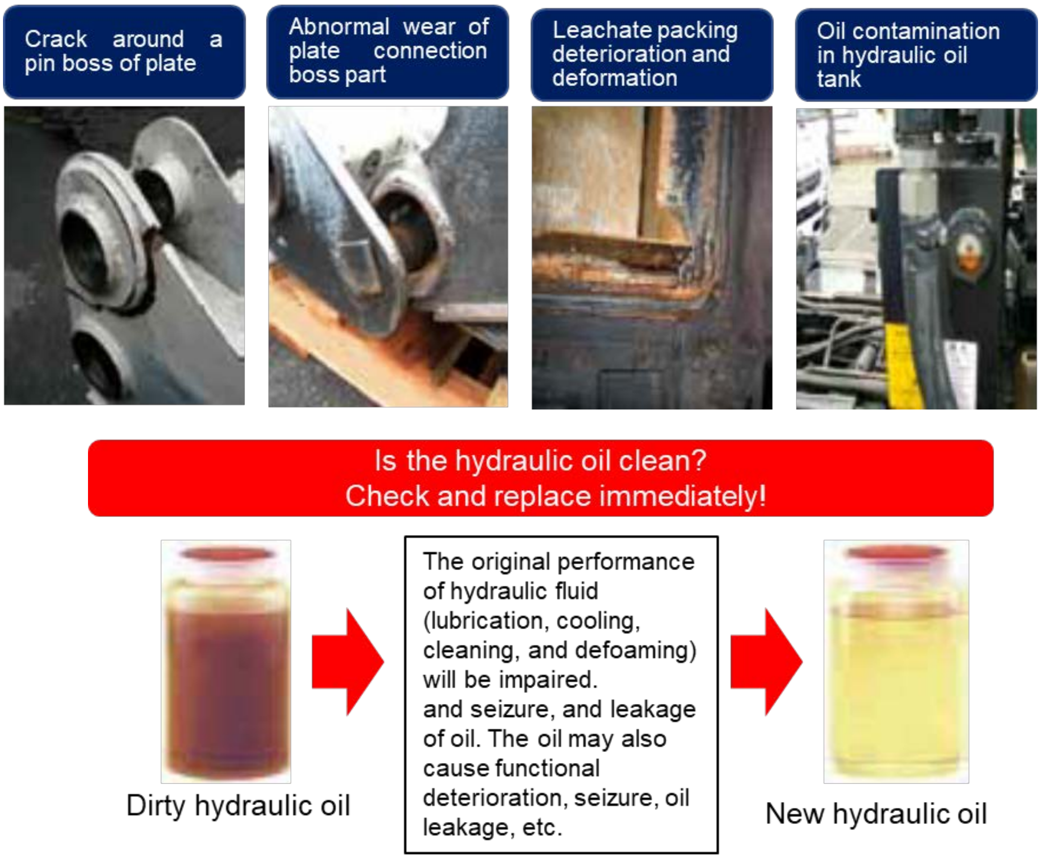


Figure 7: Hydraulic oil

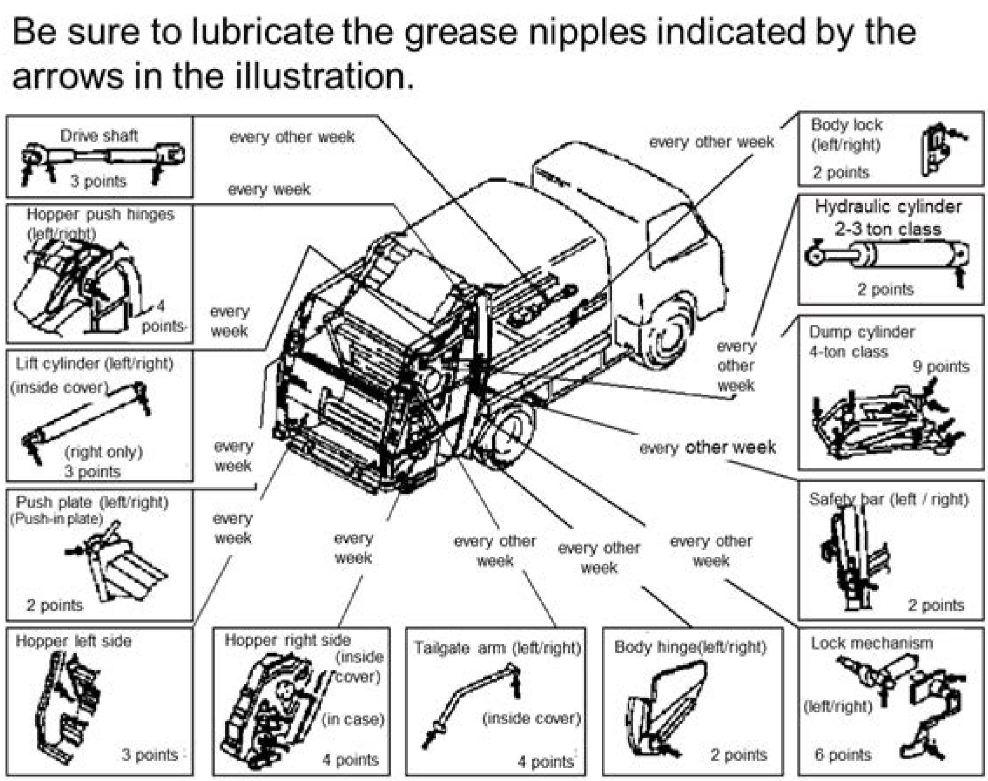


Figure 8: Lubrication

Figure 9: Inspection of consumables

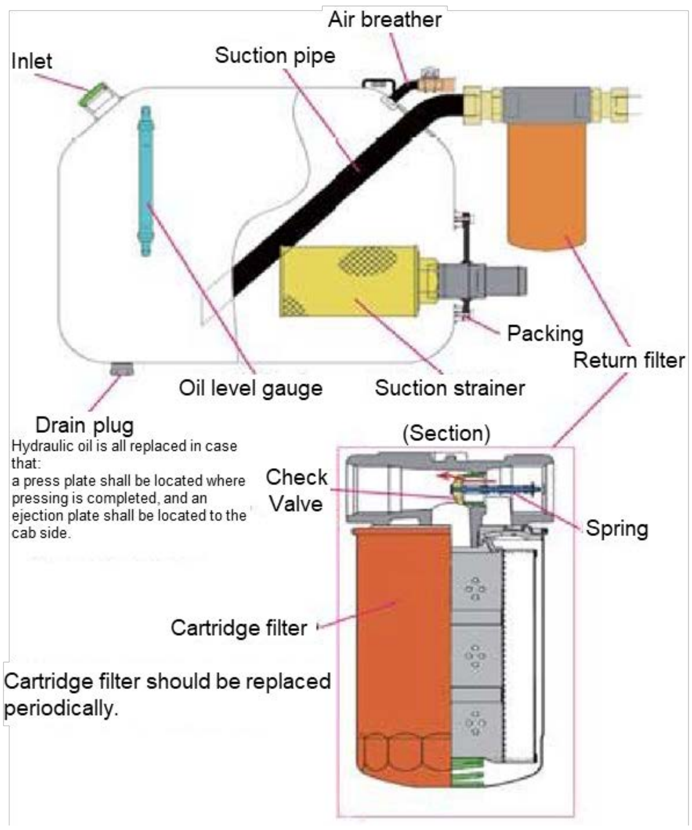


Figure 10: Structure of oil tank and filter

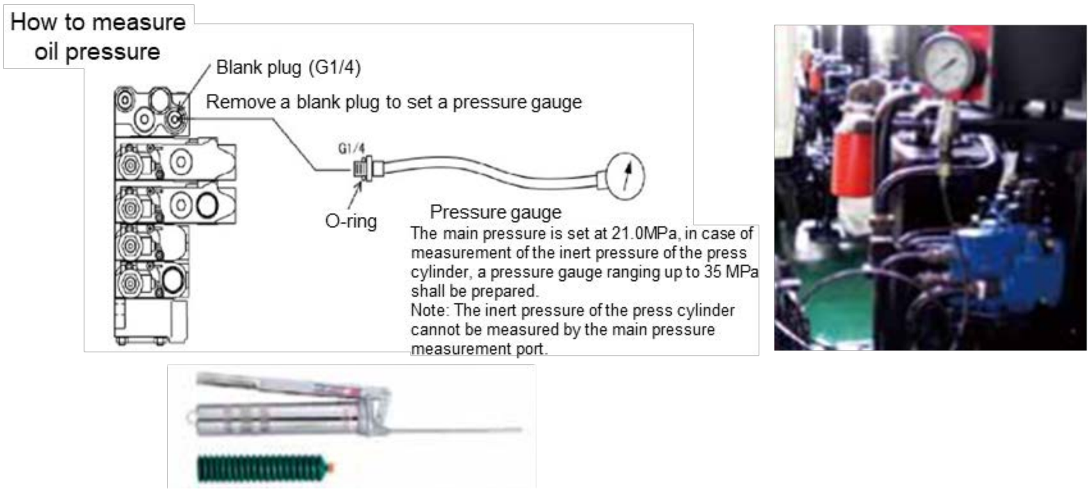


Figure 11: Inspection of oil pressure

3.3 Checkup sheet for a record

For daily or periodic inspection, a checklist should be prepared as shown in the table below.

Table 7: Checklist

Check Item: Classification	Check Item: Item(Site)	No	Inspection details	Lock	Ejection	Press	Lift	Pack	6 months	12 months	Inspection Results	Maintenance
Vehicles	Motor	1	Noise, rattle, looseness, heat generation, oil leakage, etc.						○	○		
	Power transmission equipment	2	Noise, rattle, looseness, heat generation, oil leakage, etc.						○	○		
	Traveling gear	3	Noise, rattle, looseness, heat generation, oil leakage, etc.						○	○		
	Control unit	4	Noise, rattle, looseness, heat generation, oil leakage, etc.						○	○		
	Braking unit	5	Noise, rattle, looseness, heat generation, oil leakage, etc.						○	○		
Hydraulic equipment	Hydraulic pump	6	Noise						○	○		
		7	Oil leakage						○	○		
		8	Loose mounting bolts						○	○		
	Hydraulic Cylinder			Lock	Ejection	Press	Lift	Pack				
		9	Damaged rod, oil leakage						○	○		
		10	Oil leakage						○	○		
		11	Abnormality of mounting part						○	○		
	Hydraulic oil	12	Amount of oil in tank, dirt (color)						○	○		
		13	Clean the strainer inside the tank							○		
		14	Filter Replacement							○		
	Rubber hose	15	Exterior damage due to contact, impact, etc.						○	○		
		16	Oil leakage, surface deterioration and cracking, etc.						○	○		
		17	Loose Tightening						○	○		
	Hydraulic Pipe Fitting	18	Loose tightening, oil leakage						○	○		
		19	Loose piping clamps, contact with other parts, etc.						○	○		
	Hydraulics	20	Check the prescribed pressure							○		
	Hydraulic valve	21	Oil leakage						○	○		
		22	Loose mounting bolts						○	○		
Electrical and control equipment	Loading switch	23	Check the operation of the rear switch						○	○		
		24	Damaged waterproof rubber cover, loose installation						○	○		
	Loading control	25	Operating position adjustment						○	○		
		26	Loose cam mounting bolts						○	○		
		27	Loose sensor switch mounting bolts						○	○		
		28	Loose relay/timer						○	○		
	Discharge Control	29	Operating position adjustment						○	○		
		30	Loose hopper close limit switch						○	○		
		31	Hopper lock activated						○	○		
	Wiring	32	Contact damage, connector ground corrosion, etc.						○	○		
	Rotary Solenoid (Engine constant rotation device)	33	Loose arms/wires, rattling of rods						○	○		

4 Hazardous waste treatment

Hazardous waste management is generally required to be carried out indoors and, in the case of final disposal, in a facility that is segregated from non-hazardous waste and completely isolated from the surrounding environment. The following points should be considered in practice:

- Store indoors (or in a covered area) prior to processing.
- If outdoor storage of hazardous waste is unavoidable, ensure that wastewater is properly managed.
- Stabilisation should be carried out indoors (or in a covered area).
- Wear protective equipment (eye protection, chemical resistant gloves and mask if necessary).

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Pilot Project Technical Note No.6

Conceptual Design for Remediation of Deglos Sanitary Landfill in Saint Lucia

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management
in the Caribbean Region

Pilot Project Technical Note No. 6

- Conceptual Design for Remediation of Deglos Sanitary Landfill in Saint Lucia -

Prepared by Yukihisa SAKATA, JICA Advisory Team
October 2023

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1 Introduction

1.1 Current situation and issues

Saint Lucia is an island country with a population of approximately 190,000 (2020) and its main industry is tourism. Solid waste management of the entire island is under the jurisdiction of the Saint Lucia Solid Waste Management Authority ("SLSWMA"). Waste generation per capita is estimated at approximately 1.2 kg/person/day, with a total generation of approximately 228 tons/day. Of this amount, 96%, or 219 tons/day, is collected and disposed of at the Deglos Sanitary Landfill, located in the northern part of the island. In recent years, the disposal volume remained stable, with the exception of 2021, when waste from hotels and ships drastically decreased due to COVID-19. In years when hotels and ships generate a lot of waste, plastic and paper waste make up a significant proportion of the waste. These reduce the capacity of the landfill due to their large volume.

Table 1: Waste Amount in St. Lucia

Item	2017	2018	2019	2020	2021
Waste disposal amount [ton/day]	226	206	215	219	180
Waste collection amount [ton/day]	226	206	215	219	180
Waste collection rate [%]	96%	96%	96%	96%	96%
Waste generation amount [ton/day]	235	215	224	228	188

Source: Prepared by JAT based on information from SLSWMA

Table 2: Waste Composition in St. Lucia in 2018

Component	Percent	Waste Quantity (tons)
Paper & Paperboard	12	53
Glass	4	18
Metal	3	13
Plastics	20	97
Textile	5	22
Organics	53	233
C & D Wastes	1	4

Source: SLSWMA

Currently, a World Bank intervention is underway to conduct a countrywide waste quantity and waste quality survey and to develop a national waste management strategy, which includes a feasibility study (F/S) on the development of a new sanitary landfill in the southern part of the island. However, even if a landfill were constructed based on this study, it would take some time before it could be put into service.

Therefore, the issue is to extend the life of the current Deglos Sanitary Landfill. However, the remaining capacity should be calculated based on the latest data, and there is a risk of collapse of the existing waste accumulation in the future, the leachate treatment pond does not operate as designed, and no gas vent pipe has been installed, which may cause a fire. To extend the service life of the sanitary landfill, each of these elements must be improved.

In fact, SLSWMA has been discussing and considering a comprehensive remediation of the Deglos Sanitary Landfill, and part of the budget for fiscal year 2023 has been approved.

1.2 Objective of the conceptual design

The objective of the conceptual design is to address the issues currently facing the Deglos Sanitary Landfill and to provide a way to extend the life of the landfill in a safe and environmentally sound manner. In this design report, this is referred to as "Remediation".

1.3 Contents of the conceptual design

This conceptual design covers the following items:

- Design conditions
- Overall layout plan
- Facility plan
    - Main facilities (landfill cell, landfill layer, leachate facility, stormwater facility and landfill gas facility)
    - Administrative and associated facilities (on-site roads and monitoring facility)
- Preliminary cost estimation
- Remediation project schedule

Annex

- Disaster prevention balancing pond plan
- Leachate collection and drainage calculations
- Leachate treatment facility plan
- Stormwater drainage plan
- Landfill operation and maintenance manual

2 Design conditions

2.1 Target area

The Deglos Sanitary Landfill and its surroundings (13°58'49.06"N, 60°58'38.90"W) constitute the target area and the blue line in the figures below shows the boundary of the Deglos Sanitary Landfill.

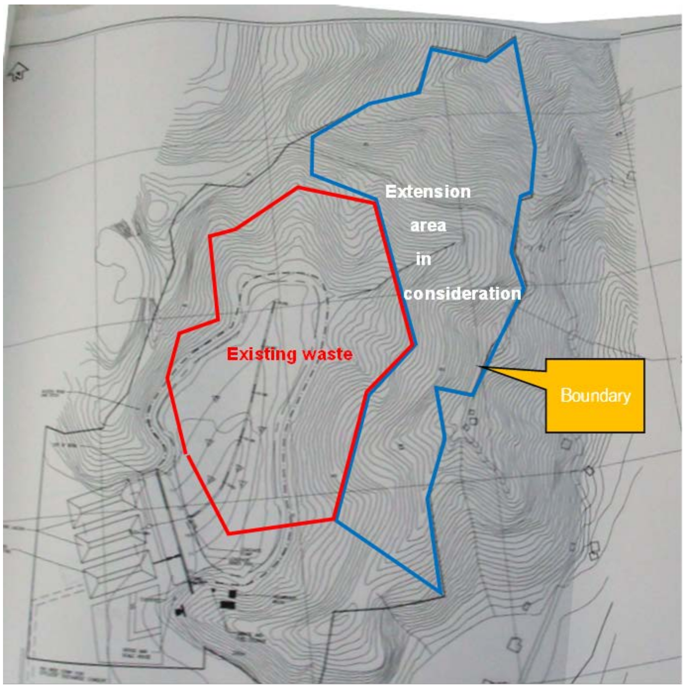


Figure 1: Deglos Sanitary Landfill

Figure 2: Deglos Sanitary Landfill (aerial photo)

2.2 Target year and expansion capacity

a. Target year

The target year is 2033. The lifespan of the landfill will thus be extended by 10 years. A new landfill is expected to be operational by then.

b. Expansion capacity

If the landfill continues to be operated as before, it will be full in about two years. The aim of the remediation is to secure the landfill capacity for the next 10 years. The amount of waste for the next 10 years is estimated based on 7 years of historical weighbridge data and estimated future population. The volume is estimated under the following conditions: the density of landfilled waste is 0.55 m^3/t and the amount of designed soil cover is 15% of landfilled waste. It is then calculated that an expansion volume of 1.72million m^3 is required to accommodate the waste over the next 10 years.

