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Abbreviations and Acronym

ACP	African Caribbean Pacific
ADB	Asian Development Bank
AIDAB	Australian International Development
Assistance	Bureau
DEC	Department of Environment and Conservation
EU	European Union
EPR	Extended Producer Responsibility
MCPNG	Manufacturers Council of Papua New Guinea
NCDC	National Capital District Council
PET	Polyethylene terephthalate
PNG	Papua New Guinea
SPREP	South Pacific Regional Environment
Programme	
TA	Technical Assistance
TOR	Terms of Reference
WASTE	Lome IV Pacific Regional Waste Awareness & Education Programme

Executive Summary

Action Plan

IMPLEMENTATION OF THE PLAN	ACTIONS			RESPONSIBILITY	TIMEFRAME
	Priority One	Priority Two	Priority Three		
	<ul style="list-style-type: none"> Establish a National Solid Waste Management Committee 	<ul style="list-style-type: none"> Organise a workshop to discuss the plan, timetable & budget 		<ul style="list-style-type: none"> DEC 	
WASTE MINIMISATION INITIATIVES					
General	<ul style="list-style-type: none"> Establish a sorting area at the landfill site 			<ul style="list-style-type: none"> NCDC 	
Paper		<ul style="list-style-type: none"> Distribute waste cardboard to rural community Distribute used paper to schools, craft center, hospitals etc. 		<ul style="list-style-type: none"> NCDC & DEC 	
Glass	<ul style="list-style-type: none"> Investigate the possibility for glass recycling to Australia 	<ul style="list-style-type: none"> Implement segregation of glass at source 		DEC, NCDC	
Metals	<ul style="list-style-type: none"> Improve on segregation of metal at source Improve on collection system of recyclable metals 	<ul style="list-style-type: none"> Investigate feasibility introducing an EPR fee 		<ul style="list-style-type: none"> DEC, NCDC & Recyclers 	
Biodegradable	<ul style="list-style-type: none"> Segregate green waste at source Allocate green waste collection days Educate Members of the public on the benefits of composting 	<ul style="list-style-type: none"> Investigate feasibility for the purchase of a shredder and chipper Involve community in the composting project through workshops, demonstration projects. 		<ul style="list-style-type: none"> NCDC, NGO's & DEC 	
Big Wastes (Scrap Metal)	<ul style="list-style-type: none"> Investigate possibility of crushing and compacting large metal wastes 			DEC	

IMPLEMENTATION OF THE PLAN	ACTIONS			RESPONSIBILITY	TIMEFRAME
	Priority One	Priority Two	Priority Three		
REFUSE COLLECTION	<ul style="list-style-type: none"> Increase the days on which green waste are to be collected Initiate a feasibility study on the development of an establishment to manage collection & management of a new engineered landfill 	<ul style="list-style-type: none"> Look into the feasibility of purchasing new compactor trucks Source funds or sponsors for provision of 50litre plastic bins 		DEC & the National Solid Waste Management Committee	
DISPOSAL TO THE LANDFILL	<ul style="list-style-type: none"> Identify a site for an engineered landfill for the National Capital District Implement a Feasibility/Environmental Assessment Study for the identified site 	<ul style="list-style-type: none"> Prepare landfill management plan and a revamped code of practice for the existing landfill 	<ul style="list-style-type: none"> Develop Rehabilitation & Management Plan for closed landfills 	DEC and National Solid Waste Management Committee	
SPECIAL WASTES	<ul style="list-style-type: none"> Conduct audit of hazardous substances Prepare plans for disposal or emergency response 	<ul style="list-style-type: none"> Recycle car and appliance batteries Implement a systematic way of collecting all waste oil for shipment to Australia 		<ul style="list-style-type: none"> Ministry of Health & DEC 	
COMMUNITY INVOLVEMENT	<ul style="list-style-type: none"> Increase community awareness through media outreach with assistance from MCPNG 	<ul style="list-style-type: none"> Solicit funds for community competition Publicity/Education through women's group, church, schools, health dept etc. 		<ul style="list-style-type: none"> DEC and the National Solid Waste Management Committee 	
ORGANISATION OF SOLID WASTE MANAGEMENT	<ul style="list-style-type: none"> Review new environmental bill Source funds to conduct a feasibility/environmental assessment study for a new regional engineered landfill 	<ul style="list-style-type: none"> Solicit funds for equipment and manpower for DEC New landfill site to be endorsed by the new National Solid Waste Management Committee 	<ul style="list-style-type: none"> Repeat every 2-3 years waste characterisation studies 	<ul style="list-style-type: none"> DEC & National Solid Waste Management Committee 	

1. Introduction

This report was financed by the European Communities from a grant of the European Development Fund and is presented by Sinclair Knight Merz for consideration of the Government of Papua New Guinea. It does not necessarily reflect either the opinion of the latter or the European Commission.

Sinclair Knight Merz was commissioned in August 1999 by the South Pacific Regional Environment Programme (SPREP), to carry out the Solid Waste Characterisation and Management Plans Project in 8 Pacific ACP countries including Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

The study brief included conducting solid waste characterisation study and developing integrated solid waste management plans for the 8 Pacific ACP Countries.

This is the final report for Port Moresby, Papua New Guinea, based on the findings of the fieldwork carried out by Messrs Maleli Naiova and Asaeli Tulagi between the 1st to the 12th November 1999.

The aim of the report is to present the results of the waste characterisation work carried out and to describe current waste management practices in PNG. The report also aims to formulate options and priorities for an integrated solid waste management plan for Papua New Guinea. The TOR for this project is found in Appendix A.

2. Overview of Existing Solid Waste Management Practices, Methods and Regulations

2.1 Introduction

Papua New Guinea is the largest of the Pacific Island countries with an area of 465, 000 square kilometres. It has a population of approximately 4 million people and gained independence in 1975 (AIDAB report 1994).

Located in the south east of the largest island is the capital, Port Moresby. The largest municipal centre, it has a population of approximately 300,000 people and is also the centre of government and administration in addition to the airport, port and hospital facilities for PNG.

According to the 1994 AIDAB report, there is a lot of movement between the highlands, outer islands and urban centre, which have resulted in an increase in the urban population growth rate of 43 per cent. This report further stated that the increase in urban population placed more pressure on inadequate infrastructure and facilities such as water supply, electricity, sewage and municipal solid waste (MSW) management.

Most of the MSW produced in Port Moresby is dumped on land, in the ocean or waterways, fed to pets and animals, and small amount are incinerated, reused or recycled.

2.2 Previous Studies

In 1985, the Department of Environment and Conservation carried out a 30-day domestic solid waste survey at the Baruni Dump. This survey estimated that the average daily waste generated by the domestic, commercial and industrial sector varied between 0.21 to 0.39kg/person/day, of which over 53% was biodegradable. Discussions with the National Capital District Council (NCDC) and Department of Environment and Conservation (DEC), highlighted that PNG does not have detailed up-to-date data on solid waste. This study therefore, will serve as a fundamental tool for solid waste management in Papua New Guinea.

In 1994, AIDAB funded a study entitled “Country Environmental Profile of Papua New Guinea”. The study outlined some major problems of urbanisation and its detrimental impacts on the local environment and infrastructure.

2.3 Port Moresby Landfill

The Port Moresby municipality covers a large area and as a result the collection and proper disposal of solid waste is a major problem. The two major landfill sites are; (i) Baruni Dump located in the west and (ii) 6 Miles Dump, east of Port Moresby. The two sites are legally gazetted and any NCDC contractor found dumping at other sites would have their contracts terminated immediately.

The landfill at 6 Miles is located on a slope and currently been used by NCDC for domestic, commercial, institutional and industrial wastes. In contrast, the second landfill at Baruni is being rehabilitated.

At the landfill controlled dumping and burning is carried out with the assistance of a bulldozer and backhoe which are hired by the NCDC at a combined cost of \$400 Kina/hr. The landfill operation also has inadequate compaction with minimal soil cover. The landfill does not have either protective lining to collect leachate or fences to prevent scavengers from entering the site.

Containment of the area to restrict people from getting into the dump is vital. Residents of nearby squatter settlements also have begun to build houses on piles or stilts adjacent to the dumping site. Scavengers have constructed temporary makeshift shelters at the landfill where they wait for trucks. Scrap metals, plastic goods, wrappings, construction materials, textiles and other reusable or recyclable goods from the trucks are salvaged for cash.

