PACC TECHNICAL REPORT 11

NOVEMBER 2014

PACC

Building Resilience to Climate Change in Pacific Communities

PACC Demonstration Guide: Improving the public water supply system in Majuro, Marshall Islands

SPREP
Secretariat of the Pacific Regional Environment Programme

UNDP
Empowered lives.
Resilient nations.

Australian Aid

gef

unitar
United Nations Institute for Training and Research

SPREP LIBRARY/IRC CATALOGUING-IN-PUBLICATION DATA

PACC Demonstration Guide: Improving the public water supply system in Majuro, Marshall Islands. Apia, Samoa : SPREP, 2014.

44 p. 29 cm. (PACC Technical Report No.11)

ISSN 2312-8224

SPREP, PO Box 240, Apia, Samoa
T: +685 21929
F: +685 20231
E: sprep@sprep.org
W: www.sprep.org

This publication is also available electronically from SPREP's website:
www.sprep.org

SPREP
Secretariat of the Pacific Regional Environment Programme

SPREP Vision: The Pacific environment, sustaining our livelihoods and natural heritage in harmony with our cultures.

www.sprep.org

PACC
Building Resilience to Climate Change in Pacific Communities

UNDP
Empowered lives.
Resilient nations.

gef

Australian Aid

unitar
United Nations Institute for Training and Research

PACC TECHNICAL REPORT 11
NOVEMBER 2014

PACC Demonstration Guide: Improving the public water supply system in Majuro, Marshall Islands

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

This report is an output of the RMI PACC Project. It was written by Louis Bouchet, and reviewed by Joseph Cain (Marshall Islands PACC Project Coordinator), Halston deBrum (Majuro Water and Sewer Company), Netatua Pelesikoti (SPREP) and Peniamina Leavai (SPREP).

The Office of Environmental Planning and Policy Coordination (OEPPC) hosted the PACC project in RMI. The Majuro Water and Sewer Company (MWSC) supported and collaborated with the PACC and OEPPC team.

The Ministry of Health, Outer Islands Health Center and CMI Land Grant collaborated to arrange installation of the solar water purifiers.

The following agencies participated in the project, providing valuable insight and feedback:

- The Environmental Protection Agency (EPA) and the IWRM unit;
- The Project Management Unit of the Ministry for Public Works (PMU) ;
- The College of The Marshall Islands Land Grant Program (CMI Land Grant);
- Women United Together Marshall Islands (WUTMI);
- Majuro Atoll Local Government (MalGov);
- Ministry of Internal Affairs;
- Ministry of Resources and Development;
- Ministry of Foreign Affairs;
- Ministry of Health;
- Ministry of Education;
- Office of the Chief Secretary;
- Economic Policy, Planning and Statistics Office.

EXECUTIVE SUMMARY

On all islands in the Republic of the Marshall Islands (RMI) rainwater is the primary source of freshwater, putting the country at high risk from droughts. The water sector was therefore chosen by the RMI Government to benefit from the PACC project, and the project has been working since 2008 to increase the country's resilience to drought events. This report details the process undertaken in the PACC demonstration project, to design and implement various measures to enhance Majuro's water reticulation system.

The island of Majuro was selected as the site for the project as it is the most densely populated area in RMI, with around 52% of the country's population. Majuro's public water network uses both rainwater and groundwater to supply Majuro's main populated areas. The rainwater is collected from the paved runway at the international airport and pumped to a series of reservoirs, a treatment plant, and then into the pipe network. However, it was estimated that 50% of the water harvested from the airport catchment is lost through the system, due to leakage in the piping network, leakage in the reservoir liners, evaporation from the reservoir, and illegal connections.

Three assessments were carried out in order to identify the most appropriate and efficient interventions within the PACC budget – vulnerability and adaptation (V&A) assessment, cost–benefit analysis (CBA), and a technical assessment of the proposed work. As a result, the following options were selected:

1. Install new liners;
2. Install an evaporation cover;
3. Support the Majuro Water & Sewer Company (MWSC) in assessing the extent of the leakages in the pipeline.

The leak detection activity was implemented in 2013. Bulk meters were purchased, delivered and installed, and a staff member from the MWSC was provided with training in leak detection.

The work at the airport reservoir was completed in the first half of 2014. The contracted company Fabtech Australia worked alongside MWSC staff in relining three storage tanks and installing a cover on one of the tanks. The work was completed and a ribbon cutting ceremony was held in April 2014. The airport reservoir now holds 36.5 million gallons, an increase of 5.5 million gallons. This has extended the availability of water during drought periods for the people of Majuro.

A major need for sustainability of the project is institutional reform of the country's water sector and the development of mechanisms to finance the maintenance and further development of the water infrastructure. The Water and Sanitation Policy Framework, developed as a collaboration by PACC, the IWRM project and the RMI government, aims to drive reforms in the sector.

Two main lessons were drawn from the experiences of the RMI PACC team.

1. Efficient coordination and communication is critical. The PACC project is hosted by one government agency and implemented through another agency, which required excellent coordination for success. The creation of the PACC core group was an important factor, ensuring that every important decision was discussed and approved by the majority of the agencies involved in the sector.
2. Technical assessments, carried out at the right time, are essential for complex infrastructure projects. The V&A process helped to identify issues with the Majuro water network and possible adaptation options. MWSC conducted various evaluations to assess the leakages of each storage tank and the loss of water through evaporation, and the assessment by Fabtech confirmed these results. CBA clarified how to maximise benefits within the given budget. These technical assessments helped design a tailored, relevant and effective demonstration project.

RMI has also replicated successful adaptation measures demonstrated in another of the PACC projects. Based on success of solar purifiers demonstrated under the PACC project in Nauru, additional funding from the Australian Government (called PACC+) was used to provide solar water purifiers to some of RMI's remote northern atolls. The solar purifiers can produce up to 20 litres of clean freshwater per day per unit from any source of water (e.g. groundwater or seawater). The solar purifiers are being installed at health centres, with installation due to be completed by March 2015.

ABBREVIATIONS

CBA	Cost–benefit analysis
CMI Land Grant	College of the Marshall Islands Land Grant
DRM	Disaster risk management
DUD	Djarrit, Uliga, Delap
ENSO	El Niño Southern Oscillation
EPA	Environment Protection Agency
EPPSO	Economic Policy, Planning and Statistics Office
HH	Household
IWRM	Integrated Water Resources Management [project]
JNAP	Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management
MWSC	Majuro Water & Sewer Company
NCCPF	National Climate Change Policy Framework
NGO	Non-governmental organisation
ODM	Office for Disaster Risk Management
OEPPC	Office of Environmental Planning and Policy Coordination
PACC	Pacific Adaptation to Climate Change [programme/project]
PACCSAP	Pacific–Australia Climate Change Science Adaptation Planning [program]
PMU	Project Management Unit
RMI	Republic of the Marshall Islands
RND	Ministry of Resources and Development
RO	Reverse osmosis
SOPAC	Applied Geoscience and Technology Division of SPC
SPC	Secretariat of the Pacific Community
V&A	Vulnerability and adaptation [assessment]
WUTMI	Women United Together for the Marshall Islands

1. INTRODUCTION

The Pacific Adaptation to Climate Change (PACC) programme is the largest climate change adaptation initiative in the Pacific region, with projects in 14 countries and territories. PACC has three main areas of activity: practical demonstrations of adaptation measures; driving the mainstreaming of climate risks into national development planning and activities; and sharing knowledge in order to build adaptive capacity. The goal of the programme is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in three key climate-sensitive development sectors: coastal zone management, food security and water resources management. The programme began in 2009 and is scheduled to end in December 2014.

In the Republic of the Marshall Islands (RMI), the PACC project began with a two-day inception workshop in February 2008. It was decided at the workshop that the project would focus on the water sector, due to the vulnerability of the sector to climate variability and change. At the same time it was acknowledged that addressing climate change requires a holistic approach, as it impacts on all sectors.

The island of Majuro was prioritised as the site for the project, as it is the most densely populated area in RMI, with currently around 52% of the country's population. Acknowledging the high risk that drought events pose to the RMI, the PACC project is working to increase water storage and enhance existing structures to better conserve the limited water available. This will increase the country's resilience to drought events that are likely to be exacerbated by climate change.

These guidelines have been developed as a key output of the PACC demonstration project. The guidelines detail the process undertaken by the project team to design and implement various measures to enhance Majuro's potable water scheme. They are mainly directed at government agencies, local non-governmental organisations (NGOs), regional organisations and donor agencies interested in pursuing efforts to maintain and upgrade Majuro's water reticulation system. They are also aimed at climate change practitioners across the Pacific islands region who are developing similar water management projects.

In detailing the steps to design and implement the demonstration project, this document aims to provide the reader with the following information:

- An understanding of the challenges during drought events in the RMI, and how these may change in the future due to climate change;
- The current management of water resources in Majuro, including water supply and sanitation;
- The main features and state of Majuro's rainwater collection, storage and reticulation network, and the urgent need to better manage it;
- The design and implementation of upgrades and water demand management measures on Majuro's water network;
- Experiences of the RMI PACC project team, and lessons learned.

1.1. The PACC project in RMI

1.1.1. Project objectives and outcomes

The objective of the PACC project is to contribute to reducing vulnerability and increasing adaptive capacity to the adverse effects of climate change in RMI. In order to reach this objective, three outcomes have been identified:

Outcome 1: Develop policies and plans, mainstreamed to build resilience in the context of emerging climate risks in the RMI water sector.

Outcome 2: Increase water security in RMI in times of drought through demonstration measures to improve water retention in Majuro's water reticulation system.

Outcome 3: Increase understanding of climate change impact and awareness of how to adapt and build resilience at community level.

The current report focuses on the demonstration project (Outcome 2). The goal of the demonstration project is 'to improve retention in Majuro's water reticulation system to enhance resilience to drought events by the end of the project cycle' (PACC, 2008; PACC, 2014b).

1.1.2. Institutional framework

The PACC project in RMI is hosted under the Office of Environmental Planning and Policy Coordination (OEPPC), under the Office of the President. Climate change activities are coordinated through the National Advisory Committee on Climate Change and implemented through several government agencies (Figure 1).

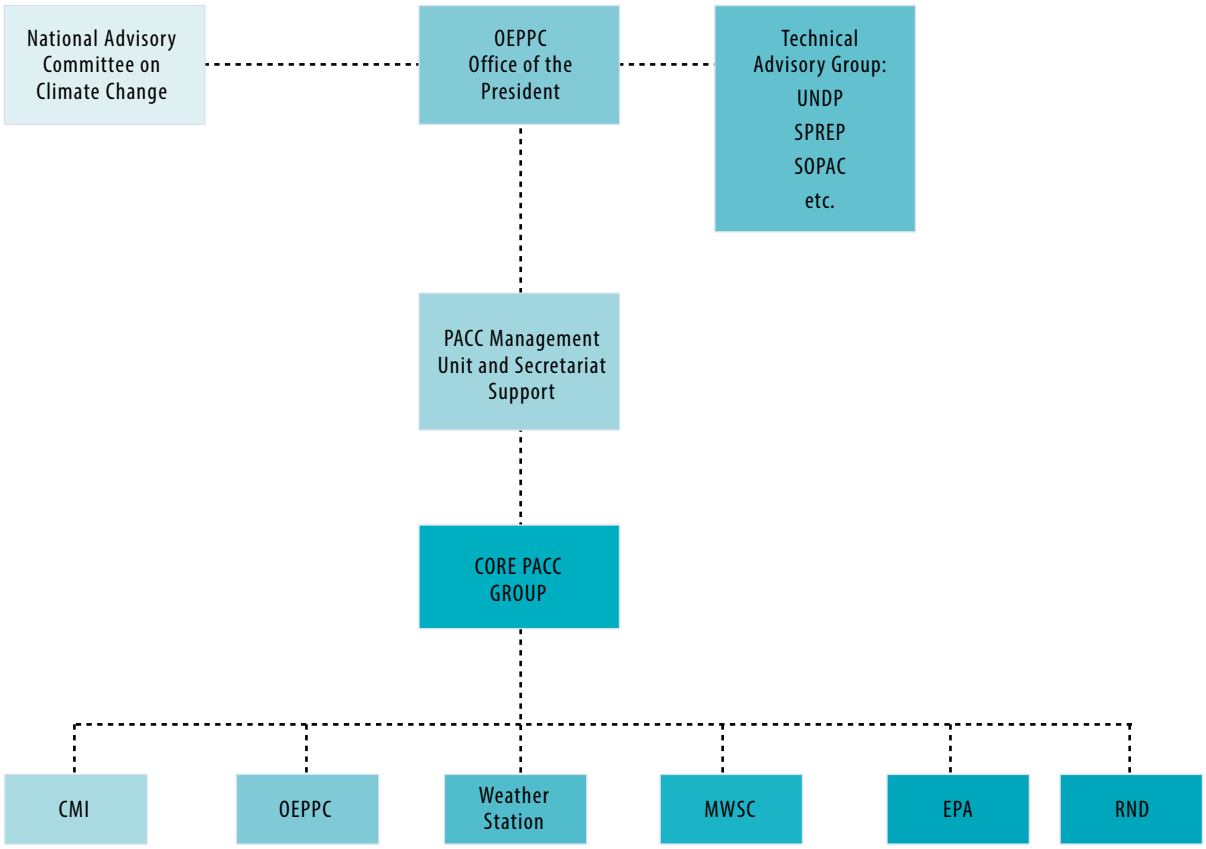


Figure 1. Institutional framework for PACC RMI (as at the start of the project; PACC, 2008).