Table 3: Future waste amount projection

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Population	180,251	180,805	181,310	181,703	182,096	182,488	182,881	183,274	183,405	183,535	183,666	183,796
Per capita waste generation rate	1.2223354	1.2257884	1.2287795	1.2314178	1.2337779	1.2359129	1.2378619	1.2396549	1.2413149	1.2428603	1.244306	1.245664
Waste generation (ton/day)	220	222	223	224	225	226	226	227	228	228	229	229
Waste generation (ton/year)	80,419	81,116	81,318	81,670	82,003	82,548	82,629	82,927	83,097	83,488	83,416	83,566
Waste volume (0.55t/m^3)	146,217	147,484	147,852	148,490	149,096	150,086	150,235	150,776	151,085	151,796	151,665	151,939
Cover soil volume (15% of landfilled waste)	21,933	22,123	22,178	22,274	22,364	22,513	22,535	22,616	22,663	22,769	22,750	22,791
Total volume landfilled (m^3)	168,150	169,606	170,029	170,764	171,461	172,599	172,770	173,392	173,748	174,565	174,415	174,729
Accumulated landfilled volume (m^3)	168,150	337,756	507,785	678,549	850,010	1,022,609	1,195,379	1,368,772	1,542,520	1,717,085	1,891,500	2,066,229
	1	2	3	4	5	6	7	8	9	10		

Year	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Population	183,927	184,058	184,188	184,319	184,449	184,580	184,711	184,841	184,972	185,102	185,233
Per capita waste generation rate	1.2469443	1.2481554	1.2493044	1.2503973	1.2514394	1.2524351	1.2533884	1.2543028	1.2551814	1.2560267	1.2568414
Waste generation (ton/day)	229	230	230	230	231	231	232	232	232	232	233
Waste generation (ton/year)	83,712	84,082	83,989	84,122	84,252	84,610	84,503	84,624	84,743	85,093	84,975
Waste volume (0.55t/m^3)	152,203	152,877	152,707	152,949	153,185	153,836	153,641	153,862	154,079	154,714	154,500
Cover soil volume (15% of landfilled waste)	22,830	22,931	22,906	22,942	22,978	23,075	23,046	23,079	23,112	23,207	23,175
Total volume landfilled (m^3)	175,033	175,808	175,614	175,892	176,163	176,912	176,687	176,941	177,190	177,921	177,675
Accumulated landfilled volume (m^3)	2,241,263	2,417,071	2,592,684	2,768,576	2,944,739	3,121,651	3,298,338	3,475,279	3,652,470	3,830,391	4,008,066

Source of population data: Saint Lucia Population 2022 (Demographics, Maps, Graphs) (worldpopulationreview.com)

2.3 Other design conditions

i. Residents of private houses located south-east of the boundary accept the continued operation and remediation of the Deglos Sanitary Landfill.

ii. Due to the limited presence of power lines, the on-site roads surrounding the landfill area should be narrow, e.g. 1-2m wide.

iii. After the expansion, the sloping land to the south-east should be used for further expansion of the landfill area.

iv. A groundwater drainage system has been installed under the landfill layer. Therefore, the function of the groundwater passage is continuously maintained.

v. A concrete drainage system already exists in the south, therefore the newly constructed drainage channel should be connected to the existing channels.

vi. The pond should be surrounded by concrete walls to store leachate as before. The function of this pond is the sedimentation of polluted particles in the leachate.

vii. The stabilisation pond will remain the same with fully covered HDPE liners.

3 Overall layout plan

The overall layout plan is shown in the figures below.

The scope of the remediation includes the construction of the embankment as well as improvements to the stormwater drainage and the leachate treatment systems.

The new embankment is designed to accommodate future waste accumulation at the bottom of the slope and will be sufficiently stable under its own weight on a gentle slope.

Leachate will be collected in the sedimentation tank, which will replace an existing open sump. The tank will be constructed of concrete to store all incoming leachate from the landfill layer for sedimentation prior to treatment.

Leachate entering the treatment pond from the sedimentation tank will be subjected to a process of multi-stage gravity aeration.

For stormwater drainage, open channels will first be installed around the perimeter of the landfill area to prevent rainwater from the landfill area, particularly from the north and east, from entering the stormwater balancing pond. A large pipe (1800 mm diameter) will be re-laid from the stormwater balancing pond to convey the water to the discharge point. The access road currently in the middle of the landfill will be moved to the west side.

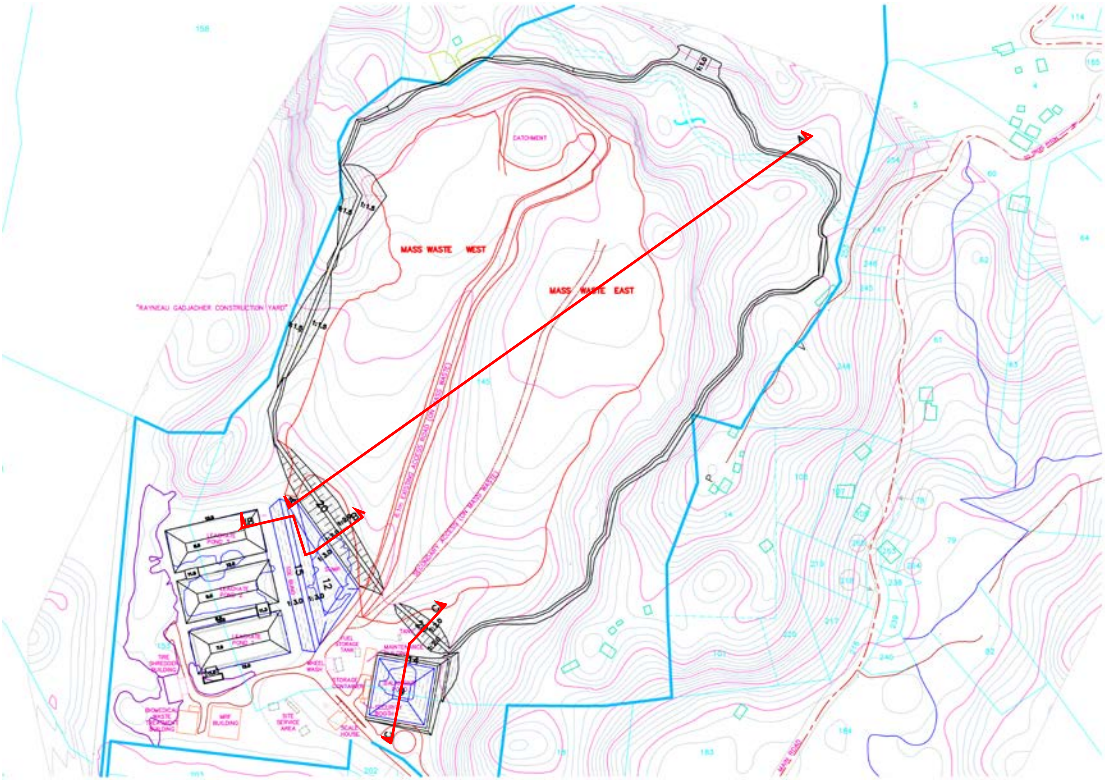


Figure 3: Overall layout

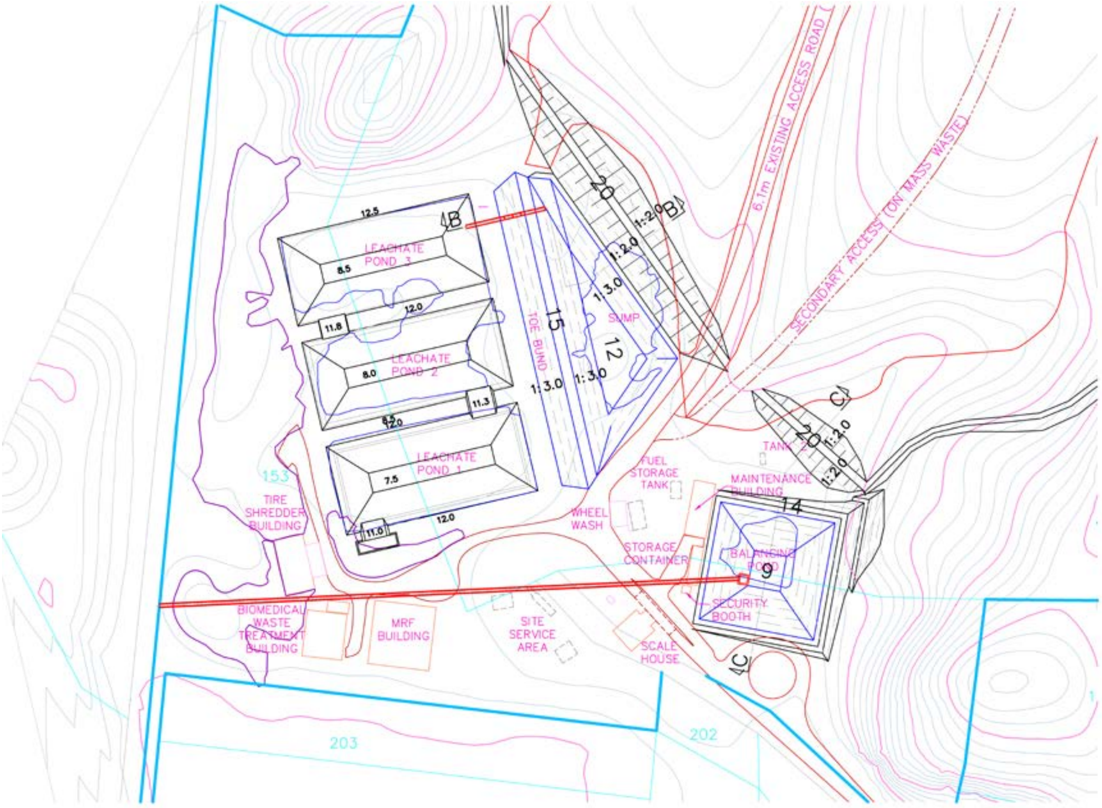


Figure 4: Leachate treatment and stormwater balancing ponds

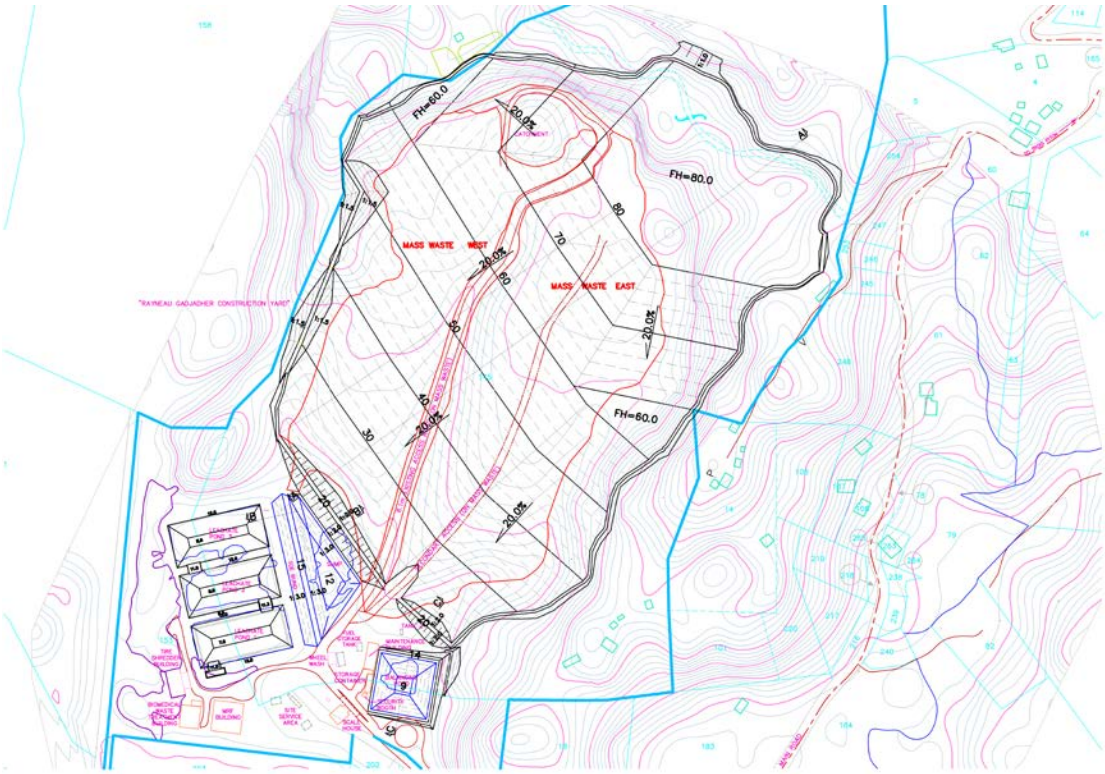


Figure 5: Overall layout after closure

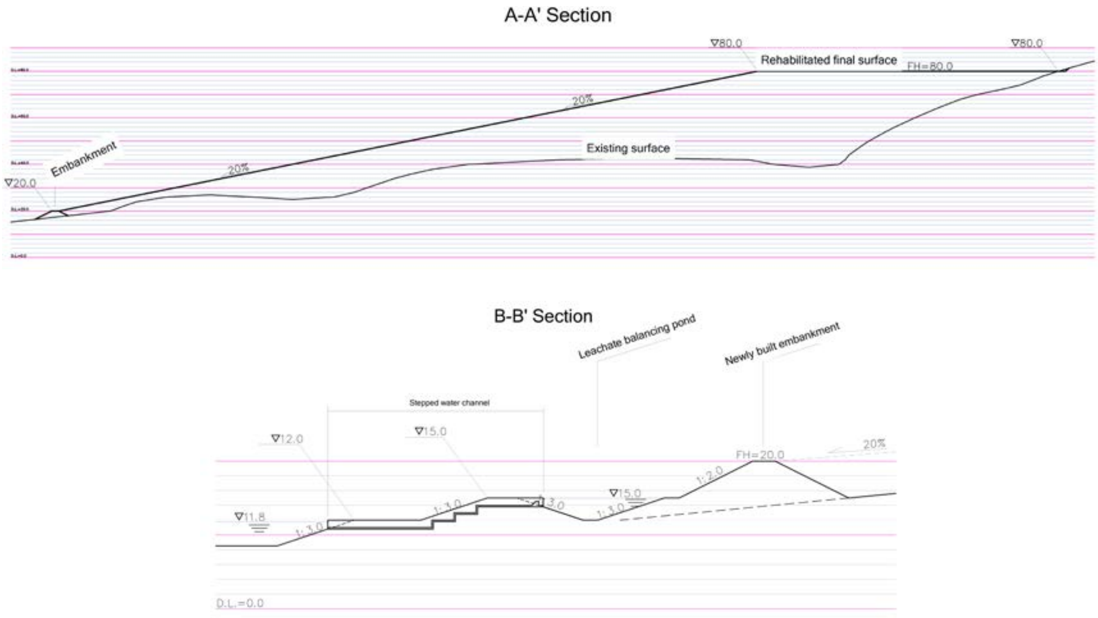


Figure 6: Cross-sectional view (after improvement)

4 Facility plan

4.1 Landfill structure

4.1.1 Landfill structure in the original design

The figure below shows a representative section of the landfill structure. The original ground is clay with low permeability. Due to its impermeability, this structure does not require any artificial liner sheet to prevent leachate leakage. Leachate generated in the landfilled waste layer above this structure is collected by three main perforated drainpipes and flows down to the leachate treatment pond through the sump.

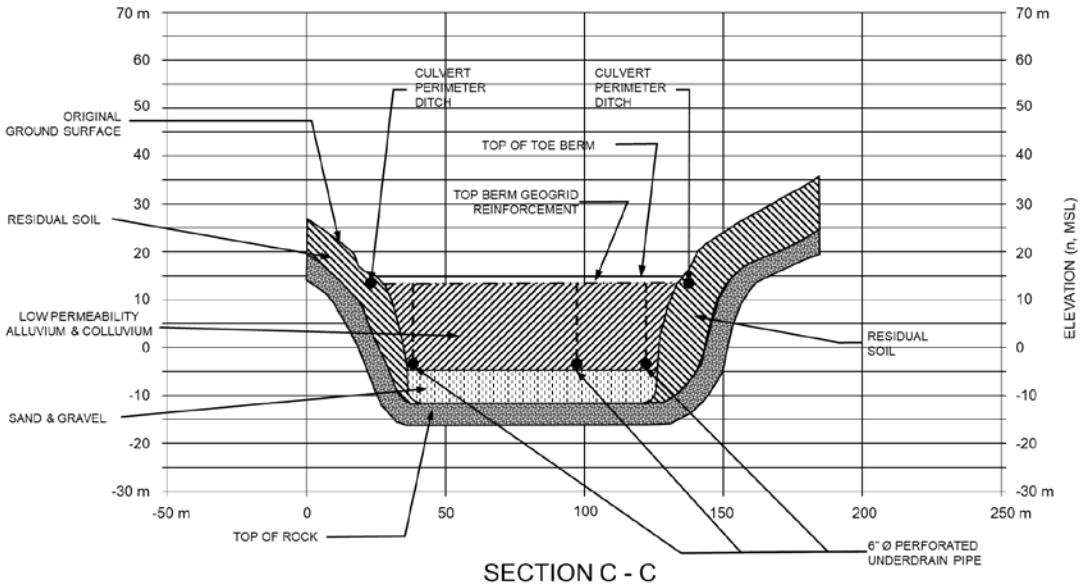


Figure 7: Representative section of landfill structure in the initial design

4.1.2 Landfill structure in the remediation plan (Semi-aerobic landfill structure)

The figure below shows a standard sectional drawing of the landfill structure in the remediation plan. Perforated leachate collection and gas vent pipes are installed on top of the existing waste layer. In order to promote the decomposition of the waste in the waste layer, the gas vent pipes are installed vertically on top of the leachate collection pipes. Ensuring air flow in the waste layer is very important in semi-aerobic landfills.

