Updating of the Solid Waste Master Plan for the Seychelles: 2003-2010

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EXECUTIVE SUMMARY AND SUGGESTED STRATEGY

Study Objectives

A few years ago significant advances were made in the effective management of solid wastes in the Seychelles. Two major initiatives contributed to these advances: the establishment of a dedicated waste management authority (SWAC) and the letting of a major contract for the collection, treatment and disposal of solid waste to a specialist contractor (STAR). SWAC is primarily responsible for the enforcement of legislation and the minimisation of environmental impact of waste management whilst ensuring that appropriate facilities and operational activities are provided.

Despite these advances the Seychelles has experienced some difficulties over recent years with the effective and efficient management of solid wastes. Many of these difficulties are a result of the peculiar nature of the island group; their relative isolation, recent economic advances and the desire to both improve the unique local environment and prevent its further degradation. There is also a significant reliance on tourist visitors who are increasingly more enlightened with respect to environmental issues and make destination decisions based on these assessments. Another major difficulty is considered to be under investment in operational plant and equipment as a result of insufficient foreign exchange to purchase and maintain such equipment.

Although not a significant contributor to the current difficulties, the existing solid waste master plan (produced in 1995) under-estimated the volumes of waste arising and proposed a management system that it has not been possible to achieve for a number of reasons predominantly related to finances.

A number of recent studies have identified the need to revise and update the master plan to better reflect the current situation and provide a clear indication of the way forward in the medium term, especially with respect to determining the measures that might require funding from the 9th European Development Fund. Although the intention of the commission was to produce a plan for the years up to 2010 there is a stated objective for this to follow the previously produced Environmental Management Plan for the Seychelles. This states that by 2010 waste management should be sustainable. This has been interpreted to mean that by 2010 facilities and mechanisms should be in place to cater for a further generation's waste arisings.

Current Waste Management Situation

The majority of waste is managed by STAR under a number of service contracts overseen by SWAC. This includes waste collection, treatment and disposal. On Mahé most solid waste is disposed of at the Providence dumpsite with some green waste being composted and a small inert fraction being diverted to the landfill at Anse Royale. On Praslin the majority of the waste is taken to a site at Amitie were open dumping takes place. The waste collected in La Digue is taken to a small purpose built engineered landfill although it is thought that a significant quantity of waste is burnt on individual properties.

The failure of a number of previous studies to accurately predict the true volumes of waste being generated in the Seychelles has led to difficulties with the deployment of sufficient facilities and mechanisms to effectively deal with the waste. Recently more effective data collection and management has enabled a more accurate picture of waste quantities and types to be determined, although there are still some shortcomings in this area.

On Mahé it is estimated that some 45,000 tonnes per year of waste require disposal at Providence dumpsite. For Praslin the quantity is around 3,500 tonnes per year whilst on La Digue it is estimated to be around 670 tonnes per year. It is considered that the recent dramatic rise in waste requiring disposal (particularly on Mahé) is as a result of significantly

improved waste collection efficiency. It is thought that this efficiency has now peaked and any further increase in waste quantities will be as a result predominantly of increased economic development (perhaps more slowly in the immediate few years due to current economic pressures but increasing thereafter). Although there will be a number of waste management activities implemented that will reduce the production of waste, the overall trend will be upwards and we estimate that waste quantities will grow at up to 3% per year for the foreseeable future.

Waste analysis suggests that around 50% of the waste arisings are organic in nature (vegetation, food, putrescible, wood, paper and cardboard).

Assessment Methodology

After quantification of the size and nature of the current solid waste management situation (undertaken largely through a series of audits, consultations, observations and detailed document reviews) the assessment followed a series of defined procedures to identify the most appropriate strategy.

Problem analysis is a technique used as a precursor to the development of a strategy. The initial stage is the identification and definition of the specific problems. This was largely undertaken at a Problem Analysis Workshop held in Victoria, Mahé, to which a wide range of interested parties contributed. A number of problems, causes and effects were identified and these were distilled into each individual area or activity in the waste management cycle.

The corollary of the problems identified in this stage is the strategic objectives for the future management of waste. From the problem analysis the following specific objectives were identified:

Strategic Objectives for Waste Management in the Seychelles	
Core Objective	**Waste management shall be sustainable for a period of thirty years by the year 2010.**
Area/Activity	**Objectives**
1. Policy & Legislative Framework	1.1 A new national master plan reflects the existing situation on waste management. 1.2 Enforcement of legislation relating to waste management is effective. 1.3 Legislation adequately supports enforcement. 1.4 Penalties for littering and fly-tipping are sufficiently high to be effective.
2. Institutional / Organisational Arrangements	2.1 Institutional / organisational responsibilities for waste management are clearly defined between the various ministries and departments. 2.2 Contractual arrangements for service provision achieve the intended results.
3. Human Resources / Capacity	3.1 Existing human resources in the public sector are able to fulfil their regulatory duties completely. 3.2 Health and Safety issues have been addressed.
4. Financing / Cost Recovery	4.1 The revenue flows from existing waste management charges are sufficient to be able to meet the full costs of providing a sustainable system.
5. Stakeholder Awareness & Communication	5.1 General public have a sufficient awareness of the need to prevent littering. 5.2 A communications campaign has been established to promote waste reduction.
6. Data Availability / Reporting	6.1 Available data on certain priority waste streams is available.
7. Waste Avoidance & Reduction	7.1 The potential for waste avoidance and reduction is exploited.

	7.2	Attention is given to importing more durable products.
8. Waste Recovery & Recycling	8.1	The potential for further waste recovery and recycling is realised.
9. Waste Segregation, Storage, Collection & Transport	9.1.1	Sufficient number of bin sites .
	9.1.2	Sufficient cleaning round bin sites.
	9.1.3	Sufficient appropriate collection vehicles / systems used in Mahé and Praslin / La Digue.
	9.1.4	Frequency of collection is maintained.
	9.2	Separation of recyclables and compostables is taking place.
10. Waste Treatment / Processing	10.1	Existing facilities / practices for the treatment / processing of wastes comply with appropriate environmental standards.
	10.2	Appropriate treatment facilities for hazardous wastes exist.
11. Final Disposal	11.1	Existing facilities / practices for the final disposal of wastes comply with appropriate environmental standards.
	11.2	Existing facilities for the final disposal of wastes have sufficient capacity to represent a sustainable solution.

This process identified the fundamental difficulty with waste management in the Seychelles; the lack of sustainability in the current system. After discussion 'sustainability' was deemed to be the provision of adequate provision for the management of waste for a generation (i.e. around 30 years) and this was taken as the focus of the strategy to be developed.

A suitable strategy comprises two key elements: the strengthening and development of the institutional and managerial aspects of waste management and the development of the infrastructure, facilities and operational aspects of the handling, processing and disposal of wastes. Although both these elements have been considered separately there is significant overlap between the two and each has had an influence on the other. Through the strategy development process a guiding tenet has been the reinforcing of existing sound practices and arrangements rather than the wholesale introduction of radically different procedures.

A key component of the development of the strategy was the identification of options for the management and treatment of waste through the full waste cycle (avoidance and minimisation; segregation, storage and collection; recovery and recycling; treatment and processing; and final disposal). There are numerous (modern and effective) processes available for the effective management and treatment of various waste streams. However, the efficacy of a particular technology has to be judged against the local situation and conditions. The key issues and constraints considered to have an impact on the selection of the optimal strategy are those relating to policy and legislation, environmental impacts, land use, operational practicality and flexibility, public acceptability and economics.

The assessment process has involved the consideration of the best practicable environmental option (BPEO). This has been achieved by scoring viable options against a series of criteria, weighted for the particular conditions pertaining in the Seychelles. Those particular waste management options scoring highest within each part of the waste cycle are considered to be the best option for inclusion into the strategy.

Strategy

The suggested way forward and the scenario considered to offer the most effective solution comprises two twin components: enhanced institutional arrangements and the development of new facilities and practices for the physical aspects of waste handling, processing and disposal. The recommendation incorporates a number of individual activities that can be implemented either concurrently or over a period of time although to be most effective the majority of initiatives ought to be implemented (to a degree) as soon as is practicable.

With respect to strengthening the ***institutional elements*** of waste management the following are recommended:

Policy & Legislation

- Develop and introduce technical standards for all aspects of solid waste management including, but not restricted to, waste control, enforcement (including pollution control),

bins, collection centres and landfill management (including control of odour and birds / vermin).

- Introduce a formal licensing procedure for the operation of waste management facilities (this could equally well be managed through the conditions of the contracts awarded for such operations if these are few in number).
- Formalise the current procedure of issuing business licences only when adequate evidence of provision for waste collection / disposal is given.
- Enforce penalties for littering and fly-tipping. Fines should be set at a level to be a significant deterrent.

Institutional & Organisational Arrangements

- Clearly define the roles and responsibilities of each Ministry and department with respect to the regulation and enforcement of waste management (particularly the Ministry for Environment and Ministry for Health).
- Organise SWAC internally to focus on the various components of waste management, particularly the aspects of waste storage, collection and transport and into waste treatment and disposal.
- Legally strengthen the mandate of SWAC and provide legal powers to issue enforcement notices.
- Renegotiate and redraft the contract with STAR clearly defining the services to be provided, the long term responsibilities for environmental impacts, issues of health and safety of staff and a well defined price adjustment formula to account for changes over the contract period.
- Develop and implement a framework for the increase in participation of the Seychelles private sector in the management of solid wastes in the Seychelles.
- Introduce an environmental management system (such as ISO 14001) for the entire waste sector.

Human Resources & Capacity

- Strengthening of SWAC by ensuring all vacant positions are staffed with competent personnel and through the development of a long-term human resources management plan and training strategy.
- Appropriate training for SWAC inspectors and other officers responsible for waste treatment and disposal.
- Identify and implement training and capacity building activities throughout the entire sector- to include private sector operators as well as those associated with Government; in particular, but not restricted to, ensure that only trained staff operate specialist equipment and the proper management of landfill sites.
- Empowerment of staff in the implementation of the legal provisions together with appropriate training to support it.
- Proper monitoring and data management to be put in place.
- Ensure all appropriate Health and Safety legislation is applied to ensure the well-being of all waste operatives

Sustainable Financing / Cost Recovery

- The Government to explore and implement a ‘polluter-pays’ principle approach to solid waste management in the Seychelles.

- The existing system should be reviewed with a view to implement a more realistic and uniform charging system for the private and commercial sectors.
- For the domestic household sector, several mechanisms should be explored, such as, a tax-based system or an annual fee per household. This could be introduced in a phased process and over a period of time reflect the full cost of collection, treatment and disposal of solid waste in the Seychelles. Initially this could be zero-rated.
- Introduce disposal charges for those bringing waste directly to the landfill. Increase charges over time to reflect the full cost of treatment / disposal.

Stakeholder Awareness & Communication

- Reinforce programmes to educate the public on issues such as littering and waste segregation (when this is introduced).
- Involve the local communities in the monitoring and improving the performance of the solid waste collection service.

Data Availability & Reporting

- The quantities of certain waste streams (in particular healthcare wastes but also from the port and harbour) must be recorded and made available as a matter of urgency to ensure that the appropriately sized treatment facilities for these waste streams can be provided.
- A weighbridge should be installed at the waste disposal site in Praslin to ensure the true quantities of waste can be determined for payment purposes and to ensure an appropriately sized waste disposal facility can be designed.

Environmental Monitoring

- Regular, systematic monitoring of certain environmental parameters (notably ground water and the marine waters and sediments, leachate and landfill gas), particularly around the dumpsite at Providence, must be initiated soon.
- There should be a co-ordinated approach to environmental monitoring whereby the resources of the Ministry for Environment, Department of Health, PUC and Seychelles Standards Bureau and others are controlled and managed centrally to ensure effective use of staff and resources.
- Further training of staff in the methods and techniques of sampling and analysis and the acquisition of appropriate equipment to ensure comprehensive monitoring of waste activities is required.

Avoidance and minimisation

- Imposition of tariffs on selected potentially polluting imports: restrictions on the importation of PVC bottles are already being implemented and consideration should be given to extending this to other products.
- Encouragement of home composting in situations where it is appropriate.

Segregation, storage, collection and transportation

- Separate collection of green / bio waste. This could be implemented by including a separate receptacle (or replacing a general waste receptacle) at each bin site with a green bin of similar design to the existing bins. This material could be collected by a separate collection round. The effectiveness of such a system would require public education and could be initiated in a pilot basis.
- The substitution of the existing waste collection vehicles with a dedicated fleet of purpose built waste compactor vehicles is recommended. The current arrangements whereby bins are manually lifted onto the vehicles is unsatisfactory for health and safety reasons and should be discontinued as soon as practicable.

- In the future, consideration should be given to reducing the frequency of waste collection.
- Encourage the further development and utilisation of the existing 'bring' sites and consider developing others.

Recovery and recycling

- Encouragement of reuse and recycling of various waste categories by householders and the public and private sector industries. Put in place national programmes for reuse and recycling, including incentives for industry and the private sector.
- Encourage and support the efforts of Seybrew to have all reusable glass bottles collected and extend this model to other companies.
- Mandatory introduction and use of PET bottles (in place of PVC) and put in place a national framework for recycling of the same. This effort should be implemented nationwide and not restricted to only willing companies. It may be possible to utilise infrastructure and facilities currently used by Seybrew.
- Encourage organisations with an interest, such as SAMLO (the metals recycler) and others to become involved in other forms of material recycling where they can identify a market for the recyclate.
- Encourage and provide incentives for the development of art and craft industries based upon recyclable materials such as glass, paper and others.
- Assist in the development of centralised 'bring' sites (amenity sites) located in well-populated areas for the recovery of green / bio waste, plastic bottles and inert (construction and demolition) waste. Appropriate education and training needs to be included to ensure these facilities are effectively used.

Treatment and processing

- Increase the throughput and further encourage the development of the existing composting plant at Providence. The enhanced collected of green / bio waste identified above would ensure the production of increased quantities for use in Seychelles. The price required (by SWAC) for the sale of compost should be reconsidered and lowered to encourage its wider usage. Simple windrow composting of segregated green waste could readily be started on Praslin to reduce the dependency on landfill.
- Increase the use of the compost by both export and local markets through a combination of improved quality, marketing and price.
- Explore the feasibility of separating out construction and demolition waste and crushing and screening the material to produce low grade construction materials that could be used for landfill engineering or land reclamation. In time the development of such activities could produce materials of a quality suitable for use in place of virgin materials
- There is an urgent need for the proper incineration of healthcare waste and also a requirement for similar disposal of certain wastes from the airport and the marine port to assist in the eradication of incoming pests. A central incinerator (probably located at Providence) should be provided.

Final disposal

- In the short and medium term there appears to be little option but continued reliance on landfill for the final disposal of waste arisings. However, such reliance can be reduced by the implementation of the strategies identified above and by ensuring the landfill sites are managed in the optimum manner possible. A new landfill at Providence appears to offer the best option for the disposal of the residual fraction on Mahé.
- On Praslin a new engineered landfill should be developed as soon as practicable, probably in the area adjacent to the existing facility.

- The transfer of all waste from La Digue to Praslin should be considered after the closure of the existing landfill, which could be extended slightly to increase its capacity and prolong its life.
- Anse Royale is currently an under-utilised resource because the disposal of inert materials into a fully lined and engineered landfill is not considered the most effective use of this facility. The under utilisation of this site has arisen partly due to strong public protest. The crushed glass and ash could readily be disposed of at the existing and new landfill with little disbenefit and the plastic bottles could be recycled together with those processed by Seybrew. It is therefore proposed that the landfill is held in resserve until it can be used to dispose of fly ash from a future incineration scheme.
- Rehabilitation of the existing closed waste disposal sites (including Amitie, La Digue and Providence I, when these become full) should be initiated in a comprehensive programme aimed at reducing the environmental harm these are causing.
- Although not a final disposal option the mass incineration of waste should be considered as the medium to longer term solution for the reduction of waste volumes required to be disposed of to landfill on both Mahé and Praslin. On Mahé the incinerator could be coupled with energy recovery and located either at Providence or on one of the more distant offshore reclamations near Victoria.

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1. INTRODUCTION

1.1. Background

Scott Wilson Kirkpatrick & Co Ltd was appointed to provide "technical assistance for the updating of the Solid Waste Master Plan for the Seychelles for the period 2003 to 2010" by the Delegation of the European Commission, Port Louis, Mauritius on 25th September 2003.

This appointment follows the completion of a Solid Waste Management Plan for Mahé by ITW for the Republic of Seychelles Ministry of Foreign Affairs, Planning and Environment in March 1995. The goal of that study was to propose a financially feasible, practical waste treatment concept that will have maximum ecological benefits.

The ITW report stated that:

- The waste requiring disposal per capita is projected to increase from 0.34 to 0.38 tonnes per annum;
- The quantity of waste requiring disposal would increase from 24,000 tonnes in 1994 to 34,000 tonnes per annum by 2016; and
- The rate of increase in waste requiring disposal can be limited to 0.1% per annum if a strict waste avoidance policy is adopted by the nation as a whole.

After source separation, the ITW report concludes that one third of the municipal waste can be converted into high grade compost – with the remaining two thirds being treated in a co-composting plant together with sewage sludge.

ITW found no evidence of markets for re-used or recycled materials and estimated that only two thirds of the waste generated is collected and disposed of in a managed system. The ITW report accordingly included a range of recommendations for the improvements in this area and for the additional equipment and vehicles required.

Following assessment of non-variable (i.e. avoidance, recycling and landfilling of residuals) components of an integrated waste management strategy, ITW considered five variable components:

- Multi-bin collection system;
- Recycling of secondary raw materials;
- Digestion and/or composting of bio-waste;
- Composting of the remaining waste and sewage sludge; and
- Incineration of remaining waste.

Incineration was not recommended by ITW as it was viewed as contributing significantly to air pollution – an important issue in an ecologically sensitive area such as the Seychelles.

Following evaluation of the options shortlisted, the option based on biological waste treatment and the development of a fully engineered landfill site at Anse Royale was recommended.

The ITW report also included and considered:

- Collection of hazardous waste;
- The need to establish executing agencies;
- Time schedule for implementation
- Cost analysis; and
- Project planning matrix.

Following a variety of difficulties experienced in implementing the 1995 Solid Waste Management Plan, the Ministry commissioned Hydroplan Ingenieur-Gesellschaft mbH to critically review the progress of implementing the Plan; draw lessons for application of future

projects and to examine the need to begin the construction of an additional landfill on Mahé. The Hydroplan report, dated March 2003, concluded that:

- ITW underestimated the amount of waste which would need to be disposed of;
- The design criteria recommended by ITW for the Anse Royale landfill lacked rigour;

Whilst Hydroplan supported ITW's recommendations for improved waste reduction, re-use and recycling, they recommended the implementation of a segregated household organic collection service within 5 years and the introduction of Regional Collection Centres.

Hydroplan also recommended that Providence be developed as the main landfill for Mahé. For Anse Royale, Hydroplan recommended filling with "almost inert material" and fine fraction of material re-mined at Providence 1.

1.2. Objectives of study

The specific objectives of this study are to:

- Project solid waste arisings over the period to 2010;
- Develop alternative waste management scenarios;
- Identify alternative methods for waste collection and treatment and appraise their financial, environmental and technical implications;
- Identify the need for new legislation, institutional and contractual strengthening;
- Identify and recommend an approach to raise public awareness of the problems and the strategy for their solution;
- Develop and appraise a set of strategic options;
- Identify a preferred option, investigate further including the costs thereof.

The final deliverable of the project is to be the key to determining the way forward in the medium term with respect to waste management and is to identify the measures requiring funding from the 9th European Development Fund (EDF).

The Master Plan is also required to be consistent with the existing Environmental Management Plan for the Seychelles 2000 – 2010.

In undertaking the work the consultant team undertook an extensive review of the current situation based on:

- A detailed analysis of the current situation on Mahé, Praslin and La Digue;
- Consultations with stakeholders (including government departments, the private sector, institutions and parastatial bodies and the interested members of the public);
- Inspections and audits of the existing operations and practices.

1.3. The report structure

This report begins with an executive summary and introduction and is structured as follows:

- Assessment of the nature, quantities and fate of the current waste arisings;
- Description of the existing situation i.e. geography and demography, national economy, existing studies and reports, legislation and policy, institutional and organisational aspects, commercial aspects, data availability, stakeholder awareness and communication and waste handling processing and disposal;
- Problem analysis;
- Proposed strategic objectives;
- Future waste arisings;
- Options for the future management of wastes;
- Evaluation of institutional and management options;
- Evaluation of options for waste handling, processing and disposal;
- Evaluation of alternative scenarios and integrated systems for waste management;
- Key conclusions and recommendations.

2. WASTE ARISINGS

2.1. Nature, quantities and fate of current waste arisings on Mahé

Since April 1999, STAR has collected data on all waste passing over the weighbridge at Providence Landfill on Mahé. This data provides the main source of information on waste arisings in the Seychelles. At present each load is classified into one of ten classes. The number of classes has increased over the period since records began. The classes reflect the waste type and/or source and are also used by STAR as the basis for charging. A description of each of the classes is given in Table 1.

The weighbridge also records the load carried on each vehicle. This information is used to prepare a daily total for the amount of waste in each class. During the field mission the Consultant collected the records of the daily quantities of solid and liquid waste recorded between April 1999 and the end of September 2003. A summary of the annual waste arisings in each waste class is given in Table 2 for the past four years. The quantity and type of waste produced does not appear to vary seasonally. Fluctuations in waste do occur as a result of one-off events such as the 'Clean up the world' campaign, weather storms and changes in the charging system for particular waste types.

It should be noted that the weighbridge records only account for waste that passes over the weighbridge at Providence. Waste that does not pass over the weighbridge will not be included in the records. Any waste that is not collected or is disposed of informally will not be accounted for. Wastes that go to other treatment or disposal points are also not quantified in this way, such as healthcare wastes that are incinerated at the hospital. The broad categorisation of the waste types does not give information on the quantity of specialist waste streams such as the different types of hazardous waste.

Other data collected by STAR that was also made available to the Consultant included:

- Data for the compost facility at Providence including quantity of vegetation waste diverted to the facility, quantity of discarded material and quantity of compost produced;
- Summary of the source and quantities of putrescent waste arising.

Table 1: Description of waste classes as used by STAR

Class	Waste Type	Waste Description / Source	Comments
1	Solid Waste (SWAC)	• Household waste. • Litter bins. • Most commercial and industrial waste producers and hotels.	• Waste collection carried out by STAR. • SWAC pay STAR for waste collection. • Waste disposal carried out by STAR. • SWAC pay STAR for waste disposal. • Waste disposed of in Providence Landfill. • Small businesses and households requesting doorstep /private collection have an individual contract with SWAC for collection. Waste collection carried out by STAR with household waste and litter. SWAC pay STAR for waste collection.
2	Solid Waste (STAR)	• Larger industrial and commercial waste producers.	• Private contracts. • Waste collection carried out by STAR. • Client / waste producer pay STAR for waste collection. • Waste disposal carried out by STAR. • SWAC pay STAR for waste disposal. • Waste disposed of in Providence Landfill.

Class	Waste Type	Waste Description / Source	Comments
3	Green Waste / Vegetation	• Green waste arising from various sources. • Only source segregated green waste. Green waste mixed with waste in other classes is not included. Includes green waste diverted to the composting plant. Green waste that is not diverted to the compost plant is disposed of in the landfill. • Some of the material classed as 3 will be unsuitable for composting (e.g. large logs, contamination with other wastes) and will be sent to landfill.	• STAR does not carry out waste collection. • Suitable green waste is diverted to the composting plant when capacity is available at the plant – the remaining green waste goes straight to Providence landfill. • STAR is paid by SWAC for the amount of compost produced NOT for the amount of green waste into the compost plant. (STAR get paid for the green waste that goes to landfill at the standard disposal rate)
4	Liquid Waste	• Liquid wastes including sludges and grease.	• Most liquid waste is collected by STAR (since 1998-99 – under separate contract with SWAC) as there are few other tankers or suitable collection facilities on the island. • PUC (Water) may bring sludges in own vehicles. • SWAC pay STAR for waste collection. • Waste disposal carried out by STAR. • Waste disposed of in Providence Landfill • SWAC pay STAR for waste disposal. • Indian Ocean Tuna have private contract with STAR for waste collection and disposal.
5	Mixed Waste / Others	• Basically all waste that does not fit in any other category. • Includes street sweeping and beach cleaning waste. • (Until 25 August 2003 mixed waste included construction and demolition waste. Construction waste is now a separate Class (Class 9))	• STAR does not generally carry out mixed waste collection (except for beach cleaning and road sweeping). • Anyone can bring mixed waste onto the site. • Waste disposal carried out by STAR. • SWAC pay STAR for waste disposal. • Waste disposed of in Providence Landfill.
6	Scrap Metal / Metal	• Scrap metal	• Weighed and recorded by STAR using weighbridge. • STAR receives no payment for weighing. • Waste passed directly to SAMLO. • Non-metal and non-recyclable components in the waste go to Providence landfill but are not recorded.
7	Putrescent Waste	• Putrescent waste including: o Abattoir waste, o Food, meat, vegetables, milk, juice etc (mainly from SMB) o Indian Ocean Tuna o Veterinary waste	• STAR does not generally carry out waste collection. • Waste disposal carried out by STAR. • Client / waste producer pay STAR for waste disposal. • Waste disposed of in Providence Landfill.
8	Special Waste	• Oils • Contaminated hydrocarbons • Batteries • Others	• STAR may carry out waste collection. If so, client / waste producer pay STAR for waste collection. • Waste disposal carried out by STAR (Except lead acid batteries that go to SAMLO to recover lead). • Client / waste producer pay STAR for waste disposal. • No pre-treatment or treatment of waste is carried out by STAR. • Much is stored awaiting facilities for treatment or sufficient quantity to export.

Class	Waste Type	Waste Description / Source	Comments
9	Construction Waste	• Construction and general building waste • This is a new category of waste established on 25 August 2003. Prior to this date this waste was included in the mixed waste category 5.	• STAR does not generally carry out waste collection. • Anyone can bring waste onto the landfill. • Quantity of waste arriving at the landfill is recorded at the weighbridge. • Waste disposal carried out by STAR. • Client / waste producer pay STAR for waste disposal. • Waste disposed of in Providence Landfill and/or retained for site engineering.
10	Inert Waste	• Glass from Seybrew. • Plastics. • Incinerator ash (stabilised by Client) • This is a new category of waste established in October 2003.	• STAR does not generally carry out waste collection. (Although may include plastics from Civic Amenity Sites) • SWAC pay STAR to accept this waste. • Materials are weighed and temporarily stored at Providence and transported to Anse Royale Landfill for disposal.

Table 2: Annual quantity of waste by class recorded on the weighbridge at Providence Landfill for the previous 4 years

Class	Waste Type	Waste Quantity (Tonnes)			
		Oct 99 – Sep 00	**Oct 00 – Sep 01**	**Oct 01 – Sep 02**	**Oct 02 – Sep 03**
Class 1	Solid Waste (SWAC)	12,350	12,429	13,299	15,279
Class 2	Solid Waste (STAR)	3,824	4,569	5,559	7,586
Class 3	Green Waste/Vegetation	2,373	2,194	1,215	1,458
Class 4	Liquids	5,625	6,051	3,283	3,055
Class 5	Mixed Waste	13,852	13,975	17,152	18,706
Class 6	Metal	1,138	890	555	696
Class 7	Putrescent Waste	1,538	1,871	2,362	2,245
	TOTAL	**40,699**	**41,980**	**43,424**	**49,025**

Note:

[1] Class 9 (construction waste) and Class 10 (inert waste) are not included in Table 2 because they were only introduced in August and October 2003. Waste in these classes in the Oct 02 to Sep 03 period has been included in the Class 5 total to be consistent with previous years.

[2] Class 8 (hazardous waste) is not included in Table 2 because these records are kept separately for the small quantities of waste involved.

2.1.1. Waste composition

During the field mission the Consultant carried out two types of audit on the waste arriving at Providence Landfill, as follows:

- Quantitative audits of the composition of waste from collection vehicles containing Class 1 waste (municipal solid waste, industrial and commercial waste and litter bins);
- A semi-quantitative visual audit of all wastes deposited in Providence Landfill.

Composition of municipal solid waste

Two quantitative waste audits were each carried out each on samples of approximately 500kg of Class 1 waste. The waste samples were separated into the following 17 components:

1. Vegetation, green, food and kitchen wastes (including meat and fish);
2. Cardboard and paper (e.g. packaging, newspaper, office paper);
3. Plastic film (e.g. plastic bags, food wrapping);
4. Plastic bottles (e.g. all plastic bottles);
5. Other plastics (e.g. yoghurt cartons, product components, household articles);
6. Textiles;
7. Wood (e.g. furniture, off-cuts);
8. Leather and rubber;
9. Glass;
10. Metal cans;
11. Other metals;
12. Electrical and electronic equipment (e.g. telephones, televisions, stereo systems, computers);
13. Miscellaneous non-combustible (e.g. bricks, stones and other inert materials);
14. Miscellaneous combustible (e.g. disposable nappies and Tetra Pack);
15. Liquids;
16. Batteries;
17. Hazardous waste (e.g. solvents, pesticides, oils, syringes).

The average composition of the waste from the quantitative audit is shown in Figure 1. Plate 1 shows a photograph of a sample of material used in the waste audit. A comparison between the data obtained in the 2003 waste audit and that presented by ITW in 1995 is given in. To enable the comparison to be made the total number of components of the waste has been reduced by combining similar elements.

From Table 3 it can be seen that the relative proportions of most components of the waste have not changed substantially since 1995. The exceptions to this are the reduction in card and paper and increase in non-combustible material. The increase in non-combustible material may be due to the increase in waste electrical and electronic equipment. The reason for the apparent decline in card and paper is unknown.

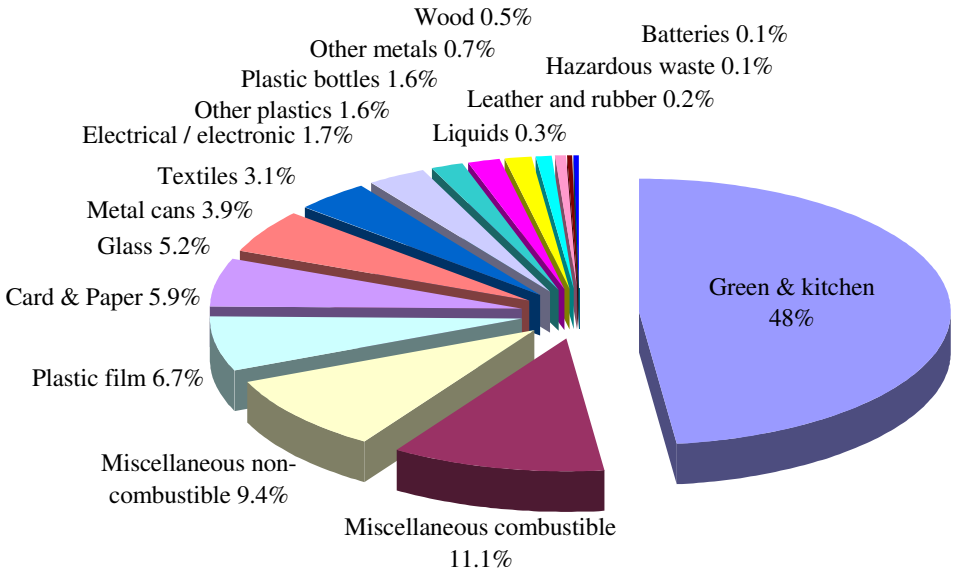


Figure 1: Composition of municipal solid waste on Mahé (Class 1 – Solid waste (SWAC))

Table 3: Composition of municipal solid waste on Mahé in 2003 and 1995

Waste Component	**Scott Wilson, 2003**			**ITW, 1995**		
	Min	**Average**	**Max**	**Min**	**Average**	**Max**
	%	%	%	%	%	%
Green & kitchen	47.3	48.5	49.7	16.5	43.9	54.5
Miscellaneous combustible	7.9	11.1	14.3	3.0	7.2	12.6
Miscellaneous non-combustible	5.5	11.1	16.8	0.0	1.1	2.0
Plastics	7.9	9.9	11.8	6.8	9.2	12.1
Card & Paper	4.9	5.9	6.9	6.3	16.7	42.0
Glass	3.0	5.2	7.4	1.1	7.2	12.9
Metal	3.1	4.5	6.0	3.1	9.5	19.7
Textiles	2.3	3.3	4.3	3.7	4.6	5.5
Batteries	0.1	0.1	0.1	0.0	0.1	0.3
Hazardous waste	0.0	0.1	0.2	0.0	0.1	0.4
Liquids	0.3	0.3	0.3	n/d	n/d	n/d

Plate 1: Sample of municipal solid waste (Class 1 – Solid Waste (SWAC))

Total waste composition

To obtain an assessment of the composition of all waste on Mahé the Consultant carried out a semi-quantitative visual audit of wastes deposited at Providence Landfill. The audit involved a visual estimate of the relative composition of each load of waste. The observed composition was compared to the data recorded at the weighbridge for each load including the tonnage and class ascribed.

The data from the two audits and the weighbridge records were used to calculate an estimated composition for all wastes arising on Mahé, as shown in Figure 2. A number of assumptions and simplifications have been used in calculating these proportions as follows:

- The number of components of the waste has been simplified compared to the audit of the Class 1 waste. For example 'plastic film', 'plastic bottles' and 'other plastics' have been combined into the single component 'plastics';
- The composition of Class 2 and 5 wastes is assumed to be that shown by the semi-quantitative waste audit. The audit represents only a small sample of these wastes and thus, due to the variability of these waste streams, the actual composition may be different;
- Class 3 waste is assumed to be 100% vegetation waste;
- Class 4 waste is assumed to be 100% liquid waste and no account has been taken of the moisture content of the waste;
- Class 6 waste is assumed to be 100% metals;
- Class 7 waste is assumed to be 100% putrescent waste;
- Hazardous wastes are not included;
- Wastes that are not recorded at the weighbridge at Providence Landfill are not included.

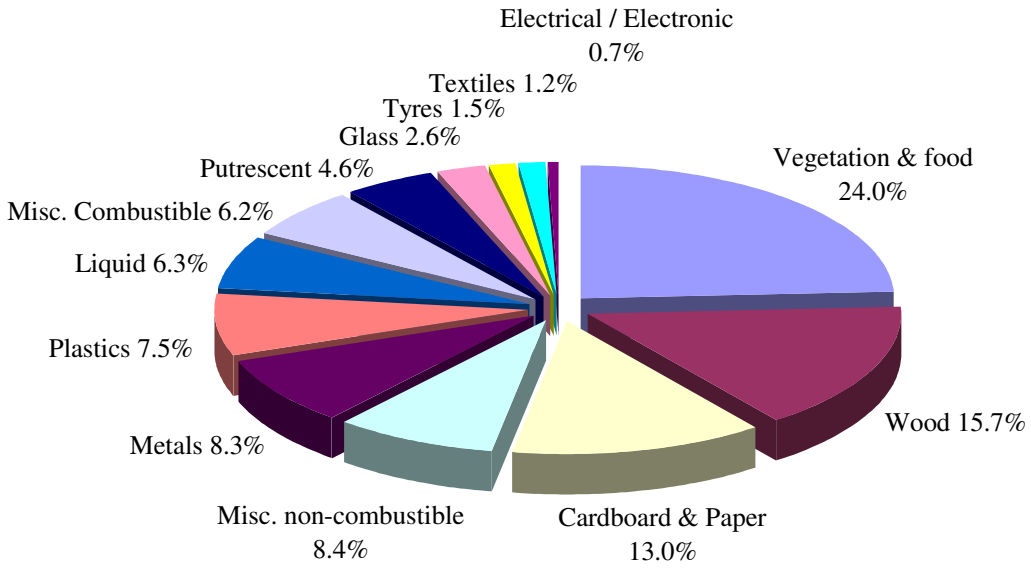


Figure 2: Composition of waste on Mahé

2.1.2. Municipal solid waste (MSW)

Municipal solid waste accounts for about 31% of the waste arising on Mahé, which equates to about 15,300 tonnes over the last 12 months. The composition of the municipal solid waste on Mahé is shown in Figure 1 and Table 3.

At present all municipal solid waste collected on Mahé is landfill at Providence. In 1995, ITW estimated that only two thirds of the waste generated on Mahé was collected. Since 1995 it is thought that the efficiency of waste collection on Mahé has increased significantly, particularly in the municipal waste sector. This improvement in the collection system is likely to account for some of the increases in municipal waste generation observed over the past four years.

Two trial household waste recycling centres have recently been established on Mahé to collect bulky waste, plastics and green waste. At present these wastes are generally landfilled at Providence.

All glass drinks bottles that are filled in the Seychelles are reused and are subject to a 2 Rupee return deposit. As such there is only a relatively small quantity of glass in the household waste stream. A similar scheme is being introduced for some plastic bottles, although these will be exported for recycling rather than being reused.

Some open burning of household wastes, particularly green waste occurs on Mahé.

2.1.3. Non-hazardous commercial and industrial wastes

The Seychelles has no major heavy industry. Sources of commercial and industrial wastes include:

- Shops and restaurants;
- Hotels;
- Fish canning factory;
- Street and beach cleansing;
- Slaughter house and animal farms;
- Brewery;

- Seychelles Marketing Board;
- Seychelles petroleum;
- Ship generated and other waste from the port;
- Airport generated waste;
- PUC power generation and water and sewage;
- Construction and demolition;
- Hospitals;
- Workshops, including mechanical workshops, petrol stations, photographic laboratories, dry cleaning launderette, paint factory etc.

Non-hazardous commercial and industrial wastes account for the majority of the wastes generated on Mahé that are not household wastes. They are mainly disposed of in Providence Landfill with a number of exceptions that are described further in this section.

In recent months Anse Royal Landfill has begun to be used for the disposal of a number of selected waste streams with the intention that the generated leachate does not become highly contaminated. The wastes disposed of at Anse Royal are currently broken glass bottles from the brewery (Seybrew), segregated plastics from household, commercial and industrial sources and stabilised incinerator ash from the hospital incinerator.

Indian Ocean Tuna canning factory appear to be a major producer of wastes on Mahé. During the waste audit at Providence Landfill, described in Section 2.1.1, waste from Indian Ocean Tuna accounted for some 20% of the total tonnage of waste although it is considered that this is not typical. Wastes from Indian Ocean Tuna include general packaging, unused tin cans and can labels, liquid waste and putrescent waste.

Construction and demolition wastes

The quantity of construction and demolition waste generated on Mahé is currently unknown. However, recent changes to the charging system for disposal of this waste type (Class 9) will allow data for this waste stream to be obtained. This type of waste is now weighed and recorded at the weighbridge at Providence Landfill. An estimate from the changes observed in the weighbridge records during the first month of the new system, indicate that construction and demolition waste may account for 15 to 20% of the waste arising on Mahé. It is proposed that this waste be used for engineering works at the landfill.

Scrap metal

Source segregated scrap metals are reclaimed by a specialist scrap metal operator, Samlo. On a site adjacent to Providence Landfill, Samlo sort and bale scrap metal, pack it into containers and then ship it to Mauritius and India for reprocessing. Samlo carry out a similar operation across most of the Indian Ocean islands for improved economies of scale.

The weighbridge records at Providence suggest that about 700 tonnes of scrap metal were sent to Samlo over the past 12 months. Any contaminant in this material is deposited in Providence Landfill.

2.1.4. Port and airport wastes

Wastes from the port and airport are currently collected in bins and compactor skips and transported to Providence landfill for disposal. In the past both the port and airport have used incinerators for the treatment of wastes although the facilities are no longer operational. Mahé has been subject to an increasing problem with 'fruit flies' attacking crops on the island. As part of the eradication measures it is proposed to reintroduce incineration at the port and airport to control incoming pests.

An additional waste stream arriving at the port is by-catch from the fishing industry. Although Indian Ocean Tuna convert much of the by-catch into fish-meal, offshore dumping of by-catch is still carried out on the surplus fish. This has apparently been done for years with no obvious adverse effects.

The port has seen a decline of up to 80% in the number of cruise ships visiting the island since 9/11/01. This has reduced the waste arisings from visiting ships. An evaluation of the waste generated by the yachting industry in the Seychelles is currently underway and will enable a better allocation of bins for each nautical base in Mahé and Praslin.

2.1.5. Green waste

From Table 2 the amount of source segregated green waste passing over the weighbridge at Providence Landfill was recorded as 1,458 tonnes in the past year. However, using the data from the waste audits shown in Figure 2 together with the data in Table 2 it is estimated that a total of about 11,800 tonnes of vegetation and food waste and 7,700 tonnes of wood waste crossed the weighbridge at Providence in the past 12 months. At present most of this green waste arrives at Providence mixed with other waste streams. These figures show that about 40% (19,500 tonnes in 2002-2003) of all waste arising in the Seychelles has the potential to be composted if it were segregated from other waste streams. However between October 2002 and September 2003 only about 680 tonnes of source segregated green waste were diverted to the Providence composting plant. The remaining green waste was landfilled at Providence.

Informal burning and/or composting of green waste by households and waste producers was also observed and thus the total quantity of green waste arising on Mahé may be significantly greater than the figures given above.

