

# Water Research Laboratory

## **Coastal Adaptation Needs for Extreme Events and Climate Change, Avarua, Rarotonga, Cook Islands**

### **Project Stage 1: Scoping and Collation of Existing Data**

WRL Technical Report 2013/11  
November 2013

by  
M J Blacka, F Flocard and B Parakoti



**UNSW**  
THE UNIVERSITY OF NEW SOUTH WALES

Water Research Laboratory  
University of New South Wales  
School of Civil and Environmental Engineering

**Coastal Adaptation Needs for Extreme Events and Climate  
Change, Avarua, Rarotonga, Cook Islands**

**Project Stage 1: Scoping and Collation of Existing Data**

---

WRL Technical Report 2013/11  
November 2013

by  
M J Blacka, F Flocard and B Parakoti

## Project Details

Report Title	Coastal Adaptation Needs for Extreme Events and Climate Change, Avarua, Rarotonga, Cook Islands Project Stage 1: Scoping and Collation of Existing Data
Report Author(s)	M J Blacka, F Flocard and B Parakoti
Report No.	2013/11
Report Status	Final
Date of Issue	November 2013
WRL Project No.	2010062
Project Manager	Matt Blacka
Client Name	Climate Change Cook Islands
Client Address	Climate Change Cook Islands Office of the Prime Minister Private Bag Rarotonga, Cook Islands
Client Contact	Ana Tiraa
Client Reference	

## Document Status

Version	Reviewed By	Approved By	Date Issued
Draft V1.0	J T Carley	B M Miller	28/06/2013
Final V2.0	J T Carley	B M Miller	13/11/2013

Water Research Laboratory  
110 King Street, Manly Vale, NSW, 2093, Australia  
Tel: +61 (2) 8071 9800 Fax: +61 (2) 9949 4188  
ABN: 57 195 873 179  
www.wrl.unsw.edu.au  
Quality System certified to AS/NZS ISO 9001:2008

*Expertise, research and training for industry and government since 1959*



A major group within  
**water@UNSW**  
water research centre

*This report was produced by the Water Research Laboratory, School of Civil and Environmental Engineering, University of New South Wales for use by the client in accordance with the terms of the contract.*

*Information published in this report is available for release only with the permission of the Director, Water Research Laboratory and the client. It is the responsibility of the reader to verify the currency of the version number of this report. All subsequent releases will be made directly to the client.*

*The Water Research Laboratory shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance on the content of this report.*

## Contents

---

<b>1. Introduction</b>	<b>3</b>
1.1 Project Overview and Context	3
1.2 Project Goals and Objectives	7
<b>2. Summary of Overall Project</b>	<b>9</b>
<b>3. Project Inception</b>	<b>10</b>
<b>4. Scoping Field Trip</b>	<b>11</b>
<b>5. Collation of Existing Data</b>	<b>12</b>
5.1 Library of Relevant Existing Information	12
5.2 Existing Geospatial Data Sets	13
<b>6. References</b>	<b>15</b>
<b>Appendix A Catalogue of Existing Information</b>	<b>16</b>

## List of Tables

---

Table 1.1: DRM, CCA and Project Outcomes	7
Table 4.1: Summary of Initial Stakeholder Engagement Meetings	11

## List of Figures

---

Figure 1.1: Cook Islands Location Map	3
Figure 1.2: Study Area	4
Figure 1.3: Components of DRM Including CCA (Cook Islands Government, 2012)	6
Figure 2.1: Project Stages and Outcomes	9
Figure 5.1: Schematic of Rarotonga Coastal Engineering Information Library	12
Figure 5.2: Existing Topography and Bathymetry Data Sets	14

## Acronyms

---

AusAID	Australian Agency for International Development
CCA	Climate Change Adaptation
CCCI	Climate Change Cook Islands
CEIL	Coastal Environmental International Limited
CIMS	Cook Islands Meteorological Service
CIPA	Cook Islands Port Authority
DCCEE	Department of Climate Change and Energy Efficiency
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
JNAP	Joint National Action Plan
NES	National Environment Service
PASAP	Pacific Adaptation Strategy Assistance Program
REA	Rarotonga Environment Authority
TC	Tropical Cyclone
UNSW	University of New South Wales
WRL	Water Research Laboratory