To oversee and advise on project activities, a PACC core group was constituted comprising key stakeholders in the sector. The NGO Women United Together for the Marshall Islands (WUTMI) has been one of the key members of the PACC core group.

The project is being implemented by the Majuro Water & Sewer Company (MWSC), the authority in charge of Majuro's water and sanitation infrastructure, in collaboration with OEPPC.

1.1.3. Policy framework

The project is being implemented within three main policy frameworks (Table 1). The National Climate Change Policy Framework is the overarching climate change document in the RMI. Completed in 2011, the Framework defines priorities and activities necessary to build resilience to climate change in several strategic sectors. The Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management (JNAP) serves as the action plan for the Climate Change Policy Framework. It details measures and actions needed in order to reach

the policy objectives. The Water and Sanitation Policy Framework and proposed Action Plan were approved by the Cabinet in 2014. This Framework is presented in Section 3.2.2.

Table 1. PACC RMI and relevant national policies.

Policy or strategy	Type	Sector	PACC project is contributing to:
Vision 2018	Strategy	All	Goal 10: Environmental sustainability
National Climate Change Policy Framework	Policy framework	Climate change	Goal 2: Adaptation and reducing risk for a climate future: • Objective 1: Food and water security
National Water and Sanitation Policy	Policy framework	Water	Policy area 1: Reduce the occurrence of waterborne illness • Strategy 1.1.h: Maintaining and upgrading municipal infrastructure where necessary to achieve required water quality Policy area 3: The cost of operation and maintenance of water supply and sanitation systems shall be recovered from service users through a fair and transparent tariff • Strategy 3.2.b Monitor and report to continually reduce unaccounted for water and increase cost recovery from services. Policy area 5: Ensure water and sanitation provision through proactive risk reduction and comprehensive monitoring • Strategy 5.3.d Promotion of rainwater harvesting as the preferred water source wherever feasible.
Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management	Action Plan	Climate change and DRM	Goal 5: Enhanced local livelihood and community resilience: • Address substantial leakage/waste/evaporation (immediate issue) • Address failing and climate-exposed infrastructure (e.g. underground pipelines, airport catchment, reservoirs)

2. COUNTRY INFORMATION AND CONTEXT

2.1. Geographic and socio-economic background

The Republic of the Marshall Islands consists of 29 low-lying atolls and five coral islands with a total land area of 181 km^2. Most of the islands are located within two parallel chains: the Ratak (sunrise) chain and the Ralik (sunset) chain. Five outer islands are located north of the two chains (Figure 2).

The average elevation is about 2 m above sea level with a maximum elevation of 10 m. The exclusive economic zone totals around 2 million square metres (SOPAC, 2007). The atolls and islands are made of calcium carbonate minerals and have developed over 150 million years. The atolls generally enclose a lagoon with depth of up to 100 m (USGS, 1997).

The total population of the RMI is 53,158 (27,243 males and 25,915 females), with 74% living in the urban centres of Ebeye (Kwajalein atoll) and Majuro (EPPSO and SPC, 2012).

Marshallese and English are the official languages of the RMI, with Marshallese being the primary language. Culturally, the population still largely follows the traditional matrilineal and chief/clan system.

The economic profile of the RMI is largely dictated by the US economy and the official currency is the US dollar. The establishment of compacts of free association with the US in the late 1980s has seen the RMI's economy and national budget becoming strongly influenced by the scope of economic assistance defined in the agreement. The RMI is also highly dependent on other external aid assistance (UNDP and EPPSO, 2005).

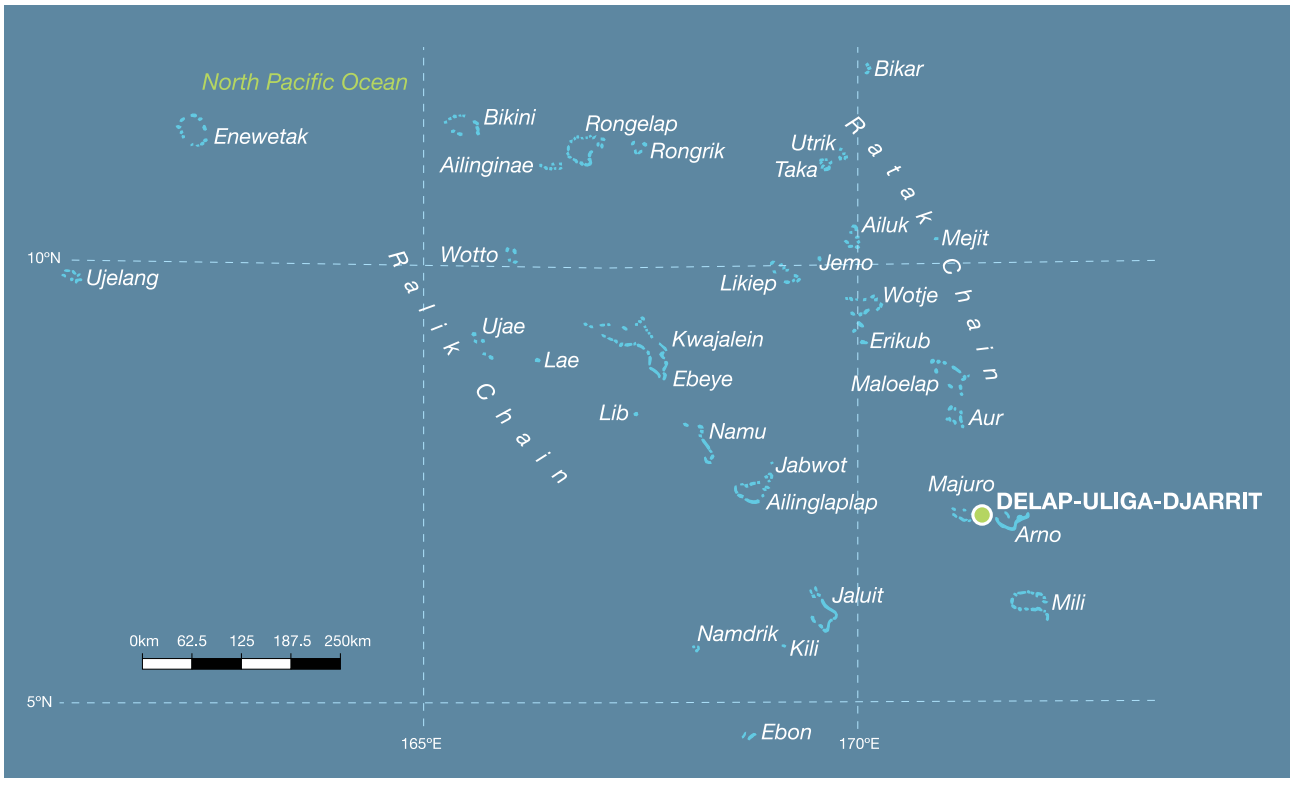


Figure 2. Map of the Marshall Islands (from Australian BoM and CSIRO (2011), with permission).

2.2. Climate

2.2.1. Observed trends

The RMI climate is humid and tropical with mean temperatures of around 27°C. Rainfall varies greatly from north to south, from 1,250 mm of rain per year for the northern atolls to more than 2,500 mm per year in the southern ones. Both Majuro and Kwajalein have a dry season and a wet season that extend respectively from December to April and from May to November (Figure 3) (Australian BoM and CSIRO, 2011).

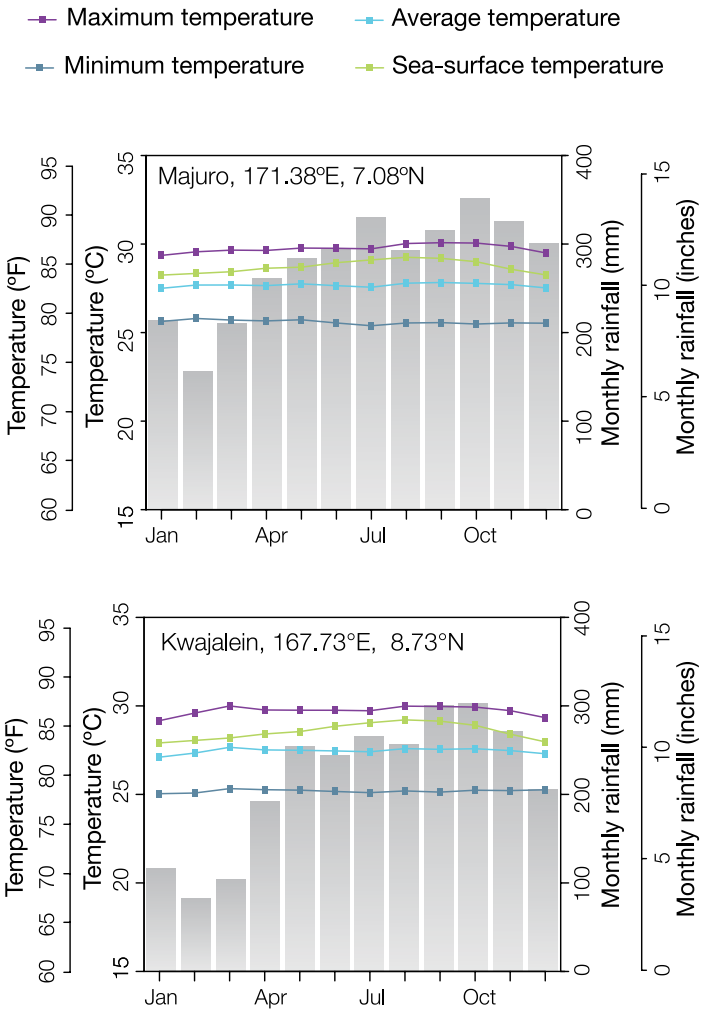


Figure 3. Mean annual climate cycle for Majuro and Kwajalein (from Australian BoM and CSIRO (2011), with permission).

Similar to other Pacific Islands, climate variability is high in the RMI and influenced by El Niño Southern Oscillation (ENSO) events. In the RMI, the El Niño phase will generally bring drier conditions with reduction in average rainfall of up to 80%. In the La Niña phase, conditions are likely to be wetter than normal (Australian BoM and CSIRO, 2011).

During the last 50 years, an increase in temperature and decrease in rainfall has been observed in the region. Sea level, measured since 1993 by satellite altimeters, has risen by about 7 mm per year in the last 20 years. Ocean acidification has also increased since the 18th century.

Three main types of extreme weather events affect the RMI: typhoons (tropical cyclones), droughts and storms. Typhoons are not considered a great risk, as they are normally weak when they pass through the region. Typhoons

normally occur between September and November and tend to be more intense during El Niño years.

Droughts are of greater concern because of the impact they have on the islands' water supply. Occurring generally between 4 and 6 months following an El Niño event (which occurs every 5–9 years), droughts are characterised by a 3–7 month period of lower than average rainfall and a 1–4 month period of less than 50 mm of rain per month (Australian BoM and CSIRO, 2011; USGS, 2005).

2.2.2. Projected trends

The Pacific–Australia Climate Change Science Adaptation Planning (PACCSAP) programme has published trends for the RMI. According to their findings (Table 2), future climate in the region will be characterised by:

- An increase in sea surface and air temperature;
- More extreme events (heat and rainfall);
- An increase in rainfall;
- Frequency of drought events could decline;
- Less frequent typhoons;
- Sea level rise and ocean acidification will continue.

Table 2. Trends in future climate for RMI (Australian BoM and CSIRO, 2011).

Projected trend	Confidence
Increase in sea surface and air temperature: By 2030, increase in temperature could reach up to 0.4 to 1°C	Very high
Increase in frequency of extreme heat days: This is a result of global increase in temperatures	Very high
Mean sea level will continue to rise: By 2030, sea level rise could have rise of 3 to 16 cm	Very high
Ocean acidification will continue to rise	Very high
Annual and seasonal mean rainfall is expected to rise: All global climate models show an increase in average rainfall. However, there are some uncertainties on the values	High confidence
Increase in frequency of extreme rainfall days: This is a result of global increase in rainfall	High confidence
Drought events are expected to decrease	Moderate confidence
Number of tropical cyclones are expected to decrease	Moderate confidence

3. THE WATER SECTOR

3.1. Overview

3.1.1. Water resources

Freshwater resources are scarce in RMI (Table 3). There is no surface water, and on all islands rainwater is the primary source of freshwater. Reliance on rainwater puts the country at high risk from drought events.

In Majuro, fresh groundwater is extracted in Laura, on the western part of the Island. The groundwater is heavily relied upon especially during drought periods. However, this poses a health problem because of bacterial contamination and salinity. There are little data available on the groundwater reserves of outer islands and atolls.