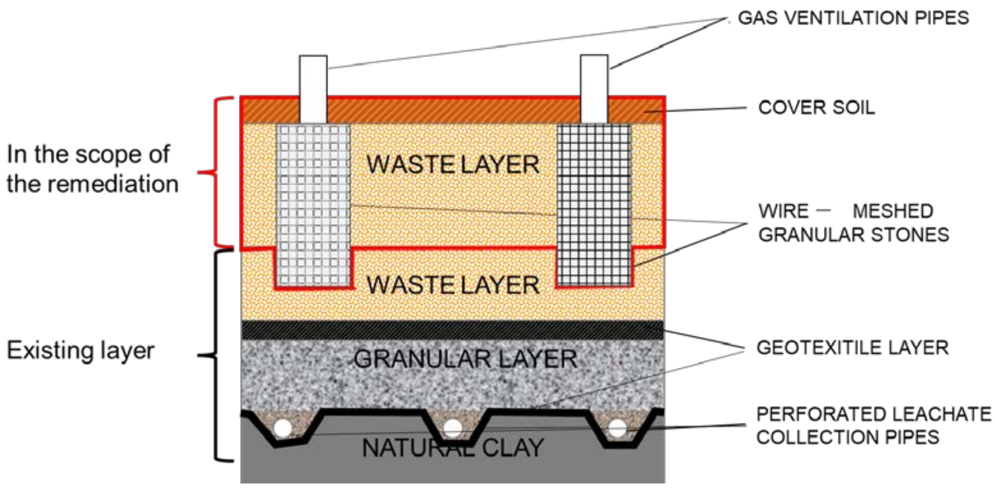


Figure 8: Section of liner structure in the remediation plan

4.1.3 Landfill slope stability

To ensure the stability of the slope, step cutting of the existing layer is first carried out in order to unify both the existing layer and the new layer.

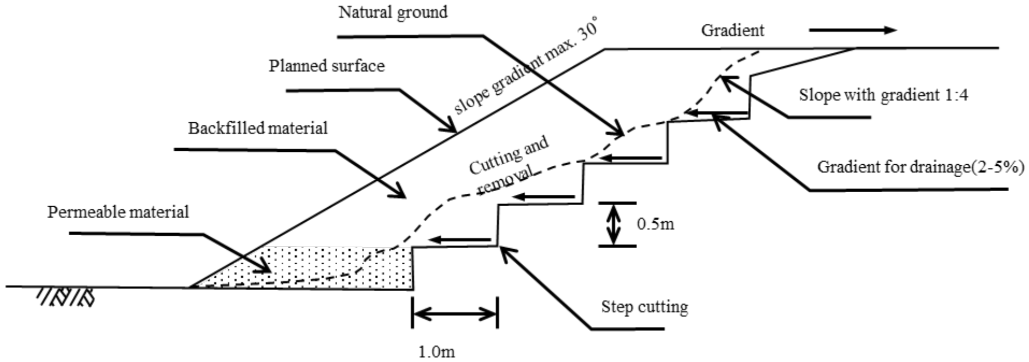


Figure 9: Step cutting on the slope

A slope protection system is often installed at the foot of the slope. It consists of protective walls and open channels to allow smooth drainage from the slope as shown in the figure below.

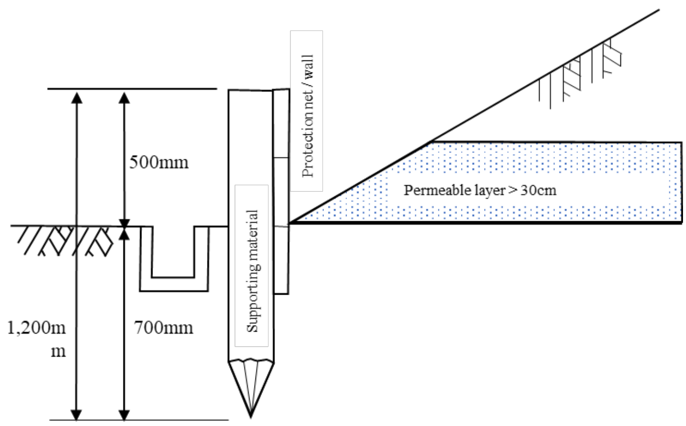


Figure 10: Slope protection system

4.2 Leachate collection system

4.2.1 Purpose and function of the leachate collection and drainage system

Rain that falls on the landfill surface becomes leachate. The purpose of the leachate collection system is to convey the leachate to the leachate treatment system without delay. It should be constructed according to the principle of “prompt drainage of leachate from the landfill”.

According to the technical standards established by the government of Japan, “landfills shall be equipped with culverts and other collection and drainage facilities of leachate”. Furthermore, with respect to the calculation of pipe diameter, the performance guidelines state the following:

- The water level in the landfill shall be less than 50 cm according to the design rainfall intensity, e.g. the average daily rainfall during the month of maximum rainfall.
- The diameter of the pipes shall be large enough to allow for aeration.

If the landfill structure is semi-aerobic, the leachate collection and drainage pipes shall also serve as air supply pipes.

4.2.2 Leachate collection and drainage system

Leachate collection and drainage systems are generally classified as shown in the figure below.

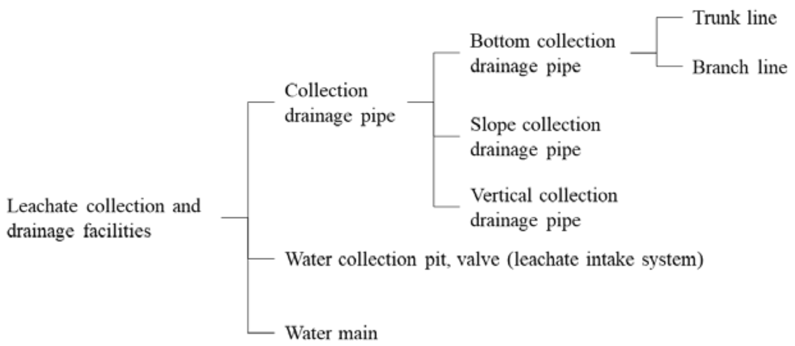


Figure 11: Leachate collection and drainage systems

A conceptual leachate collection and drainage system is shown in the figure below.

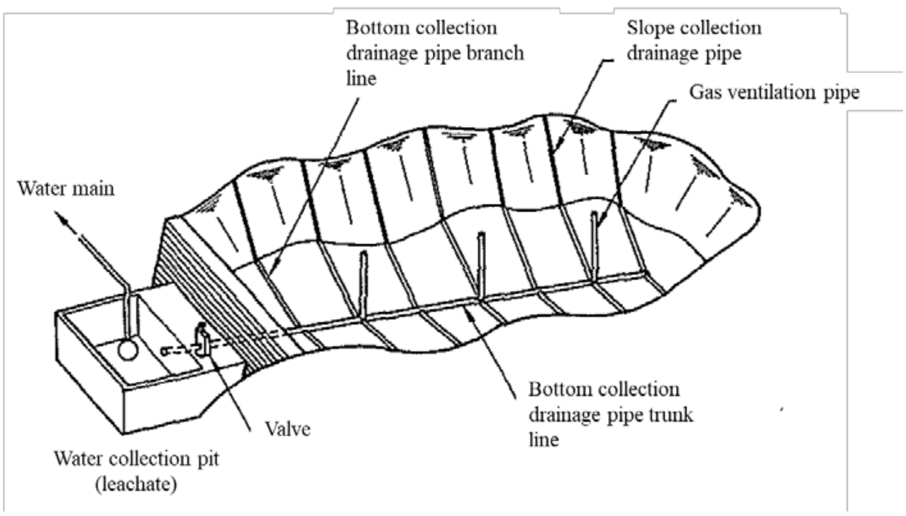


Figure 12: Conceptual layout of a leachate collection and drainage system

4.2.2.1 Layout and structure of leachate collection and drainage systems

a. Layout of collection and drainage pipes

Depending on the shape of the landfill and the landfilling method used, collection and drainage pipes are placed at the bottom as shown in the figures below.

If the waste layer is thick, collection and drainage pipes may be placed in the middle layer as necessary to ensure collection and drainage of leachate.

The distance between the placement of the support lines (branches) should be 10 to 20 m. In addition, there should be at least one vertical collection and drainage pipe every 2,000 m^2. In other words, a spacing of approximately 45 m is required ($\sqrt{2{,}000m^2} \simeq$ 45m)[1].

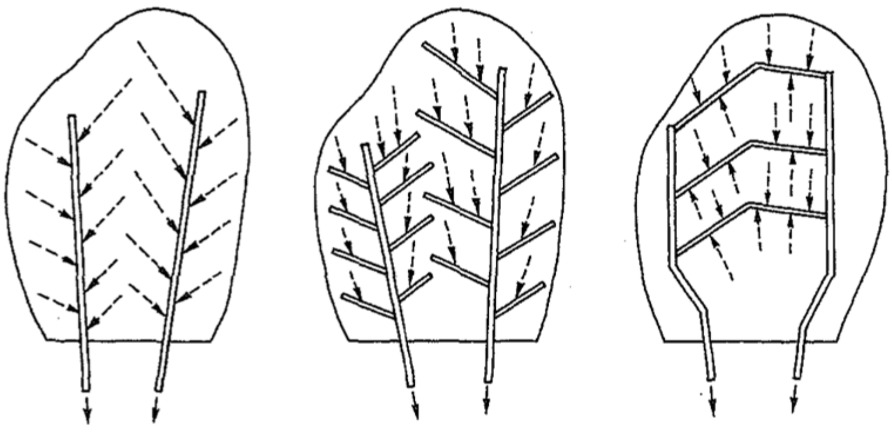


Figure 13: Example of bottom collection and drainage pipe arrangements

b. Materials of leachate collection and drainage systems

The following table shows common materials for leachate collection and drainage systems.

Table 4: Materials for leachate collection and drainage systems

Materials	Characteristics
Perforated Concrete Pipe	Widely used from water collection pipes to drainage pipes. Its high rigidity makes it suitable when deformation of pipes is to be avoided.
Perforated Synthetic Resin Tube Reinforced plastic tube Rigid polyethylene pipe Rigid polyvinyl chloride pipe	Widely used from water collection pipes to drainage pipes. Due to its high flexibility, it can follow ground subsidence to a certain extent. Generally resistant to corrosion, depending on the material. The coating is light and relatively easy to treat, which makes it easy to install.
Gravel, crushed stone, etc. (Horizontal drainage layer)	The collection and drainage effect can be improved by using a bottom drainage system in conjunction with a water collection pipe. In order to prevent damage to the impervious sheet, gravel and crushed stone layers should not be laid directly on top of the impervious sheet but should be laid on top of it via a protective material.
Geo-composite (Synthetic drainage material)	In addition to being an intermediate protection material for double impervious sheets and horizontal drainage material, it is often used for drainage collection on slopes because of its easy installation.

[1] Japan Waste Management Association, Guidelines for designing and planning the construction of a final disposal site, 2020, p.312.

4.3 Leachate treatment facility

4.3.1 Calculation of leachate amount and capacity of the leachate balancing pond

The leachate treatment facility plan has been developed according to the “Guidelines for the Planning, Design, and Management of Final Waste Disposal Facilities” (Japan Waste Management Association).

The design influent rate of the leachate treatment plant was set between the maximum and minimum of the design influent rate of the leachate treatment plant. The capacity of the leachate balancing facility has been set so that the amount of leachate exceeding the treatment capacity of the leachate treatment plant can be stored in the leachate balancing facility.

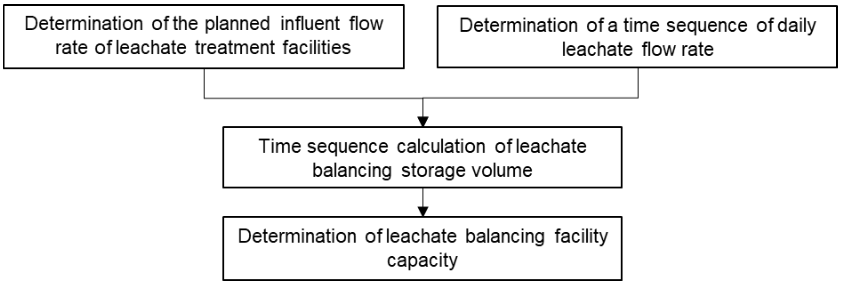


Figure 14: Method for determining the size of the leachate balancing pond

Using local rainfall statistics, a treatment plant with a capacity of 300 m^3/day and a leachate balancing pond with a capacity of 5,500 m^3 have been constructed.

Since the above capacities could be met with the existing ponds, it was decided not to increase the number of ponds.

The calculation procedures are described in more detail in the Annex III Leachate treatment facility plan.

4.3.2 Design discharge criteria for the leachate treatment facility

When designing a leachate treatment system, certain parameters concerning the concentration of contaminants are required. Once the criteria have been defined and the target concentration of raw leachate is set, the design can be considered.

These design criteria are not effluent and environmental standards but are for design purposes only.

a. Definition of the discharge point

The outlet of the mixing box should be the leachate discharge point. In this box, the leachate is mixed with stormwater, which reduces the concentration of pollutants. This point is important to meet the existing pollutant criteria recommended by CARPHA. These figures from CARPHA are relatively low.

b. Handling of chemical compounds related to pesticides

As part of the periodic environmental monitoring, many parameters need to be analysed for pesticides. However, pesticide purification requires certain types of advanced technologies such as ozonolysis / UV irradiation. Therefore, chemical compounds related to pesticides are not considered in the design criteria.

c. Recommended design discharge criteria for leachate

In the design concept developed by SLSWMA and JAT, a cost-effective treatment system with low energy consumption is recommended. Thus, general and representative indicators of design discharge criteria are suitable. On the other hand, the criteria must confirm the effectiveness of the leachate treatment system.

In addition to basic conditions such as temperature, pH, and EC, the design criteria for leachate are shown in the table below.

Table 5: Design criteria for leachate in Deglos Sanitary Landfill

Parameter	Limit*	Lab's recommendation
COD[2]	90 mg/l	30 mg/l
BOD[3]	60 mg/l	30 mg/l
Oil and Grease	30 mg/l	15 mg/l
TSS[4]	60 mg/l	30 mg/l
TN[5]	60 mg/l as daily average	80 mg/l
Nitrate	Not stipulated**	5 mg/l
Ammonia Nitrogen		10 mg/l
Coliform	200 CFU/100 ml	200 CFU/100 ml

*: Parameters from the Ministry of Health
**: To be analysed, these parameters are evaluated as TN.

For Phosphates, criteria should be set based on cost-effectiveness.

4.3.3 Leachate treatment system

a. Water quality analysis

Water quality analysis was conducted. The results showed that the difference with and without aeration was in the number of coliforms, which was 1,000 CFU/100 ml and 4,000 CFU/100 ml, a significant difference. There were no differences in other pollutant indicators. On the other hand, there were no significant differences linked to the purification function of the wetland installation, and the results of this experiment did not confirm the effectiveness of the wetlands. Details are shown in the attached document "Water analysis results".

Although the experiment did not confirm the effectiveness of the wetlands, there are many examples of wetland installation around the world. Therefore, this wetland technology can be introduced and contaminant removal is expected. The C/P has already identified the plant species (Vetiver) and the source of procurement has been confirmed.

The C/P plans to conduct a wetland experiment using the leachate treatment pond at the existing landfill. A modification of the leachate treatment system will be designed based on the results of the experiment.

b. Determination of leachate treatment system

According to the C/P, regular water quality analyses are carried out annually at various locations (more than 30 points). Only the main organic pollutants can be treated without the use of chemicals or electrical equipment. Regarding the improvement of leachate treatment, the C/P considered that in the past leachate treatment had become uncontrollable due to aerator

[2] COD: Chemical Oxygen Demand
[3] BOD: Biochemical Oxygen Demand
[4] TSS: Total Suspended Solids
[5] TN: Total Nitrogen

failures. A gravity flow leachate treatment system was preferred to the installation of an electric aerator as originally recommended by the experts. The plan for the treatment system is shown in the figure below:

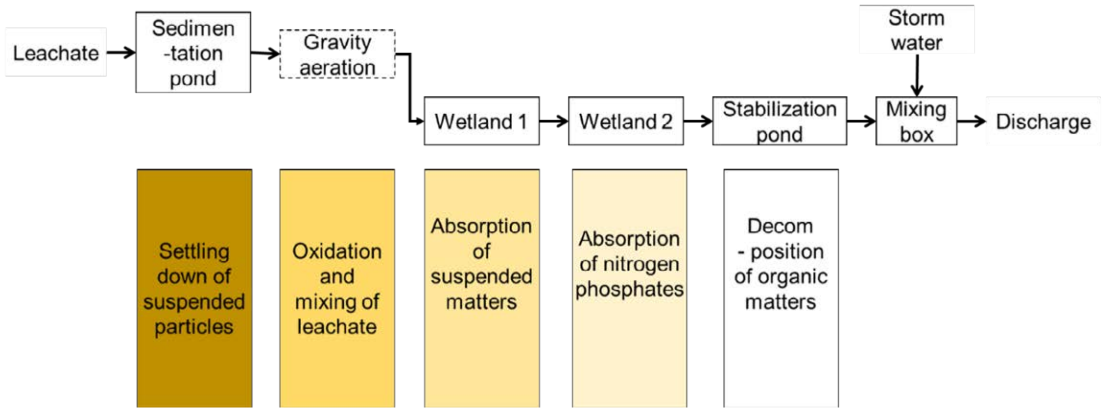


Figure 15: Leachate treatment system

In this system, once the leachate has been collected, it enters a sedimentation pond to allow suspended matters to settle down. Since the sedimentation pond is located at a relatively high elevation, the system takes advantage of the drop-off to provide gravity flow aeration as the leachate flows into the leachate treatment pond. After the aeration, organic pollutants are adsorbed and decomposed in the wetland, and leachate from these processes is allowed to flow downstream over a certain period and eventually discharged into an environmental water body (Cul de Sac River) with some stormwater mixture before discharge. The wetlands will be installed on the second pond, with some plants in the first pond. The planar flow is shown in the figure below:

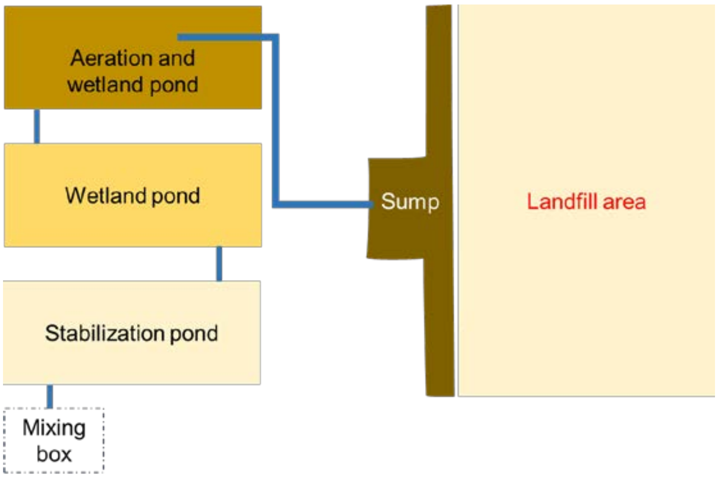


Figure 16: Leachate treatment system (planar view)

Since the depth of each pond where the wetlands are to be installed is approximately 3 m, and the plant species (Vetiver) to be used for wetlands are immersed at a depth of 50 cm, the bottom of the ponds will be elevated for installation as shown in the figure below. SLSWMA is elevating the bottom of the pond as part of a specific wetland project. As shown in the figure below, clay soil is used for the elevation. In this context, the plan was developed to allow for dredging of accumulated sludge and other materials and replacement of plant species every few years.