# 1. Introduction

## 1.1 Project Overview and Context

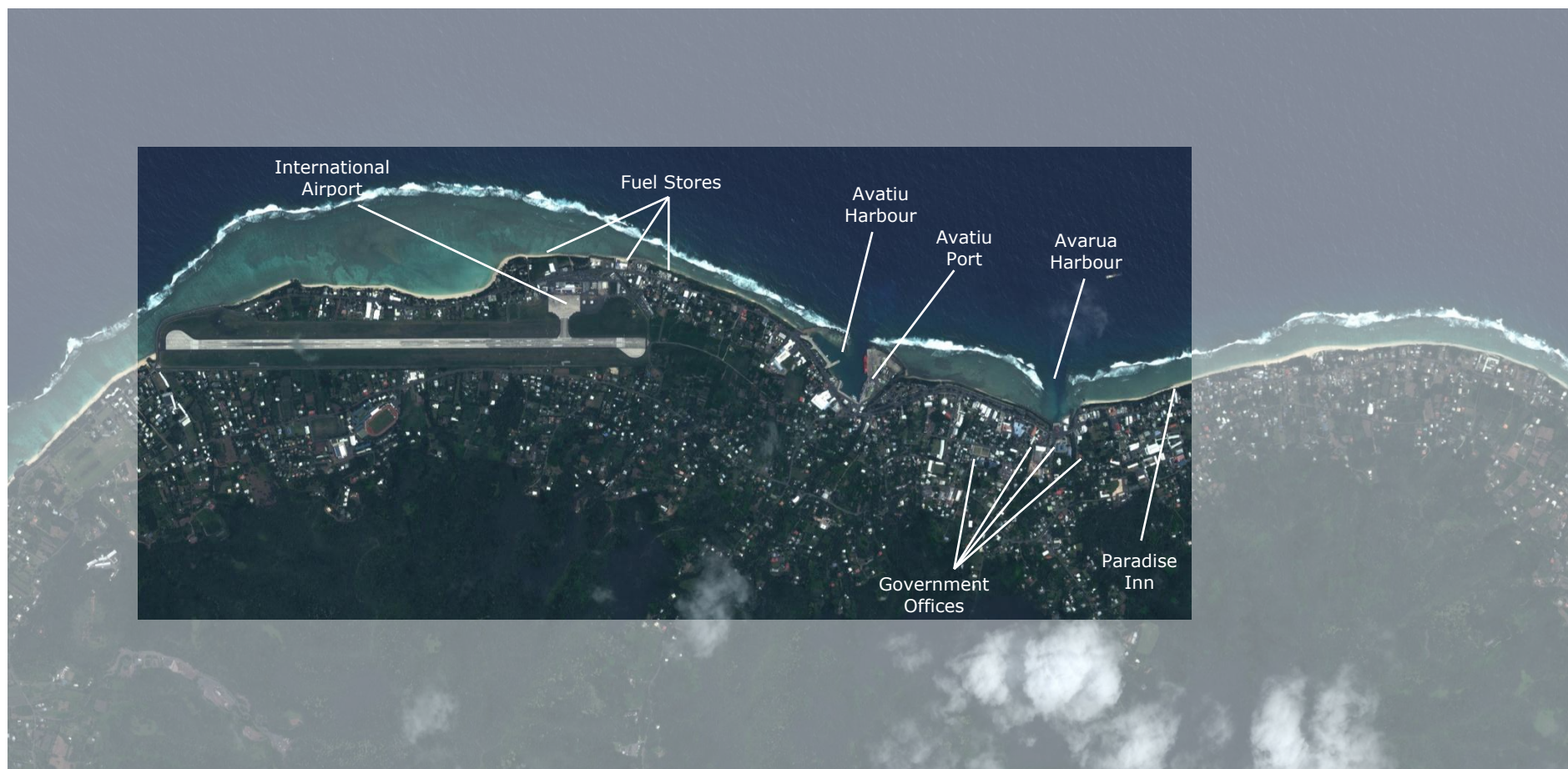
In June 2012 the project *Coastal Adaptation Needs for Extreme Events and Climate Change, Avarua, Rarotonga, Cook Islands*, was formally initiated by the Cook Islands Government, under the Pacific Adaptation Strategy Assistance Program (PASAP). The PASAP project was funded by AusAID through the Australian Government Department of Climate Change and Energy Efficiency (DCCEE) with contract administration undertaken by Climate Change Cook Islands (CCCI). The Water Research Laboratory (WRL) of The University of New South Wales (UNSW) was engaged as lead engineers for the project, working in conjunction with a local counterpart engineer (Mr Ben Parakoti) contracted specifically by CCCI for the project.

The Cook Islands are made up by thirteen (13) inhabited and two uninhabited islands spread over nearly 2 million square kilometres of ocean between French Polynesia and American Samoa (see Figure 1.1). The town of Avarua is the capital of the Cook Islands and is on the north coast of the Island of Rarotonga, within the Southern Group of volcanic islands (Cook Islands Government, 2012). Avarua is the hub of the Cook Islands economy and industry, and is also the densest residential area on any of the Cook Islands. Along the Avarua to Nikao stretch of the Rarotongan coastline (see Figure 1.2) are government and police offices, the international airport, the main fuel stores, Avatiu Harbour which processes all incoming freight to Rarotonga and the other Cook Islands, as well as the main shopping and residential districts. Tourism is the main economic sector of the Cook Islands (BoM and CSIRO, 2011), and the tourism industry depends heavily on functionality of this stretch of coast.



**Figure 1.1: Cook Islands Location Map**

The study area for the project (Figure 1.2) was initially restricted to the zone between the Paradise Inn (eastern boundary) to the area just west of Avatiu Harbour (western boundary), and extended inland to the extent of any coastal processes (almost the Ara Metua). The study area was later extended west to include several key infrastructure items, with the final western boundary being the western end of the airport runway (basically the COPED breakwater).



