Tonkin+Taylor

Job No: 1005126
2 May 2018

Nauru Department of Industry, Commerce and the Environment
Yaren District
Nauru

Attention: Bryan Star

Dear Bryan

Waste Management System Operations and Policy - Preliminary Advice

1 Introduction and background

Tonkin & Taylor International Ltd (T+TI) has been engaged by Nauru Department of Industry, Commerce and the Environment to provide advice on solid waste management operations and policy. This report summarises the outcome of T+TI work on the project, as follows:

- Section 1 provides an introduction and background to waste management on Nauru;
- Section 2 considers waste disposal including the current Nauru Dump Site;
- Section 3 considers options for resource recovery on Nauru;
- Section 4 covers options for charging for waste and resource recovery activities;
- Section 5 comments on organic waste management; and
- Section 6 sets out proposed actions to build on and improve current solid waste management activity on Nauru.

1.1 Scope of Work

The scope of work covered by this report is set out in our Letter of Offer dated 26 October 2017 and a subsequent variation to the Terms of Reference dated 31 January 2018. This comprises the following tasks:

Letter of offer dated 26 October 2017:

1 Review of background information provided by Nauru including the National Solid Waste Strategy and background data.

2 A visit to Nauru with a four day programme including:
- A visit to the NRC managed dumpsite to observe site conditions and discussion operations with current staff.
- Consider potential on-island construction resources - equipment, materials, and available staff.
- Discussions regarding environmental approvals requirements (Department of Commerce Industry and Environment)
- Observation of waste collection and handling practices on the Island.

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3 Drafting a scope of work for completing an upgrade of the current dumpsite to a suitably designed, constructed and operated disposal facility. This is likely to include:

- **Concept Design** including documentation for environmental approvals and funding for detailed design and construction.
- **Detailed Design**
- **Construction** including tendering for construction contractor(s), supervision of construction activities and training of site operators.
- If required, ongoing operational support - designing additional landfill components and addressing issues as they arise and supporting local technical and operational staff

The Variation to Terms of Reference dated 31 January 2018 added the following tasks:

4 Spend an additional 1-2 days on Nauru (Task 2 in offer dated 26 October 2017) to allow for discussion and where relevant site visits relating to:

- Establishment of a waste resource facility;
- Utilizing mined out lands for landfill;
- Waste Billing;
- Creating new soil (processing of organic waste);
- Creating aggregates from waste;

5 Compiling a summary of the discussion on the matters above and setting out a scope of work to progress each matter. This will form part of the report to be delivered under Task 3 (refer our offer dated 26 October 2017).

6 Completing an outline business case that covers each of the components noted above and landfill design and operations improvements. This will provide an outline of proposed actions, very high level costs and indicative benefits to enable the relevant budget holders within the Department of Commerce Industry and Environment to approve additional investment in design and detailed costs to inform a final business case.

1.2 Environment Management Bill 2011

This framework bill makes provision for issues related to the management and protection of the environment, and permits regulations to be made for environmental matters, including:

- Regulating or prohibiting the pollution of the air, water or land, and the depositing or dumping of litter, rubbish, or any substance of a dangerous, noxious or offensive nature;
- Managing landfill sites and otherwise providing for the administration, management and regulation of waste management processes, facilities and services; and
- Prescribing fees for applications, permits or approvals under any law relating to the management of the environment, or for the provision of advisory, inspection or other services by CIE.

1.3 Institutional arrangements

The Department of Commerce, Industry & Environment (CIE) is responsible for the strategic planning and regulatory aspects of waste management.

Solid waste management disposal operations and waste collection are carried out by the Nauru Rehabilitation Corporation (NRC) or private businesses. Each community determines the approach to collection of waste, typically using wheelie bins with no separation of recoverable material. In some cases the wheelie bins are taken to the landfill to be emptied directly, in others they are emptied into bags or using the single compactor truck on the Island.

1.4 National Solid Waste Management Strategy

Nauru has a National Solid Waste Management Strategy (2017-2026) that contains a range of actions intended to improve solid waste management in Nauru. The Forward to the strategy notes that:

> *"The National Solid Waste Management Strategy (NSWS) ... promotes and reinforces responsible of Solid Waste Management by including responsibility and mandatory advanced recycling fees, where necessary and to reduce environmental pollution from the generation and disposal of solid waste.*
>
> *Nauru is a small island in appropriate for imports of excessive non-biodegradable packaging and a harsh environment decreasing the life of many consumer goods. The long distances between [the] island and markets and relatively small volumes place conventional solutions like recycling beyond the reach of most inhabitants*
>
> *Waste is an economic as well as an environmental issue. Increasingly, Nauru necessity to rely on tourist image as a 'pleasant island' but litter on roads and beaches will slow this important economic drive waste is also inflating our healthcare costs by increasing pollution and mosquito breeding which cause disease like dengue and malaria. Not managing waste well is already costing Nauru significantly."*

The strategy sets out a range of targets, those relevant to the scope of work for this project are highlighted in **bold**. The specific targets for each of these 6 areas are:

- Practical and enforceable regulations for waste management enacted by 2019, and enforced beginning in 2020.
- Increase the percentage of the population aware of and engaging in good solid waste management practices by at least 10% yearly over the 2017 levels.
- Solid waste management integrated into the Nauru school curriculum by 2017.
- **By 2017, adequate numbers of trained staff are effectively implementing the National Solid Waste Management Strategy, and there is a plan in place for continuous staff development.**
- **Improved operation and management of the NRC-managed dumpsite by 2017 in order to extend the operational life and minimize the pollution risks and other environmental impacts (odours, pests, fires, etc).**
- An efficient and sustainable collection system in place by 2018.
- **30 % reduction in the amount of solid waste requiring disposal to landfill by 2020 compared to 2017 baseline data**
- 75% reduction in bulky waste stockpiles by 2020.
- **Fair application of the polluter pays principle – i.e., those who cause pollution should pay the cost of managing that pollution.**
- **At least 15% of the waste management budget generated from sustainable means by 2020, and 30% by December 2023.**

1.5 Strategic objectives for solid waste management

The vision for the National Solid Waste Management Strategy is identical to the strategic goal identified in Nauru's National Sustainable Development Strategy 2005-2025: ***Effective management of waste and pollution that minimizes negative impacts on public health and environment.*** This vision is underpinned by three goals:

1 To reduce environmental pollution from the generation and disposal of solid waste

2 To increase economic benefits and efficiency by reusing and recycling wastes where possible

3 To reduce the costs to society of managing waste through efficient and responsible management and equitable distribution of costs

To achieve the stated goals, 6 priority thematic areas were identified through wide stakeholder consultations. These thematic areas (in no order of priority), are:

(A) Legislation;

(B) Awareness;

(C) Capacity building;

(D) Waste disposal;

(E) Waste reduction, reuse, and recycling; and

(F) Sustainable financing.

This strategic framework provides a basis for assessment potential options, using the strategy goals, to address the areas that the focus of this report.

1.6 Waste management system components

There are several aspects to effective solid waste management that worth identifying here. At a basic level:

1 Solid waste is generated by households, government or businesses;

2 Waste is either managed on site (for example fed to animals or reusing containers) or collected for management off site;

3 Once collected waste is:

- Sorted for recycling or reuse; and/or
- Placed in landfill.

The focus of this report is on the management of materials that have been collected for recovery or disposal. It is important to recognise that there is potential to make the management of waste easier (operational less complex, lower cost) through considering how was is generated and ensuring the collection system is well design and operated. In Nauru this could include:

- Policy initiatives that incentivise the import and use of easily recoverable materials e.g. preferring aluminium over plastic containers.
- Policy initiatives that allocate some costs of waste management to importers or manufacturers e.g. an import levy on items like cars or electronics, ring fenced to fund collection and export for recycling.
- Promoting waste minimisation to the community, for example avoiding plastic bags, reusing containers.
- Providing for separate collection of recoverable materials from households and businesses e.g. cardboard, green waste, aluminium cans, scrap steel.

