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

Palau

Prepared for:
Secretariat of the Pacific Regional Environment Programme (SPREP)

Prepared by:
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Date:
July 2014

Project Number:
AS140211

EUROPEAN UNION

ENVIRON

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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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VERSION CONTROL RECORD

Document File Name	**Date Issued**	**Version**	**Author**	**Reviewer**
AS140211_SPREP_Healthcare Waste Report_Palau_DRAFT_20140613	13 June 2014	Draft 1	Natalie Stella	Trevor Thornton
AS140211_SPREP_Healthcare Waste Report_Palau_rev0	4 July 2014	Final	Natalie Stella	Geoff Latimer
PacWaste_HCW_Baseline_Report_PALAU_v1.1	10 & 23 Oct 2014	Final 1.1	J. Tavane	EU emblem & disclaimer added

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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.

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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 the assessment conducted for Palau.

Current Healthcare Waste Management in Palau

Belau National Hospital is the only hospital on the island nation of Palau and as such was the only one assessed for Palau as part of this project. Information regarding the waste management process occurring, from ward-level waste generation through to ultimate treatment and disposal was collected during an audit of the hospital conducted on 28 March 2014.

A minimum standards framework has been developed to set a benchmark for the sustainable management of healthcare waste in the Pacific Island region. 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 audit, Belau National Hospital was assessed against this framework. Table ES1 highlights the key areas of concern in terms of health services delivery by the hospital, as part of this assessment.

A full description and definitions of minimum standards applicable for healthcare waste management, as well as a comprehensive assessment against each of the criteria is presented in **Appendix C**.

Target areas have been rated as follows:

	Meets minimum standards assessment criteria
	Partially meets minimum standards assessment criteria.
	Does not meet minimum standards assessment criteria.

Table ES1: Healthcare Waste – Key issues for Palau (BNH)

Scale	Category	Item	Minimum Standard Criterion	Belau National Hospital
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	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	
		Storage before treatment	Meets the standards stated in Appendix E, Recommendation 2, *Correct Storage*.	
Healthcare Facility	Training	Curricula	A structured waste management training program has been developed that targets the different roles within the hospitals.	
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	Treatment	Suitability of treatment for healthcare waste	The method for treating healthcare waste is in accord with required standards - this includes operating parameters and location of the treatment unit.	
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	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.	

Key Issues

The most significant health care waste management issues observed at Belau Hospital were:

- There is no signage and very poor segregation –healthcare waste and general waste are often combined in the same bins with very few dedicated coloured coded waste containers and colored coded bag liners. Sharps are separated into dedicated containers (combination of reusable and disposable) however they reportedly 'constantly overfill' due to lack of resources. There is also a very high frequency rate of Needle Stick Injures (NSI) reported by both cleaning/ maintenance and nursing staff due to improper handling and disposal of sharps **(Photo 1)**.
- An incinerator was commissioned in 1992 however; it has not been used since early 2013 (exact date unknown) **(Photo 2)**. There were frequent complaints from neighboring residents regarding smoke emissions and a decision was made to stop using it until the incinerator is moved to its new location approximately 1 km away from the hospital adjacent to the Koror Wastewater Treatment Plant. Since January 2013 all waste has been transported to the M-Dock Landfill, Koror and disposed of without being treated. There is no incinerator at the landfill. There is reportedly a dedicated cell for healthcare waste but inspection was not possible at the time of the audit.
- There Belau National Hospital has an Infection Control Manual which includes a section of healthcare on healthcare waste management (sighted during the audit) however; there is no healthcare waste management framework for the hospital.
- There is a structured training program in place that covers proper disposal of healthcare waste and infection risk from improper handling of infectious wastes, however according to the Chief Infection Control Nurse attendance at the training sessions and compliance with training materials post training is poor.
- No PPE such as gloves, protective clothing, eye protection or covered footwear was observed for waste management staff and spill control kits were not observed anywhere throughout the facility.
- There is no 'responsible person/ officer' who oversees the management of healthcare waste at the Belau National Hospital
- The area where healthcare waste is stored before disposal need to be secured with a lockable door and fencing and signposted with hazardous waste signage to prevent hospital patient or public access **(Photo 4)**.

Analysis of Options for Sustainable Healthcare Waste Management in Palau

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

For treatment 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 Palau-specific feasibility assessment, using an analysis of 10 criteria (**Appendix D**).

Treatment options that rated best for Palau were:

- ***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*** could be acceptable in the short term to remedy current unacceptable practices at a site too small to justify costs of expensive equipment. However, Palau solid waste regulations state that incinerators must be 'multiple chambers', which medium temperature incineration typically is not. Medium temperature incineration would also have difficulty meeting the particulate standards laid out in these regulations.
- ***Autoclaving*** is an acceptable disinfection practice where units with shredder are affordable and locked in supplier maintenance and training contracts are in place.
- ***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.

Encapsulation ranks as an effective way to deal with the residual risk from already disinfected sharps. Encapsulation is never recommended as an isolated form of treatment, as it does not disinfect or otherwise treat the hazard of the waste.

Belau National Hospital has an incinerator that has ceased operation due to receipt of frequent complaints about smoke emission from neighbouring residents. Since this time, healthcare waste (including sharps) has been transported to the public landfill, untreated.

Part 2401-31-21 of the Hazardous Waste Disposal Standard (under the Solid Waste Management Regulations) state that Infectious and pathological wastes generated at medical, veterinary, and other facilities shall be incinerated, sterilized or otherwise rendered safe prior to removal from these facilities for final disposal.

This is not occurring. Immediate action should be taken to prevent the short-term disposal of untreated healthcare waste at the M-Dock Landfill.

The intention is to move the incinerator from the hospital to a new location adjacent to the Koror/Airai Water Treatment Plant, and recommence its use. Given the age of the existing incinerator (1992), the requirements under Palau's Air Pollution Control Regulations (requirement for multiple chambers on incinerators, particulate emission limits and prohibition on odours), alternative treatment options should be considered for the medium to long term.

Recommendations

Table ES2 provides a summary of the recommendations for Palau.

*Where a recommendation is **unique** to the circumstances of a particular hospital, because of issues identified that are **unique** to that hospital, the recommendation (and associated implementation action) is appended with the annotation **U2H**.*

Table ES2: Recommendations for Palau

Recommendation 1: Develop a Waste Management Framework	
Description	• A *Healthcare Waste Management Plan*, specific to each healthcare facility • Appoint an *officer responsible* for the development and implementation of the Healthcare Waste Management Plan • A *waste management committee*, appropriate to the scale of each facility.
Output	• An agreed *Healthcare Waste Management Plan*, specific to each healthcare facility outlining procedures and guidelines, waste definitions and characterisation, segregation techniques, containment specifications and storage practices, collection and transport, treatment and disposal and emergency procedures • Accountability for healthcare waste management through clearly defined roles and responsibilities
Monitoring & Evaluation Indicators	• Plan approved by Department of Health • Approved budget for implementation of Healthcare Waste Management Plan • The Plan should be regularly monitored, reviewed, revised and updated. • Annual assessment of 'Responsible Officer's' or Waste Management Committees' performance against key healthcare waste management competencies.
Costs ($US)	• Establishment – Low, if existing systems (such as those for Fiji) are used as a starting points and document drafting assistance is provided • Ongoing – Low
Recommendation 1b: Appointment of a Responsible Officer and/or Waste Management Committee	
Description	Development of and resourcing a structure of accountability for ensuring waste management practices (i.e., Policies and Procedures), are developed for the hospital, implemented and there is a clear direction for continual improvement.
Output	• Accountability for healthcare waste management through clearly defined roles and responsibilities.
Monitoring & Evaluation Indicators	• Annual assessment of 'Responsible Officer's' or Waste Management Committees' performance against key healthcare waste management competencies.
Costs ($US)	• Establishment – Low; • Ongoing - Low
Recommendation 2: Implement Segregation Signage	
Description	Supply of **signage** to explain the colour-coded segregation system as well as **posters** to promote it.
Output	More informative visual cues for staff to carry out rigorous segregation practices

Table ES2: Recommendations for Palau	
Monitoring & Evaluation Indicators	• Wastes are segregated at their place of production. • Infection wastes, general wastes and used sharps are stored in separate colour coded containers and locations within medical areas. • Zero Needle Stick Injuries.
Costs ($US)	• Establishment – Low; • Ongoing - Low
Description	Supply of **signage** to explain the colour-coded segregation system as well as **posters** to promote it.
Recommendation 3: Procurement of Consumables (Segregation & Storage)	
Description	• Supply of colour-coded **waste bins** and **plastic liners** in quantities sufficient to serve all wards/departments for a period of time sufficient to allow bedding down of the segregation process. • Supply of small number of colour-coded **wheelie bins** (where required) per hospital to act as both in-ward/department storage and internal transport trolleys. • Supply of **signage** to explain the colour-coded segregation system as well as **posters** to promote it.
Output	Adequate supply of consumables to bed down more rigorous segregation practices
Monitoring & Evaluation Indicators	• Wastes are segregated at their place of production. • Infection wastes, general wastes and used sharps are stored in separate colour coded containers and locations within medical areas. • Zero Needle Stick Injuries.
Costs ($US)	Establishment – Low; Ongoing - Low, sustainably funded by country
Recommendation 4: Improve the Current Training Program [UTH]	
Description	• Improve the current training program so that participation and compliance is improved. • SPREP staff, or outside trainers, or a combination of both, could assist in the improvement of the training program and developing ways to incentivise staff to participate and comply with learning outcomes. • Training should be coordinated with other countries' needs in the region.
Output	• Improvement of personnel skills and competency in managing healthcare waste • Promotion of the advantages of sustainable segregation and storage techniques for the different waste streams and an understanding of the health and safety risks resulting from the mismanagement risks of healthcare waste.
Monitoring & Evaluation Indicators	• Frequent competency assessments following training program • Annual refresher training