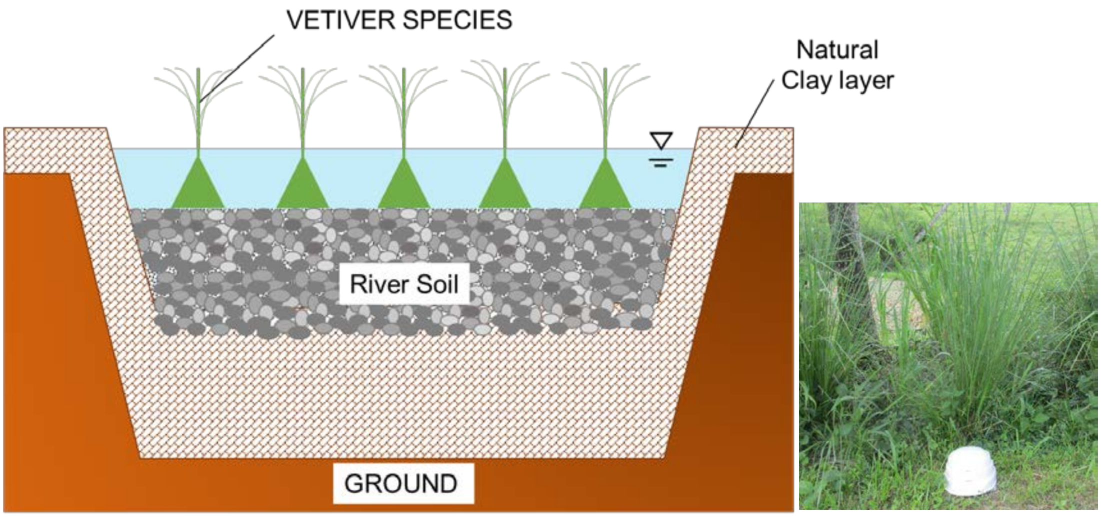


Figure 17: Wetland installation method

4.4 Stormwater drainage system

The existing landfill has an issue with insufficient separation of leachate from stormwater flowing from outside of the landfill area. Due to this uncontrolled situation, the leachate treatment system receives a large amount of leachate from the landfill area via a sump. This could result in a shortage of hydraulic retention time of the leachate in the treatment system.

By avoiding the stormwater to come into the landfill area, the leachate treatment system could operate appropriately. For this purpose, a stormwater drainage system is installed all around the landfill area, which allows all the stormwater to be routed to a balancing pond.

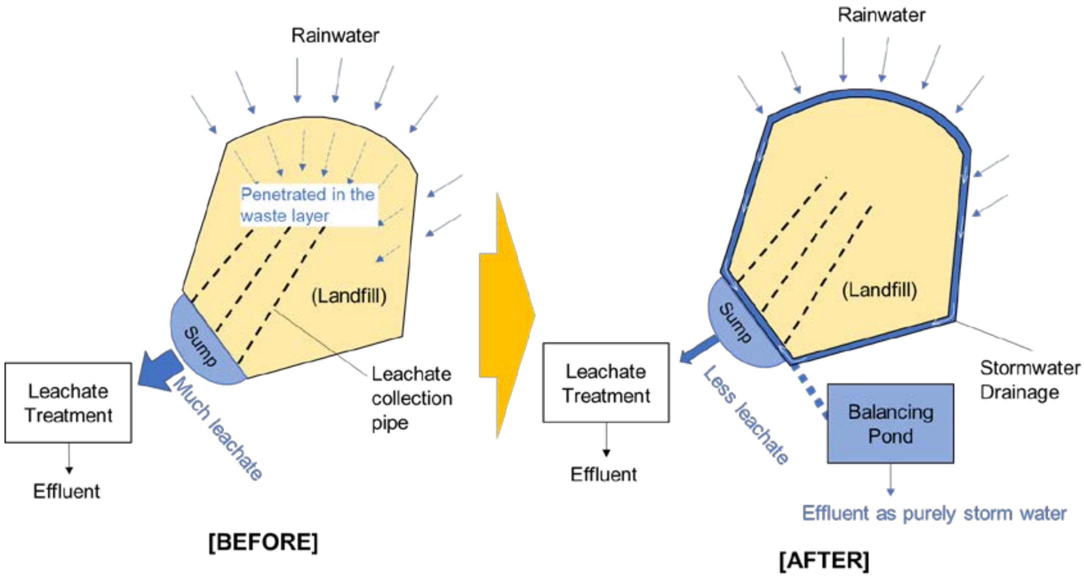


Figure 18: Stormwater and leachate control in the remediation

4.4.1 Stormwater drainage plan

This project includes a drainage system for rainwater from the surface of the final soil cover after the landfill is completed. The size of the drainage system will be defined based on the landfill after remediation.

Figure 19: Stormwater catchment area (C-1 to C-10)

Open channels will be installed around the perimeter of the landfilling area to quickly conduct stormwater to a balancing pond located downstream. In addition, a simple walkway will be provided in the drainage channel to allow workers to enter the area for inspection (see figure below).

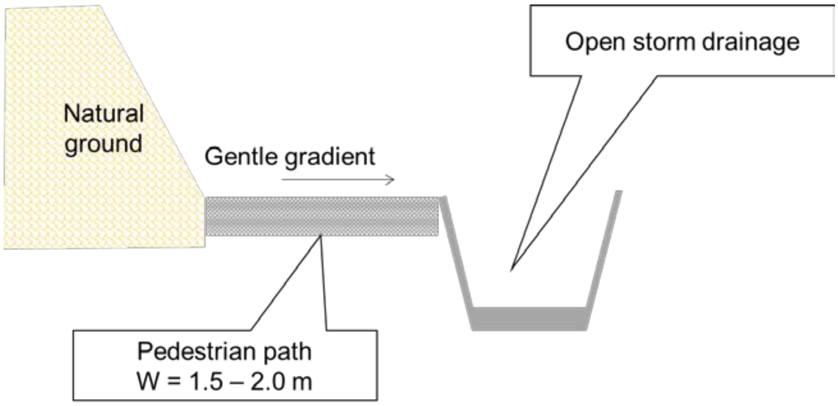


Figure 20: Storm drainage channel around the perimeter (standard section)

Figure 21: Storm drainage plan (dark blue line)

The drainage system will be installed at the height of the final shape of the waste cells and the capacity of the balancing pond will be extended. Four culverts will be installed under the access road for the transport of waste and cover soil.

4.4.2 Calculation of the capacity of the drainage system and the stormwater balancing pond

In order to receive and drain all the rainwater captured by the landfill site, it is necessary to ensure sufficient capacity of the drainage system. The results of the calculation for the drainage system are described in the Annex "Disaster Prevention Balancing Pond Plan".

The minimum capacity of the balancing pond is 3,823 m^3 and a new concrete pipe with a diameter of 1,800 mm is necessary for the evacuation of the water received from the balancing pond.

4.5 Gas ventilation system

The gas ventilation system is expected to enhance the aerobic decomposition of organic matters in the waste layer by drawing in air.

The figure below shows a standard type of gas ventilation unit. A vertically installed pipe needs sufficient diameter, and the pipe is wrapped with medium-sized stones in order to gather the various gases generated in the waste layer.

If the ventilation system is raised to allow higher accumulation of waste, a new perforated pipe is covered with the same wrapping material. At the contact faces between the new and old pipes, complete contact is not necessary because the waste accumulation could support the ventilation by piling up the waste.

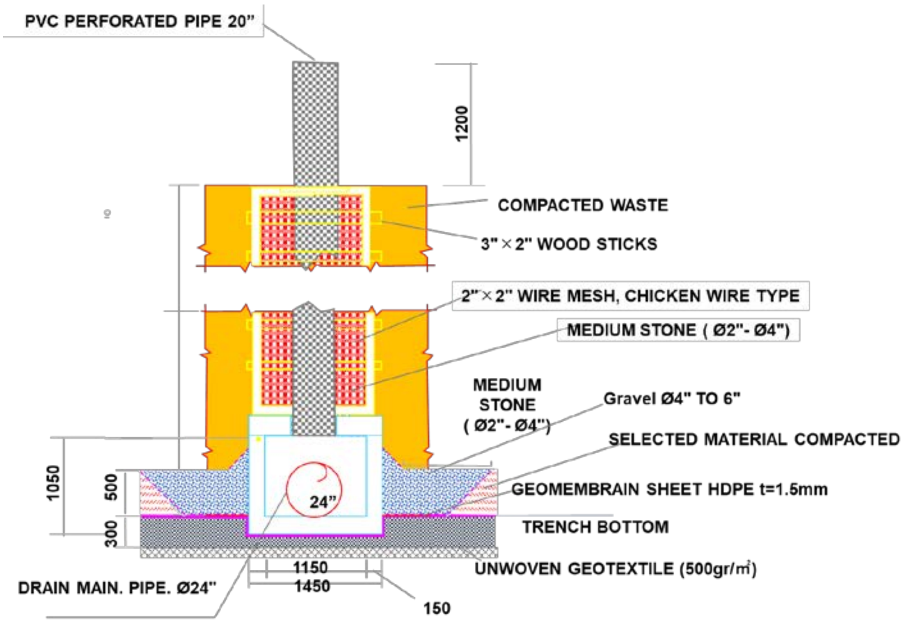


Figure 22: Gas ventilation unit

4.6 On-site road plan

On-site roads include maintenance roads and temporary roads. The maintenance roads are permanent roads, while the temporary roads are temporary for incoming vehicles unloading waste.

4.6.1 Roads for waste unloading

The existing temporary roads are used for unloading waste and they all have temporary drainage channels on both sides. In Saint Lucia, all roads have drainage system for brief and intense rainfall.

During the construction phase of the embankment, the temporary road needs to be moved from its current location and it should be a temporary road that can be used even during the installation of the embankment.

For the further discussion, the design of the temporary road shall be by SLSWMA and the Contractor.

There is one issue on the existing temporary road leading to the top of the dumping area. A stormwater drainage system of a similar level to the current one is required, however, the current stormwater drainage system should also eliminate obstructions in the stormwater trenches as there are areas where waste accumulates.

4.6.2 Maintenance roads

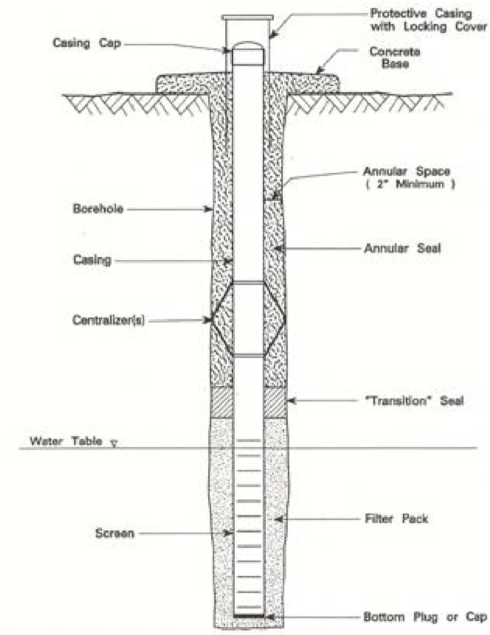
For the maintenance of the rainwater drainage system, maintenance roads are built around the perimeter of the landfilling area.

The width of the road is 1.5 to 2.0 m to ensure that all the drains can be maintained manually. Therefore, there is no passage of vehicle or other machinery units.

4.7 Monitoring system

A monitoring facility is installed to monitor whether polluting substances leak from the landfill site. Therefore, it should be installed downstream of the natural waterflow of the landfill. In addition, in order to compare the state of the surroundings, another monitoring device is installed upstream of the natural waterflow. Generally, monitoring wells are installed to monitor the state of operation.

In the remediation plan, two monitoring wells are installed upstream and downstream respectively. The figure below shows a general monitoring well for landfill operation.



Source: California Department of Water Resources

Figure 23: Typical monitoring well (section)

Regarding the monitoring parameters, they should be determined continuously, thus electrical conductivity (EC), pH and other major parameters are recommended.

5 Preliminary cost estimation of the remediation project

Based on the design under the above conditions, the construction quantity was calculated and multiplied by the unit cost to obtain the entire estimated construction cost of the project.

The unit prices were set based on the unit price of the small embankment installation carried out during the second visit. The rest of the hidden costs have been inferred from Japanese examples, taking into account the gap of economic situations between the Caribbean region and Japan.

It should be noted that the importation of certain construction materials may be considerably more expensive than the procurement of materials from the American continent, due to transportation costs and the frequency of procurement in Saint Lucia. Currently, since the project is at the stage of estimated cost, it is unlikely to be a problem. However, in the actual implementation of the project, it will be important to take measures such as conducting soundings to potential contractors, etc., who can participate in the project.

The next page shows a breakdown of the estimated project cost.

The overall total is approximately 6.3 million U.S. dollars, or 930 million Japanese yen. In addition, the following costs will be required: a topographic survey (about USD 3,000), geotechnical survey of the embankment foundation (about USD 3,000), and detailed design (about 5 – 10 % of the total project cost).

It is assumed that it would take about two to three years to complete the improvement project all at once. It would be realistic to divide the works into at least two categories given the present situation at the Deglos Sanitary Landfill: i. works that should be done immediately and ii. other works that will be carried out successively in the coming years.

Table 6: Estimated project cost breakdown

Category	Item	Qty.	unit	Unit price USD	Price '000USD	Remarks
Structure construction					<1,581>	
	Clearing and stumping	54,000	m^2	3.70	199	
	Earth cutting	17,300	m^3	12.67	219	Excavator Bucket1.0cu.m
	Loading and transport	17,300	m^3	5.56	96	Move inside the site
	Embankment	17,300	m^3	45.79	792	Dozer 21t-class
	Trimming and clearing slopes (cutting)	8,100	m^2	5.56	45	
	Trimming and clearing slopes (filling)	5,900	m^2	14.81	87	
	Greenary planting on slopes	11,300	m^2	12.67	143	Spraying t ＝2cm
Storm water drainage system					<1,631>	
	Concrete channel wire meshed	350	m	150.38	52	In site concreting works U-1000×600×400 t=150
	Concrete channel wire meshed	350	m	195.49	68	In site concreting works U-1200×400×800 t=150
	Concrete channel wire meshed	350	m	210.53	73	In site concreting works U-1500×700×800 t=150
	Concrete channel wire meshed	400	m	210.53	84	In site concreting works U-1700×800×800 t=150
	Access chamber	17	pts	1,390.98	23	In-site concreting works
	Stormwater balancing pond					
	Desilting	1,600	m^3	4.21	6	
	Trimming and clearing slopes (filling)	1,800	m^2	14.81	26	
	Effluent pipes	210	m	6,152.63	1,292	φ1800 Hume pipe
	Surge tank	1	set	7,518.80	7	2800 × 2800 × 6000
Leachate collection and drainage system					<178>	
	Leachate collection tank	2	set	41,353.38	82	2000 × 2000 × 6000
	Leachate collection pipes (Core lines)		m	601.50		φ800 HDPE perforate pipes
	Access chamber for leachate		m	601.50		φ800 HDPE non-perforate pipes
	Leachate collection pipes (sub collection lines)		m	48.00		φ200 HDPE perforate pipes
	Gas ventilation pipe (slope-installed)	700	m	48.00	33	φ200 HDPE perforate pipes
	Gas ventilation pipe(vertically-installed)	50	pts	1,278.20	63	φ500 HDPE perforate pipes
Reception control equipment					<105>	
	Internal roads	700	m	150.38	105	Concreting pavement W=7.0m t=230mm
Leachate treatment plant					<480>	
	Leachate collection pond					4,300m3
	Desilting	2,200	m^3	4.21	9	Excavator Bucket1.0cu.m
	Trimming and clearing slopes (filling)	3,000	m^2	14.81	44	
	Greenary planting on slopes	1,100	m^2	12.67	13	Spraying t=2cm
	Stepped channel	20	m	225.56	4	In-site concreting works 1000×1000
	leachate treatment pond					300m^3/day
	Desilting of leachate ponds	15,600	m^3	4.21	65	5200m^3×3pcs
	Overflow channel	3	pts	7,518.80	22	
	Trimming and clearing slopes (filling)	6,000	m^2	14.81	88	2000m^2×3pts
	Foundation installation	12,000	m^3	18.57	222	4000m^3×3pcs Gabion
	Wetland installation	3,600	m^2	3.01	10	1800m^2×2pts
	Discharging point	1	pts	3,759.40	3	
Direct expense					3,975	
	Temporary works				397	10% of direct expense
	General expense and tax				1,311	30% of direct expense and temporary works
Sub-total					5,683	
Contingency cost					568	10% of sub-total cost
Grand total					6,251	

6 Remediation project schedule

6.1 Phase setting for the remediation project

The total cost for the remediation is calculated in Chapter 5, however, the budget securement and the budget allocation of an amount over USD 6 million represent an important decision for a single island country.