At the 6 Miles Dump the drivers and operators of machines working on the collection truck and dump area do not wear protective gear. Waste collectors and operators are also not properly trained and therefore are not aware of relevant waste management issues.

The 6 Miles Dump has an Environmental Code of Practice which at times operators do not adhere to.

There is also no rehabilitation plan for closure of the landfills.

Siting of a new sanitary landfill is difficult due to land tenure issues. Most areas outside the suburbs and cities are customary land, and the landowners demand very high fees for leasing their land.

Due to the huge population that the 6 Miles Dump caters for, it is imperative that the DEC has a landfill that is well managed in economic and environmental terms. It is important that daily records of data on the number of loads, weight and types of waste

reaching the landfill are made available for future planning. However, at present this data does not exist for the NCDC controlled dumps.

2.4 Collection System

Refuse collection and daily maintenance of the landfill is the responsibility of NCDC and their contractors. NCDC charges a range of collection fees relating to whether the refuse is from private dwellings or commercial entities. NCDC also caters for sanitary wastes, school waste and public waste (refuse from public amenities). NCDC has a yearly waste management budget of approximately \$4 million Kina (NZ\$2.5 million), the largest of the 8 ACP countries.

Many locals do not pay their waste collection fee and are responsible for their own waste disposal, e.g. the settlement in Sabama (part of the low-income group in the waste characterisation survey).

The Council contracts out all collection services to three contractors who collect domestic waste from the three major electorates in Port Moresby and another contractor who services the commercial and industrial areas. About 270 commercial and industrial entities have their refuse collected by NCDC from areas such as Badili, Boroko, Gordons, Ela Beach, Hohola, Koki, Konedobu, Sabama, Tabari, Tokarara, Town area, Waigani, Gerehu, 7 Mile, 6 Mile, 4 Mile and 2 Mile. Some commercial organisations and industries transport their own waste to the landfill. The commercial collection service is governed by a commercial service agreement, which also applies to the domestic collection service. The client and the municipal authority are both bound by this service agreement.

Domestic waste is collected once or twice a week from Monday to Saturday and also on special request. Commercial and industrial waste collection varies from once to seven days a week. There is no segregation of green or other wastes.

A driver and four collectors are usually assigned for each tipper or refuse compactor truck. There are a total of 19 trucks that collect commercial/industrial and domestic wastes. 12 trucks collect domestic waste and the remaining trucks collect the commercial and industrial wastes. Of these, eight are compactor vehicles with a capacity ranging from 4.5 cubic metres to 15.3 cubic metres. The rest of the fleet is open trucks ranging in size from 0.35 cubic metres to 1.5 cubic metres.

The NCDC believe that 12-15 compactor trucks with a volume of 15.3 cubic metres would be sufficient for refuse collection within the city, that is, 4 x 15.3 cubic metre trucks for each electorate.

The current rate structure set out by the NCDC is accepted by all with the exception of a few private dwellers who feel that the fee of K15/year is very expensive. Some feel that the service should be provided free of charge.

Table 2.1 summarises the waste collection fees.

**Table 2.1: National Capital District Commission
Waste Management Rates**

Frequency of Collection	Fees (K)
SANITARY FEES PER MONTH	
Daily collection [per bin]	10
Twice weekly collection [per bin]	23
Special collection [per lift]	5
DOMESTIC FEES PER MONTH	
Twice weekly collection [bin]	10
(mobile garbage bin 240 litres)	33
Daily collection [per bin]	35
(mobile garbage bin 240 litres)	115
Special collection [per bin collection]	8
(Drum per collection)	30
COMMERCIAL AND INDUSTRIAL GARBAGE FEES PER MONTH	
Once weekly	20
Twice weekly	33
Three times weekly	40
Four times weekly	60
Five times weekly	85
Six times weekly	100
Daily service	115
Twice daily service	130
Three times daily service	145
N.B. A K10.00 additional charge shall be levied for any additional bin service.	
FEES FOR USE OF WASTE DISPOSAL DEPOTS	
Small cars	5
Utilities to 4WD	7
1.5 Tipper Truck and above	10
K600 Tipper Truck and above	8
Industrial Waste bins	

As part of their community outreach project, NCDC have contracted a tipper truck from a village called Motukoita at \$2 000Kina a fortnight to collect village refuse. The council provided the village with one 44gallon drum for every three houses.

2.5 Education

At present, the DEC is planning to launch an education and awareness campaign where key stakeholders of solid waste management (such as the World Health Organisation, Ministry of Health, MCPNG, NGOs) will work together with members of the community.

Effective community based education and awareness is vital in the area of solid waste management. There is a need to educate the public on the environmental and financial benefits of waste minimisation. Some funding for such projects can be sourced from various businesses that are part of MCPNG, a strong supporter of waste minimisation.

MCPNG are already in the process of setting up a committee of representatives from manufacturers, users, domestic reps, regulators (DEC) and packers. This committee will look into educational programs to promote the three R's of waste minimisation: Reduce, Reuse and Recycle.

2.6 Littering and Illegal Dumping of Wastes

Even though the Public Health Act states that an offender found dumping rubbish illegally could be fined up to K1000, indiscriminate dumping of refuse in some parts of Port Moresby into waterways, drains, roadsides and other public places still persists. These areas are littered with beer cans/bottles, soft drink bottles, used plastic containers, wrappings, packaging and beetle nut peelings.

The DEC and NCDC lack resources to enforce legislation such as the Public Health Act and the new Environmental Bill.

2.7 Legislation

There are number of pieces of legislation that deal with solid waste disposal and management in Papua New Guinea. These include the:

- *The Public Health Act (PHA)*
This Act outlines provisions for regulating and controlling domestic refuse, the establishment of refuse points, and also covers health, sanitation, cleaning, scavenging and disposal of waste. This Act also prohibits the disposal of municipal solid waste into an area other than the designated dumping sites.

Offenders can be fined K1000, but there is a lack of enforcement of this law.

-
- *The Environmental Planning Act (EPA), Chapter 370, 1978*
The EPA provides for an environmental impact assessment of major development projects. It is used as an instrument to monitor and control developments, including proposed sanitary landfills.
 - *The Environmental Contaminants Act (ECA), Chapter 386, 1978*
The ECA provides the mechanism for regulating the importation, distribution, and discharge of contaminants into the environment. It has provisions for regulating littering, the breaking of glass, and general regulation of discharges from waste dumps into the environment. It is an instrument for the prevention, abatement and control of contamination and of the protection of the environment.
 - *The Water Resources Act (WRA), Chapter 205, 1982*
The Act deals with the protection of natural water resources and its management. It provides the regulatory mechanism for controlling discharges of contaminants into natural water systems.
 - *The Amended Organic Law on Provincial Government, 1995*
This Act provides the mechanism and gives powers to local governments to set up by-laws to cover municipal waste management.

The new Environment Bill is still in its draft form. Generally, there is a need for the development of regulations that would cover waste minimisation and waste disposal. It is also important that regulation be put in place for the environmental assessment, codes of practice and management plans for future landfills in Port Moresby.

2.8 Recycling Initiatives

In Papua New Guinea there are about eight companies involved in the recycling of scrap metal such as aluminium cans, copper, brass, other aluminium, lead, stainless steel, hot water systems, batteries, radiators and all other non-ferrous scrap metals. From the presence of people scavenging at the landfill, it is obvious that a majority of the locals are aware of the values of these materials.

During the WASTE Project Co-ordinator's last visit to Port Moresby, he suggested that a regional directory for companies involved in recycling should be developed. This would be a useful way of making the public aware of the recycling opportunities in their country.

The National Capital District Commission initiated a campaign in 1999, for the collection of plastics at a rate of 20t (cents) per bag. This campaign appears to have been successful, however, the common disposal practice of trench is not very environmentally acceptable. It was recommended that the relevant authority should investigate the possibility of sending the collected plastic to Australia or New Zealand for recycling. During consultation, Coca-Cola Amatil Ltd (Papua New Guinea) indicated that a PET bottle recycling company is to commence operation in PNG in December 1999. The representatives of the company also expressed intentions to provide monetary incentives for the return of PET bottles as practiced in Fiji.

According to people contacted by the project team, there is no waste paper or cardboard recycling facilities in Port Moresby.

3. Audit and the Characterisation of the Solid Waste Stream

3.1 Introduction

In Papua New Guinea one of the factors that contributes to the poor management of solid waste is the lack of consistent data on the composition and quantity of solid waste being produced. The data will be necessary for the design of a new landfill site for the Port Moresby area, in the event that this is required. It is also necessary for the setting of targets for waste reduction, reuse, recycling and will allow the measurement of success of any waste minimisation initiatives.