Table ES2: Recommendations for Palau	
	• No/very little cross contamination between waste streams demonstrated by waste audits.
Costs ($US)	• Establishment – Low-medium per facility if regional synergies are utilised • Ongoing – Low-medium per facility if regional synergies are utilised
Recommendation 5: Establish a Waste Segregation Auditing Program	
Description	• Development and delivery of a structured healthcare waste audit program • Establishment of that in the waste management planning system and the training program • Review the program delivered by Belau National Hospital to establish elements for refresher trainer conducted more regularly (at least annually)
Output	• An established segregation audit program for Palau • Improvement of personnel skills and competency in managing healthcare waste
Monitoring & Evaluation Indicators	• No/very little cross contamination between waste streams demonstrated by waste audits • Zero Needle Stick Injuries.
Costs ($US)	• Establishment – Low- if regional synergies are utilised • Ongoing – Low- if regional synergies are utilised
Recommendation 6: Short-term Treatment Infrastructure and Procure a New Incinerator [UTH]	
Description	• Procure a new incinerator, housed adjacent to the Koror/Airai Water Treatment Plant, with maintenance support contract • Until the existing incinerator has been procured the following interim measures to treat healthcare waste at the hospital and landfill should be considered: • Sharps and Infectious Healthcare Waste: **Low Temperature** burning offsite at the landfill to remove "infectious" aspect of waste and reduce volume. • Sharps (only) : **Encapsulation**: disinfected sharps (after burning) could be placed within high-density plastic containers or metal drums and when full an immobilizing material such as plastic foam, sand, cement or clay could be added.
Output	A disposal system that reduces the potential hazard posed by healthcare waste, while endeavoring to protect the environment.
Monitoring & Evaluation Indicators	• Ensure all sharps are encapsulated appropriately. • Zero Needle Stick Injuries • Reduced risk of infection or ongoing public health or environmental harm from untreated healthcare waste being disposed of at the landfill. • Ensure burn times are sufficient at the landfill to reduce waste ash volumes For the existing incinerator: • Operations and construction (e.g. pre-heating and not overloading the incinerator and incinerating at temperatures above 800ºC only)

Table ES2: Recommendations for Palau	
	• Maintenance program – are maintenance issues dealt with promptly?
Costs ($US)	• Low-Medium to set up encapsulation and low temperature burning infrastructure; • Ongoing – (Existing Incinerator) - medium (fuel and maintenance)
Recommendation 7: Procurement of Consumables (PPE)	
Description	• Supply appropriate PPE including overalls/protective clothing, gloves and eye protection for all waste handlers. • Incinerator staffs are provided with additional PPE such as face masks and noise protection.
Output	• Adequate supply of PPE for protection of waste handlers
Monitoring & Evaluation Indicators	• PPE is provided to all staff and staff are aware on how to protect themselves from injuries and infectious wastes • Zero Needle Stick Injuries.
Costs ($US)	Establishment – Low; Ongoing - Low, sustainably funded by country
Monitoring & Evaluation Indicators	• Plan approved by Department of Health • Approved budget for implementation of Healthcare Waste Management Plan • The Plan should be regularly monitored, reviewed, revised and updated. • Annual assessment of 'Responsible Officer's' or Waste Management Committees' performance against key healthcare waste management competencies.
Costs ($US)	• Establishment – Low, if existing systems (such as those for Fiji) are used as a starting points and document drafting assistance is provided • Ongoing – Low
Recommendation 8: Upgrade of Storage Area	
Description	• The storage area of healthcare waste before disposal is not locked or adequately signed; it can be accessed by members of the public.
Output	• Storage area is fenced, lockable, suitably designed and isolated from patients and the public.
Monitoring & Evaluation Indicators	• Suitability of storage areas frequently assessed by the 'responsible officer' to ensure that it is locked and appropriately signed.
Costs ($US)	• Establishment – Low (procurement of signage and lock for door and spill kit) • Ongoing – Low

Implementation actions are suggested for each recommendation, classified as short, medium and long-term priorities.

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 the assessment conducted for Palau.

1.1 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'* as it specifically relates to Palau and includes:

- Collection and collation of data on the current practice(s) used to dispose of hazardous healthcare waste in Palau. Data collected includes:
  - 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.
- Consultation 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).

- Identification of 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.

1.2 Report Structure

This report is structured as follows:

- an introduction to the project (**section 1**)
- discussion of current healthcare waste management in Palau, including the current regulatory framework and hospital details (**section 2**)
- a summary of existing waste management practices, waste streams and quantities, waste management and infection control framework, the waste management process that were reviewed, training and education programs and identified healthcare waste management issues (**section 3)**
- key healthcare waste management issues and any county-wide or regional themes that were identified (**section 4**)
- a summary of hospital and national authority consultation outcomes (**section 5**)
- an assessment of contractor roles and their capacity to sustainably manage and treat healthcare waste, including any training or education capacity (**section 6)**
- an analysis of the healthcare waste management and treatment options available, both regionally and specific to Palau, to address the key issues identified (**section 7**)
- recommendations and prioritization of actions necessary to enable sustainable hazardous healthcare waste management and disposal in Palau (**section 8**)

2 Healthcare Waste Management in Palau

2.1 National Regulatory Framework

The Republic of Palau comprises the western-most group of the Caroline Islands of Micronesia and is made up of over 340 islands. Palau has a democratic form of government patterned after that of the United States. The country is divided into sixteen states each with its own constitution, governor and legislature. Under the national constitution, states have special responsibility for environmental protection, land use planning, health and welfare.

The Environmental Quality Protection Board (EQPB) implements a range of environmental regulations such as Solid Waste and Water Quality Regulations.

A summary of relevant legislation is provided in Table 1.

Table 1: National Environmental Legislation Summary

Legislation	Type	Summary References to Solid/HCW	Regulator/ Agency
Environmental Quality Protection Act 2003	Act	The purpose of the Environmental Quality Protection Act is to ensure protection of the environment while promoting sustainable economic development. The Act created the Environmental Quality Protection Board (EQPB), a semi-autonomous agency of the Republic, responsible for the protection and conservation of the environment. EQPB oversees regulations regarding: (1) Earthmoving, (2) Marine and Freshwater Quality (3) Pesticides (4) Environmental Impact Statements, (5) Air Pollution Control.	Environmental Quality Protection Board
Public Health, Safety and Welfare Act (Title 34)	Act	The purpose of this Act is to maintain and improve health and sanitary conditions, minimize and control communicable disease, establish standards of medical and dental care and practice, encourage scientific investigation in the field of health, supervise and administer all sanitariums, clinics, dispensaries and such other medical and dental facilities as are or may be established throughout the Republic.	Palau Bureau of Health Services
Solid Waste Management Regulations	Regs.	The purpose of these regulations is to establish minimum standards governing the design, construction, installation, operation and maintenance of solid waste storage, collection and disposal systems. *Defines 'Infectious Waste' as: 'Equipment, instruments, utensils, and fomites of a disposable nature from the rooms of patients who are suspected to have or have been diagnosed as having a communicable disease and must therefore be isolated as required by public health agencies.* **Part 2401-31-21 –Hazardous Waste Disposal Standard:** Infectious and pathological wastes generated at medical, veterinary, and other facilities shall be incinerated, sterilized or otherwise rendered safe prior to removal from these facilities	Environmental Quality Protection Board

<table>
<tr><th colspan="4">Table 1: National Environmental Legislation Summary</th></tr>
<tr><th>Legislation</th><th>Type</th><th>Summary
References to Solid/HCW</th><th>Regulator/ Agency</th></tr>
<tr><td></td><td></td><td>for final disposal.
Part 2401-31-19 Incineration Standards
(A) Incinerator fly ash and residue generated from incineration of solid waste shall be treated and disposed of in a manner to prevent odor and dust nuisance and to control insects, birds, rodents and other vectors.
(B) Salvaging or reclamation of materials shall be controlled at the facility to prevent interference with the prompt sanitary disposal of solid waste and the creation of health hazards. Scavenging is prohibited.</td><td></td></tr>
<tr><td>Air Pollution Control Regulations</td><td>Regs</td><td>CONTROL OF PARTICULATE EMISSION FROM INCINERATOR: DESIGN AND OPERATION
These regulations apply to an incinerator used to dispose of refuse.
<table>
<tr><th colspan="2">PARTICULATE EMISSION ALLOWABLE BASED ON COMBUSTION OF FUEL</th></tr>
<tr><th>Operating Rate in Million BTU's per hour</th><th>Maximum allowable emissions of particulate in pounds per million BTU's heat input</th></tr>
<tr><td>5</td><td>5</td></tr>
<tr><td>10</td><td>10</td></tr>
<tr><td>100</td><td>100</td></tr>
<tr><td>250</td><td>250</td></tr>
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</table>
2401-71-51 Multiple Chamber-Cylinders Required
All new incinerators and all existing incinerators shall, by December 25, 1981 be multiple-chamber incinerators, provided that the Chairman may approve any other type of incinerator if it is demonstrated such design provides equivalent performance.
2401-71-53 Prohibition on Odors
No person shall discharge into the atmosphere, or cause to be discharged into the atmosphere, from any source whatsoever any amount of odorous or gaseous emission, material, or air contaminant of any kind or description, which is injurious or detrimental to health or safety, or which in any way unduly interferes with or prevents the comfortable enjoyment of life or property</td><td></td></tr>
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2.2 Hospital Assessed - Belau National Hospital

The Belau National Hospital (BNH) has 80 beds and was built with funding from the United States. It is located on the island of Koror and can be reached from most regions of the country within two hours. BNH provides primary healthcare, emergency care, surgery, inpatient, pediatric and outpatient services, basic physiotherapy, decompression chamber and dialysis unit.

