

Baseline Study for the Pacific Hazardous Waste Management Project - Healthcare Waste

The collection, collation and review of data on the management of healthcare waste and best-practice options for its disposal in participating Pacific Island Countries

Whole of Project – Summary Report

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This document is issued in confidence to Secretariat of the Pacific Regional Environment Programme (SPREP) for the purposes of collection and collation of information on the regional management of healthcare waste and its disposal, as part of their broader strategy of improving hazardous waste management in Pacific Island countries, and specifically to assist in establishing sustainable healthcare waste management. This report presents the findings of this assessment. It should not be used for any other purpose.

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Executive Summary

Introduction

The Secretariat of the Pacific Regional Environment Programme (SPREP) is the Pacific region's major intergovernmental organisation charged with protecting and managing the environment and natural resources. SPREP works with and on behalf of its 21 member countries and territories to promote cooperation in the Pacific islands region, providing assistance to protect and improve the Pacific environment and to ensure sustainable development for present and future generations.

SPREP is implementing the Pacific Hazardous Waste Management (PacWaste) Project, a four year, €7,850,000 (2013 – 2017) project funded by the European Union and administered through SPREP. The project will provide fundamental on-ground improvement in the way priority high risk wastes are managed in Pacific Island Countries to help build a healthy, economically and environmentally sustainable Pacific for future generations. The PacWaste project is funded by the European Union under its 10th European Development Fund (EDF 10). The project focuses on three priority hazardous waste streams including asbestos, E-waste and healthcare waste.

ENVIRON was engaged by SPREP to collect and collate information on the regional management of healthcare waste and its disposal, as part of their broader strategy of improving waste management in Pacific Island Countries, and specifically to assist in establishing sustainable healthcare waste management. This report presents the findings of this assessment.

Existing Hospital Waste Management Practices

Information regarding the waste management process occurring, from ward-level waste generation through to ultimate treatment and disposal, was collected during audits of 42 hospitals across the Pacific Islands region, from March to May 2014.

A minimum standards framework has been developed to set a benchmark for the sustainable management of healthcare waste in the region (**Appendix C**). This framework is drawn from the *Industry code of practice for the management of biohazardous waste (including clinical and related) wastes*, Waste Management Association of Australia (2014), Draft 7th edition, taking into account the Pacific Island hospital and environmental context.

Using information obtained from the audits, the hospitals were assessed against this framework. Table ES1 highlights the most regularly encountered key issues in terms of health services delivery by the hospitals, as part of this assessment. The table also explores potential options to address these issues.

Table ES1: Potential Options for Sustainable Healthcare Waste Management in Pacific Island Countries

Key Issue Category	Regularly Encountered Key Issue	Potential options to address the issue
A. Waste Management Framework	There is either no documented **waste management plan**ning system in place, or significant gaps present, in 37 of 42 hospitals (88%) visited. There is often limited evidence of waste management committees.	Establish a waste management framework including: • Waste Management Plan • Responsible officer for implementation of waste management plan • Waste management committee, appropriate to the scale of each facility.
B. Signage, Segregation & Containers	**Segregation and containment** practices are generally below minimum standard in that: • 30 of 42 hospitals (71%) visited had no signage present • While sharps segregation was typically practiced, segregation of other wastes occurred well in only 9 of 42 hospitals (21%). • Only 14 of 42 hospitals (33%) visited had adequate colour coded bins and liners present.	Improve segregation practices (where required) by: • Supply of colour-coded waste bins and plastic liners in quantities sufficient to serve all wards/departments for a period of time sufficient to allow bedding down of the segregation process. • Supply of small number of colour-coded wheelie bins (where required) per hospital to act as both in-ward/department storage and internal transport trolleys. • Supply of signage to explain the colour-coded segregation system as well as posters to promote it.
C. Training & Audit	There is no structured **training** program in 30 of 42 (71%) hospitals visited. There is no waste segregation **auditing** program in place in 33 of 42 (79%) hospitals visited.	Development and delivery of a structured healthcare waste training program to all hospital personnel as well as personnel from other stakeholders (e.g., government health and environment agencies). This could be facilitated/ delivered by: 1. SPREP staff, **or** 2. International technical training providers (or a combination of both), - as no competent healthcare waste management training capability exists in any of the countries visited.
D. Treatment	The method for **treatment** of healthcare waste is regularly not in accord with required standards: 18 of 42 (43%) hospitals visited did not have functional treatment infrastructure capable of definitively destroying the infection risk.	Treatment using one (or a combination) of the following for each hospital: 1. Rotary kiln (highest temperature) 2. Incineration (high temperature) 3. Incineration (medium temperature) 4. Low temperature burning (single chamber incinerator/ pit/ drum/ brick enclosure/ land) 5. Autoclave 6. Chemical 7. Microwave 8. Encapsulation 9. Landfill (without disinfection) 10. Onsite burial 11. Shredding
E. Occupational Health and Safety	Waste handlers regularly do not always use or sometimes have appropriate **PPE** including overalls /protective clothing, gloves and eye protection. 14 of 42	Procurement of Consumables (PPE): • Supply spill kits and appropriate PPE including overalls/protective clothing, gloves and eye protection for

Table ES1: Potential Options for Sustainable Healthcare Waste Management in Pacific Island Countries		
Key Issue Category	**Regularly Encountered Key Issue**	**Potential options to address the issue**
	hospitals (33%) visited were deficient in their use of PPE. Adequate s**pill control kits** were not observed in <u>any</u> of the 42 hospitals visited.	all waste handlers. • Incinerator staff are provided with additional PPE such as face masks and noise protection.
F. Storage (before treatment)	Only 10 out of 42 hospitals (23%) visited had suitable storage facilities	Upgrade storage before disposal areas to prevent access to the public. This can be achieved by either a built storage shed/ structure or, in many circumstances, simply a wheel able bin with sufficient storage volume, lockable lid and signage.

Analysis of Options for Sustainable Healthcare Waste Management

Where <u>non-treatment</u> waste management aspects were observed to be performing below the Minimum Standards Framework, this framework is referenced for recommended actions.

For <u>treatment</u> of healthcare waste, various options used around the world were considered in the Pacific Islands context, via a two stage process:

- Stage 1: High-level costs and benefits (cost, lifespan, technical feasibility and how that relates to the Pacific Island regional context); and
- Stage 2: A country-specific feasibility assessment, using an analysis of 10 criteria (**Appendix G**)

All 15 countries' second stage local feasibility assessments showed some quantitative variation, as would be expected with different local factors influencing each country's assessment. But they were unanimous in ranking ***high temperature incineration*** is the preferred disinfection practice throughout the region, where units are modern, maintained, have sufficient waste volumes and locked in supplier maintenance and training contracts.

Wastes should be treated and disposed of accordingly to ensure the infectious hazard is destroyed.

Using this two-stage analysis process, 32 out of 42 hospitals (76%) in the Pacific study region are recommended to be considered for investment in either replacement or maintenance of treatment infrastructure to achieve this, as described by their respective individual country reports.

Recommendations

Recommendation details in full for each hospital and corresponding short, medium and long-term implementation actions are provided in individual country reports.

Review of all 15 country-specific reports finds the following list of 9 recommendation types that were applied (when applicable) to a significant proportion of countries across the region.

Table ES2 employs a shading system to describe when intervention in a particular country (in any way relevant to the recommendation type) is recommended:

	Intervention is recommended for <u>at least one</u> hospital assessed within the country With respect to the recommendation type, where there is an inadequacy identified in at least one of the hospitals assessed in the country, some level of intervention action is recommended.
	Intervention is not recommended for <u>any</u> of the hospitals assessed within the country With respect to the recommendation type, there has been no inadequacy identified at any one of the hospitals assessed in the country, so no level of intervention action is recommended.

The degree of applicability of each recommendation to each hospital in a country is described in detail in Section 8 of each country-level report.

Table ES2: Applicability of Recommendations (listed in Individual Country Reports)

Recommendations	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Nauru	Niue	Palau	PNG	Samoa	Solomon Islands	Timor Leste	Tonga	Tuvalu	Vanuatu
Recommendation 1: Develop a Waste Management Framework	■	■	■	■	■	■	■	■		■	■	■	■	■	■
Recommendation 2: Procurement of Consumables (Segregation & Storage)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Recommendation 3: Provide a Sustainable Training Program	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Recommendation 4: Improved Treatment Infrastructure	■	■	■	■	■	■	■	■		■	■	■	■	■	■
Recommendation 5: Procurement of Consumables (PPE) & Spill Kits	■	■		■	■	■		■			■	■	■	■	■
Recommendation 6: Appoint a 'Waste Management Officer'								■							
Recommendation 7: Upgrade Storage Facility		■	■	■		■		■	■	■	■	■		■	■
Recommendation 8: A Short-term Whole of Country Co-ordination Resource			■												
Recommendation 9: Incinerate Existing Waste Stockpiles				■						■					

Table ES3 shows establishment costs estimated for these recommendations, if implemented as described in individual country reports.

Table ES3: Estimated Establishment Cost - Implication of Recommendations

Recommendations	Establishment Cost ($US) per Country															
	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Nauru	Niue	Palau	PNG	Samoa	Solomon Islands	Timor Leste	Tonga	Tuvalu	Vanuatu	Total
R1: Develop a Waste Management Framework	1,000	12,000	2,000	6,000	6,000	3,000	1,000	2,000	-	6,000	18,000	15,000	12,000	3,000	12,000	99,000
R2: Procurement of Consumables (Segregation & Storage)	1,000	6,000	2,000	3,000	3,000	1,500	500	3,000	2,000	3,000	7,000	6,000	6,000	1,500	7,500	53,000
R3: Provide a Sustainable Training Program	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	150,000
R4: Improved Treatment Infrastructure	20,000	80,000	105,000	70,000	30,000	50,000	50,000	50,000	-	35,000	195,000	45,000	130,000	50,000	200,000	1,110,000
R5: Procurement of Consumables (PPE) & Spill Kits	1,000	4,000	-	1,000	2,000	1,000	-	1,000	-	-	4,000	5,000	4,000	1,000		24,000
R6: Appoint a 'Waste Management Officer'	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R7: Upgrade Storage Facility	-	1,000	6,000	1,000	-	1,000	-	1,000	10,000	1,000	16,000	10,000	-	1,000	16,000	64,000
R8: A Short-term Whole of Country Co-ordination Resource	-	-	75,000	-	-	-	-	-	-	-	-	-	-	-	-	75,000
R9: Incinerate Existing Waste Stockpiles	-	-	-	5,000	-	-	-	-	-	5,000	-	-	-	-	-	10,000
Total Estimated Costs ($US)	**33,000**	**113,000**	**200,000**	**96,000**	**51,000**	**66,500**	**61,500**	**67,000**	**22,000**	**60,000**	**250,000**	**91,000**	**162,000**	**66,500**	**245,500**	**1,585,000**

Key Themes and Lessons Learnt

1. There are Low Hanging Fruit Opportunities for Improvement of Healthcare Waste Management

- Significant opportunity exists for low investment related improvement of healthcare waste management in Pacific Island countries, particularly if SPREP's internal capability can be used to resource implementation of recommendations such as waste management policy and plan development, training, co-ordination assistance and some relatively small investment in simple consumables such as segregation bags and bins, particularly for those hospitals without these basics.

2. Better Quality Data would assist Key Investment Decisions

- The process of data collection from hospitals across the Pacific was slow and gave patchy results. Hospital response rates for survey information are described at Appendix B.
- Waste volume data was occasionally measured by hospitals throughout the region. Consequently the estimates provided for waste generation rates (if they were provided at all) were often poor.
- This is illustrated by the "kg HCW generated per occupied bed" figures reported in Table 2. In some regions/ countries there is reasonable agreement on generation rates of healthcare waste (typical ranges 0.5 - 1.5 kg per occupied bed) but within the data there are also some very large estimates (3 of more than 3kg per occupied bed. These figures have been largely estimated through ENVIRON staff judgment, which has resulted in better agreement between hospitals than would have been the case if hospital estimates were taken on face value.
- To provide increased confidence in investment decisions, as well as to engage the commitment of the infrastructure-receiving hospital, this data should be re-gathered with a greater level of trust in the estimates. This should be achieved by a clear estimation approach comprising either of the methods below (in order of preference):
    - Actual weighed data of all healthcare waste generated, taken over a period of at least one month
    - Actual numbers of healthcare waste bags generated, counted over a period of at least one month, with an estimate derived for an average weight per bag
    - A spot audit, where two to three days of actual weighed data for all healthcare waste generated is obtained.
- This requirement could fall on the hospital that will be recipient of the infrastructure, as a demonstration of their engagement and commitment, although records of the assessment would need to be provided to underpin the volumes provided.
- As a footnote to this task, ENVIRON's experience was that getting any data or information at all – for example through surveys – proved difficult, particularly prior to face to face meetings but also in post meeting follow up requests.

3. Avoid Past Mistakes - Stranded Infrastructure

- The region is littered with examples of historically donated incinerators that have not been maintained or, in some cases, ever used.
- In addition to obtaining more confident waste generation data for each hospital under consideration for infrastructure-related assistance, it is essential that funding for equipment purchase also includes provision for maintenance support contracts from suppliers.

4. Economic Drivers are Sometimes Absent

- Either if healthcare waste is collected by external agencies, or processed onsite within existing resources, there is generally no direct cost attributed to the hospital – or at least no perceived cost. (If treatment is via external private contractor this is not the case)
- This lack of economic valuing removes a driver for better segregation, at least a visible one to the staff making the waste generation (waste in bin placement) decision.
- Hospitals need to record some economic factors to encourage better segregation.

5. Low Resourcing and Priority of Healthcare Waste Management

- There are typically minimal resources being provided for management of healthcare waste by hospitals and government agencies across the region. This includes the better-performed countries, such as Fiji (as evidenced by the fragility of key waste management staffing at the well-performed hospitals and much lower standards of waste management at the smaller hospitals in Fiji).
- Healthcare waste is generally left up to the hospital to manage with little assistance from the National governing bodies (i.e. Communication between the Department of Health and the hospital is sometimes non-existent in relation to healthcare waste).
- There does not appear to be a culture of accountability and self-regulation in many of the country's hospitals visited.

6. There is Commonly Insufficient Training Provided

- A common observation throughout the region was a lack of adequate and appropriate training for all stakeholders – ranging from in-hospital to treatment/disposal operators. This is a direct reflection of the low resourcing and priority given to the issue of healthcare waste management.

7. Sustainable Change Will Require Investment of Time with Stakeholders

- As well as funding equipment and training, investing time beyond the establishment phase in bedding down learning, systems and ongoing resourcing will pay dividends. All countries were open to improving their practices but in many cases there is some institutional inertia to be overcome, which could be helped with the assurance of some help and support.
- The recommendation relating to Fiji only at this stage, to provides a short-term whole of country co-ordination resource, is based on the fact that Fiji are a good regional leader in the making in terms of healthcare waste management, because they have

the basis of a good management and implementation framework but it is somewhat stalled in the bigger hospitals and seriously languishing in the smaller hospitals. This recommendation could be applied to other countries in the region, building confidence, momentum and providing both co-ordination and accountability for action.

8. In-Country Assistance Capability is Not Present

- In-country expertise in relation to all aspects of waste management and infection control training, plus servicing and repair of waste treatment systems (i.e. incinerators) does not exist.

9. Consider Regional Issues in Project and Budget Management

- National focal point contacts should be established wherever possible, in relation to the project at hand, well in advance of any field work in the region.
- Factor some redundancy into travel budgets to account for unforeseen (but likely) impacts such as extreme weather events, flight cancellations and potential absence of key people in hospitals or other agencies and departments.

10. Achievements 'against the odds'

- The three divisional hospitals in Fiji, alongside smaller hospitals like Rarotonga Hospital (Cook Islands) and Niue are well-performed hospitals against the Minimum Standards Framework for good healthcare waste management.
- This adherence to standard has been achieved against a difficult backdrop of a large Dengue Fever outbreak at the time of auditing and, for the size of the hospitals, limited infection control and waste management resources (this is particularly so of Lautoka). These hospitals appear to have achieved this level of performance due to the commitment of individuals in these roles and some degree of co-operation and information sharing across the infection control function at divisional level in Fiji.
- In Fiji's case this contrasts with the much weaker performance of their smaller (sub-divisional) hospitals, if the two audited are representative across the country.