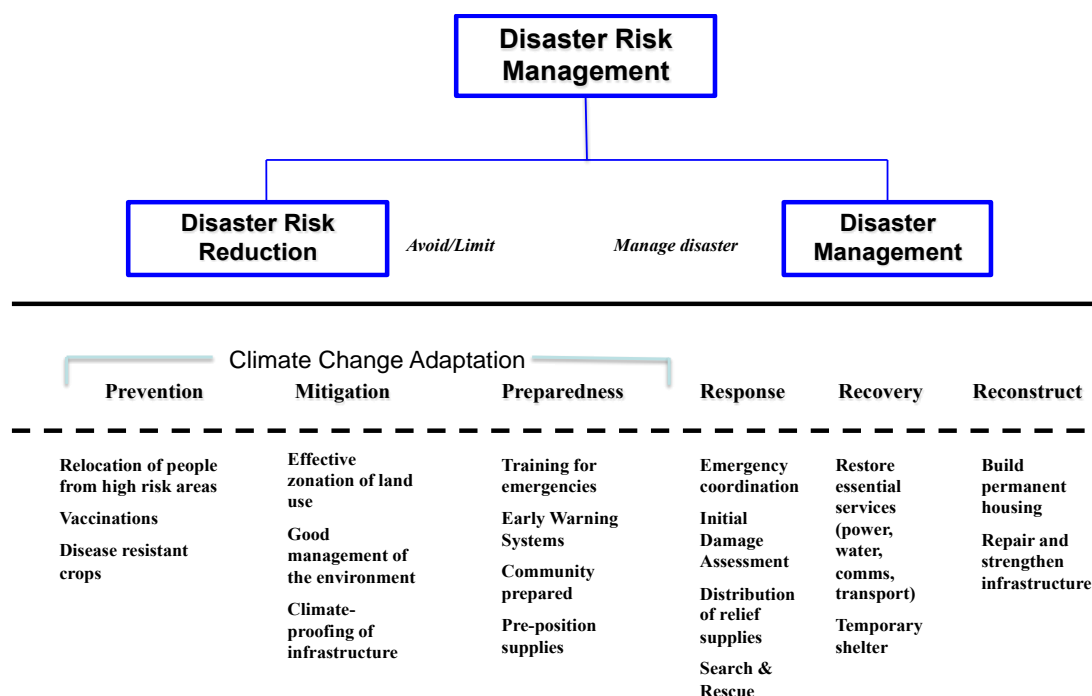
**Figure 1.2: Study Area**

For several decades it has been recognised that this stretch of coast is particularly susceptible to tropical cyclone events. This susceptibility was brought to the forefront in recent years, most notably with the unprecedented five cyclones within one month in February and March 2005, and again with Tropical Cyclone (TC) Pat in February 2010. As with most Pacific Island States, the Cook Islands' infrastructure is ill prepared against such events, as highlighted by the Cook Islands case study in the ADB (2005) CLIMAP project. Potentially vulnerable infrastructure in the Avarua area include the runway and airport buildings, three fuel bulk storage depots, LPG bulk gas tanks, the Avatiu wharf buildings and the main commercial district and Government buildings. A direct hit from a cyclone of the magnitude of any of the five experienced in 2005 has the potential to not only cause widespread destruction to infrastructure, but to also place a large number of lives at risk. The economic consequences of such a disaster were spelt out by the Cook Islands Tourist Authority in September 2000 when they said:

- a) Such damage would be devastating to the tourist industry and the economic effect would be both drastic, immediate, and long term for everyone;
- b) It is unlikely most of the commercial sector would have the ability to either reconstruct or retain staff in the absence of insurance cover and the economic disaster that would prevail;
- c) The economic effect would be such that large numbers of people both in the private and government sectors would lose their employment and the consequences of this would most likely be the rapid and substantial migration of Cook Islanders to other countries;
- d) As Rarotonga is the hub for all Outer Islands their economy would be destroyed also.

The Cook Islands Joint National Action Plan for Disaster Risk Management and Climate Change Adaptation (JNAP) (Cook Islands Government, 2012) identified a range of climate change and extreme event related risks for Rarotonga. Some of these risks include extreme weather events such as tropical cyclones as well as longer term processes such as sea level rise. In particular these processes could have significant impacts on the coastal zone and nearby infrastructure. In order to minimise the impacts of these risks, the JNAP identified the need to build a culture of preparedness and Figure 2 of the JNAP (see Figure 1.3) shows schematically the processes needed to achieve this.





**Figure 1.3: Components of DRM Including CCA (Cook Islands Government, 2012)**

This project links the regional scientific information from studies such as the Pacific Climate Change Science Program (PCCSP) and the national administrative and policy frameworks such as the JNAP and the Climate and Disaster Compatible Development Policy (Draft) (CIG, 2013) to provide practical ground level guidance for building preparedness across the localised study area. Looking directly at the components of DRR, CCA, and DRM as identified in the JNAP, the outcomes of this project provide direct guidance that is specific to the physiographic processes and risks to the study area to improve preparedness as shown in Table 1.1.

The outcomes of the project have been developed on the basis of discussions with key Cook Islands Government ministries so that the information can be incorporated into the existing systems such as the development assessment and compliance process as well as DRM planning.

**Table 1.1: DRM, CCA and Project Outcomes**

Disaster Risk Reduction	Prevention	Identifying high risk areas in order to relocate people and infrastructure
	Mitigation	Advising on coastal hazard areas so that appropriate land use zoning can be implemented
		Providing accurate and higher resolution topography data
		Providing technical data that can be used to improve EIA reports for development
		Providing technical data so that infrastructure and houses can be designed to be climate resilient (floor levels, materials types etc.)
	Preparedness	Identification of hazard zones during extreme events
		Predicting the damage extent and likely impacted areas for approaching cyclones
		Predicting the damage costs of an approaching cyclone
		Identifying cyclone shelters potentially at risk from coastal hazards
Disaster Risk Management	Response	Identifying areas of priority for emergency evacuation
	Reconstruction	Guidance for suitable areas for reconstruction and requirements for building in a climate resilient manner

## 1.2 Project Goals and Objectives

The key objectives of the study were to:

1. Understand the risk posed by changes to sea level and wave climate on coastal infrastructure and community in the Avarua area, particularly during extreme events;
2. Identify needs and develop options for responses to the risks; and
3. Build local capacity to understand the science and manage the risk assessment and planning process.