Table 2 summarises key contact personnel and key hospital administrative statistics for the hospital.

Table 2: Hospital Details – Palau	
Hospital/Region	**Belau National Hospital**
Contact Name, Position	Temmy Temengil, International Health Coordinator
Pop Served	21,000
No. of Beds	80 (surge capacity of 100)
Annual Average Occupancy Rate (%)	67%
OBD's [1]	
No. Operations	369
No. of Births	229
Emergency Patients Attended	14,159 Emergency Room Visits 139 Actual Emergencies
Out-Patients Attended	Not known
Total No. of staff	400
No. of staff per function	
Doctors	26
Nursing	110
Infection Control	1
Dedicated Waste Management – Internal Management	0
Dedicated Waste Management – Treatment Operation	3 – Maintenance Team
Administration	Not provided
Other	Not provided

Notes:

1. OBDs = Occupied Bed Days (previous 12 months)
2. Infection Control staff are also included in Nursing/ Medical numbers

3 Existing Waste Management Practices at Belau National Hospital

This section describes waste management practices observed during the hospital audit. Information regarding the waste management process occurring, from ward-level waste generation through to ultimate treatment and disposal is described in Table 3.

Audit observations are then elaborated upon further for the remaining issue headings:

- Wastestreams, Treatment Constraints and Costs
- Waste Management and Infection Control Framework and
- Training.

A comprehensive list of all data collected from the site audit of Belau Hospital is located in **Appendix B**.

Table 3: Waste Management Process - Observations

	Hospital Name	Belau National Hospital			
Generation & Segregation	Dedicated Containers/ Bags	Very Limited			
	Colour Coding	Very Limited			
	Sharps segregated & secure	Y – 'Constantly Overfill"			
	Signage Present	N			
Internal Handling	Degree of manual handling of bags	High			
	Internal Transport Mode	Trolley			
	Spill Kit Present	N			
Storage	Dedicated & Appropriate Area	Y			
	Loading/unloading acceptable	N			
	Spill Kits Present	N			
	Monitoring & record keeping occurs	N			
Treatment	Treatment per Waste Stream		Tech. Type	Volumes (kg/week)	Stockpile Volume (kg)
	Healthcare Waste	✓	Landfill (without treatment)	~200[1]	NA
	Sharps	✓	Landfill (without treatment)	~10	NA
	Pharmaceutical	✓	Landfill (without treatment)	Not measured	NA
	Cytotoxic	×	NA	NA	NA
	General	✓	Landfill (without treatment)	Not measured	NA
	If incinerator present				
	Make, Model, Year commissioned	1992			
	Operating Temp (^{0}C)	unknown			
	No. chambers	1			
	Condition	Reasonable			

[1] Based on estimation only – no weighed data provided or approximate quantities provided, based on anecdotal evidence from hospital staff.

Table 3: Waste Management Process - Observations			
	Hospital Name	Belau National Hospital	
	Comments	Belau National Hospital has an incinerator, which was donated by the Government of Taiwan in approximately 1992. The incinerator s has no pollution control system and since receiving frequent complaints about smoke emission from neighbouring residents (including the President of Palau) use of the incinerator has ceased. Since this time, healthcare waste (including sharps) has been transported to the public landfill, untreated.	
	Operational statistics	Per week	Per year
	Waste Throughput (kg)	-	-
	Operating Hours (hr)	-	-
	Fuel	Diesel	
	Fuel use (kg/litres)	Unknown	
	Fuel use per kg waste burnt	Unknown	
	Technology siting and operation issues	Poor Incinerator to be moved to a site approximately 1 km away from the hospital due to frequent complaints about smoke emissions.	
	Offsite transport assessment	Good	

3.1 Wastestreams, Treatment Constraints and Costs

Belau National Hospital generates general wastes and healthcare wastes (including infectious waste, sharps and pharmaceutical wastes) in the approximate quantities described in Table 3. They do not generate cytotoxic waste. All of these wastes are disposed of at the M-Dock Landfill in Koror. None of these wastes are treated before disposal.

No costs information was obtained; since waste disposal costs are internally borne by the hospital it is not directly measured. There are no landfill fees for disposal of wastes.

3.2 Waste Management and Infection Control Framework

The following summarises the waste management and infection control framework at Belau National Hospital:

- There is no waste management policy, plan or formalized waste management procedure. There is a maintenance team of three people who are responsible for the day-to-day collection and disposal of waste.
- There is an infection control manual (sighted at the time of the audit) that made reference to 'waste management procedures such as the infection risks associated with the improper handling of healthcare waste and proper segregation of infectious waste.
- There is no formal waste auditing or inspections.

3.3 Training at BNH

The hospital has a formal Infection Control Training Program which includes healthcare waste management and disposal. It is facilitated by the Infection Control Nurse and is

delivered to each staff member at the commencement of employment and every two years thereafter.

The curriculum for the training program is sourced from the *Ministry of Health Infection Control Handbook* which derives its content from World Health Organisation Sources. The Infection Control handbook was sighted at the time of the audit.

The Infection Control Training Program covers the following material:

- General Infection Control
- Hand Washing
- Isolation Techniques
- Spill Prevention and Control
- Healthcare Waste Disposal and Segregations.

According to Chief Infection Control Nurse – Belinda Eungel - attendance at the two year refresher training is poor and compliance post training is also negligible. No records of attendance or competency assessments were sighted during the audit.

4 Key Healthcare Waste Management Issues at BNH

This section takes the collected information from Section 3 and summarises and critically assesses it, for Niue Foou Hospital, in the context of a Minimum Standards Framework.

A key issues summary is also provided.

4.1 Minimum Standards Framework

A minimum standards framework has been developed to set a benchmark for the sustainable management of healthcare waste in the Pacific Island region. 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.

A full description and definitions of minimum standards applicable for healthcare waste management, as well as a comprehensive assessment against each of the criteria 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.

Table 5 highlights the key areas of concern in terms of health services delivery by Belau National Hospital as part of this assessment.

Table 5: Healthcare Waste – Key issues for Palau (BNH)

Scale	Category	Item	Minimum Standard Criterion	Belau National Hospital
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	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	
		Storage before treatment	Meets the standards stated in Appendix E, Recommendation 2, *Correct Storage*.	
Healthcare Facility	Training	Curricula	A structured waste management training program has been developed that targets the different roles within the hospitals.	
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	

Table 5: Healthcare Waste – Key issues for Palau (BNH)				
			waste management strategy) are remedied.	
Healthcare Facility	Treatment	Suitability of treatment for healthcare waste	The method for treating healthcare waste is in accord with required standards - this includes operating parameters and location of the treatment unit.	
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	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.	

4.2 Belau National Hospital – Key Issues

The most significant health care waste management issues observed at Belau Hospital were:

- There is no signage and very poor segregation –healthcare waste and general waste are often combined in the same bins with very few dedicated coloured coded waste containers and colored coded bag liners. Sharps are separated into dedicated containers (combination of reusable and disposable) however they reportedly 'constantly overfill' due to lack of resources. There is also a very high frequency rate of Needle Stick Injures (NSI) reported by both cleaning/ maintenance and nursing staff due to improper handling and disposal of sharps **(Photo 1)**.
- An incinerator was commissioned in 1992 however; it has not been used since early 2013 (exact date unknown) **(Photo 2)**. There were frequent complaints from neighboring residents regarding smoke emissions and a decision was made to stop using it until the incinerator is moved to its new location approximately 1 km away from the hospital adjacent to the Koror Wastewater Treatment Plant. Since January 2013 all waste has been transported to the M-Dock Landfill, Koror and disposed of without being treated. There is no incinerator at the landfill. There is reportedly a dedicated cell for healthcare waste but inspection was not possible at the time of the audit.
- There Belau National Hospital has an Infection Control Manual which includes a section of healthcare on healthcare waste management (sighted during the audit) however; there is no healthcare waste management framework for the hospital.
- There is a structured training program in place that covers proper disposal of healthcare waste and infection risk from improper handling of infectious wastes, however according to the Chief Infection Control Nurse attendance at the training sessions and compliance with training materials post training is poor.
- Spill control kits were not observed anywhere throughout the hospital or storage areas

- No PPE such as gloves, protective clothing, eye protection or covered footwear was observed for waste management staff and spill control kits were not observed anywhere throughout the facility.

- There is no ‘responsible person/ officer’ who oversees the management of healthcare waste at the Belau National Hospital

- The area where healthcare waste is stored before disposal need to be secured with a lockable door and fencing and signposted with hazardous waste signage to prevent hospital patient or public access **(Photo 4)**.

5 Consultation

At the hospital discuss and consultation was had with Temmy Temengil the International Health Coordinator, Belinda Eungel, Infection Control Nurse and Antonnette Meuer Acting Chief of Nursing at the Ministry of Health Palau.

Apart from hospital staff across all four hospitals, discussions with the Minister of Health Gregorio Ngimang. The Minister confirmed the status of the incinerator and provided information on the overall strategic direction of the Belau National Hospital.

No PacWaste Focal point was provided for Palau therefore a connection was made through Ms. Patricia Pedrus of the Office of Environment and Emergency Management, Federated States of Micronesia.

6 Contractor Roles and Capacity

No in-country contractors were identified as providing or having the capacity to provide healthcare waste management support services. This includes training (in areas like waste management, infection control, technology operation and maintenance) and risk management.

It was reported by hospital personnel that the government is going to assume the management and operation of the incinerator once it has been relocated.

7 Analysis of Options for Sustainable Healthcare Waste Management in Palau

Section 4 identifies key issues that need to be addressed in improving healthcare waste management in Palau. This section evaluates the potential options that could be employed to respond to these key issues.