Therefore, it is important to divide the project into several phases, prioritising and implementing one phase after another.

As described in the design concept, the priority is to secure the remaining volume for landfilling in the future. Then follows a comprehensive stormwater drainage system for protecting the landfill layer. The leachate treatment system is a very important function, however, since the continuous operation of the landfill is essential in the remediation project, these prioritizations are supposed to be rational for the near future in Saint Lucia.

The tables shown below are breakdowns of each phase (Phase 1, 2, and 3).

For Phase 1, the cost can be divided into two components, namely the western embankment and the eastern embankment with the main on-site road as boundary.

For Phase 2, the cost can also be divided into smaller components. As well as ordinary road extension construction, the quantity of drain channels installation can be adjusted by its total extension.

Table 7: Breakdown of each phase (Phase 1)

Category	Item	Qty.	unit	Unit price USD	Price	Remarks
Structure construction					<1,581>	
	Clearing and stumping	54,000	m^2	3.70	199	
	Earth cutting	17,300	m^3	12.67	219	Excavator Bucket1.0cu.m
	Loading and transport	17,300	m^3	5.56	96	Move inside the site
	Embankment	17,300	m^3	45.79	792	Dozer 21t-class
	Trimming and clearing slopes (cutting)	8,100	m^2	5.56	45	
	Trimming and clearing slopes (filling)	5,900	m^2	14.81	87	
	Greenary planting on slopes	11,300	m^2	12.67	143	Spraying t =2cm
Direct expense					1,581	
	Temporary works				158	10% of direct expense
	General expense and tax				521	30% of direct expense and temporary works
Sub-total					2,260	
Contingency cost					226	10% of sub-total cost
Grand total					2,486	

Table 8: Breakdown of each phase (Phase 2)

Category	Item	Qty.	unit	Unit price USD	Price	Remarks
Storm water drainage system					<1,631>	
	Concrete channel wire meshed	350	m	150.38	52	In site concreting works U-1000×600×400 t=150
	Concrete channel wire meshed	350	m	195.49	68	In site concreting works U-1200×400×800 t=150
	Concrete channel wire meshed	350	m	210.53	73	In site concreting works U-1500×700×800 t=150
	Concrete channel wire meshed	400	m	210.53	84	In site concreting works U-1700×800×800 t=150
	Access chamber	17	pts	1,390.98	23	In-site concreting works
	Stormwater balancing pond					
	Desilting	1,600	m^3	4.21	6	
	Trimming and clearing slopes (filling)	1,800	m^2	14.81	26	
	Effluent pipes	210	m	6,152.63	1,292	φ1800 Hume pipe
	Surge tank	1	set	7,518.80	7	2800×2800×6000
Direct expense					1,631	
	Temporary works				163	10% of direct expense
	General expense and tax				539	30% of direct expense and temporary works
Sub-total					2,333	
Contingency cost					233	10% of sub-total cost
Grand total					2,566	

Table 9: Breakdown of each phase (Phase 3)

Category	Item	Qty.	unit	Unit price USD	Price	Remarks
Leachate collection and drainage system					<178>	
	Leachate collection tank	2	set	41,353.38	82	2000×2000×6000
	Leachate collection pipes (Core lines)		m	601.50		φ800 HDPE perforate pipes
	Access chamber for leachate		m	601.50		φ800 HDPE non-perforate pipes
	Leachate collection pipes (sub collection lines)		m	48.00		φ200 HDPE perforate pipes
	Gas ventilation pipe (slope-installed)	700	m	48.00	33	φ200 HDPE perforate pipes
	Gas ventilation pipe(vertically-installed)	50	pts	1,278.20	63	φ500 HDPE perforate pipes
Reception control equipment					<105>	
	Internal roads	700	m	150.38	105	Concreting pavement W=7.0m t=230mm
Leachate treatment plant					<480>	
	Leachate collection pond					4,300m3
	Desilting	2,200	m^3	4.21	9	Excavator Bucket1.0cu.m
	Trimming and clearing slopes (filling)	3,000	m^2	14.81	44	
	Greenary planting on slopes	1,100	m^2	12.67	13	Spraying t=2cm
	Stepped channel	20	m	225.56	4	In-site concreting works 1000×1000
	leachate treatment pond					$300m^3$/day
	Desilting of leachate ponds	15,600	m^3	4.21	65	$5200m^3$×3pcs
	Overflow channel	3	pts	7,518.80	22	
	Trimming and clearing slopes (filling)	6,000	m^2	14.81	88	$2000m^2$×3pts
	Foundation installation	12,000	m^3	18.57	222	$4000m^3$×3pcs Gabion
	Wetland installation	3,600	m^2	3.01	10	$1800m^2$×2pts
	Discharging point	1	pts	3,759.40	3	
Direct expense					763	
	Temporary works				76	10% of direct expense
	General expense and tax				251	30% of direct expense and temporary works
Sub-total					1,090	
Contingency cost					109	10% of sub-total cost
Grand total					1,199	

6.2 Timeline of the remediation project

Based on experience with constructions of comparable capacity and similar components, the timeline of the remediation project is estimated below.

Table 10: Timeline of the remediation project

Phase	Price	Duration
Preparation (Detailed design and topographic survey)		8 months
Phase-1(Structure construction)	2,486	8 months
Phase-2 (Storm water drainage system)	2,566	6 months
Phase-3 (Leachate treatment system)	1,199	10 months
Grand total	6,251	

ANNEX I

Disaster prevention balancing pond plan

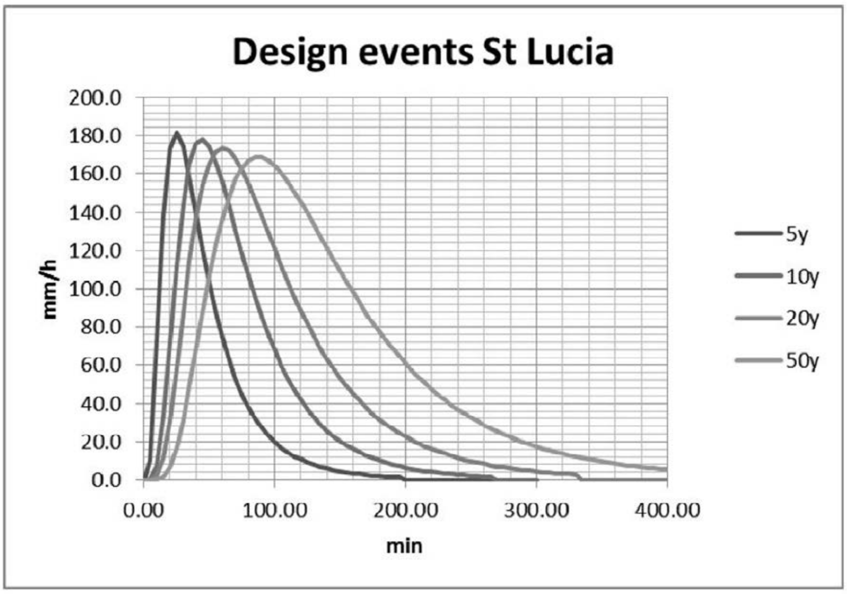
Disaster Prevention Balancing Pond Plan

1. Planning Criteria

In planning a disaster prevention regulating pond, the basin area, landfill area, installation of rainwater catchment/drainage facilities, developed area other than landfill, and downstream river flow capacity must be considered.

Considering these various conditions, the planning of disaster prevention reservoirs shall be conducted in accordance with the "Draft Technical Standards for Disaster Prevention Reservoirs" (Japan Rivers Association).

Since the existence of a rainfall intensity formula that can be applied to the plan has not been confirmed, the precipitation intensity shown in the figure below (Design events St Lucia), which is statistically processed for safety, is used for the calculation of the regulating basin capacity, as in the rainwater drainage plan.



	1:5 y	1:10 y	1:20 y	1:50 y
Depth (mm)	154.0	197.8	247.4	325.3
Max Intensity (mm/h)	181.8	178.2	173.5	168.5
Duration (min)	195	265	330	400

Source: https://www.cdema.org/virtuallibrary/index.php/charim-hbook/use-case-book/8-hazard-assessment/8-2-analysing-rainfall

Figure 1: Design events St Lucia

2. Organize design conditions

The following table summarizes the basic design conditions for the Disaster Prevention Regulating Pond Plan.

Table 1: Basic design conditions

Condition Item		Conditional value/expression	Remarks
Watershed specification	Watershed area (A)	16.0 ha	
	Allowable discharge volume	Flow rate equivalent to 10-year probability in Figure-1	
	Efflux coefficient (f)	0.60	
	Time to reach (t)	According to the empirical formula of the Public Works Research Institute of the Ministry of Construction $t = 1.67\times10^{-3}（L/\sqrt{S}）^{0.7}\times60 = 22.0$ min t: Flood time to reach (min) L: Length of flow path from the furthest point in the basin to the flow calculation point (m) S: Average slope from the furthest point in the basin to the flow calculation point	
Setting the size of the regulating pond	Calculation of flood control capacity	Flood control capacity using simplified method $Vt = (ri - rc/2)\times60\times ti\times fr\times A\times1/360 = 3{,}263\ m^3$ Vt: Volume (m^3) ri: Precipitation intensity (mm/hr) for any precipitation duration ti Maximum precipitation intensity of 181.8 mm/hr in Figure-1 rc: Rainfall intensity corresponding to the allowable downstream discharge (mm/hr) Maximum rainfall intensity in Figure-1: 178.2 mm/hr ti: Arbitrary rainfall duration (min) Arrival time 22.0min fr: Outflow rate (coefficient of outflow) A: Basin area (ha)	
	Influx formula	$Q = \frac{1}{360} \cdot f \cdot r \cdot A$ Q: Flow rate (m^3/s) f: Outflow coefficient r: Rainfall intensity (mm/hr) A: Catchment surface area (ha)	

(1) Catchment area

Based on the existing topography, the area shall be 16.0 ha, which is equivalent to the total basin area of stormwater enclosed by the ridge.

Figure 2: Catchment area for a balancing pond (16ha)

(2) Allowable discharge

The adjustment volume generally covers the incremental runoff associated with development, but in this case, the allowable discharge volume is equivalent to the 10-year probable rainfall intensity of 178.2 mm/hr in Figure-1 for the entire watershed.

$$Q = 1/360 \cdot f \cdot r \cdot A = 1/360 \times 0.6 \times 178.2 \times 16.0 = 4.752 \mathrm{m}^3/\mathrm{s}$$

Q: Outflow rate (m^3/s)

f: Outflow coefficient

r: rainfall intensity (mm/hr) (10-year exact rate r = 178.2 mm/hr)

A: Catchment surface area (ha)

(3) Outflow coefficient

The runoff coefficient depends on the topography, geology, ground surface, etc., including the proposed site. The majority of the so-called developed area of the project is reclaimed land. The percentage of developed area other than reclaimed land in the catchment area is extremely small. Rainwater falling on the landfill area will be drained separately in the system as leachate. The surface of the reclaimed surface is basically treated to promote surface drainage, but a site check revealed that the environment is conducive to the growth of low grass and vegetation.

Therefore, overall, it is judged to be a land use type with large infiltration and water retention capacity.

Although there are a wide variety of ways to capture the runoff coefficient, we adopt Monobe's proposal shown in the table below, which is considered to be the most representative, as well as the storm drainage plan. Based on a comparison of the topographical conditions in the table below and the proposed site, intermediate values for "undulating mountainous and wooded areas," "flat arable land," and "paddy fields under irrigation" are judged to be safe and appropriate. The upper limit of f=0.60, which is also the upper limit of "flat arable land," is used.

Table 2: Peak runoff coefficients presented by Monobe (JSCE 1999)

Terrain Condition	f_p
Steep mountainous terrain	0.75～0.90
Triassic mountain range	0.70～0.80
Undulating land and wooded areas	**0.50～0.75**
Level arable land	**0.45～0.60**
Paddy field under irrigation	**0.70～0.80**
Mountain rivers	0.75～0.85
Flatland small rivers	0.45～0.75
Large rivers where more than half of the watershed is flat	0.50～0.75

(4) Arrival time

The arrival time is based on the following empirical formula from the Public Works Research Institute of the Ministry of Construction.

$$t = 1.67\times10^{-3}(L/\sqrt{S})^{0.7}\times60$$

$$= 1.67\times10^{-3}(687.8/\sqrt{0.096})^{0.7}\times60 = 22.0\text{min.}$$

t: Flood arrival time (min)

L: Length of stream channel from the furthest point in the basin to the flow calculation point (m) 1375.7/2 = 687.8 m

S: Average slope from the furthest point in the basin to the flow calculation point (14m-80m)/687.8 = 0.096

(5) Amount of sand deposited

The design sediment volume shall be 150 (m^3/ha/year) per unit area.

$$V_S = v \cdot A$$

Where. V_S : Amount of sand deposited (m^3)

v : Amount of sand deposited per land area (= 150 m^3/ha/year)

A : Causing area (=12.5ha)

$V_S = 150 \times 12.5 \times 0.5$ (Shall be dredged every 6 months)

$= 937.5 (m^3)$

Therefore, a capacity of 940 m^3 will be secured. The sediment level is assumed to be +0.6 m.

3. Calculation of Adjustment Capacity

Based on the basic design conditions shown in Table-1 and the basic structural conditions such as discharge holes shown in Table-3, the flood control capacity is determined by a simplified method.

$Vt = (ri - rc/2) \times 60 \times ti \times fr \times A \times 1/360$

$= (181.8 - 178.2/2) \times 60 \times 22.0 \times 0.6 \times 16.0 \times 1/360 = 3{,}263 m^3$

The regulating pond capacity shall be at least 3,263 m^3.

Table 3: Basic structural conditions

Item	Structural Basic Conditions	Remarks
Regulating Pond Top Height	+2.50m	
Planned flood level	+2.20m	
Initial water level	+0.60m	
Mouth height	+0.60m	Deposited sand level
Total capacity	4,763m^3	
Amount of sand deposited	940m^3	
Capacity for balance	3,823m^3	

4. Scaling of flood discharges

A free overflow flood discharge should be provided in the regulating reservoirs in case of abnormal floods. The design flow rate of the flood discharge should be 1.5 times the discharge in a 1/10-year flood with a probability of exceeding the annual probability, and the structure should be of the tower type.

The probability rainfall intensity used in the planning is the 1/10-year probability.

1/10-year probability rainfall r=178.2 mm/hr

(1) Cross-sectional calculations

The spillway design flow rate is shown as follows

$$Q = \frac{1}{360} \cdot f \cdot r \cdot A \cdot 1.5 = \frac{1}{360} \times 0.6 \times 178.2 \times 16.0 \times 1.5 = 7.128\, m^3/sec$$

The spillway discharge for this plan shall be rectangular (square).

$$Q = C \times L \times H^{3/2}$$

Where: Q: Flood overtopping flow (m3/sec)

C: Flow coefficient (1.8)

L: Overflow length (m)

H: Overflow depth

Assuming overflow depth H = 0.30 m

$$L = Q \div (1.8 \times H^{3/2}) = 7.128 \div (1.8 \times 0.30\text{^}(3/2)) = 11.201m$$

$$\therefore B = 11.201 \div 4 = 2.8\mathrm{m}$$

Here, the spillway must have a square opening cross-section with at least 2.8 m on one side.

Therefore, the discharge basin should be a square basin with an opening of 2.8 m on one side.

5. Calculation of discharge pipe

The cross-section of the discharge pipe is determined in accordance with the 'Technical Standards for Disaster Prevention Regulating Basins (Draft) Commentary and Design Examples' (Japan River Association). The maximum cross-sectional area of the discharge pipe should be designed so that the maximum value is less than 3/4 of the cross-sectional area of the pipe.

Discharge pipe flow rate QH (m3/s)

$$Q_H = \frac{1}{n} \cdot A \cdot R^{2/3} \cdot I^{1/2}$$

Where: A: Cross-sectional area of flowing water (m2)

R: Diameter depth (m)

$$R = \frac{A}{P}$$

P: Hydrodynamic edge (m)

I: Gradient (m)

n: Roughness coefficient (for polyethylene pipes = 0.010)

If the above equation is transformed by assuming a circular cross-section and the cross-sectional area of flowing water to be 3/4 of the pipe cross-sectional area,

$$Q_H = \frac{0.262}{n} \cdot D^{8/3} \cdot I^{1/2} \geqq Q_O$$

D: Pipe diameter (m)

The pipe diameter should satisfy the above equation.

In order to determine the pipe diameter of the discharge pipe, the minimum D = 1m, considering maintenance after completion.

Therefore, if D = 1.8 m,

Q_H = 0.262/0.013 x 1.8008/3 x 0.041/2

= 6.109 (m3/s)

Combined with the existing, the discharge is,

Q_H = 0.516 + 0.516 + 6.109 = 7.141 ≥ Maximum discharge = 7.128

Therefore, the pipe diameter of the discharge pipe for the additional maintenance should be a φ1800 hume pipe, as the maximum discharge can be discharged.

Since two sets of 600 diameter hume pipes are already installed, this facility shall be left in place, and the result of the calculation for discharge pipe is as shown in the table below.

Table 4: Discharge pipe calculations

Type	—	Existing hume pipe (2sets) (Assumed)	New hume pipe
Pipe diameter	mm	600	1800
Roughness coefficient (n)	—	0.013	0.013
Margin height	mm	179	536
Water depth	mm	421	1264
Cross-sectional area for water passage (A)	m^2	0.2121	1.9085
Length of wetted side (P)	m	1.1920	3.5760
Diameter depth (R)	m	0.1779	0.5337
Gradient (I)	‰	10.0	4.0
Flow velocity (V)	m/sec	2.433	3.201
Flow rate (Q)	m^3/sec	0.516	6.109

ANNEX II

Leachate collection and drainage calculation

Leachate collection and drainage plan

1. Purpose and function of leachate collection and drainage facilities

Leachate collection and drainage system is provided in order to quickly transfer rainwater and leachate that has infiltrated into the landfill layer to a leachate treatment facility.