In order to meet the project key objectives, a range of sub objectives were identified which were to:

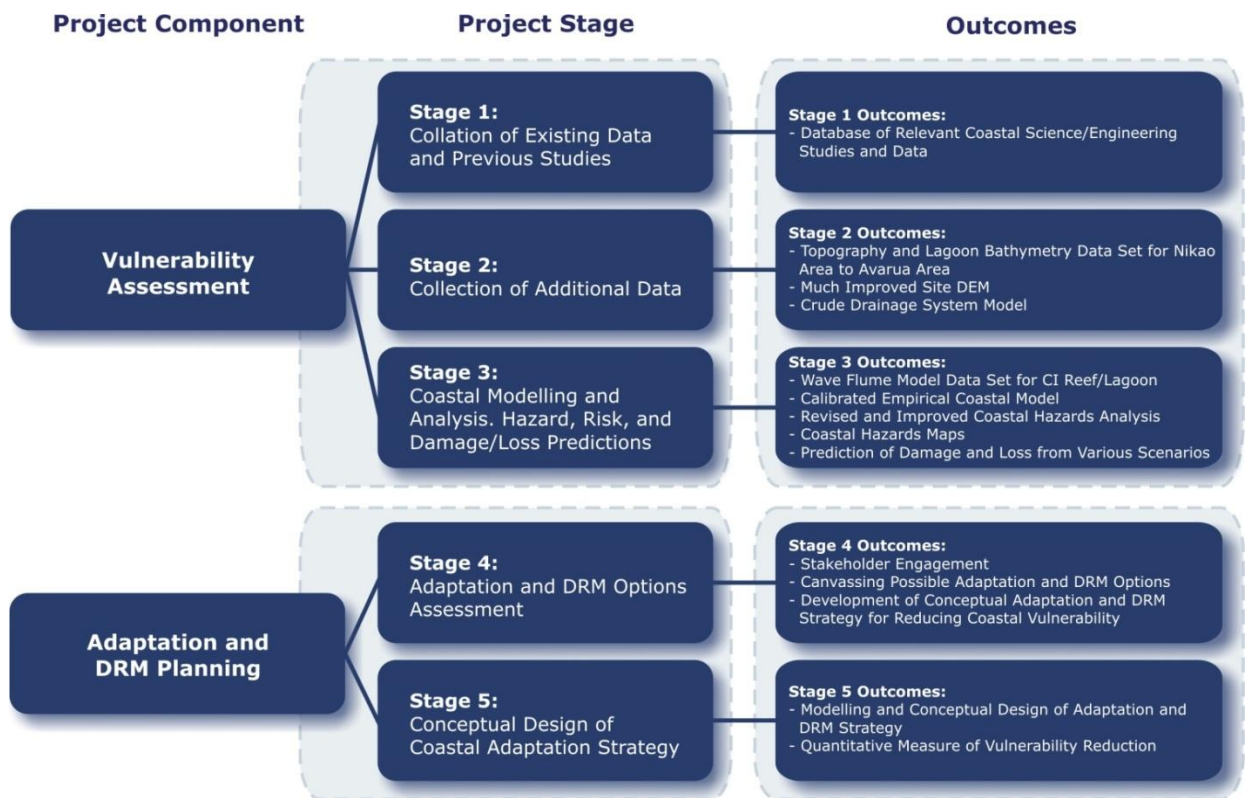
1. Understand the physiographic characteristics of the study area, both above and below the ocean;
2. Undertake a review of available literature and data;
3. Understand the typical and extreme wave and water level processes;
4. Understand projected climate change impacts;
5. Undertake modelling and analysis of coastal processes and hazards;
6. Prepare a vulnerability and risk assessment report;
7. Identify, develop, cost and canvass adaptation options; and
8. Build local capacity to understand and manage vulnerability, risk, and adaptation.

## 2. Summary of Overall Project

The project was undertaken as a series of five stages, which allowed the opportunity for adjustment in the study direction in the later stages based on the findings of the earlier stages of the project. The stages of the project were:

- Stage 1: Inception, scoping, and collation of existing data;
- Stage 2: Collection of additional bathymetry and topography data;
- Stage 3: Coastal processes and hazards analysis;
- Stage 4: Adaptation analysis, reporting, and stakeholder engagement;
- Stage 5: Conceptual design of adaptation strategy.

Figure 2.1 shows the basic structure of the project. This report presents the work undertaken for Stage 1, and provides a summary of the project scoping and collation of existing data. Stages 2 to 5 of the project are covered in separate reports.



**Figure 2.1: Project Stages and Outcomes**

### **3. Project Inception**

---

Work on the project started in July 2012, with a range of internal discussions and team meetings held by the WRL project team. These discussions were targeted at:

- Confirming the project goals, deliverables and program;
- Confirming the WRL team member roles throughout the project;
- Discussions regarding technical aspects of the analysis;
- Planning for technical review and quality control; and
- Potential issues and risks for the project.

Planning for the initial scoping trip was also undertaken during the inception stage of the project, which included identification of relevant stakeholders and scheduling of meetings with stakeholder representatives. This was undertaken in conjunction with CCCI and the project counterpart engineer.

## 4. Scoping Field Trip

WRL Senior Coastal Engineer Mr Matt Blacka travelled to Rarotonga to undertake the initial scoping field trip during the week of 22/07/2012 to 27/07/2012. The goals of this scoping trip were to:

- Raise awareness and discuss the project with relevant stakeholders;
- Identify relevant data sets and reports;
- Undertake a scoping of the study area; and
- Plan for the data collection trip to be undertaken during Stage 2 of the project.

A summary of the stakeholder engagement meetings held during the scoping trip are outlined in Table 4.1.