In order to implement an effective solid waste management program, quantitative data on the composition of waste being generated within Port Moresby, must be obtained.

For this study a household waste survey was used to identify the waste composition in Port Moresby.

3.2 Methodology

3.2.1 Bag and Bin Collection

3.2.1.1 Preparation

This survey was carried within the National Capital District Municipality in Waigani, Port Moresby on eight consecutive days.

1. In order to study the waste characterisation at the source, five households were selected at Sabama Settlement, ten households at Waigani PTC housing scheme and another ten at the suburb of Waigani Heights in Port Moresby. The selection of households was achieved with the assistance of staff of NCDC.
2. The houses were selected according to the following socio-economic groups: low, middle and high income. A number of large businesses were also included for commercial waste analysis.
3. Each house was assigned a number and given eight garbage bags, one for each day. The purpose of the survey was explained during the distribution of the garbage bags, with the number of persons in each household noted.

-
4. The waste generated was collected every day at a fixed time for eight consecutive days to allow for variation in waste generation over the week.

Note:

The first day's samples have been excluded from the analysis as they may contain waste from two or more previous days.

3.2.1.2 Sorting Procedure

The following procedure was followed:

1. Weigh all 25 garbage bags and record against allocated number.
2. Select 10 bags randomly from the total but keeping in mind the need for equal representation of the different income earning groups. Open all of the randomly selected bags and empty their contents into a bucket.
3. Spread the contents of the bucket over a plastic sheet or tarpaulin (7m x 4m). Repeat the process until all the bags for each sample area are emptied. Count the number of bucketful loads, to be recorded for the volume determination.
4. Separate the waste into the nine different components and weigh each category on a scale and record on data sheet.
5. Dump all the waste properly and clean the equipment used. Repeat steps 1 through 5 everyday for the duration of the study.

3.2.1.3 Analysis and Reporting

The main points in analysis are:

- the statistical unit is the household, not the bag
- detailed analysis and reporting is by weight
- total volumes of wastes should also be determined to give general indication of landfill space requirement keeping in mind that volume is greatly affected by the compaction of the refuse.

The mean percentage composition for a waste type is determined from the total weight of the constituent divided by the total weight of refuse sampled. This is not the same as the average of the compositions of the individual samples.

Data from the number of households sampled is extrapolated to provide an estimate of refuse generation for the full number of houses in the collection area.

For potentially hazardous substances it is appropriate to only list the substances found.

The analysis will identify the following data:

1. Mean Bulk Density
2. Mean Daily Generation (domestic/small business)
3. Percentage (by weight) of waste streams

3.3 Results

3.3.1 Waste Characterisation of Bag and Bin Collection

Table 3.1 below shows the weight of waste in kilograms collected from each of the selected houses each day. The column showing ‘family size’ is the number of people living in each house.

Table 3.1: Data sheet for daily domestic waste generation rate

House No	Family Size	Day 1 Kg	Day 2 kg	Day 3 Kg	Day 4 kg	Day 5 kg	Day 6 Kg	Day 7 kg	TOTAL kg
1	8	7.8	5.0	4.5	0	3.9	4.6	0	25.8
2	8	3.7	5.8	4.2	2.1	3.3	0	0	19.1
3	9	4.6	2.4	2.5	0	1.3	0.4	2.6	13.8
4	9	0.5	0.5	2.7	0	2.1	0.8	0	6.6
5	5	2.0	4.2	4.0	0	3.5	0	3.7	17.4
6	4	1.3	4.3	2.0	1.5	0	2.4	2.6	14.1
7	6	2.2	4.5	3.5	3.9	1.9	1.2	9.1	26.3
8	8	9.0	2.3	4.9	4.6	3.8	0	8.4	33
9	6	1.3	3.2	1.4	2.0	0	1.7	0.9	10.5
10	4	3.3	0	3.5	4.5	0.9	0	3.0	15.2
11	4	3.3	0	0	4.5	0.6	4.4	2.4	15.2
12	9	2.0	8.0	3.0	2.2	3.5	0	0	18.7
13	2	3.1	5.7	4.0	2.2	0	4.5	0	19.5
14	6	4.0	5.7	6.3	0	6.3	1.7	6.9	37.2
15	6	6.8	1.6	0	0	0.7	2.9	3.8	15.8
16	4	2.0	1.4	2.9	3.5	2.6	3.2	1.3	16.9
17	5	5.4	2.3	1.3	1.5	0	0.9	1.6	13
18	13	5.0	2.0	5.6	5.5	4.1	6.0	4.5	32.7
19	9	1.3	0.8	2.4	5.3	0.9	1.0	2.5	14.2
20	8	3.8	2.7	0.7	2.5	5.2	0	1.3	16.2
21	9	2.3	2.4	6.6	7.0	0	2.6	3.1	24
22	5	3.2	3.0	0.5	0	2.1	5.1	0	13.9
23	6	4.5	1.3	4.3	1.6	0	2.0	3.9	17.6
24	6	2.4	0.8	1.7	1.0	1.6	1.3	1.6	10.4
25	7	5.6	4.1	2.0	5.5	0.9	5.0	3.0	26.1
TOTAL	166 (A)								473.2 (B)

$$\begin{aligned} \text{Mean daily generation} &= B/A/7 \text{ kg/person/day/household} \\ &= 0.41 \text{ kg/person/day} \end{aligned}$$

Table 3.2 shows the records of the total volume of waste from the 10 randomly selected houses in the bag and bin collection. The total volume can be used to calculate the average density of waste.

Table 3.2: Data sheet for volume recording for 10 randomly selected houses

Day	1	2	3	4	5	6	7	Total
Total No. of bucketful loads	7	7.25	5.25	7.75	6.5	5.75	6.5	40.75
Volume of bucket (litres)	20	20	20	20	20	20	20	
Total Volume (litres)	140	145	105	155	130	115	130	920

Grand total volume = 920 litres (A)

Table 3.3 shows the weight of waste recorded for each of the 10 randomly selected houses on each day.

Table 3.3: Data sheet for recording of weights corresponding to the 10 randomly selected houses

Day	1	Day	2	Day	3	Day	4	Day	5	Day	6	Day	7
Hse No	Wt Kg	Hse No	Wt kg	Hse No	Wt Kg	Hse No	Wt kg	Hse No	Wt Kg	Hse No	Wt kg	Hse No	Wt Kg
1	7.8	1	5.0	3	2.5	18	5.5	22	2.1	1	4.6	3	2.6
2	3.7	2	5.8	4	2.7	2	2.1	11	0.6	3	0.4	5	3.7
4	0.5	4	0.5	9	1.4	17	1.5	10	0.7	17	0.9	19	2.5
6	1.3	6	4.3	19	2.4	6	1.5	2	3.3	6	2.4	20	1.3
9	1.3	9	3.2	24	1.7	9	2.0	3	1.3	9	1.7	21	3.1
14	4.0	14	5.7	6	2.0	10	4.5	5	3.5	14	1.7	16	1.3
20	3.8	20	2.7	20	0.7	20	2.5	7	1.9	25	5.0	2	3.9
21	2.4	21	2.4	23	4.3	21	7.0	19	0.5	21	3.1	24	1.6
23	4.5	23	1.3	16	2.9	23	1.6	24	1.6	23	2.0	6	2.6
24	2.4	24	0.8	21	6.6	24	1.0	25	0.9	24	1.3	9	0.4
Total	31.7		31.7		27.2		29.2		16.4		23.1		23

$$\begin{aligned} \text{Grand total weight} &= 182.3 \text{ kg(B)} \\ \text{Mean Bulk Density} &= (B)/(A) \text{ kg/litre} \end{aligned}$$

= 0.198kg/litre(198kg/m³)

= 0.2kg/litre(200kg/m³)