2 Existing dump site

2.1 Description

The current dump site on Nauru has been operating for an extended period of time with imagery from 2005 (Google Earth) showing site has been operating for an extended period of time and mapping from 1992 noting the current site in operation. The most recent imagery (2016) is shown in Figure 1.

Figure 1 Current Nauru dump site (2016 imagery)

The current operation is spread over approximately 5 ha with approximately 1.5 ha currently in use for filling or stockpiling of materials as part of firefighting operations. The remainder of the 5 ha is uncovered waste with patchy vegetation growth (to the north and east of the active area) and an approximately 0.5 ha area for sorting and storing recoverable materials adjacent to the road.

Dumping is uncontrolled with several areas being used and limited use of cover. Periodic fires have been addressed through excavation of waste resulting a number of stockpiles of exposed material around the site. Black soil (overburden from historic mining across the Island) and road base has been used as cover material. There is no liner system, leachate collection or separation of stormwater in place. Waste is compacted using an excavator bucket when suitable equipment is available, nominally twice a week but often much less frequently.

General waste material entering the site is typical municipal solid waste from a Pacific Island community with a relatively low organic material content. This reflects the use of food waste for animals. Garden waste and cardboard is set aside (for the manufacture of compost) but there is still a large amount of both materials in the general waste stream observable on site. Where possible site staff are also separating white goods, tyres and scrap steel.

Waste entering the site from community or business collections is recorded and billed each month. Communities are billed $2.50 per cubic meter, businesses are charged $20 per cubic metre.

There is no detailed information available on waste quantity or composition. Based on materials received at the dump site in the week of 26 February 2018, an estimated 26,000 m^3 or 4 to 5,000 tonnes[1] of material is received each year. Visual observation of waste material entering the Nauru dump site indicates that cardboard, plastic bottles and plastic bags are a significant portion of the waste stream. Aluminium cans, food tins, nappies and a wide range of broken items were also present.

2.2 Hydrogeology and groundwater context

Nauru, in the central Pacific Ocean, is a raised atoll capping a volcanic seamount arising from an ocean floor depth of 4300 m. The land area is 22 km, and the island rises to 70 m above sea level. Drilling has proved dolomitised limestone of upper Miocene or younger age to a depth of 55 m below sea level. Gravity and magnetic surveys indicate that the limestone probably overlies volcanic bedrock at a depth of about 500 m.

[1] The density of uncompacted material entering the site is likely to be in the range 0.15 0.20 T/m^3

Work completed in the late 1980's and early 1990's[2] including reverse-circulation drilling and geoelectrical probes indicated that there is a discontinuous freshwater layer averaging 5 m thick beneath Nauru. This is underlain by a mixing zone of brackish water, 60 to 70 m thick. The exceptional thickness of the mixing zone is ascribed to high permeability of the karstified limestone. The forthcoming cessation of phosphate mining will mean a shortfall in water supply which will probably have to be met by the desalination of brackish water. Groundwater beneath the mined-out area, and the settled coastal terrace, is highly vulnerable to pollution, and waste disposal management needs to be considered in relation to groundwater protection.

A recently published paper[3] suggests that the situation may be different with the freshwater layers identified in earlier work being related to a period of high rainfall. The 2017 paper identified stable freshwater aquifers at the north and southern ends of the Island. The southern aquifer is between the current Nauru dump site and ocean.

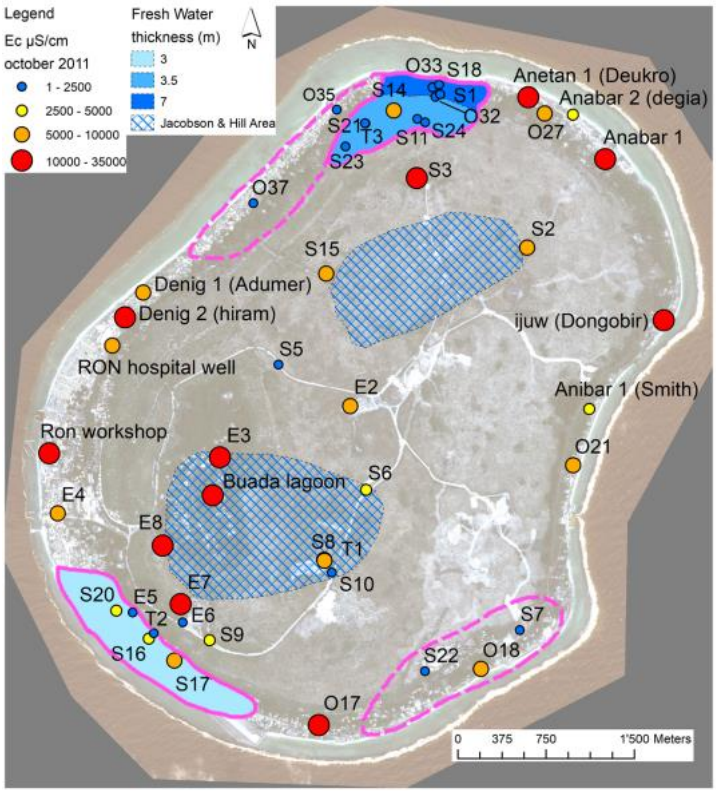

Figure 2 Nauru hydrogeology (Figure 13 from 2017 paper[3])

2.3 Issues and opportunities

There are a number of issues and opportunities for the Nauru dump site, these are noted below. The options discussed in this report (Section 2.4) are intended to address the issues and assist in realising the opportunities identified here.

- The current operation involves open dumping at several locations on site resulting in a large 'active' tipping area. This in turn results in most of the rain water falling on the site percolating through exposed refuse, creating leachate. With no leachate collection any leachate generated will percolate through the underlying soil and rock to groundwater.

[2] From https://data.gov.au/dataset/hydrogeology-and-groundwater-resources-of-nauru-island-central-pacific-ocean.
[3] Saltwater Intrusion and Freshwater Storage in Sand Sediments along the Coastline: Hydrogeological Investigations and Groundwater Modeling of Nauru Island, Alberti et al, Water, 2017 (www.mdpi.com/2073-4441/9/10/788/pdf)

- The current approach to placing waste, with multiple piles of material and little or no compaction, is an inefficient use of the available space on site.
    - Planned placement of waste helps in efficient utilisation of the available space and provides for 'completion' of specific areas followed by placing cover to contain waste and divert rainwater away from open waste.
    - Compaction of waste, either as part of placement or prior to placement (compaction into bales) maximises the amount of waste that can be placed in a given area.
- There are ongoing issues with landfill fires at the site. These are a concern in their own right and also cause problems with firefighting often involving excavating and stockpiling previously placed waste across the site.
- There have been ongoing challenges with access to suitable equipment to operate the site. There are two broken down bulldozers and an inoperative motorised compactor trailer on site. A NRC loader is available Monday and Fridays for the site but is often diverted to mining activities.
- Cover is typically black soil (overburden from phosphate mining) or roading base. There is a large amount of this material available but it is also a resource for rehabilitation of the formerly mined areas across Nauru.
- While the proportion of organic waste is low compared to typical urban waste, the green and food waste disposed of in the landfill will contribute to leachate and fugitive gas emissions as it degrades in the dump site.
- The dump site is over groundwater resources identified in a 1994 study and up gradient of groundwater resources identified in a more recent groundwater study. In this context the dump site represents a risk to groundwater quality given the dump is unlined and has no control of leachate or surface/rainwater ingress.
- Waste disposal is subject to charges with businesses and communities charged for disposal. There is potential to accept garden waste and cardboard for free or reduced charges to encourage the separation of these materials.
- A resource recovery area is identified and had been set up with stone walls to provide bunkers for various recovered materials. The walls are in poor repair and the area is not currently being used.