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

Table 6: Options for Sustainable Healthcare Waste Management in Palau

Key Issue Category	Key Issue	Options to address the issue
A. Waste Management Framework	There is no documented **waste management** planning system in place.	Establish a waste management framework including: • Waste Management Plan • Responsible officer for implementation of waste management plan
B. Signage, Segregation & Containers	**Segregation and containment** practices are generally below minimum standard in that: • There is virtually no signage present • The only segregation regularly practiced is for sharps. • There were very few colour coded bags and waste containers used throughout the hospital. • Reportedly, bags and sharps containers are constantly out of supply.	Improve segregation practices 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 a structured **training** program however training sessions are rarely attended and according to the Chief Infection Control Nurse compliance with training lessons and objectives is poor.	A review of the development and delivery of the healthcare waste training program. Ensure that all hospital personnel as well as personnel from other stakeholders (e.g., government health and environment agencies) undertake the training session. This review could be undertaken by: 1. SPREP staff, **or** 2. International technical training providers (or a combination of both), Provide incentive for staff to attend or make attendance compulsory, assess competency through waste audits and continually follow up on areas for improvement.
D. Treatment	The method for **treatment** of healthcare waste is typically <u>not</u> in accord with required standards.	Treatment using one (or a combination) of the following for each hospital: 1. Rotary kiln (highest temperature) 2. Incineration (high, medium temperature) 3. Low temperature burning (single chamber incinerator/ pit/ drum/ brick enclosure/ land) 4. Autoclave 5. Chemical 6. Microwave 7. Encapsulation 8. Landfill (without disinfection)

Table 6: Options for Sustainable Healthcare Waste Management in Palau		
		9. Onsite burial 10. Shredding
E. Occupational Health and Safety	Waste handlers regularly do not use appropriate **PPE** including overalls /protective clothing, gloves and eye protection. NSI's frequently occur amoungst cleaning/maintenance staff. **Spill control kits** were not observed anywhere.	Procurement of Consumables (PPE): • Supply spill kits and appropriate PPE including overalls/protective clothing, gloves and eye protection for all waste handlers.
F. Responsible Person	There is no one person who has accountability of healthcare waste management at the hospital through a clearly defined role.	Appoint a responsible officer and defined their role and key accountabilities for the management of healthcare waste at the hospital
G. Suitable Storage	Storage before disposal areas is not locked or signed	Upgrade storage before disposal area to prevent access to the public and procure spill kits for the storage area

7.1 Options for (Non-Treatment) Waste Management Aspects

Those options that do not relate directly to the waste treatment 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 & F in Table 6)
- The waste management process, from generation to transport and storage up to the treatment location (B & G in Table 6)
- Training systems for sustainable healthcare waste management (C in Table 6)
- OHS related protection for waste handlers (E in Table 5)

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

7.2 Options for Treatment of Healthcare Waste

Healthcare waste treatment (key issue category D) has a range of alternative approaches, as 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 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 generic to the Pacific region so is included in the *Whole of Project – Summary Report*, Appendix E. This analysis highlights the following technologies as worthy of consideration for Palau's Stage 2 assessment:

1. Incineration (high temperature: >1,000^{0}C [2])
2. Incineration (medium temperature: 800 – 1,000^{0}C [4])
3. Low temperature burning (single chamber incinerator/ pit/ drum/ brick enclosure/ land: <400^{0}C [4])
4. Autoclave
5. Encapsulation (of sharps only, in combination with a form of disinfection).

7.2.1 Waste Treatment Systems Relevant for Palau

The Stage 2 local feasibility assessment (for Palau) takes these first four[3] technologies and assesses them against the local feasibility assessment criteria listed above.

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

[3] Encapsulation is assessed separately 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.

These criteria are explored qualitatively in **Appendix D**. Table 7 takes these qualitative descriptions and assigns a quantitative score from 1 – 5, to prioritise local applicability of technology options to the Palauan context, on a relative basis as follows:

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

The treatment technologies suitable for the Palauan context are ranked in order of preference:

Table 7: Quantitative Treatment Technology Options Assessment - Local Feasibility (Palau)

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	5	4	4	3	3	3	36	1
Incineration at med. temperature (800 - 1000^{0}C)	4	4	3	3	2	4	2	2	2	4	30	2
Autoclave with shredder	2	4	4	3	4	2	2	4	2	2	29	3
Low temperature burning (<400^{0}C)	5	3	1	1	1	1	1	1	5	5	24	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 6'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*** could be acceptable in the short term to remedy current unacceptable practices at a site too small to justify costs of expensive equipment. However, Palau solid waste regulations state that incinerators must be 'multiple chambers', which medium temperature incineration typically is not. Medium temperature incineration would also have difficulty meeting the particulate standards laid out in these regulations.
- ***Autoclaving*** is an acceptable disinfection practice where units with shredder are affordable and locked in supplier maintenance and training contracts are in place.

- ***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.

Based on the qualitative assessment in **Appendix D**, ***encapsulation*** ranks as an effective way to deal with the residual risk from already disinfected sharps. 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 emission 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 Palau does not generate cytotoxic wastes, limitations regarding this waste are not relevant for healthcare waste treatment choices at Belau National Hospital.

7.2.2 Treatment Investment Options for Belau National Hospital

Belau National Hospital has an incinerator that has ceased operation due to receipt of frequent complaints about smoke emission from neighbouring residents. Since this time, healthcare waste (including sharps) has been transported to the public landfill, untreated.

Part 2401-31-21 of the Hazardous Waste Disposal Standard (under the Solid Waste Management Regulations) state that *Infectious and pathological wastes generated at medical, veterinary, and other facilities shall be incinerated, sterilized or otherwise rendered safe prior to removal from these facilities for final disposal*.

This is not occurring. Immediate action should be taken to prevent the short-term disposal of untreated healthcare waste at the M-Dock Landfill.

The intention is to move the incinerator from the hospital to a new location adjacent to the Koror/Airai Water Treatment Plant, and recommence its use. Given the age of the existing incinerator (1992), the requirements under Palau's Air Pollution Control Regulations (requirement for multiple chambers on incinerators, particulate emission limits and prohibition on odours), alternative treatment options should be considered for the medium to long term.

Table 8 determines 'intervention' options that are suggested to improve treatment of healthcare waste in Palau. Shading in green indicates where investment is proposed, while orange shading shows where a technology consideration is also relevant.

Table 8: Technology Options Applicable for Belau National Hospital	
Remaining Technology Options	**Technology Applicability**
Belau National Hospital	
Disinfection & Encapsulation (only sharps assessed)	Short term solution only - Disinfected sharps should be placed within high-density plastic containers or metal drums and when full an immobilizing material such as plastic foam, sand, cement or clay is added and then disposed of at the landfill. *Note that this must occur in conjunction with a form of disinfection, such as low temperature burning, below.*
Incineration at high temperature (>1000^{0}C)	The existing incinerator is over 20 years old and there are reportedly ongoing issues with pollutant and odour emissions. Moving and re-commissioning would involve significant costs. Procurement of a new incinerator – a MediBurn 30 model has a manufacturer's claimed throughput of 200 kg/day of healthcare waste. At Belau National an estimated rate of 320 kg healthcare waste per week (10% of which is sharps) this unit is theoretically large enough to treat all the HCW at BNH with capacity for future growth
Incineration at med. temperature (800 - 1000^{0}C)	Not applicable at BNH - large enough to justify a better performing larger higher temperature option that meets regulatory requirements.
Autoclave with shredder	Not compelling or cost-effective for Palau at present.
Low temperature burning (<400^{0}C)	Given the relatively small volumes of waste involved, and the urgency of the problem a short term 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 M-Dock Landfill • Burning sharps separately in the burning block, to disinfect, followed by concrete encapsulation and burial at the M-Dock Landfill • 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 would only serve as a short term solution ton whilst the new incinerator is being procures. Burning should take place under controlled conditions and permission will need to be granted by the Environmental Quality Protection Board.

Timing considerations for these options, in the context of other (non-treatment) options, is provided in the Section 8 (Recommendations).

8 Recommendations

The following section outlines recommendations and a proposed implementation plan for each recommendation to achieve sustainable management of healthcare waste in Niue. Further details and guidance on each recommendation are provided in **Appendix E**.

Table 9 provides a summary of the recommendations for Palau.

In terms of relative priorities of the five recommendations, they are all similar, based on the deficiencies addressed against the minimum standards framework. They are also 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/ auditing. 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.

However, the staggered timing of actions required implementing the recommendations, as outlined in section 8.1, and their different short, medium and long term approaches give an indication of priority of the recommendation actions themselves.