2.1.6. Liquid wastes

About 3,000 tonnes of liquid waste were recorded at the weighbridge at Providence in the past 12 months. The liquid waste consists of:

- Septic tank sludge;
- Grease and water sludge from Indian Ocean Tuna;
- Brewing waste from Seybrew and Tropical Rum;
- Sludge from paint manufacture;
- Other greases, sludges and liquids.

Liquid wastes are deposited in a pit dug in the waste at Providence Landfill. Some septic tank waste is taken to the PUC (Water) wastewater treatment plant at Providence although PUC has declined to take other liquid wastes into the plant.

2.1.7. Hazardous wastes

Sources of hazardous waste on Mahé include:

- Households (batteries, paints, solvents, engine oil, acids, pesticides, healthcare waste etc);
- Workshops (oily materials from workshops, waste and sludge from petrol stations, chemicals from photographic labs, dry cleaning launderettes, chemical laboratories, off-cuts from production, organic waste from food production, lead acid batteries, etc);
- Waste oil (PUC power station, other generators, from ships, vehicles etc. Generator, lubrication, hydraulic, transformer and cooking oils plus oil-water mixtures, contaminated soils and sludge from petrol stations, oil storage, emergency spillage, workshops etc);
- Hospital waste (infectious waste, human parts, radioactive waste, sludge from septic tanks etc).

Waste oils

Waste oils arise from a number of sources including:

- PUC (Power) electricity generation;
- Private electricity generation, including hotels;
- Ships;
- Bus garage;
- Cars;
- Restaurants (cooking oils).

The total quantities of waste oil are not known for certain at present. PUC (Power) produces approximately 2000 litres of oil sludge per day, which following dewatering by flocculation and settlement tanks results in about 1200 litres of waste oil per day. This waste oil is burnt by PUC (Power) in a special incinerator and the energy is used for additional power generation. At present PUC (Power) will not accept waste oil from other sources.

The majority of other waste oil is stored at Providence landfill. Two storage tanks have recently been installed with funding from the Ministry of Environment and SEPEC. Waste oil arriving in drums or containers at Providence is emptied by STAR into these storage tanks. When the tanks are full the waste oil is sent to Reunion by boat for reprocessing.

Oil drums and containers are currently stored on the ground before being landfilled or sent to Samlo for recycling.

By May 2004, improvements had been made to the storage of drums and waste oil at Providence landfill. The tanks for storage of waste oil are now contained within an area of bunded concrete hardstanding, accumulated drums containing waste liquids and oils are being emptied and an area of bunded hardstanding has been constructed on which incoming drums of waste oil and other liquid wastes can be stored prior to being emptied.

The Consultant observed some waste oil and/or oily sludges being deposited into Providence Landfill. It is also thought that some waste oils are used informally as fuel.

Healthcare wastes

Healthcare wastes on Mahé are generated by the hospital, health clinics, nursing homes, dentists and households. Healthcare wastes are supposed to be separated from other wastes and stored in yellow bags. The Ministry of Health is responsible for the collection of the yellow bags and their transport to the hospital where they are incinerated. There are not any accurate records of the quantity of healthcare wastes arising on Mahé. In 1995, ITW estimated that healthcare waste arisings on Mahé were about 200 tonnes per annum.

Some comparisons are appropriate. In Botswana, it was estimated that healthcare waste arisings amounted to approximately 1.7 kg/capita/day in 1996. Using this as a basis, a figure of 3 kg/capita/day might well be appropriate for the Seychelles in today's conditions. This would imply arisings of the order of 250-300 tonnes per annum.

In Guernsey, an island with a population around 65,000, arisings are about 400 tonnes p.a. Whilst Seychelles is likely to have a lower generation rate, this would tend to support a figure of around 300 tonnes per annum. During the Consultants visit to the hospital it was noted that the hospital incinerator, which was installed in 2000, was severely damaged. It is likely that the damage was caused by an untrained operator. During the Consultants visit the old hospital incinerator was being used. This incinerator is also damaged and is unlikely to burn the wastes at the temperatures required to make the wastes biologically safe. The ash and residue from the hospital incinerator is sent to Providence Landfill although it is proposed to start sending it to Anse Royal landfill.

Although all clinical wastes are supposed to be incinerated at the hospital, the actual quantity and type of wastes treated in this way are not entirely known. During the Consultants visit and waste audit healthcare syringes were found in one of the samples of Class 1 (municipal and commercial/industrial) wastes. This indicates that not all healthcare waste is currently being segregated and/or sent to the hospital for incineration.

Putrescent waste

Segregated putrescent wastes account for about 4.5% of the waste recorded at the weighbridge at Providence (Class 7). They are generated from the following sources:

- Indian Ocean Tuna Canning factory;
- Seychelles Marketing Board (SMB) – warehouses, agro, fruit and vegetables, meat corner;
- Abattoir and hatchery;
- Seybrew brewery;
- Hospital;
- Veterinary centres;
- School meals;
- Other restaurants, takeaways and shops.

Putrescent wastes are disposed of in Providence Landfill. To reduce the release of odours from putrescent wastes, the waste is covered with coral fill material following deposition in the landfill.

Other hazardous wastes

Lead-acid batteries from vehicles and boats are accepted by Samlo. Samlo store the batteries until they have a sufficient quantity to export for recycling and recovery of the lead and other parts. The number of lead-acid batteries returned to Samlo is not known and the number of batteries being disposed of in the landfill or by other means is also undefined. An estimated figure in the region of 4 tonnes per annum has been suggested. Further monitoring of the lifecycle of lead-acid batteries may be required to ensure they are managed safely.

Other household batteries are generally disposed of within other waste streams that are taken to Providence Landfill. Most types of batteries for household use do not contain sufficient concentrations of contaminants to cause concern. Mercury was historically found in batteries but has widely been reduced to acceptable concentrations since the 1980's. Nickel-cadmium (NiCd) batteries do however still contain significant quantities of cadmium and it may be necessary to introduce a system for the collection and treatment of this type of battery.

Most hazardous household wastes end up in Providence landfill.

Other hazardous wastes are stored in a building at Providence awaiting export or treatment when facilities become available.

2.1.8. Sewage sludge

The Greater Victoria Sewerage Project that was completed in 2001 allowed much of Greater Victoria to be connected to a central sewerage system. The wastewater treatment plant is located at Providence Industrial Estate, close to Providence Landfill. It is currently operating at only 20 to 25% capacity. A number of the major hotels have their own wastewater treatment plants. The remaining population rely mainly on septic tanks or cesspits. The septic tanks are emptied by STAR and the waste is mainly deposited in PUCs (Water) wastewater treatment plant, with small quantities being deposited in Providence Landfill.

Approximately 20m^3 of sewage sludge is generated per day.

2.2. Nature, quantities and fate of current waste arisings on Praslin

There are few records of the quantity and type of waste arising on Praslin. Estimates from observations suggest up to 20m^3 per day although STAR estimate about 30 tonnes per day based on two short weighbridge trials at the dumpsite, although the validity of this data is likely to have been influenced by the storms that occurred at around the time of the trial. Utilising the per capita waste generation rates from Mahé a total waste production figure of around 4,500 tpa is suggested. However, there is little if any industrial activity on Praslin and the actual per capita waste generation rate is considered to be less than on Mahé. Using all the available data a figure of approximately 3,000 tonnes of waste per annum is estimated. Most of the waste originates from households and hotels. Although there is currently little industrial activity on the island this may change with the development of the reclaimed land in Baie Ste Anne.

The majority of waste generated on Praslin is deposited into the waste dump at Amitié. Observations at the dumpsite indicate that the waste is more than 50% green waste. Waste from the airport and two harbours are taken to the waste dump.

Scrap metals, lead-acid batteries and healthcare waste are all collected, stored and transferred to Mahé for recycling, treatment and/or disposal. The glass bottle deposit scheme operated on Mahé is extended to Praslin. The procedure for handling waste oils from power generation and other sources was not identified.

Many hotels have septic tanks that are emptied and the waste deposited in a hole in the ground adjacent to the dumpsite at Amitié. Few households have septic tanks that require emptying. The emptying of septic tanks requires the approval of the Ministry of Environment.

2.3. Nature, quantities and fate of current waste arisings on La Digue

There are no records of the quantity and type of waste arising on La Digue. Observations during the site visit suggest 6 to 7m^3 of uncompacted waste per day; this equates to around 1 – 2 tonnes per day. This is expected to increase slightly as waste collection coverage improves and the public become better educated. The majority of waste is disposed of in the landfill site on the island. Observations of the waste indicated that it was composed largely of vegetation and plastics. The waste originates from households and the tourist industry, as there is little other activity on the island.

During visits to the island open burning of waste, particularly household green waste, was widely observed. Food waste is often fed to pigs and other animals.

As on Praslin, scrap metals, lead-acid batteries and healthcare waste are all collected, stored and transferred to Mahé for recycling, treatment and/or disposal. The glass bottle deposit scheme operated on Mahé is extended to La Digue. The procedure for handling waste oils from power generation and other sources was not identified.

3. FUTURE WASTE ARISINGS

3.1. Factors influencing waste generation

3.1.1. Population

Naturally, the amount of household waste produced is related to the number of people who produce it. It seems reasonable to assume that the quantity of household waste produced will be directly proportional to population growth, but then further influenced by other factors, such as GDP, which are discussed in the sections below. We believe that commercial and industrial waste will be subject to the same growth influences as household waste.

It should be noted that forecasts based on GDP growth include the effect of population growth. Predictions based on population growth are therefore only relevant for waste streams whose growth is independent of GDP.

3.1.2. Household size

The average household size in Western Europe has been declining in recent years. It is not certain that the same trend can be expected in the Seychelles. If it does, it will contribute to an increase in per capita waste generation, although it is difficult to assess the magnitude of this effect and we are unaware of any quantitative work that has been done on the subject. This factor has therefore been ignored.

3.1.3. Per capita generation

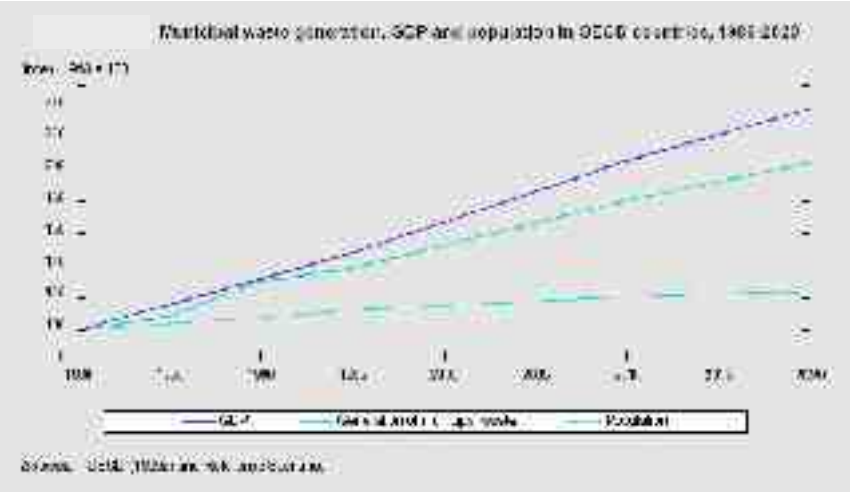
Using the population projections derived in Section 4.1.3, the per capita generation of MSW in Mahé is currently 209 kg per annum. This is a surprisingly low figure for a middle income country, especially when it is appreciated that a fairly substantial, although unknown, proportion of this waste arises from commercial undertakings rather than households. We suspect that the main reason for this is the constraints imposed on imports of goods as a result of foreign exchange controls. When these are lifted, waste generation may increase significantly. Per capita generation of all wastes in Mahé is 611 kg per annum.

We assume that similar per capita generation rates for MSW apply to Praslin and la Digue but that other wastes arising are minimal, except from the hotels, where we have assumed a per capita generation rate of twice that for residents.

3.1.4. Economic development

Affluence affects the amount of waste generated. Figures produced for the OECD indicate a very strong correlation between growth of Municipal Solid Waste generation and per capita GDP. This is shown in Figure 3 below.

Figure 3: Projected MSW growth and GDP



It will be seen that the rate MSW of growth is somewhat lower than that of GDP, but when an adjustment is made for the growth in population, the growth is clearly quite close to that for GDP per capita. Industrial waste generation tends to correlate with total GDP rather than the per capita figure.

There are no official forecasts of GDP growth but a period of low or zero GDP growth may be likely over the next three to five years, while the economy adjusts to the cut backs in Government spending and to the gradual re-alignment of exchange rates.

For the purposes of forecasting waste generation, we propose that the basic growth rate shall be proportional to growth in GDP per capita, before the impact of any waste reduction takes effect.

3.1.5. Changes in economic sectors

Relative changes in the sectoral composition of the economy can have an impact on commercial and industrial waste production if there is a shift between sectors with differing waste generation rates or which generate different types of wastes. Little information is available on the forecast structural changes in the economy of the region, so we are unable to take account of this factor. Fortunately, the effect on those commercial and industrial wastes that form part of MSW is unlikely to be significant.

One of the reasons that tourists choose to visit the Seychelles is the purity of the environment and 'eco tourism' is being actively promoted in Seychelles. This may lead to pressure from businesses involved in tourism to minimise wastes and to ensure their effective management, although there has not, as yet any evidence of a willingness to pay for such environmental improvements. The effect of this on future waste arisings is difficult to predict as any decrease in quantities could be offset by increased visitor numbers.

3.1.6. Changes in waste management methodology

Waste collection service provision

Much of the growth in waste generation experienced in recent years is almost certainly the effect of increasing the coverage of waste collection, both for household waste and also commercial and industrial waste. It is probable from what we have seen, however, that this has now reached close to saturation and it seems unlikely that any significant further increases in generation can be expected from this source. It is possible, however, that there may be some additional green waste from gardens, which is sometimes burnt at the present time. Hazardous household wastes are not currently collected separately, but we believe that they

are being collected in the mixed household waste, so no additional waste generation can be expected from this source.

Waste reduction

Waste reduction is sometimes considered to be a key future waste management technique destined to have a dramatic impact on waste generation. It should be noted, however, that in practice whilst the will to reduce waste generation is present in abundance, the ability to achieve this, particularly in the household waste sector, is limited. For industrial, commercial and construction wastes, however, the opportunities are likely to be somewhat greater.

With little hard data to make use of, we propose the following annual waste reduction targets to be incorporated into our waste forecast for a period of ten years: Household 0.5%, Industrial, Commercial, Construction waste 1%. Given that little emphasis has yet been placed on waste reduction, we suggest that it will be about three years before the impact of waste reduction is felt. Following ten years of waste reduction, we propose that no further reduction will be achievable.

Recycling, treatment and disposal

Methods and availability of recycling services may affect the amount of waste requiring subsequent treatment and disposal. Neither it, nor any treatment or disposal process, will affect the quantities of waste that arise.

3.2. Household waste composition

Our analysis of the existing waste composition carried out during the baseline study produced the results shown in Section 2.

3.3. Projected waste generation

From the above, it may be that waste generation in the Seychelles will remain largely static for a period of 5 years and before continuing to grow at about 3% per annum. Nevertheless, we are aware that all previous forecasts of waste generation have underestimated the actual growth, with unfavourable impacts on the projection of required facilities. The effects of removing foreign exchange controls and the prevention of the burning of green wastes from gardens also need to be taken into account. We therefore believe that it is better to err on the side of overestimating rather than underestimating waste generation, since it is better in the long term to provide overcapacity rather than a capacity shortfall. Consequently, we propose to use a forecast based on continued growth of 3% per annum. Waste reduction, however, may be anticipated to take effect after three years, at the rates described above.

Projections for Mahé are derived from current waste generation figures. Projections for Praslin and la Digue are based on using a similar per capita generation rate but the estimated tourist population has been added to the resident population using a generation rate of double that for residents.

Using these assumptions, we forecast that waste generation in the Seychelles will be as shown in Table 4.

Table 4: Projected waste generation in the Seychelles (tonnes per annum)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
MSW											
Mahé	15,500[1]	15,965	16,444	16,855	17,276	17,708	18,151	18,605	19,070	19,547	20,035
Praslin / La Digue	3,398	3,500	3,605	3,695	3,787	3,882	3,979	4,078	4,180	4,285	4,392
TOTAL	18,898	19,465	20,048	20,550	21,063	21,590	22,130	22,683	23,250	23,831	24,427
Other Wastes											
TOTAL*	29,800[1,2]	30,694	31,615	32,255	32,909	33,576	34,256	34,950	35,659	36,381	37,119
All wastes											
Mahé	45,300[1,2]	46,659	48,059	49,110	50,185	51,284	52,407	53,555	54,729	55,928	57,154
Praslin / La Digue	3,398	3,500	3,605	3,695	3,787	3,882	3,979	4,078	4,180	4,285	4,392
TOTAL	48,698	50,159	51,663	52,805	53,972	55,166	56,386	57,633	58,909	60,213	61,546

* This figure is assumed to be all generated on Mahé.

[1] Figure from weighbridge data for January to September 2003 and a pro-rata estimate of growth in waste arisings for period from October to December 2003.

[2] Total for other wastes excludes liquid wastes, metals that are recycled and any green waste composted. This is the reason for the variations observed between Table 2 and Table 4.

4. DESCRIPTION OF EXISTING SITUATION

4.1. Geographic and demographic data

4.1.1. Geography and geology

The Seychelles is an archipelago of over 100 islands located in the Indian Ocean between latitudes 4° and 10° south and longitudes 46° and 56° east. The islands are very dispersed and the landmasses themselves cover about 450 km^2, on which a total population of about 85,000 are living. A map of the archipelago is shown in Plate 2. The area is famous for its unique, often endemic exotic terrestrial and aquatic flora and fauna, natural peculiarities, mainly unpolluted environment and nuances of cultures. With a life expectancy of 70 years, a low infant mortality and literacy rate of nearly 100% compares favourably with the indicators of many higher-income countries. The transition to a multi-party democracy lead to presidential and legislative elections in 1993, and was accompanied by the relaxation of price and import controls – measures promoting private investment.

The geology of the Seychelles reflects in miniature the key events in the formation of the Indian Ocean as a whole. About 130 million years ago Africa, Madagascar, The Seychelles, India, Antarctica and Australia are supposed to have formed parts of a super continent (Gondwana). The northeasterly movement away from Africa of a Malagasy-Indian block was replaced, probably in the Jurassic or early Cretaceous time, by the separation of India, leaving the Mozambique Channel with approximately its present relationship to the African coast. Between 75 million years and about 45 million years ago, India moved progressively northeasterly, carried away from a spreading axis lying roughly parallel to the northeastern margin of the Seychelles bank. This left behind the island group of the Seychelles. To the east lie the granite islands of the Mahé-Praslin group. About 30% of the islands are granite and rise sharply from sea level. South and west of these are islands such as the Amirantes and the Aldabra-Astove that are coralline islands. 70% of the islands are flat coral islands. About 30 of the islands are inhabited.

Mahé is the largest granitic island and is about 27km long and up to 8km wide (152km^2). It rises steeply out of the ocean reaching a highest point of 905m above sea level. Mahé accommodates almost 90% of the Seychellois population. Victoria, the commercial and administrative capital of the Seychelles, is situated on the east coast of Mahé.

Praslin is the second largest island in the Seychelles in terms of area and population and is situated about 45km northeast of Mahé. It has an area of 37km^2 and is 12km long and up to 5km wide and the highest point is 367m.

La Digue is the third largest island in terms of its population and fourth in terms of its size. It is situated 4km east of Praslin, covers an area of 10km^2 and rises to a height of 333m. The island is about 6km long and just over 3km wide.

Plate 2: Map of the Seychelles archipelago (Source: www.lonelyplanet.com)

Hydrology and sources of water supply

Water supply on Mahé is sourced from two reservoirs (Rochon, capacity 51,000m^3 and La Gogue, capacity 900,000m^3), the desalination plant at Providence and extractions from various other streams with intakes typically above the 200m contours. A further desalination plant is currently being constructed at Anse Boileau that will bring the desalination capacity on Mahé up to about 7,500m^3 per day. Generally it is only in the dry season that recourse to the use of the desalination plants for water production is necessary.

The Greater Victoria Sewerage Project that was completed in 2001 allowed much of Greater Victoria to be connected to a central sewerage system. The wastewater treatment works are located at Providence and are currently operating at only 20 to 25% capacity. Most other areas of Mahé rely on septic tanks and soakaways and do not yet have access to a sewer.

Water supply on Praslin is currently sourced from rivers. A new desalination plant will provide up to 600m^3 of freshwater per day. Central sewerage facilities on Praslin are currently under development. Two independent treatment plants are proposed at Grand Anse and Baie Ste Anne, on opposite sides of the island. Works are expected to commence in December 2003 with a completion date early in 2006.

Until recently, the vast majority of potable water on La Digue has been sourced from groundwater. Bottled water is extensively used. The new desalination plant will shortly be able to supply up to 300m^3 of freshwater per day. There is currently no central sewage treatment facility on La Digue and septic tanks and soakaways are the norm. PUC (Water) is currently preparing a feasibility report for the provision of a centralised sewerage system for La Digue.

Transport network

Mahé has a good network of well maintained roads with sealed surfaces that provide access around the majority of the islands coastline and crosses the island in 6 places. The main roads are principally single carriageway with the only stretch of dual carriageway being located on

reclaimed land along a section of the route between the airport and Victoria. There is also a network of minor roads that are generally narrower and less well maintained and are often very steep. Mahé has frequent bus services on many routes around the island, mainly during daylight hours only. The service is well used by the local population.

Praslin also has a network of sealed roads that mainly run along most of the coastal strip. One road crosses the island. Buses run regularly along the main routes around the island during daylight hours.

On La Digue there is road access to about half of the coast, a single road that crosses the island and a small network of surfaced and unsurfaced roads and paths on the relatively flat western side of the island where the majority of the population lives. The main roads are in various states of repair, although the busiest roads around the port and populated areas have recently been resurfaced. There are no buses on La Digue and only a few essential motorised vehicles. The principal forms of transport are bicycles, ox carts and by foot.

Transport between the islands of Mahé and Praslin is by aeroplane or boat. Flights depart every 15 minutes and the duration of the flight is about 15 minutes. A catamaran service operates twice daily between the two islands with a journey time of about 1 hour. A ferry service between Praslin and La Digue operates 5 journeys a day.

Boats carrying cargo also make the journey between the three islands although due to the size of the boats and the port facilities available, supplies destined for La Digue must be transhipped on Praslin.

4.1.2. Climate

The climate in the Seychelles is hot and humid all year round. On the island of Mahé temperatures range between 24°C and 32°C controlled by the monsoonal wind shifts induced by seasonal pressure changes. The southeast trade winds blow steadily from May to October. The northwest monsoon winds, which blow from November to March, are more gentle. Average annual rainfall on Mahé varies from 1,846mm at Anse Royal on the coast to 3,250mm at Salazie in the mountains. December and January are the wettest months and June and July are the driest.

4.1.3. Demography

At the most recent census, in 1997, the population of the Seychelles was 75,876, of which 67,338 people were living on Mahé, 6,091 on Praslin, 1,998 on La Digue and only 449 on the outer islands. The number of households was 17,878 – an average size of 4.24 persons. Within Mahé, the population of Greater Victoria was 24,701 and the other major concentration of population is to be found around Beau Vallon on the West coast. The population growth rate was calculated to be 0.69%.

More recent[1] population estimates are as follows:

2003	85,913
2010	94,386
2019	102,000

By applying the growth rates used in these projections (which are greater than the 0.69% mentioned above) to the Mahé population from the 1997 census, it is possible to estimate the population of Mahé in 2003 to be 74,109.

Tourists are also an important part of the population. The number of beds available for tourism was 4,940 in 2001 and the occupancy rate 52%, resulting in an equivalent additional

[1] *Statistical Abstract 2001*, Management and Information Systems Division.

population of 2,568. Slightly more than half of these are found on Mahé, with most of the remainder on Praslin and La Digue.

4.2. National economy

4.2.1. Political structure and situation

Seychelles has had a multi-party system with the adoption of a new constitution in 1992. Since then, three multi-party elections took place in 1993, 1998 and 2001. All three elections were won by the Seychelles People's Progressive Front (SPPF) led by President France Albert Rene. Other parties also have a significant following.

Despite its success as a public sector led nation, the government has now moved to more liberal economic policies promoting private investment and more selective public investment. This is most prominent in the encouragement it gives to the tourism sector.

The Seychelles practises gender equality. Women enjoy equal access to education and jobs and make up over 43% of the labour force. They also account for a fair share of management positions and enjoy senior positions within the government sector.

4.2.2. Economic situation

Since independence in 1976, per capita output in this Indian Ocean archipelago has expanded to roughly seven times the old near-subsistence level. Growth has been led by the tourist sector, which employs about 30% of the labour force and provides more than 70% of hard currency earnings, and by tuna fishing. In recent years the government has encouraged foreign investment in order to upgrade hotels and other services. At the same time, the government has moved to reduce the dependence on tourism by promoting the development of farming, fishing, and small-scale manufacturing. The vulnerability of the tourist sector was illustrated by the sharp drop in 1991-92 due largely to the Gulf war. Although the industry has rebounded, the government recognizes the continuing need for upgrading the sector in the face of stiff international competition. Other issues facing the government are the curbing of the budget deficit and further privatisation of public enterprises.

Real GDP contracted by 3 percent in 1999 mainly due to declining tourism earnings. This decline took place despite strong growth in manufacturing output - owing to the expansion of the Indian Ocean Tuna (IOT) company - and expansion of the construction sector. There was a mild recovery in 2000, with GDP growth estimated at 1.2 percent. The fiscal position weakened considerably during 1998-99, with the budget deficit after grants averaging at 18 percent of GDP. The external current account deficit has been about 17 percent of GDP in recent years. These deficits, which were mainly incurred for important investments in national infrastructure (waste water treatment, desalination, land reclamation and road building), were financed largely by domestic borrowings and drawdown of reserves, resulting in a shortage of foreign exchange.

Unemployment is low, at about 5% of the working population, of which 38% is employed in the public sector.

Tight controls on exchange rates and the scarcity of foreign exchange have hindered short-term economic prospects. The black market value of the Seychelles rupee is said to be about half the official exchange rate; without a devaluation of the currency the tourist sector is likely to remain sluggish as vacationers seek cheaper destinations such as Comoros, Mauritius, and Madagascar. The Government is trying to avoid devaluation by making substantial spending cuts and balancing its budget. These cuts may have an impact on the immediate affordability of the further upgrading of waste management systems.

The World Bank has no investment projects in Seychelles. The Bank's assistance to Seychelles focuses on environmental protection. The Bank has played an active role in helping Seychelles protect its environment under the Global Environment Facility (GEF) and the Institutional Development Fund (IDF). Following the completion of a GEF operation for

Biodiversity Conservation, a medium-sized GEF and an IDF grant for the second Environment Management Plan are under implementation. A GEF Indian Ocean Islands Oil Spill Contingency and a new medium-sized GEF for marine ecosystems was approved in December 1998 and April 2000 respectively.

4.3. Existing studies and reports

Waste management issues in Seychelles have attracted considerable interest over recent years as the need to develop sustainable practices, particularly in island communities, has become essential to enable such countries to maintain and develop their tourism advantage. Such interest has resulted in a considerable number of studies and reports being commissioned and produced ranging from Government initiated activities to designs and suggestions promoted by interested parties. The documents made available for and consulted during this study include:

- The Environmental Management Plan; 2000 – 2010
- The Solid Waste Management Plan for Mahé; ITW 1995
- Note sur la gestion des dechets solides aux Seychelles; DoE 1999
- Priced works bill of quantities for Anse Royale Landfill; Veejay 1998
- Anse Royale Landfill leachate treatment study: Scott Wilson 2000
- Note on proposed extension of the Providence Landfill; DoE Feb 2000
- EIA Report for Anse Royale; IPC 1995
- Etude de trios centres de stockage de dechets aux Seychelles. Avant project sommaire. CETTE Lyon. Fevrier 2001
- Evaluation of the Anse Royale Solid Waste disposal Project; HydroPlan 2003
- The Contract between STAR and SWAC (including the technical proposal).

In addition to the specific reports and information available related to waste management a number of other more general documentation (regulations, standards, statistical data etc) was reviewed.

4.4. Legislation and policy

4.4.1. Current legislation

The Environment Protection Act 1994 provides the main primary legislation with respect to waste management.

Section 12 provides powers for the Minister of Environment to:

- Prescribe standards for classification and analysis of wastes
- Prescribe standards for treatment and disposal methods
- Issue regulations relating to all aspects of hazardous waste management
- Designate an Agency responsible for the management of wastes

This section declares that is an offence to deposit waste except at a "designated waste dump for the type of waste" in accordance with the authorisation from the Agency, or else in a receptacle adapted for the purpose and there is an arrangement for the collection and disposal of the waste. Equally, hazardous wastes may only be disposed with authorisation from the Agency. It also makes littering or driving a vehicle from which litter can escape an offence.

It also gives powers to the Agency, *inter alia,* to designate, monitor and regulate waste disposal sites.

Section 13 addresses the issue of recycling and cleaner technology. It provides power for the introduction of regulations to

- Control the raw materials or components present in or the proportions of recycled materials in products sold in the Seychelles
- Prohibit or regulate the use of specified materials in e.g. packaging
- Introduce product charges on certain materials or products imported into the Seychelles

The Environment Protection (Designation of Solid Waste Agency) Regulations 1995 designate the Agency referred in the Environment Protection Act to be the Solid Waste and Cleaning Agency (SWAC) and set out its powers in greater detail.

Essentially it may be said that SWAC has been established as the competent authority for regulatory purposes (e.g. licensing of waste disposal facilities) and also the executive agency for the provision of waste management services for Municipal Solid Waste (MSW).

4.4.2. Current policies and strategies

The principal guiding document on strategy is the Environmental Management Plan for the Seychelles (EMPS), the latest version of which was prepared for the period 2000 – 2010.

The management priority areas in relation to waste management identified in this plan are:

- Continue implementing an integrated solid waste management programme
- Support or implement regional programmes for the control of waste at sea
- Support or implement regional programmes for the disposal of hazardous wastes
- Encourage waste minimisation strategies
- Encourage composting schemes where appropriate
- Make solid waste management financially sustainable

The main sectoral goal is to manage waste sustainably. Since this is currently not being achieved, it is deduced that this goal is intended to be reached before the end of the plan period, i.e. by 2010.

The objectives within this goal are:

- To manage and dispose of solid waste in an ecologically sustainable manner
- To improve institutional capacity and human resources for solid waste management

4.5. Institutional and organisational aspects

4.5.1. Regulation and enforcement

SWAC was established under the Environment Protection (Designation of Solid Waste Agency) Regulations 1995 and took over waste management from the PUC.

This regulation gives it extensive duties to both manage and regulate waste management and it is the competent authority for waste regulation and enforcement. It was originally established as a parastatal with the DG Pollution Control from the MoE as chairman and board members from other ministries. In 2003, SWAC was subsumed into the Ministry of Environment. The managing director has been appointed as managing director of the Marine Parks Authority and Seychelles Centre for Marine Research and Technology, but currently continues in her role with SWAC as well. It is not clear when or whether she will be replaced but in the interim, she is acting as a consultant.

There are three senior positions at SWAC: technical manager (a post currently vacant), senior inspector and administration manager. SWAC have 7 inspectors on Mahé, 2 on Praslin and 1 on La Digue. In addition, there is an inspector at the STAR weighbridge. The inspectors check that the bins sites are being emptied, identify waste spillage and also investigate allegations of illegal dumping, open burning etc. They have powers of entry onto private land

and can even require householders to remove small accumulations of waste and scrap from their own gardens if there are complaints of unsightliness by neighbours.

In practice, it seems that the SWAC inspectors are not the only ones involved in the enforcement process at the present time, because they do not currently have the power to issue enforcement noticesInspectors from the Pollution Control Directorate and also from Environmental Health and representatives from the Local District Authorities (who are often those first notified of particular issues) also undertake these duties, in some cases by all visiting the same sites at the same time.

4.5.2. Service delivery

SWAC ensures waste management service delivery. It does this though a contract with STAR, a waste management company, which is part of a large French waste management group as discussed in the next section.

In addition, healthcare wastes are managed at the hospital by the Ministry of Health, while wastewater treatment sludge is managed by the PUC.

4.6. Commercial aspects

4.6.1. Contractual issues

The service is provided by STAR under a contract dated 24th February 1997. It should be appreciated that this contract was designed to be for waste collection, treatment, recycling and disposal of the residues at Anse Royale, which had not, by this time been constructed; this site was completed in 2000 using finance from the EU

There are no formal contractual arrangements for collection or disposal on Praslin and La Digue, although STAR currently carries out these tasks under an ad hoc arrangement. Contracts for these islands are to be tendered shortly.

4.7. Data availability

The contractor has installed a weighbridge at Providence, which enables accurate data to be provided on the quantities of waste that are collected, treated and disposed of on Mahé.

The problem is that information on specialist waste streamssuch as waste oil or batteriesis not available partly because some of it is collected on the same vehicles as other wastes or, in the case of healthcare wastes, is collected by the Ministry of Health and taken to the hospital for incineration. There is also currently no information of construction and demolition waste as a separate waste stream, although the recent (August 2003) introduction of charging for these wastes means that such information is now being recorded and useful information can be expected within the next 12 months.

Finally, there is no weighbridge on either Praslin or la Digue, so that reliable, detailed information on quantities is unknown.

4.8. Stakeholder awareness & communication

General awareness of the environment and the need for its protection among the general public is high. The attitude to litter, however, is disappointing. Particular problems relate to the polystyrene boxes used for take-away food and the Tetra-Pak juice cartons.

Householders have little awareness of the need for waste reduction, although the scope for this type of activity is small, relying mainly on home composting and the reuse of plastic bags (or, better still, not using them at all). Awareness of the benefits of and requirements for source segregation of recyclable or compostable materials is also not well developed, although a number of trials have been held which have had relatively positive results. Contamination of compostables with plastic bags, however, remains a problem.

Some of the larger manufacturing companies, such as IOT, Seybrew and Penlac, which are subsidiaries of multinational companies, have forward-looking policies and are concerned about waste reduction, reuse and recycling. IOT has implemented ISO14000, Seybrew are considering it and Penlac would like to do so but cannot afford the equipment required.

Seybrew operates a deposit and return system for both glass and PET bottles. Penlac also operates a deposit and return scheme for clean plastic paint cans, though very few are actually returned.

SMB, which operates a Tetra-Pak filling plant for milk and fruit juice also claims to place strong emphasis on environmental issues, but this seems to be largely aimed at sponsoring recycling fairs and clean-up campaigns, rather than operating any reuse or recycling schemes themselves.

In the smaller companies, so far as we can tell, there is less awareness of the need for waste reduction. This has been true for construction companies but the introduction of a fee of R210/tonne has led to a marked reduction in the quantities of construction and demolition waste being delivered to the landfill. It is too early to say whether this reflects waste reduction and reuse or fly-tipping and stockpiling.

SWAC has had, in the past, an officer with responsibility for raising public awareness. This post is currently vacant, but recruitment is under way. SWAC works with other departments in this field, such as the Pollution Control Division and the Ministry of Health.

There is currently no formal evaluation and monitoring of the status of public awareness.

4.9. Waste handling, processing and disposal

4.9.1. Waste reduction

For household waste it is thought that a reasonable amount of home composting and/or burning of green waste occurs at present. However, the large proportion of green and kitchen waste observed in the waste stream indicates that there is still considerable scope to increase this proportion and thus reduce the waste requiring collection and disposal.

Commercial and industrial waste producers and a number of households that receive doorstep collection are charged by the volume of their bins and the frequency of collection. This type of charging mechanism often results in a reduction in waste arisings with customers saving money by reducing their required collection capacity.

There are some good examples of waste reduction at Indian Ocean Tuna. They have been very proactive in their efforts to promote waste minimisation as part of their recent attainment of ISO14000. They have monitored all 27 individual activities that collectively represent their business process. Each activity has been reviewed using materials and energy balances. Initial efforts focused on savings that could be made with respect to energy and water usage. Data was also collected on waste production and two of the resulting initiatives were:

- Production of animal feed from a mixture of the fish debris, by-catch and fish waste from other companies. Some of the WWTP sludge also goes into the animal feed.
- Reuse/recycling of pallets

IOT are keen to adopt further waste minimisation initiatives.

Other industrial and commercial operations have also expressed interest in reducing their waste arisings although most say they are limited by resources and/or costs.

4.9.2. Storage

Storage of waste prior to collection

Household waste is stored in public bin sites situated along the roadside as shown in Plate 3.There are currently a total of 472 bin sites on Mahé. Each bin site generally houses between 1 and 6 bins. The bins are mainly 240 litre wheeled bins. Many are in good condition particularly in the densely populated areas although in other areas some have lids or wheels missing or are split or broken. Where wheeled bins are not available discarded metal drums are used. The drums sometimes have modifications and/or attachments to enable them to the lifted by hand and/or by a hydraulic bin lift. Bins are the responsibility of STAR and should be replaced when broken.

The public bin sites usually consist of a housing with a concrete base and walls on three sides. The inner dimensions of the walls are slightly larger than those of the 240 litre wheeled bins in height and depth. The length of the bin housing varies depending on the number of bins that are required to service the particular area. The concrete bin sites are constructed wherever possible. However, sometimes it is difficult to get permission from the landowner to build the site and in this case the bins may be placed on a hardstanding only or directly on the ground. Sometimes this means that the bin sites are located far from some residences and there have been complaints that they are not in convenient locations. This is a particular issue in the south of the island and in the district of Anse Royale where there is a lack of space for bin sites along the main roads.

Each bin site serves a number of households in the area and the number of bins provided is a reflection of the number of households served. Residents take their waste to the bin sites. Due to the hilly terrain and the daily frequency of collection it would not be practical to provide doorstep collections. In a number of cases the number of bins provided is not sufficient and complaints have been made that bins are full or overflowing.

All bin sites are uniquely numbered by SWAC and it is proposed to include this information on a GIS database / layer, although this is not available at present. The numbering system is particularly useful for passing on complaints/instructions from SWAC to STAR. Initially, all bins were also uniquely numbered, but the numbers faded and/or were washed off.

The bins in the public bin sites are washed and disinfected about twice each year.

Litter bins are located on the streets in Victoria and other built up areas. They are also found at most bus stops. Waste from litter bins is collected with the waste from household bin sites.

Households and businesses with private / doorstep collections also generally store waste in 240 litres bins. STAR has 3 mobile compactor skips (dimensions approximately 2mx2mx3m) that are located at Indian Ocean Tuna, Airchef (airport) and the Plantation Club Hotel. Star also provides other closed and open skips to the port when required for ships.

Storage of waste awaiting treatment and/or disposal

A number of waste streams are stored, following collection, prior to final treatment or disposal.

Samlo operate the scrap metal reclamation facility adjacent to Providence landfill. Their scrap yard is used to sort incoming materials, segregate the different types of metal and bale the materials and load then into containers that are then shipped to Mauritius for reprocessing. Samlo also accept lead-acid batteries that are currently stored at the scrap yard. Once a sufficient quantity is available, Samlo propose to remove the acid and extract the lead for recycling. There are some questions currently being raised about Samlo's approach to health and safety issues, following adverse experience in Mauritius.

Plate 3: Typical public bin site

Waste metal drums are currently stored by STAR at Providence landfill. Most contain some residual product whilst others contain significant quantities of waste or contaminated materials. Many contain oils. The drums were stored on the ground without any shelter and there are obvious signs of leakage and contamination of the underlying coral sand of the land reclamation as shown in Plate 4.

The Ministry of Environment and SEPEC have recently funded the construction of two tanks for the storage of waste oil prior to its shipment to Reunion for reprocessing, as shown in Plate 5.

By May 2004, improvements had been made to the storage of drums and waste oil at Providence landfill. The tanks for storage of waste oil are now contained within an area of bunded concrete hardstanding, as shown in Plate 5. The accumulated drums containing waste liquids and oils are being emptied (see Plate 6) and an area of bunded hardstanding has been constructed on which incoming drums of waste oil and other liquid wastes can be stored prior to being emptied. The areas for storing drums and waste oil are not protected from rainfall.

Other hazardous wastes delivered to Providence are currently stored in a building adjacent to the landfill site. There are currently no proposals for the treatment or disposal of these wastes except to export them when a sufficient quantity is available.

Plate 4: Storage of waste drums at Providence

Plate 5: Tanks for storage of waste oil at Providence Landfill prior to shipment to Reunion

4.9.3. Waste collection

Waste from public bin sites and litter bins is mainly collected daily although some of the more remote southern districts receiving collections twice per week. Where bin sites do not exist, the collection of plastic bags of waste left by the roadside is carried out twice a week. Some private households that require direct collection ('from the door') are on different contracts and their frequency of collection varies according to their contract. Waste from commercial and other non-public bin sites are collected in accordance with SWAC's Solid Waste Service Agreement, which is summarised in Table 5 below. Waste collected according

to the private contracts shown in Table 5 is generally carried out with the collection of waste from the public bin sites and litter bins.