Other water resources include seawater and brackish groundwater. While seawater resources can be used only for toilet flushing purposes, brackish groundwater offers more flexibility of use depending on its salinity and quality (e.g. toilet flushing, laundry, washing dishes, cooking, personal bathing) (SOPAC, 2007).

Table 3. Freshwater resources in RMI (SOPAC, 2007).

	Majuro	Kwajalein	Northern islands	Southern islands
Rainwater availability	Average: 3,300 mm per year Extreme drought: 50 mm/month	Average: 2,540 mm per year Extreme drought: 40 mm/month	Average: 1,250 mm per year Extreme drought: 20 mm/month	Average: 2,540 mm per year Extreme drought: 40 mm/month
Groundwater availability	Some freshwater lenses. Main site at Laura: estimated yield 1,500 m^3/day	Some freshwater lenses, mostly non-exploited	Mostly brackish. Some islands have thin freshwater lenses	Mostly brackish. Some islands have thin freshwater lenses

3.1.2. Water supply

Most of the households in RMI are equipped with rainwater harvesting facilities (except on Kwajalein). Domestic access to groundwater is limited in most communities, and public groundwater reticulation (piped water) is only available in some parts of Majuro Island. Public water infrastructure varies greatly from reticulated water supply in Majuro and Kwajalein (Ebeye) to no public infrastructure in some of the outer islands (Table 4).

Table 4. Water supply infrastructure on the islands of RMI.

	Majuro	Kwajalein	Outer islands
Rainwater	Public: Reticulated network Private: 70% of HHs are equipped with RH facilities	Public: None Private: 22% of HHs are equipped with RH facilities	Public: None Private: >90% of HHs are equipped with RH facilities
Groundwater	Public: Borehole production field at Laura. Capacity: 100,000 gallons daily Private: Limited information available	Public: None Private: One private well	Public: None Private: Limited information available
Desalinated water	Public: None Private: Some businesses have small RO units	Public: Reticulated RO water to the Ebeye district	Public: Emergency small RO plants have been delivered to most outer islands during the last drought in 2013
Brackish groundwater	Not widely used	Not widely used	Not widely used
Sea water	Public: Reticulation system to most households and businesses in DUD and Rairok district	Public: Reticulation system to most households and businesses in Ebeye district	None

DUD = Djarrit, Uliga, Delap, HH = household, RH = rainwater harvesting, RO = reverse osmosis. (Source: SOPAC, 2007; OEPPC, 2010.)

3.1.3. Public water supply in Majuro

This section describes in more detail the public freshwater supply in Majuro, which is the focus of the PACC demonstration project.

WATER INFRASTRUCTURE AND SERVICES

Majuro's public water network uses both rainwater and groundwater to supply Majuro's main populated areas (the communities of Djarrit, Uliga and Delap (DUD), and Rairok). The rainwater is collected from the paved runway at the international airport and pumped to a series of six raw water reservoirs (Figure 4) before passing through a small treatment plant.

Figure 4. Rainwater catchment and storage at Majuro International Airport (from Google Earth, 2013).

The treatment plant consists of two sand filter units and one chlorination chamber. The water is then pumped into the potable water reservoir before being pumped into the pipe network and distributed. Water is also delivered via tanker truck to other locations outside the water network (Figure 5). In addition, groundwater is extracted at Laura to supply the population of Laura and Ajeltake.

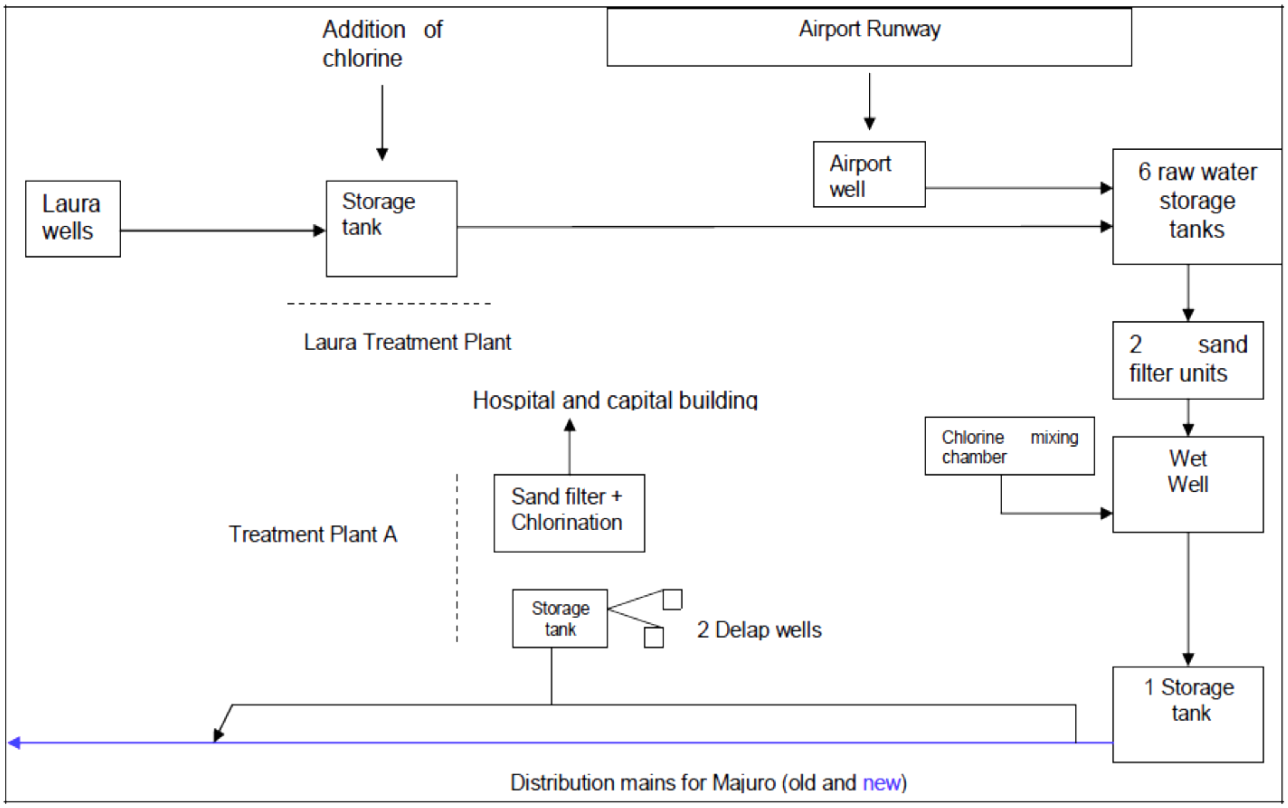


Figure 5. Majuro water reticulation network (SOPAC, 2007).

Groundwater extraction and supply is currently not under legal regulation. Previously, groundwater at Laura was piped into the airport water reservoir to supplement rainwater harvesting (Figure 5). However, following the 1998 drought, when groundwater was heavily extracted from Laura to supply Majuro's main districts, the Laura community expressed its concern about the degrading quality of the groundwater (i.e. increase in salinity) and asked to stop the extraction. Thus, in more recent years, the groundwater has only been used to supply the population of Laura and Ajeltake.

About 75% of Majuro's households (3,232) have been connected to the network in the past, however only 19% (841) remain connected as of July 2014. Most have been disconnected due to non-payment of water bills. The recently introduced Water and Sanitation Policy Framework promotes the introduction of new pricing strategies and better monitoring for illegal connections that contribute to water losses.

The current cost of water is dependent on the delivery mode and quantity:

- Pipeline water (residential): $0.006 per gallon;
- Pipeline water (commercial and government buildings): $0.015 per gallon;
- Bulk water – truck delivery: $0.058 per gallon (commercial); $0.045 per gallon (residential) (also varies according to location for delivery);
- Bulk water – collected at facilities: $0.025 per gallon.

It is estimated that 50% of the water harvested from the airport catchment is lost through the system. Losses have been attributed to (by order of magnitude):

- Leakage in the piping network;
- Leakage in the reservoir liners;
- Evaporation from the reservoir;
- Illegal connections.

SANITATION MANAGEMENT

There are two main types of sanitation system in the RMI:

- Seawater flushing and reticulated sewerage: Seawater is piped to houses and buildings and the effluent is directly discharged into the sea (if connected), or into septic tanks or cesspits;
- Septic tanks/cesspits: Freshwater or brackish groundwater is used to flush toilets down to a septic tank or cesspit.

Seawater is reticulated to the main populated districts of Kwajalein (i.e. Ebeye) and Majuro Atoll (DUD and Rairok). Other areas commonly use septic tanks or cesspits. In some urban centres, sewage trucks are available to discharge septic tanks. There are no functional sewage treatment plants in RMI.

3.2. Institutional and policy context

3.2.1. Institutional framework

The institutional capacity of the water sector has historically been low, especially because roles and responsibilities are fragmented among different agencies. However the capacity of the water sector has substantially improved since the start of the PACC project in RMI.

The main stakeholders in the water sector are as follows.

- The Environmental Protection Agency (EPA) is mandated to preserve and regulate the quality of the environment of RMI. The national water quality monitoring laboratory is housed at the EPA. EPA is also the focal point for the Pacific IWRM project.
- The Majuro Water & Sewer Company (MWSC) is in charge of the operation and maintenance of the public water distribution and sewerage network on Majuro Atoll.
- Kwajalein Atoll Joint Utility Resources (KAJUR) is the power, water and sewerage utility in charge of operation and maintenance of the public water distribution and sewerage network on Ebeye within Kwajalein atoll.
- Majuro Weather Station (MWS) is in charge of rainfall monitoring.
- The Office for Environmental Planning, Policy and Coordination (OEPPC) is the regulatory agency in charge of drafting policies and plans for the environment sector (including water resources). OEPPC is also coordinating climate change activities and hosts the PACC project.
- The Economic Policy, Planning and Statistics Office (EPPSO) is the regulatory agency for economic development and statistics (including water infrastructure planning).
- The Office for Disaster Management (ODM) is responsible for disaster management including drought.
- The Project Management Unit of the Ministry for Public Works (PMU) is responsible for infrastructure maintenance and development (including some water infrastructures).
- The College of the Marshall Islands Land Grant Program (CMI Land Grant) is providing support to ongoing projects such as awareness and training activities in relation to climate change and water, as well as funding to EPA for water monitoring activities.
- Women United Together for the Marshall Islands (WUTMI) is the largest NGO in the country, and is actively involved in most sectors, including water and climate change.

With many agencies involved in the water sector, coordination and planning is a major issue. Recently the IWRM task force was created under an initiative from the Pacific IWRM project in collaboration with the PACC project. The task force comprises the heads of department of key agencies and is chaired by the Chief Secretary, who is also Chairman for the National Advisory Committee on Climate Change (Figure 6).

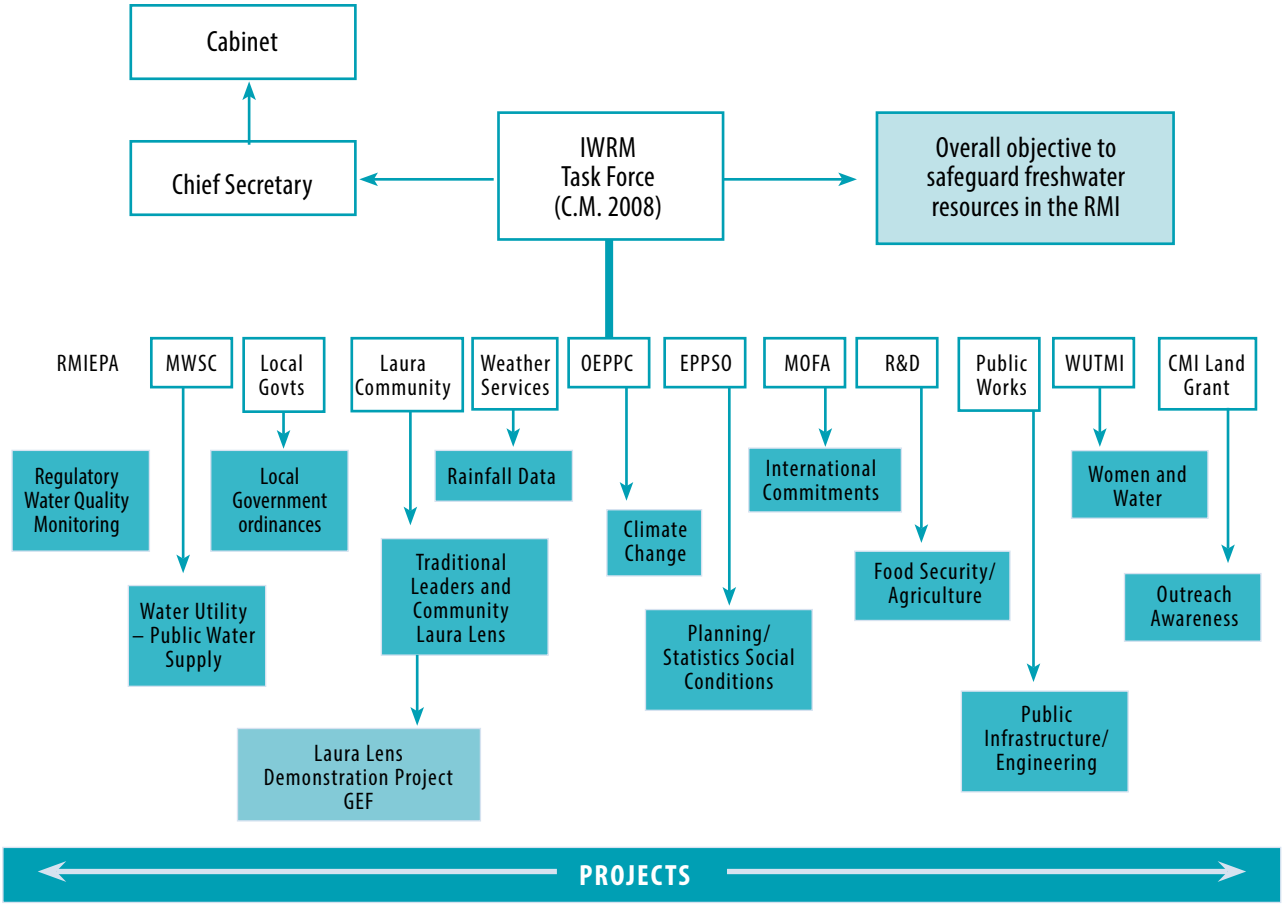


Figure 6. Institutional framework for the water sector (Tibon and Manase, 2010).