*Where a recommendation is **unique** to the circumstances of a particular hospital, because of issues identified that are **unique** to that hospital, the recommendation (and associated implementation action) is appended with the annotation **U2H**.*

Table 9: Recommendations for Palau

Recommendation 1: Develop a Waste Management Framework	
Description	• A *Healthcare Waste Management Plan*, specific to each healthcare facility • Appoint an *officer responsible* for the development and implementation of the Healthcare Waste Management Plan • A *waste management committee*, appropriate to the scale of each facility.
Output	• An agreed *Healthcare Waste Management Plan*, specific to each healthcare facility outlining procedures and guidelines, waste definitions and characterisation, segregation techniques, containment specifications and storage practices, collection and transport, treatment and disposal and emergency procedures • Accountability for healthcare waste management through clearly defined roles and responsibilities
Monitoring & Evaluation Indicators	• Plan approved by Department of Health • Approved budget for implementation of Healthcare Waste Management Plan • The Plan should be regularly monitored, reviewed, revised and updated. • Annual assessment of 'Responsible Officer's' or Waste Management Committees' performance against key healthcare waste management competencies.
Costs ($US)	• Establishment – Low, if existing systems (such as those for Fiji) are used as a starting points and document drafting assistance is provided • Ongoing – Low
Recommendation 1b: Appointment of a Responsible Officer and/or Waste Management Committee	
Description	Development of and resourcing a structure of accountability for ensuring waste management practices (i.e., Policies and Procedures), are developed for the hospital, implemented and there is a clear direction for continual improvement.
Output	• Accountability for healthcare waste management through clearly defined roles and responsibilities.
Monitoring & Evaluation Indicators	• Annual assessment of 'Responsible Officer's' or Waste Management Committees' performance against key healthcare waste management competencies.
Costs ($US)	• Establishment – Low; • Ongoing - Low
Recommendation 2: Implement Segregation Signage	
Description	Supply of **signage** to explain the colour-coded segregation system as well as **posters** to promote it.
Output	More informative visual cues for staff to carry out rigorous segregation practices

Table 9: Recommendations for Palau	
Monitoring & Evaluation Indicators	• Wastes are segregated at their place of production. • Infection wastes, general wastes and used sharps are stored in separate colour coded containers and locations within medical areas. • Zero Needle Stick Injuries.
Costs ($US)	• Establishment – Low; • Ongoing - Low
Description	Supply of **signage** to explain the colour-coded segregation system as well as **posters** to promote it.
Recommendation 3: Procurement of Consumables (Segregation & Storage)	
Description	• Supply of colour-coded **waste bins** and **plastic liners** in quantities sufficient to serve all wards/departments for a period of time sufficient to allow bedding down of the segregation process. • Supply of small number of colour-coded **wheelie bins** (where required) per hospital to act as both in-ward/department storage and internal transport trolleys. • Supply of **signage** to explain the colour-coded segregation system as well as **posters** to promote it.
Output	Adequate supply of consumables to bed down more rigorous segregation practices
Monitoring & Evaluation Indicators	• Wastes are segregated at their place of production. • Infection wastes, general wastes and used sharps are stored in separate colour coded containers and locations within medical areas. • Zero Needle Stick Injuries.
Costs ($US)	Establishment – Low; Ongoing - Low, sustainably funded by country
Recommendation 4: Improve the Current Training Program [UTH]	
Description	• Improve the current training program so that participation and compliance is improved. • SPREP staff, or outside trainers, or a combination of both, could assist in the improvement of the training program and developing ways to incentivise staff to participate and comply with learning outcomes. • Training should be coordinated with other countries' needs in the region.
Output	• Improvement of personnel skills and competency in managing healthcare waste • Promotion of the advantages of sustainable segregation and storage techniques for the different waste streams and an understanding of the health and safety risks resulting from the mismanagement risks of healthcare waste.
Monitoring & Evaluation	• Frequent competency assessments following training program • Annual refresher training

Table 9: Recommendations for Palau	
Indicators	• No/very little cross contamination between waste streams demonstrated by waste audits.
Costs ($US)	• Establishment – Low-medium per facility if regional synergies are utilised • Ongoing – Low-medium per facility if regional synergies are utilised
Recommendation 5: Establish a Waste Segregation Auditing Program	
Description	• Development and delivery of a structured healthcare waste audit program • Establishment of that in the waste management planning system and the training program • Review the program delivered by Belau National Hospital to establish elements for refresher trainer conducted more regularly (at least annually)
Output	• An established segregation audit program for Palau • Improvement of personnel skills and competency in managing healthcare waste
Monitoring & Evaluation Indicators	• No/very little cross contamination between waste streams demonstrated by waste audits • Zero Needle Stick Injuries.
Costs ($US)	• Establishment – Low- if regional synergies are utilised • Ongoing – Low- if regional synergies are utilised
Recommendation 6: Short-term Treatment Infrastructure and Procure a New Incinerator [UTH]	
Description	• Procure a new incinerator, housed adjacent to the Koror/Airai Water Treatment Plant, with maintenance support contract • Until the existing incinerator has been procured the following interim measures to treat healthcare waste at the hospital and landfill should be considered: • Sharps and Infectious Healthcare Waste: **Low Temperature** burning offsite at the landfill to remove “infectious” aspect of waste and reduce volume. • Sharps (only) : **Encapsulation**: disinfected sharps (after burning) could be placed within high-density plastic containers or metal drums and when full an immobilizing material such as plastic foam, sand, cement or clay could be added.
Output	A disposal system that reduces the potential hazard posed by healthcare waste, while endeavoring to protect the environment.
Monitoring & Evaluation Indicators	• Ensure all sharps are encapsulated appropriately. • Zero Needle Stick Injuries • Reduced risk of infection or ongoing public health or environmental harm from untreated healthcare waste being disposed of at the landfill. • Ensure burn times are sufficient at the landfill to reduce waste ash volumes For the existing incinerator: • Operations and construction (e.g. pre-heating and not overloading the incinerator and

Table 9: Recommendations for Palau	
	incinerating at temperatures above 800ºC only) • Maintenance program – are maintenance issues dealt with promptly?
Costs ($US)	• Low-Medium to set up encapsulation and low temperature burning infrastructure; • Ongoing – (Existing Incinerator) - medium (fuel and maintenance)
Recommendation 7: Procurement of Consumables (PPE)	
Description	• Supply appropriate PPE including overalls/protective clothing, gloves and eye protection for all waste handlers. • Incinerator staffs are provided with additional PPE such as face masks and noise protection.
Output	• Adequate supply of PPE for protection of waste handlers
Monitoring & Evaluation Indicators	• PPE is provided to all staff and staff are aware on how to protect themselves from injuries and infectious wastes • Zero Needle Stick Injuries.
Costs ($US)	Establishment – Low; Ongoing - Low, sustainably funded by country
Monitoring & Evaluation Indicators	• Plan approved by Department of Health • Approved budget for implementation of Healthcare Waste Management Plan • The Plan should be regularly monitored, reviewed, revised and updated. • Annual assessment of 'Responsible Officer's' or Waste Management Committees' performance against key healthcare waste management competencies.
Costs ($US)	• Establishment – Low, if existing systems (such as those for Fiji) are used as a starting points and document drafting assistance is provided • Ongoing – Low
Recommendation 8: Upgrade of Storage Area	
Description	• The storage area of healthcare waste before disposal is not locked or adequately signed; it can be accessed by members of the public.
Output	• Storage area is fenced, lockable, suitably designed and isolated from patients and the public.
Monitoring & Evaluation Indicators	• Suitability of storage areas frequently assessed by the 'responsible officer' to ensure that it is locked and appropriately signed.
Costs ($US)	• Establishment – Low (procurement of signage and lock for door and spill kit) • Ongoing – Low

8.1 Implementation Priorities

8.1.1 Recommendation 1: Develop a Waste Management Framework

Develop a **Healthcare Waste Management Plan** specific to Belau National Hospital, including technical guidelines and procedures relating to healthcare waste management.

The Management Plan should be developed in accordance with the Palau Solid Waste Management Regulation, to ensure policy and legislative needs are considered.

8.1.1.1 Short Term (0-6 months)

- Identify existing documents and systems that may have been used in the past
- Responsible officer or healthcare waste management committee set up as part of infection control.
- Definitions of responsibilities and key accountabilities of responsible officers and Waste Management Committee developed for inclusion in Waste Management Plan.

8.1.1.2 Medium Term (6 months-1 year)

- Formulate a Draft Waste Management Plan drawing on the results of this 'Baseline Assessment' (i.e. present situation, quantities of waste generated, possibilities for waste minimization, identification of treatment options, identification and evaluation of waste-treatment and disposal options, identification and evaluation of record keeping and documentation and estimations of costs relating to waste management)
- The draft discussion document would be prepared in consultation with hospital staff, and officials from the relevant government agencies.

8.1.1.3 Long Term (1year-3 years)

- Finalise the Waste Management Framework
- Continually improve the mandatory standards of healthcare waste management
- Implement a program 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.

8.1.2 Recommendation 1b: Appointment of a Responsible Officer and/or Waste Management Committee

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

2. Establish a **waste management committee**, appropriate to the scale of the facility (given the size of Belau National Hospital, simply establishing "1" may be sufficient).

A responsible officer or **waste management officer** would be responsible for the day-to-day operations and monitoring of the waste management system and is usually established as a separate post in larger hospitals (however, one appointee could be responsible for the waste management performance for a number of hospitals with a stated time fraction allocated to each hospital). It is important that the waste management officer be adequately resourced to enable them to undertake their role as well as supported by hospital management to ensure that all staff recognise the importance of adopting waste management practices that are in accord with all requirements.

A **waste management committee** 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.

8.1.2.1 Short Term (0-6 months)

- Responsible officer or healthcare waste management committee set up
- Definitions of responsibilities and key accountabilities of responsible officer(s) and/ or Waste Management Committee developed for inclusion in Waste Management Plan.

8.1.2.2 Medium Term (6 months-1 year)

Nil

8.1.2.3 Long Term (1year-3 years)

Effective systems are in place to ensure that any non-conformances (with the hospital waste management strategy) are remedied.

8.1.3 Recommendation 2: Implement Segregation Signage

Supply **signage** to explain the colour-coded segregation system as well as **posters** to promote it.

8.1.3.1 Short Term (0-6 months)

Procurement of classification and segregation signage as well as instructional posters to promote good healthcare waste management practices (all hospitals)

8.1.3.2 Medium Term (6 months-1 year)

Nil

8.1.3.3 Long Term (1-3 years)

Nil

8.1.4 Recommendation 3: Procurement of Consumables (Segregation & Storage)

Waste should be collected in accordance with the schedules specified in the Waste Management Plan (Recommendation One).