Plate 6: Emptying liquid waste from drums at Providence Landfill

Table 5: Summary of SWACs Solid Waste Service Agreement Options

Collection Class	**Premises**	**Frequency**	**Volume of waste (No. of Bins)**
1	Commercial	Daily	$2m^3$ (10 bins) or less per collection
2	Commercial	Daily	$1.4m^3$ (7 bins) or less per collection
3	Commercial	Daily	$1m^3$ (5 bins) or less per collection
4	Commercial	Daily	$0.6m^3$ (3 bins) or less per collection
5	Commercial	3 times per week	$0.8m^3$ (4 bins) or less per collection
6	Commercial	Twice per week (usually Tues/Fri, but can be Wed/Sat)	$0.6m^3$ (3 bins) or less per collection
7	Commercial	Weekly (Thursday)	$0.6m^3$ (3 bins) or less per collection
8	Domestic	Weekly (Thursday)	$0.4m^3$ (2 bins) or less per collection
9	Commercial	On demand ('special collection')	$0.4m^3$ (2 bins) or less per collection
10	Domestic	Twice per month	$2m^3$ or less per collection

A number of hotels expressed concern over the quality of the waste collection services that they received. Comments included that the service was unreliable and waste was not collected on time, that the waste collection vehicles did not meet the required image for the hotel (e.g. they are old and/or inappropriate), that the vehicles would drip liquids from the waste onto roads, the waste collection produced bad odours and that littering often occurred. Some hotels are looking to invest in alternative waste collection facilities or to employ private contractors.

Waste collection vehicles and routes

STAR currently has 3 compactor vehicles (2 with bin lifts) (see Plate 7) and 1 pick up truck for refuse collection. Due to a shortage of vehicles STAR subcontracts the majority of the waste collection routes. The subcontractors use open backed pickup vehicles with 'greedy boards' to increase the capacity of the vehicle, as shown in Plate 8.

Plate 7: Waste collection on Mahé using a 7 tonne compactor vehicle with bin lifts

Plate 8: Waste collection on Mahé using a pick up with 'greedy boards'

STAR often experiences vehicle breakdowns and because it is difficult to purchase spare parts (due to the lack of foreign exchange) the vehicles may be out of action for some time. When mechanical problems are encountered, other collection vehicles may have to do 2 rounds in one day and may have to start collections at 3am and not finish until as late as 10pm. During the Consultants visit STAR had minor problems with their 7 tonne compactor.

STAR currently divides their standard refuse collection service for Mahé into 9 routes. STAR does not have a map or any other form of graphical presentation of their routes. Instead they produce computer generated lists of the sites to be collected on each of the 9 collection routes. Each day two daily 'Solid Waste Collection Client' lists are produced for each driver; one is for collection from public bin sites and the other is for collection from private contracts. A summary of the waste collection routes, vehicles and crew is given in Table 6.

Table 6: STAR refuse collection for Mahé

Area/Route	**Contractor**	**Vehicle Details (Registration)**	**Capacity**	**Crew Size**
Victoria	STAR	Compactor with bin lift (S11488)	5 tonnes	Driver + 2
Central	STAR	Compactor (S10573)	5 tonnes	Driver + 2
North (main roads)	STAR	Compactor with bin lift (S12593)	7 tonnes	Driver + 2
North (secondary roads)	Subcontractor	Pick up (S9927)	3 tonnes*	Driver + 4
North and Central	Subcontractor	Pick up (S13978)	3 tonnes*	Driver + 4
Central and East	Subcontractor	Pick up (S2351)	3 tonnes*	Driver + 4
East	Subcontractor	Pick up (S7398)	3 tonnes*	Driver + 4
West	Subcontractor	Pick up (S10149)	3 tonnes*	Driver + 4
South (main and secondary roads)	Subcontractor	Pick up (S4477)	3 tonnes*	Driver + 4

- Capacity should be 3 tonnes, but crew often manage to load up to 4.5 tonnes and have even reached 5 tonnes.

During the Consultants observation it was noted that bags of waste left on the roadside (but not at bin sites) were often collected. Householders would hang/pin the bags of waste off the ground (e.g. on a tree) to avoid interference from animals. Some mistakes have been made when collecting what is thought to be bags of waste. But this was usually the fault of householders leaving goods that were assumed to be waste due to appearance and location.

The waste collection routes are generally very hilly and mainly involve steep narrow roads. During the Consultants observations of three different routes in the waste collection system, the typical journey time between household bin sites was calculated at between 30 seconds and 2 minutes with an average of about 80 seconds. The time to empty an individual bin was typically between 20 and 75 seconds. Each refuse collection vehicle must complete its planned collection from all sites given on the Supervisors lists – therefore the number of return trips to the landfill for each vehicle/crew will depend on the quantity of waste to be collected. Wednesdays, Saturdays and Sundays are usually 'light days' that can be completed with a single round trip because there are very few private contract collections to make. Other weekdays will usually require at least 2 or even 3 round trips.

STAR operates a separate collection service for bulky and green wastes. Bulky waste is collected by STAR on a monthly schedule. The drivers from the standard collection routes, STAR supervisors and SWAC inspectors inform SWAC of bulky green waste that has accumulated at public bin sites. STAR collects this waste when requested to do so by SWAC. The collection of bulky waste from private sites involves an additional charge. The vehicles used for bulky waste collection are summarised in Table 7.

Table 7: STAR bulky waste collection for Mahé

Area/Route	Contractor	Vehicle Details (Registration)	Capacity	Crew Size
Not defined	STAR	Pick up (S3447)	3 tonnes	Driver + 2
Not defined	Subcontractor	Pick up (S13546)	3 tonnes	Driver + 2
Not defined	Subcontractor	Pick up (S2629)	3 tonnes	Driver + 2

Health and Safety Issues

STAR labourers on the waste collection vehicles are provided with T-shirt, trousers, boots and gloves. The gloves and boots have to be bought locally and are of poor quality. They would generally not prevent sharps from penetrating and incidents of spikes and scratches have occurred. On the subcontractors waste collection vehicles two labourers are provided by STAR and two by the subcontractor. Labourers paid by the subcontractors are responsible for providing their own personal protective equipment.

Labourers were observed standing on plates/ledges on the rear of the waste collection vehicles whilst they were moving. This was observed for both compactor vehicles. During longer stretches of driving the labourers usually rode in the vehicle cab. In the pick-up vehicles the 4 labourers ride in the back of the vehicle standing on the collected waste.

When collected waste in the pick-up vehicles and the compactor vehicles without bin lifting facilities, the labourers must lift the bins by hand to empty them into the vehicles.

Collection of healthcare waste

Collection of healthcare waste is the responsibility of the Ministry of Health. Producers of healthcare waste, such as clinics, nursing homes and dentists are supposed to separate the clinical waste into a yellow plastic bag for separate collection as shown in Plate 9. The collected waste is then taken to the hospital for incineration. Sometimes the clinical waste is separated from the main waste but not stored in a yellow bag and may be collected by mistake. There have been reports of waste collection workers being pricked by syringes. The Consultant team also observed syringes (insulin) during the waste audit of municipal waste.

Collection of other wastes

Liquid wastes are currently collected mainly by STAR using their two liquid waste tanker vehicles. Some liquid waste and putrescent waste is transported in drums/barrels by independent carriers.

Waste in Class 5 (mixed waste – see Table 1) is generally collected by independent waste carriers. Most of these carriers are individuals with a vehicle, usually a pick up, who collect waste from industrial and commercial waste producers or bring waste generated by their own businesses to the landfill. Other waste carriers include various government ministries, such as the Ministry of Landscape and Environment and the Ministry of Education.

Collection of wastes on Praslin and La Digue

The collection of waste on Praslin and La Digue is similar to that carried out on Mahé. Waste from public bin sites and litter bins is collected daily and commercial and industrial wastes are collected as contracted. Waste collection is the responsibility of STAR on both Praslin and La Digue. On La Digue STAR operates one 5 tonne compactor vehicle. On Praslin, STAR's compactor vehicle has been broken down for the past 6 months and consequentially the waste collection is currently sub-contracted to two teams with pick up trucks.

Plate 9: Segregated healthcare waste at a clinic

4.9.4. Re-use

The main area of reuse currently active in the Seychelles is that of returnable glass bottles. All local beer and soft drinks that are sold in glass bottles are currently subject to a 2 Rupee deposit (equivalent to about 0.3Euro). Penlac paint factory operate a deposit / return scheme for their plastic paint containers. Penlac will only accept returned containers if they are not damaged and are clean (ready for reuse) – very few are returned. They will pay 15 rupees for a large container that was sold for 570 rupees (full of paint) and which would cost them 20 rupees to buy new. They will pay 5 rupees for a small container that was sold for 150 rupees (full of paint) and which would cost them 8 rupees to buy new. Empty solvent drums are given away (there is a high demand), but are not cleaned beforehand.

There is also a certain amount of *ad hoc* reuse activity. Examples include the reuse of plastic carrier bags for waste bags, the salvaging of spare parts from motor vehicles and other goods and donating unwanted items to friends or neighbours.

4.9.5. Recycling and recovery

Scrap metal and lead-acid batteries are recovered by Samlo. The scrap yard, adjacent to Providence landfill is used to sort, segregate and bale the different metals and then load them into containers that are then shipped to Mauritius for reprocessing. Samlo operate similar facilities across most of the Indian Ocean. This improves the economies of scale of their operation.

Seybrew offer a deposit scheme for PET bottles (2 Rupees per bottle) used for their soft drinks. The returned plastic bottles are ground (with labels and caps) and exported to mainland China as recycled materials using pre-used bags. Seybrew receives 40 to 65 Euros per tonne, which does not quite cover the cost but is continued for environmental reasons.

Most waste oils are taken to Providence landfill where STAR store them in tanks before being shipped to Reunion for reprocessing.

About 3 years ago, PUC Power generation installed its own incinerator for burning waste oil and recovering energy. Before the incinerator was operational a stockpile of approximately 1,000,000 litres of waste oil sludge had accumulated. The incinerator currently burns about

1700 to 2000 litres of dewatered waste oil per day. The incinerator could burn as much as 2500 litres/day but it is becoming less efficient with increasing age (cannot be fully maintained and have the lining replaced due to lack of foreign exchange). It is estimated that the stockpile is now about 400,000 litres of waste oil sludge and that this will have all been incinerated by March 2004. In addition to the stockpile, approximately 2000 litres per day of waste oil sludge are produced, which equates to about 1200 litres per day of waste oil (following dewatering by flocculation and settlement tanks). This is also being burnt in the incinerator.

4.9.6. Waste treatment

STAR currently operates a green waste composting plant adjacent to Providence landfill as shown in Plate 10. The plant was opened in 2000 and has a capacity of about 3000 tonnes of compost per year. STAR is currently producing only about 1000 tonnes of compost per year. STAR is paid by SWAC for the amount of compost that is produced.

Plate 10: Composting plant at Providence landfill

There are currently difficulties in finding a market for the compost. STAR donates some (maybe 5 to 10%) of the compost to government organisations e.g. landscape management, and give samples to various organisations such as the Ministry of Agriculture for their test station and the Association of Farmers. However, the farmers are not buying the compost and prefer to use the cow or chicken manure. STAR has also carried out activities to promote the compost to households with only limited success.

The compost is sold at 2 Rupees per kg (in 25kg bags). If the compost is bought in bulk (unbagged) and collected by the purchaser then the price is 1 Rupee per kg. The price of the compost is considered to be too expensive and is inhibiting sales. From January 2004 the price of purchasing the compost has been reduced to 1 Rupee per kg for private clients and 0.5 Rupee per kg for all administrations. STAR has been looking for external markets for the compost, but again the price is currently inhibitive.

European Consultants were involved in establishing the composting facility. Initially the process was carried out in windrows although due to space limitations the process is now carried out in a number of larger piles. This method may not be as effective as the original windrow methodology. STAR together with the Seychelles Bureau of Standards have developed standards and procedures for the production of compost - Standard SS29:2001.

Some trials have also been carried out into the composting of sewage sludge but it has proved to be difficult.

Healthcare waste from all sources, including clinics, dentists and the hospitals, is supposed to be collected by the Ministry of Health and incinerated at the hospital. During the Consultants visit the newer hospital incinerator was broken and an older hospital incinerator, in poor state of repair, was being used. This incinerator is not thought to produce the temperatures and degree of burning required to effectively treat this waste stream. In addition to this, it was apparent that some healthcare waste was being collected from clinics and dentists with the household and commercial waste and deposited directly into Providence landfill.

4.9.7. Final disposal

Mahé

Providence

The majority of the waste arisings on Mahé are disposed of at the Providence dumping site. A photograph of the site is shown in Plate 11. The site is located on reclaimed land off the east coast to the south of Victoria and covers an area of around 3.5 hectares. The site is bounded by the Cerf Channel to the west, the main east coast highway to the east, by industrial units to the north and newly reclaimed land to the south.

Plate 11: Providence Landfill

Currently operated by STAR under the main waste management contract with SWAC the site was originally started and operated by the Public Utilities Company (PUC) in the early 1990s until handed over to STAR in 1998.

The site is unlined, there are no leachate or landfill gas control systems in place and minimal environmental monitoring is undertaken, being limited to bi-annual sampling and analysis of adjacent marine sediments for a limited number of heavy metals only. Although there is no general filling plan currently used, a general sequence of filling has been established. It is understood that waste has been placed at or just above sea level. In recent times the management of the site has improved in terms of its operational performance and nuisance mitigation; waste is deposited in layers in defined areas, compacted and covered with inert material on completion of each main filling phase.

Cattle egrets are regular visitors to the site and are considered to be a potential hazard to the nearby airport, particularly if they should 'flock'. Agreement has been reached with the airport authority and reportedly waste filling can continue up to a height of 12m above sea level. It is worth noting that the trees that currently screen the landfill and the nearby industrial units exceed this height.

Based on a maximum permissible height of 12m above sea level there is estimated to be a void space of 110,000m^3 remaining. This is considered to be sufficient capacity for about 2.5 years waste filling at current input rates.

Anse Royale

In addition to the site at Providence there is an engineered landfill at Anse Royale as shown in Plate 12. This site was constructed with a low permeability basal liner (clay and plastic) and has facilities for the collection and storage of leachate. Currently this site receives only very small quantities of inert waste (crushed glass and plastic bottles).

The site reportedly has a void capacity of around 80,000 m^3.

Plate 12: Engineered landfill at Anse Royal

Other sites

There are a number of closed waste disposal sites around Mahé. The most notable are near to the sports stadium (Roche Caimans), at La Retraite and a small site at Barbarons. None of these sites was properly engineered to modern standards or has any environmental controls in place. The sites at the stadium and La Retraite have been covered with inert material ('red earth') and are used for recreational purposes. The site at Barbarons appears not to have been effectively covered on completion and is untidy.

Praslin

Currently waste is disposed of at a single dump site near to the airport at Amitie. The location is in an area understood to have been the general area used for waste disposal over a number of decades. Generally waste has been disposed of into excavations below the water table, which have developed as a result of sand quarrying activities. The site has no environmental controls and existing operational activities are not generally in accordance with modern waste disposal practices; large areas of waste are left uncovered causing littering and a potential pest

/ rodent nuisance. Wastes deposited below the groundwater level are likely to be degrading and causing pollution of the aquifer, which is understood to be abstracted locally for agricultural uses.

The remaining capacity is difficult to determine as there are no well-defined site boundaries and current disposal activities are somewhat haphazard. However, it is likely that the current area could accommodate a few years waste filling if this was acceptable.

The site is operated by STAR, which has undertaken to improve the condition of the site in upcoming months.

La Digue

An engineered landfill facility is used for the disposal of all waste collected on La Digue. The site is lined with clay and plastic sheeting and leachates are collected in a holding tank before being re-circulated to the waste mass as a means of volume reduction. The operation of the re-circulation activity appears to be somewhat sporadic and there was evidence of leachate leakage in the tank area at the time of the site inspection in January 2004.

Reportedly much waste goes uncollected and is reportedly burnt on individual properties together with garden waste.

The landfill has received waste for around 4.5 years and there is an estimated 2 years void capacity remaining. The site is operated by STAR.

5. PROBLEM ANALYSIS AND PROPOSED STRATEGIC OBJECTIVES

5.1. Stakeholders

All relevant stakeholders – from the public and private sectors, major waste generators and representatives of environmental NGOs – were invited to a problem analysis workshop, which was held on 23rd October 2003. These included:

- Mr Maurice Loustau-Lalanne, Principal Secretary, Ministry of Environment
- Mr Jude Florentine, Director General, Pollution Control and Environmental Impact Assessment, Ministry of Environment
- Mr Louis D'Offay, Chairman, Seychelles Hotels Association
- Mr. Maximilian Lennkh, General Manager, Banyan Tree Resort
- Mr. Albert Payet, Chairman – Seychelles Chamber of Commerce and Industry
- Mr Pradeep, Managing Director, SAMLO
- Mr. Thomas Forgacs, Director – STAR Seychelles
- Mr Patrick Vel, Deputy MD, Seychelles Marketing Board
- Mr Patrick Herminie, Director General – Disease Prevention & Control, Ministry of Health
- Mr Mohammed Afif, Principal Secretary, Ministry of Economic Planning
- Mr. Kris Seeboo, Managing Director, Ste Anne Resort
- Mr. Glenny Savy, Managing Director, Island Development Company
- Mr David Bentley, General Manager, Indian Ocean Tuna
- Mr Antoine Moustache, Ministry of Agriculture and Marine Resources
- Mrs Tania Laporte, SWAC
- Mr Berry Antat, SWAC
- Captain Robert Padayashi, Port & Marine Services, Ministry of Transport

The following were the attendees:

- Maurice Loustau-Lalanne, Principal Secretary, Ministry of Environment
- Jude Florentine, Director General, Pollution Control and Environmental Impact Assessment, Ministry of Environment
- Tania Laporte, SWAC
- Berry Antat, SWAC
- Kantilel Jivan Shah, Chamber of Commerce
- Nicholas Shamlage - Ministry of Health
- Patrick Appoo - SMB Trading
- Steve Mussard - PUC (Water)
- Jude Anglousa - PUC (Electricity)
- Rajiv Goloressoo - SAMLO & Sons
- Marie – Yvonne Auguste - Seychelles National Youth Association
- Mohammad Ferozuddim - Visitor from India with Ministry of Education
- Maurice Lalanne– Principal Secretary, Ministry of Environment
- Sandrine Vaneph - Local waste management consultant
- Henry Maltér, concerned resident

5.2. Procedure

Problem analysis is a technique used as a precursor to the development of a strategy. Its ultimate purpose is to identify a set of objectives against which the strategy can be prepared. This is done by first identifying and defining all of the specific problems that need to be addressed by the strategy, thus introducing a basic logic into the strategy development process.

A comprehensive waste management strategy needs to address all significant problems that exist. The essence of problem analysis is to identify and define clearly all of these significant problems, constraints and deficiencies associated with the existing waste management arrangements. It is important to appreciate, however, that a problem is not the absence of a solution, but an existing negative state, such as a failure, deficiency or other negative condition.

The first stage of a problem analysis workshop is to try to identify the fundamental problems facing waste management. Ultimately, it is the intention to identify the core problem, which effectively summarises the whole situation in a single sentence. Typically, however, when a diverse group participates in a problem analysis workshop, there is a natural tendency for individual members to focus on the problem areas that most concern them. This is natural and beneficial to the problem analysis process and will help in the identification of the core problem. Many of the problems proposed by members of the workshop group will frequently be subsidiary to other, broader problems. Thus, they will be contributory causes of the core problem. Other "problems" proposed may actually be effects of the core problem. There may be several levels of causes and effects. When endeavouring to identify, define and analyse the problems associated with existing waste management arrangements and practices, it is important to be as specific as possible, and to articulate the true nature of their causes and effects.

When a single core problem has been selected, the causes can be categorised according to the principal functional areas or activities. The next stage is to arrange the identified problems into a series of cause and effect relationships, leading to the development of a problem matrix identifying the individual problems, their causes and effects.

5.3. Problems, causes and effects

The participants appeared to find the workshop useful and a meaningful result was obtained.

The Core problem was identified as follows:

Waste management in the Seychelles is not currently sustainable.

A discussion ensued about the definition of "sustainable" in the context of the waste management master plan. It was concluded that the term referred not only to environmental sustainability but also that the waste management facilities should be in place by the end of the plan period to last for a further generation (30 years).

The sub-problems, causes and effects were identified as shown in Table 8.

Table 8: Seychelles – Existing Waste Management System – Problem Analysis

Area/Activity	Key Problems	Principal Causes	Principal Effects
1. Policy & Legislative Framework	1.1 Existing national master plan does not reflect the existing situation on waste management	1.1 The master plan has not been updated since 1995	1.1 No clear and formal basis is available for determining WM priorities or targets.
	1.2 Enforcement of legislation relating to WM is not effective.	1.2.1 Enforcement is not considered to be a priority.	1.2.1 Wastes are not managed in accordance with legal requirements and/or best practices / techniques.
		1.2.2 Resources / procedures for monitoring and enforcement are insufficient & ineffective.	1.2.2 Littering & fly tipping in some areas.
			1.2.3 Some hazardous materials are being landfilled
	1.3 Legislation does not adequately support some of the enforcement that is carried out	1.3 No legislation exists requiring waste producers to have a contract for the disposal of their waste	1.3 SWAC using informal contacts with Licensing Department to apply pressure to waste producers
		1.4 Littering penalty recently reduced to R200	
	1.4 Penalties for littering and fly-tipping are not sufficiently high to be effective		1.4 Littering in public places is uncontrolled and fly-tipping may be increasing
2. Institutional / Organisational Arrangements	2.1 Existing institutional / organisational responsibilities for WM are not clearly defined between the various ministries and departments	2.1 Recent reorganisations have not yet been fully carried through and rationalised.	2.1 Confusion / overlap of functions & responsibilities, leading to less than wholly efficient allocation of resources.
	2.2 Contractual arrangements for service provision are not achieving the intended results	2.2 Conditions of contract are not being adhered to by either party	2.2 Service being provided is not what was envisaged by either party
3. Human Resources / Capacity	3.1 Existing human resources in the public sector are unable to fulfil their regulatory duties completely.	3.1.1 Public sector WM personnel are insufficiently trained.	3.1.1 WM activities are not regulated effectively.
		3.1.2 Inappropriate use of trained staff	3.1.2 Private sector waste producers do not apply best WM practices and techniques.
	3.2 Health and Safety issues have not been addressed	3.2 Some services are provided without adequate Health and Safety conditions	3.2 Risk to Health and Safety of Operatives
4. Financing / Cost Recovery	4.1 The revenue flows from existing WM charges are insufficient to be able to meet the full costs of providing a sustainable system.	4.1 Imbalances in Seychelles balance of payments.	4.1 Without full cost recovery, waste generators will not be aware of the cost of managing their own wastes
		4.2 Existing national economic situation precludes the possibility of immediate action on implementation of the polluter pays principle	4.2 Financing a long term sustainable waste management system requires financing by Government
5. Stakeholder Awareness & Communication	5.1 General public do not have a sufficient awareness of the need to prevent littering	5.1.1 Penalties are inadequate	5.1 Littering in public places is widespread and uncontrolled
		5.1.2 An active communications campaign has failed to make the necessary impact	
	5.2 Stakeholders are not aware of the need for waste reduction	5.2 No communications campaign has been established to promote waste reduction	5.2 Stakeholders are not implementing waste reduction programmes

Table 8: Seychelles – Existing Waste Management System – Problem Analysis

Area/Activity	Key Problems	Principal Causes	Principal Effects
6. Data Availability / Reporting	6.1 Available data on certain priority waste streams are not available	6.1 Generators of these priority waste streams do not have separate identifiable contracts for their wastes management	6.1.1 Reliable data & information relating to specific / priority waste streams is inadequate / unavailable (e.g. healthcare wastes, port and airport wastes, wastes at La Digue and Praslin). 6.1.2 A comprehensive and reliable statistical basis for planning, management and control of facilities for the management of priority waste streams is not available.
7. Waste Avoidance & Reduction	7.1 The potential for waste avoidance and reduction is not being exploited.	7.1.1 The current financial costs of managing and disposing of wastes provide little or no incentive to avoid / reduce waste generation. 7.1.2 Product suppliers, consumers and other waste generators are not aware of the potential opportunities for, and benefits of, avoiding and / or reducing wastes. 7.1.3 Information on the opportunities & techniques for wastes avoidance and reduction is not readily available to waste generators.	7.1.1 Resources are not used efficiently with both actual & potential economic & environmental consequences. 7.1.2 The current / future volumes of waste requiring handling, processing and disposal are / will be higher than need be. 7.1.3 The resource requirements for handling, processing and disposing of wastes are / will be higher than need be.
	7.2 Many imported products have a short life before disposal	7.2.1 Lack of local repairing skills 7.2.2 Low quality of imported goods	7.2 waste generation is higher than need be

Table 8: Seychelles – Existing Waste Management System – Problem Analysis

Area/Activity	Key Problems	Principal Causes	Principal Effects
8. Waste Recovery & Recycling	8.1 The potential for further waste recovery and recycling is not being realised.	8.1.1 Users of raw materials do not consider waste to be part of the material cycle. 8.1.2 Stable, long-term market outlets for many types / grades of recyclable materials do not exist. 8.1.3 Domestic market outlets for many types / grades of recyclable materials do not exist. 8.1.4 Costs incurred for collection, segregation and shipment inhibit the export of recyclable materials. 8.1.5 The current financial costs of managing and disposing of wastes provide little or no incentive to recover / recycle materials from waste. 8.1.6 Government policy and support for secondary raw material markets do not exist. 8.1.7 The price required to be charged for the sale of compost by the contractor does not enable local demand to be maximised. 8.1.8 The market for compost in the Seychelles at any price is not sufficiently large. 8.1.9 Some materials, e.g. certain plastic products, imported could be replaced with others for which waste management techniques are more environmentally acceptable.	8.1.1 The recovery of many types / grades of potentially recyclable materials is not financially viable under prevailing conditions. 8.1.2 The current / future volumes of waste requiring handling, processing and disposal are / will be higher than need be. 8.1.3 The resource requirements for handling, processing and disposing of wastes are / will be higher than need be.

Table 8: Seychelles – Existing Waste Management System – Problem Analysis

Area/Activity	Key Problems	Principal Causes	Principal Effects
9. Waste Segregation, Storage, Collection & Transport	9.1.1 Insufficient number of bin sites 9.1.2 Insufficient cleaning round bin sites 9.1.3 Insufficient appropriate collection vehicles / systems used in Mahé and Praslin / La Digue 9.1.4 Frequency of collection not always maintained 9.2 Separation of recyclables and compostables is not taking place	9.1 Insufficient government financial resources in the short to medium term. 9.2.1 Existing arrangements for segregating and separately storing some types of waste prior to collection are inadequate. 9.2.2 Systems for segregating & separately storing recyclable materials prior to collection are not sufficiently developed. 9.2.3 Systems for the separate collection of biodegradable wastes do not exist except on a trail basis.	9.1.1 Increased health / environmental risks from improper segregation / storage. 9.1.2 Increased levels of littering 9.2 Opportunities for further recovery / recycling of some waste materials cannot be realised.
10. Waste Treatment / Processing	10.1 Existing facilities / practices for the treatment / processing of wastes do not comply with appropriate environmental standards. 10.2 Treatment facilities for hazardous wastes do not exist	10.1.1 Existing waste incinerators do not comply with appropriate environmental standards. 10.1.2 Standards governing the treatment / combustion of some types of waste are not yet developed. 10.2 Contractor has not provided facilities required under the contract	10.1.1 Enhanced pollution & hazard potential from such incinerators. 10.1.2 Some wastes are treated / burnt in inadequate / inappropriate facilities. 10.1.3 Significant risks to the health / safety of operatives handling wastes, and to other people entering waste disposal sites. 10.2 Hazardous wastes are not being treated in an environmentally sound manner
11. Final Disposal	11.1 Existing facilities / practices for the final disposal of wastes do not comply with appropriate environmental standards. 11.2 Existing facilities for the final disposal of wastes do not have sufficient capacity to represent a sustainable solution.	11.1.1 Standards governing the final disposal of wastes are inadequate. 11.1.2 Insufficient monitoring of technical performance. 11.2 Capacity of secure and well-designed facilities for the final disposal of wastes only exists for a very short time period.	11.1 Pollution risk from existing landfill, especially to the sea and adjoining marine park. 11.2 Waste management in Seychelles is not sustainable

5.4. Proposed strategic objectives

From the problem analysis, the objectives for the waste management master plan are proposed as shown in Table 9.

*Table 9: **Strategic Objectives for waste management in the Seychelles***

Core Objective		Waste management shall be sustainable for a period of thirty years by the year 2010.
Area/Activity		**Objectives**
1.	**Policy & Legislative Framework**	1.1 A new national master plan reflects the existing situation on waste management 1.2 Enforcement of legislation relating to WM is effective. 1.3 Legislation adequately supports enforcement. 1.4 Penalties for littering and fly-tipping are sufficiently high to be effective
2.	**Institutional / Organisational Arrangements**	1.1 Institutional / organisational responsibilities for WM are clearly defined between the various ministries and departments 2.2 Contractual arrangements for service provision achieve the intended results
3.	**Human Resources / Capacity**	3.1 Existing human resources in the public sector are able to fulfil their regulatory duties completely. 3.2 Health and Safety issues have been addressed
4.	**Financing / Cost Recovery**	4.1 The revenue flows from existing WM charges are sufficient to be able to meet the full costs of providing a sustainable system.
5.	**Stakeholder Awareness & Communication**	5.1 General public have a sufficient awareness of the need to prevent littering 5.2 A communications campaign has been established to promote waste reduction
6.	**Data Availability / Reporting**	6.1 Available data on certain priority waste streams is available
7.	**Waste Avoidance & Reduction**	7.1 The potential for waste avoidance and reduction is exploited. 7.2 Attention is given to importing more durable products
8.	**Waste Recovery & Recycling**	8.1 The potential for further waste recovery and recycling is realised.
9.	**Waste Segregation, Storage, Collection & Transport**	9.1.1 Sufficient number of bin sites 9.1.2 Sufficient cleaning round bin sites 9.1.3 Sufficient appropriate collection vehicles / systems used in Mahé and Praslin / La Digue 9.1.4 Frequency of collection is maintained 9.2 Separation of recyclables and compostables is taking place
10.	**Waste Treatment / Processing**	10.1 Existing facilities / practices for the treatment / processing of wastes comply with appropriate environmental standards. 10.2 Appropriate treatment facilities for hazardous wastes exist
11.	**Final Disposal**	11.1 Existing facilities / practices for the final disposal of wastes comply with appropriate environmental standards. 11.2 Existing facilities for the final disposal of wastes have sufficient capacity to represent a sustainable solution.

5.5. Workshop 2

A second workshop was convened with interested stakeholders on 21 January 2004 to identify gaps in the initial report. The salient points identified from this discussion are incorporated in Appendix C.

6. INSTITUTIONAL AND MANAGEMENT ISSUES AND RECOMMENDATIONS

6.1. Legislation and enforcement

Primary legislation largely meets requirements. Provisions are made for a competent authority to control the environmental impact of waste management and it has the necessary powers.

Enforcement, however, whilst effective in relation to the collection of wastes, is less so as far as the environmental impact of waste management facilities is concerned. This is largely due to a lack of formally laid down technical standards – for example for landfills and incinerators.

A licensing procedure for waste management facilities, with penalties for non-compliance, is the normal way in which such controls are imposed. It is recommended that SWAC, as the competent authority, introduces a system of licensing – for which the legislative powers are already established – although a regulation may need to be introduced to provide the detailed powers and procedures.

A pre-requisite for a licensing system is that technical standards are established and that the staff charged with enforcement have the necessary technical knowledge and experience both to design and then interpret them. This is addressed further in section 6.3.

Problems with littering and fly-tipping have also been identified. We understand that the maximum fine for littering has recently been set at a level (Rs200) that is having some effect. Enforcement and punishment are meted out. We recommend that the level should be raised to one that is more effective; particularly for fly-tipping.

Finally, SWAC ensures that business licences are not granted unless a business has a contract for the collection and disposal of its waste. This is an informal procedure arranged between the licensing department and SWAC. It is recommended that legislation be introduced to formalise this arrangement, as it provides a very useful check on waste generators.

6.2. Institutional and organisational arrangements

6.2.1. Waste regulation and enforcement

The organisation primarily responsible for the enforcement of waste management legislation is clearly SWAC. Other departments of the Ministry of Environment and also the environmental health departments also become involved in this enforcement. This results in duplication of effort which may not be necessary if SWAC had the power to issue enforcement notices. It is recommended that such duplication is eliminated by setting out clear responsibilities for each Ministry / department and giving SWAC the power to issue enforcement notices.

6.2.2. Involvement of new entities in waste management

It has been suggested that other entities might be able to become involved in the waste management sector by, for example, public-private partnerships. There is, at the present time a public-private partnership in the form of the existing STAR contract. There seems little scope for further public-private partnerships whilst this contract continues.

If the STAR contract were to be terminated, we have some doubt as to whether introducing new private sector partners would have any positive effect over the existing situation, as STAR are a specialist, international company. If the contract were to be terminated, we have some doubt as to whether an atmosphere of trust would be generated whereby other international companies would be prepared to participate.

6.2.3. Contractual arrangements

It is recommended that the contract be completely renegotiated and redrafted.

The new contract should not be based on the existing one, but should be re-designed from the beginning to reflect modern contractual practice in waste management. Before commencing the negotiations, a clear specification of the services to be provided should be prepared, in the light of the recommendations in this master plan, taking account of current affordability

6.3. Human resources and capacity

It has been identified that the SWAC inspectors require additional training to enable them to perform the full range of inspection duties.

In addition, SWAC needs to be strengthened by the appointment of a new technical manager with the necessary skills and experience to establish waste management facility licensing criteria and write the appropriate inspection procedures. If a suitable individual is not available in the Seychelles, then appropriate training should be provided.

It should be mentioned that one of the problems identified is the inappropriate use of trained staff. An example of this was identified at the hospital, where a new incinerator was installed and an operator trained in its use. The operator was then transferred to other duties and, as a result, the incinerator was damaged beyond repair within two years of its purchase. It must be recognised that modern waste management equipment requires careful stewardship and that it should only be operated by trained employees. It is recommended that, where waste management equipment is owned and operated by the public sector, care should be taken to ensure that appropriate training is provided. On the other hand, it has been the clear intention that all waste management services should be provided by professional private sector firms and a provision exists in the STAR contract to provide a healthcare waste incinerator at Providence.

6.4. Financing and cost recovery

6.4.1. General observations

In order to implement the Polluter Pays Principle, thereby raising awareness of the need to minimise waste, all waste generators should pay the full cost of a sustainable waste management system. At the present time, industrial and most commercial waste generators are believed to pay the full cost of the current system, but householders do not pay a charge and are thus unaware of the costs of waste management – which they bear indirectly through the taxation system. It is felt, however, that in the present economic climate it would not be appropriate to introduce a system of full user charges for household waste management. We do not feel that industry and commerce should be charged higher fees to cover these costs as this would represent an unfair burden.

However, there should be some mechanism initiated whereby householder charges are gradually introduced over a period of years. There are several options for the implementation of cost recovery, which are described below.

Furthermore, the charges currently being paid cover the cost of the present system but do not reflect the need for additional investment in the future. In order to achieve this, the charges made should reflect the long run marginal cost of service provision. It will be seen that, for a sustainable waste management system, the costs are likely to be significantly higher in the long term. Where possible, charges should be increased towards long run marginal cost as soon as practicable.

The waste generators that can best afford higher charges at the present time are mainly the industrial companies and the larger hotels. It should be noted that, at the present time, these generators tend to have contracts directly with STAR, the private sector waste services provider. It is important to ensure that any price increases imposed by STAR are used to

finance the provision of necessary new facilities, and it is likely that a new contractual arrangement will be required to achieve this. This topic has been addressed in Section 6.2.

In view of the cuts in Government spending, we believe that it will not be possible for the Seychelles Government (through SWAC) to bear any additional costs for a period of 2-3 years. Any additional facilities required during this period (such as a new landfill to follow on from Providence or an incinerator for healthcare and food wastes) will only be affordable if the capital expenditure is funded through grants or loans with a three year grace period before repayments and interest charges are paid.

In addition to the capital costs for new facilities, there will be some additional operating cost – mainly for additional labour, although the actual amount is likely to be relatively small. It is assumed that the Government would be prepared to pay this additional cost on the grounds of job creation.

6.4.2. Options for cost recovery relating to household waste

User Charges

In an increasing number of locations throughout the world "user charges" rather than general taxes are levied, either directly or indirectly, specifically to recover the costs of solid waste management services, especially where cost recovery is being introduced for the first time.

This is because opportunities for introducing new general taxes are limited and, generally, undesirable. People resent new taxes, especially if the uses to which the new funds are to be put are unclear or cannot be assured to the public. This is one of the reasons why service-specific user-charges are preferred: they are earmarked for a defined purpose.

The principal differences between taxes and charges are:

- Funds generated by taxes are generally paid directly into a consolidated revenue account, whilst funds generated from user-charges may be allocated to a specified use.
- Taxes do not relate to the costs of providing a specific service, whereas user-charge levels are set with a view to their making a specific contribution to the costs of providing a service.

Charges are therefore preferred because they can be presented and justified to the public on the grounds that they are required for and will be used in the provision of an essential public service. They can, nevertheless, also meet with public criticism. Reasons for this might be:

- Citizens may be reluctant to pay additional charges before they experience real improvements in service quality.
- The view that public services should be provided "free-of-charge".
- The view that the service is already being paid for out of general taxes, such as a property tax.
- People do not want the proposed services and are unwilling to pay from them.

These issues therefore need to be addressed as part of the strategy formulation and implementation process. Departing from a traditional approach of funding public services out of consolidated revenue to one of imposing user-charges can have important cultural, legal and political implications.

There are two broad types of charging mechanism: direct and indirect charges.

Direct Charges

Direct charges relate to the level of demand for a service, and involve service users being charged directly for their use of the service. Waste producers may thus be charged directly for the removal and disposal of waste from their premises, according to the quantity of waste collected, in the same way as they pay for, for example, electricity. Equally, they may be

charged different rates for different types of waste, such as source segregated recyclables or "biowaste", which may be charged at a lower (or zero) rate. There is a direct relationship, however, between the level of charge and the level of service provided. Such a system is the most effective way of implementing the Polluter Pays Principle and may also be used to encourage waste minimisation, recycling or source segregation.

Direct charges may be totally proportional to the quantity (volume or weight) of waste, or they may incorporate a combination of fixed rate and proportional rate. The latter system more accurately reflects the true cost structure, especially of the collection service.

The advantages of direct charging are:

- It presents an incentive for waste producers to minimise their waste production or to undertake recycling.
- It provides the best way to avoid collection contractors from including other wastes they have collected for a fee being disposed of free of charge as household waste.
- It can reflect the marginal cost of disposal.

Direct charges are levied for household waste management in some parts of the world, largely in the affluent nations of Western Europe and North America, where they are usually imposed to encourage waste minimisation and recycling. There are, however, some problems associated with their introduction, namely:

- They may encourage fly-tipping or other environmentally or socially unacceptable behavior.
- The difficulty in using withdrawal of service as a sanction to enforce payment (environmental and public health considerations militate against this).
- The cost and complexity of establishing and administering the system.
- Direct charges provide little scope for introducing a progressive element into the charge system to reflect the ability to pay.
- Some of the costs of waste management, notably collection and an element of the disposal cost, do not vary significantly with the amount of waste produced.
- The actual pecuniary effect on a householder of reducing their waste may be trivial.

The "free-loader" problem, wherein it is difficult to enforce payment or withdraw services from householders unwilling (or unable) to pay the charges, is mainly a matter of enforcement. This can be a particular problem in communal housing such as blocks of flats, where the waste producer cannot always be readily identified.

There are a number of different ways in which a direct charging system for household waste can be applied in practice. One of the simplest is the use of pre-paid bags or tags which can be affixed to bags or bins. This is known as the "tag & bag" method. The bags or tags may be supplied directly by the local authority or could be marketed at supermarkets etc. allowing a small margin for the administrative expense. Only waste in such bags is then collected. There is, of course, the risk that tags could be stolen, but international experience does not indicate that this is a problem. Where plastic "wheelie" bins are used for individual properties, these can be marked with stickers (similar in principle to a car tax disc) which signify that an annual fee has been paid, authorising weekly (or more frequent) collection of the container. A "tag & bag" system would incur some administrative costs, in terms of issuing the tags. The tags could be sold through supermarkets and shops, in which case a margin would need to be allowed. The total administrative costs might be as much as 10% of the revenue generated.

These systems do not normally make any significant allowance for the degree to which the container (be it bag or bin) is filled. In some cases, the collector will inspect a bin and make a judgement as to whether it is full, half-full etc. but such systems are rather subjective (and open to abuse). A more sophisticated alternative is the use of an "electronic bin", which has a bar code or microchip indicating the identity of the householder, so that the collector can record the number of times the bin is emptied. Some systems can also record the degree to

which the bin is filled. Probably the most sophisticated system in use at present involves automatic weighing of electronic bins, so that the actual weight of waste collected is recorded and charges are then appropriately applied.

Indirect Charges

The principal difference between direct and indirect charges is that direct charges relate directly to the level of demand for the service, based on the principle that users should pay the full costs of services they receive. With indirect charging mechanisms, however, there is no such direct link between level of use and level of charges. Because indirect charges are not volume-based and the service is free at the point of consumption, householders have little economic incentive to reduce the waste stream.