Table 3.4: Data sheet to determine weight of the various components

Primary waste Classification	Day1 kg	Day2 kg	Day 3 Kg	Day 4 kg	Day 5 kg	Day 6 Kg	Day 7 kg	Total Weight	Wt %
Paper	1.9	3.4	1.6	5.5	2.4	1.0	3.5	19.3	11.9
Plastics	2.9	2.2	1.9	4.5	2.6	3.2	3.4	20.7	12.8
Glass	3.5	4.3	1.9	1.4	0.8	1.0	1.7	14.6	9.0
Metals	5.8	3.5	1.2	2.7	0.9	3.5	2.3	19.9	12.3
Biodegradable	9.0	16.0	18.9	14.7	5.4	8.5	9.1	81.6	50.4
Textiles	-	0.1	0.7	0.4	0.5	-	0.7	2.4	1.5
Hazardous	-	0.5	0.4	-	-	0.5	1.9	3.3	2.0
Construction and Demolition	-	-	-	-	0.6	0.9	-	1.5	0.9
Other	-	-	-	-	-	-	-	-	-
Total	23.1	30.0		29.2	13.2	18.6	22.6	161.8	100

NB: Biodegradable - kitchen waste, shells, grass clippings,

3.3.2 Summary of Results for Bag and Bin Collection Analysis

1. Mean Bulk Density of Waste = 0.20 kg/litre (200 kg/cubic metre)
2. Mean daily generation(domestic) = 0.41kg/person/day
= 2.8 kg/household/day
3. Percentage of waste streams:

Table 3.5: Waste classifications of bag and bin survey

Primary Waste Classification	Secondary Classification	Examples of Waste	Weight of Waste Recorded kg	Weight % (Total)
Paper	Corrugated cardboard	Boxes	19.3	11.8
	Magazines	All magazines		
	Newspaper	All newspapers		
	Office	Computer, printer, copier		
	Tetra pak	Waxed, carton		
	Other packaging	Cereal box, shoe box		
	Sanitary	Nappies		
Plastics	Polyethylene terephthalate (PET)	Soft drink bottles	20.7	12.7
	Rigid high density Polyethylene(HDPE)	Milk bottles		
	Flexible HDPE	Plastic bags		
	Other Plastics	Not covered above		
Glass	Returnable bottles	Beer & soft drink bottles	14.6	8.9
	Bottles and jars	Wine bottles and jam jars		
	Other glass	Window glass		
Metals	Steel cans	Baked bean can	19.9	12.2
	Aluminium	Soft drink can, beer can		
	Appliances	Fridge		
	Other ferrous	Car body, roofing iron		
	Other non - ferrous	copper pipe		
Biodegradable	Kitchen waste	Vegetable peelings, food scraps	81.6	50.0
	Garden waste	Grass clippings, branches		
	Soil	Topsoil		
Textiles	Clothes	Clothing	2.4	1.5
	Fittings	Carpet, curtains		
Potentially hazardous MSW	Small batteries	Dry cell, alkaline and button batteries	3.3	2.0
	Vehicle batteries	Car, truck and motorcycle		
	Other batteries	Solar systems		
	Residuals of cleaning fluids & pesticides	Used containers		
	Other potentially hazardous	Florescent tubes, light bulbs, needles & syringes, expired drugs		
Construction and demolition (C&D)	Wood	sawn timber	1.5	0.9
KNIGHT MERZ		Final	210	

Primary Waste Classification	Secondary Classification	Examples of Waste	Weight of Waste Recorded kg	Weight % (Total)
	Wood fibre products	softwood, hardboard, particle board		
	Rubble	bricks, concrete		
	Cleanfill	clay, sand, rock		
	other C&D	not covered above		
Other	Rubber	Tyres	-	-
	Other	Not classified above		
TOTAL			161.8	100

3.3.3 Analysis of Waste Characterisation Results

It is assumed that the result of the household survey conducted at the Sabama settlement (low income), Waigani PTC Housing Scheme (middle income) and Waigani Heights represents waste generation patterns for Port Moresby.

1. Average no. of People in a Household = 6.6
2. Total population of Port Moresby = 300,000
3. Total no. of households in Port Moresby = 42,857
4. Bulk Density of Waste = 200kg/m³
5. Waste Generated from households = 2.8 kg/house/day
= 0.40kg/p/day
6. In 1 year = 146
kg/person/year
7. For Port Moresby in 1 year = 43,800
tonnes/year
= 219,000 m³/year
8. If the refuse were compacted to half its volume =109,500
m³/year
9. Surface Area needed for a 1 metre high landfill = 109,500
m²/1000m²
Surface Area = 0.109 km²
10. The volume could be reduced further
by 50% through composting of
biodegradable wastes = 547,495 m³/year

4. Evaluation of Waste Management Systems and Markets for Recyclable Materials

This section of the report reviews existing integrated waste management programmes and resource recovery systems and evaluates them for their applicability to conditions in Papua New Guinea. Access to markets for recyclables is assessed and the cost of utilising these markets is discussed.

The feasibility of establishing recycling markets within the country is examined with respect to scrap metals, glass, paper, plastics and compost.

Factors to be considered in strategic waste management planning is summarised in Table 4.1, taken from the World Health Organisation Publication Document Series, No.6 titled “Healthy Cities – Healthy Islands”.

This table is prepared to help decision-makers at national and local government level make strategic decisions for the improvement of their solid waste management services. The table shows issues that should be considered when prioritising waste management strategy actions.

Table 4.1 Strategic Issues for Solid Waste Management in Port Moresby

Requiring Special Attention	Special Characteristic of Solid Waste Management	Strategic Measures to Improve Solid Waste Management
Small country size	Excessive amounts of packaging - recycling is difficult due to lack of economies of scale and remoteness from recycling market	Firm commitment of the relevant Authorities for better solid waste management - credibility of waste management authorities is vital
Economy of country	Difficulty in equipment	Strategic planning

<ul style="list-style-type: none"> - small economy - dependence on foreign aid 	maintenance <ul style="list-style-type: none"> - problems getting spare parts - lack of skilled mechanics 	<ul style="list-style-type: none"> - waste management planning is essential to achieve cost-effective use of limited resources
Improvement of environmental health <ul style="list-style-type: none"> - through better solid waste management 	Difficulty in site acquisition for landfill <ul style="list-style-type: none"> - lack of land - land ownership issues 	Waste minimisation first <ul style="list-style-type: none"> - source reduction is the most important rule for solid waste management in the future
Protection of fragile environment <ul style="list-style-type: none"> - groundwater - coral and mangrove ecosystems are resource base for fisheries and tourism 	Insufficient or not duly trained human resources for waste management	Improvement of collection service and cost saving <ul style="list-style-type: none"> - collection is the most expensive process in solid waste management; improvement and cost savings can generate financial resources for sanitary landfilling
Promotion of tourism <ul style="list-style-type: none"> - clean town and beaches will attract more tourists 	Lack of cleanliness awareness among the public <ul style="list-style-type: none"> - urban dwellers not familiar with disciplines of urban living such as refraining from littering 	Use of saved cost for final disposal improvement <ul style="list-style-type: none"> - careful siting and management are key to successful landfill

It is recommended that the people involved in solid waste management in Port Moresby Town Council and the Department of Environment and Conservation use the World Health Organisation document “Healthy Cities – Healthy Islands” as a reference for strategic planning of waste management in Port Moresby. This document contains specific recommendations and criteria for the collection service, vehicles, waste receptacles, composting, recycling, transfer stations, management of contractors, landfill site selection, controlled landfill requirements, operation of landfill, as well as management and organisation of solid waste.

4.1 Evaluation of Waste Management Programmes

4.1.1 Waste Reduction

Waste reduction activities are important to halt or slow down the increasing rate of waste generation per capita. Waste reduction has several aspects, all of which should be addressed. These include toxicity reduction and volume reduction as well as encouraging products that can be recycled more easily. There are many successful cases of reduction of wastes by individuals, commercial enterprises and agencies using their purchasing power, as well as governments and industries.

In Pacific Island countries, almost all goods are imported to sustain people’s daily needs. This generates an excessive amount of packaging waste which, because of the limited market, has very little possibility of recycling except for aluminium cans and beverage bottles. Waste minimisation measures such as recycling of package

waste practicable in other parts of the world are not easily applicable in Pacific Island countries.

Waste reduction is therefore one of the most critical elements of a solid waste management strategy for Port Moresby and is a practical option for a Pacific Island country. There **must** be a major focus on waste reduction in Port Moresby in the future.

Recommendations

1. Prepare an action plan identifying how to reduce the amount of waste produced in Port Moresby, including education, media campaigns, legislation, home composting.
2. Set targets for waste reduction for various waste streams and monitor them at regular intervals.

4.1.2 Collection and Transfer of Wastes

The waste collection system in Port Moresby is generally unsuccessful in terms of providing for the efficient, effective and economic removal of waste from source to point of disposal. This is the case in many of the Pacific Islands. The domestic collection system has been privatised in Port Moresby but the benefits of privatisation have not been achieved.