3.2.2. Policy context

The National Climate Change Policy Framework (2012) incorporates water issues under 'food and water security'. More recently, the JNAP also includes some water activities (see Table 1).

Recognising the need to increase institutional capacity for the sector, an IWRM task force chaired by the RMI EPA has been taking the lead in developing the Water and Sanitation Policy Framework. Approved by Cabinet in early 2014, the Policy is likely to drive important changes in the sector, notably for the management of water and sanitation services. Under the Policy, five main areas are being addressed:

- Waterborne illness;
- Resource sustainability;
- Water and sanitation services;
- Target the disadvantaged;
- Climate variability and extreme events.

3.3. Climate risks, vulnerabilities and impacts

Climate change is likely to exacerbate current threats for the water sector. The following risks have been prioritised by potential impact on the sector.

SEA LEVEL RISE

The steady rise in mean sea level poses a serious threat to the country. With a very low elevation, the entire country is exposed to the risk brought by sea level rise. Specific risks to the water sector include saltwater intrusion into the water systems, and damage to water infrastructure. Soil will also be affected by seawater and food crops will be at risk. Indirectly, there will be health implications due to drinking water scarcity. Other risks include the exacerbation of current threats such as coastal erosion, inundation, storm surge and reduction of groundwater resources (i.e. reduction of recharge area and saltwater intrusion).

MORE EXTREME EVENTS

Extreme events such as heavy rainfall and drought could become more intense. Recent climate change scenarios are projecting a possible reduction of drought events for the RMI. However, an increase in drought intensity (duration and reduction in average rainfall) will seriously threaten the country, which relies intensively on rainwater for its freshwater supply. Heavy rainfall events, although an opportunity to collect more water, bring the risk of floods, with related socio-economic issues.

TYPHOON/STORM SURGE

Typhoons and storm surges, although not a major risk for RMI, could pose a serious threat to water infrastructure which is located very close to the coast. Related impacts also include flooding and damage to the natural environment.

3.4. Non-climate drivers (risks/impacts)

Non-climate drivers that affect the water sector include the following.

POPULATION

Population growth, especially in the main urban centres of Majuro and Kwajalein, is increasing the demand for water, putting more pressure on the water supply.

POLLUTION

Contamination of the groundwater with sewage effluent is a recurrent problem in low-lying atoll islands. In Majuro, regular monitoring of the groundwater in Laura indicates variable concentrations of *E. coli*. Monitoring of the water reticulation system also indicates high concentrations of *E. coli* and total coliform bacteria. Infiltrations of sewage and storm water into the system and illegal connections are most likely to be the main source of pollution. MWSC recommends the water be treated before use (i.e. boiled). Pollution also affects domestic rainwater harvesting facilities, with typical low maintenance increasing the risk of contaminants entering the system.

POOR GOVERNANCE

Poor governance and management practices are the main issues for the water sector in RMI. This exacerbates other risks such as pollution and population growth, as well as climate-related risks (Figure 7). It is anticipated that the Water and Sanitation Policy and its implementation will drive improvements such as:

- Prioritising activities and identifying agencies responsible for their implementation;
- Reform of the water utility management;
- A clear and transparent budget that will attract more funding.

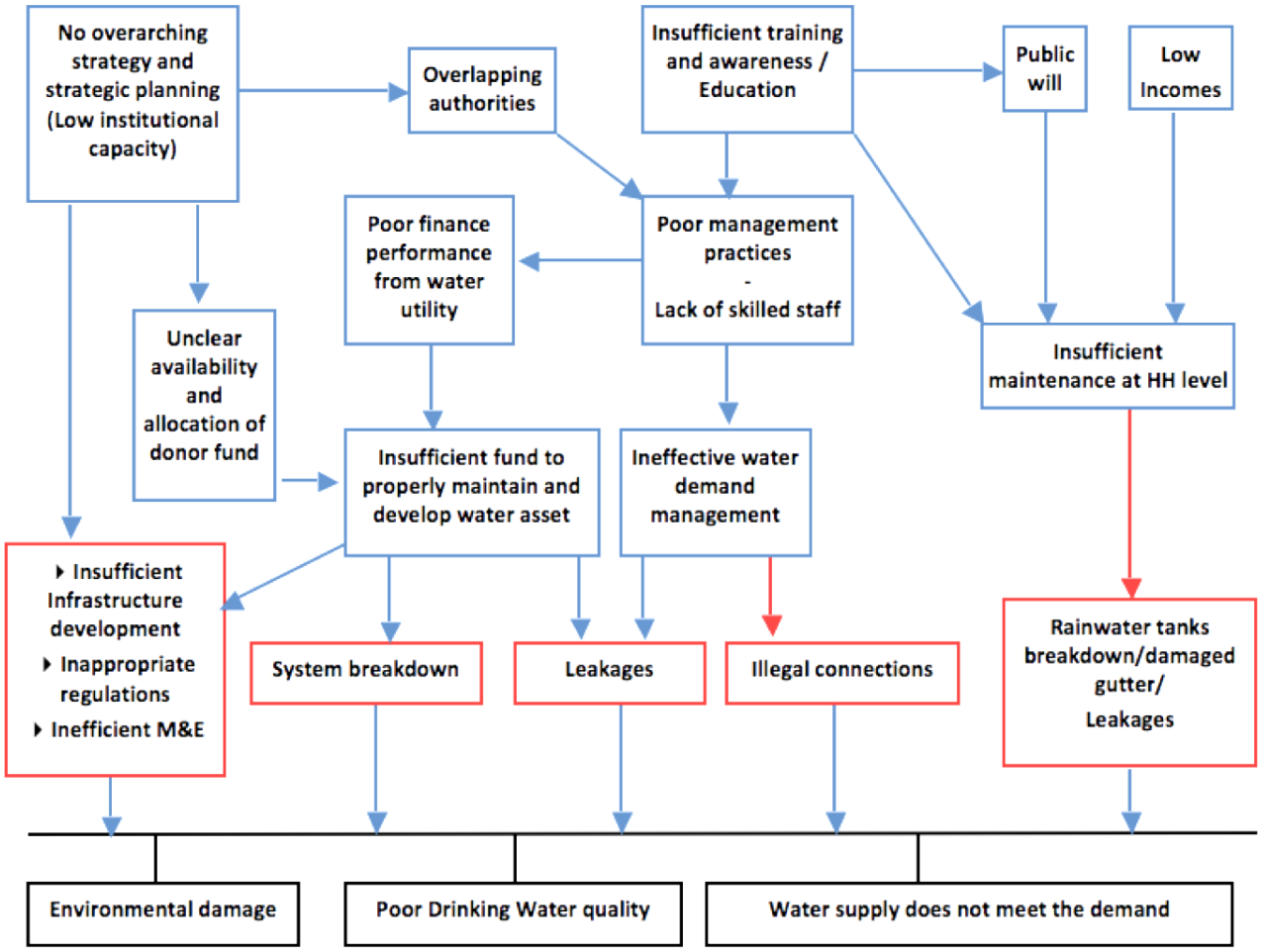


Figure 7. Major risks and impacts linked to poor governance in RMI (2013).

4. THE DEMONSTRATION PROJECT

4.1. Initial priority setting

The water sector was chosen by the RMI government to benefit from the PACC project. The sector was fragile at both governance and infrastructure levels and the PACC project, with components in both governance and on the ground activities, was a great opportunity to improve sector capacity and resilience to climate variability and change.

In order to identify a demonstration project that best addressed the water sector's issues with climate variability and climate change, a review of sector vulnerabilities was carried out by SPREP in 2008. This included consultations with the GEF secretariat and the RMI government (PACC, 2008).

The island of Majuro was prioritised as the site for the project as it is the most densely populated area in RMI, with currently around 52% of the country's population and an annual growth rate of 1.4% (EPPSO and SPC, 2012).

During the initial stakeholder consultations, three project options were identified for Majuro (PACC, 2008):

- Demo 1: Reduce water loss by minimising evaporation from current water storage facilities (proposed budget of US $350,000 with co-financing);
- Demo 2: Reduce water usage from the main water source through provision of an alternative source of water for drought resilience and food security (proposed budget of US $200,000 with co-financing);
- Demo 3: Demonstrate alternative water sources using reverse osmosis and alternative energy sources (proposed budget of US $350,000 with co-financing).

After discussion with the GEF secretariat, the third option was discarded and the remaining two options were redefined:

- Enhancement of the current rainwater storage facility of the public water reticulation network in Majuro.
- Provide an additional water source for the Laura community in order to reduce the use of groundwater resources.

Vulnerability and adaptation (V&A) assessments were carried out to select the most suitable adaptation interventions. For Laura, a V&A assessment was first undertaken in 2011. However, due to the anticipated high cost of the first project option, and because the Pacific IWRM project was focusing on the Laura community with a water project, the PACC team decided to progress with the first project option: enhancing the rainwater harvesting and reticulation network.

4.2. The project site

4.2.1. Current issues

The demonstration project focuses on the public water supply on Majuro Island, described in Section 3.1.3. The water network supplies the densely populated areas of DUD and Rairok, which are home to more than 40% of the total population of RMI.

The water network covers nearly the entire area of Majuro Island, which is the longest continuous landmass in Majuro Atoll, at about 50 km. The water infrastructure is ageing and faces multiples issues:

- 50% of the water that enters the system is lost before delivery;
- The system is able to provide supply for only 7 hours per week, due to losses in the system and scarce water availability;
- Though initially treated with chlorine, the water is likely to become contaminated in the system. The absence of pressure (water) in the network most of the time allows sewage and storm water to enter the system through leakages and illegal connections;

- Poor financial performance of MWSC does not allow sufficient maintenance, repairs and development of the network.

In recent years the RMI government, with the support of the European Union and the Australian Government, has provided numerous rainwater catchment systems to households in the country. However, little effort has been made to enhance the reticulated water supply.

The RMI PACC project team identified the opportunity to improve this vital water infrastructure for Majuro, and demonstrate the benefits of targeted technical improvements and ongoing monitoring to improve resilience to climate variability and climate change.

4.2.2. Socio-economic context

The total population of Majuro Atoll is 27,797. The areas of DUD and Rairok, covered by the water supply network, host 80% of Majuro's population, with a population density of over 2,500 per square metre. The annual growth in population is 1.4%, increasing the stress on the water resources (EPPSO and SPC, 2012).

Majuro is characterised by a relatively high level of poverty (EPPSO and SPC, 2012).

Of the 3,285 households in the DUD-Rairok area, only 25% are officially connected to the municipal freshwater supply service provided by the MWSC (as of July 2014). Around 2,000 of the houses have been disconnected because of unpaid water bills.

4.3. Selection of adaptation interventions

Three assessments were carried out in order to identify the most appropriate and efficient interventions for the water network within the PACC budget:

- V&A assessment;
- Cost–benefit analysis (CBA);
- Technical assessment of and quotation for the proposed work.

4.3.1. V&A assessment

The V&A for the water sector focused on the piped network for Majuro Island, and also assessed the institutional and adaptive capacity of the RMI's water sector in response to climate change (PACC, 2014a).

The methodology used in the V&A included three steps:

- Baseline assessment;
- Vulnerability assessment;
- Identification of adaptation options.

Seven feasible and appropriate adaptation options were identified:

- Install new liners in airport reservoirs;
- Install evaporation covers on the reservoirs;
- Repair pipes in main and distribution lines;
- Improve runaway air vents efficiency;
- Expand airport rainwater harvesting;
- Expand household rainwater harvesting;
- Expand community rainwater harvesting.

The full V&A report has been published as PACC Technical Report No. 5 (PACC, 2014a).