**Table 4.1: Summary of Initial Stakeholder Engagement Meetings**

Date	Attendees (Organisation)	Date	Attendees (Organisation)
23/07/2012	Ana Tiraa (OPM) Rerekura Teaurere (CCCI) Othenial Tangianau (OPM) Willie Tuivaga (EMCI) Nga Puna (OPM) Ben Parakoti (Contractor) Matt Blacka (WRL)	25/07/2012	CI News Matt Blacka (WRL) Ben Parakoti (Contractor)
23/07/2012	Don Dorrell (CEIL) Matt Blacka (WRL) Ben Parakoti (Contractor)	25/07/2012	Ian Karika (REA) Matt Blacka (WRL) Ben Parakoti (Contractor)
24/07/2012	Miimetua Matamaki (NES) Matt Blacka (WRL) Ben Parakoti (Contractor)	26/07/2012	Donye Numa (MOIP) Matt Blacka (WRL) Ben Parakoti (Contractor)
24/07/2012	Arona Ngari (CIMS) Matt Blacka (WRL) Ben Parakoti (Contractor)	26/07/2012	Professor John Hay (USP) Matt Blacka (WRL) Ben Parakoti (Contractor)
24/07/2012	Atatoa Herman Matt Blacka (WRL) Ben Parakoti (Contractor)	27/07/2012	Liz Koteka (OPM) Ana Tiraa (CCCI) Matt Blacka (WRL) Ben Parakoti (Contractor)
24/07/2012	Bim Tou (CIPA) Gareth Clayton (BECA) Matt Blacka (WRL) Ben Parakoti (Contractor)		

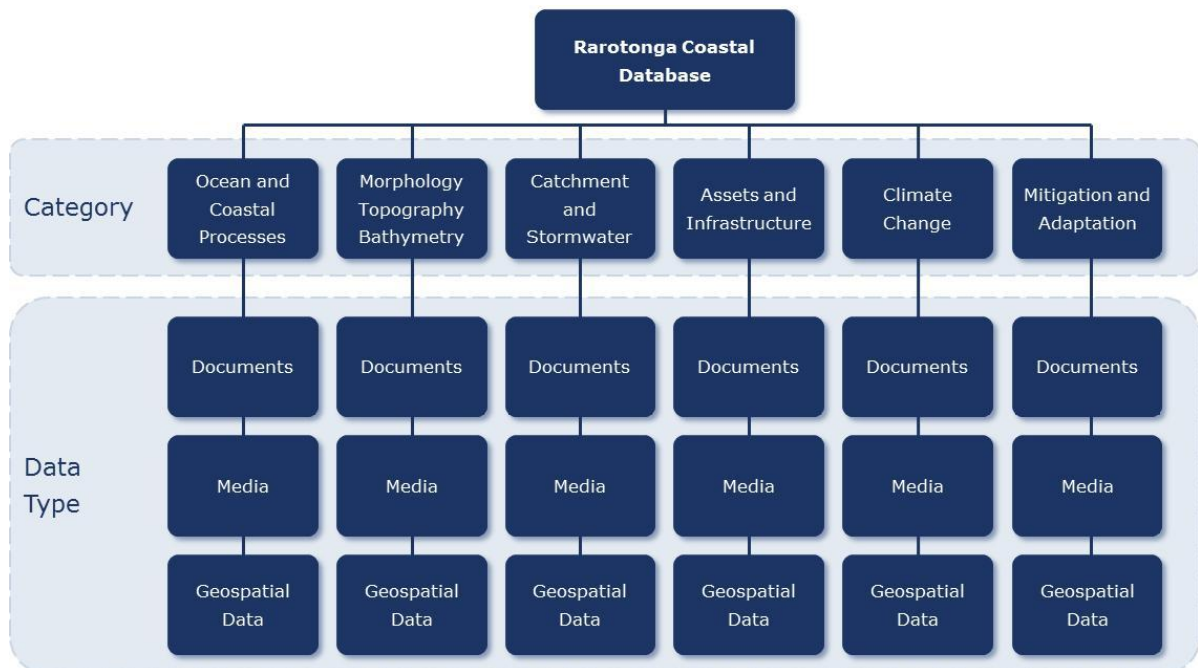
The responses and feedback at the scoping meetings helped to more firmly identify the context of the project, and also specific relevant issues with regards to coastal management and coastal infrastructure.

## 5. Collation of Existing Data

### 5.1 Library of Relevant Existing Information

It was identified during the initial scoping trip that a considerable amount of relevant work has been undertaken for Avarua, Avatiu, and Rarotonga in general. However, the reporting and data sets from the work are held by various organisations and there was no concise summary of relevant projects and reports. It became clear that a well catalogued inventory of relevant information and data would be a valuable tool for future projects and management. While collating relevant data and information, WRL developed this catalogue and library, which forms a valuable output from this study to build the knowledge and capacity of the Cook Islands Government to manage coastal and foreshore issues in the future.

The catalogue for the library has been assembled in a Microsoft Excel spread sheet so that it can be easily distributed and used. Where possible the data/documents listed in the catalogue are actually contained in the library. However, this was not always possible, in particular for data sets owned/distributed by other organisations. In these cases the access information for obtaining the data sets has been included in the catalogue. The structure of the library is shown schematically in Figure 5.1.