The collection system is an integral part of the waste management strategy for Port Moresby and in order to improve the current collection system and overcome the inefficiencies the following factors must be considered in a detailed analysis of how to improve the current situation:

- Identify a funding source and plan for the next 5 years
- Plan for maintenance and operations of collection vehicles
- Clarify the definition of services to be provided by contractors
- Clarify responsibilities and key performance issues
- Ensure the contractors/waste workers are competent and trained
- Effective monitoring and control – implementation and enforcement of services to be provided
- Foreign aid and privatisation – public sector assets donated by foreign aid may be leased by contractors

Recommendations

1. It is recommended that a complete review of the collection system arrangements in Port Moresby is carried out and the following issues are considered:

- Clarify the definition of services to be provided
- Ensure the contractors are competent
- Choose a fair fee structure – payment by either lump sum per month or payment by weight or volume of waste collected
- Effective monitoring and control – implementation and enforcement of the contractual agreement
- Foreign aid and privatisation – public sector assets donated by foreign aid may be leased by contractors

4.1.3 Legislation/Regulation

One mechanism for waste reduction is to examine the imports to a country and identify which materials will lead to significant quantities of wastes. Action by the Government to reduce the imports that create wastes, through legislation or tariffs could be part of the waste management strategy. This type of intervention may not be appropriate due to the following reasons:

1. Reluctance to interfere with consumer choice
2. Contravention of World Trade Organisation agreements
3. Restricted sources of imported goods.

In Papua New Guinea the use of legislation or tariffs to influence the purchasing and distribution policies for imported goods is a waste management option that should be considered in detail.

Government can also have influence on the success of waste minimisation schemes through tax structures. The exemption of taxes for the export of recyclable materials from Papua New Guinea or other tax incentives should be considered as part of the waste management strategy.

The draft Environment Bill has not yet been implemented. There is still a requirement for the development of regulations covering the transport, collection, treatment, storage and disposal of wastes as well as the management of landfills and waste minimisation. An important part of the waste management strategy will be the implementation of this legislation as well as improving the enforcement of the Environment Contaminants Act. Factors that need to be considered to achieve this are:

1. Which authority will have responsibility for implementing the Environment Bill
2. Multi-sectoral nature of waste management legislation
3. Number of officers for enforcement of litter by-laws
4. Training for enforcement
5. Level of fines
6. Regular review and updating of legislation
7. Financial resources for enforcement of legislation

Recommendations

1. Set up a working group to specifically examine, recommend and implement waste management legislation.

4.1.4 Recycling

There are two basic approaches to recycling. The first involves separating recyclable materials at source (by the waste generator) and separately collecting and transporting these materials to recycling markets. The second involves collecting mixed wastes and separating these at a central processing facility. The key factors in the success of pre-separation efforts are the cooperation and willingness of the waste generator to participate in the programme over the long term, and the additional collection and transport costs that may be required. The success of centralised recycling plants depends on the processing costs and the quality of the recyclable material produced.

The highest recycling rates reported in 15 countries in 1990, were in the range of 10-18%. There are many good examples of successful recycling programmes throughout the world.

A major recycling impediment is the question of continued viability and availability of secondary materials market. The key points are:

- Recycling only occurs when the separated material is incorporated into a product that can be sold.
- Separation of materials does not constitute recycling – markets must be found first.
- Recycled products must be of a quality and price that compete in the marketplace.
- The difference in cost of disposal and recycling must be examined – ie. the price received for the recycled material, the waste collection and disposal costs avoided, the cost of separation, the costs of collection and processing the separated materials.

“The remoteness, relatively small size of the country and high degree of dispersion pose severe difficulty in transportation and market fragmentation. As a result, procurement of solid waste management tools, equipment, machinery, spare parts and even fuel is not only expensive but in many cases, very difficult to obtain. Very often the procurement encounters excessive delay. This situation also creates many constraints in waste recycling and often renders many alternatives not feasible.” (Ref: World Health Organisation Publication Document Series, No.6 titled “Healthy Cities – Healthy Islands”).

The transportation of recyclable goods is one of the highest costs and can be higher than the return on the commodity carried. The opportunity to backload recyclable goods should be investigated in detail. The significant imbalance of imports to exports in Papua New Guinea means that there are significant opportunities to utilise empty ships leaving Port Moresby. Negotiation of appropriate

shipping rates will also be critical to the viability of recycling in Port Moresby. It is recommended that a working group is formed to examine the feasibility of shipping recyclable materials to Australia, New Zealand and Asia, including importers, shipping companies, container leasing companies, government and local government representatives.

Recycling has considerable to be potential, but is likely to be marginally viable in economical terms and may need to be subsidised by the community, government or another body wishing to dramatically reduce the amounts of material entering the landfill. Recycling of some materials might be feasible in Port Moresby or within the Pacific Region. Government, community and business support will be critical to the success of recycling.

Recommendations

1. Form a working group on feasibility of shipping recyclable materials from Port Moresby to overseas destinations.
2. Gain government and business support for implementing recycling in Port Moresby.
3. Negotiate a deal for the recycling of materials that have been identified as feasible. Consider using the existing recycling agencies to implement the recycling project.

4.1.5 Incineration

Incineration/combustion processes use the controlled combustion of solid waste for the purposes of reducing its volume. The advantages are destruction of hazardous waste, reduction of volume by up to 90%, and the possibility of energy recovery. In Denmark, Switzerland and Luxembourg over 75% of the municipal waste stream is treated by combustion with energy recovery. In Sweden it is over 60%, in France 43% and in USA 17%. Japan uses waste combustion to treat over 75% of the waste remaining after recycling.

The disadvantages of incineration are high capital expense, complex technology, complex operations, air emissions and management of ash residues. Incineration in Port Moresby has not been very successful to date.

It is likely that incineration will be viable for the disposal of hazardous wastes, if appropriate management systems are put in place. Detailed planning on the management of the incinerator is needed, with investigations into waste composition, potential users, funding and operations and maintenance.

Recommendations

-
1. Prepare full operations and management plans for the hospital incinerator.

4.1.6 Sanitary Landfills

The disposal of waste to landfills continues to be the predominant method used worldwide. The 1990 International Solid Waste Association report indicated that the percentage of waste disposed of by landfills ranged from 20% to over 90% for 15 countries that were examined (Ref. Skinner, J.H. 1998. International Progress in Solid Waste Management in "Solid Waste in the Pacific". Proceedings 6th Annual Conference, Christchurch 1994).

Open dumping of waste on land without adequate controls as occurs in Port Moresby can result in serious public health and safety problems and severe adverse environmental impacts. Modern sanitary landfills are equipped with leachate collection systems, liner systems, systems for control of landfill gas, groundwater monitoring, closure and post-closure care plans. The objective is to ensure that the landfilling activities are performed in a manner that greatly reduces the chance of release of contaminants to the environment and that any release is quickly detected and corrected.

The issues that need to be considered in improved landfill management for Port Moresby are:

- Sources of funding and financial constraints
- Short term and long term planning
- Access to suitable land
- Lack of technical training
- Inappropriate selection of equipment

The provision of sanitary landfill services is a critical component of the integrated waste management strategy for Port Moresby.

Recommendations

1. A full review of landfill management in Port Moresby should be conducted by a working group and a programme and timeframe developed for the implementation of a new landfill and closure of the existing site.
2. A landfill management plan for the existing landfills should be prepared and implemented.
3. Identify funding for new landfill.

4.1.7 Composting

Due to the quantity of biodegradable waste being produced in Port Moresby it is recommended that composting be implemented as a major part of the waste management strategy. Composting produces a valuable product that can minimise the need to import expensive fertilisers. Composting is a well known technique and there are numerous proven operations around the world.

The issues that need to be carefully considered before implementing a composting scheme in Port Moresby are:

- Composting at community level or household level?
- Initial funding
- What is the economic value of the product - can it be sold?
- Private scheme or government operated scheme?

Assuming a community or municipal scheme, there is at least 21,900 tonnes per annum of organic matter available in Port Moresby based on the current waste generation figures. Assuming an 80% capture rate for this material and an average compression ration of 20 to 1 from loose green matter to finished product then there is approximately 4,400 cubic metres per annum of compost as product available. (This figure is conservative). Assuming compost could sell at Aus\$20/cubic metre, there is a potential return of Kina\$176,000 per annum (Aus\$87,000 per annum). Note: the value of the compost product in Port Moresby will have to be determined.