4.3.2. Cost–benefit analysis

A CBA was carried out in parallel with the V&A. The CBA focused on five adaptation options identified by the V&A which related to the airport catchment and piped water supply. The main findings are presented in Table 5.

Table 5. CBA results summary (PACC, 2013).

	1. Reline reservoir	2. Evaporation cover	3. Repair and replace leaking pipes	4. Airport runway maintenance		5. Expand airport catchment	
				(a) Valves	(b) Cracks	(a) Geo-membrane	(b) Asphalt
(1) Present value of costs at 4% discount rate	125,130	53,383	2,029,619	56,026	135,345	801,510	2,024,658
(2) Present value of benefits at 4% discount rate							
Additional water supply	10,829,855	1,019,567	18,805,024	205,111	490,446	3,471,456	3,471,456
Improved health	*Not valued*	*Not valued*	*Not valued*	*Not valued*	*Not valued*	*Not valued*	*Not valued*
(3) NPV = (2) – (1)	10,704,724	966,185	16,775,406	149,085	355,101	2,669,947	1,446,799
(4) BCR = (2) / (1)	86.55	19.10	9.27	3.66	3.62	4.33	1.71

The CBA reported that all options would generate a net benefit for the RMI community. However, budget for the PACC RMI was limited to US$800,000, which had to be taken into account on selecting options.

Within the budget, the options that would generate the greatest net benefits for the community were therefore identified by the CBA to be:

- Install new liners;
- Install evaporation cover;
- Fix a portion of the pipeline.

More detail on the CBA is given in PACC Technical Report No. 2 (PACC, 2013).

In order to assess the relevance and feasibility of installing new liners and evaporation covers in the airport reservoirs (the preferred adaptation options), the Australian company Fabtech was requested to carry out a technical assessment and provide a quote for the work.

4.3.3. Technical assessment and quote for liners and covers

In parallel, and to provide figures to feed into the CBA, the company in charge of supplying and installing the existing liners at the airport reservoir in 1998 (Fabtech) was contracted to conduct an assessment of the current liners, provide quotes, and propose a workplan to carry out these interventions.

Following the assessment, it was suggested to:

- Replace liners in storage tanks 3, 4 and 5;
- Install a new floating cover in storage 3 to reduce evaporation;
- Replace timber battening with aluminium battening on all reservoirs.

The price for this work was quoted at US $496,856 (in January 2012).

4.4. Objective and targets

The main objective of the demonstration project is to increase water security in the RMI in times of drought. With a set of activities selected for the demonstration project, PACC RMI defined the following targets to be reached in order to achieve the objective:

- By 2017, 90% of water samples meets WHO standards;
- By 2017, 90% of the population has access to safe drinking water;
- By 2016, 80% of the leaks are repaired and/or infrastructure replaced;
- By end of 2014, the percentage of water retention in the reservoir is increased from 50% to 70%;
- In time of drought, the water delivery in the MWSC reticulated system is 2 hours per day every day;
- By the end of 2014, Majuro communities have access to a minimum of 47 days of water during drought;
- By the end of the project, evaporation from the storage tanks is reduced to 2 mm per day;
- By the end of 2014, there are no leaks from storage tanks;
- By the end of the project, total water leakages are reduced by 50%.

This set of targets was integrated into the project logical framework in order to monitor the progress of the project in reaching its objective. The monitoring and evaluation process is detailed in Section 4.11.

4.5. Project process

The process used by the RMI PACC team for its demonstration project can be divided into three main phases: inception, design, and implementation (Figure 8).

Community engagement was an ongoing part of the process, and is described in Section 4.8. Monitoring and evaluation was also part of the process from the start of the project and is detailed in Section 4.11.

INCEPTION

- Establishment of the PACC core group (coordination group)
- Identification of two recipient communities/project sites
- V&A for 1. The water sector in Majuro and 2. Laura community
- Scope of project reduced to one site: Water reticulation network in Majuro
- Identification of possible demonstration activities for the water reticulation network in Majuro

DESIGN

- Technical assessment and quote for upgrade of the airport reservoirs
- CBA between adaptation options identified in the V&A
- Evaluation of evaporation rate at the airport reservoirs
- Ordering of bulk meters to assess leakages in the piped network
- Approval of co-financing of the reservoir works with MWSC
- PACC+ technical evaluation for additional funding

IMPLEMENTATION

- Installation of bulk meters and training of one permanent staff at MWSC in leak detection
- Contracting of Fabtech for provision of liners and covers for the reservoir and support for installation
- Installation of covers and liners at the airport reservoir
- Ribbon cutting ceremony

Figure 8. Milestones for the project process.

4.6. Design phase

The design phase that started in 2011 was lengthy, partly due to a change in directorate at MWSC, PACC partner agency on this project, and the need to renegotiate financial arrangements.

Following the renegotiation, PACC and MWSC started working together in identifying the technical challenges faced by the network. As described in Section 4.3, three technical assessments were conducted and the options were prioritised as follows:

1. Install new liners;
2. Install evaporation cover;
3. Repair a portion of the pipeline.

Considering the expected extent of the leakages in the pipeline, repairing/replacing parts of the pipeline was outside the budget of the PACC project. It was therefore decided to focus on the leaks in the reservoirs while assisting MWSC in assessing the extent of the leakages in the pipeline. To do that, PACC agreed to supply bulk meters, cover costs of training in leak detection for one staff member of the MWSC, and co-finance (with MWSC) the purchase of a car to conduct the leak detection activity.

For the reservoir works, MWSC agreed to co-finance the project using US CIP compact funding (i.e. annual grant given to MWSC for infrastructure improvement) up to US $140,000 (to cover all labour work). The remaining costs were US $550,000, but the PACC project did not have enough money at this stage to go ahead with the implementation of the project. At this stage, the Australian Government (AusAID) expressed interest in providing additional funding to the PACC programme (PACC+) for replication and upscaling of successful demonstration projects. This was a opportunity for the PACC RMI project, and following review, it was agreed that PACC+ would provide an additional $450,000 to assist the implementation of the current demonstration project and fund an additional project (see Section 4.12).

The design drawings are reproduced in Appendix 1.

4.7. Implementation

The implementation was done in two phases, due to funds availability.

4.7.1. Leak detection

The leak detection activity was implemented in 2013. One staff member from the MWSC was provided with training in leak detection and a car was purchased to conduct the fieldwork. Bulk meters were also purchased, delivered and installed in 2012–2013 (Figure 9).

Figure 9. A bulk meter installed in a manhole on the pipeline. Photo: Louis Bouchet.

Bulk meters are used to measure the total water flow that is being distributed through the treatment plant and to the main supply pipes. The total flow that is measured as the water 'exits' the treatment plant to 'enter' the main supply line is then compared to the total water volumes received by customers (through their households water meters. The difference between the two is called the non-revenue water. Non-revenue water is usually attributed to illegal connections or leaks in the system.

MWSC is now also able to carry out leak detection work, which helps ascertain the state of the reticulation network. Leaks are repaired if within MWSC capacity. For bigger leaks or when a part of the pipeline has to be changed, additional funding has to be sourced.

4.7.2. Enhancement of the airport reservoir

The work at the airport reservoir was completed in the first half of 2014. The materials for the reservoir liners and covers (geomembrane) were shipped from Canada, and arrived in Majuro in January 2014. The work at the site started the same month. The contracted company Fabtech Australia sent a consultant to work alongside MWSC staff in relining storage tanks 3, 4, and 5 and installing the cover on storage tank 3 (Figure 10). The work was scheduled to be completed in June, but favourable weather and availability of local heavy machinery meant it was completed early, within 2 months. The ribbon cutting ceremony was held in April 2014.

The airport reservoir can now function at full capacity (holding 36.5 million gallons compared with 31 million prior to the PACC intervention). This brings the water availability up to 1–2 months of supply during a drought period. This is a major improvement for the network that serves most of Majuro's population.

Figure 10. Airport reservoir (storage tank 3), showing the new lining. Photo: Joseph Cain.

4.8. Community engagement and awareness

To raise awareness of climate change and support for the demonstration project, the RMI PACC team developed a Communications Plan and implemented the following activities.

- An outreach awareness programme on water and climate change, in coordination with CMI Land Grant, Ministry of Education, Ministry of Internal Affairs, and WUTMI. The PACC team took part in visits to Ebeye, Jaluit and other atolls to conduct awareness raising.
- The team visited elementary schools in Majuro to conduct climate change awareness, as well as presenting to various youth groups such as the Uniting Church Youth Group and Youth to Youth in Health.
- The PACC team regularly presented at national conferences, including the annual WUTMI conferences, the Protestant Church Youth Rally and the Marshall Islands Mayors' Association (MIMA) annual conferences.
- The team carried out consultations with the Laura community on the Water and Sanitation Policy in collaboration with IWRM EPA, Majuro Atoll Local Government and MWSC.
- A survey, needs analysis, and awareness raising on climate change and disaster preparedness was conducted in Laura village in June 2011. All of the participants were women.
- The PACC project co-financed some of the materials for the CMI Land Grant 4-H water quality testing awareness program on Majuro and outer islands. The project also collaborated with CMI Land Grant, CMAC, RMIEPA, MICS and Youth to Youth programs to conduct water quality testing and training for the communities on Ebon atoll.
- PACC supported and co-financed national events such as the Ministry of Education's Education Week, World Water Day, Biodiversity Week, and Ramsar events. Pens, T shirts and caps with the PACC logo were made and distributed to participants at events.
- A climate change and renewable energy workshop was held at a University of the South Pacific (USP) summer camp.

4.9. Gender mainstreaming

In RMI, gender equality is relatively low. The proportion of women in parliament (3%) or holding executive positions is low. Salary disparities between men and women are also common within the country.

However, the council of Iroij (Chiefs) has roughly equal number of males and females. The council does not hold much legislative power, but does have considerable influence on matters relating to traditional land tenure and customary rights (UNDP and EPPSO, 2005).

The group Women United Together Marshall Islands (WUTMI) has been involved with the project since early stages. WUTMI was invited to join the PACC core group, and has been an active member, i.e. has been present at most of the meetings. An MoU was signed in 2012, strengthening the relationship between PACC and WUTMI and ensuring representation of women in PACC activities. PACC and WUTMI have also collaborated on awareness raising activities (Section 4.8).

An emphasis on gender was brought into the PACC programme midway through the project. Efforts were made by the Regional Programme Management Unit to increase gender awareness of the PACC project teams, to analyse gender implications of climate change impacts and of project interventions, and to begin collecting gender-responsive data to better understand gender effects. As M&E progresses, and sex-disaggregated data are collected, it should be possible to define benefits of the project to women and to men.

4.10. Communications and knowledge management

The project addressed communications and knowledge management at different levels, and both formally and informally.

Community engagement both on Majuro and other islands was guided by a communications plan developed early in the project. Activities for community engagement are described in Section 4.8.

Other key target audiences were identified by the project, at both national and regional levels, and communications products were developed and disseminated. Examples include news stories published on the PACC webpages (www.sprep.org/pacc; for example *New reservoir increases water security on Majuro*), and further circulated in the online magazine Climate Change Matters; a 'country brief' describing the project and targeting decision makers across the region; and various technical reports targeting primarily other climate change practitioners in the region, such as details of the CBA (PACC, 2013) and the V&A assessment (PACC, 2014a) carried out by the project. Information and case studies were also drawn from the RMI PACC project in synthesis publications, in particular the *PACC Experiences* series (see for example PACC Experiences No. 4: Building resilient freshwater systems).

For communications and knowledge management targeting audiences beyond RMI, the PACC webpages (www.sprep.org/pacc), and in particular the RMI project webpage (https://www.sprep.org/pacc/marshallislands), has been the main dissemination tool used to share information and knowledge generated by the project. Outputs are also being shared through the Pacific Climate Change Portal, and other online information hubs, such as the Climate & Development Knowledge Network (CDKN), Eldis and ReliefWeb.

4.11. Monitoring and evaluation

From the design phase until project completion and beyond, monitoring and evaluation (M&E) is vital to control and correct project activities in order to ensure that the project delivers its expected outcomes. For the PACC project, the RMI team has been reporting quarterly on project activities. This includes reports on progress, issues, gaps and needs, lessons learnt, risks and recommendations.

The PACC project uses a logical framework (logframe) to monitor progress against the project objectives. For each outcome, a series of targets have been selected. Each target should be achieved in order to reach the project outcomes. Each target is associated with an indicator that is measured and compared against the baseline value (i.e. value at the start of the project) to evaluate progress. As much as possible, quantitative indicators are used to monitor progress (Table 6).

Table 6 describes the indicators, targets, and methods of data collection for the RMI PACC project. MWSC is responsible for most of the M&E activities.

Some targets are already (at mid 2014) being reached, such as:

- Evaporation cover and liners installed at airport water storage;
- By the end of 2014 Majuro communities will have a minimum of 47 days of water during drought;
- No water losses from airport water storage by end of 2014.

The main activities of the demonstration project (i.e. replacement of liners and installation of covers) had only recently been completed at the time of writing. Thus, it is too early to evaluate progress and results at this stage.