By controlling the amount of leachate generated in the landfill as much as possible and by quickly transferring it to the leachate treatment facility, it is considered that it will not remain in the landfill, thus reducing the water pressure on the liner structure and storage structure. The pipe diameter should be such that air can be vented into the collection and drainage system, and the end of the pipe should be open to the atmosphere.

2. Layout of leachate collection and drainage pipes

(1) Bottom collection and drainage pipes

The layout of the bottom collection and drainage pipes should be determined considering the permeability coefficient of the waste, the permeability coefficient of the impermeable sheet protection layer, the topography and size of the landfill site, as well as the fact that leachate collection and drainage system also serve as air supply in landfills with semi-aerobic landfill structures. In this plan, the main line shall be a straight line due to the shape of the landfill facility, and the layout of branch lines shall conform to Japanese laws, regulations and guidelines, which indicate a range of 10 m to 20 m, with the intermediate value of 15 m as the basic layout.

(2) Slope collection and drainage pipes

Slope collection and drainage pipes are placed at intervals of about twice the distance of the bottom collection and drainage pipes in this plan, as they perform the function of vertical drainage rather than the function of collecting water.

(3) Vertical collection and drainage pipes

Vertical collection and drainage pipes should be installed at least once every 2,000 m^2 and at intervals of about 45 m as installation intervals. Vertical collection and drainage pipes shall have a pipe diameter of 600 mm.

3. Setting the pipe diameter of leachate collection and drainage pipes

(1) Calculation of leachate volume

The amount of leachate generated for leachate treatment planning is planned based on daily rainfall, but the time that leachate remains in the landfill site must be as short as possible in order to implement hygienic landfill. It is important that the collection and drainage system have sufficient capacity to drain leachate quickly if the impermeable layer is damaged, as leakage will hardly occur if there is no water level in the landfill.

Therefore, collection and drainage system should ensure that it is capable of immediate drainage, similar to stormwater drainage schemes. From the above perspective, the leachate runoff volume, as well as the stormwater runoff volume, is calculated using the most common rational formula below.
The following formula is used to calculate the leachate runoff volume.

$$Q = \frac{1}{360} \times f \times r \times A \quad (\mathrm{m^3/sec})$$

Where Q: planned runoff volume (m^3/sec)

f: Runoff coefficient (-) = 0.51 (calculated)

r: Design rainfall intensity (mm/hr) = 178.2 mm/hr (10-year probability)

A: Catchment area (ha)

Table 1: Leachate calculation results

Landfill	Catchment area (ha)	Rainfall infiltration rate (m^3/s)
		r=178.2mm/hr f=0.51
Minimum block*	6.00	1.515

*: ※） Assumed to be about 1/2 of the total landfill area.

(2) Drainage capacity of leachate collection and drainage pipes

Volume of run-off

$$Q = A \cdot V \quad (\mathrm{m^3/sec})$$

Flow velocity

$$V = \frac{1}{n} \times R^{2/3} \times I^{1/2} \quad (\mathrm{m/sec})$$

Where Q: Flow rate (m^3/sec)

A: Cross-sectional area of flowing water (m^2)

V: Flow velocity (m/sec)

n: Roughness coefficient (double polyethylene pipe 0.01 in this plan)

R: Diameter depth (=A/P) (m)

P: Length of the stream's wetted edges (m)

I: Gradient (1.0%)

The drainage capacities of the catchment pipes by pipe diameter are shown in the table below.

Table 2: Drainage capacity of leachate catchment pipes (m^3/s)

Type			Full flow
Gradient		‰	10.0
			Flow rate m^3/sec
Pipe diameter mm	mm	200	0.043
		300	0.126
		400	0.271
		500	0.491
		600	0.798
		700	1.204
		800	1.719

3) Pipe diameter setting

The pipe diameters of the collection and drainage pipes by location are shown in the table below.

Table3 Diameter of the types

Location	Pipe diameter
Bottom collection pipe	φ800
Slope catchment pipes	φ200
Vertical collection pipes	φ600

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ANNEX III

Leachate treatment plan

Leachate treatment facility plan

The leachate treatment facility plan should be based on the 'Guideline for the Planning, Design and Management of Final Waste Disposal Facilities' (Japan Waste Management Association), with the following simultaneous setting of treatment volume and adjustment facility capacity.
The planned inflow rate of the leachate treatment plant is set between the maximum and minimum of the planned inflow rate of the leachate treatment plant, and the capacity of the adjustment facility is determined so that the amount of leachate exceeding the treatment capacity of the leachate treatment plant can be stored in the leachate adjustment facility, so that the leachate generated daily can be treated without delay.

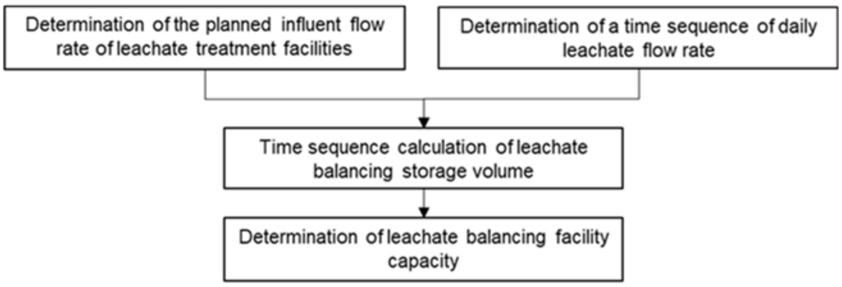


Figure – 1: Method for determining the capacity of leachate treatment facilities

The capacity of the leachate adjustment facility is determined by considering the water balance between the daily leachate volume generated (planned inflow volume) and the treatment capacity of the leachate treatment facility (possible discharge volume), and calculating the leachate adjustment facility capacity by performing water balance calculations for the several types of leachate treatment facility planned inflow volumes that have been set, and the appropriate leachate treatment facility planned inflow is determined by considering factors such as the operating rate (treated water volume/treatment capacity) and economic efficiency of the leachate treatment facility.
Precipitation data is used for the 12-year period 2000-2006, 2008, 2015-2016 and 2019-2020, when there are almost no missing measurements at the nearest George V Park. Planning will be conducted for two cases, one for the existing landfill (CASE-1; landfill in operation) and one for the expansion landfill (CASE-2; landfill completed), according to capacity.
The situation where the entire existing landfill site is assumed to be in operation is assumed to be the maximum, and in the case of the expansion, the sections of the landfill that are not in operation, such as the completed landfill surface, are to be excluded as much as possible as storm water.

Table - 1: Summary table of leachate treatment plan specifications

Plan specifications		CASE-1 (in operation)	CASE-2 (completed)
Precipitation data		2000-2006, 2008, 2015-2016, 2019-2020 (12years in total)	
Average daily precipitation (mm)		5.1	
Landfill area (ha)		7.1	11.5
Leaching coefficient (average)	In operation	0.51	
	Completed	0.31	
Average leachate rate (m^3/day)		190	190
Maximum leachate rate (m^3/day)		660	660
Calculation result	Daily throughput (m3/day)	300	300
	Adjustment capacity (m^3)	6,200	5,500

1. Design conditions

(1) Calculation method for planned inflow

The average leachate and maximum leachate rates shall be calculated using the rational formula. The precipitation data used are data for the 12 years 2000-2006, 2008, 2015-2016 and 2019-2020 with almost no missing data from the nearest George V Park station.

$$Q = \frac{1}{1000} \cdot I \cdot \left(C_1 \cdot A_1 + C_2 \cdot A_2 \right)$$

Where Q: Leachate rate (m^3/day)

I: Daily precipitation (mm/day)

C1: Leaching coefficient during operation period (-)

C2: Leaching coefficient during landfilling suspension or after landfill closure (-)

A1: Area of the cell in operation (m^2)

A2: Cell area during landfill suspension or after landfill closure (m^2)

For daily precipitation, the average daily precipitation is used when calculating the average leachate rate and the daily equivalent of the maximum monthly precipitation is used when calculating the maximum leachate rate.

(2) Target landfill area (CASE-1; 7.1 ha, CASE-2; 11.5 ha)

The leaching coefficient is calculated from the evapotranspiration based on temperature and sunshine hours and is determined on a monthly basis. For temperature and sunshine hours, 2021 data from Union Agromet Station, for which data are available, were substituted. The average values are 0.51 for landfill-in-operation cells and 0.31 for previously landfilled cells, as shown in the table below: from January to May, rainfall is low and the amount of leachate is reduced by the amount of emanation; from June to December, rainfall increases leachate amount.

Table – 2: Area subject to leachate treatment (ha)

Period	Area (A)			Leaching Coefficient (C)	
	Cell in operation (A_1)	Cell completed (A_2)	Total ∑A	Cell in operation (C_1)	Cell completed (C_2)
CASE-1	7.1	—	7.1	0.51	0.31
CASE-2	—	11.5	11.5		

(3) Determination of precipitation

The following table shows the results of the data compiled for the last 12 years, covering the period 2001-2010 at the George V Park station. There are no outstanding years in the last 10 years of data, with an average of 1,832 mm/year and the maximum rainfall in 2010 (2,059 mm).

Table - 3: Statistical table of precipitation data

		1	2	3	4	5	6	7	8	9	10	11	12
		2000	2001	2002	2003	2004	2005	2006	2008	2015	2016	2019	2020
Calendar days		366	365	365	365	366	365	365	366	365	366	365	366
Days measured		366	365	365	364	366	365	365	366	365	366	363	365
Precipitation		1918	1515	1526	1492	1817	2331	1946	2527	1344	2395	1571	1901
Daily average		5. 2	4. 1	4. 2	4. 1	5. 0	6. 4	5. 3	6. 9	3. 7	6. 5	4. 3	5. 2
Monthly	January	116. 5	48. 0	97. 4	79. 3	58. 9	220. 2	166. 0	86. 6	82. 1	108. 7	93. 2	117. 4
	February	221. 4	77. 4	171. 7	87. 0	51. 8	80. 0	59. 0	129. 8	46. 3	74. 7	43. 7	82. 0
	March	200. 5	18. 8	42. 2	45. 8	134. 1	28. 3	59. 7	107. 2	99. 1	92. 4	73. 4	62. 4
	April	60. 7	40. 2	149. 7	47. 9	59. 6	27. 6	44. 2	128. 7	72. 2	33. 8	90. 1	20. 8
	May	119. 8	36. 9	63. 3	33. 9	230. 6	285. 1	59. 1	75. 3	23. 3	211. 7	92. 4	28. 2
	June	84. 9	154. 3	107. 1	160. 8	191. 4	344. 2	299. 9	186. 3	52. 8	236. 7	134. 9	107. 6
	July	182. 9	161. 6	157. 2	203. 3	203. 7	278. 6	155. 4	281. 0	193. 1	346. 5	167. 3	186. 7
	August	198. 1	251. 2	136. 8	167. 3	137. 8	156. 3	166. 7	248. 9	127. 2	176. 7	180. 7	231. 5
	September	168. 7	151. 5	219. 2	161. 7	182. 0	122. 7	229. 0	286. 2	168. 4	384. 8	221. 7	122. 2
	October	186. 0	252. 6	222. 1	207. 7	96. 8	312. 2	274. 7	547. 8	84. 1	176. 5	224. 0	447. 0
	November	214. 1	73. 8	132. 9	201. 5	318. 3	382. 1	255. 4	276. 1	314. 1	343. 2	147. 9	412. 8
	December	164. 1	248. 2	26. 3	96. 2	152. 3	94. 0	177. 2	173. 5	81. 6	209. 4	101. 3	82. 6
Monthly maximum daily precipitation	January	11. 0	9. 3	13. 0	9. 1	13. 1	53. 6	23. 4	13. 2	15. 0	20. 0	23. 5	20. 0
	February	62. 0	29. 4	110. 3	30. 0	10. 8	20. 9	11. 5	24. 6	9. 0	18. 0	15. 0	27. 5
	March	91. 0	6. 5	7. 9	11. 8	26. 6	12. 5	53. 6	34. 3	22. 5	21. 0	13. 5	11. 0
	April	17. 5	10. 4	35. 4	11. 5	10. 1	12. 5	9. 8	35. 9	22. 0	9. 0	22. 5	7. 0
	May	73. 3	14. 3	10. 0	8. 4	48. 2	67. 9	14. 4	31. 0	7. 4	50. 0	47. 0	9. 4
	June	17. 8	82. 1	22. 1	45. 5	60. 6	57. 4	104. 2	32. 0	15. 5	65. 0	42. 0	21. 5
	July	33. 0	43. 0	31. 8	40. 8	43. 7	51. 1	19. 7	48. 3	92. 5	67. 0	27. 5	58. 0
	August	38. 2	43. 0	40. 0	53. 6	38. 1	21. 7	40. 0	30. 8	37. 0	65. 0	38. 0	40. 0
	September	19. 0	26. 0	69. 4	21. 4	51. 3	36. 4	63. 0	61. 2	42. 0	196. 4	47. 0	25. 0
	October	42. 1	64. 5	61. 0	45. 8	22. 0	48. 6	62. 2	97. 5	17. 8	32. 0	70. 0	78. 2
	November	34. 0	31. 2	34. 8	60. 1	94. 8	87. 6	52. 6	61. 6	112. 0	48. 6	30. 0	67. 0
	December	40. 5	55. 6	5. 8	15. 1	63. 7	29. 3	49. 0	59. 6	16. 0	29. 0	27. 5	12. 0
	Max Jan-Jun	91. 0	82. 1	110. 3	45. 5	60. 6	67. 9	104. 2	35. 9	22. 5	65. 0	47. 0	27. 5
	Max Jul-Dec	42. 1	64. 5	69. 4	60. 1	94. 8	87. 6	63. 0	97. 5	112. 0	196. 4	70. 0	78. 2
Rainy days over 10mm/day	January	2	0	1	0	1	8	5	2	2	2	3	6
	February	6	1	2	2	2	3	2	4	0	2	1	2
	March	4	0	0	1	4	1	1	2	2	3	3	2
	April	1	1	4	1	1	1	0	4	1	0	2	0
	May	1	1	1	0	6	9	2	2	0	5	2	0
	June	3	4	3	4	6	11	8	8	1	7	3	3
	July	6	4	5	7	6	10	6	8	5	10	5	3
	August	6	7	3	4	4	6	5	9	5	5	5	6
	September	8	7	5	6	7	3	7	8	7	9	8	5
	October	6	5	5	9	3	11	6	16	3	5	6	13
	November	6	2	4	5	9	8	8	6	9	11	6	14
	December	6	7	0	4	3	3	4	3	2	9	4	2
	Max	8	7	5	9	9	11	8	16	9	11	8	14

Number of days of observation: 4,381

Total rainfall: 22,284 mm

Maximum year: 2008

(4) Calculation of planned water inflow

1) Average leachate rate

From the tabulation table, the total rainfall for the 12 years was 22,284 mm and the number of days of observation was 4,381. The average daily rainfall is as follows.

I = 22,284 mm/4,381 days = 5.1 mm/day

Therefore, the average leachate is as follows.

CASE-1

$$Q = \frac{1}{1000} \times 5.1 \times 0.51 \times 70{,}627 = 183.7\, m^3/day$$

CASE-2

$$Q = \frac{1}{1000} \times 5.1 \times 0.31 \times 115{,}480 = 182.6\, m^3/day$$

2) Maximum leachate rate

From the tabulation table, the maximum monthly precipitation was 547.8 mm/month in October 2008, and the daily equivalent of the maximum monthly precipitation is as follows.

$$I = 547.8\,mm/30\,日 = 18.3\,mm/day$$

The maximum leachate rate is therefore as follows.

CASE-1

$$Q = \frac{1}{1000} \times 18.3 \times 0.51 \times 70{,}627 = 659.2\, m^3/day$$

CASE-2

$$Q = \frac{1}{1000} \times 18.3 \times 0.31 \times 115{,}480 = 655.1\, m^3/day$$

The above results are summarised in the following table.

Table – 4: Results of calculation of planned inflow

Target precipitation		Annual average daily precipitation	Daily equivalent of maximum monthly precipitation
CASE-1	Average leachate rate	190 m^3/day	—
	Maximum leachate rate	—	660 m^3/day
CASE-2	Average leachate rate	190 m^3/day	—
	Maximum leachate rate	—	660 m^3/day

The calculation case for the daily treatment volume used in the time series calculation of the leachate adjustment facility storage volume shall be the safest case, such as the maximum value, using the results of the situation-specific studies as a guide, as described below.

2. Setting of leachate adjustment facility capacity

The daily treated water volume for 10 cases shall be set using the average leachate rate and maximum leachate rate as a guide, and leachate adjustment facility capacity calculations shall be conducted. The calculation method is based on a water balance calculation (in/out calculation) of the amount of leachate generated (= inflow I) calculated from the daily rainfall time series data and the set daily treated water volume (= outflow O) to determine the maximum capacity. The calculation results of each case are compared and discussed, and the capacity of the leachate adjustment facility and the daily treatment volume are set.

(1) Water balance calculation method

The water balance calculation assumes that the difference between the inflow I and the daily treatment volume O is stored horizontally in the regulating facility, the increase or decrease in storage volume ΔV in any given day is expressed as,

$$\Delta V = I - O$$

Therefore, the storage volume V(d) at the end of any day (d) is calculated by the following equation

$$V(d) = V(d-1) + \Delta V$$

$$= V(d-1) + \{I(d) - O(d)\}$$

Where V: storage volume (m^3)

I: generated leachate rate (m^3/day)

O: daily treated water rate (m^3/day)

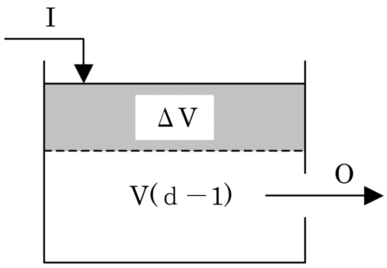


Figure – 2: Landfill water balance model

1) Setting up a daily precipitation time series

The daily precipitation time series data used for the water balance calculations shall be the daily precipitation time series from the most recent 12-year mean approximation year.