Changes to the dump site design or operation will interact with other aspects of the scope of work covered by this report. For example:

- Charging at the landfill will interact with any charges levied for waste collection from businesses and if well designed will encourage resource recovery and sorting prior to collection.
- Establishing a resource recovery area at the landfill will reduce the need for disposal capacity.
- Removing organic waste from the material placed in the dump site will reduce the strength of any leachate produced and reduce potential fugitive emissions.
- With appropriate redesign and configuration of the current dump site it may be possible to accommodate a range of resource recovery and/or rehabilitation activities. Examples include space for sorting and stockpiling of materials, space for processing of organic material into compost and space for processing materials into aggregate (for rehabilitation activities).

2.4 Nauru Dump Site - options

The dump site as currently operated and configured is not meeting the needs of NRC and presents risks to both groundwater and air quality (from fires). As noted above, there are several issues that should be addressed and some opportunities that could be realised with changes at the dump site.

At a high level there are three options that can be considered. For each option there are likely to be a number of variations in detail. These can be considered once the preferred option is identified.

Option D1 - continue with the status quo

It would be possible to continue with the status quo, namely relatively uncontrolled dumping across the active area of the site with limited diversion. This would involve no additional investment or change in current operational costs. Given the inefficient utilisation of available space on the site it is likely that a new site would be required within a relatively short timeframe i.e. future investment will be required to establish a new location. Key challenges for a new site are noted for Option D3 below.

The uncontrolled nature of the current operation has several negative aspects. These include:

- With the waste largely uncovered, any rainwater falling on the site will percolate through waste creating leachate.
- With no liner, any leachate that is generated will move through the underlying rock to groundwater (estimated 30 m below ground level in the top side).
- Fires are common on the site, potentially exacerbated by limited compaction and covering of waste. Fires are put out by excavating waste and placing and covering burning material.
- While there is space put aside for stockpiling recoverable materials, this is periodically used for putting aside material during firefighting.

Table 1 Option D1 (Nauru dump site status quo) evaluation

Waste strategy goal	**Comment**	
To reduce environmental pollution from the generation and disposal of solid waste	The current approach of open dumping with no capture of leachate, diversion of rainwater or capping of placed refuse presents a risk to groundwater. Ongoing fires present an air quality risk alongside potential soil and groundwater contamination from burnt out waste/ash.	✘
To increase economic benefits and efficiency by reusing and recycling waste where possible	The current approach is achieving some diversion of materials (green waste and cardboard for composting, tyres and scrap metal). There is still a significant amount of recoverable material present in the landfill waste.	-
To reduce the costs to society of managing waste through efficient and responsible management and equitable distribution of costs	The current approach is low cost and charging for waste disposed of at the dump site attributes some costs back to the community and businesses.	-
Cost	This option will not involve costs above those currently incurred. With the site nearing capacity, based on current operations/estimate of available space, investment will be required to establish a new site.	-

This option is **not preferred** due to the environmental risks associated with uncontrolled waste disposal.

Option D2 - upgrade the existing site - cap completed area, develop a new landfill cell on site

It would be possible to improve the utilisation of available space on the site and improve environmental protection through developing and filling landfill cells on the site. These could be

constructed over existing filled areas and include measures to prevent rainwater falling on the site coming into contact with waste as much as possible. There is potential to use an engineered liner system, simple leachate collection and treatment and good practice waste placement and compaction to maximise the available space and limit discharges to the environment.

Engineered low permeability liner - this could take the form of compacted materials available in Nauru (fine crushed limestone) or combine a local sourced soil materials with a geosynthetic liner.

Leachate collection - leachate (water contaminated by waste, liquid from the breakdown of organic waste) contained by a liner system can be collected in perforated pipes and/or in a high permeability drainage layer on top of the liner and underneath the waste. Given the topography of the site leachate may require pumping to a storage pond. Treatment requires further consideration but may rely on evaporation, aeration (potentially including mechanical aerators) and/or recirculation through the waste. Consideration will need to be given to peak flows of leachate as a result of storm events.

Diversion of surface and rainwater - rainwater falling on the site should, were possible, be diverted away from open dumping areas. This avoids generating additional leachate and means the rainwater can be treated as clean water. If composting is established on site (see Section 3) rainwater could be retained and used for maintaining compost moisture in the optimum range.

Changes at the site should include:

- Improving the design of the dumping area:
    - Preparing a master plan for the development of the site including staging of cell development and filling (refer Figure 2 for a high level plan).
    - Consolidating the historic waste on the site, either in constructed cells or specific areas.
    - Developing cell(s) for controlled dumping of waste.
    - Identifying a suitable approach to achieving acceptable compaction of waste placed in the new landfill cell(s).
- Securing suitable equipment (bulldozer, digger and/or loader) for operation and ongoing construction and maintenance activity.
- Maintaining a stockpile of suitable material for cover and construction of bunds and cap on site.
- Keeping the active tipping area as small as possible to minimise the amount of rainwater falling on open waste dumping area.

These changes will require capital investment and a commitment to ongoing resourcing for improved operations. Materials and equipment are available on the island but the waste management team compete with mining operations within NRC for access to both.

Consolidating existing waste on site and specifying specific areas for future filling provides an opportunity to develop other parts of the site for resource recovery activities. This could include:

- Securing an area for resource recovery (sorting and stockpiles, nominally adjacent to the road at the front of the site).
- Making space available for processing of garden waste and cardboard - shredding, stockpiling of mulch including periodic turning).
- Making space available for a NRC nursery.

Figure 3 is an initial sketch of a master plan for the dump site illustrating how different areas of the site could be developed over time to improve environmental protection, maximise capacity for disposal of residual waste and make provision for resource recovery activities. Figure 4 illustrates

some of the details that will be required and will be developed during the development of a designs to support a Master Plan.

Figure 3 Sketch master plan for dump site (2016 imagery)

Key

1 Resource recovery area
2 Existing landfill with final cap in pace (see Figure 4 for indicative detail), composting/nursery
3 Area where loosely tipped material should be consolidated and capped
4 Potential new landfill cell(s)
5 Area for leachate storage/treatment.

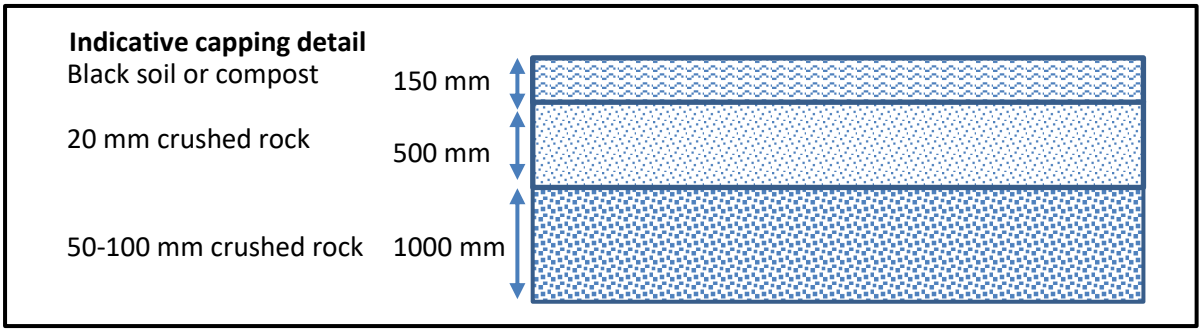

Figure 4 Indicative capping details - capping, cell, waste placement

We propose new landfill cells be established with compacted road base material on the base and bunds creating a filling area. The base should be contoured to provide for collection of leachate for storage, treatment and/or irrigation of active areas of the filling area.

The bunds can be constructed from old waste covered with road base material with soil slope angles designed based on the stability of the material used.

The base of the cells should be designed to allow any leachate generated to flow to a collection point for capture and treatment. The compacted base should have 100-200 mm of 50 - 100 mm crushed rock to allow leachate to drain to the collection point.