**Figure 5.1: Schematic of Rarotonga Coastal Engineering Information Library**

The catalogue and data sets (where possible) have been included on an attached DVD with this report and summarised in Appendix A. The following references were of particular relevance to the coastal vulnerability assessment in Stage 3 of the project, and are also of high importance for local engineers undertaking Environmental Impact Assessments for development assessment and compliance:

- Photographs and video from TC Sally and the various cyclones in 2005 showing wave impacts and resulting damage to infrastructure;

- JICA (1987) *Report on Countermeasures Against Coastal Hazards by Cyclone in the Cook Islands*
- JICA (1994) *The Additional Study on Coastal Protection and Port Improvement in the Cook Islands*
- Kirk (1992) *Analysis and Numerical Modelling of Cyclone Sea-States, Avarua Area, Rarotonga, Cook Islands*
- GHD (2005) *Coastal Protection Feasibility Study*
- NIWA (2012) *Climate Change Impacts on Coastal Inundation at Oneroa Village Mangaia*

## 5.2 Existing Geospatial Data Sets

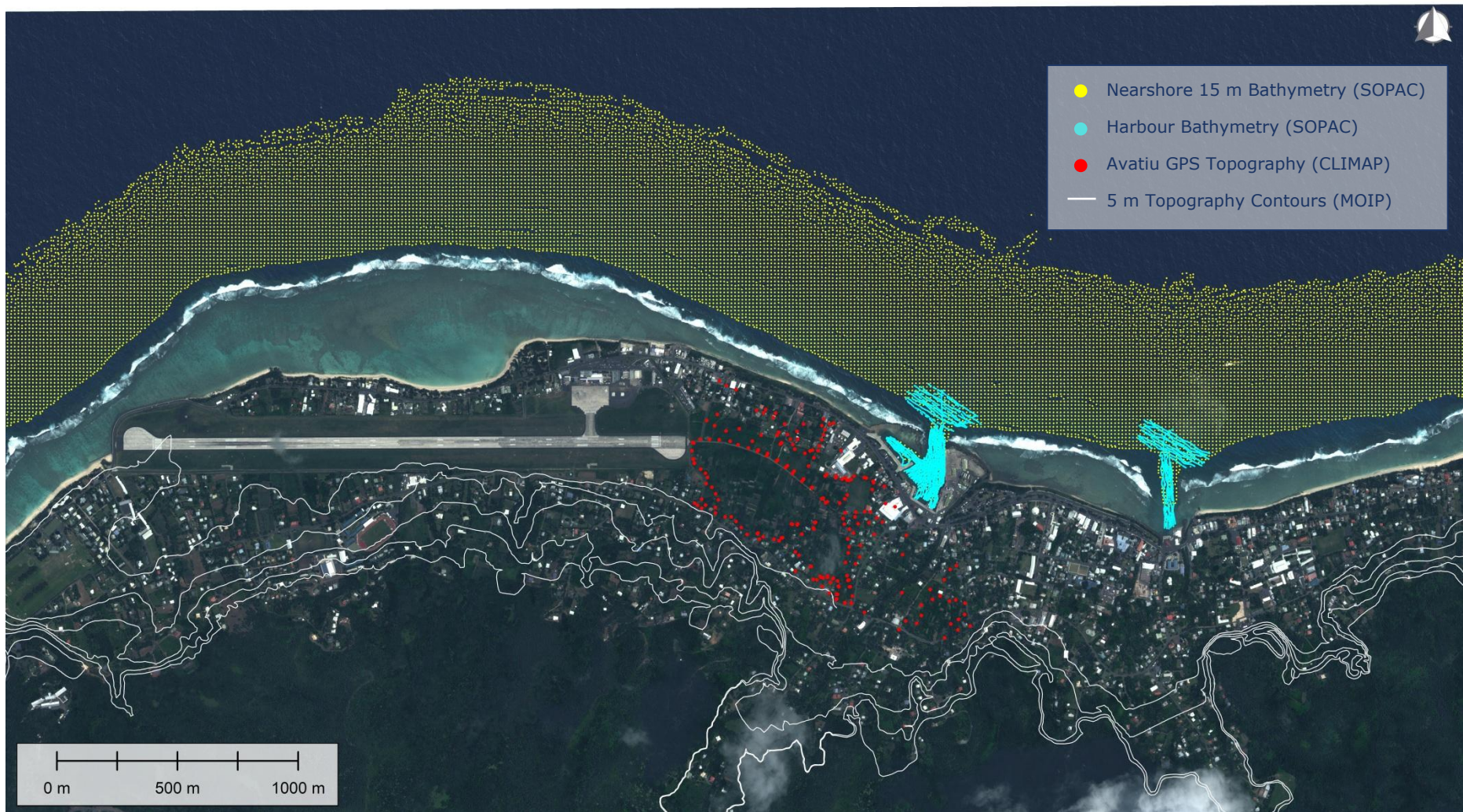
While the previous investigations of ocean and coastal processes provide valuable insight, the analysis of coastal hazards and vulnerability depends heavily on having good topography and bathymetry data for the study area. Of particular importance for understanding wave processes is the bathymetry of the fringing reef and lagoon. To understand and map the impacts of storm surge and wave overtopping, topography data for coastal land between mean sea level and an elevation of approximately the 5 m MSL is also of particular importance. By compiling and mapping all of the relevant existing geospatial data sets, WRL were able to identify gaps in the existing data, and therefore target the data collection program in Stage 2 of the project at filling in these gaps. Figure 5.2 shows a map of the key existing topography and bathymetry data sets for the study area. These can be summarised as:

- 5 m interval topographic contours (provided by MOIP);
- GPS topographic data points from CLIMAP project (provided by MOIP);
- Rarotonga nearshore bathymetry data (provided by SOPAC);
- Avarua harbour bathymetry data (provided by SOPAC); and
- Avatiu harbour bathymetry (provided by SOPAC).