Table 6. Extract from the logframe for the PACC demonstration project.

Outcome 2: Increased water security in RMI in times of drought through demonstration measures to improve water retention			
INDICATOR	**SOURCE / DATA COLLECTION METHOD**	**BASELINE**	**TARGET**
% water samples meeting Ministry of Health (or WHO) standards	EPA lab/ IWRM	EPA lab	90% of water samples meets WHO standards
% population with access to water (gender disaggregated)	Census 2011	Only 8.6% have access to public piped water 79.1% with rainwater catchment and 10.3% use bottled water	By 2017, 90% have access to safe drinking water
Litres of loss and demand side management	MWSC monitoring log	50% water loss from leaks and illegal tapping	By 2016, 80% of leaks repaired and/or replaced
Water loss reduced (evaporation)	MWSC assessment report	50% loss from evaporation and leakages	By end of 2014, % of water retention in the reservoir increased from 50% to 70%
DUD area in Majuro and outer islands level of access to potable water during drought	MWSC monthly monitoring log sheet and report	Currently water delivery in the MWSC reticulated system is cut to 2 hours/day for 2 days a week in times of drought	Water delivery in the MWSC reticulated system is 2 hours/day for 7 days a week in times of drought
Number of days DUD households have access to water in times of drought	MWSC monitoring log report	28 days of water access by DUD area in Majuro during drought	By the end of 2014 Majuro communities will have a minimum of 47 days of water during drought
mm of water lost from evaporation and leakages	MWSC weekly monitoring Monitoring program database Monitoring logsheet Preliminary assessment report	3.4 mm/day evaporation rate reported	By the end of the project, evaporation will be reduced to 2 mm/day
m^3 lost due to water losses	As above	Tank 4 leaked 50,000 m^3 a year	No water losses from airport water storage by end of 2014
m^3 or number of litres lost due to water losses in water pipes	As above	50% of water in pipes is lost	By the end of the project water leakage reduced by 50%

4.12. Upscaling and/or replication (PACC+)

In May 2013, an exercise was undertaken to identify recommended countries for up-scaling of demonstration interventions (under PACC+, with funding from the Australian Government). Even though PACC RMI had not fully implemented its adaptation project at this stage, it was selected because all technical assessments were completed and its ambitious demonstration project needed additional funding to be implemented. Also at that time, the RMI was experiencing a severe drought and had declared a 'state of disaster'. This contributed to the decision to also use PACC+ funds for a different intervention on the outer islands of RMI: installing solar purifiers, which had been demonstrated in Nauru under the Nauru PACC project, at health centres.

4.12.1. Solar purifiers for outer islands of RMI

This replication activity was based on the success of the solar purifiers demonstrated under the PACC project in Nauru. The solar purifiers can produce up to 20 litres of clean freshwater per day per unit from any source of water (e.g. groundwater or seawater). Solar panels use the sun's heat to evaporate the water, which leaves behind contaminants such as salt or bacteria. The water that condenses from the unit is pure drinking water.

It was decided that five islands, which were severely affected by drought, would benefit from the project: Wotho, Ujae, Meijit, Lip and Jaluit. The solar purifiers would be primarily installed at health centres. Installing the solar panels in RMI's outer islands directly addresses strategy 5.1.4 of the country's JNAP: Examine feasibility of centralized and households solar powered water purification/desalinization systems for the Outer Island.

A total of 168 solar purifiers and 56 solar pumps were purchased from the Australian company FCubed at a cost of US $90,000, and arrived in Majuro in February 2014. In June 2014, on the island of Jabor, Jaluit Atoll, His Excellency President Loeak officially commissioned the delivery, installation and maintenance of the solar water purifiers. A consultant from FCubed conducted training for the installation and set up of the purifiers in the presence of representatives from the Ministry of Health and CMI Land Grant.

Installation of all the units is expected to be completed before March 2015. An MoU was signed between the Ministry of Health and OEPPC in April 2014 to define roles in the delivery, installation, monitoring and maintenance of the panels and pumps.

As part of the training activity, panels were mounted on a rooftop and monitored daily at the Jaluit health centre (Figure 11). Results showed no *E. coli* or salt in the water, and a daily production rate of 15–20 gallons even during cloudy days, which was better than expected.

Figure 11. Solar purifiers installed at the Jaluit health centre. Photo: Joseph Cain.

5. SUSTAINABILITY, RELEVANCE, EFFECTIVENESS AND EFFICIENCY

5.1. Sustainability

The RMI PACC project activities have only recently been completed, and monitoring over the coming months and years will provide evidence of sustainability. Table 7 summarises the factors relating to sustainability of the project. The following are key issues supporting sustainability:

- Risk of technical failure is very low as no new technology is being introduced;
- Political support is currently strong for the project;
- There are clear short- and medium-term benefits to the community;
- There should be long-term environmental benefits relating to the groundwater lens in Laura.

Table 7. Factors contributing to sustainability of project interventions.

Area	Factor	Details
Socio-cultural	Water demand	Water demand is expected to increase with population growth (1.4% per annum). The demonstration project is expected to be a first step toward meeting the future demand that represent 40% of the total water demand for RMI
	Cultural compatibility	The proposed enhancement does not alter the status quo of water delivery or infrastructure
Infrastructure	Life span	Life span of covers and liners are 15 to 25 years
	Required maintenance	Maintenance of liners and cover does not involve expensive parts replacement, however regular cleaning and careful handling is required. Training in maintenance has been provided by Fabtech The overall rainwater harvesting and supply system needs extensive maintenance, which is a major concern for the sustainability of the project
Political	Political support/ in line with public policy/political agenda	The project is considered a top priority by the government, and this is reflected in the JNAP
Economic	Energy consumption	The project is not expected to affect current energy consumption
	Net benefit/return on investment	Without reforms of the water pricing strategy or a more defined subsidised system, economic return on investment will continue to be negative. This is a serious threat to infrastructure maintenance and development
Environmental	Groundwater resource	Improved water retention in the network will reduce the pressure on groundwater from Laura lens
	Adverse effect on environment	None identified at this stage
	Climate resilience	Improvement of the infrastructure has increased resilience to drought Liners and cover are vulnerable to sun damage. The overall rainwater harvesting and supply system is vulnerable to typhoons, storm surge, extreme drought and sea level rise

A major need for sustainability of the project is institutional reform of the sector and the development of mechanisms to finance the maintenance and further development of the water infrastructure. Without such mechanisms in place, the current project is at risk of only 'patching' the problem.

The Water and Sanitation Policy Framework, developed as a collaboration by PACC, the IWRM project and the RMI government, aims to drive reforms in the sector. In the meantime, the enhancement work and the leak detection programme are providing short- and medium-term benefits while allowing time for the government to carry out necessary reforms.

5.2. Relevance

The PACC demonstration project is strongly relevant to national priorities as it directly fulfils two national priorities under the fifth goal of the JNAP (Enhanced local livelihood and community resilience):

- 1.1.9: Address substantial leakage/waste/evaporation (immediate issue);
- 1.1.10: Address failing and climate-exposed infrastructures (e.g. underground pipelines, airport catchment, reservoirs).

The relevance of enhancing the rainwater harvesting, storage and distribution network in Majuro also lies in the fact that:

- The system already exists and is relied upon by most of Majuro's population for their water needs;
- It uses rainwater, a sustainable source of freshwater, and has the capacity to capture and store enough water to supply most of Majuro's population for 3–4 months during a drought period;
- Current projections for future climate indicate the probability of an increase in rainfall, which will enable the system to supply more water.

5.3. Effectiveness

The adaptation interventions of the PACC project are proving effective. The new liners have brought the storage capacity from 31 to 36.5 million gallons, which brings the water availability from a few weeks up to 1–2 months of supply during drought periods.

As the main activities of the demonstration project (i.e. replacement of liners and installation of covers) had only recently been completed at the time of writing, it is too early to assess progress on most of the targeted results. However, some targets are already being reached such as:

- Evaporation cover and liners installed at airport water storage;
- By the end of 2014 Majuro communities will have a minimum of 47 days of water during drought;
- No water losses from airport water storage by end of 2014.

5.4. Efficiency

In low-lying atolls with no surface water and limited groundwater, rainwater harvesting is one of the cheapest options to obtain potable water. In Majuro, with a yearly rainfall averaging 3,300 mm, there is an opportunity to capture a considerable volume of water. Large rainwater harvesting infrastructures such as the airport catchment and reservoir in Majuro are not so common in the Pacific, mainly because of the high up-front cost (compared to desalination). However, once implemented, such infrastructure can provide water at a much cheaper rate than desalination technologies. It is also less impacting on the fragile atoll environment (i.e. no brine discharge, less energy consumption).

Because the system relies on rainwater, the storage capacity needs to be sufficient to sustain long drought periods. Also, in the case of a reticulation network such as in Majuro, the extensive network is expensive to maintain.

The efficiency of the demonstration project lies in the prioritisation of activities in accordance to the PACC budget. Two main activities were identified as priorities by both government and PACC water experts:

- Repair/reduce leaks in the reticulation network;
- Improve water retention in the reservoirs.

The funding needed to repair (or replace) the entire reticulation network was much higher than the PACC budget. Therefore, the project team decided to develop a leak detection programme instead. This is a cost-effective way to identify, prioritise and repair leaking pipes while additional funding is secured to replace the entire pipeline.

The cost of improving water retention in the reservoir was also higher than the initial PACC budget but with co-financing from MWSC and additional funding from PACC+, the project has managed to successfully implement this activity.

The PACC project has thus mobilised its funding to fully address one of the high priority activities – improved water retention in the reservoir – while providing assistance and supporting the second priority: upgrade of the reticulation network.

6. LESSONS LEARNED AND RECOMMENDATIONS

6.1. Overall

The PACC project in the RMI has been successful in enhancing a vital infrastructure for the RMI. The project has however been challenging to implement, notably because of the low level of coordination between agencies involved in the sector and the technical complexity of the project. The following recommendations were drawn from the experiences of the RMI PACC project team.

1. Efficient coordination and communication is critical. The PACC project is hosted by one government agency and implemented through another agency, requiring excellent coordination for success. Several strategies can be used to improve coordination and communication between agencies. The creation of the PACC core group was important for the implementation of the project. It helped ensure that every important decision was discussed and approved by the majority of the agencies involved in the sector. Bilateral arrangements (such as a Memorandum of Understanding) with other agencies such as MWSC also helped defined the roles and responsibilities of each actor and provided some guarantee on agreed decisions.
2. Support from the regional programme team was also essential to the smooth running of the project, and especially when challenges arose. This included support with financial challenges, but also political challenges within the country, and internal governance issues. The backing of the regional team allowed all of these issues to be managed in a timely way so that the project could progress, rather than being stalled.
3. Technical assessments, carried out at the right stage in the project, are essential for complex infrastructure projects such as the reticulation network in Majuro. The V&A process helped to identify issues with the network and possible adaptation options. From there, MWSC conducted various evaluations to assess the leakages of each storage tank and the loss of water through evaporation. The assessment of the reservoir by Fabtech later confirmed these results and evaluated the costs involved in the adaptation options. Finally, the use of a CBA provided important insight on how to maximise benefits within the given budget. These technical assessments helped design a tailored, relevant and effective demonstration project.
4. There are significant gender aspects to access to water, and the project ideally would have considered gender issues from the start. This would have involved gender analysis of the situation and the problem, and of the proposed solutions. The collection of gender-sensitive data to track changes in gender inequalities is also important, and is recommended in future projects relating to water resources management.

6.2. Step by step

As part of the M&E process, the project team made quarterly reports on progress, issues faced and lessons learned in dealing with these issues. Table 8 summarises the main lessons learned by the PACC team in this way.

Table 8. Lessons learned during the course of the project.

Coordination	• Consultation and close collaboration with other agencies is important to access information and avoid duplication. The collaboration with the Pacific IWRM project, the Sustainable Land Management project and the Second National Consultation projects as well as collaborative partnerships with different agencies on water resources, have been quite successful in implementing some of the activities in the PACC work plan, given the short lead time
Community engagement, awareness and training	• NGOs and other institutions and groups, such as CMI and WUTMI, can be important as both channels for dissemination and sources of information • Even a simple survey requires good planning, such as preparation of materials and questionnaires • Survey questionnaire should be in the appropriate local language
Implementation	• A Memorandum of Understanding between parties concerned with the implementation of a project (e.g. planning/financing agency and recipient agency/community) is a convenient and quick way to define roles and responsibilities during implementation and beyond
M&E	• The M&E process is an effective way to gauge progress of the implementation to improve delivery, allocation, planning and demonstrate the results for accountability • It is important to be familiar with the M&E process at the outset of a project in order to keep track of its progress from the start and prevent and or reduce the incidence/ magnitude of issues

REFERENCES

Australian BoM and CISRO (2011) Climate Change in the Pacific: Scientific Assessment and New Research. Volume 2: Country Reports, Chapter 7: The Republic of the Marshall Islands. Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (CSIRO).

EPPSO and SPC (2012) Republic of the Marshall Islands, 2011 Census Report. Secretariat of the Pacific Community, Noumea, New Caledonia.