11. Quarantine Incinerator Agencies Have Healthcare Waste Concerns

- Co-burning healthcare waste with quarantine waste, in an existing (and in some cases large) high temperature incinerator run by Quarantine Agencies, is an attractive and common sense proposition, particular in small countries or as a back-up option to breakdown scenarios. However, quarantine incineration operators/ agencies were generally not interested – they were very concerned about their ability to handle safely what they saw (in healthcare waste) as a greater risk compared to what they were familiar with treating.
- Only Niue has potential for a combined treatment infrastructure, but this would need to be sited and managed at the hospital in any case, due to the sentiment above

1 Introduction and Background

The Secretariat of the Pacific Regional Environment Programme (SPREP) is the Pacific region's major intergovernmental organisation charged with protecting and managing the environment and natural resources. SPREP works with and on behalf of its 21 member countries and territories to promote cooperation in the Pacific islands region, providing assistance to protect and improve the Pacific environment and to ensure sustainable development for present and future generations.

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ENVIRON was engaged by SPREP to collect and collate information on the regional management of healthcare waste and its disposal, as part of their broader strategy of improving waste management in Pacific Island countries, and specifically to assist in establishing sustainable healthcare waste management. This report presents the findings of this assessment.

1.1 The need for this project

Poor waste management is a major threat to sustainable development in Pacific Island Countries and Territories (PICTs) as it has negative impacts on the region's environment, as well as on public health, water resources quality, fisheries, agriculture, tourism and quality of life. Healthcare waste has been identified as a priority waste stream as it is potentially hazardous and if poorly managed it may lead to adverse environmental and community health effects.

Healthcare waste is an unavoidable by-product of community healthcare and can be classified into two major groups: general waste and hazardous waste. The majority of waste, which is 75-90% of the waste produced by healthcare activities, is non-risk, or general waste that is comparable with domestic or municipal solid waste. The remaining 10-25% of healthcare waste is regarded as hazardous waste according to the World Health Organisation.[1]

Management of healthcare waste is problematic due to its heterogeneity, containing a broad mix of hazardous substances including sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive material. The extent of the risk involved in the management of healthcare wastes depends on a number of interrelated factors, including the likelihood of human or other living organism's exposure, and of the volume and potential hazard of the waste.

[1] World Health Organization (2013), Safe management of wastes from healthcare activities, Second edition

Quantities of healthcare waste being generated in the region are increasing with escalating population growth and with improved medical services reaching the region. Typically, healthcare waste is poorly managed in the Pacific, and is usually disposed of through low temperature combustion within hospital compounds or by uncontrolled dumping in landfills. Improper disposal of medical wastes can result in contamination of water supplies or aquatic environments and burning of medical wastes at low temperatures results in the release of toxic pollutants to the air. Landfill dumping of medical wastes results in unacceptable community health risks and expired drugs may be acquired by children or scavengers if disposed in a landfill.

There may also be ineffective separation of medical waste at source. In many cases where medical waste incinerators exist, they are often incorrectly operated, have technical problems or there is a lack of trained operators or a shortage of money for diesel fuel. Often the incinerators are donated, but they do not comply with best available technology or practices. An integrated framework to manage pharmaceuticals and progressively implement routine medical waste disposal through controlled high temperature incineration is essential for infection control and protection of the health of many Pacific island communities.

Recognising the urgency of this problem, a growing number of countries have taken initial steps to respond to this need however in general management of healthcare waste still remains largely inadequate. The management of healthcare waste is an integral part of a national healthcare system and a robust approach to healthcare waste management should include a clear delineation of responsibilities, occupational health and safety programs, waste minimization and segregation, the development and adoption of safe and environmentally-sound technologies, and capacity building. This report explores how a cost-effective and self –sustaining healthcare waste management system can be implemented in across the region.

1.2 Project Scope

This report covers the approach specified in the Request for Tender AP 6/5/6/2 '*The collection, collation and review of data on the management of healthcare waste and best practice options for its disposal in selected Pacific Island communities'* and includes the following deliverables

The scope of work for this assessment was carried out in each of the sub-regions detailed below:

- Sub-region A: (Western Pacific)
  - Timor Leste, Papua New Guinea
- Sub-region B: (Micronesia)
  - FSM, Kiribati, Marshall Islands, Nauru, Palau
- Sub-region C: (Melanesia)
  - Fiji, Solomon Islands, Vanuatu
- Sub-region D: (Polynesia)
  - Cook Islands, Niue, Samoa, Tonga, Tuvalu

- Collect and collate data on the current practice(s) used to dispose of hazardous healthcare waste in each nominated Pacific Island country identified in the work region(s). Sites assessed must include, but not be limited to those included in Annex B of the RFT. Data collected for each site should, at a minimum, include:
  - Basic background data on the operation of the site (number of beds, population served, current and projected rates of hazardous healthcare waste generation;
  - Healthcare waste separation and infection control practices;
  - Adequacy of supply of hazardous healthcare waste collection equipment
  - Hazardous healthcare waste storage;
  - Hazardous healthcare waste transportation;
  - Hazardous healthcare waste disposal practice and annual operating costs;
  - Frequency and adequacy of infection control training;
  - Frequency and adequacy of waste disposal training;
  - Adequacy of supply of personnel protective equipment.
- Consult with national authorities to review and identify best-practice option(s) and preferences for national hazardous healthcare waste management by considering technical feasibility within the existing health infrastructure (including review of existing local institutional, policy and regulatory arrangements).
- Identify local contractors who may have the expertise and capacity to potentially partner with regional or international expert's in future hazardous healthcare waste management including infection control training.

The methodology followed to deliver on this scope is described in **Appendix A**.

1.3 Purpose of Report

This report sits above the 15 participating countries' individual reports, as an overarching summary of the data collected, with a particular focus on relative and broader scale issues, impacts and possible solutions.

Individual country reports should be consulted where detailed country-specific information is required.

1.4 Report Structure

This report is structured as follows:

- an introduction to the project, its purpose and the need for sustainable healthcare waste management across the Pacific (**section 1**)
- an overview of the hospitals audited, their existing waste management practices and a summary of key information collected for each hospital to characterize their scale, level and nature of waste generation (**section 2**)

- a list of the key healthcare waste management issues identified per country and per hospital, by comparison of Section 2's data with a Minimum Standards Framework, including a discussion of regional themes (**section 3**).
- an overview of healthcare waste treatment technologies and a brief summary of technologies used internationally that constitute best or acceptable practice (**Appendix E**)
- an analysis of healthcare waste management and treatment options, including a high level assessment of relative costs and feasibility of potential improvements for each country in the region (**section 4**)
- recommendations for sustainable hazardous healthcare waste management and treatment for each country and hospital audited, including an assessment of likely cost implications of implementing these recommendations (**section 5**) and
- Lessons learnt from the project (**section 6**).

2 Existing Hospital Waste Management Practices

This section summarises the hospitals visited and some key information collected for each to characterize their scale, level and nature of waste generation. More detailed information regarding the waste management process, from ward-level waste generation through to ultimate treatment and disposal, along with all aspects of these hospitals' waste management practices is described within each country's respective individual report.

This information was gathered for each hospital via pre-visit surveys and consultation, site audits and post-visit follow-up, as described in **Appendix A**.

In some cases detailed elements of information or data were not forthcoming, even after repeated onsite and offsite attempts by the project team to gather it. This was often because the data simply wasn't collected or known by hospital staff. A summary of the response rate for the pre-visit surveys is provided in **Appendix B**.

2.1 Hospitals Assessed

The Terms of Reference, as part of the Consultancy Agreement, provided for hospitals to be assessed per country, through a combination of specifically listed and indicative healthcare facilities. Where this was non-specific the project team developed a candidate list of hospitals for a particular country from a combination of liaison with SPREP, research and in-country consultation with health and environment authorities. A final list of hospitals to be visited was agreed with SPREP. These hospitals are shown in Table 1.

Table 1: Hospitals Assessed

Country	Hospitals visited per Country					
The Cook Islands	Rarotonga General Hospital, Rarotonga	Aitutaki District Hospital, Aitutaki				
FSM	Yap Memorial Hospital, Yap	Chuuk State Hospital, Chuuk	Pohnpei State Hospital, Pohnpei	Kosrae State Hospital, Kosrae		
Fiji	Colonial War Memorial Hospital (CWMH) Suva, Viti Levu	Lautoka Hospital, Viti Levu	Labasa Hospital, Vanua Levu	Nadi Hospital, Viti Levu	Sigatoka Hospital, Viti Levu	
Kiribati	Tungaru Hospital, South Tarawa	London Hospital, Kiritimati Island				
The Marshall Islands	Ebeye Hospital. Kwajalein Atoll	Majuro Hospital				
Nauru	Republic of Nauru Hospital					
Niue	Niue Foou Hospital, Niue					

Table 1: Hospitals Assessed						
Country	**Hospitals visited per Country**					
Palau	Belau National Hospital					
PNG	Port Moresby General Hospital, National Capital District					
Samoa	Tupua Tamasese Meaole Hospital, Upolu	Malietoa Tanumafili II Hospital, Savaii				
Solomon Islands	Honiara National Referral Hospital, Guadalcanal Island	Gizo Hospital, Western Province	Helena Goldie Hospital, Munda, Western Province	Kilu'ufi Hospital, Malaita Province	Atoifi Adventist Hospital, Malaita Province	Kirakira Hospital, Makira-Ulawa Province
Timor Leste	Guido Valadares National Hospital, Dili, Dili District	Baucau Referral Hospital, Baucau District	Maliana Referral Hospital, Bobonaro District	Suai Referral Hospital, Cova Lima District	Maubisse Referral Hospital, Ainaro District	
Tonga	Vaiola Hospital	Prince Ngu Hospital	Niu'eiki Hospital	Niu'ui Hospital		
Tuvalu	Princess Margaret Hospital, Funafuti					
Vanuatu	Port Vila General Hospital, Efate Island, Shefa Province.	Northern Districts Hospital, Espiritu Santo Island, Sanma Province	Lenakel Hospital, Tanna Island, Tafea Province	Norsup Hospital, Malakula Island - Malampa Province	Panunagis Health Centre, North Efate Island, Shefa Province	

2.2 Existing Waste Management Practices

Key hospital administrative and waste generation statistics are shown in Table 2.

Information gathered about treatment technologies employed at each hospital is shown by technology type and condition (Table 3a) and capacity of each hospital's infrastructure to treat the volumes of waste they are currently generating (Table 3b).

Table 2: Key Statistics per Hospital (previous 12 months)

Country	Hospital	Key Hospital Statistics					Type of Healthcare Waste Generated				HCW Data[5]			
		Pop Served	No. of Beds	Annual Average Occupancy Rate (%)	OBD's	No. of staff	HCW (infectious non-sharps)	Sharps	Pharmaceutical waste	Cytotoxics	Hospital measures HCW volumes?	HCW including sharps (kg/week)	HCW including sharps (kg/year)	kg HCW generated per occupied bed
The Cook Islands	**Rarotonga General Hospital**	17,794	70	50%	12,775	217	✓	✓	✓	×	Y	95	4,940	0.4
	Aitutaki District Hospital	3,500	26	7%	696	20	✓	✓	✓	×	N	33	1,716	2.5
The Federated States of Micronesia (FSM)	**Yap Memorial Hospital**	11,000	43	60%*	9,417	125	✓	✓	✓	×	N	170	8,840	0.9
	Chuuk State Hospital	48,651	140	60%*	30,660	229	✓	✓	✓	×	N	560	29,120	0.9
	Pohnpei State Hospital	34,000	100	56%	20,440	242	✓	✓	✓	×	N	180	9,360	0.5
	Kosrae State Hospital	7,600	45	62%	10,184	100	✓	✓	✓	×	N	330	17,160	1.7
Fiji	**Colonial War Memorial Hospital**	243,594	481	113%	158,008	1,370	✓	✓	✓	✓	Y	2,540	132,080	0.8
	Lautoka Hospital	238,547	340	73%	90,593	786	✓	✓	✓	✓	Y	1,160	60,320	0.7
	Labasa Hospital	103,122	182	77%	51,151	NS	✓	✓	✓	×	Y	700	36,400	0.7
	Nadi Hospital	~50,000	71	48%	12,439	82	✓	✓	✓	×	N	200	10,400	0.8
	Sigatoka Hospital	~20,000	68	57%	13,651	47	✓	✓	✓	×	N	155	8,060	0.6
Kiribati	**Tungaru Hospital**	50,000	200	110%	80,300	53	✓	✓	✓	×	Y	260	13,520	0.2
	London Hospital	6,000	10	100%	6,570	30	✓	✓	✓	×	N	22	1,144	0.2
The Marshall Islands	**Ebeye Hospital**	11,000 +	45	50%	8213	80	✓	✓	✓	×	N	170	8,840	1.1
	Majuro Hospital	30,000 +	80	9%	2628	112	✓	✓	✓	×	N	420	21,840	8.3
Nauru	**Republic of Nauru Hospital**	11,000	56	100%	20,440	NS	✓	✓	✓	✓	N	550	28,600	1.4
Niue	**Niue Foou Hospital**	1,600	10	37%	1,351	40	✓	✓	✓	×	N	30	1,560	1.2

Table 2: Key Statistics per Hospital (previous 12 months)

Country	Hospital	Key Hospital Statistics					Type of Healthcare Waste Generated				HCW Data[5]			
		Pop Served	No. of Beds	Annual Average Occupancy Rate (%)	OBD's	No. of staff	HCW (infectious non-sharps)	Sharps	Pharmaceutical waste	Cytotoxics	Hospital measures HCW volumes?	HCW including sharps (kg/week)	HCW including sharps (kg/year)	kg HCW generated per occupied bed
Palau	**Belau National Hospital**	21,000	80	28%	8,030	250	✓	✓	✓	×	N	210	10,920	1.4
PNG	**Port Moresby General Hospital**	325,000	758	100%*	276,670	1,300	✓	✓	✓	×	N	3,500	182,000	0.7
Samoa	**Tupua Tamasese Meaole Hospital**	135,000	140	100%	51,100	NS	✓	✓	✓	×	N	540	28,080	0.5
	Malietoa Tanumafili II Hospital	43,000	30	100%	10,950	NS	✓	✓	✓	×	N	125	6,500	0.6
Solomon Islands	**Honiara National Referral Hospital**	93,000	360	100%*	131,400	310	✓	✓	✓	×	N	2,500	130,000	1.0
	Gizo Hospital	76,649	82	40%	11,972	69	✓	✓	✓	✓	N	600	31,200	2.6
	Helena Goldie Hospital	76,649	65	30%	7,118	58	✓	✓	✓	✓	N	250	13,000	1.8
	Kilu'ufi Hospital	132,000	148	40%	21,608	101	✓	✓	✓	×	N	268	13,910	0.6
	Atoifi Adventist Hospital	23,000	45	50%	8,213	65	✓	✓	✓	×	N	150	7,800	0.9
	Kirakira Hospital	45,000	70	50%	12,775	58	✓	✓	✓	×	N	450	23,400	1.8
Timor Leste	**Guido Valadares National Hospital**	200,000	260	80%	75,920	427	✓	✓	✓	×	N	500	26,000	0.3
	Baucau Referral Hospital	111,486	114	70%	29,127	190	✓	✓	✓	×	N	250	13,000	0.4
	Maliana Referral Hospital	97,000	45	50%	8,213	103	✓	✓	✓	×	N	100	5,200	0.6
	Suai Referral Hospital	60,063	24	40%	3,504	88	✓	✓	✓	×	N	75	3,900	1.1
	Maubisse Referral Hospital	59,382	24	50%	4,380	62	✓	✓	✓	×	N	75	3,900	0.9
Tonga	**Vaiola Hospital**	75,416	274	58%	58,006	680	✓	✓	✓	×	Y	1,026	53,352	0.9

Table 2: Key Statistics per Hospital (previous 12 months)