Waste should be placed and compacted in relatively small layers with areas likely to be exposed for extended times covered with intermediate cover. Intermediate cover can be in the order of 100 - 150 mm compacted road base and should be removed before placing additional waste.

Table 2 Option D2 (Nauru dump site new cell) evaluation

Waste Strategy Goal	Comment	
To reduce environmental pollution from the generation and disposal of solid waste	Implementing controlled disposal of residual waste with limited active dumping area, control of leachate and capping of previously dumped waste will significantly reduce the environmental risks posed by the dump site. Controlled dumping and capping of placed materials and will also reduce the potential for landfill fires.	✓
To increase economic benefits and efficiency by reusing and recycling wastes where possible	Reconfiguring the dump site to make provision for resource recovery (sorting and stockpiling), management of garden waste and cardboard is anticipated to increase reuse and recycling of materials from across Nauru.	✓
To reduce the costs to society of managing waste through efficient and responsible management and equitable distribution of costs	Upgrading the dump site will require significant capital investment. Some of the investment is focussed on addressing historical waste disposal practices (consolidating and capping historic waste). The remainder is focussed on reducing risks from future waste disposal and enabling enhanced resource recovery through sorting, stockpile space and processing of garden waste and cardboard. It is unlikely to be feasible to cover all investment costs from charging. In other words the full costs are unlikely to be equitably distributed.	-
Cost	This option will involve additional capital costs and will require ongoing operational resources (plant for placement and compaction of waste, plant for processing and handling of recovered materials).	✗

This is the **preferred option** based on the environmental and economic benefits. These benefits are offset to some degree by additional costs. Redeveloping the existing site will be cheaper than completing the site (capping) and developing a new site (Option D3).

Option D3 - close the current dump site and develop a new site elsewhere on the Island.

Selecting a new site should be guided by a range of considerations including:

- Landfill ownership (or ability to lease).
- Proximity to identified groundwater resources.
- Anticipated capital expenditure - site preparation, landfill construction.
- Operational costs, and distance from key population centres (south and east of Island).
- Determining the role of the existing dump site.
  The current dump site could be retained as the location to deliver waste and recoverable materials with NRC staff transferring residual waste to the new landfill site elsewhere on the island. Alternatively the new site could be configured to completely replace the existing site. In both cases the current dump site will need to be completed with activities including

consolidating material and installed appropriate capping to contain placed refuse and avoid rainwater coming into contact with uncovered waste.

NRC has indicated an interest in utilising one of the areas that have been used to pilot secondary mining. This would enable NRC to achieve the complimentary objectives of rehabilitating the mined out area while providing a new disposal facility for Nauru.

Development of a new site should adopt a similar philosophy to that for ongoing improved operation at the existing dump site. This includes preventing rainwater falling on the site coming into contact with waste as much as possible, potentially using an engineered liner system, simple leachate collection and treatment and good practice waste placement and compaction to maximise the available space. Development of a new site should include:

- Developing a master plan for the development of the site including staging of cell development and filling.
- Constructing cell(s) for controlled dumping of waste.
- Determining an approach to management of leachate, potentially including an engineered liner, leachate collection and leachate treatment.
- Identifying a suitable approach to achieving acceptable compaction of waste placed in the each landfill cell.

If the site is to be developed as a full replacement for the current dump site additional considerations include:

- Securing an area for resource recovery (sorting and stockpiles, nominally adjacent to the road at the front of the site).
- Making space available for processing of garden waste and cardboard - shredding, stockpiling of mulch including periodic turning).
- Making space available for a NRC nursery.

Table 3 Option D3 (new Nauru landfill) evaluation

Waste Strategy Goal	Comment	
To reduce environmental pollution from the generation and disposal of solid waste	Developing a new site with controlled disposal of residual waste, limited active dumping area, control of leachate will significantly reduce the environmental risks posed waste disposal. Capping of previously dumped waste at the current dump site will have a similar impact. Controlled dumping and timely capping of placed materials and will also reduce the potential for landfill fires.	✓
To increase economic benefits and efficiency by reusing and recycling wastes where possible	Either reconfiguring the current dump or making provision at the new site for resource recovery (sorting and stockpiling), management of garden waste and cardboard is anticipated to increase reuse and recycling of materials from across Nauru.	✓

Waste Strategy Goal	Comment	
To reduce the costs to society of managing waste through efficient and responsible management and equitable distribution of costs	Capping the current dump site and developing a new landfill will require significant capital investment. Some of the investment is focussed on addressing historical waste disposal practices (consolidating and capping historic waste). The remainder is focussed on managing risks from future waste disposal and enabling enhanced resource recovery through sorting, stockpile space and processing of garden waste and cardboard. It is unlikely to be feasible to cover all investment costs from charging. In other words the full costs are unlikely to be equitably distributed.	-
Cost	This option will involve significant additional capital costs and will require ongoing operational resources (plant for placement and compaction of waste, plant for processing and handling of recovered materials). Retaining the existing dump site for resource recovery and to accepted waste for transport to the new landfill would require less capital but require more operational funding. Develop a new resource recovery and landfill site would require more capital but avoid additional transport costs.	✘

The option is **not preferr**ed based on the costs of developing a new site (similar but higher than upgrading the existing site) and the operational challenges of utilising a new site that is further from where most waste is generated on Nauru.

3 Establishment of a resource recovery centre

3.1 Description

The operation of the current dump site includes some resource recovery activities. These include:

- A simple office/work area utilising shipping containers, simple roofing materials and subbase material to create a covered hardstand workspace. There is power available to this area.
- Tyres - stockpiled alongside the site entry, periodically removed for landscaping by households or Districts.
- White goods - stockpiled alongside the site entry, often picked over by appliance repairers
- Garden waste - collected in hook bins, periodically transported to NRC Workshop for shredding and composting with cardboard. NRC has purchased a Red Roo ™ shredder that can handle green waste (up to 4 inches) and cardboard, the intention is to locate this at the landfill once a secure storage area (inside a shipping container) has been established.
- Cardboard - collected in hook bins, periodically transported to NRC Workshop for shredding and composting with garden waste.
- Scrap steel - stockpiled alongside the site entry, no market identified.
- Asbestos is placed in shipping containers (4 on site in late February 2018).

Stone walls form bunkers for sorting and stockpiling materials alongside the road (to the south east of the site entry). The bunkers are overgrown and some of the walls in a state of disrepair. The current staff are keen to re-establish this area for sorting and stockpiling of material. The NRC

rehabilitation team have access to utes and trailers for moving materials around but larger equipment is difficult to secure (see commentary on plant for landfill operations).

NRC has reported there is a cardboard baler on the island that is available for NRC use. The baler could be located in the workspace, making use of the power supply and secure storage. This is waiting on completion of the office/work area including providing a weather tight area and connecting power.

3.2 Issues and opportunities

There are a number of issues and opportunities for resource recovery at the Nauru dump site or elsewhere, as follows:

- There are challenges in securing access to suitable equipment for resource recovery:
  - Vehicles and equipment for moving material about the site and loading.
  - Stockpile locations including protection from weather related degradation (cardboard, plastics).
  - Equipment for consolidating materials - cardboard baler, aluminium baler.
- Markets for materials
  - Cardboard and green waste can be utilised on Nauru subject to effective composting.
  - Steel, aluminium and potential PET could be exported for sale on commodity markets. International prices are low (at early 2018) so export costs are unlikely to be fully recovered from any revenue on sale.
- As noted previously, charging for waste disposal has the potential to be designed as an incentive for sorting of materials and resource recovery.

3.3 Resource recovery activities and options.

Rather than a series of discrete options, resource recovery often involves a range of activities that can be considered with reference to their cost and their benefits (for example cost savings, diversion of material from landfill). The options noted in Table 4 are relevant whether resource activity is maintained at the current Nauru dumpsite or elsewhere.