A simple system is to charge an explicit waste management fee as a proportion of a property tax. This system will better reflect ability to pay, since larger properties tend to be occupied by wealthier individuals. It may also reflect, to some extent, the volume of waste generation, since people living in larger houses tend to produce more waste.

The advantages of the indirect approach are:

- Administrative simplicity.
- Low fee collection costs and high collection ratio.
- Reflects, to some extent, ability to pay.
- Convenience for customers.
- Billing process not disturbed by a change of contractor.
- Availability of sanctions for non-payment.
- Revenue reliability and predictability.

Another indirect charging mechanism, used in many parts of the world, is to link charges for waste management services to another service for which charges ***are*** paid on the basis of demand, and where the sanction of disconnection exists for non-payment. Examples are water and electricity supplies. Here, although there is not a direct connection with demand, the demand for the other service acts as a proxy for allocating costs between users of the waste management service. This is likely to reflect ability to pay more closely and may also be more equitable, in that households that consume larger quantities of water or electricity are more likely to generate more waste. The legal implications of imposing a levy of this kind, and the willingness of the utility to levy and collect it, are important matters to be addressed when considering this approach.

6.5. Stakeholder awareness and communication

SWAC has undertaken a substantial amount of awareness raising, which has been effective, though the problem still persists. The Ministry places great importance on this issue. There is also a communication and education section within the Ministry, under the direct control of the Minister. This section operates a telephone "hotline" which accepts complaints from the public and is responsible for all external communication with the public, through TV spots on environmental issues and awards for good environmental practice. Any further activity in this field needs to be focussed on the specific problems, which relate to certain articles (e.g. Tetrapak and take-away boxes) and to specific areas where the problem still exists – notably public places.

Little attention has yet been placed on the need for waste reduction – both by businesses and also by householders. We recommend that a programme be introduced to raise awareness in this area.

In addition, trials have been held for source segregation of wastes, particularly biodegradable wastes suitable for composting. SWAC has stationed inspectors at the location of the trails and they report quite positive results. Capacity for processing the segregated wastes, however, does not currently exist and it is likely that, unless such capacity is provided, public

enthusiasm will wane. An awareness campaign for source segregation should ultimately be introduced, but not until processing capacity is available.

6.6. Data availability and reporting

Data on quantities of construction and demolition waste should become as available, as discussed in Section 4.7.

Data on healthcare waste arising form the hospital together with other medical facilities and vetinary centres is a particular problem. Without it, it will not be possible to determine the capacity of any facilities which are provided for these wastes. It is recommended that the hospital be required to record the quantities of waste incinerated in volume terms, since weighing is not practical. The hospital should also record the volumes of any wastes which are collected by STAR.

There is also no information on the quantities of wastes arising at the port and airport. This data is also required to determine the capacity of facilities which may be provided for these wastes. Since these wastes are collected by STAR, STAR should record and make available data on the quantities of these wastes. Indeed, they may be able to provide this information at the present time from their invoicing records.

Eventually, a weighbridge should be installed on Praslin, enabling the quantities of waste to be recorded. In the meantime, the number of vehicle loads delivered to the existing dump site at Praslin and the landfill at La Digue should be formally recorded.

6.7. Environmental monitoring

Currently environmental monitoring is only carried out in response to a particular concern or event; that is it is reactive. Staff, equipment and testing facilities are divided between a number of organisations including the Ministries of Environment and Health, the Seychelles Standards Bureau, the Public Utilities Corporation and others. Hence, although there is a degree of co-operation between these organisations, there is very limited baseline data on the condition of the water and ground media and no single data bank of environmental quality parameters.

Limited monitoring of groundwater has taken place around the Providence dump-site and a recently-initiate programme of six-monthly sea sediment monitoring has commenced. However, this is of limited extent and the parameters tested for are considered not to be truly appropriate for the situation.

A schedule of required environmental monitoring requirements (primarily associated with waste management activities) should be produced detailing the scope and range of parameters and media to be regularly measured and recorded. This should specifically include sampling and analysis of groundwaters (for which monitoring boreholes will need to be installed) and sea water for particular leachate components. Additionally, leachate within the waste mass and landfill gas monitoring around the dump-sites should be initiated. In time methods and equipment for the sampling and testing of certain (potentially hazardous) wastes could be considered.

Furthermore, it is suggested that a comprehensive audit of all the government and parastatial technical staff, their qualifications and experience, the testing and analysis equipment and facilities available and the regime of testing works currently undertaken is carried out. The inventory produced should be used to identify duplications and technical deficiencies in resources between and within the various organisations and, together with the comprehensive environmental monitoring requirements identified above, should be used to identify the training, staffing and full equipment requirements necessary to properly monitor the impacts of waste management. The responsibility for co-ordination of such efforts should rest with the Ministry for the Environment.

6.8. Other Considerations

In addition to implementing the various options identified above into the future strategy it is considered that other tangible benefits may accrue by the introduction of an environmental management system (such as ISO 14001) for the entire waste sector.

In order to develop the 'polluter pays' principle it is suggested that 'user charges' are implemented whereby all householders receiving a utility bill have an entry included on the invoice for waste collection and disposal. Initially this can be set at a zero rate and this could be increased over a period of time to fully reflect the true cost of the service.

Additionally, there are considered to be a number of health and safety issues associated with some of the individual activities in the waste sector (notably collection and processing) which ought to be addressed in the immediate future to ensure the safety and welfare of all those persons directly involved in the sector.

7. OPTIONS FOR WASTE HANDLING, PROCESSING AND DISPOSAL

7.1. Introduction

In this section all the potentially practicable options for the handling, processing and disposal of wastes in the Seychelles are identified and described. In Section 1 the options are subjected to a more detailed evaluation.

Some costs have been identified in this section, which are expressed in Euros. Where local costs have been incorporated into the calculation, they have been converted at the official rate of R6 = €1.

7.2. Waste avoidance and minimisation

7.2.1. Waste minimisation by householders, commerce and industry

Household and commercial waste minimisation

The issue of reduction in the production of household waste receives much publicity. It should be noted however, that from a practical stance, the reduction in household waste is mainly in the hands of the producers of the products that eventually become waste. Waste minimisation is therefore also an important duty for manufacturers and suppliers of household consumables.

There is little doubt that potential does exist - for example by the reuse of plastic shopping bags and certain containers and the elimination of junk mail (unsolicited advertising material).

A study of the potential for household waste minimisation was undertaken in the UK in 1997[2]. This showed a number of interesting facts:

- Newsprint, putrescibles and garden waste make up the majority of most household waste in the UK. The production of these waste streams is also more under the control of the householder than other wastes such as packaging. Therefore actions directed at these fractions will have a more discernible impact on waste minimisation than the much smaller elements of household waste.
- Only about 20% of households participated in the scheme despite extensive publicity.
- A reduction of 15-25% should not be unrealistic in the households that participate. The greatest reduction is generally achieved through home composting.

Due to the large proportion of biodegradable waste in the Seychelles, the reduction in waste arisings could be higher than those achieved in the UK if home composting is encouraged.

Some of the achievements in waste minimisation are likely to be offset by per capita growth in waste production, which has been demonstrated to be an effect of increasing affluence. However, with the governments plans to control spending over the next 5 years, in order to pay off foreign loans, the growth in waste production per capita may theoretically be stabilised.

Industrial waste minimisation

The minimisation of waste produced by industrial activities forms part of the internationally recognised requirements of environmental management systems, such as ISO 14000. As such, a number of the largest industries in the Seychelles have actively sought and encouraged waste minimisation as an integral part of their environmental management. Indian Ocean Tuna are a notable example. The small scale and limited diversity of much of the industry in

[2] *Slim your Bin*, a study undertaken by the Nailsea Waste Prevention Campaign, supported by North Somerset District Council, Going for Green and Waste Watch, 1997

the Seychelles provides limited opportunities for waste avoidance and minimisation. However, there is also scope for consideration and encouraging entrepreneurial activities.

7.2.2. Charge for waste collection and disposal by volume

One option which can lead to waste minimisation in household, commercial and industrial sectors is to introduce a system of direct charging, in which waste generators are charged directly for the removal and disposal of waste from their premises, according to the quantity of waste collected, in the same way as they pay for, for example, electricity.

Charges may be applied at different rates for different types of waste, such as source segregated recyclables or "biowaste", which may be charged at a lower (or zero) rate. There should be a direct relationship, however, between the level of charge and the level of service provided. Such a system is the most effective way of implementing the Polluter Pays Principle and may also be used to encourage waste minimisation, recycling or source segregation.

Direct charges may be totally proportional to the quantity (volume or weight) of waste, or they may incorporate a combination of fixed rate and proportional rate. The latter system more accurately reflects the true cost structure, especially of the collection service.

The advantages of direct charging are:

- It presents an incentive for waste producers to minimise their waste production or to undertake recycling.
- It provides the best way to avoid collection contractors from including other wastes they have collected for a fee being disposed of free of charge as household waste.
- It can reflect the marginal cost of disposal.

Direct charges are levied for household waste management in some parts of the world, largely in Western Europe and North America, where they are usually imposed to encourage waste minimisation and recycling. There are, however, some problems associated with their introduction, namely:

- They may encourage fly-tipping or other environmentally or socially unacceptable behaviour.
- The difficulty in using withdrawal of service as a sanction to enforce payment (this would be contrary to environmental and public health best practice).
- The cost and complexity of establishing and administering the system.
- Direct charges provide little scope for introducing a progressive element into the charge system to reflect the ability to pay.
- Some of the costs of waste management, notably collection and an element of the disposal cost, do not vary significantly with the amount of waste produced.
- The actual financial effect on a householder of reducing their waste may be trivial.

Enforcing payment can be a particular problem in communal housing such as blocks of flats, where the waste producer cannot always be readily identified.

Commercial and industrial users, on the other hand, offer significant scope for the application of direct charging systems and, as a consequence, are normally charged in this way throughout the industrialised world. This is because:

- The extent and nature of waste generation patterns can differ considerably between users.
- Individual waste quantities can be large.
- The number of users is relatively small.

In the Seychelles a system of charging according to waste generated is already in place for many commercial and industrial waste producers and a very small number of households. The cost of waste collection is defined by the number and/or volume of bins and the required frequency of collection. Although the type of contract is the choice of the waste producer, SWAC has the power to enforce alternative collections if the existing arrangements do not provide adequate capacity.

There are a number of different ways in which a direct charging system for household waste can be applied in practice. One of the simplest is the use of pre-paid bags or labels that be affixed to bags or bins. The bags or labels may be supplied directly by the waste collection contractor or the relevant government department or could be marketed at supermarkets etc. allowing a small margin for the administrative expense. Only waste in such bags is then collected. There is, of course, the risk that labels could be stolen, but international experience does not indicate that this is a problem. Where individual plastic wheeled bins are used, these can be marked with stickers (similar in principle to a car tax disc) that signify an annual fee has been paid, authorising collection of the container. Such a system would incur some administrative costs, in terms of issuing the bags or labels. The total administrative costs might be as much as 10% of the revenue generated.

These systems do not normally make any significant allowance for the degree to which the container (be it bag or bin) is filled. In some cases, the collector will inspect a bin and make a judgement as to whether it is full, half-full etc. but such systems are rather subjective (and open to abuse). A more sophisticated alternative is the use of an "electronic bin", which has a bar code or microchip indicating the identity of the householder, so that the collector can record the number of times the bin is emptied. Some systems can also record the degree to which the bin is filled. Probably the most sophisticated system in use at present involves automatic weighing of electronic bins, so that the actual weight of waste collected is recorded and charges are then appropriately applied.

The problem with introducing a system of direct charging for households in the Seychelles is that almost all household waste and some industrial waste is collected from communal containers that are provided for the deposit of waste. It is very difficult to introduce such a system in these circumstances. A pre-paid bag system might be used, but it would be difficult to determine who was responsible for placing waste in the bins without the pre-paid bags. Consequently, such a system would tend to penalise honesty rather than excessive waste generation and is not therefore recommended for use in the Seychelles for household waste

One alternative to charging for the amount of waste collected is to limit the size of the bins provided. Again this system is difficult to implement when household waste is deposited at communal bin sites.

7.2.3. Provide incentives for home composting

Home composting can be regarded as waste minimisation or as recycling. It is a waste minimisation option insofar as the waste does not need to be collected or processed. Materials suitable for home composting are green (garden) waste and kitchen waste.

In the Seychelles the majority of the population live in houses rather than apartments, thus making home composting a more viable options for the Seychelles. Many people appear to take great pride in their outdoor space. It is thought that home composting and burning of green waste already widely occurs. However, the waste composition illustrates that there is still a substantial quantity of green and kitchen waste in the household waste stream. Thus it is believed that there is potential to increase the amount of green and kitchen waste composting undertaken in households in the Seychelles.

Incentives for home composting often include subsidised composting containers, reduction in waste collection costs and education into the use and advantages of composting for the householder.

7.2.4. Controlling the import and use of materials

With the Seychelles being a series of island communities with limited resources it is necessary for many goods to be imported. The government controlled Seychelles Marketing Board has responsibility for importing staple foods and goods. There are also some private sector importers of products. This generates an environment with far more potential than most countries to control the imports of materials that are difficult to reuse, recycle or dispose of.

At present Mauritius is in the process of banning the import of plastic bags, and propose the use of paper bags instead. The stakeholders in the Seychelles are keen on implementing similar schemes and the opportunities should be investigated further.

Mechanisms that may be employed to reduce the presence of difficult materials could include:

- Legislation;
- Import tariffs and charges;
- Environmental levies and taxes.

Disadvantages of implementing such a system may include limiting choice, increasing costs and stifling entrepreneurial activity.

7.2.5. Repair and resale centres

It is common in most countries to have formal and informal systems for the repair and/or resale of items that are no longer required by their owner. Such systems may be carried out by charities, organisations providing training for the young or unemployed, by schools, individuals etc. Such systems already exist for many items in the Seychelles.

7.3. Waste segregation, storage and collection

7.3.1. Separate collection of recyclables

There is clearly potential to increase the recovery rate of recyclables, if this is deemed to be desirable. There are two main options to achieve this: a “bring” scheme or to introduce separate collection of recyclables from households.

A “bring” scheme relies on householders bringing recyclables to a point where containers are provided for each type of material. This type of system is currently being piloted at two locations on Mahé and has potential for further expansion. It is often the most economic scheme to introduce, but the amount of material which is actually sorted tends to be less than systems which involve separate collection from households.

Although not currently practised, if separate collection of recyclables from households were to be considered, then the collection method needs to be determined. There are a number of options:

- Two compartment vehicles
- Multi-compartment vehicles in conjunction with “blue box” system
- Use existing vehicles with “survival bag” system
- Separate collection of recyclables using separate containers

Two compartment vehicles are rear-loading refuse collection vehicles designed to accept two types of waste – either in containers or in bags. One waste type is always residual waste but the other could be green waste, paper or mixed recyclables. It is possible to have a third compartment for recyclables. The small size of vehicles that can be operated in the Seychelles precludes the use of these vehicles, since the payloads would be too small to be economic.

Multi-compartment vehicles rely on kerbside sorting by the operatives. The householder puts out his mixed recyclables (paper, glass, cans and maybe plastics and textiles) in a plastic box and the loaders sort these and place them in different compartments. Since collection is not currently undertaken on a household by household basis, such a system is unlikely to be practical in the Seychelles.

"Survival bags" are heavy gauge plastic bags, usually transparent, in which recyclables are placed and then collected with the residual waste. Because of their extra strength, most of them (typically about 90%) do not rupture and can then be picked out of the waste at a sorting facility ("dirty MRF" q.v.). This system is worth further consideration.

Separate collection of recyclables can be undertaken using normal refuse collection vehicles if the recyclables are placed in separate containers from the residual waste by operating separate collection rounds for each material. There are two options: a container for each recyclable type may be used, in which case separate collection rounds are used for each recyclable, or mixed recyclables could be collected in one vehicle and then sorted at a MRF. The former is the most likely system to be appropriate for the Seychelles.

7.3.2. Hazardous household wastes

In some countries, "hazardous household wastes" are collected separately, to avoid the additional contamination of leachate by their being placed in a landfill. The actual level of increased contamination is not great and it is questionable whether such a system is required in the Seychelles, certainly at the present time.

There are essentially two options for the collection of hazardous household wastes – they can be collected in a special service to all households or householders can bring them to a central point for collection (i.e. a bring system).

For the small quantities involved, the former can be immediately rejected on economic grounds. Indeed, we are not aware of a special collection system for hazardous household wastes being undertaken anywhere.

If a bring system is adopted, there are again two options – a single central point or the provision of containers for such materials at several sites. The problem with the latter is that hazardous materials of this kind may need to be segregated – for safety reasons.

We do not recommend that such a system is considered for the medium term. In the longer term, it may be appropriate to consider providing a single central collection point, probably at Providence.

7.3.3. Residual wastes

Coverage

The existing system, as far as we are aware, provides full coverage for the whole of Mahé, Praslin and la Digue. Very few households, however, have their own dedicated container, so that the system is effectively a form of the "bring" system. Providing each household with a container would increase the collection cost significantly and is not recommended for consideration.

Collection frequency

Whilst waste is collected daily in the Seychelles, in many countries, weekly collection of waste is the norm. Provided that sufficient container capacity is provided to ensure secure storage for a whole week, weekly collection does not present any environmental problems and leads to a more cost-effective service. In the high ambient temperatures and humidity of the Seychelles, weekly collection is unlikely to be acceptable because of the potential problems with smell and flies. We believe that collection three times a week, however, is unlikely to cause a problem and could offer cost savings, although it would require a significant investment in additional containers, although such an approach is not favoured by the

Ministry of Environment. This in turn would present problems of finding suitable container locations and it is probable that a move to providing each house with a container would be necessary, which would negate the savings from less frequent collection. It is probably inappropriate to consider such a system at the present time..

Vehicle type

At the present time, three vehicle types are being used: rear-end loading compactor vehicles with capacities of 5 and 7 tonnes and high-sided tipper lorries. Larger vehicles are not practical in the narrow roads of the Seychelles. The tipper vehicles require a crew of four and loading them requires heavy lifting to a significant height, which is unacceptable form a health and safety point of view. The selection of future vehicle types should be investigated.

7.4. Waste reuse, recovery and recycling

When discussing recycling options, it should be noted that, the segregation of recyclable materials is a process that may assist recycling to take place but is not in itself recycling. Recycling has not actually occurred until those segregated materials have been used in the manufacture of new products. Options for recycling and recovery are discussed in the sections below.

7.4.1. Recyclables separated from household waste

In Europe, facilities are generally provided for the separate collection of the following recyclable materials:

- Paper
- Cardboard
- Glass
- Metal cans and other metals
- Textiles
- Plastics
- Green / biodegradable waste

The viability of recycling depends largely on the availability of a market for the recyclate and the price paid for the recyclate compared to the cost of separating and transporting the material. In the Seychelles the markets for recyclate are limited by the facilities available on the islands and the relatively small economies of scale that apply to the export of recyclate. Not all of the materials listed above will be viable to segregate and recycle in the Seychelles.

7.4.2. Deposit return schemes

The glass bottle reuse scheme currently carried out by Seybrew is very effective. This scheme is viable financially and technically and should be encouraged. On an island such as the Seychelles reuse options are often favourable to recycling, as the equipment required is usually less expensive and complex.

Seybrew's scheme of a deposit refund on their plastic bottles is also effective, although not currently self-sufficient financially. The expansion of the plastic bottle return scheme to other users in the Seychelles, such as the water bottling companies, is likely to improve the economies of scale. Other opportunities for reuse could also be encouraged.

7.4.3. Encouraging entrepreneurial activity

At present, bulky scrap metal is segregated and exported for recycling in Mauritius by Samlo. This process is currently financially viable and could be encouraged to expand, with the potential to include household sourced metal wastes such as food and drink cans.

Samlo and other entrepreneurs should also be encouraged to identify markets for recyclates. It is probable that alternative uses could be found of many waste materials in the Seychelles. Financial or other incentives could be provided to stimulate these industries.

7.4.4. Materials recycling facilities (MRFs)

Recovery of materials from waste may be performed by a variety of mechanical methods or by semi-manual methods.

Where the input waste stream is fairly consistent and the components to be extracted are easily identified, then it is possible to construct mechanical equipment which will effectively extract a good percentage of the available selected materials. This approach, however, is capital intensive, requires substantial buildings to contain the equipment and is relatively inflexible in its operation.

The degree of technology applied at an MRF can be gradually increased over time, as the volume of waste and demand for recyclables increases.

An MRF can be conveniently located wherever waste is to be delivered. Where transfer stations are used, they make an ideal location, provided sufficient space is available - both for the sorting of the waste and also for the storage of the recovered materials. Mechanical sorting also is the normal first stage in some other processes for the treatment of MSW, for example, anaerobic digestion, composting and MBT.

An alternative, proven, technique is to use manual sorting techniques which are less demanding in capital, require more modest facilities and which are more flexible and adaptable to changes in a potentially volatile market which may give preference to a particular material or component.

The simplest manual system involves hand selection of recyclable materials, usually from a conveyor belt. It is usually known as 'hand picking'. Hand picking is normally used on segregated mixed recyclables from household waste, or else on selected commercial or industrial waste, which contains a higher proportion of recyclables. Hand picking of unsorted MSW has been practised in the past, notably in the USA. Such systems are, however, no longer popular because of concerns about health and safety issues and working conditions.

There are a number of options for mechanical sorting of wastes. The objective is to handle it the minimum number of times and to use equipment that is robust and flexible. This approach has led to the development of standard components for waste or materials segregation, and these may be assembled in various combinations to give the required result for a particular waste stream.

Components of a MRF may include, for example, conveyor belts, crushers or pulverisers, trommels and sieves, magnetic metals separation using an overband magnet or equivalent, non magnetic metals separation using eddy current separators, air classification, ballistic classification and flotation, optical classification for glass and other sorting devices.

The cost of operating MRFs varies depending on the scale, sophistication and degree of separation achieved. The simple picking belt MRF can operate economically at throughputs as low as 3,000 tonnes per annum and the economies of scale above this figure are not very great. For mechanical sorting, it is generally accepted that a minimum throughput of 100,000 tonnes per annum is required to achieve reasonable economies of scale.

Advantages:

- Flexible system that can be gradually upgraded in technology as higher yield rates are required;
- Reduce the amount of waste requiring landfilling, although only by the proportion of waste recovered, which is generally no more than 30% by weight;

- Automated MRFs can be developed into a 'front-end' for other waste processing systems thereby further reducing the landfill requirement.

Disadvantages:

- Often more expensive than the simple landfill alternative;
- Overall economics are difficult to forecast because of the dramatic fluctuations in the prices paid for recyclables.

7.4.5. Specialised waste streams

There are a number of specialised waste streams that need to be considered in the context of recovery. These are wastes that may arise in household, commercial or industrial waste but with particular characteristics that render them worthy of special consideration. Some of these have recycling potential, the implications of which needs to be investigated. These are shown below.

Fluorescent tubes

Most fluorescent tubes contain mercury in the fluorescence powder coating. Mercury is a harmful pollutant. These tubes may be crushed, placed in drums and landfilled in a secure hazardous waste landfill. There are, however, recycling processes. The mercury can be extracted and recovered, but the quantities are small and the process tends to be expensive. An alternative option is now available whereby the fluorescence powder can be recycled and used for the manufacture of new lighting equipment. Due to the current limited number of fluorescent tubes arising no special measures are thought to be required at present. However, the situation should be monitored and if facilities for reprocessing are available in the Indian Ocean then the recovery of these materials may be viable.

Waste Electrical and Electronic Equipment

Waste electrical and electronic equipment (can be collected separately to enable materials or products to be extracted for reuse or recycling at a specialised facility. However, since such facilities do not exist in the Seychelles the potential for repair is likely to be the only viable option. Consideration and control over the products that are imported could also have a positive effect on the amount of this type of waste arising.

Ozone depleting Substances (ODSs)

Ozone Depleting Substances such as refrigerators require particular treatment. CFCs can fairly simply be removed from the cooling system however the foam from refrigerators also contains CFCs. It is unlikely that it would be economic to install a specialist plant in the Seychelles due to the small number of waste refrigerators arising. Export may be an option although the quantity of CFCs generated in the Seychelles is unlikely to be significant on a global scale.

End-of-life Vehicles (ELVs)

There are currently no special procedures for end-of-life Vehicles (ELVs), other than the activities of the scrap metal dealer Samlo. By the time an ELV reaches Samlo most of the component parts of the vehicle will have been salvaged for reuse and only the carcass remains. Activities, such as those carried out by Samlo, should be encouraged.

Batteries

Lead-acid batteries are recovered by Samlo and this should be encouraged. A system for the collection of other batteries is not thought to be required at present will ultimately be required in order to comply with the forthcoming new EU Batteries Directive.

Oils

Waste oil from domestic, industrial and commercial sources are currently collected and exported to Reunion for reprocessing. Waste oil from PUC Power generation is incinerated in a purpose built plant with energy recovery. Some waste oils are still discharged into Providence Landfill and this should be controlled through education and awareness initiatives. The quantities of oil arising are unlikely to be sufficient to warrant a treatment plant on the island, however, other waste oils could be incinerated if such facilities were available.

Tyres

Tyres can provide a useful energy source and can be effectively used as a supplementary fuel for industrial processes or incineration. This opportunity should be considered when incineration facilities become available.

7.4.6. Aggregate crushing

Characteristics

Coarse aggregate is used for two main purposes; fill and base material and concrete making. Finer aggregates are used for making mortars, render and screeds. In the Seychelles, it is generally made by crushing hard rock.

Certain construction wastes, notably stone and concrete, can be crushed to form recycled aggregate. This requires substantial washing and grading before it can be used for concrete making and, indeed, may still not be suitable. It can, however, be used for backfill material and, if suitably graded, for sub-base in road construction.

In the EU, the use of secondary aggregates is well established and many companies produce quality materials which are sold. Different qualities of aggregate are sold for different purposes and there are few limitations.

In the Seychelles, some aggregate crushing is undertaken in a very basic way by STAR to make fill material and also to produce material for engineering purposes at the landfill.

We believe that there is potential to crush aggregates more effectively in the Seychelles if proper crushing and screening equipment were provided. This will serve to reduce the demand for landfill.

Advantages and Disadvantages

The main advantages of aggregate crushing are:

- It reduces the requirement for extraction of virgin material, thus saving natural resources.
- It reduces the demand for landfill space.

The disadvantages are:

- The material is not suitable for all civil engineering applications
- Specification is important which means that the process should be managed by a professional and responsible operator

7.5. Waste treatment and processing

7.5.1. Thermal processes for MSW

Thermal processes, whereby wastes are thermally oxidised, releasing energy which may be used for electricity generation and sometimes also for heat recovery if local demand exists, perform the very useful function of reducing the volume of waste requiring final disposal. This is achieved by oxidising (and therefore removing) the biodegradable element of the waste. They provide the most reliable means by which the landfilling of biodegradable can be reduced.

There are two types of process. The most commonly used is incineration. The second, pyrolysis, is beginning to show potential, because the volume of emissions is substantially lower, thus appealing to the environmental lobby. There are few, if any, pyrolysis systems operating on mixed MSW at the present time and it would appear that this must be regarded as a technology of the future.

Thermal processing options have two main disadvantages: they are very capital intensive and, for reasons, which are not based on factual information, they cause public concern about harmful emissions. Operating costs are three or more times higher than a well-engineered landfill.

They are extensively used in many of the more highly developed EU countries, and also in locations where space for landfill is limited. Thermal processing may have a role in the Seychelles in the longer term.

Incineration characteristics

The technology of the recovery of energy from MSW by means of incineration is practiced extensively in Europe. The high emission standards now normally imposed mean that the health risks are negligible - although the general public does not necessarily perceive incineration in this light.

Generally technology is tried and tested. The most environmentally effective method of energy recovery is the so-called Combined Heat and Power (CHP) system, whereby the "low-grade" heat is recovered as hot water which is used for heating purposes, e.g. in an industrial process. It is essential, however, to have a use for such heat conveniently close to the incineration plant for this to be economic, otherwise only electricity generation is practical. Incineration without energy recovery is not so environmentally or economically attractive, are not normally used except in the case of very small plants (e.g. for healthcare or hazardous wastes – see below).

The most commonly used method of incineration for MSW is the so-called "mass burn" system, which burns the waste without pre-processing - other than separating out bulky non-combustible items such as white goods. Large plants (>150,000 tonnes per annum) offer substantial economies of scale, but the current trend in the EU is to choose smaller plants to conform with the proximity principle, requiring waste to be treated as close as possible to its point of generation. Electricity is generated from steam produced in boilers within the plant.

An alternative, which is beginning to receive substantial attention, is the fluidised bed system, which offers better thermal efficiency and more effective burnout - leading to a more inert bottom ash. Some of these systems can generate power directly from gas turbines powered by the combustion gases. The fluidised bed consists of sand or limestone which is rendered into a fluid-like state by blowing air through it. This ensures very efficient combustion. The wastes are normally processed before introducing into fluidised bed plants.

The advantages of fluidised bed combustion are:

- Greater thermal efficiency (20% more net power output than mass burn)
- Less corrosion
- Lower maintenance costs
- Gas cleaning is easier, since many pollutants taken out at RDF stage
- Better combustion
- Carbon in ash up to 100 times lower than for mass burn.
- Ash may be used for lightweight building blocks.
- The front end of the plant is effectively an MRF and may readily be developed further to extract additional recyclables.
- Higher yields/quality of extracted metals because they are recovered before combustion

The key components of a modern MSW incineration plant are:

- A facility and equipment for handling incoming waste.

  For MSW, the waste is normally discharged into an enclosed reception area, which is designed to minimise the spread of litter and the dispersion of dust and odours - with extracted air typically being fed into the incinerator. Waste is usually fed to the charging equipment using a gantry-grabbing crane.

  Additional dedicated equipment would be required for sewage sludge and also for healthcare waste, if either of these materials were to be handled.

- Waste charging equipment.

  Waste is fed into the plant by means of ram, gravity or hopper feeds. Arrangements need to be made to prevent back flow of combustion products.

- The combustion furnace.

  A number of different moving grate systems are used for transporting the waste through the combustion chamber. Primary combustion air is pumped through the grate. Secondary air is then introduced into the combustion gases above the waste to ensure complete combustion. A minimum combustion temperature of 850ºC is normally required for MSW, whilst for healthcare waste 1000ºC or even 1100ºC is needed. The residence time for the combustion gas should be at least 2 seconds, with a minimum of 6% excess oxygen. Healthcare waste incinerators usually require a secondary combustion chamber to achieve the necessary temperature and residence time.

  Modern MSW incinerators incorporate an additional "burn-out zone", in which the materials falling from the grate after combustion are maintained at an elevated temperature for a further period to maximise burn-out

  The primary combustion chamber for most hazardous waste and some healthcare waste incinerators takes the form of a rotary kiln, similar in design to a cement kiln. These types of plant also require a secondary combustion chamber reaching temperatures of 1100ºC and 1000ºC respectively.

  If healthcare waste is to be burnt in an MSW incinerator, it normally requires a separate primary combustion furnace, secondary combustion chamber and loading mechanism.

- Ash handling equipment.

  Two types of ash are produced. The major quantity (around 90%) of solid residues consist of "bottom ash", which falls off the grate after combustion. This tends to be a relatively inert, dense material and, in many countries, is used for such applications as sub-base in road building. It may therefore be possible to sell the material, although it would be more conservative to assume its disposal at zero cost. If these uses are not acceptable in the Seychelles, it will require landfill. It may contain significant quantities of ferrous metal, if this has not been pre-sorted. This can be removed by magnetic extraction. Non-ferrous metals can also be removed using eddy current separators.

  The flue gas cleaning equipment will also produce fly ash. This material contains heavy metals and other contaminants and is usually regarded as a hazardous waste. It will require to be landfilled provided in a landfill suitably lined to prevent leaching (i.e. a secure landfill).

- A waste heat boiler

  Energy recovery is achieved by means of a waste heat boiler located in the hot combustion gases. Enclosed systems can be used whereby the water used for steam

raising is recycled. In this case, the water used can be as little as 0.25 litres per tonne of waste incinerated. The water will require neutralisation and de-ionisation.

- Flue gas cleaning equipment

  Flue gas cleaning is now a requirement for all MSW incinerators as well as for hazardous waste and healthcare waste incinerators. Particulate (dust) emission controls have been a feature of MSW incinerators for many years but current standards require additional scrubbing for acid gases, heavy metals and organic compounds.

  Two systems of scrubbing are in general use - wet scrubbing with water or, better, lime or caustic, and dry scrubbing using lime, with the possible additional of activated carbon to remove dioxins and heavy metals. The latter system is gaining in popularity. With either system, a bag filter is frequently incorporated to remove the particulates, particularly form the dry system.

- A chimney stack to emit the cleaned flue gas.

  The required chimney height will normally be determined by air dispersion modelling techniques and will depend on the volumes of waste handled and the combustion and gas cleaning technology employed. Wet scrubbing systems can give rise to a large visible steam plume. This should be avoided, by reheating the flue gases or by using a dry scrubbing system, since it frequently gives fire to objections from the public - whether or not it contains pollutants.

- Cooling towers.

  Cooling towers or condensers are normally required in conjunction with the energy recovery process. A sealed system will avoid the production of a steam plume and problems with the need for biocides and their potential release to atmosphere.

- Process and flue gas monitoring equipment.

  Continuous monitoring is required for temperature (throughout the process), oxygen, dust and HCl, and periodic monitoring for SO_2, HF, heavy metals and VOCs. In addition, the ash should be sampled at regular intervals, together with any liquid effluent.

An important feature of modern incineration plants is that they are designed for continuous operation, 24 hours a day and 7 days a week. Typical availability for a single line plant, such as would be appropriate for the Seychelles, is around 7,800 hours a year. Operating plants on a single shift leads to greater stresses on a number of components, notably the refractory lining.

Economics

Economies of scale are substantial in waste-to-energy facilities. The generally accepted minimum annual throughput for an economic plant is around 100,000 tonnes. At this level, the cost is estimated to be around €60/tonne, whilst at double the throughput, the cost falls by about €10/tonne.

Fluidised bed combustion plants have similar economics at throughputs of 200,000 tonnes per annum and above but they are not so good below this level and are therefore unlikely to be appropriate for the Seychelles.

Smaller, modular, waste-to-energy plants are now available for communities the size of the Seychelles. A plant with a capacity of 50,000 tonnes per annum with full gas cleaning using lime and activated carbon is estimated to cost around €50 million.

For a plant of this size, we would estimate that costs (including finance costs) would be about €75/tonne if the ash is landfilled and €70/tonne if it is reused.

Sewage sludge could also be incinerated in such a plant. In this case, unit costs would be reduced by about 5-10% on the greater throughput - but total costs, of course, would not change and would increase slightly by the cost of providing the necessary handling equipment.

Advantages and Disadvantages

The advantages of incineration are:

- A renewable source of energy.
- Five times greater useful energy per tonne of waste compared with landfill gas utilisation.
- Very high waste volume reduction - up to 90% by volume and 67% by weight of the original input crude waste.
- Converts organic wastes into biologically less active forms.
- Suitable for hazardous and healthcare wastes which should not be landfilled.
- Easily manageable, fairly compact plant with modest requirements in terms of site area.
- Very high plant availability and reliability is attainable.
- The potential exists to recover "low-grade" heat via CHP as well as to generate power.

The disadvantages of incineration are:

- Very high initial capital cost of building a plant.
- Sophisticated technology is employed requiring competent management and skilled technicians to operate and maintain effectively.
- May compete with recycling options.
- Possible objections to plant emissions, although modern process controls and gas-cleaning systems have reduced the levels of emissions dramatically over recent years;
- Possible objections associated with the stack.
- The ash residues need further treatment / handling and probably disposal to landfill.
- The fly-ash from gas cleaning is a potentially hazardous waste.

Pyrolysis

Characteristics

Pyrolysis is a term commonly given to a range of pyrolytic thermal treatment processes, which apply heat to waste (or other materials) in the absence of air to achieve a chemical transformation.

Pyrolysis, as applied to mixed wastes, is only just starting to be applied on a commercial scale. Its main potential advantages are that it offers greater thermal efficiency than straightforward incineration and also reduces the potential for harmful emissions. It must be stressed, however, that little experience has yet been obtained of running plants on a commercial scale and there have been some expensive failures in the relatively recent past. It cannot therefore yet be regarded as proven technology.

There are three basic types of pyrolytic thermal treatment processes which may be applied to waste, namely:

- Pyrolysis
- Gasification
- Liquefaction

The term pyrolysis describes the thermal degradation of waste in the complete absence of air, oxygen or any other oxidising agent, or with such a limited supply that the gasification (see below) process does not take place to an appreciable extent. It may be described as partial gasification. Relatively low temperatures are employed (400-900^{o}C, compared with 800-

1200°C in gasification). Three products are always produced: gas, liquid and char, the relative proportions of which depend upon the pyrolysis method and reaction parameters.

Fast or Flash Pyrolysis is used to maximise either gas or liquefied products according to the temperature employed. Moderate temperatures of 400-500°C and slow heating rates give charcoal as the main product; higher temperatures of 450-600°C and high heating rates give liquids as the main product and the highest temperatures of 700-900°C give gas as the main product.

The heat required for pyrolysis can be added indirectly in a variety of ways such as indirect heating through the reactor wall, direct contact with hot gas or hot liquid such as metal or molten salt, or directly by partial gasification with a limited addition of oxidising agent such as air to give a direct heat input from the waste itself.

Gasification is another major thermochemical conversion technology. In this process the primary products from pyrolysis react with oxygen in either air, steam and/or pure oxygen to convert all the solid and liquid products into gas through partial oxidation and thermal cracking reactions. Gas is the main product although a small amount of tar is also produced which can cause problems in some applications.

Liquefaction is the third main thermochemical conversion technology. This can be considered to be pyrolysis in a solvent at high pressure with reducing gases and a catalyst added to improve the liquid product quality. Little work is known to have been carried out on liquefaction of solid wastes and as this is already viewed as a long term option for biomass and wastes, it is unlikely to be a serious possibility for MSW. There are however some interesting possibilities with related technologies.

The oil produced from pyrolytic processes has quite unique characteristics in that:

- Although it is an oil which will burn, it cannot be mixed with other oils
- It is very sensitive to temperature and irreversible physical and chemical changes take place above 100°C or 60°C for sustained periods.
- It cannot be distilled.

The development of processes to change substantially the proportions of the gas, liquid and solid products has only occurred over the last fifteen years. This is achieved by adjusting the rate of heating, the final pyrolysis reaction temperature and vapour residence time. From wood, for example, total yields are maximised at around 75% w/w at a temperature of 910°C and vapour residence times up to 1 second. Other work has attempted to exploit the complex degradation mechanisms by carrying out pyrolysis in unusual environments such as vacuum and hydrogen.

The pyrolysis process cannot really yet be described as proven technology and is not appropriate for remote islands where back-up facilities are not available.

Economics

The figures and economics for pyrolysis of MSW are not well known but are likely to be less favourable than for incineration - probably >€100/tonne or more for a plant on a scale suitable for the Seychelles.

Advantages and Disadvantages

The advantages of pyrolysis are:

- A better thermal output per tonne input that straight mass burn incineration.
- Low temperature technology
- The cost of a suitable plant would be comparable with a mass-burn incinerator
- Air emissions are better than those for an incinerator.

The disadvantages of pyrolysis are:

- The technology for MSW is relatively unproven

- The cost of pre-sorting might tip the balance more in favour of mass-burn with its proven technology and ability to take a wider range of wastes.

7.5.2. Thermal processes – other wastes

Thermal processes are also frequently used for other waste types – hazardous wastes, healthcare wastes, animal carcases and food wastes. These materials are normally processed in various types of incinerators. Wastes with a high energy content, such as oils and tyres are also used as an energy source in power stations and cement kilns, usually after some form of pre-processing.

The waste streams arising in the Seychelles which may be appropriate for these processes are:

- Hazardous wastes
- Healthcare wastes
- Waste oils
- Food wastes from sea port and airport

Waste oils and healthcare wastes are normally classified as hazardous wastes but may be treated differently from more hazardous materials and have hence been considered separately.

Hazardous wastes

Incinerators for hazardous waste are considerably more specialised than those for MSW, burning at higher temperatures (1100°C) and having more extensive gas cleaning. Such a plant would not be appropriate for the Seychelles because of the very high cost and the low quantity of hazardous waste produced. Some hazardous wastes require to be incinerated in such specialised plants, especially materials containing halogens, but we believe that the quantities of these materials arising in the Seychelles are almost negligible and, if they do arise, can be accumulated into economic quantities and then exported. Healthcare wastes

Healthcare wastes

Incinerators for healthcare wastes also tend to be specialised - particularly in relation to the facilities for handling the incoming wastes. The incinerator performs two important functions: eliminating the risk of infection form healthcare wastes and destroying some of its more intractable components. Because PVC, which contains chlorine, is used for some materials which arise in healthcare waste, e.g. IV tubes and bags, while some drugs, particularly the cytotoxics, also contain halogens, healthcare waste in Europe is normally incinerated in plants with combustion conditions and gas cleaning similar to those for hazardous waste incinerators.