Three key factors in the support of home composting are:

- Improvement in nutritional balance
- Waste reduction at source
- Reduction in importation of food items

Keys to successful home composting are – organise community group; use grass-root communications; and make the operation simple with use of local resources.

Recommendations

1. Implement a home composting scheme in Port Moresby with appropriate initiatives for participants.
2. Implement a demonstration composting scheme at botanical gardens, the existing landfill or some other public place. Use market waste initially.

4.2 Opportunities and Obstacles

A summary of specific opportunities and obstacles to the successful implementation of waste minimisation initiatives in Port Moresby is highlighted in Table 4.2.

Table 4.2. Opportunities and Obstacles for Waste Minimisation in Port Moresby

Opportunities	Obstacles
Metal recycling is viable and in operation – can be expanded	Lack of funds for waste management initiatives
When new landfill is designed a recycling centre could be incorporated	Lack of public awareness on waste management issues
Likely to be a market for compost	Poor management of existing waste collection scheme
	Lack of public ability to pay
	Lack of public “perception of waste”
	No financial incentive to segregate waste at source
	Small volume of recyclable material available
	Cost of shipping material to Australia or Asia for recycling

Further key opportunities that must be considered in justifying strategies and expenditure on solid waste management are related to the following significant environmental health impacts:

- **Fisheries** is an important economic resource which can easily be affected by improper solid waste management
- Protection of the “enchanted environment” as a valuable resource for the **development of tourism** is an important objective in the development of solid waste management. Tourism development has become an important economic strategy for Papua New Guinea. Tidy towns, clean beaches and healthy people will definitely attract more tourists.
- **Health impacts** from contamination of the groundwater lens can be significant – protection of this vital resource is a priority in solid waste management
- Preventative measures to control the outbreak of infectious diseases through the improvement of solid waste management will improve the **cost-effectiveness of health care**.

4.3 Existing Markets

The only recycling that is being carried out at present in Port Moresby is scrap metal recycling and glass bottle recycling at the Brewery. Plastics collection has been tried by the NCDC but the plastic was disposed of in trench rather than recycled.

4.4 Potential Markets

Table 4.3 gives a rough indication of the prices at present in New Zealand and Australia paid for recyclable materials, the estimate of amounts available in Port Moresby.

Table 4.3 Potential Markets for Recyclable Materials

Material	Type	NZ\$/tonne (bailed and shipped to NZ)	Aus\$/tonne (bailed & sorted to Asia)	Amount available in Port Moresby (tonnes/year)
Glass	Colour sorted	80 - 85		3,900
Paper	Cardboard Newspaper Mixed	100 - 140 100 40	160 112	5,200
Plastic	PET HDPE LDPE	Low density = 50 - 100 High density = 350 - 440		5,600
Metal	Al cans Steel cans	1,500 25		5,300

Note:

Low density = loose to less than 500 kg/m³

High density = 500 kg/m³

4.4.1 Glass Recycling

There is the potential for further glass recycling to be implemented at two levels - increase the volume of recycled bottles returned to the Brewery, and shipping of crushed glass to Australia, New Zealand or Asia for recycling.

4.4.2 Paper Recycling

Paper recycling is available in New Zealand, Australia and Asia. The waste paper is sorted and bailed in NZ and shipped to Indonesia, Malaysia and Australia for processing. It is recommended that only two grades of paper be used for recycling in the Islands - mixed grade and cardboard grade. The key aspects to making a paper recycling operation successful are:

- big equipment to bail a large volume of material,
- sufficient capital behind the operation to invest in equipment,
- the ability to withstand the fluctuations in the market price,
- the ability to put a large weight of material in a container to economise on shipping costs,
- the negotiation of cheap shipping costs,
- the volume, form and quality of the material.

A small paper bailer would cost approximately NZ\$10,000 – 15,000 and could process about 5-6 tonnes paper per eight hour day. Assuming staff requirements for collection, sorting and bailing are 3 for collections and 4 for sorting and bailing and delivery to the wharf, at a cost of NZ\$5/hour, and 5 tonnes processed per day then a cost of approximately NZ\$84/tonne for collection and sorting is estimated. These costs and shipping costs must be kept to a minimum in order for paper recycling to be feasible.

4.4.3 Plastic Recycling

Plastics including PET, HDPE and LDPE are sent to Indonesia, Phillipines, Thailand and Australia for recycling. New Zealand can recycle HDPE. The process generally involves collection, sorting, grinding and packing before shipping to Australia or Asia for re-processing.

The sorting of plastics is more critical to the successful recycling of plastics. LDPE can only be processed if well sorted, HDPE is better if it is uncontaminated with other materials eg. Milk bottles are good, household chemical bottles require separation of parts. Clean plastic bags can be recycled also.

4.4.4 Metal Recycling

At present metal recycling is being carried out successfully by eight different companies. There is the potential to significantly increase the volume of metal being recycled. It is recommended that a small working group is set up, including a representative from the existing recyclers, to identify what actions are needed and what support from government is needed to increase the amount of metal recycled.

4.4.5 Composting

Composting is identified as a highly favourable option as the process can be carried out locally thereby removing the requirement for transportation of goods. The process makes a valuable product that is useful in Port Moresby. Composting will need to be carried out on a small scale initially to ascertain the best operating parameters. A demonstration composting project using market waste at the botanical gardens or some other outdoor community place would be an ideal way to start composting in Port Moresby.

4.4.6 Prices for Recyclables

Table 4.3 gives prices for recyclable materials in 1992 in New Zealand as a rough indication of the value of various materials:

Table 4.3 1992 Prices for Recyclable Materials

Material	1992 Price (NZ\$/tonne)
Glass (broken and sorted by colour)	58
Glass bottles for reuse	3-30 cents
Window glass	45-75
Cardboard	80-100
Newspaper	10-40
Mixed waste paper	35-40
Computer paper	100-120
Cardboard (kraft)	60-80
Plastics	50-350
Plastic film	10-350
Textiles (clean cotton)	300
Textiles (clean woollen)	100
Non-ferrous metals	180-3000
Scrap iron and steel	30-150
Car bodies	\$15 per car stripped
Household batteries	No market
Compost	\$5-7 per 40 litre bag
Compost (bulk)	\$50 per cubic metre

4.4.7 Issues for Recycling from Pacific Islands to Overseas Destinations

1. Government needs to look at shipping costs
2. Container Leasing Companies need to be part of the negotiations
 - Is there a build up of containers in Port Moresby that need to be transported back to another centre?
3. Shipping to a hub will be required eg. New Zealand, Australia or Asia
4. The frequency of shipping is a key factor
5. Mixed containers can be utilised eg. half plastic, half paper
6. 44 gallon drums can be used for compression of recycled materials such as paper, metal, cans, and crushed glass.

5. Alternative Integrated Solid Waste Management Activities

5.1 Introduction

Alternative integrated solid waste management systems have been developed emphasizing source segregation, collection, composting, reuse, recycling and resource recovery as well as collection, transfer and disposal to landfill. The alternative systems have been evaluated and ranked for feasibility and compatibility with the needs of Papua New Guinea. Ranking characteristics include:

- Capital costs
- Technical requirements
- Administrative requirements
- Operational requirements
- Ease of implementation
- Operation and maintenance costs
- By-products
- Political acceptability
- Social acceptability
- Environmental impacts

5.2 Implementation

The strength of an integrated waste management system lies in its working towards sustainability using an integrated approach and emphasizing prevention rather than cure. The waste management hierarchy is an important tool for prioritising actions. The definitions of levels of the hierarchy are given below:

- Prevention: covers methods whereby wastes or emissions are prevented from being generated at their source.
- Reduction covers methods whereby the quantity or hazardous nature of wastes and emissions are reduced at source.
- Re-use covers methods whereby waste and emissions are re-introduced to the same production process or re-used for the same purpose. These wastes do not require processing prior to re-use.
- Recycling covers methods whereby wastes and emissions are re-introduced to the same process or made available for use in another process. Recycling can occur on-site or off-site and the wastes and emissions usually require some form of processing prior to re-use.
- Treatment covers methods whereby wastes and emissions are altered in some way to reduce their quantity, concentration or hazardous properties.