The mean approximation year was 2001 (annual precipitation = 1,515 mm) from the statistical table of precipitation data.

2) Calculation of leachate generation rate

Calculation of leachate generation rate is based on a rational formula.

$$Q = \frac{1}{1000} \cdot I \cdot (C_1 \cdot A_1 + C_2 \cdot A_2)$$

Where Q: Leachate rate (m^3/day)

I: daily precipitation (mm/day)

C_1: Leaching coefficient during landfill (-)

C_2: Leaching coefficient during landfill suspension or after landfill closure (-)

A_1: Area of the plot under reclamation (m2)

A_2: Plot area during landfill suspension or after landfill closure (m2)

(2) Water balance calculation results

Water balance calculations were conducted by setting the daily treated water volumes for the 10 cases shown in Table 5 and Table 6, based on the above-mentioned in-and-out calculations, average leachate and maximum leachate as a guide. The calculations were conducted for the year 2010 to approximate the mean value and to calculate a safer scale. The calculation results are shown in the table and Figures 3 to 6.

As a result of the water balance calculations, the leachate adjustment amount remained at the end of December, so continuous calculations were conducted using the same daily precipitation time series data, and this remaining amount was absorbed due to the low precipitation from January to May.

Table – 5: Water balance calculation results (CASE-1)

Case	Daily treated water volume (m^3/day)	Average approximate year (2001)	
		Maximum leachate adjusted capacity (m^3)	Treatment plant utilisation rate (%)
1	200	21,664	90.9%
2	250	12,503	72.7%
3	300	6,179	60.6%
4	350	4,238	52.0%
5	400	3,755	45.5%
6	450	3,551	40.4%
7	500	3,501	36.4%
8	550	3,451	33.1%
9	600	3,401	30.3%
10	650	3,351	28.0%

Note: Treatment plant utilization rate = Total treated volume / total daily treated volume

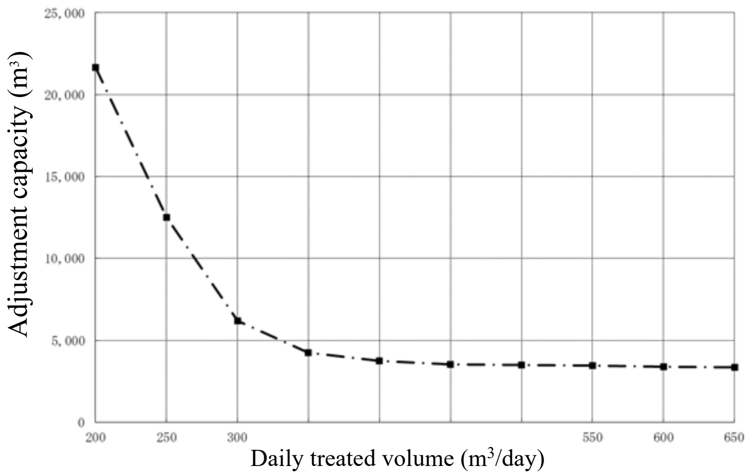


Figure – 3: Daily treated volume and adjustment capacity (CASE-1)

In the mean value approximation year (2001), the adjustment capacity changes uniformly with the increase in treated water volume in this calculation case. A daily treated water volume of 300 m^3/day is set as the size of the system, based on an operating rate of about 60%. The following graph shows the time-series changes in storage capacity at a daily treated water volume of 300 m^3.

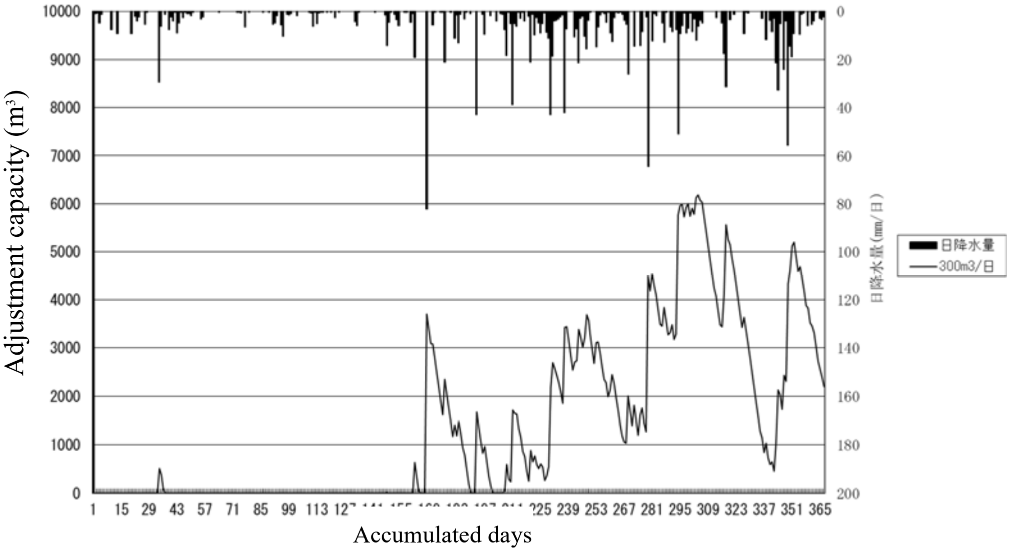


Figure – 4: Time-series change in storage volume (average approximate year 2001) at a daily throughput of 300 m^3/day (CASE-1)

Table – 6: Results of in-and-out calculations (CASE-2)

Case	Daily treated water volume (m^3/day)	Average approximate year (2001)	
		Maximum leachate adjusted capacity (m^3)	Treatment plant utilisation rate (%)
1	200	20,302	80.8%
2	250	11,377	71.0%
3	300	5,440	59.2%
4	350	4,006	50.7%
5	400	3,534	44.4%
6	450	3,437	39.5%
7	500	3,387	35.5%
8	550	3,337	32.3%
9	600	3,287	29.6%
10	650	3,237	27.3%

Note: Treatment plant utilization rate = Total treated volume / total daily treated volume

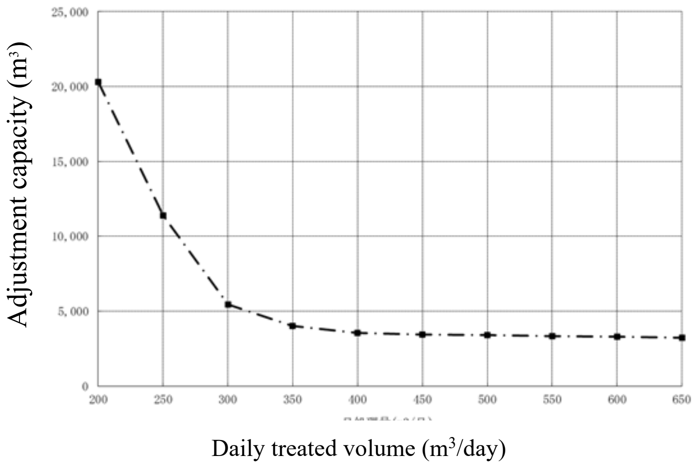


Figure – 5: Daily treated volume and adjustment capacity (CASE-2)

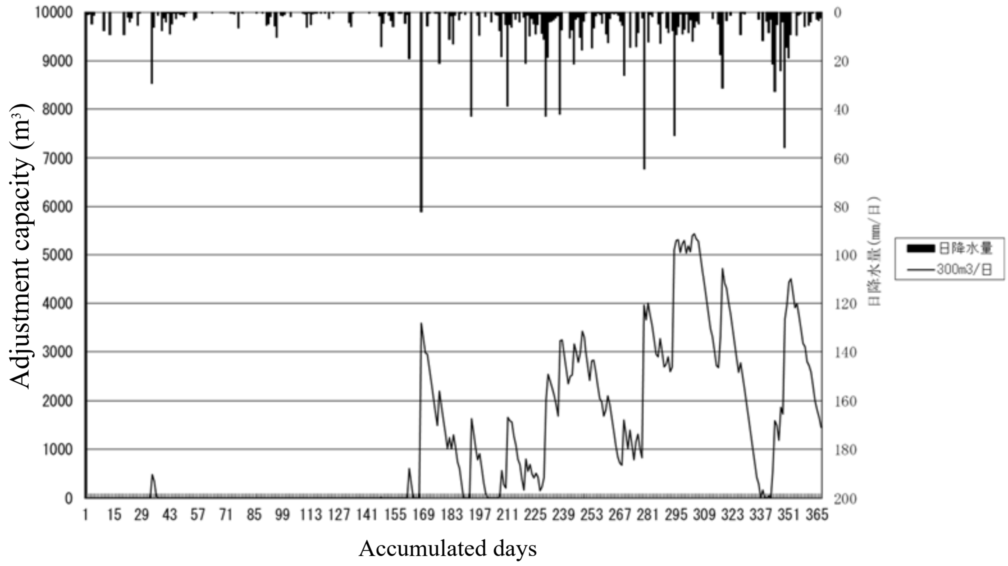


Figure – 6: Time-series change in storage volume (average approximate year 2001) at a daily throughput of 300 m^3/day (CASE-2)

In this plan, the daily treatment capacity with a margin was set at a plant utilisation rate of 60%. As shown in the table below, CASE-1 requires a daily treated volume of 300 (m^3/day) and an adjusted capacity of 62,000 (m^3), while CASE-2 requires a daily throughput of 300 (m^3/day) and an adjusted capacity of 5,500 (m^3). The daily treated volume can be reduced to 300 (m^3/day) by landfill management that keeps landfill plots below the same size as existing landfill sites.

Table – 7: Capacity of leachate treatment facility

Item	CASE-1	CASE-2
Daily treatment capacity (m^3/day)	300	300
Adjustment volume (m^3)	6,200	5,500

End of Document

ANNEX IV

Storm water drainage plan

Stormwater Collection and Drainage Plan

1. Purpose and function of stormwater collection and drainage facility

The purpose of the stormwater collection and drainage facility at a final disposal site is to isolate the waste in the landfill from the stormwater. Stormwater collection and drainage facilities reduce leachate by preventing the inflow of stormwater into landfills and have a role of reducing the load on leachate treatment facilities and water blocking works. In this project, there is inflow of stormwater into the landfill because of insufficient stormwater drainage system around the landfill and it also serves as a stormwater drainage on the surface of the final soil cover after the completion of the landfill, therefore, the scale of the drainage facility was planned in consideration of the completion of the landfill.

2. Arrangement of stormwater collection and drainage channels

Drainage channels will be installed as gutters along roads around the landfill. The landfill site will be divided into two large sections to collect stormwater around the landfill. Collected water is channeled to the balancing pond so that there is no stagnation in the surrounding area.

3. Setting of the cross-section of the storm drain channel

1) Stormwater runoff

Stormwater runoff is calculated by the following most common rational formula:

$$Q = 1/360 \times f \times r \times A$$

Here, Q; Stormwater runoff (m^3/sec)
f; Outflow coefficient
r; Precipitation intensity (mm/hr)
A; Catchment area (ha)

2) Outflow coefficient

The runoff coefficient varies depending on the topography, geology, ground surface, etc. including the planned site. Most of the so-called development area of this project is landfill. The ratio of development areas other than landfills to the catchment area is extremely small. Stormwater falling in the landfill area is separately drained by the leachate system. Reclamation completion surfaces are treated to promote surface drainage, but in general, vegetation has taken root well, and the land use form is in the form of a mountainous area with a gentle slope or a park with many turf and trees.

Therefore, it can be determined to be a land use form with large permeability and water retention capacity as a whole.

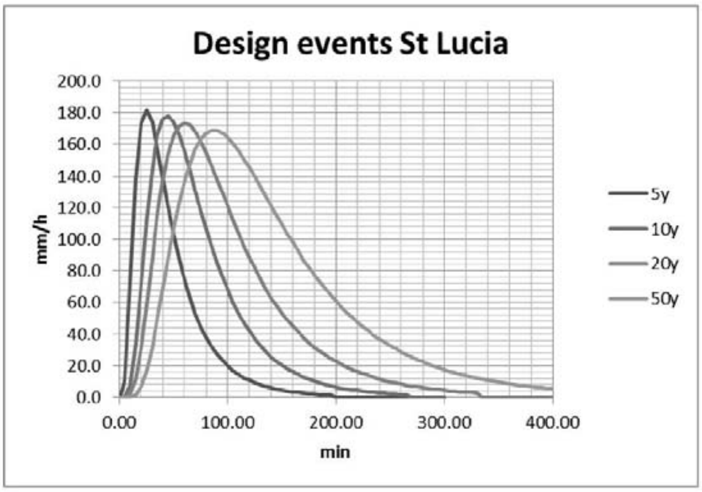
Although there are a wide range of ways to understand the outflow coefficient, figures shown in the table below is recommended, which is considered to be the most representative. Based on the comparison of the topography conditions in the table below with the planned site, the intermediate values of "undulating mountainous and forested land", "flat arable land", and "irrigated paddy fields" are adopted to be safe and reasonable. f = 0.60, which is also the upper limit of "flat arable land".

Table 1 Peak outflow coefficient presented by the Monobu
(Japan Society of Civil Engineers, 1999)

Terrain conditions	f_p
Steep mountains	0.75～0.90
Sanki Mountains	0.70～0.80
Undulating land and forest land	**0.50～0.75**
Flat arable land	**0.45～0.60**
Paddy field during irrigation	**0.70～0.80**
Mountain rivers	0.75～0.85
Flatland small rivers	0.45～0.75
Large rivers with more than half of the basin flat	0.50～0.75

3) Precipitation intensity

Landfills will inevitably have a stormwater regulation function due to their structure during the landfilling period. The landfilling period is short-term, about 10 years, but referring to the figure below (Design events St Lucia), which has been statistically processed for safety, the probability year of precipitation is Adopt 10 years. Since the existence of a rainfall intensity formula that can correspond to the plan cannot be confirmed, when calculating the stormwater flow rate, the peak value of 1/10 year probability rainfall intensity is assumed to be 178.2mm/hr.



	1:5 y	1:10 y	1:20 y	1:50 y
Depth (mm)	154.0	197.8	247.4	325.3
Max Intensity (mm/h)	181.8	178.2	173.5	168.5
Duration (min)	195	265	330	400

Figure 1 Design events St Lucia

(https://www.cdema.org/virtuallibrary/index.php/charim-hbook/use-case-book/8-hazard-assessment/8-2-analysing-rainfall)

4) Setting the target catchment area

The target catchment area when setting the drainage channel cross-section will be maximum when the entire landfill site is completed. In this plan, as well as the leachate treatment plant plan, the minimum unit of the catchment zone is about 2.0 ha, and considering 20% of allowance of water volume, under the condition of the completed shape of the landfill, the accumulative cross-section in stages is planned. During the transition period until the completion of the final landfill, water shall be appropriately channeled from the completion surface to reduce the amount of leachate.

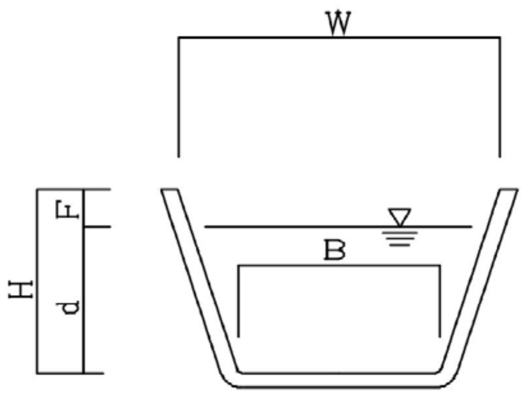
Figure 2 Reservoir basin map (16.0ha)

5) Setting the drainage channel cross-section

The drainage channel shall be a trapezoidal concrete-lining channel. When determining the cross-section, the average flow velocity is calculated according to the typical Manning formula, taking the accumulation of sediment into account, etc., and a margin of 20% of the water depth is expected, and the allowable cross-section is set. The calculation results are shown in the flow calculation table.

Table 2 Flow Calculation Table

Hydro-graphic number	Catch-ment area	Outflow coeffi-cient	Precipita-tion inten-sity	Outflow	Waterway cross-section			Waterway gradient	Rough-ness fac-tor	Average flow ve-locity	Permissi-ble flow rate	summary
	ha	-	mm/hr	m^3/sec	W(mm)	B(mm)	H(mm)	‰	-	m/sec	m^3/sec	
1	2. 0	0.6	178.2	0. 594	1000	600	400	15.0	0.015	2. 958	0. 719	
2	4. 0	0.6	178.2	1. 188	1200	400	800	15.0	0.015	2.853	1. 315	1+2
3	6. 0	0.6	178.2	1.782	1500	700	800	10.0	0.015	2. 938	1. 918	1+2+3
4	8.0	0.6	178.2	2. 376	1700	800	800	9.0	0.015	2. 931	2. 579	1+2+3+4
5	2.0	0.6	178.2	0.594	1000	600	400	15.0	0.015	2.853	1. 315	
6	4. 0	0.6	178.2	1. 188	1200	400	800	10.0	0.015	2. 938	1. 918	5+6
7	6. 0	0.6	178.2	1.782	1500	700	800	10.0	0.015	2. 938	1. 918	5+6+7
8	8.0	0.6	178.2	2.376	1700	800	800	9.0	0.015	2. 931	2. 579	5+6+7+8



(Cross section of water channel)

Manning formula

$Q = A \times V$

$V = 1/n \times R^{(2/3)} \times I^{(1/2)}$

Planned water depth: 80%

Roughness coefficient: 0.015

Top length W mm	1000	1200	1500	1700
Bottom length B mm	600	400	700	700
Depth H mm	400	800	800	1000
Margin height F mm	80	160	160	200
Water depth d mm	320	640	640	800
Water flow cross section area A m^2	0.2432	0.4608	0.6528	0.8800
Wetted perimeter P m	1.1155	2.2311	2.2311	2.7889
Hydraulic radius R m	0.2180	0.2065	0.2926	0.3155
Gradient I‰	15.0	15.0	10.0	9.0
Velocity V m/sec	2.958	2.853	2.938	2.931
Flow rate Q m^3/sec	0.719	1.315	1.918	2.579

ANNEX V

Operation and maintenance plan

Table of Contents

Tables

Figures

In this plan, the existing facilities and equipment that will continue operation after remediation are not covered. Only the facilities and equipment relevant to this remediation plan are covered in the operation and maintenance plan.