Nevertheless, the quantities of these types of materials arising in Seychelles healthcare waste is relatively small, such a plant may not be necessary, especially in the medium term.

The most important function for a healthcare waste incinerator, especially in these days of HIV infection, is to eliminate infection risk. This can be done in a very much simpler and less costly plant. Indeed the plant purchased by the hospital in 2000 would have been perfectly adequate for the purpose if it had not been damaged, possibly beyond repair, by unskilled operation.

Waste oils

Waste oils and non-halogenated solvents do not require such demanding conditions. Waste oils can be incinerated in relatively simple plant, such as the incinerator at the PUC power generation plant. This plant has some spare capacity, but PUC is unenthusiastic about accepting wastes from other generators, as they do not see this as their business and would not want the potential liabilities. It should be pointed out that this incinerator is not used for the production of energy and waste oils are not technically suitable for burning in the power generation plant itself because of the water and suspended solids content.

Food wastes

Food wastes, especially from ports and airports, are often incinerated to reduce the risk of infection or pest invasion. Plants for such wastes do not need sophisticated emission controls and are not very costly. The Seychelles has a problem at present with melon fly, which is believed to have arisen from contaminated food from planes or ships. Incineration of these wastes would thus be desirable.

7.5.3. Biological processes for mixed MSW

There are three options for biological processes for the treatment of mixed MSW, as discussed below. It should be noted that composting of segregated biodegradable waste is discussed separately.

Composting (an aerobic process, leading to the production of a compost material, mechanical-biological treatment (which is effectively a special case of aerobic composting) and anaerobic digestion (an anaerobic biological degradation process which produces a similar compost-type material plus energy from the methane gas generated) may, in theory, be used for they processing of mixed MSW. These processes, however, have not so far been adopted other than in a few demonstration projects, for the following reasons:

- High capital cost
- Requirement for pre-sorting to remove non-biodegradable materials
- Lack of markets for the compost product – due, inter alia, to contamination with heavy metals
- Questionable reliability of the technology

Aerobic Composting

Characteristics

Aerobic composting describes a controlled process of aerobic decomposition of suitable organic waste matter. Composting is a natural process, the basic conditions for which are very simple and straightforward. It is necessary to create and maintain the optimum conditions for decomposition in respect of the mix and particle size of raw materials, temperature, moisture content and aeration.

Aerobic Composting results in two principal products: a moist, ammonia-rich gas containing odorous sulphur compounds, which is generally allowed to escape to atmosphere with or without treatment, and a rich humus material ("compost") which may be used as an organic soil conditioner or plant growing medium. This compost is generally free from pathogenic bacteria due to the elevated temperatures achieved by the organic material as a consequence of its biological degradation. The suitability of the compost for a given use may be affected by the quality of the feedstock and the significance of contaminants, which may be derived from it. Whatever the standard of the product, compost is not a direct substitute for fertilizer as it lacks many of the nutrients required for plant growth. However, its use will enhance the productivity of the host soils by ensuring applied fertilizers are retained in the root zone for longer periods, thus reducing the overall fertilizer application rate.

The process can be conducted in varying degrees of sophistication ranging from open windrows turned by a simple loading shovel, through highly mechanised covered plant with forced draught and specialised turning equipment, to highly sophisticated process vessels and plant. The choice will depend upon the quantity, type and quality of the end product to be achieved and the process time required. It may also depend on the feedstock. Typically, a windrowing process, whilst not capital-intensive, can take about 6-8 weeks for conversion of the feedstock to product. Consequently, without accelerating techniques, a relatively large area of land is required to provide for storage of material in the process of decomposition.

Where there is a market for the end product then the high cost of separating contraries/non-compostable materials and the investment in plant may be worthwhile. Where there is no

market, then composting may be considered as a simple volume reduction route prior to landfilling - provided the costs are kept low.

A distinction can be made between composting systems which are designed to receive and process MSW or similar *mixed* wastes, and those which are designed to process "green" wastes (garden wastes) or "bio-wastes" (the source separated fraction of MSW, comprising vegetable, fruit and garden waste, sometimes with the addition of non-recyclable paper).

Systems that operate on mixed MSW usually involve pre-sorting of the waste using MRF techniques (q.v.). If MSW is used as the feedstock, significant concerns exist about the content of heavy metals in the growing medium product. The process, because it operates on a solid feedstock with a critical regime of aeration and water content, is less capable of offering separation of contaminants than anaerobic digestion and they may persist into the eventual product. A significant proportion of the contraries are suitable for recycling (mainly metals and plastics), although the glass fraction is more suitable for use as recycled aggregate, because of contamination with ceramics and other heavy non-metallic materials. There will also be a reject stream which must be landfilled. This typically amounts to about 15-20%.

It should be emphasised that, whilst aerobic composting reduces the organic loading and pollution potential of the waste stream, it is only an economically viable process for MSW if a use can be found for the compost. If the product has to be landfilled, the additional costs of composting must be less than the cost of the incremental void space consumed by waste which is not composted. Once in a landfill, however, provided that it is designed with suitable controls for leachate and landfill gas, a similar reduction in volume will take place by either aerobic or anaerobic decomposition (albeit over a longer period). This can be achieved with no extra (composting) effort so that there is no economic justification for composting in such a case.

In its simple (windrowing) form, following the removal of metals, plastics and other non-compostable materials from the feedstock as necessary, the waste will require handling into prismatic rows on a drained hard surface, aeration by turning and/or forced ventilation, frequent moisture content adjustment and handling into storage or despatch to the end user. The control of moisture is critical and in wet climates can oblige that the area is put under cover so that rainfall does not interfere with an otherwise regulated process. The emissions of ammonia similarly can require some form of enclosure or collection ducting to collect and scrub the exhaust gas stream - which may be done with water and/or a “biofilter” made from compost mixed with woodchips.

A more recent development is in-vessel composting, in which the waste is placed in enclosed chambers that enable better control of the aeration process.

Composting technology is well developed in Europe and North America, and can be applied to a wide range of waste feedstocks. In common with anaerobic digestion (AD), sewage sludge may be included in the feedstock stream, provided particular attention is given to the turning and aeration regime to avoid an immobile core which can become anaerobic and odorous. The addition of such sludge can add much needed moisture to the process and would assist in the disposal of another difficult waste stream. However, there is potential for sludges to add contaminants to the compost particularly where they are derived from waste waters with a heavy industrial loading. Currently this is not yet the case in Seychelles and there may be merit in considering this route for the disposal of sewage sludge from the Victoria treatment works. Its inclusion in the composting process would necessitate increased control of the process. Additionally, there may be some reluctance (particularly from growers) to use such a product for producing foodstuffs.

Economics

Simple green waste windrow composting may be undertaken for about €25/tonne, with relatively low capital expenditure.

An in-vessel composting plant for 12,000 tonnes per annum of green wastes is likely to cost about €2.5 million (including the cost of mobile plant). Total operating costs, including depreciation are estimated to be about €30-40/tonne before product sales. This method could be used for green wastes together with separately collected bio-waste, provided that its quality is carefully controlled to minimise the content of contraries.

Mixed MSW composting is likely to cost around €60-75/tonne at the scale appropriate for the Seychelles and there are doubts about its practicability, as mentioned above.

Advantages and Disadvantages

The advantages of aerobic composting are:

- Provided that a market can be found for the compost product, composting reduces substantially the amount of waste requiring landfilling.
- The reject material that does require landfilling has a substantially lower biodegradable content.
- Sorting, leading to recycling, is a prerequisite for a compost plant for mixed waste, which assists in the achievement of recycling targets.
- There is already a plant in operation at Providence producing a reasonable quality product.

The disadvantages are:

- Composting, whether of mixed waste or biowaste, is a relatively expensive process.
- The quality of the compost product from mixed waste composting is often poor and markets are difficult to find with any long term security.
- The process requires careful attention to turning and aeration regimes, which become more critical as food wastes and sewage sludge are added to the feedstock.
- The land take for a plant is comparatively great, compared with other processes.
- Mixed waste composting often leads to odour problems and thus limits the locations where such a plant may be established.

We do not believe that composting of mixed MSW should be considered for the Seychelles, because the quality of the compost would be so poor that a market for its use is unlikely to be found. Additionally, the efforts required purely for volume reduction would not be justified.

Mechanical-biological treatment (MBT)

This type of system is currently attracting considerable attention in EU member states in order to meet the specialised requirements of EU legislation in reducing the quantity of biodegradable waste which is landfilled. It is effectively a form of aerobic composting for mixed waste and consists, at its most basic, of a mechanical process to separate recyclables (thus reducing the need for separate collection systems) plus a composting process to treat the biodegradable materials. It generally produces low-quality compost, but there is little demand for this and it therefore usually has to be landfilled. The biodegradation process helps to reduce the quantity of biodegradable waste which requires to be landfilled, but not to any major extent and the residues are certainly not inert.

There are two added sophistications to the process. First it may be undertaken in the so-called "closed-cycle" manner, whereby the biological processing is performed "in-vessel" leading to improved odour control and, if anaerobic digestion is used, energy can be recovered form the methane produced. This system, which is of course more expensive, may further reduce the amount of biodegradable material requiring landfill – but again not by a great extent. Secondly, the biodegradable fraction can be processed to form a fuel from which energy can be recovered. In this case the reduction of biodegradable waste requiring landfill is significant, but the fuel needs to be burnt in a plant with similar emission controls to those for a conventional mass-burn incinerator – and thus it results in being a rather expensive pre-treatment process for an energy from waste plant.

It is very doubtful that such a process has any potential role in the Seychelles.

Anaerobic Digestion

Characteristics

The term anaerobic digestion (AD) - digestion in the absence of air or oxygen - is customarily used to describe the artificially accelerated decomposition of biodegradable matter in enclosed spaces or vessels. AD has been used for many years as a method of handling and processing certain types of organic wastes, for example sewage sludge and animal slurry. As a treatment for the organic fractions of Municipal Solid Wastes (MSW), however, it is relatively new and there are few plants in operation. Anaerobic digestion results in two principal products: a methane-rich biogas, and a rich humus material ("digestate"), which may be used as an organic soil conditioner or plant growing medium.

If MSW is used as the substrate, significant concerns exist about the content of heavy metals in the growing medium product. This can also be alleviated by separating vegetable, fruit and garden waste ("VFG waste" or "bio-waste") at source and applying the process to this waste stream only. Paper is also a suitable substrate, now that heavy metals from inks have been reduced and do not create such a problem. It can actually contribute to a higher grade of growing medium because of the fibres that it contains. Consequently, an alternative is to apply the process to mixed MSW by separating the non-biodegradable "contraries" (glass, plastic, metal etc.) mechanically at the front end of the process and then to digest the remainder of the material, including the paper. The AD process, because it operates on a liquid or semi-liquid substrate (water is added to the process), offers better separation of contaminants than aerobic composting. A number of claims have been made that the heavy metals problem experienced with aerobic composting of mixed MSW can be resolved in this way.

A significant proportion of the contraries are suitable for recycling (mainly metals and plastics), although the glass fraction is more suitable for use as recycled aggregate, because of contamination with ceramics and other heavy non-metallic materials. There will also be a reject stream which must be landfilled. This typically amounts to about 15-20%.

It should be emphasised that, whilst AD reduces the organic loading and pollution potential of the waste stream, it is only an economically viable process for MSW if a use can be found for the digestate. If the digestate has to be landfilled, the high capital costs of AD cannot be economically justified, even though the digestate does not produce so much leachate or landfill gas as raw MSW.

The constituents of the material fed into the AD process have a significant effect on gas production and the quality of the organic product at the end of the process. Some systems are designed to optimise gas yield for energy production, while others aim to optimise production of soil conditioner/growing medium, with energy as a less important by-product. Different systems can handle varying percentages of solid to liquid. While typical solid-to-liquid ratios are 10-25%, certain technologies can cope with solids as high as 30%.

Unit costs depend on the market for the products - gas and a growing medium. Gas can be used as an energy source and this normally has a readily available market - for heat or power generation. It can also be used to sterilise the growing medium product, although with a temperature of 70ºC in the process, this may not be necessary. The market for the growing medium product is less easy to confirm. It will depend on the product quality, in terms of consistency of specification and heavy metal content. Extensive tests have been undertaken on the growing properties of the product from a pilot plant in the UK over an extended period of time with positive results.

Economics

Whilst AD is, like most other waste management technologies, subject to economies of scale, a typical plant throughput is about 30-50,000 tonnes per annum, which could be appropriate for the Seychelles. Capital costs for such a plant lie in the range of €8-10 million.

Provided that reasonable markets for the products exist, costs are likely to range from €40 to €50 per tonne.

Advantages and Disadvantages

The advantages of AD are:

- The generation and recovery of bio-gas from MSW is substantially more efficient compared with gas recovery from a landfill site, thus contributing to reduction of the greenhouse effect (methane in landfill gas is six times more powerful a greenhouse gas than carbon dioxide - the product of combustion of the gas). In an AD plant, degradation is accelerated and all of the bio-gas generated can be collected - as opposed to less than half in a landfill.
- Since the gas can be collected, it can be used as fuel - providing energy recovery, unlike aerobic composting.
- Treatment of MSW in an AD plant reduces substantially the volume of waste requiring landfilling (by around 80-85%), and also makes landfill sites easier to manage by removing potentially problematic organic wastes.
- Sorting, leading to recycling, is a prerequisite for an AD plant for MSW. This may assist in the achievement of recycling targets.
- The digestate can, after screening and curing, be used as a high-grade organic soil conditioner/plant growing medium comparable in quality and appearance to natural peat.
- An AD plant is completely enclosed and does not produce a significant odour problem - unlike aerobic composting.
- An AD plant does not require such a large amount of land as an aerobic composting plant.

The disadvantages of AD are:

- The technology is still under development and has yet to be fully proven and reliable. However, a great deal of research and development is under way at present and several full-scale AD plants for treating MSW are already in operation or under construction worldwide.
- AD plants involve fairly sophisticated equipment and process controls, with a corresponding requirement for skilled operation and maintenance.
- AD plants are expensive to build and operate, although little different from an enclosed aerobic composting plant with odour removal.
- AD plants are relatively sensitive to significant variations in the quality of the feedstock.

We do not believe that AD for mixed MSW has any future in the Seychelles, because, as for composting, the quality of the product is likely to be poor and the technology is even more complex and less proven.

7.5.4. Biowaste (green waste) composting

Characteristics

The processes for composting have been described in detail in Section 7.5.3. Segregated biowaste can, and does in the Seychelles, produce a good quality compost product. Finding markets for this material can be a problem, especially if it is expected that customers pay a significant price for the material. At the present time, SWAC requires that compost be sold at R2,000/ tonne. Only a very small amount of material has been successfully sold at this price. If food waste from households were to be segregated, then the potential quantities of waste for composting would be significantly greater. Whilst it may be possible to make use of this

material on agricultural land, it is very doubtful that these greater quantities can be sold at the above price. Indeed, we suspect that a very much lower, or possibly even zero price will need to be selected in order to ensure that all the material is taken up.

Provided that a use for the material can be found – so that it does not then need to be landfilled, there is a benefit in producing compost from green waste, because it reduces the overall quantity of waste that needs to be landfilled. Consequently, the composting of separately collected biowaste should be investigated.

There are basically two options for processes of composting of green waste:

- Open windrows – where the waste is placed in piles, which are turned frequently to ensure adequate aeration.
- In-vessel systems, where the waste is composted in a concrete tunnel or fed by an auger through a metal tube with adequate aeration. This process is more expensive than windrows but avoids the production of odours and is thus considered more acceptable in densely populated areas.

In-vessel composting is not currently used in the Seychelles but it may have a future, when affordable, as increased odours from expanded composting at Providence could become a problem with the neighbouring housing.

Economics

Windrow composting should be able to be undertaken for about €50-60/tonne. This is rather more expensive than typical rates in the EU, but reflects the higher cost of providing concreted and covered areas for the composting area.

Advantages

- Reduces the demand for landfill.
- Reduces the organic content of the landfill leachate.
- Produces a valuable soil conditioning product

Disadvantages

- More expensive process than landfilling
- Land take is relatively high

7.6. Final disposal

It should be noted that whatever system of waste management is adopted, there will always be a need for final disposal; inevitably landfill. There is a need to have void capacity for wastes that cannot be recycled, recovered or treated or which is the residual of a treatment process (such as fly-ash from incineration). Additionally there are likely to be occasions when other disposal routes, such as recycling, recovery and treatment, are inoperative for a sustained period of time – and during which waste still needs to be disposed of.

Modern landfills are designed with due consideration to both environmental and nuisance issues. Proper investigations, studies and risk assessments can be used to formulate the design requirements to ensure harmful emissions are minimised and the site has negligible impact on the surrounding land users. Essentially such facilities incorporate barriers to prevent the uncontrolled release of leachates and gases and installed systems to collect and treat such potential emissions. Additionally, the development of and adherence to sound operational practices can minimise the effect the landfill may have on nearby activities.

The development of a landfill requires infrastructure; reception cabins, weighbridges, treatment facilities etc and the creation of sufficient engineered void capacity to enable waste disposal. It is not usually necessary or indeed desirable to construct the entire waste void at once; rather the development of the disposal area should be undertaken in a phased manner whereby sufficient engineered void capacity is created for a few years waste filling. Subsequent void capacity is then created ahead of waste filing every few years.

7.6.1. Mahé

There will be a need for a landfill on Mahé; its capacity and life expectancy being dependant on whatever other waste management options are selected.

Providence II

Part of the area of reclaimed land immediately to the south of the existing Providence dumping site has been identified as a possible location for a new landfill. In total around 18 hectares has been reclaimed and 5 hectares of this has been 'set aside' for potential waste disposal. The reclaimed area comprises a rock bund wall infilled with dredged coral sand to a height of around 1.5m above sea level.

The extension site has been partially prepared in that a coral sand bund some 6 – 7 metres high has been constructed around three sides of the area identified for waste filling; the remaining side adjoins the edge of the current waste filling activity. The new area has been decided in agreement with the Airport Authority, which has concerns about the potential hazards associated with possible aircraft bird strike.

The use of such a site for the continuance of waste disposal in this locality appears to be sound from a logistical and financial perspective in that it would fully utilise the existing infrastructure that has developed in this area. Furthermore, the area has an established history of waste disposal and is located in and acknowledged industrial zone. Additionally, the construction of the environmental management systems that would be required in a modern landfill could readily be linked to the retro-fitted systems that will need to be developed on Providence I to mitigate the harmful impacts of uncontrolled leachate and gas escape from there.

Conversely, with regard to potential environmental impact the site, being immediately surrounded on two sides by open water will require careful engineering in terms of containment and environmental control systems. Such systems would be designed after consideration of the results of detailed environmental risk assessments, predominantly related to potential sea water pollution. Additionally, the feasibility of utilising the site would also be dependent upon the results of a comprehensive bird-strike risk assessment.

Advantages

- Land currently available (few other sites are likely to be suitable);
- Little lead time available to develop an alternative site (the new site will be required in about 2 years);
- Existing infrastructure is place;
- Environmental control systems can be linked to those that will be required for the rehabilitation of the existing site.

Disadvantages

- Immediately adjacent to the sea;
- Near the airport

Anse Royale

The current use of Anse Royale (essentially for inert waste disposal) is not considered to be an effective utilisation of this resource. The volumes of material disposed of are small (and would have minimal impact if disposed of at Providence where some of them could even be used for engineering purposes), the transportation costs (from Providence) are high and the management costs are also high. Additionally, at the current rate of filling it will take many years for the void to be filled.

Other options for the utilisation of Anse Royale include:

- Continue to maintain the facility and in the future use it for the disposal of ash from the incinerator(s) (This will require continual ongoing maintenance);
- Utilise for hazardous waste disposal only (requires higher operational management and would only be filled very slowly);
- Utilise for the disposal of waste arisings from the southern part of Mahé only (estimated to be some 20% of the total waste on Mahé). The site would require similar management and control levels as at Providence (thus increasing costs) but would reduce vehicular movements and extend the life span of the landfill at Providence. However, if used for general waste disposal there would be a requirement for long term environmental management;
- Utilise as a waste transfer station.

Other sites

The potential options of reopening previously abandoned dumpsites has been considered but is not thought to present a viable alternative to the development of Providence II.

7.6.2. Praslin

It is apparent that the current waste disposal activities at Praslin are environmentally unsound and whilst improved operational management may be considered to reduce the impacts and nuisance situation in the short term this cannot be considered to be an acceptable solution for the medium and longer term. In the short term reducing the area open for waste disposal to the minimum necessary for such activity, compacting the emplaced waste and covering the waste at the end of each day will alleviate many of the nuisance issues associated with current activities. The development of and adherence to a site-filling plan would also enable site activities to be more appropriately controlled.

The options for final waste disposal on Praslin are limited to landfill or transportation off the island (probably for disposal on Mahé). The adoption of an incinerator would still require the development of a landfill for the residue and non-combustible materials.

Off-island waste removal would necessitate the development of specialised transportation facilities and equipment (possibly including a dedicated boat). The practicalities of adopting such a mechanism could present difficulties and may place over-reliance on a single system that would be dependant on the weather at certain periods.

Hence, the development of an engineered landfill would provide a number of years waste disposal.

7.6.3. La Digue

Waste quantities on La Digue are small. This is probably a function of the low collection rates and may improve in the future.

Although the existing waste disposal facility has an estimated two-year's life remaining it is considered that an extension of this may be achievable, with minimal extra engineering, to give an additional few years use. It may be possible to extend the footprint of the site in the vicinity of the existing site entrance by clearing and levelling (recontouring) an area of some 25m x 12m and preparing this with a clay and plastic liner similar to and tied in with the existing barrier system. Without a detailed survey it is difficult to estimate the additional void capacity that may be created by such works but it could provide an additional 2 to 3 year's lifespan. The cost of such works could be some €150-180,000. If this option is to be considered further it is important that waste in not placed over the upper edge of the existing lining system in the meantime.

Alternatively, consideration should be given to shipping all waste off the island (probably to Praslin) or thermal treatment in a specialist incinerator. However, a landfill for residues would still be required.

7.7. Summary of handling and process options for detailed evaluation

Having eliminated those options that are considered not to be appropriate for the Seychelles, we have identified the following options for further detailed evaluation in the following section.

Waste avoidance & reduction

- Controlling material imports
- Import tariffs / charges
- Charging householders by quantity of waste
- Limiting access to large containers
- Home composting
- Repair centres

Waste segregation, storage and collection

- Survival bags
- Separate collection rounds
- Amenity ('bring') sites
- Central collection point for hazardous household wastes
- Reduce collection frequency
- Collection vehicle types

Waste recovery & recycling

- Return schemes
- Materials Recycling Facility
- Aggregate crushing

Waste treatment / processing

- Mass-burn incineration with energy recovery
- Incineration of other wastes (hospital etc)
- Windrow composting of separately collected biowaste
- In-vessel composting of separately collected biowaste

Final disposal (landfill)

Mahé

- Providence II
- New site
- Anse Royale
    - Disposal of waste from southern Mahé
    - Disposal of incinerator ash (in future)
    - Transfer station / amenity 'bring' site

Praslin

- New landfill site
- Incinerator (with small landfill for residues)

La Digue

- Incinerator (with small landfill for residues)
- Transfer off-island

8. EVALUATION OF OPTIONS FOR WASTE HANDLING, PROCESSING AND DISPOSAL

8.1. Key issues and constraints

The main issues and constraints that will have an impact on the selection of a waste management strategy are those relating to:

- Legislation
- Policy
- Environmental quality objectives
- Land use and availability
- Operational practicability and flexibility
- Economic factors
- Public perception
- Planning horizon

Each of these is discussed below.

Legislation and policy

Seychelles legislation is broadly adequate for the control and regulation of waste management, although, as mentioned above, technical standards need to be established.

The driving policy for this master plan is set out in the Environmental Management Plan for the Seychelles (EMPS). It requires that waste management shall be sustainable. This has been interpreted during the consultation process to mean that, by the end of the plan period – 2010 – a system shall be in place to ensure that environmentally acceptable waste management facilities can be provided for a period of 30 years.

Land use and availability

Land suitable for the construction of waste management facilities is in extremely short supply in the Seychelles, since most land is too mountainous to be considered for construction.

Operational reliability and flexibility

The Seychelles, being a group of islands at a substantial distance from other countries, is not in a position to receive emergency assistance in the event of a breakdown of its waste management facilities. Operational reliability is therefore a prerequisite of any waste management system that is selected. For this reason, only truly proven technology can be contemplated.

Economic factors

Cost, both in terms of unit cost (per tonne of waste treated/disposed) and also in terms of the size of any capital investment to be financed, will clearly be an important consideration. At the present time, the Seychelles Government is making significant expenditure cutbacks in order to balance its budget, and additional expenditure in the short term is almost certainly not practicable.

Economies of scale are also important. Some processes that might be suitable in Western Countries may not be able to be considered for the Seychelles due to the prohibitive costs of operating on a small scale. Hazardous waste treatment processes are a typical example.

Recognition must also be given to the difference between markets for recovered materials in the Seychelles and Western countries. It is economic and environmentally responsible to undertake certain recycling processes in these countries which do not make economic sense in the Seychelles, either because of scale or because the cost – in financial and environmental terms – of transporting these materials to remote markets is not justifiable.

Public perceptions

The waste management systems for the future which are selected for the Seychelles will be provided for the benefit of its citizens. Consequently, the views and wishes of the population need to be taken into account. Consultation will be an important issue.

Planning horizon

The required planning horizon for this master plan is to 2010, which is the plan period for the EMPS. The issue of sustainability, however, expends beyond this period, as has been explained in Section 5.3. The master plan should look, at least in outline terms, beyond this horizon for a period of 30 years.

8.2. Evaluation criteria

As part of the development of the Waste Management Strategy it has been necessary to develop a set of **evaluation criteria** based on the above constraints, which have been used to carry out an assessment of the specific waste management options identified. These criteria have been derived from the problems and priorities identified in the **Problem Definition and Strategy Development Workshop** held on 23 October 2003 in Victoria.

The criteria have been be used to screen and rank the various options identified, and prepare a short-list of options for incorporation into the suggested strategy.

Consistency with policy

- Will the option achieve the goal of sustainable waste management by 2010 as stated in the Environmental Management Plan for Seychelles?
- Does the option represent an advance in terms of the existing Master Plan (prepared by ITW) – which is recognised as in need of updating?
- Does the option accord with the SWAC strategy of developing more advanced waste management procedures?

Technical suitability

- Is the option technically suitable for the specific conditions (e.g. climate, topography) found in Seychelles?
- Does the option avoid dependency on high technology solutions which could generate issues in terms of technical capacity and support?

Land use

- Does the option minimise the development of flat land which is in short supply on the Seychelles?
- Does the option avoid the need to develop waste management facilities, in or close to, residential areas?
- Does the option avoid the need to develop land which is constrained from a land use planning point of view (development and environment)?
- Does the option accord with the Proximity Principle i.e. that waste should be treated close to its point of generation?

Operational reliability and security

- Does the option minimise the likelihood of emergency waste management assistance being required - would be difficult to provide given the isolated location of the Seychelles?
- Does the option offer operational reliability based on truly proven technologies?

Environmental performance and risk criteria

- Would the option ensure that there are minimal uncontrolled releases to air or water e.g. fully lined and controlled facilities?
- Would the option ensure that there are minimal negative impacts on health and welfare of population and compliance with local standards for releases (to be adopted)?
- Would the option avoid any significant detriment to Seychelles wildlife and comply with local planning and operational management controls (to be adopted)?
- Would the option adhere to sustainable land use principles i.e. use of previously developed sites rather than virgin land?
- Does the option include closure planning (i.e. definition of long term post operational phase activities) prior to facilities development and operation?

Public acceptability

- Is the option likely to prove acceptable to the public, based on their perception of what is right for the Seychelles community?
- Is the option likely to prove acceptable to the public, based on its environmental (and possibly) economic judgements?
- Is the option likely to be well received if made the subject of a well managed communications campaign?

Cost and cost-effectiveness

- Is the option likely being both acceptable in terms of cost and cost effectiveness – including both construction and operational costs?
- Does the option minimise the risk of longer term liabilities (particularly in connection with environmental controls in the post operational phase)?

Long term sustainability

- Does the option offer the benefit of long-term sustainability in terms of social, environmental, financial and other relevant considerations?

Some criteria are more important than others. Accordingly, the relative weighting to be applied during the assessment will be as shown in Table 10.

Table 10: Proposed Weighting of Criteria

Generic Criteria	Relative Weighting	Sub-Criteria	Sub-criteria maximum scores
Environmental Sustainability	50	Consistency with policy	5
		Sustainability	20
		Environmental performance and risk	15
		Land-use	10
Practicality	25	Technical suitability and reliability	15
		Land-use	5
		Public acceptability	5
Cost and cost effectiveness	25	Cost and cost effectiveness	25

If the answers to the questions posed in the evaluation criteria above are strongly in the affirmative the option in question has been be given the maximum score. Conversely, if the answers are strongly negative the score is zero.

8.3. Evaluation and comparison of options

8.3.1. Waste avoidance and minimisation

Home composting

The waste minimisation option with the most potential is to encourage home composting. The large quantities of biowaste in the household waste stream could result in reductions in waste requiring collection in the order of 20%. Incentives such as subsidised composting containers, reduction in waste collection costs and education into the use and advantages of composting for the householder may be required.

Charge for waste collection and disposal by volume

Due to the collection systems currently employed for household waste the option for charging according to waste generated is not viable. The current system for charging commercial and industrial waste producers for the collection capacity required should continue.

Controlling the import and use of materials

With the Seychelles being a series of island communities with limited resources it is necessary for many goods to be imported. This generates an environment with far more potential than most countries to control the imports of materials that are difficult to reuse, recycle or dispose of. The use of legislation, import tariffs and charges and environmental levies and taxes should be considered.

Repair and resale centres

New and existing repair and resale centres could be encouraged.

8.3.2. Waste segregation, storage, collection & transport

This section contains some projections of changes in collection costs. We have estimated the current level of collection cost on the basis as if it were operated using modern compactor vehicles – as was proposed and intended by STAR. We estimate the full cost of providing one such vehicle, including its crew to be about €70,000 per annum and STAR estimates that 5 vehicle routes would be required to cover Mahé with a spare vehicle as backup for maintenance and repairs. We concur with this opinion. We have studied the collection operation and have made some timings of the activities of the crew. From this we have deduced that approximately 50% of the crew's time (for a compactor vehicle) is spent loading and 50% travelling over the route. All our projections are based on these assumptions.

Separate collection of recyclables and biowaste

If recyclables or biowaste is to be collected separately, there are three practical options: a bring system, survival bags or using separate collection rounds.

Bring system

The existing bring system trials could be extended to cover wider areas. This might involve the need to find additional container sites, which is likely to present problems of acceptability to residents. Some of the existing container sites could, however, be adapted to have bins for different materials. This is discussed below.

Survival bags

Survival bags could be used with no change to the collection rounds and thus no increase in collection cost. It would be necessary, however, to provide them free of charge if householders are to be persuaded to use them. They are expensive. In Europe they cost about €0.065 each and will be more expensive to import into the Seychelles – perhaps €0.08 without import duty. For biowaste, which is the most likely material for separate collection, it will probably be necessary to provide each household with at least 3 per week. The cost of this on Mahé would be about €187,500 per annum which, in itself is probably prohibitive.

In addition, however, the bags must be sorted at the delivery point – either on the landfill, which would probably not be acceptable from a health and safety viewpoint, or else by depositing all the waste at Providence and then reloading the residual waste for disposal at the landfill. This would incur substantial additional cost.

If they were used for recyclables, only one per week would be needed, but the need for sorting at the delivery point would remain.

Separate collection rounds

If the biowaste or recyclables were placed in separately identified containers located at the existing container stands, different collection rounds could be used to collection the different materials. For biowaste, if daily collection were continued, we estimate that collection costs would increase by 50% - based on timings undertaken for rear-loading vehicles. If rear-loading vehicles of reasonable quality were used, we estimate that the increase in cost would be about €175,000. Since no additional sorting would be required, this will clearly be the cheaper of the two alternatives.

Central collection point for hazardous household wastes

We do not see the separate of hazardous household wastes as a major priority, but some materials, such as fluorescent tubes, batteries, waste oils and pesticides etc. would be better not landfilled. It is proposed that a reception site for such materials is provided at Providence on a trial basis, to ascertain the public response. The additional cost of this measure is unlikely to be great, requiring simply the provision of four containers (preferably 1100 litres) at a one-off cost of about €1,500. The wastes collected can then be stored in drums until a sufficient quantity is accumulated for economic transport to an overseas location for treatment.

The problem with collecting these hazardous wastes is that treatment costs, especially for small quantities, can be very high – as much as €500-1,000/tonne. The quantities collected, however, are likely to be small – probably no more than 10-20 tonnes a year and probably considerably less.

Reduce collection frequency

Reducing the collection frequency will require the provision of additional containers. Generally speaking, if the frequency is halved, i.e. collecting every other day, roughly twice as many containers would be required. This will present significant problems in making space for the containers and may not be practical. One way to overcome this might be to provide some containers to individual houses, perhaps on a voluntary basis. The capital cost of providing the 1,800 additional containers needed for Mahé would be about €90,000 (in foreign exchange) which would imply an annual depreciation cost of €18,000 per annum. Collection costs would be reduced, however, by about 20%, or about €88,000, resulting in a net saving of about €70,000 per annum.

This option may not be easy (or even desirable) to implement but does have the potential to reduce collection costs.

Collection vehicle types

At the present time, a number of sub-contractors are using high-sided tipper vehicles. No doubt this is being done because foreign exchange is in short supply. Nevertheless, these vehicles have a low productivity and are almost certainly more expensive to operate than normal rear-loading compactor vehicles. They are also unacceptable from a health and safety point of view. As soon as practicable, proper compactor vehicles should be provided, which will result in a more cost-effective operation. It could be argued that this is merely a decision to be taken by STAR, the contractor, but since it has been recommended that the contract be renegotiated, clearly the most cost-effective method will be advantageous to both parties.

STAR estimate that 5 compactor vehicle routes are needed, as opposed to the present 3 compactors and 6 tippers. Of these 5, it is likely that 2 or 3 should be of 7 tonnes capacity and the others of the smaller 5 tonne type, for ease of access on the narrower roads. A spare vehicle will be required as backup.

8.3.3. Waste reuse, recovery and recycling

In the Seychelles the markets for recyclate are limited by the facilities available on the islands and the relatively small economies of scale that apply to the export of recyclate. Not all of the common recyclates will be viable to segregate and recycle in the Seychelles. Those materials with a market for the recyclate are described below.

Deposit-return schemes

Deposit-return schemes such as the glass bottle return currently carried out by Seybrew are very effective at reducing waste and achieve very good levels of returns. The current scheme is also viable financially and technically and should be encouraged. The plastic bottle return scheme is not currently financially self-sufficient, however, the expansion of the scheme is likely to improve the economies of scale and is therefore recommended. Opportunities for other such schemes are also worthy of investigation.

Other recycling

At present, bulky scrap metal is segregated and exported for recycling in Mauritius by Samlo. This process is currently financially viable and could be encouraged to expand, with the potential to include household sourced metal wastes such as food and drink cans. Samlo and other entrepreneurs should also be encouraged to identify markets for recyclates. This could be done through financial or other incentives.

The composting of green waste has been successfully achieved in the Seychelles, although the price is currently too high to stimulate the market for the product. However, the substantial quantities of biodegradable waste that exist in the municipal waste indicate that there is considerable further potential for composting in the Seychelles. Composting options are considered further in Section 8.3.2 and 8.3.4.

In addition, or as an alternative, to separate collection of biowaste, amenity sites could be established for the collection of this material.

Materials Recovery Facility

Due to the limited number of waste streams that will require segregation from the bulky waste it is not anticipated that any complex MRF will be required. A simple picking belt may be necessary to remove contaminants from source-segregated materials and should be considered. The existing plant provided by STAR was originally intended for the separation of recyclables. It does not, however, have a picking belt and is more suitable for the grading of compost.

Specialised waste streams

The treatment of special wastes has been addressed in Section 8.3.2 and 8.3.4 with the suggestion that a centralised collection and storage point is established and the waste exported to suitable facilities in bulk.

Aggregate crushing

At the present time, STAR does some crushing of construction and demolition waste in a rather basic manner. When accurate data becomes available on the quantities of these wastes, we recommend that the installation of a proper crushing plant (similar to that used in quarries) be considered. The product from such crushing could be used as base course for road construction or for land reclamation. Normally, second-hand plant is used for this purpose and the availability and cost of such equipment should be investigated, when the required capacity is identified. Additional inert waste from households could be collected at amenity sites.

8.3.4. Waste treatment and processing

Mass-burn incineration with energy recovery for MSW

In Section 8.3.5, we have identified that the maximum potential life for identifiable landfill capacity on Mahé is currently some 12 years. Thus by 2010 there will be no more than about 5 years capacity remaining. Beyond this, it is not clear where landfill space can be found. Even if new sites on reclaimed land similar to Providence 2 are found, it is not clear that such space cab be made available indefinitely and we do not consider that there is likely to be sufficient capacity for thirty years beyond 2010. We therefore believe that it is not too early to contemplate mass burn incineration as a measure to increase the life of the remaining landfill space.

Organising the finance and obtaining the necessary consents for an incineration plant will take many years and planning should commence before too long. It is suggested that a plant should be envisaged to be operational around 2010.

Further work will be necessary to determine the plant capacity, but present indications are that it should be around 30,000 to 40,000 tonnes. This is less than the total waste generation on Mahé, but there will be some wastes which are not appropriate for incineration, such as biowaste and construction / demolition wastes.

The capital cost of such a plant will depend on ground conditions at the selected site and also on any elaborate architectural treatment which may be required in order to obtain the necessary planning permission. We estimate that the cost will lie in the range of €40-75 million.

Site selection will also require further investigation, but we recommend the use of reclaimed land to the north of Victoria, as it will be important that the incinerator stack is not too close to the airport.

If an incineration plant is to be constructed, a secure landfill will be required for the fly ash, which is a hazardous waste and is likely tot arise at the rate of about 1,000 – 1,200 tonnes per annum. Anse Royale is ideally suitable for the purpose and, in our opinion, should be conserved for this purpose. The bottom ash, amounting to some 9-12,000 tonnes per annum, can be used as fill material in road construction or land reclamation.

Incineration of other wastes

There is a more important need for incineration facilities for other wastes. Waste oils are currently being exported for incineration at a power station in Reunion. Whilst this is environmentally acceptable, it seems to be a waste of energy-containing resources which could be used as fuel for the incineration of other materials. The installation of a simple

oil/water separation plant would enable waste oil arising in the Seychelles to be used for this purpose.

The provision of capacity for the incineration of healthcare wastes is a major priority. The existing plant at the hospital is probably beyond repair. It was originally the intention of STAR that it would provide a healthcare waste incinerator (albeit without the emission controls required in the EU) at Providence. Certainly a plant is required either at the hospital or at Providence. We favour the latter, because if STAR undertakes the operation, they can be required to ensure that the plant is correctly operated as part of their contract conditions.

Ideally, the plant should conform to EU standards and have appropriate gas cleaning facilities. The cost of such a plant, however, is likely to be around €1 million, which we do not believe is affordable.

There is also a need for an incinerator for food waste from the port and airport. It is understood that funding for incinerators at both locations has already been allocated as part of a project to eradicate melon fruit fly. We can see little logic in having two or three separate plants, which would result in poor economies of scale, resulting in appreciably higher capital and operating costs. Indeed, the same plant as is used for healthcare wastes could be used for these wastes.

We have discussed the situation with the consultants advising the Ministry of Agriculture on the melon fruit fly project and they confirm that they would also favour a centralised plant, for similar reasons to our own. The food wastes can be transported from the port and airport in containers with close fitting lids.

We therefore recommend that a single incinerator site is established at Providence to handle healthcare wastes together with food wastes from the port and airport. The total plant capacity would be required to be approximately 1.5 tonnes/day, with some 500 kg/day originating from the food waste from the port and airport. Most manufacturers recommend single shift operation for plants of this kind.

If an oil/water separation plant is installed, this plant could be fired using waste oil as fuel, thus minimising the operating costs.

The incineration plant would be operated by STAR. This would require a change to the existing contract.

There are essentially two options – to provide a plant which will effectively destroy the infectious healthcare waste and food waste from the port and airport without visible smoke from the stack or to provide a plant with appropriate gas cleaning to meet EU emission standards.

Incinerators require regular maintenance with downtime of at least three weeks each year. To ensure availability, it is proposed that two small plants should be provided side by side, to ensure that at least one is available at all times. The additional cost of such an option is not very great.

The plant should comprise:

- Incinerator
- Hydraulic ram feed
- Container tippler
- Oil tank
- Spares
- Installation/commissioning
- High intensity airport lighting on stacks

We estimate that without gas cleaning, the plant would cost would cost in the region of €400,000. With gas cleaning, this would increase to about €1million.

The healthcare waste should be collected in a dedicated vehicle. We recommend that the waste is collected in 240 litre containers, which are loaded onto a box van with a tail lift and transported to the incinerator, where they can be automatically discharged using the tippler mechanism. The vehicle would cost about €30,000 and have operating costs of around €18,500 including depreciation.