-
- Disposal covers methods whereby wastes and emissions are eventually returned to the earth or the atmosphere.
- Good waste management also depends on a partnership between all levels of government and the community. The success of recycling collection schemes can be highly variable. Often the collection and sorting of recyclables has been emphasized rather than the development of recycling schemes which produce marketable products. The future of recycling schemes is dependent on establishing viable markets for targeted materials.

Options for implementation of these integrated waste management strategies include the following:

- Through national environmental or waste management legislation
- Through health legislation
- Through local legislation and regulations
- Research, education and promotion of environmentally sound waste management practices
- Technical and general advice to authorities, operators and industry
- Voluntary measures such as codes of practice
- Economic instruments
- Bans of particular materials or products
- Systems for recovery

The options can be implemented at all levels of the community including the following groups:

- Central Government
- Local Government
- Waste collection and disposal operators
- Commercial waste producers
- Manufacturers
- Importers
- Domestic waste generators
- Special interest groups
- The public

5.3 Ranking of Alternatives

Table 5.1 gives a ranking from 1 to 3 for various waste management options against criteria including cost, social, environmental and technical criteria. A ranking of 1 is generally indicates a more preferable options where 3 indicates a less preferable option. The cost criteria are added to give a costs total and cost ranking and then all criteria are added to give a total and overall ranking.

Table 5.1 Ranking of Waste Management Options against Criteria

Criteria	Costs				Effectiveness				
	Capital Costs	O&M costs	Cost Total	Cost Ranking	Technical Requirements	Operational Requirements	Ease of Implementation	By-products	Political Social acceptability
Waste Management Option									
Disposal to landfill	2	1	3	2	2	2	1	3	1
Incineration	3	3	6	5	3	3	3	3	3
Municipal Composting	2	2	4	3	3	2	2	1	1
Home Composting	1	1	2	1	1	1	2	1	2
Recycling within country	3	2	5	4	3	3	2	1	1
Recycling overseas	1	2	3	2	1	3	2	2	1
Reuse	1	1	2	1	1	2	2	1	3
Legislation to ban products	1	1	2	1	1	2	3	1	3
Legislation to tax packaging	1	1	2	1	1	2	3	1	3
Segregation at landfill	2	2	4	3	2	2	1	1	1
Segregation at source	1	2	3	2	1	2	3	1	2
Education programme	2	1	3	2	1	1	1	1	1
Media Campaign	2	1	3	2	2	1	1	1	1
Glass recycling to supplier	1	1	2	1	1	1	2	1	1
PET recycling by Coca-Cola	1	1	2	1	2	1	2	1	1
Paper recycling	1	2	3	2	2	2	2	1	1
Metal recycling	1	2	3	2	2	2	1	1	1

Note:

1. Cost total is equal to the sum of rankings for capital costs and O&M costs.
2. The effectiveness total is equal to the sum of rankings for technical and operational requirements, ease of implementation, by-products, political and social impact and environmental impact.
3. Overall total is equal to the sum of ranking for all criteria.

Based on the criteria described under effectiveness the prioritised options would be as follows:

Effectiveness Priorities

- 1 Education Programme
- 2 Media campaign / Glass recycling to supplier
- 3 Metal recycling/ PET recycling by Coco-cola Amatil / Home composting
- 4 Segregation at landfill
- 5 Municipal composting / Reuse / Paper recycling / Segregation at source
- 6 Recycling both within Port Moresby and overseas / Legislation to ban or tax products
- 7 Disposal to landfill
- 8 Incineration

This ranking process gives the following overall priorities for waste management options in Port Moresby:

Overall Priority

- 1 Glass recycling to supplier / Education programme
- 2 Media campaign / PET recycling by Cocacola Amatil/ Home composting
- 3 Metal recycling
- 4 Reuse/ Segregation of wastes at landfill
- 5 Paper recycling / Legislation to tax or ban products / Segregation at source
- 6 Municipal Composting / Recycling overseas
- 7 Disposal to landfill
- 8 Recycling within Port Moresby
- 9 Incineration

6. Rate Structure for Finance Waste Management Activities

This section of the report assesses the capital and operational costs of the waste management programmes and the benefits of income generating waste minimisation activities. Recommendations are made on fee collection systems/disposal costs.

6.1 Cost Priorities for Waste Management Options

Based on the ranking procedure carried out in Table 5.1 above based on cost criteria only the following priorities were determined for Port Moresby:

Cost Priority

- 1 Glass recycling to supplier / Legislation to tax or ban products/ Reuse / Home composting / PET recycling by Coca-cola Amatil
- 2 Education programme / Media campaign / Segregation at source / Recycling overseas / Paper recycling / Metal recycling / Disposal to landfill
- 3 Segregation at landfill / Municipal composting
- 4 Recycling within country
- 5 Incineration

6.2 Recommendations on Fee Collections

The current rate structures for waste collection and disposal are given in Table 6.1 below for the eight countries in the Pacific that have been studied are part of the SPREP Waste Characterisation and Management Plans Study.

Table 6.1 Comparative Costs of Waste Collection and Disposal

Country	Collection per week	Domestic Waste	Commercial Waste	Industrial	Tip Fees	Skip/Bin (per load)
Papua New Guinea (Aus\$)	1-7	120 – 420 (Aus\$60 – 208) (small) 395 – 1380 Aus\$196 – 685) (2401)	240 – 1380 (Aus\$119 – 685)		2(2.5) - car/utility 7(3.5) -1.5Tonne 10(5) -K600 Truck 8(4) -industrial bin	
Solomon Islands - SBD	1 - 2	Free	2.50/ collection (Aus\$0.79)	5.00/ collection (Aus\$1.59)	Free	
Fiji - FJS	2 - 3	Free	Free	-	3.30 (\$2.5) – household 5.50 (\$4.30)– trade/ commer. 16.50 (\$12.85)- condemned 22.00 (\$17)- hazardous	30 (Aus\$23)
Vanuatu - Vatu	3	6,000 (Aus\$72)	9,000 (Aus\$108)	60,000 – 360,000 (restaurants – hotels) (Aus\$722-4,337)	100 – car (\$1.2) 200 – Hilux (\$2.4) 300 –Lorry (\$3.6) 1,500 – Disclutcher (\$18)	2,500 – 3,500 (Aus\$30 – 42)
Tonga - Panga	1 - 2	6 (Aus\$5.77)	12 – 18 (Aus\$11-17)	24 (Aus\$23)	Free	-
Kiribati (Aus\$)	1	(Aus\$17 – 29)	(Aus\$50 – 600)	-	Free	-
Tuvalu (Aus\$)		(Aus\$30 10/load green waste)	(Aus\$100 – 400)	-	Free	15
W. Samoa	2 - 7	Free	Free	Free	Free	-
New Zealand (Aus\$)	1	185 (Aus\$145) 6.5(Aus\$ 5.10) – recyclables			50 (Aus\$39)	

Note:
 Figures given in brackets are in Australian Dollars.
 All other figures are in the local currency.

The table above shows that the charges for waste collection in Port Moresby are similar to New Zealand prices but the fees charged at the tip are low compared to New Zealand. In Western societies the rate structure for waste management is moving towards full cost recovery. Full cost recovery for waste collection and disposal in Port Moresby is the ultimate aim. However the public “ability to pay” is a significant factor to be considered in Port Moresby. It is recommended that the costs of waste collection and disposal are accounted for on an annual basis and that charges are set for the public based on a survey of “ability to pay”, with increases towards

full cost recovery over the medium term. It is recommended that the fees charged for vehicles entering the landfill to tip waste are increased. This increased revenue can be put towards the selection of a new landfill site. Records of vehicles entering the landfill and the amount collected should be kept as part of the daily operations.

7. Integrated Solid Waste Management Plan

7.1 Objectives of the Plan

The objectives for the Integrated Solid Waste Management Plan for Port Moresby, PNG are:

1. To create a framework for solid waste management in Port Moresby that integrates all levels of solid waste management including legislation, government involvement, municipal council management, waste management operations, businesses, community bodies and the public.
2. To ensure that that solid waste is managed in the most appropriate manner for Port Moresby and the people that live there, both economically and environmentally.
3. To incorporate sustainable environmental management principles and waste minimisation initiatives into the plan so as to minimise the environmental effects of solid waste management.

The Plan will provide a basis for prioritising actions required by waste managers in Port Moresby in the short to medium term.

The Plan will be based on information as presented in this report as well as economic factors, regional waste management activities and international best practice in solid waste management. The Plan will take in account the current status of solid waste management, current waste generation rates and classification data on Port Moresby. It would also consider future solid waste generation, rate of growth, wealth, social change, education, markets for recyclable materials and regional influences.

