APPENDIX F

Asset Replacement and Renewal Cost Estimating

1 Introduction

To provide public services effectively and cost efficiently requires ongoing investments in infrastructure asset maintenance, repairs and renewal in a timely way. In the absence of such investments, infrastructure assets suffer premature degradation and failure, disrupting public services and significantly reducing the service life of assets.

Lack of adequate funding for asset maintenance, repairs, and renewal is one of the main reasons for premature infrastructure failures in most Pacific island countries. To facilitate pro-active investment planning, this document provides guidelines for estimating required investment levels for:

- renewal of short-life components of infrastructure assets
- replacement of infrastructure assets when they reach the end of their economic service life.

All per-unit costs provided in this document are in Australian Dollars (AUD) and are based on estimated costs in 2019. For preparing investment level needs during subsequent years after 2019, the per-unit costs provided in this document should be adjusted for inflation.

This document provides unit costs for estimating investment needs for the following infrastructure assets:

a. buildings and building components
b. roads and road components
c. airport runway and runway components
d. wharfs and boat harbors
e. coastal protection — sea walls and rip raps
f. solid waste management infrastructure
g. sewage treatment plants
h. telecommunication towers
i. motor vehicles
j. boats.

Nauru Utilities Corporation (NUC) manages electricity and water infrastructure and they have already completed an asset management plan for electricity and water infrastructure assets. These assets are, therefore, not covered in this report.

2 Buildings

2.1 Estimating replacement cost of buildings

Construction costs for buildings vary across a wide range, depending on the building design and quality of materials used. At the investment planning stage, when the building design is not completed, it is difficult to accurately estimate the construction costs. However, with the per-unit costs provided in Table F-1, it should be possible to Class 3 accuracy (-20%, +30%), suitable for budget approvals.

For estimating building construction costs, the government-owned buildings in Nauru can be divided into three categories:

1. basic design, one storey, non-engineered buildings, timber framing, standard height, including pre-assembled trailer buildings

2. standard construction, one-storey, engineered buildings (steel or wood framing), for example, the administrative government office building

3. superior construction, high ceiling height, or multi-storey, engineered buildings (reinforced concrete), for example, the sports arena or the parliament building.

Based on the recent construction costs of public sector buildings in South Pacific island countries, the per-unit replacement cost for each category of building and their components, not including the cost of land, are shown in Table F-1.

Table F-1: Per-unit building construction costs

	Units of Measurement	Per Unit Cost (GRC) in Australian Dollars		
Building Components	**Floor Area (Exterior)**	**Basic Design**	**Standard Design**	**Superior Design**
Substructure	m^2	150	200	300
Structure	m^2	500	800	1500
Roofing	m^2	100	150	300
Exterior Wall Cladding	m^2	150	230	300
Fitouts	m^2	250	350	500
Floor Covering	m^2	100	150	300
Service Mechanical	m^2	80	100	150
Services Electrical	m^2	80	100	150
Services Sanitation	m^2	100	130	150
Services Water	m^2	20	40	70
Total		1530	2250	3720

The unit costs are based on the following references:

- iBuild kit homes indicative price[1]
- Tuvalu asset management framework
- average cost of construction in Australia.[2]

3 Road infrastructure

3.1 Roads

To estimate the greenfield construction cost of roads, i.e. construction of road on land where no road existed before, three components are involved:

a. Earthworks

Earthworks involves creating a pathway for road construction. It may involve clearing obstructions in the path by rock blasting, removal of trees, vegetation and debris, removing and stockpiling top soil, excavating or backfilling earth to create a graded surface for road construction. Earthwork costs are highest for steep roads, moderate for rolling roads, and lowest on flat land.

b. Base pavement

Base pavement is typically constructed from durable, non-shrinkable, and suitably compacted aggregates of adequate strength and depth, based on traffic needs. The base pavement supports the surface layer — it absorbs the vehicular loading and spreads it over a larger area, without deforming or deflecting under the load.

c. Surface pavement

Surface pavement in small island countries is typically constructed from asphalt concrete or two layers of chip seal. The surface layer is the hardest surface of the road and the materials are selected to withstand tyre wear and erosion.

The earthwork component of the cost is a one-time sunk cost and unless the land has been washed away or has developed structural cracks or sunk during a major catastrophic event, i.e. earthquake or extreme heavy rain, this cost is not required to be repeated during road renewal projects.

Similarly, as long as the repairs, renewal and maintenance work on the surface pavement is carried out in a timely manner, the base pavement has a long useful life.

The surface pavement requires periodic renewal. The typical useful life of an asphalt concrete surface is about 15 years and the typical useful life of a two-layer chip seal surface pavement is about 10 years.