Composting of separately collected biowaste

On the basis of current information, the total biowaste in MSW is currently approximately 7,450 tonnes. Whilst overall waste generation may grow, the quantity of biowaste is unlikely to do so, as people are unlikely to eat more food because they become more affluent. The growth in waste generation is therefore likely to comprise other materials, such as packaging and discarded products.

For separate collection of biowaste, we would expect that no more than 75% of households to participate in such a scheme (figures of 60% are quite common in parts of the EU) and that the capture rate of biodegradable waste will certainly not exceed 70%. Thus the maximum quantity of biowaste that can be expected to be collected separately will be no more than 4,000 tonnes per annum.

Windrow composting

The current process for composting of green wastes uses the windrow method. Segregated biowaste is likely to contain plastic bags. Householders should be encouraged not to use these where practical, but it is very likely that substantial amounts of the biowaste placed in separate containers will still be in plastic bags, as there are not many other options. These bags will need to be separated from the biowaste before composting. Fortunately, STAR has a system of conveyors and a trommel. The trommel can be used to extract much of the plastic.

To handle 4,000 tonnes per annum there may be a need to construct an additional covered and concreted area for maturation of the compost. We estimate that a further 1,500 sq. m. may be needed.

Simple windrow composting of segregated green waste could readily be started on Praslin to reduce the dependency on landfill.

In-vessel composting

In-vessel composting would be more desirable, in order to eliminate the nuisance from odours. There is a range of different types of equipment but the plant proposed by STAR in their technical proposal is one of the most cost-effective. We estimate that the capital cost for such a plant would be about €1 million. At the present time, we doubt that this is affordable, but should be considered around 2010.

Marketing of Compost

The constraint on expanding the amount of biowaste which is composted is, as is usually the case, constrained by the ability to find markets for the material. If green waste composting is to be expanded, the marketing of the product must be improved. In the interests of expanding the composting activity, it is recommended that the price at which the product is sold is substantially reduced. There is anecdotal evidence that currently the high price for the product is limiting its use. It should be borne in mind that in Europe, compost is typically sold at much lower prices. Prices of €30/tonne (i.e. about R0.15/kg) are common.

8.3.5. Final disposal

Irrespective of selection of other options for the treatment of wastes there will always be a need for landfills. A process for the identification of sites suitable for the development of landfills has previously been undertaken and no appropriate candidate sites have been identified. For this reason the development of the new landfill in Mahé at Providence is

considered to offer the optimal final disposal solution for the immediate and medium term, subject to appropriate risk assessments (environmental impacts and also those associated with aircraft bird strike due to the proximity to the airport) and design. Initially the site should be developed with sufficient void capacity for (say) around two years waste infilling and should utilise the existing infrastructure; subsequently additional void space (essentially lining and installation of environmental control systems) can be created to cater for the rate of demand. It is estimated the development of the first phase of the site to accommodate some two years waste input would be in the region of €1.5 million.

The alternative would be the development of a completely new site on one of the areas reclaimed from the sea (and not considered in the previous screening exercise). There would be a need to commence a formal process of site identification and assessment. Whilst it is possible to establish a new set of infrastructure should such a location be identified this is unlikely to offer any benefits over the site at Providence.

However, in the longer term (in about 12 - 15 years time when Providence II is full) there will be a need to identify further landfill capacity and it is recommended that mass incineration of waste is considered to prolong void space for waste disposal of residues only.

Previous work undertaken on Praslin suggests that a new landfill could be established on the land near to the existing dump-site at Amitie. In view of the poor environmental control associated with the existing facility it is recommended that this option be considered further.

Waste disposal on La Digue can continue at the current facility for about two years, which could be increased by the modification / extension of the existing layout. However, in the near future this capacity will be used up and consideration should be given to the transfer of all waste arising to the new facility to be constructed on Praslin. The adoption of such a system would require the acquisition of specialist waste compactor containers, handling equipment and vehicles.

8.4. Comparison and ranking of options

The options discussed in this section have been scored against the criteria identified in Section 8.2. The results are shown in Table 11.

Table 11: Ranking of short list candidates

Category	Option	Sub-options	Score against individual criteria							Total Score
			Consistency with policy (5)	Land use (15)	Technical suitability (20)	Sustainability (15)	Environment (15)	Cost (25)	Public acceptability (5)	
Waste avoidance and minimisation	Controlling material imports		**2**	**15**	**7**	**15**	**15**	**12**	**1**	**67**
	Import tariffs / charges		**4**	**15**	**14**	**15**	**15**	**12**	**2**	**77**
	Charging householders by quantity of waste		**4**	**15**	**4**	**15**	**15**	**21**	**0**	**74**
	Limiting access to large containers		**3**	**15**	**14**	**15**	**15**	**25**	**1**	**88**
	Home composting		**5**	**14**	**14**	**15**	**15**	**22**	**4**	**89**
	Repair centres		**5**	**11**	**8**	**15**	**15**	**10**	**5**	**69**
Segregation, collection, storage and transportation	Separate collection of biowaste	Survival bags	**5**	**12**	**11**	**14**	**14**	**5**	**3**	**64**
		Separate rounds	**5**	**12**	**18**	**14**	**13**	**15**	**4**	**81**
	Collection point for hazardous household waste		**5**	**10**	**15**	**14**	**14**	**10**	**4**	**72**
	Reduce collection frequency		**1**	**12**	**10**	**12**	**12**	**23**	**1**	**71**
	Collection vehicle types	Existing	**3**	**14**	**8**	**10**	**10**	**20**	**2**	**67**
		Compactors	**5**	**15**	**20**	**12**	**12**	**12**	**5**	**81**
Recovery / Recycling	Return		**4**	**14**	**17**	**15**	**14**	**15**	**5**	**84**
	Materials Recycling Facility		**3**	**10**	**9**	**11**	**12**	**10**	**4**	**59**
	Amenity sites ('bring-system')		**5**	**10**	**16**	**12**	**10**	**17**	**4**	**74**
	Aggregate crushing		**4**	**11**	**19**	**14**	**10**	**15**	**4**	**77**
Treatment & processing	Incineration of MSW		**3**	**10**	**12**	**11**	**11**	**11**	**2**	**60**
	Incineration of other wastes (hospital etc)		**5**	**12**	**16**	**11**	**13**	**15**	**5**	**77**
	Composting of biowaste	Windrow	**5**	**11**	**19**	**14**	**10**	**17**	**4**	**80**
		In-vessel	**4**	**10**	**15**	**14**	**14**	**11**	**4**	**72**
Final disposal / Landfill	Providence II		**4**	**9**	**18**	**6**	**7**	**17**	**3**	**64**
	New site		**1**	**0**	**18**	**6**	**7**	**12**	**1**	**45**
Mahé	Anse Royale	Southern area	**1**	**15**	**12**	**11**	**13**	**17**	**1**	**70**
		Incinerator ash	**1**	**14**	**14**	**12**	**14**	**19**	**1**	**75**
		Transfer	**2**	**15**	**16**	**12**	**14**	**13**	**1**	**73**
Praslin	New site (adjacent to Amitie)		**3**	**2**	**18**	**6**	**7**	**17**	**3**	**56**
	Incinerator (plus small landfill)		**2**	**4**	**12**	**11**	**11**	**8**	**1**	**49**
La Digue	Incinerator (plus small landfill)		**2**	**3**	**11**	**11**	**11**	**6**	**1**	**45**
	Transfer off-island		**3**	**10**	**18**	**11**	**11**	**17**	**4**	**74**

8.5. Preferred options

Based upon the options assessments it is considered that the following practicable options ought to be incorporated into the future waste management strategy:

Avoidance and minimisation:

- Imposition of tariffs on selected potentially polluting imports: a restriction on the importation of PVC bottles is already being implemented and consideration should be given to extending this to other products.
- Encouragement of home composting.

Segregation, storage, collection and transportation

- Separate collection of green / bio waste. This could be implemented by including a separate receptacle (or replacing a general waste receptacle) at each bin site with a green bin of similar design to the existing bins. This material could be collected by a separate collection round. The effectiveness of such a system would require public education and could be initiated on a pilot basis.
- The substitution of the existing waste collection vehicles with a dedicated fleet of purpose built waste compactor vehicles is recommended. The current arrangements whereby bins are manually lifted onto the vehicles is unsatisfactory for health and safety reasons and should be discontinued as soon as practicable.
- In the future, consideration should be given to reducing the frequency of waste collection.

Recovery and recycling

- Encouragement of reuse and recycling of various waste categories by householders and the public and private sector industries. Put in place national programmes for reuse and recycling, including incentives for industry and the private sector.
- Encourage and support the efforts of Seybrew to have all reusable glass bottles collected and extend this model to other companies.
- Mandatory introduction and use of PET bottles (in place of PVC) and put in place a national framework for recycling of the same. This effort should be implemented nationwide and not restricted to only willing companies. It may be possible to utilise infrastructure and facilities currently used by Seybrew.
- Encourage organisations with an interest, such as SAMLO (the metals recycler) and others to become involved in other forms of material recycling where they can identify a market for the recyclate.
- Encourage and provide incentives for the development of art and craft industries based upon recyclable materials such as glass, paper and others.
- Assist in the development of centralised 'bring' sites (amenity sites) located in well-populated areas for the recovery of green / bio waste, plastic bottles and inert (construction and demolition) waste. Appropriate education and training needs to be included to ensure these facilities are effectively used.

Treatment and processing

- Increase the throughput and further encourage the development of the existing composting plant at Providence. The enhanced collected of green / bio waste identified above would ensure the production of increased quantities for use in Seychelles. The price required (by SWAC) for the sale of compost should be reconsidered and lowered to

encourage its wider usage. Simple windrow composting of segregated green waste could readily be started on Praslin to reduce the dependency on landfill.

- Increase the use of the compost by both export and local markets through a combination of improved quality, marketing and price.
- Explore the feasibility of separating out construction and demolition waste and crushing and screening the material to produce low grade construction materials that could be used for landfill engineering or land reclamation. In time the development of such activities could produce materials of a quality suitable for use in place of virgin materials
- There is an urgent need for the proper incineration of healthcare waste and also a requirement for similar disposal of certain wastes from the airport and the marine port to assist in the eradication of incoming pests. A central incinerator (probably located at Providence) should be provided.

Final disposal

- In the short and medium term there appears to be little option but continued reliance on landfill for the final disposal of waste arisings. However, such reliance can be reduced by the implementation of the strategies identified above. A new landfill at Providence appears to offer the best option for the disposal of the residual fraction on Mahé.
- On Praslin a new engineered landfill should be developed as soon as practicable, probably in the area adjacent to the existing facility.
- The transfer of all waste from La Digue to Praslin should be considered after the closure of the existing landfill, which could be extended slightly to increase its capacity and extend its life.
- Anse Royale is currently an under-utilised resource because the disposal of inert materials into a fully lined and engineered landfill is not considered the most effective use of this facility. The under utilisation of this site has arisen partly due to strong public protest. The crushed glass and ash could readily be disposed of at the existing and new landfill with little disbenefit and the plastic bottles could be recycled together with those processed by Seybrew. It is therefore proposed that the landfill is held in reserve until it can be used to dispose of fly ash from a future incineration scheme. Another alternative use for Anse Royal landfill is as a waste transfer station. This option should also be considered.
- Rehabilitation of the exiting closed waste disposal sites (including Amitie, La Digue and Providence I, when these become full) should be initiated in a comprehensive programme aimed at reducing the environmental harm these are causing.
- Although not a final disposal option the mass incineration of waste should be considered as the medium to longer term solution for the reduction of waste volumes required to be disposed of to landfill on both Mahé and Praslin. On Mahé the incinerator could be coupled with energy recovery and located either at Providence or on one of the more distant off-shore reclamations near Victoria. There would still be a need to dispose of fly-ash probably to a small specially constructed nearby landfill.

A summary of the strategy assessment, including the strategic importance, ranking and relative costs of the strategy components, is given in Table 12.

Table 12: Strategy assessment

	Strategy Component	Strategic Importance	Assessed Ranking	Relative Cost	Comments
A	**Institutional & Management Issues**				
1	Develop & introduce technical standards	Desirable	7	M	
2	Increase data capture and reporting	Desirable	6	L	
3	Communications / education	Essential	5	M	To educate and inform the public
4	Audit of STAR contract	Essential	1	L	To identify potential service improvements
5	Develop new service contracts	Essential	4	L	For new facilities and services
6	Training for SWAC (& other) staff	Essential	3	M	Capacity building
7	Co-ordinate environmental monitoring	Optional	8	L	
8	Introduce user charges	Essential	2	L	Possibly unpopular but significant cost savings
9	Introduce ISO 14000 system	Optional	9	L	
B	**Waste Handling, Treatment & Disposal**				
1	Separate collection of biowaste	Optional	10	M	
2	Reduced waste collection frequency	Optional	14	-ve	Possibly unpopular but potential cost savings
3	3 additional bring sites	Optional	12	M	
4	Increased composting on Mahé	Optional	9	M	Dependant on compost market development
5	Composting on Praslin	Desirable	6	M	Reduces volumes to be landfilled.
6	Crush and screen C&D waste	Optional	13	L	
7	Special (inc healthcare) incinerator	Essential	2	H	Linked to harbour / airport project.
8	Healthcare waste collection	Essential	3	L	Linked to Item 7
9	Providence II Landfill	Essential	1	H	Void deficit in 2 yrs
10	Praslin Landfill (Amitie)	Essential	5	H	Improved environmental control
11	La Digue landfill extension	Essential	4	M	Void deficit in 2 yrs
12	Rehabilitation of old landfills (esp P I)	Desirable	7	H	Improved environmental control
13	Environmental monitoring	Desirable	8	M	Improved environmental control
14	Anse Royale transfer station	Optional	11	M	
15	Impose import tariffs on polluting items	Optional	16	L	
16	Encourage home composting	Optional	15	L	

9. ECONOMIC AND FINANCIAL APPRAISAL

9.1. Methodology

The normal way of evaluating the cost of raising waste management standards is by means of the so-called Average Incremental Cost per tonne (AIC). This is calculated by discounting the cash costs (including the capital and revenue expenditure) to produce a Net Present Value (NPV) and then dividing this by the discounted value of the tonnes of waste handled. Such a calculation is needed because both the cash costs and the waste tonnages vary over time. It is particularly useful when comparing two options, especially when the timing of the cash flows is different.

AIC can also be used for setting the appropriate rate of cost recovery, though affordability and willingness-to-pay are other issues which need to be taken into account.

It should be noted that, in addition to costs of Works, Technical Assistance and Supplies, the costs also include on-going operational costs for additional facilities or services.

9.2. Assumptions

Two separate spreadsheets have been developed to calculate the NPV of the incremental costs of implementation of the Solid Waste Master Plan. These reflect two different sets of assumptions:

1. The costs of those items identified by the Consultants as forming the 'essential' part of the Master Plan.
2. The costs of those items identified as 'essential' plus selected key components.

For each of the assumptions given above two scenarios have been considered for the management of solid waste on La Digue, as follows:

a) La Digue Landfill extension;

b) La Digue waste transferred to Praslin.

For these assumptions and scenarios, the detailed analysis spreadsheets are given in Appendix E* and the overall NPV and AIC/tonne are shown below:

Assumption	Scenario	NPV (€ '000)	AIC/tonne (€)
1	La Digue Landfill	4,842	13.81
	Transfer to Praslin	4,692	13.38
2	La Digue Landfill	7,665	21.86
	Transfer to Praslin	7,515	21.44

The AIC per tonne is the incremental cost per tonne of managing all wastes, i.e. the additional "with project" cost. The individual costs for particular waste streams will vary according to the nature of the waste stream and the processes applied to it.

* Electronic versions of the financial models are also included in the back of the report. With these models it is possible to identify the individual impact on the cost of the strategy of each component and to identify the cost of the strategy with or without any individual element.

9.3. Strategic comparisons

Two strategic elements have been evaluated separately:

- Providence II landfill
- Praslin & La Digue: using a landfill extension for La Digue or transfer of all waste to the Praslin landfill at Amitié

The AICs for these elements are independent of the assumptions described above.

For Providence II, the AIC would be €19.30 per tonne.

The AIC for Praslin and La Digue is much higher, because of the very low volumes and resulting poor economies of scale. The AIC for Praslin and La Digue would be around €77 per tonne if the La Digue landfill extension is used. For the transfer option to be more economically attractive, the shipping cost must be no more than €7 per tonne. The transfer system used for these calculations is based on using an additional refuse collection vehicle, which is shipped to Praslin on a ferry each day. The construction of a transfer station would probably result in an even greater cost but would not be practicable, because there is no suitable location, especially in the port area, which would not have an adverse impact on tourism.

9.4. Capital Costs

A summary of the capital costs of the main components of the strategy are given in Table 13. The further details of other related costs are given in the detailed analysis spreadsheets in Appendix E.

Table 13: Summary of capital costs (essential elements only)

Component of Strategy	**Capital Costs Only**
Capital expenditure (works)	
Providence II Landfill	€ 1,322,500
Praslin Landfill (Amitie)	€ 1,180,000
La Digue landfill extension	€ 168,000
La Digue transfer (1 RCV excludes sea transfer)	€ 100,000
Special incinerator	€ 935,000
Supplies	
Provision of the collection vehicle for health care waste	€ 30,000
Provision of enclosed containers for healthcare waste collection	€ 20,000

9.5. Landfill sizes and lifespans

9.5.1. Providence II, Mahé

Based on a generic type of design and the area currently available for landfilling (ie excluding peripheral bunds, tracks, fencing etc and areas to be utilised for leachate lagoons etc) a total of approximately 5 hectares is available with a void capacity of 495,000m^3 has been estimated. This volume of void would result in a landfill with a lifetime of about 10 years of waste disposal.

9.5.2. La Digue

Detailed topographical surveys are not currently available for the existing engineered landfill on La Digue and the possible extension and thus it is difficult to calculate the total volume of the void. An estimate based on a visual assessment of the area available for the extension to the site suggests an additional void capacity of around 1,500 - 2,000m^3. This volume should be sufficient for up to two years extra filling.

9.5.3. Amitié, Praslin

Amitié landfill on Praslin has no defined boundaries and no topographical information on which to determine the extent of a possible new landfill and to calculate its likely void capacity. Based on an assessment of the area visited by the Consultant (to the east of the existing site and probably the same area visited by previous consultants), it is estimated that an area of approximately 1 hectare is available. Assuming a total waste depth of up to 6 or 7 metres this equates to an available volume of around 65,000m^3 suggesting a lifespan of around 10 years.

9.6. Social impacts

The social impacts of the proposed strategy will be derived largely from the environmental impacts. The beneficiaries will be the entire population of the Seychelles, which will benefit from greater environmental protection and less pollution. It should be said that the current waste management system is not having any severe adverse environmental impacts. It is not, however, sustainable as the existing facilities will shortly cease to be available unless further investment and construction work is undertaken. Thus, whilst the implementation of the strategy is important for sustainability, the actual positive impact which will be perceived by the population will be relatively slight.

In terms of sectoral impact, the environmental improvements will naturally have a positive impact on the tourism sector although the magnitude of this impact is probably small. The Seychelles already offer a pure and clean environment and it is unlikely that, for example, the amount of recycling carried out is going to have any significant impact on the numbers of tourists visiting the islands.

The impact on employment, except during the construction phase, will also be insignificant.

Appendix A: Table of Consultees

CONSULTEES

Organisation	Individual
Ministry of Environment	Mr Maurice Loustau-Lalanne Mr Jude Florentine Mr Joseph Fransoir Mr Flavian Joubert Ms Nadine Dulac Ms Lynn Bastienne
SWAC	Mrs Mary Stravens Mrs Tania Laporte Mr Berry Antat Mr Barry Joseph
Ministry of Health	Mr Nicholas Shamlage Dr Patrick Herminie Mr Danny Poiret
Ministry of Agriculture	Mr Antoine Moustache
Ministry of Land Use & Habitats	Mr Terry Bisconet Mr Patrick Lablache
Ministry of Foreign Affairs	Mrs Jeannette d'Offay Mr Jean-Paul Adam
Ministry of Economic Planning	Mr Ahmed Afif
Ministry of Tourism	Ms Dominique Verdugo
Civil Aviation Authority	Mr Wilfrid Fockcave
Port and Marine Services	Capt Robert Padayachy
Public Utilities Company	Mr Stephen Rausseau Mr Jude Anglousa Mr Steve Mussard Mr Phillip Morin Mr Anil Singh Mr Jude Anacoure
Seychelles Marketing Board	Mr Patrick Appoo Mr Amitesh Banerjee
STAR	Mr. Thomas Forgacs Mr Serge Troian Mr George Troian Ms Regina Sinon Mr Michael Ah Kong
Seychelles Hotels Association	Mr Francis Mondon
Banyan Tree Hotel	Mr. Maximilian Lennkh
Sainte Anne Resort	Mr. Kris Seeboo
Indian Ocean Tuna	Mr Robert Stravens
Seychelles National Youth Association	Ms Marie – Yvonne Auguste
Chamber of Commerce	Mr Kantilel Jivan Shah Mr Albert Payet
SAMLO	Mr Rajiv Goloressoo
Penlac	Mr Nicholas Pothin
Seybrew	Mr Nick Woodgate Mr Harry Gabriel Mr Kenneth Gabriel
Mauritius Commercial Bank	Mr Ah-Yu
Independent waste consultant (later STAR)	Ms Sandrine Veneph
Navins Paper Recycling	Mr Nigel Confiance

Appendix B: Environmental Impacts

Environmental impacts of waste disposal

1 BACKGROUND

Mahé is the main island within the Seychelles group and approx 85% of the population of the country is resident there. A majority of waste generation and disposal is therefore on this island. The collection and disposal system on Mahé, which currently concentrated on the landfill facility at Providence, is therefore the primary focus of the current assessment. However impacts may also arise from the disposal on the smaller island and from previous, now closed, disposal sites. This review will, therefore, cover the following:

- Providence landfill
- Historic disposal site on Mahé
- Mahé waste collection system
- Disposal operation on the smaller islands (principally Praslin and La Digue)

Data for the assessment of impacts is drawn from previous reports, site monitoring data (where available) and site inspections. In conclusion to this section recommendation are made on the upgrading of current monitoring systems.

2 PROVIDENCE LANDFILL

2.1 Background

The Providence landfill site is located on reclaimed land approximately 5 km south east of Victoria and 1.8 km north west of the International Airport runway. The reclaimed land forms a level platform at approximately 1.5 m to 2 m above sea level, constructed from dredged coral sand and extends to approximately 600 m out from the original coast line. Adjacent to the landfill zone, the reclaimed land encloses a small lagoon some 100 m wide backed by the steeply rising ground of the former coast line.

The main land uses around the landfill site are set out within Table 1.

Table 1 - Main land uses within vicinity of Landfill

Direction	Main Land uses within 0.5 km	Main land uses 0.5 to 2 km
North east	Open seas (Cerf Channel)	Open seas (Cerf Channel) and St Anne Island and Marine park.
North west	Industrial estate and small marine park.	Industrial estate and undeveloped reclaimed land, causeway and lagoons
South west	Narrow lagoon to mainland with steep sloping, wooded land including significant area of residential development.	Steep, wooded areas with scattered residential developments.
South east	Recent extension of the reclaimed land on which landfill is formed, backed by open marine lagoon.	Open lagoon and Mahé international airport (end of runway 1.8 km from edge of landfill).

This landfill is understood to have been operational since the early 1990s but control of deposition and operational practices was updated by STAR after takeover of the site in 1998. The potential impacts defined below relate to those likely or actually arising from the current site and practices.

2.2 Leachate Impacts on Water/Marine Resources

The Providence landfill is an unlined facility reportedly involving partial initial void infill (up to 3m below sea level – IPC 1996) with subsequent land raise, i.e. waste is deposited directly into the excavated coral sands, and the site then raised above surrounding ground to maximise void space. No leachate collection and control systems are installed and therefore the control of impacts from leachate generated relies on the principle of dilute and disperses.

The current landfill practice is to place fill within defined cells, compact these and use cover materials (either imported soils waste or coral sands) to limit exposure of the waste to the elements and limit litter blow. This is accepted good practice for modern waste disposal and limits the potential for leachate generation. However the site is within an area of relatively high rainfall, average 2,335 mm/yr, which exceeds the average open pan evaporation of 1,666 mm (Payet 1998). The rainfall distribution, with most rain falling during the northwest monsoon, October to March, results in rainfall significantly exceeding evaporation over this season.

Taking account of the filling methods and the climatic factors at the site, leachate will be, and will continue to be, generated from the decomposing wastes. This has been confirmed by a limited series of trial pits dug at the site that showed the water table at 4 m to 5 m depth (no survey control, therefore relationship to sea level unknown) within the waste and leachate was visible within this saturated zone (pers com – MoE). Boreholes installed in 1995 were also sampled and analysed for a broad suite of determinants. The results show elevated concentration of elements associated with leachate but not to concentrations typical of pure leachate indicating a high degree of dilution within the samples taken. However, no systematic sampling programmes have been undertaken around or within the site and therefore actual leachate levels, qualities, variations over time and movement off sites, cannot be defined. Impacts are therefore assessed in general terms.

At Providence the site is constructed using dredged coral sand, which will have a high permeability, is on reclaimed land only a few metres above sea level and filling occurs to within a few metres of the reclaimed shoreline. Being at low level, on reclaimed land the site is well removed from any ground or surface water supply point (lowest collection point is at Cascade close to the site but which is at 160m above sea level). The only target for leachate is therefore the marine environment adjacent to the site with a high potential for migration to occur due to the high permeability of the coral sands.

Again no systematic sampling of the waters close to the site has been undertaken to quantify impacts. A number of studies have taken one off samples from the general area both close to the shore and within the Cerf Channel (Ocean Surveys Inc – 1992, Ogden 1993, A.R. Landfills 1995, Payet 1998, Biwater Sept 2001). The range of determinants for these studies was limited but water quality was generally typical of the marine environment although some elevated metal concentrations were found. These do not provide conclusive evidence of either the presence or absence of impacts on the marine environment from the landfill site.

Site inspection did show evidence of a dark liquor seeping out onto the adjacent beach at low tide, which may be an indication of leachate migration. However no analysis of this material has been conducted to confirm its origin. From current data impacts from the landfill on the marine environment cannot therefore be quantified.

On a generic assessment, based on observation on site, it is concluded that the risk of leachate being generated and migrating off site, is high. As land filling progresses and the site is raised across its full width, leachate volumes will increase and the potential for a hydraulic gradient to develop, encouraging movement of leachate from the site, will also increase.

Impacts arising from any migration are, however, more difficult to assess. Once in the seas any leachate will be subject to a significant level of dilution and mixing by the action of tide and wave within this zone. This near coast area has also be subject to significant impacts from the reclamation process with the seabed being dredged causing habitat loss and creating high sediment loads impacting on adjacent areas. The near coast area is not therefore a

pristine environment. In addition the coal sand beds, as found around the site, are defined as impoverished habitat due to the very low nutrient status (ITW 1994) and are therefore not permanent fish habitats. However the site is relatively close to the Cerf Channel and associated fringe reef as well as the St Anne Marine National Park so the wider natural environment is highly sensitive to marine pollution. In addition supplementary potable water supplies are provided for Mahé from a newly commissioned desalination plant constructed on land adjacent to the landfill site. The intake for this plant is within the near shore zone and is therefore also a potential target for any leachate migration. Due to this sensitivity a more detailed quantification of actual impacts is required.

To quantify impacts from the current operations a network of monitoring boreholes and systematic sampling programme should be set up as outlined in section 2.8 below (and recommended in the main report text). This monitoring should be continued through the remaining life of the landfill and post closure to a point where the degradation process is effectively complete.

2.3 Landfill Gas

The second principal environmental concern at modern landfill sites is the generation of landfill gas (primarily methane). Modern filling techniques necessitate rapid cover and encapsulation of waste as practised at Providence. However this has the effect of increasing the degree of anaerobic decomposition and therefore the potential for landfill (methane) gas generation. Gas migration has the potential to cause odour problems (see section 2.4) and is a potentially significant health risk as, in concentration of 5% to 15% in air, methane is explosive.

At present no gas monitoring is conducted at the site therefore the concentrations, rate of generation and degree of migration of any gas at the site cannot be quantified.

The prime targets for any migration are adjacent buildings. Those close to the fill area include the landfill site offices, the wastewater treatment plant and the new RO plant. These are backed by the industrial estate the closer properties of which are also defined as a potential target. The residential development on the mainland areas is unlikely to be at risk due to the intervening lagoon.

The current degree of risk from landfill gas cannot be quantified. However, filling with putrescible waste in the tropical climate will result in gas generation. The high permeability of the materials within which the site is formed, and surrounded, will also allow off site migration of any gas generated. However this coral sand material will have two counteracting effects.

Being of high permeability, gas present on site will migrate easily into the surrounding areas. This migration will be encouraged as the vertical migration within the waste itself will be low as materials are placed, compacted and covered in horizontal layers. The path of least resistance for gas migration will therefore tend to be horizontally into the surrounding land leading to off site migration. However the risk to building is countered in part, as this high permeability is also likely to encourage surface venting of gas, close to the site boundary, as gas follows the path of least resistance, moving vertically up though these soils and out to atmosphere. However any alteration of the surface, hard standing, soils layers, compaction, etc. will reduce this effect increasing the risk of more distant migration. The main risk occurs along the north west boundary as the remaining areas border open water or newly reclaimed but undeveloped land.

From this initial assessment, the high permeability of the surrounding soils and the fact that there is only a limited amount of still decaying waste below surround ground level are likely to reduce any risk to surrounding site users. However, no data are available to confirm this situation and therefore a risk exists that requires quantification. Monitoring, as set out in section 2.7 should therefore be undertaken. Should actual risks be identified then relatively

simple mitigation measures can be implemented on this site such as the installation of passive vent trenches.

2.4 Odour

Odour occurs at landfill sites as a result of the degradation process, either at the landfill site, or within the collection bins prior to delivery to the site. This latter point is an issue in tropical climates where the degradation process starts very rapidly. The gasses generated during this process vary but trace elements can result in high and unpleasant odours being created.

Sensitivity to odours is greatest in residential areas but will also impact commercial development and public building such as schools.

At present, levels of impacts are assessed from the number of complaints received by the MoE (or SWAC). A register of all complaints is kept but was not available for review at the time of this study. However, comment was made (MoE Pers comm.) that problems had occurred at the site over many years, but under current site management better control was being achieved and complaints had reduced over the last year. This is therefore a live issue for the management of the site but is an improving situation. All complaints received are reported to the site operators, the cause of the problem identified and suitable actions taken to mitigate the cause. Current practices or rapid filling, compaction and covering of materials are recognised methods for the control of odours.

As noted within section 2.1 the site is close to residential properties, which lie to the west and south of the fill area. Odour problems only arise when the wind blows towards the sensitive areas. Data from the Met office show that winds are generally from the south east during May to October and from the north west during the rains from December to March. Wind directions are not therefore predominantly on shore for this part of the island. The main sensitivity is therefore during the transition periods between these seasons when winds are more variable in direction.

Odour is a recognised problem from landfill sites and, as reported from the complaints received, the current site operators are tackling this problem by the introduction of the more controlled filling techniques.

2.5 Bird Nuisance

At any landfill site birds will be attracted to the area to feed off the scraps of food waste included within the general waste stream. This is the case at Providence where the birds present are predominantly cattle egret. At this site two primary problems occur from bird infestations, nuisance (and potential health risk) of birds roosting on adjacent properties and risks to aircraft coming into the main airport i.e. bird strikes.

From the short site visit detailed impacts from birds cannot be assessed or from current data and the complaints register. However, it is understood (Airport Authority; Pers comm) that the majority of the cattle egrets roost in the trees to the west of the airport. To validate this assessment a detailed review of the complaints register should be undertaken and observation made of bird migration and roosting patterns undertaken.

The effect of bird strikes is well recognised internationally and is an issue of importance to airports. The site is currently 1.8 km from the closest point of the runway. The only current observation made for this study is that the birds colonising the site, i.e. cattle egret, do not, by habit, fly high and soar and therefore will not tend to encroach on the flight path. The egret tends to spend time on the ground or within a roost on a tree and flies at low level between the two.

Preliminary discussions between the Airports Authority and the Ministry of Environment over the development of an extension to the Providence Landfill has resulted in a limit to the extent of the landfill of no nearer than 1.5 km from the end of the runway.

2.6 Noise Impacts

Landfill sites involve the use of heavy plant and machinery and delivery lorries entering and leaving the site on a regular basis. The potential for noise impacts therefore exists. However impacts only arise if sensitive receptors are present close to the site and the background noise environment is such that the operations cause an unacceptable increase in general noise levels.

At Providence impacts are unlikely to arise. The closest sensitive properties (residential areas to the west and south) are at between 250 m to 300 m from the closest area of the site. All closer property is industrial or commercial. On the boundary of the site facing the residential area is the busy main road leading from the airport and areas beyond, to Victoria. The residential areas are also formed along the old main road with moderate traffic flows.

Noise standards for the Seychelles are set out within the Environmental Protection (Noise Emission Standards) Regulation, 1999. These provide maximum noise limits for different areas and times of day. For residential areas (most noise sensitive receptors) the daytime limit (0600 hrs to 2300 hrs) is set at 60 dB(A) L_{eq} and night time at 55 dB(A) L_{eq}. From these a noise impacts assessment requires a simple comparison of noise within residential areas to ensure these limits are not exceeded. However noise assessment are also undertaken by reference to the existing noise environment (background) and defining impacts based on the predicted increase in noise over this background level caused by an operation.

For either method of assessment, the combination of distance to residential area, the existing noise sources (road and industrial estate), and the fact that the landfill only operates during the working day, indicates that noise generation from the landfill will not cause impacts in excess of these standards or a significant increase over background.

2.7 Landscape

Within a holiday island such as the Mahé, impacts on the landscape setting of any area can be detrimental to visitor's perception of the location and therefore impact on future earning potential for the country. Local impacts may also be caused by view from residential properties being blighted by the site of landfill operations or impacts on the surrounding area by accumulation of litter blow from the site.

Again impacts from this site are assessed as low. The site has a very well developed screen of trees to all sides and particularly to the landward boundary. These are of sufficient height and density to obscure any clear view of the operations and only occasional gaps allow very limited views into the site from ground level. Visitor views from the main road from the airport, and from local residences along the old coast road, are therefore well screened.

Properties do exist on the higher ground above the old coast road and limited views into the site from some of these are likely (as assessed from looking out from the site onto the surrounding hillside). However, most of these are partially or totally screened from the site by existing vegetation on the slopes or by the natural topography. In addition the land reclamation process and the construction of the industrial estate have already substantially altered all these views for properties that were once on the coastline. As such significant impacts do not occur although (as is generally deemed to be good practice) each site should have a closure plan that adequately defines the final profiles and planting to be achieved..

2.8 Monitoring Proposals

The most significant finding of this impacts assessment is that there is a significant lack of current on-site monitoring. Therefore, quantification of current impacts, the need for additional mitigation works, and long-term management of impacts cannot be defined. The setting up of a monitoring network at Providence is therefore recommended.

The detail of the network should be agreed with the MoE however the following gives an outline structure for the proposed scheme.

Leachate

Leachate monitoring boreholes should be installed at maximum 50m intervals on all sides of the landfill. This should ensure a minimum of two boreholes per side, installed to at least 1 m below base of filling. Samples should be taken on a monthly basis for the first six months to establish an initial picture of the current position and then quarterly from then onwards. All boreholes should be surveyed in to provide a reference level from which height of leachate above sea level can be established. Prior to sampling depth to water in borehole should be taken and the depth of tide at the time of sampling recorded.

In addition at least two sampling points should be included within the waste mass to assess the nature of the leachate being generated.

Ideally the analysis suite should include:

Determinand	Symbol	Units
PH[†]	pH	pH Units
Conductivity	EC	µS/cm
Dissolved oxygen[‡]	DO	mg/l
BOD	BOD	mg/l
COD	COD	mg/l
Total Organic Carbon	TOC	mg/l
Chloride (-)	Cl	mg/l
Sulphate (-)	SO_4	mg/l
Nitrogen Ammoniacal (+)	NH_4-N	mg/l
Total Oxidised Nitrogen (-)	TON	mg/l
Sodium (+)	Na	mg/l
Potassium (+)	K	mg/l
Calcium (+)	Ca	mg/l
Magnesium (+)	Mg	mg/l
Cyanide	CN	µg/l
Sulphide	S	mg/l
Phenols (total monohydric)	Ph-OH	µg/l
Iron (+)	Fe	mg/l
Manganese (+)	Mn	mg/l
Cadmium	Cd	µg/l
Chromium	Cr	µg/l
Lead	Pb	µg/l
Copper	Cu	µg/l
Nickel	Ni	µg/l
Zinc	Zn	µg/l
Arsenic	As	µg/l
Mercury	Hg	µg/l
PAH (Total)	PAH	µg/l
VOCs (speciated)	VOCs	µg/l
SVOCs (speciated)	SVOCs	µg/l
Pesticides	Pest	µg/l
Organo Tin	OrgSn	µg/l

Landfill Gas

Leachate monitoring boreholes should be designed so as to allow their use for gas monitoring. These should include sealed caps on the boreholes fitted with a sampling nozzle, complete with control tap. Gas monitoring for oxygen, methane and carbon dioxide should be conducted on a monthly basis. Where combined gas and leachate monitoring is undertaken, gas sampling must be conducted prior to opening the borehole for leachate sample collection.

Marine environment

The near shore water around the site should be monitored to provide data on current quality and to identify any changes with time. Samples should be collected from four locations along the north east (seaward) side of the fill area (location to be clearly marked to ensure regular sampling at the same locations) and at four locations to the landward side, two within the lagoon formed between the reclamation area and the road, and two within the lagoon between the road and the former coast.

Samples should be taken on a quarterly basis and analysed for the same determinants as for leachate. Monthly walk round inspections should also be undertaken of all beach locations adjacent to the site to check for visible signs of leachate migration.

Consultation should be undertaken with PUC who operate the wastewater treatment plant and the RO plants both of which utilise the near coast zone. Any monitoring initiated for the landfill should be integrated with that for these plant to maximise the value of the results obtained.

3 HISTORIC DISPOSAL SITES ON MAHÉ

3.1 Background

Three former landfill sites were inspected to provide an initial assessment of their current condition and potential to cause ongoing impacts. This assessment was based purely on visual observations of the sites and knowledge of the typical disposal practices utilised during their operation.

The three sites identified are:

- La Retriate – approximately 4 km north of Victoria on the island's northwest coast.
- Roche Caiman – Approximate 2 km southeast of Victoria on an area of reclaimed ground.
- Barbarons – approximately 12 km from Victoria located centrally on the island's southwest coast.

3.2 La Retriate

This site is located on low lying, level ground within a small bay protected to the north by a small headland. The site is approximately square in shape, 2 ha in area and is bordered by sea on two sides and the steep, rising ground of the mainland on the remaining sides. An area of newly reclaimed land now forms a lagoon to the seaward side of the site, which was formerly on the original coastline and exposed to the open sea. This reclaimed land now protects the site from any significant wave action.

The site itself is a low level area now used as a football pitch. The surface has a moderately good grass vegetation cover with some scrub and tree cover around the perimeter. Limited areas of bare ground have developed. Fill depths are unknown but tipping is reported to have been below sea level (ITW 1995) and is therefore likely to be only 2 m to 3 m overall. The seaward edges of the site have been subject to erosion and waste material is exposed along this edge. This consists largely of glass, scrap metal objects now severely rusted, plastic bags

and containers. The boundary to this side of the site appears to have been created using stone/rock revetments, which remain partially in place although the sections have been dislodged exposing the waste.

There is no evidence of any leachate emanating from the site and no significant odour or vegetation die back suggesting gas generation is occurring. However, the ITW report, noted that during their inspection in 1995 odours were present. Therefore either the degradation process has completed over the last 8 years or the atmospheric condition at the time of the most recent site visit inhibited gas release. There is no monitoring data from the site to indicate whether the degradation process is still ongoing. Houses are located close to the western edge of the site that may be affected if gas generation is a problem.

Overall the site is not visually intrusive although the exposure of waste on the seaward sides is visible to anyone using the site. The area has been restored to a beneficial after use as an open recreational area however some areas of bare ground detract slightly from this use. It is recommended that remedial works be undertaken to rebuild the edge protection to the seaward side of the site and that audit monitoring for gas and leachate is undertaken to ensure the waste has now stabilised and does not pose a risk to adjacent properties.

3.3 Roche Caimans

This site is within the ground of the current sports complex and close to an area of new housing development. On the ground the only visual evidence of where the former landfill is understood to be, is a raised area of ground now well vegetated. No visible evidence of any waste materials was identified.

The site shows no evidence of vegetation die back that may indicate gas generation. However the site is close to the sports stadium and housing is present within 200 m to the southwest. If gas generation is present then potential sensitive targets exist.

As with other sites there is no historic or current record of monitoring for either gas or leachate and therefore the status of the site in terms of the final degradation and stabilisation of the waste cannot be confirmed. The condition of the site suggests impacts are not arising but this can only be confirmed by undertaking audit monitoring. It is recommended that such monitoring is undertaken.