Some of the options noted in Table 4 draw on existing resources, for example staff at the landfill, hook or skip bins. In most cases additional resources will make targeting materials and preparing them for re-use or sale easier. Examples include appropriate plant for moving materials around the dump site, installation of a baler for consolidating recovered materials (aluminium cans, plastics)[4], and cutters for tyres or scrap steel. Many materials will degrade if not appropriately stored. In most cases this can be as simple as a covered area rather than leaving material open to the elements,

A key challenge for recoverable materials is identifying suitable markets for the materials. On Nauru using the materials on the island is always going to be more straightforward than exporting materials for recovery. The current initiative to shred and compost green waste and cardboard is a good example of a pragmatic use of available materials. Aluminium cans are another obvious target with aluminium scrap generally attracting high prices internationally. Scrap steel and plastics can be recycled but relatively low prices internationally mean that any revenue from sale is unlikely to cover the cost of exporting the materials.

The evaluation summarised in Table 4 suggests that most activities are worthy of further consideration. In summary:

[4] Baler is currently on Nauru, waiting on installation at the landfill office/work area.

- Recovery of **green waste** and **cardboard** (for composting and use in mine rehabilitation) should continue.
- Stockpiling of **tyres** with provision for the community to take them for use in landscaping should continue. Consideration should be given to periodically cutting up surplus tyres and disposal in the landfill to avoid accumulating a large stockpile with associated fire risk.
- Stockpiling of unwanted **white goods** should continue with provision for appliance repairers to take parts for repairs. If scrap steel is being recovered for export consideration should be given to disassembly to recovery steel.
- Stockpiling of **scrap steel** should continue with provision for people to take materials for reuse. Securing equipment capable of cutting and/or compacting scrap steel would have benefits for both stockpiling and export. Equipment may also be suitable for cutting and baling unwanted **tyres**. Revenue for sale of scrap steel is unlikely to fully cover export costs.
- **Aluminium cans** are easily collected and attract strong prices internationally. The baler awaiting installation can produce bales suitable for export. The ad hoc can collections on the island should be enhanced with additional collection points and supporting communications and promotion.
- The value of recycled **plastics** is relatively low on international market with PET and HDPE the materials that present the best opportunities. With a large number of drinks containers (water and soft drinks) a PET container collection with baled material exported for recycling is worthy of consideration. Revenue for sale of PET is unlikely to fully cover export costs.
- Given the challenges with economic recycling of plastics, consideration should be given to a public education around minimisation of the use of single use containers, bottles and bags, encouraging either not using them in the first place or reusing them as much as possible, taking into account public health considerations.

Table 4 Resource recovery activities and options

Material	Current activity/ infrastructure	Potential new activities	Waste Strategy Goals			Cost
			To reduce environmental pollution ...	**To reuse and recycle wastes where possible**	**Effective management and cost distribution**	
Green waste	Hook bin at dump site, shredded at NRC Workshop. Chipping during vegetation removal for mining activities (in some cases).	No charge for sorted green waste at Nauru dump Site. Skip bins for green waste in each District.	✓ Reduce organic material in landfill.	✓ Capture materials available for reuse in rehabilitation	✓ Use charging to encourage diversion	- Existing equipment, space required for composting
Cardboard	Hook bin at dump site, shredded at NRC Workshop. Skips bins at Capelle Partners.	No charge for sorted cardboard. Collect cardboard from households separately from general waste. Skip bins for cardboard in each District.	✓ Reduce degradable material in landfill.	✓ Capture materials available for reuse in rehabilitation	✓ Use charging to encourage diversion	- Existing equipment, space required for composting
Tyres	Stockpiled at dump site, some periodically taken away for landscaping.	Establish stockpile area, manage fire risk. Cut up tyres not wanted for landscaping.	✓ Manage fire risk (small stockpile, disposal/cover)	✓ Make materials available for reuse	✓ Avoid unnecessary use of landfill space.	✘ New cutting equipment required
Whitegoods	Stockpiled at dump site	Establish stockpile area. Disassembly to recover metals De-gassing (potential for SPREP funding)	✓ Avoid electronics and/or gases entering landfill	✓ Make materials available for reuse or recycling	- Funding unclear, potential import/ sales levy	- Funding required

Material	Current activity/ infrastructure	Potential new activities	Waste Strategy Goals			Cost
			To reduce environmental pollution ...	To reuse and recycle wastes where possible	Effective management and cost distribution	
Scrap steel	Stockpiled at dump site	Establish stockpile. Develop market for export (subsidy likely to be required).	- Saving space but relatively low environmental impact	✓ Make materials available for reuse or recycling	✓ Avoid unnecessary use of landfill space.	✘ Export costs unlikely to be recovered on sale
Aluminium cans	Some collection points on the island	Baling (to make export easier, use baler that is waiting to be installed).	- Low volume and low environmental impact	✓ Capture materials for recycling	✓ Capture materials that have value	✓ Potential to cover export costs from sales revenue.
Plastics	-	Target PET bottles, baling for export use baler that is waiting to be installed. Education regarding avoiding and reuse where possible.	- Saving space but relatively low environmental impact	✓ Capture materials for recycling	✓ Avoid unnecessary use of landfill	✘ Export costs unlikely to be recovered on sale
All materials	Ad hoc sorting/picking at landfill	Target specific waste streams in residual waste for recovery e.g. cardboard, scrap, tyres. A key consideration managing health and safety (suitable equipment, only targeting materials when easily accessible).	✓ Reduce degradable materials in landfill	✓ Make materials available for reuse or recycling	✓ Capture materials that have value, avoid unnecessary use of landfill space.	- Existing equipment and staff time

4 Waste billing/charging for waste (incl advanced disposal fee)

As noted previously, waste taken to the Nauru dump is charged on an estimated per cubic metre basis. Businesses are charged $20 per cubic metre and community collections are charged $2.50 per cubic metre.

There are typically two reasons for imposing charges on solid waste management activities.

- To cover some or all of the costs of providing a solid waste management service; and/or
- To incentivise particular behaviour e.g. charging for waste disposal but offering green waste or recycling at a lower cost or at no charge.

In some jurisdictions management of specific waste materials are funded (in part or entirely) by charges paid by importers or manufacturers of those materials. This may be through voluntary arrangements[5] or through statutory requirements[6].

Potential actions in Nauru include:

- Modifying the charging regime at the Nauru dump site to incentivise sorting of materials that can be recovered.
    - Increase costs for disposal of general waste.
    - Free disposal of sorted cardboard and green waste.
    - Consider free or low cost disposal for other materials where markets can be identified e.g. plastic bottles, aluminium cans, scrap steel.
- Considering targeting specific materials that are challenging to manage as waste materials. Examples include:
    - Vehicles - there are a large number of cars, trucks and other equipment stockpiled (adjacent to the dump site and adjacent to the Refugee Processing Centre) and around the island.
    - White goods.
    - Electronic waste.

5 Organic waste management

There is an ongoing need for compost or alternative soil replacements as part of the mining rehabilitation efforts on Nauru. In addition to its use as the top layer in backfilling of mined areas, compost can be used in growing media for plants that will be used for re-establishing vegetation once areas are rehabilitated.

In addition to garden waste (from households and businesses and also from areas being cleared for mining) there is potential to include other degradable materials. Cardboard is the most obvious example and NRC is already including this material in compost piles. NRC has recently purchased a Red Roo ™ shredder capable of shredding both cardboard and green waste up to 4 inches in diameter.

[5] For example the collection of unwanted agrichemicals and chemical containers funded by agrichemical suppliers in New Zealand and Australia.
[6] Examples include import levies put aside to manage end of life vehicles and statutory requirements to offer end of life management for specific product (often focussed on high risk products like e-waste, chemicals, batteries and lubricants).

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The warm, wet (average 2000 mm rain per year) climate on Nauru is well suited to composting of organic materials. Shredded materials are currently stockpiled at the NRC workshop in the middle of the island.