[1] https://i-build.com.au/delivery-costs-to-south-pacific-countries/
[2] https://www.bmtqs.com.au/construction-cost-table

Estimates of road replacement costs in Nauru can be developed based on the per-unit construction costs, as shown in Table F-2. These per-unit costs have been developed based on the following references:

- Road Construction Cost and Infrastructure Procurement Benchmarking: 2017 update Department of Infrastructure, Regional Development and Cities Canberra, Australia.
- Samoa Land Transport Authority Renewals and Depreciation Funding Gap Assessment — Adam Smith International.
- Observation of Nauru's Roads, Runway and Taxiway Areas — Fulton Hogan 2016.

Table F-2: Per-unit replacement cost of sealed road components

Road Components	Units of Measurement	Per Unit Cost (GRC) in Australian Dollars		
Road Formation	Surface Area	Road Formation (Earthwork)		
		Flat	Rolling	Steep
	m^2	40	55	110
Base Pavement	Surface Area	Base Pavement		
		Light	Standard	Heavy
	m^2	18	22	26
Road Surface	Surface Area	Road Surface		
		Inferior	Standard	Superior
	m^2	20	30	45
Curb and Gutter	Road Section Length	Curb and Gutter		
		None	One Side	On Both Sides
	m	0	100	200
Drainage Sumps c/w Soak Pits	Quantity per Section	Drainage Sump c/w Soak Pits		
		None	One	Two
	#	0	20000	40000

Road renewal work typically involves profile-milling of the surface to remove the corrugations ("shimmies"), using a milling machine with a fine profiling drum, tractor broom and bobcat sweeper, applying a membrane seal before paving the new surfacing layer, and an asphalt layer of approximately 30 mm.

Alternatively, road surface renewal can be completed with chip seal. For this option, the existing surface would require profile-milling to remove the shimmies in selected areas with bumps or corrugations on the road surface, pre-seal repairs to fill up hollows in the existing surface with either cold mix or hot mix, and the application of a two-coat chip seal with hot spray.

It typically requires approximately 0.1 m^3 of concrete per meter of curb and gutter to construct as road in Nauru. Assuming a concrete delivery cost of approximately \$500/m^3 in Nauru for 25 MPA of concrete strength, with additional cost of labor and equipment for concrete placement and finish for roadside curbing and guttering of approximately \$50/m, the replacement cost of road side curbs can be estimated using unit rate of \$100/m of curb and gutter.

The replacement cost of unsealed roads can be calculated from the per-unit costs indicated in Table F-3.

Table F-3: Per-unit replacement cost of unsealed roads

Road Components	Units of Measurement	Per Unit Cost (GRC) in Australian Dollars		
Road Formation	Surface Area	Road Formation (Earthwork)		
		Flat	Rolling	Steep
	m^2	40	55	110
Base Pavement	Surface Area	Base Pavement		
		Light	Standard	Heavy
	m^2	18	22	26

3.2 Footpath replacement or renewal cost

For a 1.2 m wide concrete footpath, 100 mm thick concrete slab poured in place on top of 150 mm of compacted aggregate, requires 0.12 m^3 of concrete per meter of footpath. Assuming concrete delivery cost of approximately \$500/m^3 in Nauru for 25 MPA concrete and \$60 per m for construction of sub-base and labor, the replacement cost of footpaths is calculated at \$120/m of footpath.

4 Airport runway

Greenfield construction of an airport runway involves extensive planning and engineering for construction of three key components:

a. Earthworks

Earthworks involve creating the required length of a straight pathway for runway construction that may involve rock blasting; removal of trees, vegetation and debris; removing and stockpiling topsoil; and moving earth to create a graded surface. In countries like Nauru, where land is limited, it may also require reclaimed land from the ocean.

b. Base pavement

Base pavement is typically constructed from durable aggregates of required depth based on traffic needs, suitably compacted. The base pavement supports the surface layer by taking the structural load and spreading it evenly over a large area. In the case of a runway, the base pavement is approximately twice the depth of pavement for roads; the depth can vary from 300–1200 mm, depending on the type of aircraft the runway is designed for.

c. Surface pavement

Surface pavement for the runway is typically constructed from superior quality asphalt concrete to withstand high temperatures generated during aircraft landing. Chip seal is not a viable for runway surfacing.

The surface pavement requires periodic renewal. The typical useful life of an asphalt concrete surface is a function of the number of flights landing each day. Under current use pattern at Nauru airport, the surface pavement is expected to have a useful service life of 15 years.

Estimates of runway replacement costs in Nauru can be developed based on the per-unit construction costs shown in Table F-4. The following references were used to develop average per unit costs:

- Road Construction Cost and Infrastructure Procurement Benchmarking: 2017 update Department of Infrastructure, Regional Development and Cities Canberra, Australia.
- Samoa Land Transport Authority Renewals and Depreciation Funding Gap Assessment — Adam Smith International.
- Observation of Nauru's Roads, Runway and Taxiway Areas — Fulton Hogan 2016.