This draft report only discusses some of the priorities and options that have been identified during the fieldwork in Papua New Guinea, that may be incorporated into the final solid waste management plan. Other issues such as institutional strengthening and financing of options will need to be addressed for the implementation of the Plan.

7.2 Waste Minimisation

- Implement a packaging legislation with appropriate taxes to enable the return of recyclable packaging

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- Install paper bins or receptacles in government departments, businesses, schools. etc. for segregated collection
 - Government to purchase a baler and shredder for paper waste.
 - Implement segregated municipal waste collection for all recyclables
 - Investigate the possibility of exporting collected plastics to Australia for recycling
 - Implement segregated municipal waste collection for all recyclables at source (at house level)
 - Investigate the feasibility of compacting or crushing used cars, scrap metal, wrecks to export to Australia for recycling.
 - MCPNG to identify funding for waste minimisation demonstration projects around Port Moresby.
 - Islander Travelodge Hotel and Arnotts to be set up as models of waste minimisation for the commercial sector. They currently segregate their waste at the source into recyclable, reusable and disposables.
 - DEC to allocate an area at the landfill for biodegradable or green waste storage.
 - Improve facilities and method of collection of aluminium cans.
 - DEC to investigate the possibility of introducing EPR. This is the introduction of a fee on purchase of cans or bottles of beer and soft drink. This fee would be used for the return of glass bottles and cans to recycling points locally or offshore. Refunds for the empty cans and glass bottles will be made at a number of collection points or shops e.g 4t/can (similar to the plastic project). The DEC and the Manufacturers Council to co-ordinate this venture.
 - DEC to allocate separate days for collection of green waste from domestic sources. Biodegradable waste to be distributed at various points on the island for demonstration composting projects. About 50% of the wastes currently generated are biodegradable.
 - With assistance from the Manufacturers Council develop and implement an educational and awareness program on waste

minimisation e.g. segregating waste at home with the aim of encouraging home composting.

- DEC to investigate the feasibility of a shredder for green waste to be operated by NCDC.

7.3 Refuse Collection

- DEC in collaboration with NCDC to seek funds for the purchase of at least seven new 15 cubic metre compactor trucks.
- DEC to look for funding for more 50 litre rubbish receptacles.
- NCDC to designate one day per week for collection of all green waste.

7.4 Disposal of Refuse to the Landfill

- The current 6 Mile Landfill Code of Practice (COP) to be adhered to by the contractors and the NCDC and a management plan for the operation of the current landfill site to be developed. The COP and management plan should cover daily refuse collection, disposal, greenwaste dumping, security of the landfill, health and safety issues, segregation of recyclable, re-useable items, compaction, landfill cover, leachate control, wall lining, site rehabilitation, etc.
- DEC and NCDC to identify new landfill sites immediately.
- Consider the feasibility of the new landfill site having a weighbridge.
- Conduct an Environmental Impact Assessment for the selected landfill site.

The EIA should address issues such as:

1. The feasibility of constructing engineered landfill on identified sites with minimal impact to the environment
2. The area of land available and the amount required (sourced from results of waste characterisation)
3. Rehabilitation of the landfill sites at the end of its life.

7.5 Special Wastes

Hazardous or special wastes include medical wastes, waste oil, paint solvents, batteries etc.

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- Conduct a quantitative audit of producers or consumers of hazardous and special waste substances. Identify and list storage, transportation and disposal methods for the different items.
 - DEC to legislate the collection of waste oil at designated areas at the landfill or at one of the major oil companies. Waste oil to be transported to Australia for recycling or undergo controlled burning.
 - All car batteries to be collected and recycled. Other batteries could be sent to Australia for safe disposal.

7.6 Community Involvement

In Port Moresby wide community participation and consultation will be necessary for the effective implementation of a waste management plan.

- Develop educational and awareness programmes with specific waste management and minimisation issues. The DEC has already begun this initiative in conjunction with the MCPNG.
- Promote anti-litter campaigns in rural and urban areas
- DEC to increase community education and awareness through the local media with assistance from the MCPNG.
- DEC to prepare information booklets on waste management for different NGO's, media, community groups, MCPNG etc.
- Find sponsors for annual "keep the village contests ", school & business competitions, etc. through the DEC.
- DEC to organise a clean-up day once a year within Port Moresby first and then throughout PNG.
- Investigate the possibility of integrating waste minimisation topics as part of the primary and secondary school curriculum

7.7 Organisation of Solid Waste Management

- Develop a new National Solid Waste Management Committee to review and prioritise options in the solid waste management plan and to allocate responsibilities and timeframes for achieving goals.

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- Need to identify funding and staffing responsibilities for the enforcement of the litter laws and by-laws of the NCDC.
 - The DEC should ensure that the NCDC is always consulted or be part of any initiative that involves solid waste minimisation in Port Moresby. This has not occurred in the past.
 - The NCDC with the assistance of their Solid Waste Officer, should review their by-laws, relevant legislation and Code of Practice to identify gaps in existing legislation.
 - The DEC to obtain funding from donors for the development of educational and awareness programs.
 - DEC to obtain funding from overseas donor agencies for a feasibility study on a new landfill site and its construction.
 - Siting of landfill sites should be discussed and endorsed by the new National Solid Waste Management Committee.
 - Carry out waste characterisation exercise at least every three years. This allows any changes in waste management and the effectiveness of the Waste Management Plan to be monitored.

7.8 Implementing the Plan

Form a National Solid Waste Management Committee (similar to the one in Fiji). This committee could comprise of representatives from:

- Department of Environment & Conservation - First Secretary or Director as Co-Chairperson, Solid Waste Specialist
- Department of Lands - Co-chair
- Department of Health
- Department of Mineral Resources
- Department of Finance
- Department of Transport & Works
- Valuer Generals Office
- Department of Treasury and Planning
- National Capital District Commission
- Manufacturers Council of PNG

The committee could be chaired by the DEC. Its functions should include:

1. Facilitating waste reduction and minimisation initiatives

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2. Research and co-ordinate EIA and feasibility studies for new landfill sites and the rehabilitation of old sites
 3. Act as a focal point for any solid waste management studies in Port Moresby.
 4. Seek funds for other solid waste management projects from the relevant funding agencies
 5. Lobby for reviews on legislation and regulations on waste management.

Appendix A - Terms of Reference

Appendix B - Study Methodology

Appendix C - Curriculum Vitae

Appendix D - List of Contacts

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 4. Mr. Sekove Naqiolevu. High Commissioner. High Commission of the Republic of the Fiji Islands. 4th Floor, Defence House, Port Moresby, Papua New Guinea. Phone: (675) 321 1914. Fax: (675) 321 7220
 5. Mr. Soina Ravu. Production Manager. Coca-Cola Amatil Papua New Guinea. P.O. Box 167 Waigani, NCD, 131 PNG.
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 6. Mr. Maryanne P. Macdonald. Executive Officer. Manufacturers Council of Papua New Guinea. P.O.Box 598, Port Moresby, NCD, PNG 121.
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 15. Mr. Ken. Neyakawapa. Environmental Health Officer. Health Department. Waigani. Port Moresby. Papua New Guinea.
 16. Mr. William Muru. Environmental Health Officer. Health Department. Waigani. Port Moresby. Papua New Guinea.

Appendix E - References

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1. Alcorn J.B. 1993. Papua New Guinea Conservation Needs Assesment. Government of Papua New Guinea, Department of Environment and Conservation. Coperate Press Inc., Landover, Maryland, Volume 1.
 2. Alcorn J.B. 1993. Papua New Guinea Conservation Needs Assesment. Government of Papua New Guinea, Department of Environment and Conservation. Coperate Press Inc., Landover, Maryland, Volume 2.
 3. AIDAB, 1992. Environmental Development: a Pacific Island perspective, Manila.
 4. AIDAB, 1994. Country Environmental Profile of Papua New Guinea. Microdata Strategic Marketing & Printing, Australia.
 5. Department of Environment and Conservation, 1999. Environment Bill – Consultation Draft. Unpublished Script.
 6. Department of Environment and Conservation, 1985. Urban Waste and Management in Papua New Guinea. Unpublished Report.
 7. Raj. S.C (1998). Duty Travel Report to Papua New Guinea. Project No. 7 ACP RPR 584 (REG/7714/000). Unpublished report.