Supply colour coded bags and containers for the segregations of healthcare and general waste streams

8.1.4.1 Short Term (0-6 months)

- Procurement of in-hospital healthcare waste management consumables including:
  - Colour coded bins and bin liners
- Procurement plan developed to ensure the sustainable supply of healthcare waste management resources.

8.1.4.2 Medium Term (6 months-1 year)

As per short term above.

8.1.4.3 Long Term (1-3 years)

Consumables to be supplied from in-country health agency budgets.

8.1.5 Recommendation 4: Improve Current Training Program

Review the delivery of the structured healthcare waste training program. Ensure that attendance is compulsory and competency is assessed at the completion of the training session.

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 Palau.

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

8.1.5.1 Short Term (0-6 months)

- Identify potential trainers and build training skills
- Develop a budget for long term training delivery
- Identification and prioritisation of employees that need to be trained or re-trained.
- Defining the specific learning objectives for each target audience
- Develop a detailed curriculum specifying the training plan for each session.

8.1.5.2 Medium Term (6 months-1 year)

Explore incentives for training (e.g. training in collaboration with a health professional society or university that can award certificates or professional credentials)

8.1.5.3 Long Term (1 year-3 years)

- Continually improve the mandatory standards of healthcare waste management
- A continuing audit program could be implemented to identify incorrect waste management practices and results of such audits communicated to staff in all

wards/departments. Results from these audits and corrective actions to be reported to the facility waste management committee (Recommendation 4)

- Review the program delivered by Belau National Hospital to establish elements for refresher trainer conducted more regularly (at least annually).

8.1.6 Recommendation 5: Establish a Waste Segregation Auditing Program

Development and delivery of a structured healthcare waste audit program to assess compliance with training program learning objectives

A segregation auditing system, carried out on a regular basis (for example monthly) can be a very effective way of embedding learning of good segregation practice in all staff as well as monitoring performance against the waste management framework and training goals.

8.1.6.1 Short Term (0-6 months)

Develop a waste audit program to capture a point in time picture of waste segregation performance across all wards and department. This should use regional programs as a basis and its design and frequency should be relevant to the scale of Belau National

8.1.6.2 Medium Term (6 months-1 year)

- Implement a program to ensure waste audits are conducted of all waste materials/systems in all wards/departments on a regular basis to identify incorrect waste management practices
- Results from these audits and corrective actions to be reported to the facility waste management committee and communicated to staff in all wards/departments.
- Effective systems are in place to ensure that any non-conformances (with the hospital waste management strategy) are remedied.

8.1.6.3 Long Term (1 year-3 years)

Continually improve the mandatory standards of healthcare waste management

8.1.7 Recommendation 6: Improved Infectious Waste Treatment Infrastructure U2H

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

- **Procure a new incinerator**, housed adjacent to the Koror/Airai Water Treatment Plant, with maintenance support contract; and
- Until the existing incinerator has been procured take interim measures to treat healthcare waste at the hospital or landfill to remove the infectious hazard (see *Short Term* below).

8.1.7.1 Short Term (0-6 months)

- Immediately halt the current process of sending untreated waste to landfill and establish a short-term disinfection procedure as follows:
    - Build a concrete floored brick burning block at the landfill
    - Burn sharps separately in the burning block, to disinfect, followed by concrete encapsulation in a metal drum. The drum can then be buried at the landfill
    - Burn healthcare waste separately in the burning block, to disinfect, followed by burial (separate burning is suggested as only the sharps need to be encapsulated).
- Establish a procedure to measure all waste disposed. No investment decisions can be made without more concrete waste generation data. If there is no measurement scale, this can be done by measuring the number of bags in the short term.

8.1.7.2 Medium Term (6 months-1 year)

- Evaluate measured waste generation data to determine required capacity of new infrastructure
- *Start the process of procurement of a new incinerator* – one that is sized according to BNH's (likely) weekly throughput of approximately 200kg/week of healthcare waste. This is likely to be a compact but dual chamber unit, along the lines of a MediBurn 30.
- Key considerations with such a purchase are: capacity, purchase cost, operating costs, ease of operation, durability and life span.
- The existing incinerator could be maintained at the hospital for back-up purposes, but given Palau's regulatory requirements around incineration and the age of the equipment, it is not recommended to disassemble/move/ reassemble the unit at the landfill.

8.1.7.3 Long Term (1-3 years)

- Procure, install and commission new infrastructure, with supplier support and maintenance contract.
- Recording of waste treatment quantities and operating conditions (e.g. burn temperatures per batch)
- Maintain training of operators as required.

Appendix A

Photo Log

Appendix B

Collected Data from Hospital Audit in Palau

Table B1: Collected Data from Hospital Audit in Palau

HOSPITAL DETAILS	Region		Palau	
	Facility Name & Contact Information	Hospital Name	Belau National Hospital	
		Contact Name & Position	Temmy Temengil International Health Coordinator	
		Email	-	-
		Phone	(680) 488-2553	
	Key Services Data	Summary of Services Provided	Patient Care, Emergency, outpatients, in-patients (general care), pharmacy, laboratory , dental, reproductive health, hyperbaric edicine, physical therapy, radiology	
		Pop Served	21,000	
		No. of Beds	80	
		OBD's [1]	27.5	
		No. Operations	-	
		No. of Births[2]	247	
		Emergency Patients Attended[2]	-	
		Out-Patients Attended[2]	-	
		No of Staff	250	
WASTE MANAGEMENT PROCESS	Waste Steams Managed	Estimates	Volumes (kg/wk)	Cost ext. ($US)
		Healthcare Waste	~200	
		Sharps	~10	
		Pharmaceutical	Not Measured	
		Cytotoxic	NA	
		General	Not Measured	
		Recycling	Not Measured	
		TOTAL	210	
	Generation & Segregation	Dedicated Containers/ Bags	Very Limited	
		Colour Coding	Very Limited	
		Sharps segregated & secure	Y	
		Signage Present	N	
	Internal Handling	Degree of manual handling of bags	High	
		Internal Transport Mode	Trolley	
		Spill Kit Present	N	
	Storage	Dedicated & Appropriate Area	Y	
		Loading/unloading acceptable	N	
		Spill Kits Present	N	
		Monitoring & record keeping occurs	N	
	Treatment	Treatment per Waste Stream	Tech. Type	Int/Ext
		Healthcare Waste	Landfill (without treatment)	External
		Sharps	Landfill (without treatment)	External
		Pharmaceutical	Landfill (without treatment)	External
		Cytotoxic	NA	NA
		General	Landfill (without treatment)	External
		If incinerator present		
		Make, Model, Year commissioned	1992	

		Operating Temp (^{0}C)	unknown	
		No. chambers	1	
		Condition	Reportedly in good condition but don't use because of complaints	
		Comments	Has not been used for 1 year.	
		Comments		
			Per week	Per year
		Waste Throughput (tonnes)	unknown	
		Operating Hours (hr)	unknown	
		Fuel	Diesel	
		Fuel use (kg/litres)		
		Fuel use per kg waste burnt		
		Technology siting and operation issues	Often get complaints from hospital staff/patients and near-by residents. Use twice a week only	
		Offsite transport assessment	Good	
WASTE MANAGEMENT FRAMEWORK	Waste Management Documents	Waste Management Policy	N	
		Waste Management Plan	N	
		Waste Management Procedure	N	
		Waste Management Committee	N	
	Infection Control	Infection Control Policy	Y	
		Infection Control Procedures	Y	
	Auditing and Record Keeping	Audit Program	N	
		What is audited	Segregation	NA
			Compliance P&P	NA
			Int. transport	NA
			Storage	NA
			Treatment/ disposal	NA
		Frequency	NA	
	Training	Training Program	Y	
		Curricula	Infection Control	Y
			Waste Mgt	Y
			PPE	Y
			Treat. Tech operation	No
		Duration / frequency of training	Upon commencement and every two years	
		Records of who has been trained	No	
		Monitoring or refresher courses	Every 2 years	
PROJECTED ISSUES	Forecasting	10 year projections for waste management	NA	
		Barriers to change	According to the Chief Infection Control Nurse, compliance is reportedly an issue	
		Other issues		
LOCAL CONTRACTORS		Potential in-country contractors	Who	Key Capability

[1] *Occupied Bed Days (previous 12 months) annual average occupancy rate (as %) 2011 statistics*
[2] *Previous 12 months*

Appendix C

Minimum Standards Assessment

HEALTHCARE WASTE - MINIMUM STANDARDS FRAMEWORK & ASSESSMENT FOR PALAU				
Scale	**Category**	**Item**	**Minimum Standard Criterion**	**Belau National Hospital**
National Authority	National Legislation	Definitions	A clear definition of hazardous health-care 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 health-care 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.	
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 method for treating healthcare waste is in accord with required standards - this includes operating parameters 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

Qualitative Local Feasibility Assessment – Treatment Technology

Table D1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (Palau)

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)	$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	Palau solid waste regs require incineration or 'sterilization', has particulate emissions standards and incinerators must be 'multiple chambers'. HTI meets all three.	Incinerator has historically been used at BNH	Equipment breakdown and lack of local skills to maintain equipment – moderate 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)	$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	Equipment lifespan ~ 5 years; sustainability dependant on maintaining operator skills plus proper operation and	Palau solid waste regs require incineration or 'sterilization', has particulate emissions standards and incinerators	Incinerator has historically been used at BNH	Equipment breakdown and lack of local skills to maintain equipment – managed through skills training & supplier support and the fact that it	Emissions of air pollutants/ smoke and leaching from ash disposal to receiving environment are potential impacts. Med.	Equipment lifespan typically less ~ 5 years but will only last if maintained. Equipment is prone to require a	Requires less skilled operators than high temperature equipment - training simplifies operation

Table D1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (Palau)										
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**
			fully controlled)	maintenance	must be 'multiple chambers'. MTI unlikely to have multiple chambers and may have difficulty with particulate stds.		is simpler infrastructure than HTI. Significant regulatory barrier with 1 chamber MTI.	temperature operation increases risks of air pollution.	moderate level of maintenance	
Low temperature burning (<400^{0}C)	$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 but current policy environment means it could not be sustainable	Palau solid waste regs require incineration or 'sterilization', has particulate emissions standards and incinerators must be 'multiple chambers'. LT burning fails at least 2 out of 3, with 'disinfection' a	Burning of rubbish not as prevalent in Palau as other Pacific countries. Some community concern possible if healthcare waste was burned in an open situation	Major regulatory barrier (Solid Waste Regs).	Emissions of air pollutants/ smoke and leaching from ash disposal to receiving environment. Low temp 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.