Country	Hospital	Key Hospital Statistics					Type of Healthcare Waste Generated				HCW Data[5]			
		Pop Served	No. of Beds	Annual Average Occupancy Rate (%)	OBD's	No. of staff	HCW (infectious non-sharps)	Sharps	Pharmaceutical waste	Cytotoxics	Hospital measures HCW volumes?	HCW including sharps (kg/week)	HCW including sharps (kg/year)	kg HCW generated per occupied bed
	Prince Ngu Hospital	15,505	62	33%	7,468	80	✓	✓	✓	×	N	190	9,880	1.3
	Niu'eiki Hospital	5,206	20	19%	1,387	21	✓	✓	✓	×	N	13	676	0.5
	Niu'ui Hospital	7,570	18	25%	1,642	31	✓	✓	✓	×	N	105	5,460	3.3
Tuvalu	**Princess Margaret**	11,000	50	100%	18,250	35	✓	✓	✓	×	N	110	5,720	0.3
Vanuatu	**Port Vila Central Hospital**	65,000	146	85%	45,297	102	✓	✓	✓	×	N	750	39,000	0.9
	Northern Districts Hospital	40,000	43	65%	10,202	107	✓	✓	✓	×	N	250	13,000	1.3
	Lenakel Hospital	32,000	43	65%	10,202	50	✓	✓	✓	×	N	250	13,000	1.3
	Norsup Hospital	36,000	54	33%	6,504	33	✓	✓	✓	×	N	100	5,200	0.8
	Panunagis Health Centre	12,000	4	10%	146	4	✓	✓	✓	×	N	10	520	3.6

Notes:

1. OBDs = Occupied Bed Days
2. Occupied Bed = No. of Beds x Annual Average Occupancy Rate (%)/100
3. NS = Not supplied by hospital
4. HCW = Infectious (non-sharps) Health Care Waste
5. = Only infectious (non-sharps) HCW quantities shown as this is the major volume. Refer to individual country reports for volumes of sharps, cytotoxics & pharm. wastes

* = no data supplied – estimated by ENVIRON

Table 3a: Treatment Technologies Observed for Health Care Waste Management in the Pacific Islands

HCW Treatment Approach	Hospitals per Country																																										
	Cook Is		FSM				Fiji					Kiribati		Marshall Islands		Nauru	Niue	Palau	PNG	Samoa		Solomon Islands						Timor Leste					Tonga				Tuvalu	Vanuatu					
	Rarotonga	**Aitutaki**	**Yap**	**Chuuk**	**Pohnpei**	**Kosrae**	CWMH	Lautoka	Labasa	Nadi	Sigatoka	Tungaru	London	Ebeye	Majuro	Nauru	Niue Foou	Belau	Pt Moresby	TTMH	MT II	Honiara	Gizo	Helena Goldie	Kilu'ufi	Atoifi	Kirakira	Guido Valadares	Baucau	Maliana	Suai	Maubisse	Vaiola	Prince Ngu	Niu'eiki	Niu'ui	Princess Margaret	Port Vila	Northern Districts	Lenakel	Norsup	Panunagis H/ Centre
High TI - 1	■					■		■	2					#	E				E									■															
High TI – 2				■			■					■																															
High TI – 3				■				■													■	■																					
High TI – 4					■											■		■											■							■		■						
Med TI – 1																							■							■							# E 2						
Med TI – 2			■														■								■	■	■																
Med TI – 3																															■	■	E	■									
Med TI – 4										■	■	■	■											■	■																		
Low TB		■																											■						■	■						
SS																																■										
SS&S														■																													
Landfill							■	■	■					■				■													■	■	■										
Open dump																														■				■			■					■
Onsite burial	■	■																																	■							

Treatment Approaches:

High TI – 1 = High temperature incineration – working (> 1000 ºC)

High TI – 2 = High temperature incineration – working (semi effectively)

High TI– 3 = High temperature incineration – not working

High TI – 4 = High temperature incineration – decommissioned

Med TI – 1 = Medium temperature incineration – working (800 – 1000 ºC)

Med TI – 2 = Medium temperature incineration –working (semi effectively)

Med TI – 3 = Medium temperature incineration – not working

Med TI – 4 = Medium temperature incineration - decommissioned

Low TB = Low temperature burning (< 400 ºC)

Landfill = Engineered landfill

SS&S = Steam steriliser (autoclave) and shredder

Open dump = Surface dump site with limited engineering controls

Onsite burial = Burial of waste on site with limited engineering controls

Treatment Technology present: ■ **# Not yet commissioned**

2. = Second incinerator present of same type/ condition

E. = External contractor responsible for treatment technology

Table 3b: Treatment Technologies Capacity (at time of site audit)

HCW Treatment Approach	Hospitals per Country																																								
	Cook Is		FSM				Fiji					Kiribati		Marshall Islands		Nauru	Niue	Palau	PNG	Samoa		Solomon Islands						Timor Leste					Tonga				Tuvalu	Vanuatu				
	Rarotonga	Aitutaki	Yap	Chuuk	Pohnpei	Kosrae	CWMH	Lautoka	Labasa	Nadi	Sigatoka	Tungaru	London	Ebeye	Majuro	Nauru	Niue Foou	Belau	Pt. Moresby	TTMH	MT II	Honiara	Gizo	Helena Goldie	Kilu'ufi	Atoifi	Kirakira	Guido Valadares	Baucau	Maliana	Sual	Maubisse	Vaiola	Prince Ngu	Niu'eiki	Niu'ui	Princess Margaret	Port Vila	Northern Districts	Lenakel	Norsup	Panunagis H/ Centre
Functioning Incinerator Present	✓	×	✓	✓	×	✓	✓	✓	✓	× O	× O	✓	✓	×	✓ E	×	✓	×	✓ E	✓	✓	×	✓	×	✓	✓	×	✓	×	✓	×	×	×	×	×	×	✓ O E	×	✓	✓	✓	× O
Functioning SS only [1] Present	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-
Functioning SS&S Present	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sufficient Capacity #	✓	-	✓	✓	-	✓	✓	✓	✓	-	-	×	×	×	✓	-	✓	-	✓	✓	✓	-	✓	-	✓	✓	-	✓	-	✓	-	-	×	-	-	-	✓	-	✓	✓	✓	-
Stockpile	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	✓	-	✓ s	-	-	✓	✓	-	✓ s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] SS only = Steam Steriliser (no shredder)

\# Where Treatment Technology is functioning it has Adequate Capacity to Treat Current Volumes of HCW

O HCW taken Off-Site for Treatment

E External/Contractor Operated Treatment Technology

\- Not Applicable

s Small stockpiles of sharps present

3 Key Healthcare Waste Management Issues

This section summarises and critically assesses the information collected through the auditing process, for each hospital surveyed, in the context of a Minimum Standards Framework.

3.1 Minimum Standards Framework

A minimum standards framework has been developed to set a benchmark for the sustainable management of healthcare waste management. Where a hospital has fallen below this minimum standard it has been flagged in red.

A full description and definitions of minimum standards applicable for healthcare waste management is presented in **Appendix C**.

Target areas have been rated as follows:

Table 4: Assessment Criteria Rating System	
	Meets minimum standards assessment criteria
	Partially meets minimum standards assessment criteria.
	Does not meet minimum standards assessment criteria.

Individual country reports provide a full assessment of each hospital, against these minimum standards. Table 5 highlights the key areas of concern highlighted by this analysis, identified for all hospitals.

Table 5: HealthCare Waste Management in the Pacific Islands - Minimum Standards Framework (Key Issues)

Minimum Standard Criterion	Hospitals per Country																																									
	Cook Is		FSM				Fiji					Kiribati		Marshall Islands		Nauru	Niue	Palau	PNG	Samoa		Solomon Islands						Timor Leste					Tonga				Tuvalu	Vanuatu				
	Rarotonga	Aitutaki	Yap	Chuuk	Pohnpei	Kosrae	CWMH	Lautoka	Labasa	Nadi	Sigatoka	Tungaru	London	Ebeye	Majuro	Nauru	Niue Foou	Belau	Pt Moresby	TTMH	MT II	Honiara	Gizo	Helena Goldie	Kilufi	Atoifi	Kirakira	Guido Valadares	Baucau	Maliana	Suai	Maubisse	Vaiola	Prince Ngu	Niu'eiki	Niu'ui	Princess Margaret	Port Vila	Northern Districts	Lenakel	Norsup	Panunagis H/ Centre
Mgt Plan																																										
Responsible Person/ Mgt C'tee																																										
Signage																																										
Segregation																																										
Storage (interim)																																										
Storage (before treatment)																																										
Containers																																										
Training																																										
Waste Audits																																										
Treatment																																										
PPE																																										
Staff Risk																																										
Spill Kits																																										

3.2 Key Issues Summary

The minimum standard criteria reported against for each country and hospital in Table 5 has been distilled into the five groups of key issues, which are discussed below.

3.2.1 A. Waste Management Framework

There is either no documented waste management planning system in place, or significant gaps present, in 37 of 42 hospitals (88%) visited. There is often limited evidence of waste management committees and in some cases no clear person responsible for waste management at a hospital.

Despite this many hospitals still manage reasonable levels of segregation, particularly of sharps. This is because there is often the fabric of an undocumented system (policies, procedures and sometimes audit and monitoring) that is passed on through the knowledge of infection control and other staff members. Failing to document this has made it difficult for many hospitals to gain sufficient awareness across the entire staff, and therefore achieve the legitimacy and momentum the subject requires. It also limits the chances of embedded sustainable practices in the long term.

3.2.2 B. Signage, Segregation & Containers

Segregation and containment practices are generally below minimum standard in that:

- While sharps segregation was typically practiced, segregation of other wastes occurred well (met minimum standard) in only 9 of 42 hospitals (21%).
- Only 17 of 42 hospitals (40%) visited routinely used appropriate colour coded bins.
- Only 16 of 42 hospitals (38%) visited routinely used appropriate colour coded bin liners (bags).
- 30 of 42 hospitals (71%) visited had no signage present.

Appendix D further investigates the Minimum Standard Criteria relating to consumable items (segregation and storage containers, PPE) to provide a more fundamental picture of the presence of these items.

There are a concerning number of hospitals that did not have the basics: only 33% of hospitals visited (14 out of 42) used colour coded bins and bin liners together to the meet the minimum standard – to adequately control infection risk at the source and clearly identify the hazard to waste handlers further along the management pathway.

3.2.3 C. Training & Audit

There is no structured training program in 30 of 42 hospitals (71%) visited. Typically only the largest hospitals in a country's delivery framework had training programs in place, and these were not always conducted at the minimum annual level or for all staff. Similarly of the training programs in place, record keeping of both the training sessions themselves and who attended was often not available on the day of the audits.

There is no waste segregation auditing program in place in 33 of 42 hospitals (79%) visited.

3.2.4 D. Treatment

The method for treatment of healthcare waste is regularly not in accord with required standards: 18 of 42 hospitals (43%) visited did not have functional treatment infrastructure capable of definitively destroying the infection risk.

An all too familiar situation throughout the region was the evidence of a donated incinerator that had been left to go to ruin on account of eminently fixable reasons:

- A broken fuel line/ pump
- Fuel is too expensive
- Stack wasn't fitted correctly or building structure was not adequate
- Electrical problems
- It was never commissioned
- Corrosion beyond repair
- Broken down equipment for unknown reasons.

Depending on how long it had been since treatment equipment had failed, practices were often in place that were clearly inadequate, such as direct transport of untreated healthcare waste to landfill, open surface dump or onsite dump.

Stockpiles were also observed where a decision about how to deal with the waste in a treatment failure situation had not been made. These are depicted in Table 3b.

3.2.5 E. Occupational Health and Safety

Waste handlers regularly do not always use or sometimes have appropriate PPE including overalls /protective clothing, gloves and eye protection. 20 of 42 hospitals (48%) visited were undersupplied on PPE while 14 of 42 hospitals (33%) weren't observed to be using what they had appropriately or at all.

The lack of use of supplied PPE was common, with possible reasons relating to ignorance of the risk, heat-related discomfort of PPE and a lack of enforcement of requirements.

3.2.6 F. Storage

Storage of waste awaiting treatment was only managed appropriately in 10 out of 42 hospitals (23%) visited. The requirements basically provide for containment, safety, hygiene, security, adequacy of volume and signage to designate what is being stored. This can be achieved in some cases simply by the purchase of a lockable bin that can be easily maneuvered to the treatment location, while in other situations a hospital's volume may dictate a more permanent weather-proof structure.

3.3 Key Issues – Priorities for Action

The relative priorities of key issues identified in specific hospitals are matters for the country-specific reports. These will be driven by the inherent risk posed by the key issue and the urgency of that risk.

The generic issues raised in this section were common to all countries. In terms of relative priorities of these generic issues, and therefore the priority given to their response, they are all significant, because they are based on deficiencies addressed against the minimum standards framework. They are also highly inter-related, for example: segregation practices cannot be sustainably improved without the requirements and responsibility of the waste management framework; which in turn cannot be turned into active policies and procedures without the understanding and reinforcement that comes from training. Effective treatment and use of PPE cannot be sustained without the reinforcement of training, effective segregation and the procedures and monitoring spelled out in the waste management framework.

Having the tools to ensure good infection risk control and waste management, alongside the knowledge to make it happen, routinely, are probably the first things necessary on the road to improved health care waste management outcomes. To make that improvement sustainable, documented systems, policies, procedures, technical notes and responsibilities are necessary.

Therefore the principles for prioritising these key issues for action could look like this:

1. A *sustainable* a waste management framework (Key Issue A) needs to be established or improved, to allow a reference point for all procedures and training in the application of those procedures. This is enhanced through the knowledge gained from participation in a structured training program (2)

2. The *knowledge to make it happen, routinely* will be an outcome of a structured training program (Key Issue C), which may develop (at least in an interim form) in parallel with principle 1.

3. The basic *tools* should be put into place, once the knowledge of how to use them is clearly held, at least by the responsible person(s):

    a. Colour coded-segregation containers, liners, wheelie bins and signage (Key Issue B)

    b. Treatment methods appropriate to destroy the infection risk as a first priority (Key Issue D)

    c. Personal protective equipment to safely enable the carrying out of these treatment methods (Key Issue E)

4. Further enhancements to ensure longer-term staff and community safety (Key Issue F) and conformance with policies and procedures (waste audit program covered in Key Issue C).

This approach guides the selection of recommendations and the short, medium and long-term order of implementation actions, all provided in the Recommendations sections of the individual country reports (Sections 8 respectively).

An important qualification with the above prioritization principles is that there is flexibility in its adoption, depending on the inherent risk posed by the key issue and the urgency of that risk.

For example:

- if there is a clear and immediate risk that staff or the community are currently exposed to an unacceptable risk from exposure to wastes; and
- this risk could be eliminated with simple action such as supply of basic consumables or PPE; and
- there is sufficient existing knowledge with existing staff on how to use the consumables/ PPE; then
- supply of some of the basic tools (principle 3) could be actioned first, to mitigate the risk without waiting for the relatively lengthy system establishment and training steps to occur first.

Counter to this scenario is the potential for consumables to be supplied ahead of training on their use, which could result in mis-use, non-use or the provided goods being lost or stolen and thus wasted. The key issue in deciding whether to change the order of the prioritization is to balance the degree and immediacy of risk posed with the degree of existing knowledge in proper waste management practices.

4 Analysis of Options for Sustainable Healthcare Waste Management in the Pacific Islands

Section 3 identifies key issues that need to be addressed in improving healthcare waste management in the Pacific region. This section evaluates the potential options that could be employed to respond to these key issues.

Table 6 categorizes these key issues (A – F) against potential options that could be adopted to tackle them, as a collated list of high-level responses.