In terms of suitable data to model coastal processes and map the subsequent coastal hazard zones, the following gaps were identified in the existing data sets and formed the target for the project Stage 2 data collection program:

- No bathymetry data for the surrounding lagoon; and
- No topography data for most land areas between mean sea level and 5 m MSL.





**Figure 5.2: Existing Topography and Bathymetry Data Sets**

## 6. References

---

Asian Development Bank (2005) *Climate Proofing: A Risk Based Approach to Adaptation*, Pacific Studies Series

Australian Bureau of Meteorology and CSIRO (2011) *Climate Change in the Pacific: Scientific Assessment and New Research*, Volume 2: Country Reports

Cook Islands Government (2012) *Joint National Action Plan for Disaster Risk Management and Climate Change Adaptation (JNAP): 2011-2015*, Office of Prime Minister, Rarotonga

Cook Islands Government (2013) *Climate and Disaster Compatible Development Policy 2013-2016*, Office of Prime Minister, Rarotonga

## Appendix A Catalogue of Existing Information

**Table A.1 Ocean and Coastal Processes References**

Title	Personal Author	Corporate Author	Published Year	Type
Baseline Study for Coastal Management Reef, Beach, and Lagoon Near Rarotongan Hotel Rarotonga, Cook Islands	R. Carter and J. E. Steen	SOPAC	1984	Document
The Climate and Weather of the Southern Cook Islands	C. S. Thompson	New Zealand Meteorological Service	1986	Document
Installation of Waverider Buoy Offshore Rarotonga	R. Carter	SOPAC	1987	Document
Report on Countermeasures Against Coastal Hazards by Cyclone in the Cook Islands		Japan International Cooperation Agency (JICA)	1987	Document
Beach Processes and Coastal Stability, Avarua-Avatiu Coastline, Rarotonga Cook Islands	R. D. Gillie	SOPAC	1991	Document
The Study on Coastal Protection and Port Improvement in the Cook Islands Final Report		Japan International Cooperation Agency (JICA)	1992	Document
Ocean Currents and Circulation Cook Islands Avarua - Motutoa, Rarotonga	B. Holden	SOPAC	1992	Document
Analysis and Numerical Modelling of Cyclone Sea-States, Avarua Area, Rarotonga, Cook Islands	R. M. Kirk	Ministry of Planning and Economic Development, Government of the Cook Islands	1992	Document
Analysis and Numerical Modelling of Cyclone Sea-States, Avarua And Nikao Areas, Rarotonga, Cook Islands	R. M. Kirk and D. E. Dorrell	Ministry of Planning and Economic Development, Government of the Cook Islands	1992	Document
The Wave Climate of the Cook Islands	S. Barstow and O. Haug	OCEANOR	1994	Document
The Additional Study on Coastal Protection and Port Improvement in the Cook Islands		JICA	1994	Document

Wave Set-Up And Wave Generated Currents on Coral Reefs	M.R. Gourlay		1994	Document
Wave Set-Up on Coral Reefs. 1. Set-Up and Wave-Generated Flow on an Idealised Two Dimensional Horizontal Reef	M. R. Gourlay		1996	Document
Wave Set-Up on Coral Reefs. 2. Set-Up on Reefs With Various Profiles	M. R. Gourlay		1996	Document
Cyclone Hazard - Analysis of Existing Cyclone Sea-State Protection and Disaster Potential - Avarua Town Area and Avatiu Harbour	D. E. Dorrell	Coastal Environmental International	1999	Document
On the Modelling of Wave Breaking and Set-up on Coral Reefs	S. R. Massel and M. R. Gourlay		2000	Document
Coastal Protection Feasibility Study		GHD	2005	Document
A History of Tropical Cyclones and Their Impacts in the Cook Islands	F. A. de Scally et al.	Cook Islands Meteorological Service	2006	Document
Historical Tropical Cyclone Activity and Impacts in the Cook Islands	F. A. de Scally		2008	Document
Pacific Country Report Sea Level and Climate: Their Present State Cook Islands		Bureau of Meteorology (BOM)	2010	Document
Evidence of a Previously Unrecorded Local Tsunami, 13 April 2010, Cook Islands: Implications for Pacific Island Countries	J. Goff		2011	Document
Climate Change Impacts on Coastal Inundation at Oneroa Village Mangaia	S. Stephens and D. Ramsay	National Institute of Water & Atmospheric Research (NIWA)	2012	Document
Shore Protection Against Sea Level Rise and Tropical Cyclones in Small Island States	M. Umeyama		2012	Document
Avatiu Tide Data		Bureau of Meteorology (BOM)	1993 - 2009	Data
Tropical Cyclones Information		Joint Typhoon Warning Centre (JTWC)	1997 - 2010	Data
Coastal Protection in the South Pacific		SOPAC	1994	Document

Tropical Cyclone 1935 Pictures			1935	Media
Tropical Cyclone Olaf 2005 Pictures	D. Dorrell	CEIL	2005	Media
Tropical Cyclone Sally 1987 Pictures	D. Dorrell	CEIL	2005	Media
Tsunami 29 September 2009	J. Ngamata		2009	Media
Tropical Cyclone Meena 2005 Pictures		Cook Islands News	2005	Media
Tropical Cyclone Meena, Heta, Nancy, Olaf Video Footage	P. Cattania		2005	Media
Tropical Cyclone Meena 2005 Video		Cook Islands TV News	2005	Media
Tropical Cyclone Val 1991 Video	D. Dorrell	CEIL	1991	Media