Composting is a natural aerobic (with oxygen) process where microorganisms break down organic material producing stabilised material (compost), CO_2, water and heat. Effective composting relies on several factors being in the right balance:

- The right mix of carbon rich ('browns' like wood, cardboard and sawdust) and nitrogen rich ('greens' green vegetation, food waste) materials.
  A mix high in 'browns' will compost slowly. A mix high in greens will compost rapidly with a high risk of excessive heat and/or developing anaerobic areas within the composting mass that produce odour.
- A suitable water content (wet but not saturated).
  The mix should feel like a damp sponge, too much water will limited the circulation of air, not enough water will inhibit the activity of the microorganisms, slowing down the composting processing.
- Aeration of the composting material, achieved by periodic turning or mechanical aeration of the composting pile.
  Inadequate aeration can result in anaerobic conditions slowing down degradation and releasing odour when disturbed. Too much aeration can increase the evaporation of water in the composting mass and/or cooling, in both cases slowing the composting process.

An important consideration on Nauru is maintaining the right feedstock mix. The use of cardboard (high in carbon) with woody garden waste means that it is important to ensure there are adequate leaves and other 'green' material. There are calculators available on line to determine the right mix of materials to enable effective composting[7].

Actively composting material can get very hot, at times in excess of 70 °C. If the composting mass is too dry or hot spots develop it is possible for the composting pile to catch fire. This can be managed by regular turning (to avoid hotspots developing) and addition of water. Too much water can inhibit the circulation of air through the composting pile result in anaerobic activity. Anaerobic degradation produces methane and a range of odorous compounds including hydrogen sulphide.

As noted elsewhere, there is potential to establish a site for composting at the current Nauru dump site. This would include provision for pre-processing of materials (shredding, blending), space for several windrows of composting material and stockpile of mature compost. In the indicative layout for the dump site the area to the north of the resource recovery area is proposed with space for composting and nursery operations if required.

Commercial scale composting is ideally undertaken on a prepared area that provides for the movement of machinery between windrows. The composting area should be graded to avoid ponding of rainwater and allow for the capture of rainwater and leachate from the composting material. It is likely given Nauru's climate that any water captured will be used to maintain a suitable water content in the composting material. Figure 5 shows an example layout.

[7] For example http://compost.css.cornell.edu/download.html

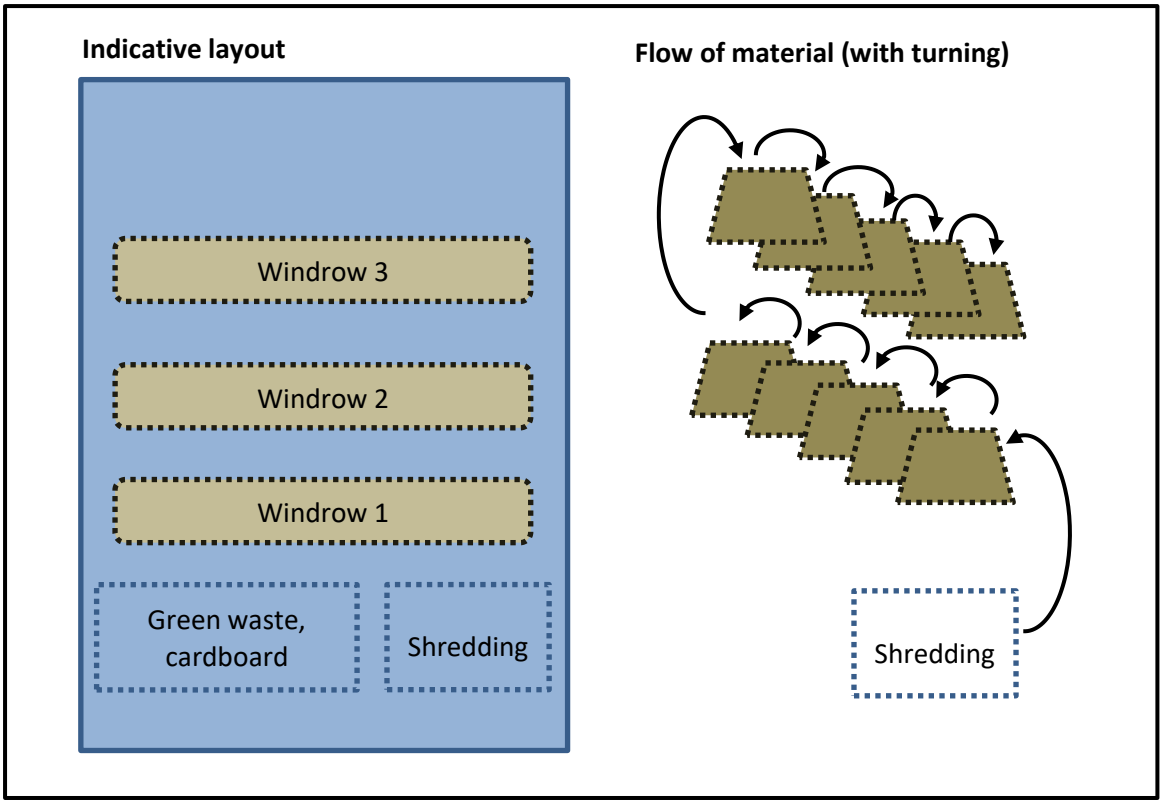

Figure 5 Indicative composting site layout and material flow

6 Proposed actions

Table 5 sets out a series of proposed actions to improve the design of the current dump site, provide for improved disposal operations and make space available for resource recovery and organic waste processing. Figure 6 replicates Figure 3 and is provided here for ease of reference while reading Table 5. In addition to identifying options the table summarises:

- Resource requirements - personnel, equipment, materials and any external support (design, construction supervision, policy support) required.
- Proposes a timeline recognising personnel availability, financial constraints and pre-requisites for some activity[8].
- Provides comment on indicative costs, namely:
    - In some cases noting the use of existing NRC and CIE personnel and equipment. As noted elsewhere in this report access to heavy plant can be difficult when it is also required for mining activities. On this basis consideration should be given to securing equipment dedicated to the solid waste activity/Nauru dump site.
    - In others noting the need for external design, construction supervision or policy support with associated cost estimates.

Appendix A provides outline terms of reference for key activities. Where cost and timings are noted in Table 5, further details on underlying assumptions and calculation s are provided in Appendix B.

[8] For example, an organic waste processing area cannot be established on Area 2 until filling and capping is completed.

Figure 6 Sketch master plan for dump site (2016 imagery)

Table 5 Proposed actions, resource requirements, timeline and indicative costs.

Action	Comments	Resource Requirements	Timeline	Indicative cost
1 Establish resource recovery in Area 1	Complete office/workshop area including installation of baler and under cover storage area Repair bunkers for storage of scrap steel, white goods	Carpenters, electrician, road base, cardboard baler	Q2 2018	Existing resources + in-house trade staff from NRC
2 Master plan for Nauru Dump Site	Detailed plans for stages of development and intervening stages including: • Site plans with designated areas • Landfill cell design including bund detail, liner detail, leachate drainage details, leachate pond details. • Capping detail (existing areas, new cell) • Filling plan • Resource recovery area layout • Composting site layout	Landfill/Civil Designers NRC and CIE Review	Q2 2018	Master plan and design details $50-75,000 (Refer Appendix A for ToR)
3 Operations/ Management Plan	A site operations plan covering • Waste disposal (acceptance, placement, compaction and cover). • Resource recovery (sorting of material, processing, stockpile(s) and dispatch). • Organic waste processing (materials preparation, composting, product storage). A key consideration for improving operations is securing access to appropriate equipment. In the short term this may be more regular and reliable access to existing NRC equipment, longer term there may be a case for dedicated equipment for the site.	Landfill/Civil Designers NRC and CIE Review	Q2 2018	Operations/Management Plan $25,000 Business Case for dedicated plant for dump site operations $15,000. Estimated capital cost for suitable equipment 0.25M per vehicle + ongoing servicing costs. (Refer Appendix A for ToR)