Table D1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (Palau)										
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**
					question mark					
Autoclave with shredder	$158,000 USD over 10 years (ref Whole of Project – Summary Report, Appendix E)	Cannot treat all waste types, achieves complete sterilization when correctly operated, no combustion required, shredder destroys needles	Some issues for operators (requires training & PPE); small potential for odours and wastewater discharge (community)	Equipment lifespan ~ 10 years; sustainability dependant on maintaining operator skills plus longevity of equipment use given technology complexity	No legal barriers; no potential for smoke nuisance; some potential for odour nuisance; no air pollution and some potential for waste water management issues	Not familiar with use of sterilisers for waste – potential community issue with waste appearance if steriliser not operated correctly or shredder not used	Equipment breakdown and lack of local skills to maintain equipment – real barrier but can be managed through skills training & supplier support. Increased complexity of equipment (compared to incineration) increases barrier	No emissions of air pollutants/ smoke; some potential for odour impacts; still requires landfill or dump disposal of residue so some potential for leaching on burial. Some potential for waste water management issues	Equipment will only last if maintained. Adding shredder to autoclave technology increases mechanical parts that can go wrong. May require moderate level of maintenance	Requires skilled operators to achieve best 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.	No legal barriers; no smoke nuisance; no odour nuisance; no air pollution and some potential	No particular cultural fit concerns.	No obvious implementation barriers, although this would be unnecessary if HTI is used	Encapsulation itself poses no smoke nuisance; no odour nuisance; no air pollution and some potential for	Highly durable due to its simplicity.	Simple procedure once operator understands and manages the risk of sharps handling and

Table D1: QUALITATIVE Treatment Technology Options Assessment - Local Feasibility (Palau)										
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		for leachate to groundwater, although limited inherent hazard			leachate to groundwater, although limited inherent hazard		knows how to mix cement correctly.

Legend: 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

Appendix E

Recommendation Guidelines

Recommendation 1: Develop a Waste Management Framework

Healthcare Waste Management Plan

Hospital waste management plans should incorporate strategic objectives of the national medical waste management strategy as well as the following information:

- Location and organisation of collection and storage facilities
- Overview of the purpose of, and design specifications:
  - Drawing showing the type of waste container to be used in the wards and departments (eg., sizes, colours and wording)
  - Drawing illustrating the type of trolley or wheeled container to be used for bag collection
  - Minimum specifications of sharps containers
- Required Material and human resources
- Responsibilities:
  - Including definitions of responsibilities, duties and codes of practice for each of the different categories of personnel of the hospital who, through their daily work, will generate waste and be involved in the segregation, storage and handling of the waste.
  - Definitions of responsibilities of hospital attendants and ancillary staff in collecting and handling wastes, for each ward and department.
- Procedures and practices
- Training
  - Description of the training courses and programs to be set up and the personnel who should participate in each.
- Implementation Strategy

It is important that it also is compatible with any National Waste Management Strategies to ensure consistency of approaches such as with external transport and disposal of treated residues.

Appointment of a Responsible Officer

A responsible officer or waste management officer would be responsible for the day-to-day operations and monitoring of the waste-management system and is usually established as a separate post in larger hospitals (however, one appointee could be responsible for the waste management performance for a number of hospitals with a stated time fraction allocated to each hospital).

It is important that the waste management officer be adequately resourced to enable them to undertake their role as well as supported by Hospital management to ensure that all staff recognise the importance of adopting waste management practices that are in accord with all requirements.

Appointment of a Waste Management Committee

A waste management committee should also be established to provide guidance and support to the waste management officer and assist in implementation of developed actions. In larger hospitals, a separate waste management committee should be formed. For smaller hospitals, such a committee could be either part of the responsibility of another related committee (eg., infection control or quality assurance), or a sub-committee reporting back to this related committee.

This Committee should not necessarily undertake all activities themselves, but by the nature of the members and the professions/departments represented will ensure that there is a balanced approach to the investigations and analysis to ensure that patient and staff safety will not be compromised.

In addition, the Committee approach will enable advocates for such factors as environmental and economic performance to be heard in a balanced manner.

Waste Management Committee Members should serve for a minimum period of 2 years, with the option of reappointment.

The Waste Management Committee will work with hospital staff, stakeholders and the wider community to develop a culture of environmentally responsible waste management through information sharing and education.

Its members will ensure that waste management issues are considered on committees that deal with product evaluation, infection control and occupational health and safety, and in user groups such as Unit/Department Managers.

The Waste Management Committee should:

- Develop a waste management policy that meets current environmental legislation “due diligence” requirements. This policy is to include strategic directions for correct waste minimisation and management.
- Ensure that the hospital is meeting due-diligence requirements as specified by the Waste Management Team.
- Develop and implement a system to document waste and recyclable quantities on a spreadsheet to evaluate these quantities and therefore the waste minimisation programs that have been implemented, ensuring the results are circulated to all Unit managers/department managers on a regular basis.
- Review and submit subsequent reporting to Unit managers/department managers of the results of all implemented programs and trials.
- Work on implementing the most appropriate waste minimisation/management recommendations as agreed with hospital management and the Waste Management Team.

- Target in order the waste items that are contributing the most significant quantities of waste being generated and in particular waste segregation methods.
- Agree on the Waste Reduction targets for the hospital and outline the key objectives of the committee
- Review current work and waste management practices and develop waste management/minimisation initiatives.
- Conduct mini audits to review progress.
- Visually inspect waste and recycling containers to ascertain if staff are depositing appropriate items into them.

Recommendation 2: Procurement of Consumables (Segregation & Storage)

The correct segregation of healthcare waste is the responsibility of the person who produces each waste item, regardless of 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 adheres to the correct procedures.

Ideally, the same system of segregation should be in force throughout a country, and many countries have national legislation that prescribes the waste segregation categories to be used and a system of colour coding for waste containers. Colour coding makes it easier for medical staff and hospital workers to put waste items into the correct container, and to maintain segregation of the wastes during transport, storage, treatment and disposal. Colour coding also provides visual identification of the potential risk posed by the waste in that container.

Labeling of waste containers is used to identify the source, record they type and quantities of waste produces in each area, and allow problems with waste segregation to be traced back to a medical area.

Waste containers specification and siting

Containers should have well-fitting lids, either removable by hand or preferably operated by a foot pedal. Both the containers and the bags should be of the correct colour for the waste they are intended to receive and labeled clearly.

All containers should be able to adequately contain the wastes deposited into it – to prevent the possibility of spills.

Sharps should be collected in puncture proof and impermeable containers that are difficult to open after closure.

The appropriate waste receptacle (bags, bins, sharps containers) should be available to staff in each medical and other waste-producing area in a healthcare facility. This permits staff to segregate and dispose of waste at the point of generation, and reduces the need for staff to carry waste through a medical area. Posters showing the type of waste that should be disposed of in each container should be displayed on the walls to guide staff and reinforce good habits.

Segregation success can be improved by making sure that the containers are large enough for the quantities of waste generated at the location during the period between collections, as well as a collection frequency that ensures no container is overfilled.

Setting and Maintaining Segregation Standards

Segregation requirements and methods should be clearly set out in the waste-management policy of a healthcare facility. It is important that the waste-management policy is supported and enforced by senior staff and managers. Managers and medical supervisors should know the relevant legislation and understand how to implement waste audits.

The 'Responsible Person' or Waste Management Committee should be responsible for seeing that segregation rules are enforced and waste audits are carried out to quantify the amount of waste produced.

Correct Signage

Signage indicating correct waste segregation practices is a valuable tool to provide ongoing guidance to staff. The success of the waste/recycling system will depend on having a clearly identified container for each type of material. This is achieved by the use of colour coded containers, symbols and wording. In addition, signage must be placed so that those wanting to dispose of materials can clearly and readily identify which container to deposit such materials into.
Once designed, signs should be located on walls above all waste containers as well as on the container itself.

Correct Storage

The storage area should be signposted with the bio-hazard symbol and other labeling appropriate to the types of waste stored in the area (eg healthcare) and includes the following:

- The base should be an impervious surface (eg. concrete) surrounded by a bund appropriate to contain any spill.
- All loading/ unloading takes place within the bunded area in such a manner to ensure any spills are appropriately managed.
- The base and walls of bunded areas are free of gaps or cracks.
- No liquid waste, wash down waters or stormwater contaminated with biohazardous wastes are disposed of via the stormwater drainage system; and
- The bunded area drains to a sump or sewer to collect spills and wash waters. Cut-off drains, which drain to a sump, should be used instead of bunds if approved by the relevant authority.
- Loading/ unloading of waste is carried out in accordance with designated safe procedures, and relevant records are completed and maintained.
- Containers in which biohazardous waste are stored secured when loading/unloading is not taking place.

- Spill Kits for biohazardous waste located in the storage areas.