1 Landfill operations management

1.1 General

A plan illustrating the waste landfill area and shall compare the planned and actual quantities of waste delivered and landfilled shall be prepared. The date of landfill, location, quantity items and photographs of the waste shall be recorded and entered in the daily landfill management report and the plan and cross-sectional drawings. The records shall be used as a reference for later construction.
Landfill capacity shall be measured periodically and recorded. The remaining landfill capacity shall also be controlled by the waste landfill calculation sheet.

1.2 Landfilling

The landfill method presented here is the sandwich method (see figure below), where the waste layer (H = 3.0 m) and the intermediate cover layer (H = 0.5 m) are repeatedly filled. The waste layers are formed with waste cells. Each cell is filled with waste delivered on the same day. The surface of the cell is then covered with soil every day. During this process, the waste is well mixed and compacted.

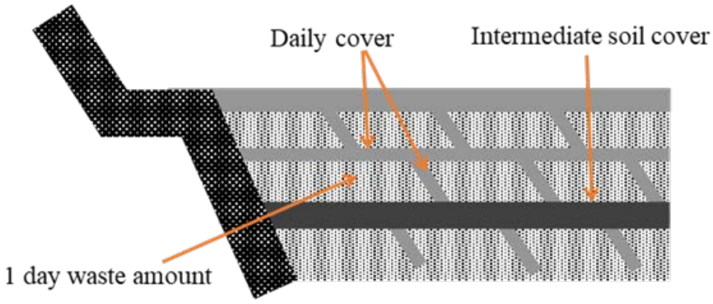


Figure 1: landfilling method

Issues to consider
1) Poorly permeable waste should not be placed around leachate collection and drainage pipes. (Avoid impermeable layers around the pipes).
2) To protect against heavy machinery, a protective layer (t = 0.5 m) of tyres, mountain sand, etc. should be placed on the inside of slopes and small embankments before the area is reclaimed and compacted.
3) Small compaction equipment should be used to carefully backfill areas near vertical drainage pipes and vertical gas ventilation pipes.
4) After the day's backfilling landfilling is completed, the soil is covered on the same day. During covering, bulldozers and other equipment should be driven repeatedly to ensure adequate compaction. Covering should normally be carried out at the end of the day, but in the event of strong winds, covering should be carried out to prevent dust from the waste from being dispersed.5) For the first layer of waste, the spreading out thickness should be 0.5 m or more so as not to affect the leachate collection and drainage pipes, and compaction should be carried out with a bulldozer.
6) As a measure to prevent accidents when moving back of heavy machinery, visual check of the rear and the surrounding structures shall be implemented before getting on the machine.

A board with the rules for moving back should be placed inside the heavy machinery, and efforts should be made to ensure that the rules are thoroughly enforced.

1.3 Soil cover

There are three types of soil cover: Daily cover, intermediate cover, and final cover.
Only soil or other materials should be used for daily and intermediate cover.
At the end of each day's work, whether the immediate covering soil is good or bad shall be checked, and the daily report on landfilling management shall be prepared attaching photographs.

1.3.1 Daily soil cover

Waste shall be covered with soil at the end of each day of landfilling to prevent dispersal and odour. Landfills where there is a normal tendency for the waste to disperse or spill, to emit offensive odours or to be a source of rodents, birds, flies or other pests shall be covered with soil. Soil cover shall be applied immediately after the waste has been compacted at the discretion of the operator. The cover material should be temporarily placed in the vicinity of the landfill on a case-by-case basis.

[How to check the daily soil cover]

- The operator confirms the completion of the daily soil cover and reports to the landfill manager.
- The landfill manager confirms the completion of the daily soil cover on site.
- If rework is required, it shall be re-covered as soon as possible.

1.3.2 Intermediate soil cover

An intermediate soil cover is recommended when the thickness of the waste layer (including the daily soil cover) reaches H = 3.0 m, with a soil layer of t = 0.3 - 0.5 m.

The intermediate cover shall be voluntarily inspected after implementation.

[How to check the intermediate soil cover]

- Inspections of the intermediate soil cover should be carried out at a rate of one site per 500 m^2.

1.3.3 Final soil cover

The top layer of the landfill shall be covered with at least 1 m of soil. The soil type, thickness and surface finish of the final soil cover should be determined on the basis of the landfill use plan.

The surface of the soil cover should be compacted and carefully constructed, as it will be exposed to the elements for a long period of time as the surface of the landfill.

1.3.4 General observation

A fixed-point observation of the waste disposal from an elevated point overlooking the landfill site shall be carried out weekly.

1.4 Precautions for soil covering operations

There are many important structures at the bottom of the landfill, on the slope and on the surface of the embankment. Precautions should be taken to avoid damage to them. For example, areas around leachate collection pipes and vertical gas ventilation pipes should be carefully and evenly filled with waste using a small machine to avoid uneven loading that could damage the pipes.

2 Maintenance plan

The main facilities covered in this plan are as follows.
- Leachate drainage facilities: Leachate sedimentation tank, multi-stage channels
- Leachate treatment facilities: Treatment pond 1, treatment pond 2, settling pond
- Storm water drainage facilities: Storm water drainage channels, balancing pond
- Gas ventilation pipes: Gas ventilation pipes, slope gas ventilation pipes.
- Storage structures: embankments
- Monitoring facilities: Groundwater monitoring wells
- Ancillary facilities: Access roads, internal roads

2.1 First sedimentation pond

2.1.1 Function

The first sedimentation pond is also known as a leachate collection pit (sump), which receives leachate from the leachate collection pipes under gravity flow conditions. The leachate is retained for a period of time and a certain amount of sediment is separated before the water is sent to the leachate treatment pond.

2.1.2 Inspection

Visual inspections should be carried out once a year to check for cracks and leaks in the structure. The use of an internal camera is also effective. Sediment should also be removed during the inspection.

2.1.3 Sediment removal

Sediment accumulated should be checked and removed if present. The amount sucked by the vacuum car shall be measured.

2.2 Leachate treatment facility

2.2.1 Daily inspections

The operational status [treatment status, operation status of monitoring equipment] shall be checked on every operating day.

2.2.2 Annual maintenance and inspection

Equipment and instrumentation shall be inspected, maintained, and they shall be repaired and renovated if necessary.

2.2.3 Periodic water quality analysis

The analysis is conducted by a company specialising in analysis to carry out water quality analysis.
- Groundwater observation wells
- Leachate sedimentation tanks
- Discharge point

2.2.4 Water quality self-checks

Water quality shall be checked once a week with a portable analyser for the following locations and water quality items.

a. Water sampling locations

- Leachate sedimentation tank
- Discharged water

b. Water quality items

pH, EC[1], and water temperature

2.2.5 Maintenance of monitoring equipment

a. Frequency of inspection

Once a year, manufacturer's inspection, and calibration

b. Inspection details

Loop test, pseudo-flow test with calibrator, scaling on detectors

c. Description of work

Open detector, manufacturer's inspection, removal of scale build-up and cleaning

2.3 Storm water drainage system

The items listed in the table below and the channels around the perimeter of the facility shall be inspected.
If the inspection reveals sediment accumulation or damage, the sediment accumulation shall be removed, and the damage shall be repaired.

Table 1: Inspection list

Location	Item	Frequency
Storm water channel (Point of water velocity)	Visual inspection (sediment deposition/damage)	Daily
	Visual inspection (overflow)	Rainfall
Road to disposal site	Visual inspection (sediment run-off)	Weekly / rainfall

2.4 Landfill gas removal facilities

2.4.1 Vertical gas vents

The items to be managed are listed in the following table.

[1] EC: Electrical Conductivity

Table 2: Inspection list

Location	Item	Frequency	Report
Vertical gas vents	Blockage	Monthly	Daily operation report
	No overturned or damaged		Daily operation report
	Record of height at time of raising	When raised	Construction record*
	Measurement of concentration of gases generated	Weekly	Weekly operation report
	Visual inspection (appearance, water stagnation around the perimeter, smoke)	Weekly	Weekly operation report
	Gas analysis	Twice a year	Analysis report

*: Construction records include construction photos, construction drawings, material documents and other documents.

Note:
The depth of the vertical vent pipe is measured with a weight to check the integrity of the vertical vent pipe.
Raise the vertical vent pipe as the landfill progresses.
If blockages, overturned or damaged pipes are found during the inspection, a report should be submitted with photographs and other information. If repairs are made, the details of the repairs and photographs shall be attached and kept as a record.

2.4.2 Slope gas vent pipes

The items to be managed are listed in the following table.

Table 3: Inspection list

Location	Item	Report
Slope gas vents	No damage, no overflows	Weekly operation report
	Gas analysis (twice a year)	Analysis report

[Precautions for work]
Blockages are checked by checking the gas concentration from the release section and the integrity of the gas vent pipe is confirmed.
The slope gas vent pipe is already in place (bent joint stop) at the start of landfilling along the slope. The vertical pipe is raised during the construction of the small embankment.
During the inspection, any damage or overflows shall be reported. If repairs are made, the details of the repairs and photographs should be attached and kept as a record.
The area around the site is strictly closed to fire as flammable gases may be trapped in the area.
The pipe connection at the road crossing (unconnected section) should be made according to the status of the waste landfill.

2.5 Monitoring facility

2.5.1 Functions and structures

Monitoring wells are installed in and around the landfill site to monitor the holding water level and water quality in the vicinity of the location.

Table 4: Monitoring of groundwater

Type of monitoring well	Location	Objective	Main device	Frequency of inspection
Groundwater observation wells	Two locations outside the landfill site (upstream and downstream)	Management of groundwater quality	Wells, water level meters	Weekly

2.5.2 Inspection and management

Visual inspection of the function shall be conducted, and appearance of the water level gauges and control panels in the groundwater shall be observed, and a weekly report on facility management shall be prepared.
In addition, water level records shall be carried out for the water level observation wells and entered in the weekly facility management report.

2.6 Accessory facilities management

2.6.1 Road facilities

a. Management issues.

1) On delivery roads, traffic shall travel at a speed of less than 10 km/h.
2) On the management road, traffic shall travel at a speed of less than 10 km/h.
3) On the temporary on-site road, traffic shall travel at a speed of less than 10 km/h.
4) The management road and the uppermost slope on the north side of the landfill site shall be visually inspected once a month.

The following table shows inspection items.

Table 5: Inspection list

Location	Item	Frequency
Access road	Cleaning of road surface (removal of soil, sand, and dust)	Weekly
	Cleaning of channels and catch basins	Weekly
	Cleaning of rubbish (removal of scattered rubbish)	Weekly
	Weeding of surrounding areas	Twice a year
Management road	Cleaning of road surfaces	Weekly
	Cleaning of channels and catch basins	Weekly
	Weeding of surrounding areas	Twice a year
	Visual check for cracks and fissures on slopes	Weekly
Internal road	Inspection of pavement for cracks, sinking and swell	Every inspection day
	Collapsed shoulders, soil spills	Daily
	Presence of standing water (if present, drainage should be carried out)	Daily

2.7 Storm water balancing pond

The management points of the storm water balancing pond are as follows. However, they should always be inspected in conjunction with inspections of other facilities immediately after heavy rainfall, earthquakes, etc.

If a large amount of sediment is deposited, the effective water depth cannot be guaranteed. If sediment and other materials are deposited on the pond bottom and discharge pipes and this is affecting the operation of the system, removal work should be carried out as soon as possible.

The storage structures of the storm water balancing pond shall be visually inspected for cracks and other deformations in the concrete. The storage capacity shall be visually checked at the reference observation points and inspected once a week to ensure that there are no obstructions to the storage function. If any damage to the concrete is found during the inspection, it should be repaired immediately. In addition, a record and photographs of the repairs shall be reported as a repair record, and the location, date, time and outline of the repairs shall be recorded in the facility management daily report and kept with the repair record.

ANNEX VI

Water quality analysis results

Aeration effect

Certificate of Analysis

REPORT No. 20220197

Report to:
EX Research Institute
Tokyo, Japan
Attention: Mr. Yukihisa Sakata

Environmental Testing & Consultancy Services Ltd.
Gablewoods South
Unit 24
La Tourney, Vieux Fort
Saint Lucia
Tel: 454 7302

DATE RECEIVED: 2022-10-17
DATE REPORTED: 2022-11-05

PROJECT: Water Quality Analysis of Deglos Sanitary Landfill Monitoring- **Sampling Session #2**

Test	Method	Result	Units	Date Tested
20220197-01	**Aeration**	**Surface Water**		
Fecal Coliform	SM 9222 D	1000	CFU/100ml	2022/10/17
Nitrates	SM 4500 NO3-E	7.3	mg/L	2022/10/20
BOD	SM5210 B	35	mg/L	2022/10/17
COD	HACH 8000	294	mg/L	2022/10/21
Total Nitrogen	SM 4500-N	76.1	mg/L	2022/10/21
Ammonia Nitrogen	SM 4500	55.7	mg/L	2022/10/21
pH	SM 4500H^+ B	8.07	units	2022/10/17
Temperature	Temp. Probe	27.9	°C	2022/10/17
Total Suspended Solids	SM 2540 D	13	mg/L	2022/10/20
Oil & Grease (Total)	SM 5520-F	< 2	mg/L	2022/10/27
20220197-02	**Aeration Blank**	**Surface Water**		
Fecal Coliform	SM 9222 D	4000	CFU/100ml	2022/10/17
Nitrates	SM 4500 NO3-E	7.3	mg/L	2022/10/20
BOD	SM5210 B	39	mg/L	2022/10/17
COD	HACH 8000	282	mg/L	2022/10/21
Total Nitrogen	SM 4500-N	70.1	mg/L	2022/10/21
Ammonia Nitrogen	SM 4500	52.1	mg/L	2022/10/21
pH	SM 4500H^+ B	8.09	units	2022/10/17
Temperature	Temp. Probe	27.8	°C	2022/10/17
Total Suspended Solids	SM 2540 D	9	mg/L	2022/10/20
Oil & Grease (Total)	SM 5520-F	< 2	mg/L	2022/10/27
20220197-03	**Sump Pump**	**Surface Water**		
Fecal Coliform	SM 9222 D	71,000	CFU/100ml	2022/10/17
Nitrates	SM 4500 NO3-E	2.7	mg/L	2022/10/20
BOD	SM5210 B	293	mg/L	2022/10/17
COD	HACH 8000	530	mg/L	2022/10/21
Total Nitrogen	SM 4500-N	154	mg/L	2022/10/21
Ammonia Nitrogen	SM 4500	139	mg/L	2022/10/21
pH	SM 4500H^+ B	7.81	units	2022/10/17
Temperature	Temp. Probe	32.7	°C	2022/10/17
Total Suspended Solids	SM 2540 D	3000	mg/L	2022/10/20
Oil & Grease (Total)	SM 5520-F	19	mg/L	2022/10/27

The reported results pertain only to the specified sample(s) tested.
Analyses for pH was done at the time of sampling.

References:

- Standard Methods for the Examination of Water and Wastewater, 23rd Edition, 2017, AWWA/APHA/WEF.

Approved By: NLouisy

N. Louisy-Manager

Wetland effect

Certificate of Analysis

REPORT No. 20220201

Report to:
EX Research Institute
Tokyo, Japan
Attention: Mr. Yukihisa Sakata

Environmental Testing & Consultancy Services Ltd.
Gablewoods South
Unit 24
La Tourney, Vieux Fort
Saint Lucia
Tel: 454 7302

DATE RECEIVED: 2022-10-24
DATE REPORTED: 2022-11-17

PROJECT: Water Quality Analysis of Deglos Sanitary Landfill Monitoring- **Sampling Session #3**

Test	Method	Result	Units	Date Tested
20220201-01	**Wetland**	**Surface Water**		
Fecal Coliform	SM 9222 D	1000	CFU/100ml	2022/10/24
Nitrates	SM 4500 NO3-E	< 0.6	mg/L	2022/10/28
BOD	SM5210 B	48	mg/L	2022/10/24
COD	HACH 8000	470	mg/L	2022/11/09
Total Nitrogen	SM 4500-N	121	mg/L	2022/11/08
Ammonia Nitrogen	SM 4500	86.4	mg/L	2022/11/08
pH	SM 4500H^+ B	8.06	units	2022/10/24
Temperature	Temp. Probe	28.4	°C	2022/10/24
Total Suspended Solids	SM 2540 D	40	mg/L	2022/10/25
Oil & Grease (Total)	SM 5520-F	< 2	mg/L	2022/10/27
20220201-02	**W- Blank**	**Surface Water**		
Fecal Coliform	SM 9222 D	1000	CFU/100ml	2022/10/24
Nitrates	SM 4500 NO3-E	< 0.6	mg/L	2022/10/28
BOD	SM5210 B	26	mg/L	2022/10/24
COD	HACH 8000	415	mg/L	2022/11/09
Total Nitrogen	SM 4500-N	125	mg/L	2022/11/08
Ammonia Nitrogen	SM 4500	91.4	mg/L	2022/11/08
pH	SM 4500H^+ B	8.05	units	2022/10/24
Temperature	Temp. Probe	28.2	°C	2022/10/24
Total Suspended Solids	SM 2540 D	37	mg/L	2022/10/25
Oil & Grease (Total)	SM 5520-F	< 2	mg/L	2022/10/27

The reported results pertain only to the specified sample(s) tested.
Analyses for pH was done at the time of sampling.

References:

- Standard Methods for the Examination of Water and Wastewater, 23rd Edition, 2017, AWWA/APHA/WEF.

Approved By: NLouisy

N. Louisy-Manager