Action	Comments	Resource Requirements	Timeline	Indicative cost
4 Complete filling in Area 2	Remove large rock backfill Place waste to current level with compaction and appropriate fall to south west of site. Place cap across Area 2 maintaining appropriate fall	Excavator Excavator and loader Excavator, Loader, grader, roller/compactor	Q2 - Q3 2018	Existing NRC resources will need to be mobilised or additional plant procured (excavator, loader, compactor). Engineer to supervise capping placement. Significant quantity of capping material required depending on final design.
5 Clear Area 3/4	Push material in Area 3 and 4 to the rear (north) of Area 2 to same level as waste in Area 2 (including compaction of waste as it is placed). Place cap across Area 2 maintaining appropriate fall	Loader, excavator, large dump truck. Excavator, Loader, grader, roller/compactor	Q2 - Q3 2018	Existing NRC resources will need to be mobilised or additional plant procured (excavator, loader, compactor, dump truck) Engineer to supervise capping placement.
6 Develop new filling cell in Area 4	Previously cleared area, need to designate area for staging burning/burnt waste. Lay compacted road base on at base of cell, appropriate fall to leachate drain) Build bunds for filling cell using waste capped with compacted road base. Build leachate storage pond (Area 5), compacted base and sides, HDPE liner. Gravity fed from new filling cell(s), sized for heavy storm event, targeting evaporation with potential for (truck based) irrigation over new cells if required.	Loader, Excavator Loader, Excavator Loader, Excavator, specialist HDPE liner installation team.	Q3 - Q4 2018 and as required.	Subject to completing site master plan including concept design. Pricing will include: • Materials (roading base, sub 20 mm, ...) • Construction plant. • Construction personnel • Engineer to supervise capping placement. Likely capital cost range 1.0 - 1.5M

Action	Comments	Resource Requirements	Timeline	Indicative cost
7 Establish organic waste processing on Area 2	Set out waste (pre-processing), shredding, active composting and stockpile areas. This action can commence once adequate space with a final cap in place is available in Area 2 and/or Area 3.	Red Roo ™ shredder, excavator, loader.	Q4 2018	Existing resources + in-house staff from NRC
8 Waste strategy/policy	Consider, and where appropriate implement: • Differential charging for different materials e.g. lower cost or free disposal of garden waste, cardboard and other recyclable materials. • Import levy or similar policy instrument to assist in funding the management of difficult wastes for example end of life vehicles, white ware, tyres. • Communications initiatives to educate the community and businesses about the importance of waste sorting and waste minimisation. • Develop a business case for investment in dedicated mobile plant/equipment for the dump site, for example an excavator, loader and/or bull dozer/compactor.	Waste Policy Specialist NRC and CIE Review Policy development process through parliament.	Q2 - Q4 2018	$50,000 (Refer Appendix A for ToR)

7 Applicability

This report has been prepared for the exclusive use of our client Nauru Department of Industry, Commerce and the Environment, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

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Appendix A: Draft Terms of Reference

Draft Terms of Reference - Landfill Master Plan and Operations Plan

1 **Nauru Dump Site Master Plan**

- Design philosophy statement.
- Key design assumptions (materials, compaction achievable, equipment to be used).
- Drawings to include:
  - 5-10 x Site layout (current, staged through initial upgrade and then planned every 3-5 years (for each new cell development)
  - 1 x Landfill capping detail
  - 1 x Landfill cell bund detail
  - 1 x Landfill cell base detail
  - 1 x Leachate drainage arrangements details
  - 2-3 x Leachate pond details
  - 1 x Composting/Organic waste processing area layout
  - 1 x Resource Recovery area layout
- Construction planning (scheduling, supervision)
- Construction monitoring and quality assurance.
- Construction cost estimate
  - Materials
  - Plant (including operating costs)
  - Construction personnel
  - Construction quality assurance

Cost estimate (all completed at home base i.e. no allowance for time on Nauru)

Task	**Cost Estimate**
Design Report including construction cost estimate	$20,000 - $30,000
15 - 20 Drawings (draft and then issued for construction)	$22,500 - $30,000
Construction Plan (specification, quality assurance)	$10,000 - $15,000
Total	$50,000 - $75,000

2 **Nauru Dump Site Operations Plan**

- Waste disposal
  - Waste acceptance - checking for hazardous waste, diverting materials to resource recovery, charging.
  - Waste placement - directing loads to active tipping area, managing customer and site staff safety.
  - Compaction - depth of waste, compaction methodology (multiple passes)
  - Cover - placing working cover (material, depth, compaction), placing intermediate cover.
- Resource recovery
  - Diverting material on acceptance
  - Sorting of material
  - Processing (baling, disassembly)
  - Stockpile locations and management
  - Dispatch of materials.
- Organic waste processing
  - Materials preparation (shredding, mixing)
  - Composting (turning, moisture, odour)
  - Product storage (location, managing moisture and dust).
- Develop a business case for investment in dedicated mobile plant/equipment for the dump site, for example an excavator, loader and/or bull dozer/compactor.

Cost estimate (assuming Master Plan has been produced)

Task	**Cost Estimate**
Waste disposal operations	$10,000 - $15,000
Resource recovery operations	$5,000 - $10,000
Organic waste processing operations	$10,000 - $15,000
Total	$25,000 - $40,000
Optional - business case for investment in dedicated plant for Nauru dump site.	$10,000 - $15,000

Draft Terms of Reference - Site supervision (capping, landfill cell construction)

Key tasks

- Construction information requirements (drawing sets, quality assurance methodology)
- Materials, plant and equipment requirements
- Site supervision

Cost estimate (assuming Master Plan has been produced)

Task	Cost Estimate
Construction information requirements and specification (from Master Plan, set up for construction monitoring purposes)	$5,000 - $10,000
Site supervision (per week)	
Expenses - mobilisation i.e. travel to/from Nauru	$3,500 - $5,000
Expenses - Subsistence on Nauru (7 x $260[9])	$1,820
Fees (depending on personnel, per 7 days)	$6,500 - $16,500

Draft Terms of Reference - Waste Policy

Waste policy support could focus on a range of different policy areas. In each case policy development could progress from a remote base with potential for in country stakeholder consultation, liaison with Government of Nauru legal advisors and presentations to decision makers. A typical policy paper should:

- Define the policy issue (problem or opportunity) that is to be addressed
- Set out a range of policy options that could be employed
- Evaluate the options using a cost benefit and/or multi-criteria evaluation framework
- Identify the preferred option and set out the next steps (policy design, legislative/ regulatory process, stakeholder engagement, ...)

Potential focus areas include:

- Differential charging for different materials
- Import levy or similar policy instrument to assist in funding the management of difficult wastes for example end of life vehicles, white ware, tyres.
- Communications/waste education initiatives

Cost estimate (assuming Master Plan has been produced)

Task	Cost Estimate
Policy development - draft policy paper for stakeholder and internal consultation, finalise paper based on stakeholder and departmental feedback (per policy area).	$5,000 - $15,000
Stakeholder consultation - 2-3 days in Nauru, potentially covering multiple policy initiatives at once.	$12,000 - $15,000

[9] NZ MFAT Per diem rate of NZ$285

Appendix B: Assumptions and Calculations

The information presented in Appendix B is based on indicative information including:

- Site dimensions;
- In situ waste volume and density;
- Transported waste volume and density;
- Indicative cost ranges for materials and construction activities;
- Indicative productivity for materials moving and placement; and
- Indicative cost ranges for landfill operation and construction equipment.

The cost and quantity data needs to be updated following further design work and based on market testing/engagement for equipment purchase and construction costs.

Nauru dump site calculations

Currently was is placed in piles around the site with recent waste and older material covered in vegetation. Based on observations during the sites visits and checking aerial photos/GIS data there is an estimated approx 3.5 Ha of piles of waste.

Calculating volume of waste and potential additional capacity.