Table F-4: Per-unit replacement cost of runway

Air Strip Components	Units of Measurement	Per Unit Cost (GRC) in Australian Dollars
Air Strip Formation	Surface Area	Air Strip Formation (Earthwork)
	m^2	150
Base Pavement	Surface Area	Base Pavement
	m^2	60
Air Strip Surface	Surface Area	Air Strip Surface
	m^2	100

Runway renewal work typically involves profile-milling of the surface to remove the corrugations ("shimmies"), markings and grooves, using a milling machine with a fine profiling drum, tractor broom and bobcat sweeper, applying a membrane seal before paving the new surface layer and laying asphalt of approximately 40 mm.

The renewal costs for the runway surface are expected to be $\$100/m^2$.

For the chain link security fence around the runway, the replacement cost is approximately $50/m.

For all remaining assets, including navigation aids, replacement costs should be based on quotations obtained from equipment manufacturers.

5 Wharfs and boat harbor

Wharfs and boat harbors are highly complex, engineered structures and their replacement costs can vary over a very broad range, depending on the design.

To estimate the replacement cost of these structures, it is recommended that the original construction costs be adjusted for inflation and the inflation-adjusted cost be used as replacement cost for these structures.

5.1 Coastal protection structures

Engineered reinforced concrete seawalls are complex structures and their replacement costs can vary significantly, depending on the design. To estimate the replacement cost of these structures, it is recommended that the original construction costs are adjusted for inflation and the inflation-adjusted cost be used as replacement cost for these structures.

The sea wall construction costs typically vary from $1500–$4000/m of wall[3] and the costs of different types of coastal protection, including rip raps[4], are shown in Table F-5.

Table F-5: Per-unit replacement cost of coastal protection structures

Infrastructure Asset	Units of Measurement	Per Unit Cost (GRC) in Australian Dollars
Sea Wall - Steel Reinforced Concrete	Length in m	$4,000
Masonry Wall of Rock (Std)	Length in m	1500
Masonry Wall of Rock (Superior)	Length in m	2500
Rip rap	Length in m	500

6 Solid waste management facility

6.1 Landfill facility

The replacement cost of landfill facilities are a function of their design and size and should be based on actual construction costs, adjusted for inflation. The landfill facility in Nauru is basically a parcel of land where waste is stockpiled and covered with dirt. It does not have any liners or provision for leachate collection.

The actual original cost, adjusted for inflation, should be used as replacement cost for the landfill site.

6.2 Medical waste incinerator

The replacement cost of the medical waste incinerator is estimated to be approximately $100,000.[5]

3 Ware, D. and Banhalmi-Zakar, Z. “Funding coastal protection in a changing climate: Lessons from three projects in Australia”.
4 Rodriguez, J. “Costs and Installation Tips When Building a Riprap” Updated 29 October 2018.
5 Tuvalu Asset Management Framework.

7 Sewage treatment plant

The cost of sewage treatment plants can vary significantly depending on design and the type of contaminants required to be removed from wastewater.

The typical construction cost for sewage treatment plants is approximately $500 per capita.[6] Therefore, to construct a treatment plant serving the need of 12,000 persons should cost approximately $6,000,000.

8 Motor vehicle fleet

The replacement cost of motor vehicles should be based on the actual procurement cost, adjusted for inflation, from the year the asset was procured to the current year.

9 Boats

The replacement cost of boasts should be based on the actual procurement costs, adjusted for inflation, from the year the asset was procured to the current year.

10 Telecommunications infrastructure

A majority of the telecommunication infrastructure in Nauru is owned by private companies. Telecommunication towers that the telecommunication equipment is mounted on are owned by the government. The estimated replacement costs for telecommunication towers are shown in Table F-6.

Table F-6: Per-unit replacement cost of telecommunication antenna towers

Infrastructure Asset	Units of Measurement	Per Unit Cost (GRC) in Australian Dollars
Antenna Towers (Light Duty)	Each	100,000
Antenna Towers (Standard)	Each	150,000
Antenna Towers (Heavy Duty)	Each	200,000

For the remaining telecom equipment, the replacement costs should be based on original equipment manufacturers' quoted prices.

11 Electricity infrastructure

Electricity infrastructure in Nauru is owned and managed by Nauru Utilities Corporation and they have recently completed an asset management framework and asset register. The current replacement cost of electricity assets should be based on actual procurement costs, with adjustments for inflation from the year the asset was procured to the current year.

[6] U.S. Department of Health, Education and Welfare, 1964. "Modern Sewage Treatment Plants — how much do they cost?": A Practical Guide to Estimating Municipal Sewage Treatment Plant Construction Costs.

12 Water supply systems

The water purification and distribution infrastructure in Nauru is owned and managed by Nauru Utilities Corporation and they recently completed an asset management framework and asset register. The current replacement cost of water purification and distribution assets should be based on actual procurement costs, with adjustments for inflation from the year the asset was procured to the current year.

13 Fuel storage yard

While the fuel storage yard assets are owned by the government, a private corporation, Vital FSM PetroCorp, has been retained by the government under a long-term contract to manage Nauru's fuel storage facilities. The current replacement cost of infrastructure assets at the fuel storage yard should be based on actual procurement costs, with adjustments for inflation from the year the asset was procured to the current year.