Table 6: Potential Options for Sustainable Healthcare Waste Management in Pacific Island Countries

Key Issue Category	Regularly Encountered Key Issue	Potential options to address the issue
A. Waste Management Framework	There is either no documented **waste management plan**ning system in place, or significant gaps present, in 37 of 42 hospitals (88%) visited. There is often limited evidence of waste management committees.	Establish a waste management framework including: • Waste Management Plan • Responsible officer for implementation of waste management plan • Waste management committee, appropriate to the scale of each facility.
B. Signage, Segregation & Containers	**Segregation and containment** practices are generally below minimum standard in that: • 30 of 42 hospitals (71%) visited had no signage present • While sharps segregation was typically practiced, segregation of other wastes occurred well in only 9 of 42 hospitals (21%). • Only 14 of 42 hospitals (33%) visited had adequate colour coded bins and liners present.	Improve segregation practices (where required) by: • Supply of colour-coded waste bins and plastic liners in quantities sufficient to serve all wards/departments for a period of time sufficient to allow bedding down of the segregation process. • Supply of small number of colour-coded wheelie bins (where required) per hospital to act as both in-ward/department storage and internal transport trolleys. • Supply of signage to explain the colour-coded segregation system as well as posters to promote it.
C. Training & Audit	There is no structured **training** program in 30 of 42 (71%) hospitals visited. There is no waste segregation **auditing** program in place in 33 of 42 (79%) hospitals visited.	Development and delivery of a structured healthcare waste training program to all hospital personnel as well as personnel from other stakeholders (e.g., government health and environment agencies). This could be facilitated/ delivered by: 1. SPREP staff, **or** 2. International technical training providers (or a combination of both), - as no competent healthcare waste management training capability exists in any of the countries visited.
D. Treatment	The method for **treatment** of healthcare waste is regularly not in accord with required standards: 18 of 42 (43%) hospitals visited did not have functional treatment infrastructure capable of definitively destroying the infection risk.	Treatment using one (or a combination) of the following for each hospital: 1. Rotary kiln (highest temperature) 2. Incineration (high temperature) 3. Incineration (medium temperature) 4. Low temperature burning (single chamber incinerator/ pit/ drum/ brick enclosure/ land) 5. Autoclave 6. Chemical 7. Microwave

Table 6: Potential Options for Sustainable Healthcare Waste Management in Pacific Island Countries		
Key Issue Category	**Regularly Encountered Key Issue**	**Potential options to address the issue**
		8. Encapsulation 9. Landfill (without disinfection) 10. Onsite burial 11. Shredding
E. Occupational Health and Safety	Waste handlers regularly do not always use or sometimes have appropriate **PPE** including overalls /protective clothing, gloves and eye protection. 14 of 42 hospitals (33%) visited were deficient in their use of PPE. Adequate s**pill control kits** were not observed in <u>any</u> of the 42 hospitals visited.	Procurement of Consumables (PPE): • Supply spill kits and appropriate PPE including overalls/protective clothing, gloves and eye protection for all waste handlers. • Incinerator staff are provided with additional PPE such as face masks and noise protection.
F. Storage (before treatment)	Only 10 out of 42 hospitals (23%) visited had suitable storage facilities	Upgrade storage before disposal areas to prevent access to the public. This can be achieved by either a built storage shed/ structure or, in many circumstances, simply a wheel able bin with sufficient storage volume, lockable lid and signage.

4.1 Options for (Non-Treatment) Waste Management Aspects

Those options that <u>do not</u> relate directly to the waste <u>treatment</u> process tend to have limited alternatives that can address their respective key issue, given they typically relate to the fundamentals of hazardous waste management. These are:

- The waste management (and infection control) framework, including policies, plans, procedures, responsibility for implementation and audit of the functioning of the framework (A in Table 6)
- The waste management process, from generation to transport and storage up to the treatment location (B, E & F in Table 6)
- Training systems for sustainable healthcare waste management (C in Table 6)
- OHS related protection for waste handlers (E in Table 6)

These areas have not been subjected to an options analysis, because the minimum standards framework has clear requirements with limited variation options.

4.2 Options for Treatment of Healthcare Waste

Healthcare waste <u>treatment</u> (key issue category D) has a range of alternative approaches used around the world, as introduced by **Appendix E** and summarized in Table 6. These have strengths and weaknesses that need to be considered in the context of criteria such as performance and cost of the technology itself, the waste types and volumes it is required to process, the environment it would be operating in and a range of factors specific to the Pacific Islands region and in some cases an individual country's circumstances.

Treatment solutions may involve a single technology, more than one technology for sub-categories of healthcare waste or combination of the technologies listed in Table 6. These alternatives have been assessed for each country using a two stage process:

Stage 1: High-level costs and benefits

- Cost (capital, operating, maintenance)*
- Lifespan
- Technical feasibility (advantages and disadvantages) and how that relates to the Pacific Island regional context

* Costs are estimated at a high level for relative comparison purposes. Detailed quotations, particularly for equipment purchase and associated operating and maintenance costs will be required as part of any future procurement process to be managed by SPREP.

Stage 2: Local feasibility assessment (per country)

- comparative cost to implement
- comparative effectiveness across all HCWs
- health and safety considerations
- sustainability
- institutional and policy fit
- cultural fit
- barriers to implementation
- environmental impact
- durability and
- ease of operator use.

The stage 1 treatment technology options assessment is provided by the table at **Appendix F**. This analysis effectively rules out the following technologies (for all of the Pacific Islands) for the following reasons:

- **Rotary kiln** – high cost and too large for Pacific Island capacity purposes
- **Chemical** – High risk of ineffective treatment due to knowledge and skills required to ensure appropriate concentrations, durations and waste segregation is used. Also high risk of handler injury and high risk of inappropriate disposal, both due to inappropriate handling practices.
- **Microwave** – high cost and too much technological complexity for a durable solution in the Pacific context
- **Sanitary Landfill (without disinfection)** - does not meet minimum standards framework on the grounds that the primary waste hazard (infectious risk) is not treated by landfilling alone (although it would become applicable in combination with disinfection technology). Tapuhia Landfill in Tongatapu is the only site applicable to this category as it is the only engineered sanitary landfill in Tonga.

- **Onsite burial** (without disinfection) – does not meet minimum standards framework on the grounds that the primary waste hazard (infectious risk) is not treated by burial alone (although it may be applicable in combination with disinfection technology)
- **Shredding** (without disinfection) - does not meet minimum standards framework on the grounds that the primary waste hazard (infectious risk) is not treated by shredding alone (although it may be applicable in combination with disinfection technology)

Consequently the following technologies were highlighted by Stage 1 as worthy of further consideration in an individual Pacific Island country's context:

- Incineration (high temperature: >1,000^{0}C [2])
- Incineration (medium temperature: 800 – 1,000^{0}C [2])
- Low temperature burning (single chamber incinerator/ pit/ drum/ brick enclosure/ land: <400^{0}C [2])
- Autoclave
- Encapsulation (of sharps only, in combination with a form of disinfection).

The stage 2 local feasibility assessment may vary between countries so consequently this is contained in each individual country report. An example of the latter is provided at **Appendix G** which, for illustrative purposes, uses the example of a local feasibility assessment for *Tonga*.

All 15 countries' second stage local feasibility assessments showed some quantitative variation, as would be expected with different local factors influencing each country's assessment. But they were unanimous in ranking ***high temperature incineration*** is the preferred disinfection practice throughout the region, where units are modern, maintained, have sufficient waste volumes and locked in supplier maintenance and training contracts.

4.3 Waste Treatment Systems Relevant for individual Hospitals

Wastes should be treated and disposed of accordingly to ensure the infectious hazard is destroyed.

Using this two-stage analysis process, 32 out of 42 hospitals (76%) in the Pacific study region are recommended to be considered for investment in either replacement or maintenance of treatment infrastructure to achieve this, as described by their respective individual country reports. Further detail on this recommendation is provided in Section 5.

[2] As defined in *Management of Solid Health-Care Waste at Primary Health-Care Centres - A Decision-Making Guide*, WHO (2005)

5 Recommendations

Section 4 assessed a number of options for healthcare waste management, narrowing them to a set of treatment and non-treatment based practices applicable to specific Pacific Island countries. Individual country reports have selected from these options to produce a suite of recommendations per country.

This section reports on these in a whole of project context. It outlines:

- A short description of each recommendation-type listed in each country report
- An overview of all recommendations for all countries (Table 7), as detailed in individual country reports (at the hospital level)
- A matrix of estimated establishment costs for all recommendations (Table 8), should they be implemented as described in individual country reports and
- A summary of all treatment-based recommendations per hospital (**Appendix H**), since this is the largest area of recommended investment.

These recommendations have been made in response only to the shortfalls identified by the Minimum Standards Framework assessment and with reference to the data collected through the field audit process. They do not consider other factors that could impact the viability of respective recommendations from one country to another, such as pre-existing programs, arrangements or commitments.

Recommendation details in full for each hospital and corresponding short, medium and long-term implementation actions are provided in individual country reports.

5.1 Recommendations and their Descriptions

The number and type of recommendations nominated in country-reports vary depending on the key issues observed and options applicable for their resolution in that country's context. Review of all 15 country-specific reports finds the following list of 9 recommendation types that were applied (when applicable) to a significant proportion of countries across the region.

Recommendation 1: Develop a Waste Management Framework

1. Develop a **Healthcare Waste Management Plan** specific to each hospital, including technical guidelines and procedures relating to waste management and if not already present, infection control.

2. Appoint an **officer responsible** for the development and implementation of the Healthcare Waste Management Plan

3. Establish a **waste management committee**, appropriate to the scale of the facility.

Recommendation 2: Procurement of Consumables (Segregation & Storage)

The correct segregation of healthcare waste is the responsibility of the person who produces each waste item, whatever their position in the organisation. The healthcare facility is responsible for making sure there is a suitable segregation, transport and storage system, and that all staff adhere to the correct procedures. Labeling of waste containers is used to identify the source, record their type and quantities of waste produced in each area, and allow problems with waste segregation to be traced back to a medical area.

Recommendation 3: Provide a Sustainable Training Program

Development and delivery of a structured healthcare waste training program to all hospital personnel as well as personnel from other stakeholders (e.g., government health and environment agencies).

This could be facilitated/ delivered by SPREP staff, or outside trainers, or a combination of both, as no competent healthcare waste management training capability exists in any of the Pacific Islands countries.

Training should be coordinated with other countries' needs in the region.

Recommendation 4: Improved Treatment Infrastructure

Wastes should be treated and disposed of accordingly to ensure the infectious hazard is destroyed. 32 out of 42 hospitals (76%) in the study region require some investment in either replacement or maintenance of infrastructure, as described in detail in **Appendix H**, Tables H1 and H2.

Recommendation 5: Procurement of Consumables (PPE) & Spill Kits

All waste handlers should be provided with and use appropriate PPE including overalls/protective clothing, gloves and eye protection. Incinerator staff should be provided with additional PPE such as face masks and noise protection

Sufficient spill control kits should be provided for stationing throughout the ward, storage and treatment areas.

Recommendation 6: Appoint a 'Waste Management Officer'

Accountability for healthcare waste management should be assigned to one or more people through clearly defined roles and responsibilities.

Recommendation 7: Upgrade Storage Facility

The healthcare waste storage area should be locked, bunded (contained), isolated from patients and the public and should contain signage identifying the hazard present.

Recommendation 8: A Short-term Whole of Country Co-ordination Resource

A dedicated person responsible for inter-hospital co-ordination, setting work programs, prioritising project actions (as they relate to Fiji) and monitoring progress towards improved waste management. This would provide the 'push' and direction required to establish a coordinated and functioning waste management system throughout divisional and sub-divisional hospitals.

Recommendation 9: Provide Resources to Clean-up Stockpiled Waste

Waste storage areas have volumes of treated and untreated healthcare waste as well as ash from the incinerator. This poses a safety risk to facility operators as well as potential environmental impacts. By cleaning up all storage areas, it not only reduces the risks, but also sends a strong message on the adoption of improved waste management strategies.

5.2 Overview of Recommendations per Country

Table 7 employs a shading system to describe when intervention in a particular country (in any way relevant to the recommendation type) is recommended:

	Intervention is recommended for <u>at least one</u> hospital assessed within the country With respect to the recommendation type, where there is an inadequacy identified in at least one of the hospitals assessed in the country, some level of intervention action is recommended.
	Intervention is not recommended for <u>any</u> of the hospitals assessed within the country With respect to the recommendation type, there has been no inadequacy identified at any one of the hospitals assessed in the country, so no level of intervention action is recommended.

The degree of applicability of each recommendation to each hospital in a country is described in detail in Section 8 of each country-level report.

5.3 Estimated Implementation Budgets

Table 8 is a matrix of establishment costs that are estimated for all recommendations, should they be implemented as described in individual country reports. These are based on technology cost estimates in **Appendix F**, plus the implementation cost range estimates provided in individual country reports' Recommendation Table as follows:

	Cost Ranges ($USD)
Low	$0 – $5,000
Medium	$5,000 - $30,000
High	$30,000 - $100,000

Table 7: Applicability of Recommendations (listed in Individual Country Reports)

Recommendations	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Nauru	Niue	Palau	PNG	Samoa	Solomon Islands	Timor Leste	Tonga	Tuvalu	Vanuatu
Recommendation 1: Develop a Waste Management Framework	■	■	■	■	■	■	■	■		■	■	■	■	■	■
Recommendation 2: Procurement of Consumables (Segregation & Storage)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Recommendation 3: Provide a Sustainable Training Program	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Recommendation 4: Improved Treatment Infrastructure	■	■	■	■	■	■	■	■		■	■	■	■	■	■
Recommendation 5: Procurement of Consumables (PPE) & Spill Kits	■	■		■	■	■		■			■	■	■	■	■
Recommendation 6: Appoint a 'Waste Management Officer'								■							
Recommendation 7: Upgrade Storage Facility		■	■	■		■		■	■	■	■	■		■	■
Recommendation 8: A Short-term Whole of Country Co-ordination Resource			■												
Recommendation 9: Incinerate Existing Waste Stockpiles				■						■					

Table 8: Estimated Establishment Cost - Implication of Recommendations

Recommendations	Establishment Cost ($US) per Country															
	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Nauru	Niue	Palau	PNG	Samoa	Solomon Islands	Timor Leste	Tonga	Tuvalu	Vanuatu	Total
R1: Develop a Waste Management Framework	1,000	12,000	2,000	6,000	6,000	3,000	1,000	2,000	-	6,000	18,000	15,000	12,000	3,000	12,000	99,000
R2: Procurement of Consumables (Segregation & Storage)	1,000	6,000	2,000	3,000	3,000	1,500	500	3,000	2,000	3,000	7,000	6,000	6,000	1,500	7,500	53,000
R3: Provide a Sustainable Training Program	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	150,000
R4: Improved Treatment Infrastructure	20,000	80,000	105,000	70,000	30,000	50,000	50,000	50,000	-	35,000	195,000	45,000	130,000	50,000	200,000	1,110,000
R5: Procurement of Consumables (PPE) & Spill Kits	1,000	4,000	-	1,000	2,000	1,000	-	1,000	-	-	4,000	5,000	4,000	1,000		24,000
R6: Appoint a 'Waste Management Officer'	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R7: Upgrade Storage Facility	-	1,000	6,000	1,000	-	1,000	-	1,000	10,000	1,000	16,000	10,000	-	1,000	16,000	64,000
R8: A Short-term Whole of Country Co-ordination Resource	-	-	75,000	-	-	-	-	-	-	-	-	-	-	-	-	75,000
R9: Incinerate Existing Waste Stockpiles	-	-	-	5,000	-	-	-	-	-	5,000	-	-	-	-	-	10,000
Total Estimated Costs ($US)	**33,000**	**113,000**	**200,000**	**96,000**	**51,000**	**66,500**	**61,500**	**67,000**	**22,000**	**60,000**	**250,000**	**91,000**	**162,000**	**66,500**	**245,500**	**1,585,000**

To a large extent, the total estimated cost per country in Table 8 is a function of the degree to which Recommendation 4 (treatment infrastructure investment) applies, which is entirely dependent on the number of hospitals assessed within the country and the performance of the existing treatment infrastructure in each hospital visited. In the main, where a need for new treatment infrastructure has been identified, the purchase of incinerators of varying scales has been recommended.

Table 8 does not consider operating costs, because the authors are not privy to ongoing program implementation plans, details and times of tenure for the overall PacWaste Project. However, as discussed in Section 6 (Key Themes and Lessons Learnt), our experience from field observations is that hospitals in the Pacific region have far too many examples of previously donated incineration and related treatment equipment that have not fulfilled their potential and are beyond repair. Some ongoing operating budget is important to support the hospitals in the implementation of these recommendations so that sustainability of solutions has a chance.

Consequently, in addition to the total figure indicated ($US1,585,000), it is important to isolate additional funds to be used beyond the establishment period. A minimum of $US600,000 is suggested to be used as an operational budget for at least the first 3 years of implementation, to ensure momentum is maintained in the change process. This could be used for tasks such as:

- Assistance with infrastructure operating and maintenance costs, if this is likely to be a barrier to sustainability in a particular country
- Ongoing training and waste management framework development support
- Monitoring and reporting on program implementation or
- Applying Recommendation 8 (Short Term Whole of Country Co-ordination Resource) across the region more broadly.