- Piles of waste approx 5 m high
- Treat each pile as a cone 5m x 10 m, a cone uses approximately 25-30% of available airspace in a given volume.
- So additional airspace available = 3.5 Ha x 5 m x 70% = 122,500 m^3.
- Allow 15% for cover so capacity = 85% x 135,000 = 104,125 m^3 for waste.
- Based on site records the dump site is received approximately 26,000 m^3 of loose waste per year (estimate average 0.15 T per m^3, potential up to 0.2 T/m^3)
- Waste can be compacted to approximately 0.5 - 0.7 T/m^3 i.e.
  26,000 x 0.15 / 0.7 = 5,600 m^3 per year (over 18 years to fill 115,000 m^3)
  26,000 x 0.2 / 0.5 = 10,400 m^3 per year (approx. 10 years to fill 115,000 m^3)

Calculating the current volume of waste (requiring consolidation).

- Piles of waste approx. 5 m high
- Treat each pile as a cone 5m x 10 m, a cone uses approximately 25-30% of available airspace in a given volume.
- So volume of waste is estimated at = 3.5 Ha x 5 m x 26% = 45,500 m^3.
- Space used for consolidated material = 45,500 m^3 / 5 m high = 9,100 m^2 (0.9 Ha)
  \$25 - \$50 per m^3 for capping = 9,100 m^2 x 1 m x \$25 - \$50 = \$227,500 - \$455,000
  \$25 - \$50 per m^3 for bund = approx. 400 m x 15 m^2 section x \$25 - \$50 = \$150,000 - \$300,000
  Total \$375 - \$750,000
- Loader to move materials, bulldozer to place and compact.
- Assume move/place approx. 25 - 50 m3 per hour (for each machine), 6 hour day.
  45,500 m^3 / (25 -50 m^3/hr x 6 hr/day) = 150 - 300 days.

We have noted indicative costs in the Action Table (Section 6, Table 5) for a new cell development "Likely capital cost range 1.0 - 1.5M". This allows for materials and labour for developing an approximately 0.5 Ha on the existing dump site. Cost estimates will be better refined through a design process and should include allowance for:

- 280 m x 5 m bunds built with waste and capped with road base 280 x 15 m^2 = 4,200 m^3.
- 5,000 m^2 of cell base requiring 6-7,000 m^3 of 50-100 mm aggregate, 3-4,000 m^3 of 20 mm aggregate i.e. approx. 11,000 m^3 in total.
- Suitable leachate drainage and collection structures.
- Assume move/place approx. 25 - 50 m3 per hour (for each machine), 6 hour day.
  (4,200 + 11,000) m^3 / (25 -50 m^3/hr x 6 hr/day) = 50 - 100 days.
- Cost estimates simple calculations
  $25 - $50 per m^3 for bund = 280 m x 15 m2 section x $25 -$50 = $100,000 - $200,000.
  $25 - $50 per m^3 for base = 11,000 m3 x $25 - $50 = $275,000 - $550,000
  Allowance for leachate collection - lay pipes, trenching, ... estimate $100,000 - $200,000
  200 m^2 leachate holding/treatment pond estimate $100 - $150,000
  Other construction activity (roading, buildings, resource recovery area) $150 - $200,000
  Contingency 30% on $750,000 - $1,300,000 = $250 - $400,000
  Total in the range 1 - 1.7M (use 1 - 1.5M)

New site development.

Assume allowance for 5,000 m^3 per year + 750 m^3 cover. A cell adequate for 5 years would be around 0.5 Ha at slightly lower than current filling rates at an average waste depth of 5 m. 20 years capacity would require 2 Ha. This assumes:

- Waste generation is slightly lower than current i.e. successful diversion activity for organic and cardboard.
- Waste compaction is 0.7 T/m^3 or better.
- Design builds on design work completed for extending the life of the existing site.

A new site will need to be prepared by developing a relatively flat area (removal of pinnacles and backfilling with crushed material). Consideration will also need to be given to what infrastructure will be required on site. Scenarios include:

- New site for landfill only i.e. the existing dump site remains the area open to the public and continues to be used for resource recovery activities.
  This would require development of a relatively flat area (back fill with pinnacle based aggregate) for the new fill site. Simple transfer infrastructure would be required at the existing dump site and operational costs would increase (transport of waste material from the existing dump site to the new landfill.
- New site replaces the existing dump site i.e. resource recovery, waste acceptance and landfilling activities all move to the new site.
  This would require development of a relatively flat area (back fill with pinnacle based aggregate) for the new fill site and other site operations (resource recovery, waste acceptance/gate house).

Cost estimates can be better refined through a design process and should include allowance for:

- Construction of an initial 0.5 Ha cell (see above, estimate 1 - 1.5M)
- Levelling of 3 - 5 Ha area. Estimate $250 - $500,000, will depending on area and topography of site that is selected.
- Additional operational costs for waste transfer - estimate 2 trips per working day (Mon - Fri). Probably reasonable to assume a dedicated vehicle for waste transport and movement of materials during construction (base materials, cover) and operations (materials from resource recovery, compost, ...).
- Additional costs for development of waste acceptance and resource recovery areas on new site (if required). Estimate $100 - $200,000 assuming levelled area available (see above) and reuse of existing container based buildings from Nauru dump site.
- Total range estimated $1.5 - 2.5M

Equipment requirements

Various types of equipment could be utilised for landfill construction and operation. A key consideration is long term maintenance - there is limited access to specialist maintenance spares, equipment and technicians on Nauru. Consideration could be given to purchasing a full service package that includes periodic maintenance with standard tasks undertaken by local technicians and periodic specialised maintenance completed by the suppliers. Ideally any package would make allowance for transporting specialist technicians and spares to Nauru and removing end of life spares and equipment.

- Excavator - trenching, construction and if more suitable equipment is not available compaction. Allow US$250,000 ($150 - $250,000) purchase price but need to consider shipping and ongoing maintenance costs.
- Wheeled Loader - moving waste and construction materials around the site (alongside dump trucks from NRC mining operations). Unlikely to be suitable for general waste operations or compaction. Allow US$300,000 ($150 - $500,000) purchase price but need to consider shipping and ongoing maintenance costs
- Compactor - moving waste (pushing), achieving better compaction in situ, some construction activities. Allow US$350,000 ($200 - $500,000) purchase price and up depending on size but need to consider shipping and ongoing maintenance costs.
- Bulldozer - moving waste, compaction, construction. Not as effective as a dedicated compactor but more flexible for construction activities. Allow US$200,000 ($100 - $200,000) purchase price but need to consider shipping and ongoing maintenance costs.

We have noted indicative costs in the Action Table “Estimated capital cost for suitable equipment 0.25M per vehicle + ongoing servicing costs.”

We would suggest seeking pricing (purchase, shipping to Nauru and ongoing servicing in Nauru) for a bulldozer (Cat D4 or equivalent) with suitable attachments - landfill blade. If ongoing access to NRC equipment (excavator, loader and dump tracks) cannot be secured it may be worth considered seeking pricing and funding for some of this equipment as well.

Summary

Table B1 Summary of indicative pricing

Action/Activity	Timeline	Equipment	Materials	Indicative Pricing
Nauru dump site upgrade				
Consolidate existing material	30 - 60 weeks	Loader + bulldozer	15 - 20,000 m^3	$0.35 - 0.75M
Construct new cell	26 - 52 weeks	Excavator or loader + bulldozer	15 - 20,000 m^3	$1 - $1.5M
New dump site development	36 - 70 weeks	Excavator or loader + bulldozer	20 - 30,000 m^3	$1.5 - $2.5M
New equipment	-	Excavator	-	$250,000 purchase only
Purchase price, also need to consider shipping and ongoing maintenance costs.	-	Wheeled Loader	-	$300,000 purchase only
	-	Compactor	-	$350,000 purchase only
	-	Bulldozer	-	$200,000 purchase only