GRMI (2001) Vision 2018 – The strategic development plan framework 2003–2018. Government of the Marshall Islands, Majuro.

GRMI (2011) National Climate Change Policy Framework. Government of the Marshall Islands, Majuro.

GRMI (2014a) National Water and Sanitation Policy. Government of the Marshall Islands, Majuro.

GRMI (2014b) Republic of the Marshall Island Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management 2014–2018. Government of the Marshall Islands, Majuro.

OEPPC (2010) Majuro and Kwajalein Atoll Household Water Survey Report.

PACC (2008) Republic of The Marshall Island Project Proposal – Pacific Adaptation To Climate Change Project.

PACC (2013) Informing climate resilient development: The application of cost-benefit analysis (CBA) in the Pacific Adaptation to Climate Change (PACC) Programme. Experiences and lessons learned in the application of CBA to PACC demonstration projects. PACC Technical Report No. 2. SPREP, Samoa.

PACC (2014a) Vulnerability and adaptation (V&A) assessment for the water sector in Majuro, Republic of the Marshall Islands. PACC Technical Report No. 5. SPREP, Samoa.

PACC (2014b) PACC RMI Logframe, 20-07-2014 edit. SPREP, Samoa.

SOPAC (2007) Pacific Integrated Water Resource Management project (IWRM), Republic of the Marshall Islands diagnostic report, SOPAC-SPC, Fiji.

Tibon, J. and Manase, D.B. (2010) Governance and integrated water resource management (presentation). SOPAC-SPC, Fiji http://www.pacificwater.org/userfiles/file/Micronesia%20summit/Day%201d_%20Presentation-governance%20(Deborah-Jorelik).pdf

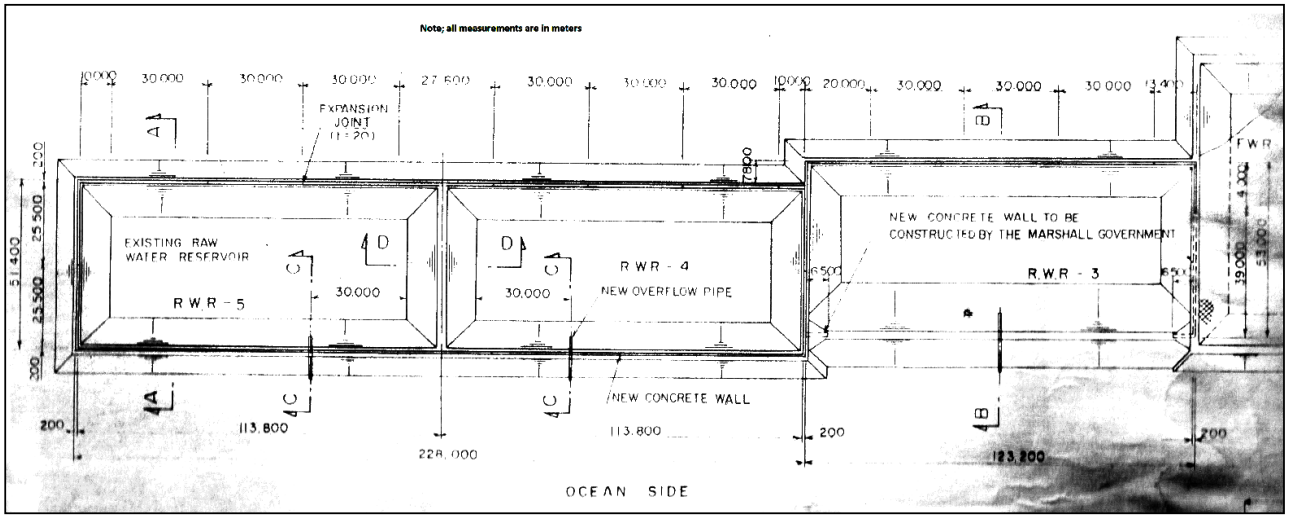
UNDP and EPPSO (2005) Millennium Development Goals National Country Report – RMI.

US Geological Survey (1997) Ground-water Geochemistry of Kwajalein Island, Republic of the Marshall Islands. USGS.

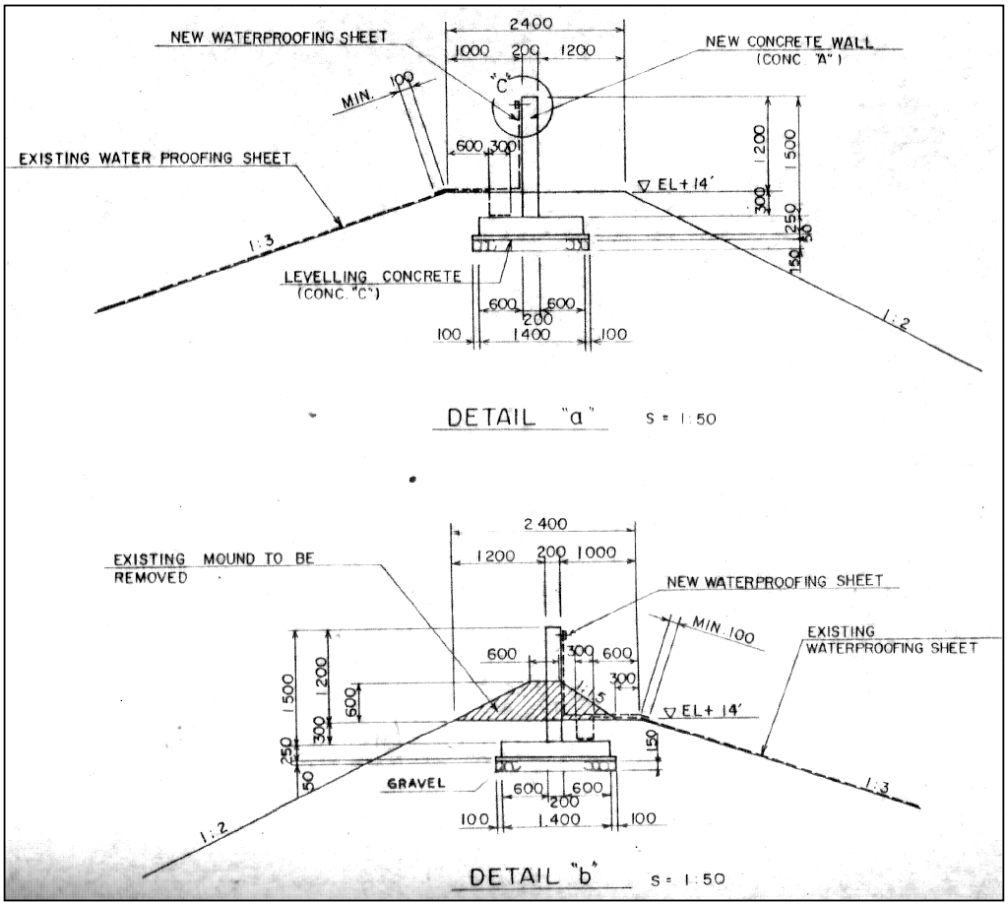
US Geological Survey (2005) Effects of the 1998 Drought on the Freshwater Lens in the Laura Area, Majuro Atoll, Republic of the Marshall Islands. USGS.

APPENDIX 1. DESIGN DRAWINGS

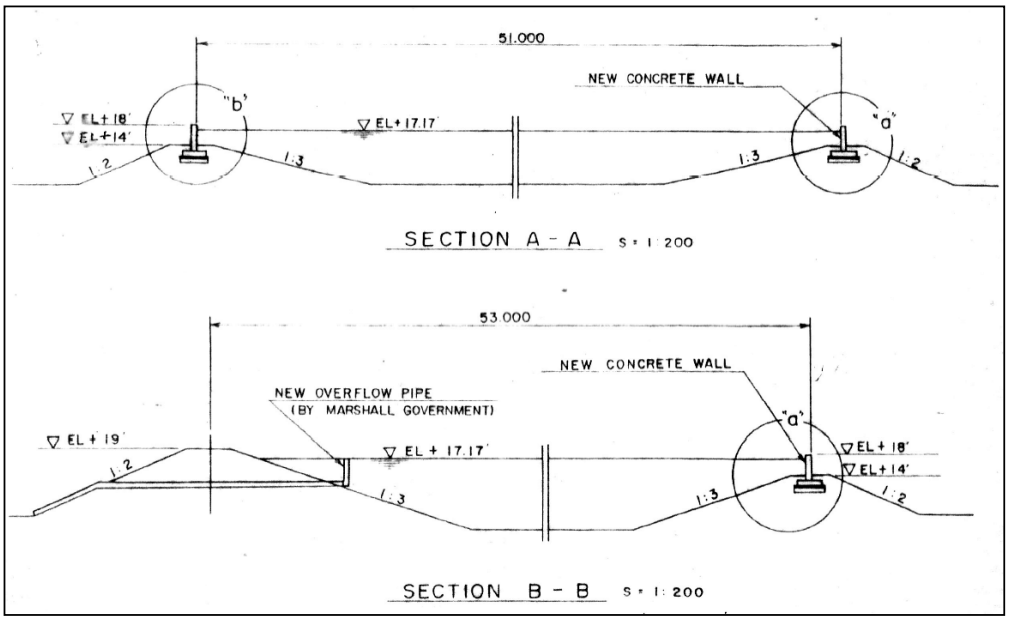
Drawing 1: General layout.



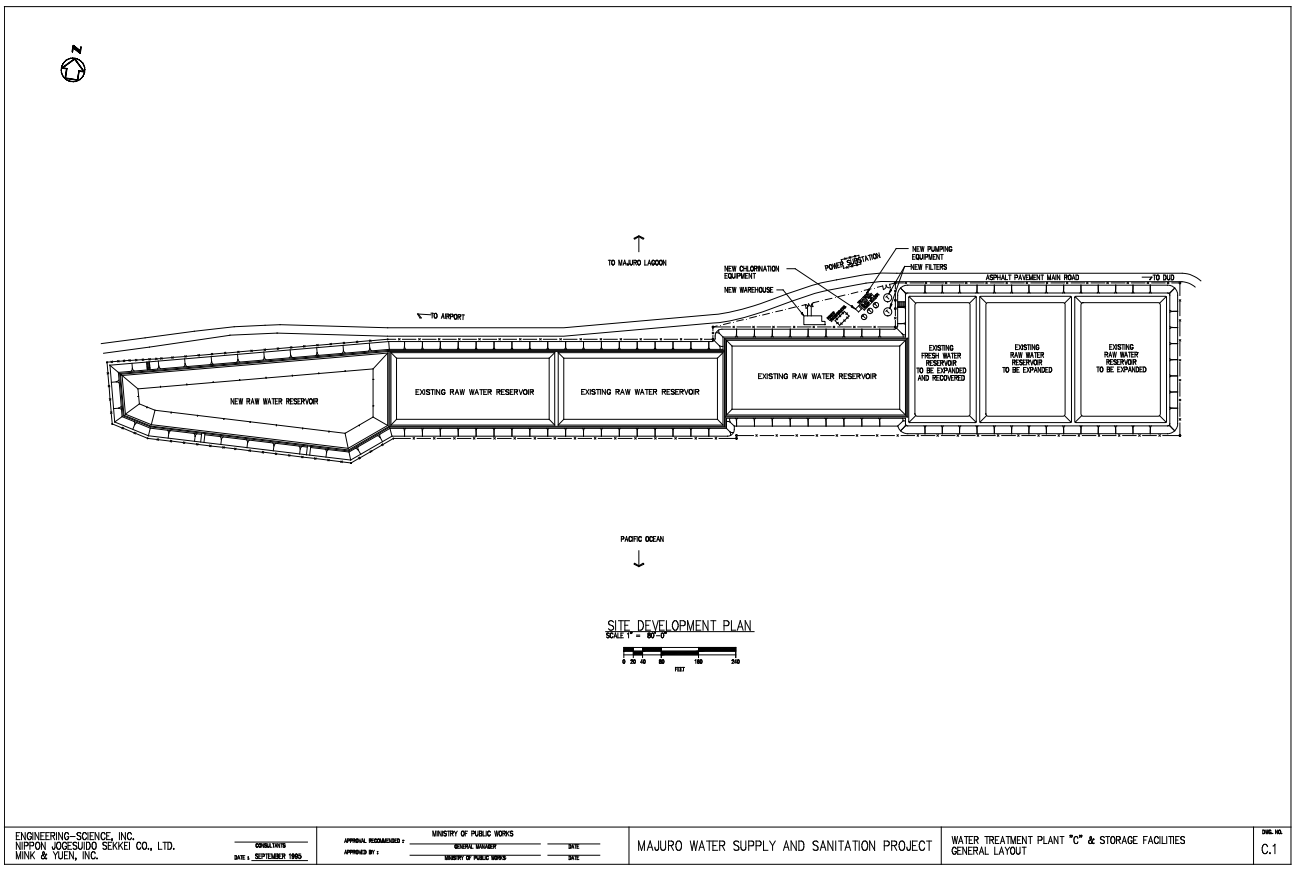
Drawing 2: Reservoirs 3, 4 and 5 plan.