6 Key Themes and Lessons Learnt

This section provides some key themes and lessons learnt by the ENVIRON project team in carrying out this work, and in particular the field based component, that may be useful to SPREP in their implementation of these recommendations and other components of the PacWaste Project.

1. There are Low Hanging Fruit Opportunities for Improvement of Healthcare Waste Management

- Significant opportunity exists for low investment related improvement of healthcare waste management in Pacific Island countries, particularly if SPREP's internal capability can be used to resource implementation of recommendations such as waste management policy and plan development, training, co-ordination assistance and some relatively small investment in simple consumables such as segregation bags and bins, particularly for those hospitals without these basics.

2. Better Quality Data would assist Key Investment Decisions

- The process of data collection from hospitals across the Pacific was slow and gave patchy results. Hospital response rates for survey information are described at Appendix B.
- Waste volume data was occasionally measured by hospitals throughout the region. Consequently the estimates provided for waste generation rates (if they were provided at all) were often poor.
- This is illustrated by the "kg HCW generated per occupied bed" figures reported in Table 2. In some regions/ countries there is reasonable agreement on generation rates of healthcare waste (typical ranges 0.5 - 1.5 kg per occupied bed) but within the data there are also some very large estimates (3 of more than 3kg per occupied bed. These figures have been largely estimated through ENVIRON staff judgment, which has resulted in better agreement between hospitals than would have been the case if hospital estimates were taken on face value.
- To provide increased confidence in investment decisions, as well as to engage the commitment of the infrastructure-receiving hospital, this data should be re-gathered with a greater level of trust in the estimates. This should be achieved by a clear estimation approach comprising either of the methods below (in order of preference):
    - Actual weighed data of all healthcare waste generated, taken over a period of at least one month
    - Actual numbers of healthcare waste bags generated, counted over a period of at least one month, with an estimate derived for an average weight per bag
    - A spot audit, where two to three days of actual weighed data for all healthcare waste generated is obtained.
- This requirement could fall on the hospital that will be recipient of the infrastructure, as a demonstration of their engagement and commitment, although records of the assessment would need to be provided to underpin the volumes provided.

- As a footnote to this task, ENVIRON's experience was that getting any data or information at all – for example through surveys – proved difficult, particularly prior to face to face meetings but also in post meeting follow up requests.

3. Avoid Past Mistakes - Stranded Infrastructure

- The region is littered with examples of historically donated incinerators that have not been maintained or, in some cases, ever used.
- In addition to obtaining more confident waste generation data for each hospital under consideration for infrastructure-related assistance, it is essential that funding for equipment purchase also includes provision for maintenance support contracts from suppliers.

4. Economic Drivers are Sometimes Absent

- Either if healthcare waste is collected by external agencies, or processed onsite within existing resources, there is generally no direct cost attributed to the hospital – or at least no perceived cost. (If treatment is via external private contractor this is not the case)
- This lack of economic valuing removes a driver for better segregation, at least a visible one to the staff making the waste generation (waste in bin placement) decision.
- Hospitals need to record some economic factors to encourage better segregation.

5. Low Resourcing and Priority of Healthcare Waste Management

- There are typically minimal resources being provided for management of healthcare waste by hospitals and government agencies across the region. This includes the better-performed countries, such as Fiji (as evidenced by the fragility of key waste management staffing at the well-performed hospitals and much lower standards of waste management at the smaller hospitals in Fiji).
- Healthcare waste is generally left up to the hospital to manage with little assistance from the National governing bodies (i.e. Communication between the Department of Health and the hospital is sometimes non-existent in relation to healthcare waste).
- There does not appear to be a culture of accountability and self-regulation in many of the country's hospitals visited.

6. There is Commonly Insufficient Training Provided

- A common observation throughout the region was a lack of adequate and appropriate training for all stakeholders – ranging from in-hospital to treatment/disposal operators. This is a direct reflection of the low resourcing and priority given to the issue of healthcare waste management.

7. Sustainable Change Will Require Investment of Time with Stakeholders

- As well as funding equipment and training, investing time beyond the establishment phase in bedding down learning, systems and ongoing resourcing will pay dividends. All countries were open to improving their practices but in many cases there is some

institutional inertia to be overcome, which could be helped with the assurance of some help and support.

- The recommendation relating to Fiji only at this stage, to provides a short-term whole of country co-ordination resource, is based on the fact that Fiji are a good regional leader in the making in terms of healthcare waste management, because they have the basis of a good management and implementation framework but it is somewhat stalled in the bigger hospitals and seriously languishing in the smaller hospitals. This recommendation could be applied to other countries in the region, building confidence, momentum and providing both co-ordination and accountability for action.

8. In-Country Assistance Capability is Not Present

- In-country expertise in relation to all aspects of waste management and infection control training, plus servicing and repair of waste treatment systems (i.e. incinerators) does not exist.

9. Consider Regional Issues in Project and Budget Management

- National focal point contacts should be established wherever possible, in relation to the project at hand, well in advance of any field work in the region.
- Factor some redundancy into travel budgets to account for unforeseen (but likely) impacts such as extreme weather events, flight cancellations and potential absence of key people in hospitals or other agencies and departments.

10. Achievements 'against the odds'

- The three divisional hospitals in Fiji, alongside smaller hospitals like Rarotonga Hospital (Cook Islands) and Niue are well-performed hospitals against the Minimum Standards Framework for good healthcare waste management.
- This adherence to standard has been achieved against a difficult backdrop of a large Dengue Fever outbreak at the time of auditing and, for the size of the hospitals, limited infection control and waste management resources (this is particularly so of Lautoka). These hospitals appear to have achieved this level of performance due to the commitment of individuals in these roles and some degree of co-operation and information sharing across the infection control function at divisional level in Fiji.
- In Fiji's case this contrasts with the much weaker performance of their smaller (sub-divisional) hospitals, if the two audited are representative across the country.

11. Quarantine Incinerator Agencies Have Healthcare Waste Concerns

- Co-burning healthcare waste with quarantine waste, in an existing (and in some cases large) high temperature incinerator run by Quarantine Agencies, is an attractive and common sense proposition, particular in small countries or as a back-up option to breakdown scenarios. However, quarantine incineration operators/ agencies were generally not interested – they were very concerned about their ability to handle safely what they saw (in healthcare waste) as a greater risk compared to what they were familiar with treating.

- Only Niue has potential for a combined treatment infrastructure, but this would need to be sited and managed at the hospital in any case, due to the sentiment above.

Appendix A

Project Methodology

A1. Desktop Research

A desktop assessment was carried out to gain an appreciation of current healthcare waste management approaches by facilities within the Region as well as type, location and availability of waste treatment/disposal sites, numbers and capacity of contractors and related infrastructure such as waste transport and other management systems a review of relevant documents and services will be conducted. This enabled the targeting of the most relevant healthcare facilities to audit.

An international literature review was also completed to determine approaches utilised in countries with similar demographics, waste volumes and management capacity to identify opportunities for this project.

A2. Regulatory Review

ENVIRON compiled a literature review and collected information from national authority databases to summarise and analyse the current position each participant country is in with respect to healthcare waste management, including commitments made and their respective progress towards implementation of these.

A3. Project Inception Meeting (Samoa)

An inception meeting took place in Samoa on the 17 February 2014 attended by Geoff Latimer of ENVIRON and SPREP in order to gain a shared understanding of the scope and expectation of the project.

A4. Project Planning

A draft project plan was submitted capturing planning and the project management approach, including scope, methodology, logistics, team roles, consultation strategy, communication protocols, timeframes and risk and safety management. After review by SPREP, the Project Plan was finalised and issued. The project plan included a 'Gantt Chart' which was used actively throughout the project to track progress and milestones.

A5. Data Gathering and Consultation Stage

A5.1 Focal Point Communication

SPREP provided ENVIRON with selected PacWaste Focal Points that were to be the primary points of contact for each nation. Where PacWaste focal points were not provided, ENVIRON endeavored to make contact with SPREP National Focal Points in order to establish a national contact, introduce the project and the nature of our work and gather hospital specific contact details.

A5.2 Distribution of Pre-audit Survey

Once hospital specific contacts were established initial information was sought via a pre-audit survey. The survey was planned to introduce the project and to obtain the following information about each hospital:

- Hospital administrative details (facility name/location, contact name/position and population served);
- A summary or services;
- Hospital specific details (number of beds, occupied bed days (as average occupancy rate, number of operating theaters and operations, number of births, emergency patients attended and out-patients attended);
- Number of staff;
- Waste streams managed;
- Estimated volumes generated;
- Cost of management;
- Existence of waste management training/education programs;
- Waste treatment and disposal;

Data on waste generation and management systems including copies of waste management policies, procedures, and relevant information control regimes (related to waste management) was also requested.

A5.3 Development of Hospital Audit Survey

A detailed audit survey was also developed at this time that would serve as an audit tool during the hospital visits. These surveys were developed in order to obtain further detailed information on the areas detailed below. ENVIRON used these surveys during the hospital audits and completed them in consultation with relevant hospital staff and waste management personnel.

- Quantities and observations in regard to levels of cross contamination between waste streams;
- Details on internal waste storage facilities;
- Details on internal and external waste treatment;
- Details of contractors or external waste management services;
- Waste auditing procedures;
- Waste management training/education;
- Infection control;
- Alternative national/regional healthcare waste treatment options and capacity to utilise these;
- Any issues that may pose barriers to change;
- Projected issues for the next 10 years that may impact on service delivery and/or waste generation/management.

A6. Site Visits

ENVIRON assembled a facility audit team to carry out site based investigations across 15 participating countries. During the site visits, ENVIRON conducted waste assessments to validate data/information provided by the facility to aid in the development of a waste generation profile (types and quantities) as well as to identify support systems (bin types/colour coding, location, signage, cleanliness, use of appropriate personal protective equipment (PPE) by waste management personnel, on-site storage etc.

The waste assessments were also focused on determining levels and correctness of waste segregation. By conducting the waste assessments ENVIRON could also more accurately calculate treatment/disposal requirements based on levels of correctness of waste segregation. In determining waste volumes, ENVIRON could also consider issues of increased medical waste generation due to disaster and epidemic incidents and the subsequent management needs.

During the site visits ENVIRON reviewed on-site infrastructure such as internal collection equipment (e.g. trolleys, PPE), and storage so as to ascertain issues associated with improvements (actual infrastructure/equipment requirements, costing for improvements, personnel required and training issues). These reviews measured such infrastructure and procedures against those stated in SPREP's draft *Pacific Healthcare Waste: A Regional Strategy and Action Plan 2013-2015*, WHO publications and other Regional management publications (including those in Australia and New Zealand). During the site visits detail of all training relevant to effective waste management (including such training as sharps management even if the focus is on reduction of needle-stick injuries) was assessed, so as to determine what occurs, when and how. This was undertaken in order to provide a series of recommendations for improving both the content and delivery of training services.

A6.1 Hospital Consultations and Interviews

Interviews with relevant facility personnel (environmental/waste, infection control, WH&S and supply) were conducted to ascertain approaches and issues with current management systems and procedures for healthcare waste.

A7. Analyse Survey Data

Based on the data obtained from the survey and the site visits, ENVIRON developed a profile of waste types/quantities by facility type and country along with current management approaches and identification of health and environmental issues associated with these approaches. This has been used to develop a minimum standards assessment tool that can be used for all types of healthcare facilities to benchmark generation and management practices. This will allow for monitoring of such areas as segregation, education, monitoring etc. and directs the hospital as to where improvements in waste management should be targeted.

A7.1 Evaluate Practices at Landfills

Where possible ENVIRON also viewed and evaluated practices at landfills for the acceptance and burial of healthcare waste noting issues such as locations, depth of burial, use of PPE, record keeping and other issues (such as compaction that could result in aerosol formation). This was done on an adhoc basis depending on the significance of landfill/ dump disposal in the context of the treatment approach used at the hospital and whether the landfill be conveniently be reached in the allotted audit time.

A8. Consultation with National Authorities

ENVIRON held meetings with national environmental, health and workplace health & safety agency representatives to gain an understanding of the current status of healthcare waste management in their region, legislative approaches (now and future), provision of guidelines, waste reporting frameworks by facilities, existing waste management infrastructure, approximate volumes, treatment/disposal facility standards and licensing and other related issues. These discussions also explored government views on:

- Impediments to locating and developing treatment/disposal facilities (including exiting facilities) for healthcare waste
- Capacity of contractors to effectively manage current and future healthcare waste quantities
- Changes in delivery of healthcare services and likely impacts on waste management
- What is considered best practice approaches in their jurisdiction
- Role of implementing waste reduction within the sector
- Practical local considerations
- Logistical requirements, limitations, regulatory compliance implications and costs and
- Any other informational inputs to the impact assessment

Where possible ENVIRON visited examples of local waste management infrastructure of specific interest to current or potential healthcare waste management to better understand some of the local problems and assist with options development and quantification of impacts arising from each.

ENVIRON also investigated opinions on potential local contractors who have a current, or could have a future, role in healthcare waste management and will request contact information and/ or the potential for accompanied site visits of existing waste treatment/disposal infrastructure.

Where possible ENVIRON also investigated issues with similar waste types (e.g. quarantine waste) that are generally managed in the same manner as healthcare waste, as increases in types and quantities of this waste may have a significant impact on infrastructure and systems to manage healthcare waste.

A8.1 Contractor Expertise and Capacity Identification

ENVIRON investigated the existence, capacity and capabilities or any national or regional contractors for managing healthcare wastes.

During these consultations, ENVIRON identified the capacity of the contractors to effectively manage healthcare waste – by inspecting storage facilities, operational vehicles, review staff training and competencies, incident management as well as capability of providing additional services such as waste audits, education and reporting of waste generation to the facilities.

A9. Project Deliverables

A9.1 Draft Report

ENVIRON and team members have collaborated to draft a consolidated report (this one) and 15 individual country reports for SPREP's consideration which include:

- Data/information on healthcare waste generation rates for all facilities reviewed, summaries of current waste management systems (level and extent of training, waste segregation practices, on-site management, treatment/disposal facilities used, costs associated with management of healthcare waste, issues that need addressing).
- Summaries of all waste treatment/disposal facilities in use and potentially could be used in all country reviewed.
- Review of all jurisdictional approaches – legislation, policies, guidelines and these will be compared with what would be considered best-practice for the Pacific Region.
- Details of what is considered best-practice healthcare waste management.
- Details of contractor capacity for all countries.
- Options and recommendations for building capacity (per country or region) for healthcare waste treatment and/or disposal so as to ensure sustainable systems for this waste management as well as meeting best-practice requirements.
- Outline of healthcare waste training needs, in terms of delivery, curricula, competencies currently achieved by the various personnel, skill development for trainers and training evaluation methodologies.
- Short, medium and long-term actions necessary to achieve best-practice healthcare waste management.

A9.2 Deliver Final Report

Following the comment and revision process with SPREP and acceptance of the first draft(s), final reports were developed to a consistent style so that no further editing was required prior to publication.