3.4 Barbarons

This site consists of a fill area located on slight raised ground approximately 400 m in from the beach, behind the village of Barbarons. The fill area has been covered with soil as part of the restoration process but this has been partially removed or regraded resulting in waste materials being exposed at the surface. The area is partly used for vegetable and fruit cropping (small scale) and partially left with a rough scrub and grass cover. Where the soil has been scraped away the area is devoid of any significant vegetation. The fill depth appears to be 1.5 m to 2 m and exposed fills consist of plastic bags and containers, fabrics and broken glass bottles. Some post closure tipping (primarily bottles) appears to have been undertaken within the bare area.

The site is close to a block of new housing (within 20 m) and the southeastern boundary is formed by a wetland that, during the site visit, had water flowing along the tip perimeter. As with the other sites no obvious leachate migration was seen and no strong odour was evident suggesting gas generation was occurring. However undecomposed waste was evident at the surface of the site.

The site is in a sensitive location with a wetland and stream to its southwest and housing very close to the western edge. Any gas or leachate generation would therefore have the potential for significant impacts. There is no monitoring data, current or historic, to assess the pollution status of the area. The restoration of the site was either poorly undertaken at the time of closure or subsequent disturbance has disrupted the work to the extent that the site is not in a satisfactory post closure condition.

To confirm the status of the site audit monitoring for gas and leachate is recommended. With the current exposed waste on the surface, particularly the glass, the site is also a potential safety hazard to anyone occupying the area. A revised restoration scheme should therefore be developed and implemented for the site.

4 TRAFFIC IMPACTS - MAHÉ WASTE COLLECTION SYSTEM

Traffic impacts from the waste collection system are an area of specific potential concern from both current and future waste collection systems. Traffic impacts include;

- Increased congestion on the road network.
- Increased risk of road accidents and reduced safety of other users.
- Noise and vibration impacts to properties along the collection routes, and
- Reduced air quality from exhaust fumes due to increased traffic volume.
- Leaking of 'juices' from some waste collection vehicles.

The scale of the potential impacts relates to the number of traffic moments on each road section, the existing traffic flows on these sections, the size and layout of the roads, the location of sensitive properties and the size of the vehicles used.

As part of this study a detailed assessment of each of these potential impacts for every section of road used cannot be undertaken. However, an overall assessment of the potential for significant impacts to occur is undertaken and the need for more detailed studies or remedial measures set out where appropriate. The initial focus of the assessment is therefore to gain an understanding of the road network and establish a likely volume of traffic movements generated by the waste collection system.

Although unsightly and possibly an occasional nuisance the leaking of expressed liquids ('juices') from transported wastes is not considered to be a significant hazard due primarily to the disparate nature of such occurrences and the fact that such liquids are unlikely to be highly polluting unless the wastes concerned are particularly hazardous or highly decomposed.

4.1 Waste Vehicle Traffic Movements

The site receives waste from two primary sources, i.e. the regular public and private bin collections undertaken by Star or its subcontractors, and private waste brought to the site by vehicles not controlled by Star. For the period January to September 2003 the average number of loads per day, from all sources entering the site, was approximately 105. This ranged from 86 per day to 115 per day although seven of the nine months are between 101 and 112 loads per day. The bulk of this waste consists of three primary waste streams, the standard bin collection (average 18 loads per day), private contracts collection by Star (average 14 loads per day) and general industrial and commercial waste from local businesses (average 55 loads per day). As is clear from this breakdown a majority of waste is from sources not controlled by the landfill operator. Accurate definition of where the main loads derive from is not therefore possible within the confines of this study

For the regular bin collections there are 9 individual collection routes serviced by small compactors or pick up trucks. The routes and trucks are set out in Table 2. This provides an indication of the potential road sections used by each lorry.

Table 2 - Bin collection routes and vehicles used

Area/Route	Contractor	Vehicle Details	Capacity	Crew Size
Victoria	STAR	Compactor with bin lift, 11488	5 tonnes	Driver + 2
Central	STAR	Compactor, 10573	5 tonnes	Driver + 2
North (main roads)	STAR	Compactor with bin lift, 12593	7 tonnes	Driver + 2
North (secondary roads)	Subcontractor	Pick up, 9927	3 tonnes*	Driver + 4
North and Central	Subcontractor	Pick up, 13978	3 tonnes*	Driver + 4
Central and East	Subcontractor	Pick up, 2351	3 tonnes*	Driver + 4
East	Subcontractor	Pick up, 7398	3 tonnes*	Driver + 4
West	Subcontractor	Pick up, 10149	3 tonnes*	Driver + 4
South (main and secondary roads)	Subcontractor	Pick up, 4477	3 tonnes*	Driver + 4

This accounts for only 17% of total traffic movement. For the bulk of the loads accessing the site detailed locations are not known. However, Victoria and surrounding areas represent the only major area of development on the island and are the focus of most industrial and commercial activity. A majority of the waste will therefore derive from this area.

4.2 Road Network

Due to the steep terrain on Mahé the main road network is restricted to the perimeter coast road and five main crossing routes running from the east to west coasts. A network of smaller distributor roads and feeders from these main routes service the main residential and commercial/industrial areas.

The main road network is general a full two lane width (approximately 6 m to 8 m), tarmac surfaced and maintained in a reasonable order. From Victoria to the Providence site a new coast road has been constructed along the strip of reclaimed land that spans most of the north west coast of the island. This is a wide, relatively straight section of road allowing good traffic flows. From Providence to the airport this road becomes a twin lane dual carriageway.

Apart from this new section of road the main network winds around the island with few long straight sections. As most of the built development is along the coastal strip, this road network also passes the main developed areas and the district centres. On the five crossing points, built development is less common but the roads are very steep and require frequent sharp bends as the roads climb up the central hills. Again road widths are good allowing vehicles to pass in each direction although on the sharp bends, larger vehicles cut across lanes to negotiate the corners.

The feeder road from this main network to the various residential and commercial areas around the island tends to be narrower twin or single-track roads with occasional passing places. Again many are tarmac surfaced but this network includes graded, unsurfaced roads.

4.3 Existing Traffic Flow Data

No current traffic flow data were identified during the site visit. Direct comparisons of traffic flows are not made. However, within the main centre of Victoria and the surrounding industrial and commercial areas traffic flows are heavy (in relation to road capacity) at rush hour causing congestion at the main junctions. During the normal working day regular traffic movements are lower and were assessed in these areas (from short term roadside observations) as being within the order of 60 to 120 traffic movements per hour. On the more remote sites away from the east coast, movements were significantly less, however, no assessment was undertaken.

For detailed traffic impacts assessment all main road networks would require monitoring of existing traffic flow.

4.4 Traffic Impacts Assessment

This generic impacts assessment is divided between the main road network around the east coast, the perimeter and crossing network and the smaller feeder roads. To conduct this assessment an initial estimate of the direction of traffic leaving the site is also made. Based on an estimation of population split, it is assumed that 80% of loads entering the site arrive from the northwest (Victoria direction) and 20% arrive from the southeast (Airport direction). An eight hour working day is also assumed and that one load equates to two traffic movements, one into the site and one out. Taking 105 loads, total movements are therefore 210 with approximately 170 from the northwest and 40 from the southeast.

Based on the eight hour operating day this equates to 21 movements per hour to and from the northwest, and 5 movements per hour to and from the southeast

East coast road and Victoria

All waste vehicles must use this road system to access the site. Therefore the full 210 movements per day, 26 per hour, must use this road. As noted in section 4.2 this road network is constructed along the reclaimed land formed off the original coast. This is a wide, good quality, straight section of road including a dual carriageway section from Providence to the airport. This road also has limited development along its length. This road has ample capacity to carry the 26 loads (or 21 and 5 from each direction) and therefore impacts on this section prior to first turn offs will be insignificant.

As the road enters the Victoria areas routes will divide. By Mont Fleuri a junction feeds north into the industrial estate and new port area and to the south into Mount Fleuri and the La Misere route to the west coast. At the next junction, the roundabout at Le Chantier, the route splits further via 5th June Avenue to the north of Victoria and to the northern section of the island, via Francis Rachel or Liberation Avenue to the town centre and to Sans Souci and the pass to Beauvallon.

It is not practical with the currently available data to assign traffic movement to each of these routes. However with estimates of approximately 21 movements per hour travelling to and from this centre, waste traffic flows on any one spur leading off these junctions will be significantly less than this total. Waste collection requirements are spread across this area and the route through to other parts of the island, and as such distribution of waste lorries to all routes will occur.

As noted a quantitative evaluation of impacts in this area is not possible, however, an initial evaluation from the above data indicate that significant problems are unlikely. The likely traffic movement per hour on any one section of road will be in the order of 10 to 12 (5 to 6 in each direction). The roads in this location are all twin carriageway width and are subject to the highest traffic flows on the island. Traffic flows from waste vehicles will therefore be low in overall terms and represent a small proportion of the current traffic flows. The conclusion is therefore that impacts are unlikely in terms of noise, vibration and increased safety risk. However additional traffic at peak time, morning and afternoon rush hour, may increase congestion at the main junctions. That stated, it is considered that impacts from the waste traffic will not be sufficient to justify a full TIA on any specific road spur or junction and remedial road design improvements unnecessary in relation to waste traffic volumes alone.

Main coast and crossing roads

On the main coast roads and crossing routes, carriageway widths are generally 6 m to 8 m allowing good two way flow of traffic. Only on sharp bends will restrictions to this two way flow occur where heavy vehicles are negotiating these corners. The coast road in particular does pass a large number of houses and business/hotel premises so is sensitive to increased traffic flows.

For routes southeast of the landfill site, assumptions for this study indicate that traffic movements for waste vehicles will be in the order 5 per hour on the main road leaving the

landfill site. As with the routes northwest, traffic flows will be distributed to feeder roads and the routes across the island. Flows to the estimated maximum will therefore only occur from the landfill site to the first main junctions.

Traffic flows on the coast road north from Victoria are not known however as a bulk of the waste generated will come from the greater Victoria area, traffic flows beyond this are unlikely to exceed the predicted flows to the south. Impacts are therefore assessed based on the maximum five movements per hour. Waste traffic flows will reduce the greater the distance from the disposal site. The area furthest from the landfill will therefore have the least waste traffic movements.

As with the east coast road, the predicted level of waste traffic flow is insufficiently high to cause any of the identified potential impacts. These roads are the main transport routes around the island and therefore carry most existing traffic flows. Waste traffic movement are therefore likely to be low both in overall terms and in relation to existing traffic movements. The only potential impact is on increased congestion, as the waste lorries have to make regular stops to pick up bins. These roads have few, long straight sections and therefore if the bin locations are such that a clear view along the road, allowing safe passing of the waste vehicle, does not exist, then an increase in congestion or safety risk may arise. From an initial review of bin locations some were identified in such locations.

Local feeder roads

Most feeder roads in residential areas will be subject to only one or two collection loads per day. Irrespective of road layout, condition, etc. this will not have any significant impact on local properties in relation to noise, vibration or fumes. Lorries are small (maximum 7 tonnes) and the frequency very low.

The only potential impact is on small roads with a lack of passing places where local traffic may get stuck behind the collection vehicle either travelling slowly or at a stop point to empty bins. This is a local issue that would require identification by the residents involved and if appropriate (and where practical) additional passing bays may be installed.

Conclusion

For a more detailed analysis to be undertaken traffic count data will be required and more defined route analysis for the waste vehicles established. Coupled to this the key routes should be identified where impacts are of concern or are likely to be most significant and carriage and junction design assessed. However from this initial review of traffic impacts arising from the movements generated as part of the waste collection system, such a study is considered unnecessary.

Overall traffic flows are generally low in relation to the highway capacity and in relation to estimated current traffic movements. Impacts that are identified relate solely to the nuisance caused by increased congestion at key junctions or at bin collection points where passing is difficult.

4.5 Secondary Impacts

The collection system can cause secondary impacts not directly related to the highways. These arise from the use of inappropriate vehicles for collection leading to the potential for waste materials to be deposited on the highway causing potential health and safety and visual impacts. Collection lorries should be fully enclosed to ensure waste can be loaded and transported without the possibility of waste deposition onto the highways. Minor impacts of this nature were observed during the site visit.

The second impact related to collection systems timing. In tropical climates waste degradation, particularly food waste, is very rapid and such wastes will generate smells that are unpleasant for any neighbouring properties. It is understood that all bin wastes are

collected on a daily basis so this impact should not arise. However performance of collection must be maintained to ensure this level of service is achieved.

Appendix C: Workshops

WORKSHOP 1; PROBLEM ANALYSIS

THURSDAY 23 OCTOBER 2003

Problem Analysis and Strategy Development Workshop: Thursday 23 October 2003

Purpose of the Study

The Environmental Management Plan of Seychelles 2000 – 2100 says:

'The principal objective of Government's policy is to collect, treat and dispose of all the solid waste generated in a sustainable manner by the year 2010.'

Scott Wilson role

Scott Wilson has been commissioned to:

- Investigate the current situation
- Identify options for future waste management
- Prepare a strategy report

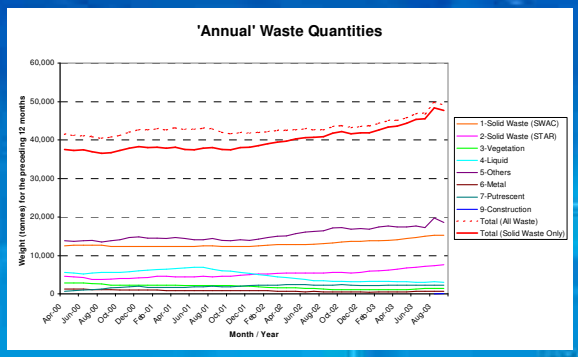
Workshop aims and format

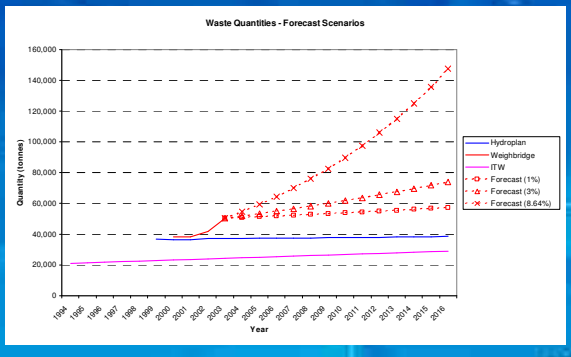
- Problem analysis and strategy development.
- Exchange of information and ideas.
- Programme: Three sessions covering
  - Existing situation
  - Problem analysis
  - Option identification
  - Evaluation criteria
- Team

Appreciation of the Existing Situation

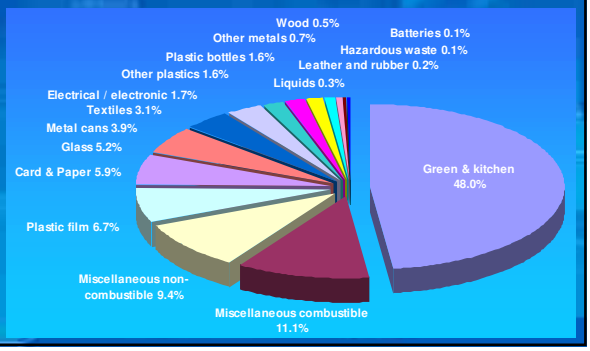
Data availability

- Basic weighbridge data from Providence appears reliable and gives a good understanding of the situation in Mahé
- Figures on waste arisings from ports, airport and hospital less well understood
- Figures for Praslin and La Digue also not accurately known





Household / Commercial Waste Composition



Collection

- Household waste & litter bins collected daily
- Industrial / commercial waste collected as contracted
- Collection vehicles
  - STAR owned refuse compactor vehicles
  - Sub-contractors operating open pick-up vehicles
  - Other contractors with compactor vehicles and open pick-ups
  - Open skips, compactor skips and tankers

Separate collection

- Initial separate collection trials by STAR/SWAC have proved partially successful, showing that householders are capable of achieving high levels of segregation
- Metal tends to be collected outside of the household waste collection system (except for bulky waste)
- There appears to be potential for additional separation of compostable materials (green and food wastes) but at the present time this may constrained by the lack of available outlets

Recycling

- The potential for recycling on Seychelles appears limited due to the high costs of transportation to suitable markets and the small quantities of material – which leads to lack of interest by recyclers. This applies to glass, paper and plastics, although glass may have use on the islands
- There is a market for metals
- Compost also has a market, although this may be limited within the Seychelles, especially at the prices currently sought. Attempts are being made to find outlets in the Middle East

Waste Disposal

- Mahé
  - Landfilling of the majority of wastes at:
    - Providence
    - Anse Royale
  - Incineration of certain wastes (some hotels and hospital)
  - Composting of green waste
- Praslin
  - Dump at Amitie
- La Digue
  - Landfill

Waste Disposal / Landfill

Mahé: Providence

- Operated in cells
- Waste compacted to maximise void utilisation
- Waste covered to reduce nuisance
- Some liquid waste disposal
- Adjacent to the sea
- Unlined (no leachate control)
- Near to airport
- Land in government ownership
- Limited environmental monitoring
- Future planning of disposal
- Approximately 2 years void space remaining

Mahé: Anse Royale

- Sanitary landfill (funded by EU)
- Pre-selected inert waste disposal

Praslin

- Open dumping; limited control
- Waste deposited into excavations below water table
- Some waste compaction
- Some future planning
- Unknown lifespan

La Digue

- Small size sanitary landfill (funded by EU)
- Lined with plastic sheeting
- Leachate collection and recirculation
- No weighbridge
- No environmental monitoring
- Approximately 2 – 3 years void space remaining

Plans for future incineration

- Some waste is incinerated at hotels
- Programmes have been put forward for several new incinerators – at the airport, sea port, La Digue, hospital, hazardous waste etc.
- None of the currently envisaged incinerators would meet current EU standards. To do so would be very expensive

Healthcare waste

- The new incinerator at the hospital appears to be terminally damaged: had it still been working, it probably would not comply with modern EU standards for emissions
- An old incinerator is used for some materials – probably dressings etc (although exactly what these materials are is uncertain)
- Remaining waste (including sharps) is landfilled at Providence, much reportedly by being placed in the household waste bins
- A segregation procedure exists but there is evidence that it is not being followed

Sludges and Used Oils

- PUC accept most septage at Providence WWTP
- Some liquid wastes are still disposed of at the landfills on Mahé and Praslin
- Used oils are currently shipped to Réunion where they are treated to remove water and solids and then burnt for power generation, except for the power station which has its own incinerator

Environmental impacts

- Dilute and disperse
  - Groundwater pollution
  - Impact marine environment
- Air pollution
  - Localised odour
  - Uncontrolled gas emissions
- Site monitoring
  - No monitoring to quantify impacts
  - Affects closed and current sites

Legislation and regulation

- EPA 1994 provides wide powers to control litter and illegal waste disposal
- SWAC established by regulation to ensure service delivery and monitor quality of service
- SWAC also has powers to authorise specific waste management facilities, which could be interpreted as a permitting system
- SWAC recently re-integrated with MoE
- Some overlap between roles of SWAC and MoE inspectors

Human resources

- SWAC is well-resourced for its inspection tasks, which it appears to perform effectively
- Neither SWAC nor MoE inspection appear to have sufficient training in the principles of design and operation of waste management facilities, especially landfills
- MoE has limited experience with specific waste management issues, especially on technical aspects
- SWAC has also recently lost much technical expertise

Contractual arrangements

- STAR has (nearly?) exclusive contract for all waste management on Mahé and ad-hoc arrangements on Praslin & La Digue
- Specifications for most of STAR's tasks exist
- Some issues in the contract unclear e.g. relating to residual liability for the landfills.
- Government financial constraints are preventing STAR from realising all its intentions (if the situation becomes worse, service quality could fall)

Stakeholder awareness

- The general level of public awareness about both the environment and littering is very high in the Seychelles – probably better than in many parts of Europe
- The recycling fair and Clean up the World campaign are both well supported, with the Minister and PS leading from the front

Are we right so far?

Problem analysis

Problem Analysis

- **Problem analysis is a technique for:**
  - Analysing the *existing situation* surrounding a given negative condition.
  - Identifying the *major problems* in this context.
  - Defining the *core problem* of a situation.
  - Establishing a hierarchy of *cause and effect* relationships for the major problems identified.

Problem analysis

The basic purpose of problem analysis is to identify and define clearly all of the significant problems, constraints and deficiencies associated with the existing situation. A problem is not the absence of a solution, but an existing negative state.

Example:-

- **Existing facilities for treating & disposing of wastes are inadequate - *Wrong***
- **Wastes are not managed in a safe and/or environmentally-sound manner - *Right***

Problem analysis

- **A comprehensive strategy for remedying an existing negative condition needs to identify and address all significant problems, and establish a hierarchy of cause and effect relationships.**
- **An effect means a direct consequence or impact of a negative condition.**
- **In order to eliminate or mitigate an adverse effect, it is necessary to devise and implement measures which specifically address the underlying cause of that effect**

Problem analysis

Example:-

The pollution of ground and/or surface waters arising from the disposal of wastes is an adverse effect or consequence of which underlying cause(s):

- **A lack of proper waste disposal facilities ??**
- **Poor management / operation of existing waste disposal facilities ??**
- **Inadequate monitoring of existing waste disposal facilities ??**
- **Regulations and standards governing waste disposal are inadequate and / or not enforced effectively ??**

Problem analysis

- **Matrix analysis can be used to identify**
  - **principal areas of concern**
  - **key problems for each area**
  - **their main underlying causes**
  - **their significant effects**
- **All significant aspects or activities concerning wastes management e.g. financing of waste management facilities and services can be included.**

Problem analysis

Simplified example:

Area or Activity	Key Problems	Principal Causes	Principal Effects
Institutional Framework	National policy on wastes management (WM) not sufficiently developed.	Existing policy does not address all key areas of performance for wastes management.	No clear basis for determining priorities, performance requirements or targets.
	Existing legislation governing waste management inadequate.	Proposed new legislation not yet implemented.	Required standards for WM are difficult/impossible to implement and enforce.
Waste Arisings	Data sources, nature and quantities of wastes are inaccurate and/or unreliable.	Regular monitoring of waste types and quantities is not carried out effectively.	Planning, management and control of wastes management services is made more difficult.

Problem analysis

Area or Activity	Key Problems	Principal Causes	Principal Effects
Waste Avoidance	Waste producers are not aware of potential opportunities for, and benefits of, avoiding wastes.	Information on opportunities and techniques for wastes avoidance is not generally available. The true costs of environmentally-sound wastes management are not perceived or met by waste producers.	Resources, including resources for wastes management, are not used efficiently. Requirements for wastes treatment and disposal are higher than need be.
Segregation and Recycling	Limited or no demand for some recyclable materials.	Low quality and market value of some recyclable materials. Lack of local market outlets for some recyclable materials.	Without intervention, scope for further recovery and recycling of some materials is severely constrained.
Wastes Treatment and Disposal	Wastes are not treated and disposed of in an environmentally-sound manner.	Legislation and standards not effectively enforced.	Pollution of air, water resources and land.

Problem analysis – Stage 1

- **Try to identify and agree the core problem relating to waste management in the Seychelles**

Problem analysis – Stage 2

Then, try to identify, define & agree the key existing problems and their underlying causes in the following areas:

- Policy & legislative framework
- Institutional & organisational arrangements
- Data availability & monitoring
- Public awareness and communication
- Waste prevention / reduction / recycling
- Financing / cost recovery
- Waste storage, collection & transport
- Waste processing / treatment & final disposal

WASTE MANAGEMENT OPTIONS

Waste Management Options and Scenarios

- **An *option* is one discrete process for managing waste, such as:**
  - **Incineration**
  - **Organising the service provision**
  - **Separate collections**
  - **etc**
- **A *scenario* is a set of options which taken together will enable the waste to be managed, e.g. it may consist of waste minimisation, recycling at a specific facility, composting and landfilling of residues.**

The *preferred scenario* is the particular scenario that offers the optimal efficacy considering all the issues.

Waste Management Options - 1

- **Minimisation**
  - **Limiting / prohibiting the importation of certain products; purchase selection, tariffs, etc**
  - **Home composting**
- **Storage / Collections**
  - **Island transfer**
  - **Frequency**
  - **Different bins for different fractions**
  - **Local collection sites**
- **Separation Facility**
  - **Materials segregation**
  - **Recyclate market development**

Waste Management Options - 2

- Treatment
  - Pre-treatment of organics (volume reduction)
  - Anaerobic digestion
  - If a small treatment plant were installed, could used oils be used as fuel for the incineration of other materials such as hospital waste
- Final disposal
  - Landfilling (standards and locations)
  - Effective utilisation of Anse Royale
  - Incineration; local or centralised (economies of scale and also the ability to control the environmental impact), energy recovery
  - Pyrolosis / gasification

Waste Management Options - 3

- Organisational
  - Separating the roles of regulation / enforcement and service provision / management
  - Combining resources and skills
  - Public / private sector contract arrangements
- Education
  - Training / capacity building: who?
  - Public sensitisation

Waste Management Options

- Suggestions?

Suggested evaluation criteria

Consistency with policy

- EMPS, which required waste management to sustainable by 2010
- ITW Master Plan – recognised to require updating
- SWAC strategy

Technical suitability

- Must be technically suitable for the specific conditions (e.g. climate, topography) found in Seychelles
- Certain high technology solutions may also present problems in terms of technical capacity and support.

Land use

- Suitable flat land for the establishment of waste management facilities is in short supply
- Much of this land already occupied by, or in close proximity to, residential development
- There are constraints from a land use planning point of view (development and environment)
- Proximity principle applies – waste should treated close to its point of generation

Operational reliability and security

- Seychelles, being a group of isolated islands, cannot readily accept emergency waste management assistance from elsewhere, as is the case in larger countries.
- Operational reliability is therefore a prerequisite of any waste management system that is selected. For this reason, only truly proven technology can be contemplated.

Environmental performance and risk criteria

- No uncontrolled releases to air or water
  - Fully lined facilities?
- No negative impacts on health and welfare of population
  - Adopt appropriate standards for releases (national or international)
- No significant detriment to Seychelles wildlife
  - Planning controls
  - Operational management controls
- Adhere to sustainable land use principles
  - Brownfield land use
  - Closure planning prior to operation

Public acceptability

- Any option that is to be implemented must be acceptable to the public, based on their perception of what is right for the Seychelles community.
- This will, no doubt, involve environmental and possibly economic judgements.
- It should be recognised that public opinion can be influenced by a well managed communications campaign.

Cost and cost-effectiveness

- Cost and cost effectiveness will clearly be one of the most important criteria.

Long term sustainability

- Social
- Environmental
- Financial
- etc

Weighting

- Some of criteria are more important than others and we need to agree the relative weighting to be applied
- An example:

Criterion	Weighting
Consistency with policy	15
Land use	10
Technical suitability	10
Reliability	10
Environmental performance	10
Public acceptability	5
Cost	25
Sustainability	15

SCOTT WILSON KIRKPATRICK & CO LTD
SEYCHELLES SOLID WASTE MANAGEMENT STRATEGY JOB NO: D103247

Solid Waste Management Workshop
23 October 2003 – Victoria Conference Centre, Victoria, Mahé, Seychelles

Attendees

1. Kantilel Jivan Shah - Chamber of Commerce [322310]
2. Nicholas Shamlage - Ministry of Health – Environmental Heath [388079 / 388191]
3. Patrick Appoo - SMB Trading [715054]
4. Steve Mussard - PUC (Water) [smussard@puc.sc]
5. Jude Anglousa - PUC (Electricity) [713029, janglousa@puc.sc]
6. Rajiv Goloressoo - SAMLO & Sons [516918 / 266725]
7. Tania Laporte – SWAC [225114, swac@seychelles.net]
8. Berry Aniat – SWAC [225114, swac@seychelles.net]
9. Marie – Vonne Auguste - Seychelles National Youth Association (SNYA) (Works for Ministry of Agriculture) [371290 / 226252, SNYA@seychelles.sc]
10. Mohammad Ferozuddim - Visitor from India with Ministry of Education [767600, mdferozuddin@yahoo.co.in]
11. Thomas Forgacs – STAR Seychelles [521059, starsey@seychelles.net]
12. Maurice Loustau-Lalanne – PS, Ministry of Environment
13. Sandrine Vaneph - Local waste management consultant [247423, sandrine@vaneph.com]
14. Jude Florentine – DG – PCEI, Ministry of Environment [722452]
15. Maltér Henry – Seychelles resident [718936]

Consultant Team – Scott Wilson

Barry Gore
Nicholas Crick
Matthew Polson
Jeremy Short
Annette Hill

Welcome – Jude Florentine (Ministry of the Environment, Seychelles)
Welcome to the workshop
Thanked Consultant Team and Stakeholders for attending

Introduction – Barry Gore (Consultant Team)
[For presentation details see slides]
Introduced Consultant Team Members to the Attendees.
The Environmental Management Plan for the Seychelles 2000 to 2010 states that the Seychelles shall have a sustainable solid waste management strategy by 2010.
Described the role of the Consultant Team.
Workshop aims and objectives.

Introduction of all workshop attendees.

Appreciation of the Existing Situation – Matthew Polson (Consultant Team)
[For presentation details see slides]

Feedback from session:

Presentation raised issue of significant growth in waste volumes since 2002. Possible reasons discussed:
Maurice Loustau-Lalanne:

- STAR added 600 more bins to household waste sites in January 2003.
- Initially STAR/contractors were paid a fixed rate for collection. Now they are paid by tonne of waste collected.
- Larger skips have been introduced.

Kantilel Jivan Shah:

- Increased public education.
- New and more active NGOs including education programmes for school children.

Nicholas Shamlage:

- There is an ongoing waste prevention programme (focuses on litter), beautification programme, rodent control.
- Programmes are monitored by SWAC, who also carry out public education.
- People are aware of the problems of waste in relation to health issues.
- The mentality of the Seychellois population is that as long as they keep their own gardens and houses clean, tidy and free of litter then they do not need to concern themselves with other areas.
- Public littering is increasing significantly.
- Need an increase in public awareness.
- Seychelles has a public liaison programme.

Maurice Loustau-Lalanne:

- Issues relating to the waste dump at Praslin:
    - Last year there were two trial periods where weighbridge data for waste entering the Praslin dump was recorded.
    - A survey plan for the site is available.
    - Survey suggests an estimated remaining volume of 100,000m3, corresponding to a finished level of 9m. From this volume a compaction factor was used to estimate the remaining life of the site to be 10 years.
- Issues relating to medical waste management:
    - His understanding was that all medical waste was collected separately in yellow bags and taken to the hospital for incineration.

Matthew Polson: From observation of waste collection and conversations with people involved that this segregation does not always happen.

Nicholas Crick: Commented that the new incinerator (approx. 3 years old) is now broken and the old incinerator is back in use. The breakdown of the new incinerator is potentially due to use by untrained operators and incorrect installation (it was not supplied installed and requires professional installation).

Maurice Loustau-Lalanne:
Site monitoring:

- Some site monitoring for heavy metals was carried out when the desalination plant was implemented.
- More monitoring and training in monitoring required.
- Open to suggestions to improve monitoring.
- Understands that the Providence 1 will need monitoring after closure, and that future landfills will require engineered liners etc.
- On Praslin the dumpsite has no liner and it will need attention and monitoring.

Comments on the relatively high quantities of waste generated on Praslin during the weighbridge trial compared to Mahé.

Kantilel Jivan Shah: Relatively high quantities of waste on Praslin may be due to the large number of hotel beds on the island.

Maurice Loustau-Lalanne: Need to factor in the waste produced by the storm at this time.

Matthew Polson: Also may be the result of the 'Clean Up the World Campaign'.

Maurice Loustau-Lalanne: The contract with STAR is for 20 years and they have completed 5 or 6 to date. The contract is currently being renegotiated due to the Governments current financial problems. The contract with STAR covers Mahé only (not Praslin and La Digue). On Praslin, STAR does some of the waste collection and also manages the dumpsite. The collection contract on Praslin will be put out to tender and STAR will be able to apply. STAR should continue to sub-contract some of the waste collection activities to enable local people to get work and experience.
Current financial constraints: The government have defaulted on payments of foreign exchange. The period up to December 2002 has been settled. An interim agreement has been set up for the period to January 2006, where the government will make some payments in foreign exchange. The government wants STAR to continue to invest and STAR have placed some orders to improve facilities. Over the period from 2003 to 2006 the government hopes to balance its foreign exchange debt by making cutbacks in spending and implementing a micro-economic reform programme.

Methodology of Problem Analysis – Nicholas Crick (Consultant Team)
[For presentation details see slides]

Core Problem Analysis – Group Discussion Session
Statements written on cards:

- Should adopt 'polluter pays principle'
- High waste production
- Proper waste treatment facility
- Lack of commitment from other departments (other government ministries)
- Waste water
- Collaboration between stakeholders
- Analyse waste
- Non-biodegradable waste (is what is seen in the countryside)
- Education of Seychelles people
- Public participation in storage, collection and disposal
- Inadequate public education on waste management at all levels
- Not sustainable in the long term
- Legislation and enforcement
- Recycling
- Attitude (particularly in relation to litter)
- Should analyse current situation

Discussion on Sustainability
Sandrine Vaneph: Long-term, at least 20 years, maybe 50 years, time over which we will know what waste treatment is being implemented and that it is being carried out in an environmentally acceptable manner.

Jude Florentine: must not compromise future generations.

Discussion concluded the following requirements of a sustainable system:

- Cost / affordability

- Technically appropriate
- Human resources (technical competence and appropriate use of trained human resources)

Individual Problem Areas – Break-out Discussion Groups

Group A: Chair –
- Polluter pays is necessary but not at the moment.
- Policy and legislation exist but are not enforced.
- Institutional framework – lack of clearly defined roles.
- Lack of trained staff.
- Inappropriate use of trained staff.

Group B: Chair - Annette Hill

Data Availability and Monitoring
- Need legislation / technical standards / enforcement for monitoring waste management facilities
- Require a better understanding of the waste composition to enable effective solutions to be identified.

Awareness and Communication
- Littering is considered to be a major problem that is getting worse despite education campaigns and fines.
- Littering will affect tourism. Littering is small in volume but big in impact.
- Littering by non-biodegradable waste is seen as the biggest problem – and hence non-biodegradable waste has a bad name!
- Require public education / awareness with deterrents / fines (linked to litter, use of household waste bin sites, source segregation of waste).
- Technical education requirements.
- Communication – technical and stakeholder involvement.

Waste Prevention / Reduction / Recycling
- Introduce Government control / ban on the import of non-biodegradable products (for example, Mauritius have recently banned the import of plastic bags and use paper instead).
- Source segregation of waste with deterrents / fines for non-compliance (as with litter).
- Compost ALL biodegradable waste (or significantly more than present).
- Need markets for recyclates.
- Barriers to recycling thought to be largely financial. Consider government or other sources of supporting funds.

Group C: Chair -
- Maintenance / cleanliness of bin sites.
- Not enough bin sites / inappropriate locations.
- Access to sources of waste generation.
- Usage of collection / storage by public and business.
- Collection vehicles not appropriate.
- Frequency of collection not always maintained – rodents, smell, aesthetics
- Storage, collection and transport of waste from Praslin and La Digue is not appropriate.
- Landfill location issues.
- Landfill void space limited – not sustainable.
- Environmental management of landfills is not appropriate.
- Limited sites for waste management.
- Praslin – uncontrolled landfill – not acceptable.
- La Digue – Collection unsuitable.

Identification of Relevant Waste Management Options – Barry Gore (Consultant Team) + Discussion
[For presentation details see slides]

Sandrine Vaneph: Disposal of sludges should be part of the waste management plan. Concerns over smell, pollution in landfill, and gases etc in incineration. She has previously worked with composting sludges but has come across problems with its use and public perception.

Identification of Criteria for Evaluation of Options – Nicholas Crick (Consultant Team) + Discussion
[For presentation details see slides]

Proposed evaluation criteria for discussion.

Criteria	**Weighting**
Consistency with existing policy	15
Technical suitability	10
Land use	10
Operational reliability and security	10
Environmental performance and risk criteria	10
Public acceptability	5
Cost and cost effectiveness	25
Long term sustainability	15

Jude Florentine: Land use weighting should be higher than 10 and cost should be the most important.

Closing Remarks – Barry Gore (Consultant Team)

Close – Jude Florentine (Ministry of Environment, Seychelles)

WORKSHOP 2; REFINEMENT OF SHORT-LIST / DEVELOPMENT OF STRATEGY

WEDNESDAY 21 JANUARY 2004

Updating the Solid Waste Master Plan for the Seychelles: 2003 -2010

Workshop 2: Refinement of Short-list / Development of Strategy

Barry Gore

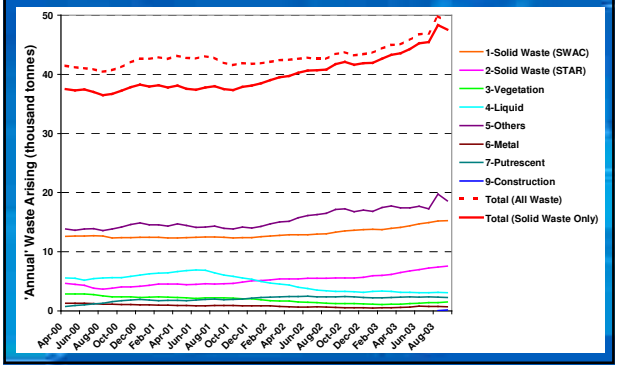
Waste Arisings

- Basic weighbridge data from Providence appears reliable and gives a good understanding of the situation in Mahé
- Figures on waste arisings from ports, airport and hospital less well understood
- Current annual waste arisings:

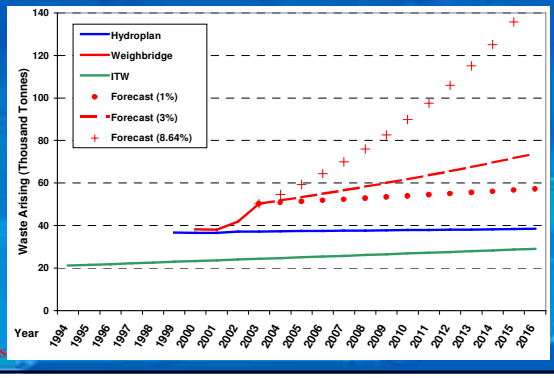
Mahé	Praslin and La Digue
45,300 tonnes	2,440 tonnes

Figures for Praslin and La Digue are estimates

Waste Arisings - Mahé

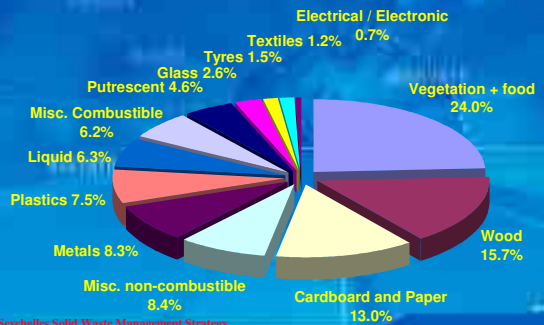


Waste Arisings - Forecast



Waste Composition - Mahé

Compiled from waste audits



Waste Collection

- Household waste & litter bins collected daily
- Industrial / commercial waste collected as contracted
- Collection vehicles
  - STAR owned refuse compactor vehicles (not sufficient quantity for all collections)
  - Sub-contractors operate open pick-up vehicles
  - Other contractors with compactor vehicles and open pick-ups
  - Open skips, compactor skips and tankers

Separate Collection

- Initial separate collection trials by STAR/SWAC have proved partially successful
  - Householders capable of high levels of segregation
- Metal tends to be collected outside of the household waste collection system (except for bulky waste)
- Potential for additional separation of recyclable materials
  - Which waste streams should be collected separately?

Reuse and Recycling

- Seybrew operate a successful deposit / return scheme for glass bottles. Similar scheme recently established for some plastic bottles
- Metals recovered by private operator and exported for recycling
- Some green waste composted at Providence
  - Market has been small so far
  - Current prices may be too high
- Further opportunities appear limited because
  - Small quantities of material
  - High costs of transportation to markets
  - Encouragement / support required?