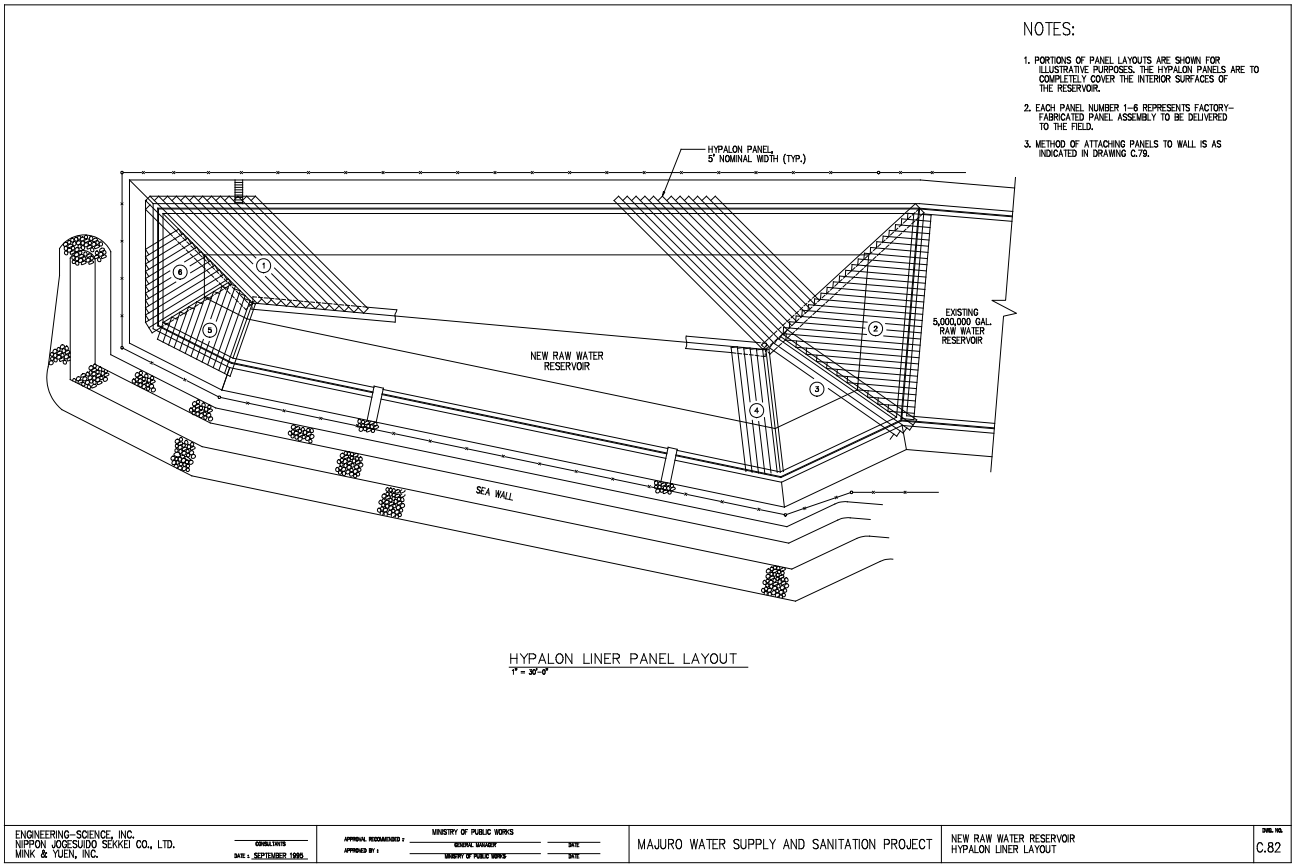
Drawing 3: Detail cross section.



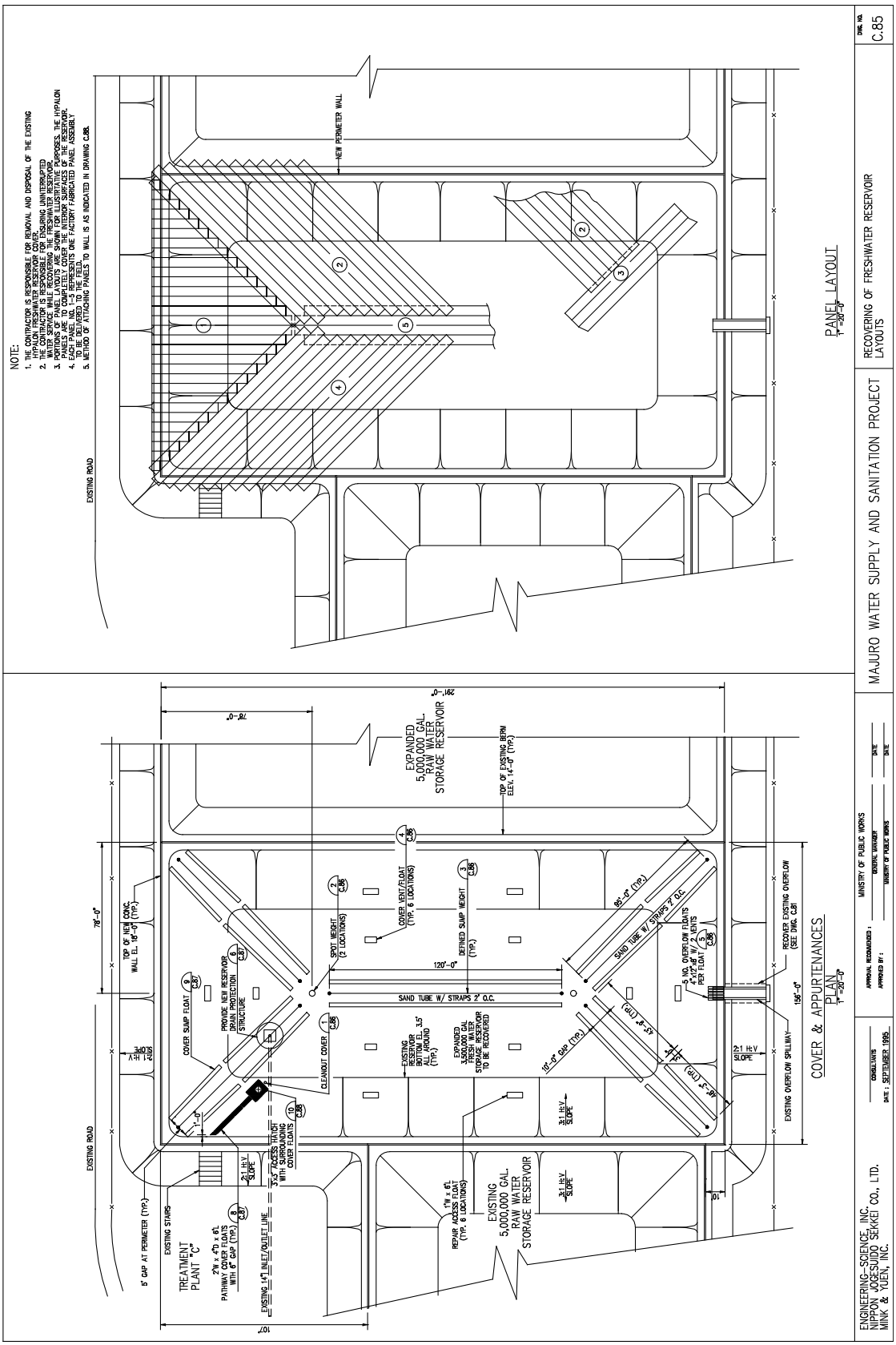
Drawing 4: Existing cross section layout.



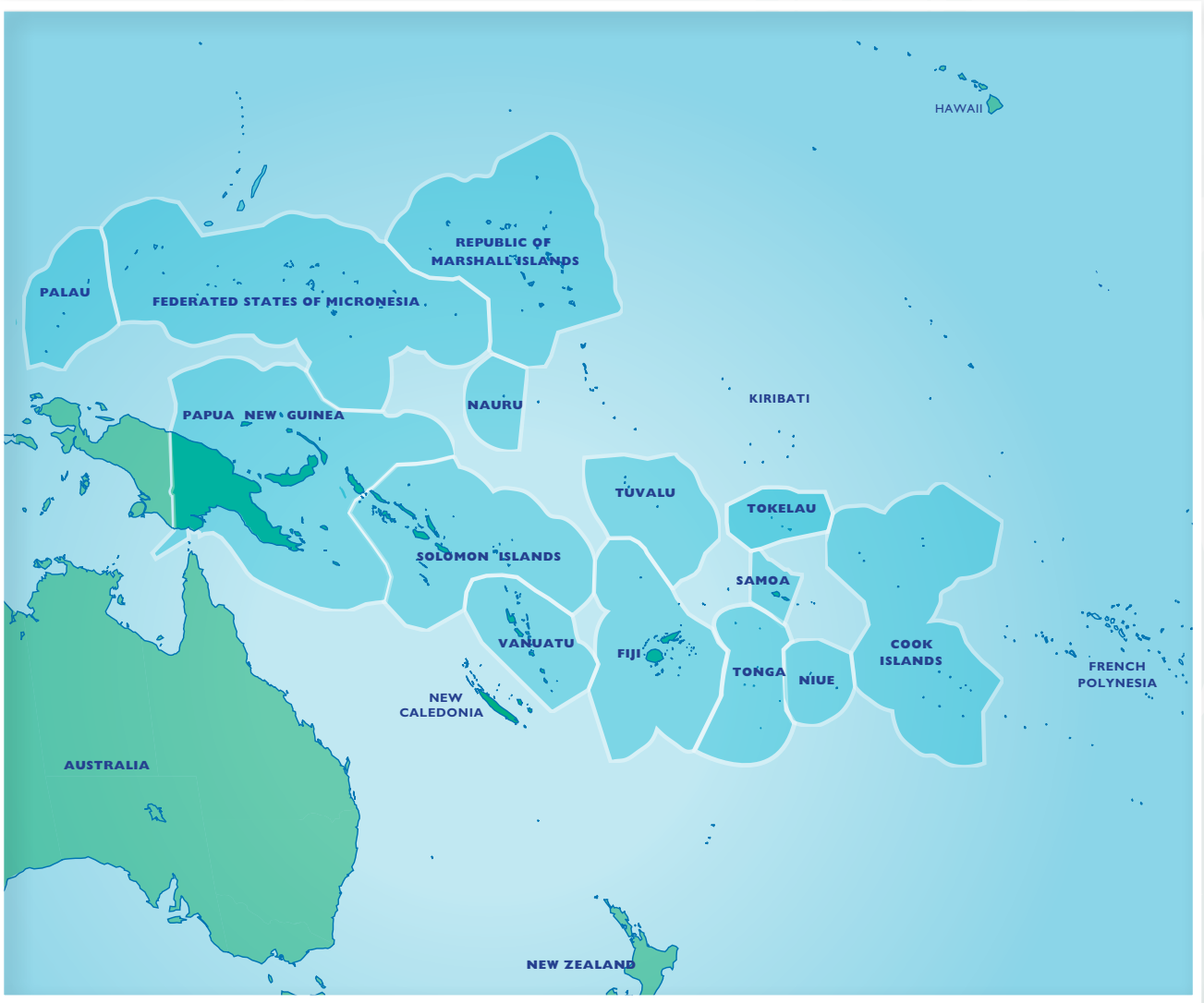
Drawing 5: C1 reservoir.



Drawing 6: C82 reservoir 6 liner.



Drawing 7: C85 TW reservoir cover.



PACC – building adaptation capacity in 14 Pacific island countries and territories

PACIFIC ADAPTATION TO CLIMATE CHANGE (PACC) PROGRAMME

The PACC programme is the largest climate change adaptation initiative in the Pacific region, with activities in 14 countries and territories. PACC is building a coordinated and integrated approach to the climate change challenge through three main areas of activity: practical demonstrations of adaptation measures, driving the mainstreaming of climate risks into national development planning and activities, and sharing knowledge in order to build adaptive capacity. The goal of the programme is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in three key climate-sensitive development sectors: coastal zone management, food security and food production, and water resources management. PACC began in 2009 and is scheduled to end in December 2014.

The PACC programme is funded by the Global Environment Facility (GEF)'s Special Climate Change Fund (SCCF) and the Australian Government with support from the United Nations Institute for Training and Research (UNITAR) Climate Change Capacity Development (C3D+). The Secretariat of the Pacific Regional Environment Programme (SPREP) is the implementing agency, with technical and implementing support from the United Nations Development Programme (UNDP).

www.sprep.org/pacc

PACC TECHNICAL REPORTS

The PACC Technical Report series is a collection of the technical knowledge generated by the various PACC activities at both national and regional level. The reports are aimed at climate change adaptation practitioners in the Pacific region and beyond, with the intention of sharing experiences and lessons learned from the diverse components of the PACC programme. The technical knowledge is also feeding into and informing policy processes within the region.

The Reports are available electronically at the PACC website: www.sprep.org/pacc, and hard copies can be requested from SPREP.

ISSN 2312-8224