Appendix B

Country Information Requests – Response Rates

Table B1: Pre-Audit Survey Response Process

Country	Hospital	Primary Contact Person	Was pre-audit survey (mostly) completed:				Challenges/ alternative approaches to data collection
			Pre-visit?	During visit?	Post-visit?	Not at all	
The Cook Islands	Rarotonga	Mrs. Helen Sinclair			✓		Delay getting response but contact provided good assistance
	Aitutaki	Ms. Tara Tschan-Toi		✓	✓		Delay getting response but contact provided good assistance
The Federated States of Micronesia (FSM)	Yap	Mr.. James Gilmar	✓				All communications were facilitated through Ms Patricia Pedrus she provided a high level of assistance and distributed and returned the pre-audit surveys.
	Chuuk	Mr. Julio Marar	✓				
	Pohnpei	Mr. Paulino Rosario	✓				
	Kosrae	Dr. Livinson Taulung	✓				
Fiji	CWMH	Sr. Sarita Goundar	✓				Very thorough responses and provided high level of assistance
	Lautoka	Sr. Ana Radolo		✓			Very thorough responses and provided high level of assistance
	Labasa	Sr. Sera Lasakula Senior Nurse				✓	Only some data collected during audit. There have been multiple attempts to obtain the majority of the data but has not been provided.
	Nadi	Dr. Susana Nakalevu				✓	Only some data collected during audit. There have been multiple attempts to obtain the majority of the data but has not been provided.
	Sigatoka	Sr. Kelera Vosailagi		✓			Provided high level of assistance during the audit but no response to post visit requests for final small pieces of outstanding data
Kiribati	Tungaru	Mr. Tebikau Noran	✓				A substantial amount of information provided prior to the visit
	London	Dr. Teraira		✓			Most data collected during audit.
The Marshall Islands	Ebeye	Mr. Abon Jeadrik		✓			Very thorough response provided during visit, had prepared much of it prior to my arrival.
	Majuro	Ms. Malia E. Heine			✓		Some data collected during audit, the remainder was sent through post-audit.
Nauru	Nauru	Ms. Lucy Duburiya			✓		Multiple attempts to get data with most provided after the site visit.
Niue	Niue Foou	Ms. Grizelda Mokoia	✓				Very thorough responses and provided high level of assistance
Palau	Belau	Mr. Temmy Temengil			✓		Some information provided post visit.
PNG	Port Moresby	Mr. Bobby Tau		✓	✓		Only some data collected during audit. Was relatively helpful during the audit and post audit however due to the size of the hospital obtaining data was difficult.
Samoa	TTMH	Mr. Lameko Tesimale				✓	Only some data collected during audit. There have been multiple attempts to obtain the majority of the data but has not been provided.
	MT II	Mr. Lameko Tesimale				✓	
Solomon Islands	Honiara	Mr. Rolly Vigar			✓		Only some data collected during audit. Contacts were responsive but had difficulty getting the data
	Gizo	Mr. Hugo Loseni				✓	Only some data collected during audit.

Table B1: Pre-Audit Survey Response Process

Country	Hospital	Primary Contact Person	Was pre-audit survey (mostly) completed:				Challenges/ alternative approaches to data collection
							Contact not responsive.
	Helena Goldie	Mr. Andrew Telo		✓			
	Kilu'ufi	Mr. Nixon Olofisau	✓				Contact very responsive prior to audit, during the audit and post audit.
	Atoifi	Ms. Peggy Kendall		✓			Contact was helpful in collecting data for the audit and responsive post audit.
	Kirakira	Mr. Marcel Weape		✓			Contact was helpful in collecting data for the audit
Timor Leste	Guido Valadares	Ms. Paulina Pinto		✓			Did not have all the data available during audit. Difficult to contact post audit.
	Baucau	Mr. Simone Sracs		✓			
	Maliana	Dr. Bourdaloue Moniz		✓			
	Suai	Dr. Hormausigifdo				✓	Language barriers were challenging during the audit and contact has not been responsive post audit.
	Maubisse	Ms. Gabrialla Perira		✓			
Tonga	Vaiola	Mr. Isileli Fakailoatonga		✓			Had prepared much of it prior to my arrival and provided good information during the audit.
	Prince Ngu	Mr. Leopino Fa'asolo		✓			Provided excellent assistance on the day to get all of the required information
	Niu'eiki	Sr. 'Amelia Vea	✓				Ensured pre-audit form was completed prior to arrival for visit
	Niu'ui	Dr. Tevita Vakasiuola	✓				Ensured pre-audit form was completed prior to arrival for visit
Tuvalu	Princess Margaret	Mrs. Avanoa Homasi-Paelate				✓	Only some data collected during audit. Attempts to obtain the majority of the data proven unsuccessful
Vanuatu	Port Vila	Leipakoa Matarika				✓	Did not have a lot of the data available for the audit. Was not responsive post audit.
	Northern Districts	Dr Sam Ailo			✓		Did not have a lot of the data available for the audit. Some data was provided post audit.
	Lenakel	Mr. Simon Saika		✓			
	Norsup	Mr. Noel Nathan		✓			
	Panunagis H/ Centre	Kalwad Poilapa		✓			

Appendix C

Minimum Standards Framework

Table C1: HEALTHCARE WASTE - MINIMUM STANDARDS FRAMEWORK			
Scale	**Category**	**Item**	**Minimum Standard Criterion**
National Authority	National Legislation	Definitions	A clear definition of hazardous healthcare wastes and its various categories has been developed and used by generators.
National Authority	National Legislation	Annual Compliance Reporting	Hospitals required to annually report on waste generation and management
	National Legislation	Technical Guidelines	Practical and directly applicable technical guidelines
National Authority	Regulations	Annual Compliance Reporting	
National Authority	Policy	National healthcare waste management plan	A national strategy for management of healthcare waste has been published and is up to date (ie., within 5 years) and hospitals required to adhere to its requirements
Healthcare Facility	Policy	Infection Control	Infection control policy incorporates principles of waste management within it
Healthcare Facility	Policy	Waste Management Plan	Has been developed by the hospital and is based on a review of healthcare waste management and is current (within 5 years)
Healthcare Facility	Responsible Person		An officer has been appointed to assume responsibility for waste management within the hospital, and has been allocated sufficient time and resources - this person could have waste management as part of other duties
Healthcare Facility	Management Committee		A waste management committee has been formed that has representatives from a broad range of departments and meets at least twice per year. A clear set of objectives has been developed for this committee. It reports to the senior management of the hospital.
Healthcare Facility	Signage		Signs are located in all wards/department areas where waste bins are located indicating the correct container for the various waste types
Healthcare Facility	Segregation		Waste are correctly segregated in all wards/departments with use of containers that are colour coded for the different waste types
Healthcare Facility	Containers		All areas have dedicated waste containers are suitable for the types of waste generated. All waste containers are colour coded and have correct wording on them. Sharps are deposited into containers that reduce potential for needle-stick injury
Healthcare Facility	Storage	Interim storage in healthcare facility	Storage areas at ward/department level should be secure and located away from public areas. Storage areas should be sufficient in size to allow waste to be segregated and so as to avoid waste of different classifications being stored together.
		Storage before treatment	Meets the standards stated in Appendix E, Recommendation 2, *Correct Storage*.
Healthcare Facility	Internal Handling	Transport Trolley	A dedicated trolley is used for waste transport. The trolley is designed so that any spills are contained.
	Internal Handling	Routing	Healthcare waste is not transported where clean linen and/or food are transported
Healthcare Facility	Training	Planning and implementation	A structured waste management education program has been developed with a clear delivery structure
Healthcare Facility	Training	Curricula	A structured waste management training program has been developed that targets the different roles within the hospitals.
Healthcare Facility	Training	Follow-up & refresher courses	All staff receive waste management education during induction. All staff receive refresher training annually. Waste management training is delivered following an adverse incident to the relevant staff/ward/department.

Table C1: HEALTHCARE WASTE - MINIMUM STANDARDS FRAMEWORK			
Healthcare Facility	Training	Training responsibility	A hospital officer has responsibility for ensuring all training occurs as required and that records are maintained of all training and attendance.
Healthcare Facility	Waste Audits		A program has been implemented to ensure waste audits are conducted of all waste materials/systems in all wards/departments on an annual basis and reports are provided to the waste management committee. Effective systems are in place to ensure that any non-conformances (with the hospital waste management strategy) are remedied.
Healthcare Facility	Transport - External		A dedicated vehicle is used to transport untreated healthcare waste. This load carrying area of the vehicle is enclosed and constructed so that any spilt material is contained within this area. A split kit is provided.
Healthcare Facility	Treatment	Suitability of treatment for healthcare waste	The treatment process should render the waste material so that there are no pathogens likely to cause harm as well as be conducted in a manner that reduces any environmental consequences. The method for treating healthcare waste is in accord with Appendix E - including operating parameters, relevance to each waste to be treated and location of the treatment unit.
Healthcare Facility	Economics	Cost Effectiveness	A process has been developed that cost all aspects of waste management and these costs are reported annually to the waste management committee.
Healthcare Facility	Occupational Health and Safety	PPE	All waste handlers are provided with and use appropriate PPE including overalls/protective clothing, gloves and eye protection. Incinerator staff are provided with additional PPE such as face masks and noise protection. A system is in place to monitor correct use of PPE.
Healthcare Facility	Occupational Health and Safety	Staff risk	Waste containers, locations, storage and management procedures for healthcare waste incorporate identified risks to staff in accessing the waste and/or having needle-stick injuries.
Healthcare Facility	Occupational Health and Safety	Patient/Visitor risk	Waste containers, locations, storage and management procedures for healthcare waste incorporate identified risks to patients and visitors in accessing the waste and/or having needle-stick injuries.
Healthcare Facility	Healthcare waste management emergencies	Spill Prevention and Control	Spill kits are provided or all types of healthcare waste in all wards/departments, storage areas and on trolleys and vehicles. Staff are trained on the use of spill kits. All incidents of spills of healthcare waste are investigated and where appropriate remedial actions implemented.
Healthcare Facility	Future Planning	Planning for change	Hospitals have developed a process to benchmark waste generation so as to (amongst other requirements), plan of future hospital development in terms of services and numbers of patients.
Local Council	Waste Treatment Facility	Landfill	Healthcare waste is disposed of at a dedicated location and covered immediately on arrival. Scavengers cannot access untreated healthcare waste.

* The minimum standard is drawn from the *Industry code of practice for the management of biohazardous waste (including clinical and related) wastes*, Waste Management Association of Australia (2014), Draft 7th edition, taking into account the Pacific Island hospital and environmental context

Appendix D

Presence of basic waste management consumable items

Table D1: Presence of basic waste management consumable items

Country	Hospital	Are correct colour-coded bins mostly used?	Are correct colour-coded bags mostly used?	Are correct dedicated sharps containers mostly used?	Are sharps containers fit for purpose (reduce potential for NSI)?	Are appropriate bins present for in-ward interim storage?	Are there adequate supplies of PPE onsite for use by waste handlers?
The Cook Islands	Rarotonga	✓	✓	✓	✓	✓	✓
	Aitutaki	x	x	✓	✓	✓	✓
The Federated States of Micronesia (FSM)	Yap	✓	✓	✓	✓	x	x
	Chuuk	x	x	x	✓	x	x
	Pohnpei	x	x	✓	✓	✓	x
	Kosrae	x	x	✓	✓	✓	x
Fiji	CWMH	✓	✓	✓	✓	✓	✓
	Lautoka	✓	✓	✓	✓	✓	✓
	Labasa	✓	✓	✓	✓	✓	✓
	Nadi	✓	✓	✓	✓	✓	✓
	Sigatoka	✓	✓	✓	✓	✓	✓
Kiribati	Tungaru	✓	x	✓	✓	✓	x
	London	x	x	✓	✓	x	x
The Marshall Islands	Ebeye	x	x	✓	✓	✓	x
	Majuro	x	x	✓	✓	x	x
Nauru	Nauru	x	✓	✓	✓	x	x
Niue	Niue Foou	✓	✓	✓	✓	✓	✓
Palau	Belau	x	x	✓	✓	x	x
PNG	Port Moresby	✓	✓	✓	✓	✓	✓
Samoa	TTMH	x	x	x	x	✓	x
	MT II	✓	x	✓	✓	✓	x
Solomon Islands	Honiara	✓	✓	✓	✓	✓	✓
	Gizo	x	✓	✓	✓	x	✓
	Helena Goldie	✓	x	✓	✓	✓	x
	Kilu'ufi	x	x	✓	✓	x	✓
	Atoifi	x	x	✓	✓	x	x
	Kirakira	x	x	✓	✓	x	x
Timor Leste	Guido Valadares	x	x	✓	✓	x	✓
	Baucau	x	x	✓	✓	x	✓
	Maliana	✓	✓	✓	✓	✓	✓
	Suai	✓	✓	✓	✓	✓	✓

Table D1: Presence of basic waste management consumable items

Country	Hospital	Are correct colour-coded bins mostly used?	Are correct colour-coded bags mostly used?	Are correct dedicated sharps containers mostly used?	Are sharps containers fit for purpose (reduce potential for NSI)?	Are appropriate bins present for in-ward interim storage?	Are there adequate supplies of PPE onsite for use by waste handlers?
	Maubisse	x	x	✓	✓	x	✓
Tonga	Vaiola	✓	✓	✓	✓	✓	x
	Prince Ngu	x	x	✓	✓	x	x
	Niu'eiki	x	x	✓	✓	x	x
	Niu'ui	x	x	✓	✓	x	x
Tuvalu	Princess Margaret	✓	✓	✓	✓	✓	x
Vanuatu	Port Vila	x	x	✓	✓	x	✓
	Northern Districts	x	x	✓	✓	x	✓
	Lenakel	x	x	✓	✓	x	✓
	Norsup	x	x	✓	✓	✓	✓
	Panunagis H/ Centre	x	x	✓	✓	x	✓
TOTAL ✓ (out of 42)		**17**	**16**	**40**	**41**	**22**	**22**

Appendix E

Overview of Healthcare Waste Management Treatment Technologies

Overview of Healthcare Waste Management Treatment Technologies

The healthcare waste stream is diverse in that it contains a variety of chemical substances, organic materials, plastics, metals and materials that are potentially contaminated with pathogenic substances. The primary aim of treating this waste stream is to minimise or remove potential negative impact to human health or the environment as a consequence of the components of this waste not being treated adequately. This means that the treatment process should render the waste material so that there are no pathogens likely to cause harm as well as be conducted in a manner that reduces any environmental consequences.

There are a number of treatment processes for healthcare waste. However, not all of these are able to treat all types of healthcare wastes. Materials such as pharmaceuticals, cytotoxic and anatomical wastes can only currently be treated by incineration. Therefore, when selecting a process to treat healthcare wastes, the generator must be aware of the capabilities and limitations of each of the various treatment processes and ensure that only those wastes that can be thus treated are actually sent to such a facility, and the remainder sent to an incineration facility. This is part of any facilities due diligence process.

Healthcare waste requires treatment to primarily reduce:

- Pathogenicity (*capacity of a virus, bacteria etc. to cause a disease*)
- Toxicity (*the degree to which a substance can damage an organism*)
- Volume

An article by Diaz *et al* (2005)[3] summarises the main issue in relation to the requirement for treating healthcare waste:

> *"Inappropriate treatment and final disposal of the wastes can result in negative impacts to public health and to the environment. In addition, pathological (infectious) and hazardous healthcare wastes, when inappropriately managed, may be the source of intra-hospital infections and may pose serious occupational health risks to those who care for the patients, as well as to those who participate in the management of the wastes within and outside the healthcare facility.*
>
> *The scavenger population, which works on the streets or at the final disposal facilities, is another relatively large population that is exposed to the risks posed by improperly treated healthcare wastes (HCW) in developing countries."*

The main or acceptable approaches to treating healthcare waste are (with variations on the technology) – note also that some of these technologies are also used in conjunction with shredding/maceration:

[3] Diaz, L. F., *et al* (2005), Alternatives for the treatment and disposal of healthcare wastes in developing countries, Waste Management 25 (2005) 626–637

- Incineration
- Open burning
- Autoclave (steam or heat sterilisation)
- Chemical
- Microwave
- Irradiation
- Landfill without disinfection

According to the World Health Organization[4], the choice of treatment system involves consideration of waste characteristics, technology capabilities and requirements, environmental and safety factors, and costs – many of which depend on local conditions.

A report by Health Care Without Harm Europe[5] indicated that healthcare facilities should consider the following factors when selecting a non-incineration technology:

- Regulatory acceptance
- Throughput capacity
- Types of waste treated
- Microbial inactivation efficacy
- Environmental emissions and waste residues
- Space requirements
- Utility and other installation requirements
- Waste reduction
- Occupational safety and health
- Noise
- Odour
- Automation
- Reliability
- Level of commercialisation
- Background of the technology manufacturer or vendor
- Cost
- Community and staff acceptance.

Of the treatment technologies currently utilised, incineration is the primary method internationally (the other main option is landfill disposal, but as this is not *disinfection*

[4] World Health Organization (2013), Safe management of wastes from health-care activities, Second edition.
[5] Health Care Without Harm Europe (2004), Non-Incineration Medical Waste Treatment Technologies in Europe.

treatment, it is not discussed in this context). There are a variety of reasons for this, however, it is a technology that is relatively easy to operate, appropriate units can be "bought off the shelf", pollution control approaches are well understood, fuel sources can be tailored to the location and the process can treat all types of healthcare waste (dependant on the actual unit (1^o and/or 2^o chambers, pollution control, operating temperatures and loading regimes). In addition, the units can be "stand alone" so that they can be located away from communities and environmentally sensitive areas.