**Table A.2 Climate Change References**

Title	Personal Author	Corporate Author	Published Year	Type
The Cook Islands—Climate Risk Profile <sup>1</sup>		Asian Development Bank (ADB)	2005	Document
Climate Risk Profile for Cook Islands		Asian Development Bank (ADB)	2005	Document
Climate Proofing a Risk-Based Approach to Adaptation		Asian Development Bank (ADB)	2005	Document
Sea Level and Climate: Their Present State Cook Islands		Bureau of Meteorology (BOM)	2006	Document
Pacific Island Framework for Action on Climate Change 2006-2015		SPREP	2011	Document
Pacific Country Report on Sea Level and Climate: Their Present State Cook Islands		Bureau of Meteorology (BOM)	2009	Document
Pacific Country Report on Sea Level and Climate: Their Present State Cook Islands		Bureau of Meteorology (BOM)	2010	Document

Climate Change in the Pacific: Scientific Assessment and New Research Volume 1: Regional Overview		BOM and CSIRO	2011	Document
Climate Change in the Pacific: Scientific Assessment and New Research   Volume 2: Country Reports		BOM and CSIRO	2011	Document
JNAP for Disaster Risk Management and Climate Change Adaptation 2011-2015		Emergency Management Cook Islands and Climate Change Cook Islands	2012	Document
Climate Change Impacts on Tropical Cyclones and Extreme Sea Levels in the South Pacific - A Regional Assessment			2012	Document

**Table A.3 Mitigation and Adaptation References**

Title	Personal Author	Corporate Author	Published Year	Type
Rarotonga Tourism Vulnerability Pilot Study	R. Howorth		1998	Document
Strengthening Disaster Management and Mitigation		ADB	2007	Document
Tsunami Warning and Mitigation Systems		Bureau of Meteorology (BOM)	2008	Document
National Action Plan for Disaster Risk Management		Government of the Cook Islands	2009	Document
Pacific Adaptation to Climate Change Cook Islands		SREP	2009	Document
JNAP for Disaster Risk Management and Climate Change Adaptation 2011-2015		Emergency Management Cook Islands and Climate Change Cook Islands	2012	Document

**Table A.4 Hydrology and Stormwater References**

Title	Personal Author	Corporate Author	Published Year	Type
Hydraulic Network Modelling of the Rarotonga Water Supply System	P. Dawe and H. Schölzel	SOPAC	2000	Document

**Table A.5 Topography and Bathymetry References**

Title	Personal Author	Corporate Author	Published Year	Type
1978 Cruise Report Avarua Avatiu	P. J. Hill et al.		1978	Document
Sea Bed Studies in Nearshore Areas of Rarotonga, Cook Islands	G. A. Gauss		1982	Document
1981 Cruise Report Avarua Avatiu	G.A. Gauss			Document
Coastal Morphology of Rarotonga	B. M. Richmond	Techsec	1990	Document
1994 Cruise Report Avarua Avatiu		SOPAC	1994	Map
Survey Report Precise Differential Levelling Cook Islands August 2004		Bureau of Meteorology (BOM)	2004	Document
EDM Height Traversing Levelling Survey Report Rarotonga Cook Islands	S. J. K. Yates and A. Lal		2011	Document
Coastal Mapping to Assist with Development of a Strategy for Foreshore Protection and Development, Rarotonga, Cook Islands	Chaoxiong He	SOPAC	1999	Document
Rarotonga Airport Survey		Eagle Land Survey	2013	Data
Avarua RTK-GPS Survey	M. Blacka, D. Rayner, B. Parakoti	Water Research Laboratory, UNSW	2013	Data
Aerial Photos	D. Dorrell	CEIL	Various	Media
5 m Topographic Contours GIS Layer				Data
CLIMAP Project Elevation Data Points				Data
Cadastre GIS Layer				Data

Rarotonga Nearshore Bathymetry Survey Dataset		SOPAC		Data
Avarua Rarotonga Bathymetry Dataset		SOPAC		Data
Avatiu Rarotonga Bathymetry Dataset		SOPAC	2006	Data

**Table A.6 Assets and Infrastructure References**

Title	Personal Author	Corporate Author	Published Year	Type
The Effects Of Cyclone Sally on Rarotonga, Cook Islands	G. Cowan and A. Utanga		1987	Document
Rarotonga After Cyclone Sally	E. M. Bridges		1988	Document
Pacific Catastrophe Risk Assessment and Financing Initiative - Country Risk Profile - The Cook Islands		The World Bank	2011	Document
The Effects Of Cyclone Sally on Rarotonga, Cook Islands	G. Cowan and A. Utanga		2012	Document
Avatiu Harbour Western Breakwater Extension		RAIRI Designs	2012	Document
Avatiu Harbour Western Side Development Study		Wilton and Bell	1987	Document
Avatiu Harbour - Rarotonga, Cook Islands, Western Breakwater and Harbour Layout Model Studies	D. Haradasa, D. Cox and R. Cox	Water Research Laboratory, UNSW	1988	Document
Avatiu Wharf After Cyclone 1976	D. Dorrell	CEIL	1976	Media
Rarotonga Roads GIS Layer				Data
PCRAFI Building Footprints and Infrastructure Location GIS Layers		The World Bank	2011	Data
Environmental Impact Assessment Report – Proposed Relocation of TOA Petroleum Fuel Storage Facility, Panama, Rarotonga	D. Rairi and A. Herman		2012	Document
Environmental Impact Assessment Report – TRIAD Fuel Tank Farm, Foreshore Rehabilitation	T. Rongo and A. Herman		2008	Document