Waste Disposal

- Mahé
  - Majority of wastes landfilled at Providence
  - Selected wastes to Anse Royale landfill (inerts)
  - Incineration of certain wastes
    - E.g. hospital and some hotels
  - Composting of some green waste
- Praslin
  - Dump at Amitié
- La Digue
  - Landfill

Waste Disposal / Landfill

Mahé: Providence

- Operated in cells
- Waste compacted to maximise void utilisation
- Waste covered to reduce nuisance
- Some liquid waste disposal
- Adjacent to the sea
- Unlined (no leachate control)
- Near to airport
- Land in government ownership
- Limited environmental monitoring
- Future planning of disposal
- Approximately 2.5 years void space remaining

Mahé: Anse Royale

- Sanitary landfill (funded by EU)
- Pre-selected inert waste disposal

Praslin: Amitié

- Open dumping; limited control
- Waste deposited into excavations below water table
- Some waste compaction
- Some future planning
- Unknown lifespan

La Digue

- Small size sanitary landfill (funded by EU)
- Lined with plastic sheeting
- Leachate collection and recirculation
- No weighbridge
- No environmental monitoring
- Approximately 2 years void space remaining

Incineration

- Some hotels incinerate their wastes
- PUC incinerate oil residues
- Programmes have been put forward for new incinerators – at the airport, sea port, La Digue, hospital, hazardous waste etc
- The incinerators currently envisaged would NOT meet EU standards
  - To do so would be very expensive

Healthcare Waste

- New incinerator at the hospital is damaged and unusable
  - Probably would not comply with modern EU standards for emissions
- Old incinerator used for some materials
  - Probably dressings etc (but not certain)
- Remaining waste (including sharps) landfilled at Providence
  - Often placed in the household waste bins
- Segregation procedure exists - but is not always followed

Sludges and Oils

- PUC accept most septage at Providence WWTP
- Some liquid wastes still deposited to landfill on Mahé and Praslin
- Used oils:
  - Power station has an incinerator to burn their used oils
  - Other waste oils collected by STAR and shipped to Réunion for treatment and incineration with energy recovery

Environmental Impacts

- Dilute and disperse
  - Groundwater pollution
  - Impact marine environment
- Air pollution
  - Localised odour
  - Uncontrolled gas emissions
- Site monitoring
  - No monitoring to quantify impacts
  - Affects closed and current sites

Legislation and Regulation

- EPA 1994 provides wide powers to control litter and illegal waste disposal
- SWAC established by regulation to ensure service delivery and monitor quality of service
- SWAC also has powers to authorise specific waste management facilities
- SWAC recently re-integrated with MoE
- Some overlap between roles of SWAC and MoE inspectors

Human Resources

- SWAC is well-resourced for its inspection tasks, which it appears to perform effectively
- SWAC and MoE have limited experience with specific waste management issues especially on technical aspects (such as landfill)

Contractual Arrangements

- STAR has a nearly near-exclusive contract for all waste management on Mahé and ad-hoc arrangements on Praslin & La Digue

Stakeholder Awareness

- General level of public awareness about the environment and littering is very high in the Seychelles – probably better than in many parts of Europe
- The recycling fair and Clean up the World campaign are both well supported, with the Minister and PS leading from the front
- Some larger industries have environmental management policies/systems

Updating the solid waste master plan for the Seychelles: 2003 - 2010

Phase 3: Refinement of Short-list / Development of Strategy

General Areas

- Institutional and management arrangements
- Technologies, systems and processes for waste handling processing and disposal

Problem Analysis

Key issues identified at the problem analysis workshop under the main aspects / activities:

1. Policy & Legislative Framework
2. Institutional / Organisational Arrangements
3. Human Resources / Capacity
4. Financing / Cost Recovery
5. Stakeholder Awareness & Communication
6. Data Availability
7. Waste Avoidance & Reduction
8. Waste Recovery & Recycling
9. Waste Segregation, Storage, Collection & Transport
10. Waste Treatment / Processing
11. Final Disposal

Problem Analysis

1 Policy & Legislative Framework

- Existing national master plan does not reflect the existing situation on waste management
- Enforcement of legislation relating to waste management is not effective
- Legislation does not adequately support some of the enforcement that is carried out
- Penalties for littering and fly-tipping are not sufficiently high to be effective

Problem Analysis

2 Institutional / Organisational Arrangements

- Contractual arrangements for service provision are not achieving the intended results
- Existing institutional / organisational responsibilities for waste management are not clearly defined between the various ministries and departments

Problem Analysis

3 Human Resources / Capacity

- Existing human resources in the public sector are unable to fulfil their regulatory duties completely
- Health and Safety issues have not been addressed

Problem Analysis

4 Financing / Cost Recovery

- The revenue flows from existing waste management charges are insufficient to be able to meet the full costs of providing a sustainable system

Problem Analysis

5 Stakeholder Awareness & Communication

- Stakeholders are not aware of the need for waste reduction
- General public do not have a sufficient awareness of the need to prevent littering

Problem Analysis

6 Data Availability / Reporting

- Available data on certain priority waste streams are not available
- No systematic environmental performance monitoring

Problem Analysis

7 Waste Avoidance and Reduction

- The potential for waste avoidance and reduction is not being exploited
- Many imported products have a short life before disposal

Problem Analysis

8 Waste Recovery & Recycling

- The potential for further waste recovery and recycling is not being realised.

Problem Analysis

9 Waste Segregation Storage Collection & Transportation

- Insufficient cleaning round bin sites
- Insufficient appropriate collection vehicles / systems used in Mahé and Praslin
- Frequency of collection not always maintained
- Insufficient number of bin sites

Problem Analysis

10 Waste Treatment / Processing

- Existing facilities / practices do not comply with sound environmental standards (nor good health & safety practices)
- Treatment facilities for hazardous wastes do not exist

Problem Analysis

11 Waste Disposal

- Existing facilities / practices do not comply with sound environmental standards.
- Existing facilities for final disposal do not have sufficient capacity to represent a sustainable solution

Strategy Objectives

The corollary of the problems are the strategy objectives

Essentially Waste Management in the Seychelles ought to be sustainable by 2010 (this is taken to mean that sufficient facilities and management systems should be in place to last for the next generation)

Institutional and Management Issues

1 Policy & Legislation

- Policy states that waste management will be sustainable by 2010 (EMP)
- Primary legislation satisfactory
- Develop technical standards
- Waste licensing (or contract conditions)
- More stringent enforcement

Institutional and Management Issues

2 Institutional & Organisational Arrangements

- SWAC retain responsible for ensuring waste is properly managed
- MoE responsible for policy and environmental protection
- Continue current waste service provision contract arrangements
- Greater co-ordination between ministries / departments

Institutional and Management Issues

3 Human Resources and Capacity

- Ensure all technical posts are filled
- Enhance training
- Ensure only trained staff operate plant, equipment and systems

Institutional and Management Issues

4 Financing & Cost Recovery

- Householders should make a direct contribution for full waste services (cost added to utilities bill?)
- Commercial & industrial waste producers should contribute to the cost of disposal

Institutional and Management Issues

5 Stakeholder Awareness & Communication

- Public awareness campaign related to waste reduction (and segregation when this is introduced)
- Education (linked to other regional initiatives)

Institutional and Management Issues

6 Data Availability & Reporting

- Collection of data on certain waste streams required (especially healthcare, port, harbour)
- Weighbridge for Praslin
- Formal records of volumes on La Digue
- Establish a data base of certain environmental parameters (especially around landfills)

Institutional and Management Issues

6 (cont) Environmental Monitoring

- Define a schedule of environmental monitoring requirements (especially around landfills)
- Establish / audit available testing and measuring resources (in the public sector)
- Consider pooling / co-ordinating such resources to enable routine monitoring of certain environmental parameters
- STAR to increase environmental monitoring

Waste Handling Processing & Disposal

Options for each phase of the waste management cycle have been considered

- Waste avoidance & reduction
- Waste segregation storage & collection
- Waste recovery & recycling
- Waste treatment & processing
- Final disposal

Coarse screening of non-viable options

Waste Handling Processing & Disposal

Waste avoidance & reduction

- Controlling material imports
- Import tariffs / charges
- Charging householders by waste quantity
- Limiting access to large containers
- Home composting
- Repair centres

Waste Handling Processing & Disposal

Waste segregation storage & collection

- Survival bags
- Separate collection rounds
- Amenity sites
- Central collection of hazardous waste
- Reduce collection frequency
- Collection vehicle types

Waste Handling Processing & Disposal

Waste Recovery & Recycling

- Return schemes
- Material Recycling Facility (MRF)
- Aggregate crushing

Waste Handling Processing & Disposal

Waste Treatment & Processing

- Incineration with energy recovery
- Incineration of other wastes (esp healthcare)
- Windrow composting (green waste)
- In vessel composting (green waste)

Waste Handling Processing & Disposal

Final Disposal

Mahe
- Providence II
- New site
- Anse Royale (disposal of MSW from South, incinerator ash, transfer station)

Praslin
- New landfill
- Incinerator

La Digue
- Incinerator
- Off-island transfer

Waste Handling Processing & Disposal

Evaluation Criteria

- Environmental Sustainability 50%
  - consistency with policy 5%
  - sustainability 20%
  - environmental performance 25%
  - land-use 10%
- Practicality 25%
  - technical suitability / reliability 15%
  - land-use 5%
  - public acceptance 5%
- Cost & Cost Effectiveness 25%

Waste Handling Processing & Disposal

Avoidance & Minimisation

- Imposition of tariffs on potentially polluting imports
- Encouragement of home composting

Waste Handling Processing & Disposal

Separation Storage Collection & Transport

- Separate collection of green / bio waste
- Replacement of existing collection vehicles with purpose built compactor fleet
- Reduce frequency of collection in future

Waste Handling Processing & Disposal

Recovery & Recycling

- Collect all reusable glass bottles
- Extend the collection of plastic bottle recovery
- Encourage others to enter the recycling market (paper?)
- Develop bring sites (green, glass, plastic and C&D)

Waste Handling Processing & Disposal

Treatment & Processing

- Enhance composting at Providence
- Introduce composting on Praslin
- Crush and screen (and re-use) C&D waste
- Incineration of healthcare waste (together with air and harbour wastes)

Waste Handling Processing & Disposal

Final Disposal

- New landfill (Providence II)
- New engineered landfill on Praslin
- Future transfer of waste from La Digue to Praslin
- Anse Royale (landfill for south / transfer station / fly ash disposal in the future)
- Rehabilitation of closed dump sites
- Mass incineration of waste on Mahe and Praslin in the future

Updating the solid waste master plan for the Seychelles: 2003 - 2010

The next steps

- Agree key components
- Develop strategy

Updating the solid waste master plan for the Seychelles: 2003 - 2010

Discussion Topics

General Areas

- Institutional and management arrangements
- Technologies, systems and processes for waste handling processing and disposal

Institutional and Management Issues

- What environmental standards should be adopted?
- Charging waste producers (including householders)?
- More competition in waste service provision?

Waste Handling Processing & Disposal

Waste avoidance & reduction

- Import tariffs / charges on which items?
- How should home composting be encouraged?
- Repair centres for which items?

Waste Handling Processing & Disposal

Waste segregation storage & collection

- Separate collection rounds
- Amenity sites: where located and what collected?
- Reduce collection frequency?

Waste Handling Processing & Disposal

Waste Recovery & Recycling

- How should recyclers be supported?
- Public education

Waste Treatment & Processing

- Public acceptability of incineration (with energy recovery)
- Incineration of other wastes (esp healthcare)
- Compost utilisation increase?

Final Disposal

Mahe

- Providence II
- Anse Royale (disposal of MSW from South, incinerator ash, transfer station)

Praslin

- New landfill
- Incinerator

La Digue

- Incinerator
- Off-island transfer

WORKSHOP 2

Wednesday 21st January 2004

Attendees:
Jude Florentine (MoE)
Barry Joseph (SWAC)
Thomas Forgacs (STAR)
Nadine Dulac (TA MoE)
Jean-Paul Adam (Min of FA)
Lyn Bastienne (education, information & communication officer MoE)
Sandrine Veneph (STAR)
Nicholas Shamlege (plus ano: Min of Health)
BCG

- Efficacy of previous waste separation trials largely unknown; heresay only; no hard data or records. [NB this is a common result of many such initiatives].
- Cattle egrets important for pest control on landfill.
- Height limit of 12m (ASL) of landfill agreed between Airport Authority and MoE; details of reasoning unsure. (Post meeting note: Jude confirms this not formally recorded).
- Licensing Act covers requirement for businesses to provide for waste management / collection. (Post meeting note: couldn't find it in the text).
- Public Health Act also covers some waste management aspects.
- 'Task forces' cover waste misdemeanours.
- Competition already exists for waste collection.
- Considered impossible to put tariffs on certain imports (WTO; Seychelles to join soon) better to put outright ban on polluting substances; but too many loopholes in either case. [NB some illegal pesticides brought in from Mauritius]. There used to be a prohibition on ?crisp / snack packets but faded away.
- Composting at home should not be a major initiative; many households are on small plots, also many new flats etc. Also there would be a lack of sustainability to government support.
- Daily collection of household waste is important; ie may be some considerable time before collection frequency could diminish.
- Any separate collection (of green waste) should be introduced in selected areas only and only after careful monitoring and assessment of efficacy. A green bin may be appropriate. [NB homes would have to have a separate bin in the home for this].
- Access routes in south difficult for collection vehicles.
- Some recyclable waste is being stored at source of production awaiting recycling schemes / markets? Idea of recycling credits to encourage recycling activity favourable. NB Paper recycler not progressed beyond planning application (apparently successful but not pursued: unknown why). [Post meeting note: scheme proponent subsequently consulted].

Appendix D: Incinerator

The pictures below display how an incinerator for the treatment of healthcare and port and Harbour wastes might appear.

Overall view of a similar plant in Qatar

Detailed view of plant with loading ram

View of Container tippler

Appendix E: Financial Evaluation Models

Financial Evaluation Model Printouts:

- ***Essential Elements Only***
- ***Essential Elements plus Key Desirable and Optional Elements***

Financial Evaluation Models Diskette

Financial Evaluation Model Printout

Essential Elements Only

Financial Evaluation Model - Essential Elements Only

Key Input Data

Operator profit		15.0%
Interest rate		11.0%
Waste reduction:	**MSW**	0.5%
	Industrial	1.0%
	Euro	**€1 = SCR** 6

Wage rate for labourers	3,000	**Rupees/month**
Wage rate for drivers	3,750	
Fuel price (excluding tax)	€ 0.93	

0
1

Financial Evaluation 2005-2015

To select landfill or transfer for La Digue, use buttons on Data sheet

Essential Elements

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Technical assistance											
Design and tender documentation for incinerator	€ 100,000	€ 54,000									
Design and tender documentation for Providence II	€ 200,000	€ 100,000									
Design and tender documentation for Amitie	€ 200,000	€ 100,000									
Design and tender documentation for La Digue landfill extension / transfer to Praslin	€ 45,000	€ 24,000									
Education and sensitisation	€ 20,000	€ 20,000	€ 20,000	€ 15,000							
Training for SWAC & ISO 14000 (3 years)	€ 20,000	€ 19,000									
Renegotiation of STAR contract	€ 60,000										
EIA	€ 90,000										
Tender documentation	€ 50,000										
Introduction of user charge	€ 10,000	€ 20,000	€ 20,000								
Preparation of tender document for supplies		€ 20,000									
Capital expenditure (works)											
Special incinerator		€ 935,000									-€ 467,500
Providence II Landfill		€ 1,000,000	€ 322,500								
Praslin Landfill (Amitie)			€ 1,000,000	€ 180,000							
La Digue landfill extension			€ 150,000	€ 18,000							
La Digue transfer (1 RCV)				€ -							
Supplies											
Provision of the collection vehicle for health care waste			€ 30,000								
Provision of enclosed containers for healthcare waste collection			€ 20,000								
Total Funded activities	**€ 795,000**	**€ 2,292,000**	**€ 1,562,500**	**€ 213,000**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**-€ 467,500**
Cash operating costs											
Special incinerator			€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000
Healthcare waste collection			€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500
Providence 2 Landfill operation + restoration/aftercare provision (€8.16/t)				€ 144,535	€ 148,149	€ 151,853	€ 155,649	€ 159,540	€ 163,529	€ 167,617	€ 171,807
Praslin Landfill (estimate - operation & R&A)				€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000
La Digue landfill extension (estimate - operation & R&A)				€ 30,000	€ 30,000	€ 30,000	€ 30,000	€ 30,000	€ 30,000	€ 30,000	€ 30,000
Transfer from La Digue				€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Total	**€ -**	**€ -**	**€ 37,500**	**€ 282,035**	**€ 285,649**	**€ 289,353**	**€ 293,149**	**€ 297,040**	**€ 301,029**	**€ 305,117**	**€ 309,307**
Total Cash Costs	**€ 795,000**	**€ 2,292,000**	**€ 1,600,000**	**€ 495,035**	**€ 285,649**	**€ 289,353**	**€ 293,149**	**€ 297,040**	**€ 301,029**	**€ 305,117**	**-€ 158,193**
Total tonnes	51,663	52,805	53,972	55,166	56,386	57,633	58,909	60,213	61,546	62,909	64,302
NPV - all waste management activities	**€ 4,841,711**										
AIC - all waste management activities	**€ 13.81**	**per tonne**									
AIC for Providence 2											
Tonnes				17,708	18,151	18,605	19,070	19,547	20,035	20,536	21,050
Costs	€ 200,000	€ 1,100,000	€ 322,500	€ 144,535	€ 148,149	€ 151,853	€ 155,649	€ 159,540	€ 163,529	€ 167,617	€ 171,807
NPV	**€ 1,894,759**										
AIC	**€ 19.30**	**per tonne**									
AIC for Praslin / La Digue											
Tonnes				3,882	3,979	4,078	4,180	4,285	4,392	4,502	4,614
Costs	€ 245,000	€ 124,000	€ 1,150,000	€ 298,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000
NPV	**€ 1,668,941**										
AIC	**€ 77.54**	**per tonne**									

Financial Evaluation 2005-2015

To select landfill or transfer for La Digue, use buttons on Data sheet

Essential Elements

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Technical assistance											
Design and tender documentation for incinerator	€ 100,000	€ 54,000									
Design and tender documentation for Providence II	€ 200,000	€ 100,000									
Design and tender documentation for Amitie	€ 200,000	€ 100,000									
Design and tender documentation for La Digue landfill extension / transfer to Praslin	€ 22,500	€ 12,000									
Education and sensitisation	€ 20,000	€ 20,000	€ 20,000	€ 15,000							
Training for SWAC & ISO 14000 (3 years)	€ 20,000	€ 19,000									
Renegotiation of STAR contract	€ 60,000										
EIA	€ 90,000										
Tender documentation	€ 50,000										
Introduction of user charge	€ 10,000	€ 20,000	€ 20,000								
Preparation of tender document for supplies		€ 20,000									
Capital expenditure (works)											
Special incinerator		€ 935,000									-€ 467,500
Providence II Landfill		€ 1,000,000	€ 322,500								
Praslin Landfill (Amitie)			€ 1,000,000	€ 180,000							
La Digue landfill extension			€ -	€ -							
La Digue transfer (1 RCV)				€ 100,000							
Supplies											
Provision of the collection vehicle for health care waste			€ 30,000								
Provision of enclosed containers for healthcare waste collection			€ 20,000								
Total Funded activities	**€ 772,500**	**€ 2,280,000**	**€ 1,412,500**	**€ 295,000**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**	**-€ 467,500**
Cash operating costs											
Special incinerator			€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000
Healthcare waste collection			€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500
Providence 2 Landfill operation + restoration/aftercare provision (€8.16/t)				€ 144,535	€ 148,149	€ 151,853	€ 155,649	€ 159,540	€ 163,529	€ 167,617	€ 171,807
Praslin Landfill (estimate - operation & R&A)				€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000
La Digue landfill extension (estimate - operation & R&A)				€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Transfer from La Digue				€ 13,000	€ 13,000	€ 13,000	€ 13,000	€ 13,000	€ 13,000	€ 13,000	€ 13,000
Total	**€ -**	**€ -**	**€ 37,500**	**€ 265,035**	**€ 268,649**	**€ 272,353**	**€ 276,149**	**€ 280,040**	**€ 284,029**	**€ 288,117**	**€ 292,307**
Total Cash Costs	**€ 772,500**	**€ 2,280,000**	**€ 1,450,000**	**€ 560,035**	**€ 268,649**	**€ 272,353**	**€ 276,149**	**€ 280,040**	**€ 284,029**	**€ 288,117**	**-€ 175,193**
Total tonnes	51,663	52,805	53,972	55,166	56,386	57,633	58,909	60,213	61,546	62,909	64,302
NPV - all waste management activities	**€ 4,692,071**										
AIC - all waste management activities	**€ 13.38**	**per tonne**									
AIC for Providence 2											
Tonnes				17,708	18,151	18,605	19,070	19,547	20,035	20,536	21,050
Costs	€ 200,000	€ 1,100,000	€ 322,500	€ 144,535	€ 148,149	€ 151,853	€ 155,649	€ 159,540	€ 163,529	€ 167,617	€ 171,807
NPV	**€ 1,894,759**										
AIC	**€ 19.30**	**per tonne**									
AIC for Praslin / La Digue											
Tonnes				3,882	3,979	4,078	4,180	4,285	4,392	4,502	4,614
Costs	€ 222,500	€ 112,000	€ 1,000,000	€ 363,000	€ 83,000	€ 83,000	€ 83,000	€ 83,000	€ 83,000	€ 83,000	€ 83,000
NPV	**€ 1,519,301**										
AIC	**€ 70.59**	**per tonne**									

Financial Evaluation Model - Essential Elements Only

Waste Growth

"Normal" GDP growth 3.00% Initial GDP growth 0.00% for 0 years

waste minimisation factor - Industrial 1.00% for ten years
waste minimisation factor - MSW 0.50% for ten years
(after 3 years)

Linkage factor between GDP growth and waste growth 100%

			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Year			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Projected Mahe population			74109	75216	76297	77365	78424	79446	80455	81418	82353	83260	84121	84954	85746	86494	87186	87842	87986				
Projected total population			85913	87196	88450	89688	90915	92100	93270	94386	95470	96521	97520	98485	99404	100271	101073	101833	102000				
growth factor				1.015	1.014	1.014	1.014	1.013	1.013	1.012	1.011	1.011	1.010	1.010	1.009	1.009	1.008	1.008	1.002				
Projected population Praslin / La Digue (inc. tourists)*			11659	11833	12003	12171	12338	12499	12657	12809	12956	13099	13234	13365	13490	13608	13716	13819	13842				
Growth factor - MSW / Green				3.00%	3.00%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Compounded				103.00%	106.09%	108.74%	111.46%	114.25%	117.10%	120.03%	123.03%	126.11%	129.26%	132.49%	135.80%	139.88%	144.07%	148.40%	152.85%	157.43%	162.16%	167.02%	172.03%
Growth factor - Industrial / C&D				3.00%	3.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Compounded				103.00%	106.09%	108.21%	110.38%	112.58%	114.84%	117.13%	119.47%	121.86%	124.30%	126.79%	129.32%	133.20%	137.20%	141.31%	145.55%	149.92%	154.42%	159.05%	163.82%
Tonnage																							
MSW			15,500	15,965	16,444	16,855	17,276	17,708	18,151	18,605	19,070	19,547	20,035	20,536	21,050	21,681	22,332	23,002	23,692	24,402	25,134	25,888	26,665
MSW per capita (kg p.a.)			209	212	216	218	220	223	226	229	232	235	238	242	245	251	256	262	269				
Green			1,550	1,597	1,644	1,686	1,728	1,771	1,815	1,860	1,907	1,955	2,004	2,054	2,105	2,168	2,233	2,300	2,369	2,440	2,513	2,589	2,667
Industrial / Commercial / C&D (non-SWAC)			28,250	29,098	29,970	30,570	31,181	31,805	32,441	33,090	33,752	34,427	35,115	35,817	36,534	37,630	38,759	39,921	41,119	42,353	43,623	44,932	46,280
Composting	Input		1,550	1,597	1,644	1,686	1,728	1,771	1,815	1,860	1,907	1,955	2,004	2,054	2,105	2,168	2,233	2,300	2,369	2,440	2,513	2,589	2,667
	Reject	40%	620	639	658	674	691	708	726	744	763	782	801	821	842	867	893	920	948	976	1,005	1,036	1,067
	Losses	35%	543	559	576	590	605	620	635	651	667	684	701	719	737	759	782	805	829	854	880	906	933
	Product	25%	388	399	411	421	432	443	454	465	477	489	501	513	526	542	558	575	592	610	628	647	667
Total to landfill			44,370	45,701	47,072	48,099	49,149	50,222	51,318	52,439	53,584	54,755	55,952	57,175	58,425	60,178	61,984	63,843	65,758	67,731	69,763	71,856	74,012
5 year totals for Providence II										251,226					279,892								
Total waste generation			45,300	46,659	48,059	49,110	50,185	51,284	52,407	53,555	54,729	55,928	57,154	58,407	59,688	61,479	63,323	65,223	67,180	69,195	71,271	73,409	75,611
Total waste generation per capita			611	620	630	635	640	646	651	658	665	672	679	688	696	711	726	743	764				
MSW																							
	Mahe		15,500	15,965	16,444	16,855	17,276	17,708	18,151	18,605	19,070	19,547	20,035	20,536	21,050	21,681	22,332	23,002	23,692				
	Praslin / La Digue		3,398	3,500	3,605	3,695	3,787	3,882	3,979	4,078	4,180	4,285	4,392	4,502	4,614	4,752	4,895	5,042	5,193				
	TOTAL		18,898	19,465	20,048	20,550	21,063	21,590	22,130	22,683	23,250	23,831	24,427	25,038	25,664	26,434	27,227	28,043	28,885				
Other																							
	Mahe		29,800	30,694	31,615	32,255	32,909	33,576	34,256	34,950	35,659	36,381	37,119	37,871	38,639	39,798	40,992	42,222	43,488				
All wastes																							
	Mahe		45,300	46,659	48,059	49,110	50,185	51,284	52,407	53,555	54,729	55,928	57,154	58,407	59,688	61,479	63,323	65,223	67,180				
	Praslin / La Digue		3,398	3,500	3,605	3,695	3,787	3,882	3,979	4,078	4,180	4,285	4,392	4,502	4,614	4,752	4,895	5,042	5,193				
	TOTAL		48,698	50,159	51,663	52,805	53,972	55,166	56,386	57,633	58,909	60,213	61,546	62,909	64,302	66,232	68,218	70,265	72,373				

* twice the number of tourist beds has been used to allow for greater per capita waste generation

Financial Evaluation Model Printout

Essential plus Key Desirable Elements

Financial Evaluation Model - Essential plus Key Desirable Elements

Key Input Data

Operator profit		15.0%
Interest rate		11.0%
Waste reduction:	**MSW**	0.5%
	Industrial	1.0%
	Euro	**€1 = SCR** 6

Wage rate for labourers	3,000 **Rupees/month**
Wage rate for drivers	3,750
Fuel price (excluding tax)	€ 0.93

0
1

Financial Evaluation 2005-2015

To select landfill or transfer for La Digue, use buttons on Data sheet

Essential Elements plus Key Desirable and Optional Elements

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Technical assistance											
Design and tender documentation for incinerator	€ 100,000	€ 54,000									
Design and tender documentation for Providence II	€ 200,000	€ 100,000									
Design and tender documentation for Amitie	€ 200,000	€ 100,000									
Design and tender documentation for La Digue landfill extension / transfer to I	€ 45,000	€ 24,000									
Design and tender documentation for Providence I rehabilitation	€ 45,000	€ 24,000									
Education and sensitisation	€ 20,000	€ 20,000	€ 20,000	€ 15,000							
Re-inforcement of institutional capacities (3 staff)	€ 10,000	€ 20,000	€ 20,000	€ 20,000	€ 20,000	€ 10,000					
Organisational set-up of SWAC and auditing of STAR	€ 30,000										
Training for SWAC & ISO 14000 (3 years)	€ 20,000	€ 19,000									
Renegotiation of STAR contract	€ 60,000										
EIA	€ 90,000										
Tender documentation	€ 50,000										
Institutional support	€ 50,000	€ 50,000	€ 50,000								
Introduction of user charge	€ 10,000	€ 20,000	€ 20,000								
Training for environmental monitoring	€ 8,000	€ 8,000	€ 8,000								
Preparation of tender document for supplies		€ 20,000									
Capital expenditure (works)											
Separate collection of biowaste		€ 240,000					€ 240,000				
3 collections / week		€ 90,000									
3 additional bring sites		€ 36,000									
Increased composting on Mahe			€ 420,000								-€ 210,000
Composting on Praslin			€ 112,500								-€ 56,250
Crush and screen C&D waste	€ -										
Special incinerator		€ 935,000									-€ 467,500
Providence II Landfill		€ 1,000,000	€ 322,500								
Praslin Landfill (Amitie)			€ 1,000,000	€ 180,000							
La Digue landfill extension			€ 150,000	€ 18,000							
La Digue transfer (1 RCV)				€ -							
Rehabilitiation of old landfills (Providence I)			€ 922,500								
Environmental monitoring equipment											
Supplies											
Provision of the collection vehicle for health care waste			€ 30,000								
Monitoring equipment for air quality			€ 100,000								
Provision of enclosed containers for healthcare waste collection			€ 20,000								
Mobile plant for composting and collection vehicle Providence			€ 340,000								
Supplies for composting plant in Praslin			€ 50,000								
Contingency			€ 750,000								
Total Funded activities	**€ 938,000**	**€ 2,760,000**	**€ 4,335,500**	**€ 233,000**	**€ 20,000**	**€ 10,000**	**€ 240,000**	**€ -**	**€ -**	**€ -**	**-€ 733,750**
Cash operating costs											
Separate collection of biowaste		€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000
3 collections / week (savings)		-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000
3 additional bring sites											
Increased composting on Mahe			€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500
Composting on Praslin			€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000
Crush and screen C&D waste	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000
Special incinerator			€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000
Healthcare waste collection			€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500
Providence 2 Landfill operation + restoration/aftercare provision (€8.16/t)				€ 144,535	€ 148,149	€ 151,853	€ 155,649	€ 159,540	€ 163,529	€ 167,617	€ 171,807
Praslin Landfill (estimate - operation & R&A)				€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000
La Digue landfill extension (estimate - operation & R&A)				€ 30,000	€ 30,000	€ 30,000	€ 30,000	€ 30,000	€ 30,000	€ 30,000	€ 30,000
Transfer from La Digue				€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Rehabilitation of old landfills			€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Environmental monitoring			€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000
Total	**€ 4,000**	**€ 16,000**	**€ 84,000**	**€ 328,535**	**€ 332,149**	**€ 335,853**	**€ 339,649**	**€ 343,540**	**€ 347,529**	**€ 351,617**	**€ 355,807**
Total Cash Costs	**€ 942,000**	**€ 2,776,000**	**€ 4,419,500**	**€ 561,535**	**€ 352,149**	**€ 345,853**	**€ 579,649**	**€ 343,540**	**€ 347,529**	**€ 351,617**	**-€ 377,943**
Total tonnes	51,663	52,805	53,972	55,166	56,386	57,633	58,909	60,213	61,546	62,909	64,302
NPV - all waste management activities	**€ 7,665,044**										
AIC - all waste management activities	**€ 21.86** per tonne										
AIC for Providence 2											
Tonnes				17,708	18,151	18,605	19,070	19,547	20,035	20,536	21,050
Costs	€ 200,000	€ 1,100,000	€ 322,500	€ 144,535	€ 148,149	€ 151,853	€ 155,649	€ 159,540	€ 163,529	€ 167,617	€ 171,807
NPV	**€ 1,894,759**										
AIC	**€ 19.30 per tonne**										
AIC for Praslin / La Digue											
Tonnes				3,882	3,979	4,078	4,180	4,285	4,392	4,502	4,614
Costs	€ 245,000	€ 124,000	€ 1,264,500	€ 300,000	€ 102,000	€ 102,000	€ 102,000	€ 102,000	€ 102,000	€ 102,000	€ 45,750
NPV	**€ 1,742,341**										
AIC	**€ 80.95 per tonne**										

Financial Evaluation 2005-2015

To select landfill or transfer for La Digue, use buttons on Data sheet

Essential Elements plus Key Desirable and Optional Elements

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Technical assistance											
Design and tender documentation for incinerator	€ 100,000	€ 54,000									
Design and tender documentation for Providence II	€ 200,000	€ 100,000									
Design and tender documentation for Amitie	€ 200,000	€ 100,000									
Design and tender documentation for La Digue landfill extension / transfer to I	€ 22,500	€ 12,000									
Design and tender documentation for Providence I rehabilitation	€ 45,000	€ 24,000									
Education and sensitisation	€ 20,000	€ 20,000	€ 20,000	€ 15,000							
Re-inforcement of institutional capacities (3 staff)	€ 10,000	€ 20,000	€ 20,000	€ 20,000	€ 20,000	€ 10,000					
Organisational set-up of SWAC and auditing of STAR	€ 30,000										
Training for SWAC & ISO 14000 (3 years)	€ 20,000	€ 19,000									
Renegotiation of STAR contract	€ 60,000										
EIA	€ 90,000										
Tender documentation	€ 50,000										
Institutional support	€ 50,000	€ 50,000	€ 50,000								
Introduction of user charge	€ 10,000	€ 20,000	€ 20,000								
Training for environmental monitoring	€ 8,000	€ 8,000	€ 8,000								
Preparation of tender document for supplies		€ 20,000									
Capital expenditure (works)											
Separate collection of biowaste		€ 240,000					€ 240,000				
3 collections / week		€ 90,000									
3 additional bring sites		€ 36,000									
Increased composting on Mahe			€ 420,000								-€ 210,000
Composting on Praslin			€ 112,500								-€ 56,250
Crush and screen C&D waste	€ -										
Special incinerator		€ 935,000									-€ 467,500
Providence II Landfill		€ 1,000,000	€ 322,500								
Praslin Landfill (Amitie)			€ 1,000,000	€ 180,000							
La Digue landfill extension			€ -	€ -							
La Digue transfer (1 RCV)				€ 100,000							
Rehabilitiation of old landfills (Providence I)			€ 922,500								
Environmental monitoring equipment											
Supplies											
Provision of the collection vehicle for health care waste			€ 30,000								
Monitoring equipment for air quality			€ 100,000								
Provision of enclosed containers for healthcare waste collection			€ 20,000								
Mobile plant for composting and collection vehicle Providence			€ 340,000								
Supplies for composting plant in Praslin			€ 50,000								
Contingency			€ 750,000								
Total Funded activities	**€ 915,500**	**€ 2,748,000**	**€ 4,185,500**	**€ 315,000**	**€ 20,000**	**€ 10,000**	**€ 240,000**	**€ -**	**€ -**	**€ -**	**-€ 733,750**
Cash operating costs											
Separate collection of biowaste		€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000
3 collections / week (savings)		-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000	-€ 88,000
3 additional bring sites											
Increased composting on Mahe			€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500
Composting on Praslin			€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000	€ 2,000
Crush and screen C&D waste	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000	€ 4,000
Special incinerator			€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000	€ 25,000
Healthcare waste collection			€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500	€ 12,500
Providence 2 Landfill operation + restoration/aftercare provision (€8.16/t)				€ 144,535	€ 148,149	€ 151,853	€ 155,649	€ 159,540	€ 163,529	€ 167,617	€ 171,807
Praslin Landfill (estimate - operation & R&A)				€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000
La Digue landfill extension (estimate - operation & R&A)				€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Transfer from La Digue				€ 13,000	€ 13,000	€ 13,000	€ 13,000	€ 13,000	€ 13,000	€ 13,000	€ 13,000
Rehabilitation of old landfills			€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Environmental monitoring			€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000	€ 16,000
Total	**€ 4,000**	**€ 16,000**	**€ 84,000**	**€ 311,535**	**€ 315,149**	**€ 318,853**	**€ 322,649**	**€ 326,540**	**€ 330,529**	**€ 334,617**	**€ 338,807**
Total Cash Costs	**€ 919,500**	**€ 2,764,000**	**€ 4,269,500**	**€ 626,535**	**€ 335,149**	**€ 328,853**	**€ 562,649**	**€ 326,540**	**€ 330,529**	**€ 334,617**	**-€ 394,943**
Total tonnes	51,663	52,805	53,972	55,166	56,386	57,633	58,909	60,213	61,546	62,909	64,302
NPV - all waste management activities	**€ 7,515,404**										
AIC - all waste management activities	**€ 21.44** per tonne										
AIC for Providence 2											
Tonnes				17,708	18,151	18,605	19,070	19,547	20,035	20,536	21,050
Costs	€ 200,000	€ 1,100,000	€ 322,500	€ 144,535	€ 148,149	€ 151,853	€ 155,649	€ 159,540	€ 163,529	€ 167,617	€ 171,807
NPV	**€ 1,894,759**										
AIC	**€ 19.30 per tonne**										
AIC for Praslin / La Digue											
Tonnes				3,882	3,979	4,078	4,180	4,285	4,392	4,502	4,614
Costs	€ 222,500	€ 112,000	€ 1,114,500	€ 365,000	€ 85,000	€ 85,000	€ 85,000	€ 85,000	€ 85,000	€ 85,000	€ 28,750
NPV	**€ 1,592,700**										
AIC	**€ 74.00 per tonne**										

Financial Evaluation Model - Essential plus Key Desirable Elements

Waste Growth

"Normal" GDP growth 3.00% Initial GDP growth 0.00% for 0 years

waste minimisation factor - Industrial 1.00% for ten years Linkage factor between GDP growth and waste growth 100%

waste minimisation factor - MSW 0.50% for ten years

(after 3 years)

			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Year			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Projected Mahe population			74109	75216	76297	77365	78424	79446	80455	81418	82353	83260	84121	84954	85746	86494	87186	87842	87986				
Projected total population			85913	87196	88450	89688	90915	92100	93270	94386	95470	96521	97520	98485	99404	100271	101073	101833	102000				
growth factor				1.015	1.014	1.014	1.014	1.013	1.013	1.012	1.011	1.011	1.010	1.010	1.009	1.009	1.008	1.008	1.002				
Projected population Praslin / La Digue (inc. toruists)*			11659	11833	12003	12171	12338	12499	12657	12809	12956	13099	13234	13365	13490	13608	13716	13819	13842				
Growth factor - MSW / Green				3.00%	3.00%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Compounded				103.00%	106.09%	108.74%	111.46%	114.25%	117.10%	120.03%	123.03%	126.11%	129.26%	132.49%	135.80%	139.88%	144.07%	148.40%	152.85%	157.43%	162.16%	167.02%	172.03%
Growth factor - Industrial / C&D				3.00%	3.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Compounded				103.00%	106.09%	108.21%	110.38%	112.58%	114.84%	117.13%	119.47%	121.86%	124.30%	126.79%	129.32%	133.20%	137.20%	141.31%	145.55%	149.92%	154.42%	159.05%	163.82%
Tonnage																							
MSW			15,500	15,965	16,444	16,855	17,276	17,708	18,151	18,605	19,070	19,547	20,035	20,536	21,050	21,681	22,332	23,002	23,692	24,402	25,134	25,888	26,665
MSW per capita (kg p.a.)			209	212	216	218	220	223	226	229	232	235	238	242	245	251	256	262	269				
Green			1,550	1,597	1,644	1,686	1,728	1,771	1,815	1,860	1,907	1,955	2,004	2,054	2,105	2,168	2,233	2,300	2,369	2,440	2,513	2,589	2,667
Industrial / Commercial / C&D (non-SWAC)			28,250	29,098	29,970	30,570	31,181	31,805	32,441	33,090	33,752	34,427	35,115	35,817	36,534	37,630	38,759	39,921	41,119	42,353	43,623	44,932	46,280
Composting	**Input**		1,550	1,597	1,644	1,686	1,728	1,771	1,815	1,860	1,907	1,955	2,004	2,054	2,105	2,168	2,233	2,300	2,369	2,440	2,513	2,589	2,667
	Reject	40%	620	639	658	674	691	708	726	744	763	782	801	821	842	867	893	920	948	976	1,005	1,036	1,067
	Losses	35%	543	559	576	590	605	620	635	651	667	684	701	719	737	759	782	805	829	854	880	906	933
	Product	25%	388	399	411	421	432	443	454	465	477	489	501	513	526	542	558	575	592	610	628	647	667
Total to landfill			44,370	45,701	47,072	48,099	49,149	50,222	51,318	52,439	53,584	54,755	55,952	57,175	58,425	60,178	61,984	63,843	65,758	67,731	69,763	71,856	74,012
5 year totals for providence 2										251,226					279,892								
Total waste generation			45,300	46,659	48,059	49,110	50,185	51,284	52,407	53,555	54,729	55,928	57,154	58,407	59,688	61,479	63,323	65,223	67,180	69,195	71,271	73,409	75,611
Total waste generation per capita			611	620	630	635	640	646	651	658	665	672	679	688	696	711	726	743	764				
MSW																							
	Mahe		15,500	15,965	16,444	16,855	17,276	17,708	18,151	18,605	19,070	19,547	20,035	20,536	21,050	21,681	22,332	23,002	23,692				
	Praslin / La Digue		3,398	3,500	3,605	3,695	3,787	3,882	3,979	4,078	4,180	4,285	4,392	4,502	4,614	4,752	4,895	5,042	5,193				
	TOTAL		18,898	19,465	20,048	20,550	21,063	21,590	22,130	22,683	23,250	23,831	24,427	25,038	25,664	26,434	27,227	28,043	28,885				
Other																							
	Mahe		29,800	30,694	31,615	32,255	32,909	33,576	34,256	34,950	35,659	36,381	37,119	37,871	38,639	39,798	40,992	42,222	43,488				
All wastes																							
	Mahe		45,300	46,659	48,059	49,110	50,185	51,284	52,407	53,555	54,729	55,928	57,154	58,407	59,688	61,479	63,323	65,223	67,180				
	Praslin / La Digue		3,398	3,500	3,605	3,695	3,787	3,882	3,979	4,078	4,180	4,285	4,392	4,502	4,614	4,752	4,895	5,042	5,193				
	TOTAL		48,698	50,159	51,663	52,805	53,972	55,166	56,386	57,633	58,909	60,213	61,546	62,909	64,302	66,232	68,218	70,265	72,373				

* twice the number of torist beds has been used to allow for greater per capita waste generation