In general, technologies such as autoclave, chemical and microwave require greater levels of operator management in regards to ensuring correct wastes only are loaded into the units as well as in the operation of the units themselves. This former point would require a much higher level of correct segregation within the wards/departments than is currently being achieved. Then as the waste is generally still recognizable as healthcare waste, shredding/maceration is usually required to render the waste unrecognisable – thus adding an extra layer of treatment to the process.

These technologies are also generally more expensive to purchase and operate than incinerators as well as higher operational and maintenance costs.

In regards to maintenance, the alternate technologies[6], except for steam autoclave units, also require specialised maintenance regimes and personnel that are not readily available in the Pacific Islands.

There has been some discussion over a trend by some to shift to a non-incineration based management strategy. This is something that will be more relevant to developed countries as the capacity to shift to alternate technologies (eg., costs, infrastructure, technical capability etc), are more readily available and not so in developing countries.

What is not in dispute is the almost unanimous opinion that healthcare waste should not be landfilled (even in engineered landfills), untreated.

[6] This is a term that is commonly used when referring to non-incineration technologies.

Appendix F

Treatment Technology Options Assessment (Stage 1) – High Level Assessment for the Pacific Islands Region

Table F1: Treatment Technology Options Assessment (Stage 1) – High Level Assessment for the Pacific Islands Region

Technology Option	Capacity (kg per hour)	Cost ($USD)			Lifespan (years)	Lifespan Cost ($USD)	Technical Feasibility	
		Capital	Operating	Maintenance			Advantages	Disadvantages
1. Rotary kiln (1200 – 1600^{0}C)	100-3,000 (use 200)	500,000	70,720	10,608	10	1313280	Can treat all healthcare waste types Removes infectious risk associated with the waste Renders the waste unrecognizable Does not require at-source waste segregation Significant reduction in volume and weight	High costs Requires skilled staff to operate Requires a fuel source Ash requires careful management Air pollution if not operated correctly Maintenance and repair issues Siting must be appropriate
2. Incineration at high temperature (>1000^{0}C) (small to medium scale units)	18-50 (use 30)	20,000 – 60,000	14040	2106	10	211460	Can treat all healthcare waste types Removes infectious risk associated with the waste Renders the waste unrecognizable Does not require at-source waste segregation Significant reduction in volume and weight	Staff training required to operate Requires a fuel source Ash requires careful management Air pollution if not operated correctly Regular maintenance required Siting must be appropriate
3. Incineration at medium temperature (800 - 1000^{0}C) (small scale units)	10	3000 - 10000	4680	702	5	34910	Removes infectious risk associated with the waste Renders the non-sharps waste unrecognizable Does not require at-source waste segregation Significant reduction in volume and weight Lower fuel costs (may use biomass) Lower purchase costs than more complex incinerators	Some staff training required to operate Requires a fuel source, at least for start up Ash requires careful management Air pollution more likely than higher combustion temperature processes Potential heavy smoke Regular maintenance required Siting must be appropriate Potential for needle stick injuries since some needles may not be destroyed
4. Low temperature burning (<400^{0}C)	0.5 - 15 (use 5)	2,000	390	59	10	6485	Simple (zero) technology Removes infectious risk associated with the waste Renders the non-sharps waste unrecognizable Significant reduction in volume and weight	Minimal training necessary Should not be used for waste containing plastics and chemicals Increased air pollution (including heavy

Table F1: Treatment Technology Options Assessment (Stage 1) – High Level Assessment for the Pacific Islands Region								
Technology Option	**Capacity (kg per hour)**	**Cost ($USD)**			**Lifespan (years)**	**Lifespan Cost ($USD)**	**Technical Feasibility**	
		Capital	**Operating**	**Maintenance**			**Advantages**	**Disadvantages**
							Lowest fuel costs (may use biomass) No establishment or maintenance cost	smoke) Cannot be used during rain periods Fire risk Cannot treat anatomical, cytotoxic or pharmaceutical waste Ash requires careful management Siting must be appropriate Potential for needle stick injuries since some needles will not be destroyed
5. Autoclave	2 - 100 (use 30)	10,000 - 150,000	3600	1200	10	98000	Low operating costs Treated wastes can be landfilled Technology used in healthcare so maintenance should be easy Low adverse environmental impact	Requires trained operators Cannot treat anatomical, cytotoxic or pharmaceutical waste Loads with high density take a longer time to treat – operator knowledge critical Requires a supply of water and electricity (bigger units may have requirement for 3-phase power) Can be odorous Water requires disposal to sewer No volume reduction - landfill disposal costs Requires careful source segregation of waste Requires pre- shredding for best effectiveness - additional equipment and costs Efficiency of disinfection sensitive to operation conditions Waste appearance unchanged so potential for

Table F1: Treatment Technology Options Assessment (Stage 1) – High Level Assessment for the Pacific Islands Region								
Technology Option	**Capacity (kg per hour)**	**Cost ($USD)**			**Lifespan (years)**	**Lifespan Cost ($USD)**	**Technical Feasibility**	
		Capital	**Operating**	**Maintenance**			**Advantages**	**Disadvantages**
								undesirable reuse
6. Chemical	-	-	low-med	-		low-med	Relatively simple No capital cost - relatively inexpensive total costs No technology involved No combustion related pollution	Disinfectants may be corrosive and need to be handled safely Proper concentrations must be used for specific lengths of time to ensure adequate disinfection No waste volume reduction Environmental health concerns when disinfectants are disposed of Uncharacterised air emissions
7. Microwave	10 - 250	100,000 - 500,000	med-high	high	10	high	Significant volume reduction No liquid discharge Waste made unrecognizable Removes infectious risk associated with the waste	High purchase and operating costs Potential maintenance and operational issues due to technology complexity Requires highly trained operators Increased weight of waste Not suitable for all wastes Shredder requirement adds cost and durability/ maintenance issues Uncharacterised air emissions
8. Encapsulation	18-50 (use 30)	20,000 – 60,000	14040	2106	10	211460	Low technology Simple Prevents needle re-use Protects from future NSI's No air pollution	Relevant for sharps only Will not remove "infectious" aspect of waste Increases volume Requires space if buried Not suitable for non-sharps waste Requires correct segregation of sharps
9. Landfill (without	-	-	Gate fee	-	-	Dependa	Low technology	Waste is not treated – infectious risk remains

Table F1: Treatment Technology Options Assessment (Stage 1) – High Level Assessment for the Pacific Islands Region

Technology Option	Capacity (kg per hour)	Cost ($USD)			Lifespan (years)	Lifespan Cost ($USD)	Technical Feasibility	
		Capital	Operating	Maintenance			Advantages	Disadvantages
disinfection)			plus transport per tonne of waste			nt on gate fee and transport costs	No limit to quantity that can be deposited No air pollution No technology operation training necessary	No volume reduction Ideally requires pits to be constructed Potential contamination of groundwater High risk to persons accessing the site Wastes can be accessed by scavengers or vectors An “off-site” only option and therefore requires transport
10. Onsite burial	-	-	low	-	-	low	Low technology No air pollution No technology operation training necessary	Requires space to be available Does not disinfect waste Might be a risk to community if not properly buried Potentially easy access to non-authorized personnel No volume reduction May fill up quickly Potential soil and water pollution
11. Shredding (without disinfection)	50+	10000 - 60000	3600	1200	10	68000	Low technology No air pollution No technology operation training necessary	Requires space to be available Does not disinfect waste Might be a risk to community if not properly buried Potentially easy access to non-authorized personnel No volume reduction May fill up quickly Potential soil and water pollution

Table F1: Treatment Technology Options Assessment (Stage 1) – High Level Assessment for the Pacific Islands Region

Technology Option	Capacity (kg per hour)	Cost ($USD)			Lifespan (years)	Lifespan Cost ($USD)	Technical Feasibility	
		Capital	Operating	Maintenance			Advantages	Disadvantages

Notes:

1. Costs are supplied for comparative purposes only.

2. Costs information is sourced from equipment suppliers, equipment users (such as hospitals within this project) and the literature wherever possible. World Health Organization (2005), *Management of Solid Health-Care Waste at Primary Health-Care Centres, A Decision-Making Guide* was used in lieu of other available information.

3. Where no costs were readily available comparative estimates of high, medium and low were used.

4. Capital cost refers to equipment purchase cost only

5. Operating cost refers to fuel, electricity and water costs where applicable, as well as known consumables

6. Assume average of range given for capital costs

7. Assume 20 hours per week incinerator running time for running cost calculations

8. Assume 30 kg/hr throughput of typical incinerator likely to be suitable for many Pacific Island hospital situations

9. Assume 0.3L fuel is consumed per kg waste burnt (derived from Fijian hospital data obtained through this project)

10. Assume $1.50 USD per litre diesel cost

11. Assume maintenance costs are 15% of operating costs unless other information is located

12. Rotary kiln capacity assumed to be 200kg/hr operating at an average 20 hours per week

13. Assume USEPA estimate of average operating costs for hospitals of $0.16/ lb of waste ($0.34/kg) sourced from:

    "Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Hospital Medical/Infectious Waste Incinerators; Final Rule - 40 CFR Part 60, Federal Register, Vol. 62, No. 178, September 15, 1997, U.S. Environmental Protection Agency."

14. Assume autoclave purchase cost of $50,000

15. Autoclave operating costs (scaled back to smaller capacity unit than the one in this reference) taken from:

    http://www.mark-costello.com/downloads/medical-waste-sterilizer-general-bulletin-806.pdf

16. For standalone shredder, Assume electricity, water supply, water discharge and consumables costs are equivalent to Autoclave running costs

17. Assume standalone shredder purchase cost is $20,000

Appendix G

Stage 2 Local Feasibility Assessment for Short-listed Treatment Options – Example Country: Tonga

G1 Stage 2 Local Feasibility Assessment for Short-listed Treatment Options – Example Country: Tonga

The Stage 2 local feasibility assessment takes these technologies and assesses them against

- comparative cost to implement
- comparative effectiveness across all healthcare wastes
- health and safety considerations
- sustainability
- institutional and policy fit
- cultural fit
- barriers to implementation
- environmental impact
- durability and
- ease of operator use.

These criteria are explored qualitatively in Table G1 below. These qualitative descriptions have been assigned a score from 1 – 5, to prioritise local applicability of technology options to the Tongan context, on a relative basis as follows:

1. Very low
2. Low
3. Moderate
4. High
5. Very High.

Table G1's qualitative assessment is reflected quantitatively in Table G2, using this scoring approach.

Note that *encapsulation* is assessed separately to the other four technologies, as its potential applicability is only for sharps that have already been treated to remove the infection risk, whereas all other technologies have a wider application and are fundamentally standalone options.

Legend (to Table G1): Descriptions equate to the following scores:

	1. very low agreement with feasibility criteria
	2. low agreement with feasibility criteria
	3. moderate agreement with feasibility criteria
	4. high agreement with feasibility criteria
	5. very high agreement with feasibility criteria

Table G1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (Tonga)										
Remaining Technology Options	**Comparatively low cost to implement**	**Comparative effectiveness across all HCWs**	**Local Feasibility**							
			Health & safety to workers & community	**Sustainability of solution**	**Institutional and policy fit**	**Cultural fit**	**Implementation barriers can be overcome?**	**Receiving environment not impacted**	**Durability**	**Ease of operation**
Incineration at high temperature (>1000^{0}C [1])	$211,460 USD over 10 years (ref Whole of Project – Summary Report, Appendix E)	Most effective – can treat all waste types and achieves complete sterilization, complete combustion and destroys waste	Some issues for operators (requires training & PPE); some potential issues for community (potential for smoke, some controlled emissions)	Equipment lifespan ~ 10 years plus; sustainability dependant on maintaining operator skills plus proper operation and maintenance	No legal barriers to incineration; loses a point for potential for smoke nuisance and the potential for minor contribution to combustion derived POPs – Tonga is a party to Stockholm	Burning of rubbish is historically accepted & widely practised in Tonga. Incinerators are/ have been previously used in hospitals	Equipment breakdown and lack of local skills to maintain equipment – real barrier but can be managed through skills training & supplier support	Emissions of air pollutants and leaching from ash disposal to receiving environment are potential impacts. High temp operation minimises pollution & proper landfilling of ash restricts leaching.	Equipment lifespan ~ 10 years plus but will only last if maintained. High temperature equipment is prone to require a moderate level of maintenance	Requires skilled operators but modern equipment combined with training simplify operation
Incineration at med. temperature (800 - 1000^{0}C[1])	$69,820 USD over 10 years (ref Whole of Project – Summary Report, Appendix E)	Can treat all waste types, achieves complete sterilization, incomplete combustion, may not destroy needles	Some issues for operators (requires training & PPE); potential issues for community (smoke, emissions not fully controlled)	Equipment lifespan ~ 5 years; sustainability dependant on maintaining operator skills plus proper operation and maintenance	No legal barriers to incineration; potential for smoke nuisance is med - high and the potential for contribution to combustion	Burning of rubbish is historically accepted & widely practised in Tonga. Incinerators are/ have been	Equipment breakdown and lack of local skills to maintain equipment – real barrier but can be managed through skills training & supplier support. Simpler	Emissions of air pollutants/ smoke and leaching from ash disposal to receiving environment are potential impacts. Med. temperature operation increases risks of	Equipment lifespan typically less ~ 5 years but will only last if maintained. Equipment is prone to require a moderate level	Requires less skilled operators than high temperature equipment - training simplifies operation

Table G1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (Tonga)										
Remaining Technology Options	**Comparatively low cost to implement**	**Comparative effectiveness across all HCWs**	**Local Feasibility**							
			Health & safety to workers & community	**Sustainability of solution**	**Institutional and policy fit**	**Cultural fit**	**Implementation barriers can be overcome?**	**Receiving environment not impacted**	**Durability**	**Ease of operation**
					derived POPs & other pollutants is high – Tonga is a party to Stockholm	previously used in hospitals	infrastructure.	air pollution, but not likely to be an issue in isolated small communities.	of maintenance	
Low temperature burning (<400^{0}C [1])	$6,485 USD over 10 years (ref Whole of Project – Summary Report, Appendix E)	Not applicable for all waste types, relatively high disinfection efficiency, incomplete combustion, will not destroy needles	Some issues for operators (requires training & PPE); issues for community (smoke, emissions not controlled at all)	No equipment; sustainability dependant government & community acceptance which would be expected to decline with time	Potential for smoke nuisance is very high and the potential for contribution to combustion derived POPs & broader range of other pollutants is very high – Tonga is a party to Stockholm	Burning of rubbish is historically accepted & widely practised in Tonga.	No equipment operation reliability barrier; burning rubbish common practice in Tonga	Emissions of air pollutants/ smoke and leaching from ash disposal to receiving environment are potential impacts. Low temperature operation provides no controls on air pollution. Risk of fire impact.	Simple, zero technology so there is nothing that can break down	Simple, zero technology so there is nothing that can break down and no specific training is required other than health and safety.
Autoclave with shredder	$158,000 USD over 10 years (ref Whole of Project –	Cannot treat all waste types, achieves complete	Some issues for operators (requires training &	Equipment lifespan ~ 10 years; sustainability	No legal barriers; no potential for smoke	Not familiar with use of sterilisers for waste –	Equipment breakdown and lack of local skills to maintain	No emissions of air pollutants/ smoke; some potential for	Equipment will only last if maintained. Adding	Requires skilled operators to achieve best

Table G1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (Tonga)										
Remaining Technology Options	**Comparatively low cost to implement**	**Comparative effectiveness across all HCWs**	**Local Feasibility**							
			Health & safety to workers & community	**Sustainability of solution**	**Institutional and policy fit**	**Cultural fit**	**Implementation barriers can be overcome?**	**Receiving environment not impacted**	**Durability**	**Ease of operation**
	Summary Report, Appendix E)	sterilization when correctly operated, no combustion required, shredder destroys needles	PPE); small potential for odours and wastewater discharge (community)	dependant on maintaining operator skills plus longevity of equipment use given technology complexity	nuisance; some potential for odour nuisance; no air pollution (no combustion-POPs) and some potential for waste water management issues	potential community issue with waste appearance if steriliser not operated correctly or shredder not used	equipment – real barrier but can be managed through skills training & supplier support. Increased complexity of equipment (compared to incineration) increases barrier	odour impacts; still requires landfill or dump disposal so some potential for leaching on burial; some potential for waste water management issues. Larger residual waste compared to burning – only engineered landfill is in Tongatapu.	shredder to autoclave technology increases mechanical parts that can go wrong. May require moderate level of maintenance	level of disinfection.
Encapsulation (only post-disinfection sharps assessed)	Virtually zero additional cost to disinfection system costs	Not applicable to non-sharps waste. In the context of pre-sterilised sharps only: no combustion required and	Encapsulation has handling issues for operators (requires training & PPE) and no community	No equipment; sustainability dependant burial space available. Only engineered landfill is in Tongatapu so	No legal barriers; no smoke nuisance; no odour nuisance; no air pollution and some	No particular cultural fit concerns	New practice proposed – may face some inertia barrier. Lack of new 'shiny' machinery may imply the change is not that important.	Encapsulation itself poses no smoke nuisance; no odour nuisance; no air pollution and some potential for leachate to	Highly durable due to its simplicity.	Simple procedure once operator understands and manages the risk of sharps handling and

Table G1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (Tonga)										
Remaining Technology Options	**Comparatively low cost to implement**	**Comparative effectiveness across all HCWs**	**Local Feasibility**							
			Health & safety to workers & community	**Sustainability of solution**	**Institutional and policy fit**	**Cultural fit**	**Implementation barriers can be overcome?**	**Receiving environment not impacted**	**Durability**	**Ease of operation**
		completely removes downstream needle injury risk	issues	increases waste volume that requires burial.	potential for leachate to groundwater, although limited inherent hazard			groundwater, although limited inherent hazard.		knows how to mix cement correctly.