Storage for larger generators may involve a dedicated room that is constructed specifically for waste management, or could be via the use of appropriately sized mobile garbage bins (eg., 240 or 660 litre).

Conditions related to security of healthcare waste include the following:

(a) The operator shall ensure that loading/ unloading of waste is carried out in accordance with designated safe procedures, and relevant records are completed and maintained.

(b) Containers in which healthcare waste are stored shall be secured when loading/unloading is not taking place.

Spill Kits for healthcare and cytotoxic waste shall be located in the storage areas.

Recommendation 3: Improve Training Program

All waste management strategies (particularly resource management programs), rely on all staff to participate and co-operate in order to ensure that objectives are met. Staff therefore should receive appropriate training/education to understand the inherent hazard and risks posed of healthcare waste, and the importance of its management from generation to final treatment and disposal.

The Waste Management Committee (apart from ensuring staff education programs are developed and implemented), should also address other methodologies in order to ensure that staff receive information on waste reduction programs (eg., signage, information sheets and flow charts).

One of the initial steps for developing a structured training program is to gain management support from hospital administration. The development of a training program can be facilitated by establishing core competencies related to healthcare waste management.

In the development of a training program, the following should be considered:

- Conduct of a training needs analysis
- Identification and prioritisation of employees that need to be trained.
- Defining the specific learning objectives for each target audience.
- Develop a detailed curriculum specifying the training plan for each session.
- Incorporate pre-evaluation and post evaluation of learners, evaluation of trainers, follow-up activities, and documentation into the training program.
- Develop training content or adapt available training materials, tailor training content to specific target audiences.
- Identify potential trainers and build training skills
- Develop a budget and secure funding

- Explore incentives for training (e.g. training in collaboration with a health professional society or university that can award certificates or professional credentials)

The following is an outline of a Staff Waste Management Education Program that could be developed:

- Introduction to the session
- Importance of good waste/environment management/ infection control
- Waste management hierarchy
- Waste minimisation principles
- Brief overview of legislation pertaining to waste management
- Hospital policies on environment/waste management/ infection control/ needle stick injuries
- Overview of waste types
- Issues relating to waste reduction
- Management responsibilities
- Identification of, and hazards associated with the different types of wastes generated Importance of effective waste segregation
- Infection control and sharps management
- Waste, handling, packaging and disposal routes for the different types of wastes generated
- Questions

All staff and contractors should attend a waste management training session. This should be conducted during all induction programs in the first instance.
For those staff and contractors currently employed on-site, they should attend a dedicated training session so that they are fully aware of their roles and responsibilities in respect to waste management. Records should be maintained of all staff and contractors attendance at a training session to ensure that all personnel attend.

At a national and regional level, training programs could be in the form of train the trainer. The training of trainers approach allows rapid capacity building and widespread training outreach.

Training of Waste Disposal Treatment Operators

Incinerator/ healthcare waste treatment system operators should receive training in the following:

- Overview of healthcare waste management including risks and management approaches
- General functioning of the incinerator, including basic maintenance and repair training.

- Health, safety and environmental implications of treatment operations
- PPE, its correct use and removal and cleaning (if appropriate)
- Technical procedures for operation of the plant.
- Recognition of abnormal or unusual conditions
- Emergency response, in case of equipment failures.
- Maintenance of the facility and record keeping
- Surveillance of the quality of ash and emissions.
- Disposal of residues

Recommendation 4: Improved Treatment Infrastructure

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 ensure that there is no 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.

There are a number of means of treating healthcare waste that are in commercial use around the globe. The question arises as to what type of technology is best suited to meet the various waste categories/quantities generated, environmental requirements and that treatment is done safely and in a cost-effective manner. Treatment of healthcare wastes should achieve a change in the wastes biological or chemical hazard so as to reduce or eliminate its potential to cause disease or other adverse consequences, by meeting acceptable biological standards and to ensure that there is minimal adverse environmental impact in respect to water, soil, air and noise.

Management of wastes should be based on the **precautionary principle** in that a lack of data should not mean that options be undertaken when there is still a perceivable risk of damage (to human health or the environment). The literature and other sources of information have clearly demonstrated a need for maintaining incineration as the most preferred option for at least the treatment of pharmaceutical and cytotoxic wastes – if not other components such as microbiological specimens and body parts. Only one technology has been demonstrated to be able to effectively treat all categories of healthcare waste.

This technology is incineration (at high temperature, with sufficient residence time and appropriate air pollution control equipment).

A substantial amount of data exists on the emission 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 these 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.

It is also very clear that there is little work been undertaken on the consequences of landfilling untreated healthcare waste, and in particular pharmaceuticals and cytotoxic wastes. The literature does relate to impacts resulting from untreated pharmaceuticals being discharged into the environment from hospital sewers and wastewater treatment plants and does indicate that there are potential negative environmental and health consequences. The implications of these studies could legitimately be applied to discharge of waters such as leachate or surface water runoff from landfills should these wastes be deposited untreated. According to the World Health Organization[4, 5], incineration is the preferred method for treating pharmaceutical and cytotoxic wastes. This is further supported by the United Nations[6, 7] in that they have also recommended incineration as the preferred method for treatment prior to disposal of pharmaceuticals and cytotoxic wastes. These recommendations are generally standard throughout the world in relation to these two specific waste types[8, 9].

There are other studies that have been conducted on what is referred to as “alternate treatment technologies”, and these have demonstrated that all of these technologies cannot effectively treat pharmaceutical and cytotoxic waste, with many also unable to treat anatomical waste.. Some jurisdictions do allow alternative means of treating anatomical waste prior to disposal to landfill, but these are by far in the minority and mostly related to ethical or religious rationales.

In Australia as an example where there is allowed a variety of treatment technologies for the range of clinical and related wastes, without exception, jurisdictions do not allow treatment

[4] World Health Organization Regional Office for Europe, EURO Reports and Studies 97, Management of Wastes from Hospitals and other Health Care Establishments, 1983.
[5] World Health Organization, Safe management of Wastes from healthcare Facilities, Geneva, 1999.
[6] United Nations Environment Programme – Technical Working Group on the Basel Convention, Draft Technical Guidelines on Biomedical and Health Care Wastes, 1999.
[7] Environment Australia, Basel Convention – Draft Technical Guidelines on Hazardous Waste: Clinical and Related Waste (Y1), March 1998.
[8] Health care Without Harm, Non-Incineration Treatment Technologies, August 2001.
[9] London Waste Regulation Authority, Guidelines for the Segregation, Handling, Transport and Disposal of Clinical Waste, 2nd Edition, 1994.

other than incineration for anatomical waste, pharmaceuticals and cytotoxic wastes[10, 11, 12, 13, 14, 15]. This is also quite evident in a review of Australian State/Territory environmental agency licence conditions for approved clinical and related waste treatment technologies. In countries that do allow landfilling of clinical and related wastes, often these two specific waste categories are specifically excluded from this option[16].

In summary, 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.

Recommendation 5: Procurement of Consumables (PPE)

Personnel Protective Equipment

The use of Personal Protective Equipment (PPE) should be a condition of employment for employees with waste management responsibilities. PPE is one aspect of a multifaceted program, designed to protect employees from injuries and unnecessary exposure to hazardous substances.

Other aspects of this program are:

- employee training
- engineering controls to reduce or eliminate known hazards
- administrative controls

The following is a list of the personal protective equipment that should as a minimum to be supplied for all waste handlers:

- Gloves
- Masks
- Safety glasses/eye shields
- Overalls/aprons
- Safety boots

[10] National Health & Medical Research Council, National Guidelines for Waste Management in the Health Industry, Commonwealth of Australia, 1999.
[11] EPA Victoria, Draft Guidelines for the Management of Clinical and Related Waste, July 2003.
[12] NSW Department of Health, Waste Management Guidelines for Health care Facilities, August 1998.
[13] Queensland Government, Environmental Protection (Waste Management) Regulation, 2000.
[14] Australian/New Zealand Standard 3816:1998, Management of Clinical and Related Wastes.
[15] Australian and New Zealand Clinical Waste Management Industry Group, Industry Code of Practice for the Management of Clinical and Related Wastes, 3rd edition July 2000.
[16] Provincial Government of Gauteng (South Africa), Draft Health Care Waste Regulations, 11 September 2003.

Recommendation 6: Upgrade Storage Area

The storage area should be signposted with the internationally recognised bio-hazard symbol and other labeling appropriate to the types of waste stored in the area (eg healthcare) and includes the following:

- The base should be an impervious surface (eg. concrete) surrounded by a bund appropriate to contain any spill.
- All loading/ unloading takes place within the bunded area in such a manner to ensure any spills are appropriately managed.
- The base and walls of bunded areas are free of gaps or cracks.
- No liquid waste, wash down waters or stormwater contaminated with biohazardous wastes are disposed of via the stormwater drainage system; and
- The bunded area drains to a sump or sewer to collect spills and wash waters. Cut-off drains, which drain to a sump, should be used instead of bunds if approved by the relevant authority.
- Loading/ unloading of waste is carried out in accordance with designated safe procedures, and relevant records are completed and maintained.
- Containers in which biohazardous waste are stored secured when loading/unloading is not taking place.
- Spill Kits for biohazardous waste located in the storage areas.

Storage for larger generators may involve a dedicated room that is constructed specifically for waste management, or could be via the use of appropriately sized mobile garbage bins (eg. 240 or 660 litre).

Conditions related to security of healthcare waste include the following:

(c) The operator shall ensure that loading/ unloading of waste is carried out in accordance with designated safe procedures, and relevant records are completed and maintained.

(d) Containers in which healthcare waste are stored shall be secured when loading/unloading is not taking place.

Spill Kits for healthcare and cytotoxic waste shall be located in the storage areas.