1. As defined in *Management of Solid Health-Care Waste at Primary Health-Care Centres - A Decision-Making Guide*, WHO (2005)

The treatment technologies suitable for the Tongan context are ranked in order of preference in Table G2:

Table G2: QUANTITATIVE Treatment Technology Options Assessment - Local Feasibility (Tonga)

Stage 1-Approved Technology Options	Comparatively low cost to implement	Comparative effectiveness across all HCWs	Local Feasibility								Total Score out of 50	Rank
			Health & safety to workers & community	Sustainability of solution	Institutional and policy fit	Cultural fit	Implementation barriers can be overcome?	Receiving environment protected	Durability	Ease of operation		
Incineration at high temperature (>1000^{0}C)	1	5	4	4	4	4	3	3	3	3	34	1
Incineration at med. temperature (800 - 1000^{0}C)	4	4	3	3	2	4	4	2	2	4	32	2
Low temperature burning (<400^{0}C)	5	3	1	2	1	3	5	1	5	5	31	3
Autoclave with shredder	2	4	4	3	5	2	2	3	2	2	29	4

Notes:
- Scored on a scale of 1-5, where 1= very low; 2 = low; 3= moderate; 4 = high and 5 = very high
- Criteria given equal weighting
- Possible maximum score: 50

In support of Table 8's ranking:

- ***High Temperature Incineration*** is the promoted disinfection practice where units are modern, maintained, have sufficient waste volumes and locked in supplier maintenance and training contracts.
- ***Medium Temperature Incineration*** is acceptable in the medium term to remedy current unacceptable practices at sites too small to justify costs of expensive equipment.
- ***Low temperature burning*** is a borderline practice which can only be acceptable in the short term, in low population density environments, to remedy current unacceptable practices.
- ***Autoclaving*** is an acceptable disinfection practice where units with shredder are affordable and locked in supplier maintenance and training contracts are in place, but borderline beyond Tongatapu due to lack of lined landfills and increased complexity of machinery.

Based on the qualitative assessment in Table G1, ***encapsulation*** ranks as an effective way to deal with the residual risk from already disinfected sharps: i.e., the risk of needle stick injury by healthcare workers or the community (waste disposal area) due to the fact that sharps are disinfected but not physically destroyed by the low-medium temperature of open burning (or non-destruction of autoclaving). Encapsulation is never recommended as an isolated form of treatment, as it does not disinfect or otherwise treat the hazard of the waste.

A substantial amount of data exists on the emissions generated from incinerators, but conversely, little studies have been conducted on all aspects of alternate technologies performance. While the literature is inconclusive on the requirements needed to effectively manage the blood and body fluid contaminated and infectious components of the waste streams, there does seem to be consensus that hazardous components such as pharmaceuticals and cytotoxic wastes do need to be treated prior to final disposal to ensure there is no risks to the environment or health of humans and other species. No publication from a government environmental or health agency, or any article reviewed advocated any other preferred form of treatment for pharmaceuticals and cytotoxic wastes than incineration. In most instances the preference for anatomical waste was also incineration.

Since Tonga does not currently generate cytotoxic wastes and typically returns anatomical waste to the family of the patient for cultural reasons, limitations regarding these wastes are not particularly relevant for healthcare waste treatment choices in Tonga.

G2. Treatment Investment Options for individual Tongan Hospitals

Wastes should be treated and disposed of accordingly to ensure the infectious hazard is destroyed. All four hospitals in Tonga require some investment in either replacement or maintenance of infrastructure to achieve this.

Table G3 determines 'intervention' options that are suggested to improve treatment of healthcare waste in each Tongan hospital visited. Shading in green indicates where investment is proposed, while orange shading shows where a technology consideration is also relevant.

Table G3: Technology Options Applicable for Each Hospital in Tonga

Remaining Technology Options	Technology Applicability
Vaiola Hospital	
Disinfection & Encapsulation (only sharps assessed)	Not applicable to Vaiola, as autoclaved waste goes to Tapuhia Landfill, which is the only new and functional sanitary landfill in Tonga.
Incineration at high temperature (>1000^{0}C)	The existing autoclave/ steam sterilizer has insufficient capacity to treat all healthcare waste (and is possibly not used at all, meaning large infectious waste quantities are taken to landfill untreated). ENVIRON recommends to: • *Procure a new incinerator* – a MediBurn 30 model has a manufacturer's claimed throughput of 200 kg/day of healthcare waste. At Vaiola's estimated rate of 1,000 kg healthcare waste per week (10% of which is sharps) this unit is theoretically large enough. However, it is likely that the existing autoclave would need to be operated in tandem to ensure these volumes (plus future growth) could be managed. Alternatively a larger incinerator may be required.
Incineration at med. temperature (800 - 1000^{0}C)	Not applicable to Vaiola - large enough to justify a better performing larger higher temperature option.
Autoclave with shredder	The existing autoclave should be used for healthcare waste (with sharps as a priority) to its maximum capacity, ensuring sufficient temperature/ pressure/ time, followed by landfill of treated waste at Tapuhia Landfill. Using this existing infrastructure alongside a new high temperature incinerator allows for current volumes to be treated with some spare capacity. Since autoclaved waste goes to Tapuhia Landfill, which is the only new and functional sanitary landfill in Tonga, it is acceptable to autoclave in this instance without a shredder (not part of the current set up at Vaiola).

Table G3: Technology Options Applicable for Each Hospital in Tonga

Remaining Technology Options	Technology Applicability
Low temp. burning (<400^{0}C)	Not applicable to Vaiola - it has sufficient waste volumes to justify better performing disinfection technology.
Prince Ngu	
Disinfection & Encapsulation (only sharps assessed)	Not applicable when incinerator is operating.
Incineration at high temperature (>1000^{0}C)	Not applicable to Prince Ngu as current single chamber incinerator is sufficient for volumes handled if replacement transformer is fitted and it is made operational again.
Incineration at med. temperature (800 - 1000^{0}C)	The existing incinerator should be supplied with a replacement transformer urgently and repaired to provide the hospital with a functional treatment option.
Autoclave with shredder	Not applicable to Prince Ngu as current single chamber incinerator handles volumes produced when it is operational.
Low temperature burning (<400^{0}C)	Not applicable to Prince Ngu as it has sufficient waste volumes to justify a better performing disinfection technology choice.
Niu'eiki Hospital	
Disinfection & Encapsulation (only sharps assessed)	Given the small volumes of waste involved, and the small and dispersed population on 'Eua Island, a low cost alternative to incineration could be implemented, at least in the short term. For sharps this could involve concrete encapsulation of disinfected sharps in a metal drum, at the dump site. The drum could then be buried at the dump.
Incineration at high temperature (>1000^{0}C)	Not applicable to Niu'eiki as waste volumes are insufficient to justify the investment required.
Incineration at med. temperature (800 - 1000^{0}C)	Healthcare waste volumes at Niu'eiki appear to be underestimated by a factor of 10, when compared to Vaiola and Prince Ngu. Adjusting healthcare waste generation to approximately 50kg/ week, this would be sufficient to consider a small medium temperature incinerator. However, given Niu'eiki's lack of even the most basic investment in health care waste management (supply of bins would be a forward step) it is hard to foresee the fuel and related operating costs of approximately $5,000 pa being sustainable.
Autoclave with shredder	Not applicable to Niu'eiki on the grounds of waste volume justification, cost, complexity and ease of operation.
Low temperature burning (<400^{0}C)	Given the small volumes of waste involved, and the small and dispersed population on 'Eua Island, a low cost alternative to incineration could be implemented, at least in the short term. This could involve: • Building a concrete floored brick burning block at the dump site • Burning sharps separately in the burning block, to disinfect, followed by concrete encapsulation and burial at the dump. • Burning healthcare waste separately in the burning block, to disinfect, followed by burial at the dump. (separate burning is suggested as only the sharps need to be encapsulated). This could serve as a short term solution to the lack of reliable disinfection practices currently, should a low cost incinerator option be pursued, as well as build redundancy into the system should there be operational issues with a new incinerator. Because the population of 'Eua Island is small and dispersed, the air quality impact from low temperature burning of healthcare waste is not a pressing issue.
Niu'ui Hospital	
Disinfection & Encapsulation (only sharps assessed)	Given the small volumes of waste involved, and the small and dispersed population on 'Lifuka Island, a low cost alternative to incineration could be implemented, at least in the short term. For sharps this could involve concrete encapsulation of disinfected sharps in a metal drum, at the waste disposal area at the back of the hospital, and buried there.

Table G3: Technology Options Applicable for Each Hospital in Tonga

Remaining Technology Options	Technology Applicability
Incineration at high temperature (>1000^{0}C)	Not applicable to Niu'ui as waste volumes are insufficient to justify the investment required.
Incineration at med. temperature (800 - 1000^{0}C)	Healthcare waste generation is reported to be approximately 100kg/ week. This appears a little high given the number of beds. Regardless, this volume would be sufficient to consider a small medium temperature incinerator, to replace the ruined onsite incinerator. However, given Niu'ui's lack of investment in health care waste management it is hard to foresee the fuel and related operating costs of approximately $5,000 pa being sustainable.
Autoclave with shredder	Not applicable to Niu'ui on the grounds of waste volume justification, cost, complexity and ease of operation.
Low temperature burning (<400^{0}C)	Given the small volumes of waste involved, and the small and dispersed population on Lifuka Island, a low cost alternative to incineration could be implemented, at least in the short term. This could involve: • Building a concrete floored brick burning block at the back of the hospital, by demolishing the ruined incinerator unit and utilizing the existing two bricked walls and adding a third. • Fencing the waste dump/ burning area • Burning sharps separately in the burning block, to disinfect, followed by concrete encapsulation and burial onsite. • Burning healthcare waste separately in the burning block, to disinfect, followed by burial onsite. (separate burning is suggested as only the sharps need to be encapsulated). This could serve as a short term solution to the lack of reliable disinfection practices currently, should a low cost incinerator option be pursued, as well as build redundancy into the system should there be operational issues with a new incinerator. Because the population of Lifuka Island is small and dispersed, the air quality impact from low temperature burning of healthcare waste is not a pressing issue.

Timing considerations for these options, in the context of other (non-treatment) options, are provided in the Tonga's individual country report Section 8 (Recommendations).

Appendix H

Types of Treatment Infrastructure Investments Recommended

Table H1: Types of treatment Infrastructure recommendations - per hospital

Treatment Infrastructure Recommendation Type	Hospitals per Country																																										
	Cook Is		FSM				Fiji					Kiribati		Marshall Islands		Nauru	Niue	Palau	PNG	Samoa		Solomon Islands						Timor Leste					Tonga				Tuvalu	Vanuatu					
	Rarotonga	Aitutaki	Yap	Chuuk	Pohnpei	Kosrae	CWMH	Lautoka	Labasa	Nadi	Sigatoka	Tungaru	London	Ebeye	Majuro	Nauru	Niue Foou	Belau	Pt. Moresby	TTMH	MT II	Honiara	Gizo	Helena Goldie	Kiluufi	Atoifi	Kirakira	Guido Valadares	Baucau	Maliana	Sual	Maubisse	Vaiola	Prince Ngu	Niu'eiki	Niu'ui	Princess Margaret	Port Vila	Northern Districts	Lenakel	Norsup	Panunagis H/ Centre
HTIS - new		■											■																						■	■								■
HTIM - new					■							■				■	■	■										■									■		■					
HTIL - new																						■											■					■					
Repair			■	■			■	■													2		■	■		■			■		■	■		■					■	■	
Enclosure									■			■	■	■		■	■						■	■		■														■	■	
Costs															■																												
Tech							■																																	■	■	
Contract		■	■		■		■	■	■			■	■			■	■	■		■	2	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Commission														■																													
Total new HTIS (5)	**1**		**0**				**0**					**1**		**0**		**0**	**0**	**0**	**0**	**0**		**0**						**0**					**2**				**0**	**1**					
Total new HTIM (8)	**0**		**1**				**0**					**1**		**0**		**1**	**1**	**1**	**0**	**0**		**1**						**0**					**0**				**1**	**1**					
Total new HTIL (3)	**0**		**0**				**0**					**0**		**0**		**0**	**0**	**0**	**0**	**0**		**1**						**0**					**1**				**0**	**1**					

Treatment recommendations proposed:

HTIS - new = Procure a new (small capacity) high temperature incinerator
HTIM - new = Procure a new (medium capacity) high temperature incinerator
HTIL - new = Procure a new (large capacity) high temperature incinerator
Repair = Repair existing incinerator
Enclosure = Upgrade treatment technology housing structure
2 = Two units at one location relevant to recommendation
Costs = Financial support for fuel cost
Tech = Technical modifications for incinerator
Contract = Maintenance support contract
Commission = Commissioning support for existing (unused) incinerator

Table H2: New incinerator purchases – estimated capacity requirements					
Incinerator Scale Required	**Country**	**Hospital**	**HCW generated (kg/wk.)**	**Estimated capacity required (kg/load) [1]**	**Optimum capacity range (kg/ load)**
Small	Cook Islands	Aitutaki	33	3	5 - 10
Small	Kiribati	London	22	2	5 - 10
Small	Tonga	Niu'eiki	13	1	5 - 10
Small	Tonga	Niu'ui	105	11	5 - 10
Small	Vanuatu	Panunagis H/ Centre	10	1	5 - 10
		Average	**37**	**4**	**5 @ 5 - 10kg/ load**
Medium	FSM	Pohnpei	180	18	30 - 50
Medium	Kiribati	Tungaru	260	26	30 - 50
Medium	Nauru	Nauru	550	55	30 - 50
Medium	Niue	Niue Foou	30+	3+	30 - 50 *
Medium	Palau	Belau	210	21	30 - 50
Medium	Solomon Islands	Kira Kira	450	45	30 - 50
Medium	Tuvalu	Princess Margaret	110	11	30 - 50
Medium	Vanuatu	Northern Districts	250	25	30 - 50
		Average *	**287**	**29**	**8 @ 30 - 50kg/ load**
Large	Solomon Islands	Honiara	2500	250	250 - 500
Large	Tonga	Vaiola	1026	103	50-100
Large	Vanuatu	Port Vila	750	75	50-100
		Average	**1425**	**143**	**1 @ 250 - 500kg/ load**
					2 @ 50 - 100kg/ load

* Niue Foou excluded - decision on capacity is predicated on larger volume from possible addition of quarantine waste

1. - Based on 2 loads (batches) run per day, 5 days per week

2. Niu'eiki and Niu'ui waste generation appears to be under and over-estimated respectively- actuals likely to be in the middle (approx. 50kg/wk)

3. Nauru waste generation appears to be overestimated by approx. 1.5-2 fold

4. Princess Margaret Hospital waste generation appears to be underestimated by approx. 3 fold